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THEME:

THE ROLE OF HORTICULTURE IN FOOD SECURITY AND SUSTAINABLE HEALTH IN ERA OF CLIMATE CHANGE AND COVID-19 PANDEMIC

14TH - 18TH NOVEMBER, 2021

LAWRENCE OPEKE HALL,
COCOA RESEARCH INSTITUTE OF NIGERIA (CRIN), IBADAN.

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PRESIDENTIAL ADDRESS AT THE OPENING CEREMONY OF THE 39TH ANNUAL CONFERENCE OF THE HORTICULTURAL SOCIETY OF NIGERIA (HORTSON) HELD AT THE COCOA RESEARCH INSTITUTE OF NIGERIA, IBADAN, OYO STATE ON 14TH - 18TH NOVEMBER, 2021

Dr. Usman Ibrahim
President-in-Council, Horticultural Society of Nigeria

The President of the Federal Republic of Nigeria
The Honorable Minister of Agriculture
The Honorable Minister of Education
The Executive Governor of Oyo State, Engineer Abiodun Oluseyi Makinde
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All Invited Guests
The Chairman and Members of Local Organizing Committee
Respected Members of HORTSON and Conference Participants
Members of the Press, Ladies and Gentlemen

It is a great pleasure, honor and privilege to deliver this address and welcome you to the 39th Annual Conference of HORTSON taking place at Cocoa Research Institute of Nigeria (CRIN) located in the ancient city of Ibadan, the political headquarters of Yoruba land. Ibadan is ranked among the most peaceful cities in Nigeria and highly accommodating to visitors. You are, therefore, highly welcome to the capital city of the pacesetter State and to CRIN.

I want to thank the Executive Director of CRIN, Dr. Patrick O. Adebola, for hosting this year's conference. I want to assure you that our Executive Director, who is also a member of this great society, has made full arrangements for us to have an enjoyable experience throughout our stay and also go home with Cocoa, Coffee, Cashew, Kola and Tea.

The theme of this year's conference is: "the role of horticulture in food security and sustainable health in era of climate change and Covid-19 pandemic". This theme is coined taking into consideration the increasing demand for horticultural crops and the pressing needs for prevention and treatment of communicable and non-communicable diseases. The Covid-19 pandemic is putting diets and food security in jeopardy around the world with markets, affordability, and access to healthy and nutritional food out of reach. Evidence shows that horticulture is a notable solution for improved food security. Foods such as fruits, vegetables and spices play key roles in the health and well-being of families and communities. Sustainable horticultural production aims to produce nutritious and healthy foods, while reducing negative environmental impacts, conserving natural resources, and enhancing healthy ecosystem services.

Climate change, environmental degradation and stagnating yields threaten crop production and world food security. It is now recognized that the enormous gain in agricultural production and productivity achieved through the green revolution were often accompanied by negative effects on agriculture's natural resource base. These negative effects are so serious that they jeopardize its productive potential in the future. It is also clear that the current food production and distribution systems are failing to feed the world. Given the current and the increasing future challenges to our horticultural crop supply and to the environment, sustainable horticultural production is emerging as major priority for policy makers and international development partners.

The population of hungry and malnourished people in the world stands at about 1 billion. There is a need for a major increase in food production to feed a population of 9 billion people by 2050. This can be achieved by doubling crop production in developing countries like Nigeria. However, there is decreasing availability and more competition for land and water, increasing urbanization and shift to peri-urban production, changing consumption patterns, and climate change. Increasing crop production is usually associated with increase in pesticides and fertilizer use, plus subsidiary elements such as the supply chain and transportation.

Currently, in order to increase production, many farmers in Nigeria use conventional chemical control methods and cultural methods to control plants infestation by pests. It has, however, been recorded that these methods are not an environmentally friendly option for pest management due to indiscriminate use and disposal of pesticides wastes which poses major threat to the environment. The indiscriminate use and disposal use of pesticides has resulted in its persistence in the environment, thereby affecting the ecosystems and non-targeted organisms including humans and animals. These pesticides are known to be major causes of cancers, cardiovascular diseases, dermatitis, birth defects, morbidity, impaired immune function, neuro behavioural disorder and allergy, which are public healthcare challenges in Nigeria. Whereas the key concern should be how to increase production sustainably, without causing damage to vital natural resources, or to the ecosystem in general. Thus, there is the need for production systems that will take into considerations health, environmental, institutional, and social principles.

It is our role, as horticulturists, to provide farmers with adaptable and relevant technologies, and ensure that governments provide them with enabling policies, infrastructural and institutional support. It has now become obvious to me, as a horticulturist, that we need to expand the scope of horticulture beyond the growing and eating of foods. We need to find a political voice, align closely with social movements and focus on developing grassroots and community based alternative horticultural production systems that are trans-disciplinary, participatory and action oriented to be most effective in bringing about changes that are urgently needed. We are the change makers who can make a difference.

In order for our society to champion the needed changes, we have developed a strategic plan for the society which will cover 2020-2027, when the society will be 50 years old (1977-2027). We have also developed a draft document for a proposed "Council for Regulation of Horticulture (CORHORT) in Nigeria". This document has been reviewed by various stakeholders. A copy of the draft document is being circulated for review, corrections, and observations. You can send all your observations to info@hortson.org.ng or to any Council member.

The society is proposing to organize a National Summit that will bring all horticulturists in Nigeria together to discuss the way forward and to form a national technical review and implementation committee for CORHORT. The date for the summit will be communicated. We have also developed partnerships with many key organizations that include the International Society for Horticultural Science, American Society for Horticultural Science, American Public Garden Association, Agriculture to nutrition Community of Practice, Agriculture Nutrition and Health Academy, Longwood Gardens, Federal and State Ministry of Agriculture and Private Agricultural Companies inorder to further enhance our ambition of horticultural and agricultural development in Nigeria.

Over the next three days, more than 250 researchers, policy and programming experts working in all areas of horticulture will gather to learn, share, and innovate. Over 280 scientific presentations would look at:

a) Public horticulture for sustainable environment, health, and economic development
b) Combating horticultural enemies for human sustainability.
c) Ensuring availability of horticultural produce through value addition and preservation.
d) Development of horticultural platforms for information dissemination and technology transfer.
e) Forest horticulture, medicinal and aromatic plants utilization.
f) Climate and crop modelling for the advancement of horticultural crop production.
g) Gender and social economic issues in horticulture.
h) Role of government in horticultural transformation in a developing economy.

I very much encourage you to make the most use of this opportunity to gain new knowledge and skills and foster new inter-disciplinary collaborations. I am proud to present to you a programme pack full of skill-enhancing presentations, inspiring keynote speeches, thought provoking panel discussions and innovative presentations from researchers all over the country. As change-makers, I challenge everyone here to put at least one thing they have learned into action from this conference. I call on all to support our mission to CORHORT and the government at all levels to support horticulture in all its ramifications for the betterment of the country.

Finally, we have also created spaces for less formal interactions and learning, including cocktail, and social events at the same time observing the Covid-19 guidelines for meetings and conferences as prescribed by the PTF protocol on Covid-19.

It is with great thanks to our combined efforts that we can meet here in CRIN and push our ambitious agenda forward. I am grateful to our Local Organizing Committee. Thank you all for joining us for this exciting HORTSON conference! Wishing us a fruitful deliberation and safe trip back to our respective destinations.

Long Live Horticultural Society of Nigeria!
Long Live Cocoa Research Institute of Nigeria!
Long Live Oyo State!
Long Live the Federal Republic of Nigeria!

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KEYNOTE ADDRESS

THE ROLE OF HORTICULTURE IN FOOD SECURITY AND SUSTAINABLE HEALTH IN THE ERA OF CLIMATE CHANGE AND COVID-19 PANDEMIC

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Forum for Agricultural Research in Africa (FARA)

ABSTRACT
Food and nutritional insecurity is a major developmental issue in African countries; it spans from future generations' economics, health, intelligence, and cognitive potentials. The problems of climate change and the Covid-19 pandemic have exacerbated the pandemic's negative effect, triggering a threshold of the adverse impact that requires urgent intervention. This paper explains the cause of food and nutritional security In Nigeria using a mixed method comprising a systematic review of recent published articles and analysis of the available dataset. Food insecurity in Nigeria is associated with household poverty status and influenced by the national state of insecurity and displacement due to civil disturbance. Available data did not clearly show the influence of the covid-19 pandemic of food production and marketing in Nigeria; it rather affected trade and indirectly household income. However, the changes in weather variables occasioned by climate change reduce the production and distribution of horticultural commodities. The study confirms that a functional production system for horticultural commodities using the agricultural innovation systems approach could significantly enhance food and nutritional security in Nigeria. Policy action to trigger the desired change will include investment in research, advocacy, and awareness creation around the consumption of underutilized indigenous commodities.

INTRODUCTION
Food insecurity is a major global problem with multidimensional causes and effects. Global statistics on food insecurity indicated that about 690 million people at the global level do not have sufficient food, and about 95% of these individuals reside in the developing countries of the world, mainly in Africa and Asia (FAO, IFAD, UNICEF, WFP and WHO. 2020). The state of hunger in Africa is a precursor of many other health and social problems; civil disturbances, violent crime, dangerous migration, and other social vices, directly and indirectly, link hunger and food insecurity (Caughron, 2016). *Food security* is defined as a situation when all people, always, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for active and healthy life (FAO, 2002). This definition remains the most popular among intellectuals, having taken up the various dimension of the issues. Clay (2002) documented the evolution of the definition of food security; it explicated the policy, social, economic, and governance dimensions of the issues. The four interrelated elements in this definition include. Availability, access, utilization, and stability; each of the elements is a composite of issues. While availability refers to the physical presence of food for consumption, it encapsulates the issues of quantity, quality, diversity of food. It also covers the primary issues of maintaining a productive farming system and management of natural resources. Access refers to the ability of users to obtain food physically; it covers the issues of market access for producers and consumers, the cost of production, and retailers' price for food items; in other definitions, this is referred to as affordability. Utilization covers the issues of diversity and nutrient quality in the right proportion to meet the body's needs for a healthy life. Implicit in this is also the base issues of processing, packaging, and storage to retain quality. Stability covers the need always to have a regular supply of food, irrespective of the seasonal variation in production. The need to ensure constant supply to prevent the forces of demand and supply from shooting up the consumer's price. Issues of food price policies and provision of infrastructures for strategic food reserve to cater for emergencies such as drought, flood, and fire. The notion of nutritional security was added to food security issues,

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nutritional security refers to access to food with adequate quantity and number of nutrient elements in a balanced form to meet the need of the body for a healthy life (Ingram, 2020). The world committee on food security thus gave a broader definition of food an nutritional security as a state "when all people, at all times, have physical, social and economic access to food which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life" (FAO, 2012). The crave for nutritional security came up following strong observation of stunting and wasting in children as well as the development of obesity and other diseases including Diabetes 2 in adults. This situation is not necessarily due to lack of food but imbalanced consumption of calorie dense food commodities at the expense of nutrient dense food. The consequences of poor nutrition on societal health, economy, cognition of the labor force and intelligence of the future generation is a cause for concern (Prado and Dewey, 2016).

According to World Bank data, Nigeria is rated as the most populous country in Africa, with 206.1 million, about 16.5% of Africa's total population. The diversity of culture and languages in Nigeria is the highest on the continent, providing economic and social stability opportunities. However, the food and nutritional security statistics are poor and do not reflect the enormous potentials of the most populous country in Africa. Available data indicated that about 14 million Nigerians are experiencing severe food insecurity (Owoo, 2021). This situation is mainly due to a more aggravated poor economic situation due to climate change, Covid-19 pandemic, and growing insecurity. These climatic and social disturbances prevented farming activities leading to a reduction in food production and a high increase in the price of food commodities.

In most food crises across the globe, the initial household response tends toward reducing the consumption of nutrient-dense food commodities. These commodities are traditionally high valued and costly; they are mostly the sources of protein and essential vitamins, viz., meat, fish and other seafood, fruits, vegetables, and legumes. The attention is shifted from having nutritious food to having food on the table to maintain life; essentially, the more affordable high calory food items predominate at this stage. This has its effects on the health and wellbeing of the society at large and the development of children and infants. The cause issues for the current surge in Nigeria's food and nutritional insecurity status requires more intellectual inputs in devising a sustainable solution.

Traditional problem-solving efforts revolve around tackling the cause issues viz., climate change, insecurity, covid-19 pandemic and the more endemic poor agricultural sector productivity, poor infrastructure, and rural poverty. These are ongoing, but such an approach is time-consuming and costly. A complimentary response mechanism could be strengthening the food system for the production and consumption of nutrient-dense food commodities. It essentially points at the horticultural sectors with over 300 indigenous nutrient-rich fruits and vegetables. The indigenous food commodities also need to be explored as sources of nutrient-rich diet to generate a resilient food system.

This paper discusses the various options to leverage the advantages of the horticultural crops as solutions to the food and nutritional security problems in Nigeria in the face of climate change, the covid-19 pandemic, and other emerging constraints. The paper use mixed methods comprising of extensive literature review, data sourcing from popular public data repository.

CAUSE AND CONSEQUENCE OF FOOD INSECURITY IN NIGERIA

Food insecurity is endemic to the rural settings in Nigeria, mainly due to several factors that limit sustainable agrarian livelihood, which is the primary means of living for rural settings. Nigerians living in the rural area is 99.1 million, about 48.04 % of the country's population in 2020. This figure has increased from 46.9 million in 1971 to 99 million in 2020, growing at an average annual rate of 1.54%. This is due to the expansion of the peri-urban area into the rural settings and the associated growth of the middle class. The middle class currently constitute 23% of the population, 92% of these individuals have post-secondary education, and their priority is to provide their wards with higher education. These individuals live in a decent apartment, and 18% plans to move to the owned apartment (Robertson et al., 2016). Available statistics indicated that the rural to urban migration has increased at 4.5% per annual mainly due to migration searching for higher income and quality of life (World Bank, 2016). The reason for this relocation is the protracted lack of infrastructures such as road networks, health facilities, education, employment opportunities, access to input and output market. All these factors make rural life unappealing and trigger the protracted shortage in farm labor with its attending social and economic effects. Smith et al. (2017) reported a significant association of food insecurity with low household income, poor social capital, low educational level, low household income, and the country's GDP.

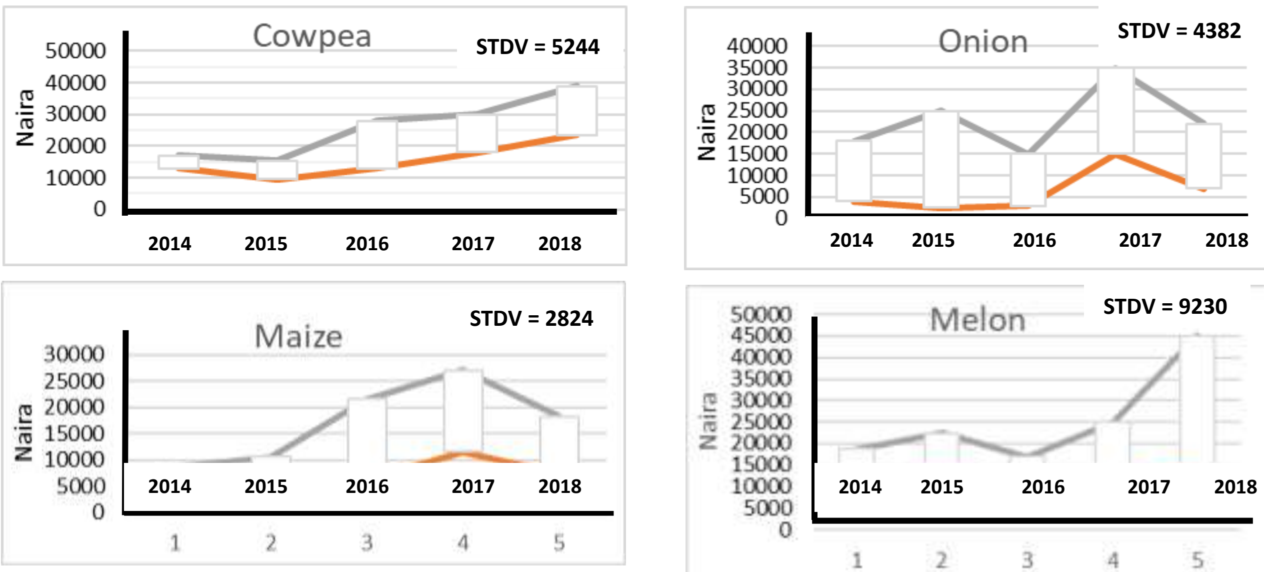

Figure 1. Fluctuations in market prices of food commodities in Nigeria

Data Source: Authors data courtesy the National Agricultural Research and Extension Liaison Services (NEARLS) /ABU, Zaria

POVERTY LEVEL

Available data indicated that a strong relationship exists between food insecurity and poverty in Nigeria. Data from the Nigeria Bureau of Statistics indicated that 40% about 83 million Nigerians live below the poverty line of US $1.9 as of the year 2020 (Onyeiwu, 2021). This estimate uses the headcount poverty index; when multidimensional poverty measure was employed, about 98 million Nigerians, i.e., 47.3% Nigerians, live under poverty, and the more significant proportion is found in the northern part of the country. The food price inflation in Nigeria ranged between 30.52% - 17.64% (Figure 1), following the national price index report in 2021 (NBS, 2021). This contributed significantly to the total inflation in the country. It is noteworthy that the percentage of income spent on food in Nigeria ranked very high compared to other countries of equal standing. The world economic forum reported that an average family in Nigeria spends 56.4% of household income on food compared with America that spends 6.4%, Kenya 46.4, Cameroon 45.6%; and Algeria, 42.5% (Gray, 2016). A smart indicator of human development and wellbeing is the proportion of household income spent on food. The implication of this occurrence is the push of more families in Nigeria below the poverty line. Often, the pressure of insufficient household income affects the kind and quality of food consumed. In a study reported by Omotesho et al. (2008), accessibility to health facilities, household size, farm size, and household expenditure on food were critical determinants of a household's food and nutritional security status. These indicators are mainly pointing at the household capacity to produce and realize sufficient income to purchase food items over the lean period.

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GROWTH OF THE MIDDLE CLASS

The growth in the middle-income class is a constant measure of development in a country. It is a pointer to some developmental factors that will emerge due to the demand of this class of individuals. The middle-income class is defined as individuals and households that fall between the higher and lower level of the socio-economic hierarchy (Hayes, 2020). They are mainly in the working class with the educational qualification that allows them to have a relatively good income, access to a comfortable house and vehicle. In Nigeria, the average middle-class income ranged between US$ 3 - $10 per day based on the World Economic Forum report of 2015; the lower percentile of $3 is consistent with the Africa Development Bank estimate that households that earn $4-$10 per day are in the lower middle class. Using the current exchange rate of $1 = N530, any household that earns up to N1,590per day could be regarded as fitting into the middle-class category. The 2015 estimate is outdated, and a new range is needed for Nigeria due to its recent financial downturn and fluctuation in the currency rate.

The bottom-line effect of the growth in the middle class is the change in food consumption patterns and the increase in demand for rich and more appetizing food commodities. The effect of this rise is always a sharp increase in price and unavailability of the commodities to meet the new demand. This will also have a multiplier effect on the industries and the national economy in the net importers of food like Nigeria. (Euromonitor, 2013)

INCOME LEVELS

The general income level is a significant contributor to food and nutritional security; it refers to the available purchasing power an individual or household could muster to acquire necessities such as food, clothing, housing, and health facilities. Income disparity is associated with food insecurity (FAO, 2019). Most countries with high-income disparity also have low per capita income and low purchasing capacity for food. Income disparity occurs when members of the working force do not get the same share of the economy's value. (Karmakar and Sarkar, 2013). When the disadvantaged population increases, the capacity to access nutritious food decreases, and insecurity increases within the system. The Gini coefficient in Nigeria is in the margin of 35.1; it is 31.9 in the urban area and 32.8 in the rural area (Figure 2). Income disparity in Nigeria is high; popular data suggests that more than 41% of the population is living below the poverty line.

Rural poverty is a cause for concern, significantly where the urban, rural migration is increasing. An earlier report indicated that the depth of rural poverty in Nigeria is 33% compared to urban poverty at 23% (Anyawu, 2006). The more significant proportion of the Nigerian labor force is in the agricultural sector, and they reside in the rural area; the poverty status of the rural household is indicative of the sector's performance. World Bank (2014) reported the likely effect of the increase in agricultural productivity on the poverty status of the farming household in Nigeria. A 10% increase in agricultural productivity will reduce the likelihood of being poor by 2.5% -3% in a typical Nigerian farming family.

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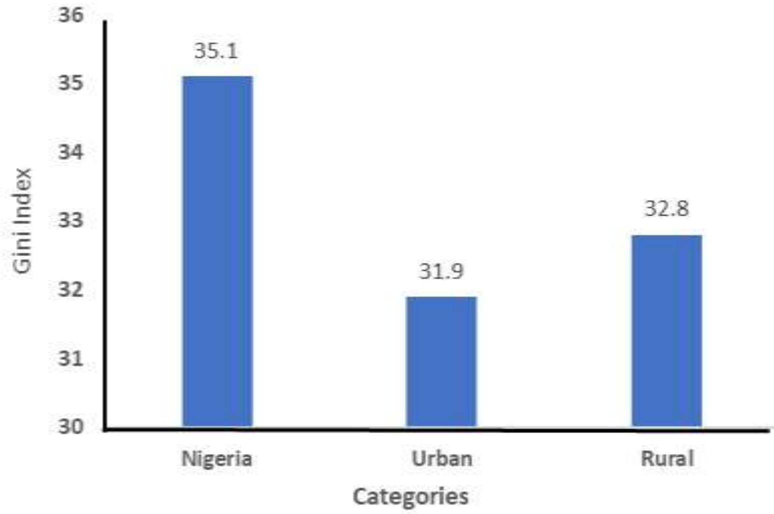

Figure 2. Gini Coefficient in Nigeria showing the state of income disparity in 2019

Data is sourced from https://www.statista.com/statistics/1121404/gini-coefficient-in-nigeria/ (accessed 1st Nov 2021)

EFFECTS OF CLIMATE CHANGE ON FOOD SECURITY IN NIGERIA

Climate change is a protracted global problem that is currently receiving broad-based attention; climate change is projected to affect the ailing agricultural sector in African countries. Nigeria is currently experiencing the debilitating effects of climate change on its agriculture; such effects will range from reduction in growing season due to fluctuation in the amount and distribution of rainfall, incidence of floods, dry spells, and progressive desertification. The surge in new pests and diseases with crops and livestock has been noticed in recent times. The button-line effect is reduced food production and the associated increase in food price (Ifeanacho, 2020).

The global effort at curtailing the effects of climate change in the agricultural sector is the development of the Climate Smart Agriculture (CSA) concept. The pillars of the CSA include mitigation, adaptation, and sustainable intensification. In the last decade, research actors, technocrats, and policymakers have taken up the CSA concepts and swung into actions to generate policies, systems, and technologies that are CSA compliant and respond to the need of the end-users.

RELATIVE EFFECT OF COVID-19 PANDEMIC ON FOOD AND NUTRITIONAL SECURITY IN NIGERIA

Covid pandemic had a harsh negative effect on the food and nutritional security in Nigeria. Due to the pandemic that affected food and fiber production processing and marketing, the already weak sector became weaker. The most vulnerable households were severely affected. Up to October 2021, the total reported infection in Nigeria was 207,618 and total death of 2,745, giving a recovery rate of 98.6%. Despite this impressive recovery rate, the national economy experienced a considerable downturn due to fiscal failures and breakdowns in arrangements and networks with partners from other countries. Poverty rates increased due to unemployment; many businesses and manufacturing companies also closed. The agricultural sector grew at 2.2% before the pandemic; this rate is far lower than the continental average of 3.4%. In 2020, the growth rate came down to 1.8%, leading to a shortage in supply and a hike in the food price.

The world Bank predicted that the Covid-19 pandemic would most likely push more than 5 million Nigerians below the poverty line due to its effects on the economy, in addition to the expected increase of 2 million due to population growth (Olurombi, 2020). The report specified that the Nigerian economy might shrink between 3.2% –

7.4% in 2021, while the poverty rate may increase from 40.1% in 2019 to 42.5% in 2020 (World Bank, 2020). The implications of covid-19 are traceable to the shortage in supply of imported commodities and disruption in the flow of export trade; resulting in high inflation with resultant effects on the prices of food commodities.

LEVERAGING THE BENEFITS OF HORTICULTURAL PRODUCTION SYSTEM FOR FOOD AND NUTRITIONAL SECURITY IN NIGERIA

The need to foster the availability, accessibility, and affordability of nutrient-dense food is vital to resolving Nigeria's food and nutritional security. The bulk of these food commodities falls under the horticultural crop category, and they are produced and marketed by smallholders in negligible quantity. Sixty-five percent of the cultivated land area in Nigeria is dedicated to the critical six energy commodities, viz., cassava, yam, maize, sorghum, rice, and millet. Cowpea and soybean, groundnut occupy a sizeable portion of the land, while a negligible portion is grown to horticultural crops (Bala, 2010).

The horticultural food commodities are fruits, vegetables, spices, and medicinal herbs. They are known to be rich in nutrients and are often depended upon as sources of essential vitamins and minerals rather than calories. Table 1 showed the nutrient content of selected horticultural crop commodities. It attempts to present two conventional commodities Maize and cowpea, just for comparison on nutrient composition.

Horticultural commodities are high valued crops for their nutrient content, and they are consumed as an accompaniment to main meals. They are a good income source for farmers and other marketers that engage in their value chain businesses.

The constraints to the production of horticultural crops are like those experienced by the other food crop commodity such as cereals, legumes, root and tubers, and tree crops. Ibeawuchi et al. (2015) reported the specific constraints confronting the development of horticultural commodities in Nigeria. The problems can be categorized into three broad groups, namely technological, institutional, and policy constraints. The three categories are not mutually exclusive as the component issues do have cross-cutting dimensions (Figure 3). Central to the development of the horticultural sector is the need to establish a functional research system to generate the required knowledge, technologies, and inventions. Horticultural research would respond in the affirmative to the low productivity of the different horticultural commodities and bridge the yield gap. The yield gaps are mainly due to the poor potential of the seeds, the production system, and the inefficient use of external inputs. Plaiser et al., (2019) reported that most vegetable producers in Nigeria recycle old seeds and use less fertilizer than the recommended rate. The best technologies for the smallholders' farmers should be packaged in the seeds by the researchers. Seeds should thrive under marginal nutrients, water, and flood; they should produce a good yield, have multiple resistance to pests and diseases, and possess desirable culinary properties. The breeders need to embrace the multistakeholder approach and run demand-driven breeding of improved varieties; this will facilitate meeting the needs of the technology end-users and adoption rate.

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Table 1. Nutrient content of selected Horticultural Crop in Nigeria

Food Commodity	Nutrient type						
	Vitamin C (%)	Fiber (g)	Protein (g)	Calories (kcal)	Carbohydrates (g)	Calcium (%)	Water (%)
Leafy Vegetables							
Jute Mallow	.	1.7	3.2	.	4.88	18.4	75.82
Amaranthus	52	NA	2	.	4	22	91.69
Cabbage	60	2.5	1.3	25	6	4	92
Lettuce	15	1.1	1.4	15	2.9	35	95.63
Bitter leaves	.	29.2	33.3	.	.	.	.
Fruit Vegetable							
Egg plant	3	3	1	.	6	9	92
Tomato	28	1.2	0.9	18	3.9	.	95
Pepper	23.9	1.5	.	40	9	1	88
Okro	23	3.3	.	.	7.46	82	89.6
Turkey berry	.	25	50	.	.	10	.
Root Vegetables							
Onion	7.4	1.7	1.1	.	9.34	23	89.11
Carrot	9	2.8	0.9	41	10	3	88
Ginger	5	2	1.82	.	17.77	16	79
Beetroots	4.9	2.8	1.61	180	9.56	16	87.58
Fruits Tree							
Mango	36.4	1.6	0.82	250	15	11	83.5
Orange	53.2	2.4	0.94	197	11.75	40	86.75
Pawpaw	23.5	.	2	120	30	.	.
banana	8.7	2.6	1.09	371	22.84	.	74.91
guava	228.3	5.4	2.55	285	14.32	18	.
Shrub fruits							
Watermelon	8.1	0.6	0.16	46.2	11.6	10.8	91.45
Pineapple	47.8	1.4	0.54	209	13.12	13	86.0
pumpkin	9.0	0.5	1.0	1.9	6.5	21.	91.6
Bottle neck	8.4	1.2	0.6	63	3.69	24	.

Source: USAID https://fdc.nal.usda.gov/ndb/search/list?qlookup=11219&format=Full

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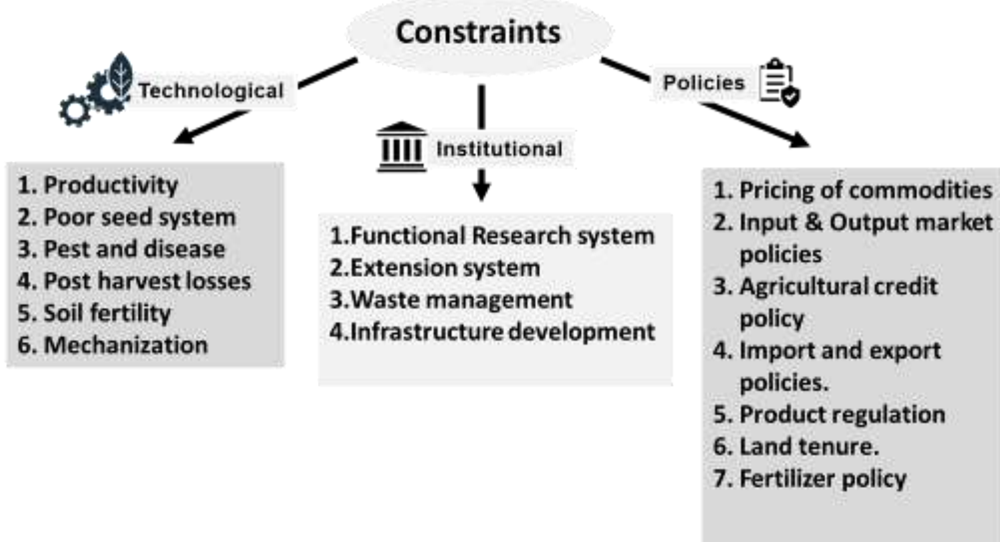

Figure 3. Category of constraint to the development of horticultural crops in Nigeria

Horticultural crops are highly susceptible to insect pests and diseases; most often, agrochemicals are used to control the infestation and reduce yield loss. Research effort needs to give attention to pest-resistant breeding to develop varieties tolerant to diseases and resistant to pest attack. More than 20% -50% of horticultural crops produced in Nigeria are subjected to post-harvest losses (Muhammad et al., 2012). This leads to loss of income for farmers and traders; it is mainly due to a lack of processing facilities and preservation techniques. Leafy vegetables need to be consumed the same day they are harvested, while most fruits should be kept under certain conditions if they will still be suitable for consumption within two weeks of harvest. In a more advanced clime, cold storage facilities transport fruits and vegetables over a long distance to processing and storage facilities. Research efforts are further needed to develop a post-harvest handling method that could be used at the farmer's level to preserve horticultural commodities.

Efforts to enhance the contribution of horticultural crop commodities to food and nutritional security would require changes in institutional order. This could start from reorganizing the research and extension systems to be more functional in delivering knowledge and technologies to the end-users. In Nigeria, research funding is a significant constraint, the same as the fund for research equipment and other infrastructure. The researchers depend primarily on donor-funded projects designed in the direction of the interest of the development partners and, most time, not in the country's direction for sectoral growth. Bubu et al., (2017) recommended an intelligent funding strategy for agricultural research in Nigeria through the Agricultural Research Council of Nigeria (ARCN). One percent tax is requested from import duties on agricultural commodities to service research activities in its 17 research institutes. Innovative funding strategies like this are required to drive the horticultural research for delivery of outputs.

Furthermore, the research implementation method needs to be all-encompassing using the innovation systems approach. The multistakeholder approach needs to be institutionalized to ensure that research is demand-driven and the research output responds to the felt needs of the end-users. Other institutional changes will include revamping the agricultural extension systems and reintegrating them as part of the research organ in the country. This will remove the organizational gap and strengthen the communication between the researcher and the extension system for delivery. Within this form of institutional change, the mandate of the research organization will no longer be sole technology generation, but technology needs assessment, generation of solutions, dissemination, and facilitation of other enabling factors. With this model, the research organization's role will now be the holistic generation of innovation for impact.

The forum for Agricultural Research in Africa (FARA) worked with its stakeholders to develop the innovation to impact framework that could drive the restructuring of the research and extension system at the country level. Figure 4 depicts the core functions that should define a research system with an innovation outlook; it includes mobilizing the enabler factors, such as policy, capacity building, knowledge management, and private sector engagement as an intrinsic part of the organization's function. The central issues of technology generation, dissemination, adoption, lesson learning, technology refinement, and commercialization will now be an integrated whole.

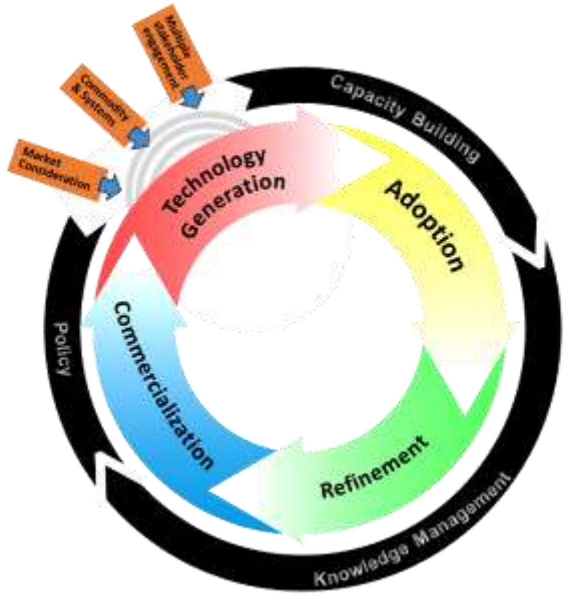

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Figure 4. Technology to Innovation Impact Pathway

The development of operational policies around the pricing of agricultural commodities is central to the sustainability of livelihood in the agricultural sector. Currently, the prices of agricultural commodities are subjected to the forces of demand and supply. This is counterproductive for producers of highly perishable horticultural commodities tied to the seasons of the year. Everyone moves to the market at the same time with their supplies, forcing down the price far below the cost of production. This is a major demotivating factor against the production of horticultural commodities in Nigeria. An informed policy is needed to ensure that the farmers can make a livelihood compliant margin from their endeavor. The use of the livelihood Compliant Pricing of Agricultural Commodities (LCPAC) could be a way to ensure sustainable livelihood from the agricultural endeavor. Other policy action will be on regulating input and output market to ensure fair pricing, regular supply, and eradication of the market lords and tyrants. There should be an effective agricultural credit policy that will ensure the availability of credit facilities at an interest rate suitable for the peculiarities of the agricultural sector. Import and export policies, regulation of product qualities, land tenure law, and fertilizer blending and marketing policies.

ROLE OF FORGOTTEN OR UNDERUTILIZED FOODS COMMODITIES IN ACHIEVING FOOD AND NUTRITIONAL SECURITY IN NIGERIA

Currently, about 7,000 plant species out of about 30,000 identified edible plant species had been used in the history of humanity to meet food needs (FAO 1998). Among these species, just 103 crops species provide 90% of the calories in the human diet, while only four of these (rice, wheat, maize, and potato) account for 60% of the human energy supply (Tontisirin and Bhattacharjee, 2010, Padulosi *et al.*, 2013). This suggests that many crop species are forgotten (i.e., underutilized, neglected, unimproved). They are underutilized in terms of consumption. They are neglected in terms of research, extension, commercialization, and conservation. The long-term neglect of these commodities has dramatically changed the national food system and led to a gradual decline in the consumption of the traditional food resources in many communities, as well as the conveyance of knowledge associated with the plants (Vorster *et al*., 2008; Bvenura and Afolayan, 2015). Based on this fact, there is a strong rationale for diversification of production and consumption in favor of the underutilized crop commodities as this would significantly contribute to improved nutrition and household food security (Jaenicke and Höschle-Zeledon, 2006).

The prevailing food and nutritional security situation in Nigeria is necessitating the need to think outside the box and explore options that are erstwhile ignored. Exploring and reintegrating forgotten or underutilized food commodities into the mainstream food system is a viable option. The term forgotten food refers to crop and livestock commodities that are erstwhile sources of food but have been neglected due to the advent of other food commodities. Forgotten foods are neglected and underutilized species, indigenous food commodities, orphan crops, etc. Padulosi *et al.* (2011, 2013) defined forgotten foods as crops that attract little attention or have been entirely ignored by agricultural researchers, plant breeders, and policymakers. Over millennia, the currently forgotten foods were the primary source of food (Demi, 2014). They are resilient and well adapted to the needs of farmers in agricultural environments. The adaptation of most forgotten foods to low-input agricultural systems and their nutritional composition has made them a reference point for having the potential to reduce food and nutrition insecurity, particularly for resource-poor households in Africa.

Furthermore, the adaptability of forgotten foods suggests that their cultivation is less damaging to the environment and addresses cultural needs. They also play an essential role in the cultural heritage of local communities (Mabhaudhi *et al*., 2016). Traditional foods are often a symbol of cultural heritage; they are part of the identities of diverse ethnic groups (Engler-Stringer, 2010; Sharif *et al*., 2016).

Agulana (2020) reviewed the importance of forgotten food to food and nutritional security in Nigeria; his work clearly showed that forgotten foods could have a much higher nutrient content than most nationally known species commonly produced and consumed. They stand out in commodity selection for nutrition-sensitive agriculture due to their great potential for improving nutrition and climate change resilience. The forgotten foods also play an important role in diversifying the food base to enhance food and nutrition security due to the varieties of nutrients the crop species can provide. Diversity of diets based on diverse crops delivers better nutrition and more significant health with additional benefits for human productivity and livelihoods. Also, because the crops serve as alternatives in crop failure, they readily fit into different cropping systems or schemes.

Despite the value that forgotten foods can contribute to Nigeria's food system, they have not attracted sufficient research and development attention. Therefore, collective actions are required to harness these potentials at the global, regional, and national levels. These actions involve creating awareness and communicating these foods' economic, nutritional, environmental, and cultural values to improve their consumption. They also provide the enabling environment for developing these foods through research, empowering farmers in production, and supporting the private sector in processing, value addition, and marketing.

CHARACTERIZATION OF FORGOTTEN FOODS IN NIGERIA

A prime crop commodity in a particular place could be termed as forgotten in another place due to the utilization status of the crop. Thus, the use of multiple factors to characterize forgotten food includes the prominence of the commodity in household food preference, the scale of production, market status, agronomy of the crop, nutritional quality, adaptation to agro-ecology, etc. Several authors have classified forgotten foods based on their understanding of the crop in their regions; Mabhaudhi *et al.* (2017) identified 13 priority forgotten foods in South Africa and categorized them into cereals, legumes, root and tuber crops, and leafy vegetables based on drought and heat stress tolerance and nutritional value. Dansi *et al.* (2012), in a survey conducted in 50 villages in the Republic of Benin, identified 41 neglected and underutilized species forgotten foods based on many factors, among which the extent and degree of consumption were paramount. In another study, Chivenge *et al.* (2015) identify and characterize forgotten foods in SSA with agronomic potential to those that can grow under water-scarce conditions, water requirements, and water productivity. The Africa Orphan Crop Consortium (AOCC) produced a compilation of different groupings and proposed that it will be most appropriate to characterize the forgotten food in Africa based on the following:

1. Period or life cycle: Annual, short-lived, and long-lived perennial
2. Consumable, edible parts or purpose of use:
    1. Fruit vegetable,
    2. Leafy vegetables
    3. Shrubs or small trees with edible fruits, nuts, and seeds
    4. Trees with industrial uses (Tianjin, dyestuff, etc.)
    5. Edible root and tubers
    6. Cereal grains
    7. Grain legumes
    8. Medicinal food crops
    9. Medicinal tree crops

A review of about 100 compiled forgotten foods found in Africa revealed that about 63% are horticultural crops; shrubs or small trees with edible fruits, nuts and seeds, fruit and leaves vegetables, while very few (about 1%) are in the category of annual industrial crops (Figure 5).

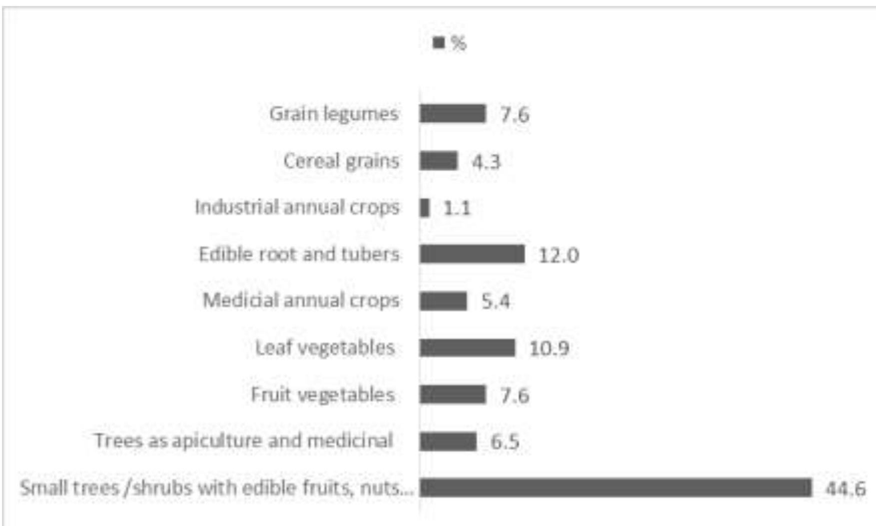

Figure 5. Characterization of 100 main Forgotten Foods

WAYS TO MAINSTREAM FORGOTTEN FOOD INTO NIGERIA FOOD SYSTEM

To mitigate the danger of food shortage and nutritional insecurity orchestrated by various constraints and lately aggravated by climate change, COVID-19, increased desertification, among others. There is the need to invest in life-saving crops that are resilient and well adapted to a broader range of environment and cropping systems. This will require a significant modification in the agricultural research and innovation approaches towards identified NUS in each region of Africa. As part of the global effort to reintegrate forgotten foods into the mainstream foods in Africa, FARA mobilized Africa stakeholders to develop the continental manifesto on forgotten and underutilized commodities; the following action plan is imperative for the reintegration of the commodities into the food system.

1. Awareness Raising for recognizing the values of forgotten foods by all in the society.
2. Creation of novel research development and networking

3. Promotion of concerted efforts in participatory plant breeding that will improve the adaptation of forgotten foods.
4. Development of sustainable seed systems that will enhance accessibility, availability, and affordability of high-quality seeds of forgotten foods.
5. Promote collection and conservation of genetic resources of forgotten foods for germplasm exchange.
6. Development of a specialized capacity instrument for NARES and relevant institutions towards the development of forgotten foods.
7. Facilitation of better access to markets, support to short supply chains, and alternative retail structures.
8. Encourage more advocacy and evidence-based policy change.
9. Introduction of knowledge on forgotten foods into teaching modules in educational programs.
10. Encouraging more advocacy and evidence-based policy change.
11. Adoption of new metrics and indicators to show the value of forgotten foods.
12. Fund and resources mobilization for investment on Forgotten Foods.

RECOMMENDATIONS AND CONCLUSION

Food and nutritional security are central developmental issue in the nation's life; it revolves around health, societal wellbeing, the integrity of the labor force, cognition potential of the posterity, and economic stability. Recent negative happenings in Nigeria's economic, social life, security status, political stability, and general societal wellbeing tend to put more pressure on the nation's food and nutritional security status. Available evidence suggests that climate change, the covid-19 pandemic, and national security are the primary factors aggravating the problems of food and nutritional insecurity in Nigeria.

The bottom line to food and nutritional security is the income level of the majority in Nigeria, vis-à-vis the price of nutritious food. Our review indicated that poverty is endemic in the rural area, and the urban to rural migration is on the increase in Nigeria due to the expansion of the urban in the peri-urban area and gradual reduction of the rural-urban land gap. The recommended effort to reduce poverty is to ensure the sustainability of the agrarian livelihood. We proposed the leveraging of appropriate measures to ensure the total factor productivity of our agriculture. We propose the adoption of Livelihood Compliant Agricultural Commodity Pricing to shield the price of agricultural commodities from the market forces of demand and supply. It will secure the livelihood of the smallholder farmers and secure the baseline income.

Efforts to eradicate the problem of food and nutritional insecurity in Nigeria will require a holistic approach. Such an approach will need to support the agricultural sector with interventions that will make it functional. The research systems may explore the innovation systems approach in its operations to ensure coherent generation of knowledge, technologies, and innovation. The role of the systems will not be limited to research only but also the identification of constraints, generation of solutions, dissemination, and lesson learning for societal improvement. It will also involve the mobilization of enabling factors.

Prime concentration on horticultural research and development is vital to ensure nutritional security. Our review indicated that 63% of the nutrient-dense food among Nigeria's forgotten or underutilized foods falls under the horticulture crop categories. It is essential to channel 63% of the research fund for food crops in this direction with demand for commensurate outcomes. We recommended that a specialized research program should be established for the reintegration of the forgotten food into the mainstream food systems in Nigeria with demand for intermediate development outcomes from the practitioners.

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LEAD PAPER

ROLE OF RESEARCH AND DEVELOPMENT IN TRANSFORMING HORTICULTURE AND HORTICULTURAL INDUSTRY IN NIGERIA

Dr. Prof. Garba Hamidu Sharubutu
Executive Secretary ARCN

INTRODUCTION

Agriculture is the singular most important sector that can transform the economy of our great country to meet the growing demands for food, nutrition, industry and jobs. It forms the bedrocks for the diversification and economic recovery plan of the Federal Government and plays critical roles in the livelihoods of many individuals in Nigeria. The population of Nigeria presently stands at 200 million and it is one the fastest growing in the world. By 2050, these populations will double and Nigeria's population will be 450 million. This will bring in-balance between agricultural productivity and the population growth rates, which may exacerbate widespread food insecurity and poverty (Van der Waal 2020). Accordingly, increase in agricultural productivity is the key determinant to alleviate the foreseen circumstances and positively transform socio-economics and livelihood of Nigerians farmers.

CURRENT STATE OF NIGERIA'S AGRICULTURE

Crop production is the largest segment of Nigeria's agriculture, which accounts for about 87.6% of the sector's total output. This is followed by livestock, fishery and forestry at 8.1%, 3.2% and 1.1%, respectively. Agriculture remains one of the key sectors in Nigeria, contributing an average of 24% to the nation's GDP over the past seven years. In addition, the sector employs more than 60% of the country's labour force and more than 80% of Nigeria's farmers are smallholders, which accounts for 90% of Nigeria's agricultural produce (PwC Nigeria 2020).

Agriculture budget is only about 1.8% of the total national budget size, which significantly falls short of the 10% specified in the Maputo Declaration. Nigeria's agricultural trade deficit stood at N689.7 billion in 2019 compared to N549.3 billion in 2018, while Nigeria's cumulative agricultural imports stood at N3.35 trillion, four times higher than the agricultural export of N803 billion between 2016–2019 (PwC Nigeria 2020).

AGRICULTURAL RESEARCH SYSTEM IN NIGERIA

Agricultural Research Council of Nigeria (ARCN) was established in 2006 to coordinate and supervise agricultural research, training and extension in Nigeria. The mission of ARCN is to achieve significant improvements in agricultural productivity, marketing and competitiveness through generation of appropriate technologies, policy options and knowledge management of the agricultural research system. National Horticultural Research Institute, Ibadan, is one of the sixteen Agricultural Research Institutes under the purview of ARCN and has the national mandate for research in horticulture. The institute was established in 1975 and has two substations located in Mbato-Okigwe, Imo state and at Bagauda, Kano state.

GENERAL CONCEPT FOR RESEARCH AND DEVELOPMENT

Research and Development (R&D) involved generation of new knowledge that include activities undertaken to innovate and introduce new products, processes, services or improving existing ones. It is a systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications (Kadir *et al*., 2015). R&D activities include basic research, applied research and experimental development (Bronzini and Paolo, 2006) and it is the first stage of the product lifecycle during which a product team will conceptualize and assess the viability of a new product to decide whether it is worth taking or not. R&D is applied to every area of specialization and have different approaches but there are

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some common factors, which include concept development, prototyping, IP management and technology licensing (Keith Fuglie *et al.,* 2015).

Research and Development represent a large and rapidly growing effort in both industrialized and semi-industrialized nations. The reason for increased emphasis on R&D is because it creates new or improved technology that in turn can be converted into a competitive advantage at the business, corporate, and social levels (Lawrence 2018). While the process of technological innovation is complex and risky, the reward can be high if the technology is safeguarded as proprietary and protected by patents, trade secrets, nondisclosure agreements, etc., in which case the technology becomes the exclusive property of the company or organization and the value is much higher (Sadraoui and Deguachi 2014). In agriculture, scientists actively seek to discover procedures that will increase livestock and crop yields, improve farmland productivity, reduce loss due to disease and insects, develop more efficient equipment, and increase overall food quality, among others.

AGRICULTURAL R&D KEY DRIVER FOR INCREASING PRODUCTIVITY

Research and Development in agriculture is designed to optimize total farm inputs to achieve maximum output both in terms of quantity and value. It leads to increased knowledge about high yielding crops; invention of drought resistant crops, which help in preventing crop failures in the event of drought; better ways of improving soil fertility, which leads to increased yield; introduction of advanced machines in production, which made the production process to go faster, and leading high quality and quantity of products within a short period of time. The advanced machines may include machines for tilling land like tractors, planting and harvesting machines. Agricultural R&D could also lead to the discovery of crop and livestock diseases, their causes, preventive and curative measures. It also leads to development of better preservation and storage methods and facilities that could help reduce post-harvest losses by the farmers. It also leads to development of better planting and farming methods and improved marketing services, which further leads to improved agricultural productivity.

OVERVIEW OF HORTICULTURAL INDUSTRY IN NIGERIA

Horticulture is the practice or science of growing fruits, vegetables, flowers and landscaping. Most fruits and vegetables are used as food while some are for seasoning of foods such as garlic, ginger, onion, amongst others. Nigeria as a country is unable to meet its domestic requirements for vegetables, fruits, floriculture, herbs and spices, dried nuts and pulses. Nigeria is a net importer of horticultural crops. In 2019, Nigeria imported a total of 80,227 metric tonnes of tomato paste valued at over 25 billion naira to bridge the deficit gap between supply and demand in the country (FAOSTAT 2021, Table 1).

Nigeria horticultural crops production has been increasing over the years. FAO data for ten of the most widely cultivated horticultural crops in Nigeria revealed increased production for most crops between 2009 – 2019 (Table 2). Tomato production rose from 1.75 million tonnes to 3.81 million tonnes representing 118% increase, while ginger production rose from 168,800 tonnes to 691.239 tonnes representing 309% increase during the same period (FAO 2021). This increase is largely due to increase in land areas for cultivation of these crops. Onion, peppers, citrus and mangoes have a marginal increase of 2.2 – 13.4% over the same period (Table 2).

A comparative study for yield of tomato in five African countries namely, Egypt, Kenya, South Africa, Senegal and Nigeria showed that all the countries have a declined yield over period 2009 – 2019 with South Africa and Egypt having the lowest decline (-3.1 and 4.4%, respectively), while, Kenya and Senegal had yield decline of 33.3 and 23.1%. respectively (Table 3). Nigeria produced the lowest yields for both 2009 and 2019 and showed a declined yield of 29% between 2009 and 2019 (Table2).

Table 1. Value of Nigeria's imports and exports of some selected fruits and vegetable in 2019

Commodity	Import value ($)	Export value ($)	Net import value ($)
Almonds shelled	779,000	1,000	778,000
Almonds, with shell	10,000	0	10,000
Apples	38,510,000	1,000	38,509,000
Fruit, cooked, homogenized preparations	481,000	0	481,000
Fruit, dried nes	86,000	45,000	41,000
Fruit, fresh nes	254,000	16,000	238,000
Fruit, prepared nes	1,629,000	358,000	1,271,000
Fruit, tropical fresh nes	6,000	0	6,000
Grapes	8,945,000	0	8,945,000
Juice, apple, concentrated	2,406,000	14,000	2,392,000
Juice, apple, single strength	1,217,000	288,000	929,000
Juice, fruit nes	4,475,000	2,771,000	1,704,000
Juice, grape	7,751,000	9,000	7,742,000
Juice, orange, concentrated	1,776,000	5,000	1,771,000
Juice, orange, single strength	2,556,000	37,000	2,519,000
Juice, pineapple, concentrated	3,274,000	2,000	3,272,000
Spices nes	17,977,000	1,962,000	16,015,000
Tomatoes, paste	70,982,000	39,000	70,943,000
Tomatoes	300,000	0	300,000
Tomatoes, peeled	108,000	5,000	103,000
Total	163,522,000	5,553,000	157,969,000

Source: Based on FAOSTAT (2021)

Table 2. Production of 10 major horticultural crops in Nigeria in 2019

Crops	Production (MT)		% Increase
	2009	2019	
Tomato	1,750,000	3,816,009	118.1
Onion Dry	1,344,769	1,374,764	2.2
Chilies/Pepper Green	727,814	753,116	3.5
Fruit Citrus	3,800,000	4,160,568	9.5
Mangoes	835,000	946,695	13.4
Ginger	168,800	691,239	309.5
Pineapple	1,000,000	1,671,440	67.1
Plantain	2,700,000	3,182,872	17.9
Vegetables	5,752,013	7,631,012	32.7
Okra	1,050,000	1,819,018	73.2

Source: Based on FAOSTAT (2021)

Table 3. Comparative Yield of tomatoes in 5 African countries 2009 and 2019

Country	Crops	Yield t/ha		% Growth
		2009	2019	
Egypt	Tomato	40.8	39	-4.4
Kenya	Tomato	30.6	20.4	-33.3
South Africa	Tomato	69.2	67.1	-3.1
Senegal	Tomato	27.3	20.7	-24.1
Nigeria	Tomato	6.5	4.6	-29.0

Source: Based on FAOSTAT (2021)

A similar study for yields of citrus in five African countries namely, Egypt, Kenya, South Africa, Ethiopia and Nigeria (Table 3) showed a declined yield for Egypt and Kenya (-16.1 and -7.6%) respectively over a period 2009 – 2019. Ethiopia and South Africa have a modest yield increase of (18 and 20.7%) respectively, while Nigeria produced the lowest yields in both periods and had a marginal increase in yield (2.6%) between 2009 and 2019 (Table 4).

Table 4. Comparative Yield of fruit citrus in 5 African countries 2009 and 2019

Country	Yield t/ha		% Increase
	2009	2019	
Egypt	16.6	13.9	-16.1
Kenya	7.4	6.8	-7.6
South Africa	35.3	42.6	20.7
Ethiopia	6.4	7.6	18.0
Nigeria	4.9	5	2.6

Source: Based on FAOSTAT (2021)

Nigeria is importing large quantities of horticultural produce, among which tomato paste, apple and spices account for the large chunk of the import. More than 90,000 thousand tonnes of tomato paste was imported by Nigeria in 2009 but the figure dropped to about 80,000 tonnes in 2019 representing 11% decline during the ten-year period. Vegetables and spices import rose 120.6 and 62.4% respectively between 2009 and 2019, while apple import rose from a mere 52 tonnes in 2009 to 44,013 tonnes during the study period (Table 5)

ROLE OF R&D IN TRANSFORMATION OF HORTICULTURAL INDUSTRY

Transforming Horticulture and Horticultural Industry in Nigeria from the point of view of R&D advocates increased availability of generated improved technologies as well as accessibility and utilization of those technologies by farmers for increased food production, reduction of poverty, supply of raw materials to industries and improved livelihood of the farmers. Gaps in production of horticultural crops, including that between potential and actual yields obtained by farmers warranted continuous research for improved varieties, production and post-harvest technologies for increased productivity and farmers' income.

There is also the need for capacity building of farmers to understand how to face the challenges of social and economic barriers, regulations, access to finance and information, competition, their managerial capacities, market related risks, low bargaining power, vulnerability to economic shocks and business dynamics to be able to seize opportunities. Consequently, having in place entrepreneurial centres to cater for the practical needs of farmers/students will make them better equipped for a successful career in agribusiness.

Table 5. Import of major horticultural crops in Nigeria 2009 and 2019

Crop	Import (MT)		% Increase
	2009	2019	
Tomato paste	90,221	80,297	-11.0
Peppers dry	58	1,168	1913.8
Juice Orange	27	692	2463.0
Apples	52	44,013	84540.4
Spices	3,228	5,241	62.4
Vegetables	165	364	120.6

Source: Based on FAOSTAT (2021)

Therefore, to fast track the process of increased production and marketing of horticultural produce for economic exploitation, awareness of the economic, medicinal and nutritional values of these spices should be emphasized. Also, success in commercializing horticulture depends on the orientation of production to meet market demand and on the removal or reduction of a broad range of marketing constraints.

WAY FORWARD TO SUSTAIN R&D FOR TRANSFORMATION OF HORTICULTURE

The following should be done to maintain the positive and significant effect of agricultural R&D expenditure and R&D in other sectors.

1. Alignment of research in horticulture to government policies and priorities as was the case for import substitution enshrined in agricultural promotion policy should be encouraged and holistically implemented.
2. Increase the budgetary allocations to agricultural R&D so that more serious and high value agricultural research can be undertaken. Inekwe (2014) found that research and development expenditure had a positive significant effect on economic growth in countries.
3. Establish concrete collaborations between scientists and research institutions worldwide to encourage knowledge sharing and communication.
4. Employ and build capacities of agricultural research scientists, trained to facilitate serious agricultural research that can lead to more discoveries.
5. Provide terms and conditions that are favourable to agricultural research scientists in terms of remunerations and job security so as to motivate them to put more effort in their work.
6. Ensure that the knowledge generated through agricultural research is disseminated to the public by employing more agricultural extension officers. It has been established that improved varieties had a major positive impact on productivity growth (Fuglie and Maeder, 2015).
7. Intellectual property rights need to be enhanced through patents, copyrights and trademarks so as to encourage firms producing agricultural products and inputs to carry out agricultural research and spend more on agricultural research.
8. Ensure that more agricultural research institutions including private ones are established to increase the intensity of agricultural R&D.
9. Development of input and output markets structures and incentives that allow the full realization of the value of increased production.
10. Well-functioning and vibrant private sector that can manage, and allocate skill and capital to scale emergent success and drive long-term sustainable agribusiness growth.

CONCLUSION

Alignment of R&D in horticulture to government policies and priorities, effective utilization and proper targeting of available funds, establishment of private research outfits, establishment of intellectual property right and effective utilization of improved technologies will go a long way to transform the horticultural industry in Nigeria.

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THE ROLE OF URBAN FORESTRY IN GREEN HOUSE GAS REDUCTION AND WILDLIFE CONSERVATION: A REVIEW

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ABSTRACT

For millions of years, human survival and evolution depended on our ability to cope with the natural world; learning what was safe and dangers involve in negative emotional reactions to various natural stimuli. The complex symbolic and emotional ties that humans have with trees have important implications for the importance of sound urban forest management practices that impact not only quality of life on an ecological level, but on the human and cultural level. Urban forestry is the care and management of urban forests, i.e., tree populations in urban settings for the purpose of improving the urban environment. Recently, Global warming has become the major topic of discussion around the world, conserving the forest and wildlife in a sustainable manner is key to reducing the emissions of Green House Gas (GHG) and wildlife conservation from extinction. This review paper critically highlights the role of urban forestry in wildlife conservation and Green House Gas reduction.

Key words: Urban Forestry, Green House Gas, Wildlife, Conservation, Energy

INTRODUCTION

Urban forestry is the careful care and management of urban forests, i.e., tree populations in urban settings for the purpose of improving the urban environment. Urban forestry advocates the role of trees as a critical part of the urban infrastructure (Caves, 2004). Urban foresters plant, prune, maintain trees, support appropriate tree and forest preservation, conduct research and promote many benefits trees provide. Urban forestry is practiced by government and commercial arborists, environmental policymakers, city planners, consultants, educators, researchers and community activists (Campanella, 2003). Trees are usually selected, planted, trimmed, and nurtured by people, often with specific intentions, as when a tree is planted in a front yard to shade the driveway and frame the residence. The functional benefits provided by this tree depend on structural attributes, such as species and location, as well as management activities that influence its growth, crown dimensions, and health (Campanella, 2003).

The complex symbolic and emotional ties that humans have with trees have important implications for the importance of sound urban forest management practices that impact not only quality of life on an ecological level, but on the human and cultural level. People develop emotional attachments to trees that give them special status and value. For many, feelings of attachment to trees in cities influence feelings for preservation of trees in forests (Coder, 1996).

The social and even medical benefits of nature are also dramatic. Urban poverty is common to areas lacking green spaces. Visiting green areas in cities can counteract the stress of city life, renew vital energy and restore attention, and improve medical outcomes. Simply being able to see a natural view out of the window improves one's admiration of nature. Having regular access to woodland is desirable for schools, and indeed Forest kindergartens take children to visit substantial forests every day, whatever the weather. When such children go to primary school, teachers observe a significant improvement in reading, writing, mathematics, social skills and many other areas. Various methods are available to capture the value of urban trees, each designed to analyze a specific type of green space (individual trees, parks, trees on golf courses etc.) (Kaplan and Kaplan 1989; Kaplan 1992).

Environmental values of trees in urban areas: watershed, energy and air quality benefits

In the past, trees were often included in local plans primarily as beautification elements. Today many planners have realized that trees play a much greater role. They are a critical factor in human health and well-being, affecting the overall quality of life in communities. Over the past twenty years, urban tree researchers have learned that trees in urban areas improve air quality, conserve energy, reduce storm water runoff, increase property values, attract businesses, reduce stress, increase healing, and decrease crime. More recently, researchers at the Centre for Urban Forest Research have been able to place a dollar value on some of these benefits, such as storm water runoff, air quality, and energy conservation.

The Clean Water Act regulations require municipalities to obtain a permit for managing their storm water discharges into water bodies. Each community's program must identify which best management practices (BMPs) will be implemented to reduce pollutant discharge. Healthy trees with large leaves and rough surfaces can reduce the amount of runoff and pollutant loading in receiving waters. Trees control runoff at the source by intercepting and storing rainfall, reducing runoff volumes and erosion of watercourses, as well as delaying the onset of peak flows. Rainfall that is stored temporarily on leaf and bark surfaces is called interception. Intercepted water evaporates, drips from leaf surfaces, and flows down stem surfaces to the ground. Saturation generally occurs after 1 to 2 inches of rain have fallen (Xiao et al., 2000). Rainfall interception by large trees is a relatively inexpensive first line of defense in the battle to control nonpoint-source pollution when compared with more expensive solutions like retention basins.

Energy enhances economic growth and is an essential ingredient for quality of life. Greening cities with trees can help conserve this energy, and this technique is often a cost-effective solution. For example, the Centre for Urban Forest Research found that strategically planting 50 million more shade trees in California cities on the east and west sides of buildings will provide savings equivalent to seven 100-megawatt power plants (McPherson and Simpson, 2003). The cost of peak load reduction is $63/kW, considerably less than the $150/kW benchmark for cost effectiveness.

The amount of gaseous pollutants and particulates removed by trees depends on tree size and architecture, and local meteorology and pollutant concentrations. Uptake rates are high when pollutant concentrations and leaf surface areas are high. For example, in Western Washington, where air pollutant concentrations are low, annual O3 uptake rates for a 20-year old red oak and purple-leaf plum were 0.35 pounds and 0.13 pounds, respectively. In Los Angeles, where concentrations are higher, uptake rates for the Shamel ash and crape myrtle were 1.26 pounds and 0.19 pounds, respectively (McPherson et al., 2001). In the Chicago region, 51 million trees remove about 250 tons of PM10, 200 tons of O3, 100 tons of SO2, and 20 tons of carbon monoxide annually. This environmental service is estimated to have an annual value of nearly $10 million (Nowak, 1994).

Urban forestry, wildlife conservation and greenhouse gas reduction: the interrelationship

Human activities, primarily fossil-fuel consumption, are adding greenhouse gases to the 'atmosphere, resulting in gradual temperature increases. This warming is expected to have a number of adverse effects. With 50 to 70 percent of the world's population living in coastal areas, a predicted sea level rise of 6 to 37 inches could be disastrous. Trees have been recognized as important storage sites for carbon dioxide (CO2), the primary greenhouse gas (Nowak and Crane, 2002). At the same time, private markets dedicated to economically reducing CO2 emissions are emerging. Carbon credits are trading for$0.11 to $20 per metric tonne, while the cost for a tree planting project in Arizona was $19/metric tonne (McPherson and Simpson, 1999). As carbon reductions become accredited and prices rise, carbon credit markets could become monetary resources for community tree programs.

The concept of accommodating both humans and wildlife in the same area is nothing new. Humans have always lived with other animals.

However, over geologic time, human populations have increased and drastically extended their dominance on the landscape. Many plant and animal species that were once wild are now domestic. Ecosystems that evolved through millennia of natural processes and stochastic events have been severely humanized within decades. Many benefits can result from efforts to enrich and manage wildlife in urban forests. Native animals attracted to properly managed sites can provide recreational and educational opportunities for local residents. People involved in planning, installing and using areas managed for wildlife realize how decisions can directly influence environmental quality and are likely to develop a better land ethic. These areas also include the use of native plants that require less water and nutrients than exotic grasses and ornamental plants.

Living and non-living ecosystem components installed in urban areas help to restore the natural value of sites making them better places for native wildlife to live. In other words, management practices that would include adding native components would improve the habitats for much native wildlife. These components provide some of the essential requirements for animals: food, cover, water, and space (Herwitz, 2001).

CONCLUSION

Urban forestry provides sustainable forest practice that ensures that trees are managed and care for. This process ensures that there are enough trees in the urban environment to sink carbon dioxide which is a major GHG that is responsible for global warming, by promoting urban forestry water quality will be improved as well as clean energy and air quality. Furthermore, urban forestry ensures that the natural habitat of wildlife is intact to prevent extinction of endangered species.

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HEALTH BENEFITS OF WATER MELON (C*itrullus lanatus*)

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ABSTRACT

Watermelon (Citrullus lanatus) belongs to the family Cucurbitaceae (Schippers, 2000), a vine-like (scrambler and trailer) flowering plant in West Africa. It is cultivated for its fruit. Its centre of origin has been traced to both the Kalahari and Sahara deserts in Africa (Jarret et al., 1996). In some African cuisines, however, watermelons are served as a cooked vegetable. Watermelon seeds are ground into flour and baked as bread in some parts of India. In addition, watermelon is also used as feed for livestock. The seeds and flesh are used in cooking; it has been taken to prevent and treat a wide range of ailments and diseases. Watermelon is effective in prevention of heart disease, high blood pressure, cancer, diabetes, as well as curing effect on coronary, liver and kidney disorders. It is good source of minerals, and vitamin C; half kg of fruit can satisfy our daily need in vitamin C. Other than 85% water content it contains 7-15% of sugar, also minerals, vitamins and little bit of proteins as well. Vitamins present are carotenes, vitamin B complex and traces of C vitamin required to boost our immune system. Mineral content present are potassium, magnesium, phosphorus, calcium, zinc, iron, and cuprum. It is a good source of carotenes and lycopens as well. This article reviews the importance of Watermelon (Citrullus lanatus) as potential natural sources for the development of novel drugs.

Key words: Watermelon, health benefit, vitamin C and vegetable

INTRODUCTION

The rapid increase in the risk of chronic illnesses such as renal failure and cardiovascular diseases has motivated experts, researchers, and health-conscious individuals to explore ways of using dietary interventions with potential health benefits that go beyond the provision of essential nutrients. Existing literature shows that watermelon is considered to be an important fruit with vital components with anticancer, antioxidant, and anti-inflammatory properties (Ijah et al., 2015; Choudhary et al., 2015).

Watermelon (*Citrullus lanatus*) is a scrambling and trailing vine belonging to the family Cucurbitaceae (Edwards *et al*., 2003). That is among the highest of plant families for number and percentage of species used as human food. The common name of watermelon is Tarbooz (Hindi and Urdu), Indrak (Gujarati) Kankana (Hausa). Watermelon is originated from Kalahari Desert of Africa but nowadays cultivated abundantly in tropical regions of the world. It has great economic importance with 29.6 million tonnes estimated production worldwide (Reetu and Tomar, 2017). Watermelon is an important fruit crop that is currently gaining recognition as cash crop good in the generation of income and provision of nutritional value. Watermelon flesh contains high quantity of vitamins, minerals and other antioxidant compounds which play important role in human metabolism and preventing human disease by acting as oxygen radical scavenger. Watermelon rind and seed also have many health benefits due to the presence of important amino acids citrulline, fibres, minerals and phenolic compounds.

Furthermore, watermelon is one of the commonly consumed fruits in many countries. It contains more than 91% water and up to 7% of carbohydrates. Watermelon is a rich source of lycopene and citrulline. It is highly nutritious rich in vitamins C and A in the form of disease-fighting beta-carotene. Watermelon is also rich in carotenoids such as lycopene, phytofluene, phytoene, beta-carotene, lutein and neurosporene. Additionally, watermelon has a number of essential micronutrients such as potassium. Its seeds are excellent sources of protein (both essential and non-essential amino acids) and oil (Adekunle et al., 2003). In Nigeria, though there are no official figures recorded for its production, the crop has a wide distribution as a garden crop, while as a commercial vegetable production; its cultivation is confined to the drier savanna regions of Nigeria (Anon, 2006).

Lycopene is a vibrant tetrapenic carotenoid with molecular formula of $C_{40}H_{56}$and contains 11 conjugated and 2 unconjugated double bonds (Fish et al., 2002) It is an acyclic isomer and open-chain analogue of β-carotene that undergoes *cis-trans* isomerization when interact with light, temperature and chemicals (Ollanketo et al., 2001). A great majority of studies have demonstrated that human blood serum contains both *cis*- and *trans*- isomeric forms of lycopene whereas the plants have only transconfiguration except watermelon (Klipstein-Grobusch et al., 2000; Tadmor et al., 2005). Lycopene has potential to prevent various chronic ailments like dyslipidemia, diabetes, oncogenesis, neurodegenerative diseases, osteoporosis etc. The protective aspects are ascribed to the singlet oxygen scavenging ability. Numerous metabolic syndromes arise due to high free radical's formation reacting with macromolecules thus oxidizing proteins, lipids and DNA. Lycopene protects humans from various pathogenic attacks responsible for an array of diseases (Ilic and Misso, 2012; Sesso et al., 2005). Several authors have reported that lycopene holds nutraceutical potential and being antioxidant provides protection against free radicals and oxidative damage (Krinsky, 1998; Rao and Agarwal, 1999; Choksi and Joshi, 2007). Free radicals are produced in the body during oxidation reduction reaction however, excessive production deteriorates body defense mechanism, cell membrane and organelles. These degenerative processes resulted in life threatening ailments (Humberto, 2000; Heber and Lu, 2002; PerkinsVeazie and Collins, 2006). The presence of large number of double bonds is responsible for its fairly high free radical scavenging or singlet oxygen quenching ability even better than α- and β-carotene, lutein and α-tocopherol (Rivero et al., 2001; Perkins-Veazie and Collins, 2004). Lycopene provides protection against degenerative disorders via mechanisms like gap-junction communication, gene function regulation, phase II drugmetabolizing pathways and carcinogenic metabolism (Arab and Steck, 2000; Collins et al., 2004). It has been established through epidemiological studies that lycopene plays a_role in maintaining normal cellular differentiation and division (Giovannucci et al., 2002; Choudhary et al., 2009). Lycopene scavenges free radicals at cellular level due to its attachment in cell membrane thereby may prevent hypercholesterolemia and hyperglycemia along with allied dysfunctions (Marinova et al., 2005; Fisher and Frazee, 2006).

METHODS

Narrative review method was adopted and used to explore the potential health impacts of phytochemicals present in watermelon. The research process entailed conducting a systematic search of electronic databases to identify articles on health impacts of watermelon. The articles were obtained from printed and electronic databases and used to meet the objectives of the study.

1. Prevention of high blood pressure: High blood pressure (also called hypertension) happens when your blood moves through your arteries at a higher pressure than normal. Uncontrolled high blood pressure puts you at a higher risk for stroke, heart attack, as well as heart and kidney failure. Watermelon supplements in diet can reduce aortic blood pressure and may even provide cardio protection to keep human heart healthy and working smoothly. The carotenoids present in watermelon help prevent the hardening of arteries and veins, thereby also helping reduce the risk of blood clots and atherosclerosis. Watermelon contains citrulline which helps to manage high blood pressure by aiding in nitric oxide production in the body. Watermelon fruit is also a good source of potassium. Potassium is an important component of cell and body fluids that helps controlling heart rate and blood pressure. Thus, it prevents against stroke and coronary heart diseases (Le et al., 2005).

There are several studies on changes in blood pressure readings when people consume extracts from watermelon. Figueroa et. al. (2012) while studying obese adults with prehypertension or hypertension found that when people ate watermelon extract, their ankle and brachial systolic blood pressure, diastolic blood pressure, and mean arterial pressure were significantly reduced. In similar study on postmenopausal women with hypertension, Figueroa et. al. (2013) observed reduced aortic blood pressure readings and reduced stiffness in the arteries when watermelon extract was consumed. According to Davis et al. (2015) watermelon is rich in citrulline, which is an amino acid that is converted to arginine in the body. Citrulline and arginine help in the production of nitric oxide, which is a vasodilator, it helps relax and dilate blood vessels. When the vessels are dilated, more blood can pass freely through, leading to lower blood pressure and less of a risk for such things as stroke and cardiac infarctions; the carotenoids present in watermelon help prevent the hardening of arteries and veins, thereby also helping reduce the risk of blood clots and atherosclerosis. Watermelon extracts help to reduce hypertension and lower blood pressure in obese adults.

Nutrient	Amount in 1 cup watermelon	Daily adult requirement
Energy (calories)	46.2	1,800 – 3,000
Carbohydrate (g)	11.6, including 9.6 g of sugar	130
Fiber (g)	0.6	22.4 – 33.6
Calcium (millgrams [mg])	10.8	1,000 – 1,200
Phosphorus (mg)	16.9	700
Magnesium (mg)	15.4	320 – 420
Potassium (mg)	172	4,700
Vitamin C (mg)	12.5	75 – 90
Folate (mcg, DFE)	4.6	400
Choline (mg)	6.3	425 – 550
Vitamin A, RAE (mcg)	43.1	700 – 900
Beta carotene (mcg)	467	No data
Lutein & zeaxanthin (mcg)	12.3 mcg	No data
Lycopene (mcg)	6,980	No data
Phytosterols (mg)	3.08	No data

Source: Kathy, (2019)

2. Prevention of kidney disorders: Watermelon is a natural diuretic which helps increase the flow of urine, but does not strain the kidneys. Watermelon helps in liver process ammonia (waste from protein digestion) which eases strain on the kidneys while getting rid of excess fluids. Just as drinking several glasses of water is beneficial, Watermelon's high water content induces frequent urination, which, once again, is always helpful in cleansing the kidneys and keeping them functioning properly. Watermelon will provide you with an ample amount of hydration while also adding a sweet taste and delicious texture (Davis et al., 2015).

Kidney disease is one of the lifestyle conditions that affect several people around the world. Furthermore, the disease can increase the risk of other chronic disorders and make it difficult for patients to live a healthy and active life (Wayan, 2020). One of the fruits that are considered to be a source of important minerals and nutrients that can help improve kidney function and health is watermelon (Ijah et al., 2015; Choudhary et al., 2015; Naz et al., 2014; Romdhane et al., 2017). In fact, watermelons actually have a very abundant supply of both calcium and potassium, each of which contributes to helping flush out the toxins in the body's kidneys (Dogukan and Tuzcu, 2011). Even better, the calcium provided by watermelon is important for regulating cell functions, maintaining cell structure, and benefitting the cell differentiation process. Extra calcium also aids in reducing the concentration of uric acid in the blood. Too much uric acid can cause hyperuricemia, which will make you very sick. By decreasing any extra amounts of this acid, the calcium and potassium in watermelon help to reduce the chances of kidney diseases. Although these two compounds are very important, we cannot forget about water, the namesake of this beneficial fruit (Butt et al., 2009).

Epidemiological research shows that the chemicals in the watermelon have antioxidant, anti-inflammatory, and antihypertensive properties that protect against radical ions that can worsen the symptoms of kidney diseases (Kim et al., 2014; Naz et al., 2014; Romdhane et al., 2017). Siddiqui et al. (2018) recorded reduced calcium oxalate (CaOX) crystal count following the treatment with the watermelon extracts. The reduction was witnessed both in the urine and kidney samples. They also observed that the pulp extracts that were used in the *in vivo* experiments led to an increase in urinary output and pH while also preventing weight loss. Atlas et al. (2011) reported that the administration of CCL, together with watermelon extracts, reduced the level of lipid peroxide in the brain, liver, and kidney tissues. The authors concluded that the watermelon juice samples had a protective effect on the tissues that were examined.

3. Prevention of cancer: Watermelon is a good source of vitamin c, beta carotene and lycopene, a phytochemical with antioxidant activity that may protect against cancer. Some studies have also linked lycopene intake with a lower risk of prostate cancer. Scientific researches proved that watermelon have antioxidant properties, as such it may be helpful in reducing the risk of cancer. According to the National Cancer Institute, Lycopene helps in reducing prostate cancer cell proliferation. Consumption of natural fruits rich in Vitamin-A is known to protect from lung and oral cavity cancers (Reetu and Tomar, 2017). The health benefits of lycopene might extend beyond fighting prostate cancer. Accumulating evidence suggests that the anti-proliferative properties of lycopene may extend to other types of cancer (Giovannucci, 1999).

CONCLUSION

Humans cannot synthesize carotenoids and must attain these micronutrients exclusively through their diets. The consumption of Lycopene, a carotenoid that lacks Pro-Vitamin A activity, have been shown to be associated with decreased risk of chronic diseases such as cancer and cardiovascular diseases in several recent studies. Many have attributed the health benefits of lycopene to its antioxidant properties. Researches revealed presence of appreciable quantity of lycopene in watermelon. There is a need to create awareness for watermelon cultivation and consumption considering that it is highly nutritious, health promoting, easy to cultivate and produce stable yields, even under difficult climatic and edaphic conditions. However, there is still the need for more research for better understanding of role of lycopene on human health.

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EDE OFE (*COLOCASIA ESCULENTA* L.): A POTENTIAL FOOD CROP FOR NUTRITIONAL AND HEALTH SECURITY IN NIGERIA: A REVIEW

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ABSTRACT

Ensuring food, nutritional and health security in Nigeria and other groups of developed, developing and underdeveloped nations has remained a world widespread challenge especially at these era of unstable government policy implementation, impact of climate change, Phytophthora leaf blight epidemic of taro and COVID-19 pandemic on food production irrespective of high teaming population. In the effort of ensuring nutritional, health security and better livelihood status, the underutilized, less exploited and neglected food crop and other food based product(s) should get a deserved attention. Colocasia esculenta (common name: cocoyam) popularly referred to as Ede ofe in the Southeastern States of Nigeria is an important herbaceous underground starch-rich tropical tuber food crop. It is the third most important root and tuber crops after cassava and yam in Nigeria and fourteenth vegetable crop worldwide. Its production and consumption systems, research grant, extension services and socio-economic values are not given a due attention in spite of its nutritional and health benefits. The neglect of Colocasia spp as a notable food source was as a result of inadequate knowledge and unrecognized value of its nutritional and health benefits compared to other popularly known food and medicinal crops. Therefore, there is a need to review nutritional and health status of Colocasia spp. which is a product of many research works, workshops, and experiences from many low, medium, and high income resource consumers of Ede ofe.

Key words: Ede ofe, *Colocasia esculenta*, Potential, Nutritional, Health security.

INTRODUCTION

The challenges of food security have been a serious order of the day among all classes of economic development worldwide especially at these period of poor government policy implementation, impact of climate change and COVID -19 pandemic on food production. Food provides not only essential nutrients needed for life, but also other minerals, vitamins and phytochemical compounds for health promotion and disease prevention. The promotion and consumption of underutilized food crop like *Colocasia esculenta* (taro, cocoyam) could help to mitigate food insecurity and alleviate malnutrition in underdeveloped, developing and developed nations. Traditional vegetables, which cocoyam tubers, petioles, leaves and flowers are inclusive, are valuable sources of nutrients (Nesamvuni et al., 2001; Yang and Keding, 2009) with some having important medicinal properties (Hilou et al*.,* 2006). Vegetables contribute substantially to food security (Yiridoe and Anchirinah, 2005). Overcoming food, nutritional and health insecurity among all classes of humans such as women, children, pregnant and lactating mothers, remains a challenge in many developing countries in Sub-Sahara African nations (Andersen *et al.,* 2003), including all classes of poor and rich income resources families.

Ede ofe (*Colocasia spp.*) is an important edible underground starch-rich food crop cultivated in upland or wetland of tropical and sub-tropical regions. It is the third most important starch tuber crop after cassava and yam in Nigeria; second and first in Ghana and Cameroon, respectively and fourteenth vegetable crop worldwide (Brooks, 2012). *Colocasia spp.* is a unique and giant crop because all parts (tubers, stems, leaves and flowers) are good sources of carbohydrate, protein, minerals, vitamins and phytochemical compounds. However, the neglect of

Colocasia spp. might be due to poor knowledge and less popularization of its nutritional and health advantages both for low, medium and high income resources families. The nutritional and health status popularization of cocoyam diet deserved full attention at the recent period of high rate of malnutrition, due to high intake of processed and packaged food materials and as well as a lot of diseases related to poor intake of rich diet like *Colocasia spp.*

NUTRITIONAL AND HEALTH STATUS OF EDE OFE

Nutritionally, as food for humans and livestock consumption and also source of agro-based industrial raw materials for mankind, the value of cocoyam parts is caloric (Davies et al., 2008). Cocoyam is superior to cassava and yam because of its high protein contents, minerals, vitamins and as well high digestible starch (Onyenweaku and Okoye, 2007). The nutritional content of cocoyam tuber like other root and tuber crops is low in protein and fat, but high in the starch and also good source of minerals. The consumption of nutrient rich foods like cocoyam helps the body to utilize protein, carbohydrates and other nutrients (Njoku and Ohia, 2007).

Starch: Cocoyam tuber has been reported to have high (70 - 88%) carbohydrate on dry weight basis mainly in the form of starch (Bradbury and Holloway, 1988; Onwueme and Charles,1994). The carbohydrate content of cocoyam not only impart desirable functional property to foods, but also provides high energy value and promotes satiety to consumers (Owusu-Darko et al.*,)*, granule size (1-4μm) in diameter of its starch which vary with cultivars. Cocoyam starch is highly gluten free (Rekha and Padmaja, 2002), and contains about 50% less amylose and amylopectin content which is higher compared to cereals. The amylose/amylopetin ratio is 1:7. The most important sugar content in cocoyam is sucrose and small quantities of fructose, maltose, glucose and raffinose. The most important organic acids are malic acid (60%), followed by citric acid (25%) and oxalic acid (15%) (Arnavid-vinas and Lorenz,1999). In view of cocoyam small starch granule size, it aids easy digestion, improves bowel movement, absorption and as well prevents constipation. It has also been used for industrial purposes (Uguru, 2011) like alcohol production (breweries), baby foods, cocoyam bread, biscuits, plastics, paste, cosmetics etc. The easily digestible small starch granule size are used by diabetics, weaning children, aged people, people with allergic gastro intestinal stomach disorder, obesity, cancer (Opara, 2002, Dimelu et al., 2009; Uguru, 2011); peptic ulcer patients, patients with pancreatic diseases, chronic liver problem, inflammatory bowel disease like pile and gall bladder disease (Emmanuel-Ikpeme, et al., 2007), stroke and obesity patients due to its low glycemic index or hypo allergenic nature (low tendency to cause reaction). Also, its low glycemic index makes it an excellent food for diabetics, who require glucose to be released into their bloodstream slowly. Cocoyam small granule starch size can also be used for the treatment of cough, wound, sore throat, ringworms (Chatterjee and Pakrashi, 2011; Kirtikar and Bassua, 2001), mild laxative, snake bite and high body temperature in Malaysia (Ofu,1994) and swollen joints in Nsukka area.

Protein and amino acid: Cocoyam tuber has been known to contain 10.8 - 11% crude protein on dry weight basis (Chinnasarn and Manyasi, 2010. This protein value is more than yam (7:4%), cassava (4.5%) and sweet potato (8.5%) (Jane et al.,1992). It was observed that protein content of cocoyam tuber is more towards periphery than toward its centre, which suggest that care should be taken when peeling cocoyam tuber, otherwise a large amount of protein could be lost in the peeling processes (Mbofung et al., 2006). On cocoyam leaves, it contains high protein (23%) on a dry weight basis (Onwueme, 1994; FAO, 1999) which is rich compared to other root and tuber crops. The protein content is rich in essential amino acids of threonine, argnine, leucine, valine and phenylalanine. The methionine, leucine, lycine, throenine and phenylalanine are more in the leaf than the tubers. Cocoyam tubers contain higher amount of threonine leuice, argaine, valine and phenylalanine. Sulphur containing amino acid is limiting (Mwenye et al., 2011).

Moisture: Moisture content of cocoyam is very high and records about two third (>70%) and ranges from 60 – 83 % of the total weight of fresh crops (FAO, 1999; Huany et al., 2007. Moisture content of cocoyam varies with cultivars, time of harvesting, growth environment and storage conditions. The high moisture content of cocoyam is associated with high rate of spoilage (rots) after harvest and during storage by myco-induced rot pathogens.

Minerals: Cocoyam tubers and leaves are rich in minerals with potassium recording the highest followed by phosphorus (Olayiwola et al., 2012; Ukpong et al., 2014) and next by calcium. The other important minerals include iron, copper, sodium, manganese, magnesium (Abbo et al., 2000; Onyeka, 2014). The potassium rich diet like cocoyam is essential for osmotic pressure regulation in the body. It helps to promote the excretion of excess sodium ions in the body, improve eye functioning, and maintains water and sodium balance in the body. Phosphorus in cocoyam is required by every cell in the body for normal functioning, male fertility and reproduction. Calciun in conjunction with phosphorus, potassium and magnesium improves skeletal structure of bone and teeth formation. The calcium fraction of cocoyam is located in the skin (Abbo et al., 2000) and the consumption of non-peeled boiled tuber would be helpful in calcium deficient diet. Magnesium in cocoyam decreases inflammation in blood vessels, increase blood flow. It also boosts men's sexual urge (arousal) and make sex more pleasurable and as well make men erection to perform more naturally. Cocoyam diet can also boost testerone in the body system. Potassium and magnesium rich diets promote heart health. Cocoyam contains high levels of iron (10.4mg/100) compared to other root and tuber crops. Iron is a useful micronutrient for haemoglobin building, normal functioning of central nervous system and in the oxidation of carbohydrate, protein, and fats. (Mlitan et al*.,* 2014). It facilitates carbohydrate, protein, and fat to control body weight which is very essential factor in diabetes (Moses et al*.,* 2012). Iron is essential for oxygen transfer in human and low iron content in diet causes gastrointestinal infection, nose bleeding, myocardial infection (Ulla et al., 2012). Iron rich diets are a cure to anaemia. Zinc is an essential microelement that plays an important role in various cell processes such as brain development, normal growth behavioral response, bone formation, and wound healing (Mlitan et al., 2014). Zinc promote protein and carbohydrate metabolism and also help in mobilizing Vitamin A in the liver and as well enhance the synthesis of DNA and RNA necessary for cell formation (Jabeen et al*.,* 2010). Zinc deficiency symptom is common in people suffering from Chrohn's disease, hypothyroidism and gum disease and probably plays a role in susceptibility to viral infection and diabetes mellitus. Zinc play a good role in the treatment of viral infection including AID patients, prostate gland enlargement, rheumatoid arthritis, wound healing, acne eczema and stress (Ker manshah et al., 2014), promotes normal fertility and reproduction. The minerals content of cocoyam varies among cultivars especially between the green and purple cultivars as observed by Olayiwola (2012) and Ukpong *et al.,* (2014). The mineral variation may be attributed to growth environment, soil types, and genotype and other cultural practices applied like manuring/fertilization types and rates. In general, cocoyam parts contain a lot of minerals which their salts are used as a regulator of acid - base balance of the body (Njoku and Ohia, 2007, Niba, 2013). The micronutrient in cocoyam help in building strong immune system, thereby helping the body to digest, absorb and utilize nutrients (Muinat *et al.,* 2009)

Cocoyam dietary fibers: Cocoyam diet is rich in fiber. Cocoyam diets contain (dry matter basis) high dietary fibers ranging from 1.28 - 5% (Chinnasarrn and Manyasi, 2010; Matikiti, 2017). The high dietary content of cocoyam parts plays active role in the regulation of intestinal transit, increasing dietary bulk and faeces consistency due to their ability to absorb water (Singh et al*.,* 2012); Abujah et al., 2015). Dietary fiber (non - carbohydrate) promote the growth and protects the beneficial intestinal flora. Further, high intake of dietary fiber diet reduces the risk of colon cancer (Dar zynski et al., 2007). Fiber rich diets help to lower cholesterol and reduce constipation. However, low fiber is unhealthy, as it can cause constipation resulting in disease of the colon like pile, appendices and cancer (Olalege et al*.,* 2013)

Cocoyam crude fat/ lipid: Cocoyam is a low fat crop. Dietary fats promote the palatability of food by absorbing and retaining flavors (Antia et al., 2006).

Consumption of excess fats have been implicated in certain cardiovascular disorders such as anthrsclerois, cancer, aging, whereas a diet supplying less than 2 % of caloric energy as fat is said to be good for human (Arua et al., 2011). In general, the crude fat content of cocoyam range from 0.20 – 1.10% (Chinnasarn and Manyasi, 2010; Mitikiti, 2017) and varies among cultivars.

Vitamins: Cocoyam parts especially the leaves, petioles and flowers are rich in vitamins such as vitamin A and C, thiamine (B_1), riboflavin (B_2), niacin (B_3) (FAO,1993; Barua,2002). The Vitamin C rich diet, like cocoyam, is a key for immune system support, fighting free radicals, anti-heart diseases and eye health. Vitamin C supports overall brain health and prevents brain cells from becoming damaged. Thiamin (Vitamin B_1) rich diet like cocoyam taro is necessary in our modern daily feeding systems where a lot of refined starch is eaten (Parkison, 1984 Ezedinma, 2006). Cocoyam rich in Vitamin B_1 is required for normal growth, proper functioning of the heart and nervous system. B_6 (niacin) vitamin is needed for cellular respiration. The niacin, thiamin and riboflavin in cocoyam diet help the body cells to regenerate and form new tissues. The boiled cocoyam leaf contains beta-carotene (996 g/100g), iron (12mg/100g, ascorbic acid 87mg/100g (FAO, 1990; Jirarat et al., 2006). Cocoyam with yellow fleshed tuber contains more levels of beta - carotene than white fleshed tuber cultivar type/genotype. High levels of beta-carotene support vitamin A formation (pro - vitamin A production) which is essential for a healthy immune system that promote good eye, bone formation. Food rich in carotenoids have been shown to protect body against chronic diseases like heart disease, cancer, cardiovascular disease, diabetes etc. (Engilberger et al.,2003; Uguru, 2011).

Ash contents: Ash content value is a measure or reflection of the nutritionally important mineral contents present in the food materials (Omotosho, 2005); Nnamani et al., 2009). It helps to determine the much and type of minerals in cocoyam as minerals are essential for growth and metabolism in humans and helps to reduce mineral deficiency disease like cancer, goiter, crenistism and mycardiopathy and also reducing the risk of contracting other chronic diseases like cancer and cardiovascular (Wiesler et al*.,* 2010). The ash content of cocoyam ranges from 3 -5% as reported by many literatures (Chinnasarn and Manyasi, 2010; Lewu et al., 2010).

Total energy value (Kcal/100g): Energy content of any diet is associated with its carbohydrate content (higher energy value more carbohydrate content). Gross energy value varies among cocoyam cultivars. It has been reported that the gross energy (kcal/100) of cocoyam cultivar ranged from 380.27 in purple cocoyam, 378.47 in green cocoyam and 370 - 374 kcal/100g in Boloso 1 from Ethiopia (Adane et al., 2013). This explains why purple type (Nce 002/Nachi) in Nsukka region commands high demand/cost compared to other cultivars in soup, flaked and other cocoyam based products formulations/recipes and health applications. Phytochemically, *Colocasia spp.* has been known to possess many bioactive compounds that have biological and pharmaceutical benefits. Cocoyam taro has been reported to possess some valuable natural compounds that are health promoting materials which include antioxidants and phytochemicals. Antioxidants are substances that delay, prevent, or remove oxidative damage to some target molecules (Haliwell and Guteridge,1998), which prevent damage to cellular components arising as a result of chemical reactions involving free radicals (Prochazkova et al., 2011), prevent skin from aging, maintain and balance hormone. Antioxidants help to strengthen the body's immunity to disease and infection. Farombi et al. (1998) observed that phytochemicals are effective in combating or preventing diseases due to their antioxidant properties. These antioxidants protect biological systems and molecules from oxidation when they are exposed to free radicals and reactive oxygen species which have been implicated in the aetiology of many diseases, food deterioration and storage (Farombi, 2000).

Natural Compound Contents of Cocoyam

The biological properties of cocoyam were attributed to the natural compound contents in it such as:

Tannins: Tannins are natural occurring substances in taro plant that could be partly responsible for the bitter taste associated with the raw flowers and its use in

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wound treatment. Tannin possess astringent properties, that speed up the healing of wounds and inflamed mucous membrane (Okwu and Okwu, 2004). Tannins are water soluble high molecular weight phenolic compounds in any plants that are valuable in herbal medicine due to their wound healing properties (Nguyi, 1988). They also possess fungicidal properties, thereby serving as a defense mechanism in plants against herbivores, pathogens and hostile environment. However, Tannin content of cocoyam have been shown to interact with proteins, enzymes or no enzymes and form tannin protein complexes that can reduce protein digestibility and protein solubility. Reduction of protein digestibility could be attributed to either the inactivation of digestive enzymes or reduction of the susceptibility of the protein substrates after forming complex. Tannin also decreased the bioavailability of Vitamins A, B, C and some minerals like Zn, Fe, I, P and Mg (Chavan et al., 1986). The removal of tuber skins (peeling) and cooking can considerably reduce certain amount of tannins.

Beta-carotene: Beta- carotene is an essential substance among yellow fleshed cocoyam tubers and leaves that promotes vitamin A production. High amount of β-carotene in cocoyam tubers and leaves (96 ug/00g) will impart vitamin A and antioxidant in the body (Agwunobi et al., 2012). Beta-carotenes are commonly carotenoids of β and α - carotenes and antioxidants as well as possessing other potential health benefits. As earlier reported, carotenoids can be convertible into vitamin A by the body. Beta-carotene is most A activity of the carotenoids and are used against cataracts and lung cancers (Gallicchio et al., 2008).

Polyphenolic compounds: Phenolic compounds are phenolic acid of phosphorus that is widely distributed in the plant cell walls and as well a significant composition of human diets. Pheolic acids and flavonoids are known to possess antioxidants properties due to presence of hydroxyl in their structures and their redox properties (Zahid et al., 2015). Pale fleshed cocoyam cultivar is associated with a high level of total phenolic compounds than white fleshed cocoyam cultivar (Wolfe et al., 2007).

Alkaloids: Alkaloids are colourless, but are often optically active materials with bitter tastes e.g. alkaloid quinine. Alkaloids are mostly crystalline, but a few are liquid at room temperature. Alkaloids are mainly natural products occurring primarily in many plants. They rank among the most efficient and therapeutically significant plant substance (Okwu, 2005). Alkaloids are naturally occurring compound with pharmaceutical properties that are used as medication, as recreational drugs for local anesthetic and stimulant cocaine, nicotine, the analgesic morphine or anti-malarial drug quinine (Kam and Liew, 2002), spasmodial and bactericidal (Edoga and Eriata, 2001). Over 5,500 alkaloids like quinines, codeine, heroin, diterpanoid, berberine, glycol, harmane etc are known and they comprise the largest single class of secondary plant materials which contain one or more nitrogen atoms usually in combination as a part of cyclic structure. Alkaloids, comprising a large group of nitrogenous compound are widely used as therapeutic agents in the management of cancer. Alkaloids exhibit a marked physiological activity when administered to animals (Okwu and Okwu, 2004). Alkaloids interfere with cell division and are generally found in the form of salts with organic acids and they are also haemolytically active and as well toxic to pathogenic organisms. Some alkaloids are commonly found to have anti-microbial properties and are useful against HIV infection as well as intestinal infection associated with AIDS (Edoga and Eriata, 2001). Alkaloids acts directly on the vascular systems and also exerts a number of effect on the neural tissues and thus, indirectly affect the mechanical and electrical activities of the heart and modify vascular resistance and capacitance. Alkaloids are contained in cocoyam in moderate quantity (Ukpong et al., 2014).

Flavonoids: Flavonoids are basically a class of secondary metabolites widely distribute in plants, fruits, leaves and flowers. They are 15- carbon compounds generally distributed throughout the plant kingdom. Flavonoids are synthesized by plants in response to microbial infection and as well found *in vitro* to be effective against a wide range of pathogenic organisms. Flavonoids like anthogenina give colour to flowers, fruit and leaves in plants. The presence of flavonoids testified the possession of medicinal properties by plant leaves. Flavonoids are free radicals, scavengers, excellent antioxidant and potent water soluble compounds that prevent oxidative cell damage and have a promising anti-cancer activity (Onwueyiagba, 2001). It has been reported by that flavonoids have antiviral, anti-allergic, anti-inflammatory, anticancer and antioxidant properties. The antioxidant property and subsequent inhibition of low-density lipo have been attributed to the dietary and supplemental intake of flavonoids and other trace nutrients. Flavonoids have a significant therapeutic action and form the ingredient of many important drugs. Flavonoids help to reduce cholesterol and respiratory related problems to breath well and easily in the body. Flavonoids as the largest group of phenolics recorded in fruits, vegetables and other plant parts have been associated with the reduction of major degenerative diseases (Liu, 2003). Flavonoids are found in varying quantities in foods and medicinal plants due to its potent antioxidant property against the superoxide radicals. Ukpong *et al.,*2014) reported that cocoyam contains flavonoids in moderate quantity.

Saponins: Saponins are naturally occurring in plants that are useful in medicines and pharmaceutical industries due to its foaming potential for the production of vaccines, insecticides and synthesis of steroidal hormones. Studies have shown that saponins have a strong potential to reduce cholesterol levels in man and animals. However, Ukpong et al. (2014) reported that saponins are found in minor quantity among the photochemical components of cocoyam.

Terpene: Terpene, also known as plant terpenoids, are reported to play a role in traditional herbal medicine as pharmaceutical purposes. Ukpony et al. (2014) in their photochemical studies and mineral contents of cocoyam reported that cocoyam contained terpenoids in high quantity.

Cardiac glycosides: Cardiac glycosides are naturally occurring drug materials in plants known drugs materials in plant known for their beneficial and toxic activity on the heart. As an active ingredient in many promising heart drugs, it is used therapeutically in the treatment of disease related to heart problem like cardiac failure (Trease and Evans, 1989). Cardiac glycosides were reported to be in high quantity in cocoyam (Ukpong et al., 2014). Generally, the bioactive compounds of cocoyam, medically exhibits a lot of biological functions such as immune-stimulatory, anti-inflammatory, antimicrobial activities, anemiagenic, 5- α- reductase inhibitory, anti-tumor, α-reductase inhibitory, anti-leucotriene-D4, anti-androgenic, lipoxygenase inhibitory, anti-alopecic, inhibition of prostate and breast cancer cell lines, anti-helminthic, prospective anti prostatic and hypocholesterolemic properties in the body (Kundu et al*.,* 2012; Omotoso et al., 2014; Eleazu et al., 2016; Eleazu, 2016; Orji, 2019),), anti-mestatic activity by inhibiting the proliferation of some breast and prostate cancer cell lines (Kundu et al*.,* 2012), anti-secretory, contraceptive, choleretic, anti-spermatogenic and anti-tubercular properties (Kalaivani et al., 2012; Eleazu et al., 2016), antiradical, anti-mutagenic and antoxidant potentials (Ryszad,2007), antibacterial and antifungal properties (Karikalan and Rajangam,2014). These therapeutic properties are linked to the presence of one or more of the natural compounds as shown in Table 1.

However, cocoyam contains anti-nutrients in the food materials that act against one or more nutrients, reducing digestibility and bioavailability. The dietary minerals mostly affected include zinc, iron, calcium, magnesium, manganese and copper (Lopex et al*.,* 2002; Sarkiyayi and Agar, 2010). This is usually formed through complex processes, which reduces nutrient absorption (Dumont and Veruier, 2000) and utilization. Ukpong et al. 2014 observed that anti-nutrients of cocoyam have negative effects for cocoyam as food and as well have positive implications for cocoyam as crop that can be grown with less use of fungicides and pesticides especially in the wild taro. The anti-nutrients mainly found in cocoyam include mucilage, calcium raphide (oxalate), phytate, alpha amylase inhibitors, protease inhibitors (Ramanatha et al., 2010).

Phytate: Phytate, also referred to as phytate phosphorus, is a phosphorus containing substance that binds with minerals and reduce mineral absorption and utilization. It is also a storage form of phosphorus occurring in plants seeds and many roots and tubers (Dipak and Mukherje, 1986). The reduced mineral absorption associated with the presence of negatively charged phosphate groups that form very stable complexes with mineral ions causing non-availability for intestinal absorption (Walter et al., 2002). The dietary minerals mostly affected include zinc, iron, calcium, magnesium, manganese and copper (Lopex et al., 2002; Sarkiyayi and Agar, 2010). Phytate can also form complexes with proteins, protease and amylase of the intestinal tract therefore, reducing proteolysis**.** The phytate content in crop depends on growth conditions, soil types, season, cultivars, manuring/fertilization types and rates. Sarkiyayi and Agar, (2010) reported that both green and purple cocoyam cultivars significantly recorded high phytate quantities, but higher in purple cocoyam (187.57 mg/100g) than the green cocoyam (167mg/100g). In cocoyam, most of the anti-nutrients are partly or totally water soluble and can be significantly reduced by processing methods such as cooking, boiling, fermentation, pre-drying, deep in hot or cold water, blanching, roasting (Frias et al., 2000, Adane et al., 2013; Aneze and Molla, 2017).

Table1. Natural compounds of *Colocasia esculenta* L.

Name of compound	Molecular formula.	Molecular weight	% Content
Hexadecanoic acid methyl	$C_{17}H_{34}O_2$	270	0.43
Octadecanoic acid	$C_{18}H_{36}O_2$	284	20.91
9,12-Octadecadienoyl chloride	$C_{18}H_{31}ClO$	298	0.77
11-Octadecenoic acid methyl ester	$C_{19}H_{36}O_2$	296	2.12
9-Octadecenoic acid	$C_{18}H_{34}O_2$	282	64.37
4-Methylimidazolium ion	$C_{24}H_{45}N_2O_3$	409	1.36
Hexanedioic acid 2-ethylhexy ester	$C_{22}H_{42}O_4$	370	1.36
3,5-Di-*t*-butyl phenol 0	$C_4H_{22}O$	206	3.27

Source: Eleazu, 2016.

Oxalate: Oxalate is a chemical substance in cocoyam that imparts acrid taste or cause irritation on exposed skin during processing or in the throat and mouth epithelium especially for the less boiled cocoyam on ingestion (Akpa and Umoh, 2014) and indirectly affecting the eating value and digestibility. It is one of the major factors limiting the utilization of cocoyam. The acridity of cocoyam diet is caused by needle like calcium crystals, raphides that can penetrate soft tissues or skin (Bradbury and Nixon, 2008). The raphides may be a protease can cause discomfort in the tissue (Bradbury and Nixon, 1998). High amount (2856 mg/100g), oxalic acid is toxic to humans and can also reduce the nutritional quality of cocoyam by binding with calcium to form calcium oxalate (Hany et al., 2011). All parts of cocoyam cultivars were known to contain calcium oxalate which is destroyed by lengthy cooking (Hedyes and Lister, 2006). Studies showed that boiling cocoyam at the 90^{o}C for 30 minutes, and steeping in water at 30^{o}c for 24 hours can reduce the oxalate salt content of 32.7% and 56.7% of its original content, respectively (Iwuoha and Kalu, 1994). Also, the calcium oxalate content in cocoyam leaves can also be reduced by sun-drying and storing (Emmans, 2008). Studies on different methods of processing cocoyam tubers and leaves like boiling, fermentation, drying, cooking methods etc have shown a great effect in reducing the level of oxalate, tannin, all nutrients inhibitors, phytate and as well improve the nutrient contents of cocoyam (Malavanah *et al.,* 2008b). Further, the consumption of adequate diary or calcium based food in taro diet like milk and milk products has been reported to reduce the acridity of taro caused by calcum oxalate (Munait et al.,2009). The adequate intake of calcium together with spinach, an oxalate rich diet will help to reduce the uptake of oxalate (Brogren and Savage, 2003).

Cocoyam mucilage: Cocoyam mucilage is a slimy material like nasal discharge coming out from the raw

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cocoyam tubers or leaves when the fresh surface is cut into pieces or exposed fresh surface. Mucilage also occurs on boiled cocoyam tubers during processing for flakes. The great quantity of mucilage is removed or reduced when the pieces of cocoyam tuber are washed or placed in water (Nipp, 1997). Mucilage can also be eliminated by discarding the water used for cooking or the tubers can be cooked without water or roasted (fried or baked) in order to have a partial dehydration or dry texture. However, taro mucilage has a health benefits by aiding digestibility and slower blood glucose, slow transit of food through the upper gastro-intestinal tract, water absorption and retain moisture that reduce constipation (Njintany et al., 2011).

Protease inhibitors: Protease inhibitor also known as trysin or chymotrypsin is another causal factor of acridity from eating raw or partially cooked cocoyam parts (Bradhury et al*.,* 2008) including the poorly sun dried or boiled leaves. The acridity in the cocoyam tubers and leaves are experienced as a severe itching, stinging or burning sensation in the mouth and throat followed by swelling or as a less severe irritation or itching of external tissues (Osisiogu et al., 1994). The trypsin inhibitors constitute about 1- 4% of the total protein in tubers and are absent or inert in leaves. The twenty minute of boiling is reported to remove trypsin activity adequately and also enough to remove the acidity in many cocoyam cultivars (Bradbury and Holloway, 1988; Bradbury and Hammer, 1990).

Alpha-amylase inhibitors: Alpha-amylase inhibitors are digestive enzymes of the starch in man and animals. They are in saliva and the small intestines and can be inhibited by specific enzymes from many plants. Alpha - amylase inhibitors in cocoyam parts can inactivate human salivary and pancreatic amylases (Mace and Godwin, 2002). However, alpha –amylase inhibitors are not resistant to heat and can be deactivated by usual cooking practices.

CONCLUSION AND RECOMMENDATIONS

The nutritional and health values of a diet should be a main concern when a crop is being considered as food source. Food is one of the necessities of life for good nutritional and health security. Enough consumption of Ede ofe is an indirect way of dealing with medicinal plants which is a cornerstone of traditional practices of nutritional and health care. "You are what you consume" is a very unique saying because the food we eat plays a crucial role in our daily wellbeing. The most recent silent killer and degenerative diseases known today has been associated with our diets. Prevention is the better than cure, they say. Therefore, it is very essential that we check what we eat and as well to start to re-think the nutritional and health benefits of those neglected food crops like *Colocasia spp*. *Colocasia spp.* diet is an excellent way of ensuring that our body is well supplied with the outstanding and essential phyto-nutrients it needs to meet the demand of healthy and balanced lifestyle. Cocoyam products are locally sourced and should be included in daily feeding schedules in any form of formulation like pounded as fufu, or mixed/pounded together with either cassava, yam, garri or plantain as food softener, taro chip (achicha) with *Cajanus cajan* or black beans (Akidi) and other available ingredients.

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EVALUATION OF CASHEW KERNEL CONSUMPTION AS SUPPLEMENT TO MALNUTRITION STATUS IN LAGOS METROPOLIS

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ABSTRACT

The dangers of malnutrition pose serious health issues like cardiovascular diseases, diabetes, cancer, and stunted growth. The rate of increase in malnutrition amongst mothers and children during and after birth is significantly high, both in rural and urban Lagos State metropolis. The study evaluates cashew kernel consumption as a food supplement to curb malnutrition status in Lagos state metropolis. Information on socio-economic characteristics, macronutrients and micronutrients consumption of food nutrients by 90 respondents from three Local Government Areas: Ojo, Ikeja and Isolo were collected. The respondents were selected using simple random sampling technique with the aid of interview schedules and questionnaires administered on consumers who were 18 years and above, about 50% of self-employed. The mean age and family size of respondents is approximately 35 years and 6people respectively. The nutrient consumption revealed that macronutrients {carbohydrate (93.3%), protein (87.8%), and fat (55.7%)} were consumed more frequently than micronutrients which includes vitamins and minerals nutrients; groundnut (67.8 %), cashew nut (59%), peanuts (31.1%), and coconut (28.9) as favorite snacks respectively. The study also identified higher percent of respondents that could can spent above ₦1500 weekly on cashew nut kernel (1kg bottle size) as their favorite snack, compared with those that could afford it. Chi-square results revealed that marital (x^2=60.048, educational status x^2=42.341, and occupation (x^2=25.227, at $p\leq0.05$) were significantly related to cashew kernel consumption among respondents which implies that the aforementioned variables has positive influence on cashew kernel consumption in the study area. The dominance of macronutrients from the study shows imbalance in the daily food consumption of the respondents. The use of cashew kernel as supplement to malnutrition status was underutilized due to indicated factors faced by consumers. It is advisable that cashew kernel consumption be encouraged to be part of daily meal of families residing in Lagos State and beyond. Government establishment of polices that will encourage the production, processing and consumption of cashew nut kernel by subsidizing the cost of the production, through farm input mechanization, will trigger the rate of consumption, at an affordable price to meet with nutrients needed for balanced diet.

Key words: Malnutrition, cashew consumption, food nutrients, Lagos State.

INTRODUCTION

Cashew nut (*Anacardium occidentale*) is an economic nut tree that belongs to the family Anacardiaceae. It originated from Brazil, first introduced in Nigeria 15th century ago by Portuguese explorers as horticulture. Presently, it is domesticated in Africa, South America and Asia as a source of food, industrial raw materials and foreign exchange to many countries. Cashew nut is produced in many parts of Nigeria, but predominantly in the southern and middle belt region. Cashew kernel is the real fruit embedded inside the shell of cashew nut. It has two distinct kidney shape parts and its color varies from lite green (fresh kernel) to grayish brown (dried kernel). According to Kluczkovski (2016) about 20–25% of the cashew kernel occupied the total cashew nut, wrapped in a thin, difficult to remove peel reddish-brown membrane. Cashew kernel popularity began right from early school days, in the lives of respondents not only because it has a nice smell, with buttery flavor, but also because they are loaded with vitamins and minerals needed for a balanced diet. Laura Griffin (2017) said that the nutrients obtained from cashew kernel nutrients after oil extraction contains about 45% crude protein, 2% crude fiber and 6% ash. Both nutrients are good food materials for repairing damaged tissues (supplement). It is also known that cashew kernel nutrients are rich in essential amino acids that are normally not common in plants (Ekpeyong, 1997).

The US department of Agriculture (USDA) National Nutrient Database shows that 28.35 g of cashews kernel contains 157 calories from 1.68 g of sugar, 0.9 g of fiber, 10 mg of calcium, 1.89 mg of iron, 83 mg of magnesium, 168 mg of phosphorus, 187 mg of potassium, 3 mg of sodium, 1.64 mg of zinc, 0.1 mg of ascorbic acid, 0.120 mg of thiamine, 0.016 mg of riboflavin, and 0.301 mg of niacin, 5.17 g of protein, 8.56 g of carbohydrate, 12.43 g of total fat, also contain 50% fats in form of unsaturated fats, which helps in weight management considering that it has enough calories. It is a good source of vitamin E and minerals especially magnesium and zinc, which contain vitamins C and B. (USDA, 2019)

The nutritional status in Lagos State, the most populous city in Nigeria, is acute according to national nutrition and health survey NNHS (2018). Lagos State has all it takes to set a good nutritional record as an example to other neighboring states and other West African countries to adopt, for maximum calorie needed, for a healthy society living which improves socio economic activities of the people thereby creating more wealth for the state. But the dietary patterns and the nutritional knowledge of adults, especially women and children, in Lagos State metropolis were poor; obesity and overweight are higher than previously. Obesity is a sign of malnutrition, which promotes excessive body fat and increase in weight and sets the risk of health problems. The high rate of malnutrition status in Lagos state can cause public health outbreak amongst residents of the state especially women and children (Olatona, 2020).

In 2018, the national nutrition and health survey (NNHS, 2018) concluded that the rate of malnutrition in Lagos State is at an acute level. To alleviate the problems in a developing country like Nigeria, there is a need to accept change in nutritional patterns. Foods stuffs with lots of vitamins and minerals, and a reasonable amount of carbohydrate, protein and soluble fat should be adopted. Cashew kernel has been reported to be rich in proteins and other missing minerals causing malnutrition. It is a moderate source of iron, riboflavin, thiamine and a good source of amino acid which is not common in plants (Ekpeyong, 1997). At the peak of sudden changes and challenges in the health sector due to Covid-19 pandemic outbreak among humans, Lagos state recorded the lion share of affected persons compared to other states in Nigeria. It is advisable to improve the immune system by the use of food supplements, such as cashew kernel, to fortify missing diets in meals. Although, there are several food supplements mostly from nuts, the cashew kernel is highly favored by majority over others due to its high variety of nutrients, attractive smell and buttery taste.

The main objective of this paper is to evaluate the consumption of cashew kernel as food supplement to balance malnutrition status in Lagos state metropolis. The specific objectives are to: 1) Examine the Socio economic characteristics of respondents, 2) Determine the level of cashew kernel consumption and 3) Investigate the factors facing cashew kernel consumption as a food supplement in the metropolis.

MATERIALS AND METHODS

The study was purposively carried out in Lagos State Nigeria due to the population density of the area, as one of the most populated cities in the country and West Africa region, with higher rate of socio-economic activities and opportunities. Based on that, the study of cashew kernel consumption as food supplement was fully participatory and involved 90 respondents who were 18 years and above, selected from 3 Local Governments Areas LGAs (Ojo, Ikeja, Isolo). The respondents were sampled from a document provided by the Lagos State Ministry of Health, Alausa, Ikeja. Information from the ministry categorized these LGAs as epidemic prone areas in the state. The use of questionnaire was used in getting information from consumers. Data were analyzed with descriptive and inferential statistics. The following variables were considered in the study: socio-economic characteristics of respondents, cashew kernel, macronutrients and micronutrients consumption and constraints faced by respondents in consumption of cashew kernel as food supplement in the metropolis.

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RESULTS

The results on the socio-economic status of respondents are shown in table 1 below. The respondents were 56.7% female and 43.3% male indicating that female formed the major consumers. Fifty percent of the respondents had tertiary educational while 6.7% attended primary school. The civil servants were 17.8% with 50% self-employed. The cashew consumers' average family size is approximately 6 with the mean age of respondents as 35 years meaning that they were mostly young persons. The mean values for the respective macronutrients consumption revealed that carbohydrate (62.4), protein (55.7), and fat (27.6) were frequently consumed more than the required micronutrients, which contains fruits (54.04) vegetables (49.67) and nuts (43.70). The micro nutrients, which contain vitamins and minerals needed as food supplement, were consumed mostly from groundnut (82), cashew nut (81), peanuts (65), and coconut (62) by the respondents as favorite snacks, respectively (Table 2). The contributing factors that encourage low cashew nut consumption by respondent showed that 66 persons believe the price of cashew nut kernel contributed to the inadequate consumption, while 43 and 29 people believed that it was due to economic status and availability, respectively (Table 3). Chi-square results revealed that marital (x^2=60.048), educational status (x^2=42.341) and occupation (x^2=25.227, at $p \leq 0.05$) were significantly related to cashew kernel consumption among respondents. The implication of this is that these variables have influence on the consumption of cashew kernel in the study area. The educational level and occupation of respondents makes them to be more informed about the type of food nutrients they take.

DISCUSSION

The socio-economic characteristics of cashew kernel consumers in Lagos metropolis had significant relationship with cashew consumption, because most of the respondents were young and married. Despite the higher percentage of respondents that preferred cashew nut kernels as their favorite snacks, groundnut was highly chosen as substitute snacks to cashew nut kernel due to its relatively cheap and availability in all seasons. Apart from protein, other uncommon essential minerals possessed by cashew kernel over groundnut is its ability to supplement diets from monounsaturated and polyunsaturated fatty acid which helps to reduce the risk of coronary heart disease to about 37 percent (Megan, 2018). British Journal of Nutrition also confirmed that a person taking handful of cashew nuts daily have lower risk of coronary heart disease (Estruch, 2013). Although, most people indicated cashew nut as favorite snacks, yet they purchase more groundnuts than cashew nut, due to the price, availability and affordability as indicated by the respondents as their major constraints suppressing cashew nut kernel consumption in Lagos metropolis. Therefore, a well design polices to capture frequent consumption of cashew nut kernel by the government is a welcome development, thereby making cashew kernel available and affordable to create a free market for the consumers to bargain prices according to their budgets.

Table 1. Socio-economic characteristics of respondents (N=90)

Variables	Frequency	Percentage	Mean
1.Sex			
Male	39	43.3	
Female	51	56.7	
2.Marital status			
Single	48	53.3	
Married	41	45.6	
Divorced	1	1.1	
3. Educational status			
Primary	6	6.7	
Secondary	36	40.0	
Tertiary	45	50.0	
Non formal education	3	3.3	
4. Age			
18-25	22	24.4	35.5
26-33	21	23.3	
34-41	25	27.8	
42-49	12	13.3	
50-57	10	11.1	
5. Occupation			
Civil servant	16	17.8	
Business	24	26.7	
Self employed	45	50.0	
Jobless	5	5.60	
6. Family size.			
2-4	29	32.2	6.0
5-7	52	59.8	
8-10	9	9.9	

Field survey data, 2021

Table 2. Consumption table of Macro and micro nutrients (N=90)

Variables	Frequency	Percentage	
1. Carbohydrate			62.4
10-35	10	11.1	
36-56	20	22.2	
57-77	34	37.8	
78-98	26	28.9	
2. Protein			
10-35	19	21.1	55.78
36-56	20	22.2	
57-77	36	37.8	
78-98	15	28.9	
3. Fat			
5-25	48	53.3	27.67
26-46	25	27.7	
47-67	11	12.2	
68-88	6	6.67	
4. Fruit			
5-25	14	15.6	54.04
26-46	24	26.7	
47-67	21	23.3	
68-88	31	34.4	
5. Vegetable			
5-25	15	16.6	49.67
26-46	28	31.1	
47-67	24	26.7	
6. Nuts			
5-25	16	17.8	43.70
26-46	35	38.9	
47-67	26	28.9	
68-88	13	14.4	

Field survey data, 2021

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Table 3. Factors influencing low consumption of cashew nut in diet

Factors	Frequency (N=90)	Percent (100)
Economic status	43	47.8
Availability	29	32.2
Price	66	73.3

Field survey data, 2021

Table 4. Relationship between cashew consumption and socioeconomic status

Variables	Df	$X^{2\ value}$	P value
Marital status	2	60.048	0.000*
Sex	1	2.571	0.109
Educational status	2	42.341	0.000*
Occupation	2	25,227	0.000*

Field survey data, 2021 * = significant at p≤0.05

CONCLUSION AND RECOMMENDATION

The use of cashew kernel as food supplement to malnutrition status in Lagos State is underutilized, due to dominance of macronutrients consumption in the daily food items and poor supplement intake by the respondent. It is advisable that cashew kernel consumption be encouraged to be part of daily meal of families residing in Lagos State and beyond. Government should make polices that will encourage production, processing and consumption of cashew nut kernel by subsidizing the cost of production through supply of farm input to farmers at affordable prices. This will trigger the rate of consumption, at an affordable price to meet with nutrients needed for balanced diet.

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PRODUCTION AND MANAGEMENT OF *PENTACLETHRA MACROPHYLLA* FOR FOOD SECURITY, ECONOMIC EMPOWERMENT AND SOIL CONSERVATION

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ABSTRACT

Pentaclethra macrophylla is a forest tree crop that is grown as semi wild or cultivated crop especially in South Eastern and South southern Nigeria. It is a highly underutilized leguminous tree crop with high potentials for climate change mitigation, soil improvement, food security, poverty alleviation and health benefits. It is an important and cheap source of protein for people whose staple foods are deficient in proteins. It is also eaten as a delicacy and used as flavoring for soup. The seeds contain protein and minerals necessary for combating micronutrient deficiency and hidden hunger. Its seeds are processed through fermentation to remove toxins that that are harmful to the human body. With this, it is used is condiment and flavor in foods and diets. Due to poor management, P. macrophylla is highly threatened as trees are indiscriminately felled without adequate replacement. It is recommended that adequate attention should be given to its conservation due to the prominent position it occupies in the cropping system of the region

Key words: *Pentaclethra macrophylla,* African oil bean, food security, economic empowerment, soil conservation

INTRODUCTION

Pentaclethra macrophylla, also known as African oil bean, is an herbaceous tropical tree crops popularly gown or cultivated in South-eastern and South-southern Nigeria. It belongs to the family *Leguminoseae* and subfamily *Mimosoideae*. It is found commonly growing in the different rainforest zones of Nigeria. Its cultivation is usually under semi wild or protected condition as homestead garden crops (Okigbo, 1975). *Pentaclethra macrophylla* seedlings are often not raised under nursery conditions but are transplanted from their point of germination, which usually occurs not far from where the mother plants are located. According to Okigbo (1975), *P. macrophylla* are found growing as volunteer's seedlings which are either nurtured to maturity at the point of germination or transplanted into another field. Due to its explosive dispersal mechanism, the seedlings are found growing in semi wild conditions. It is widely consumed as snack condiments (Mbata and Orji, 2008) and a delicacy especially in South-eastern and South-southern Nigeria (Odoemelam, 2005). Other uses are for medicine, soil improvement, environmental conservation and climate change mitigation. Occasionally, the trees are found thriving in the South western part of the country as forest trees. Due to the fact that they are not widely consumed in the part of the country, they are not given the desired attention. Consequently, *P. macrophylla* has lower tree density in the south west region compared to the south east and south southern part of Nigeria. In the east, it may be found cultivated under homestead conditions. During processing, *f*ermentation is needed to eradicate any toxins. Processing involves boiling, slicing and soaking of the seeds which reduces tannins and anti-nutritional compounds with an increase in iron, calcium, potassium, thiamine and riboflavin levels (Enujiugha and Akanbi, 2005) fats, carbohydrate (Oboh and Ekperigin, 2004).

Benefits of the African Oil Bean

The seeds, leaves, stems, barks, trunks and roots of the African oil bean tree are very useful for their nutritional, medicinal and economic values (Odunfa and Oyeyiola,1985). *P. macrophylla* contains high quantity of vitamins and minerals. The nutritional composition of *P. macrophylla* makes it a viable food type for combating food insecurity (Table 1).

MATERIALS AND METHODS

The study was conducted at National Horticultural Research Institute, Mbato Out-station field orchard, Okigwe in Imo State southeast geopolitical zone, Nigeria. Structured questionnaire was distributed to residents in Okigwe, Imo State to determine sources of seeds used for processing into consumable *P. macrophylla* salads and measures adopted for conservation within the cropping systems of the community. Data obtained were analyzed using descriptive statistics.

Table 1. Nutritional values of *Pentaclethra macrophylla*

Component	Values (%)
Crude protein	9.31
Crude fibre	21.66
Moisture	39.05
Carbohydrate	38.95
Ash	3.27
Oil content	47.90

Source: Ikhoria *et al.,* (2008)

RESULTS AND DISCUSSION

The sources of seeds for processing is presented in Table 2. Sources of collection of oil bean seed were NIHORT station (26.5%), Producers (8.5%), Farms (10%), purchase from market (4.5%), picking from people's farmland (28.5%), gathering from friend (2.5%) and gathering from forest (19.5%). Oil bean seeds are common in primary and secondary forest where they germinate freely and grow as semi wild plants. Most people interviewed got their seeds from NIHORT farms in Okigwe. However, the lowest percentage was recorded in those who obtained it from other people's farmlands. People in search of firewood and bush meat; easily pick *P. macrophylla* seeds which are dispersed on the field.

Table 2. Source of oil bean seed processed

Source	Frequency	Percentage(%)
NIHORT Mbato Out-station	53	26.5
Producers	17	8.5
Personal farms	20	10
Open Market	9	4.5
Other people's farmland	57	28.5
From friends	5	2.5
From forest	39	19.5
Total	200	100

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Table 3 shows methods used in conserving *P. macrophylla*. Thirty-five (35) percent of people did nothing to conserve oil bean, 42.5% planted more oil bean, 9% maintained and protected oil bean crops found around them, 22.5% disallowed felling of trees, 13.5% encouraged people to plant more to maintain the crops while 12.5% reestablished lost stands.

Table 3. Methods used in conserving oil bean

Methods	Frequency	Percentage(%)
Planting more oil bean	85	42.5
Maintaining/protecting oil bean crop found around.	18	9
Disallowing cutting down of trees	45	22.5
Encourage people to plant/maintain the crop	27	13.5
Replace old plants with new ones	25	12.5

Indiscriminate felling of trees and poor replacement plans can lead to genetic erosion and loss of this crop in the near future. Some efforts put in place by farmers towards conservation of the African oil bean tree include: restriction of indiscriminate harvest of oil bean tree by trespassers, prohibition of forest fires, and seizure of products from offenders and punishment of forest offenders through payment of fine among others. Felling of trees is practiced, but highly discouraged, as the tree is considered as an economic tree. This accounts for the lower frequency and percentage in use of restraints in cutting down of trees as a strategy for conserving *P. macrophylla* compared to planting of more trees. *P. macrophylla* is an underutilized tree with poor conservation status. Poor regeneration and low cultivation of *P. macrophylla* could make the crop go into extinction. Some stands of *P. macrophylla* are used as firewood leading to deforestation. Indiscriminate felling of trees contributes to tree loss and increase in adverse effect of climate change. Conservation efforts should include sensitization of people on the need to preserve forest trees for economic gains, ecological and genetic conservation. Policies should be put in place while trespassers should be charged for breaking the law.

CONCLUSION

P. macrophylla plays an important role in the food system of the south eastern and south southern Nigeria. It is necessary to conserve and preserve it for utilization in the food system of the people of the region

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ASSESSMENT OF LANDSCAPE PRACTICES AND AESTHETIC PERSPECTIVES IN SELECTED LOCATIONS IN LAGOS AND IBADAN METROPOLITAN CITIES

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ABSTRACT

Landscape development has great benefits and impacts on the economic development and aesthetic appeal of most cities all over the world. This study was done to assess the effect of the various landscape practices adopted in selected LGAs of Lagos and Ibadan on the aesthetic perspectives of both cities. The study was carried out using a well-structured questionnaire to harvest relevant information about landscape practices in both cities. The questionnaire was divided into four sections which covered the socio-economic characteristics of respondents, assessment of landscape design, Maintenance practices, and Cultural/traditional beliefs about landscaping. A total of 114 responses altogether were collated and analyzed using spreadsheet analysis software (MS Excel) and Statistical Package for Social Science (SPSS), and data were presented in frequencies, percentages, and charts. Results obtained in Lagos showed that more Males (71.9%) than females (28.1%) are either involved in the act of landscaping or patronize landscape business. This was also true for Ibadan where 56.1% of Male was recorded, in contrast to 43.9% females. It was also recorded that the predominant purpose of landscaping in both cities is Beautification as it accounts for 87.7% of landscape purposes in Lagos, and 78.9% in Ibadan. Watering is the most practiced Maintenance routine in Lagos, with 87.7% of the respondents practicing it, in contrast to the 61.4% in Ibadan. 26.32% of respondents believe that Cultural/Traditional belief highly influences landscape business in Lagos, while 21.1% agree to the same assertion in Ibadan. Based on this study, it is concluded that the approach to uses of equipment and facilities differ at both locations, which is a reflection of the level of cultural belief, educational level, and probably the size of land and properties.

Key words: Assessment, Landscape Practices, Aesthetic Perspectives, Lagos, Ibadan, Metropolitan Cities

INTRODUCTION

Landscape is the visual properties or characteristics of the outdoor environment, which include natural and manmade elements, physical and biological resources (Amir and Gidalizon, 1990). Landscape practices serve as a form of trade in Nigeria, and an income generation source, apart from its primary function of beautifying the environment. Landscape practice is a service industry, which provides people with fabricated environments where man can live, work, and play, or just passes time (Asiedu et al., 2010). Metropolitan cities are cities with densely populated people in urban areas, having one or more towns connected together. Lagos is the largest Metropolitan city in Africa. It is located in the western part of Nigeria at the bank of the Atlantic Ocean. The wetland and urban region has an estimated population of 24.6 million, based on the UN-Habitat and international development agencies' estimates in 2015. In Nigeria, in particular important production and commercial centres are located in the cosmopolitan city of Lagos in South West Nigeria, alongside other cities in the humid rain forest which include Calabar in South-East and Port-Harcourt in South-South, while other centres characterized by the drier savannah vegetation include Abuja (the Federal Capital City) and Jos Plateau both located in the Middle Belt zone. (Olubode et al., 2015).

Lagos is of diverse ethnicity, due to the high rate of local and global migration, although, the dominant ethnic group is the Yoruba. It is a major financial Centre for all African countries, and the economic hub of Lagos State. It is referred to as a tourist haven, and it accounts for 180km out of Nigeria's over 700 km Atlantic sandy beaches, twenty of which are between Badagry in the west and Lekki in the east (Lagos state Government, 2006). Some of these beaches include: Bar beach, Lekki Beach, Kuramo Waters, Tarkwa Bay, Ogogoro Island, Eko Tourist Beach Resort, amongst others (Lagos State Government, 2019). The state also houses other numerous monuments and tourist attraction sites like the first Storey Building in Nigeria, Ologe Forest Reserve, Relics of Slave Trade, Egbin thermal station (largest power facility in Africa), Ijede water springs, Muritala Mohammed botanical garden, amongst others.

Likewise, Ibadan is the capital and the most populous city of Oyo, a south-west state in Nigeria. The suburban region is 128km inland northeast of Lagos (Oyo state Government, 2020) and it's the largest city in Nigeria by Geographical mass, but third largest behind Lagos and Kano in population. The city is estimated to have over 3.5 million inhabitants (Oyo State Government, 2020) and it's predominantly dominated by Yoruba. It is the prominent transit region between the coastal region and hinterland areas in the country, which makes it economically important. Ibadan houses various research institutes, monuments, recreational sites, and tourist attractions. Some of which includes; National Horticultural Research Institute, IITA forest reserve, Bower memorial tower, Agodi gardens, University of Ibadan Zoological and botanical garden, Cocoa research Institute of Nigeria, amongst others.

Landscape practices and business engagement have great potentials to uplift city status to either that of developed, under-developed or developing, with the accruing benefits including the value added to style of living, improved health status by way of alleviation of stress and development of a buoyant economy through financial in flow from provision of job opportunities and payment to garden owners for relaxation services rendered (Owolabi et al., 2020). Landscaping is widely known for enhancing the aesthetics perspective of an outdoor environment, as it can increase the value of a building during resale and present a relaxing view from the greenery of the environment. Plants are the most cost-effective and fastest agent of change that can eliminate the negative perception of an area, while enhancing the economic and social conditions, and improving psychosocial health (Relf, 1992). Landscape sights can function as healing landscapes, horticultural therapy, school gardening, community gardening and provides solutions on psycho-social issues (Relf and Lohr, 2003). Proper landscaping provides environmental benefits like air purification, reduction in noise pollution, reduction in cost of home heating and cooling, improving micro-climate, and also eliminating flooding, soil erosion, and oil spillage.

There is increasing evidence that exposure to plants and green space, and particularly to gardening, is beneficial to mental and physical health, and so could reduce the pressure on NHS services. It is not only the appearance of plants that is beneficial: their leaves remove toxins, dust and microorganisms from the air and they also produce the so-called negative ions from their leaves. (Perez *et al.,* 2013). Live indoor plants may increase workers' productivity and reduces stress. Landscaping contributes to the economic development of different states, countries, and metropolitan cites through protection of public and private structures against environmental hazards, revenue generation for the government, wealth creation and employment opportunities for individuals, attraction of tourists and investors, and lots more.

Public concern for the visual landscape has led to the widespread use of codified, replicable processes for assessing, documenting and predicting a landscape's scenic beauty (Bishop and Hulse, 1994). According to Ayuba (2019), there is insufficient data on landscape practices in terms of landscape design or the process of such designs in Nigeria; however, there is adequate data on the historical development of cities and their planning process. However, landscape practice is of great benefits and positive effects on the development and aesthetic appeal of Lagos and Ibadan. Thus, there's a need to assess the landscape practices in these metropolitan cities, to determine their strength, shortcomings, and impact on the city's aesthetic perspective and economy, while also proposing ways to further improve such practices in comparison to standard procedures. This will provide effective solutions to further improve the landscape practices in Lagos and Ibadan. The objectives of this study therefore are to evaluate the present landscape practices in Lagos and Ibadan; analyze the effects of landscape practice(s) on the aesthetic perspective of Lagos and Ibadan; evaluate the effect of landscaping contribution to cities development and growth; and determine the growth level and acceptance of landscape practice in Lagos and Ibadan.

MATERIALS AND METHODS

Survey location

This survey was carried out in Lagos metropolis and Ibadan Municipal city. Lagos is the most populous city in Nigeria, located in the south-west region and lies between Latitude: 6°27'14" N and longitude 3°23'40" E. The Mangrove rain forest region has an 11m elevation above sea level. It is the economic and commercial capital of Nigeria and the former political capital of the West-African country. Lagos has 20 Local Government Areas and 37 Local Council Development Areas. Landscape sites visited in Lagos include Ikeja, Oshodi-Isolo, Eti-Osa, Agege, Lagos-Island, and Amouwo Odofin Local Government Areas. Ibadan is the capital of Oyo state and the largest city in Nigeria by geographical mass. It is also located in south-west Nigeria and lies between latitude 7°22'39" N, and longitude 3°54'21" E. The humid rain forest region is 181m above sea level and comprises of 11 local governments area in its Metropolitan area. Landscape sites visited include Ido L.G.A, Ibadan South L.G.A, Oluyole L.G.A, and Akinyele L.G.A.

Methods

An estimated total of 20 landscape professionals was visited across Lagos and Ibadan and their opinion was sampled with aid of a structured questionnaire, and their responses were used for this analysis. A total of 140 copies of questionnaires were distributed in each of the combined ten (10) Local Government Areas visited in Lagos and Ibadan. A total 114 of questionnaires were retrieved in both cities, with both cities having 57 respondents each. Views of the various landscape sites and designs in both cities were captured with the aid of digital camera, for physical comparative analysis. The questionnaire had four (IV) different sections; **Section A** was used to determine the socio-economic characteristics and get personal information of respondents which includes gender, age, marital status, and educational status. **Section B** assessed the landscape practice in every site visited. It contained questions about the purpose of landscaping, property types, property size, materials and equipment being used, style of design, and average cost of design. **Section C** was used to get information about the maintenance practices being employed on established landscapes, in visited sites. It contained questions about frequency of maintenance, routine management practices, equipment used, cost of maintenance, and method of watering employed. **Section D** assessed the cultural/traditional beliefs of the respondents. It contained questions about the influence of their cultural/traditional belief on level of patronage, how they rate the city in terms of patronage, their experience about overflow of patronage, amongst others.

Data Analysis

Data collected using the demographics, aesthetics, and maintenance routine was analyzed using descriptive statistical tools and it was represented in percentages, bar charts, and tables. The questionnaire was collected, collated, and analyzed using spreadsheet Analysis software (M.s Excel) and Statistical Package for Social Science (SPSS).

RESULTS AND DISCUSSION

Demographic and Socio-economic characteristics of the respondent

The respondents that numbered 41 (71.9%) in numbers were male (Table 1), while 16 (28.1%) were females in Lagos, and 32 (56.1%) were male while 25 (43.9%) were females in Ibadan. This made up 57 respondents in each location and a total of 114 respondents in both locations combined. This table therefore shows that the males constitute higher percentage of the respondents in the study area. Age distribution of the respondents shows that in Lagos, 2 (3.5%) of the respondents were of the age 25yrs and below, 19 (33.3%) were of the age 26 – 40yrs, 24 (42.1%) were of age 41 – 55yrs and 12(22.1%) were 56 years and above. While in Ibadan, 9 (15.8%) were 25yrs and below, 19 (33.3%) were of the age 26 – 40yrs, 19 (33.3%) were of the age 41 – 55yrs and 10 (17.5%) were of the age 56 and above. This distribution indicates that the respondents who were of the age 41 – 55yrs constitute the highest percentage of the respondents in Lagos while those who are of the age 26 – 40yrs and 41-55 constitute the highest percentage of respondents in Ibadan. According to Owolabi et al., (2020), the gender sensitive and unmarried age brackets involved in the business indicated that more male were involved in the profession which could be due to the energy and time demanding nature of the most operations carried out in landscape work.

The respondents that numbered 49 (86%) were married and 8 (14%) were single in Lagos, while 40 (70.2%) were married and 17 (29.8%) were single in Ibadan. This result indicates that most of the respondents in both cities were married. Among the respondents about 29.8% and 42.1% worked for one company or the other which employed the use of landscape design while 33.3% and 38.6 were self-employed in Lagos and Ibadan, respectively. The respondents that numbered 24.6% in Lagos made daily income, while 7.0% did the same in Ibadan. Both cities had equal number of respondents of 12.3% on weekly wage. This result shows that Lagos had more self-employed landscape horticulturists than Ibadan, and more employers that employed the use of landscape designs.

Considering the educational level in Table 1, most of the respondents in Lagos and Ibadan (80.7% and 77.2% respectively) had tertiary education, 8.8% and 12.3% had secondary education, 1.8% had primary education in Lagos in contrast to none in Ibadan, and 3.5% had adult education in Ibadan in contrast to none in Lagos, 8.8% and 7.0% had Vocational education in Lagos and Ibadan respectively. This result shows that both cities had more learned respondents that are qualified enough to implement landscape design based on their level of experience. According to Asiedu (2010), some aspects of the practices does not require formal University education; however, others do. As observed in this study, the majority of people involved in landscape practices and business had formal education which indicated that landscape practice was a major employment opportunity for job seekers and could be a major economic force in the future. Furthermore, Fagbayide and Jonusa (2006) submitted that formal education enhanced appreciation and subsequently management of landscape work and that landscape practice is an elitist profession.

The respondents that numbered 43.9% in Lagos earned >500,000 as opposed 15.8% in Ibadan showed that there were more respondents in that category in Lagos than Ibadan. Nonetheless, Ibadan had more respondents earning <100,000 than Lagos (47.4% and 38.6% respectively), about 17.5% of the respondents in Lagos earned 100,000-500,000, while 36.8% earned within that range in Ibadan. This result shows that more of Lagos respondents were high income earners as opposed Ibadan that more dominated by middle- and low-income earners indicating the level of patronage and financial capacity of clients.

Assessment of landscape in Study Areas

The respondents that numbered 28.1% out of the study areas in Lagos were schools (Table 2), while school accounted for 24.6% in Ibadan. 26.3% accounted for hotel in Ibadan, in contrast to Lagos 10.5%. The table also showed that Hospitals were 10.5% in Lagos, and 8.8% in Ibadan. 50.9% of the remaining responses in Lagos accounted for other asset types, as against Ibadan's 40.4%. This shows that more schools were visited in Lagos, while more hotels were visited in Ibadan. The table also revealed that the most prominent cost of assets or input in Lagos and Ibadan was >₦500,000 which is 42.1% and 36.8% of total response in Lagos and Ibadan respectively, Ibadan also dominated the <₦ 100,000 assets costs, with 24.6% of the response, in contrast to 12.3% in Lagos. Lagos had 22.8% of the total assets within the range of ₦ 100,000 - ₦ 200,000, while Ibadan had 15.8% within the same range. 15.8% of total assets visited in Ibadan were within the range of 251,000-500,000, while Lagos had 14.1% within the same range. The distribution of landscape ownership shows that 66.7% of the respondents in Lagos owned the landscape property, while 68.4% accounts for the ownership in Ibadan. This result indicates that most of the respondents in Lagos and Ibadan owned the landscape while others were employed to manage for owners of the site. The respondents that numbered 42.1% and 45.6% of the landscape sites visited in Lagos and Ibadan, respectively were small plots. About 1.8% and 3.5% accounted for >10ha property size in Lagos and Ibadan, respectively, 31.6% and 35.1% were recorded for <1ha, while 24.6% and 15.8% accounts for 1-10ha. This result shows that Ibadan had more small plots of <1ha plot than Lagos, while Lagos property sizes were mostly 1-10ha. 40.4%, According to Owolabi et al., (2020), the more frequent occurrence of large hectarage sized properties observed in Lagos, Abuja and Ibadan in that order but of different ownerships in form of schools, social parks, gardens, and conference/recreation centres respectively showed the high space requirement of these businesses and the types of focuses of property owners in these cities.

Furthermore, the respondents that numbered 45.6%, 8.8%, and 5.3% accounted for the areas of landscape design done by Self, Landscape horticulturist, landscape architect, and Client's initiative respectively in Lagos, while 22.8%, 45.6%, 28.1%, and 3.5% accounted for the same in Ibadan. This result shows that most of the Landscape designs in Lagos and Ibadan were done by landscape horticulturists. The result in Table 2 indicated that 7% and 8% of the visited study area in Lagos and Ibadan, respectively were below one year of existence, 38.6% in Lagos and 52.6% in Ibadan had been in existence between 2-5 years, while 54.4% and 38.6% in Lagos and Ibadan, respectively were above 5 years of existence. Also, the table also revealed that the only respondents in Ibadan agreed that the landscape added value to the environment, while 55 (96.5%) of respondents in Lagos agreed that it added value to the environment. This agrees with the statement of Owolabi et al., (2020) that there is a general recognition of landscape business as a useful tool for enhancing property value. Lastly, the result in the table showed that the Landscape design influenced majority of the respondents in Lagos and Ibadan to use the public utilities. 87.7% and 91.2% in Lagos and Ibadan, respectively, agreed to this, while the landscape design didn't influence 12.3% of the respondent in Lagos and 8.8% in Ibadan to use public utilities

Assessment of Purpose of Landscape establishment in the Study Area

The respondents that numbered 89.5% and 78.9% in Lagos and Ibadan, respectively implemented landscape design for the purpose of beautification (Figure 1). About 8.8% of the respondents in Lagos were for advertisement, as opposed to 5.3% in Ibadan. Lagos had no response for business entrepreneurship and psychological therapy, while 3.5% of the respondents chose both categories for their purpose of Landscaping in Ibadan. This shows that majority of landscapes in the site surveyed were established for the purpose of beautification. Although Owolabi et al., (2020) identified different categories of business entrepreneurship which was not fully specified in this study and could have accounted for the response.

Soft Landscape Components in the respondent site

The response from the conducted survey showed that respondents in Ibadan used more of Lawns in their Landscape (Figure 2), than Lagos with both cities recording 17% and 14%, respectively. This probably was because of availability of abundant space in Ibadan compared to overpopulated Lagos with limited space. Also, more trees (15%) were also used by the respondents in Lagos than Ibadan (14%). This probably could be because of need to protect building from storms and need to ameliorate the effect of heat in the environment. The respondents that numbered 12%, 13%, and 11% in Lagos had hedges, shrubs, and palms, respectively, in their landscape, while 10%, 16%, and 6% had the same in Ibadan. This describes the choice of plant as ornamental palms are more prevalent in Ibadan. The respondents that numbered 1%, 3%,8%, and 4% in Lagos had established turf, green walls, bedding plants, and wild flower meadow, respectively, in contrast to the 2%, 5%, 3%, and 5% recorded in Ibadan. This corroborated earlier observation above of availability of space to accommodate the greens. About 10% of the respondent in both Lagos and Ibadan used local soft landscape components, while 3% in Lagos and 6% in Ibadan used exotic plants, respectively, while 6% in Lagos, and 14% in Ibadan represented the percentage of respondents who used mixture of both soft landscape components.

Hard Landscape Components in the respondent site

The respondents that numbered 18% and 15% of the respondent in Lagos and Ibadan, respectively used fences in their landscape, while 15% and 20% of the respondent in Lagos and Ibadan, respectively used walkway (Figure 3). This indicated that fences were the most used hardscape in Lagos while walkways were the most used in Ibadan. The respondents that numbered 17% in Lagos and 18% in Ibadan added car parks in their landscape, 4%,5%,5% and 6% of the respondent in Lagos added water fountain, pool, artifact and krebs in their landscape in contrast to 8%, 6%, 5%, 4% of the respondent in Ibadan. This response is as a matter of space availability rather than financial. Also, the trend of result in the table shows that no pergola was used in the landscape sites visited in both cities, 4%, 7%and 6% of the respondent in Lagos added irrigation system, paving, and gazebo while 6%, 7% and 1% accounts for the same components in Ibadan. Exotic, local and mixed hardscape were used by 2%, 8% and 8%, respectively by the respondents in Lagos in contrast to 1%, 3%, and 3% of the respondent in Ibadan. This describes the level of affluence, taste and financial capacity in Lagos compared to Ibadan in the use of more exotic hardscapes which probably were imported costly items for beauty.

Assessment of cost of designing and establishing the landscape in the study area

The respondents that numbered 1.8% and 3.5% in Lagos and Ibadan, respectively spent below 100,000 on the cost of establishing the landscape (Table 3), 15.8% and 17.5% in Lagos and Ibadan respectively spent between 1million naira – 5 million naira on cost of establishment while 22.8% in Lagos and 31.6% in Ibadan spent 500,000 – 1 million naira. Also, 35.1% of respondent in Lagos and 56.1% of that of Ibadan spent 100,000 – 500,000 naira on cost of establishment. This result shows that, Ibadan spends more on cost of establishment than Lagos across all price range. The respondents that numbered 43.9% in Lagos and 50.9% in Ibadan spent between 100,000- 500,000 naira to design their landscapes, while 21.1% and 22.8% in Lagos and Ibadan respectively spent less than 100,000 naira on design, 10,5% in Lagos and 12.3% in Ibadan spent greater than 500,000 on cost of design. This result shows that, the predominant cost of design in Lagos and Ibadan is 100,000 – 500,000 naira. Moreover, the higher expenditures in Ibadan compared to Lagos might indicate that Ibadan resident had more flare for beautiful environment than those in Lagos.

Maintenance practices adopted by the respondent in the study area

The analysis of the assessment of the management practices adopted by the respondent in both cities as shown in figure 4 indicates that higher percentage (22%) of the respondent in Lagos practice watering while (17%) in Ibadan do the same, weeding was carried out by 19% and 20% of the respondent in Lagos and Ibadan respectively. The table also revealed that 19% of the respondent in both Cities practiced trimming, while 11% and 12% of the respondent in Lagos and Ibadan, respectively practiced mowing. Operations like pruning, fertilizer application and pesticide application were practiced by 8%, 12% and 9% of the respondent in Lagos, respectively in contrast to the 9%, 8% and 15% in Ibadan. This result shows that watering, weeding, trimming and fertilizer application were the most common management practices in Lagos while watering, weeding and pesticide application were more commonly used in Ibadan.

Assessment on duration of maintenance in the study area

The respondents that numbered 19 (33.3%) in Lagos carried out daily maintenance practices as opposed 8(14%) of the respondent in Ibadan (Table 4), weekly and monthly maintenance practices were carried out by 16(28.1%) and 22(38.6%) of the respondent in Lagos in contrast to 19(33.3%) and 30(52.6%) of the respondent in Ibadan. The table also shows that 3.5%, 29.8% and 66.7% of the respondent in Lagos mow their lawn daily, monthly and weekly

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respectively while 5.3%, 33.3% and 61.4% of the respondent in Ibadan does the same, more of the respondent in Lagos and Ibadan (66.7%) and (54.4%) respectively trim their hedges weekly, 1.8% of the respondent in both cities carries out hedge trimming practices daily while 31.6% of the respondent in Lagos and 43.9% of the respondent in Ibadan trim their hedges monthly. The tree litter packing frequency, displayed in the table shows that 78.8% of the respondent in Lagos pack their tree litter daily while 56.2% of the respondent in Ibadan does the same, no respondent in Lagos packed their tree litters monthly but 14% of the respondent in Ibadan does, 21.1% of those in Lagos and 33.3% of those in Ibadan pack their tree litters weekly. Lastly Table 4 shows that majority of the respondent 66.7% and 64.9% in Lagos and Ibadan respectively apply manure to their landscape site monthly while 31.6% of the respondent in Lagos and 35.2% of the respondent in Ibadan carry out manure application weekly. Only one (1.8%) respondent in Lagos chose daily application in contrast to none in Ibadan.

Assessment of equipment used in maintaining the landscape sites visited

The respondents that numbered 32% and 33%, respectively in Lagos and Ibadan used hedge trimmer, 25% of the respondent in Lagos and 23% of those in Ibadan used push mower (Figure 5), 15% and 10% of the respondent in Lagos and Ibadan, respectively used brush cutter, while the use of cutlass was employed by 27% of the respondents in Lagos compared to 24% of the respondents in Ibadan. The figure also shows that 8 of the respondents in Ibadan (10%) had tractor mower in contrast to 1 (1%) in Lagos. This obviously is in support of the wider space for lawn and ground covers in Ibadan compared to Lagos.

Assessment of irrigation method adopted by the respondent in both cities

The respondents that numbered 38.6% and 54.4% in Lagos and Ibadan, respectively used sprinkler irrigation system (Figure 6), while 47.4% and 24.6% of the respondents in Lagos and Ibadan, respectively used rubber hose. 10.5% and 3.5% of the respondents in Lagos practiced drip irrigation and furrow irrigation method in contrast to the 19.0% and 7.0% in Ibadan. This result shows that sprinkler irrigation was more adopted in Ibadan as opposed the rubber hose being predominantly used in Lagos. The adoption of irrigation methods to support and supplement rain fed production agrees with findings of Olubode et al., (2015) that here exists a proportionate supportive threshold required for soil moisture indicating that rain-fed rose as well as related ornamental plants' cultivation would require supplemental irrigation for effective productivity

Assessment of cultural/traditional beliefs of respondent in the study area

The respondents that numbered 27% and 11% in Lagos and Ibadan, respectively believed that plants attract reptiles (Table 5), while 21% of respondent in Lagos and 22% of respondent in Ibadan agrees that some plants scare away reptiles, 25 (19%) of the respondent in Lagos believes maintaining plants cost more than landscape cement flooring while 20% of the respondent in Ibadan also agrees to that. 4% and 7% of the respondent in Lagos and Ibadan respectively were of the opinion that plants are cheaper to maintain compared to landscape cement flooring. The table also showed that 27% of the respondent in Lagos and 40% of the respondent in Ibadan believed that plants cool and beautifies the environment, 2% of Lagos respondent were undecided in contrast to none in Ibadan. Most of the respondents in Lagos and Ibadan, 50.9% and 52.6%, respectively believed that cultural/traditional beliefs have moderate influence on landscape business patronage, 26.3% of the respondents in Lagos and 21.1% of Ibadan respondents were of the opinion that cultural/traditional beliefs have high influence on landscape business patronage. The table also showed that 12.3% and 19.3% of the respondents in Lagos and Ibadan respectively agrees that cultural/traditional beliefs have no influence on landscape business patronage, the remaining of the respondents which are 10.5% in Lagos and 7.0% in Ibadan were undecided.

The respondents that numbered 38.5% of the respondents in Ibadan described the items of natural heritage valued within the city as few but highly valued while 31.6%of the respondents in Lagos shared the same view about their city, 5.3% and 3.5%

of the respondent in both Lagos and Ibadan believed the items of natural heritage were few but rarely valued, 33.3% of the respondents in Lagos and 21.1% in Ibadan were of the opinion that they were many and highly valued while 29.8% and 24.6% in Lagos and Ibadan respectively believed they were many but rarely valued, 7(12.3%) of the respondent in Ibadan were undecided. The respondents that numbered 10.5% and 8.8% in Lagos and Ibadan respectively believed that landscape practices add value to the environment, 7.0% in Lagos and 19.3% in Ibadan believes landscape practices attracts more customers. 54.4% and 36.6% in Ibadan and Lagos respectively believes landscape has enhanced the aesthetic appeal of the cities, 5.3%, 19.3% and 19.3% of respondent in Lagos believes that landscape helps cool the environment, improves the economy and aids tourist attraction in the city respectively while 7.0%, 10.5%, and 0% believes the same in Ibadan, respectively.

Assessment on categories of patronage in both cities

The respondents that numbered (51%) and (58%) respectively in Lagos and Ibadan had more patronage for moderate cost design (Table 6), 23% of the respondent in Lagos adopted low-cost design in contrast to the 25% of the respondent in Ibadan. 19% and 14% of the respondent in Lagos and Ibadan respectively patronized high-cost design while 7% and 3% of the respondents in Lagos and Ibadan chose the executive type. The respondents that numbered 47.4% in Lagos rated the city high in terms of patronage compared to other neighboring cities, while 21.1% of the respondent in Ibadan did the same, 36.8% and 12.3% in Lagos and Ibadan respectively rated both cities patronage moderately while 5.3% of the respondents in Lagos and 1.8% in Ibadan rated it low. The table also shows 8.8% and 1.8% of the respondent in Lagos rated the patronage very high and very low respectively while 38.6% and 14% did the same in Ibadan. No respondent was undecided in Lagos as opposed 7(12.3%) in Ibadan. Most of the respondents in Lagos (64.9%) believes over flow of patronage from neighboring cities for landscape business is few while 36.8% believes the same in Ibadan, 29.8% of the respondent in Lagos believes the over flow is large while 47.4% believes the same. The table also shows that 5.3% and 15.3% of the respondent in Lagos and Ibadan respectively were undecided.

CONCLUSION

In Conclusion, although both cities had high influence of educated practitioners among the respondents, however availability of space, choice of plants, the level of affluence, taste and financial capacity were prominent issues that differentiate the practice of landscape business in both cities. Although cultural beliefs played prominent roles in peoples' choices and behaviors but there was no significant influence observed in the differences. The majority of landscapes in the site surveyed were established for the purpose of beautification, while the approach to uses of equipment and facilities differed at both locations, which is a reflection of the level of cultural belief, educational level, and probably the size of land and properties adopted, however only Ibadan respondents had business entrepreneurship and psychological therapy in their concerns.

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Table 1. Demographic and Socio-economic characteristics of the respondent

Characteristics	Category	Frequency		Percentage	
		Lagos	Ibadan	Lagos	Ibadan
Gender	Male	41	32	71.9	56.1
	Female	16	25	28.1	43.9
Age	25 and below	2	9	3.5	15.8
	26 – 40	19	19	33.3	33.3
	41 – 55	24	19	42.1	33.3
	56 and above	12	10	21.1	17.5
Marital status	Married	49	40	86	70.2
	Single	8	17	14	29.8
Educational status	Vocational	5	4	8.8	7.0
	Primary	1	-	1.8	-
	Secondary	5	7	8.8	12.3
	Tertiary	46	44	80.7	77.2
	Adult Edu.	-	2	-	3.5
Mode of income	Daily wage	14	4	24.6	7.0
	Weekly wage	7	7	12.3	12.3
	Monthly	17	24	29.8	42.1
	Salary	19	22	33.3	38.6
	Business Ent.				
Income level	<100,000	22	29	38.6	47.4
	>500,000	25	9	43.9	15.8
	100,000 – 500,000	10	21	17.5	36.8

Table 2. Assessment of Landscape Design in Study Area

Distribution	Category	Frequency		Percentage	
		Lagos	Ibadan	Lagos	Ibadan
Asset Type	Hospital	6	5	10.5	8.8
	Hotel	6	15	10.5	26.3
	School	16	14	28.1	24.6
	Others	29	23	50.9	40.4
Asset Cost/Input	<100,000	7	14	12.3	24.6
	>500,000	24	21	42.1	36.8
	100,000 – 250,000	13	9	22.8	15.8
	251,000 – 500,000	8	9	14.1	15.8
Ownership	Yes	39	39	66.7	68.4
	No	19	18	33.3	31.6
Size Of Property	<1ha	18	20	31.6	35.1
	>10ha	1	2	1.8	3.5
	1 – 10ha	14	9	24.6	15.8
	Small plot	24	26	42.1	45.6
Design Operator	Initiative of client	3	2	5.3	3.5
	Landscape architect	5	16	8.8	28.1
	Landscape horticulturist	26	26	45.6	45.6
	Self	23	13	40.4	22.8
Age of Design	Below 1 year	4	5	7.0	8.8
Marital status	2 – 5 years	22	30	38.6	52.6

	>5 years	31	22	54.4	38.6
Influence of Design on Use of Public Utilities	Yes	50	52	87.7	91.2
	No	7	5	12.3	8.8
Influence of Design on value of property	Yes	55	57	96.5	100
	No	2	-	3.5	-

Table 3. Assessment of cost of design and establishment

Distribution	Category	Frequency		Percentage	
		Lagos	Ibadan	Lagos	Ibadan
Cost of establishment	<100,000	1	2	1.8%	3.5%
	1.1million – 5million	9	8	15.8%	17.5%
	100,000 – 500,000	20	22	35.1%	56.1%
	500,000 – 1million	13	18	22.8%	31.6%
	Nil	14	7	24.6%	12.3%
Cost of design	<100,000	12	13	21.1%	22.8%
	>500,000	6	7	10.5%	12.3%
	100,000 – 500,000	25	29	43.9%	50.9%
	Nil	14	8	24.6%	14.0%
	School	16	14	28.1	24.6
	Others	29	23	50.9	40.4
Asset Cost/Input	<100,000	7	14	12.3	24.6
	>500,000	24	21	42.1	36.8

Table 4. Assessment on duration of maintenance in the study area

Distribution	Category	Frequency		Percentage	
		Lagos	Ibadan	Lagos	Ibadan
Mowing frequency	Daily	2	3	3.5	5.3
	Monthly	17	19	29.8	33.3
	Weekly	38	35	66.7	61.4
Hedge trimming frequency	Daily	1	1	1.8	1.8
	Weekly	38	31	66.7	54.4
	Monthly	18	25	31.6	43.9
Tree litter packing frequency	Daily	45	30	78.9	52.6
	Monthly	-	8	-	14.0
	Weekly	12	19	21.1	33.3
Manure application frequency	Daily	1	-	1.8	-
	Monthly	38	37	66.7	64.9
	Weekly	18	20	31.6	35.1
Frequency of maintenance practices	Daily	19	8	33.3	14.0
	Monthly	16	19	28.1	33.3
	Weekly	22	30	38.6	52.6

Table 5. Assessment of cultural/traditional beliefs of respondent in the study area

Characteristics	Category	Frequency		Percentage	
		Lagos	Ibadan	Lagos	Ibadan
Landscape Influence city development	Add value to the environment	6	5	10.5	8.8
	Attracts customers	4	11	7.0	19.3
	Beautification	22	3	38.6	54.4
	Cools environment	3	4	5.3	7.0
	Improves the economy	11	6	19.3	10.5

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	Tourist attraction	11	-	19.3	-
Influence of Cultural/Traditional Beliefs	Plants attracts reptiles	36	11	27.0	11.0
	Plants prevent reptiles	28	21	21.0	22.0
	Costly to maintain	25	19	19.0	20.0
	Cheaper to maintain	5	7	4.0	7.0
	Ameliorate effect	35	38	27.0	40.0
	Undecided	3	-	2.0	-
Influence of Culture/Tradition	High	15	12	26.3	21.1
	Moderate	29	30	50.9	52.6
	Nil	7	11	12.3	19.3
	undecided	6	4	10.5	7.0

Table 6. Assessment on categories and level of patronage in both cities

Characteristics	Category	Frequency		Percentage	
		Lagos	Ibadan	Lagos	Ibadan
Types of patronage	Low-cost design	13	14	23.0	25.0
	Moderate cost design	29	33	51.0	58.0
	High-cost design	11	8	19.0	14.0
	Executive type	4	2	7.0	3.0
City heritage	Few highly valued	18	22	31.6	38.5
	Few rarely valued	3	2	5.3	3.5
	Many highly valued	19	12	33.3	21.1
	Many rarely valued	17	14	29.8	24.6
	Nil	-	7	-	12.3
City performance in patronage	High	27	12	47.4	21.1
	Low	3	1	5.3	1.8
	Moderate	21	7	36.8	12.3
	Very high	5	22	8.8	38.6
	Very low	1	8	1.8	14.0
Overflow of patronage from nearby cities	Few	37	21	64.9	36.8
	Large	17	27	29.8	47.4
	Nil	3	9	5.3	15.8

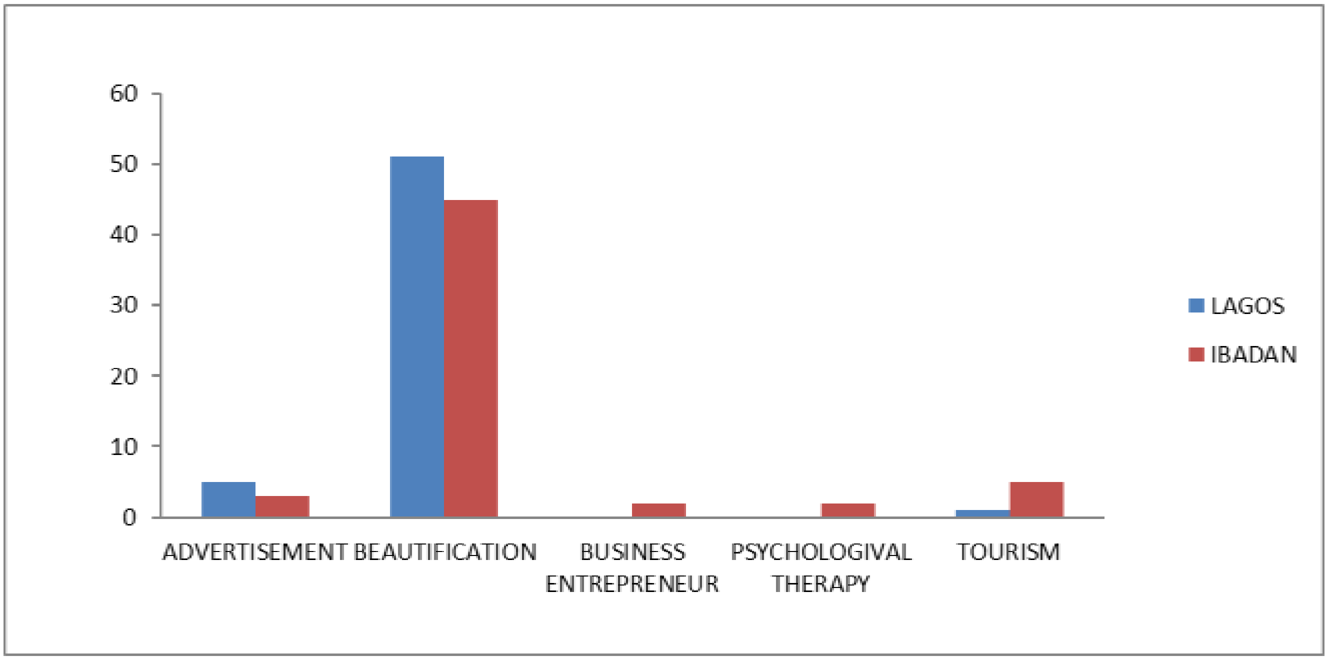

Figure 1. Distribution of Purpose of landscaping in the study area

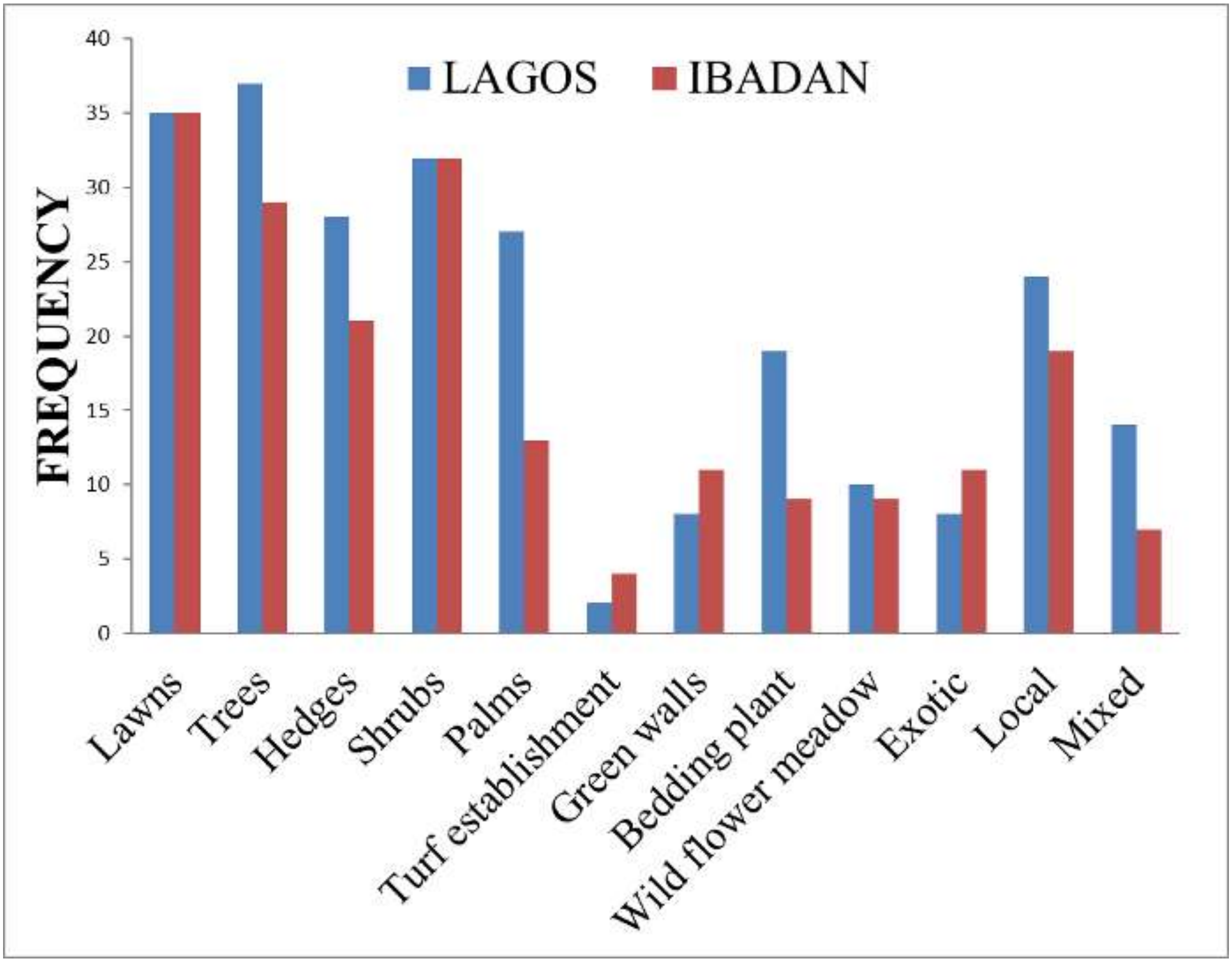

Figure 2. Distribution of Soft Landscape Components in the respondent site

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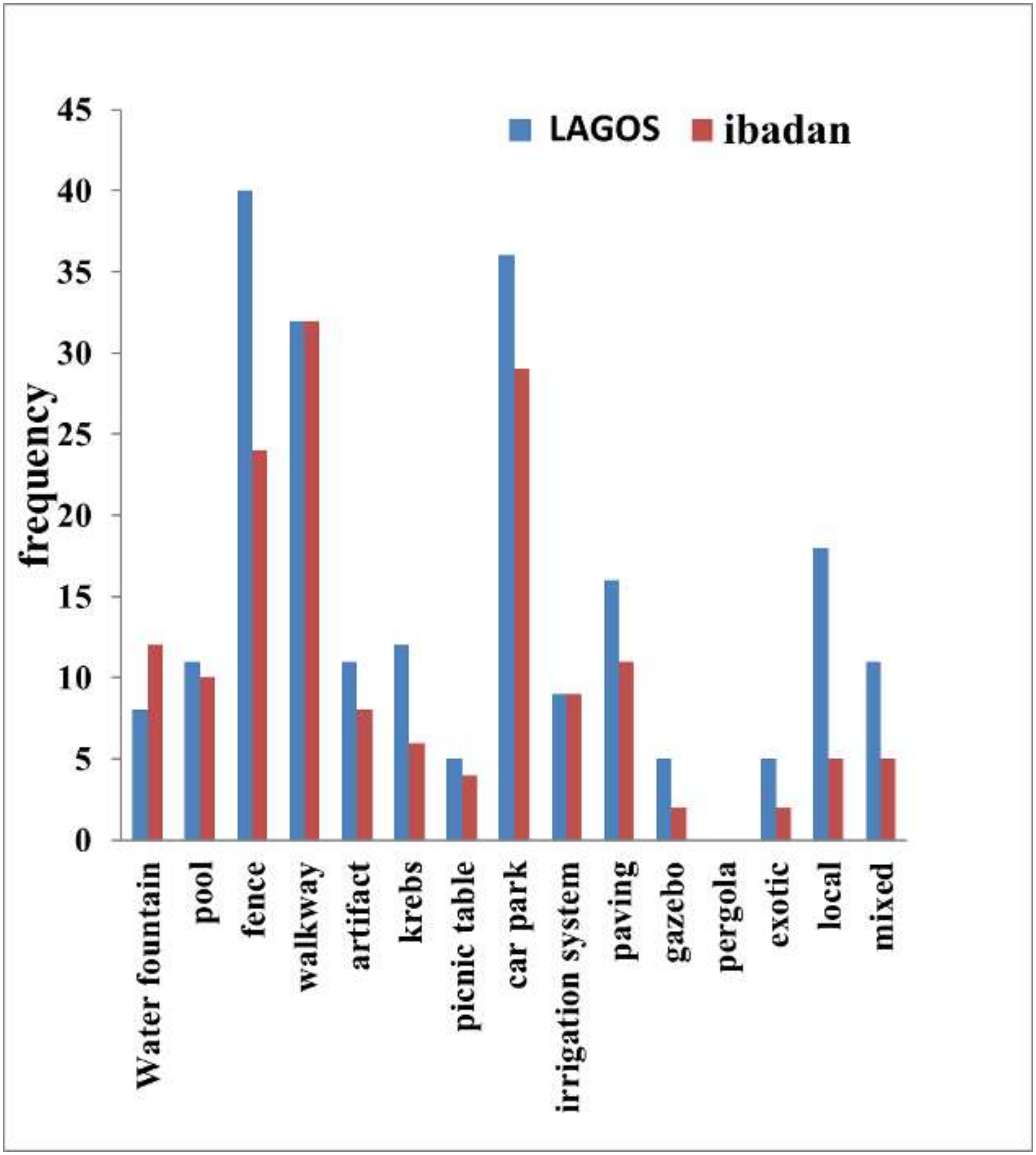

Figure 3. Distribution of Hard Landscape Components in the respondent site

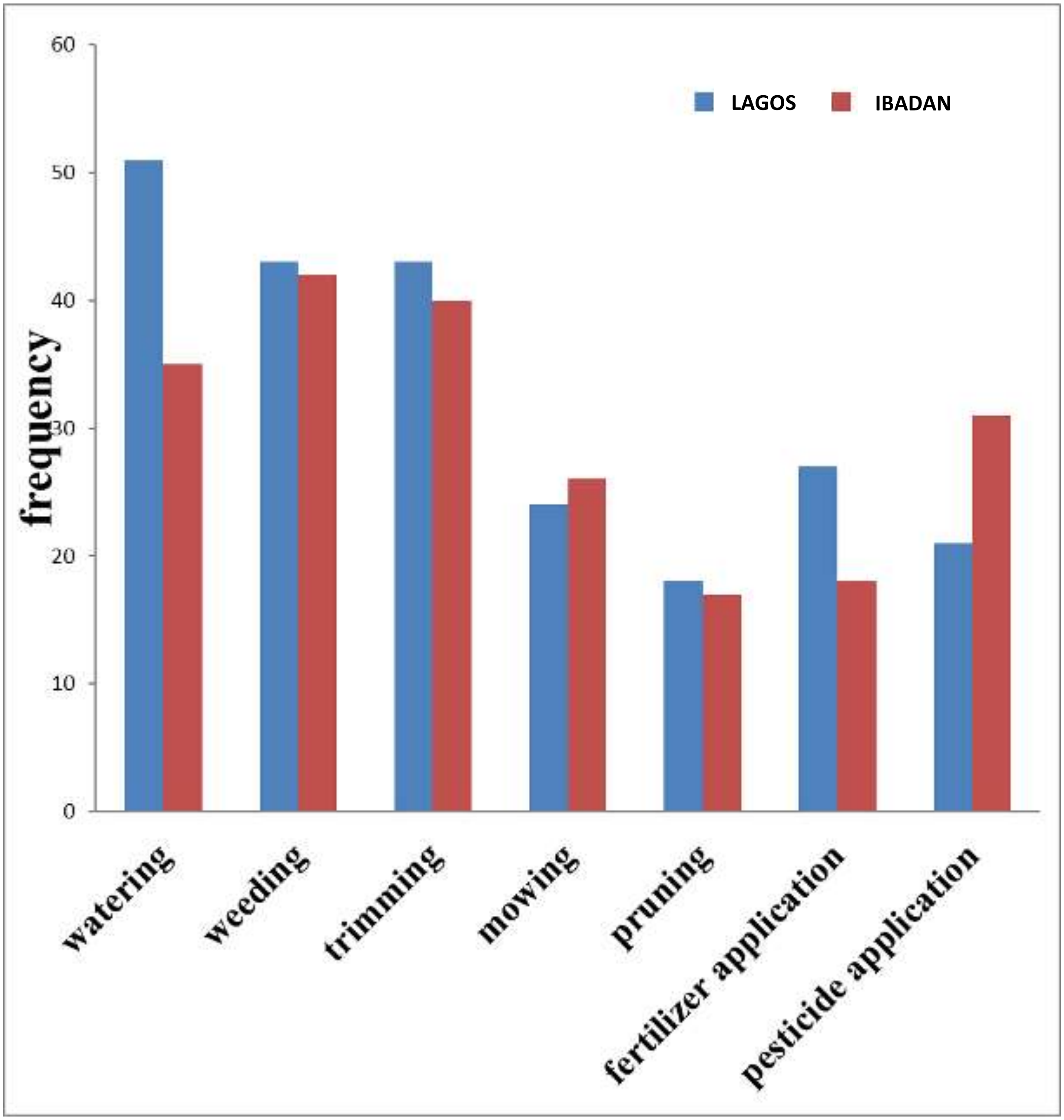

Figure 4. Distribution of Assessment of Maintenance Practices Adopted by the Respondent in the Study Area

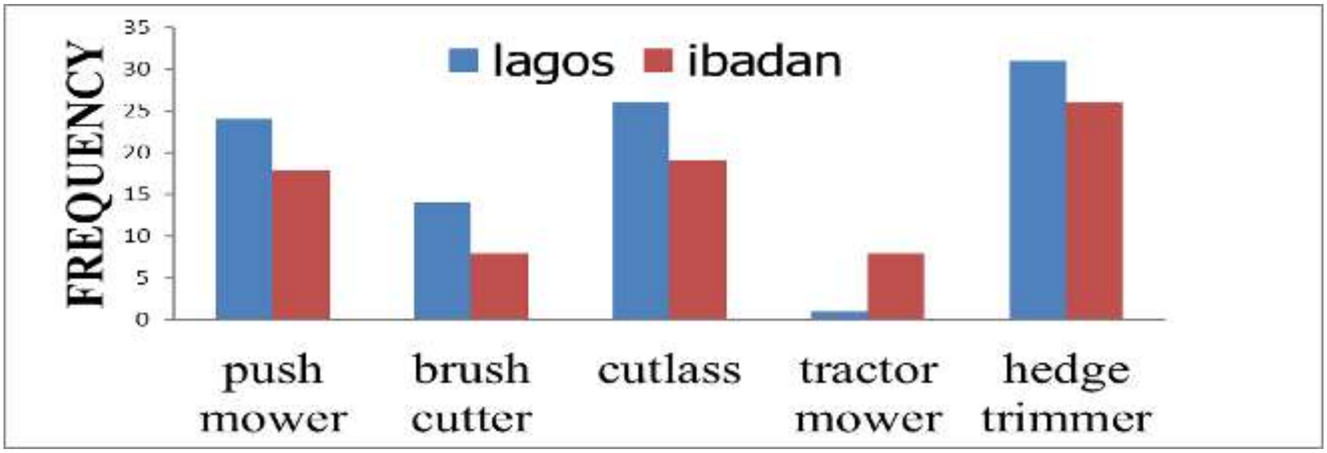

Figure 5. Distribution of Assessment of equipment used in maintaining the landscape sites visited

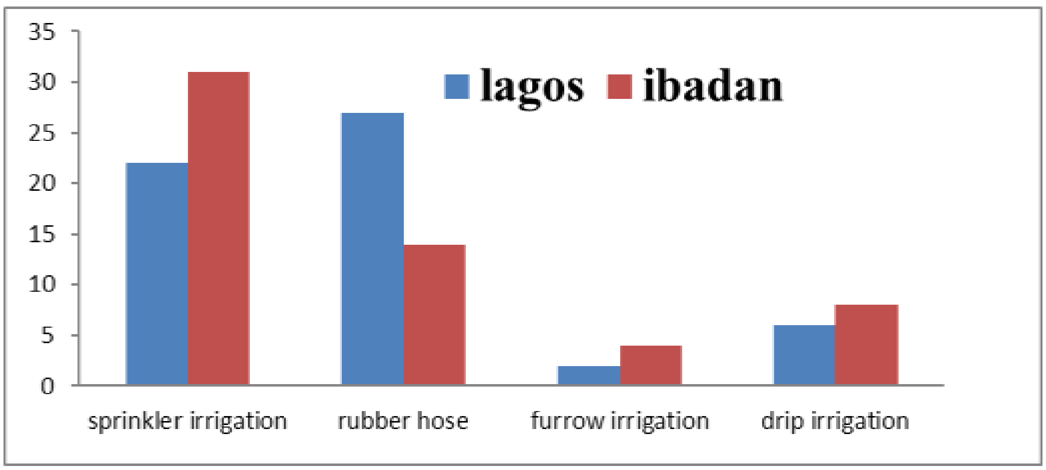

Figure 6. Distribution of Assessment of irrigation method adopted by the respondent in both cities

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PROPOSING A NIGERIAN BOTANICAL GARDEN DESIGN WITH SELECTED PLANT SPECIES FOR SUSTAINABILITY, DEVELOPMENT AND ECOSYSTEM SERVICES

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ABSTRACT

The study proposed a prototype design for the establishment of Nigerian Botanical Garden with some selected ornamental plants species that can enhance provision of ecosystem services and sustainable heritage garden development. It was based on the concept of ecological landscape and computer- aided architectural design, which was used as determinants in the formulation of floor, site layout plans and animation production. The study revealed that: Botanical Garden prototype designed ranged from site layout plan, building (9825mm by 19870mm), elevation and perspective drawing using plant species Erythrina indica, Roystenea regia, Phoenix dactylifera and Eucepalartos barteri as less varieties and more repetition species and Acacia moniliforms, Mussaenda erythrophylla, Codiaeum variegatum, and Plumera rubra as more varieties and less repetition species. The study proposed that, plant species families of Apocynaceae, Arecaceae, Zamiaceae, and Euphorbiacea out of 8 families would be good candidates for ecosystem services such as: aesthetic, pollutant removal and air quality improvement, while the families of Fabaceae, Myrtaceae, Rubiaceae and Araucariaceae would be good candidate for shading, human health and well-being, climate change mitigation, biodiversity conservation and heritage garden sustainability.

Key words: Botanical garden design, plant species, sustainability and ecosystem services

INTRODUCTION

The word garden rooted in two Hebrew words "*gan*" and "*oden*" meaning to shelter and inclination or utopia when the two words are combined, it means the enclosure of land for inclination and amusement. A botanical garden (BG) is a well-ordered and staffed establishment for the conservation of plants under scientific administration for purposes of education and research, in association with libraries, herbaria, laboratories, and museums as are essential to its particular enterprise. Each botanical garden generally cultivates its own special fields of interests reliant on its personnel, location, extent, available funds, and the terms of its charter. It may include greenhouse, a herbarium, an arboretum and other divisions of grounds. It maintains a scientific as well as a plant-growing staff, and publication is one of its major means of communication (Bailey and Bailey, 1978).

Botanical Garden design is a regenerative design which is the bio-mimicry of the biological system describing processes that restore, renew or revitalize their own sources of energy and materials, creating sustainable systems that incorporate the needs of society with the reliability of nature. It is also an outline to biological systems that can heal cities and its inhabitants through bioremediation, living architecture, and innovative water management with emphasis on an overview of urban toxicology, environmental issues, environmental justice, phytoremediation, bio-filtering, use of plant species and tree, grass, plant selection for pollution reduction. (McDonough and Micheal, 2001).

With regard to folklore the popular religions both Christianity and Islam define garden as a form of paradise. Muslim describes it as the commencement and the end of life on earth. The promised garden of Muhammed was said to be filled with groves of trees and fountains where pleasure which lasted for a brief moment on earth will be prolonged thousand years. The Christian believers considered that man was created and put in the Garden of Eden, a form of worldly paradise. With the colonization of Nigeria by the British has come the infusion of foreign and exotic garden style into the traditional styles. However, there is truly a Nigerian garden style or styles that could be attributed to the several cultural groups notably the Yoruba, Hausa, Igbo, Kanuri, just to mention a few (Falade and Oduwaye, 1998), hence the necessity for establishment of Nigerian Botanical Garden. Against this background, the study set out to achieve the objective of design a prototype national botanical garden structure with tree species either exotic or indigenous that has the potential to enhance the provision of ecosystem services, biodiversity conservation and sustainable heritage garden development.

MATERIALS AND METHODS

Collection of Plant Specimens

The study was carried out on 10 selected ornamental plant species (Table 1). Fresh leaves were collected at ornamental nursery site in Ilorin, Kwara State. The voucher specimens of all the collected plants were deposited at the University of Ilorin Herbarium, Plant Biology Department. Identification and nativity was done using local floras (Keay et al., 1990).

Table 1. Proposed Selected Ornamental Plants Species for the Planting Plan Design

	Plant Species	Common Name	Family
1	*Roystenea regia* (Kunth) O.F.Cook	Royal palm	Arecaceae
2	*Phoenix dactylifera* L.	Date palm	Arecaceae
3	*Eucephalartos barteri* Carruth.ex Miq	Cycad	Zamiaceae
4	*Codiaeum variegatum* (L.) Blume	Croton	Euphorbiacea
5	*Acacia moniliforms* Griseb.	Acacia	Fabaceae
6	*Eucalyptus citriodora* Labii	Eucalypt	Myrtaceae
7	*Erythrina variegata* L.	Coral tree	Fabaceae
8	*Araucaria heterophylla* (Salisb) Franco	Araucaria	Araucariaceae
9	*Plumera rubra* L.	Frangipani	Apocynaceae
10	*Mussaenda erythrophylla* Schum. & Thorn	Queen of Philipines	Rubiaceae

Design Process with Plant Species

Application of some basic design process (site analysis, aesthetic, spacing, selection, climatic and soil characteristics) and principles of design was used in the of prototype botanical garden site layout plan. These principles consist of various uses of line, form, texture, colour, repetition, variety, balance and emphasis. All of these terms apply to any aesthetic composition or work of art. Scale: more variety and less repetition can be used in a small-scale design such as a residential garden and in contrast to a large-scale design such as an urban park (Carpenter et al., 1990).

Computer Aided Architectural Design

This was based on the concept of ecological landscape design, which is the recognizing and mapping out natural processes in the landscape and this was used as determinants in the formulation of floor plan, elevation plan, animation production and perspective of the prototype botanical garden (McHarg, 1995; Chen et al., 2008).

Data Analysis

Introduction of shape grammers to computer software application packages - Auto-Cad 2018 was used to developing a system for interactive manipulation of architectural floor, site layout, elevation and perspective plans.

RESULTS AND DISCUSSION

Design Process with Plants Species

The site layout plan (Fig.1) is a land planning for bigger scale advancement involving subdivision into several or many parcels, including analyses of soil and landscape, feasibility studies for economic, social, political, research, technical, conservation and ecological constraints. In practice, the layout design plans rely on a deep understanding of human comfort, needs, habits, and social relationship. Exterior trim, as well as distinctive windows and entrances were used in the perspective drawings (Fig.2). The significance of these results is that the planning and design which are based on idealized (prototype) and does not take into account the numerous site and client-specific factors that are measured by the architects. According to Falade and Oduwaye (1998), many people narrowly conceive architecture as the design of buildings; it has also become necessary to extend the same argument to the garden, therefore, the site layout plan design is la-di-da by the local climate and cultural heritage, the views from environmental concern help in customizing the building as shown in the perspective drawings.

Figure 1. Prototype Botanical Garden Site Layout Plans

Figure 2. Perspective of the Prototype Botanical Garden

Computer Aided Architectural Design

Through prototyping, the schematic plans were refined into a detailed floor plan, at this stage wall classifications were pinned down and doors, windows and open walls were precisely specified. The individual components of the present design are: the prototype botanical garden structure floor plan organization (Fig.3) and elevation plan (Fig.4). The floor plan was used to construct the elevation plan, while the remaining square footage of land was developed to green area, recreational arena with proper organization of ornamental plants (Table 1) to bring out the aesthetic values of the prototype national botanical garden design. This was in line with the findings of Carpenter et al. (1990) that to create an ordinary garden, knowledge of horticulture is enough, but to create a commercial garden as an art requires the use of the skillful art of designer, horticulturist and landscape architect.

CONCLUSION

The overall implication of this study is that most of the gardens visited during the course of this research work have useful plant species similar to the proposed one in the materials and methods and can be replicated in the proposed national botanical garden. This could serve the purpose of educational, research, conservational and commercial value, human health and wellbeing, climate change mitigation, national identity and sustainable cultural heritage garden development with minimum pollution level.

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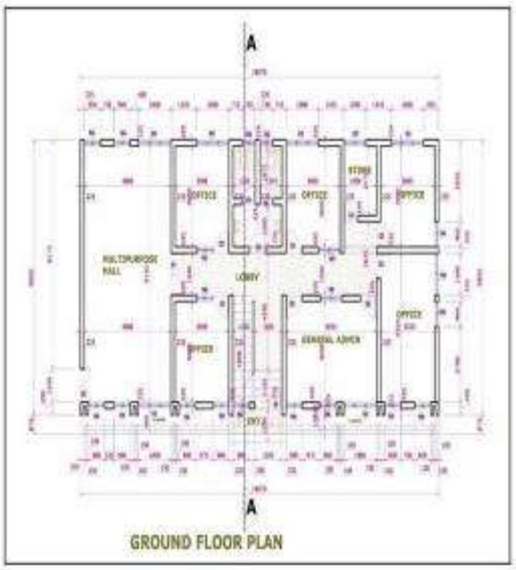

Figure 3. Prototype Botanical Garden Floor Plans

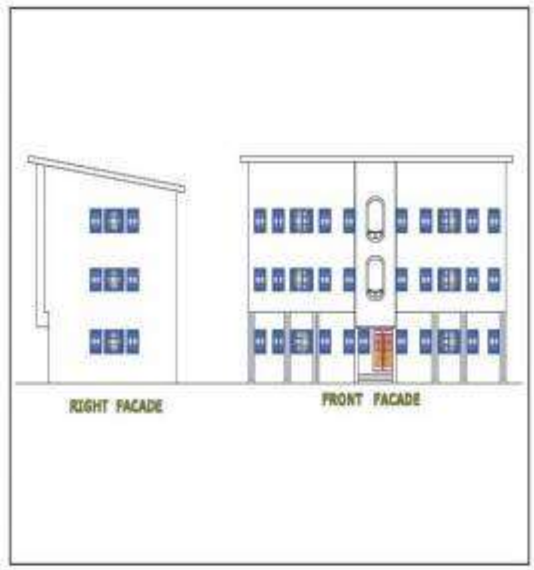

Figure 4. Prototype Botanical Garden Elevation Plans

FREE-RANGE ANIMALS AND HOME GARDENS AROUND NIHORT NEIGHBOURHOODS IN SELECTED STATES OF NIGERIA

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ABSTRACT

Home gardens can be described as a mixed cropping system that encompasses crop (vegetables, fruits, plantation crops, spices etc.) and livestock (goat, sheep, cow, poultry etc.) that can serve as source of food and income. The study was carried out in various locations across Nigeria particularly NIHORT- neighborhood in the states where the Institute is situated (headquarter in Ibadan-Oyo, Dadinkowa- Gombe, Bagauda- Kano, Mbato- Imo states). Structured questionnaire was administered to 412 home garden owners sampled across NIHORT-neighborhoods. Data collected was analyzed using descriptive statistics such as frequencies and percentages. Findings revealed that goat was the most common free-range animal observed in home gardens; 70.2% of the home gardeners do not allow free-range in their gardens while 57.7% believe that free-range animals affect home gardens. A little less than half of the respondents (47.6%) do not allow free-range animals in their home gardens due to the destruction they cause to the gardens. Season of the year was found to affect the activities of free-range animals in home gardens (67.2%). Home garden owners in the study area observed that the activities of free-range animals on their home gardens are not palatable as the animals are observed to feed on the crops in home gardens. It should be advocated that animals on free-range should be properly managed and controlled to minimize or reduce the damage in home gardens.

Key words: Home gardens, Free range animals, sources, types, seasonality

INTRODUCTION

The world population is increasing daily, if the population is to be fed adequately, the present food production level will have to be doubled and other strategies encouraged. One of such strategies that need some level of assessment is homestead farming (Ndaeyo, 2007). Home gardens can be described as a mixed cropping system that encompasses vegetables, fruits, plantation crops, spices, herbs, ornamental and medicinal plants as well as livestock that can serve as a supplementary source of food and income" (Galhena et al., 2013). They serve as a remedy for alleviating hunger and malnutrition as they contribute to food and nutrition security. Home gardening is an ancient practice worldwide. The main objective of home gardens is to grow and produce food items for family consumption as well as diversified to produce output with multiple uses such as indigenous medicine, alternative fuel source, manure, animal feed, among others (Gahlenna et al., 2013). Home gardens are a reputable source of diverse animal and food items that help in increasing dietary intake of household members while building their bioavailability and absorption of essential nutrients (Talukder et al., 2000). Livestock and poultry activities integrated into home gardens help reinforce food and nutritional security of households as they serve as a source of animal protein (de la Cerda et al., 2008).

Free range is a system of animal husbandry which usually offers the opportunity for the extensive locomotion and sunlight for the animals that is otherwise prevented by indoor housing systems. Animals that are reared in free-range systems include pigs, poultry, turkey, livestock, dairy, among others (Wikipedia, 2021). Free-range animals provide disposable cash income to poor households (Hailemichael et al., (2016). Free-range method of animal husbandry was originally concentrated in villages, while increasing urbanization has resulted in the growth of village type livestock in urban and peri-urban areas which is often called "backyard production" (Thieme et al., 2014) alongside with garden crops. Family poultry according to Thieme et al. (2014) was described as the full variety of all small-scale poultry production systems found in rural, peri-urban and urban areas of developing countries. Livestock in home garden helps provides quality nutrient of high biological (protein) value inform of food (egg, milk and meat), energy, fertilizer, diversify incomes and a renewable asset in over 80 percent of rural households (Thieme et al., 2014; Sonaiya and Swam, 2004). Moreover, the Federal Ministry of Agriculture and Rural Development (FMARD, 2017) report noted that in the year 2017, the number of livestock produced in Nigeria was 180 million poultry, 76 million goats, 43.4 million sheep, 18.4 million cattle, 7.5 million pigs, 1.4 million equids (horses, donkeys, etc.). It was also observed that most animals raised in Nigeria are on free-range production systems which comprise of smallholders and nomadic herders (FMARD, 2017). The integration of livestock activities into home gardening can expedite nutrient cycling in ecosystem and help retain moisture. (Powell and Williams,1993). Home garden, plant materials are used as fodder for the animals and animal manure is incorporated into the compost to fertilize plants, hence reducing the need for chemical fertilizer (Mitchell et al., 2004). Part of basic important component of livestock management practices are housing, and feeding, sanitations and medications with feeding taking up to 80% of livestock production cost. In Nigeria, traditionally, animals are kept in house fenced made of bamboo, roofing sheet, planks or wood in the home garden. These animals are also allowed to roam about fending for themselves with little or no supplementation from the owners. Arising from the foregoing, it is imperative to assess the activities of free-range animals in home gardens as it has been observed that these animals can serve as an integral part of home gardens.

MATERIALS AND METHODS

Structured questionnaires were developed and administered to home garden owners. Purposive sampling was used to select 412 home garden owners within 10 km radius of NIHORT-neighborhood across the geopolitical zones where the Institute is located: the headquarters Ibadan, Oyo State (South West) and substations like Dadinkowa Gombe State (North East), Bagauda Kano State (North West) and Mbato Imo State (South East). Data was collected using a structured questionnaire to assess the activities of free-range animals in home gardens across the selected locations. Of the 412 home garden owners sampled data used for analysis was obtained from 366 home gardeners. This data was analysed using descriptive statistics such as frequency and percentages.

RESULTS AND DISCUSSION

Types of Animals found on free-range

The table (1) reveals that goat is the most commonly found free-range animal (47.8%) in home gardens in the study areas. The finding is in agreement with Duku et al. (2010) that goats have the highest percentage of free range activity in Ghana. Most of the home garden owners (70.2%) opined that free-range animals should not be allowed in home gardens and 57.7% also believe that these animals affect home gardens. One-third of the respondents also noted that free-range animals are cheap to manage when they have access to home gardens. However, 47.6% opined that they do not allow free-range animals in their home gardens because the animals cause destruction to garden crops.

Other Activities of free-range animals in home gardens

More than half of the respondents stated that free-range animals are from their neighborhood (51.4%) while twenty-nine percent observed that the whole of their garden is affected by these animals. Moreover, season of the year affects the activities of free-range animals (67.2%) which 44.3% of the home garden owners attested that these activities is mostly felt in the dry season. (Table 2). This could be due to the fact that the free-range animals have to scavenge for food in the dry season due to scarcity of forage.

Table 1. Activities of free-range animals in home gardens

Variable	Frequency	Percentage
Types of animal		
Cattle	50	13.7
Goat	175	47.8
Sheep	52	14.2
Poultry	23	6.3
Rabbit	5	1.4
Dog	1	0.3
Others	6	1.6
No response	54	14.8
Should free range be allowed in home garden		
Yes	102	27.9
No	257	70.2
No response	6	1.9
Does free range animals affect home garden		
Yes	211	57.7
No	140	38.3
No response	15	4.0
Reasons for allowing free range in home garden		
Cheap to manage	113	30.9
Less stressful	63	17.2
Increase garden fertility	68	18.6
Other	11	3.0
No response	110	30.3
Reasons for not allowing free range in home garden		
Garden crops destruction	171	46.7
Leads to communal dispute	72	19.7
Predation	13	3.6
Stealing	20	5.5
Others	14	3.8
No response	76	20.7

Source: Field survey, 2017

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Table 2. Other Activities of free-range animals in home gardens

Variable	Frequency	Percentages
Sources of animals on free range		
My garden	90	24.6
Neighbourhood	188	51.4
Herders	36	9.8
Others	12	3.3
No response	40	10.9
Portion of garden affected by free range		
Whole	106	29
Half	91	24.9
One quarter	80	21.9
Others	36	9.8
No response	53	14.5
Does seasonality affect free range		
Yes	246	67.2
No	74	20.2
No response	46	12.6
Season free range mostly affected		
Raining season	140	38.3
Dry season	162	44.3
No response	64	17.5

Source; Field survey, 2017

CONCLUSION

Findings revealed that goat was the most common free-range animal observed in home gardens. Also, majority of free range animals are from neighborhood of the garden, whose activities leads to destruction of the garden crops especially during the dry season. It should be advocated that garden owners should protect their garden crops from destruction by free range animals in their neighborhood. Also, a low cost fencing and housing facilities could be made by garden owners for their livestock in order to get the best of the garden products (crop & livestock) in the farming system.

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EFFECT OF PLANT GROWTH HORMONE (BIOGRO) ON BEHAVIOR AND SERUM BIOCHEMISTRY OF WISTAR RAT

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ABSTRACT

With the purpose of studying data on spontaneous customary changes in wistar rats and effect of biogro (bio fertilizer) on organ enzymes (serum biochemistry), we administered food laced with dried okra treated with the biogro. This study was carried out at three different places which are the animal experimental house, water hyacinth, National Horticultural Research Institute (NIHORT) Ibadan, Oyo state, Nigeria, the Clinical pathology laboratory, University of Ibadan, Nigeria and the histopathology laboratory at the Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Ibadan, Nigeria. A total of 32 wistar rats were used for the experiment, with the rats divided into eight groups. Four rats occupy a unit/cell of the cage, making it eight treatments replicated four times. The experiment was laid out in complete randomized design (CRD) and data were analyzed with one-way analysis of variance (ANOVA). The biogro treatments (treated on okra plants) were administered daily as it was included in the feed given for five days (acute toxicity test). On the termination of the experiment, all the rats were observed not to have any behavioral changes as they all appear and were normally behaved, and sacrificed, blood samples were taken for analysis. At the end of the experiment it was observed that the treatment had no significant effect on both the blood parameter AST = Aspertate amino transferase, TB = Total bilirubin, EO = Eosine, ALP = Alkaline Phosphate, ALT = Alanine amino transferase, TP = Total protein, ALB= Albumin, GLB = Globulin.

Key words: Biogro, serum biochemistry, wistar rats, plant hormone

INTRODUCTION

Serum biochemical assessments are relevant tools in evaluating the physiological and pathological status of mammals and birds, as they provide information for the proper diagnosis of diseases, making a prognosis, evaluating the efficacy of instituted therapy, and toxicity of drugs and chemical substances (Stockham and Scott, 2008). Serum biochemical assessment helps to predict pathological processes in the vital internal organs of the body such as the liver, muscle, heart, pancreas and kidney (Stockham and Scott 2008). It also helps to establish the presence or absence of disease of an organ, and determine the nature and extent of a disease process (static, progressive or regressive) by serial performance of laboratory tests of the internal organs.

Several physiological factors have been known to affect the serum biochemistry parameters in apparently healthy rats. These factors are breed, sex, age, reproductive status; time of feeding, diurnal variations, nutritional state and management; and geographical/climatic factors such as temperature, humidity, altitude and day length (Weiss and Wardrop, 2010). Alterations in serum biochemistry values can be attributed to poor sample handling, stress during blood sample collection, blood sampling techniques, presence of an inhibitor such as anticoagulant and stress of capture (Stockham and Scott, 2008).

In available literature, there are reasonable amount of haematological and serum biochemistry values of rodents such as the birch mouse (Wolk 1985), juvenile laboratory rat (Ihedioha et al., 2004), African soft-furred rat (Kagira et al., 2005), wild grasscutter (Opara et al., 2006) and adult wild African giant rat (*C. gambianus*) (Oyewale et al., 1998a, 1998b; Olayemi and Adeshina, 2002; Cooper and Erlwanger, 2007), but only little information is available on the haematology and serum biochemistry values of the juvenile wild African giant rat (Nssien et al., 2002; Onwuka et al., 2003). Due to the variations in the haematological and serum biochemistry values, there is need for each clinic to establish its own reference range of values for relevant animal population. Also, due to the popularity of this rodent, efforts have been made to domesticate and keep them as pet, and attempts have also been made to use them as laboratory animals (Olayemi and Adeshina 2002).

Justification

Agrochemicals or even plant hormones such as fertilizing elements are essential to boost agricultural/horticultural production in Nigeria. The usual practice is to recommend "appropriate" doze due to observed increase in yield. However, there is the need to continue to monitor the residual effects of these agrochemicals or plant hormones so as to ensure they have no residual effect or at least, that the residuals are within safe limits recommended by regulatory authorities such as WHO and FAO. Hence, our recommendations will no longer be based on quantity (yield) only but also on food quality. The objectives of the study are: 1) To observe treated animal for behavioral changes and 2) To investigate the serum biochemistry of treated animal for possible effect.

MATERIALS AND METHODS

This study was carried out at the animal experimental house, water hyacinth National Horticultural Research Institute Ibadan Oyo state, Clinical pathology laboratory, University of Ibadan and Histopathology laboratory of the Department of Veterinary Pathology, Faculty of Veterinary Medicine, and University of Ibadan, Nigeria.

A total of 32 wistar rats were used. The rats were divided into eight groups (treatments) with four rats occupying a unit/cell of the cage, making it eight treatments replicated four times and the rats were acclimatized for one week before commencement of treatments. Feed and water were given to the animals during acclimatization ad-libitum. The biogro treatments were administered daily as it was included in the feed given for five days (acute toxicity test). On the termination of the experiment, all the rats were sacrificed and organs of interest were carefully removed through cervical dislocation for diagnosis. These include the liver and kidney for histopathological examination. The experiment was laid out in completely randomized design (CRD) and data were analyzed with one-way analysis of variance (ANOVA), group means were compared for significance at 95% confidence level (P 0.05) by Duncan's Multiple Range Test (DMRT) from SAS 2003.

Blood Sample Collection

Blood samples for the serum biochemical determinations were collected from the orbital sinus of the 32 wistar rats following the procedure of Stone (1954). These samples were collected between the hours of 8 and 11 in the morning on the same day. Blood samples (1 ml) for haematology were collected into sample bottles containing ethylene diamine tetra acetic acid (1 mg/ml of blood). For serum biochemical analysis, 3 ml of blood was put into plain glass tubes and sera harvested within 1 h after centrifuging the clotted blood with a clinical table centrifuge at 3000 rpm for 15 min. The haematological and serum biochemical analyses were carried out immediately upon blood collection

Biochemical Parameters

Serum samples were analyzed for the activities of aspartate aminotransferase (AST), alanine aminotransferase (ALT) and for the concentrations of total protein, albumin, cholesterol, total and direct bilirubin, alkaline phosphate and urea by the Roche Diagnostic Hitachi 902 Analyzer**.**

Haematological and serum biochemistry procedures Haematological and serum biochemistry determinations were carried out following standard procedures. PCV was determined by the micro-haematocrit method (Thrall and Weiser, 2002), Hbc was determined by the cyanomethaemoglobin method (Higgins et al. 2008). RBC count and total leukocyte count (TLC) were carried out by the haemocytometer method (Thrall and Weiser, 2002), differential leukocyte count was done by making a blood smear on a clean glass slide and staining it following the Leishman technique. The different cells of the leukocytic series were enumerated by the battlement counting method (Thrall and Weiser, 2002). The mean corpuscular values – mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular

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haemoglobin concentration (MCHC) – was calculated using the standard formulae (Coles, 1986). Serum biochemistry determinations were carried out using commercial test kits, Quimica Clinica Aplicada (QCA) test kits (QCA, Spain), Randox test kits (Randox, UK) for total proteins and albumin, and a digital colorimeter. Serum ALT and AST activities were determined by the Reitman–Frankel method (Reitman and Frankel, 1957). Serum ALP activity was determined by the phenolphthalein monophosphate method (Babson et al., 1966), while total serum proteins were determined by the direct Biuret method (Lubran, 1978). Serum albumin was determined by the Bromocresol green method (Doumas et al., 1971). Serum globulin was calculated as the difference between serum total proteins and serum albumin (Colville, 2002), while serum total bilirubin was determined by the Jendrassik–Grof method (Doumas et al., 1973). BUN was determined by the Berthelot–Searcy method (Fawcett and Scott, 1960), while serum creatinine was determined by the modified Jaffe method (Blass et al., 1974). Serum cholesterol was determined by the enzymatic colorimetric method (Allain et al., 1974).

Table 1. Effects of treatments on serum biochemical parameters of wistar rats

Treatment	ALT (U/L)	ALB(G/DL)	GLB (G/DL)	TP ($x10^6/mm^3$)	AST (U/L)	EOS ($x10^6/mm^3$)	ALP ($x10^6/mm^3$)
T1	7.63a	1.93b	4.33a	0.63a	34.33ab	2.00a	25.67c
T2	7.27a	2.63ab	4.33a	0.57a	37.00ab	1.67a	25.33c
T3	7.37a	2.83ab	19.50a	0.53a	38.00ab	2.00a	32.33ab
T4	7.43a	2.60ab	4.30a	0.60a	40.00ab	1.33a	33.0a
T5	6.57c	2.57ab	4.37a	0.63a	30.07ab	1.67a	33.33a
T6	7.20a	2.77ab	4.47a	0.57a	25.00b	2.33a	26.33bc
T7	7.70a	2.97a	4.40a	0.43a	35.00ab	2.00a	27.33abc
T8	8.37a	3.43a	5.43a	0.40a	44.00a	2.00a	32.00ab

Means within the same column followed by the same letter(s) are not significantly different at $P < 0.05$ using DMRT

AST = Aspertate amino transferase, TB = Total bilirubin, EO = Eosine, ALP = Alkaline Phosphate, ALT = Alanine amino transferase, TP = Total protein, ALB= Albumin, GLB = Globulin

RESULTS AND DISCUSSION

There was significant difference in Aspertate amino transferase (AST) of animals treated with biogro and biofart, while there was no significance difference from observation made among the other treatments (total protein, Eosine, Globulene and Alkaline Phosphate) and the control. However, the rats treated with T5 recorded highest means value while the lowest mean value was obtained from T2. There were no significant differences in ALT, total protein, globulin and eosin in all the treatments compared with the control but T8 was highest in mean value and lowest in the control with respect to ALT. In Total protein, control had highest mean value while T8 recorded lowest mean value, and in Eosin the highest mean value was observed in animals treated with T6 and lowest in T4 as seen in Table 1.

The results showed that there was significant difference in ALP between treatments, highest in mean value was observed control while T2 recorded lowest mean value. There was significant difference in the control and treatments for albumin where T8 had the highest mean value and treatment with T1 had the lowest mean value from Table 1.

All rats treated with biogro showed a marked increase in body weight gain and the rats showed no signs of poisoning and this is in agreement with the work of Mansour et al. (2007) that there were no signs of Toxicity noted in rats treated with plant growth hormones.

The trend in lymhpocytes revealed highest mean value in animals treated with T2 and lowest in T7 as shown in Table 1, the normality found in serum levels of protein for all the rats dosed at all dosages of treatment shows that the treatment is not toxic to the organs or health of the animals as reported in the findings of Das and Mukherjee (2000) that toxicants may cause stress-mediated mobilization of protein to cope with the detrimental condition so imposed. The protein mobilized is one of the strategies employed to meet the energy required to sustain increased physical activity, biotransformation and excretion of the toxicants.

Amino transferases (ALT & AST) are produced in the liver and are good markers of damage to liver cells but not necessarily the severity of the damage as reported by (Olav et al., 2007; Rej, 1989). The non-significant levels of EOS, TP, GLB and ALT in treated groups could be as a result of suppression of production by the liver which is in agreement with Obaineh and Mathew (2009) that they are normally present at low levels in the blood so if the liver cells are damaged, it would be expected that some of the enzymes leak into the blood and increase the levels.

Decrease levels of albumin may be due primarily to reduction in synthesis by the liver and secondarily to reduced protein intake which further confirms no hepatic damage and agree with the works of Luskova et al. (2002) and Jyotsna et al. (2003) as observed in WBC in the study.

In contrast to serum enzymes, albumin apart from being a useful indicator of the integrity of glomerular membrane is also an important indicator in determining the severity of disease as also stated by Lawrence and Amadeo (1989) and (Mukut et al. (2001). In the histopathological evaluation of the liver and kidney of rats treated with biofart and biogro showed no injury as there was no visible lesion observed neither was any severe damage in terms of necrosis observed in any of the organs of the treated animals and this is in agreement with the work of McCormack (2011). In the various treatments, the only observable change is an increased vascular congestion ranging from mild to moderate. The treatments do not have a structural change on the tubules and other anatomic structures in the kidney. The toxicity effects of treatments are not acute as the clinical symptoms did not manifest in test animals.

CONCLUSION AND RECORMENDATION

The report above has shown that the treatments had no significant effect on the behavior, serum biochemistry and on the health of the test animals hence, it is safe for use at the recommended dosage. It is hereby recommended based on this finding that the test product is safe for use at the recommended standard dosage.

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EVALUATION OF ACUTE TOXICITY EFFECTS OF PLANT BIOGRO ON THE HEALTH AND ORGANS OF WISTAR RAT

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ABSTRACT

This study was carried out at three different places which are the animal experimental house, water hyacinth, National Horticultural Research Institute (NIHORT) Ibadan, Oyo state, Nigeria, the Clinical pathology laboratory, University of Ibadan, Nigeria and the histopathology laboratory at the Department of Veterinary Pathology, Faculty of Veterinary Medicine, University of Ibadan, Nigeria. A total of 32 wistar rats were used for the experiment, with the rats divided into eight groups. Four rats occupy a unit/cell of the cage, making it eight treatments replicated four times. The experiment was laid out in complete randomized design (CRD) and data were analyzed with one-way analysis of variance (ANOVA). The biogro treatments (treated on okra plants) were administered daily as it was included in the feed given for five days (acute toxicity test). On the termination of the experiment, all the rats were sacrificed, blood samples were taken for analysis and organs of interest were carefully removed through cervical dislocation for diagnosis, these include the liver and kidney for histopathological examination. At the end of the experiment it was observed that the treatment had no significant effect on both the blood parameter Packed Cell Volume (PCV), Red blood cell count (RBC), Haemoglobin (HB), White Blood Cell counts (WBC), Neutrophiles (NEUT), and also no damage was recorded on the liver and kidney. Hence, further experiment would still be conducted before the safety of the treatments could be recommended for use at the manufacturer recommended doze.

Key words: Biogro, wistar rats, histopathology, food safety

INTRODUCTION

Hematology and serum biochemical assessments are relevant tools in evaluating the physiological and pathological status of mammals and birds, as they provide information for the proper diagnosis of diseases, making a prognosis, evaluating the efficacy of instituted therapy, and toxicity of drugs and chemical substances (Stockham and Scott, 2008). Serum biochemical assessment helps to predict pathological processes in the vital internal organs of the body such as the liver, muscle, heart, pancreas and kidney (Stockham and Scott, 2008). It also helps to establish the presence or absence of disease of an organ, and determine the nature and extent of a disease process (static, progressive or regressive) by serial performance of laboratory tests of the internal organs. The hematological parameters of utmost clinical importance include the red blood cell (RBC) counts, packed cell volume (PCV), haemoglobin concentration (Hbc), mean corpuscular values, white blood cell counts and differential cell counts (Thrall and Weiser, 2002).

Justification

The use of agrochemicals or even plant hormones as fertilizing elements or for pest control is necessary so as to boost agricultural/horticultural production in Nigeria. The usual practice is to recommend "appropriate" doze due to observed increase in yield. However, there is the need to continue to monitor the residual effects of these agrochemicals or plant hormones so as to ensure they have no residual effect(s) or at least, that the residuals are within safe limits recommended by regulatory authorities such as WHO and FAO. Hence, our recommendations will no longer be based on quantity (yield) only but also on food quality. The objectives are: 1) To evaluate the kidney and liver of treated animal for effect of treatment and 2) To investigate the hematology effects on treated animals.

MATERIALS AND METHODS

This study was carried out at the animal experimental house, water hyacinth National Horticultural Research Institute Ibadan Oyo state, Clinical pathology laboratory, University of Ibadan and Histopathology laboratory of the Department of Veterinary Pathology, Faculty of Veterinary Medicine, and University of Ibadan, Nigeria.

A total of 32 wistar rats were used. The rats were divided into eight groups (treatments) with four rats occupying a unit/cell of the cage, making it eight treatments replicated four times and the rats were acclimatized for one week before commencement of treatments. Feed and water were given to the animals during acclimatization ad-libitum. The biogro treatments were administered daily as it was included in the feed given for five days (acute toxicity test). On the termination of the experiment, all the rats were sacrificed and organs of interest were carefully removed through cervical dislocation for diagnosis. These include the liver and kidney for histopathological examination. The experiment was laid out in completely randomized design (CRD) and data were analyzed with one-way analysis of variance (ANOVA), group means were compared for significance at 95% confidence level (P 0.05) by Duncan's Multiple Range Test (DMRT) from SAS 2003.

Haematological and serum biochemistry determinations were carried out following standard procedures. PCV was determined by the micro-haematocrit method (Thrall and Weiser, 2002), Hbc was determined by the cyanomethaemoglobin method (Higgins et al., 2008). RBC count and total leukocyte count (TLC) were carried out by the haemocytometer method (Thrall and Weiser, 2002), differential leukocyte count was done by making a blood smear on a clean glass slide and staining it following the Leishman technique. The different cells of the leukocytic series were enumerated by the battlement counting method (Thrall and Weiser, 2002). The mean corpuscular values – mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) – was calculated using the standard formulae (Coles). The fixed tissues of rats were dehydrated with progressively increasing concentrations of ethanol. The tissues were passed through xylene solution to clear the ethanol and facilitate molten paraffin wax infiltration (55°C). After that, they were embedded in a wax block. Paraffin sections of 6μm thickness were cut with the rotary microtome and placed on cleaned glass slides. Finally, the sections were stained with hematoxylin and eosin. The stained slides were examined using a light microscope where the photomicrographs of the tissue samples were recorded.

RESULTS AND DISCUSSION

Result on hematological parameters of male wistar rats

Results from this study revealed significant difference in the hematological parameter (Monocyte). However, no significant difference was recorded in the white blood cell from rats treated with biofart, biogro and control as seen in Table 1. Rats from the T7 recorded the highest mean value for packed cell volumes while the lowest mean value was obtained on treatment T1. The haemoglobin recorded from treatments and control also showed significant difference, with the highest mean value for haemoglobin recorded from T7 while the lowest was from T6. Like pack cell volume and heamoglobin, significant difference was observed in the red blood cell, platelet, neut and mono of all the rats. (Table 1).

Table 1. Effects of treatments on haematological parameters of wistar rat

Treatment	PVC (%)	HB (Gg/dl)	RBC ($x10^6/mm^3$)	WBC (cells/mm^3)	LYM ($x10^6/mm^3$)	NEUT ($x10^6/mm^3$)	MONO ($x10^6/mm^3$)
T1	34.33b	11.63de	5.57c	2538.33a	63.67ab	36.33a	1.00b
T2	42.00a	13.37abc	7.18ab	1996.73	77.00a	31.67ab	2.00a
T3	39.67ab	12.53cd	7.52a	2303.33a	76.00a	22.67c	1.67ab
T4	40.00a	14.27ab	7.52a	1683.33a	58.33b	27.00bc	1.00b
T5	38.67ab	12.93bcd	6.35abc	2320.03a	69.00ab	27.67bc	1.00b
T6	37.67ab	10.5e	6.08bc	1533.33a	69.00ab	30.00abc	1.00b
T7	42.33a	14.7a	7.12ab	2472.33a	26.33c	24.00c	1.33ab
T8	39.67ab	13.63abc	6.90abc	2873.33a	70.00ab	23.33c	1.00b

Means within the same column followed by the same letter(s) are not significantly different at $P < 0.05$ using DMRT
PCV= Packed Cell Volume, HB= Haemoglobin, WBC= White Blood Cell counts
RBC = Red blood cell count, NEUT= Neutrophiles, LYMPH= Lymphocytes, MONO = Monocytes

In the histopathological evaluation of the liver and kidney of rats treated with biogro showed no injury as there was no visible lesion observed neither was any severe damage in terms of necrosis observed in any of the organs of the treated animals and this is in agreement with the work of McCormack (2011). In the various treatments, the only observable change is an increased vascular congestion ranging from mild to moderate. The treatments do not have a structural change on the tubules and other anatomic structures in the kidney. The toxicity effects of treatments are not acute as the clinical symptoms did not manifest in test animals.

The histopathologic examination of the liver, and kidney of experimental rats adjudged the increase in serum enzymes observed in the same animals. Animals on test ingredient suffered little or no defect from the test substance and this was evidence on the results shown (Plate 1) as there were no major significant differences among the parameters and also it was within the standard given by WHO (The rat report http://www.ratfanclub.org/values.html.). Absence of lesion/damage observed in the visceral organ examined could probably be attributed to the absence of toxic substances in the test substances as reported by Rajashekher et al. (1993). It is obvious that, when diet contain toxic substances such as anti-nutrient or toxin contaminants, the effect always resulted in histopathological damage to the body organs, most especially liver, spleen and kidney (Tolleson et al., 1996; Ewuola et al., 2003; Ewuola et al., 2009).

CONCLUSION AND RECORMENDATION

The report above has shown that the treatments had no significant effect on the hematology and likewise histopathology of the sample organs and invariably on the health of the test animals hence, the safety of the treatments for use would be determined after further experiments to validate the initial findings.

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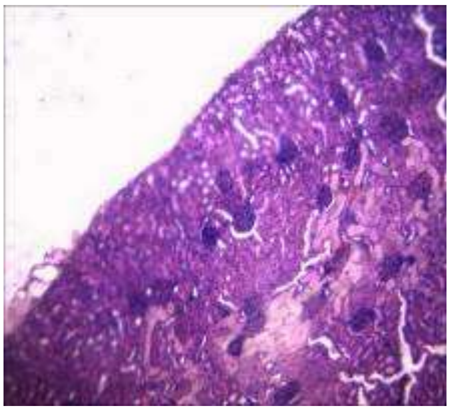

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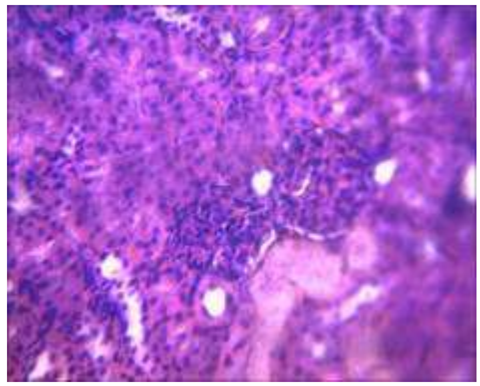

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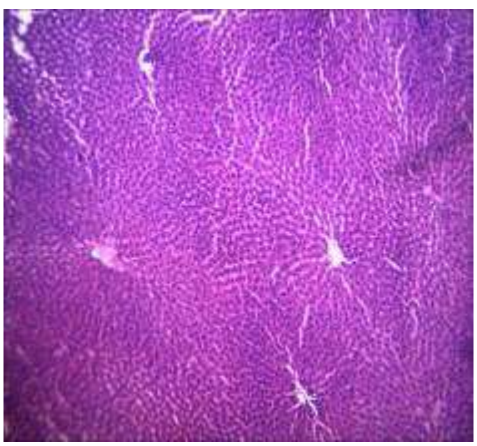

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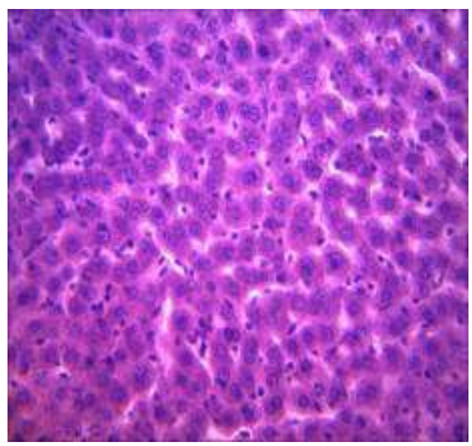

E

Plate 1. Photomicrograph of histopathology of livers and kidney of rats treated with biofart and biogro
A and **B** = kidney, **C** and **D** = liver of treated animal

TOXICITY ANALYSIS, KNOWLEDGE OF RISK AND RESTRICTION STATUS OF COMMON ACTIVE INGREDIENTS IN OPEN MARKET

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ABSTRACT
Agrochemical stores and distributing warehouses were surveyed in Ilorin, Kwara State. Structured questionnaire was administered on agrochemicals on sale in open market, associated risks and knowledge of pesticides use. Seventeen active ingredients: Paraquat dichloride, Glyphosate, Permethrin + pyriproxyfen, Dimethylamine salt, Cypermethrin, Chloropyrifos, Dichlorvos, Lambda-cyhalothrin, 2,2-dichlorovinyl Dimethyl phosphate, Hexaconazole, Imidacloprid, Dimethoate, Nicosulfuron, Profenofos + cypermethrin, S-metolachlor, Carbendazim and Mancozeb were recorded but herbicides and insecticides dominated the stores. Toxicity analysis of active ingredients were based on recommendation of international standard organizations: Fairtrade, UTZ, FSC, RSB, SAN and Pesticide Action Network, Highly Hazardous Pesticide (PAN-HHP). The results showed that some active ingredients were not approved, while some others were not listed for agricultural use. Majority of respondences (60%) know purpose of agrochemicals, 55% identified its use in agriculture, however 65% lack knowledge of its preparation, although about 57% of them claimed to have previously use pesticides. About 49% lack knowledge of active ingredients in agrochemicals, only 38% know of recommended dosage in agrochemicals. About 44% lacks knowledge of danger pesticides posed to human and environment, however around 94% believe pesticides are hazardous. About 17% of respondences know nothing about food safety, while $\geq$50% of respondences lacks proper knowledge of food safety. About 80% of respondences know nothing about pesticides standards, 74.4% lack understanding of maximum residue limit in crops, 54.5% have no knowledge of health implication of agrochemical use and 72.3% know no any agency in Nigeria with mandate for standards and registration of pesticides.

Key words: Pesticides, toxicity, active ingredients, residue, standards, risk

INTRODUCTION
Pesticides are used in agriculture to protect crops against pests, when applied to food crops it can leave potentially harmful residues. They may interact with plant surfaces, be exposed to environmental factors; wind, sun and may be washed off during rainfall. Pesticide residues are the deposits of pesticide active ingredient, its metabolites or breakdown products present in some component of the environment after its application, spillage or dumping. The presence of pesticide residues is a concern for consumers because pesticides are known to have potential harmful effects to other non-targeted organisms than pests and diseases. Infants, children and adults are commonly exposed to pesticides by eating them on and in food and animals equally ingest such through feeds and mills. Pesticides are potentially toxic to humans and have been linked to a wide range of human health hazards, ranging from short term impacts such as headaches and nausea to chronic impacts like cancer, reproductive harm, and endocrine disruption. The rise in number of chemicals being introduced into agriculture and horticulture and their popularity in recent time have led to some concerns over the operator safety. There are standard organizations that certify and license agricultural products for safe or consumption and to fulfill international requirement for trade. These standard organizations' requirement is often benchmark with provision of international organizations: 4C Association, Fairtrade International, FSC, RSB, Sustainable Agriculture Network, UTZ etc. in Nigeria, this sector seems uncoordinated, lacking regulation and enforcement required for best practices and safety measures to avoid associated risks. The study surveyed agrochemicals commonly sold in open market in Kwara State, evaluated knowledge of agrochemical risk and determine their safety statuses.

MATERIALS AND METHODS
Survey of agrochemical stores, warehouses and trading facilities was conducted round Ilorin

metropolis. A structured questionnaire was administered to store owners, students (faculties of Agricultural Science, Life Sciences and Physical Sciences), University of Ilorin and Extension officers in Ministry of Agriculture and Rural Development Kwara State. The information was sought on the trade name, status of agrochemicals (herbicide, insecticide or fungicide), active ingredient(s) present in the pesticides and target crops. Questionnaire targeted final year students of the selected faculties. The information was subjected to benchmarks of the international standards organizations as related to toxicity, restriction status, and effect of such active ingredients on human, animal and environment, and Pesticide Action Network International list of Highly Hazardous Pesticide (PAN-HHP). The responses from the structured questionnaire were subjected to descriptive statistical analysis using SPSS.

RESULTS AND DISCUSSION

Survey of three major stores which deals with agrochemicals in Ilorin showed seventeen active ingredients that are common in open market; these are dominated by herbicides and insecticides with limited number of fungicides (Tables 1, 2 and 3).

Table 1. Active ingredients in agrochemical store I and targeted crop(s)

S/N	Status	Active ingredient(s)	Targeted crop(s)
1	Herbicide	Paraquat dichloride	Maize, weeds, cowpea, rubber, oil palm
2	Herbicide	Glyphosate	Grasses, weeds, woody shrubs
3	Herbicide	Permethrin + pyriproxyfen	Maize, weed
4	Herbicide	Dimethylamine salt	Maize, tomato, cotton, fruit trees
5	Insecticide	Cypermethrin	Smaller insects
6	Insecticide	Chloropyrifos	Vegetables, rice, soya beans, cocoa
7	Insecticide	Dichlorvos	Insect of vegetable, rice, yam, cowpea
8	Insecticide	Lambda-cyhalothrin	Insect pest in maize, vegetables, rice
9	Fungicide	Hexaconazole (systemic)	Pepper, vegetable
10	Fungicide	Imidacloprid	Pepper, water mellon, groundnut, cocoa
11	Fungicide	Dimethoate	Carrot, beans, groundnut

Table 2. Active ingredients in agrochemical store II and targeted crop(s)

S/N	Status	Active ingredient(s)	Targeted crop(s)
1	Herbicide	Glyphosate	Annual grass, sugar cane,
2	Herbicide	Paraquat dichloride	Non-selective, grasses, broad leaved weeds
3	Herbicide	S-metolachlor	Potato, yam, ground nut
4	Herbicide	Di-methylamine	Corn, weeds, sugarcane
5	Insecticide	Cypermethrin	Corn, tomato, cocoa, water melon
6	Insecticide	Dimethoate	Beans, ground nut
8	Fungicide	Mancozeb	Fruits, vegetable

Table 3. Active ingredients in agrochemical store III and targeted crop(s)

S/N	Status	Active ingredient(s)	Targeted crop(s)
1	Herbicide	2,4-dimehylamine salt	Rice, rubber, wheat, sugar cane
2	Herbicide	Nicosulfuron	Maize
3	Herbicide	Glyphosate	Sugar cane, weeds
4	Insecticide	2,2-dichlorovinyl Dimethyl phosphate	
5	Insecticide	Lambda cyhalothrin	Pineapple, carrot, orange, rice, beans
6	Insecticide	Profenofos + cypermethrin	Maize, cotton, orange
7	Insecticide	Cypermethrin	Carrot, cocoa, groundnut, onion
8	Fungicide	Imidacloprid	Pepper, ground nut, cocoa
9	Fungicide	Carbendazim	Fruit and vegetables

The hazard criteria of the active ingredients are grouped into: acute toxicity, long term health effects, environmental toxicity and international regulations (global pesticide-related conventions).

The pesticides grouping, hazard and toxicity status (Table 4) were the recommendations of The Globally Harmonized System of Classification and Labelling of Chemicals (GHS), World health organization (WHO) Recommended Classification of Pesticides by Hazard, International Agency for Research on Cancer (IARC), U.S. Environmental Protection Agency (U.S. EPA) and EU categorization of endocrine disruptors. The recommendation of these organizations was as benchmarked by Fairtrade International, FSC, RSB, SAN (Sustainable Agriculture Network) and UTZ.

The knowledge of agrochemical is known by 96% of respondents, 64.5% lack knowledge of preparation of agrochemicals and 56.8% of responses have used agrochemicals before. About 51.2% have known about active ingredients in agrochemicals, only 38.8% of respondents were aware of recommended dosage for agrochemicals and majority (87.8%) agreed to the dangers pose by agrochemical use, through wrong application, body contact, toxic compounds etc.

Around 83.5% have knowledge of agrochemicals getting into food and water, majority (83.3%) have knowledge of food safety as it relates to pesticides use on crops and pre – harvest intervals, this understanding varied with proper handling, preparation, preservation and storage of food. On the pesticides data base system, 80.3% of respondents have not heard about European Union pesticide database, 74.4% have no knowledge about the maximum residue limit for pesticides in crops and public knowledge on danger or health effect of agrochemical showed that 54.5% of respondents have not heard about it on radio. Majority (72.3%) do not know any agency in Nigeria responsible for developing standards and registration of pesticides, and there was significant difference ($P < 0.05$) in the response of the respondents, especially on the basis of the interactions of faculty with institution and faculty with level. However, of the respondents that claim to know the agencies in Nigeria, 51.6% choose NAFDAC, 9.7% (NDLEA), while 19.4%, 6.5% and 3.2% stated it is both NAFDAC and NDLEA, Pest & Produce Control Department and NESREA, SON, FADAMA & Farmers. There was significant difference ($P < 0.05$) in the response of the respondents, especially on the basis of the faculty.

The environment toxicity of paraquat dichloride is that it is highly toxic to birds/may cause severe effect (Lewis et al., 2018). Paraquat is rapidly but incompletely absorbed and then largely eliminated unchanged in urine within 12–24 h, the very high case fatality of paraquat is due to inherent toxicity and lack of effective treatments (Gawarammana and Buckley, 2011).

Ingesting small to medium amounts of paraquat can lead to fatal poisoning, lung scarring and the failure of multiple organs, which include heart and respiratory failure, kidney and liver failure. Ingesting large amounts of paraquat cause confusion, muscle weakness, seizures, difficulty breathing, fast heart rate and coma (Gotter, 2018).

Mensah et al. (2015) reported that glyphosate and its formulations may not only be considered as having genotoxic, cytotoxic or endocrine disrupting properties but a causative agent of reproduction abnormalities in both wildlife and humans. This active ingredient has been restricted, only be used under specific and defined conditions. It is also a probable carcinogenic substance to human and have environmental toxicity by been very persistent in water and sediments (IARC, 2018). Glyphosate provokes oxidative damage in liver and kidneys of mammals by disrupting mitochondrial metabolism, disrupt endocrine-signaling systems and residues from glyposhate may pose higher risks to the kidneys and liver, reproductive development impairment, Vandenberg et al., 2012).

Permethrin has some health risk when used at higher levels such as headaches, dizziness, nausea, shortness of breath, skin irritation and redness of eyes (Adam, 2013). An active ingredient called cypermethrin is an insecticide, approved for use to manage agricultural insect pests. It is however listed as highly hazardous pesticide in 2011 and 2019. It is classified as highly restricted use with mandatory risk specific mitigation measures (Lewis *et al*., 2018; PAN, 2019). The half-life of cypermethrin on the environment takes about 30days, soil microbes easily breaks it down because it has low potential to move in the soil, when cypermethrin ids used accordingly at the needed sites it poses little to no risk (US-EPA, 1997). Chloropyrifos classified as highly hazardous in 2011 and 2019, poses inhalation risk to human, high aquatic toxicity, highly toxic to bees (FOOTPRINT 2007), birds with aquatic pollinator and wildlife risk (Lewis et al, 2018). Dichlorvos breaks down rapidly in humid air, in water and soil, it takes longer time on wood when exposed to humans through food can be acutely toxic with typical cholinergic signs that is highly hazardous, dichlorvos is not teratogenic in mice and rats' half-lives of recovery is about 15days in human and 2 hours in rats (Arpad, 2007). Dichlorvos is a possible and probable carcinogen (IARC, 2018; US-EPA, 2018) with high aquatic toxicity, and highly toxic to honey bees and birds (EC, 2000, 2004, 2007, 2008).

Nicosulfuron is not co formulated with other active ingredients, toxicity of Nicosulfuron in rats includes acute dermal irritation and eye irritation (FAO/WHO, 2013). Profenofos+Cypermerthrin is as a co formulated organo phosphorous insecticide, studies have shown its toxicity levels on animal, plants and even the environment fate when this insecticide comes in contact with. Profenofos was evaluated by JMPR in 1990, 1992, 1994 & 1995. Toxicological, reviews was also conducted in 2007 when an ADI OF 0 to 0.03mg/kg bw and ARfD of 1mg/kg bw were established, profenofos is a clear liquid with weak odour, its solubility in water at 22 *C is 2.8mg/l at a PH of 6.9, profenofos is slowly absorbed in metabolized, it was major residue when crops are harvested several weeks after the last applications, its residues are not expected to occur in succeeding crops reviewed by JMPR health risk shows that profenofos is unlikely to present a public health concern.

Lambda-cyhalothrinis is to be phased out by year 2024 and with highly restricted use, only be use under specific condition and according to the Globally Harmonized System (GHS) it poses fatal risk to human if inhaled. This active ingredient also poses long term health effect as endocrine disruptor and as having reproductive toxicity (EC, 2009b), 2,2-dichlorovinyl Dimethyl phosphate is another insecticide that is not listed in the active ingredients database of EU. Dimethoate is classify as probable carcinogen and with reproductive toxicity according to Globally Harmonized System (US- EPA, 2000; 2004; 2007; 2018). It is potentially to be prohibited according to standard organization like FSC, RA, UTZ. It also has inhalation risk to human, highly toxic to honey bees, birds and with aquatic, pollinator and wildlife risk according to SAN (FAO/WHO, 2013).

CONCLUSION

The information gathered from respondents in this study showed that many of the agrochemicals in Ilorin open market have some level of restriction of use based on recommendation of international standard organizations, with proved risks to humans, animals and environment. Many of the respondents also lack the expected adequate and required knowledge of use, toxicity and restriction statuses. Enlightenment and awareness by regulatory agencies on agrochemical related and safety measures will be a good channel of orientation for the public.

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Table 4. Pesticides hazardous nature and toxicity status

S/N	Active ingredient(s)	Status in EU database	Status in BCI/RA/FSC/4C/SAN/UTZ	Status in PAN-HHP
1	Paraquat dichloride	Not approved	Prohibited, to be face out by 2024 Fatal if inhaled/may cause severe effects Highly toxic to birds/may cause severe effect	Added to PAN-HHP list in 2011, 2019. Acute toxicity: Fatal if inhaled. Not yet formally listed but agreed by PIC
2	Glyphosate	Approved	May only be used under specific, defined conditions Probable carcinogenic	Added to PAN-HHP list in 2011,2014, 2019. Long term health effect: possible carcinogen. Environmental toxicity: very persistent in water/sediment.
3	Permethrin + pyriproxyfen	Approved	Prohibited, highly restricted/ restricted use/risk specific mitigation measures are mandatory Identified as hazardous, use with extreme caution Minimization of use Probable carcinogen Highly toxic to honey bees Aquatic risk, pollinator risk, wild life risk	Added to PAN-HHP list in 2011, 2019. Long term health effect: probable/likely carcinogen. Environmental toxicity: highly toxic to bees
4	Dimethylamine salt	Not listed	Not listed	Not listed
5	Cypermethrin	Approved	Highly restricted/restricted use, Risk specific mitigation measures are mandatory Highly aquatic toxicity Highly toxic to honey bees, aquatic risk, pollinator risk	Added to PAN-HHP list in 2011, 2019. Environmental toxicity: highly toxic to bees
6	Chloropyrifos	Not indicated	Potentially to be prohibited Highly restricted/ restricted use/risk specific mitigation measures are mandatory May only be used under specific condition/minimization of use Inhalation risk, high aquatic toxicity/ highly toxic to bees, birds, aquatic risk. Pollinator risk, wildlife risk	Added to PAN-HHP list in 2011, 2019 Environmental toxicity: highly toxic to bees
7	Dichlorvos	Not approved	Highly restricted/prohibited, to be phase out by 2024 May only be used under specific, defined condition Highly hazardous, fatal if inhaled. Highly aquatic toxicity/highly toxic to honey bees, birds	Added to PAN-HHP list in 2011, 2019. Acute toxicity: highly hazardous, fatal if inhaled. Long term health effect: possible carcinogen Environmental toxicity: highly toxic to bees
8	Lambda-cyhalothrin	Approved	Highly restricted/minimization of use/ may only be use under specific condition, to be phased out by 2024 Fatal if inhaled Endocrine disruptor, highly aquatic toxicity/highly toxic to honey bees/aquatic risk, pollinator risk	Added to PAN-HHP list in 2011, 2019. Acute toxicity: fatal if inhaled. Long term health effect: Endocrine disruptor, reproductive toxicity. Environmental toxicity: highly toxic to bees
9	Hexaconazole	Not approved	Not listed	Added to PAN-HHP list in 2011. Long term health effect: possible carcinogen. Environmental toxicity: very persistent in water, highly toxic to bees.
10	Imidacloprid	Approved	Restricted, prohibited with exception for certain pests in certain crops and region/minimization of use.	Added to PAN-HHP list in 2011, 2019. Environmental toxicity: highly toxic to bees

			Prohibited without exception/potentially prohibited May cause sever effects Highly toxic to honey bees, birds/Neonicotinoid/may cause severe effects	
11	Dimethoate	Not approved	Restricted, minimization of use/potentially to be prohibited Inhalation risk Highly toxic to honey bees/highly toxic to birds/aquatic risk, pollinator risk, wildlife risk	Added to PAN-HHP list in 2011, 2019. Long term health effect: probable carcinogen, Endocrine disruptor, reproductive toxicity. Environmental toxicity: highly toxic to bees
12	Nicosulfuron	Approved	Not listed	Added to PAN-HHP list in 2019. Very persistent in water /sediments
13	2,2-dichlorovinyl Dimethyl phosphate	Not listed	Not listed	Not listed
14	Profenofos + cypermethrin	Not approved + Approved	Restricted, identified as hazardous. Use with extreme caution High aquatic toxicity/ high toxic to honey bees	Added to PAN-HHP list in 2009, 2011,2019. Environmental toxicity: highly toxic to bees
15	Carbendazim	Not approved	Prohibited/potential to be prohibited, exceptions may apply for certain pests, in certain crops and regions. May only be used under specific, defined conditions Minimization of use Mutagenic, Reproductive toxin	Added to PAN-HHP list in 2011, 2019. Long term health effect: induce heritable mutations in germ cells of humans, impair fertility in humans, cause developmental toxicity to humans, probable likely carcinogen, Endocrine disruptor, reproductive toxicity
16	S-metolachlor	Approved	Restricted use, Risk specific mitigation measures are mandatory Aquatic risk	Not listed
17	Mancozeb	Approved	Restricted use pesticides, risk specific mitigation measures are mandatory. May only be used under specific, defined conditions. Minimization of use, prohibited/potentially to be prohibited Probable carcinogen. Endocrine disruptor, wildlife Risk	Added to PAN-HHP list in 2011, 2019. Long term health effect: Probable likely carcinogen, Endocrine disruptor, reproductive toxicity.

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FARM LEVEL ANALYSIS OF PESTICIDE USE IN COCOA PRODUCTION IN NIGERIA

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ABSTRACT

This study aimed at determining the degree of synthetic pesticides usage among cocoa farmers across some growing states in Nigeria with a view to improving the prevailing circumstances. Structured questionnaires were administered on cocoa farmers in Abia, Cross River and Edo States to determine and analyze their usage of pesticides in the course of production. Data were obtained on the types and frequency of usage of pesticides on the farmers' individual cocoa farms. Results obtained were subjected to statistical analysis with a view to drawing reasonable scientific inferences. Highest percentage of farmers in Bende (19.78%), Ikwuano (20.48%) and Umuahia North (28.13%) Local Government Areas (LGAs), all in Abia State, made use of Ultimax Plus/Ridomil Gold, Snipper/Combat and Ridomil Gold, respectively. Most of the farmers interviewed in Etung, Ikom, Boki and Obudu LGAs of Cross River State made use of Actara and Ridomil Gold pesticides on their farms. DDForce. Ultimax Plus and Actara gave highest usage frequency among farmers in Esan West and Owan West LGAs of Edo State. Also, most of the farmers (91.66-100%) in Cross River State made use of government approved pesticides on their cocoa farms, unlike those in Abia (46.90-60.23%) and Edo (28.57-57.90%). Continuous use of banned pesticides by some farmers in the study areas may be due to ignorance, perceived effectiveness, availability and affordability. Governments at all levels therefore need to further educate cocoa farmers on the health and economic implications of continuous use of pesticides not approved by the Federal Government.

Key words: Pesticides, cocoa, usage frequency, questionnaires

INTRODUCTION

Cacao, like many other economic crops, is faced with the challenges of pests and diseases across the regions where it is being grown. An estimated 30 to 80% loss due to diseases and pests has been recorded across various localities. The implication of this is that approximately $2 billion is lost annually by cocoa farmers across the globe to the problem of pests and diseases. These losses, no doubt, have impacts throughout the cocoa supply chain and are concentrated more on the already impoverished farmers (Akinfenwa, 2019).

In a bid to curb the devastating effects of pests/diseases, cocoa farmers have resorted to the use of synthetic pesticides (sometimes indiscriminately) across the growing communities mainly because of their quick, effective action. This has however led to the heavy pollution of plantation environments including the underground waters, nearby rivers/streams, and the disruption of the ecosystem (due to the non-selective nature of the chemicals). The problems of development of resistance by pests/pathogens, persistence of the chemicals, and the attendant health hazards on farmers as well as consumers of the crop and/or its by-products have also come to the fore (Daxl et al., 2004).

The discovery of high pesticide residue in crops, particularly cocoa beans exported from West Africa, has led to their rejection at the international market. In fact, the European Union (EU) had earlier given the Nigerian government June 16, 2016 deadline to put a management system in place to reduce pesticide contaminated food products the country exports to the region or face continued rejection of exports. This, no doubt, will bring great losses to the farmers, discourage the practice of agriculture and in the long run, impart negatively on the nation's economy (Nwaosu, 2015).

In view of the above, this study aims to determine the degree of synthetic pesticides usage by cocoa farmers across some growing states in Nigeria with a view to improving the prevailing circumstances.

MATERIALS AND METHODS

Structured questionnaires were administered on truly representative population sample of farmers in nine high cocoa producing Local Government Areas (LGAs) of three Southern Nigeria States: Abia

(Bende, Ikwuano, Umuahia North LGAs), Cross River (Boki, Etung, Ikom and Obudu LGAs) and Edo (Esan West and Owan West LGAs). Data were obtained on the types and frequency of usage of pesticides on the farmers' individual cocoa farms. The data obtained were subjected to statistical analysis with a view to drawing reasonable scientific inferences.

RESULTS AND DISCUSSION

The frequency of usage of pesticides on cacao in Abia State is as shown in Table 1. Data obtained from the structured questionnaires showed that farmers in Bende LGA often used up to eighteen (18) different pesticides on their cocoa farms, followed by those of Ikwuano (13), and Umuahia North (12). About 19.78% of farmers sampled in Bende used Ultimax Plus/ Ridomil Gold; 8.79% used Gamalin 20, while 7.69% used each of Blue Bolt, Actara, and Red Force pesticides (Table 1).

Table 1. Frequency of use of pesticides on cocoa in Abia State

LGA	Pesticide																	
	UT	RG	DDF	KN	BB	RF	ACT	FOH	BST	CYP	SNPC	TDM	GM	CDP	CUS	TMX	RUP	SFB
Bende	19.78	19.78	2.20	2.20	7.69	7.69	7.69	2.20	5.49	1.10	1.10	1.10	8.79	1.10	3.30	5.49	2.20	1.10
Ikwuano	18.07	15.66	4.82			16.87	4.82		3.61	2.41	20.48	3.61		1.20	1.20		6.02	1.20
Umuahia North	3.13	28.13	12.5	6.25		9.38	3.13	3.13		3.13			3.13		18.75		6.25	3.13

The highest proportion of farmers (20.48%) in Ikwuano used either Snipper or Combat chemicals on the farm, followed by those that used Ultimax (18.07%) and Red Force (16.87%). Very few percentage (1.20%) of farmers in this area were used to applying Copper sulphate, Champ DP and Safato/Sarosate (Table 1). Highest percentage (28.13%) of farmers in Umuahia North indicated their preference for Ridomil Gold. This was followed by those who preferred Copper Sulphate, while Cypermethrine, Gamalin 20 and Safato/Sarosate were the least used in the LGA (Table 1). The highest proportion of the farmers visited/interviewed in Abia State were used to the application of Ridomil Gold, Ultimax and Red Force pesticides on their cocoa farms, while the least figure (1.10%) was recorded against cocoa farmers that used Safato, Champ DP, Snipper/Combat and Cypermethrine (Table 1).

Frequency of pesticide usage on cocoa in Cross River State is as depicted in Table 2. A total of twelve pesticides were commonly used by farmers in the State. Only two pesticides were mostly applied on cocoa farms in Etung LGA, while about twelve were used in Boki. In Etung local government area, only Ridomil Gold (33.33%) and Actara (66.67%) were often applied on cocoa farms. This was clearly different from what obtained for the other LGAs in the State. Findings also showed that Actara (36.00%) and Ridomil Gold (32.00%) were mainly used by farmers in Ikom. These were followed by Funguran OH (12.00%), while Round up/Touch down, Cofresh and Proteus (4% each) were least used. The trend was similar for farmers in Boki and Obudu. Ultimax Plus, DDForce, Esiom and Safato (8.33% each), however, showed least farmer usage in the latter (Table 2).

Out of the thirteen pesticides often used on cocoa farms in Edo State, only three (Best, Proteus and Bush Fire) were not used in Owan West LGA. Ultimax, DDForce and Actara had the highest frequency of use (15.79% each) in the LGA. These were followed by Ridomil Gold, Funguran OH and Tackle (10.53% each), while Tricel, Cypermethrine and Termex had the least. DDForce (35.72%) and Ridomil Gold (21.43%) were however mostly used in Esan West. These were followed by Best (14.29%) and Tackle (14.29%), while Proteus (7.14%), like Bush Fire, gave the least frequency of usage in the local government (Table 3).

Table 2. Frequency of use of pesticides on cocoa in Cross River State

LGA	Pesticide											
	UT	RG	DDF	KCD	RF	ACT	FOH	RUP	CFR	PRT	ESM	SFB
Etung		33.33				66.67						
Obudu	8.33	25.00	8.33		8.33	25.00	16.67				8.33	8.33
Ikom	8.00	32.00				36.00	12.00	4.00	4.00	4.00		
Boki	6.90	24.14	3.45	10.34	3.45	24.14	13.79	3.45	3.45	3.45		3.45

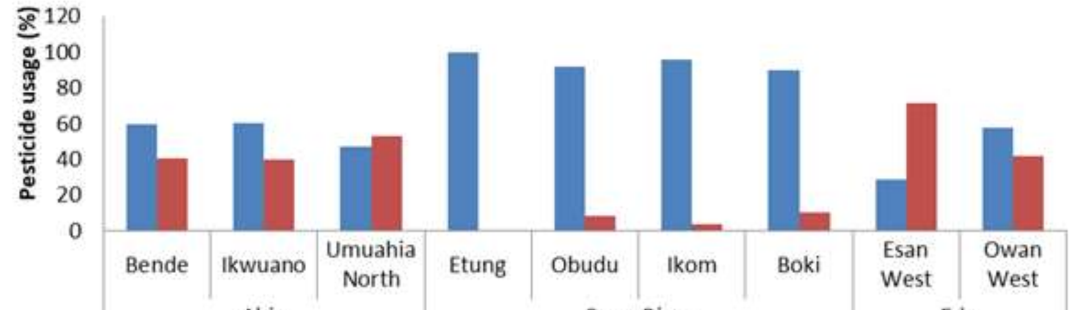
Table 3. Frequency of use of pesticides on cocoa in Edo State

LGA	Pesticide												
	UT	RG	DDF	TMX	ACT	FOH	RUP	BST	PRT	BF	TCO	TRC	CYP
Esan West		21.43	35.72					14.29	7.14	7.14	14.29		
Owan West	15.79	10.53	15.79	5.26	15.79	10.53	5.26				10.53	5.26	5.26

Key:
UT: Ultimax Plus RF: Red Force SNPC: Snipper/Combat/Attack TMX: Termex/Termikill
RG: Ridomil Gold ACT: Actara CYP: Cypermethrine/Cypertex GM: Gamalin 20
RUP: Round up/Touch down/Clear weed FOH: Funguran OH SFB: Safato /Sarosate/Supertex
DDF: DD Force/Force up/Paraforce/Paraquote/DDVP KN: Knock out BST: Best/Action 40
CDP: Champ DP BB: Blue Bolt TDM: Tandem CUS: Copper sulphate
KCD: Kocide ACT: Actara CFR: Cofresh ESM: Esiom PRT: Proteus

Figure 1 depict the percentages of pesticides usage on cocoa farms in Abia, Cross River and Edo States respectively. Findings from this study showed that 60.23% of the farmers sampled in Ikwuano LGA in Abia State, followed by those of Bende (59.34%) in the same State, used government approved chemicals on their farms. Contrary to what obtained for the duo, higher percentage of farmers (53.10%) in Umuahia North used unapproved (banned) pesticides on their cocoa farms (Figure 1).

Results obtained from Cross River State revealed that significantly high percentage (89.66-100%) of farmers applied government approved pesticides on their cocoa farms. Virtually all the farmers in Etung LGA (100%), followed by those of Ikom (96.00%) and Boki (89.66%) with the least percentage, used government approved chemicals (Table 3). But unlike what was observed in Cross River State, 28.57 and 57.90% of farmers in Esan West and Owan West LGAs of Edo State made use of government approved pesticides on their cocoa farms (Figure 1).



	Bende	Ikwuano	Umuahia North	Etung	Obudu	Ikom	Boki	Esan West	Owan West
	Abia			Cross River				Edo	
Government approved (%)	59.34	60.23	46.9	100	91.66	96	89.66	28.57	57.9
Not approved (%)	40.66	39.77	53.1	0	8.34	4	10.34	71.43	42.1

Figure 1: Percentage of usage of pesticides on cocoa Abia, Cross River and Edo States

The use of pesticides on farms has raised a lot of concerns about the safety of residues in cocoa beans, soils and water. This also portends a huge harm to humans and the environment (Denkyirah et al., 2016). Previous research conducted across six cocoa producing LGAs in Osun State revealed that Ridomil Gold pesticide had the highest frequency of usage among the farmers interviewed (Adeniyi et al., 2017). The discovery agrees with the findings of this research across the LGAs visited in Abia and Edo States (Tables 1 and 3). The pesticide, however, had the second-highest frequency of usage after Actara among the farmers visited in Cross River State (Table 2). The authors (Adeniyi et al., 2017) also discovered that most of the cocoa farmers in Osun State (about 74%) used government approved chemicals on their farms. This is in line with findings from this research among farmers in Cross River State where at least 81% of the respondents used government approved chemicals. However, contrary to the authors' findings, the percentages of banned pesticides used by farmers in Esan West (Edo State) and Umuahia North (Abia) were significantly higher than those of the government approved ones (Tables 1 and 3).

The higher number of pesticides used in some of the LGAs sampled compared with others across the States visited may be due to the level of the farmers' education. The continuous use of banned chemicals by some farmers interviewed across the States visited (even despite their knowledge of government approved ones) may be due to their perceived effectiveness in the control of cocoa pests/diseases, cost effectiveness/affordability, and ready availability. Inadequate information and appropriate registration of the agrochemicals also contribute significantly to this (Antwi-Agyakwa et al., 2015). The use of government approved pesticides by virtually all the farmers interviewed in Etung LGA (Cross River State), Ikot Ekpene and Ikono LGAs (Akwa Ibom State) may, however, be due to a better understanding of pesticides/pesticide hazard control, coupled with relative availability of the said pesticides as explained by Damalas and Koutroubas (2017) and Antwi-Agyakwa et al. (2015).

CONCLUSION AND RECOMMENDATION

The number/type of pesticides used on cocoa farms in the study areas varied with location and farmers' perceived effectiveness/availability of those chemicals. Farmers in Akwa Ibom and Cross River States impressively made use of government approved chemicals to control pests and diseases on their cocoa farms. This was a clear contrast to what obtained in Edo State. An average compliance was however noticed among farmers in Abia State. There is, therefore, an urgent need by government at all levels to further intensify efforts at educating cocoa farmers on the health and economic implications of continuous use of pesticides not approved by the federal government through its regulatory agency (Cocoa Research Institute of Nigeria) on their crop. They also need to be cautioned against an over-use of the recommended pesticides in order to forestall any undesirable long-term residue accumulation in their cocoa beans.

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NITRATE IN FRUITS AND VEGETABLES: BLESSING OR CURSE TO HUMANITY

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ABSTRACT

Recent global trend in crop production is organic and most people are turning to vegetarianism as a means of sustainable healthy living. A vegetarian's diet is rich in fruits and vegetables. Green leafy vegetables are foods that contain considerable amounts of nitrate, which can have both positive and negative effects on the human body. Nitrate potential carcinogenicity and toxicity have been proven, particularly after the reduction of nitrate to nitrite or just serving as a reactant with amines and/or amides in the formation of N-nitroso compounds, -N-nitrosamines and other nitrogen compounds, which may have high levels of nitrate. A point estimate of the daily intake to establish proper health risks that arise due to elevated levels of nitrate in fruits and vegetables need to be well researched in Nigeria, as nitrate may have high risk factor for health, during cultivation and storing of produces. A comprehensive reevaluation of food sources of nitrates and nitrites is appropriate. The strength of volumes of evidence linking the consumption of nitrate and nitrite containing plant parts to beneficial and harmful health effects support the consideration of these compounds as nutrients as well as toxins. There is a significant difference, considering possible production location and season, in the level of nitrate in certain types of green vegetables and fruits, according to researches from other parts of the world. The possible impact on human health, especially knowing that exposure to nitrate can be potentially higher for the vegetarian population should be closely monitored. The issues raised above are the major theme of this paper.

Key words: Human health, diet, nitrate, nitrite toxicity, vegetable safety, fruit safety

INTRODUCTION

Fruits and vegetables supply essential nutrients, as well as the notorious nitrate. Nitrates are a set of compounds that involve nitrogen and oxygen molecules. The nitrates found in human diets have had a bad reputation for more than half a century (Lundberg et al., 2018). In an unprecedented pattern, the concentration of nitrates in fruits and vegetables are exceeding the allowable limits worldwide (Petersen and Stroltze, 1999; Hord et al., 2009). This raises series of concern given that a direct correlation exists between the degree of toxicity of nitrate and daily intake (Uddin et al., 2021). In most Western countries, this has led to stringent regulations regarding the allowable levels of nitrate present in food sold in the open market and supermarkets. Prototypically, these regulations are based on the assumption that nitrate is overly harmful to human health. Concerns over nitrate intake originated from the fact that they are associated with some forms of cancer and methemoglobinemia throughout the world (Vickers, 2017). It is worthy to note that the nitrate, which enters into the body through fruits and vegetables, become a substance of concern if it exceeds its Acceptable Daily Intake (ADI) limit or toxicity level (Du et al., 2007). Approximately 11-41% of daily intake of nitrate enters the organism. The acceptable daily intake (ADI) for nitrate determined by the Scientific Committee on Food (SCF) in 1997 amounts to 0 to 3.7 mg/kg body weight/day, which is equivalent to 222 mg nitrate/day for an adult weighing 60 kg. Studies have shown that the average adult, on a daily basis, consumes approximately 400 g of various vegetables, from which it can be concluded that the average intake of nitrate is 157 mg/day (FAO/WHO, 2013).

Nitrates are not broken down by stomach acid. Dietary nitrates are essentially inert and acquire biological activity only with nitrate reduction to nitrite and then serving as a reactant with amines and/or amides in the formation of N-nitroso compounds (nitrosamines), some of which are known to be carcinogenic, teratogenic, and mutagenic. The main sites of reduction are in the saliva (nitrate to nitrite), and the stomach and blood vessels (nitrite to NO). As such, nitrate serves as a source, via successive reduction, for the production of nitrite and nitric oxide as well as other metabolic products. Nitrites are also produced endogenously through the oxidation of nitric oxide and through a reduction of nitrate by commensal bacteria in the mouth and gastrointestinal tract (Norman, 2009). Inarguably, constant unchecked intake creates a higher ground for the development of cancer of the stomach and esophagus (Roohparver et al., 2018; Ozdestan and Uren, 2010). Some studies have shown that a positive correlation exists between high nitrate consumption and gastric cancer in humans (Nowrouz et al., 2012).

On the other hand, several plausible health benefits and preventive effects of nitrate have also been reported. A substantial number of studies in health and hypertensive issues have shown that nitrate has beneficial cardiovascular effects, including lowering of blood pressure (Kerley et al., 2018; Machha and Schechter, 2012). Scientific evidence also suggests that having abundant vitamin C and polyphenol in fruits and vegetables facilitate the non-enzymatic reduction of toxic nitrite to beneficial nitric oxide, thereby reducing the chances of nitrite reacting with secondary amines forming nitrosamines (Erkekoglu and Baydar, 2010; Rocha et al., 2010). These evidence points at the inconsistencies found in global research efforts trying to assert or disband the adverse or beneficial effects of nitrate. As a result, the debate on risk or benefit of exposure to dietary nitrate has remained challenging and unresolved amongst scientists around the world.

NITRATE IN FRUITS AND VEGETABLES

Fruits and vegetables provide a substantial portion of nitrates in human nutritional regime. There is a significant difference in nitrate concentration present in different plant parts such as the root and tuber vegetables, fruit vegetables, and fruits (Uddin et al., 2021). Besides leafy vegetables that contain a substantial proportion of nitrate, studies have shown that other types of crops such as oilseeds, grains, tubers and nuts also contain high amount of nitrate (Gundimeda, 1993). Some studies have shown that leafy vegetables and fruits contain higher levels of nitrate and contribute to about 85% of the dietary intake of nitrates in a number of climes (Chetty et al., 2019; Bahadoran, 2016). The results of a Belgian research suggest that half of the daily intake of nitrate into the body is through vegetables, especially lettuce, and 20% is through water and water-based drinks (Temme, 2011). Significant nitrate intake by eating lettuce was also confirmed by another study conducted in Denmark, where samples of vegetables sampled in shopping centers were analyzed, and lettuce from the winter period contained more nitrate than lettuce from the summer period. High amounts of nitrate were found in dill (2.936 mg/kg), spinach (2.508 mg/kg), lettuce (2.167 mg/kg) and red beet (1.446 mg/kg) (Petersen, 1999). Nuñez de González (2015) in the USA found nitrate mean value contents to be conventional in broccoli (394 mg/kg), cabbage (418 mg/kg), celery (1496 mg/kg), lettuce (851 mg/kg) and spinach (2797 mg/kg). Zhong et al. (2002) in China reported that the mean nitrates level was higher in A. tuberosum Roth (5150 mg/kg), spinach (4259 mg/kg), intermediate in radish (1878 mg/kg) and Chinese cabbage (1740 mg/kg).

In our world today, nitrate pollution from chemical fertilizers, pesticide residue (PR) overload in vegetables, and microbiological contamination along the value chain have emerged as alarming public health issues (Chan, 2011). The application of excessive nitrogen fertilizers in fruit and vegetable production is one of the key factors for the accumulation of nitrates in fruits and vegetables (Fewtrell, 2004). However, the quantity of nitrate available in agricultural produces also depends on a number of factors, which vary greatly from region to region. Escobar-Gutierrez (2002) reported that lower levels of nitrate in fruits and vegetables result from high temperatures and longer sunshine periods. Amongst such influencing factors include: biological properties of crop, lighting conditions, soil properties, humidity, frequency of planting in the field, vegetation period, season of harvest, processing time, geographical region and fertilization (Parks et al., 2012; Rose et al., 2008; Correia, 2010). It is very important to remember that the consumption of fruits and vegetables is not the only route (though prime source) for nitrate to enter human body. Other probable sources of nitrate, such as drinking water, meat and other consumables should be checked before consumption.

CONCLUSION

From available data, it is obvious that the prime concern for nitrate rich diet is the endogenous formation of carcinogenic nitrosamines. The human sources of nitrate are mostly of natural origin: plants, animal and water. Vegetables and fruits are considered the first contributors to dietary nitrate, as such; there is the need to bear in mind that leafy

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vegetables accumulate a significant portion of nitrate from nitrogen-based fertilizers. It is also noteworthy that prolonged and inefficient storage of produces, along with excessive use of chemical fertilizers and nitrate-polluted water, contribute to the elevated levels of nitrate in fruits and vegetables. Therefore, the intake of nitrate through fruits and vegetables could be considered safe for the consumers, when appropriate measures are deployed to limit excess nitrogen available for plant uptake.

The Nigerian populace could possibly be exposed to amounts of nitrate that endanger health. It is important to emphasize that for a complete assessment of nutrient loads to the body, it is necessary to carry out chemical analysis of vegetables and fruits, meat and meat products, and drinking water and water-based drinks as well.

In the academic community, a sustained research on nitrate level of vegetables is recommended and needed in order to resolve the lingering human safety controversies surrounding nitrate and nitrite in the diet, such as "dietary nitrate - good or bad?

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EVALUATION OF NUTRIENT RELEASE PATTERN FROM COCOA POD HUSK AND OIL PALM BUNCH – (A LABORATORY INCUBATION STUDY)

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ABSTRACT

An incubation study was conducted in the Cocoa Research Institute of Nigeria (CRIN) Laboratory to determine the amount of N released by different organic materials of plant origin at each stage of incubation. The amount and type of nitrogen (NO^-_3 - N and NH_4^+ - N) released by the materials were also monitored. There were four treatments [cocoa pod husk (CPHU), Cocoa pod husk ash (CPHA), Oil palm bunch ash (OPBA) and control] replicated three times making a total of twelve experimental units which were arranged in a completely randomized design (CRD). Fifty grams of soil (40g top soil + 10g of river sand) were passed through 2 mm sieve. The samples were weighed into 72 sterilized 50cl plastic cups and 0.5g of each organic material was added into the plastic cup corresponding to each row except for the control. Results indicated that, organic materials irrespective of types significantly ($p<0.05$) increased NO_3 – N; NH_4 – N and Total N mineralization in the soil throughout the periods of incubation. Cocoa pod husk ash consistently and significantly ($p<0.05$) released the highest amount of NO_3 – N throughout the incubation periods relative to the milled CPHU and OPBA except at 12weeks after incubation (WAI) respectively. All the organic materials under consideration except CPHU reached their respective peak release two months after treatment application. It is therefore recommended that any of these materials can be used as substitute for chemical fertilizers which are quite scarce, expensive and environmentally hazardous to soil health.

Key words: Mineralization, experimental units, oil palm bunch ash, incubated samples

INTRODUCTION

Many research studies in Nigeria have focused on the use of synthetic fertilizers Information are scarce on the less known but important organic sources. Furthermore, government efforts have been concentrated on the supply and manufacture of chemical fertilizers. It has been shown that total dependence on fertilizer as main supply of plant nutrients is not sustainable at the level of majority of the peasant and small holding farmers who produce 90% of food need in Nigeria. Similarly, several studies on the use of inorganic fertilizers across the country (Nigeria) show a number of limitations to their proper, effective and profitable use. Above all, the continuous use of inorganic fertilizers has led to degrading of physical properties of soils caused by low organic matter levels, increased soil acidity and nutrient imbalance (Ayeni, 2009; Shweta Shambhavi et al., 2017). The need to increase soil organic matter contents for sustainable usage of Nigerian agricultural soils (Ogunwale, 2002) coupled with the aforementioned problems have called for a shift from the use of inorganic fertilizers to organic fertilizers. However, the rates of mineralization and nutrient release patterns of farm wastes have not been adequately studied. This study was conducted to determine the rate of nitrogen release patterns of Cocoa pod husk (CPH) and Oil palm bunch ash (OPBA) using the amount of nutrients released as indices.

MATERIALS AND METHODS

An incubation study was conducted in the CRIN laboratory to determine the amount and types of nitrogen (NO^-_3 - N and NH_4^+ - N) released by various ash materials (CPHU, CPHA and OPBA) at each stage of incubation. There were four treatments namely Cocoa pod husk (CPHU), Cocoa pod husk ash (CPHA), Oil palm bunch ash (OPBA) and control replicated three times making a total of twelve experimental units which were arranged in a completely randomized design (CRD). Fifty grams of soil (40g top soil + 10g of river sand) were sieved through 2 mm sieve into 72 sterilized 50cl plastic cups and 0.5g of each material was added into the plastic cups corresponding to each row except for the control. The contents of each sterilized plastic cups were mixed thoroughly and allowed to remain on the laboratory bench at room temperature and monitored for sixteen weeks. Moistening was carried out twice weekly to keep the soil and the treatments in the sterilized plastic cup wet at 60% field capacity at all times. Three sterilized plastic cups were retrieved per row at zero (0); fourth (4th); eighth (8th); twelfth (12th), sixteenth (16th) and twentieth (20th) weeks after incubation (WAI) respectively to give six incubation periods. The contents were leached into 100ml volumetric flask using funnel fitted with Whitman 42 filter paper. The soils were analysed for their N, NO_3 – N and $NH4^+$ - N contents as described below:

Statistical Analysis

Data obtained were subjected to statistical analysis of variance (ANOVA) procedure and means were compared at 5% level of significance using GENSTAT package (GENSTAT, 2005).

RESULTS

Nitrogen release pattern during the periods of incubation.

The different amount of N (NO3 – N; NH4 –N and Total N) released over the twenty (20) weeks of incubation is presented in Figures 1-3.

(a) Nitrate Nitrogen (NO_3- N)

The NO_3 – N release pattern of the various ash materials during the incubation periods are presented in Figure 1. Comparable to the control, all the organic materials significantly ($p<0.05$) increased NO_3 – N mineralization in the soil throughout incubation periods. CPHA produced the highest amount of NO_3^- – N released into the soil throughout the period of incubation except at

Analysis of Incubated samples

The following analyses were carried out at the end of each incubation period. Mineralized total Nitrogen (N) was determined by Kjedahl method as follows: Incubated soil (5g) was placed in digestion tube and one Selenium tablet was dropped into it with 15ml of concentrated sulphuric acid added and placed in digestion chamber for two hours, after which distillation and titration were done to determine the total Nitrogen (N). The changes in pH at each stage of release was determined in water at a ratio of 1:2 (soil/water) using a pH meter with glass electrode as described by Jackson (1965).

12WAI. The NO_3^- – N released was consistently and significantly ($p<0.05$) increased by CPHA up till the 8thWAI and a sharp reduction in the amount of NO_3 – N released was noticed up to 12WAI with an increase at 16WAI. The least NO_3- N released was recorded at 20WAI. However, the amount was significantly higher than other organic materials and control respectively. Similar trends were observed at 16th and 20th WAI respectively with CPHA maintaining the lead. This was distantly followed by OPBA with CPHU. All the materials (CPHA; OPBA and Control) reached their peak release at the same time (two months after application) except CPHU. The order of NO_3 – N release into the soil in descending order during the first two months was: CPHA > OPBA > CPHU > CTRL (Fig.1). At 12WAI, CPHU recorded highest values in NO_3 – N and this was significantly better than CPHU, OPBA and control of NO_3 – N released into the soil. At 20WAI, the amount of NO_3 – N released by CPHU and OPBA were not significantly ($p<0.05$) different from each other.

(b) Ammonium N (NH4 – N) release pattern

Figure 2 shows the amount of NH_4 – N released by the organic materials during the five months of incubation. The NH^+_4 – N released by CPHU and OPBA are not statistically different from each other but are significantly different ($p < 0.05$) from the control at the zero (0) four (4) and twentieth weeks of incubation. However, CPHA released the highest amount of NH_4 - N into the soil solution during the same period. At two months (8WAI) of incubation, the amount of NH_4 – N released into the soil by all the ash materials were significantly higher ($p<0.05$) than the control with CPHA maintaining the lead while control produced the least NH_4 - N release, this was closely followed by OPBA and CPHU respectively. The mean differences were significant. Generally, the amount of NH_4 – N released into the soil filtrate by the organic materials dropped at the end of the eighth weeks of incubation (8WAI).

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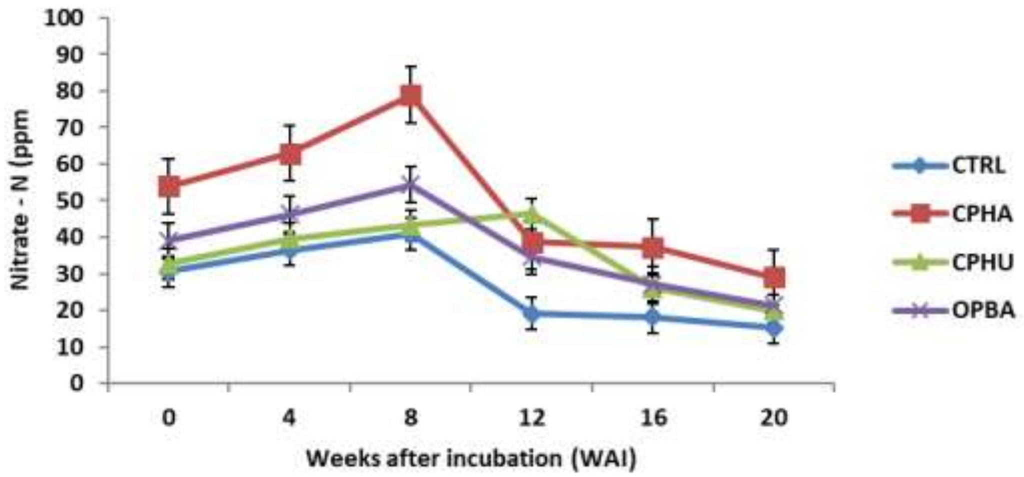

Figure 1. Effects of CPHA, CPHU and OPBA on Nitrate - N (NO_3 - N) released (ppm) during the 20 weeks' incubation periods.

CTRL= Control; CPH= Cocoa pod husk; CPHA= Cocoa pod husk ash; OPBA= Oil palm bunch ash

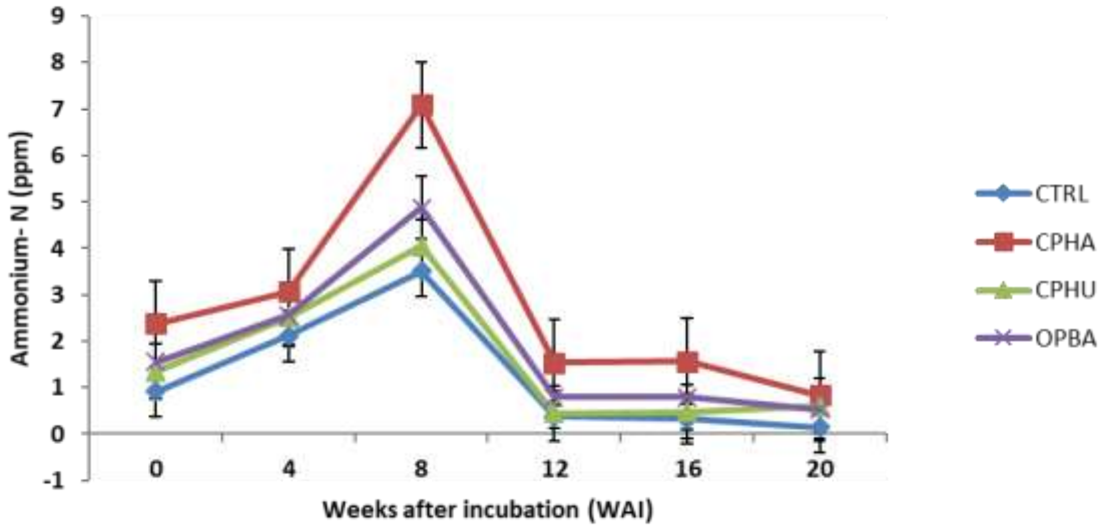

Figure 2. Effects of CPHA, CPHU and OPBA on Ammonium - N (NH4 - N) released (ppm) during the 20 weeks' incubation periods

CTRL= Control; CPH= Cocoa pod husk; CPHA= Cocoa pod husk ash; OPBA= Oil palm bunch ash

(c) Total N released pattern (N)

The total N released over 20 weeks of incubation is presented in Figure 3. The ash materials significantly ($p<0.05$) increased the total N released throughout the incubation periods. CPHA recorded the highest total N released into the soil. This was distantly followed by OPBA, while control recorded the lowest N release throughout the period. Generally, all the treatments reached their peak at the same time (8WAI) except CPHU which did at 16WAI after which the values decreased.

DISCUSSION

The incubation study revealed that application of CPH, CPHA and OPBA increased soil NO3- - N; NH4+ - N and total N. This finding was consistent with earlier incubation studies by Akanbi et al. (2014), Ogunlade (2008) and Ipinmoroti, (2006) that organic residues increased soil nutrients. Slower release of nutrient elements into the soil solution especially N from CPH compared to OPBA and CPHA based fertilizer was observed in this study. This was probably because the CPH materials would need to be decomposed by soil micro - organisms before the organic nutrients could be mineralized unlike CPHA and OPBA that have undergone process of burning such that the carbon building block had been broken and the organic nutrients are now in concentrated form. Hence, CPHA and OPBA fertilizer were quicker sources of N. The noticeable sharp increase(s) observed in all the organic fertilizer materials at 4th week of incubation led to an upsurge in the amount of various nutrient elements released into the soil. This might be probably due to the mineralization which must have taken place in the various soil media. Secondly, the marginal decrease in the amount of each of nutrient elements released at 12th weeks after incubation may have been that each material had attained the optimal release point hence, the stability after which the value dropped. Also, the differences in the periods of release by the organic materials as revealed by this study are an indication that each material mineralized at different rates. This probably might have been due to the differences in their carbon/Nitrogen (C: N) ratio. These observations were consistent with the results of incubation study of Akanbi et al. (2014).

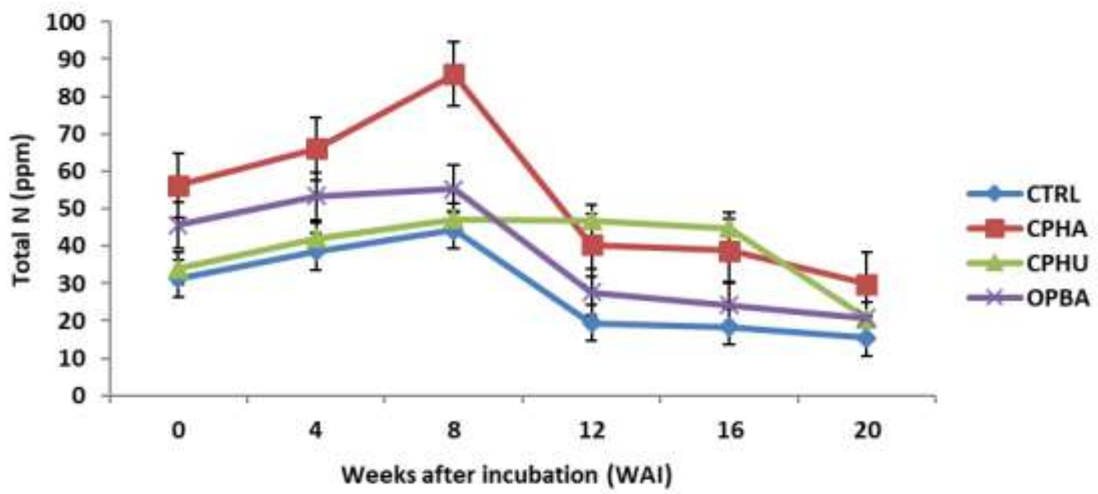

Figure 3. Effects of CPHA, CPHU and OPBA on Total N (ppm) released during the 20 weeks of incubation
CTRL= Control; CPH= Cocoa pod husk; CPHA= Cocoa pod husk ash; OPBA= Oil palm bunch ash

CONCLUSION AND RECOMMENDATION

Based on the significantly ($p < 0.05$) higher amount of nitrogen (N) released into the soil amended with organic wastes as a result of mineralization of the materials within the short periods of the incubation, it could, therefore, be concluded that CPHU, CPHA and OPBA can be used in soil amendment programme. However, application of these materials must be carried out two to four weeks before planting so that the young seedlings can benefit progressively from the released nutrients before reaching the peak at 8 weeks of application.

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DESIGN, FABRICATION AND TESTING OF A MANUAL COWPEA DEHULLER FOR SMALL SCALE FARMERS AND AGRO-PROCESSORS IN NIGERIA

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ABSTRACT

Cowpea is a major component of traditional cropping systems in many parts of the tropics and it is important because of its multiple uses in cooking, and industrial processing. Cowpea de-hulling is a long and tedious process which often involves manually detaching the cotyledon from the hull using hand–friction. The aim of this study was to design and construct a manual cowpea peeling machine to dehull soaked cowpea. The machine was designed and its performance was evaluated. The dehulling machine was made from stainless steel (for its anti- rust abilities) and wrought iron and was evaluated using three varieties of cowpea; white, mallam and oloyin. Machine efficiency was calculated for each variety and cost analysis carried out. Results showed that the dehuller's efficiency values ranged from 78%, to 82.35% for the three tested varieties, while output capacity of the machine was calculated to be 5.5kg/hr./batch. Machine performance showed that, effective threshing of different varieties of cowpea with minimum loss, improved threshing capacity, and efficiency were achieved resulting in good quality products across the three varieties. It was recommended that a cover should be provided to cover the hopper when it is not in use to prevent foreign materials from dropping into the machine.

Key words: cowpea, threshing, food processing, development, dehuller

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a major component of traditional cropping systems in many parts of the tropics and it is important because of its multiple uses. It is commonly called the '*hungry – season crop'* because it is the first crop to be harvested before cereal crops (Fawohunre and Olajide, 2020). Common uses of cowpea include soil fertility improvement through Biological Nitrogen Fixation, green manure, forage, production of high quality hay and silage, synthesis of nutritional products, suppression of weeds, food, and as a source of protein and income generation (Fawohunre and Olajide, 2020). Cowpea is one of the economically important indigenous African legume crops, especially in the dry regions covering 12.5 million hectares (Kebede et al*.*, 2020). In sub-Saharan Africa, cowpeas are produced mainly from West Africa, which accounts for 60% of worldwide production (Nkomo et al., 2021) with an estimated annual production of about 5.2 million tons. In Nigeria as well as most African countries, cowpea is eaten in various forms. It is also used in preparing a popular cowpea stew called gbegiri or kosei among the Yorubas and Hausas respectively (Babatunde, 1995). The protein in cowpea seed is rich in the amino acids, lysine and tryptophan compared to cereal grains. Cowpea can also be used at all stages of growth as a vegetable crop. Green cowpea seeds are boiled as a fresh vegetable, or may be canned or frozen, while the dry mature seeds are also suitable for boiling and canning (Fawohunre and Olajide, 2020).

In recent times, cowpea seeds are processed into packaged cowpea flour for further preparation into different food products. Cowpea dehulling is an integral part of bean processing. Olajide et al. (2019) defined de-hulling as the removal of seed coats (hull) which results in the separation of the cotyledon. Manual dehulling requires soaking the cowpea in water for 2 to 10 minutes, wherein the hulls absorb moisture and swell; thereby facilitating de-hulling by rubbing between one's palms, or beating with a wooden pestle and mortar, or grinding on stones (Aduba et. al., 2013). Housewives, small scale farmers, and food processors carry out these operations daily (Chukwu and Sunmonu, 2010), but it is an arduous task, especially when the cowpea to be manually dehulled is in large quantities (Olaoye and Olotu, 2015). Mechanical threshing involves high technology which is very expensive, and hence beyond the reach of Nigerian small – scale farmers though it helps to maintain the quality of the final products with minimum drudgery (Fawohunre and Olajide, 2020). The unstable electric power supply and high cost of fuel in the country are also deterrents to most peasant farmers. This limits the processing potential of the farmers. Hence, there is a need for a machine to circumvent these constraints at an affordable cost.

MATERIALS AND METHODS

Machine description and theoretical background

Machine design considerations hinged mainly around friction and bean transfer. De-hulling takes place through the process of the beans rubbing against each other and the separation chamber. Component parts and the fabricated cowpea dehulling machine are shown in Figures 1a, 1b, and 2, respectively. The major components of the cowpea threshing machine are: the hopper, dehulling chamber, outlet and frame. Materials used in the design of this cowpea peeler were carefully selected on the basis of properties such as power requirement, physical parameters of the cowpea, simplicity, stability, feed rate, speed of the drum, rigidity, bearings, durability, and strength of the materials, cost, and resistance to rust. The hopper is a stainless steel funnel shaped structure of length 260 mm, while the base measures 85 mm, and the upper collection part is 210 mm. The hopper is located above the dehulling chamber for easy feeding. The dehulling chamber consists of two cylindrical chambers. The internal chamber was made from wrought iron, and the outer de-hulling chamber was made from stainless steel and perforated to aid friction and bean de-hulling. The total length of the de-hulling chamber is 400 mm, while the diameter of the drum is 90 mm.

The stainless steel auger, which assists in the physical removal of cowpea skin through friction with the perforated drum, is primarily a transportation tool for the cowpea, moving beans from the de-hulling chamber to the outlet. The total length of the auger pipe is 380 mm and diameter of 480 mm. Two pillow bearings support the power shaft at both ends of the de-hulling chamber. Each of the bearing is held in position by 16mm bolts and nuts on top of the machine frame.

Dehulled beans and chaff fall and are collected through separate inclined outlets (30°) which facilitates the effective sliding of the grains. Dimensions of the outlet for de-hulled cowpea are 110 mm x 90 mm x 70 mm. The waste outlet measures 60 mm x 40 mm. The entire machine is mounted on a wrought- iron frame network of length 500.5 mm, while the lower and the upper base measures 300 mm and 200 mm respectively.

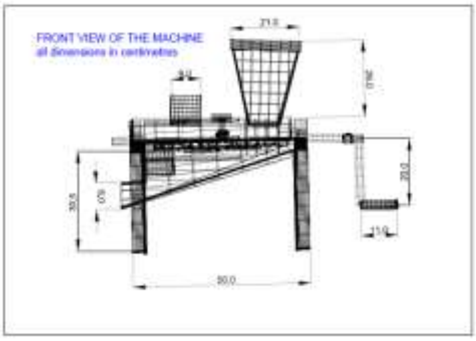

Figure 1a. Front view of the cowpea peeling machine

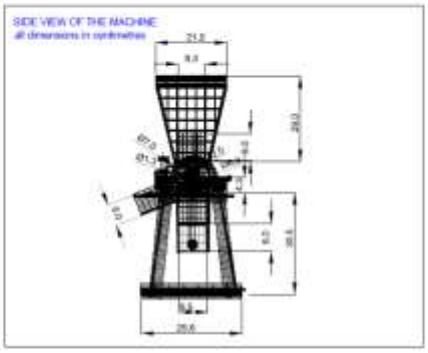

Figure 1b. Side view of the cowpea dehulling machine

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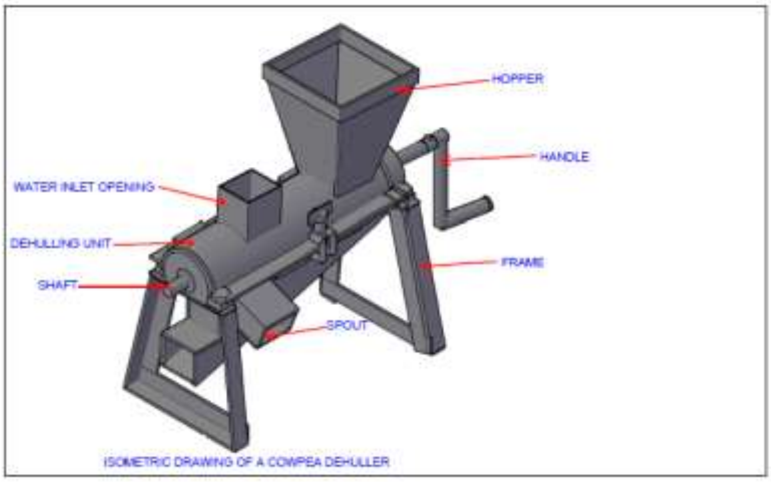

Figure 2. Isometric view of the cowpea peeling machine

Design considerations

1. Design of the dehulling unit: This was calculated using eqn. 1:

$V_{dc} = \pi r^2 h$ ….(1)

Where; V_{dc} = volume of the dehulling cylinder, r = radius of dehulling chamber, l = length of dehulling chamber

Volume of external dehulling chamber V_{dc} = 3.142 x 0.045^2 x 0. 0.00255 m^3

Volume of internal dehulling chamber (V_{idc}) = 3.142 x 0.040^2 x 0.38 = 0.00191 m3

2. Volume of cowpeas in dehulling chamber (V_c): The volume of cowpeas (Vc) in the dehulling chamber was obtained by subtracting the volume of the internal dehulling cylinder from that f the external one.

$Vc = V_{dc} – V_c$ = = 0.00255 – 0.00191 = 0.00064 m^3

3. Weight of cowpeas in dehulling chamber

Weight of cowpea (wc) = mg….. (3)

Where; m = mass of cowpeas, g = acceleration due to gravity

Also, m = ṗvc….. (4)

where; ṗ = bulk density of cowpea = 721 kg/m3 (Olajide *et al.,* 2019)., and Vc = volume of cowpea m^3

m = 721 x 0.000643 =0.461 kg/ 5 mins

Performance evaluation

The performance of the machine was evaluated using three different cowpea varieties; white, oloyin and *maalam.* 650g of each variety was soaked for five minutes and then poured into the hopper. The machine handle was turned to start de-hulling immediately and water was poured through the water inlet to avoid clogging of the de-hulling chamber. The process took a total of 10 minutes.

Machine efficiency was calculated using the formula:

$E= [(W_1-W_2)/W_1]$ x100

Where;

W1=Weight of de- hulled cowpea,

W2=Weight of cowpea un-hulled

and cost analysis carried out.

RESULTS AND DISCUSSION

The machine was observed to de-hull cowpea very effectively. Losses and breakages were found to be very negligible. Wet Weight changes were observed after de-hulling the cowpea. The cowpea de-huller removed the cowpea hull effectively.

Plate 1. Picture of the de-huller, de-hulled cowpea and chaff

Efficiency values ranged from 78% (for mallam bean) to 82.35% for white bean. This shows that the cowpea de-huller performed very well in de-hulling the three varieties of beans used. Operation time was between three to five minutes for total de-hulling.

Table 1. Performance evaluation results

Bean type	Weight of Cowpea (kg)				Efficiency
	Before de-hulling		After de-hulling		
	Dry weight	Wet weight	De-hulled bean weight	Chaff weight	
White bean	0.65	1	0.85	0.15	82%
Oloyin	0.65	1	0.85	0.15	82.35%
Maalam	0.65	1	0.7	0.15	78%

CONCLUSION AND RECOMMENDATION

A cowpea de-huller was designed, fabricated, tested and the performance evaluation was carried out. It was discovered that the quality of de-hulled cowpea increased with clearance between the hopper and the de-hulling chamber. The machine is highly efficient, economical, and stable, with highest efficiency rating of 82.35%.

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PRECLUSIVE INVESTIGATION ON NURSERY PERFORMANCE AND RESPONSE TO NATURAL DISEASE INFECTION BY BRAZILIAN LARGE BIOTYPE AND POLYCLONAL PROGENIES CASHEW

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ABSTRACT

Cashew is valued mainly by the nuts, which have been a major foreign exchange earner for many developing countries in the tropical and subtropical regions. Nearly 45% of world's cashew production comes from West Africa; Ivory Coast, Ghana and Nigeria being major producers. However, major factors limiting cashew productivity have been identified as low nut yield and nut weight. Cashew Polyclonal Seeds (PS) was sourced from Ghana through PROCashew-Nigeria project and Brazilian large (BL) biotype obtained at Ochaja substation of Cocoa Research Institute of Nigeria (CRIN). The planting materials were evaluated based on nut count, nut weight, kernel outturn, shelling %, growth performances and response to natural infection in the nursery. Nut count in PS had a mean of 145nuts while the BL was 119nut/kg. Both materials were of large nut sizes, although weight per nut was higher in BL (10.0g/nut) than 8.5g/nut recorded in PS. Seedling emergence was recorded on 12th day after planting in both materials but percent emergence varied. Percent germination in PS was 32.07% (2 weeks after planting) and 88.97% (4 weeks after planting), while the BL 55.46% (at 2 weeks) and 95.79% (at 4 weeks). The performances of BL were significantly higher in height (24.41cm and 29.34cm) at 4 and 6 weeks after planting respectively, while other growth parameters; girth, number of leaf, leaf area and branch varied with nursery period. Observations on disease infections showed no damping off of seedlings, however wrinkled leaves and leaf spot had greater incidence in PS but higher incidence of seedling dieback was recorded in BL. The BL at Ochaja substation of CRIN would compare as good material in selection for breeding except that records of yield, quality status of raw nuts and extensive genetic profiling of the materials are lacking.

Key words: Cashew, biotype, polyclonal seed, nursery, seedling performance, disease

INTRODUCTION

Cashew is a perennial tree crop, in family *Anacardiaceae*. Originated from North-Eastern Brazil and introduced into West Africa in the 16th century by the Portuguese settlers (Abdul and Peter, 2010). This crop is valued mainly by its article of trade which is the nuts, been a major foreign exchange earner for many developing countries in the tropical and subtropical regions. Around 45% of the world's cashew production comes from West Africa, which comprised of Ivory Coast, Ghana, and Nigeria being major producers (Monteiro et al., 2017). However, a prime factor identified to limit the productivity of cashew have been low nut yield and nut weight. (Adu-Gyamfi et al., 2019; Dadzie et al., 2014). This is also complicated by the new trend where nut weight is used as major criterion that determines the market value of raw cashew nuts in international trade. Low cashew productivity could be partly attributed to pest and diseases infestation, but high global demand for cashew nut from increasing world population, coupled with farmers request for varieties that provide high early yield per unit area with big nuts that can earn premium price suggest need for development of new varieties with high genetic potential for higher nut yield per unit area and improved nut quality (Gyamfi et. al., 2020).

MATERIALS AND METHODS

The PS was of Ghana origin, obtained through PROCashew-Nigeria project. The BL was obtained at Ochaja substation of Cocoa Research Institute of Nigeria (CRIN). Both planting materials were of the current year cashew fruiting season (2021). The moisture content of the raw cashew nuts (RCN) was determined, nut count, weight according to Lihong et al., (2014) and kernel outturn according Dieng et al., (2020). The RCN was sown in soil filled in a 20cm by 10cm polythene planting bags with one nut per bag. Routine nursery activities were carried out with cultural weeding and regular watering. Cashew seedlings were observed, data obtained on emergence, germination, height, girth, number of leaf, leaf area and branching were subjected to one – way ANOVA using SAS software package and the mean values were separated using Duncan Multiple Range Test (DMRT) at P≤0.05. Deviations/deformations in normal physiological growth of cashew parts were observed for symptoms and categorized according to Zhongrum and Masawe, (2014).

RESULTS AND DISCUSSION

The number of RCN in 1kg PS ranges from 144 – 147 nuts while BL had nut count of 117 – 121 nut/kg. The weight of BL and PS nuts showed that both belong to size of large cashew nut, however the weight per nut is higher in cashew BL (10.0g/nut) than 8.5g/nut recorded in PS (Table 1).

Table 1. Data on Brazilian large biotype and Polyclonal seed progenies cashew

Parameter	Polyclonal seed (PS)	Brazilian large (BL)
Source of planting material	Ghana/Tanzania	Ochaja, Nigeria
Nut count (average)	145	119
Nut weight (g)	7.0 – 8.5g	6.0g – 10.0g
Moisture content (%)	5.5 – 6.7%	8.0 – 10.0%
Outturn of RCN	48 – 56lbs	48 – 54lbs
Outturn of material at planting	47.5lbs	48.5lbs
Moisture of material at planting	5.5%	8.0%
Shelling percent (%)	34%	32%

The moisture content of RCN is directly proportion to the kernel output ratio (KOR)/outturn, which is a functional of storage. Decrease in moisture of RCN results into a reduction in outturn values, good storage enhances KOR but poor storage system brings down the kernel outturn. The outturn is important to processors, while shelling percent is one of major factor considered in materials aimed for a breeding program. The RCN of BL and PS were planted at moisture of 8.0%, KOR 48.5lbs and 5.5%, KOR 47.5lbs respectively (Table1).

Plate 1: Polyclonal seed progenies (A) Brazilian large biotype (B)

Emergence of RCN was observed on 12th day after planting (DAP) in BL and PS, with 23.53% and 10.34% respectively. Percent germination of PS was 32.07% at 2 weeks after planting (WAP) and 88.97% at 4WAP while BL recorded 55.46% at 2WAP and 95.79% at 4WAP. The percentage increase in germination from emergence to 4WAP was 11.62% and 24.56% in PS and BL respectively. While the percent increase in germination between 2WAP and 4WAP was 36.05% (PS) and 57.89% in BL (Table 2).

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Table 3 showed the performances of BL and PS in the nursery. The height of BL was significantly higher (24.41cm) than 20.64cm recorded in PS at 4WAP. Significantly higher number of leaf and branch were also recorded in BL, while the girth and leaf area were the same in both PS and BL at 4WAP. At 6WAP, there was significant similar growth in girth, number of leaf, leaf area and branch with exception of height which was significantly higher (29.34cm) in BL compared to 25.30cm recorded in PS (Table 3).

Table 2. Emergence of Brazilian large biotype and Polyclonal seed progenies cashew

Parameter	Polyclonal seed (PS)	Brazilian large (BL)
Day of emergence	12DAP	12DAP
Percent emergence (%)	10.34%	23.53%
Number of foliar at germination	4 – 5 Leaves	4 – 6 leaves
Percent germination at 2WAP	32.07%	55.46%
Percent germination at 4WAP	88.97%	95.79%
Percent increase from emergence to 4WAP	11.62%	24.56%
Percent increase from 2WAP to 4WAP	36.05%	57.89%

*DAP (Day after planting), **WAP (Week after planting)

Table 3. Performance of Brazilian large biotype and Polyclonal seed progenies cashew

Cashew material	Height (cm)	Girth (mm)	Number of Leaf	Leaf area (m^2)	Branch
		4 Weeks After Planting			
Polyclonal seed (PS)	$20.64^b \pm 0.88$	$0.28^a \pm 0.02$	$7.73^b \pm 0.28$	$9.10^a \pm 1.40$	$0.00^b \pm 0.00$
Brazilian large (BL)	$24.41^a \pm 0.83$	$0.26^a \pm 0.02$	$9.27^a \pm 0.58$	$9.31^a + 0.84$	0.25s$\pm$0.33
		6 Weeks After Planting			
Polyclonal (PS)	$25.03^b \pm 1.23$	$0.31^a \pm 0.01$	$10.13^a \pm 0.56$	$44.60^a + 3.11$	$1.00^a \pm 0.68$
Brazilian large (BL)	$29.34^a \pm 1.06$	$0.34^a \pm 0.01$	$11.73^a + 0.72$	$44.97^a \pm 2.85$	$2.50^a \pm 0.55$

Natural infections with symptoms of physiological disorders common in nursery operations were assayed: wrinkled leaf, damping off, leaf spot and dieback. The seedlings recorded no incidence of damping off, however deviations from normal physiological growth were observed in varied degrees. Wrinkled leaf (Plate 2) was observed at 2WAP in 4.43% of PS and 2.67% BL, but incidence was not on the increase throughout the nursery period. Higher incidence (3.23%) of leaf spot (Plate 3) was recorded in PS to 1.78% in BL. Although dieback incidence (Plate 4) was minimal in both PS and BL, however higher (0.89%) in BL than 0.41% recorded in PS (Table 4).

Table 4. Physiological disorders in Brazilian large biotype and Polyclonal seed progenies cashew

Cashew material	Wrinkled leaf	Leaf spot	Damping off	Dieback	Survival count (%)
Polyclonal seed (PS)	4.43%	3.23%	0	0.41%	87.93%
Brazilian large (BL)	2.67%	1.78%	0	0.89%	95.79%

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Plate 2. Wrinkled leaf: Polyclonal seed progenies (A), Brazilian large biotype (B)

Plate 3. Leaf spot: Polyclonal seed progenies (A), Brazilian large biotype (B)

Plate 4. Seedling dieback: Polyclonal seed progenies (A) Brazilian large biotype (B)

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INCIDENCE OF SEED BORNE FUNGI ON STORED RICE (*ORYZA SATIVA*, L.) SEEDS AND CONTROL WITH PLANT LATTICES

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ABSTRACT

Fungal organisms are known to produce toxins which are deleterious to human health. Therefore, this study was conducted to isolate, identify and control with two plant lattices the filamentous isolates associated with four stored rice cultivars in Ishiagu, Ebonyi State, Nigeria. Four rice cultivars: - FARO-44, FARO-45, Local foreign and Chinyere were purchased from Eke Markets and were used for the study. Potato dextrose agar was used in isolating the fungi organisms in a completely randomized design and replicated three times. The collected data were subjected to Analysis of Variance and the significant means were separated using Tukey at P<0.05. The results revealed four fungi organisms which are Fusarium oxysporum, Magnaporthe oryzae, Aspergillus niger and Aspergillus flavus. The incidence of the organisms varies significantly from one isolate to others. Fusarium oxysporum (58.33%) had the highest percentage of occurrence while Aspergillus niger (8.33%) had the least. The percentage distribution of 66.11 %, 22.22 %, 25.00 % and 16.67 % were obtained for the Chinyere, FARO-45, Local foreign and FARO-44 respectively. Fusarium oxysporum (67.24%) had the highest mycelia inhibition with the J. curcas latex while A. niger (24.52%) had the least. Similarly, the latex of C. procera showed higher mycelia inhibition of 54.52% on F. oxysprum while Magnaporthe oryzae (20.98%) had the least. Therefore, this study recommended that seed health test should be carried out before sowing or planting in agricultural field.

Key words: Incidence, fungi, stored, rice, control and lattices

INTRODUCTION

Rice (*Oryza sativa,* L.) is a monocot plant with two main cultivated species *Oryza sativa* L. and *O. glaberrima* Steud, also respectively known as Asian and African rice (Khush et al., 2013). The crop is increasingly becoming an important staple food and cash crop in Africa (Tanko et al., 2016). In this continent, 15 million tons of rice is produced annually (Ronald et al., 2014). Africa most especially Nigeria were abundantly blessed with land and water resources that can support a huge expansion in rice production (Balasubramanian et al., 2007). Rice can be cultivated under diverse environmental conditions which may include and not limited to dryland, rainfed wetland, deepwater and mangrove swamps, and irrigated wetland (Balasubramanian et al., 2007). Seed is one of the three basic elements for crop production and help to increase agricultural productivity as it provides the maximum limit of crop yield for all other production inputs. Unlike fertilizers and pesticides, farmers cannot produce without seed (Miva et al., 2017). However, seeds carry pathogens such as fungi, bacteria, nematodes and viruses responsible for transmitting seed-borne diseases, which often cause partial or total crop losses (Barret et al., 2015). When seed has good physical, physiological, health and genetic qualities, farmers have greater prospects of producing a good crop (Miva et al., 2017). Plant latex is a natural plants polymer secreted by highly specialized cells known as laticifers (Hagel et al., 2008) and mainly flow inside laticifers including roots, stems, leaves and fruits of all flowering plants (Pickard, 2008). Studies have revealed the antimicrobial potential of latex-bearing plants. It is considered as analogous to animal venom because it contains cysteine proteases, which provide defense against herbivorous insects (Kitajima *et al.,* 2010) and phytopathogenic fungi (Souza et al., 2011). Similarly, both osmatin and thumatin proteins isolated from *Calatropis procera*, were found effective against fungi *Fusarium solani* and *Colletotricum gloeporiodes* (Larhsini et al., 1997). Similar activity is reported in *Pulmera rubra* and *Euphorbia tirucallai* latex proteins against phytopathogens (Souza et al., 2011). Though plant lattices have been used in controlling pant pathogens in certain crops, their efficacy in controlling seed-borne infections of fungal pathogens in rice seeds has not yet been critically evaluated. Therefore, the needs to: determine the incidence of seed borne fungi in stored rice seeds and the effects of the plant lattices on the mycelia growth of fungi.

MATERIALS AND METHODS

The experiments were conducted at the Plant Pathology Laboratory, Federal College of Agriculture, Ishiagu Ebonyi State, Nigeria.

Source of the rice cultivars and two plant lattices

The four rice cultivars (Chinyere, Local foreign, FARO-44 and FARO-45) were source from the local farmers in Ishiagu while Physic nut (*Jatropha curcas)* and Sodom apple (*Calaropis pricera)* latex were source from Amagu community, Ishiagu Ebonyi State, Nigeria

Sterilization of materials

Glass Petri dishes were surface sterilized in a hot air oven at 160 ^{o}C for 2 hours to ensure proper sterilization. Pair of forceps were also surface sterilized by dipping in 95% alcohol and flaming in red hot.

Preparation of potato dextrose agar (PDA)

The potato dextrose agar (PDA) was prepared by weighing 39 g of PDA powdered. This was poured into sterile distilled water (SDW) in a conical flask and make up to 1.0 litre. The flask was stirred gently to allow dispersion of the PDA powder in the added water. The PDA medium contained in the conical flask was plugged with cotton wool and covered with the aluminium foil paper which were later sterilized in an auto clave at 121^{o}C for 15 mins. The sterilized medium was subsequent allowed to cool to 45% and streptomycin at the rate of 20m/L were added and poured aseptically into 9 cm diameter Petri dishes covered and allowed to solidity.

Isolation of fungi from infected rice seed

Infected rice seeds were surface sterilized (1% NaOCl) for 1 min and rinsed in three changes of sterile distilled water), dried on sterile tissue paper and plated on 0.3 ml streptomycin amended PDA medium. Five replicate pieces from each of the infected seeds were plated on each plate. The plates were incubated at temperature of 28-30 ^{o}C for 5 days. Fungal growths associated with the infected seeds were observed and detailed structural features of each isolate were compared with those described in a standard manual of fungi (Barnett and Hunter, 1999).

Percentage (%) occurrence of fungus isolated

The percentage of occurrence of isolated fungi were calculated by multiplying fungi isolated with 10 and equally divided by the total number of fungi isolated.

Effects of plant lattices on fungal growth

Effect of plant lattices on mycelia growth with test fungi were done using food poisoning techniques (Sangoyomi, 2004) 1ml of each plant lattices were dispensed per Petri dish and 9ml of the media (PDA) were added to each of the Petri dishes containing latex and carefully spread evenly over the plate. These were used for the inhibition of mycelia growth. The plates were gently rotated to ensure even dispersion of the latex. The agar latex mixture was allowed to solidify and then inoculated at the center with a 4 mm diameter mycelia dice obtained from the colony edge of 5-day old pure cultures of test fungi. Each treatment consists of three replicates. The negative control sample consist blank agar plate (no latex) inoculated with the test fungi as described above. All the plates were incubated at 25^{o}C for 5 days and examined daily for growth and presence of inhibition. Colony diameter were taken as the mean growth along two directions on two predawn perpendicular lines on the reverse side of the plates. The effectiveness of the latex was expressed as percentage reduction of mycelial growth using the formula adopted from Egbontan et al. (2014):

$$M_p = \frac{M_1 - M_2}{M_1} \times 100$$

Where M_p is percentage reduction of mycelial growth, M_1 is mycelial growth in Petri dish and M_2 is mycelial growth in Petri dish containing latex.

Statistical design and Analysis

The experimental design was Completely Randomized Design (CRD) with three replications. Treatments means was subjected to analysis of variance (ANOVA) using Minitab Version 17 and the means separated using Tukey at $p \leq 0.05$.

RESULTS

Identification and percentage of occurrence of fungi isolates associated with stored rice seeds

The result of the study revealed that the fungi incidence on the stored rice seed in Ishiagu, Ebonyi State, Nigeria. The isolated fungi organisms were *Fusarium oxysporum, Magnaporthe oryzae, Aspergillus niger and Aspergillus flavus*. The incidence of the organisms varies significantly from one isolate to others. *Fusarium oxysporum* (58.33%) had the highest percentage of occurrence, followed by *Aspergillus flavus* (22.22%) while *Aspergillus niger* (8.33%) had the least (Figure 1).

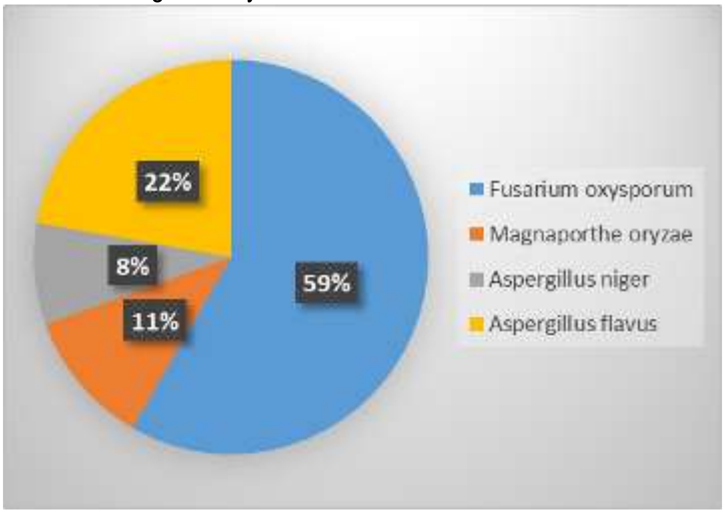

Figure 1. Percentage of occurrence of fungal isolates associated with stored rice seeds

Distribution of the fungi organisms isolated from four rice seed cultivars in storage

Table 1 showed the distribution of the fungi organisms isolated from four rice cultivars in storage. The percentage distribution of 66.11 %, 22.22 %, 25.00 % and 16.67 % were obtained for the FARO-44, FARO-45 and Local foreign respectively.

Table 1. Distribution of the fungi organisms isolated from four rice cultivars in storage

S/N	Rice cultivars	*Fusarium oxysporum* (n)	*Magnaporthe oryzae* (n)	*Aspergillus flavus* (n)	*Aspergillus niger* (n)	Distribution (%)
1	Chinyere	8	1	3	1	36.11
2	FARO-45	6	1	0	1	22.22
3	Local foreign	3	2	4	0	25.00
4	FARO-44	4	0	1	1	16.67

n= number of isolates

Effect of plant lattices on the mycelia growth of fungi isolates

Table 2 revealed the effects of two plant lattices on the mycelia growth of fungal isolates associated with rice seeds. The results showed a significant difference ($p > 0.05$) among the three isolates with the two plants lattices. *Fusarium oxysporum* (67.24%) had the highest mycelia inhibitive with the *J. curca*s latex followed by *Magnaporthe oryzae* (28 55%) while *Aspergillus niger* (24.52%) had the least. Similarly, the latex of *Calatropis procera* showed higher mycelia inhibition of 54.52% on *Fusarium oxysprum*, followed by *Aspergillus niger* (22.22%) while *Magnaporthe oryzae* (20.98%) had the least.

Table 2. Effect of plant lattices on the mycelia growth of fungi isolates

Isolates	*Jatropha curcas*	*Calatropis procera*
Magnaporthe oryzae	28.55^b	20.98^b
Aspergillus niger	24.52^b	22.22^b
Fusarium oxysporum	67.24^a	54.52^a
Means	40.10	32.57
Standard error	7.34	5.92
Coefficient of variation (%)	54.92	54.53

Means that do not share a letter are significantly different at P≤ 0.05 using Turkey.

DISCUSSION

The present study revealed four fungi isolated belonging to three genera that were associated with farmers stored rice seeds in previously harvested rice seeds in Ishiagu. The fungal isolates were *F. oxysporum, A. niger, A. flavus and M. oryzae*. Bhuiyan et al. (2103) revealed that a total of seven seedborne fungi were associated with forty rice seed samples. Furthermore, Bhuiyan et al. (2103) reported that the isolated fungus were *Bipolaris oryzae, Alternaria padwicku, Sarocladinum oryzae, Currularia lunata, Aspergillus niger*. Similarly, Yekini and Afolabi (2020) stated that *F. oxysporum, C. lunata, M. oryzae, A. niger, Sclerotium oryzae and Penicillium* species were associated with rice seeds. Moreover, the effect of *J. curcas* and *C. procera* latex on the mycelia growth of the tested isolated showed that a positive response in reducing their growth. Kitajma et al. (2010) stated that plant telex is considered as analogous to animal venom because it contains cysteine proteers which provide defense against herbivores insects. Lartex from *Hancornia* species (Apocynaceae) has shown activity against *Klebsiella, Pantoea, Enterobacter and Burkholderia* (Silva et al., 2011), while *Heven brasilensis* latex shows antifungal activity *Trichosporum cutaneum and Cryptococus neoformaus* (Giordani et al., 1991).

CONCLUSION

In conclusion, the present study revealed *F. oxysporum, M. oxyzae, A. niger and A. flavus* as seed borne fungal isolates associated with stored rice seed in Ishiagu. The study also revealed the different level of occurrence of each isolates on the five rice varieties. Likewise, the present study reveals the effect of two plant lattices; *J. curcas* and *C. procera* on the mycelia inhibition of the isolates which is worth note.

RECOMMENDATION

This study, therefore, recommended that seed health test should be carried out before sowing or planting in agricultural field. Moreover, the stakeholder should set up a modality to educate and trained rice farmers on seed testing before sowing. Pathogenicity of the isolates should be conducted to determine the casual organisms of the symptoms. The two plant lattices should also be further tested on other fungal isolates and *in-vivo*.

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FILAMENTOUS FUNGI AND THEIR TOXIGENIC IMPACTS ON STORED COCOA BEANS

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ABSTRACT

Storage filamentous fungi (moulds) are a form of fungal pathogens which cause major spoilage of stored cocoa beans and other foods/animal feeds. The beans are susceptible to fungal spoilage during and after fermentation. Contamination of the commodity by storage fungi of the Aspergillus, Penicillium and Fusarium genera often results in the production of secondary metabolites known as mycotoxins within the commodity. They include aflatoxin (AFs), ochratoxin A (OTA), zearalenone, trichothecenes and fumonisins, and are of high occurrence and toxicity. Mycotoxin contamination of cocoa beans and other stored food/plant materials has remained a threat to human as well as animal health and existence. Consumption of such food results in some carcinogenic, teratogenic, immune suppressive, or estrogenic effects in the human body, coupled with serious economic losses. Mycotoxins particularly target vital organs (the liver, kidney) of the body and the nervous as well as immune systems. Protection of consumers from the risks of mycotoxin contamination of stored cocoa beans and other foods has as a result, become pertinent. Practical steps must therefore be taken by experts towards effective control of mycotoxin production in stored products. Contamination reduction interventions/protocols are of great importance in resolving this impasse.

Key words: Mycotoxins, cocoa beans, storage moulds, contamination

INTRODUCTION

Fungi are ubiquitous pathogens that are major spoilage agents of foods and feedstuffs. The infection of plants by various fungi not only results in low crop yield and quality with sufficient economic losses but also causes contamination of grains with poisonous fungal secondary metabolites called mycotoxins. Cocoa is one of the important ingredients in several kinds of foods, such as cakes, biscuits, child-foods, ice creams and sweet consumed in developed countries. Cocoa beans originating as seeds in food pods of the tree *Theobroma cacao* are a source of cocoa powder. Neither storage nor processing conditions of cocoa are strictly controlled in most tropical countries Fungi contamination is therefore possible at many critical points in cocoa production chain (Magan and Aldred, 2005).

Cocoa beans are susceptible to fungal spoilage during and after fermentation. Filamentous fugal species (moulds) belonging to the genera *Aspergillus, Mucor, Penicillium* and *Rhizopus* are of great importance in this regard. Recently, *Aspergillus* species were the most frequently isolated fungi from samples of ground cocoa based beverage (Oyetunji, 2006). Furthermore, many fungi perticularly from the genera *Aspergillus* and *penicillum* produce mycotoxins that cause acute or chronic intoxication and damage to humans and animals after ingestion of contaminated food and feed. (Brera et al., 2005). Among the mycotoxins, aflatoxin (AFs) and ochratoxin A (OTA) are of special interest given high occurrence and toxicity. Aflatoxins are hepatoxic, teratogenic, mutagenic and carcinogenic mycotoxins produced by members of *Aspergillus* mainly *A. flavus* and *A. parasiticus.* The most potent of the four naturally occurring AFs (B_1, B_2, G_1 and G_2 is aflatoxin B_1 (AFB_1) (Horn 2007).

Beside AFs, some *Aspergillus flavus* strains, together with strains belonging to the species *Aspergillus tamari* also included in the section *flavi,* are reported to produce cyclopiazonic acid (Horn 2007). This mycotoxin is a specific inhibitor of calcium dependent ATpase which is toxic to animals and humans (Abouzied *et al.,* 2002). Ochratoxin A (OTA) is mainly a mycotoxin with nephrotoxic effect and has been associated with Balkan Endemic Nephropathy (Abouzied et al., 2002).

The quality of cocoa beans is highly dependent on processing technologies and storage conditions for preventing the defective quality. Furthermore, storage and processing conditions of raw cocoa in the producing countries are not very safe and mycotoxigenic fungi contamination may be possible at many critical points of the producing chain.

Drying limits mould growth during transportation, and storage reduce raw cocoa bean moisture content from 60 to 8%. Exposure of raw cocoa to high moisture levels is most likely to occur at stages between postharvest and final consumption. Inefficient drying systems can also lead to fungal activity. Fungal spoilage of crops will depend on cultivation, harvesting, handling, transport, and post-harvest storage and marketing conditions. Fungal activity can result in contamination with mycotoxins and could pose a health risk to the consumers. So, it is important to identify fungal contaminants in raw cocoa beans because some moulds can grow and produce mycotoxins on these commodities while certain moulds can cause infections or allergies.

Mycotoxins are toxic compounds that are naturally produced by certain types of filamentous fungi (moulds). Moulds that can produce mycotoxins grow on numerous foodstuffs such as cereals and dried fruits such as cocoa, nuts, and spices. Mould growth can occur either before harvest or after harvest, during storage, on the food itself often under warm, damp and humid conditions. Most mycotoxins are chemically stable and survive food processing. The following fungi (namely: *Aspergillus niger, A. flavus, Botryodiplodia theobromae, Fusarium* spp., *Mucor* spp., *Neurospora* spp., *Penicillium* spp., and *Phytophthora palmivora.*), were consistently isolated from mouldy cocoa bean samples. All these fungi were isolated using different methods such as washing, direct and dilution plate methods (Bhat et al., 2010).

CONDITIONS THAT ENCOURAGE PRODUCTION OF MYCOTOXINS

Mycotoxins can be synthesized under suitable biological, chemical and physiological conditions. Production of toxin is influenced by some ecological and environmental factors such as temperature, type of substrate, moisture content, relative humidity, water activity, occurrence with other fungi, physical damage by insects, use of fungicides, and storage condition. Due to the high temperature and humidity conditions in tropical and subtropical regions, high presence of mycotoxins can be expected (Bhat et al., 2010).

Stored crops under temperatures (28 to 31 ◦C), and high relative humidity (50% to 60% and 70% to 80% during the dry and wet seasons, respectively) conditions can easily be contaminated by mycotoxin-producing fungi. Other factors such as poor harvesting practices, improper processing, packaging, drying techniques, and transport activities influence fungal growth and increase the risk of mycotoxin production (Bhat et al., 2010). Climate changes seem to be another important factor affecting mycotoxin contamination of foods and feedstuffs (Paterson and Lima, 2010). Depending on the geographical and climate conditions, different fungal species can infect foods and feedstuffs. *Aspergillus, Penicillium,* and *Fusarium* species are the most important mycotoxin producers. *Penicillium* and *Aspergillus* species can grow at higher temperature and lower water activity than *Fusarium*. *Fusarium* species grow well at higher water activity and lower temperature. *Aspergillus* species can be found on nuts, cereals, palm kernels, cocoa, and coffee beans (Bhat et al., 2010).

IMPACTS OF MYCOTOXINS ON MAN'S WELL-BEING

Mycotoxin contamination of foodstuffs is a worldwide problem and a major health threat for humans and animals that cause significant economic losses in both developing and developed countries. Mycotoxin contaminations of agricultural crops pose significant economic losses to both crop producers and handlers who have to give market discounts for the contaminated products. In cases of severely contaminated crops, they have to dispose of the product.

Other economic losses related to mycotoxin contamination of foodstuffs are loss of business and product recall. Cereals (wheat, rice, maize, and sorghum), oilseed (sunflower, peanut, cottonseed, and soybean), spices (black pepper, chillies, turmeric, coriander, and ginger), tree nuts (pistachio, almond, coconut, and walnut) are the most important agricultural commodities that can be contaminated with mycotoxins. Mycotoxins may be inhaled, ingested or absorbed through the skin. No matter how mycotoxins enter the body system, they can cause sickness, lower performance, or death in both animals and humans (Bankole and Adebanjo 2004). Mycotoxicosis is the consequence of

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ingesting mycotoxin-contaminated food or feed by higher animals. Consumption of mycotoxin-contaminated food or feed results in acute or chronic consequences such as carcinogenic, teratogenic, immune suppressive, or estrogenic effects. Common symptoms of mycotoxicosis in human are diarrhea, vomiting, and gastrointestinal problems (Bhat *et al.,* 2010).

DIFFERENT TOXINS PRODUCED

Aflatoxins (AFs)

Aflatoxins are primarily hepatotoxic and they are also secondary metabolites produced by some members of the *Aspergillus* genus. Aflatoxins are difuranocoumarin derivatives, which are produced by *Aspergillus flavus* and *Aspergillus parasiticus* which are highly toxic, carcinogenic, immunosuppressive, teratogenic, and mutagenic compounds. Aflatoxins are usually found in agricultural products such as cereals (rice, wheat, maize, barley, and sorghum), spices (black pepper, chili, ginger, coriander, and turmeric), and fat-containing crops including tree nuts (pistachios, almonds, walnuts, and Brazil nuts), peanuts, and oilseeds (cotton, sunflower, sesame, and soybean). The negative effects of Aflatoxin(AFs) have been linked to kwashiorkor, low levels of secretory immunoglobulin A (IgA), loss of weight among children (Bhat et al., 2010). They were also found in the tissues of patients suffering from Reye's syndrome that is characterized by encephalopathy and visceral deterioration. Patients suffering from Reye's syndrome show kidney and liver enlargement and cerebral edema (Zain, 2010)

Ochratoxin (OTA)

Ochratoxin is the second most important mycotoxin. Ochratoxin A is the major mycotoxin of this group which is usually produced by *Aspergillus ochraceus* and *Penicillum verracosum* (CAST, 2003). Other fungi like *Asppergillus niger* group may be important in some commodities (Tjamos et al., 2004). Ochratoxin has been regarded as being produced in storage conditions which favor mold growth and toxin production. Grains that have musty odor should be suspect for mycotoxins and ochratoxin (CAST, 2003). Human exposure to OTA usually occurs through the consumption of improperly stored food products. OTA can be determined in the tissues and organs of humans and animals (including breast milk, meat, and blood). The adverse effects and toxicity of ochratoxin show that is a liver toxin, and tumors of the upper urinary tract have been associated with exposure to ochratoxin. Ochratoxin induces apoptosis in human lymphocytes and neuronal cells. Induction of apoptosis in neuronal cells contributes to the pathogenesis of neurodegenerative diseases. In a human, ochratoxin is distributed through the blood mainly to the kidneys, but in animals, it has been shown to be accumulated in body organs and tissues such as meat, liver, and kidney. Evidence has shown that exposure to OTA can cause problems for kidneys (functional and morphological changes) and some harmful effects on the liver and heart. Furthermore, OTA can cause morphological abnormalities, gastrointestinal/renal tissue lesions, lymphoid tissue lesions, blood clotting, and reduction in egg production (Bhat et al., 2010).

Zearalenone (ZEN)

This mycotoxin co-exists with deoxynivalenol (DON) as the same organism *Fusarium graminearum* or *Fusariumculmorun*. Chemically, it'sa phenolic resorcyclic acid lactone that is estrogenic when consumed by animals (CAST, 2003). The adverse effects of zearalenonne (ZEN) can cause infertility, abortion, reproduction problems (especially in swine), and is associated with cervical cancer. ZEN has the ability to disrupt sex steroid hormone functions and its metabolite. ZEN and its metabolites bind to estrogen receptors and activate gene transcription. Besides, they interfere with the regular activity of the endocrine glands (Bhat et al., 2010).

Trichothecenes

Trichothecenes are produced by *Fusarium* spp. These includes DON, T-2 toxin, diacetoxyscirpenol, and nivalenol (Glenn, 2007). Trichothecenes are produced by several fungal genera such as *Fusarium, Trichoderma, Myrothecium, Stachybotrys, Trichotecium,* and Phomopsis. Trichothecenes inhibit DNA and protein syntheses, but no mutagenic or carcinogenic effect has been reported. The main target affected by trichothecenes is the digestive system. DON and T-2 toxin affect immunity by inhibiting protein synthesis and cell proliferation. DON decreases antibody and immunoglobulin levels in the body (Bhat et al., 2010).

Fumonisins (FMNs)

Fumonisins are one of the main mycotoxin classes of concern produced by *Fusarium species* (Glenn, 2007). *Fusarium species* are able to cause seedling diseases, stalk rots, ear rots, root rots, and kernel damage. FMNs have been found in several agricultural products including corn products, medicinal plants, herbal tea, dried figs, and bovine milk. There is not enough evidence for human health hazard related to FMN contaminated food, the chronic effects of FMN is in animals which include impairment in the basic immune function, kidney and liver damage, respiratory difficulties, heart problems, reduction in milk production, weight reduction, and increase in mortality rate. Another sign of FMN toxicosis in dairy cattle included elevated serum enzyme activity of diagnostic liver enzymes that show mild hepatocellular injury (Moretti et al., 2010).

CONCLUSION

Mycotoxins are microbial secondary metabolites often produced by moulds of the *Aspergillus, Penicillium* and *Fusarium* genera. Mycotoxin contamination of cocoa beans and other stored food/plant materials has remained a threat to human as well as animal health and existence. They are carcinogenic, and negatively affect vital organs like the kidney, liver, as well as the nervous and immune systems of the body. Zearalenone is capable of causing hormonal dysfunction, abortion, infertility and other reproduction problems (especially in swine). In order to protect consumers from the risks of mycotoxin contamination of stored cocoa beans and other foods, maximum permissible levels have to be generated and subjected to control by regulatory body. Practical and more proactive steps however need to be taken by experts towards the control and mitigation of mycotoxins at storage. Intervention and reduction protocols for contamination in food commodities are also needed.

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ENVIRONMENTAL IMPACT ON INCIDENCE AND SEVERITY OF FUSARIUM WILT OF RADISH (R*APHINUS SATIVUS* L.) IN NSUKKA, NIGERIA

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ABSTRACT

Leaf samples of Raphinus sativus were collected and subjected to routine laboratory studies to determine the incidence and severity of fusarium wilt of radish from two environments (open field and high tunnel) in Nsukka, Enugu State of Nigeria. The study was carried out between March and May 2018. Thirty leaves were sampled in each environment and the samples taken using two longitudinal transepts. Result obtained from the laboratory analysis showed the presence of Fusarium oxysporum the causative organism of fusarium wilt of radish. The disease incidence was high with 57% and 70% at 2 and 3 weeks after planting respectively. Disease severity records showed 34.7% and 38.3% at 2 and 3 WAP respectively. Significantly high incidence of fusarium wilt were recorded in open field (43.3%) compared to high tunnel (16.7%), while the disease severity in open field was higher with 26.7% compared to high tunnel showing 5% severity at 3 weeks after planting.

Key words: Radish, disease, fusarium, environment, incidence, severity.

INTRODUCTION

Radish (*Raphinus sativus* L.) belongs to the family Brassicaceae, a popular root vegetable in both tropical and temperate regions. It is an edible plant, with a globular root that has a bright pink external layer and a white pulp. The root of this plant is the part consumed. One of the unique features of this plant is its short cycle, of approximately 30 days, which permits rapid gains of working capital (Rodrigues et al., 2013). *Raphanus sativus* is originally from Europe and Asia. It grows in temperate climates at altitudes between 190 and 1240m. It is predominantly a cool season vegetable crop. Being a cool season crop, it is sown during winter from September to January in northern plains. It is an annual or biennial crop depending upon the type and for the purpose it is grown (PCARRD, 2007).

Radish is one of the major vegetable crops in the Philippines. Due to its popularity, radish is often planted in many home gardens or raised commercially in the field. It is highly appreciated by consumers for its pungent taste. It could be eaten raw in salads, prepared as pickles or cooked with fish, meat and shrimp and other meals. Usually, people eat radish raw as a crunchy vegetable, mainly in salad, while it also appears in many European dishes. Some people prefer to drink its juice in pursuit of certain health benefits, as it has been reported to show antimicrobial activity against *Bacillus subtilis, Pseudomonas aeruginosa* and *Salmonella thyphosa*. In addition, the ethanolic and aqueous extracts have also shown antimicrobial activity against *Streptococcus mutans* and *Candida albicans*, *Sarcini alutea* and *Staphylococcus epidermidis (*Shukla et al., 2011*)*.

The roots are the most valuable and edible part of radish, although the stem and leaves have also been used for food flavoring or preservation (Beevi et al., 2009). As similar to other cruciferous vegetables, the nutritional value of radish is derived from its content of many essential minerals and vitamins, carbohydrates, high content of fiber, and low content of fat (Manchali et al., 2012). Radish has also valuable medicinal properties. It is widely used in traditional medicine in various parts of the world for treatment of different ailments and disorders affecting the respiratory, urinary, gastrointestinal systems, anemia, female, male infertilityand the skin (Aruna et al., 2012). The leaves and roots are also used as antimicrobial agents (Guti´errez and Perez, 2004). Many of the pharmacological activities of radish are attributed to the occurrence of a wide range of secondary metabolites, including alkaloids, phenolics, flavonoids (including anthocyanins), coumarins, carotenoids, antioxidant enzymes, terpenes, glucosinolates, and other compounds (Shin et al., 2015).

Radishes have different skin colors (red, purple, black, yellow, and white through pink), while its flesh is typically white. In addition, the edible root of radish varies in its flavor, size, and length throughout the world.

Fusarium wilt of radish caused by *Fusarium oxysporum* is one of the major diseases affecting the growth and yield of radish and causing annual yield losses in producing areas. Symptoms include leaves turning yellow on one side of plant; leaves fall from plant leaving a defoliated stem. Fungus can survive in soil for many years and can be spread to new areas via infected transplants, soil, insects or infested equipment. It may also be spread via infected water or by wind. The disease can be effectively managed and controlled by planting resistant radish varieties; once the pathogen has established, very little can be done to control it; spread can be prevented by sanitizing all equipment regularly; do not plant susceptible crops in previously infested soils and control of insect pest that can transmit the disease or harbor the pathogen (Thamburaj and Narenda, 2001).

The term "high-tunnel" often called a hoop house, is currently used to describe structures with a single or double (inflated) layer of polyethylene film stretched over hoops of metal or polyvinyl chloride (PVC). High-tunnels (HTs) in contrast to greenhouses, regardless of materials used, are not artificially heated or cooled, but rely on passive ventilation, which saves cost of both construction and maintenance. Tomatoes, peppers, cucumbers, melons, lettuces, summer squash and eggplants are the primary vegetable crops grown in High-tunnels with small fruit (berries) and tree fruit gaining importance.

MATERIALS AND METHOD

Study location

The experiment was conducted at the Research Laboratory of the Department of Microbiology University of Nigeria, Nsukka.

Collection of samples

Thirty leaves sample were collected at random from two environments (open field and high tunnel) in the experimental field where radish was grown, samples were thoroughly washed in sterile water. Thereafter, the infected tissues along with adjacent small unaffected areas were cut into small pieces of 2–5 mm squares and transferred by using flame-sterilized forceps to sterile Petri dishes containing 0.1% mercuric chloride solution.

Preparation and sterilization of media and glass wares

Potato Dextrose Agar (PDA) which contains 200.0g of peeled potato, 20.0g of Dextrose, 20.0g of Agar and 1000.0ml of water was prepared and sterilized for 20 minutes at 121°C for 15 minutes at 15psi in an autoclave.

Isolation of Fungi from Samples Collected

The tissue pieces were surface sterilized in this Sodium hypochlorite (1%) for 30–60 sec and washed in sterile water two or three times. The tissue pieces were aseptically transferred to Petri dishes containing a nutrient medium (Potato Dextrose Agar) supplemented with streptomycin sulfate at the rate of three pieces per plate. The plates are incubated at room temperature (25°–27°C).

Morphological Identification of fungi Isolates

Isolated fungi were identified based on colony and morphological characteristics such as colour and shape. The Morphological characteristics and appearance of the fungal isolation was confirmed and authenticated with the help of Mycological Atlas.

Microscopic Identification of Isolates

Slide Culture Technique

Slide cultures were prepared for fungal staining. For this, PDA agar blocks of the size of a cover slip were cut and placed on a sterile microscopic slide over a sterile 'V shaped" glass rod in a Petri dish. The agar block was then inoculated with the fungus on all the edges. A sterile coverslip was kept over the agar and the set up was then incubated at room temperature. After the growth of the fungus, the cover slip was carefully removed and stained with Lactophenol blue and was observed under a bright field microscope (Olympus, Model BX43) with ×10 and × 40 objectives.

Disease Incidence and Severity

Disease incidence for each environment was determined by counting the total number of plants sampled and the number of plants showing disease symptoms and calculated using the formula below:

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$$\text{Disease Incidence} = \frac{\text{Total number of plants showing symptoms}}{\text{Total number of plants sampled}} \times 100$$

Disease severity was scored at intervals on a 6-point scale (Nwufo and Ihejirika, 2008):

Disease Estimation (%)	Scale	Interpretation
0	0	No infection
1- 20	1	Slight infection
21- 40	2	Moderate infection
41- 60	3	Severe infection
61- 80	4	Very Severe infection
81- 100	5	Completely infected and death

$$\text{Disease severity index} = \frac{\text{Sum of disease scores}}{\text{Total number of plant sampled} \times \text{maximum score}} \times 100$$

RESULTS AND DISCUSSION

The result obtained from the laboratory for disease isolation and identification showed *Fusarium oxysporum* causing Fusarium wilt of radish to be associated with the crop. There was high significant incidence of the disease of 57% and 70% at 2 and 3 weeks after planting in March 2018 (Figure 1). There was average severity of the disease, 34.7% and 38.3% at 2 and 3 weeks after planting, respectively (Figure 2).

In April 2018, there was significantly high incidence of 43.3% in the open field and a moderate incidence of 16.7% in the high tunnel (Figure 3), while for disease severity; the open field had a moderate severity of 26.7% and the high tunnel had a relatively low severity of 5% at 3 weeks after planting (Figure 4).

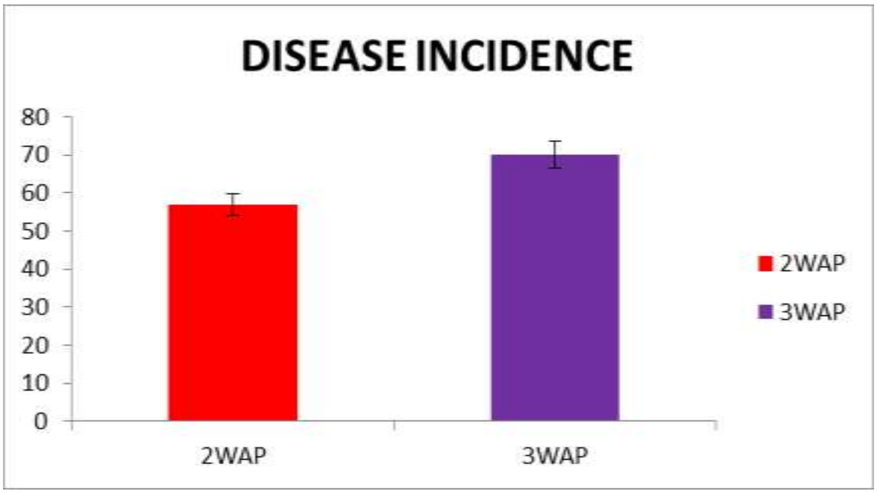

Figure 1. Disease Incidence (%) at 2 and 3 Weeks after Planting in March 2018

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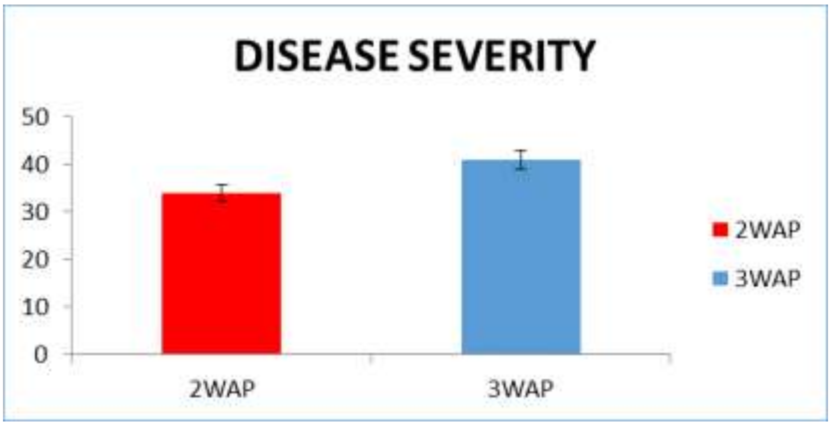

Figure 2. Disease Severity (%) at 2 and 3 Weeks after Planting in March 2018

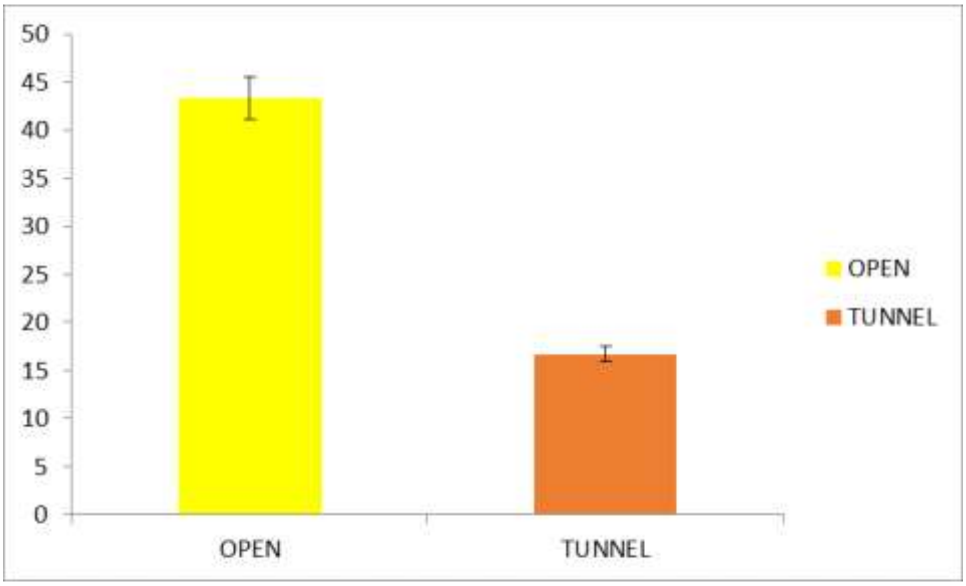

Figure 3. Disease Incidence (%) under Open and Tunnel in May 2018

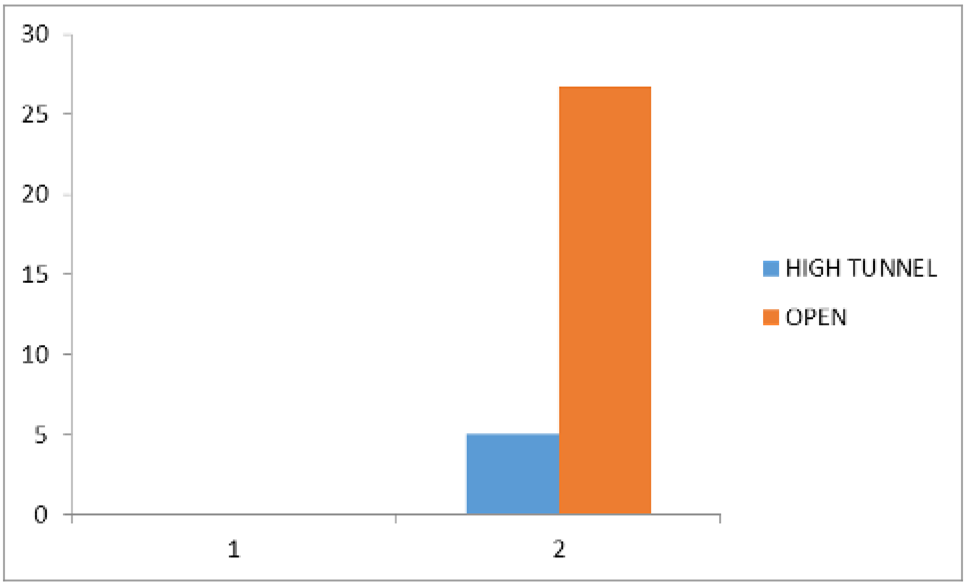

Figure 4. Disease Severity (%) under Open and Tunnel in May 2018

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Results showed that the disease incidence and severity of Fusarium wilt of radish were significantly higher in the month of March than in April and May 2018, this could be attributed to the fact that both the presence and virulence of a pathogen are higher when environmental conditions are favorable as the pathogen is favoured by high temperature range of 25 to 30°C, warm moist soils and relative humidity of 70%. The relatively high temperature of 31.9°C and relative humidity of 52.0% in the month of March (Tables 2 and 3) favoured the development of the pathogen. Likewise, there was significantly higher disease incidence and severity in the open field than in the high tunnel in both months of April and May. This conforms to the report of Rhonda et al., (2017), who reported that the incidence and severity of pest and diseases are usually reduced/lower in high tunnel.

Insect pests are known to be good vectors of plant diseases. The whitefly vector *Bemisia tabaci* is known to be a vector of several host including members of the family the family Brassicaceae which radish belongs. Most of the previous and surrounding crops in both environments (Table 1) were either solanaceous plants or crops which belonged to the same host range that are infected by the Fusarium disease pathogen. Fusarium wilt is a common vascular wilt fungal disease exhibiting similar symptoms to Verticilum wilt.

Table 1. Crop history and information

Location	Farm type	Cropping pattern	Age of plant (weeks)	Previous crop	Origin of seeds	Chemical treatment	Surrounding crop
Crop science teaching and research farm University of Nigeria, Nsukka	Pot experiment	Radish as a sole crop	2-3	Green pea (field) Green pepper (tunnel)	Certified source (Netherlands via Afri-Agro Ltd in Lagos)	Use of powdered and sprayed chemicals (pesticides, herbicides and fertilizers)	Pepper, cassava, cowpea, okra, solanum, cucumber, maize (field) Green pepper, passion fruit seedlings (tunnel)

Table 2. High-tunnel Temperature February 2018 – June 2018

Month	Rainfall (mm)	Temperature (°C) Min	Max	Relative humidity (%)
February	235.21	27.87	34.87	61.87
March	419.34	28.52	36.80	59.27
April	216.41	30.74	44.77	53.61
May	52.32	37.87	48.80	55.67
June	0.00	34.39	35.55	26.19
Total	923.28	121.52	200.79	256.61
Mean	184.66	24.30	40.16	51.32

Source: Meteorological station, Department of Crop Science, University of Nigeria Nsukka.

Table 3. Meteorological data for year 2018 in Nsukka Southeastern Nigeria

		Temperature (°C)		Relative humidity (%)
Month	Rainfall (mm)	Min	Max	
January	0.00	19.03	31.48	28.19
February	21.33	22.32	33.14	11.35
March	28.70	22.58	31.97	52.00
April	44.62	22.00	30.90	48.22
May	102.82	21.52	30.10	60.06

Source: Meteorological station, Department of Crop Science, University of Nigeria Nsukka.

The surrounding crops harbored pest like the whitefly (*B. tabaci*) and the variegated grasshopper (*Zonecerus variegatus*) which are known to be good vectors of many bacterial, viral and fungal diseases including Fusarium wilt of radish. One of the main reasons for the success of the whitefly as a pest and vector is its extreme polyphagy and was recorded on 506 plants species belonging to at least 77 families (Basu, 1995). Alegbejo and Banwo, (2005) reported whitefly to be a vector of plants in the family Solanaceae, Cruciferae and Brassicaceae to which radish belongs. Baiyeri and Soyeye (2019) also in an unpublished article reported the incidence of Fusarium wilt on green pepper which was the neighboring crop to the radish.

Lindsey and Pelter (2003) also used Potatoes Dextrose Agar to isolate *F. oxysporum* causing fusarium wilt of radish (*F. oxysporum* f.sp. raphani), it has also been previously reported in the USA in California. Symptoms progressed from yellowing of leaf, to general wilting and die back of plant. The host range of *F. oxysporum* f.sp. raphani is limited to radish. Leeman *et al*., (1996) reported that treatment of radish seed before planting has helped in suppression of *F. oxysporum* of radish in commercial greenhouses as symptoms were localized or expanded very slowly.

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SEROLOGICAL SURVEILLANCE OF EIGHT TOMATO VIRAL PATHOGENS IN SOUTHWESTERN NIGERIA

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ABSTRACT

This study was aimed at determination of the occurrence and prevalence rate of major viral pathogen infecting tomato in southwestern Nigeria. This was with a view to providing empirical information on the distribution of eight viruses of tomato crop in the study area. Two hundred and seventy-five (275) leaf samples from 16 major tomato producing towns spread across southwestern Nigeria were used for this study. The viruses studied were Tobacco mosaic virus (TMV), Tomato mosaic virus (ToMV), Tomato spotted wilt virus (TSWV), Tomato yellow leaf curl virus (TYLCV), Cucumber mosaic virus (CMV), Potato virus Y (PVY), Pepper veinal mottle virus (PVMV) and Tomato etch virus (TEV). Virus-specific antibodies were used for serological detection of viruses in leaf samples through enzyme linked immunosorbent assay (ELISA) techniques. The results of ELISA test revealed that 11 of the 16 areas surveyed recorded tomato viral incidence. Cucumber mosaic virus and ToMV were detected in the plant samples with percentage disease incidence of 19.27 (57/275) and 1.45% (4/275) in all eleven and two farm locations respectively. Tomato yellow leaf curl virus, TSWV, TMV, TEV, PVY and PVMV all recorded zero incidence. Samples from Ifo, Ogun State recorded the highest percentage incidence of CMV infection with 70%, followed by Ikorodu, Orile Ilugun, Iyana-Offa, Apomu, Alimosho, Sekona Ife, Eruwa, Ido, Iju-Atan and NIHORT with 66.67, 50, 32, 26.67, 20, 20, 20, 15, 13.33 and 6.67% respectively. Iwo, Araromi, Akure, Erio-Ekiti and Aramoko-Ekiti recorded no CMV disease incidence. Only Alimosho and Ikorodu recorded the presence of ToMV with percentage incidence of 20 and 13.33%, respectively. Mixed infections of CMV and ToMV were detected in Alimosho and Ikorodu. These data clearly revealed CMV as a major threat to tomato production while ToMV is an emerging virus in the area. However, PVY, TSWV, TEV, PVMV, TYLCV and TMV with zero incidence were unlikely threat to tomato production in the study area as at the time of report.

Key words: Tomato viruses, Southwestern Nigeria, Enzyme linked immunosorbent assay (ELISA).

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is a crop that is planted and consumed globally providing essential nutrients, antioxidants and phytochemical of medicinal value (Causse *et al*., 2002). It is a crop cultivated in Nigeria by all ethnic groups at both commercial and subsistent scale (Olaniyi *et al*., 2010). When compared with U.S.A and Taiwan, where yields as high as approximately 180 tons per hectare has been recorded (FAO, 2013), the yield of tomato in Nigeria is very low. The average in the western part of the country being only about 5 tons per hectare and 20 tons per hectare in areas of Northern Nigeria (Olaniyi *et al*., 2010). Southwest Nigerians therefore continually depend on tomatoes from the Northern region and imported processed tomatoes from foreign countries.

Most of the tomato farms in the Southwest Nigeria are perennially plagued by prevalence of observable viral-like symptoms of mottling, mosaic, leaf curl, necrosis, leaf distortion, stunting, wilting and plant death (Kayode, 2018). These symptoms of suspected tomato virus diseases are often consistently present at every planting season and farmers are usually confused about the implicated pathogen and control measures to be adopted. The high incidence of these viral-like symptoms is a major challenge to tomato cultivation in southwestern Nigeria leading to very low crop yield and poor market value of harvested fruits (Mohammed *et al*., 2017). In view of the potential devastating impact of some plant viruses on tomato crop production and the extremely low perennial yield in Southwestern Nigeria, there is need for a thorough research designed to study the distribution and prevalence rate of eight suspected viruses infecting tomatoes in the area.

The aim of this research work was to determine the occurrence and distribution of *Tobacco mosaic virus* (TMV), *Tomato mosaic* *virus* (ToMV), *Tomato spotted wilt virus* (TSWV), *Tomato yellow leaf curl virus* (TYLCV), *Cucumber mosaic virus* (CMV), *Potato virus Y* (PVY), *Pepper veinal mottle virus* (PVMV) and *Tomato etch virus* (TEV) in samples of tomato leaves collected from selected farms in major tomato producing areas in Southwestern Nigeria. The knowledge of the occurrence and prevalence rate of major tomato-infecting viruses in Southwestern Nigeria will give more insight on the integrated pest management strategy and the best tomato cultivation practice to be adopted in the control of the predominant tomato virus(es) in the study area.

MATERIALS AND METHODS

Collection of Samples

An unbiased random sampling was conducted by collecting fresh, young expanded leaves of tomato plants at regular intervals of 10 metres along the two diagonal paths of selected farms in 16 major tomato producing areas of southwestern Nigeria. The samples included symptomatic and asymptomatic leaves. The samples were preserved in air tight McCarthney bottle pre-loaded with silica gel (Sigma Aldrich) and covered with cotton wool. Two hundred and seventy-five (275) samples were collected over the six states of Southwest Nigeria. The sample sources, farm locations, global positioning system (GPS) coordinates and number of samples collected are shown in Table 1 and Figure 1. Virus-free, apparently healthy tomato plants were raised in the screen house and two healthy leaf samples were collected for use as negative controls.

Serological indexing for CMV and TSWV in leaves samples.

ELISA antisera sets and the respective controls were obtained from the Plant virus collection centre of Leibniz-Institut Deutsche Sammlung Von Mikroorganism und Zellkulturen Braunschweig, Germany (DSMZ). Antigen coated plate enzyme-linked immunosorbent assay (ACP-ELISA) method was used for the detection of CMV, Triple Antibody Sandwich ELISA (TAS-ELISA) was used for the detection of TSWV and TYLCV while Double Antibody Sandwich ELISA (DAS-ELISA) was used for the detection of PVY, TEV, ToMV, TMV and PVMV as described by the manufacturer's manual on ACP-ELISA, TAS-ELISA and DAS-ELISA available on:
https://www.dsmz.de/fileadmin/_migrated/content_uploads/ACP-ELISA.pdf
https://www.dsmz.de/fileadmin/_migrated/content_uploads/TAS_ELISA_01.pdf ,
https://www.dsmz.de/fileadmin/_migrated/content_uploads/DAS-ELISA_01.pdf, respectively.

Assessment of results were carried out through spectrophotometric measurement by placing the plate in the ELx 800 universal multiscan ELISA microplate reader provided with 405 nm filter (Bio-Tek Instrument Inc. Winooski, VT 05404, USA) and the readings were taken after 1 hour and overnight. Samples with values exceeding twice the reading of the healthy control were considered positive.

RESULTS

Incidence and distribution of viruses infecting tomato in southwestern Nigeria

Eleven of the sixteen areas surveyed recorded viral incidence. Two of the eight viruses surveyed were detected in the plant samples. These viruses were CMV and ToMV. CMV recorded its presence in 11 locations while ToMV recorded its presence in 2 locations. The ELISA result is presented on Table 4.

Out of 275 samples collected, 57 samples tested positive to the presence of the viruses. CMV had the highest incidence with 53 positive samples (19.27 %) followed by ToMV with 4 positive samples (1.45 %). TYLCV, TSWV, TMV, TEV, PVY and PVMV all recorded zero incidence. Ifo recorded the highest percentage incidence of CMV infection with 70 %, followed by Ikorodu 66.67%, Orile Ilugun 50 %, Iyana Offa 32 %, Apomu 26.67 %, Alimosho 20 %, Sekona Ife 20 %, Eruwa 20 %, Ido Ibadan 15 %, Iju-Atan 13.33 % and NIHORT 6.67 %. Iwo, Araromi, Federal College of Agriculture Akure, Erio-Ekiti and Aramoko-Ekiti recorded no CMV disease incidence. The percentage ToMV disease incidence on the farm areas were as follows: Alimosho 20 % and Ikorodu 13.33 %. Other areas recorded zero ToMV incidence. Mixed infections were detected in two areas. These included: Alimosho and Ikorodu with CMV and ToMV infections.

Table 1. Sample sources, farm locations and global positioning system (GPS) coordinates

Farm Location	State	Number of Samples collected	GPS Latitude	GPS Longitude
Sekona, Ife	Osun	10	N7° 37´ 36.354"	E4° 26´ 1.118"
Iwo	Osun	15	N7° 37´ 40.693"	E4° 9´ 40.708"
Araromi Town	Ondo	15	N6° 36´ 12.81"	E4° 29´ 34.271"
Federal College Agric.	Ondo	25	N7° 16´ 13.302"	E5° 13´ 26.607"
NIHORT Ibadan	Oyo	15	N7° 24´ 46.624"	E3° 51´ 51.179"
Iyana-Ofa	Oyo	25	N7° 30´ 1.87"	E4° 4´ 28.761"
Ido LGA	Oyo	20	N7° 23´ 3.175"	E3° 48´ 32.869"
Eruwa Road	Oyo	20	N7° 28´ 11.295"	E3° 45´ 11.738"
Erio-Ekiti	Ekiti	20	N 7° 43´ 42.186"	E4° 58´ 11.965"
Aramoko-Ekiti	Ekiti	25	N 7° 42´ 34.181"	E5° 03´ 01.952"
Orile Ilugun	Ogun	20	N 7° 14´ 37.175"	E3° 31´ 21.413"
Ifo	Ogun	10	N 6° 48´ 11.662"	E3° 12´ 29.471"
Apomu Phase 1&2	Ogun	15	N 6° 51´ 10.557"	E3° 11´ 46.522"
Iju-Atan	Ogun	15	N 6° 39´ 18.521"	E3° 4´ 24.471"
Alimosho	Lagos	10	N 6° 32´ 47.794"	E3° 14´ 17.703"
Ikorodu	Lagos	15	N 6° 37´ 9.887"	E3° 30´ 37.633"
TOTAL		275		

DISCUSSION

The result of the prevalence study revealed the presence of CMV in 53 out of 275 (19.27 %) samples from 11 of the 16 locations visited. This was followed by ToMV with an incidence of 1.45 % (4 out of 275 samples) spread across two Lagos farm areas while the PVY, TEV, TMV, PVY, TYLCV and TSWV all recorded no incidence. These findings is an indication that PVY, TEV, TMV, PVY, TYLCV and TSWV were unlikely to be a major threat to tomato production within the study area. CMV was uncovered as a major or leading viral pathogen of tomato plants while ToMV is an emerging tomato virus in the area.

The highest prevalence rate of CMV among the viruses surveyed in locations visited could be attributed to planting of infected seeds obtained from previously harvested tomatoes which had CMV infections and/or the availability of alternative host weeds and crops serving as CMV inoculum reservoirs due to the wide host range of CMV (Palukaitis and García-Arenal, 2003; Zitter and Murphy, 2009). In fact, CMV has the reputation of having the widest host range of any known plant virus and has a worldwide distribution causing economically important diseases in a large variety of crop plants.

Another possible contributory factor leading to high CMV incidence in most farms is the observable high population of the CMV-transmitting vectors (aphid species) in and around the farms. Therefore, the absence of one or two or all of the aforementioned scenarios may have accounted for the zero incidences of PVY, TEV, TMV, PVY, TYLCV and TSWV recorded in the farms visited. These observations are noteworthy given CMV is seed borne in tomato (Park and Cha, 2002), cannot withstand drying or persist in the soil (Kansas State University, 2007); not readily transmitted by handling infected plants (Edward, 1998) and no tomato variety is resistant to any of the 8 viruses (AVRDC, 2004).

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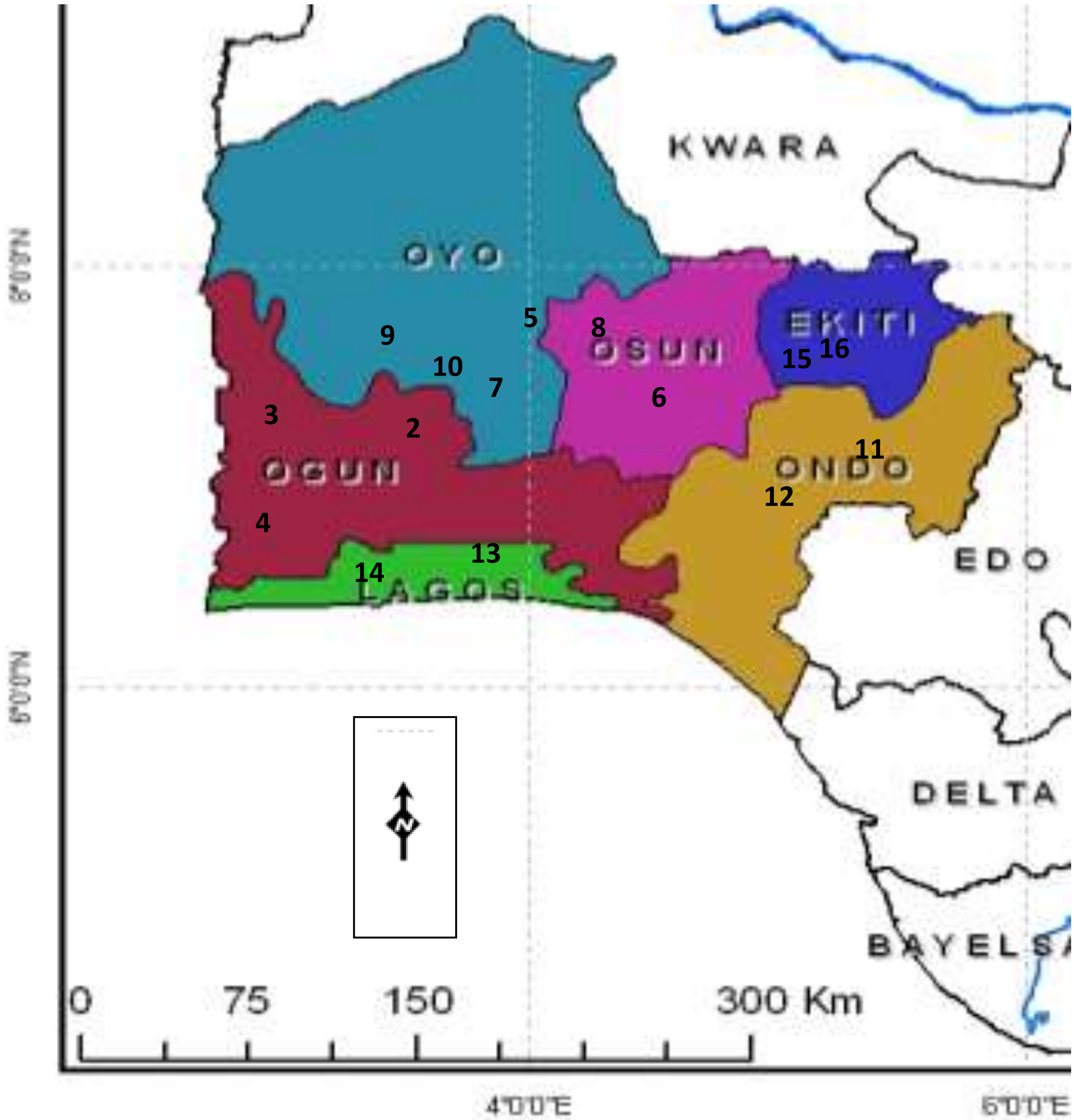

Figure 1. Map of Southwest geographic zone of Nigeria (coloured portion) showing the various sampling locations (Nigerian Expression, 2017).

KEY:

1- Ifo, Ogun State. 2- Orile-Ilugun, Ogun State. 3- Apomu Phase 1 and 2, Ogun State. 4- Iju-Atan, Ogun State. 5- Iyana offa, Oyo State. 6- Sekona, Osun State. 7- Ido LGA, Oyo State. 8- Iwo, Osun State. 9- Eruwa Road, Oyo State. 10- NIHORT Oyo State 11- Federal College of Agriculture, Akure, Ondo State. 12-Araromi Town, Ondo State. 13- Ikorodu, Lagos State 14- Alimosho, Lagos State. 15- Erio Ekiti. 16- Aramoko Ekiti.

The observations also corroborate the report of Mohammad (1999) that epidemic of CMV and other cucurbit viruses which are spread by aphids in a nonpersistent manner, depend on the abundance of virus-reservoir weed and crop host plants, the abundance of insect vectors, and the proximity of virus-infected source plants to the farms. The possibility of alternative crop hosts serving as significant sources of CMV for other crops has also been reported (Zitter and Murphy, 2009). The probable CMV host plant reservoir observed within the surroundings of the tomato farms visited included pepper, amaranth green, yam, cucumber, okra, *Petunia and Solanum* species.

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Table 4. ELISA result showing the incidence of tomato viruses in farm locations.

Farm Location	State	Number of Sample collected	CMV	PVY	TEV	ToMV	PVMV	TMV	TYLCV	TSWV
Sekona, Ife	Osun	10	2 (20 %)	0	0	0	0	0	0	0
Iwo	Osun	15	0	0	0	0	0	0	0	0
Araromi Village	Ondo	15	0	0	0	0	0	0	0	0
Federal College of Agric	Ondo	25	0	0	0	0	0	0	0	0
NIHORT Ibadan	Oyo	15	1 (6.7 %)	0	0	0	0	0	0	0
Iyana-Ofa	Oyo	25	8 (32 %)	0	0	0	0	0	0	0
Ido LGA, Ibadan	Oyo	20	3 (15 %)	0	0	0	0	0	0	0
Eruwa Road	Oyo	20	4 (20 %)	0	0	0	0	0	0	0
Erio-Ekiti	Ekiti	20	0	0	0	0	0	0	0	0
Aramoko-Ekiti	Ekiti	25	0	0	0	0	0	0	0	0
Orile Ilugun	Ogun	20	10 (50 %)	0	0	0	0	0	0	0
Ifo	Ogun	10	7 (70 %)	0	0	0	0	0	0	0
Apomu Phase 1&2	Ogun	15	4 (26.7 %)	0	0	0	0	0	0	0
Iju-Atan	Ogun	15	2 (13.3 %)	0	0	0	0	0	0	0
Alimosho	Lagos	10	2 (20 %)	0	0	2 (20 %)	0	0	0	0
Ikorodu	Lagos	15	10 (66.7 %)	0	0	2 (13.3 %)	0	0	0	0
TOTAL		**275**	**53**	**0**	**0**	**4**	**0**	**0**	**0**	**0**

The emergence of ToMV in the farms visited in Lagos could be attributed to one or more factors which included: poor sanitation, unhygienic farm practices, planting of ToMV infected seeds, cultivation of tomato on lands harbouring ToMV virion particles, continuous cropping on infected land due to scarcity of arable land, presence of alternative host crops or weeds serving as inoculum, use/consumption of tobacco products on the farms, susceptibility of many vegetable crops to ToMV (Yoon *et al*., 2002) and the exchange of infected plant materials and ornamentals between neighbouring countries and Nigeria since Lagos state is an entry point into the country.

All these observations are noteworthy considering the fact that ToMV has stable viral particles and mechanically transmissible by field workers and farming instruments which enable ToMV to spread readily and make elimination difficult (Aghamohammadi *et al*., 2013). In particular, tobamoviruses can survive for long periods in crop debris and on contaminated equipment (Broadbent, 1976). ToMV may be present in the endosperm of infected seeds and up to 94 % of the seeds may contain the virus (Broadbent, 1976). ToMV has also been isolated from different ecological niches, such as soil and even water samples (Jacobi *et al*., 1992; Castello *et al*., 1995; Fillhart *et al*., 1998). Most tobamovirus species are highly virulent in the field and management strategies for their control often have not been established successfully (Strasser and Pfitzner, 2007).

CONCLUSIONS

From the results of this present study, CMV remains a major threat to tomato production while ToMV is an emerging virus in the area. However, PVY, TSWV, TEV, PVMV, TYLCV and TMV with zero incidence may be considered unlikely threats to tomato production in the study area as at the time of this report.

RECOMMENDATIONS

To control the emergence and spread of ToMV within Southwest Nigeria, appropriate integrated pest management (IPM) strategy must be adopted. Integrated pest management should start with farmer's education on proper sanitation during farm operations since man is the principal vector transmitting the virus through cultural practices and contaminated equipment. Farmers should avoid planting of tomato on ToMV endemic farm land areas because infection can be easily introduced into tomato crops through root infection from contaminated soil and in particular, *Tobamoviruses* can survive for a long period in crop debris in the soil. Crop rotation especially planting of crops outside the solanaceous plant family should be implemented in ToMV affected areas and if possible planting of vegetables should be avoided for several years since many vegetables are susceptible to infection by *Tobamoviruses*.

Considering the fact that the presence of alternative host plants and availability of transmitting aphid populations are required for CMV outbreaks and epidemic in tomatoes, farmers should eradicate all perennial weeds and wild reservoir hosts in and around fields; maintain a distance of at least 5 metres between tomato farms and surrounding weeds; plant earlier to avoid high aphid populations that occur later in the season; plant late settings as far as possible from fields used to produce early tomatoes and peppers; scout fields for the first occurrence of virus disease (where feasible, pull up and destroy infected plants after spraying them thoroughly with an insecticide to kill any insects they may be harboring); use reflective mulches to repel aphids, thereby reducing the rate of spread of aphid-borne viruses; monitor aphid populations early in the season and apply insecticide treatments when needed. Safety standards and regulations must be adopted during application of insecticides to prevent food poisoning and health hazards.

ToMV and CMV as observed in this study have been shown to present many symptom variants, making these viruses often difficult to identify from symptoms alone, the production of affordable, rapid, easy-to-use, on-the-spot ELISA diagnostic kit should be encouraged and facilitated to enhance surveillance studies, early detection and control of outbreaks and epidemics in the study area.

Other management strategies for the control of viral diseases of tomato include: planting of virus-free seeds obtained from credible sources rather than collection of seeds from previously harvested tomato fruits, raising of tomato seedlings in screen houses or nets using sterilized soil during the nursery stage and enforcement of government policy to curb the movement of infected or questionable plant materials into the country.

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PRELIMINARY STUDY ON THE EFFECT OF NATURAL INFECTION BY BANANA STREAK VIRUS ON THE GROWTH AND YIELD OF PLANTAIN CV AGBAGBA UNDER FIELD CONDITION

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ABSTRACT

Plantain and Banana are two crops that remain important sources of food energy and minerals for many households in Nigeria. Like every other crop, plant viruses such as BSV cause considerable loss in yield and quality. The study was aimed to evaluate the loss in growth and yield due to natural infection by BSV and to determine the relationship between symptom expression and climatic elements. An established plantain field with high incidence of BSV was used for this experiment where 15 plants each were randomly selected and tagged based on their disease status. Data was collected monthly on growth and yield parameters and climatic information. The first appearance of symptom on infected suckers was observed at 8 months after planting (MAP). The plant height (179 cm), tallest sucker (105.5 cm) and number of suckers (4) were higher in healthy plants. The healthy plants fruited earlier at 11 MAP compare to 13 MAP for infected plant and the average yield of infected plant was significantly lower compare to the healthy plant. Also, periods of no rainfall and high temperature, infected plants showed no symptom of BSV. This study concludes that BSV delays fruiting and reduces yield of plantain cv. Agbagba by about 2 months and 34.5% respectively. In addition, BSV symptoms may not be expressed on an infected plant under non favourable conditions.

Key words: Average yield, infected plants, natural infection, rainfall, symptoms

INTRODUCTION

Banana is a major staple food, which is grown in the tropics and comprises a number of species in the genus *Musa* of the family Musaceae (Khoozani *et al.,* 2019). 'Bananas' refers to all the members of the genus *Musa*. Even though, plantains are a defined group within this genus which have the AAB genome and are characterized by the orange-yellow colour of the fruit pulp at ripeness (Soares *et al.,* 2011). Banana can be classified based on its sugar and starch content, while dessert banana produces fruits that converts almost all its starch into soluble sugar at ripening and can be eaten raw plantains produce fruits that remain starchy at maturity and need processing before consumption (Akinyemi *et al*., 2010).

Banana is susceptible to a couple of pests and diseases some of which are, *Banana bunchy top virus* (BBTV), *Banana streak virus* (BSV), *Banana bract mosaic virus* (BBrMV) and *Cucumber mosaic virus* (CMV) (Tripathi *et al.,* 2016). The *Banana streak virus* which is a plant pathogenic badnavirus of the family Caulimoviridae was first identified in West Africa in the year 1958 and now reported globally (Tripathi *et al*,. 2019). The virus can be transmitted mechanically or spread through infected suckers and by mealybug in a semi-persistent manner (Tripathi *et al*., 2016).

Despite the long-term presence of this virus in West Africa, there are paucity of information on the effect of the virus on yield of plantain, even though plantain is a major food crop in Nigeria.

MATERIALS AND METHODS

The experiment was carried out on the plantain orchard of the venture unit of the National Horticultural Research Institute (NIHORT), Ibadan during the 2019 and 2020 planting seasons. A diagnostic survey was conducted on two orchards planted with suckers from the same source and disease incidence was recorded on the two fields after initial observation showed symptoms of Banana streak virus on some of the plantain stands. The health status of the plants under natural field condition served as treatment in this experiment, symptomatic plants (showing isible symptom of BSV) and asymptomatic plants (apparently healthy plants). Thirty plantain stands of each treatment (those with BSV symptoms and those without symptoms) were tagged throughout the two orchards, the tagged plants were structured into plots and replicated five times. Data was collected on a monthly basis on parameters such as number of leaves with symptoms, number of suckers, number of symptomatic suckers, height of tallest sucker (cm), plant height (cm), total number of leaves, number of functional leaves and non-functional leaves, days to fruiting and flowering. Data collected was subjected to analysis using student t-Test.

RESULTS AND DISCUSSIONS

The symptom of *Banana streak virus* have been observed on plantain and banana as having chlorotic streaks on the banana leaves and splitting of their pseudo-stem (Dahal *et al.* 1998; Daniells *et al.* 2001). Symptom persisted on the diseases plants however the first symptom expression on new suckers was record 6 months after planting (MAP) (Figure 1). There was a systemic reduction in the number of symptomatic leaves from 5 MAP through 6 MAP and at 7 MAP there were no leaf with BSV symptom. However, symptom was observed on the new suckers at 8 MAP the number declined at 9 and 10 MAP respectively (Figure 1). The lack of symptom expression coincided with periods of no rain fall, low relative humidity and high temperature (Figure 1). The numbers of plants that expressed symptom during this harsh weather conditions were reduced compared to the number that showed symptom during the rains when the relative humidity was high and temperature is low.

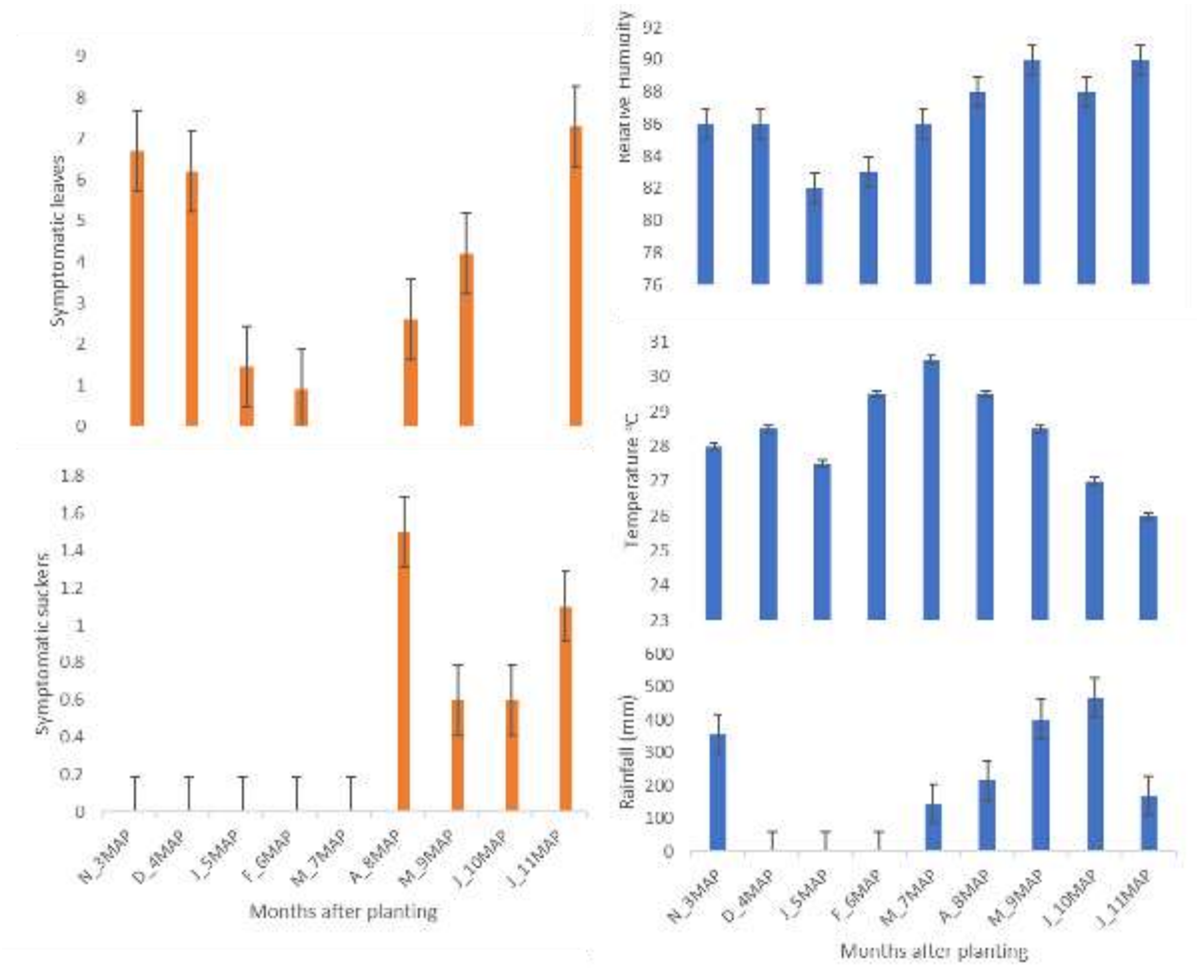

Figure 1. Number of symptomatic leaves and sucker and average weather information during the study.

Key: N_3MAP- November (3MAP), D_4MAP- December (4MAP), J_5MAP- January (5MAP), F_6MAP- February (6MAP), M_7MAP- March (7MAP), A_8MAP- April (8MAP), M_9MAP- May (9MAP), J_10MAP- June (10MAP) and J_11MAP- July (11MAP), MAP- month after planting.

The height of the mother plants, number of suckers and the tallest suckers were higher in healthy plant with 179.6 cm, 4, and 105cm respectively compared to diseases with 176cm, 3 and 87.6 cm (Figure 2). The result showed an ample variation in the growth of the healthy and symptomatic plants especially on the plant height and sucker production. Although, previous study on Cavendish variety have described the effect of the disease as small according to Daniells *et al*., 2001. The functional and non-functional leaves in the healthy and infected plants also showed a considerable variation (Figure 2). The functional and non-functional leaves in healthy plants lower at the first month after planting, however, this result showed that drought had more effects on infected plants, which led to increase in the numbers of non-functional leaves on the plants.

The fruiting in infected plants delayed by more than 2 months compared to healthy plants which started fruiting around 11 MAP (Figure 3). Yield in healthy plant was greater compared to infected plant (Figure 3). The average bunch weight recorded for healthy plants was 8kg compared to 5.25 kg average bunch weight obtained from infected plants. The findings from this study is in line with the report of Daniells et al., 2010 who suggested that the effect of BSV on yield of banana is severe in marginal climatic or soil conditions (Daniells *et al*., 2001). In conclusion, it is important to encourage an ensure the use of certified disease free seed to reduce fruiting time and increase yield which translate to increase income for the smallholder farmer that form the core of plantain production in Nigeria.

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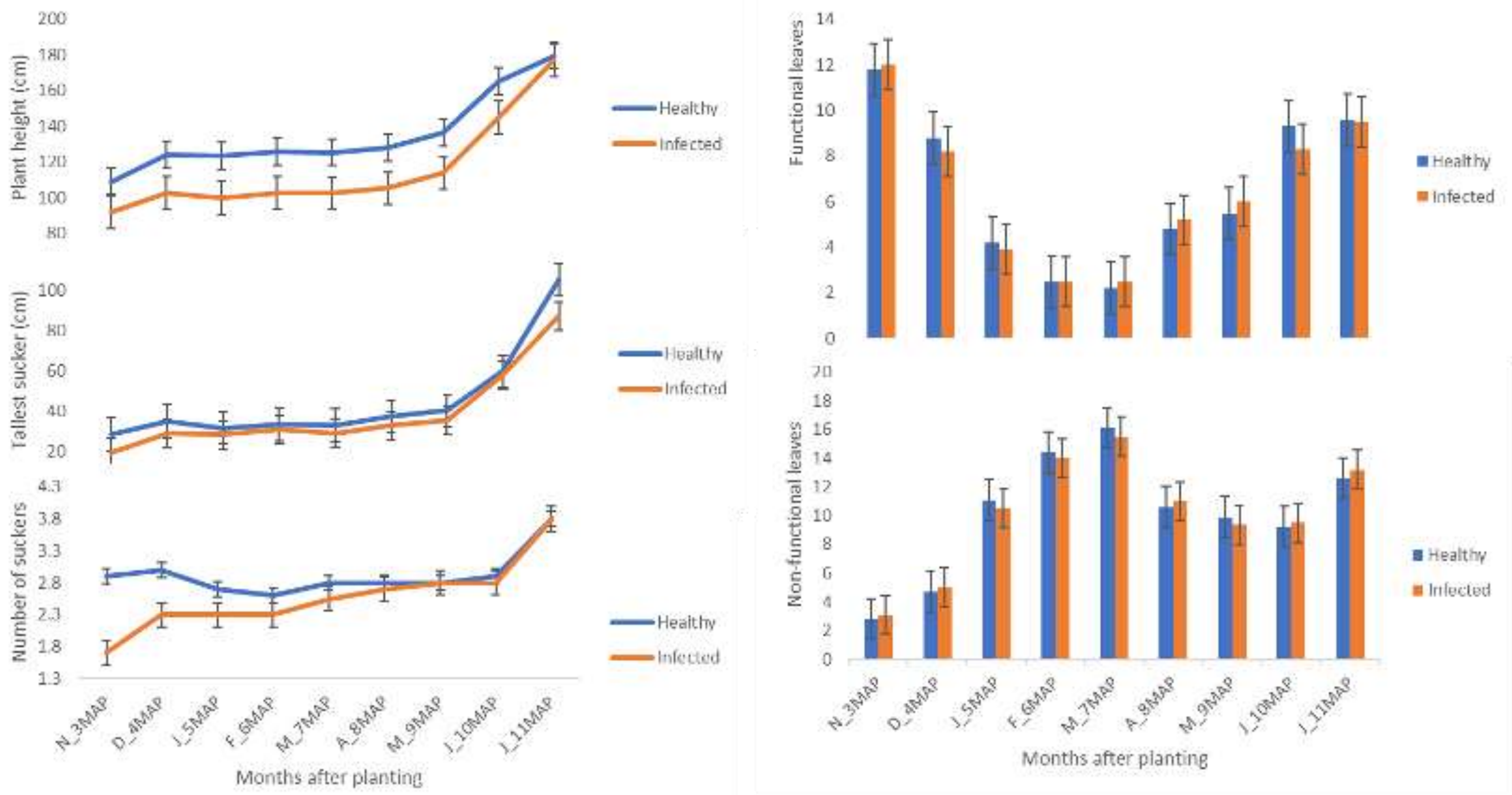

Figure 2. The effect of BSV on plant height, height of tallest sucker, number of suckers and number of leaves. Key: N_3MAP- November (3MAP), D_4MAP- December (4MAP), J_5MAP- January (5MAP), F_6MAP- February (6MAP), M_7MAP- March (7MAP), A_8MAP- April (8MAP), M_9MAP- May (9MAP), J_10MAP- June (10MAP) and J_11MAP- July (11MAP), MAP- month after planting.

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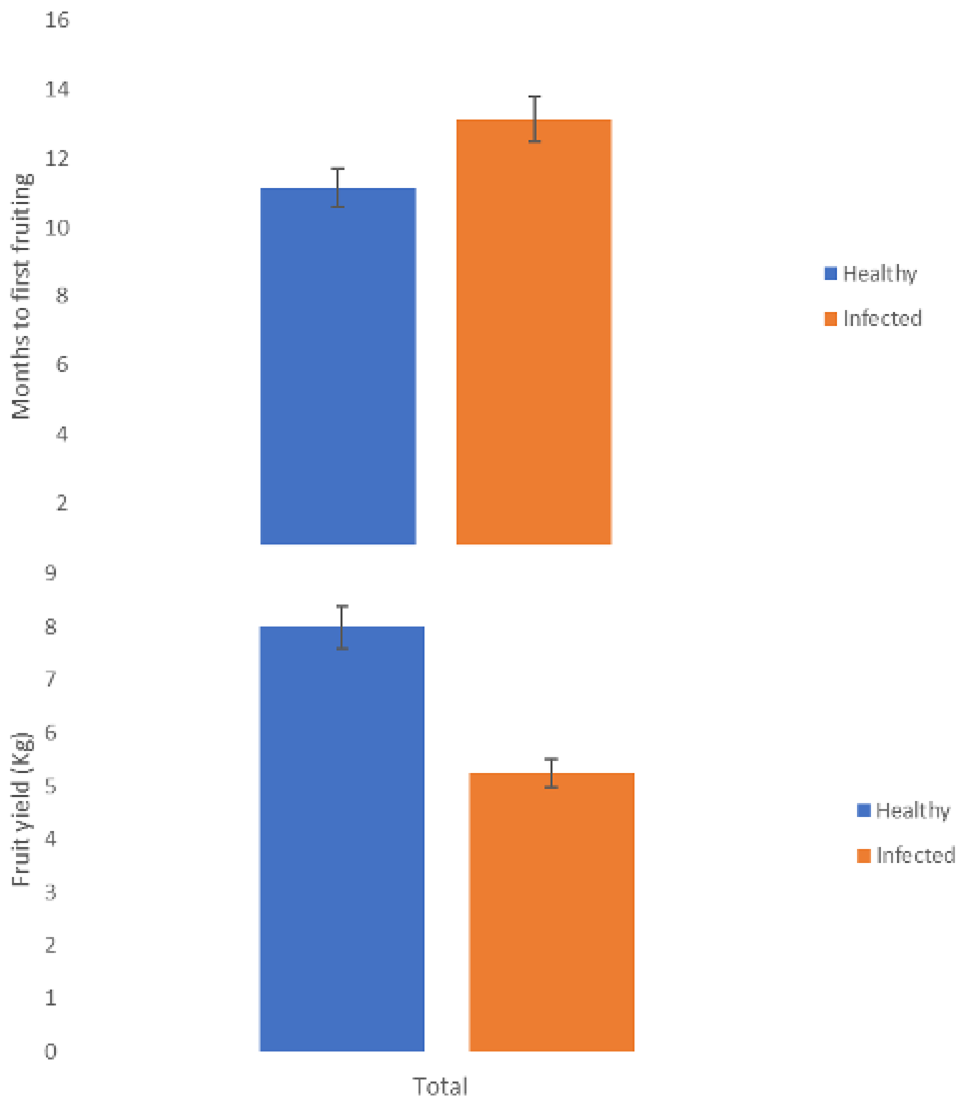

Figure 3. The Yield of the plantain as influenced by health status

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SUSCEPTIBILITY OF SOME COWPEA CULTIVARS TO SINGLE AND MIXED VIRUS INFECTION IN MOKWA, SOUTHERN GUINEA SAVANNAH

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ABSTRACT

The field trial was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Ahmadu Bello University (ABU), Zaria, Mokwa Station to evaluate the susceptibility of some cowpea cultivars to single and mixed virus infections. Three independent trials were conducted simultaneously, for single and mixed infections of BICMV and CPMeV. The treatments evaluated were BICMV-infected, CPMeV-infected, BICMV + CPMeV infected. The treatments were laid out in a Completely Randomized Design (CRD) with three replicates. In each trial, eight cowpea cultivars were evaluated. Seeds were sown in polythene pots of good drainage containing sterilized soil of 8 kg. Procedure of inoculation was carried out. The seedlings were watered regularly throughout their growing period. Data on disease severity were collected at 4 weeks post inoculation (WPI) while days to 50% flowering and grain/seed yield were collected at harvest. Data on severity and yield attributes were subjected to analysis of variance (ANOVA) using Statistical Analysis System. This experiment establishes that the cowpea cultivars tested are susceptible to single and double infections of BICMV + CPMeV. The study recorded a considerable stable and appreciable yield from IT07K-210-1-1 and IT97K-568-18. Therefore, IT97K-568-18 and IT07K-210-1-1 could be recommended to cowpea farmers as a guarantee against crop failure. They can also be used as sources of BICMV and CPMeV tolerant genes for breeding purposes.

Key words: Cowpea, Infections, Severity, Susceptibility, Grain yield.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is an herbaceous, warm season, annual legume crop belonging to the family Fabaceae and the sub family Faboideae. It's originated and was domesticated in Southern Africa. It was then cultivated in East and West Africa as well as Asia and today, it is grown mostly in semi-arid tropical zones across Africa, Asia, Europe and the Americas (IITA 2015). Nigeria was reported to be the largest cowpea producer which holds 3.1 million ha of land under cowpea, producing 2.5 million tonnes in 2008–2010 (Nedumaran *et al.,* 2015). The major cowpea producing States in Nigeria are Niger, Borno, Zamfara, Sokoto, Kano, Gombe and Yobe States in the northern part of the country (Idem *et al.*, 2005), since this region naturally possesses the recommended growing conditions for the crop.

Cowpea is susceptible to a complex of insect pests and diseases and they attack the crop from vegetative stage to storage (Dugje *et al.*, 2009). Virus diseases are the most damaging diseases of cowpea and represent significant proportion of losses regarding the potential value of the crop in sub-Saharan Africa. Estimated yield losses due to virus infection are between 10 and 100 % (Kareem *et al.*, 2007). *Blackeye cowpea mosaic virus* (BICMV) a important virus disease of cowpea can cause a yield loss of 13 – 87 % under field condition depending upon crop susceptibility, virus strain and the environmental conditions (Alegbejo, 2005). Similarly, *Cowpea mottle virus* (CPMeV) is highly prevalent in cowpea fields causing severe yield losses (Abdullahi *et al.,* 2020). Cowpea plants may be infected by more than one virus disease, resulting in serious economic losses in agricultural production (Alegbejo, 2005).

There are reports on mixed virus infections of cowpea occurring in Nigeria indicating that doubly infected plants will display increase in disease symptoms and in the accumulation of one or both of the viruses leading to double yield loss (Aliyu *et al*., 2012). Identifying natural sources of resistance to BICMV and CPMeV will facilitate the development and release of high yielding cowpea varieties with appreciable tolerance to the pathogens in Nigeria. This study was therefore conducted to determine the susceptibility status of selected cowpea cultivars to BICMVand CPMeV.

MATERIAL AND METHODS

The field trial was conducted at the Teaching and Research Farm of the Faculty of Agriculture, Ahmadu Bello University (ABU), Zaria, Mokwa Station (090211 N and 50135 E, 201 m above sea level) situated in the Southern Guinea Savannah Nigeria. The BICMV and CPMeV isolates used for this trial were obtained from the stock in the Virology Unit, IITA, Ibadan, Nigeria while ten cowpea cultivars (Ife Brown, IT90K-277-2, IT96D-610, IT97K-499-35, IT97K-568-18, IT97K-573-2-1, IT07K-210-1-1, IT11K-61-82, IT98K-205-M8 and IT98KD-288) were selected because they have not been endorsed against the single and mixed BICMV and CPMeV viruses.

The isolates are previously maintained on silica gels in vial bottles at room temperature. They were multiplied by propagating them in a susceptible cowpea cultivar "Ife Brown" through sap transmission before going to the field, for the purpose of being used later in the field for inoculation. Ife Brown seeds were sown in pots of 29.5 diameter and 38 cm deep containing sterilized soil. Twenty pots each placed in a wooden cage (to protect them from insect and contamination) for multiplying BICMV (10 pots) and CPMeV (10 pots) inoculum.

The sandy loam soil that was used for the study was sterilized before it was used to fill the polythene pots. Three independent trials were conducted simultaneously, for single and mixed infections of BICMV and CPMeV. The treatments evaluated were BICMV-infected (T_1), CPMeV-infected (T_2), BICMV + CPMeV infected (T_3). The treatments were laid out in a Completely Randomized Design (CRD) with three replicates. In each trial, eight cowpea cultivars were evaluated.

Seeds were sown in polythene pots of good drainage containing sterilized soil of 8 kg. Inoculation was done as earlier described during the multiplication of virus inocula. Seedlings of the first treatment were inoculated at 10 DAS with BICMV isolate, representing the single infection trial for virus A, seedlings of the second treatment were inoculated at 10 DAS with CPMeV isolate, representing the single infection trial for virus B, seedlings of the third treatment were inoculated with the isolates of Virus A (BICMV) and Virus B (CPMeV) at 21 DAS, representing type 1 double infections. The seedlings were watered regularly throughout their growing period. The control of insect pest and harvesting was carried out.

Data collected include number of pods, seed numbers and grain yield at harvest and were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS, 2008) to verify if there are significance differences among the cultivars at $p \leq 0.05$. Significance of the difference between inoculated plants of each cultivar was determined using independent *t*-test. Where the *F*-test ratio is significant, means were separated using Least Significant Difference (LSD).

RESULTS

Severity of single and mixed infections on cowpea cultivars

Symptom expression started one week after inoculation in all the virus treatments and 85 - 100% disease incidence was attained at 4 WPI. All the inoculated plants showed symptoms in accordance to the virus types they were inoculated with and disease severity increased progressively weeks after inoculation. At 4 WPI, cowpea cultivars infected with BICMV alone and BICMV + CPMeV were of the same severity (score = 4). In the CPMeV infected plants, Ife Brown, IT90K-277-2, IT96D-610, IT97K-573-2-1, IT98K-205-M8 and IT98KD-288 were the most affected with severity score of 4 (Table 1).

The number of days to flowering of infected plants varied significantly ($p \leq 0.05$) from 56 to 62 days after sowing (DAS) in BICMV, 54 to 60 DAS in CPMeV, 59 to 67 DAS in BICMV + CPMeV (Table 1). In BICMV infected plants, IT97K-568-18 and IT07K-210-1-1 were the first to flower at 56 DAS, whereas Ife Brown was the last to flower at 62 DAS. Similarly, in CPMeV infected plants, IT97K-568-18 and IT07K-210-1-1 had early flowering (60 DAS), followed by IT97K-573-2-1 at 62 DAS. Conversely, Ife Brown and IT90K-277-2 had delayed flowering (67 DAS). In BICMV + CPMeV infected plants, IT07K-210-1-1 was the first to flower (54 DAS), followed by IT97K-568-18 and IT97K-573-2-1 (55 DAS) then IT97K-573-2-1 and IT96D-610 (57 DAS). However, IT97K-499-35 was the last to flower at 67 DAS.

In the study, the cultivars with the highest seed numbers per plant also gave the highest grain yield. Significantly highest grain yield of 218.3 kg/ha was obtained from BICMV infected IT97K-568-18 and IT07K-210-1-1 plants, in CPMeV infected plants, IT97K-568-18 and IT07K-210-1-1 had 198.2 and 219.1kg/ha respectively which are similar followed by IT98K-205-M8 which gave 161.4 kg/ha. Similarly, BICMV + CPMeV infected plants had 205.4 kg/ha whereas Ife Brown had the lowest grain yield of 101.5 kg/ha in BICMV and CPMeV while IT97K-573-2-1 resulted to a low grain yield (99.9 kg/ha) in BICMV + CPMeV infected plants (Table 1).

DISCUSSION

Cowpea is an important pulse in sub Saharan Africa but its profitable production is greatly affected resulting to poor yields. This poor yields can be attributed to attacks by pest and infection by pathogenic micro-organisms especially viruses (Taiwo *et al.,* 2007). Cowpea can be infected by one or more than one virus (related or unrelated) which results in disease symptoms and serious reductions in the growth and yields of cowpea (Kareem and Akinjogunla, 2008). The single and double virus infections in this experiment had significant and different effects on the cowpea cultivars evaluated which might be attributed to the different tolerance levels of these cultivars to the respective viruses. All the inoculated plants exhibited disease symptoms indicating their susceptibility to single and double infections of BICMV and CPMeV. This is in agreement with Abdullahi *et al*. (2020), who reported the susceptibility of cowpea to single and double infections of BICMV and CPMV. Disease severity observed in this study was based on the cowpea cultivars and the type of virus treatment. High symptom severity exhibited by BICMV infected plants and BICMV + CPMeV infected plants in the studies might be due to BICMV (potyvirus) which was used in infecting the plants alone and in combination with another virus. This is supported by Anjos *et al*. (1992) who reported that high severity can occur when the infecting or one of the infecting viruses is a member of the genus potyvirus. The growth and subsequent yield of some cultivars can be likened for both single and double infections suggesting that the response of these cultivars to double infections was not stronger than the sum of the effects caused by each of the virus in single infection. This is contrary to the opinion of Taiwo (2003) who reported that double virus infections result in greater reduction in the growth and yield of single virus infections. Most cultivars produced pods and seeds of appreciable number but hardly gave appreciable yield which is in contrast to their initial satisfactory growth. The plants inoculated with BICMV alone were the most affected as they gave the lowest grain yield generally in studies. This is in agreement with the findings of Nsa and Kareem (2015) who reported that there are cases where single virus infections had more devastating effects on the crop than double infections involving that same virus.

Table 1. Disease severity, days to 50% flowering and grain yield of cowpea cultivars infested with BICMV and CPMeV at Mokwa during the 2020 cropping season

	Disease severity score			Days to 50% flowering			Grain/seed yield (kg/ha)		
Variety	BICMV	CPMeV	BI + CP	BICMV	CPMeV	BI + CP	BICMV	CPMeV	BI + CP
Ife Brown	4	4a	4	62a	67a	58c	101.5c	102.5e	99.9c
IT90K-277-2	4	4a	4	58d	64c	57d	192.6b	129.5cd	200.0ab
IT96D-610	4	4a	4	58d	64c	57d	199.3b	137.6cd	199.6ab
IT97K-499-35	4	3.3b	4	59c	65b	62a	197.3b	125.5d	193.3ab
IT97K-568-18	4	2.6c	4	56e	60e	55f	218.3a	198.2a	205.4a
IT97K-573-2-1	4	4a	4	60b	63d	55f	196.7b	143.5c	181.7b
IT98K-205-M8	4	4a	4	58d	64c	59b	199.2b	161.4b	192.9ab
IT98KD-288	4	4a	4	58d	64c	58e	200.0b	138.1cd	200.1ab
IT11K-61-82	4	3.0bc	4	59c	65b	58e	197.3b	129.4cd	201.2ab
IT07K-210-1-1	4	3.3b	4	56e	60e	54g	219.1a	196.9a	200.4ab
SE+	0	0.15	0	0	0	0	3.63	4.8	7.28

Means with the same letter within the column are not significantly different ($p \leq 0.05$) SNK grouping. BICMV: *Blackeye cowpea mosaic virus*, CPMeV: *Cowpea mottle virus*, BI+ CP: *Blackeye cowpea mosaic* virus + *Cowpea mottle virus*

CONCLUSION AND RECOMMENDATIONS

This experiment established the fact that the cowpea cultivars tested are susceptible to single and double infections of BICMV + CPMeV. The study recorded a considerable stable and appreciable yield from IT97K-568-18. This experiment confirms the impact of environmental conditions on the growth and yield of virus infected plants. Cowpea cultivars IT97K-568-18 could be recommended to cowpea farmers as a guarantee against crop failure. They can also be used as sources of BICMV and CPMeV tolerant genes for

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breeding purposes. Intensive biotechnological research that will result in the development of cowpea cultivars with multiple resistances to economical important viruses should be employed.

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EFFECT OF SINGLE INOCULATION WITH CUCUMBER MOSAIC VIRUS (CMV) ON THE GROWTH AND YIELD OF 31 TOMATO CULTIVARS COMMONLY PLANTED IN SOUTHWESTERN NIGERIA

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ABSTRACT

Single inoculation of potted grown seedling of tomato *Solanum lycopersicon* 31 cultivars commonly planted in southwestern Nigeria NHTO/0199, NHTO/0201, NHTO/0205, NHTO/0206, NHTO/0216, NHTO/0217, NHTO/0221, NHTO/0222, NHTO/0223, NHTO/0226 , NHTO/0227, NHTO/0229, NHTO/0237, NHTO/0238, NHTO/0239, NHTO/0240 , NHTO/0241, NHTO/0251 , NHTO/0253, NHTO/0259, NHTO/0263 , NHTO/0264, NHTO/033, NHTO/0340, NHTO/0342 , NHTO/0347, NHTO/0351, NHTO/0352, NHTO/0354 obtained from National horticultural research institute Jericho Ibadan genetic resourses unit (GRU) ,UC82B and Roma VF obtained from farmers fields at age 28 (2 WAT) and 4(WAT) 42days after sowing were studied in insect tight screen house temperature range of 28.5^0C-32.5^0C. Inoculated with $0.1mgml^{-1}$ of cucumber mosaic virus (CMV) at age 28 and 42 days after sowing respectively. No visible symptoms were observed in all the tested tomato plants, but acute flower abortion and significant reduction on the number of fruit and fruit weight ($P< 0.05$) at 10 WAT. The reveal that inoculation period after transplanting highly significantly ($P<0.01$) influence the tomato plant height, but significantly $P<0.05$ at 2 ,4 ,6,8 and 10 weeks after inoculation (WAI) respectively. The results indicate that cultural control strategy can be adopted in viral disease management; keeping young seedlings free of infection source for as long as possible especially when using non-resistant host cultivars so as to take advantage of disease tolerance conferred by age.

Key words: Cucumber mosaic virus (CMV), Inoculation Period

INTRODUCTION

Generally, viral infection often elicits visible symptoms such as leaf curl, mottling, shoestring, mosaic leaf pupling and distortions in plants with consequent reductions in crop growth and yield (Balogun, 2008, Oke *et al,* 2018). While reduction in plant size is the most general symptom induced by virus infection, there is probably some stunting of growth even with 'masked' or 'latent' infections, where the systemically infected plant shows no obvious sign of disease (Matthews, 1991). Cucumber mosaic virus (CMV) had been early reported to be infecting tomato in some farmers' fields in Oyo and Ogun state (Kayode *et al*, 2014, Odedara and Ayo-John, 2017). Cucumber mosaic virus has been reported to be prevalent virus affecting the quality and yield of fruity vegetable pepper and resulting into yield losses of 80% during sever epidemics (Li *et al.,*2020) it infects 1200 species in over 100 plant families and cause significant economic losses in many vegetable horticultural crops (Zitter and Murphy 2009). CMV causes systemic infection in most host plant most especially tomato, but may remain symptomless in some crops like alfaifa. Symptoms of CMV vary greatly depending on the crop infected and the age of the plant at the point of infection (Zitter and Murphy 2009). This research was carried out to ascertain the effect of inoculation period of tomato with CMV on growth and yield of 31 cultivars of tomato commonly planted in southwestern Nigeria in respect the virus control strategy.

MATERIALS AND METHODS

Twenty nine cultivars of tomatoes seeds NHTO/0199, NHTO/0201, NHTO/0205, NHTO/0206, NHTO/0216,NHTO/0217,NHTO/0221,NHTO/0222,0223,NHTO/0226,NHTO/,0227,NHTO/0229, NHTO/0237, NHTO/0238, NHTO/0239, NHTO/0240 , NHTO/0241, NHTO/0251 , NHTO/0253, NHTO/0259, NHTO/0263, NHTO/0264, NHTO/033, NHTO/0340, NHTO/0342 , NHTO/0347, NHTO/0351, NHTO/0352, NHTO/0354 commonly planted by the farmers in Southwestern Nigeria obtained from National horticultural research institute genetic resources unit (GRU) ,including UC82B and Roma VF that were obtained from farmers during survey. They were laid out in the screen house to ascertained the lines that is tolerance or resistance to the CMV viral infection. Top soil and green manure in the ratio 20:1 was thoroughly mixed and steam-heated (sterilized) for four hours and was allowed to cool for 24 hours. This soil was then poured into one-litre plastic bags. Two hundred and seventy-nine (279), one-liter plastic pots were filled with the steam-sterilized top soil and were arranged in 93 pots per replicate in screen house. Seedlings of the thirty-one tomatoes

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cultivars of two weeks' old were transplanted in the sterile soil, the plants were laid as Completely randomised design (CRD) with 3 replicates Treatment combinations as shown in (Table1). Two weeks after the transplanting 31 seedlings of each replicates were inoculated with CMV virus (4weeks old), inoculation was by rubbing the two primary leaves with carborundum-dusted i.e., leaves 1 and 2 from the stem base, with 0.2 mg mL^{-1} (in phosphate buffer pH 7.2) and two weeks later another 31 sets were inoculated per replicates (6 weeks old), but the control were not inoculated. The temperature of the screen house was taken twice a week Monday and Friday at the onset of flowering. The symptoms development were observed and the agronomic data of disease severity, number of leaves plant height and the flower abortion were taken at 2 weeks intervals . The tomato fruits were harvested from each pot beginning from days of mature fruit emergence, and every four days thereafter until fruiting ceases. The fruits were weighed and counted. Cumulative weights of fruits per treatment were calculated from the periodic data. Virus concentration of the inoculated plants was determined by Das-Elisa Clark and Adams (1977). And the disease severity was assessed by visual assessment in the scale of (1-5)

Severity Rating

Virus symptom severity were scored on a scale of 1-5, based on extent of leaf damage and percentage number of leaves showing symptoms, whereby 1=1-20% (very mild); 2=21-40% (mild); 3=41-60 % (moderately severe); 4=61-80 % (severe); and 5=81-100 % very severe and no fruiting (Ssekyewa. 2006; Oke *et al*., 2017). All data collected were subjected to ANOVA and treatment means was separated using LSD at 5% probability level.

RESULTS and DISCUSSION

The results of the experiment reveals that no visible foliage symptoms were observed on the leaves, but acute flower abortion and secondary manifestation of the disease symptom after the fruit harvest i.e. the new leaves coming up from the old foliage that are almost died carried mosaic symptom.

Inoculation period and effect on the number of leaves

The inoculation period after transplanting significantly ($P<0.05$) influence the number of tomato leaves at 2 ,4 ,6,8 and 10, weeks after inoculation (WAI). However, at all the sampling period tomato plant that was not inoculated had the highest number of leaves at 10WAI while the tomato inoculated at 2 weeks after transplant had the lowest number of leaves at 2 WAI (Table 2a). The number of leaves of tomato varieties was significantly differ $P<0.05$ at 2 and 10 WAI, but highly significant ($P<0.01$) at 6 and 8 WAI. Hence, NHTO/0253 at 10 WAI had significantly higher number of leaves than UC82B which had the lowest number of leaves at 2 WAI (Table 2a). The interaction effect of inoculation periods and varieties at transplanting had no significant ($P>0.05$) effect on the number leaves obtained at 2 ,4, 6, 8 and 10 WAI respectively. Nevertheless, tomato varieties NHTO/0259 at no inoculation had the highest number of leaves at 10WAI, whlie variety NHTO /206 inoculated at 2 weeks after transplanting had the lowest number of leaves at 2 WAI (Table 2b).

Inoculation period and effect on the Plant height

The inoculation period after transplanting significantly ($P<0.01$) influence the tomato plant height at 2 ,4 ,6,8 and 10 weeks after inoculation (WAI) (Table 3a). However, at 2,4,6,8 and 10WAI, tomato that was not inoculated had the highest plant height at 10WAI while the tomato inoculated at 2 weeks old after transplanting had the lowest plant height at 2 WAI (Table 3a). The tomato cultivars differ highly significantly among themselves $P<0.01$ in the plant height at 2 4,6,8and 10 WAI, However, NHTO/0259 at 10 WAI had highly significantly highest plant height than NHTO/216 which had the lowest plant height at 2 WAI of the tomato growth period (Table 3a). The interaction effect of inoculation periods and varieties after transplanting did not significantly ($P>0.05$) influence the plant height at 2,4,6,8 and 10WAI. Nevertheless, tomato variety NHTO/0259 at 4 weeks' inoculation had the highest plant height at 10WAI, while variety NHTO /216 inoculated at 2 weeks after transplanting had the lowest number of leaves at 2 WAI (Table 3b).

Inoculation period and effect on the Disease severity.

The inoculation period after 2 weeks after transplanting significantly ($P<0.01$) influence the tomato disease severity at 6 weeks after inoculation (WAI), and also significantly ($P<0.05$) at 4 WAI. However, tomato that was inoculated 2 WAT had the highest disease severity at 6WAI (Table 4a). The tomato varieties did not significantly $P>0.05$ differ in the disease severity at 2 4,6,8 and 10 WAT. However, NHTO/0216 ,0340 and 0352 at 6 WAT had highest disease severity on tomato growth period (Table 4a). The interaction effect of inoculation periods and varieties after transplanting did not significantly (P>0.05) influence disease severity at 2,4,6,8 and 10 WAI. Nevertheless tomato variety NHTO/0259 at 4 weeks' inoculation had the highest plant height at 10WAI, while variety NHTO /216 inoculated at 2 weeks after transplanting had the lowest number of leaves at 2 WAI (Table 4b).

Table 1. Treatment combination of Inoculation Period and Tomato cultivars

Inoculation periods	No Inoculation	Inoculation 2WAT	Inoculation 4WAT
Varieties	(I_0)	(I_2)	(I_4)
NHTO/0199	V_1 I_0	V_1 I_2	V_1 I_4
NHTO/0201	V_2 I_0	V_2 I_2	V_2 I_4
NHTO/0205	V_3 I_0	V_3 I_2	V_3 I_4
NHTO/0206	V_4 I_0	V_4 I_2	V_4 I_4
NHTO/0216	V_5 I_0	V_5 I_2	V_5 I_4
NHTO/0217	V_6 I_0	V_6 I_2	V_6 I_4
NHTO/0221	V_7 I_0	V_7 I_2	V_7 I_4
NHTO/0222	V_8 I_0	V_8 I_2	V_8 I_4
NHTO/0223	V_9 I_0	V_9 I_2	V_9 I_4
NHTO/0226	V_{10} I_0	V_{10} I_2	V_{10} I_4
NHTO/0227	V_{11} I_0	V_{11} I_2	V_{11} I_4
NHTO/0229	V_{12} I_0	V_{12} I_2	V_{12} I_4
NHTO/0237	V_{13} I_0	V_{13} I_2	V_{13} I_4
NHTO/0238	V_{14} I_0	V_{14} I_2	V_{14} I_4
NHTO/0239	V_{15} I_0	V_{15} I_2	V_{15} I_4
NHTO/0240	V_{16} I_0	V_{16} I_2	V_{16} I_4
NHTO/0241	V_{17} I_0	V_{17} I_2	V_{17} I_4
NHTO/0251	V_{18} I_0	V_{18} I_2	V_{18} I_4
NHTO/0253	V_{19} I_0	V_{19} I_2	V_{19} I_4
NHTO/0259	V_{20} I_0	V_{20} I_2	V_{20} I_4
NHTO/0263	V_{21} I_0	V_{21} $I_{2/}$	V_{21} I_4
NHTO/0264	V_{22} I_0	V_{22} I_2	V_{22} I_4
NHTO/0338	V_{23} I_0	V_{23} I_2	V_{23} I_4
NHTO/0340	V_{24} I_0	V_{24} I_2	V_{24} I_4
NHTO/0342	V_{25} I_0	V_{25} I_2	V_{25} I_4
NHTO/0347	V_{26} I_0	V_{26} I_2	V_{26} I_4
NHTO/0351	V_{27} I_0	V_{27} I_2	V_{27} I_4
NHTO/0352	V_{28} I_0	V_{28} I_2	V_{28} I_4
NHTO/0354	V_{29} I_0	V_{29} I_2	V_{29} I_4
UC-82B	V_{30} I_0	V_{30} I_2	V_{30} I_4
Roma VF	$V_{31}I_0$	$V_{31}I_2$	$V_{31}I_4$

Table 2a. Main effect of inoculation period with CMV and varieties on number of leaves (NL) at different times after tomato transplanting

Inoculation after transplant	2WAI	4WAI	6WAI	8WAI	10WAI
		Means			
Zero (I_0)	9.65	17.75	21.53	30.46	52.81

4 weeks (I_4)	9.13	17.04	20.25	28.28	48.43
2 weeks (I_2)	8.46	14.51	18.47	26.48	45.68
LSD 5%	0.61	2.58	1.87	2.25	3.87
Sig level	*	*	*	*	*
Varieties		Means			
NHTO/0199	10.11	18.44	24.11	31.00	49.67
NHTO/0201	7.56	14.22	18.67	26.89	39.22
NHTO/0205	9.57	17.00	23.00	30.44	46.89
NHTO/0206	8.00	15.00	20.11	28.11	48.33
NHTO/0216	7.89	13.11	17.00	24.00	40.78
NHTO/0217	9.00	1600	19.67	29.44	51.44
NHTO/0221	9.00	16.00	19.44	28.00	47.44
NHTO/0222	10.22	17.89	21.33	30.44	56.11
NHTO/0223	9.11	21.78	23.11	29.78	53.78
NHTO/0226	10.22	17.89	23.11	31.67	56.89
NHTO/0227	9.67	18.11	22.56	32.56	51.22
NHTO/0229	10.67	18.56	21.00	31.44	53.78
NHTO/0237	8.11	14.11	18.67	27.56	48.78
NHTO/0238	9.33	16.44	18.22	25.89	46.22
NHTO/0239	9.22	15.56	19.44	26.67	47.89
NHTO/0240	8.33	14.56	18.11	24.78	45.56
NHTO/0241	8.78	15.67	17.56	25.11	44.67
NHTO/0251	9.22	28.89	20.78	28.33	49.89
NHTO/0253	10.56	20.44	30.78	41.11	64.11
NHTO/0259	10.56	19.56	36.00	38.11	61.44
NHTO/0263	9.78	15.00	19.33	25.11	43.44
NHTO/0264	8.22	14.33	14.22	23.22	40.33
NHTO/0338	9.33	15.89	18.67	25.78	47.44
NHTO/0340	8.56	13.00	16.00	25.56	40.44
NHTO/0342	8.69	15.67	19.00	27.33	50.44
NHTO/0347	9.56	16.11	19.00	26.89	48.33
NHTO/0351	8.22	15.33	19.00	28.44	48.78
NHTO/0352	8.22	14.22	20.44	28.22	49.33
NHTO/0354	9.78	14.44	17.89	25.22	48.33
UC-82B	7.44	11.56	14.56	27.44	49.78
Roma VF	8.67	13.67	17.78	26.11	47.33
LSD	1.962	8.28	6.00	7.24	12.44
Sig ievel	*	Ns	**	**	*

Table 2b. Interaction effect inoculation period with CMV and tomato varieties on number of leaves (NL)

Inoculation after transplant	Varieties	2WAI	4WAI	6WAI	8WAI	10WAI
		Means				
Zero (I_0)	NHTO/0199	12.00	18.33	25.33	30.00	52.33
	NHTO/0201	9.67	17.33	23.33	33.00	53.00
	NHTO/0205	11.33	21.67	26.67	31.67	45.00

	NHTO/0206	8.67	17.33	18.67	28.67	48.33
	NHTO/0216	9.00	15.33	19.33	27.00	43.00
	NHTO/0217	9.33	18.00	23.00	28.00	51.33
	NHTO/0221	10.00	18.33	22.67	30.67	53.67
	NHTO/0222	10.00	21.00	21.67	32.00	66.33
	NHTO/0223	10.00	24.69	22.33	30.33	53.33
	NHTO/0226	11.00	16.33	22.67	29.33	57.00
	NHTO/0227	11.67	18.67	25.00	32.00	56.00
	NHTO/0229	10.00	21.00	21.67	33.00	49.00
	NHTO/0237	8.67	16.67	19.33	24.00	49.00
	NHTO/0238	9.67	16.33	22.00	30.00	56.67
	NHTO/0239	10.00	19.00	17.33	24.33	47.00
	NHTO/0240	9.00	18.00	19.67	27.33	47.33
	NHTO/0241	7.67	15.67	15.67	24.33	50.00
	NHTO/0251	10.00	18.67	21.67	30.67	53.00
	NHTO/0253	11.67	23.00	33.33	46.67	72.00
	NHTO/0259	10.67	24.00	32.00	52.00	78.00
	NHTO/0263	10.67	17.33	24.00	27.67	51.00
	NHTO/0264	8.00	14.67	15.33	27.33	46.33
	NHTO/0338	9.33	15.33	19.33	27.67	47.33
	NHTO/0340	9.00	13.67	16.00	28.00	47.33
	NHTO/0342	8.00	15.67	18.67	29.00	52.67
	NHTO/0347	9.67	15.00	19.00	27.00	48.33
	NHTO/0351	8.33	17.00	21.67	29.33	50.67
	NHTO/0352	9.33	17.00	25.00	33.33	48.33
	NHTO/0354	9.67	16.33.	20.67	28.33	58.33
	UC-82B	7.67	12.33	14.67	34.00	56.67
	Roma VF	9.33	16.67	19.67	26.00	46.67
4 weeks (I_4)	NHTO/0199	9.00	17.33	25.33	33.33	48.33
	NHTO/0201	6.00	11.33	16.00	24.67	33.67
	NHTO/0205	8.67	15.00	22.00	31.67	51.33
	NHTO/0206	9.00	13.67	22.67	30.00	50.67
	NHTO/0216	8.33	15.00	18.67	27.33	47.67
	NHTO/0217	7.67	14.00	21.00	29.67	51.00
	NHTO/0221	8.67	17.00	21.67	31.00	43.00
	NHTO/0222	10.33	18.33	22.33	30.67	56.00
	NHTO/0223	8.00	19.67	22.67	28.67	58.33
	NHTO/0226	10.00	19.00	22.67	31.00	54.67
	NHTO/0227	8.67	16.67	21.67	33.67	49.33
	NHTO/0229	11.00	20.67	21.33	30.00	51.00
	NHTO/0237	8.00	14.00	20.00	30.33	47.00
	NHTO/0238	10.67	11.67	14.00	17.67	36.67
	NHTO/0239	8.33	16.33	18.67	24.67	46.00
	NHTO/0240	7.67	14.00	16.67	23.33	42.33
	NHTO/0241	9.67	15.67	18.33	25.33	40.67
	NHTO/0251	9.33	15.67	19.00	26.67	45.00
	NHTO/0253	10.67	17.00	28.67	35.33	60.00

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	NHTO/0259	11.00	20.00	33.33	37.67	62.67
	NHTO/0263	9.67	15.67	20.00	25.67	46.00
	NHTO/0264	9.67	14.67	16.33	23.67	43.33
	NHTO/0338	10.00	16.67	17.67	22.67	46.33
	NHTO/0340	9.67	15.33	19.00	28.33	43.00
	NHTO/0342	9.22	17.00	17.33	24.67	50.33
	NHTO/0347	9.67	17.67	20.67	29.33	51.33
	NHTO/0351	9.33	17.00	18.33	31.00	51.67
	NHTO/0352	8.00	13.67	20.33	27.33	49.33
	NHTO/0354	9.67	14.33	19.00	28.33	53.33
	UC-82B	8.33	12.00	15.67	27.00	46.33
	Roma VF	9.00	12.33	16.67	26.00	45.00
2 weeks (I_2)	NHTO/0199	9.33	19.67	21.67	29.67	48.33
	NHTO/0201	7.00	14.00	16.67	23.00	31.00
	NHTO/0205	9.00	14.33	20.33	28.00	22.33
	NHTO/0206	6.33	14.00	19.00	25.67	46.00
	NHTO/0216	6.33	9.00	13.00	17.67	31.67
	NHTO/0217	10.00	16.00	15.00	30.67	52.00
	NHTO/0221	8.33	12.67	14.00	22.33	45.67
	NHTO/0222	10.33	14.33	20.00	28.68	46.00
	NHTO/0223	9.33	21.00	24.33	30.33	59.67
	NHTO/0226	9.67	18.33	24.00	34.67	59.00
	NHTO/0227	8.67	10.00	21.00	32.00	48.33
	NHTO/0229	11.00	14.00	20.00	31.33	43.33
	NHTO/0237	7.67	14.67	16.67	28.33	50.33
	NHTO/0238	7.67	21.33	18.67	30.00	53.00
	NHTO/0239	9.33	11.33	22.33	31.00	45.00
	NHTO/0240	8.33	11.67	16.00	23.67	47.33
	NHTO/0241	9.00	15.67	18.67	25.67	46.00
	NHTO/0251	8.33	15.33	21.67	27.67	41.67
	NHTO/0253	9.33	21.33	30.33	41.33	60.33
	NHTO/0259	10.00	14.67	24.67	24.67	43.67
	NHTO/0263	9.00	12.00	14.00	22.00	33.33
	NHTO/0264	7.00	13.67	11.00	18.67	31.33
	NHTO/0338	8.67	15.67	19.00	27.00	48.67
	NHTO/0340	7.00	10.00	13.00	20.33	31.00
	NHTO/0342	8.67	14.33	21.00	28.33	48.33
	NHTO/0347	9.33	15.67	17.33	24.33	45.33
	NHTO/0351	7.00	12.00	17.00	25.00	44.00
	NHTO/0352	7.33	12.00	16.00	24.00	50.33
	NHTO/0354	10.00	12.67	14.00	19.00	33.33
	UC-82B	6.33	12.00	13.33	21.33	46.33
	Roma VF	7.67	12.00	17.00	24.67	50.33
LSD 5%		3.40	14.35	10.39	12.55	21.55
Sig level		ns	ns	Ns	Ns	Ns

Table 3a. Main effect of inoculation period with CMV and varieties on Plant Height (PH) at different times after tomato transplanting

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Inoculation after transplanting	2WAI	4WAI	6WAI	8WAI	10WAI
		Means			
Zero (I_0)	22.4	39.33	61.74	89.30	109.1
4 weeks (I_4)	20.12	35.99	57.64	78.70	97.8
2 weeks (I_2)	16.16	29.88	48.70	71.00	88.6
LSD 5%	1.51	2.90	4.32	5.43	6.92
SD	**	**	**	**	**
Varieties		Means			
NHTO/0199	31.17	38.00	63.63	85.8	102.1
NHTO/0201	16.78	32.22	51.83	75.3	90.9
NHTO/0205	19.72	37.67	60.06	77.8	105.3
NHTO/0206	17.78	37.17	58.61	75.2	112.4
NHTO/0216	13.94	29.22	48.06	71.8	83.9
NHTO/0217	20.94	35.47	54.00	83.3	100.5
NHTO/0221	19.06	35.89	60.33	88.0	104.9
NHTO/0222	23.72	39.91	65.94	89.7	116.2
NHTO/0223	19.72	39.07	60.00	86.3	105.2
NHTO/0226	23.98	42.61	68.83	90.4	109.6
NHTO/0227	23.61	45.50	70.17	96.8	115.8
NHTO/0229	26.83	48.46	68.61	91.7	116.5
NHTO/0237	16.61	32.92	57.00	81.8	98.8
NHTO/0238	22.33	34.39	53.00	74.8	90.4
NHTO/0239	19.28	28.94	45.39	67.6	89.9
NHTO/0240	16.94	30.78	46.83	62.9	82.2
NHTO/0241	20.06	31.33	46.32	67.7	85.7
NHTO/0251	20.39	33.78	53.72	81.2	100.7
NHTO/0253	20.69	37.94	75.50	106.9	132.5
NHTO/0259	24.11	47.61	70.84	104.6	134.3
NHTO/0263	19.28	38.39	54.06	69.1	87.8
NHTO/0264	14.44	38.83	43.50	60.6	76.3
NHTO/0338	20.56	31.36	47.72	72.4	90.7
NHTO/0340	18.67	26.67	41.83	62.6	70.4
NHTO/0342	17.70	27.83	45.89	63.9	86.1
NHTO/0347	21.89	32.02	48.33	64.9	82.2
NHTO/0351	17.50	37.94	60.50	82.7	102.2
NHTO/0352	17.11	29.11	54.39	81.9	100.8
NHTO/0354	21.00	39.33	55.69	72.3	89.2
UC-82B	16.72	31.44	55.50	82.0	101.2
Roma VF	17.33	33.39	50.67	72.7	91.6
LSD	4.84	9.33	13.89	17.47	22.24
Sis level	**	**	**	**	**

Table 3b. Interaction effect of inoculation period with CMV and tomato varieties on Plant height

Inoculation after transplant	Varieties	2WAI	4WAI	6WAI	8WAI	10WAI
		Means				

Zero (I_0)	NHTO/0199	27.50	42.00	68.50	86.50	106.6
	NHTO/0201	21.00	43.33	69.50	106.00	125.0
	NHTO/0205	28.33	47.83	70.83	94.3	125.8
	NHTO/0206	29.83	43.83	68.00	102.5	128.8
	NHTO/0216	14.87	35.00	58.00	86.2	97.5
	NHTO/0217	22.67	39.00	66.50	94.2	106.3
	NHTO/0221	21.50	43.00	70.83	104.7	136.2
	NHTO/0222	54.17	43.33	71.17	97.0	120.3
	NHTO/0223	21.33	38.50	63.17	84.0	107.0
	NHTO/0226	26.17	44.17	68.00	92.7	108.8
	NHTO/0227	27.67	52.00	75.33	105.7	122.2
	NHTO/0229	28.67	52.03	76.17	104.5	134.0
	NHTO/0237	19.33	40.17	59.17	88.3	108.8
	NHTO/0238	28.33	39.50	63.33	86.0	101.5
	NHTO/0239	21.50	36.83	50.00	79.3	105.8
	NHTO/0240	18.67	35.17	48.17	63.5	77.7
	NHTO/0241	21.50	33.33	52.00	75.0	93.5
	NHTO/0251	23.67	41.33	56.50	86.5	108.3
	NHTO/0253	23.17	45.17	87.63	121.3	142.0
	NHTO/0259	26.83	53.33	75.67	134.2	164.5
	NHTO/0263	20.67	44.50	58.60	78.2	97.2
	NHTO/0264	17.83	28.17	50.33	74.2	88.2
	NHTO/0338	22.00	33.73	48.50	85.5	96.2
	NHTO/0340	22.82	33.33	48.67	77.3	92.0
	NHTO/0342	18.93	29.33	46.00	60.7	90.8
	NHTO/0347	23.33	33.57	48.17	66.2	84.2
	NHTO/0351	21.00	43.33	61.67	92.7	110.0
	NHTO/0352	21.50	32.17	56.83	83.3	102.5
	NHTO/0354	22.67	46.50	64.67	87.3	103.5
	UC-82B	19.33	35.33	59.17	91.7	111.3
	Roma VF	19.50	40.83	52.83	74.7	87.3
4 weeks (I_4)	NHTO/0199	18.17	38.50	62.70	86.3	100.2
	NHTO/0201	15.00	26.33	44.67	59.3	73.3
	NHTO/0205	17.33	36.17	60.33	71.2	96.8
	NHTO/0206	19.50	40.33	66.67	93.3	111.3
	NHTO/0216	15.83	33.33	50.17	76.3	91.2
	NHTO/0217	18.50	32.83	59.50	81.5	101.3
	NHTO/0221	20.00	38.33	68.17	100.3	112.0
	NHTO/0222	23.33	38.67	65.00	85.7	114.2
	NHTO/0223	20.00	41.17	69.50	94.0	111.0
	NHTO/0226	25.10	44.33	69.17	89.7	104.2
	NHTO/0227	22.17	43.83	68.67	93.0	111.5
	NHTO/0229	28.17	51.33	71.00	92.7	111.8
	NHTO/0237	16.83	32.73	59.67	81.7	93.7
	NHTO/0238	26.33	37.50	40.33	53.8	70.3
	NHTO/0239	19.50	28.67	43.50	65.5	77.7
	NHTO/0240	16.83	32.83	46.50	60.2	79.8

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	NHTO/0241	19.00	31.33	44.50	62.3	83.2
	NHTO/0251	21.67	34.33	55.50	80.0	97.5
	NHTO/0253	19.67	37.17	72.17	108.7	134.3
	NHTO/0259	25.67	50.17	90.50	112.3	149.7
	NHTO/0263	20.50	42.33	58.33	73.5	96.2
	NHTO/0264	21.17	28.83	45.17	63.8	81.7
	NHTO/0338	20.67	32.50	49.00	61.5	83.5
	NHTO/0340	20.83	29.17	42.50	63.0	69.3
	NHTO/0342	17.33	26.17	46.00	60.0	88.3
	NHTO/0347	22.83	31.67	43.33	67.7	84.5
	NHTO/0351	19.33	44.50	64.17	76.3	98.0
	NHTO/0352	16.83	33.00	64.33	89.2	112.7
	NHTO/0354	19.33	39.67	57.17	83.3	99.7
	UC-82B	17.83	34.33	58.33	81.3	100.8
	Roma VF	18.33	33.67	50.33	73.0	92.3
2 weeks (1_2)	NHTO/0199	17.83	33.50	59.67	84.5	100.2
	NHTO/0201	14.33	27.00	41.33	60.5	74.3
	NHTO/0205	13.50	29.00	49.00	68.0	93.2
	NHTO/0206	13.00	27.33	41.17	89.7	100.2
	NHTO/0216	11.17	19.33	36.00	53.00	63.00
	NHTO/0217	21.67	34.57	36.00	72.20	93.8
	NHTO/0221	15.67	26.33	42.00	59.1	66.7
	NHTO/0222	23.67	37.73	61.67	86.3	114.2
	NHTO/0223	17.83	37.53	57.33	80.8	97.5
	NHTO/0226	20.67	37.33	59.33	88.8	115.7
	NHTO/0227	21.00	40.67	66.50	91.8	113.7
	NHTO/0229	23.67	42.00	58.67	78.7	103.7
	NHTO/0237	13.67	25.87	52.17	75.5	94.00
	NHTO/0238	15.33	36.17	55.33	84.5	99.50
	NHTO/0239	16.83	21.33	42.67	58.0	77.20
	NHTO/0240	15.33	24.33	45.83	65.2	89.20
	NHTO/0241	19.67	29.33	42.67	62.7	80.20
	NHTO/0251	15.83	25.67	49.17	77.2	96.3
	NHTO/0253	19.00	37.50	66.67	90.7	121.2
	NHTO/0259	19.83	39.33	46.40	67.2	88.7
	NHTO/0263	16.67	28.33	45.33	55.5	70.0
	NHTO/0264	13.33	29.50	45.00	43.8	59.0
	NHTO/0338	19.00	27.83	45.67	70.2	92.5
	NHTO/0340	12.33	17.50	34.33	47.3	50.0
	NHTO/0342	16.83	28.00	45.67	71.0	79.2
	NHTO/0347	19.50	30.83	43.50	60.8	77.9
	NHTO/0351	12.17	26.00	55.67	79.0	98.7
	NHTO/0352	13.00	22.17	42.00	73.3	87.2
	NHTO/0354	21.00	31.83	45.00	61.3	64.5
	UC-82B	13.00	24.67	49.00	73.0	91.5
	Roma VF	14.17	25.67	48.84	70.5	95.0
LSD 5%		8.38	16.17	24.05	30.26	38.53

Sig ievel	Ns	Ns	Ns	Ns	ns

Table 4a. Main effect of inoculation period with CMV and varieties on disease severity at different times after tomato transplanting

Inoculation after transplanting	2WAI	4WAI	6WAI	8WAI	10WAI
		Means			
Zero (I_0)	1.00	1.00	1.01	1.00	1.00
4 weeks (I_2)	1.00	1.065	1.08	1.04	1.00
2 weeks (I_4)	1.00	1.130	1.70	1.09	1.00
LSD 5%	0.17	0.16	0.18	0.12	0.12
Sig level	ns	*	**	ns	ns
Varieties					
NHTO/0199	1.00	1.00	i.33	i.00	i.00
NHTO/0201	1.00	1.00	1.44	1.44	1.44
NHTO/0205	1.00	1.00	1.44	1.00	1.00
NHTO/0206	1,00	1,00	1,44	1,00	1,00
NHTO/0216	1.00	1.00	1.67	1.44	1.44
NHTO/0217	1.00	1.00	1.22	1.00	1.00
NHTO/0221	1.00	1.00	1.56	1.00	1.00
NHTO/0222	1.00	1.00	1.33	1.00	1.00
NHTO/0223	1.00	1.00	1.22	1.00	1.00
NHTO/0226	1.00	1.00	1.11	1.00	1.00
NHTO/0227	1.00	1.00	1.11	1.00	1.00
NHTO/0229	1.00	1.00	1.00	1.00	1.00
NHTO/0237	1.00	1.00	1.00	1.00	1.00
NHTO/0238	1.00	1.00	1.22	1.00	1.00
NHTO/0239	1.00	1.33	1.22	1.00	1.00
NHTO/0240	1.00	1.00	1.11	1.00	1.00
NHTO/0241	1.00	1.00	1.11	1.00	1.00
NHTO/0251	1.00	1.22	1.44	1.00	1.00
NHTO/0253	1.00	1.22	1.00	1.00	1.00
NHTO/0259	1.00	1.00	1.11	1.00	1.00
NHTO/0263	1.00	1.00	1.33	1.00	1.00
NHTO/0264	1.00	1.00	1.22	1.00	1.00
NHTO/0338	1.00	1.00	1.00	1.00	1.00
NHTO/0340	1.00	1.33	1.67	1.44	1.44
NHTO/0342	1.00	1.00	1.22	1.00	1.00
NHTO/0347	1.00	1.00	1.11	1.00	1.00
NHTO/0351	1.00	1.00	1.33	1.00	1.00
NHTO/0352	1.00	1.00	1.67	1.00	1.00
NHTO/0354	1.00	1.00	1.00	1.00	1.00
UC-82B	1.00	1.00	1.22	1.00	1.00
Roma VF	1.00	1.00	1.22	1.00	1.00
LSD	0.56	0.53	0.57	0.39	0.39
Sig level	ns	ns	Ns	ns	ns

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Table 4b. Interaction effect of inoculation period with CMV and tomato varieties on disease severity

Inoculation after transplant	Varieties	2WAI	4WAI	6WAI	8WAI	10WAI
			Means			
Zero (I_0)	NHTO/0199	1.00	1.00	i.00	i.00	1.00
	NHTO/0201	1.00	1.00	1.00	1.00	1.00
	NHTO/0205	1.00	1.00	1.00	1.00	1.00
	NHTO/0206	1,00	1,00	2.67	1,00	1,00
	NHTO/0216	1.00	1.00	1.00	2.33	2.44
	NHTO/0217	1.00	1.67	1.00	1.00	1.00
	NHTO/0221	1.67	1.00	1.00	1.00	1.00
	NHTO/0222	1.00	1.00	1.33	1.00	1.00
	NHTO/0223	1.00	1.00	1.00	1.00	1.00
	NHTO/0226	1.00	1.00	1.00	1.00	1.00
	NHTO/0227	1.00	1.00	1.00	1.00	1.00
	NHTO/0229	1.00	1.00	1.00	1.00	1.00
	NHTO/0237	1.00	1.00	1.00	1.00	1.00
	NHTO/0238	1.00	1.00	1.33	1.00	1.00
	NHTO/0239	1.00	1.00	1.00	1.00	1.00
	NHTO/0240	1.00	1.67	1.00	1.00	1.00
	NHTO/0241	1.00	1.00	1.00	1.00	1.00
	NHTO/0251	1.00	1.00	1.00	1.00	1.00
	NHTO/0253	1.00	1.00	1.00	1.00	1.00
	NHTO/0259	1.00	1.00	1.00	1.00	1.00
	NHTO/0263	1.00	1.00	1.00	1.00	1.00
	NHTO/0264	1.00	1.00	1.00	1.00	1.00
	NHTO/0338	1.00	1.00	1.00	1.00	1.00
	NHTO/0340	1.00	1.33	1.33	1.44	1.44
	NHTO/0342	1.00	1.00	1.00	1.00	1.00
	NHTO/0347	1.00	1.00	1.00	1.00	1.00
	NHTO/0351	1.00	1.00	1.00	1.00	1.00
	NHTO/0352	1.00	1.00	1.00	1.00	1.00
	NHTO/0354	1.00	1.00	1.00	1.00	1.00
	UC-82B	1.00	1.00	1.00	1.00	1.00
	Roma VF	1.00	1.00	1.00	1.00	1.00
4 weeks (1_4)	NHTO/0199	1.00	1.00	i.00	i.00	i.00
	NHTO/0201	1.00	1.00	2.44	2.33	2.33
	NHTO/0205	1.00	1.00	1.00	1.00	1.00
	NHTO/0206	1,00	1,00	1,00	1,00	1,00
	NHTO/0216	1.00	1.00	2.44	2.44	2.44
	NHTO/0217	1.00	1.00	1.00	1.00	1.00
	NHTO/0221	1.00	1.00	1.00	1.00	1.00
	NHTO/0222	1.00	1.00	1.00	1.00	1.00
	NHTO/0223	1.00	1.00	1.00	1.00	1.00
	NHTO/0226	1.00	1.00	1.00	1.00	1.00
	NHTO/0227	1.00	1.00	1.00	1.00	1.00

	NHTO/0229	1.00	1.00	1.00	1.00	1.00
	NHTO/0237	1.00	1.00	1.00	1.00	1.00
	NHTO/0238	1.00	1.00	1.00	1.00	1.00
	NHTO/0239	1.00	1.00	1.00	1.00	1.00
	NHTO/0240	1.00	1.00	1.00	1.00	1.00
	NHTO/0241	1.00	1.00	1.00	1.00	1.00
	NHTO/0251	1.00	1.00	1.00	1.00	1.00
	NHTO/0253	1.00	1.00	1.00	1.00	1.00
	NHTO/0259	1.00	1.00	1.00	1.00	1.00
	NHTO/0263	1.00	1.00	1.00	1.00	1.00
	NHTO/0264	1.00	1.00	1.00	1.00	1.00
	NHTO/0338	1.00	1.00	1.00	1.00	1.00
	NHTO/0340	1.00	1.00	2.44	2.44	2.44
	NHTO/0342	1.00	1.00	1.00	1.00	1.00
	NHTO/0347	1.00	1.00	1.00	1.00	1.00
	NHTO/0351	1.00	1.00	1.00	1.00	1.00
	NHTO/0352	1.00	1.00	1.00	1.00	1.00
	NHTO/0354	1.00	1.00	1.00	1.00	1.00
	UC-82B	1.00	1.00	1.00	1.00	1.00
	Roma VF	1.00	1.00	1.00	1.00	1.00
2 weeks (1_2)	NHTO/0199	1.00	1.00	2.00	i.00	i.00
	NHTO/0201	1.00	1.00	2.33	1.00	1.00
	NHTO/0205	1.00	1.00	2.33	1.00	1.00
	NHTO/0206	1,00	1,00	2.33	1,00	1,00
	NHTO/0216	1.00	1.00	1.33	2.44	2.44
	NHTO/0217	1.00	1.00	1.67	1.00	1.00
	NHTO/0221	1.00	1.00	2.67	1.00	1.00
	NHTO/0222	1.00	1.00	1.67	1.00	1.00
	NHTO/0223	1.00	1.00	1.67	1.00	1.00
	NHTO/0226	1.00	1.00	1.33	1.00	1.00
	NHTO/0227	1.00	1.00	1.33	1.00	1.00
	NHTO/0229	1.00	1.00	1.00	1.00	1.00
	NHTO/0237	1.00	1.00	1.00	1.00	1.00
	NHTO/0238	1.00	1.00	1.33	1.00	1.00
	NHTO/0239	1.00	1.00	1.67	1.00	1.00
	NHTO/0240	1.00	1.00	1.33	1.00	1.00
	NHTO/0241	1.00	1.00	1.33	1.00	1.00
	NHTO/0251	1.00	1.00	2.33	1.00	1.00
	NHTO/0253	1.00	1.00	1.00	1.00	1.00
	NHTO/0259	1.00	1.00	1.33	1.00	1.00
	NHTO/0263	1.00	1.00	2.00	1.00	1.00
	NHTO/0264	1.00	1.00	1.67	1.00	1.00
	NHTO/0338	1.00	1.00	1.00	1.00	1.00
	NHTO/0340	1.00	1.00	2.67	2.44	2.44
	NHTO/0342	1.00	1.00	1.67	1.00	1.00
	NHTO/0347	1.00	1.00	1.33	1.00	1.00
	NHTO/0351	1.00	1.00	2.00	1.00	1.00

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	NHTO/0352	1.00	1.00	3.00	1.00	1.00
	NHTO/0354	1.00	1.00	1.00	1.00	1.00
	UC-82B	1.00	1.00	1.67	1.00	1.00
	Roma VF	1.00	1.00	1.67	1.00	1.00
LSD 5%		0.095	0.096	0.99	0.67	0.67
sig level		Ns	ns	Ns	ns	Ns

Inoculation period, effect on flower abortion, number of fruit harvested and the fruit weight

The inoculation period after transplanting significantly (P<0.01) influence the tomato number of flowers aborted and the number of fruits harvested (Table 5a). In other words, the inoculation period after transplanting also significantly (P<0.05) influence tomato weight harvested. However, inoculated 4 weeks after transplanting tomato had the highest flower abortion, while non inoculated tomato had lowest flower abortion (Table 5a). The non inoculated tomato had highly significant highest number of fruits harvested and fruits weight respectively. While lowest number of fruits and fruit weight was observed in tomato inoculated 2 weeks after transplanting (Table 5a). The tomato varieties differ significantly (P<0.01) among themselves in the flower abortion and number of fruits harvested but significantly (P<0.05) influence the fruit weight. However, NHTO/0253 had significantly higher flower abortion than NHTO/0223 which had the lowest at the period of tomato maturation. Tomato variety NHTO/ 0259 had highest highly significant number of fruits harvested in which the lowest was observed in NHTO/0201. The highest fruit weight was observed in NHTO/0205 and the lowest in NHTO/0221(Table 5a).

The interaction effect of inoculation periods and varieties after transplanting significantly (P<0.05) influence the flower abortion, number of fruits harvested and the fruit weight of tomato. The flower abortion was highest in NHTO/0253 at two-weeks inoculation after transplanting, the lowest flower abortion was observed in NHTO/0223 zero week after transplanting. The highest number of fruits was seen in NHTO/0259 zero weeks after inoculation while the lowest was observed in NHTO/0251 2 Weeks after inoculation. Finally, the highest fruit weight was observed in NHTO/0205 at zero inoculation and the lowest was seen in variety NHTO/0221 inoculated 2 weeks after transplanting ((Table 5b).

Table 5a. Main effect of inoculation period with CMV and varieties on flower abortion, number of fruits and fruit weigh in grams at different times at tomato maturation

	Number Aborted Flowers	Number of Fruits	Fruit weight in grams
		Means	
Zero (I_0)	14.33	27.58	152.1
2 weeks (1_2)	34.63	14.52	50.0
4 weeks (i_4)	35.90	15.34	60.0
LSD 5%	3.88	1.61	9.04
SD	**	**	**
Varieties		Means	
NHTO/0199	25.00	13.65	94.7
NHTO/0201	23.63	6.33	80.7
NHTO/0205	22.00	10.00	115.2
NHTO/0206	25.11	7.11	83.0
NHTO/0216	24.22	9.11	66.2
NHTO/0217	24.24	7.44	83.8
NHTO/0221	21.22	8.22	56.6
NHTO/0222	27.78	8.44	76.3

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NHTO/0223	13.44	10.44	99.8
NHTO/0226	42.89	9.78	98.4
NHTO/0227	27.11	11.44	84.6
NHTO/0229	26.86	8.33	70.5
NHTO/0237	28.33	8.56	101.5
NHTO/0238	20.11	8.44	89.1
NHTO/0239	18.44	9.00	82.2
NHTO/0240	14.89	11.57	104.1
NHTO/0241	22.78	11.33	99.9
NHTO/0251	25.67	11.11	71.8
NHTO/0253	80.22	141.89	71.4
NHTO/0259	62.78	156.67	90.3
NHTO/0263	22.22	12.22	93.3
NHTO/0264	23.00	12.56	89.9
NHTO/0338	20.11	10.78	93.2
NHTO/0340	20.11	11.11	107.7
NHTO/0342	24.11	9.78	91.5
NHTO/0347	34.22	9.89	104.7
NHTO/0351	27.56	14.33	88.5
NHTO/0352	23.33	14.00	90.0
NHTO/0354	20.89	8.00	74.9
UC-82B	23.56	8.22	71.7
Roma VF	24.00	11.78	84.0
LSD	12.47	5.16	29.1
Sig Level	**	**	*

Table 5b. Interaction effect of seedling age at transplanting and tomato varieties on plant height

Inoculation after transplanting	Varieties	Number aborted Flowers	Number of Fruits	Fruit weight in grams
		Means		
Zero (I_0)	NHTO/0199	16.33	25.67	156.2
	NHTO/0201	20.67	18.67	176.3
	NHTO/0205	14.67	17.00	201.7
	NHTO/0206	10.00	13.33	164.1
	NHTO/0216	15.00	18.00	139.2
	NHTO/0217	19.00	15.33	177.0
	NHTO/0221	17.67	19.33	130.3
	NHTO/0222	16.00	15.33	149.2
	NHTO/0223	5.67	20.33	188.3
	NHTO/0226	14.33	15.00	166.4
	NHTO/0227	10.33	18.33	133.3
	NHTO/0229	15.00	14.67	130.3
	NHTO/0237	13.67	15.67	171.0
	NHTO/0238	11.00	14.67	156.3
	NHTO/0239	7.33	17.33	150.9
	NHTO/0240	8.33	19.67	167.4
	NHTO/0241	8.67	19.00	168.3

	NHTO/0251	16.67	20.00	116.6
	NHTO/0253	30.00	162.67	76.1
	NHTO/0259	27.00	164.0	95.9
	NHTO/0263	11.67	20.33	153.7
	NHTO/0264	11.33	20.00	155.6
	NHTO/0338	13.67	17.33	139.4
	NHTO/0340	12.00	19.67	195.0
	NHTO/0342	15.00	16.67	154.6
	NHTO/0347	18.00	14.00	168.9
	NHTO/0351	13.67	28.00	171.8
	NHTO/0352	11.33	21.67	127.5
	NHTO/0354	10.67	15.33	154.3
	UC-82B	17.00	15.67	140.6
	Roma VF	12.67	22.33	141.3
2 weeks (1_2)	NHTO/0199	28.67	17.00	49.9
	NHTO/0201	21.33	13.00	32.2
	NHTO/0205	14.33	17.33	68.9
	NHTO/0206	32.00	13.00	37.0
	NHTO/0216	29.00	13.33	18.2
	NHTO/0217	25.33	13.33	40.0
	NHTO/0221	27.67	12.67	17.7
	NHTO/0222	27.67	13.33	31.7
	NHTO/0223	17.67	15.67	51.8
	NHTO/0226	44.00	14.33	21.9
	NHTO/0227	34.00	16.00	51.0
	NHTO/0229	32.33	15.67	42.0
	NHTO/0237	26.33	14.33	58.9
	NHTO/0238	19.00	14.00	39.3
	NHTO/0239	21.00	14.33	43.8
	NHTO/0240	14.00	17.00	62.9
	NHTO/0241	30.00	15.67	53.1
	NHTO/0251	29.33	18.00	58.6
	NHTO/0253	108.33	132.33	71.2
	NHTO/0259	64.00	155.67	90.2
	NHTO/0263	36.67	17.67	56.9
	NHTO/0264	27.67	18.33	63.3
	NHTO/0338	39.33	17.33	67.8
	NHTO/0340	23.67	17.33	73.8
	NHTO/0342	27.33	15.67	53.4
	NHTO/0347	48.33	16.33	63.4
	NHTO/0351	30.33	18.33	60.3
	NHTO/0352	28.00	19.67	56.2
	NHTO/0354	24.00	13.33	32.3
	UC-82B	26.33	14.00	33.0
	Roma VF	30.00	16.00	47.7
4 weeks (1_4)	NHTO/0199	30.00	18.00	78.1
	NHTO/0201	29.00	13.33	33.7

	NHTO/0205	27.00	16.67	75.0
	NHTO/0206	33.33	15.00	47.0
	NHTO/0216	28.67	16.00	41.2
	NHTO/0217	29.00	16.67	34.3
	NHTO/0221	18.33	12.67	22.0
	NHTO/0222	37.67	16.17	48.1
	NHTO/0223	17.69	15.33	59.3
	NHTO/0226	70.33	10.00	106.8
	NHTO/0227	37.00	10.00	69.7
	NHTO/0229	33.33	14.67	38.6
	NHTO/0237	45.00	5.67	74.5
	NHTO/0238	30.33	16.67	71.6
	NHTO/0239	27.00	15.33	51.6
	NHTO/0240	22,39	8.33	82.1
	NHTO/0241	29.67	9.33	78.4
	NHTO/0251	31.00	5.33	40.2
	NHTO/0253	102.33	130.67	66.9
	NHTO/0259	97.33	150.33	84.8
	NHTO/0263	28.33	18.67	68.3
	NHTO/0264	30.00	18.33	50.8
	NHTO/0338	34.00	17.67	70.3
	NHTO/0340	24.67	16.33	54.3
	NHTO/0342	30.00	17.00	66.3
	NHTO/0347	36.33	19.33	82.0
	NHTO/0351	38.67	16.67	33.3
	NHTO/0352	30.67	10.67	36.3
	NHTO/0354	28.00	15.33	38.0
	UC-82B	27.33	15.00	41.7
	Roma VF	29.33	17.00	63.0
LSD 5%		21.58	8.94	50.36
Sig Level	P<0.005	*	*	*

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IMPACT OF WEED TYPES ON VIRUS INFECTION AND VECTOR POPULATION OF PEPPER (*CAPSICUM* SPP.)

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ABSTRACT

Chilli and sweet pepper production is constrained by weeds and viruses that easily attack plants. These spices were evaluated under different field plots to determine the impact of weed type (monocot and dicot) on virus infection and insect-vector population. These plots were categorized and maintained under four weed conditions namely: weed-free check, monocot-free, dicot-free and weedy check as treatments. Incidence and severity of virus-like symptoms were assessed bi-weekly for seven weeks after transplanting. Infection rates were consistently high under weedy check (4.4 to 4.9), intermediate under both monocot-free (3.5 to 3.8) and dicot-free (3.0 to 3.1) plots; and low under weed-free check (2.1 to 2.3). All weed types aided occurrence of aphid and white-fly which are known vectors of virus infection in pepper.

Key words: incidence, severity, alternative host, chilli, virus

INTRODUCTION

Weeds are universal constraint to all cultivated crops because they rapidly compete for growth resources (Adenubi and sanni, 2020; Arogundade *et al*., 2020). They are adaptable to adverse environmental conditions and can easily regrow from seeds or root fragments left after tillage (Bosland and Votata, 2012). Most plant viruses have weeds as alternative hosts that provide a reservoir of viruses (Arogundade *et al*., 2020). In many cases, more than one virus species attacks a pepper plant and these mixed infections eventually cause more severe disease symptoms due to synergistic interactions (Murphy and Bowen, 2006). Typical symptoms induced by virus infections include mosaic, stunting, curling and mottling of foliage or fruits (Arogundade *et al*., 2015).

Current management of virus diseases in pepper is based on the integration of several approaches such as use of protected nurseries and cultivation of disease resistant varieties (Roberts *et al*., 2004; Arogundade *et al*., 2012). Other control measures is by ensuring adequate phyto-sanitary conditions after transplanting and use of systemic insecticides to control vectors (Arogundade *et al*., 2020). The use of plastic mulches is a common practice that reduce weed pressure and virus incidence in many production fields (Bosland and Votata, 2012). Limitation of this technique is that it may not be achievable in commercial plantations because of the cost implication.

MATERIALS AND METHODS

Experimental site

This trial was carried out at the National Horticultural Research Institute (NIHORT), Ibadan, Oyo state, Nigeria (07°24.08' N and 03°50.73' E). Healthy seeds of two hot pepper cultivars (chilli and sweet) were sown in sterilized soil in nursery trays and mentained under well-protected screen-house. Watering to field capacity was three times a week for five weeks and enzyme-linked immunosorbent assay (ELISA) was used to ascertain their virus-status.

Experimental design

In the field, land was partitioned into raised beds using simple farm tools before transplanting. These beds were categorized and maintained under four weed conditions namely: weed-free check, monocot-free, dicot-free and weedy check as treatments plots. The experiment was laid out in a randomized complete block design and replicated three times within each plot.

Data collection

Biometrics was done bi-weekly from one to seven weeks after transplanting (WAT). Insects, aphids and white fly population were examined using magnifying hand lense. Then, incidence of virus infection was calculated as; percentage incidence = (number of infected plants (symptomatic plants)/total number of plants sampled) x 100. The severity of virus infection were grouped into low, intermediate and high using a standard 1.0 to 5.0 rating scale (Arogundade *et al*., 2012).

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RESULTS AND DISCUSSION

The effects of monocot and dicot weed types on biometric attributes and vector population of chilli and sweet pepper are shown in Table 1. Insect population was consistently high across the treatment plots and colony of aphids and white fly aided high incidence of virus infection (Figures 1). In chilli, very high incidence of virus infection (30.2%) occured under weedy check, followed by weed-free check with 27.0% incidence. However, low incidence of virus infection occured under monocot-free and dicot-free plots with 8.9% and 8.7% incidence, respectively. These weed types serve as natural alternative hosts for insect vectors that colonize pepper plants and reduce rate of infection. In sweet pepper, high incidence of virus infection (16.4%) occurred under weedy check, followed closely by weed-free check with 16.0% incidence. These control plots were easily colonized by vectors and chilli seemed to be more prone to invading viruses. In sweet, low incidence of virus infection was consistent under monocot-free and dicot-free plots with 12.0% and 10.0% incidence, respectively.

The study revealed correlation between weed types and severity of symptoms found (Figure 2). Infections were consistently high under weedy check (4.4 to 4.9), intermediate under both monocot-free (3.5 to 3.8) and dicot-free (3.0 to 3.1) plots; and low under weed-free check (2.1 to 2.3). The low severity of virus infection found in weed-free condition was not uncommon. However, intermediate severity found in monocot-free and dicot-free conditions was closely linked to non-persistent virus transmission notably by aphids due to alternative solanaceous hosts present. The high severity found in weedy conditions was closely linked to mixed infection that occur naturally under endemic condition. Therefore, farmers should give desired attention to the manner in which they prepare their lands.

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Table 1. Effect of weed types on vector population and biometrics of two types of pepper

Pepper	Weed types	Plant height (cm)				Number of leaves				Vector population		
		1 WAT	3WAT	5 WAT	7 WAT	1 WAT	3 WAT	5 WAT	7 WAT^{h}	Aphids^{x}	White fly^{y}	Insects^{z}
Sweet	Weed-free	8.60^{d}	12.81^{c}	16.37^{b}	20.17^{b}	8.70^{a}	13.67^{ab}	27.00^{a}	37.33^{a**}	8.67^{d}	10.67^{e+}	20.33^{d}
	Monocot-free	11.35^{a}	14.04^{ab}	18.07^{a}	21.85^{a}	6.33^{bc}	10.33^{de}	18.00^{d}	23.67^{c*}	40.33^{b+}	34.33^{cd}	74.67^{c}
	Dicot-free	10.57^{b}	14.83^{a}	18.07^{a}	21.09^{ab}	7.0^{b}	12.33^{bc}	21.67^{b}	30.33^{b**}	32.00^{bc+}	29.33^{cd}	61.33^{c}
	Weedy	6.50^{g}	8.09^{f}	11.95^{d}	16.22^{d}	5.33^{c}	9.67^{e}	19.00^{cd}	23.67^{c}	71.33^{a+}	27.67^{cd}	103.00^{a-}
Chilli	Weed-free	8.30^{e}	9.99^{e}	12.87^{d}	15.40^{d}	8.67^{a}	14.33^{a}	29.00^{a}	38.67^{a***}	7.00^{d}	23.33^{d+}	30.33^{d}
	Monocot-free	8.40^{de}	11.60^{d}	14.13^{c}	18.02^{c}	6.67^{bc}	12.67^{bc}	21.00^{bc}	30.00^{b**}	29.00^{c}	48.33^{b+}	77.33^{c}
	Dicot-free	9.52^{c}	12.90^{c}	16.17^{b}	20.23^{b}	6.33^{bc}	11.57^{cd}	21.00^{bc}	28.67^{b**}	28.00^{c}	37.00^{bc+}	65.00^{c}
	Weedy	7.6^{f}	13.67^{bc}	17.03^{b}	20.57^{b}	6.0^{bc}	9.67^{e}	15.67^{e}	18.33^{d}	79.00^{a+}	61.00^{a+}	142.00^{a+}

Presented mean values with the same superscript letter(s) along the same column are not significantly different ($P<0.05$)

^{h*} magnitude of yield at harvest

$^{x+}$ aphid vectored (non-persistent transmission)

$^{y+}$ white fly vectored (persistent transmission)

$^{z+}$ blank check (mixed transmission)

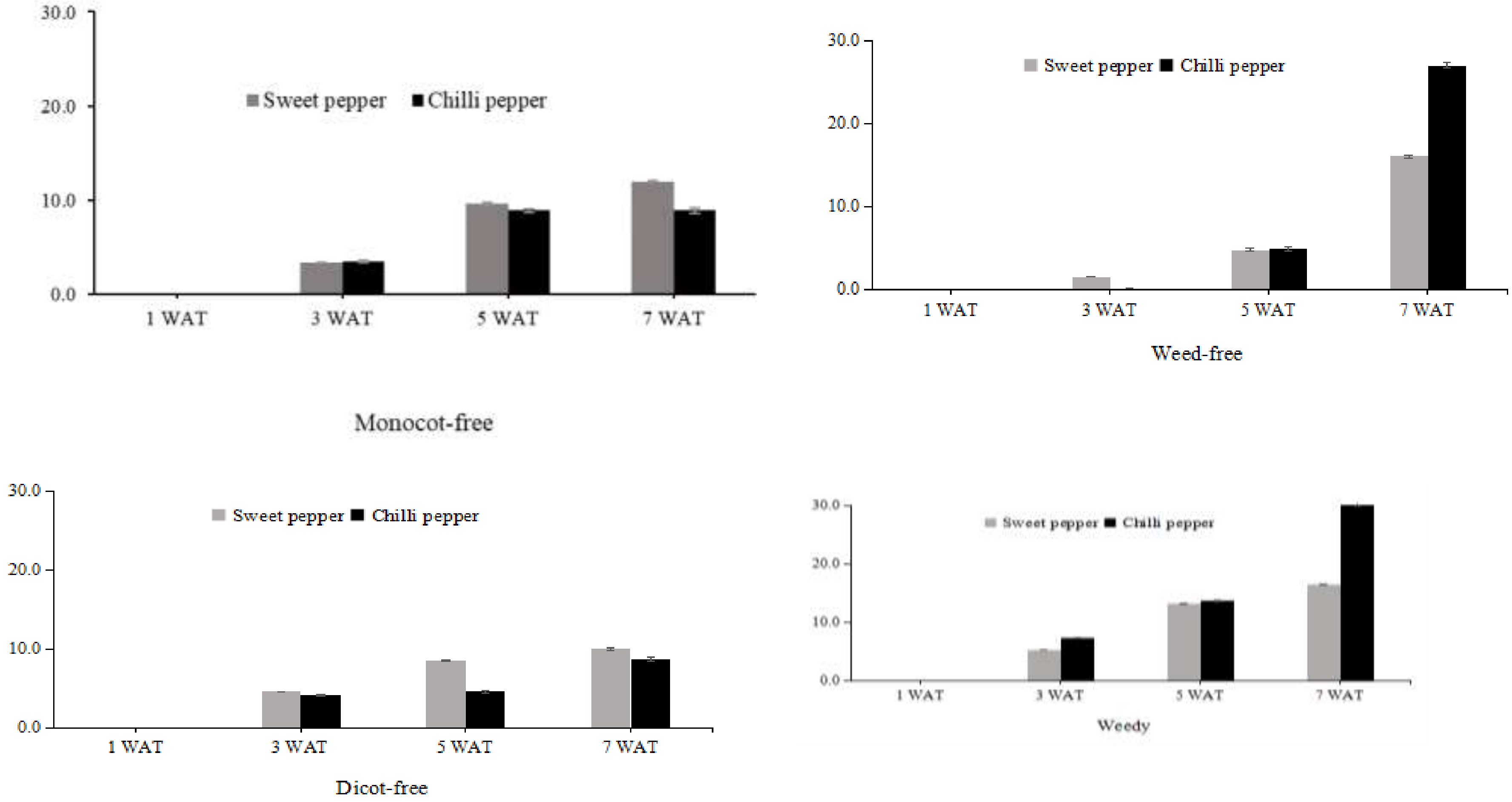

Figure 1. Progressive incidence of virus infection in chilli and sweet pepper grown under four categorized weed conditions

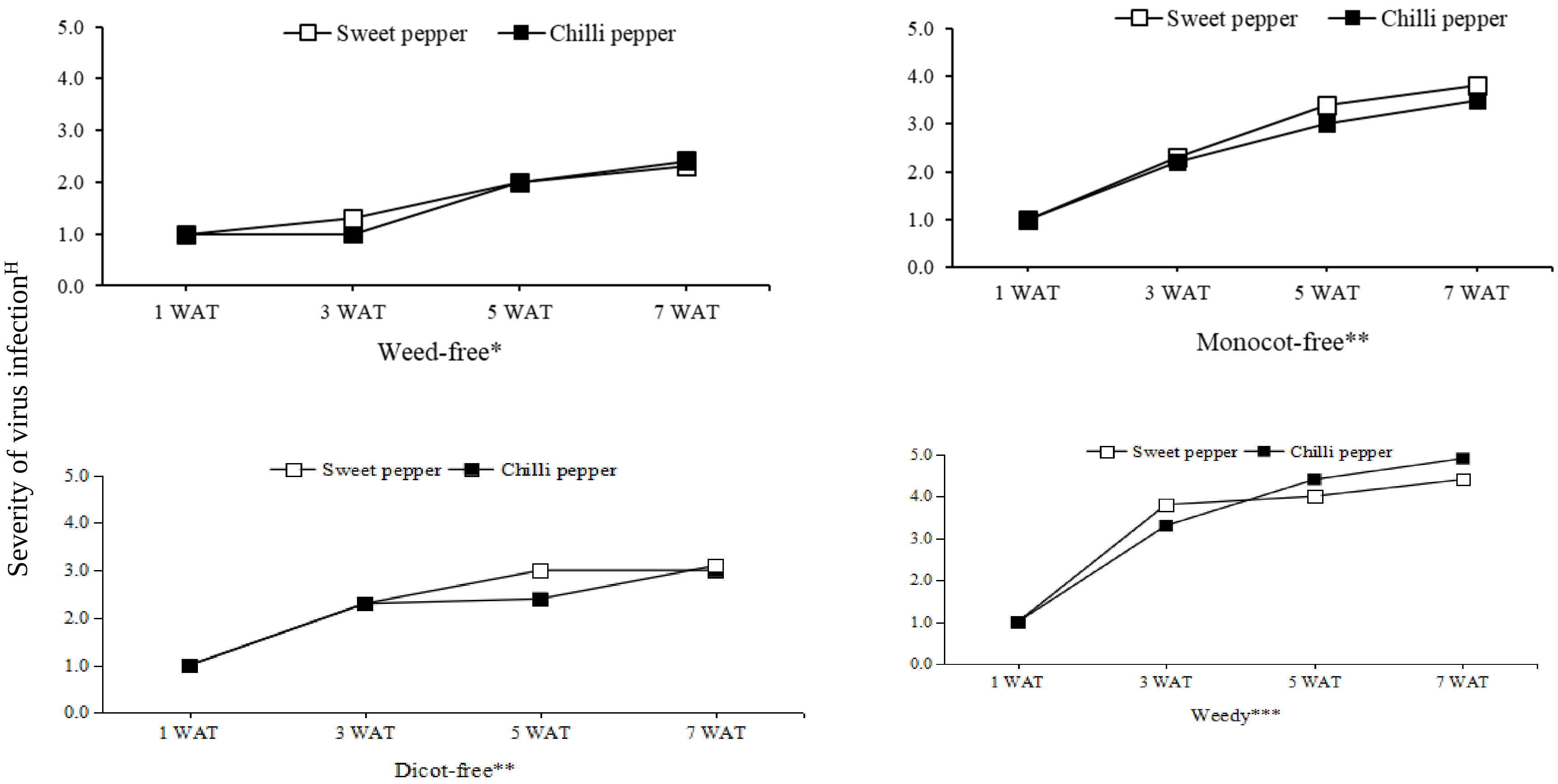

Figure 2. Severity of virus infection in chilli and sweet pepper grown under four categorized weed conditions

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DIAGNOSTIC ASSAY, IDENTIFICATION AND INCIDENCE OF CAUSAL ORGANISM(S) OF CHERELLE WILT DISEASE IN THREE MAJOR COCOA PRODUCING STATES (ONDO, OSUN AND ABIA) OF NIGERIA

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ABSTRACT

The study was initiated to investigate the high mortality of cacao cherelles reported across cocoa growing state from 2014 cropping season till date. A survey was undertaken to determine the percentage disease incidence, causal organism(s) and their percentage distributions across the affected location. Samples were collected in 3 LGAs per state across Ondo, Osun and Abia state. Routine laboratory Isolation and identification of causal organisms were done using Potato dextrose agar medium and the isolated organisms were compared with identification guide. The true statuses of the identified organisms were determined through pathogenicity test. The result shows that Ondo state has highest percentage disease incidence (94.2%) followed by Osun state (84.2%) and the least Abia with 73.4%. Lasiodiplodia species had the highest percentage occurrence (64.4%, 56.0% and 49.6%) in Ondo, Abia and Osun state respectively, while Fusarium species with 51.8%, 50.3% and 46.3% respectively followed. However, Lasiodiplodia and Fusarium spp. were implicated as the real causal organism according to pathogenicity test conducted. Further work is on-going to establish the best control or management method.

Key words: Cherelle wilt, disease incidence, causal organism(s), percentage distribution

INTRODUCTION

The cocoa tree, (*Theobroma cacao* L.), belongs to the family *Malvaceae*. It is of considerable economic importance to the producing countries, the chocolate, cocoa butter, powder and semi-finished cocoa product based companies of the western nations of Europe. The recent discovery of the health benefits of the polyphenols and flavonoids in processed cocoa products as a good antioxidant has added to the in increased demand for cocoa-based products around the world. Sequel to this development, meeting the local and international demand has become a herculean task for the producing countries of Western Africa that supply between 70-80% of processed raw bean that serves as an industrial raw material for finished cocoa products such as cocoa mass, used in making chocolate, biscuits, and confectioneries. Although these benefits, obtaining optimum yield from cacao is faced with serious challenges. Foremost among these factors that affect cocoa production is the plethora of cacao diseases, soil, and climatic conditions prevailing in the humid tropics that the perennial tree crop is grown, hinder genetic yield potential of the tree crop.

Cacao pathogens reduce the potential crop yield by an estimated 810,000 tons annually (30% of world production) and individual farm losses can approach 100%, (Guiltinan, 2007). The pathogenic organisms, soil micro flora, and fauna and plant nutrients in the tropics are variable due to the variable weather conditions of the tropics that could be hot with low relative humidity and suddenly changes becoming cloudy with accompanying heavy rainfall that results to leaching down and washing off of soil nutrients, micro flora and fauna. The rainfall also results in reduced temperature and high relative humidity of over 90%. This development affects the physiology of the cacao plant and encourages the infection and thriving of diseases of which cherelle wilt has suddenly become an important limiting factor to cacao production in Nigeria.

Matured cacao plant of fruit-bearing age produces abundant flowers of which only 0.5-5% set fruits that become young *Theobroma cacao* pods, known as cherelles. These young fruits are

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commonly lost to physiological thinning known as cherelle wilt, although some evidence is now available that indicates other possible causes that include abiotic factors such as sunscald and drought and biotic such as insect pest and disease causing pathogenic organisms. Between 20-90% of cherelles (young fruit) produced by a cacao plant can be lost to cherelle wilt. Cherelle wilt was considered a physiological thinning mechanism involving vessel occlusion in the cherelle peduncle (Melnick et al. 2013). Other possible causes have also been adduced to diseases causing organisms such as *Phytophthora* species, *Moniliophythora roreri*, *Lasiodiplodia theobromae*, and *Fusarium* species among others (Thorold, 1975; Opeke, 1992; Melnick et al. 2013). Symptoms manifest when wilting cherelles stop growing, turn yellow after a week, turn blackish-brown, and mummify remaining attached to the tree (Melnick et al. 2013). Peak wilt occurs 50 days after pollination followed by a second stage occurring around 70 days after pollination (Melnick et al. 2013). Cacao insects such as adult menbracid and adult treehoppers have been shown to cause 40% cherelle wilt (Kasran et al. 1991). Other factors such as hormonal influence and deficiency of certain essential nutrient elements such as potassium, nitrogen, calcium, magnesium, copper, manganese, zinc and boron coincide with high cherelle wilting (Kasran et al. 1991).

This study, therefore, was initiated to study the pathogenic organism(s) associated with cherelle wilt disease, their percentage incidence and distribution in the cacao field in Nigeria. The findings of this study will enable the understanding of mechanism of events that occur in the wilting cacao cherelles and further update the results of previous research in the face of changing climate.

MATERIALS AND METHODS

Samples of cherelle were collected in Abia, Ondo and Osun States. Three (3) LGAs were selected per State, with 9 farms per LGA given 27 farms per State sampled. In the states covered, systematics sampling procedure was used to select three local government areas (LGAs) starting with the local government with the highest production, the one following and the third one with marginal production. Within these LGAs, using the same sampling procedure as applied for selection of LGAs, three cocoa farming communities per LGA and three cocoa farmer's farm per community were randomly selected and surveyed. These farmers' farms measured between 2- 5 hectare and the age of the farms ranged between 10 to 30 years.

Furthermore, per farm visited, 20 cocoa trees were selected. Data was obtained for the diseased and healthy cherelles per tree selected using the eyes level as height. Leaves and diseased sample cherelle were collected from the cocoa tree and put in Ziploc plastic bags and labelled properly.

Analysis of diseased cherelle samples from the states surveyed

The diseased cherelle samples obtained were taken to the plant pathology section laboratory at CRIN headquarters and pieces of lesion sections excised from the cherelle pods were then plated after normal laboratory routine on extract of Potato Dextrose agar (PDA) medium (per liter: 200g peeled and sliced *Solanum tuberosum*, 15g agar powder, 20g dextrose, 10% solution Streptomycin antibiotics) in 9cm diameter disposable plastic Petri-dishes at 3 pieces per dish for the 3 replicates dishes per cherelle pod collected. Emerging hyphae were transferred by hyphal tip on to new PDA plates to obtain pure cultures.

Morphological data were taken of relevant colony cultural characteristics (Pigmentation, colony appearance top, and bottom of plates and conidia or spore structure under x100 and x400 objectives of Olympus microscope mounted with scope 9.0 digital imagery camera to described them). Eighteen culture samples of the fungi isolates after the morphological study were sent to CABI, UK for molecular analysis.

Pathogenicity test of the fungal isolates: Pathogenicity was conducted with the fungal isolates obtained from the various states surveyed to ascertain fungal isolates that shows the same symptom(s) observed in the field.

Statistical analysis

Percentage colony count of the organisms was done using Otuonye *et al.,* (2014) formula:

$$\%\ \text{Colony count X} = \frac{\text{X number of appearance in all replicate plates x100}}{\text{Total number of all colony counts in all replicate plates}}$$

Where,

X = colony of identified microorganism in the solid media

Total number of all colony count = microorganisms (identified and unidentified)

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While percentage disease incidence was calculated using Gashaw *et al.*, (2014) as follows

$$\% \text{ Disease incidence} = \frac{\text{No of infected plants units x100}}{\text{Total number of units assessed}}$$

where,

No of infected plants units = infected cherelles

Total number of units= diseased and healthy cherelles

RESULTS AND DISCUSSION

Table 1 shows percentage disease incidence obtained per state surveyed and frequency of occurrence of organisms as shown by the percentage colony count. The percentage disease incidence indicates that Ondo state has 94.2% followed by Osun with 84.2% and Abia with 73.4% (Table 1). Frequency of isolation showed that *Lasiodiplodia* spp was consistently isolated and had the highest percentage occurrence of 64.4%, 56.0% and 49.6% in Ondo, Abia and Osun state respectively, while *Fusarium* spp with 51.8, 50.3 and 46.3 respectively, followed (Table 1). Pathogenicity test conducted of the fungal isolates implicated *Lasiodiplodia* spp and *Fusarium* spp. *Lasiodiplopdia* spp.is widespread pathogen and has been associated with diseases such as wilt, fruit blight, dieback and fruit rot/pod rot in cacao (Punithalingham, 2005; Mbenoun et al. 2008; Twumasi et al. 2014; Alvindia and Gallema, 2017). *Fusarium* species have also been associated with wilt of crop plants and dieback disease of cacao (Mbenoun et al. 2008: Rosmana et al., 2013; Rachmawaty et al. 2019).

Results of molecular identification from CABI identified *Lasiodiplodia* spp, *Fusarium* spp (*Fusarium solani* species complex, *Fusarium decemcellulare*), *Aspergillus* section *nigiri*, *Colletotrichum gloeosporioides*, *Bionectriaceae*, *Trichoderma ovalisporum*. Based on the pathogenicity test and identification by CABI, it is obvious that *Fusarium solani* species complex, *Fusarium decemcellulare*, *Lasiodiplodia* spp, and *Bionectriaceaei* have been implicated elsewhere as wilt pathogen of cocoa organs and several plant hosts.

CONCLUSION

The high percentage disease incidence from the states surveyed shows that cherelle wilt could be exacerbated by pathogenic organisms aided by some soil factor, management practices and climate change.

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Table 1. Percentage disease incidence and frequency of isolation of fungal isolates

State Surveyed	% Disease Incidence	% frequency of fungi isolated from infected cherelle pods														
		Lasiodiplodia spp	*Aspergillus niger*	*Fusarium* species	*Rhizopus nigircans*	*Trichoderma* spp	*Colletotrichum gloeosporioides*	*Botrytis* spp	*Aspergillus* spp	*Pythium* spp	*Curvularia* spp	*Penicillium* spp	Yeast	Streptomyces	*Fusarium* Oxysporium	*Neurosopora* spp
Abia	72.35	56.0	17.0	62.3	-	-	-	-	-	22.3	-	6.10	31.0	9.55	-	2.87
Osun	84.16	49.6	8.11	68.3	2.10	7.11	9.01	-	2.34	11.0	-	1.00	-	-	8.42	-
Ondo	94.23	64.4	11.1	51.8	48.1	3.70	22.2	25.9	7.40	3.70	22.2	3.70	-	-	14.8	-

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COMPLEXES OF *PHYTOPHTHORA* AND *LASIODIPLODIA* STRAINS IN MAJOR DISEASES OF COCOA AND CASHEW IN NIGERIA

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ABSTRACT

Cocoa and cashew production are important economic activities in Nigeria, production volumes are high among other producing countries and they are leading cash crop foreign exchange earnings. These crops are threatened by many biotic constraints resulting in significant yield reduction and subsequent economic losses. Diseases are the most damaging, compromised yield in terms of quality and quantity, Phytophthora megakarya and Lasiodiplodia theobromae cause major losses in cocoa and cashew. This study focuses on characterization of established pathogens of disease conditions. Field survey was carried out targeting black pod, pod rot of cocoa in Ondo, Oyo and Cross rivers states, twig dieback, inflorescence and nut blight of cashew in Oyo state. Cocoa pods and cashew parts with typical symptom of disease conditions were collected and isolation carried out. Genera Lasiodiplodia, Botryosphaeria, Aspergillus, Fusarium, Phytophthora and Colletotricum were associated with disease conditions at varied occurrences across study areas. Morphological description of established pathogens showed presence of Botryodiplodia theobromae common to all disease conditions, P. megakarya cultured from black pod in Oyo and Cross Rivers. However, nucleotide sequences of same isolates showed diverse species identities with disease conditions. Botryosphaeria mamane was recorded in black pod (Bolorunduro, Idanre, Owena, Akure), L. pseudotheobromae in pod rot (Owena). Different strains of P. megakaya were cultured from black pod in Cross river (strain 61J5) and Oyo (strain PPG4). Lasiodiplodia theobromae was cultured from pod rot (Bolunduro, Akure, Idi-Ayunre) but were of varied strains and likewise were the strains of L. theobromae cultured from cashew twig, inflorescence and nuts in Idi-Ayunre (Oyo state). The percent identity of the cultured isolates with matched strain range from 97.47% to 100%. The genetic diversity in this study indicates knowledge gap in previous identity of Lasiodiplodia species and P. megakarya in Nigeria.

Key words: Cacao, Cashew, *Phytophthora*, *Botryosphaeria, Lasiodiplodia* Black pod, dieback

INTRODUCTION

Cocoa is an important cash crop and major source of income to many smallholder farmers in the forest region of West Africa. It is estimated that 90 % of worldwide cocoa production comes from smallholdings and most of this production occurs in areas of high biodiversity of varieties and pests' complexes. Several factors have contributed to decline and dwindling production of cocoa of which black pod disease is key factor. Black pod disease is more established in West Africa than in any other parts of the world (Adegbola, 1972). Rare report of diplodia pod rot disease of cocoa growing countries of the world and classified as an invasive species on cocoa. Cashew is very prone to wide range of pathogens which infect different parts: stems, leaves, inflorescences, apples and nuts resulting into significant and economic losses in yield and quality.

Phytophthora megakarya is the most aggressive fungal pathogen on *Theobroma cacao* L. and poses a major threat to cocoa production in West and Central Africa. It was originally identified in Nigeria in 1979 (Brasier et al., 1981). Currently, *P. megakarya* is the predominant species responsible for black pod disease of cocoa in the sub region (Opoku et al., 1997, 2000). Every stage of pod development is susceptible to infection, but immature pods are the most susceptible. The first symptom observed on cocoa pods infected by *P. megakarya* is the appearance of a small translucent spot about 2 to 3 days after infection. Under humid conditions, the spot turns brown and then darkens and spreads rapidly to cover the entire pod within 7 to 14 days. Three to five days after the appearance of the first symptom, whitish spores are produced. Pod rot symptoms due to *P. megakarya* however, are characterized by multiple lesions which spread fast and coalesce with an abundant bloom of white zoosporangia on the lesion except for about a centimetre from the advancing margin. *Phytophthora megakarya* has become the main yield-limiting factor for cocoa production in affected areas (Opoku et al., 2000), the documented host range of *P. megakarya* is limited.

Lasiodiplodia theobromae is a cosmopolitan fungus with a worldwide distribution in the tropics and subtropics with a wide host range. This pathogen has been associated with pod rot of cocoa and causes blight and dieback of cashew inflorescence and twigs in Nigeria. This study however focuses on established pathogens of pod rot and black pod of cocoa, inflorescence blight and twig dieback of cashew vis-à-vis *P. megakarya* and *Lasiodiplodia* spp. in Nigeria.

MATERIALS AND METHODS

Study location: Field survey was carried out during cocoa pod production and cashew fruiting, targeting major and established pathogens of the crops in selected study locations in Ondo, Oyo and Cross rivers state. Cocoa pods showing typical symptoms of pod rot and black pod were aseptically collected from farms in selected communities (Figure 1). Disease samples were collected in sterile Ziplock sample bags and isolation procedure carried out at the laboratory of Cocoa Research Institute of Nigeria (CRIN). The infected cocoa pods and cashew parts were aseptically excised into smaller tissues pieces of 3mm using sterile scalpel, surface-sterilized in 1% Sodium hypochlorite, inoculated on selected growth media and incubated at appropriate temperature and moisture under alternating cycles of 12hours UV light and 12hours darkness for 7days. The isolates were obtained in pure cultures. Pure cultures of isolates were transferred to Inquaba laboratory facility, Idi-Ayunre, Nigeria, for morphological character descriptions, identification and nucleotide sequences were carried out according to the methodologies of Kwon et. al., 2011.

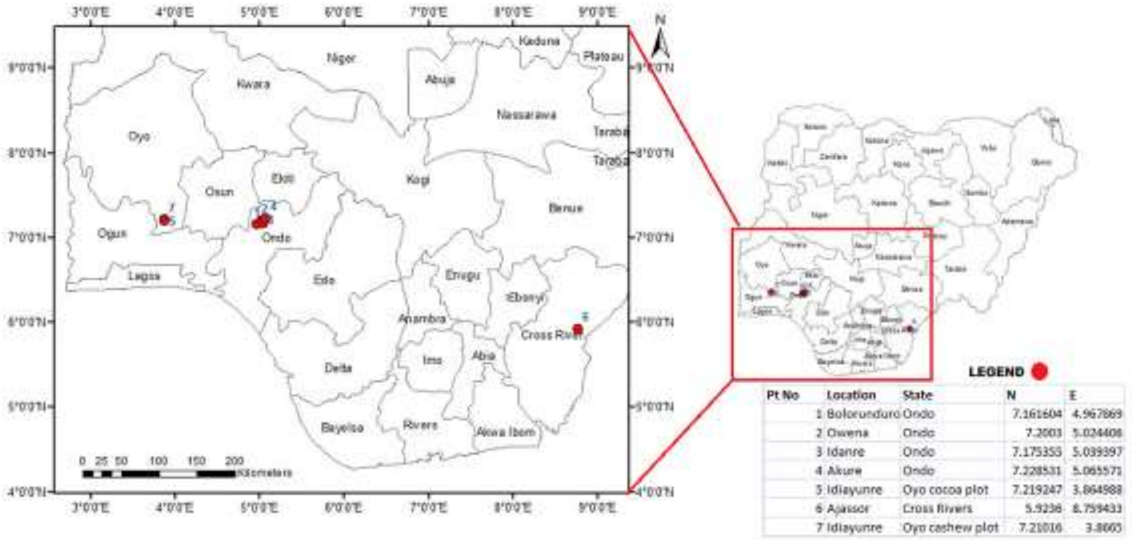

Figure 1. Map showing area of sample collection points

RESULTS AND DISCUSSION

The percent occurrence of associated organisms with pod rot and black pod of cocoa, inflorescence blight, twig dieback and nut blight of cashew varied with study locations. Total of eight genera were associated with disease conditions of cocoa and cashew.

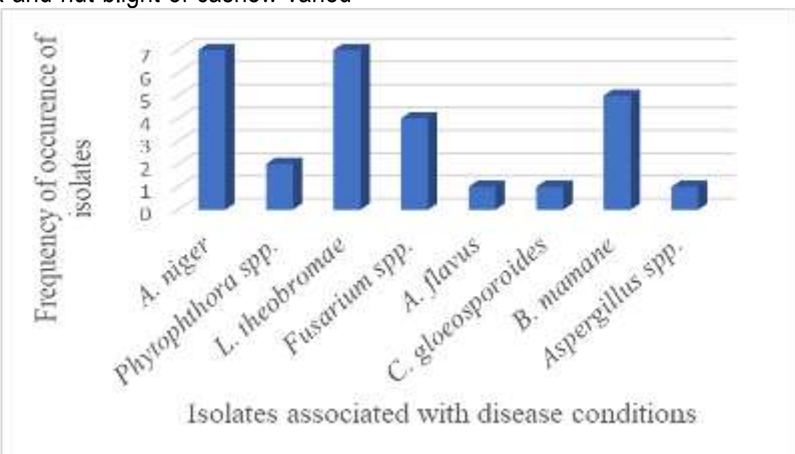

Figure 2. Occurrence of isolates with disease conditions of cocoa and cashew

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Lasiodiplodia theobromae and *Aspergillus niger* recorded the highest occurrences of 25% each, *A. flavus, Colletotricum gloeosporoides* and *Aspergillus* species each recorded 3.6% occurrence in the disease conditions. *Phytophthota megakarya* had 7.1%, 14.3% and 17.8% was recorded in *Fusarium* species and *Botryosphaeria mamane* respectively (Figure 2).

Lasiodiplodia theobromae, A. niger and *Fusarium* species were cultured from pod rot of cocoa at Bolorunduro, Owena, Idanre and Akure (Ondo state). *Botryosphaeria mamane, A. flavus* and *Fusarium* were also present in Ondo state. *Botryosphaeria mamane,* which shared similar characteristic features with *L. theobromae* was common in black pod disease in all locations except Akure. Pod rot disease condition at Idanre also recorded *B. mamane. Colletotricum gloeosporoides* was also cultured from inflorescence blight of cashew (Table 1).

Colletotricum gloeosporoides has been reported as a pathogen of cashew causing a number of diseases condition on cashew inflorescence, twig, nuts and anthracnose disease in Tanzania (Zhongrun and Masawe, 2014), however this study is the first report of *C. gloeosporoides* cultured from inflorescence blight condition of cashew in Nigeria, although this pathogen have been reported associated with anthracnose disease.

Table 1. Mycoflora associated with disease conditions of cocoa and cashew

Disease condition/crop			Location
Pod rot/cocoa	Black pod/cocoa	Cashew blight/dieback	
L. theobromae	*B. mamane*		Bolorunduro
A. niger			
L. theobromae	*B. mamane*		Owena
A. niger	*A. niger*		
B. mamane	*B. mamane*		Idanre
Fusarium spp.	*Fusarium* spp.		
L. theobromae	*L. theobromae*		Akure
A. niger	*Fusarium* spp.		
Fusarium spp.			
L. theobromae	*P. megakarya*	Inflorescence blight: *L. theobromae, A. niger, C. gloeosporoides*	Idi-Ayunre
Aspergillus spp.		Twig dieback: *L. theobromae, A. niger*	
Fusarium spp.		Nut blight: *L. theobromae, A. niger*	
	P. megakarya		Ajassor

Established pathogens of pod rot and black pod of cocoa, blight and dieback of cashew were cultured, the morphological characteristics of the isolates were described in plate 1 to 4. Record of pod rot disease of cocoa was rare in Nigeria except for the incidence of the pathogen on young cocoa seedling causing dieback. The *Lasiodiplodia* pod rot disease of cocoa was first reported in Bangladesh by Shamsi et. al., 2010.

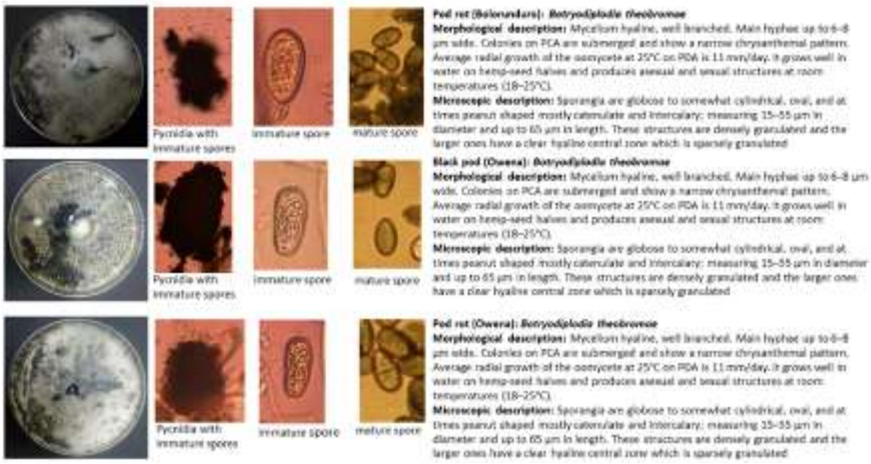

Plate 1. Morphological description and identity of pathogens on cocoa

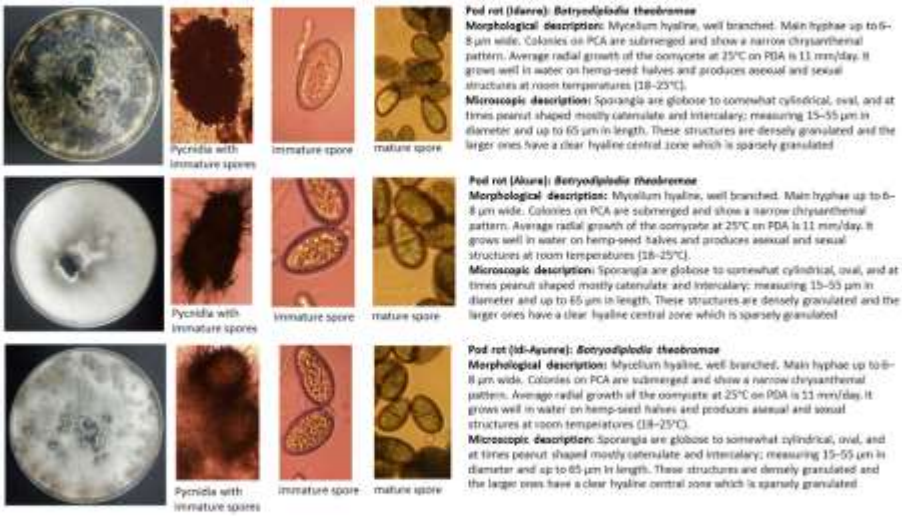

Plate 2. Morphological description and identity of pathogen on cocoa

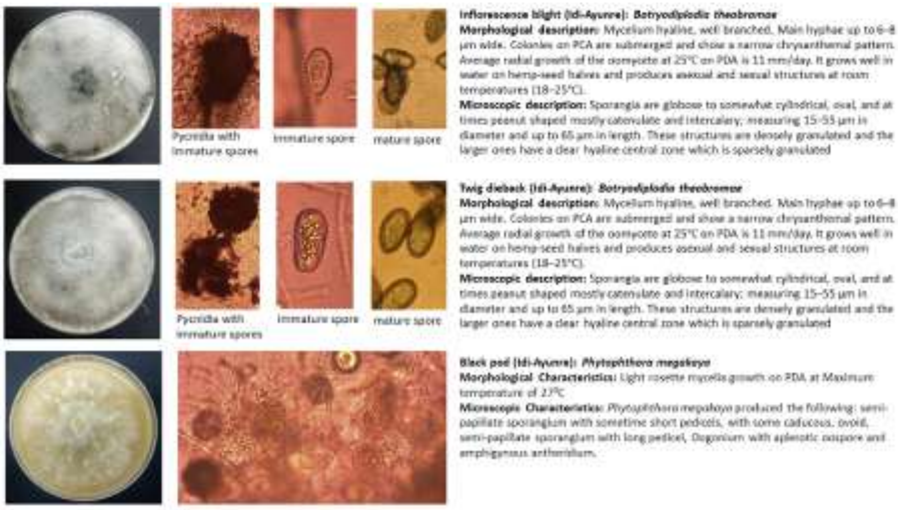

Plate 3. Morphological description and identity of pathogens on cashew and cocoa

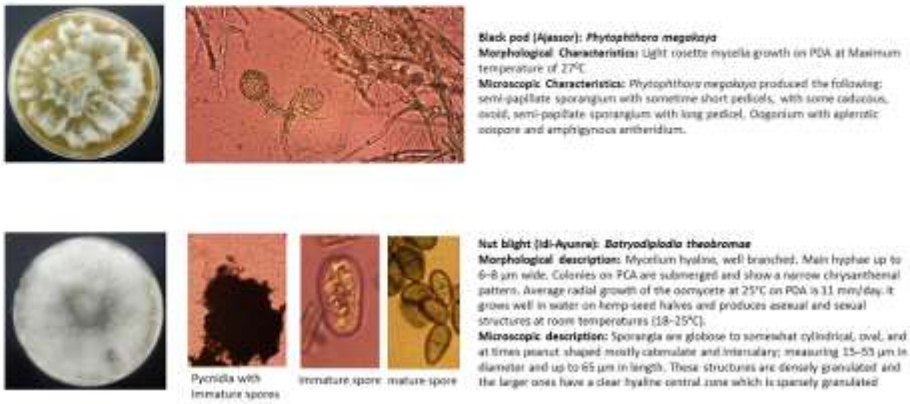

Plate 4. Morphological description and identity of pathogens on cocoa and cashew

Variations were reported in morphological characters: growth rate, sporulation, pycnidial production, colony texture and colour of *Lasiodilplodia* species associated with cashew inflorescence in Nigeria. Although all *Lasiodiplodia* isolates have one septation, but the septa size and conidial dimension also varied with source of isolates across farm locations (Adeniyi et. al., 2016). The nucleotide sequences of isolates initially reported to be *L. theobromae* through morphological descriptions showed *L. pseudotheobromae* (CUZF1QNA), *L. pseudotheobromae* (PLM-590A), *Botryosphaeria rhodina* (UCD1028BC), *L. theobromae* (670004), and *L. theobromae* (isolate 8) from cashew inflorescence blight condition (Adeniyi and Asogwa, In-press) and occurrence of *Cophinforma atrovirens* on inflorescence blight of cashew was first reported in Nigeria by Adeniyi et. al., (2020).

In this study, *L. theobromae* also showed varied strains in pod rot of cocoa: *L theobromae* (ELS4), cultured at Bolorunduro, *L. pseudotheobromae* (UY1356) at Owena, *B. mamane* (CBS117444) at Idanre and *L. theobromae* (BT02) isolated at Akure. The *L. theobromae* (zm13581) was cultured from black pod disease and pod rot of cocoa at Idi-Ayunre, Oyo state while *Aspergillus* species and *Fusarium* were associated with pod rot at Idi-Ayunre. Varied strains of *P. megakarya* were cultured from black pod at Idi-Ayunre (Oyo state) and Ajassor (Crossrivers state), PPG4 and 61J5 strains respectively. The *L. theobromae* were also occurred in varied strains in cashew disease conditions; GUCC9240, SKJM1103 and gi from inflorescence blight, twig dieback and nut blight respectively at Idi-Ayunre, Oyo state. *Aspergillus niger* was commonly associated *Lasiodiplodia* species on cashew (Table 2).

Table 2. Nucleotide sequences of pathogenic isolates in cocoa and cashew

Target crop	Matched organism			Location
Cocoa	Pod rot	Black pod		
	L. theobromae (ELS4)	*B. mamane* (CBS 117444)		Bolorunduro
	L. pseudotheobromae (UY1356)	*B. mamane* (CBS 117444)		Owena
	B. mamane (CBS 117444)	*B. mamane* (CBS 117444)		Idanre
	L. theobromae (BT02)	*L. theobromae* (BT02)		Akure
	L. theobromae (zm13581)	*P. megakarya* (PPG4)		Idi-Ayunre
		B. mamane (CBS 117444)		Idi-Ayunre
		P. megakarya (61J5)		Ajassor
Cashew	Inflorescence	Twig	Nut	
	L. theobromae (GUCC9240)	*L. theobromae* (SKJM1103)	*L. theobromae* (gi)	Idi-Ayunre

Deoxyribonucleic acid (DNA) sequences from the NCBI nucleotide database were aligned using ClustalW, and a phylogenetic tree from consensus nucleotide sequences was constructed using the neighbor joining method and visualized with Tree View. Numbers above the branches indicate bootstrap values. Bars indicate number of nucleotide substitutions per site. The present isolate infecting *Theobromae cacao* and *Anacardium occidentale* were is marked in italics (Figure 3).

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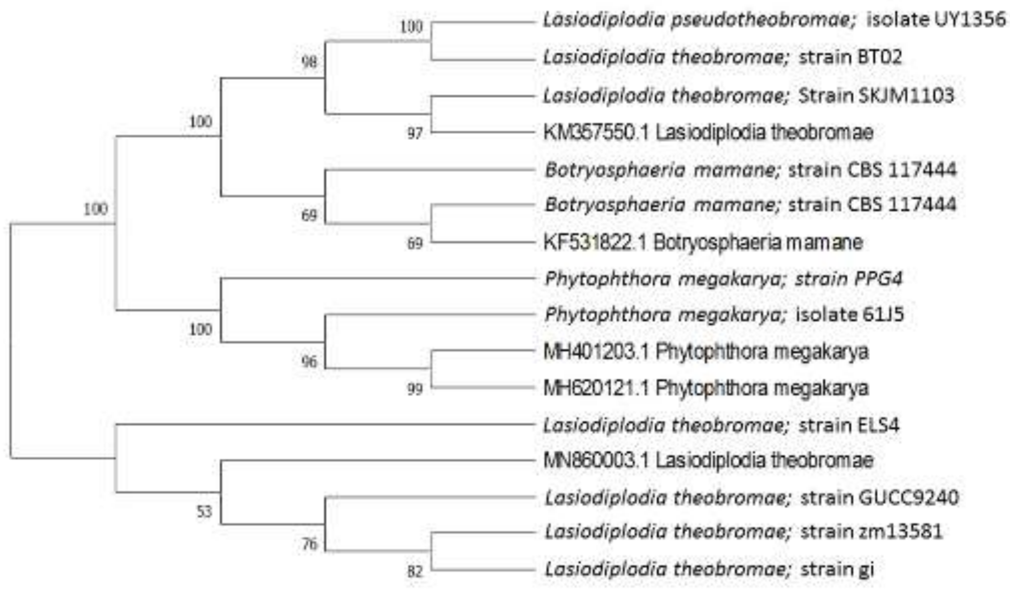

Figure 3. Phylogenetic tree using internal transcribed spacer (ITS) sequences showing closest known relatives of *Lasiodiplodia* and *Phytophthora*

COMPOSITION OF INSECTS ASSOCIATED WITH ROSELLE [*HIBISCUS SABDARIFFA* L.] AT THE VEGETATIVE GROWTH STAGE IN NORTH CENTRAL NIGERIA

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ABSTRACT

The diversity and impact of insect species associated with roselle (Hibiscus sabdariffa L.), a food, fibre and pharmaceutical resource plant, varies from one location to another. Insect infestation on the crop at the vegetative growth stage was monitored at Makurdi, Benue State in 1m x 1m grid in each of 24 field plots planted to the green and the red types of roselle. The numbers of insects collected from both types were compared using Student's t test. Thirty-five species of insects in 19 Families and 6 Orders were collected from seedling emergence [1 week after planting (WAP)] to late vegetative stage (9 WAP). Majority of the insects were categorized as pests, five were predators, one a parasitoid and few incidentals. Monolepta thomsoni Allard was the most abundant (36.7-39.8 % of total collection) followed by Nisotra sjsostedti Jacobi (25.0 %); their infestation straddled seedling emergence to late vegetative stage. The least abundant species were Aulacophora africana Weis., Cylas puncticollis Boh., and Cardiophorus hoploderus (0.02 % each). Of natural enemies, Exochomus flavipes Thunb. was the most abundant (1.08 % of total collection). Number of species and population density increased phenomenally from 7 WAP and peaked at 9 WAP with concomitant severe damage to foliage. The mean number of insects collected on the green roselle (71.5 ± 32.8) was significantly (tα = 0.05) higher than the number collected on the red roselle (65.9 ± 30.8).

Key words: *Hibiscus sabdariffa,* roselle, insects, vegetative growth stage

INTRODUCTION

Roselle (*Hibiscus sabdariffasabdariffa* L.) in the family Malvaceae is an important vegetable crop in tropical and sub-tropical regions of the world (Ahmed *et al*., 2012). In Africa, the major producing countries include Republic of Benin, Sudan, Cote d' Ivoire, Ghana, Niger, Burkina Faso, and Nigeria (Oyewole and Mera, 2010). *H. sabdariffa* var. *sabdariffa* is grown for its fleshy, shiny-red calyx, while *H. sabdariffa* var. *altissima* is grown for its fibre.

The domestic and industrial uses of Roselle include: making herbal tea and beverage from calyx and bracts, preparation of soup/sauce using calyx and bracts, consumption of leaves and stalks as green vegetable/salad, trado-medicinal usage for treatment of diverse ailments and usage in paper industry (Mahadeva and Shivali, 2009). The objective of the study is to determine species composition of insects associated with Roselle [*Hibiscus sabdariffa* L.] at the vegetative growth stage in Makurdi, Benue State Nigeria.

MATERIALS AND METHOD

Experimental Location and Source of Seed: The experiment was conducted at the College of Agronomy Experimental Field, University of Agriculture, Makurdi (Latitude 07^0 45 - 07^0 50 N, Longitude 08^0 45 - 08^0 50 E, elevation 98m above sea level). Seeds of green and red varieties of Roselle were sourced from the market in Makurdi, Benue State.

Field Plot Layout and Data Collection

Twelve plots were sown to green and red types of Roselle, each plot measured 5 m x 5 m. On rows 2 and 4 of each plot, 1 m^2 area was selected at random to document insect species infesting the crop and the number of individuals of each species observed

Data Analysis

The relative abundance (Ar) was calculated according to the method of Zaime and Gautier (1989):$Ar(\%) = \frac{Ni}{N} \times 100$

where Ni is the number of individuals of a given species and N =the total number of individuals of all species.

RESULTS AND DISCUSSION

The total count of insects on the two Roselle varieties amounted to 35 different species belonging to 6 insect Orders: Coleoptera (19 species), Hemiptera (7 species) Homoptera (2 species), Hymenoptera (2 specie), Orthoptera (4 species) and 19 Families were collected from seedling emergence (1WAP) to late vegetative stages (9 WAP). The composition of insect pests and natural enemies on Roselle are given in Table 1 and Fig. 1. The number of insect species (35) collected at the vegetative stage of growth of Roselle at Makurdi approximates the total number (36) collected by Daramola (1984) in southwestern Nigeria throughout the crop's growth. Members of three Families and two Orders not reported from southwestern Nigeria were collected.In both studies, coleopterous insects predominated and the numbers of predatory species were similar (6 and 5 in southwestern Nigeria and Makurdi, respectively The leaf eating beetles, *Monolepta thomsoni* Allard, *Nisotra sjostedti* Jacoby were the dominant insect species (they appear in large number at the same time) at the seedling and early vegetative stages of the crop, they feed on the leaves and cause small round holes. *Monolepta thomsoni* Allard (36.7-39.8 % of total collection), recorded the highest relative abundance followed by *Nisotra sjsostedti* (25.0 %) Jacoby.*N. sjostedti* are known insect pest of Kenaf (*Hibiscus cannabinus* L.), Okra (*Abelmoschus esculentus* (L.) Moench) and other malveceous plants (Echezona *et al*., 2010, Amujoyegbe *et al*., 2016). Flea beetles [*Nisotra sjostedti*; *Monolepta thompsoni*], grasshoppers [*Aiolopus thalssimus*; *Acrida bicolor*], and whiteflies [*Bemisia tabaci*; *Empoasca* sp.] were early colonizers of the crop and they persisted through to late vegetative stage (Plate 1-4). Other species include *Asbecesta cyanipennis* Har. (7.5%), *Acrida bicolor* Thunb *Acrida bicolor* Thunb (2%), *Bemisia tabaci. Cennadius* (2.6%). The least abundant species were *Aulacophora africana* Weis., *Cylas puncticollis* Boh., and *Cardiophorus hoploderus* Can. having relative abundance of 0.04% each

In Fig. 1, The first of the natural enemies was sighted from the 3rd week post-planting having been preceded by 2 weeks by insect pests of the crop. Five natural enemies were recorded during the study, *Exochomus flavipes* Thunb. was the most abundant (1.08 % of total collection).

The mean number of insects collected on the green roselle (71.5 ± 32.8) was significantly (tα = 0.05) higher than the number collected on the red roselle (65.9 ± 30.8). The number of insect species and abundance of each increased with the crop's growth and increased with opportunity for finding mates culminating in severe foliage damage at the late vegetative stage [Plates 1-4]. Insects tended to prefer the green Roselle but the degree of foliage damage did not give indication of the resistance of the red Roselle to insect attack.

CONCLUSION

The current study has shown that there are various foliage insects pest attacking roselle plant. The dominant insect pests recovered during the study include: *Monolepta thomsoni*; *Nisotra sjostedti*; *Aiolopus thalassinus* and *Acrida bicolor*. Natural enemies were also encountered during the study with *Exochomus flavipes* being the most predominant species.

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Table 1. Composition of Insect pests associated with Roselle at Vegatative Stage in North Central Nigeria

ORDER	FAMILY	GENUS/SPECIES	RELATIVE ABUNDANCE (%) GREEN ROSELLE	RED ROSELLE
Coleoptera	Buprestidae	*Sternocera* sp.	0.88	0.44
	Carabidae	*Drypta rufiocollis* Dej.	0.04	0.04
	Chrysomelidae	*Asbecesta cyanipennis.*Har.	8.64	6.72
		Asbecesta transversa. Allard	0.56	0.64
		Aulacophora africana Weise	0	0.04
		Epilachna similis.Thunb.	0.68	0.80
		Monolepta goldingi Bryant	3.28	3.21
		Monolepta nigeriae.Bryant	2.52	1.84
		Monolepta thomsoni.Allard.	39.8	36.68
		Nisotra sjostedti Jacoby	25.08	24.92
		Trichispa sericae Guer	2.04	1.2
	Coccinellidae	*Allocotocerus* sp.	0.28	0.04
		Cheilomenes sulphurea .Oliv	0.84	0.48
		Cheilomenes vicina. Muls	0.28	0.32
		*Exochomus flavipes.*Thunb.	1.24	0.92
	Curculionidae	*Cylas puncticollis* Boh	0	0.04
	Elateridae	*Cardiophorus hoploderus* Cand	0	0.04
	Lagriidae	*Lagria villosa*. F.	0.72	0.8
	Scarabaeidae	*Pachnoda* sp.	0	0.8
Hemiptera	Coreidae	*Anoplocnemisv curvipes* .Fabr.	0	0.04
	Pentatomidae	*Agonoscelis erosa* Westw.	0.04	0.04
		Aspavia sp.	0.04	0.08
		Hotea sp.	0.08	0.04
	Pyrrhocoridae	*Dysdercus volkeri* F.	1.12	0.72
	Syntomidae	*Metarctia* sp	0.12	0.04
Homoptera	Aleyrodidea	*Bemisia tabaci.* Cennadius	2.48	2.68
	Aphididae	*Myzus persicae.* Sulz.	1.24	1.52
	Cicadellidae	*Empoasca* sp	2.32	0.84
Hymenoptera	Braconidae	*Iphiaulax* sp	0.44	0.4
Orthoptera	Acrididae	*Acrida bicolor* Thunb.	1.48	1.84
		Aiolopus thalassinus. Fab.	2.04	1.84
	Hymenopodidae	*Pseudoharpax virescens*. Serv.	0.4	0.44
	Tettigoniidae	*Zabalius* sp.	0.04	0

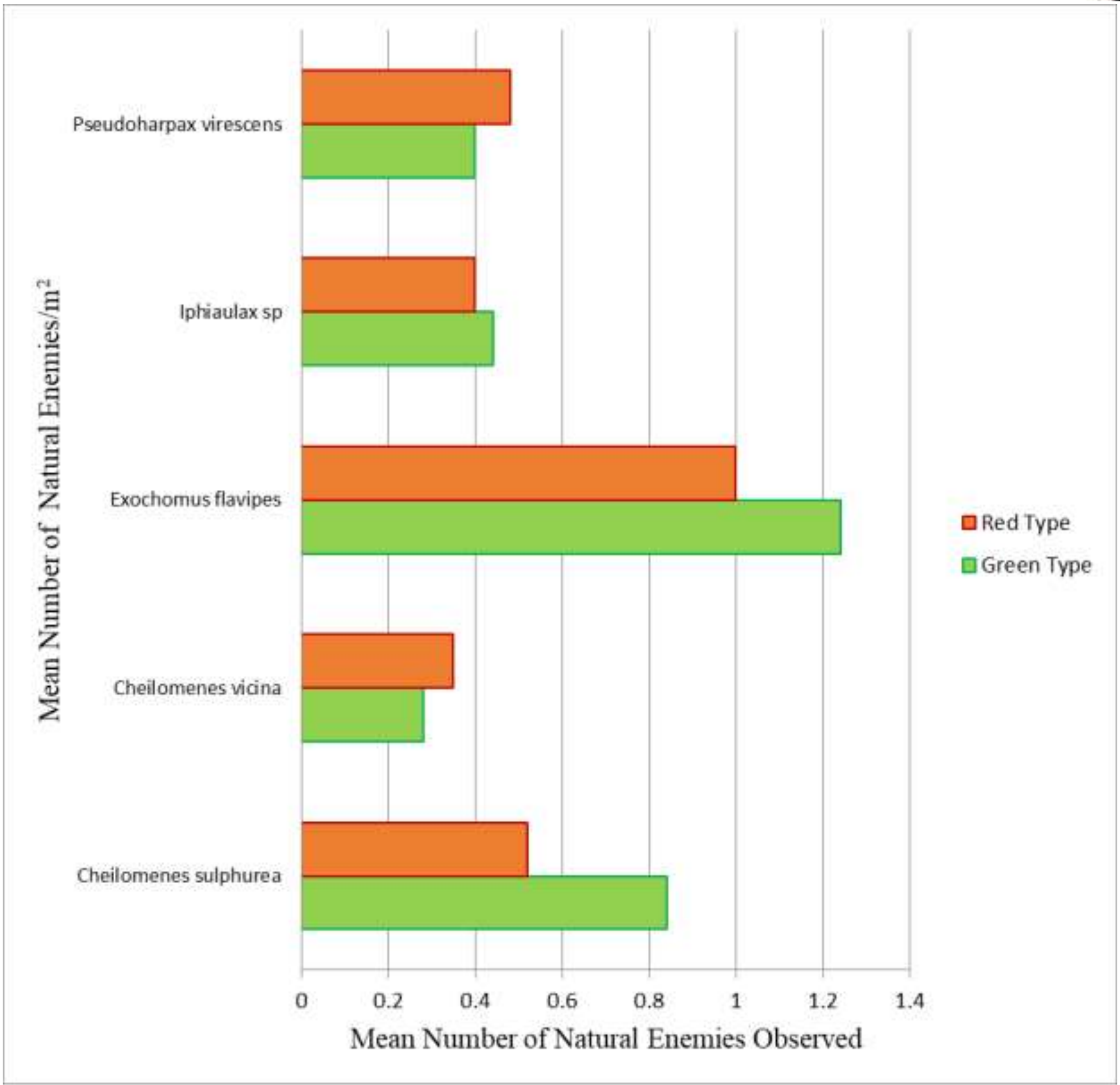

Figure 1. Number of Natural Enemies Associated with Insect Pest of Roselle


Plate 1: Insect Infestation at Early Seedling Stage

Plate 2. Insect Infestation on Red Roselle type at Mid Vegetative StageS

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Plate 3. Defoliated Green and Red Roselle at the Late Vegetative Stage

DAMAGE ASSESSMENT OF *LIXUS CAMERUNUS* KOLBE (COLEOPTERA: CURCULIONIDAE) ON *VERNONIA AMYGDALINA* IN IBADAN, SOUTH WESTERN NIGERIA

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ABSTRACT

A sudden logging of branches and stems of bitter leaf (Vernonia amygdalina) was observed in the Orchard of National Horticultural Research Institute, Ibadan as a result of continuous boring and tunneling by neonate larva Lixus camerunus during the raining season of year 2020. The first observation was on the 4th of May, 2020 with about 58.87 newly hatched weevil found on 10 sampled shrubs, the observation period lasted for eight weeks and ended on the 22nd of June, 2020, measurement of stem size, number of branches, length of branches, stem above the ground and height of the plant was carried out. Larva population, length of tunneling by larva, number of lodged branches and quantity of marketable yield was determined. The study shows positive relationship between stem size of Vernonia amygdalina and the length of tunneling by neonate larva of the weevil. Ten sucking and piercing insects "Thrips, Aphids, Emposca spp, whiteflies. Lady beetles, Black ants, Spheaorocoris annulus, Fabricius spp, Polyclaeis spp and Xanthochelus vulneratus" were found on each of the tagged plant. Planting space modification, early harvesting and early detection of insect pests are recommended to be integrated into the pest management package for the control of Lixus camerunus

Key words: *Lixus camerunus, Vernonia amygdalina,* tunneling, larva

INTRODUCTION

Vernonia amygdalina, is a perennial shrub from the Asteraceae family commonly called 'Bitter Leaf' because of it bitter taste. Bitter leaf also has a lot of other local names in different languages of the different regions of the world, such as Ewuro, Onugbu, Oriwo, Etidot and Ityuna in Nigeria and Awonwono in Ghana (Farombi and Owoeye, 2011). Bitter leaf is one of the Africa underutilized Crops and of economic value. Vernonia has close to 1000 species in its family (Keeley and Jones, 1979). The genus Vernonia gets its name after an English botanist, William Vernon who identified the plant in Maryland, in the late 1600s before his death in 1711 (Quattrocchi, 1999). This herb has been domesticated in many parts of West Africa, but grows freely in tropical Africa (Igile *et al*., 1994), it is also well distributed in Asia (Oseni and Babatunde, 2016). Nigerians are more aware about its benefit and have been utilizing this plant to its maximum usage as it has many health benefits compared to other regions. Despite the great value placed on bitter leaf, it is faced with insect pest infestation which has greatly reduced it production. Most of the pests that usually attack this shrub are Coleoptera curculionidae, weevil *Lixus camerunus* and *Zonocerus variegates* which utilize it as a source of protein (Eluwa, 1979). Ucheck Fomum, 2004 have also reported that thrips, aphids, ants, white flies, *Empoasa spp*., *Sphearocoris annulus* and *Fabricius spp* also attack *V. amygdalina.* The damage to stem and other parts of the plant has greatly contributed to death of many homestead bitter leaf plants, which calls for more attention to the control of *Lixus camerunus.* The objective of this research work is to determine population threshold of weevil *Lixus camerunus* as it affect the productivity of *V. amygdalina* in Ibadan.

MATERIALS AND METHODS

Establishment of the *V. amygdalina* orchard:

On the 7th of June, 2018 some stems of *V. amygdalina* accession was collected from an homestead garden in a nearby village not far from National Horticultural Research Institute, Ibadan (Latitude N7.40479 E7^{0} 24^{l} 17.2404'' and Longitude N3.85183 E3^{0} 51' 6.59916''), located in the rainforest region of western Nigeria, the accession was coded as Oy-NHRT-18, the coding was done for easy identification, Some portion of land measuring 1200m^2 at National Horticultural Research Institute, Ibadan was marked out and cleared manually, it was manually harrowed and bedded into plots of 2m^2. Blanket application of cured poultry manure was applied during land preparation and left for 3 weeks before planting the

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bitter leaf stems measuring 50cm. Four stems were planted per plot and replicated eight times All other agronomic practices were carried out as at when required. The stems have since growned over the years into shrub with varying heights, branches and leaf canopy which has predisposes it to arrays of insect pest

Infestation by insects:

Observations of the infestation by *Lixus camerunus* was noticed on the bitter leaf shrub located in the orchard measuring 1200m^2 at National Horticultural Research Institute, Ibadan, Nigeria (3º5 E, 7º3 N, and 168 m above sea level). The first adult weevil was noticed boring stem of *Vernonia amygdalina* on the 4th of May, 2020.

Counting of larvae / branch:

This was achieved through destructive sampling; sampling for weevils commenced on the 4th of May, 2020 and continued every week till eight different sample periods were achieved. six branches with tunnel holes was tagged for assessment. A sterilized budding knife was used to cut off the tagged branches with bore holes and taken to the entomology laboratory to check for presence of eggs, larvae, adult weevil, and length of tunneling per harvested branch. Some other data collected are number of bore holes per plant. Larvae and eggs were carefully removed for counting using a camel hair brush.

Physical parameters data taken on the 10 shrubs:

The diameter of bitter leaf shrub stem immediately above ground and height of shrub were measured. Number of branches per shrub was counted. Six branches per tree were tagged and their length and diameter (where it is joined to the main stem) were measured.

Statistical analysis

Descriptive statistics including range (maximum and minimum) and standard deviation of the trees quantitative traits were calculated. Data on number of eggs, larvae and adult weevils / branch were subjected to analysis of variance, significantly different treatment means were separated using Student Newman Keuls (SNK) (SAS, 2009) (P=0.05) and the Least significant difference (LSD) with GENSTAT software (Genstat, 2006) (P=0.05).

RESULTS AND DISCUSSION

On 4th May, 2020, some few numbers of adult *Lixus camerunus* were observed feeding on stems and branches of ten *V. amygdalina* shrubs which ranged between 1.17m - 4.10m height, 1.10cm - 8.35cm stem girth, 11-32 branches and height of stem above ground level ranging between 0.06m - 0.88m (Table 1) in the orchard of the National Horticultural Research Institute, Ibadan, Nigeria. On 4th May when the 1st sample was taken a mean of 12.30 larvae was found inside the tunnels of the branches which ranged between 0.78m - 2.10m (Table 1) were observed on branches length which ranged between 0.78m - 2.10m (Table 1). Subsequently, the number of larvae continued to reduce weekly until the population increased on 25th May, 2020, forth weeks after the first observation with a mean numbers of 19.72 larvae per branch (Table 2). The highest mean population was recorded on 8th June, 2020 with a larval population of 31.30 young weevil tunneling on different branches and stems of the shrub resulting into logging and death of the plant. On the 22nd of June, there was a drastic reduction in population of the young weevils. (4.02 larvae/ branch). A peak population of 104.60 larvae was estimated on the 10 shrubs on an area of 1200m^2. Some of these insect pests "Thrips, Aphids, *Emposca spp*, whiteflies. Lady beetles, Black ants, *Sphearocoris annulus*, *Fabricius spp*, *Polyclaeis spp* and *Xanthochelus vulneratus* were also found sucking and defoliating leaves. Some were observed to be aborting fresh flowers which is in agreement with the findings of Banjo *et al.* 2006. However, in the orchard many species of bird and lizard were observed preying on the larvae. The peak larval population was noticed on the 5th of June 2020, with peak mean population of 31.30 larvae on a branch. Table 2 shows that the higher the population of newly emerged weevils the longer the tunneling inside the branches which results into more damaged stems and eventual production of unmarketable leaves (Plates 1-3).

Table 1. Physical parameters of the 10 shrubs of *Vernonia amygdalina* attacked in the orchard

Sampled shrubs	Stem height above ground (m)	Height of shrub (m)	Mean Number of branches / shrub	Mean Diameter of branches / shrub (cm)	Mean Length of branches / shrub (m)	Mean stem girth (cm)	Length of tunnel (cm)
I	0.47	4.10	18	1.45	2.00	7.35	11.3
II	0.46	1.60	11	0.95	1.22	3.82	5.11
III	0.26	3.15	21	1.29	0.78	4.33	4.91
IV	0.54	3.05	12	4.54	1.06	6.29	8.11
V	0.24	3.15	32	4.95	2.10	8.33	12.4
VI	0.22	3.16	25	4.88	0.94	6.54	7.21
VII	0.13	2.55	16	1.53	1.70	5.11	3.56
VIII	0.07	1.36	11	1.14	0.86	2.14	2.43
IX	0.06	1.17	16	1.38	1.02	1.10	1.55
X	0.88	1.43	14	1.48	1.87	3.16	3.22
RANGE	0.06-0.88	1.17-4.10	11-32	0.95-4.95	0.78-2.10	1.10-8.35	1.56 – 12.4
LSD	-	0.81	1.41	2.32	-	-	0.67
SD	0.21	-	-	-	1.06	2.11	

Table 2. Mean weekly number of larvae of *Lixus camerunus* on 10 *Vernonia amygdalina* shrub observed per branch

Weeks of Observation	**Date**	**Mean No. of moth larvae /branch**	**Est. pop of moth larvae on 10 shrub**	**No of damaged branches on 10 shrub**	**Mean Weight (kg) of marketable leaves**
I	4th May, 2020	12.30e	58.87	11	3.45
II	11th May, 2020	8.51f	78.43	18	3.10
III	18th May, 2020	11.60e	49.65	12	4.39
IV	25th May, 2020	19.72c	87.40	9	2.39
V	1st June, 2020	21.41b	98.61	15	3.43
VI	8th June, 2020	31.30a	104.60	21	3.16
VII	15th June, 2020	15.00d	81.42	12	5.20
VIII	22nd June, 2020	4.02g	65.00	11	2.17

No-Number, Est; Estimated, Pop; population

Plate 1. Newly emerged *Lixus camerunus*

Plate 2. Transverse section of tunneled branch

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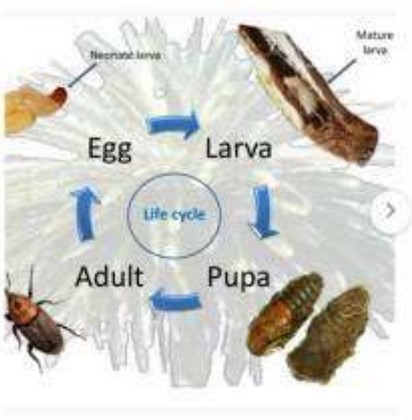

Plate 3. Lifecycle of *Lixus camerunus*

The sudden lodging of stems and branches was noticed on some of the bitter leaf shrubs in the orchards of National Horticultural Research Institute, Ibadan, Nigeria. The study showed array of insect at different population level of different insects found feeding on both leaves and stems of the bitter leaf shrub. Some of the identified insect pests are Thrips, Aphids, *Emposca spp*, whiteflies, Lady beetles, Black ants, *Sphearocoris annulus*, *Fabricius spp*, *Polyclaeis spp* and *Xanthochelus vulneratus*, with whitefly been the most abundant (134) and *Fabricius spp* (11) been the lowest. The newly emerged *Lixus camerunus* was found to be responsible for the lodging and drying up of leaves on the branches, at the onset tunneling direction by larvae was upwards, but on the death of shoots, larvae reversed direction and moved downwards along old tunnels. However, newly-emerged larvae on leaf petioles, tunneled downwards to the main branch, before pursuing an upward course. There was a significant relationship between length of tunnel and stem diameter, the bigger the stem, the longer the length of tunneling, the stem with the biggest size 8.33 cm recorded the longest tunneling 12.4 cm while the plant with the smallest stem size 1.10 cm recorded the shortest tunneling 1.55 cm, and this is in agreement with the findings of Okiwelu, 2011. These same economic insect pests have been reported by Banjo *et al* 2006 as it was found engraving holes and laying eggs inside the stems of *V. amygdalina*. The following parameters were observed on ten selected tagged bitter leaf plant, Stem height above ground, Height of shrub, Number of branches, Diameter of branches, Length of branches and Stem girth. The observation started on the 4th of May, 2020 and ended on the 22nd of June, 2020. Height above ground (trunk) ranged between 0.06-0.88 meters, height of individual plant ranged between 1.17 - 4.10 meters, number of branches ranged between 11 – 32, diameter of branches ranged between 0.95 – 4.95 cm, length of branches ranged between 0.78 – 2.10 meters and stem girth between 1.10 – 8.35 cm. There were differences in the numbers of newly emerged young adults found tunneling within the stems at different sampling period; this could be attributed to weather parameters (rainfall and temperature) during the period under observation.

CONCLUSION

This study reveals that the vegetable *V. amygdalina* cultivation in Ibadan is faced with many challenges, with insect pests playing major role in destroying many orchards. Larva stage of *Lixus camerunus* has the ability to completely destroy a whole orchard during the early season of the year. The boring activity tends to cut off nutrient supply to other parts of the plant. It is, therefore, necessary to develop an Integrated Pest Management package to deter egg lying by adult weevil. Further study will be necessary to determine the best period of control to increase marketable yield. The study also shows positive relationship between stem size and length of tunneling resulting into quantifiable losses of marketable leaves. There is need to look into modification of planting distances, frequency of harvesting and early detection of insect pests to achieve profitable *V. amygdalina* farming.

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ECONOMIC DAMAGE OF *LIXUS CAMERUNUS* KOLBE (COLEOPTERA: CURCULIONIDAE) ON *VERNONIA AMYGDALINA* IN IBADAN, SOUTH WESTERN NIGERIA

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ABSTRACT

A continuous boring and tunneling by neonate larva of Lixus camerunus during the raining season of year 2020 was observed on Vernonia amygdalina causing significant level of damage. This situation prompted interest in surveying 100 homestead gardens and few orchards within Ido Local Government to access the level of insect damage and monetary losses. Demographic information such as, marital status, educational level, household size and farm size were examined while market information such as output Price, loss caused by Lixus camerunus, and expected yield in the absent of the pest. Majority of the respondents are the male gender within their early age of 40 years, 77% of the despondence are married, and losses were categorized into severe, medium and low loss. The percentage loss caused by Lixus camerunus on bitter leaf on the sampled household was estimated to be 63% herbage yield loss which places the insect into the category of a major insect pests and calls for urgent action towards controlling it.

Key words: Yield loss, *Lixus camerunus, Vernonia amygdalina,* Ido

INTRODUCTION

Vernonia amygdalina Del can be used for many purposes and it has rapid regenerating soft wooded shrub of 2 to 10 m tall with petiolate leaves of around 6 mm in diameter. This plant hasdifferent names by different ethnics around the world. It belongs to specie under the genus Vernonia Schreb (Family: Compositae; Order: Asterales; S/C: Asteridae; Classes: Dicotyledons) which contains about 1000 species. More than 500 of these Vernonia plants are distributed in Africa and Asia, approximately 300 in Mexico, Central and South America and around 16 can be found in the United States. Austin (2000) has found that even taxonomy of V. amygdalina from different geographical area (Ethiopia and Cameroon) could be different. One of the proposed solutions is through classification of the active chemical compounds, isolated from each species (Mabry et al., 1975). V. amygdalina produces a variety of flavonoids and bitter sesquiterpene lactones which contribute to the bioactivities of this plant (Nangendo et al., 2002; Favi et al., 2008).

Africa has arguably one of the richest phytodiversities in the world. Africa's forests geographically span approximately 216,634,000 per ha (Farombi, 2003). More than 50% of all modern clinical drugs are of plant origin (Suffness and Douros, 1982). Plant products therefore play an important role in drug development programs of the pharmaceutical industry (Baker et al., 1995; Cordell, 1995). Furthermore, the consumption of plant materials is believed to contribute immensely to the improvement of the health of man and his plants and animals. Yedjou et al. (2008) estimated that 80% of the population of Africa depends on medicinal plants to satisfy their health care requirements. Knowing the nutritional, medicinal and economic value of vegetables found in Africa could add value to their cultivation, one of the major factor that affect the productivity of *Vernonia amygdalina.* Most of the pests that usually attack this shrub are Coleoptera curculionidae, weevil *Lixus camerunus* and *Zonocerus variegates* which utilize it as a source of protein (Eluwa, 1979). Ucheck Fomum, 2004 have also reported that thrips, aphids, ants, white flies, *Empoasa spp*., *Sphearocoris annulus* and *Fabricius spp* also attack *V. amygdalina.* The damage to stem and other parts of the plant has greatly contributed to economic loss to bitter leaf plants, which calls for more attention to the control of *Lixus camerunus.* The objective of this research work is to determine economic loss caused by weevil *Lixus camerunus* as it affect the productivity of *V. amygdalina* in Ibadan.

MATERIALS AND METHODS

Study area

Ido Local Government is one of the Local Government Areas in Oyo state, Nigeria. It has its headquarter in Ido town. It has latitude: 7.50678 longitudes: 3.71186 altitudes. On the account of extensive fertile soil, which is suitable for agriculture, the basic occupation of the people is farming. There are large hectares of grassland which are suitable for animal rearing, vast forest reserves and rivers. People in the area grow varieties of cash crops such as cocoa, kola nut, palm oil, timber and food crops such as tomato, amaranth, maize and rice.

Source and type of data

Primary data was collected with the aid of a well-structured questionnaire which was administered to the *V. amygdalina* farming household head in particular to collect the social economic characteristics, and other relevant information.

Sampling procedure

A multistage sampling procedure was used in selecting the respondents for this study. The first stage involved a purposive selection of 100 *V. amygdalina* farming household head in the LGA. The primary data that was collected were demographic information, marital status, educational level, household size, farm size, market information like prices of output, loss caused by *Lixus camerunus*, and expected yield in the absent of the pest infestation.

Analytical tools

Descriptive statistics

Descriptive statistics such as frequencies and means were used to profile socio economic, credit status and production characteristics of the tomato farmers in the study area.

Economic loss caused by *Lixus camerunus* on bitter leaf

Percentage economic loss is estimated by finding the difference between the expected income and actual income on bitter leaf divided by actual income multiply by 100.

$$\%\ LOSS = \frac{\Delta income}{actual\ income}\ X\ 100$$

RESULTS AND DISCUSSION

The result shows that majority of the respondents are of male gender, mean age of the respondents is 40 years, majority of the respondents of about 77% are married, mean age household size of the respondents is 6 people and years of education of the respondents is 5 years (Table 1).

Percentage loss

The percentage loss is categorized into three, those that have severe, medium and low loss (Fig. 1).

The percentage loss caused by *Lixus camerunus* on bitterleaf is estimated to be 63%. This is a great loss and this need urgent attention to increase the profitability of the vegetable.

$$\%\ loss = \frac{\Delta income}{actual\ income}\ X\ 100$$

$\%\ loss = \frac{35720}{56632}\ X\ 100$ % loss = 63.07%

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Table 1. Distribution of tomato farmers by gender

Gender	Frequency	Percentage
Male	96	77.42
Female	28	22.58
Total	124	100
AGE		
Below 20	1	0.81
21-35	45	36.29
36-50	56	45.16
51-65	20	16.12
Above 65	2	2.61
Marital status		
Single	9	7.25
Married	96	77.42
Widow	15	12.10
Divorced	4	3.23
Total	124	100
Household size		
1-5	48	38.71
6-10	66	53.23
11-15	10	8.06
	124	100
Years spent in school (years)		
No formal education	22	17.74
1-6	41	33.06
7-12	49	39.52
12 and above	12	9.68
Total	124	100

Source: field survey data (2021)

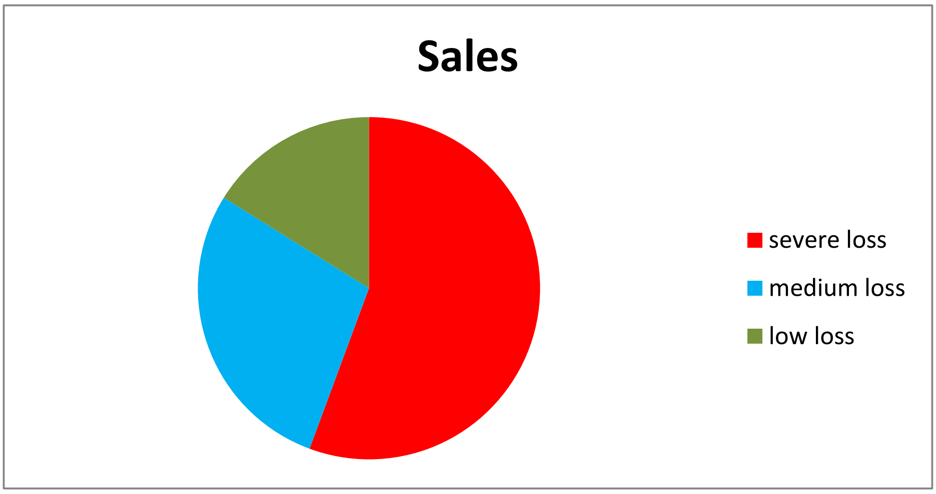

Figure 1. Distribution of respondents based on the percentage loss caused by *Lixus camerunus* on bitterleaf
Source: field survey data (2017)

CURRENT STATUS OF *RASTROCOCCUS INVADENS* WILLIAMS (HOMOPTERA: PSEUDOCOCCIDAE) INFESTATION AND PARASITISM ON MANGO TREES IN ABEOKUTA METROPOLIS

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ABSTRACT

The Mango Mealybug, Rastrococcus invadens Williams (Homoptera: Pseudococcidae), a native of India, is a serious exotic pest of horticultural crops, especially mango. For its control, its exotic parasitoid, Gyranusoidea tebygi, was imported from India, reared, and released, successfully established nation-wide However, the resurgence of the mango mealybug was noticed in Abeokuta a few years ago, the reason for which is not yet clear. This study therefore, investigated the distribution, host range and natural enemy complex of the insect in Abeokuta metropolis. The reconnaissance surveys revealed the presence of the pest in Abeokuta metropolis on no other host plant but mango trees only. The surveys also confirmed the establishment of Gyranusoidea tebygi and the presence of the local parasitoid, Anagyrus aurantifomis, which contributed meaningfully to primary parasitism, as well as Leopardina sp. and Chartocerus sp. which are hyperparasitoids which both contributed 41.6% to secondary parasitism, were also recorded. The socio-economic implications of the infestation were also discussed.

Key words: *Rastrococcus invadens,* mango mealybug, mango, Abeokuta, *Gyranusoidea tebygi, Anagyrus aurantifomis*

INTRODUCTION

Mango, *Mangifera indica* (Anacardiaceae), is one of the most profitable crops in tropical and subtropical regions of the world and is renowned for its excellent flavour, attractive fragrance, and high nutritional value (Shah *et al*., 2010). In Abeokuta, mango trees are found along major roads, car parks, markets, and residential compounds. It also serves as a major source of shade for petty traders whose stalls are usually around the neighbourhood (Pitan *et al.,* 2000). Mango Mealybug, *Rastrococcus invadens*, infestation is a major problem and a great concern to both the farmers and non-farmers alike. The mealybugs are usually found on the underside of the leaves, causing damage directly on mango leaves by sucking plant sap. The insect was first discovered in Abeokuta in 1989 and was believed to have been introduced mainly from Lagos and Republic of Benin as both share borders with Ogun State.

For its control, an encyrtid exotic parasitoid, *Gyranusoidea tebygi*, which originated from India, was imported, reared and released nation-wide. About 280 adult *G. tebygi* were released on 10th August, 1989 on mango trees in Ijebu-Ode, Abeokuta and Shagamu in Ogun State (Pitan *et al.,* 1999). Monitoring surveys carried out between 1994 and 1998, revealed the establishment of the parasitoid in all the agro-ecological regions of the country. At Abeokuta for example, the mealybug population density on mango crashed from 49 adults per leaf recorded in 1994 to zero in 1998 resulting in improved mango fruit production (Pitan *et al.,*2002). However, in 2012, mango mealybug was spotted on mango trees at many locations in Abeokuta which later became wide-spread from 2014 (Pitan O.R, *Pers. Com*). The objective of this study was therefore to determine mango mealybug status, current infestation levels and the status of the existing natural enemies of the mealybug in Nigeria.

MATERIALS AND METHODS

Monitoring surveys were carried out between May and June, 2021 in Abeokuta metropolis: Idi-Aba, Iyana Mortuary, Asero, Obantoko, Federal University of Agriculture Campus, and Adigbe (Plate 1). Sampling was carried out along the roads and four host plants: *Mangifera indica, Citrus* spp. *Plumeria alba* (Frangipani), *Ficus* spp (fig) were selected every 100 m. At each stop, all plants in the vicinity were critically examined for the presence or absence of the mealybug including the life stages. Only the plants with the life stages of *R. invadens* were considered as hosts.

Ten leaves were randomly selected from five different points on each plant species and the leaves were examined using a hand lens. The data collected were; (a) number of mealybugs; (b) number of mummified mealybug and (c) number of predators. Parasitized mealybugs (mummies) were removed from the leaves with a camel hairbrush and kept in tagged transparent sample bags until the emergence of parasitoids and/or hyperparasitoids. Mummies with emergence holes were discarded after counting and records of the number of parasitoids emerging from each sample bag was kept. They were then removed and preserved in 70% alcohol while some were mounted for identification purposes.

After 3 weeks, all the mummies from which there were no evidences of emergence were collected from the sample bags and kept in alcohol for 24 hrs to soften. They were later dissected and the insects found in the cases were identified and recorded. By so doing, all the mummies were accounted for and parasitism indices were calculated based on these data. Predators were also counted and were later kept in 70% alcohol for preservation.

Severity of infestation on the host plants was based on the number and proportion of foliage and twigs showing only the mealybug and sooty mould together where:

Light	=	<25% of the foliage of the host plant shows infestation by the mealybug and often on the abaxial surface of foliage only. (+)
Moderate	=	25 – 50% of the foliage of the host plant shows infestation by the mealybug. (++)
Heavy	=	> 60% of the foliage of the host plant shows mealybug infestation together with sooty mould on both surfaces of foliage. (+++).
Very heavy	=	entire foliage, twigs, inflorescences and sometimes fruits, are covered by the mealybug and sooty mould. (++++)

Plate 1. Map of Ogun-State Showing Abeokuta metropolis where samples were taken
Source: Adekunle *et al.,* 2019

RESULTS

Distribution of *Rastrococcus invadens* in Abeokuta metropolis

During the surveys, the mealybug was observed only on mango trees at all the sampling locations: Idi-Aba, Iyana Mortuary, Asero, Obantoko, Federal University of Agriculture Campus, and Adigbe. About 94% of all the mango trees sampled were infested with the mealybug. The mean mealybug population density was 37.6/leaf, while percent parasitism was 3.0 (Table 1). Out of this, primary parasitism was 58.4% with *G. tebigy* and *Anagyrus aurantifolis* contributing 35.6 and 22.5%, respectively. However, secondary parasitism was 41.6% with *Leopardina* sp. and *Chartocerus* sp contributing 20.6 and 21% respectively (Table 1).

Table 1. Percent mealybug parasitism as recorded on mango trees in selected locations at Abeokuta

Parameter	Value
Mean mealybug/leaf	37.6
Mean no of mummies/leaf	1.1
Percent Parasitism	3.0
Gyranusoidea tebygi	35.6
Anagyrusaurantifomis	22.8
Primary parasitism	**58.4**
Leopardina sp.	20.6
Chartocerus sp.	21.0
Secondary parasitism	**41.6**

DISCUSSION

In this study, mango mealybug was not recorded on any other host plant apart from mango trees unlike in 1988 when the insect pest was first reported in Abeokuta, many ornamentals, fruit trees and shade trees served as its hosts (Pitan *et al*., 2002). This indicates that the pest has been adequately regulated as has been reported in several other parts of Africa where as soon as the parasitoids were released, mango trees became the only host (Bokonon-Ganta *et al.,* 1988; Agounke *et al.,* 1989; Neueschwander *et al*., 1995). The percentage of infected trees appear rather to be too high considering the fact that the exotic parasitoid, *G. tebygi*, has established in Nigeria. In Abeokuta metropolis for example, the released parasitoid caused a drastic reduction in the mealybug density, while mealybug extinction and significant improvements in mango fruit production were all reported (Pitan *et al* 2001; Pitan *et al.,* 2002). Similarly, the intensity of mealybug infestation recorded in this study which is 37.8/leaf is comparable with earlier report of 49.0/leaf when the mealybug was first introduced into Nigeria in 1989 (Pitan *et al*., 2002). Surprisingly, percent primary parasitism recorded was 58.4 with the released *G. tebygi*contributing 35.6% and the local parasitoid *A. aurantifolis* contributing 22.8%. Compared to earlier reports these values are getting lower for *G. tebygi* and higher for *Anagyrus* indicating a high-level competition between them. Also, the high level of hyperparasitoid activity recorded on the parasitoids in this study is unprecedented and could be taken that the released *G. tebygi* has faced some ecological pressure over the years and would have to be re-investigated for bio-efficiency in the context of its interactions with the immediate community. Such interaction to consider for investigations may include changes in the biochemical composition of the secondary metabolites and/or the nutritional value of the mango tree, changes in parasitism and /or direct effects on the mealybug such as fecundity stimulation and increased growth rate (Pitan, 2008).

The socio-economic implication of the mealybug resurgence is that the infestation may become more severe if not controlled, and may result again in severe reduction in the yield of fruits and vegetables, and ultimately in the output from industries that process these crops. The socio-economic consequences of severe reduction or near complete loss of infested fruits and vegetables are grave on the nation, because much of the population depends on them as ready sources of cheap energy, vitamins and minerals. The aesthetic and socio-cultural values that make shade trees and ornamentals converging points for rural meetings, entertainment, and also rural and urban leisure are seriously undermined. This is because infestation renders plant canopies unsightly and unacceptable and the associated ants and flies that feed on the honeydew are also repulsive (Pitan *et al*., 2000).

CONCLUSION

In conclusion, the resurgence of mango mealybug was confirmed in the locations where the survey was carried out in Abeokuta. The infestation status is also high as 37.6% adult mealybug was recorded per leaf. The study also revealed the presence of both the exotic and local natural enemies, as well as hyperparasitoids.

RECOMMENDATION

Being exotic and polyphagous, *R. invadens* is a good candidate for biological control, however, the efficiency of *G. tebigy* has declined over the years. In other to address this, augmentation of existing population of *G. tebigy* can be done. Secondly, it is also important to understand the factors regulating its abundance with respect to current realities of climate change.

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Since the exotic parasitoid has been released, it is important to properly study the natural enemy with respect to current realities such climate change and their ability to control the pest determined before any consideration is given to the introduction of another one. If the existing ones are really suppressing the population of the mealybug for instance, then there is no need for a new introduction; only the augmentation of the existing population would then be necessary to effectively control this insect pest.

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TESTING FOR THE RESISTANCE OF NEWLY GENERATED HYBRID CACAO GERMPLASM IN THE GENE POOL OF COCOA RESEARCH INSTITUTE OF NIGERIA (CRIN) AGAINST *PHYTOPHTHORA MEGAKARYA* PATHOGEN CAUSING BLACK POD DISEASE OF COCOA

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ABSTRACT

Black pod disease caused by P. Palmivora and P. megakarya is an important disease affecting cacao in West Africa which produces 70% of the world output. Resistance to the pathogen is therefore, an important factor to be considered when breeding for high yielding and earliness in fruiting. Resistance to the pathogen using Leaf Disc Test (LDT) was conducted at the Plant Pathology Laboratory, Ibadan, on detached 15mm diameter discs of two-month-old leaves obtained from nineteen newly generated cacao hybrids in the gene pool of the Institute. Attached Whole Leaf Test (AWLT) was also conducted on few selected hybrids in the screen house at the same institute. Ten µl zoospores suspension of P. megakarya pathogen adjusted to inoculum strength of $3x10^5$ zoospores/ml using haemocytometer was used for the inoculation of the cacao LD. Using 0-5 disease rating scale, data was taken on the 5^{th} and 7^{th} day after inoculation for LDT and on the 6^{th} day after inoculation for AWLT. Data obtained were subjected to Analysis of Variance and significant means were separated using Student Newman Kuels Test at $p<0.05$. The LDT classified the hybrids into five groups namely: Resistant (hybrid 001, 003 and 005); Moderately Resistant (hybrid 006, 007, 008,013,015,018 and 019) Moderately Susceptible (hybrid 004, 014 and 017); Susceptible (hybrid 002, 010, 011 and 016) and Highly Susceptible (hybrid 009 and 012). Scores from LDT significantly correlated ($r= 0.92^{**}$) with that of AWLT. It was observed from the study that cacao hybrid 001, 003 and 005 showed traits of resistant and therefore, could be incorporated into the national breeding programs for the development of high-yielding and resistant cacao cultivars. The moderately resistant hybrids could be conserved for future germplasm enhancement program.

Key words: *P. palmivora*, *P. megakarya*, *cacao* hybrids, LDT, AWLT, breeding, resistance group, black pod disease

INTRODUCTION

Cacao (*Theobroma cacao* L.), an understory tree belongs to the order Malvales and family Malvaceae (Wickramasurya and Dunwell, 2018). It is an important cash crop cultivated for its nutritional value and industrial uses locally and internationally (Nyadanu *et al*., 2012). Fourteen states in Nigeria namely Ondo, Cross River, Osun, Ogun, Ekiti, Edo, Abia, Adamawa, Taraba, Akwa Ibom, Delta, Kogi and Kwara were reported to produce 95% of country's export (Famaye, 2013). Reports showed that eight hundred thousand (800,000) hectares of Nigeria arable land were under *cacao* cultivation between 2003 – 2005 (ICCO, 2008). Cocoa production in Nigeria, due to several factors has failed to meet the demand from local and international consumption and processing. Prominent among these factors is the difficulty in the attainment of optimal yield from this tree crop despite the increased acreages largely due to cacao diseases.

Several pathogens attack *cacao*, but one of the most important diseases of *cacao* in Nigeria is the black pod disease caused by *Phytophthora* spp. Two of the several species of the black pod pathogen namely *P. palmivora* (less than 20% distribution) and *P. megakarya* (over 80% distribution) have been identified as the causal agent of the disease in Nigeria (Akrofi, 2015). Of these two species reported on *cacao* in Nigeria, *P. megakarya* was noted to be more virulent and has been reported to displaced *P. palmivora* over period, but the strategy involved is not clear (Ali *et al*., 2017).

In Nigeria, 30% yield and crop losses due to *P. palmivora* was reported (Okaisabor, 1965) while 80% losses in *cacao* and its produce due to *P. megakarya* was reported in unkempt farms (Agbeniyi and Adedeji, 2003). In wetter part of the country, 90-100% yield losses were also recorded (Maddison and Griffin, 1981). Estimated annual yield losses of 700,000 metric tons of cocoa was reported globally due to black pod disease (Ploetz, 2016). Cultivation of susceptible varieties and the prevailing environmental conditions are factors that influence the disease (Adegbola, 1981).

Although chemical control is possible, it is expensive (Vis-a-vis 400kg/ha production) and require skills for effective application, couple with the Problem of chemical residue and environmental hazardousness (Crig, 2010). Screening for resistance to select cultivars that are resistant to the disease for field establishment has been advocated as the environmentally safe, relatively cheap and best disease management measure (Iwaro *et al*., 2005 & 2006; Surujdeo-Maharaj *et al*., 2001).

Therefore, this study was conducted to determine the resistance status of some newly generated cacao hybrids to black pod pathogen using leaf disc and attached whole leaf tests.

MATERIALS AND METHODS

Nineteen newly produced cacao hybrids (Table 1) from a new cacao breeding research plot (7° 13'N, 3° 51'E) at Cocoa Research Institute of Nigeria (CRIN), Ibadan were used for the study in 2016. Detached Leaf Discs Test (LDT) and Attached Whole Leaf Test (AWLT) were employed for black pod resistance screening in CRIN plant pathology laboratory and greenhouse respectively. Genotype C77 and Pa150 were used as resistant checks while Genotype N38 and ICS1 were used as susceptible checks

Leaf Discs Test (LDT)

Healthy young lignified cacao leaves of approximately two-month-old were obtained from the selected hybrid plants (Table 1) at CRIN headquarters, Ibadan for the study. Leaf discs (LD) were prepared, arranged, inoculated and incubated as described by Nyassé *et al*., 2002 & 1995; Tahi *et al*., 2006 and Nyadanu *et al*., 2012. Inoculum was cultured, prepared and standardized to 300,000 mL^{-1} as described by Tahi *et al*., 2006, Nyadanu *et al*., 2012 and Tijani, 2018. *Phytophthora* species used for the study was identified as *P. megakarya* according to Stamp *et al*., 1990. Data were collected on the 5th and 7th day of inoculation to described levels of infection of the LD using five-point disease assessment (rating) scale as described by Nyassé *et al*., 1995 and Nyassé 1997.

Attached Whole Leaf Test

Attached leaves that correspond to about two months old leaves were inoculated with zoospores suspension (prepared and standardised as described for LDT) on selected *cacao* seedlings in the greenhouse. Eight (8) hybrids were randomly selected such that at least one hybrid represents each resistance class and replicated three (3) times. Two attached leaves were inoculated on each seedling which amounts to six (6) leaves per genotype for the eight (8) hybrids. Ten (10) points were inoculated at the underside of each selected leaf along the midrib which amounts to sixty (60) inoculated points per hybrid. Inoculation was carried out by using a sterile automated repeatable dispenser attached to a micro-syringe (Eppendorf) to deliver 10µl droplets of the zoospore suspension on each inoculation point, at a right angle along the leaf midrib. The greenhouse was maintained at 26 ± 2°C air temperature provided by digital Samsung air conditioning unit and approximately 80% relative humidity was provided by transparent polythene bags for the 6-day incubation period.

The inoculated leaves were inspected for lesion appearance, 6th day after inoculation and data were recorded on their reaction to black pod pathogen using a five-point disease assessment scale as described above. Both the Leaf Discs Test (LDT) and Attached Whole Leaf Test (AWLT) were repeated twice.

Statistical analysis

Data obtained on the frequency and spread of lesions in LD and AWL were subjected to analysis of variance (ANOVA) using SAS (Statistical Analysis System) software. Significant means were separated using the Student Newman Kuels Test (SNK) at $p<0.05$. Means obtained from leaf disc scores (for selected lines) were correlated with that of attached whole leaf to confirm the reliability of leaf disc test at $p<0.05$.

RESULTS

Evaluation of LD and AWL of the cacao Hybrids for resistance to *P. megakarya* isolate(s):

The result of the study showed that the newly produced cacao hybrids reaction to *P. megakarya* isolate(s) varied significantly with respect to the various lesion sizes induce on LD's, (Table 1). Mean disease severity quantified by the lesions on LDs of the various cacao hybrid showed that hybrid 5 has a lowest mean disease score of 1.22 followed by hybrid 3 with a disease mean score of 1.31 and then the resistant check genotype Pa150 with a mean score of 1.33. The N38 control cacao genotype however had the highest disease mean score of 2.27 followed by cacao hybrid 12 with disease mean score of 2.17 and then the ICS1 and cacao hybrid 9 with disease mean scores of 2.15 and 2.14 respectively. Analysis of variance

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(ANOVA) done for LD's lesion scores in their reaction to the *P. megakarya* isolates, (Table 1), shows that the resistance of newly generated cacao hybrids varied significantly at p<0.05. Significant means were separated using Student Newman Kuels (SNK) Test and classified as shown in Table 1. At p<0.05, there was no significant difference in the reactions of cacao hybrid 3, 5 and the resistant check cacao genotype Pa150 to the *P. megakarya* isolates and are classified as resistant. The cacao hybrid 1 reacts significantly different but closer to others in resistant category, thus classified as resistant. However, the reaction of these cacao hybrids and genotype to the *P. megakarya* isolates significantly varied with the other cacao hybrids and genotypes. Cacao hybrids 6, 7, 8, 13, 15, 18 and19 did not differ either in their reaction to the *P. megakarya* isolates but varied significantly in their reaction when contrasted with the other cacao hybrids and genotypes, hence classified to be moderately resistant. The other cacao hybrids and genotypes reaction to the *P. megakarya* isolates varied from moderate to been highly susceptible.

In the AWL assay, Pa150 has the lowest mean lesion score of 0.95 followed by cacao hybrid 5 and 1 with mean lesion score of 1.14 and 1.15 respectively. N38 cacao genotype had the highest mean lesion score of 1.94 followed by cacao hybrid 9 with 1.84 and then ICS1 cacao genotype with lesion mean score of 1.71 (Table 1). ANOVA ran for disease mean score on attached leaves showed significant variations in the various reactions of the cacao hybrids and the check (control) genotypes. At p<0.05, Pa150 significantly varied in its reaction with the other cacao hybrids and genotypes and was classified as highly resistant. Cacao hybrid 5 and 1 did not vary in their reaction to the *P. megakarya* isolates but significantly varied in their reaction to *P. megakarya* isolates when compared with the other cacao hybrids and genotypes and are classified as resistant, (Table 1). Cacao hybrid 7 also differed significantly in its reaction with the other cacao hybrids and genotypes and was classified as moderately resistant. The other cacao genotypes and hybrids' reaction to *P. megakarya* showed various reactions that ranged from moderately susceptible to susceptible. A good correlation was found between LD and AWL score means at p<0.05 (r= 0.93**).

DISCUSSION

The study shows the intrinsic variable genetic qualities existing among cacao hybrids assayed for resistance to black pod disease in the gene pool of CRIN. The mean lesion score of the disease severity in the detached LD assay of the cacao hybrids showed that none of the hybrids was totally immune to the black pod pathogen. This observation is in agreement with earlier reports of Lawrence (1978) and Omokolo *et al*. (2003).

It was also observed in the detached LD assay in the study that the cacao hybrid 3 and 5 showed resistance to the *P. megakarya* pathogen which was not significantly different from the resistant control, Pa150 which is of the Forastero group and an Upper Amazonian cacao genotype. This finding is in agreement with the reports of Iwaro et al., 2006 and Otuonye, 2009 who reported that the Forasteros groups, which include the Amazon cacao genotypes, are made up of higher percentage of moderately resistant to resistant genotypes. It was also noted that Trinitarios, been hybrid progeny between Criollo and Forastero are highly heterogeneous in their resistant character. This may be responsible for the observed reactions of the cacao hybrids to *P. megakarya* black pod pathogen.

The study also showed that seven (7) cacao hybrids with Forastero, Amazon and Trinitario pedigree showed moderate resistance to the *P. megakarya* pathogen. This conformed with the findings of Iwaro et al., 2006 and Otuonye, 2009 who also reported resistance to *P. megakarya* pathogen for cacao genotype T12/11 and T86/2, both Upper Amazon cacao genotypes, crossed to obtain parents for some of the hybrids that showed resistant and moderate resistant respectively to *P. megakarya* pathogen. Reports from Toxopeus, 1967, Akaza *et al*., 2009 and Nyadanu *et al*., 2012 showed that T12/11 and T86/2, Sca6, T60/887, Pa150, P7 and Pa7/808 were used as crosses for some of the parents of the hybrids and resistant control as black pod disease resistant/escaping clones. In Cameroon, highest resistance to *Phytophthora* pod rot was also reported for hybrid P7 x Pa150 using LD assay which was correlated with highest resistance obtained in the field with this cacao genotype (Nyassé *et al*., 2003; Efombagn *et al*., 2011).

Table 1. Mean lesion score of black pod disease induced by *Phytophthora* spp on the cacao hybrid LD and AWL with their degree of resistance

Genotype	Hybrid	Disease mean score		Resistance status
		LD	AWL	
(T82/27xT12/11) x (T101/15xN38)	1	1.3611[ab]	1.1500[ab]	Resistant
(T82/27xT12/11) x (T65/7xT22/28)	2	1.7722[bc]	-	Moderately susceptible
(T82/27xT12/11) x (T65/7xT57/22)	3	1.3056[a]	-	Resistant
(T82/27xT12/11) x (T53/5xN38)	4	1.8889[cde]	1.6455[abcd]	Susceptible
(P_7xT60/887) x (T65/7xT57/22)	5	1.2722[a]	1.1364[ab]	Resistant
(P_7xT60/887) x (T53/5xN38)	6	1.6611[abc]	-	Moderately resistant
(T86/2xT9/15) x (T65/7xT57/22)	7	1.6333[abc]	1.3083[abc]	Moderately resistant
(T86/2xT9/15) x (T53/5xN38)	8	1.6722[abc]	1.6700[abcd]	Moderately resistant
(T86/2xT22/28) x (T65/7xT22/28)	9	2.1444[de]	1.8417[abcd]	Highly susceptible
(T65/7xT9/15) x (T65/7xT22/28)	10	1.7944[bcd]	-	Moderately susceptible
(T65/7xT9/15) x (T65/7xT57/22)	11	1.8389[bcd]	1.6455[abcd]	Moderately susceptible
(T65/7xT9/15) x (T53/5xN38)	12	2.1667[de]	-	Highly susceptible
(P_7xPa150) x (T101/15xN38)	13	1.6389[abc]	-	Moderately resistant
(P_7xPa150) x (T65/7xT57/22)	14	1.9722[cde]	-	Susceptible
(P_7xPa150) x (T53/5xN38)	15	1.6778[abc]	-	Moderately resistant
3-(P_7xT60/887) x 5-(P_7xT60/887)	16	1.8222[bcd]	1.7750[abcd]	Moderately susceptible
3-(T65/7xT101/15) x 6-(T65/7xT101/15)	17	1.9500[cde]	-	Susceptible
4-(T65/7xT101/15) x 6-(T65/7xT101/15)	18	1.5778[abc]	-	Moderately resistant
6-(T65/7xT101/15) x 10-(T65/7xT101/15)	19	1.5389[abc]	-	Moderately resistant
C77	20	1.8389[bcd]	1.5917[abcd]	Moderately susceptible
N38	21	2.2667[e]	1.9417[bcde]	Highly susceptible
Pa150	22	1.3389[a]	0.9500[a]	Resistant
ICS1	23	2.1500[de]	1.7083[abcd]	Highly susceptible

Means in the same column not followed by the same letter are significantly different according to Student Newman Kuels (SNK) Test at 5% probability level

It was observed from the detached LD assay in this study that nine (9) of the cacao hybrids with Forastero, Amazon and Trinitario pedigree showed moderate susceptibility to high susceptibility class with none of the cacao hybrids however, showing worst reaction when compared with the susceptible control ICS1 and N38 genotypes. The observation is in agreement with the findings of Tahi *et al*., 2000, Aikpopodion, 2007 and Otuonye, 2009 who reported that variation in character expression in cacao progenies given the Quantitative trait loci (QTL) of the parents of a progeny may involve either of the parents in character expression if they favorably share a common alleles brought by both or the character expression may involve each individual parent where it is not shared. They also noted that the variation in character expression between and within clones and progeny families may be due to segregation of the genome in response to resistance. Forastero is a very variable group and consist of the lower Amazon (West African 'Amelonado', 'Maranhoa', 'Comun' and 'Para' types from Brazil) and the Upper Amazonian cocoas (Costè, 1992). The lower Amazonian cacao genotypes for example, the West African 'Amelonado' are known for their susceptibility to the black pod disease. The out-breeding nature of cacao which is responsible for a high level of heterogeneity may bring about resistant variation observed in Trinitarios, been a hybrid between Forastero and Criollo (Iwaro *et al*., 2006). The variation in character expression by these cacao hybrids may be due to an involvement and expression of alleles of an individual of the parents in the QTL. This may account for the variation observed in the resistant character expressed by these cacao hybrids to the *P. megakarya* pathogen.

In the AWL assay, a high resistant trait was expressed by Pa150 in the study confirming its reliability as a resistant check. This observation was same for all the cacao hybrids and control genotypes selected for the AWL assay. It was observed for example that cacao hybrid 4 that showed susceptibility in the detached LD assay showed moderate susceptibility in AWL assay. This finding is in conformity with the findings of Iwaro et al., 2006 and Otuonye, 2009 who reported that susceptibility is generally higher in detached leaves and pods than in the attached organs. This may be responsible for the observed reaction of the AWL of the cacao hybrids to the *P. megakarya* pathogen.

The insignificant isolate x host interaction has been reported from the findings of Nyassé *et al*., 1995, Van Der Vossen, 1997, Surujdeo-Maharaj *et al*., 2001 and Nyadanu *et al*., 2012 established *Phytophthora* species non-specificity with cacao genotypes. This indicates that cacao hybrids resistance in this study to *P. megakarya* could be applicable to other *Phytophthora* species causing pod rot of cacao in the other areas of cocoa production in the world.

It was observed also from this study that C77 cacao genotype which was once used as resistant control (Otuonye *et al*., 2006; Otuonye, 2009) showed moderately susceptibility to the *P. megakarya* pathogen. This finding points to the fact that there may be changes in the population of the *P. megakarya* pathogen on cacao in Nigeria, indicating the possible diversity in the genetic make-up of the pathogen with the appearance of more virulent strains that enable it to breakdown the resistance of C77 cacao genotype and cause enormous losses in revenue for the cocoa industry. This point to the need for continuous rapid screening of cacao germplasm using leaf disc assay, which have been proven to be reliable, cheap and fast in the selection and enhancement of germplasm for resistance to black pod disease.

A good correlation obtained between detached LDT and the AWLT in this study showed the reliability of the detached LD assay as an effective screening method that could be used to predict cacao genotypes reaction and resistance in the field to *P. megakarya* pathogen.

CONCLUSION

This study revealed that some of the cacao hybrids used in this study had innate resistant trait against *Phytophthora* pathogen, the causal agent of black pod disease of cacao, in the gene pool of CRIN. Of the nineteen cacao hybrids screened, three (3) were found to be resistant, seven (7) were found to be moderately resistant, four (4) were found to be moderately susceptible, three (3) were found to be susceptible and two (2) were found to be highly susceptible. C77 cacao genotype which was previously reported and consequently use as resistant check was found to be moderately resistant in this study, thus appearing to be losing its hitherto resistant status. While the reliability of Pa150 as resistant check remained intact. The resistance in attached leaves of cacao hybrids is higher than that of the detached leaves.

RECOMMENDATION

Cacao hybrid 1, 3 and 5 which were classified to be resistant in this study, are suggested for selection in cacao breeding activities for resistant varieties. These could be recommended for incorporation into national breeding program for distribution and developing high yielding disease resistant cacao cultivar. While hybrid 4, 7, 8, 13, 15, 18 and19 which were found to be moderately resistant could be conserved for future germplasm enhancement program.

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MANAGING THE HIDDEN ENEMIES OF COCOA

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ABSTRACT

Cacao is an economic cash crop grown in many countries across the world, with Côte d'Ivoire, Ghana, Indonesia and Nigeria as the leading producers. Prominent among the major constraints against cocoa production in Nigeria is the problem of plant-parasitic nematodes, which though often confused with other infections, has led to substantial decline in production. The presence of multiple pathogens has made correct diagnosis and estimation of impacts of nematodes on cocoa somewhat difficult. This has expectedly led to adoption of erroneous control measures on the crop. Among all known nematode species, Meloidogyne incognita has been found to be of economic importance on cocoa, particularly in West Africa (including Nigeria), India, Malaysia, Venezuela and Brazil. Other species found on cocoa include M. exigua (Bolivia), M. javanica (Malawi, Venezuela and Central Africa), M. arenaria and M. thamesi (Brazil). M. incognita has been found, through experimental studies, to cause dieback, stunting, wilting, yellowing of leaves and reduction in leaf size. Pathogenicity of some other nematode species has also been confirmed by scientists. Both chemical and non-chemical methods have been used for effective management of these hidden enemies of cacao across the globe. However, non-chemical method, involving the use of organic soil amendments, is safer and cheaper for the poor resource farmers.

Keyword: Cacao, plant-parasitic nematodes, root-knot nematodes, dieback

INTRODUCTION

Cacao (*Theobroma cacao* Linnaeus) plays important roles in the agricultural sector of the Nigerian economy. The crop contributes significantly to food security, employment, diversification of income sources in rural and urban areas, and contribution to the gross national product. Cacao is cultivated in many countries of South and Central America, Africa, Asia and Oceania, located mostly between 10^0 North and South of the Equator. The principal cacao-growing countries of West Africa, namely Côte d'Ivoire, Ghana, Nigeria, Cameroon and Togo make up about 70 per cent of the world's cocoa production (Simo *et al*., 2018). Nigeria is the world's fourth largest cocoa producer, after Indonesia, Ghana and Cote d'Ivoire. It may be possible to produce cocoa beans in volume in other regions, but to replicate the unique flavour; the chemical and physical characteristics of the West African cocoa may prove to be very difficult (WPR, 2021; Taylor and Taylor, 2006).

Although cocoa farmers in the country are aware of the need to improve the productivity of the crop, pests have been a major constraint. Plant-parasitic nematodes constitute a major barrier to production accounting for a rapid decline in adult cacao productivity and establishment of seedlings in fresh and rehabilitated fields (Orisajo, 2018, Orisajo et al., 2012).

One difficulty with assessing nematode impact is that damage resulting from nematode infection is often less obvious than that caused by many other pests or diseases. Because of the ubiquitous interaction of nematodes with other pathogens, the concept of economic threshold, so well established for many crops and pathogens in temperate environments, is difficult to establish under field conditions in tropical regions. The presence of multiple pathogens makes diagnosis confusing and frequently results in underestimation of the damage caused by nematodes. The masking effects of damage caused by nematodes also can lead to the adoption of erroneous control measures, particularly in annual crops (Orisajo, 2012). For example, root-knot nematode attacked cacao seedlings leading to dieback (Figure 1), but farmers erroneously thought it was a fungal infection. Losses that result from nematode attack may not necessarily be as a consequence of direct cell death, necrosis or 'diseased' tissue but may derive from other more insidious aspects, such as interference with the root system, reducing their efficiency in terms of access and uptake of nutrients and water. Nematode-affected plants often present typical drought and nutrient stress symptoms, which are easily and often misdiagnosed (Okeniyi et al., 2009).

Figure 1. Dieback condition of cacao caused by root-knot nematodes compared to a healthy one
(Photo credit: S.B. Orisajo)

PLANT PARASITIC NEMATODES OF CACAO

Root-knot nematodes, *Meloidogyne* spp., are the most important nematodes of cacao due to their pathogenicity and wide distribution in cocoa producing regions of the world (Campos and Villain, 2005). *Meloidogyne* spp. have been found in cacao since 1900 and have been reported from Zaire, São Tomé, Java, Ghana, Malawi, Côte d'Ivoire, Nigeria, Venezuela, Brazil and India (Okeniyi et al., 2009).

Meloidogyne incognita seems to be the most frequently found in cacao. It is a common pest in West Africa, including Nigeria, where this species appears as the most economically important nematode on cacao. *M. incognita* is also common in India, Malaysia and Venezuela and is widespread in cacao regions of Brazil (Fademi et al., 2006). However, other species of *Meloidogyne* have also been found on cacao: *M. exigua* in Bolivia, *M. javanica* in Malawi, Venezuela and in Central Africa, and *M. arenaria* and *M. thamesi* in Brazil (Crozzoli et al., 2001).

Other root-feeding nematodes of cacao include *Hemicycliophora* spp. (Thorne) Entwistle & Caveness, *Hoplolaimus* spp., *Radopholus similis*, *Rotylenchulus reniformis* Linford & Oliveira, *Scutellonema brachyurus* Steiner, *Trichodorus* spp. Allen, and *Xiphinema* spp. (Cobb) Luc. *Helicotylenchus* spp. are widespread on cacao in South America and Asia, and *H. pseudorobustus* reproduced on cacao in Liberia. *H. dihystera* was reported in Bahia State of Brazil as the most widespread species on cacao, occurring in 70% of the samples. Afolami and Caveness (1983) reported the frequency of occurrence and geographic distribution of plant-parasitic nematodes associated with cacao in Nigeria. The common genera found were *Helicotylenchus*, *Hemicycliophora*, *Meloidogyne*, *Radopholus, Scutellonema*, *Trichodorus* and *Xiphinema* (Lamberti et al., 1992).

SYMPTOMS OF ROOT-KNOT NEMATODE DAMAGE ON CACAO

In artificially-infected seedlings, *M. incognita* caused dieback, stunting, wilting, and yellowing of leaves and reduction in size of leaves. Tiny galls, juveniles and females of *M. incognita* with egg masses can be observed on the roots (Fig. 2). In Nigeria, seedlings of cv. Amelonado grown in soil inoculated with *M. incognita* showed the symptoms from the 16th week, leading to wilting in the 24th week. Amazon cultivars also showed symptoms, but only after the 24th week, and without wilting. In the field, *M. incognita* produces galls with exposed egg masses on roots, dieback and sudden death of the infested plants (Orisajo et al., 2007). According to Sharma and Sher (1973), when the dieback conditions occur, the trees die down to their roots, which remain alive and send up shoots in the next growing season and also when the dead terminals are pruned off (Fig. 1). The syndrome of sudden death disease is permanent wilting, the green leaves suddenly turn yellow and brown, and they dry up to remain hanging (Fig. 3). Sharma and Sher (1973) associated the occurrence of sudden death

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with root-knot nematodes. Campelo and Galli (1980) demonstrated the pathogenicity of *Helicotylenchus* spp. on *T. cacao*. A significant reduction was observed in dry root weight and leaf number in 20-day-old inoculated seedlings.

Figure 2. Tiny galls and *M. incognita* juveniles on the roots of cacao
(Photo credit: S.B. Orisajo)

Figure 3. Sudden death of cacao seedlings by parasitic nematodes compared to a healthy one
(Photo credit: S.B. Orisajo)

MANAGEMENT OF PLANT-PARASITIC NEMATODES

Control of nematodes in perennial crops is more difficult than in annual crops. The long-time nature of perennial crops makes rotation schemes impractical. In perennial crops such as cacao, nematodes that survive the control practices have time to recover and build up again to destructive levels. Nematode control, therefore, becomes essential in order to reduce crop losses and to ensure self-sufficiency in the requirements for food and industrial raw materials. Several nematode control options are available. These can broadly be categorized into chemical and non-chemical control methods. The latter includes good farm hygiene, use of heat and organic amendments while the former essentially, involve the use of nematicides.

Chemical Control

Historically, nematicides have been highly effective and reliable in controlling a wide range of nematode species in certain crop situations. The advantages to be derived are quick effects on the plant-parasitic nematodes leading to spectacular increases in yields, especially of high-valued crops. Sosamma *et al.* (1980) have reported an increase in the number of cocoa pods by the application of Dasanit, Nemacur and Carbofuran. However, these nematicides have been banned on cocoa (Bateman, 2008) due to negative shifts such as

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health hazards, environmental pollution and potential atmospheric ozone depletion (Ghorbani et al., 2008). Hence the need to look for alternatives to chemical control.

Organic Amendments

The addition of organic amendments that stimulate growth of antagonistic microorganisms, or release toxins during decomposition has been advocated as an alternative method to chemical control of plant-parasitic nematodes. The application of organic material as soil amendment, though a traditional practice to improve soil fertility and structure, is also known as a control method for soil- borne diseases, including plant-parasitic nematodes (Houx *et al*., 2014). In recent years, a variety of organic materials, such as animal and green manures, compost, and proteinaceous wastes, are used for this purpose (Atandi et al., 2017, Shiferaw et al., 2017, Briar et al., 2016; Forge et al., 2016). Incorporation of organic amendments has been shown to be detrimental to plant-parasitic nematodes (Wang et al., 2004) due to release of NH4, formaldehyde, phenol, volatile fatty acids and toxic compounds (Briar et al., 2016). It was generally postulated that the adverse influence of organic amendment on plant-parasitic nematode is referred to increasing host resistance to nematode infection and enhancement of growth performance (Country & Millon, 2008). Therefore, soil amendment with water leaf extracts of *Acalypha ciliata, Jatropha gossypifolia, Azadirachta indica* and *Allium ascalonicum have nematicidal effects* on *Meloidogyne incognita* thereby reducing infection on cacao seedlings (Orisajo et al. 2007). Also, soil incorporation of goat dung, organo-mineral fertilizer and organic fertilizer at 200 kg/ha have been shown to enhance growth, survival and field establishment of cacao seedlings in the soil infected with plant-parasitic nematodes (Orisajo and Adejobi, 2020). Poultry litter compost soil amendments at 5% also have potential for suppressing *M. incognita* populations on cacao seedlings in the nursery (Meyer *et al*., 2011).

CONCLUSION

Plant-parasitic nematodes have remained important hidden enemies of cocoa productivity in virtually all known cocoa producing countries of the world. Their impacts on the cash crop have, often times, been confused with some other pathogenic infections. Improving the agronomic conditions for plant growth is an important factor for increasing the plant tolerance to plant-parasitic nematodes. Therefore, soil application of organic amendments is recommended for effective management of these hidden enemies of cacao and enhancement of field establishment.

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FUSARIUM WILT MANAGEMENT ON TOMATO AS INFLUENCED BY POULTRY MANURE AT DIFFERENT RATES

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ABSTRACT

Field trial was carried out in 2013 and 2014 early seasons at the National Horticultural Research Institute, Ibadan to determine the effect of poultry manure amendment on tomato fusarium wilt incidence and severity and to also determine the relationship between disease incidence and the growth parameters. The experiment was laid out in a Randomized Complete Block Design with three replications. Treatments include two tomato varieties (Roma VF and Ibadan local) and four levels of poultry manure (0, 6,12 and 18 tons/ha). Data collected on disease incidence and severity, plant height, fruit number, fruit weight among others were subjected to Analysis of Variance and means were separated using Least Significant Differences at p<0.05. in both years, the result showed that poultry manure induced disease that ranged between 38-57 % and 20 – 57 % in Ibadan –local and Roma VF respectively. While severity reduction of 28-54 % was recorded in Ibadan local variety Roma VF had severity reduction that ranged between 29-58 %. Overall assessment showed that poultry manure at 18tons/ha had the highest Fusarium wilt reduction of 56% and 59% in Ibadan local and Roma VF respectively. Therefore, Poultry manure application at 12 tons/ha should be encouraged for Fusarium wilt incidence reduction and for enhanced fruit yield.

Key words: Fusarium wilt, poultry manure, management. tomato

INTRODUCTION

Organic amendment such as animal manure improves soil structure and fertility and decrease the incidence of disease caused by soil borne pathogens (Noble and Coventry, 2005). In the past century, the introduction of synthetic inorganic fertilizers, disease-resistant varieties and fungicides has allowed farmers to break the link between organic amendments and soil fertility (Hoitink and Boehm, 1999). As a result, organic materials such as crop residues and manure from essential resources became solid wastes. After the reduction of the organic input, soil organic matter decreased over time, soil fertility declined, and a large number of diseases caused by soil borne plant pathogens spread in agro-ecosystems (Bailey and Lazarovits, 2003). However, a renewed interest in application of organic matter to soil, for soil for the management of soil borne pathogens has gained public interest because of the adverse effects of soil fumigants and fungicides on human and the environment, hence the need for healthier environment and agricultural products (Lazarovits *et al*., 1999). Poultry manure is a good depositor of major and minor mineral elements that are capable of enhancing soil fertility on application. It also acts as a substrate for soil microorganisms and increases microbial activities, thereby decomposing faster and releasing nutrients above plant uptake levels (Thomas, 1997). Additionally, amending soil with decomposable organic matter is a viable option in pathogen suppression as it changes the soil and rhizosphere environment and enriching the soil with microflora potentially competitive or antagonistic to pathogens or release inhibitory substances or volatiles during decomposition (Hoitink and Fahy, 1986). The aim of this was to determine the effects of different rates of poultry manure as soil amendment on incidence and severity of tomato Fusarium wilt under field condition.

MATERIALS AND METHODS

Experimental site

Field experiment was conducted at the NIHORT vegetable experimental block between June and October in 2013 and was repeated using the same field, in the same period in 2014. The field was endemic to *Fusarium oxysporum* f.sp. *lycopersici* from the history. The experiment was laid out in a Randomized Complete Block Design with three replications. The treatments included two tomato varieties; Roma VF (moderately tolerant) and Ib-local (moderately susceptible) and four levels of poultry manure (0, 6, 12 and 18tons/ha). The plot size of 3 m x 3 m (9 m^2) was separated by 0.5 m and 1 m from other plots and blocks respectively. Tomato seedlings were transplanted in 5 rows at spacing of 0.75 m between rows and 0.5 m within rows. The total experimental area was 30 m x11 m (330 m^2). Cured poultry manure was

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manually incorporated into the soil three weeks prior to transplanting of four weeks old seedlings of Ibadan –Local and Roma VF (Plate 1). Weeding was done thrice manually at four weeks' interval. Five plants were tagged randomly from the three inner rows. Data were collected on disease incidence and severity, plant height, fruit number, fruit weigh, fresh and dried shoot and root weight among others and were subjected to Analysis of Variance and means were separated using Least Significant Differences at p<0.05.

Disease incidence was calculated according to the formula:

$$WI = \frac{n}{N} \times 100$$

Where WI = Wilt incidence

n = Number of plants showing wilt symptoms

N = Number of plants per treatment

Percentage severity index (PSI) was calculated using the method described by Cooke (2006).

$$PSI = \frac{\sum (X \times 100)}{NR \text{ x } MCS}$$

Where: X = Score per plant

NR = Number of plant rated

MCS = Maximum score of the scale for each scoring scale

Percentage disease reduction was calculated using formular:

$$\% DR = \frac{DIC\text{- } DIT}{DIC} \times 100$$

Where: DIC = Disease incidence/severity index of control; DIT = Disease incidence/severity index of treated

RESULTS

In both years, poultry manure at different rates significantly (P≤ 0.05) reduced disease incidence on the two tomato varieties. In 2013, incidence recorded in Ib – local amended with poultry manure at rate of 12 and 18 tons/ha were comparable and incidences at these rates were significantly (P ≤ 0.05) lower than recorded at 6 tons/ ha. While highest (74.4 %) disease incidence was recorded at control plot (0 tons/ha), a range of between 41 – 60 % reductions were observed in Ib –local at different rates of manure application in 2013 (Table 1). A significantly (P ≤ 0.05) lower (28.3 %) incidence was observed in Roma VF amended with 18 ton/ha poultry manure in year 2013 while the control plot recorded the highest (62.0 %) disease incidence. Incidences due to different manure rates showed no significant difference (P ≤ 0.05) on var. Roma VF in 2013 but at 18 tons/ha application a significantly (P ≤ 0.05) lower incidence was recorded compared with the control treatment (Table 1). In 2014, wilt incidence due to different application rates of poultry manure were comparable and significantly (P≤ 0.05) lower than incidence recorded in the control plot. At different manure rates, incidence reduction that ranged between 34 – 65 % was observed in Roma VF. Disease severity on Ib – local due to manure rates between 6 – 18 tons/ha were at par in 2013, causing severity reduction that ranged between 41 – 59.0 %. In the same year, severity on Roma VF amended with poultry manure at rate of 18 tons/ha was not significantly (P ≤ 0.05) different from severity obtained at the lower rates. A range of between 33- 56 % severity reductions was recorded on Roma VF at different application rates (Table 2). However, in 2014 a significantly lower (P ≤ 0.05) severity (40.0 %) was obtained at 18 tons/ha causing 55.0 % severity reduction in var. Ib –local. Although severity at this rate was comparable with severity recorded at 12 tons/ha application. Similar trend was also observed in Roma VF.

DISCUSSION

Soil borne fungal and oomycete plant pathogens are among the major factors limiting the productivity of agro-ecosystems. They are often difficult to control with conventional strategies such as the use of resistant host cultivar and synthetic fungicides. The lack of reliable chemical controls, the occurrence of fungicide resistance in pathogens, and the breakdown or circumvention of host resistance by pathogen populations are some of the reasons underlying efforts to develop new disease control measures (McDonald and Linde, 2002). This study showed that poultry manure had significant effect in reducing disease and enhancing the growth of tomato. The effectiveness and suitability of poultry manure in this study as organic fertilizer could be attributed to high availability of NPK content it contains (Waddington, 1998). In a similar finding by (Noble and Coventry, 2005) incorporating animal and green manure into the soil was found to improve soil structure and fertility and decrease the incidence of disease caused by soil borne pathogens. Several studies have shown that organic amendments can be very effective in controlling diseases caused by pathogens such as *Fusarium* spp. (Szczech and Smolin´ska, 2001). (Noble and Coventry, 2005). Additionally, Umar *et* *al.* (2013) studied the influence of different quantities of farmyard manure (0, 25, 50, 75 and 100 g/ha) on the growth and disease incidence of *Fusarium* wilt on tomato and reported that there was consistently significant reduction in the incidences and severities of tomato wilt due to *Fusarium*, which suggest that it could be beneficial to farmers in the reduction of wilt caused by *Fusarium* for higher yield tomato production in northern Nigeria.

CONCLUSION

The use of organic amendments for soil fertility and to control soil borne plant disease is a viable option due to the fact that it provides several advantages to growers such as reduction in the use of pesticides for plant disease control thus providing both an economic and environmental benefit. Use of organic amendments also provides use for valuable underutilized agricultural by products and improve the quality of the soil.

Table 1. Effect of different rates of poultry manure on Fusarium wilt incidence of tomato varieties in Ibadan in 2013 and 2014 planting seasons

Treatment Manure rate (tons/ha)	Wilt incidence (%)					
	Ib-local			Roma VF		
	2013	2014	Pooled mean	2013	2014	Pooled mean
0	74.44 (-)	63.88 (-)	69.16 (-)	62.22 (-)	28.88 (-)	45.55 (-)
6	43.88 (41.05)	41.11 (35.65)	42.49 (38.56)	46.11 (25.89)	18.89 (34.59)	32.50 (28.65)
12	29.44 (60.45)	39.44 (38.25)	34.44 (50.20)	39.44 (36.61)	15.56 (46.12)	27.50 (39.63)
18	30.00 (59.69)	28.33 (54.79)	29.17 (57.82)	28.33 (54.46)	10.00 (65.37)	19.17 (57.91)
LSD P ≤ (0.05)	7.04	32.59	6.25	32.59	13.18	17.49

Values in parenthesis are % incidence reduction, - = not applicable

Table 2. Effect of different rates of poultry manure on Fusarium wilt severity of tomato varieties in Ibadan in 2013 and 2014 planting seasons

Treatment Manure rate (tons/ha)	Wilt severity (%)					
	Ib-local			Roma VF		
	2013	2014	Pooled mean	2013	2014	Pooled mean
0	88.89(-)	84.44 (-)	86.67(-)	75.00 (-)	46.67(-)	60.84 (-)
6	52.78 (40.62)	60.00 (28.98)	56.39 (34.86)	50.00 (33.33)	35.56 (23.80)	42.75 (29.73)
12	36.11 (59.37)	46.67 (42.70)	41.39 (52.24)	50.00 (33.33)	30.37 (43.92)	40.19 (33.94)
18	36.12 (59.36)	40.00 (54.77)	38.06 (56.09)	33.33 (55.56)	16.60 (64.43)	24.97 (58.96)
LSD P ≤ (0.05)	17.32	13.86	6.32	32.95	18.92	18.28

Values in parenthesis are % incidence reduction. - = not applicable

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SOIL MICROBIAL BIOMASS CARBON, NITROGEN AND PHOSPHORUS DYNAMICS IN PLANTAIN ORCHARD AS AFFECTED BY PLANT PARASITIC NEMATODE CONTROL AMENDMENTS

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ABSTRACT

Microbial biomass is a valuable tool for understanding changes in soil properties and analyzing the degree of soil degradation or soil quality. This experiment was carried out to monitor the change in soil microbial biomass carbon, nitrogen and phosphorus under different amendments used in the control of plant parasitic nematode in a plantain plantation. The experiment was conducted at National Horticultural Research Institute (NIHORT) experimental farm. Three plantain varieties (Obino l'Ewai, Pita 14 and Agbagba) were subjected to five nematode control amendments: Carbofuran, poultry manure, dried neem leaves, Glomus mosseae and control. The treatments were laid out in randomized complete block design with three replications. Soil samples were taken annually with respect to the treatment and assessed for microbial biomass carbon, nitrogen and phosphorus using the fumigation-extraction methods. The data were analysed by descriptive statistics and ANOVA at α0.05. Microbial biomass carbon ranged from 267.12-339.38 mg / kg, 249.47-321.83 and 131.73-258 at years 1, 2, and 3 respectively, while the microbial biomass nitrogen was in the order PM > DNL > GM > CARB > CONTROL at 36 months. The study showed that incorporation of nematode control amendment varies the quantity of soil microbial biomass; therefore, influencing the rate of immobilization and mineralization of soil nutrients.

Key words: *Musa* spp, soil microbial biomass, nematode control methods

INTRODUCTION

Banana and plantain (*Musa* spp) are major food crops in sub-Sahara Africa, providing more than 25% of the carbohydrate and 10% of the calorie for over 100 million people (Swennen, 1990; INIBAP, 2002). It contributes significantly to food security in sub-Saharan Africa (Sharock and Frison, 1998). *Musa* has provided humans with food, medicine, clothing, tools, shelter, furniture, paper, and handicrafts. It is also rich in vitamin C, B6, minerals and dietary fibre. Nigeria is the third largest producer of plantain in Africa with annual production of about 2,785,000 tons in 2006 (FAOSTAT, 2010).

One of the major pests of plantain and banana is parasitic nematode which causes toppling and a yield reduction of 30 – 80% worldwide (Duncan, 2005). Plantain parasitic nematode had been controlled using organic and inorganic substances and it was established that soil organic matter accumulation and degradation is a function of the quality and quantity of inputs added to the soil. Peacock *et al.,* (2001) reported that the quality and quantity of organic inputs determines the microbial community structure. However, the effect of the organic amendments on nutrient availability depends on their ability to decompose and its nutrient composition (Singh and Jones, 1976; Reddy *et al*., 2005).

Peacock *et al*. (2001) reported that microbial biomass and diversity are influenced by the quantity and quality of organic inputs. It was described as both a source and sink of available nutrients for plants uptake which plays a critical role in nutrient transformation in terrestrial ecosystems (Singh *et al*., 1989). Generally, microbial biomass is an indicator for assessing soil quality and restoration in different vegetation types (Groffman *et al*., 2001). Therefore, ecosystem stability and fertility is directly related to soil microbial activity and biomass (Smith *et al*., 1993). In this study, we hypothesized that different amendments used in the control of nematode can modify, to varying extents, the soil microbial biomass carbon, nitrogen and phosphorus. We aimed to investigate: (i) the effects of different amendments on the soil microbial biomass carbon, nitrogen and phosphorus and (ii) to select the most sustainable management system that will promote microbial biomass sink in plantain orchard treated with nematode amendments.

MATERIALS AND METHODS

The experiment was established at the National Horticultural Research Institute experimental plot in

Ibadan, South West Nigeria, (7^0 30' and 3^0 54'E; in an altitude of 234m above sea level). The soil had a pH of 5.89 (H_2O) and texturally sandy with a composition of 790 g / kg sand, 80 g / kg silt and 130 g / kg clay. The treatments comprised three varieties of plantain (*Agbagba, Obino l'Ewai* and *Pita 14*) and five amendments to control nematode: carbofuran, dried neem leaves, poultry manure, *Glommus mosseae* and no amendment (control). The treatments were arranged in a Randomized Complete Block Design (RCBD) and replicated three times. The total land area was 110 m x 28.5 m (3,135 m^2) with 15 plots in each replicates and each measured 5.0 m x 7.5 m (37.5 m^2). Soil samples were taken annually at a depth of 0 – 15 cm from each plot with respect to treatments and assessed for microbial biomass C (MBC) using the fumigation-extraction method according to Vance *et al*., (1987). The microbial biomass N (MBN) was determined using the method of Brookes *et al*., (1985). The microbial biomass P (MBP) was determined using the fumigation-extraction method according to Brookes *et al*., (1982). Data were subjected to descriptive statistics and analysis of variance (ANOVA) using GLM procedure (SAS, 2002) and means were separated using least significant difference (LSD) at 5 % level of probability.

RESULTS

Microbial biomass carbon under the application of *Glomus mosseae* was higher at years 1 and 2 after planting. Concentration of microbial biomass carbon under the application of poultry manure and *Glomus mosseae* was similar at 1st year after planting; however, it was significantly higher than other treatments at 2nd year (Table1). The microbial biomass carbon under poultry manure at three years after planting was significantly higher than other treatments. The least was observed without nematode control methods at years 1, 2, and 3 after planting.

Microbial biomass nitrogen under the application of poultry manure was higher than other nematode control treatments at the 1st and 2nd years but similar to dried neem leaves at the third year after planting. The concentration of microbial biomass nitrogen under the application of *Glomus mosseae* at year one was significantly lower than other treatments. The least was observed under the application of carbofuran at second and third years after planting (Table 1).

Concentration of microbial biomass phosphorus under the application of poultry manure was significantly higher than other treatments at years 1, 2 and 3 (Table 1). Microbial biomass phosphorus under the application of *Glomus mosseae* was significantly lower than other treatments at the first year after planting. Microbial biomass phosphorus concentration under the applications of dried neem leaves, *Glomus mosseae* and control was comparable and they were significantly higher than carbofuran at two years after planting. Microbial biomass phosphorus concentration under the application of dried neem leaves, poultry manure and *Glomus mosseae* are similar at the third year after planting (Table 1).

Table 1. Effects of nematode control methods on microbial biomass carbon, nitrogen and phosphorus at different years after planting under field conditions

Nematode control methods	Years after planting								
	1	2	3	1	2	3	1	2	3
	MBC (mg/kg)			MBN (mg/kg)			MBP (mg/kg)		
Dried neem leaves	319.02	301.38	214.96	34.77	38.86	48.88	2.8	3.9	4.1
Poultry manure	327.06	309.44	258.31	40.95	44.40	53.07	5.4	6.4	7.2
Carbofuran'	283.44	265.49	167.36	31.29	27.62	29.00	2.0	3.9	4.7
Glomus mosseae	339.38	321.83	220.22	26.40	31.98	38.42	1.2	3.1	4.6
Control	267.12	249.47	130.73	33.35	26.88	9.65	2.9	4.4	6.0
$LSD_{0.05}$	2.70	0.43	0.63	0.93	0.89	0.81	0.6	1.6	1.0

$LSD_{0.05}$ – least significant difference at 5 % level of probability, MBC - Microbial biomass carbon, MBN - microbial biomass nitrogen, MBP - microbial biomass phosphorus

DISCUSSIONS

The increase observed in microbial biomass carbon under the application of *Glomus mosseae* (AMF) could be as a result of higher soil carbon storage as reported by Rillig *et al*. (2001) that arbuscular mycorrhiza fungi contribute to soil carbon pool by increasing the hyphal biomass in the soils and root of the host plant. Reduction in microbial biomass phosphorus with the application of *Glomus mosseae* signifies effective utilization of phosphorus. Arbuscular mycorrhizal fungi colonization enhances the uptake of relatively immobile soil ions (Marschner and Dell, 1994; Liu *et al*., 2000).

Soil microbial biomass is an important component in the cycling of nutrients in soils particularly when organic materials are used as amendments (Aoyama and Nozawa 1993). It can be used to characterize the microbiological status of soil (Nannipieri *et al*., 1990). The soil and its components determine the microbiological activities that are facilitated by the microorganism (Zhu *et al.,* 2003). Aoyama and Nozawa 1993 reported that variation in N mineralization and immobilization processes of different organic materials defines the microbial biomass N pattern.

Glomus mosseae treated plots having the highest amount of MBC after one year is in corroboration with the work of Rillig *et al.(*2001), which suggests that mycorrhiza fungi contribute to soil carbon storage due to the hyphal biomass in the soils and root.

The data showed higher microbial biomass nitrogen at one and two years respectively in poultry manure amended plot and in dried neem leaves amended plot at three years after planting. According to Ross and Tate (1993), crop residues can have a large effect on soil microbial biomass and activity, which in turn, affect the ability of soil to supply nutrients to plants through SOM turnover. It was also observed that the least amount of microbial biomass phosphorus was observed at the arbuscular mycorrhiza amended plot (Table 1) this signifies effective utilization of phosphorus. This in line with the report of (Marschner and Dell, 1994; Liu *et al*., 2000) that AM colonization enhances the uptake of relatively immobile soil ions and far more mobile nitrogen (N) ions, particularly under drought conditions (Tobar *et al*., 1994).

CONCLUSIONS

The organic amendments have higher potential to broaden or enhance microbial biomass. Therefore, the dual purpose served by organic amendments should be harnessed in order to attain sustainability especially in large scale production of plantain.

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MANAGEMENT OF *FUSARIUM OXYSPORIUM* INFECTION IN LETTUCE (*LACTUCA SATIVA* L.) USING *TRICHODERMA LONGIBACHIATUM*

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ABSTRACT

Lettuce (Lactuca sativa L.) is the most valuable salad vegetable in the world. However, its production is affected by biotic and abiotic stresses and Fusarium oxysporium is one of the biotic stresses affecting lettuce production. The study was therefore conducted to determine the biocontrol effect of Trichoderma longibrachiatum on Fusarium infection in lettuce. Two varieties of lettuce (Greatlake and Eden) were propagated using conventional and in-vitro techniques. Soils endemic with Fusarium oxysporum were inoculated with mycelial plugs of Trichoderma longibrachiatum at different positions before lettuce were grown on them. The control soils were not treated with T. longibrachiatum. Results revealed that lettuce grown on T. longibrachiatum-treated soil had reduced incidence and severity of F. oxysporum while the controls of Greatlake and Eden lettuce propagated conventionally had Fusarium incidence values of 100% and 79% respectively. The ability of T. longibrachiatum to reduce Fusarium infection in lettuce indicates its potentials in improving plant health for sustainable food security.

Key words: Biocontrol; Disease; Lettuce; Management; *Trichoderma*

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an annual leafy vegetable from the Compositae (Asteraceae) family (Romani *et al*., 2002). It is regarded as an important crop because it is the most consumed among the salad vegetables (Nicolle *et al*., 2003). Lettuce is a rich source of vitamins and minerals, recommended as a fiber rich diet because of its low calorie (Filgueira, 2008). In addition, lettuce contains appreciable amount of β-carotene and lutein capable of reducing risk of cancers, cataracts, heart diseases and stroke (USDA, 2004). *Lactuca* has also been reported to prevent chronic diseases and its seeds are used for the treatment of inflammation and asthma (Pavlou and Vakalounakis, 2005).

Inspite of the importance of lettuce, its production is hindered by biotic and abiotic stresses. Among the biotic stresses are fungi in which *Fusarium oxysporium* is one. *Fusarium oxysporium* is the major cause of *Fusarium* wilt in vegetables. It is an important disease of lettuce all over the world causing yield losses ranging between 20 and 70% depending on cultivar susceptibility, management practices and the prevailing environmental conditions (Pasquali *et al*., 2007). Symptoms induced by *F. oxysporium* in lettuce include chlorosis and/or necrosis of older leaves, stunting and plant death before maturity (Scott *et al*., 2010). One of the management strategies of *Fusarium* infection is the use of fungi as biocontrol agents of the disease. *Trichoderma* spp. is a fungus which has the ability to antagonize the growth of disease-causing fungi by secreting enzymes which degrade the cell walls of other fungus (Kawalekar, 2013). The objective of this study is to determine the biocontrol properties of *Trichoderma longibrachiatum* on the incidence and severity of *F. oxysporium* in lettuce.

MATERIALS AND METHODS

Seeds of lettuce; Greatlake and Eden were obtained from National Horticultural Research Institute sub-station at Kano State. The seeds were packaged in sealed water-proof sachets until when needed.

Trichoderma longibrachiatum was obtained from the International Institute of Tropical Agriculture (IITA)-Bioscience Center, Ibadan. The isolate was maintained on Potato Dextrose Agar (PDA) and kept in the refrigerator at 4 ^oC until when required. *Fusarium oxysporum* was isolated from the rhizosphere of lettuce plant according to the procedure of Barakate *et al*. (2002). One gramme of soil sample obtained from the rhizosphere of lettuce was transferred into a test tube and 9 ml of distilled water added. Serial dilution was carried out until 10^{-6} dilution was obtained and aliquots of 1ml from the dilution were inoculated on PDA. The inoculation was done in duplicates and the plates incubated at 25 ^oC for 72 hrs after which the plates were examined for fungal growth. Pure cultures of *Fusarium oxysporum* were obtained from the mixed cultures produced after incubation. *Fusarium oxysporum* was maintained in the laboratory by periodic transfer onto slants on PDA and kept in the refrigerator at 4 °C until when required. Identification of *Fusarium oxysporum* was carried out using morphological and microscopic characteristics.

Biocontrol of *F. oxysporum* by *T. longibrachiatum* was carried out on the field. The experiment was divided into two groups. The first group was carried out by propagating lettuce on Murashige and Skoog (MS) medium. The micropropagated seedlings were moved to the acclimatization chamber and later transplanted on the field. During transplanting, a 10 mm cork borer was used to transfer mycelial plugs from actively growing margins of *T. longibrachiatum* on PDA into the soil and treatments were carried out as follows; (i) seedlings and *T. longibrachiatum* in the same 3 cm deep hole (T1), (ii) seedlings in 3 cm deep hole with *T. longibrachiatum* placed 3 cm below the seedlings (T2), (iii) seedlings in 3 cm deep hole with *T. longibrachiatum* placed on one side of the seedlings (T3), (iv) seedlings in 3cm deep hole with *T. longibrachiatum* placed 3 cm on both sides of the seedlings (T4), (v) seedlings in 3 cm deep hole without *T. longibrachiatum* (control). For the second group of experiment lettuce seeds were sown directly on the field and the same *T. longibrachiatum* treatments above were applied. Natural infection was allowed to set in as the field used was known to be endemic with *F. oxysporum* infection. The effects of the treatments were observed on disease incidence and severity of *F. oxysporum*.

RESULTS AND DISCUSSION

The incidence of *F. oxysporum* on the *in-vitro* propagated Greatlake lettuce revealed that 80% of the control plants were infected with the fungus. The susceptibility of the *T. longibrachiatum*-treated plants ranged from 25% to 42.85%. One hundred percent (100%) of the control plants of the conventionally propagated Greatlake lettuce were infected with *F. oxysporum* while the susceptibility of the *T. longibrachiatum*-treated plants ranged from 33.33% to 75% (Fig. 1a).

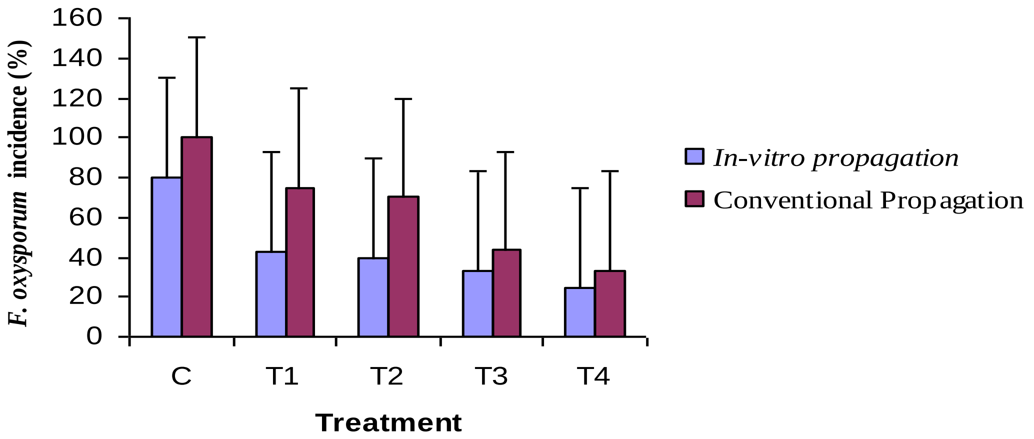

Figure 1a. Incidence of *Fusarium oxysporum* in Greatlake lettuce

The severity of the *in-vitro* propagated Greatlake lettuce to *F. oxysporum* revealed that the control had the highest severity score of 4. Treatments T3 and T4 were mildly infected while T1 and T2 were moderately infected by the fungus. The control plants of the conventionally propagated plants were severely infected by the fungus, very few survived the infection and the severity score was 5. The *T. longibrachiatum*-treated plants were not severely infected by the fungus, the severity scores tended towards moderate infection (Fig. 1b, Plate 1). This could be due to the ability of *T. longibrachiatum* to colonize the rhizosphere and utilize nutrients more than *F. oxysporum* (i.e competition). Among others, *T. longibrachiatum* may improve mineral uptake efficiency, increase resistance to abiotic stresses and exhibit adverse effect towards deleterious microorganisms or induce systemic resistance (ISR) in plants (Harman *et al*., 2004).

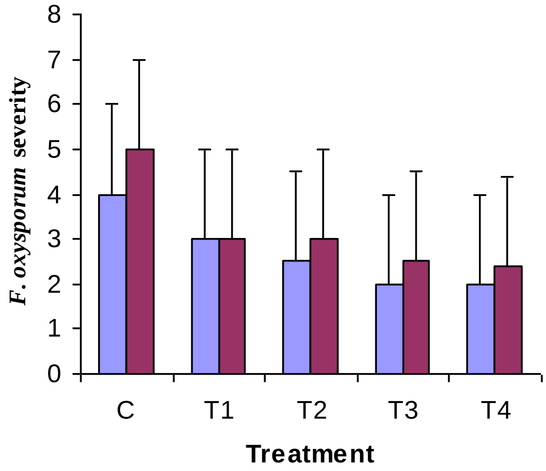

Figure 1b. Severity of *Fusarium oxysporum* in Greatlake lettuce

C- control; T1- seedling and *Trichoderma longibrachiatum* in the same 3cm deep hole; T2- seedling in 3cm deep hole with *Trichoderma* put 3cm below the seedlings; T3- seedling in 3cm deep hole with *Trichoderma longibrachiatum* placed on one side of the seedlings; T4- seedling in 3cm deep hole with *Trichoderma longibrachiatum* placed on both sides of the seedlings.

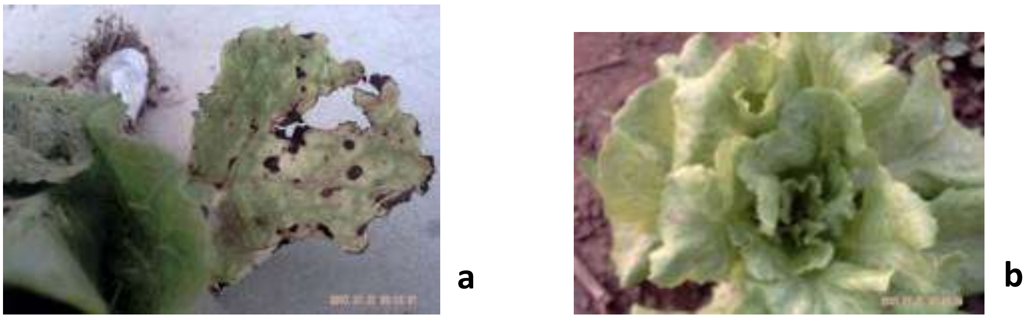

Plate 1. Conventionally propagated Greatlake lettuce (a) Control showing necrotic lesions and yellowing of leaves after infection with *Fusarium oxysporum* (b) *Trichoderma*-treated lettuce

The incidence of *F. oxysporum* in the micro-propagated Eden lettuce was very low in T4 with a mean value of 20% while those of the other *T. longibrachiatum*-treated plants were within the range of 38% to 50%. The incidence of the control of the conventionally propagated Eden lettuce was 79%, meanwhile, the fungal incidence of the *T. longibrachiatum*-treated plants was lower with T4 having the least value of 28% while those of T1, T2 and T3 were 44%, 55% and 42% respectively (Fig. 2a).

The severity of *F. oxysporum* on the *in-vitro* propagated plants was high in the control plants with a score of 4 while those of the *T. longibrachiatum*-treated plants had mean scores that ranged from 2 to 3. The severity score obtained from the control of the conventionally propagated plants was 4.5 while scores that ranged between 2 and 3.33 were recorded for the *T. longibrachiatum*-treated plants (Fig. 2b). The reason for this is the ability of *T. longibrachiatum* to grow faster than *F. oxysporum,* thereby occupying available space and utilizing available nutrients. This is in conformity with the report of Siameto *et al*. (2010) which stated that *T. harzianum* inhibited the growth of the target organisms through its ability to grow much faster than the pathogenic fungi thus competing efficiently for space and nutrients.

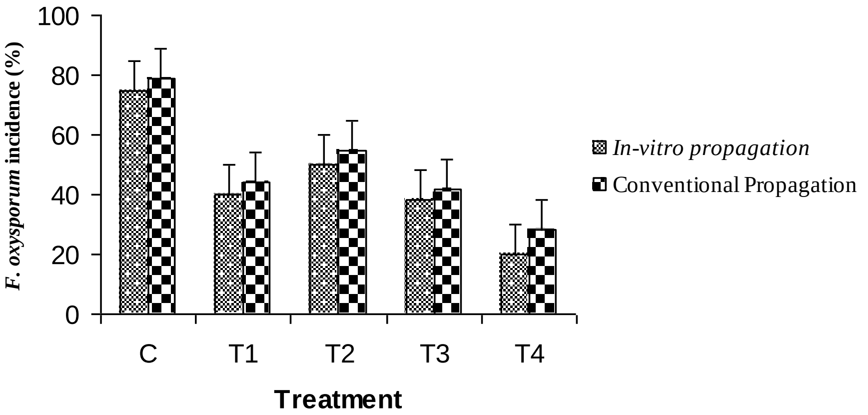

Figure 2a. Incidence of *Fusarium oxysporum* inEden lettuce

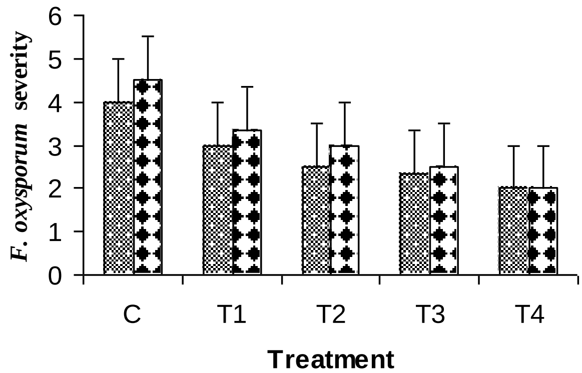

Figure 2b. Severity of *Fusarium oxysporum* in Eden lettuce

C- control; T1- seedling and *Trichoderma* in the same 3cm deep hole; T2- seedling in 3cm deep hole with *Trichoderma* put 3cm below the seedlings; T3- seedling in 3cm deep hole with *Trichoderma* put 3cm below the seedlings and in other 3cm hole on one side of the seedlings; T4- seedling in 3cm deep hole with *Trichoderma* placed in hole 3cm below and 3cm on both sides of the seedlings.

CONCLUSION

The use of plant growth-promoting fungi as biocontrol agents is promising in agricultural setting as they improve plant health with no adverse effect on the environment and the consumers at large. The use of *Trichoderma* spp. should be encouraged for use by farmers to enhance plant health and increase food security.

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POTENTIALS OF BOTANICALS TO CONTROL *BALANOGASTRIS KOLAE (DESBROCHERS)*, A MAJOR PEST OF STORED KOLA NUT IN NIGERIA: A REVIEW

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ABSTRACT

Kola nut is an important cash crop in Nigeria and some other African countries. It is a major source of livelihood to many, most especially, in the south western part of Nigeria. However, Balanogastris kolae infestation and damage has been a major challenge to kola nut while in storage. Several measures have been employed by farmers, particularly, the use of synthetic chemicals which have detrimental effects on man and the environment. In Nigeria, several studies have been conducted to investigate the potentials of some botanicals against B. kolae using bioassays and storage trials. Interestingly, all the plant samples tested were found effective against kola nut weevil's infestation. It was observed that as the concentrations of the plant samples (crude extracts and powders) increased, the mortality of adult B. kolae increased with increase in time of exposure. Therefore, any of the plant samples used in these researches can be explored as biopesticides against B. kolae. Future research should focus on determination of active components in candidate extracts and bioassay of those compounds against the kola weevil.

Key words: *Cola nitida*, *Cola acuminata*, *Balanogastris kolae*, Plant extracts, Biopesticides

INTRODUCTION

Kola nut is a traditional plant belonging to the family *Sterculiaceae*. There are about 125 species of trees in this family native to the tropical rainforests of Africa. C*ola nitida* and *C. acuminata* are the two species that are very common most especially among the Yoruba tribe of Southwestern Nigeria (Odebunmi *et al*., 2009). *C. nitida* (Vent) Schott and Endl can be easily differentiated from *C. acuminata* (P. Beauv) Schott and Endl as it has two cotyledons with varieties of colour which are red, pink and white. *C. acuminata* on the other hand has three to six cotyledons. Farmers cultivate *C. nitida* more than *C. acuminata* because of its higher economic importance (Adeyeye *et al.,* 1994).

The nut has varying degrees of importance to the three major Nigerian ethnic groups, the Hausa, Igbo and Yoruba. Kola nuts are used as stimulants because they contain caffeine and theobromine. They are equally used in the production of beverages and pharmaceutical products due to these alkaloids and other phytocompounds they possess. Kola nuts also find application in the textile industry as they possess tannins and they are also used in production of wines, liquid soap, soft drinks and feed formulation, among other uses (Azeez, 2015; Ndagi *et al*., 2012).

However, Nigeria has witnessed a downward trend in kola nut production due to numerous factors such as the trees not producing fruits or very low yield due to self-and-cross incompatibility among trees, partial and total sterility, inefficient natural pollination, old age, field and storage pests, and diseases (Ndagi *et al*., 2012; Mokwunye *et al*., 2017). Kola nut weevils, *Balanogastris kolae* and *Sorphrorhinus* spp. are the two most important field-to-store pest of kola nut (Asogwa *et al*., 2015, Azeez 2015).

ECONOMIC IMPORTANCE OF *BALANOGASTRIS KOLAE*

The *a*dult kola weevil, *Balanogastris kolae* (Desbrochers), a member of the *Curculionidae* family is the most common pest of kola nut. They are identified as field-to-store pests of kola because their infestation starts from the field and continues till storage, thereby causing huge losses to stored nuts (Azeez, 2015). They are usually dark brown to grey in colour and 0.3 - 0.4 cm long and 0.15 - 0.2 cm wide.

The female oviposit either on the nuts or inside it to about 1cm deep through wounds or holes created by other insects or through cracks on the husk that occurred when the follicles dehisce before harvest or during processing. Larva feeds extensively on kola nut thereby reducing it to yellowish brown powdery mass (Popoola *et al*., 2020). Kola weevils have a rostrum which they use to bore into the nut and feed on internal content. Larvae feed on the kola nut cotyledon and develop inside the nuts. The undetected infestation of kola nuts in storage by these weevils results in considerable high losses, which sometimes can be as high as about 60% of the total production in a year (Asogwa *et al*., 2015).

MANAGEMENT OF KOLA WEEVIL WITH INSECTICIDES

In order to prevent kola nuts in storage from the attack of kola weevils and other pests, farmers and traders use various types of pesticides which are very effective in protecting the products (Lale, 2002). These chemical pesticides include lindane, cypermethrin and phostoxin that are banned due to their detrimental effects in the environment. Some of these insecticides are systemic in nature and usually they do not easily biodegrade after application, they remain as residues in the environment. Aikpokpodion *et al* (2013) reported that kola nuts obtained from selected markets in southwestern Nigeria contained some levels of residues of chlordane and endosulfan. The effects of exposure to pesticides on human includes: development of different types of cancers as well as the risk of immunotoxic, neurotoxic and adverse reproductive effects. They also cause an increased incidence of psychiatric and dermatologic conditions (Alavanja *et al*., 2004; Sanborn *et al*., 2004). Due to the detrimental effects of synthetic pesticides, they are seriously discouraged from being used for the control of storage insect pests and this necessitates the search for alternative sources for the containment of storage insect pests. Several plant extracts, volatile oils and compounds have been reported as effective biopesticides against many stored product pests (Aikpokpodion *et al*., 2013; Asogwa *et* al., 2015; Adewole and Alabi, 2017; Noudegbessi *et al*., 2021).

Investigations on the efficacies of insecticidal plants for control of weevils on storage kola nut in Nigeria, has received much attention. The different results obtained from the studies indicate that there is a potential to be valued after several years of research from the various botanicals. To achieve this, an analytical synthesis of the results and a reframing of the researches are needed to optimize the practical use of plants that have already proved their effectiveness. Therefore, this review on the potential of the plants species for the control of *B. kolae* summarizes the researches undertaken since early 2000 till 2020.

PLANT SPECIES WITH INSECTICIDAL POTENTIAL TO CONTROL *B. KOLAE*

The use of plant material for the preservation of storage products is considered as a promising alternative to synthetic insecticides (Akunne *et al*., 2018). In Nigeria, several studies have been carried out on the effects of plants with insecticidal potential to control *Balanogastris kolae* infestation (Table 1). Extensive studies were conducted on some plant species from different families through bioassays and storage trials on *B. kolae*. Plants with biopesticides ability were found in 18 plant families. The plants with pesticidal properties were distributed among the following growth habits; tree (*Senna alata, Cedrela odorata, Alstonia boonei, Azadiracta indica, Hura crepitans*), shrubs (*Jatropha curcas*, *Vernonia amygdalina*) and herbs (*Hyptis sauveolens, Musa paradisiaca*). All categories of plants produce secondary plant metabolites that play important roles in the ecosystem and one of such is pesticidal attributes.

POTENTIAL OF BOTANICALS TO CONTROL *B. KOLAE*

The insecticidal ability of the plants tested against *B. kolae* can be divided into bioassays and storage trials. In all the studies conducted, crude extracts (aqueous and ethanolic extracts) and powdered plant materials were used. They were found to be effective against *Balanogastris kolae*, though they were all dose dependent. However, Azeez 2015 reported that ethanolic plant extracts of *Lycopersicon esculentum, Hyptis suaveolens, Cymbopogon citratus, Loranthus braunii, Alstonia boonei and Sarcocephalus latifolius* caused 100% mortality of the weevils within 20 minutes of exposure whereas the aqueous extracts achieved 10% or none for the same period. Similar trend was observed by Ugwu *et al*., 2019 in which at 100% concentrations of *Azadiracta indica*, *Piper guineense* and *Afframomum melegueta*, caused 100% mortality of the adult *Balanogastris kolae*.

Table 1. Plants materials used experimentally for the control of *Balanogastris kolae* from early 2000 to 2020 in Nigeria

Plant species tested	Family name	Common name	Parts used	Mode of action	Reference
Senna alata	Fabaceae	Candle stick	Leaf	Stomach Poisoning	Ifebueme *et al.*,2020
Hura crepitans	Euphorbiaceae	Sand box tree	Leaf	Stomach Poisoning	Ifebueme *et al.*,2020
Calophyllum inophyllum	Calophyllaceae	Alexandra laurel tree	Leaf	Stomach Poisoning	Ifebueme et al.,2020
Nicotiana tabacum	*Solanaceae*	Tobacco	Leaf	Stomach Poisoning	Asogwa et al., 2015
Vernonia amygdalina	*Asteraceae*	Bitter leaf	Leaf	Stomach Poisoning	Asogwa et al., 2015
Eucalyptus camaldulensis	Myrtaceae	Red river gum	Leaf	Stomach Poisoning	Asogwa et al., 2015
Hyptis sauvolens	Lamiaceae	Pignut	Leaf	Stomach Poisoning / Contact toxicity	Asogwa et al., 2015 and Azeez 2015
Musa paradisiaca .	Musaceae	Banana	Stem	Stomach Poisoning	Asogwa et al., 2015
Cymbopogon citratus	Poaceae	Lemon grass	Leaf	Stomach Poisoning / Contact toxicity	Asogwa et al., 2015 and Azeez 2015
Lantana camara	Verbanaceae		Leaf	Stomach Poisoning	Asogwa et al., 2015
Tetrapleura tetraptera	*Mimosaceae*	Aidan	Fruit	Contact toxicity	Anikwe et al 2005
Azadirachta indica	*Meliaceae*	Neem	stem bark	Stomach Poisoning	Asogwa et al., 2009 and Ugwu et al., 2019
Cedrela odorata	*Meliaceae*	Spanish cedar	stem bark	Stomach Poisoning	Asogwa et al., 2009
Chrysophyllum albidum	*Sapotaceae*	White star apple	stem bark	Stomach Poisoning	Asogwa et al., 2009
Khaya senegalensis	*Meliaceae*	African mahogany	stem bark	Stomach Poisoning	Asogwa et al., 2009
Chromolaena odorata	*Asteraceae*	Siam weed	Leaf	Stomach Poisoning	Asogwa et al., 2009
Lycopersicon esculentum or *Lycopersicon solanum*	*Solanaceae*	Tomato	Leaf	Contact toxicity	Azeez 2015
Loranthus braunii	*Loranthaceae*	Mistletoes	Leaf	Contact toxicity	Azeez 2015

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Alstonia boonei	*Apocynaceae*	Stool wood	Leaf	Contact toxicity	Azeez 2015
Sarcocephalus latifolius	*Rubiaceae*	*African peach*	Leaf and bark	Contact toxicity	Azeez 2015
Derris elliptica	*Fabaceae*	Poison vine	Root	Contact toxicity	Akunne et al., 2018
Jatropha curcas	*Euphorbiaceae*	Barbados nut	Seed	Contact Toxicity/stomach poisoning	Ugwu et al., 2019
Piper guineense	*Piperaceae*	Black pepper	Seed	Contact Toxicity/stomach poisoning	Ugwu et al., 2019
Afframomum melegueta.	*Zingiberaceae*	Alligator pepper	Seed	Contact Toxicity/stomach poisoning	Ugwu et al., 2019

The powdered root and fruit of *Derris elliptica* and *Tetrapleural tetraptera*, respectively were investigated on the adult mortality of the kola nut weevil. It was discovered that at higher doses, the two plant samples were efficacious against *Balanogastris kolae* (Akunne *et al*., 2018 and Anikwe *et al*., 2005). Ethanolic plant extracts of *Senna alata*, *Hura crepitans* and *Calophyllum inophyllum* at various concentrations recorded a significantly lower adult emergence from week five to nine after treatment applications compared with the untreated, although storage of kola nut with 1.5 g of *C. iInophyllum* was found to be more potent.

Moreover, from storage trial experiments carried out by Asogwa *et al*., 2009 and Asogwa *et al*., 2015 in which ethanolic and aqueous plant samples of *Azadirachta indica* (stem bark), *Cedrela odorata* (stem bark), *Chrysophyllum albidum* (stem bark), *Khaya* spp. (stem bark), *Chromolaena odorata* (leaf) and leaf samples of Nicotiana tabacum L., *Vernonia amygdalina* Delile, *Eucalyptus camaldulensis* Dehnh, *Hyptis sauvolens* Poit, *Cymbopogon citratus* Stapf, *Lantana camara* L. and the base trunk of *Musa paradisiaca* L. ,respectively were evaluated against kola nut weevil. The emergence of adult *B. kolae* decreased with increasing concentrations of the various extracts.

CORRELATION BETWEEN INSECTICIDAL PROPERTIES OF BOTANICALS AND THEIR PHYTOCONSTITUENTS

Secondary metabolites are synthesized by plants and they function as defense mechanisms against damage cause by herbivores (Ifebueme *et al*., 2020). These synthesized secondary metabolites influence the behavior of growth or survival of these herbivores (Duke *et al*. 2010). From Table 2 below, all the plants used have the major phytochemicals such as saponins, flavonoids, tannins, alkaloids, phenols, and cardiac glycoside. These are known to have activity against pathogens and therefore aid the insecticidal activities of botanicals (Ghosh *et al*., 2010). Saponins generally have a wide range of biological activities which may have roles in plant defense. This is usually attributed to the fact that most of them consist of a hydrophobic triterpene or sterol backbone and a hydrophilic carbohydrate chain (amphipathicity), thus permeating plasma membrane where they form complex with sterols and cause the formation of pores in order to exert their cytotoxic effect (Armah *et al*. 1999 and Mugford *et al*., 2013). Also, flavonoids are very important in plant resistance to pathogens as its compounds are transported to the site of infection and triggers hypersensitivity reaction, which consequently causes cell damage or death (Mierziak *et al*., 2014). Flavonoids can also prevent insects from laying eggs (War *et al*., 2012).

Table 2. Phytochemical constituents of plant materials used experimentally for the control of B kolae from 2000 to 2020 in Nigeria

Plant species	Flavonoids	Tannins	Alkaloids	Saponins	Phenols	Glycosides	References
Senna alata	+	+	+	+	+	+	Abubakar et al,, 2015
Hura crepitans	+	+	+	_	+	_	Oloyede et al., 2016
Calophyllum inophyllum		+	+	+	+	+	Indrakamar et al,. 2012
Nicotiana tabacum	+	+	+	+	+	NF	Oyekunle et al., 2019
Vernonia amygdalina	+	+	+	+	+	_	Teye et al., 2019
Eucalyptus camaldulensis	_	+	_	+	NF	+	Sanni et al., 2014
Hyptis sauvolens		+	+	+	NF	+	Rajarajan 2014
Musa paradisiaca	+	+	+	+	+	+	Onyenekwe et al.,2013
Cymbopogon citratus	+	+	_	+	+	NF	Unuigbe et al., 2019
Lantana camara	+	+	+	+	NF	+	Leena et al.,2015
Tetrapleura tetraptera	+		+	+	+	+	Ebana et al., 2020
Azadirachta indica	+	_	_	+	NF	_	Mariana et al., 2017
Cedrela odorata	+	+	_	_	NF	+	Khaled 2014
Chrysophyllum albidum	+	+	+	+	NF	+	Ademoye et al., 2018
Khaya spp.	+	+	+	+	NF	_	Aguoru et al., 2017
Chromolaena odorata	+	+	+	+	NF	_	Usunomena et al.,2016
Lycopersicon esculentum	+	+	+	+	NF	+	Umar *et al.*, 2016
Afframomum melegueta	+	+	+	+	+	+	Doherty *et al.*, 2010
Alstonia boonei	_		+	+	NF	_	Ajose *et al.*,2019
Sarcocephalus latifolius	+	+	_	_	NF	+	Ndukwe *et al.*,2017
Derris elliptica	+	+	_	+	NF	NF	Saifillah *et al.*,2011
Jatropha curcas	+	+	+	+	_	+	Ebuehi *et al.*, 2009

Key: + (present); - (absent); NF (not found)

CONCLUSION AND RECOMMENDATION

Kola nut is a major cash crop grown in Nigeria for its economic, social and traditional uses. It is very important to preserve these nuts from *Balanogastris kolae* infestation preferably by using any of the botanicals listed in this review since they showed insecticidal potentials against the insect. Further works have to be done to identify and characterize the active ingredients present in these botanicals.

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POPULATION TREND OF *BALANOGASTRIS KOLAE* IN KOLANUT TREATED WITH TWO BOTANICAL POWDER EXTRACTS

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ABSTRACT

The study was conducted at the Entomology Laboratory of CRIN to evaluate the population trend of Balanogastris kolae in kolanut treated with powders extracts of Rice Husk and Melon Shell (RHP and MSP), under tropical ambient conditions. The test insect was reared in basket lined with black polyethene sheet on kolanut obtained from local market. RHP and MSP at four levels of 4,8,12 and 16g/kg were applied on healthy kolanut in basket lined with black polyethene sheet. Five pairs ((♀&♂) of B. kolae were introduced to each treatment. An untreated control and standard control treated with 8g of Phostoxin/kg of healthy kolanut was set up. Population trend of emerging weevil was monitored by taking live and dead counts on weekly basis for a period of 4 months. The experiment was arranged in a Completely Randomized Design in three replicates. The RHP treatment recorded significant mortality of 33.33% of B. kolae at high levels of application (16g/kg of kolant), 48 hours after application. Both treatment reduced F_1 progeny population of B. kolae as against the untreated control. Treated kolanut showed considerably low percentage weight loss unlike the untreatment control. Percentage weight loss due to insect infestation and weight loss due to mould growth as secondary infection were positively correlated and both negatively correlated to adult mortality rate. As an alternative for food safety, from this study, the results obtained indicated that higher dosage of RHP and MSP can be used to reduce weevil infestation in kolanut.

Key words: *Balanogastris kolae,* Rice Husk Powder, Melon Shell Powder, population, kolanut

INTRODUCTION

Cola is a tropical plant belonging to the genus of the family Malvaceae and Subfamily Sterculioideae. It is indigenous to Tropical Africa with great diversity in West Africa (Opeke, 1982; 1992; 2005) of which two species *Cola nitida* and *Cola acuminata* are of economic importance. West African countries like Nigeria, Ghana, and Ivory Coast are major producers of kolanuts with Nigeria accounting for about 70% of the total world production of kola nuts (Oluokun and Oladokun, 1999). About 90% of the kola nuts produced in Nigeria is locally consumed and the remaining 10% exported to other parts of Africa especially neighboring countries in West Africa (Oluokun and Oladokun, 1999; Okunade, 2003). The *C. nitida* and *C. acuminata* commonly referred to as kolanuts are consumed raw as masticatory because of their stimulating effects. Their nuts are important raw materials in the pharmaceutical and confectionery industry where the essential oils such as theobromine, caffeine and kolatine are used (Ogutuga, 1975, Akinbode, 1982). It is also a source of colorants for dyeing in textiles and threads due to the presence of tannin. Kola nut plays significant role in the tradition and spiritual practice of many West African ethnic groups (Esther *et al*., 2010).

With the high values attached to kolanut and high demand in Africa, its production keeps declining due to a number of factors amongst which are the insect pests' infestations from field to store. The attack of weevils of different species in kolanut production which is usually from field-to-store is a notable challenge. *Balanogastris kolae* and *Sophrorhinus spp.* are predominant damaging insect pests of economic importance which often result to about 100% loss without proper control in kolanut storage (Asogwa *et al*.., 2008). Weevil infestation also predisposes the nuts to fungal attack thus reducing the market value and causing subsequent destruction of the nuts. The major problem reported in kola nut trading business was mainly insect attack, causing up to 53.33% damage (Esther *et al*.., 2010).

However, kolanuts are usually consumed raw, thus the choice of weevil control is of great concern. Kolanut is often stored for as long as a year or two by traders that prefers the choice of synthetic pesticides to reduce weevil damage and reduce economic losses. Olorunmota *et al.,* (2021), in a survey of methods of kolanut preservation in 3 Southwestern States of Nigeria reported that only 2.5% of respondents in each state adopted the use of botanicals while over 90% used insecticides, which have the potentials to leave residues in the nuts. Several authors have reported the presence of pesticide residues in various foods, vegetables, soils, sediments and diverse environment. Unlike some produce that pass through primary processing before consumption kolanut does not, there is need therefore to source for safer alternatives with minimal or no human and environmental health hazards.

Many authors have reported the efficacy of plant materials in controlling store product insect pests. These include but not limited to the powders, essential oils and aqueous extracts of *Azadiracta indica, Curcuma longa, Tetrapleura tetreptera, Cassia nigricans* and *Capsicum spp*. *Piper ginnensis*and *Nicotiana spp* have been shown to be effective against bruchids, curulionids and the *Tribolium castaneum.* Seeds of *Azadiracta indica* and *Dennettia tripala* and the fruits of *Piper guinenses* have pesticidal and behaviour modifying properties against various pests of stored products (Agbakwuru *et al.,* 1978; Ivbijaro and Agbaje 1986; Lale, 1992).

MATERIALS AND METHODS

This study was conducted in the Entomology Laboratory of the Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria located at an approximate geographical coordinate of 07°10'N, 03° 52'E, 122 m ASL and the Tropical Ambient Laboratory conditions during the period of study were 28 ± 4°C temperatures and 68 ± 10% relative humidity.

Source of kolanut Used for the Experiment

Freshly harvested "unskinned" kolanuts (*Cola nitida*) were bought from local markets in Ogun state of Nigeria. The purchased nuts were kept in woven basket for a period of five days during which, they were sprinkled with water and turned to facilitate decay and easy removal of the testa. After the removal of the testa, the nuts were rinsed in clean water, drained and spread on the laboratory table to gradually drain out the water absorbed during the curing process. The nuts were sorted into healthy and infested nuts. All nuts with entry and or exit holes, feeding points and any developmental stage of insects were removed while the remaining nut were further cured in baskets lined with banana leaves and covered with same for 3 days to achieve sweating of the nuts and reduce the water content of the nuts. The nuts were removed and sorted again and the banana leaves were changed for curing the nuts for another 3days. On the third day, the kolanuts were checked and all damaged nuts were removed while the remaining healthy nuts were used for the experiment.

Culturing of Insect

The kola weevil, *Balanogastris kolae* used for the experiment was obtained from already infested nuts purchased from the market. The nuts were kept in a polyethene bag and checked at three days' intervals to collect new emergent. Also, the nuts with entry/exit holes oviposition holes and feeding points which were sorted out during the curing process were kept in another basket lined with black polyethene sheet and checked weekly for weevil emergent. The cultures were maintained in the laboratory and the daily emerging adult weevils were used for the bio-assay.

Collection and Preparation of the Powders

Rice husks and melon shell used for the experiment were obtained from Bodija Local Market in Ibadan. Each material was air-dried and blended into fine powder, allowed to cool and stored in an air-tight container. The conventional Aluminium phosphide tablet, used by kolanut traders was purchased from an agrochemical store to set up a standard control.

Experimental Design

The experiment was laid out in a Completely Randomized Design (CRD) and each treatment
was applied at four levels of: 4.0, 8.0, 12.0 and 16.0 g per kg of healthy kolanut in a black polyethene sheet kept in a woven basket. A standard control with 0.8g of Aluminium phosphide per kilogram of kolanut and no-treatment control were set up. The treatments and the two controls were replicated thrice. Each powdered material was well mixed with the kolanut for even distribution. Five pairs (♀&♂) of new emergent of *Balanogastris kolae* from the cultures in the laboratory were introduced into each 0.5kg kolanut in a nylon kept in woven basket. Adult mortality of the weevils was counted and represented in percentages, at 48hrs after weevil introduction while the remaining weevils were removed. The nuts were checked on weekly basis for adult emergence and the live and dead counts of the emerged weevils were recorded for a period of four months. The powdered material was removed as soon as it was seen to have absorbed moisture from the nuts and the nuts exposed for few hours to dry before being tied again. At the end of the experiment, kolanuts with mould growth were removed and weighed and the kolanut without entry/exit hole and mould growth were considered as healthy nuts and were also weighed. Weight loss

was computed by deducting the final weight from the initial weight of 500g.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS version 9.1 software package and Duncan's Multiple Range Test (DMRT) was used to separate the means at 5% probability level.

Percentage Mortality and percentage weight loss were calculated as follows:

$$\text{Percentage Mortality} = \frac{\text{No. of dead weevil}}{\text{No. of weevils introduced}} \times 100(\%)$$

$$\text{Percentage Weight loss} = \frac{(W_1 - W_2)}{(W_2)} \times 100(\%);$$ where W_1 is initial weight and W_2, the final weight

RESULTS

Mortality of the introduced weevil in the experiment as seen in Table 1 showed significantly low (P ≤ .05) toxicity on *B. kolae* in both treatment and the control, unlike the standard control. The powders had significantly low toxicity when compared with the conventional Phostoxin used by kolanut traders. The MSP treatment at all levels of application recorded zero mortality just as the no treatment control, while the RHP treatments though at 4.0 and 8.0 level of application recorded zero kill also, but at 12.0 and 16.0 recorded 3.33 and 13.33 kill of the insect. The standard control of Phostoxin recorded significantly higher (P ≤ .05) mortality (90.00) of *B. kolae*.

Table 1. Percentage mortality of *B. kolae* in the powders

Conc.(gkg^{-1})	Adult mortality	
	RHP	MSP
0	0.00c	0.00c
4.0	0.00c	0.00c
8.0	0.00c	0.00c
12.0	3.33c	0.00c
16.0	13.33b	0.00c
Standard	90.00a	90.00a

Means with the same subscripts are not significantly different at (P ≤ .05) using DMRT, RHP- Rice Husk Powder, MSP- Melon Shell Powder

Table 2 shows the population growth of *B. kolae* in the treatments. *B. kolae* in the standard control had significantly low (P ≤ .05) population growth when compared with the treatments. From the total adult emergent the no-treatment control recorded significantly higher value of 46.33 as against the treatments at all levels of application. RHP and MSP treatment at lower application rate of 4.0g/kg recorded 32.67 and 25.99 and at highest application rate of 16.0g/kg recorded 15.66 and 17.66 respectively However, the standard control treatment had significantly (P ≤ .05) low population growth of 0.66 compared to the treatments.

Table 2. Population growth of *B. kolae* in the powders

Conc(gkg$^{-1)}$	Dead		Live		Total Emergent	
	RHP	MSP	RHP	MSP	RHP	MSP
0	0.00f	0.00f	46.33a	46.33a	46.33a	46.33a
4.0	13.00a	9.00bc	19.67bc	16.00bcd	32.67b	25.99cd
8.0	11.00ab	11.00ab	21.33b	15.66cd	32.33b	26.99c
12.0	4.33e	8.67bc	14.66cd	13.33d	18.99e	22.00d
16.0	2.33de	6.00dc	13.33d	11.67d	15.66fg	17.66ef
Standard	0.33f	0.33f	0.33e	0.33e	0.66h	0.66h

Means with the same subscripts are not significantly different at (P ≤ .05) using DMRT
RHP- Rice husk powder, MSP- Melon shell powder

Mean dead count of adult *B. kolae* in both powders is significantly different (P ≤ .05) from the no - treatment control and the standard control which recorded 0.00 and 0.33 respectively. At lower application rate of 4.0g/kg mean dead count in RHP and MSP treatments were 13.00 and 9.00 while at the higher rate of 16.0g/kg they recorded 2.33 and 6.0 respectively. The weight of mouldy nuts was significantly higher in the no- treatment control than the treatments (Table 3). Mouldy nuts accounted for 116.67g in the no treatment control while the MSP treatment recorded 36.67g at a lower application rate of 4.0g/kg to as low as 16.67g in the high application rates of 8.0 12.0 and 16.0g/kg that is not significantly different from the standard control. The RHP treatment also recorded significantly low weight of mouldy nuts at all levels of application as against the no treatment control.

Percentage weight loss in the treatments at all levels differs significantly from untreated control. While the untreated control lost up to 59.33% weight, the MSP treated kolanut lost between 17.33 to 28.67% and RHP treated kolanut lost between 22.13 to 42.67%.

Table 3: **Mean Percentage weight loss in treated kolanut**

Conc (gkg$^{-1)}$	**Weight of Mouldy nuts**		**% Weight loss**	
	RHP	MSP	RHP	MSP
0	116.67a	116.67a	59.33a	59.33a
4.0	58.33b	36.67b	42.67b	28.67bcd
8.0	11.33b	16.67b	22.13d	38.00bc
12.0	12.67b	16.67b	22.60cd	20.67d
16.0	54.67b	16.67b	30.67bcd	17.33d
Standard	13.33b	13.33b	16.00d	16.00d

Percentage adult mortality was negatively correlated to weight of mouldy nuts and percentage weight loss. There was however a positive correlation between weight of mouldy nuts and percentage weight loss in treated kolanut (Table 4).

Table 4. Correlation between Adult Mortality, Mould weight and Weight loss

	% Mortality	Mould weight	Weight loss
% Mortality	1.00	- 0.15	- 0.30
		0.42	0.11
Mould weight	- 0.15	1.00	0.80
	0.42		< 0.0001
Weight loss	- 0.30	0.80	1.00
	0.11	< 0.0001	

DISCUSSION AND CONCLUSION

There was a relatively high percentage mortality recorded in the RHP treatments especially when compared with the no treatment control. This high mortality occurred at high level of application. It indicated that higher dosage is needed to achieve appreciable kill of the weevils. High level of efficacy at high level had been reported by many authors. Efficacy of powdered plant materials like *Eugenia aromatica, Aframomummelegueta*, wood ash against *Sitophilus zeamais*, *Rhizoperta dominica* and *Calosobruchus maculatus* at high concentrations were reported by different authors (Lajide *et al*., 1998: Olorunmota *et al*., 2021). In the present study the two powders induced significantly low F_1adult emergence of B. kolae in contrast to the no treatment control. The reduction in F_1 progeny emergence in the kolanut treated with RHP and MSP might be resulted from increased ovicidal and larvicidal properties of powders which agrees with the findings that leaf bark, seed powders, oil extracts of plants reduced oviposition rate and suppress progeny production in stored grains (Shaaya et al., 1997; Tunc *et al.,* 2000; Tapondjou *et al*.,2002). Ofuya (1990) and Tapondjou *et al*. (2002) have suggested that oviposition inhibition property of botanical powders on adult *C. maculatus* by weakening of adults in grains treated with plant powder made them laid fewer eggs and killed the larvae that hatched from eggs laid on grains. These two powders may hinder the movement of male weevil to locate the female weevil and cause reduced ovipostion. Blockage of the spiracles of the weevils by the powders may occur which will impair spiracle respiration and the subsequent death of the weevil (Law-Ogbomo and Enobakhare, 2007; Mulungu *et al*., 2007).

This oviposition inhibition effect on Sitophilus zeamais in maize grain treated with RHP and MSP was also reported by Olorunmota *et al.,* (2021), however, the ash of these two powders were said to be highly effective in inhibiting oviposition by the weevil.

The significantly low weight loss as a result of weevil infestation and mould growth on the treated kolanuts as contrast to the no-treatment control demonstrated that the powders at higher dose could serve as a cheap and safe alternative to the use of insecticides in kolanut storage. There is need for future research on the use of ash from these two waste farm products in controlling *Balanogastris kolae* in kolanut storage.

The fact that the powders killed relatively low weevil in contrast to phostoxin, which is synthetic does not negate the assertion that there should be check in its usage especially in kolanut which does not undergo any primary processing before consumption. The low adult emergence and reduced weight percentage weight loss, recorded in the powders as against the no treatment control is an encouragement for the production of organic kolanut, perhaps at increased rate of application and /or trials on some other bioactive plants materials that have volatile compounds with pungent smell that can serve as fumigants like Phoxtoxin.

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ENTOMO-LETHAL EFFECTS OF FISH BEAN PLANT, *TEPHROSIA VOGELII* EXTRACT AND APPLICATION FREQUENCY ON THE FIELD CONTROL OF EGGPLANT FRUIT AND SHOOT BORER (EFSB), *LEUCINIDES ORBONALIS* GUEN. (LEPIDOPTERA: PYRALIDAE) INFESTING *SOLANUM GILO* IN OKIGWE, NIGERIA

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ABSTRACT

Entomo-lethal effects of Fish Bean Plant, Tephrosia vogelii extracts were tested on the population of Eggplant Fruit and Shoot Borer (EFSB) infesting eggplant var. Solanum gilo in the field. The trial was conducted 2018 cropping seasons. The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications. Six treatment levels of 9% v/v (T_9), 18% v/v (T_{18}), 27% v/v (T_{27}) of ethanol extracts of T. vogelii and 10% w/v (T_{10}), 15% w/v (T_{15}) and 20% w/v (T_{20}) of T. vogelii aqueous extracts, Cypermethrin and control were applied as treatments. Data were taken on percent shoot and fruit infestations, numbers of adult moth and larvae of L. orbonalis. Statistical analysis was by means of Analysis of variance using GenStat Software Programme 2010. Results of analyzed data showed that treatments were significantly ($P<0.05$) effective in controlling the infestation of EFSB on S. gilo when compared with the control. The treatments also varied significantly in their efficacy against the population of L. orbonalis adult moth and larvae at $P=0.05$. Amongst the T. vogelii extracts tested, T_{27} had the lowest percent fruit infestation (4.17%). Numbers of adult moth and larvae of L. orbonalis were also significantly reduced in all the treated plants compared to the control.

Key words: *Leucinodes orbonalis,* Eggplant, Damage, Infestation, *Tephrosia vogelii*

INTRODUCTION

There are many species of Eggplant; over 1000 species are well known and documented (Grubben and Denton, 2004). Eggplants are scientifically referred to as *Solanum Species* and they belong to the family, *Solanaceae* (Agoreyo *et al.,* 2012). They are grown all over the world. They are cultivated for food and medicine, and 25 species have been known to be most popular and domesticated in Nigeria (Bonsu *et al.,* 2002).

Eggplants has appreciable quantities of some phytochemical compounds especially saponins, phenols, flavonoids, tannins among others. They also serve as supplementary source of nutritional and medicinal requirements in our daily diets, especially in southeastern Nigeria. Consumption of Eggplant fruits are helpful in the prevention and treatment of several folklore ailments., it lowers the level of blood cholesterol, it plays effective role in blood pressure regulation, aids in weight reduction and it possess anti-haemorrhoidal and anti-glaucoma effects, the use of the roots and fruits as carminative and sedatives, and to treat coelic problems, leaf juice as a sedative to treat uterine complaints, an alcoholic extract of leaves as a sedative, anti-emetic and to treat tetanus after abortion (Ibiam, and Nwigwe, 2013; Doganlar *et al.,* 2002).

The economic importance of eggplants can never be overemphasized. Most rural and semi-urban farmers are dependent on the production of the fruits as means of livelihood and survival, economic empowerment and emancipation. In southeastern Nigeria, there is a daily demand for the fresh leaves and fruits of eggplants as most staple local delicacies are cooked with them. It is a fruit or vegetable crop of significant importance to the culture and tradition of the locals.

One of the greatest challenges facing the cultivation of eggplant is pest insects. Eggplant Fruit and Shoot Borer, *L. orbonalis* has been reported as the most significant and economic pest insect infesting the fruits and shoots of this crop (Uwalaka *et al,* 2018). The nature of damage of *L. orbonalis* is such that it renders the fruits unwholesome, reduces the nutritional qualities and shelf life, and exposes the shoots and fruits to secondary pests (Emeasor and Uwalaka, 2018). The time of infestation by *L. orbonalis* and timely application of effective control measures is very important in effective control of *L. orbonalis.*

This scientific study was focused on the evaluation and determination of most efficacious rate of application of aqueous and ethanol extracts of Fish Bean plant, and application frequency.

MATERIALS AND METHODS

The seeds of *S. gilo* were sourced from National Horticultural Research Institute (NIHORT) Mbato Outstation Okigwe, Imo State. Seedlings of *S. gilo* were nursed and transplanted to the experimental units at 6 weeks old. Fresh leaves of fish bean plant; *T. vogelii* leaves were harvested and dried at room temperature (20°C - 25°C) for 14 days, then ground to fine powder with a motorized blender. Aqueous extract of *T. vogelii* was formulated by mixing the powdered plant material with distilled water following the methods of Inades, (1996) and Sihwinarni, (1999). Three levels of the aqueous extract: 10% w/v, 15% w/v, and 20% w/v were made. Ethanol extract of *T. vogelii* was formulated by mixing 25 kg of ground freshly harvested leaves with 20 L of ethanol and 1 cup of detergent (Karlsson, 1995). Dilution was made to obtain; 9% v/v, 18% v/v and 27% v/v. Cypermethrin (10 E.C) was applied at manufacturer's recommended rate (Hamman *et al.,* 2012) and Control (no treatment application). Three application frequencies were adopted in this study; spraying once a week (1WK), once in two weeks (2WK) and once in three weeks (3WK).

The experimental design was 8 x 3 factorial experiments with 8 levels of botanical treatment and 3 levels of application frequency laid out in Randomized Complete Block Design (RCBD) with 3 replications. The plot size measured 2.25 m x 2.25 m and plant spacing was 0.75 m x 0.75 m which gave 16 stands of plant per plot. Data were taken on percent shoot and fruit infestations, numbers of adult moth and larvae of *L. orbonalis.* Statistical analysis was by means of Analysis of variance using GenStat Software Programme 2010.

RESULTS AND DISCUSSION

Figure 1 shows that treatments were effective in controlling the infestation of EFSB on *S. gilo* though significant variation ($P \leq 0.05$) existed amongst the treatments. The lowest percent fruit infestation, 2.04% was observed on plots treated with Cypermethrin (CYP) while the highest, 77.04% was observed at the control plot (C). However, CYP differed significantly ($P \leq 0.05$) from the other treatments in reducing fruit infestation of EFSB except 27% v/v *T. vogelii* ethanol extract (T_{27}) at which percent fruit infestation of 4.17% was observed. The percent mean infestation observed at the control treatment differed significantly from the other treatments ($P<0.05$). This finding corroborate the earlier report of Onekutu, (2011) that *L. orbonalis* infestation caused between 75%-90% yield reduction.

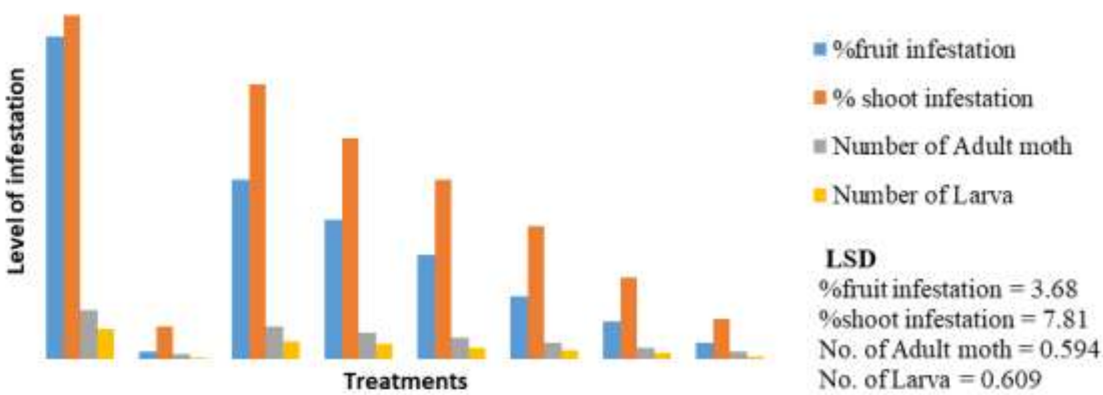

Fig. 1: Effects of treatments on the infestation of EFSB on *S. gilo*

The CYP also had the lowest percent shoot infestation of 7.87%, though it varied significantly from the other treatments but had statistical similarity with T_{27} which recorded percent shoot infestation of 9.74% (Figure 1). The highest percent shoot infestation of 82.14% was recorded at the control plot, and this differed significantly from the other treatments. The highest number of adult moth of *L. orbonalis* (11.761) was observed at the control plot, and this varied significantly from the

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other treatments. The lowest number of the adult moth (1.376) was recorded at the CYP which varied significantly from the other treatments except T_{27} (1.852). The number of larva (7.192) was also highest at the control plot which was not statistically similar (P>0.05) with the treatments. The CYP also had a record of the lowest number of larva (0.462) which was statistically similar to the mean value of 0.824 recorded at T_{27}. Uwalaka *et al.* (2018) in their screening of five varieties of eggplant for susceptibility to *L. orbonalis* infestation had reported mean numbers of adult moth and larva of between 0.79-16.15 and 2.06-41.98 respectively, this result confirms that population of *L. orbonalis* thrives on *S. gilo* without control measures.

Table 1 shows the effects of treatments on the level of damage caused by EFSB on *S. gilo*. The treatments were effective in controlling the damage resulting from EFSB infestation. However, there was significant variation (P≤0.05) among the treatments in reducing the damage caused by EFSB. The highest percent reduction in number of holes per fruit, 94.57% was observed at CYP followed by T_{27} (86.34%) while at the control plot, there was 0 % reduction in the number of holes per fruit. However, the CYP differed significantly from the other treatments in reducing the number of holes per fruit. At the second planting season, the highest percent reduction in number of holes per fruit (92.67%) was also observed at the CYP which differed significantly from the other treatments.

Table 1. Effects of treatments on damage caused by EFSB on *S. gilo*

Treatments	Number of holes /fruit /plant	% Reduction in number of holes / fruit	Number of holes / shoot / plant	% Reduction in number of holes / shoot	Number of damaged fruits / plant	% Reduction in fruit damage
C	5.467	0.00	5.560	0.00	76.29	0.00
CYP	0.308	94.57	0.583	87.69	3.87	93.93
T_{10}	2.161	61.85	1.667	57.91	31.04	53.06
T_{15}	2.011	63.90	1.444	65.01	28.98	56.34
T_{20}	1.901	64.98	1.439	65.18	24.64	65.55
T_9	1.684	69.05	1.494	71.15	18.91	73.68
T_{18}	1.386	74.93	0.778	80.13	11.82	83.23
T_{27}	0.798	86.34	0.500	90.47	7.09	88.89
LSD	0.509	3.78	0.422	8.03	6.67	6.93

The percent reduction in the number of holes per shoot was highest, 90.47% at T_{27} which was not significantly different from the CYP (87.69%) but varied significantly from the other treatments (Table 1). The control plot however had a 0% reduction in the number of holes per fruit while among the levels of plant extract, T_{10} had the lowest percent reduction in the number of holes per shoot (57.91%). The highest percent reduction in fruit damage (93.93%) at the first planting season was recorded at CYP which differed significantly from the other treatments except T_{27} (88.89%). The control plot had 0% reduction in fruit damage while among the levels of plant extract, T_{10} had the lowest percent reduction in fruit damage (53.06%), and this varied significantly from the observations made on the other levels of plant extract.

The highest number of holes per fruit per plant (5.467) was obtained at the control plot, and this varied significantly from the treatments. However, the lowest number of holes per fruit per plant (0.308) was observed at CYP but this was statistically similar to T_{27} (0.798). In comparing the various levels of the plant extract, T_{27} was most effective against EFSB in reducing the number of holes per fruit per plant, while the T_{10} which recorded the highest number of holes per fruit per plant (2.161) among the levels of plant extract showed the least effect in controlling EFSB against boring holes in the fruit of eggplant. However, the effect produced by T_{10} in reducing the number of holes per fruit per plant was statistically similar to those of T_{15} (2.011), T20 (1.901) and T_{25} (1.684).

The highest number of damage fruits per plant (76.29) was observed at the control plot while the lowest (3.87) was observed at CYP. The control treatment differed significantly from the other treatments in the number of damaged fruits per plant while CPY also varied significantly from the other treatments except T_{27} (7.09). Among the levels of plant extracts, T_{10} had the highest number of damaged fruits per plant (31.04), and this differed significantly from the other levels while T_{27} had the lowest number of damaged fruits per plant (7.09) which was not statistically different from T_{18} (11.82). The highest number of infested shoot (7.71) was

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recorded at the control treatment which varied significantly from the other treatments. The CYP had the lowest number of infested shoots (0.96), and was statistically similar to T_{27} (1.18) but varied significantly from the other treatments. However, among the levels of the plant extracts in the first planting season, T_{10} had the highest record of the number of infested shoots (6.60) which varied significantly from the other levels of plant extracts.

Table 2 shows the effects of application frequency on the level of damage caused by EFSB on *S. gilo*. Results showed that the levels of the application frequency varied significantly ($P \leq 0.05$) in the percent reduction in the number of holes per fruit. The highest percent reduction in the number of holes per fruit of 66.84% was observed at 1 WK which varied significantly from the other levels of application frequency, while the lowest percent reduction in the number of holes per fruit (62.02%) was recorded at 3 WK, and it varied significantly from the other levels of application frequency (Table 2).. There was no significant difference ($P \leq 0.05$) among the levels of the application frequency in the percent reduction in number of holes per shoot. However, the highest percent reduction in the number of holes per shoot (67.41%) was obtained at 2WK application frequency while the lowest (63.81%) was obtained at 3WK. The levels of application frequency were also not significantly different in the percent reduction in fruit damage though the highest (66.03%) and lowest (62.14%) percent reduction in fruit damage were observed at the 1WK and 3WK levels of application frequency, respectively (Table 2). The highest (2.015) and lowest (1.909) number of holes per fruit per plant were obtained at the 2WK and 1WK levels of application frequency, respectively though these were not significantly different from the 3WK application frequency.

Table 2. Effects of application frequency on the level of damages caused by EFSB on gilo in the two planting seasons

	% Reduction in damage due to *L. orbonalis* infestation on *S. gilo*					
Application frequency	%Reduction in no. of holes/fruit	%Reduction in no. of holes/shoot	%Reduction in fruit damage	Number of holes/ fruit/ plant	Number of damaged fruits/plant	Number of holes/ shoot/plant
1WK	66.84	63.8	66.03	1.909	22.18	1.571
2WK	64.51	67.41	64.83	2.015	25.74	1.790
3WK	62.02	63.61	62.14	1.97	28.07	1.729
LSD	2.32	NS	NS	NS	4.08	NS

The highest number of damage fruits per plant (28.07) was recorded at the 3WK application frequency which differed significantly from the 1WK application frequency but was statistically similar to the 2WK application frequency. On the other hand, the lowest number of damaged fruits per plant (22.18) was observed at the 1WK application frequency which was not significantly different from the 2WK application frequency (25.74). There was no significant difference ($P \leq 0.05$) among the levels of application frequency in the number of holes per shoot per plant. However, the lowest (1.571) and highest (1.790) number of holes per shoot per plant were observed at 1WK and 2WK application frequency, respectively.

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EFFECT OF PLANT EXTRACTS PRIMING ON THE CONTROL OF SEED-BORNE PATHOGENIC FUNGI OF TOMATO (*SOLANUM LYCOPERSICUM* L.) IN DADIN-KOWA, GOMBE STATE

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ABSTRACT

Tomato is one of the important vegetable crops. The problem of seedling establishment is found in tomato due to several soil borne diseases. There are many chemical methods available to control these diseases, but use of chemicals deplete the soil micro-environment and causes soil and water pollution and also do not fit within the framework of 'Organic farming'. Seed priming with certain phytochemicals may be an economic and ecofriendly alternative to such chemicals. A study was conducted in Federal College of Horticulture Dadinkowa, Gombe State to study the effect of tomato seed priming with plant extracts. The experiment was laid in a completely randomized design (CRD) replicated three times. In present study, two sources of tomato seeds were primed with extracts of three different plants (Neem seeds, ginger and Cassia alata leaves) and mancozeb which served as a positive check. Different leaf extracts doses of 40% was taken independently for seed priming in the laboratory and nursery conditions. It was found that priming with neem seeds, ginger and Cassia alata, extract had an improvement in seed germination, survival and seedling growth parameters in both conditions. Priming with mancozeb however was most promising in reducing the effect of pathogens in all the parameters. Seed priming with neem extract exhibited highest germination and survival rate (43.33% and 74.00%) and (48.70% and 46.70%) in farmers seed in laboratory and nursery respectively.

Key words: Plant extracts; seed priming; seedling, tomato, germination, nursery, laboratory

INTRODUCTION

Seed constitute the basic input for crop production in phanerogams so that pathogen free healthy seeds are considered as the vital factor for desired plant population and good economic harvest. Seeds are known to be contaminated with diverse fungal micro-propagules, some of them attack the seeds in the field internally contaminating the seed sheaths, tissues of embryo, endosperm and others under storage as a result of environmental conditions of high relative humidity, suitable temperature and high level of seed moisture content. The seed carrying organism's causes manifold loses to the crop and reduced the agricultural productivity (Bhajbhuje, 2013). Seed-borne diseases are able to spread across international borders very easily and are often difficult to identify as their typical symptoms being rare on seed surfaces as economic impact and importance has increased in recent years with regards to many kinds of crop worldwide (Lew-Smith, 2013). Planting infected seeds result in a widespread distribution of diseases within the crop, and an increased count of initial infection sites from which disease can spread. High rate of seed-to-seedling transmission of seed borne pathogens create alarming situation, even a small percentage of infected seed can result in significant seedling infection in the field (Saskatchewan, 2013). Major genera of plant-pathogenic seed borne fungi infect seedlings, some of them causing severe diseases. They limit the ability of plants to produce healthy fruit bearing shoots, causing damping-off, collar rot, stem canker, leaf blight and fruit rot resulting in premature defoliation, reduction in size and quality of fruits, thereby reducing potential yield to the extent of 20-30% (Lew-Smith, 2013). Seed deterioration is an inexorable, continuous and irreversible process, involves succession of seed borne fungal pathogens under storage resulting in loss of seed nutrients, alteration of physio-chemical properties of seeds, loss in seed weight, seed viability and vigour, medicinal properties, aesthetic changes including discoloration, heating and mustiness, cracking and abnormal odors contributing seed losses to the extent of 24% (Bhajbhuje, 1989). The consequences deterioration leading to series of deteriorative changes include membrane degradation, toxic metabolites accumulation, loss of enzymatic activity, lipid autoxidation, failure of repair mechanisms, genetic degradation, reduced productivity, finally loss of germinability or death of seed (Debnath *et al.*, 2012). Some fungal propagules may bring about certain biochemical changes and toxic metabolites that elicit a toxic response such as carcinogenicity, genotoxicity, terrotogenicity, hepatotoxicity, immunosuppression etc. Secondary fungal metabolites are reported to be toxic to man, animals and pose serious health hazard (Jain, 2008; Brakhage and Schroeckh, 2011; Shephard, 2012).

Tomato (*Solanum lycopersicum* L.) belongs to the family *solanaceae* and it is an annual sub-tropical fruit vegetable crop. The crop originated from South America and was introduced to Europe in the 16th Century and later to East Africa by colonial settlers in early 1900 (Wamache, 2005). In Nigeria, tomato plays a vital role in meeting domestic and nutritional food requirements, generation of income, foreign exchange earnings and creation of employment (Sigei *et al*., 2014). The crop is grown for both fresh domestic and export market but there is increasing demand for processed tomato products (Mungai *et al*., 2000).

Tomato crop does well in warm climate with an altitude range of 0 – 2100 m above sea level. It requires rainfall ranging between 760 mm to 1300 mm and deep fertile loam soil that is well drained, with high content of organic matter and a pH ranging between 5-7 (Rice *et al*., 1994). Fruits are used in salads or cooked as a vegetable, processed into tomato paste, sauce and puree. The nutritional value of tomato makes it a widely accepted vegetable by consumers. Fruits are rich in calcium, phosphorus, magnesium, copper, niacin, iron, folate, Vitamin A, B6, Vitamin E, Vitamin B2, Vitamin C, iron and carbohydrates (Wamache, 2005). Furthermore, the fruit has medicinal value as a gentle stimulant for kidneys, and washing off toxins that contaminate the body systems. It improves the status of dietary anti-oxidants (lycopene, ascorbic acid and phenols) in diet (George *et al*., 2004). Tomato juice is known to be effective for intestinal and liver disorders (Wamache, 2005).

The cultivation of fruit and vegetables in Nigeria is undertaken by small farmers who usually have a small land holding of less than two hectares. As a result, the yield is low and coupled with inadequate postharvest experience, lack of storage facilities and postharvest diseases have made fresh tomato fruit unavailable abundantly all year round in the market in the country. The lack of postharvest management experience, sanitation of the environment of the farm and problem of handling and transportation may lead to pathogen infection which affects the quality of tomatoes. Large quantities of fruits and vegetables are produced and staggering yield figures are quoted as annual production. For example, 6 million tonnes of tomatoes was reported as the annual yield (Idah *et al*., 2007). However, it is the amount of the produce available to the consumer that is more important.

The major constraints to production in Nigeria are; pest and diseases, seed, rainfall, marketing, postharvest losses etc. Amongst the production constraints, pest and diseases are the major ones. The wilt diseases of tomato caused by *Alternaria solani* is one of the devastating diseases of tomato and can reduce yields of the crop significantly and above- all, largely seed transmitted. World-wide, there are numerous reports on seedborne fungi of tomato (Neegaard, 1977; Surayanarayana, 1978). Seedborne fungi are of considerable importance due to their influence on the over-all health, germination and final crop stand in the field. Farmers have to deal with significant losses due to infections by serious seedborne pathogens on their plants, which may start from germinating seed, seedling in the nursery, matured plants in the field and proceed till the products are harvested and fruits and seeds stored. Significant crop losses due to seedborne pathogens have been recorded. Pimentel and Perkins (1980) for example, estimated total world food losses at about 45% due to diseases. The Commonwealth Agricultural Bureaux in their thirty-ninth annual report of 1968 estimated that losses due to diseases alone in the tropics are of the order of 10-13% (CAB, 1968).

Seed treatments for the control of soil-borne seedling diseases have generally met with failure. The only hope of controlling such diseases by seed treatment is that a sufficient quantity of fungicide be carried on the seed into the soil to protect the seedling until it becomes well established. Certain types of seed; such as -the tomato, will ·carry large quantities of material, but, when highly toxic compounds are used, there is almost always considerable damage done to the seed.

The control of seedborne pathogens is the first step in any agricultural crop production and protection programme. Attempts have been made to reduce seedborne infection by chemical treatment of the seeds and some successes have been reported. Messiaen (1992) reported that dressing seeds with non-systemic broad spectrum fungicides such as Thiram, Maneb, Mancozeb, Difolatan, etc at rates of 2-4g a.i/kg of dry dust to very wrinkled hairy seeds of tomato and carrots can kill superficial fungi of spores of *Fusarium* species and *Alternaria* species and can protect seedlings before emergence against *Pythium* species. Though, chemical controls of seedborne pathogens have been very successful, however, chemical pesticides have the additional potential disadvantages of accumulation in the ecosystem and of induction of pesticide resistance in pathogens (Adeniji, 1970, Okigbo and Ikediugwu, 2000; Okigbo, 2004). There is also the problem of lack of expertise in the safe handling of chemical pesticides amongst most of the farmers. It is therefore, necessary to search for seed quality control measures that are cost effective, ecologically sound and environmentally safe to eliminate or reduce incidence of pathogens of economic importance to increase both seed germination and yield of plant crops.

In recent years much attention has been given to non-chemical systems for seed treatment to protect seeds against many plant pathogens (Nwachukwu and Umechuruba, 2001). Anti-fungal activity of different plant extracts has been reported earlier by several investigators against a number of plant pathogens (Hassan *et a*l, 2005; Yang and Clausa, 2007). However, information on management of seedborne fungal pathogens using botanicals on the major vegetable crops is generally lacking. There is therefore the need to investigate into the effect of different botanicals that will reduce or eliminate the incidence of plant pathogens and increase yields of crops. The main objective of the study is to assess the presence and significance of pathogenic fungi on tomato seeds collected from the study area and the possibility of controlling these pathogens using botanicals.

MATERIALS AND METHODS

Experimental Area

The experiments were set out at the Pathology Laboratory and screen house, Federal College of Horticulture Dadinkowa, Gombe State.

Seed Health Testing

Tomato seeds were collected from tomato growers and commercial seed companies. Fifty out of the tomato seed samples collected were plated using the Blotter method at the Crop Protection Laboratory, Modibbo Adama University of Technology Yola, as recommended by Mathur and Kongsdal (2003). The petri-dishes with seeds were arranged in seed trays and incubated for 7 for 12 hours alternating cycles of light (near ultraviolet NUV or florescent daylight) and darkness to enhance sporulation of seedborne fungi. Each seed sample at the end of the incubation was examined thoroughly under stereomicroscope for the growth of fungi. Fungi found associated with seeds were carefully examined and identified based on 'habit characters' (Mathur and Kongsdal, 2003). Slide preparation of fruiting structures, such as conidia borne in conidiosphere, spores held together in spore masses, sporodochia, and acervuli, pycnidiospore in pycnidia, ascospores in perenthecia were examined each using compound microscope to confirm their identity using reference publication (Mathur and Kongsdal, 2003). Records were then taken on incidence and infection percent of the seedborne fungal pathogens identified on seeds.

Preparation of plant extracts

Fresh ring worm plant (*Cassia alata)* leaves and neem (*Azadirachta indica*) seeds were collected within the college environment, while ginger (*Zingiber officinale)* rhizomes and wettable mancozeb powder were purchased in Gombe main market and Agro-chemical stores respectively. Aqueous extracts of each of the plant materials were prepared as recommended by Okigbo and Nmeka (2005).

Neem seed extract

To prepare the solutions, eighty grams of de-pulped dry neem seeds, was weighed using the electronic weighing machine. The seeds were then ground in a blender with 200 ml distilled water. These were vigorously stirred and left to stand for one hour. The solutions were later filtered through layers of muslin cloth. A concentration of 40% of the neem seed extracts was then prepared.

Ginger rhizome

Fresh ginger or *Zingiber officinale* rhizomes were washed and scrapped-off the outer-coverings/skins. Also 80 grams of the scrapped ginger rhizomes was weighed using the laboratory digital weighing machine. This was chopped into pieces and separately ground in a blender with 200 ml of distilled water. It was vigorously stirred and left to stand for one hour. The solutions were filtered through muslin cloth and concentration of 40% of ginger rhizome extracts was prepared.

Cassia alata extracts

Fresh leaves of *Cassia alata* were washed in the laboratory with tap water; 80 g of the washed fresh leaves was weighed using the laboratory weighing machine. The leaves were ground in a blender with 200 ml of distilled water. These were vigorously stirred and left to stand for one hour. The solutions were filtered through muslin cloth. Concentrations of 40% of *Cassia alata* extracts were prepared.

Seed treatment using plant extracts

Samples of the infected tomato seeds were treated with each of the plant extracts by soaking the seeds in each of the concentrations for 12 hours. Treated seeds were dried on clean sheets of paper overnight under room conditions. Seeds were also soaked in 3% concentrated aqueous Mancozeb solutions for 12-hour period and dried under the same conditions similar to the other treatments, while untreated seeds (seeds soaked in distilled water) serving as the control.

Determination of the effects of plant extracts on percent incidence of fungal pathogens and seed germination

Three replicates of 50 seeds per Petri-dish for each of the treated tomato seeds including the controls were plated using the Blotter Method as recommended by Mathur and Kongsdal (2003). They were then observed for 10 days and then examined for seedborne pathogens. Records on incidence of seedborne fungi and germination of treated seeds were taken.

Preparation of plant growing media

Top-soil was steam pasteurized at the Horticulture Department of the Federal College of Horticulture Dadinkowa. Seed sowing pans filled with sowing mix made up with the pasteurized top-soil and fine river sand at the ratio of 2:1 was arranged randomly in the Screen House.

Sowing of the treated tomato seeds

The trial was arranged in a Completely Randomized Design (CRD). For each of the treatments, three replicates of 50 seeds were sown making a total of 250 seeds for each treatment. Sowing was done by the broadcast method and fine sieved pasteurized top-soil was spread evenly on seeds before watering using a watering can and a fine netted screen was used to cover all the bowls containing the treated sown tomato seeds. Watering of germinating seedlings was done every other day with equal amounts of water in the screen house. Records on germination, seedling mortality, and seedling population were taken at 30 days after sowing.

Growing tomato seedling under fine netted screen

Parameters studied

Seed health testing

Data on the incidence and severity of pathogenic fungal infection was collected by examination of incubated seeds under stereomicroscope and compound microscope as recommended by Mathur and Kongsdal (2003).

Determination of effect of plant extracts on incidence of seedborne fungi

The Blotter Method of Mathur and Kongsdal (2003) were used to determine the effect of plant extracts on incidence of important fungal pathogens. This involved plating treated seeds, i.e. 3 replicates of the 5 treatments at the concentration levels of the plant extracts and the recommended Mancozeb (fungicide) and the controls. Observations for the incidence of important fungal pathogens were made under microscope at the end of the incubation period. Records on incidence will be taken using the standard recording sheets.

***Effects of plant extracts on percent seed germination (Laboratory* experiment)**

Records on percent germination were made through counting of normal, abnormal seedlings, freshly un-germinated, hard and dead seeds per treatment in the Laboratory.

Effects of plant extracts on percent seed germination (Screen house experiment)

Standard germination test

Three replications of 50 seeds of each treatment were counted and sown in free drainage plastic bowls of 35cm diameter filled with the sowing-mix' mixed up with the sterilized top-soil and a fine river sand in the ratio of 2:1. Germinated seedlings were counted at 14 days after sowing. Seeds were considered germinated when the radical has emerged from the seed coat with the cotyledons partly or fully exposed.

Effect of plant extracts on seedling mortality and seedling population

The method of Daftari and Verma (2006) was used to determine the effect of plant extracts on seedling mortality and seedling population per treatment. This involved the count of dead and dying seedlings due to infections by seedborne fungi associated with the seed for seedling mortality, while seedling population per treatment were determined by counting the number of surviving healthy seedlings. Records were then taken on seedling mortality and seedling population per treatment at 3 and 4 weeks after sowing respectively.

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Statistical analysis of Data

Analysis of variance (ANOVA) was performed on all the data collected in respect of parameters studied on effects of plant extracts and separation of treatment means was done using the LSD at 5% level of significance.

RESULTS AND DISCUSSION

Incidence of fungal species on tomato seeds

Out of the fifty seed samples tested for seedborne fungal pathogens, a total of 4 genera of 6 species of fungi were recorded (Figure 1). The mean percentage incidence and percent severity of seedborne fungi of tomato revealed by the Blotter Method are given. The fungal pathogens recorded were *Aspergillus flavus, Aspergillus niger, Colletotrichum dematium, Penicillium spp, Rhizopus spp* and *Fusarium solani.*

The Blotter Method results revealed that apart from *Aspergillus flavus, A. niger, Penicillium spp and Fusarium solani* all other fungal pathogens were recorded in the farmers with a mean incidence of 2.00 percent. The storage fungus (*Aspergillus flavus*) recorded the highest mean infection percentage of 4 percent, while the lowest mean infection of 0.3 percent was recorded by *Fusarium Fusarium solani.* In the seeds collected from vendors, apart from *Rhizopus spp and Colletotricum dematium* all other fungal pathogens were recorded with a mean incidence of 0.92 percent. *Aspergillus flavus* recorded the highest mean infection of 4 percent, while *Fusarium solani* recorded the lowest mean infection of 0.3 percent.

The highest percentage fungi incidence as well as severity on tomato seeds collected from different farmers may be attributed to inadequate seed drying by most tomato farmers. It may also be attributed to their storage environment (i.e. under high storage humidity and temperatures). In contrast, the lowest incidence of fungal pathogens recorded from vendors' seeds may be attributed to the proper drying of extracted tomato seeds before storage. Of the fungal species identified, *Fusarium spp* and the storage fungi (saprophytes), for example *Aspergillus spp* were found to be predominant. Similar reports have been reported by Orlova *et al*. (1982), Marcinkowska (1982) and Huang and Sun (1986) who found that *Alternaria alternata, Aspergillus flavus, Aspergillus niger* and *Fusarium oxysporum* were predominantly associated with tomato seeds.

Aspergillus, Rhizopus and *Penicillium* sp. are probably not pathogenic pathogens on tomato. They are however, storage fungi (saprophytes). Harman and Pfleger (1974) and Kulik (1973) reported that *Aspergillus* sp. have no effect on germination of tomato seeds. Of the high incidence of storage fungi, these conditions were found to be as a result of their pre-treatment of their seeds and farmers' storage condition of their seeds.

Effect of plant extracts on percentage seed germination of tomato in the screen house

The results of the effects of plant extracts on percentage seed germination of tomato in the laboratory and screen house is presented in Table 1. The result shows highly significant ($P<0.05$) differences among the extracts for seeds collected from farmers. Results of the study for in-vivo tomato seed was almost similar as obtained by the in-vitro seed germination test. Kuhn and Hargreaves (1997) reported that substances found fungicidal in-vitro, in almost all cases kill the fungus in-vivo and could improve upon subsequent seedling growth when used properly in the seed treatment. In the comparison for example, seed treated with mancozeb recorded the highest percentage germination of 77.30 percent just like the in-vitro experiment with the highest percent (83.30%). Reasons for the high percentage germination by mancozeb treatment may be attributed to the suppression of fungi incidence and above – all, offered a better protection of embryos of the treated tomato seed from damage by *Fusarium moniliforme*.

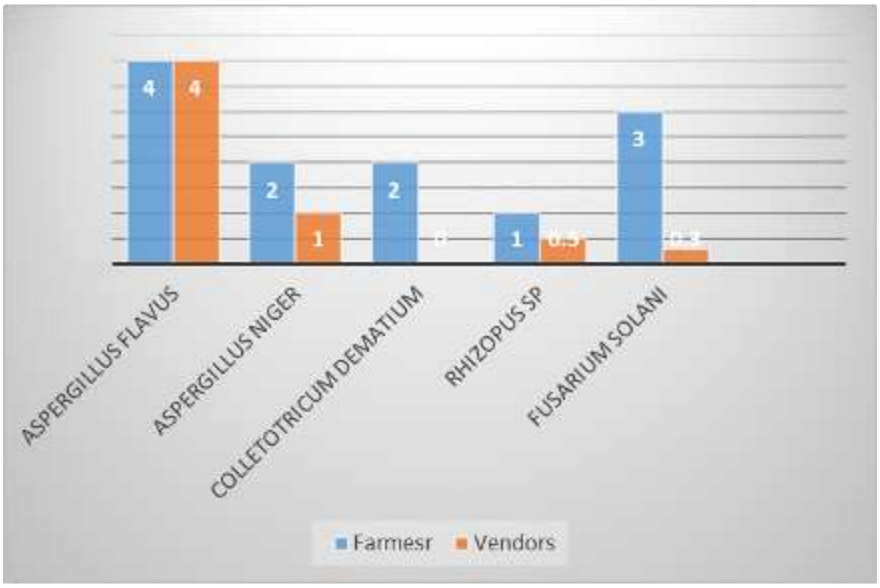

Figure 1. Mean percentage incidence of fungal pathogens on tomato seeds collected from farmers and vendors

Table 1. Effect of plant extracts on percentage seed germination of tomato in the laboratory and nursery

Treatment	Laboratory		Nursery	
	Farmers Seed	Vendors Seed	Farmers Seed	Vendors Seed
Mancozeb	59.33	77.30	77.30	83.30
Neem Seed	43.33	64.00	74.00	54.70
Ginger	40.00	68.70	62.00	64.70
Cassia	36.00	62.00	66.70	80.00
Control	32.67	38.70	38.70	60.30
P<F	<0.001	<0.001	<0.001	0.019
LSD (0.05)	6.904	11.850	12.810	16.700

Effect of plant extracts on percentage seedling mortality of tomato

The result for the effect of plant extracts on percent seed mortality of tomato is presented in Table 2. Results of the study on seedlings mortality indicated significant differences ($P<0.05$) for the effects between plant extracts. Significant reductions of tomato seedlings were therefore observed. Mancozeb achieved the highest of seedling mortalities both in the laboratory and in the screen house. One of the reasons being that, earlier results indicated that mancozeb had some inhibitory effects and that probably could have accounted for the significant reductions. Similarly, results of the study also indicated that extracts of neem seeds compared favourably to mancozeb to achieve control in tomato seed. The reasons may be due to its greater quantities of antifungal activities and that could have contributed in achieving a better control than the other plant extracts. Infected seed is less viable, has low germination, reduced vigour and reduced yield (van Gastel, 1996). Wilting and death of shoot in cucurbits caused by *Fusarium moniliforme* has been reported by Palodhi and Sen (1980).

Table 2. Effect of plant extracts on seedling mortality of tomato in laboratory and nursery conditions

Treatment	Laboratory		Nursery	
	Farmers Seed	Vendors Seed	Farmers Seed	Vendors Seed
Mancozeb	12.70	18.70	24.00	27.37
Neem Seed	14.00	19.30	25.30	33.30
Ginger	16.70	23.30	24.00	30.30
Cassia	13.30	27.30	32.00	33.30
Control	45.30	50.00	44.70	50.70
P<F	0.002	0.007	0.004	0.005
LSD (0.05)	6.50	14.310	10.880	10.630

Effect of plant extracts on seedling population (%) of tomato

Results of the study revealed that there were significant differences (P<0.05) for the effects between plant extracts for both laboratory and screen house experiments. The results of the study showed that mancozeb gave the highest seedling population (39.30% and 58.70%) in the laboratory and (52.70% and 58.70%) in the screen house (Table 3). It is possible that mancozeb might have possessed greater and stronger anti-fungal activities that probably remained with the seedlings throughout the growth period to offer better protection against seedling mortality. Secondly, seeds treated with mancozeb gave the same good percentage germination at the end of the study period. Thirdly, mancozeb did not encounter serious seedling mortality incidence unlike *Cassia alata, Zingiber officinale* and *Azadirachta indica* extracts which recorded significant percentage seedling mortality. This work is in agreement with the findings reported by Sinnadurai, (1992) that optimum plant densities can influence increased yield and one of several means of achieving this is through the use of good quality seed (Asuboah, 2009). Quality seeds can also be obtained through the use of effective seed treatment method (Asuboah, 2009).

Table 3. Effect of plant extracts on seedling population (%) of tomato in the laboratory and nursery conditions

Treatment	Laboratory		Nursery	
	Farmers Seed	Vendors Seed	Farmers Seed	Vendors Seed
Mancozeb	39.30	58.70	52.70	58.70
Neem Seed	29.30	44.70	48.70	46.70
Ginger	22.70	45.30	42.70	37.30
Cassia	22.70	34.70	30.00	34.70
Control	7.30	22.00	20.70	22.00
P<F	0.019	<0.001	0.002	<0.001
LSD (0.05)	9.250	16.650	9.810	14.400

CONCLUSION

It can be concluded from this work that the use of neem seed extract has the potential of controlling the pathogenic fungi of tomato seeds. Generally, the results also indicated that all plant extracts used to treat the seeds did not significantly reduce seed germination and plant mortality of tomato. However, mancozeb was comparably most efficacious in the control of pathogenic fungi. Tomato farmers should therefore use neem seed extract for seed priming.

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EVALUATION OF ANTIFUNGAL ACTIVITY OF SOME PLANT EXTRACTS IN THE MANAGEMENT OF FUSARIUM WILT PATHOGEN ON TOMATO (*LYCOPERSICON ESCULENTUM* MILL.)

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ABSTRACT
Herbal fungicides are mostly used to control plant disease because of their ecofriendly nature and cost effectiveness. The present investigation focuses on the antifungal activity of some plant extracts viz., Chromolaena odorata L, Tetrapleura tetraptera (Taub) and Vernonia amygdalina (Delile) The ethanolic and aqeuous extracts of C. odorata L, T. tetraptera and V. amygdalina were tested at concentrations of 5%, 10% and 15% (w/v) for their in vitro fungicidal activities against Fusarium oxysporum Schlecht causing wilt disease in Tomato. The experiment was arranged in a Completely Randomized Design (CRD) in three replications. The results showed a promising antifungal activity of both the aqueous and ethanolic extracts of these plants against F. oxysporum. The inhibitory activity ranges from 34.4 – 15.4% in aqueous extracts and 39.8 – 18.4% in ethanol extracts. Ethanolic extract of V. amygdalina gave the highest inhibition of 39.8% at 15%, while aqueous extract of C. odorata gave the highest inhibition of 34.4% at 15% mycelial reduction (P< 0.05) and these can be compared to 47.6% obtained from plates impregnated with synthetic fungicide (Mancozeb) while the untreated plates had 100% mycelial growth. The results of the investigation indicated that plant extracts possess antifungal activity that can be exploited as an ideal treatment for future plant disease management.

Key words: Tomato, Fusarium, inhibition, eco-friendly, antifungal

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae; it is the most important tropical vegetable crop widely used throughout the world (Hadian *et al.,* 2011). Tomato is a high-value horticultural crop for the local market and an important dietary component, contributing to improved nutrition and livelihood for both rural and urban population (Waiganjo *et al*., 2006). It grows well in a wide range of soil types which are high in organic matter, well drained with pH range of 5-7.5, and optimum temperatures of 15°C – 25°C (Bawa, 2016). The demand for tomato in developing countries such as Nigeria has increased significantly in the last decade, due to its ability in the prevention of heart diseases and prostate cancer (Jones, 2008) coupled with the treatment of high blood pressure (Andersson, 2002).

However, many constraints affect productivity and quality of tomato among which diseases play a salient role (Pritesh *et al*., 2011). The common diseases of tomato include; late blight, early blight, anthracnose, wilt and canker (Winand *et al*., 1999). Out of these diseases, the wilt and root rot caused by species of Fusarium remain a challenging task in terms of tomato farm managements throughout the world, especially in the tropical region as it accounts for 90 % economic losses (Sahu, 2013). Fusarium wilt is caused by *Fusarium oxysporum* Schlecht or *Fusarium solani;* it is one of the most prevalent and damaging disease wherever tomatoes are grown intensively because the pathogen can persist indefinitely in infested soils which may damage plants upon penetration of the root or basal stem (Agrios, 1997; Ajilogba and Babalola, 2013). The disease caused by this fungus is characterized by browning colouration of the vascular bundles of the stem, yellowed leaves, wilted plants and reduced or even total loss in crop yield (Burgess *et al*., 2008). Apart from causing diseases, they also colonize outer cells of roots as harmless endophytes after the pathogen has killed the root tissues and others live as saprophytes in soil (Fravel *et al*., 2003).

Synthetic fungicides have been used majorly for the control of Fusarium wilt but have been found to be considered hazardous, as it is not easily biodegraded, and the excessive misuse of a wide range of fungicides has led to soil deterioration and subsequently increases the resistant pathogen populations (Özgönen *et al.,* 2001; Bajwa *et al.,* 2003).

There is, therefore, a need to encourage the use of natural products like botanical amendments or botanical extracts for the management of Fusarium wilt disease in tomato plants; this is considered as a substitute method to synthetic fungicides and these may be used for formulating new, safer and ecofriendly fungicides.

MATERIALS AND METHODS

Isolation and identification of Pathogen

Isolation of *F. oxysporum* was done using the direct plating method. Infected tomato stem was washed thoroughly in sterilized distilled water, cut into small pieces with a sterile scalpel, surface-sterilized in 5% sodium hypochlorite, rinsed in three changes of sterile distilled water, air-dried on sterile filter paper and plated on Petri dishes containing Potato Dextrose Agar (PDA) amended with (60mg/ml) chloramphenicol. The inoculated plates were incubated at 26^{o}C ± 2°C. Identification of *F. oxysporum* was done through morphological and cultural characteristics exhibited by the fungal isolate.

Preparation of plant extracts

Botanicals were prepared using the procedures of Amadioha, (1999). Fresh leaves of *Chromolaena odorata*, L. (Siam weed, Ewe Akintola), *Tetrapleura tetraptera* Taub. Preseke, soup perfume, African comb. Aidan) and *Vernonia amygdalina* Delile. (Bitter leaf, Ewuro) were collected and air dried for 14 days after which they were ground with the aid of a mechanical grinder to powder. The two soft sides of *T. tetraptera* fruits were cut into 5cm segments (pulp) before grinding. Two solvents (water and ethanol) were used in extract preparation at 5%, 10% and 15% concentrations. Aqueous extracts were prepared by adding 5, 10 and 15g of leaf and pulp into a beaker and adding sterile distilled water until the 100 ml mark on the beaker. The contents in the beaker were thoroughly mixed and left to stand for 24 hours. Thereafter it was filtered with a Whatmann No.1 filter paper. Ethanol extracts were also prepared as above. All plates were incubated at 28±2°C for 5 days. Measurement was taken as the mean growth along the two axes on two pre-drawn perpendicular lines on the reverse side of plates. Data were analysed using ANOVA and means were compared using Fisher's Least Significant Difference (Fisher's LSD) at 5% Probability level.

In-vitro evaluation of botanicals for antifungal activity

In-vitro evaluation for antifungal activity was conducted using the agar dilution method described by Okhuoya, (2012). Two perpendicular lines were drawn at the bottom of each Petri-dish (Amadioha and Obi, 1999). One (1) ml of extract was introduced into sterile Petri-dishes; PDA was added to the Petri-dishes containing the extracts and gently swirled to ensure homogeneity of mixture. Five (5) mm agar plug of 7 days old *Fusarium oxysporum* culture was placed at the center of each petri-dish containing chloramphenicol amended PDA (at the intersection of the two perpendicular lines), the experiment was arranged in complete randomized design in three replicates. The radial growth was measured at 24 hours' interval for 96 hours and the percentage inhibition was calculated using the following formula:

%age inhibition =Dc- Dt/DC x 100

Where; Dc = Diameter of colony in control plate

Dt = Diameter of colony in treatment plate.

All the data obtained were subjected to analysis of variance (ANOVA) and means were compared using Fisher's Least Significant difference at 5% level of Probability (P>0.05).

RESULTS AND DISCUSSION

The effects of both the aqueous and ethanol extracts of the three plant materials on mycelial growth inhibition of *F. oxysporum* are presented in tables 1 and 2 (P>0.05). Percentage inhibition of mycelial growth of *F. oxysporum* varied with the type of plant materials, solvent of extraction and extract concentration. It was also observed that reduction in mycelial growth increased with duration of incubation (P>0.05). Among the plant extracts, aqueous extract of *Chromolaena odorata* gave the highest mycelial reduction (34.37%) at 15% concentration. However, there was no significant difference in mycelial reduction between the aqueous extracts of *T. tetraptera* and *V. amygdalina* at the same concentration (15%) and recorded significantly lower mycelial reduction compared with *C. odorata* extracts. Mancozeb a synthetic fungicide inhibited mycelial growth (45.76%). At 15% ethanolic extract concentration, *V. amygdalina* gave the highest mygelial reduction (39.80%), while at 10% concentration ethanolic extracts of *C. odorata* and *V. amygdalina* gave similar comparable (35.62% and 34.64% respectively) effect on mycelial reduction while the ethanolic extract of *T. tetraptera* gave the least activity (18.43%) in reducing mycelial growth of *F. oxysporum.*

The presence of antifungal active ingredients in the leaves of selected botanicals was demonstrated in this study as it was indicated in their ability to inhibit the growth of *F. oxysporum* in culture. The antifungal activities of different plant species and their importance as possible sources of natural fungicides has been reported, the results obtained in this study confirmed the previous studies showing the antifungal activities of leaf extracts *C. odorata* on *L. theobromae* (Adejumo, 2000; Adeniyi and Joseph, 2015). The aqueous extract of *V. amygdalina* leaves can inhibit the growth of *Fusarium moniliforme* on seeds of maize (*Zea mays*) as well as mycelial and conidial growths of *Colletotrichum gloeosporioides* in rubber tree (Ogbebor *et al*., 2007; Owolade *et al*., 2000; Suleiman *et al*., 2008).

The effectiveness of the extracts increased with increase in concentration and maximum inhibition was recorded at 15%. The mycelial reduction activities of the extracts were solvent and concentration dependent. This is in agreement with the report of Ilondu (2012) and Chiejina and Ukeh (2013) who indicated that increase in the antifungal activities had corresponding increase in concentration of plant extracts. Edward, 2015 had reported the effectiveness of *C. odorata* on Cassava rot disease. Umana et al., 2016 had also reported complete inhibitory activities of *T. tetraptera* on *Penicillium* species in *Arachis hypogaea*. The differences in the effectiveness of the extracts could be attributed to the differences in their active ingredients and ability of the extraction solvent to release the active components in the plants (Onifade, 2002; Okigbo et al. 2009). The fungitoxic effects of these plant extracts indicate their potentials and this could be explored as part of sustainable Integrated Pest Management (IPM) strategy to manage Southern blight on tomato.

Table 1. Antifungal activity of Aqeous plant extracts on mycelial growth of *Fusarium oxysporum*

Plant extracts	*Chromolaena odorata*		*Tetrapleura tetraptera*		*Vernonia amygdalina*	
Concentrations (w/v)	Mycelia growth(mm)	% inhibition	Mycelia growth(mm)	% inhibition	Mycelia growth(mm)	% inhibition
5%	8.86	21.10	8.9	20.75	9.5	15.41
10%	7.5	33.21	9.16	18.43	8.5	24.31
15%	7.37	34.37	9.03	19.59	8.97	20.12
Mancozeb	5.9	47.46	5.9	47.46	5.9	47.46
Control	11.23	-	11.23	-	11.23	-

Table 2. Antifungal activity of Ethanolic plant extracts against wilt caused by *Fusarium oxysporum*

Plant extracts	*Chromolaena odorata*		*Tetrapleura tetraptera*		*Vernonia amygdalina*	
Concentrations (w/v)	Mycelia growth(mm)	% inhibition	Mycelia growth(mm)	% inhibition	Mycelia growth(mm)	% inhibition
5%	7.93	29.39	7.9	29.65	7.53	32.95
10%	7.23	35.62	9.16	18.43	7.34	34.64
15%	8.4	25.20	9.03	19.59	6.76	39.8
Mancozeb	5.9	47.46	5.9	47.46	5.9	47.46
Control	11.23	-	11.23	-	11.23	-

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EVALUATION OF STERILISATION METHODS ON THE ANTIFUNGAL ACTIVITY OF SAWDUST EXTRACT OF SOME TROPICAL TREES

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ABSTRACT

The most common challenge in carrying out studies on plant extract is the contamination due to bacteria, fungi, and mould, which may occur during various stages of extraction and following experimental procedures. Hence, this study investigated the effects of two sterilization methods on three sawdust (Cola nitida, Anogeissus leiocarpus and Gmelina arborea) extracts on antifungal activity against Southern blight pathogen (Sclerotium rolfsii). The experiment was conducted in the Pathology laboratory of National Horticultural Research Institute (NIHORT) Ibadan, Nigeria, and laid out in a Completely Randomized Design (CRD) with 3 replicates. Three concentrations (5, 7.5, and 10 %) and two methods of sterilization (autoclave and Ultraviolet light) were employed to sterilized the extracts and fungitoxicity determined. The in vitro results showed that highest mycelial growth inhibition was recorded at 10 % on all the extracts, however, UV sterilized extract gave higher mycelial inhibition throughout the period of observation and values obtained were significantly comparable with values observed on commercial fungicide (mancozeb at 2.5 g/l) treated plates. It was concluded that the sawdust extracts used at highest concentration gave promising prospects for the management of Southern blight. However, there is a need to further evaluate the antifungal potential of these sawdust on the field to establish their antifungal effectiveness on Southern blight of tomato.

Keyword: Fungitoxicity, autoclave, ultraviolet, sawdust, blight

INTRODUCTION

Sclerotium rolfsii Sacc. is one of the most destructive soil inhabiting pathogens and causes heavy loss to over 500 host plants belonging to 100 different families (Liamngee, 2015). In severely infected field, loss ranges from 10 to 25 per cent and sometimes reaches up to 80 per cent. (Aycock, 1966; Punja, 1988) The hazards involved in using chemical fungicides and the development of resistance to synthetic fungicides by plant pathogenic organisms, make alternative control desirable. This experiment seeks to evaluate the effect of sterilization methods on antifungal activity of sawdust extract in the management of *S. rolfsii*.

MATERIALS AND METHODS

Sawdust was collected from Sango sawmill in Ibadan metropolis, Oyo state, Nigeria. Fifty, 75 and 100 g of each sawdust type was soaked in 1 L sterilized distilled water for 24 h and sieved through four layer sterilize cheese cloth to obtain 5, 7.5 and 10 % w/v) concentrations respectively. The prepared extract was sterilized either in autoclaved at 1.1 kg/cm^2 pressure at 121˚C for 15 minutes or ultraviolet light (254 nm) for 30 minutes.

Sterilization of materials

The inoculating needle and the cork borer were sterilized by flaming using a spirit lamp. The glass wares such as the petri dishes, the conical flasks and test-tubes were sterilized in a hot air oven at 160^o C for 2 hours. The table was sterilized using 70 % alcohol for 30 minutes.

Isolation of pathogen

Sclerotium rolfsii was isolated from infected tomato stem collected from NIHORT vegetable experimental field, washed with clean water and was cut into about 5cm segments. One percent sodium hypochlorite (1% NaOCl) was added for 1 minute and rinsed in four changes of sterilized distilled water and was left to dry for 30 minutes at 28 + 2°C. The segments were then plated on sterilized Potato Dextrose Agar (PDA) in petri dishes. Inoculated petri dishes were incubated at 28 + 2°C for 4 days and observed daily for fungal growth. Subcultures were made by transferring hyphal tips from the colony edge of the mixed cultures to fresh plates of PDA using flame sterilized inoculating needle and incubating at 28 + 2°C to obtain pure culture of *S. rolfsii*. Colony characteristics were examined with the aid of a microscope. Cultural and morphological

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characteristics observed were recorded and compared with typical conidial structures using identification keys described by Barnett and Hunter (1999) and Watanabe (2002).

Three ultraviolet light and autoclave sterilized sawdust extract were screened against *S. rolfsii in vitro* to examine the inhibitory effect on mycelial growth and sclerotial production evaluation of antifungal activities of the extracts, Autoclaved sawdust extract was obtained by autoclaving at 121°C for 15 minutes while the UV sterilized extract was obtained by exposure of the extract to 280 nm wavelength for 45 minutes. The prepared sterilized extracts were used at desired concentrations of 5, 7.5 and 10 % and introduced using standard procedure replicated for each treatment. PDA without plant extract and with commercial fungicide (Mancozeb 80 wettable powder) served as control. Each plate was inoculated with a 5 mm diameter mycelial disc taken from 5-days-old culture of *S. rolfsii* grown on PDA. The inoculated plates were incubated at 25 +2^{o}C and radial mycelial growth was recorded at 24 hours' interval for 4 days. The experiment was arranged in completely Randomized Design (CRD).

The fungitoxicity in terms of percentage inhibition of mycelial growth was calculated using the formula adopted by Shikha *et al*., (2013), that is;

Where; dc = Average increase in mycelial growth in control; dt = Average increase in mycelial growth in treatment.

Data obtained were analysed using Analysis of variance (ANOVA) and the means were separated using Least Significant Difference (LSD) at p = 0.05.

RESULTS AND DISCUSSION

Mycelial growth inhibition was significantly different (P ≤ 0.05) in autoclave and UV sterilized extract (Figure 1- 3). Generally, mycelial growth inhibition was low at reduced concentration (5 %) whereas, it was significantly higher at 7.5 and 10 % extract concentration. At 24 and 72 h, mycelial inhibition was found to be 62.7 and 45.82 % and this was significantly (P ≤ 0.05) comparable to what was observed on plates treated with mancozeb which recorded 87.46 and 60.78 % respectively in UV sterilized *C. nitida* extract while autoclave sterilized extract gave mycelial growth inhibition of 57.4 and 38.00 % at 48 and 72 hours and this was found to be significantly (P ≤ 0.05) similar to 48.04 and 38.33 % recorded on mancozeb treated plate at 2.5 g/l, the sane trend was observed at 96 h (Figure 1). *Anogeissus leiocarpus* autoclaved and UV sterilized aqueous extract exhibit significantly different effect on mycelial growth of *S. rolfsii* (Figure 2). In UV sterilized extract at 24 h and 48 h mycelial growth inhibition at 5 and 7.5% concentrations were not significantly different (P ≤ 0.05), likewise between 7.5 and 10 %.

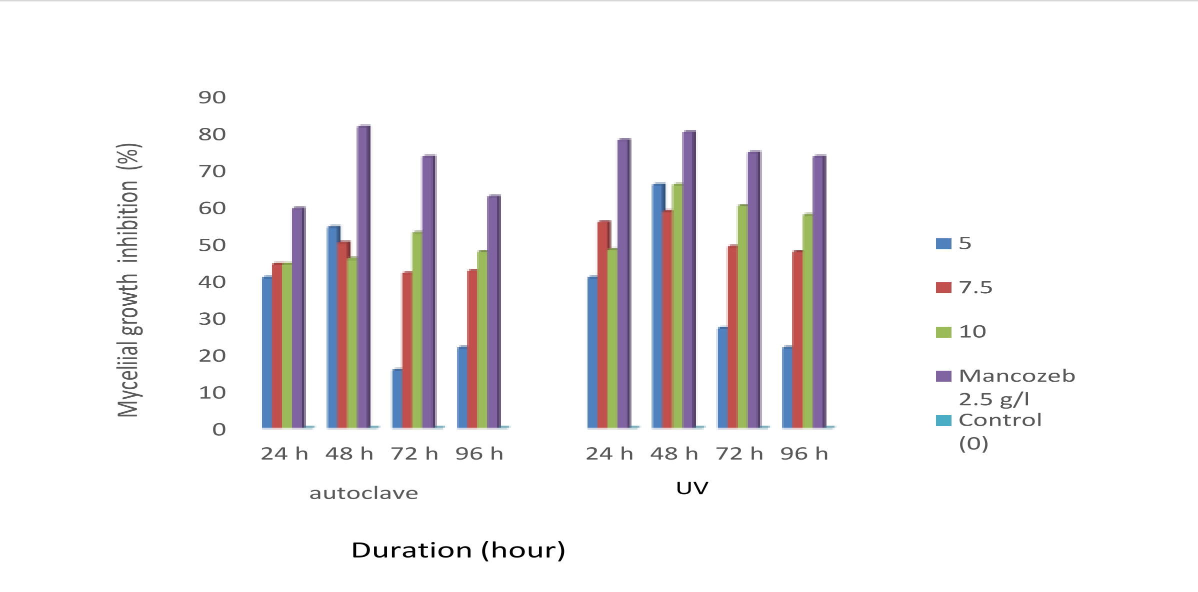

Figure 1. Effect of *C. nitida* extract on mycelial growth of *S. rolfsii* Sacc

However, highest mycelial growth inhibition was recorded at 10 % concentration throughout the period of observation and values obtained were significantly comparable with values observed on mancozeb treated plate (Fig 2). The effect of aqueous *Gmelina arborea* sawdust extract on *S. rolfsii* mycelial growth inhibition is presented in plate 3. In autoclave sterilized extract, highest mycelial inhibition 73.08 % on plate impregnated with 10 % concentration and this was comparable to 67.23 and 65.03 % taken on plates with 7.5 concentration at 24 h. It was observed that at 96 h mycelial growth inhibition (52.07 %) obtained on plate treated with 10 % extract was significantly higher than other concentrations but comparable to 57.115 % recorded on mancozeb impregnated plate. However, in UV sterilized extract highest mycelial inhibition (49.61 %) was recorded in plate with 10 % extract when compared with other extract at 96 h (Fig. 3).

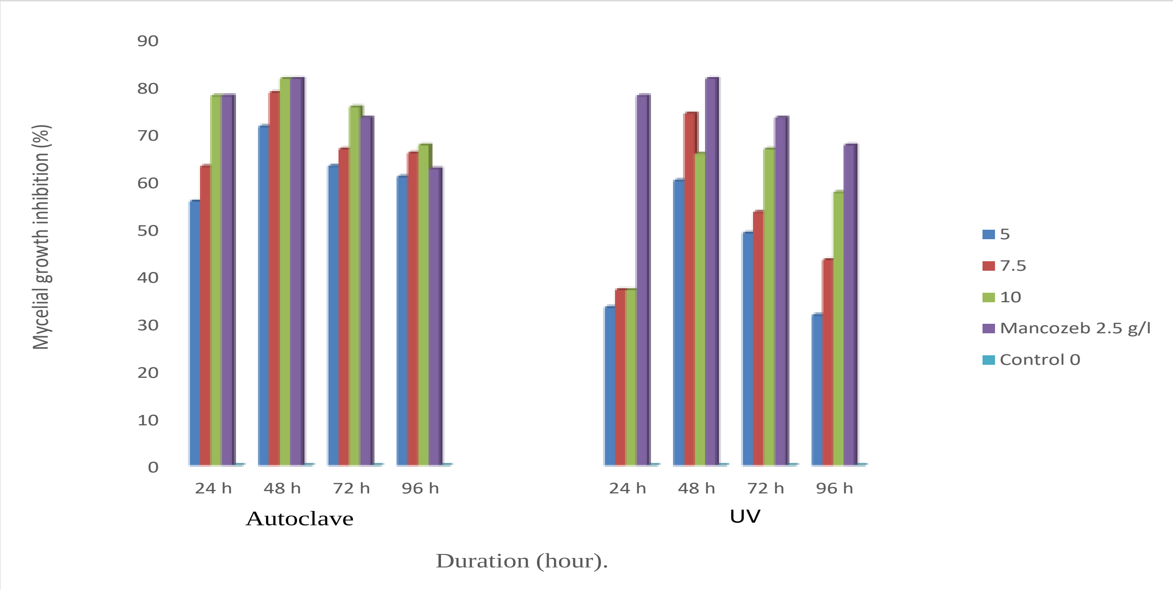

Figure 2. Effect of *A. leiocarpus* extract on mycelial growth of *S. rolfsii* Sacc

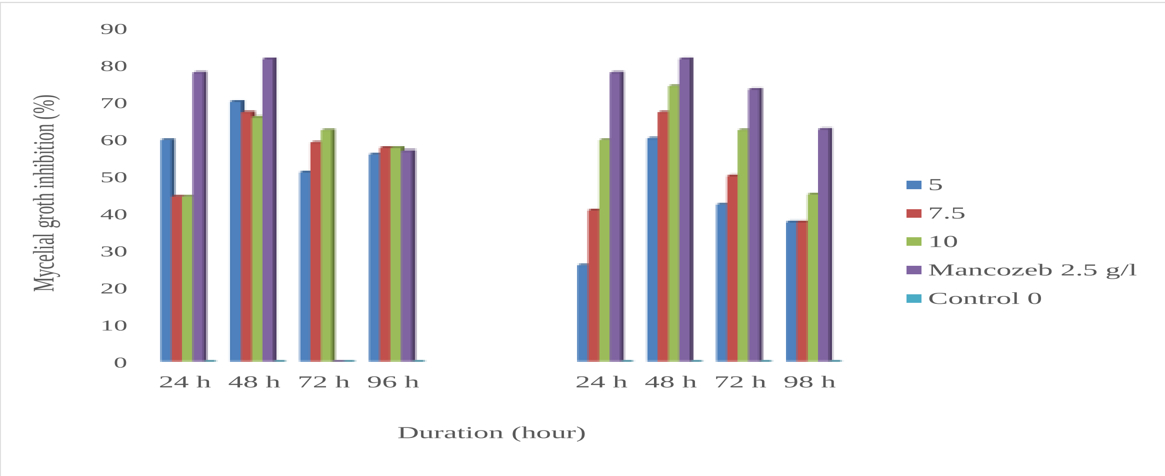

Figure 3. The effect of aqueous *Gmelina arborea* sawdust extract on *S. rolfsii*

Studies have shown that UV at 254 nm is effective against all pathogens, natural microbiota, moulds, and yeasts. Ultraviolet sterilized extracts from *Datura metel* L. at wavelength of 250-280 nm has been reported to enhance the potency and antimicrobial effect when the extracts were evaluated against 3 strains of pathogenic organisms (Abd-Allah *et al*., 2018). Ultraviolet radiation at 280nm for 45 minutes have also been reported to preserve the chemical and molecular components in Spathiphyllum plant (Metwally *et al*., 2019). Also, extracts of *C. nitida* has been reported to contains reasonable amounts of phenolic compounds including bioflavonoids, xanthones and benzophenones which reduced the mycelial growth of *Aspergillus niger*, *Aspergillus fumigatus* and *Mucor racemosus*. The effectiveness of *A. leiocarpus* sawdust extract in this study is corroborated by the findings of Mann *et al*. 2008, who reported that the root extract of *A. leiocarpus* was effective in inhibiting the growth of *Aspergillus* and *Penicillium* species. The root extract of *Gmelina arborea* have been reported to inhibit the growth of *Aspergillus niger*, *Penicillium notatum* and *Candida albicans* (Charu and Vinita, 2017) and also served as botanical fungicide (Okunji *et al*., 2007, Okoko, 2009). The results obtained from this study on the antifungal potential of the sawdust extract of *Cola nitida, A. leiocarpus* and *G. arborea* is corrobated by the report of Beckley and Awoyemi, (2021). The antifungal activity of constituents from the heartwood of *G. arborea* against *Trametes versicolor* and *Fomitopsis palustris* was also reported by Kawamura *et al* (2005).

CONCLUSION

This study revealed that sterilization method with high temperature such as in the autoclave could seriously damage the structure of bioactive compounds in extracts, which, in turn, decrease the activity (Watanabe 2002), and that higher concentrations (> 5%) of the plant extract should be considered for use if antifungal potential is expected (Adesegun *et al* 2014). Ultraviolet light sterilization is a better alternative for plant extract to avoid contamination and maintain the antifungal potential.

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COMPARATIVE EFFECTS OF NEEM EXTRACTS AND SYNTHETIC NEMATICIDES (CARBOFURAN) ON THE GROWTH AND YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS*) INFECTED BY ROOT KNOT-NEMATODE IN KOGI STATE NIGERIA

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ABSTRACT
The nematicidal effect of aqueous Azadiractha indica leaf extract and a standard synthetic nematicide, carbofuran were evaluated for their effect on pathogenicity of Meloidogyne spp on growth and yield of okra. The experiment was carried out during the 2019/2020 cropping season. There were seven treatments and control replicated three times in a Randomized Complete Block Design to give a total of twenty-four plots. Data collected on growth and yield parameter were subjected to analysis of variance (ANOVA) and means were separated using Duncan Multiple Range Test (DMRT) test at 5% level of probability. The results obtained indicated that effect of T7 (carbofuran) on okra was significantly better than all other treatments tested in both growth and yield characters. Also at harvest, galling was significantly lower in carbofuran treated plants compared to the neem treated plants. The control plants were most galled with poor yield and had stunted growth. The moderate concentrations of both neem (100ml aqueous, 200ml aqueous, 100ml ethanol, 200ml ethanol, 25g neem powder, 50g neem powder and 0.26g of carbofuran performed significantly (p<0.05) better than control plants in suppressing the effects of root-knot nematode on yield and growth of okra. These suggest that the neem extract have nematicidal property and would be effective in management of root-knot nematodes. Treatment T5 (Powder of neem 25g) had significantly better plant height and was therefore recommended to farmers in the study area, pending further studies.

Key words: Okra, Neem, Carbofuran, Aqueous, Azadirachta

INTRODUCTION
Okra (*Abelmoscus esculentus* (L) moench) belongs to the family Malvaceae. Okra is usually grown in Nigeria for its mucilaginous content. The importance of Okra as a vegetable crop lies in a drawing quality that aids easy consumption of bulky staple food like Gari, Fufu, and pounded yam (Agbogidi and Nweke, 2005). The mucilaginous extract from okra is reportedly useful in curing ulcer as well as the relief of humor hoods and also a dealing agent in sugar processing. (Schippers, 2000) noted that the tender pod contain vitamin A and C traces of B vitamin, Okra provide good source of calcium and other body building minerals that contribute to healthy living and is native of tropical parts of Africa but it is now widely grown in the tropics. The fruit is a long pod, usually ribbed, spineless in cultivated kinds and harvested when three-four inches long. Pods are harvested while still tender and immature. It is a tropical plant, which grows best in warm climate. It is available all year round, with a peak during summer months (Adekunle and Fawole, 2003). The pods grow rapidly being ready for harvest in about 30-40 days (depending on the variety) when grown from seed. But the plants will continue to bloom and produce pods if they are harvested continuously before they get too large. Root-knot nematodes (*Meloidogyne spp*) infect almost all types of pants and may cause considerable damage. During surveys, most vegetable crops including okra were found to be affected with *M. incognita*. Root-knot nematodes (*Meloidogyne spp*) are minute, worm-like animals which are very common in virtually in every environment. They are major pathogens of vegetables in the world, affecting both quantity and quality of marketable yields. With severe infestations of nematode, yields loss ranges between 10-50%, and the use of chemical (synthetic) nematicides have been discourages because of its residual effects and high toxicity to the soil. Nematode management is complicated and difficult and at present, chemical control is employed in many crops to maintain their populations below economic threshold levels (Abad *et al*., 2003, Eapen *et al*., 2005). Therefore, the researcher sorts to compare the effect of neem extract which is a natural nematicide, environmental friendly with synthetic nematicides on the growth and yield of okra infected with root knot nematode.

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MATERIALS AND METHODS

Description of Study Location

The experiment was carried out in a section of the Teaching and Research Farm of Kabba College of Agriculture, Ahmadu Bello University, Nigeria during the cropping seasons of 2019/2020. The site is located on the latitude of 07^0 35'N and longitude 06^0 08E and is 435m above sea level, in Southern Guinea Savanna Agro-Ecological Zone of Nigeria. Rainfall spans between April to November with the peak in June. The dry season extends from December to March. The mean annual rainfall is 1340mm per annum with an annual temperature range of 18-32˚C. The mean relative humidity (RH) is 60% (College of Agriculture Meteorological data, 2019). The major soilsin the experimental site are Alfisols and Ultisoils (Babalola, 2010).

The main vegetation of the area is; tall grasses, shrub, some trees, plantains, oil palm, etc. Some parts of the site are used such as cowpea, cassava, maize and tomato being planted.

Field Work

Okra seeds were source from Horticultural section of Kabba College of Agriculture, Ahmadu Bello University. The experiment was conducted using single field of dimension 12m x $8m^2$ which consisted of eight treatments and were replicated three times. The experiment was laid out in a Randomized Complete Block Design (RCBD). The treatments consisted of the followings: T1= Aqueous extract of neem at 100ml, T2=Aqueous extract of neem at 200ml, T3=Ethanol extract of neem at 100ml, T4=Ethanol extract of neem at 200ml, T5=Powder of neem at 50g, T6=Powder of neem at 25g, T7=Carbofuran 1.5kg ai/ha (0.26/stand) and T8=control.

Experimental Procedure

Seeds of Okra were sown on a flatbed; three seeds were planted at a spacing of 60cm x 30cm. The fully emerged plant was thinned down into two healthy plants per stand.

Source of Test Plant and Carbofuran

The text plant, *Azadirachta indica* (neem) was sourced for around Kabba College of Agriculture and synthetic nematicide; (carbofuran) was purchased from KI Bello Agro-Allied Nigeria Limited Muritala way Ilorin Kwara State, Nigeria.

Preparation of Test Plant

Fresh leaves of *Aradirachta indica* were harvested and chopped into pieces using blender. 1 kilogram (1kg) of tested leaves were taken and mixed with 1ltr of water and allowed to soak overnight, which was later sieved to obtain 100% test plant extract. From this 100% test plant extract the different levels of the plant extract were obtained as a treatment for application.

Extraction of Nematode Eggs

Galled root was collected from *celosia argentea* on which a pure culture of *Meloidogyne incognita* was raised. The galled root was washed properly under the running tap in order to get rid of the attached soil. The root was cut into small pieces and shaken with 5% of Sodium hypochlorite solution (NaOCl) (5ml parazone + a 5ml distill water for about 5minutes in a Kilner's jar (Hussey and Barker, 1973) in other to digest the gelatinous matrix encasing eggs. This was carried out at Land Mark University Science Laboratory in Omu- Aran Kwara State.

Inoculation

After fourteen days of planting the experimental plot was inoculated with juveniles of *Meloidogyne*. The size of each plot is 10 by 4 m; the experimental plots were inoculated with 50g of infected root of *celosia angentea* containing 1000 of *Meloidogyne incognita* at juvenile stage which was carried out in the field.

Data Collection

Data were collected from the experimental plots in the field one month after planting. Subsequently, data were collected at weekly interval based on the following parameters: Plant height (cm), was talking with the use of measuring tape, number of leaves was obtained by counting numerically, leaf area (m^2) was taking with the use of measuring tape, stem girth at 30 cm from the base of the plant (cm) was taken with the use of Vernier caliper, average pod weight (kg) this was obtained with the use of weighting scale, pod length (cm) was talking with the use of measuring tape, number of fruit per plant was obtained by counting numerically, Pod diameter (cm) was taken with the use of measuring tape and nematode population was taken at initial stage and final stage.

Data Analysis

Data collected from field experiments were subjected to the analysis of variance (ANOVA) using the SPSS version 21 and where there was a significant difference in their means. The New Duncan's Multiple Range Test (NDMRT) was used to separate them at a 5% level of significance.

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RESULTS

In the preliminary phytochemical investigations, it was observed that alkaloids tannins, phenols, flavonoids, terpenoids, sterols, saponins, glycosides and reducing sugar were present in the neem extract (Table 1). These compounds also serve to protect the plant against infections by parasitic nematodes, microorganisms, predations by insects and herbivores, while their odor and flavor are responsible for their pigments (El-Mahmood *et al*., 2008).

Table 1. Phytochemical Screening of Leaf Extracts *A. Indica* in Different Solvent.

Tests	Plant Extracts	
	Aqueous	Ethanol
Alkaloids	+	+
Flavonoids	+	+
Glycosides	+	+
Reducing Sugar	+	+
Tannins	-	+
Terpenoids	-	+
Saponins	-	+
Polysaccharides	+	+
Phytosterols	+	+
Phenols	+	+

There was significant difference between the treatments for plant height (cm), number of leaves, stem girth (cm), leaf area (m^2). The highest plant height was observed in treatment T5 (36.8cm), powder of neem at 25g, followed by T7 (36.4cm) carbofuran at 0.26g/stand (Table 2). The highest number of leaves, stem girth and leaf area was T7 (carbofuran), followed by T5 (powder of neem 25g). The lowest produced was observed in T8 (control).

Table 2. Effect of Treatments on Growth Parameter

Treatment	Plant height (cm)	Number of leaves	Stem girth (cm)	Leaf area (m^2)
T1- Aqueous of neem 100ml	29.4^b	20.4^a	1.66^a	1.14^c
T2- Aqueous of neem 200ml	26.8^b	19.5^a	1.84^a	1.08^c
T3- Ethanol of neem 100ml	32.1^{ab}	21.6^a	1.96^a	1.11^c
T4- Ethanol of neem 200ml	31.4^{a}b	18.7^a	1.81^a	1.23^{bc}
T5- Powder of neem 25g	36.8^a	22.4^a	1.96^a	1.31^{bc}
T6- Powder of neem 50g	29.6^b	20.1^a	1.87^a	1.54^{ab}
T7- Carbofuran	36.4^a	22.8^a	2.01^a	1.63^a
T8- Control	18.31^c	13.0^b	0.98^b	0.71
LSD	6.31	4.63	0.38	0.26

Average weight of pod (kg), pod length (cm), pod diameter (cm), and number of fruit per plant, were highly significantly better in T7 (Carbofuran 0.26g) compared to all others treatments. T5 have the same pod length (cm) with T7 (6.1). T8 had the lowest average pod weight (kg), pod length (cm), pod diameter (cm), and number of fruit per plant (Table 3).

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Table 3. Effect of Treatments on Yield Parameters

Treatment	Average pod weight(kg)	Pod length(cm)	Pod diameter(cm)	No of fruit per plant
T1-Aqueous 100ml	0.71^{b}	4.6^{b}	3.1^{a}	6.2^{c}
T2-Aqueous of neem 200ml	0.76^{ab}	5.3^{b}	3.1^{a}	7.4^{c}
T3-Ethanol 100ml	0.91^{ab}	5.8^{ab}	3.0^{a}	7.6^{bc}
T4-Ethanol of neem 200ml	0.94^{a}	5.7^{ab}	2.9^{a}	8.3^{ab}
T5-Power of neem 25g	0.85^{ab}	6.1^{a}	3.4^{a}	9.4^{ab}
T6-Powder of neem 50g	0.76^{ab}	6.0^{ab}	3.0^{a}	9.3^{ab}
T7-Carbonfuran	0.93^{a}	6.1^{a}	3.6^{a}	10.1^{a}
T8-Control	0.34^{c}	2.8^{c}	1.9^{b}	3.1^{d}
LSD	0.21	0.73	1.21	2.41

The initial nematode population was collected and the final nematode population was also collected (Table 4). The effect of the treatment uses to control the nematode population was express mathematically as: Efficiency of material use =value of treatment/value of control ×100.The result show that T7 (carbofuran at 0.26g) was 0.71 time better than the control, T3 was 2 times better than control, T1 was 9 times better than control.

Table 4. Effect of Treatment on Nematode Population

Treatment	Initial nematode population	Final nematode population	Efficiency of material used
T1-Aqueous of neem 100ml	1000	126	9.96
T2-Aqueous of neem 200ml	1000	84	6.64
T3-Ethanol of neem 100ml	1000	31	2.45
T4-Ethanol of neem 200ml	1000	63	4.98
T5-Powder of neem 100ml	1000	86	6.80
T6-Powder of neem 200ml	1000	46	3.63
T7-Carbonfuran	1000	09	0.71
T8-Control	1000	1264	

DISCUSSION

The findings of this study showed that both growth and yield parameters were significantly increased in treatments with plant materials and synthetic nematicide (carbofuran) whether infected or not with *Meloidogyne spp* compared to the plant that were untreated with botanicals and carbofuran. This could be as a result of the presence of some active ingredient present in carbofuran and test plant (neem extract). The results also revealed that the chemical components (alkaloids, tannins, phenols, flavonoids, terpenoids, sterols, saponins, glycosides, terpenoids, phenols and reducing sugar) present in *Azadiractha indica* leaf extract are responsible for the nematicidal effect on the root knot-knot nematodes (Saravanapriya and Sivakumar, 2005, Hayat *et al*., 2012, Onyeke and Akueshi, 2012).

These compounds also serve to protect the plant against infectious microorganisms, predations by insects and herbivores, while their odor and flavor are responsible for their pigments (El- Mahmood et *al*., 2008). The results revealed that significant increase in plant growth and yield parameters was observed when neem leaves extract were applied at 25g of powder of neem, 100ml of aqueous of neem and 100ml of ethanol of neem and carbofuran at 0.26gcompared to other doses. The aqueous neem extract and powder of neem improved plant growth parameters of okra over control. Plant growth and yield parameters of okra were improved significantly by all the different doses. These results are in agreement with Ramkrishnan *et al*. (1997) who reported increase in plant growth characters through botanicals as soil amendments. The study supports the findings of other researchers who reported the importance of various soil amendments in reducing plant-parasitic nematodes population to build up resulting in an increase in plant yield (Abolusoro and

Oyedunmade, 2008; Izuogu *et al*., 2015, 2016). The study revealed that the neem leaf extract used had significant nematicidal effects on *Meloidogyne incognita* as it caused a reduction in nematode population in okra compared to control. This is in line with the reports of some earlier researchers who reported that the effect of the different levels of extract on juvenile mortality could be due to the presence of tannins, alkaloids and flavonoids which have been reported to killed nematodes leading to effective reduction in nematode population by botanicals (Adegbite and Adesiyan, 2005), Umar, 2012).

CONCLUSIONS

These findings provided valuable data and information on the need to provide a wide support for nematicidal activity and suggest that the addition of botanicals to soil has potential for development as novel nematicides for the control of the root-knot nematodes. Neem extract incorporated to soil can be recommended as an alternative to nematicides. This knowledge will help in better developing the use of organic materials in the control of plant parasitic nematodes. However, more field trials need to be carried out on this material to test the efficacy under natural conditions.

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TOXICITY OF NEEM AND PALM KERNEL OIL MIXTURES AGAINST COWPEA BRUCHID (*CALLOSOBRUCHUS MACULATUS* L.: COLEOPTERA BRUCHIDAE) ON STORED COMMON BEANS, *PHASEOLUS VULGARIS* L.)

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ABSTRACT

The main delimiting factor in the wide acceptance of Neem (Azadiracta indica A. Juss) oil as a storage biopesticide is its foul sulfurous odour and bitter taste which impinges on the acceptability and marketability of treated produce. To reduce this shortfall, proportional mixtures of neem and palm kernel oils (PKO) were evaluated to test their effectiveness in the control of cowpea weevil (Callosobruchus maculates L.) with the aim of reducing some of the side effects of neem on treated produce. The treatment comprised common bean grains (Phaseolus vulgaris L.) and proportional admixtures of neem oil and palm kernel oil at the following mixtures per 50 g cowpea grains various concentrations: N_0P_0 = No neem, No PKO; N_1 = Neem at 1.0 ml; N_2 = Neem at 2.0 ml; 1N:1P_1 = 10 ml Neem + 10 ml PKO at 1.0 ml; 1N:1P_2 = 10 ml Neem + 10 ml PKO at 2.0 ml; 1N: 2P_1 = 10 ml Neem + 20 ml PKO at 1.0 ml; 1N:2P_2 = 10 ml Neem + 20 ml PKO at 2.0 ml; 1N: 3P_1 = 10 ml Neem+30 ml PKO at 1.0 ml; 1N:3P_2 = 10 ml Neem + 30 ml PKO at 2.0 ml; P_1 = PKO at 1.0 ml; P_2 = PKO at 2.0 ml. A synthetic pesticide (Phostoxin, P_t) at 0.2 g/kg cowpea grain served as the positive control. The treatments were laid out in a completely randomized design (CRD) on a laboratory bench and replicated three times. Data collected on adult bruchid mortality at 24 hours, 48 hrs, and 7 days after infestation (DAI), oviposition counts and percentage damaged grains were compared with the untreated samples. Results showed that grains that received 1N:1P_1, and 1N:1P_2 had significantly higher ($p < 0.05$) adult bruchid mortality, oviposition reduction and significantly lower ($p < 0.05$) grain damage compared to other treated and untreated grains. Their performance was closely comparable to Synthetic pesticide (P_t) as they showed high prospects with the standard positive control (Phostoxin, P_t) treated grains. They could therefore be evaluated further for use as effective bruchid control alternatives in place of the conventional insecticides or sole neem oil treatment.

Key words: Toxicity, Neem oil, Palm kernel oil, Cowpea bruchid, *Phaseolus vulgaris*

INTRODUCTION

Common beans (*Phaseolus vulgaris* L.) is an indigenous African legume crop belonging to the Fabacceae/Leguminosae family. It is an important edible legume crop in many parts of the world especially in tropical and subtropical regions. It has been reported to be of great economic importance in human and animal nutrition. Common beans is used as human food due to its high nutritional content especially protein content (Diouf, 2011). The genus *Vigna* contains about 170 plant species with the largest number occurring in Africa, but some are found in India, Australia and the New world. However, only three species of *Vigna* are important as legumes. Common beans (*Phaseolus vulgaris L.*) is the most important protein-source grain legume for direct consumption in the world (Broughton, 2003). Cowpea originated in the southern and east African region (Adesoya and Ojobo, 2015) but has spread and is now cultivated in more than 100 countries between 40° N and 30° S latitude. Nigeria is the second highest consumer of cowpea in the whole world (Egho, 2009). World production of cowpea was estimated to be 2.27 million tonnes of which Nigeria produces about 850,000 tonnes (about 37%) (FAO, 2002; Adaji *et al*., 2007). Cowpea is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics. FAO, (2001) and Islam *et al*. (2006) emphasized that all parts of the plant used as food are nutritious providing protein and vitamins.

It is widely recognized that one of the major constraints of cowpea production in African is the high incidence of insect pest and disease attacks which cause heavy losses. Zahra *et al*. (2006) reported that all stages of cowpea production were subject to damage and losses due to insect pests leading not only to substantial reduction in yield but reduced quality. What is eventually obtained by the farmer is far below the potential of the crop. According to them high yields of cowpea were largely hindered by insect pest damage and suggested that applying control methods could lead to yield increases. Cowpea suffers heavily from insects, both in the field and in the store. Yield reductions caused by insects can reach as high as 95%, depending on location, year, and cultivar (Carlos, 2000). Infestation begins in the field at low levels. After the crop is placed in storage, the insect population continues to grow until the cowpea is completely damaged. Among the insects which causes serious loss of cowpea seeds during storage is *Callosobruchus maculatus* (bean weevil) and *Bruchidius atrolineatus.* The importance of cowpeas to West African farmers and the destructiveness of the cowpea weevil to stored cowpeas have spurred many researchers and farmers in West Africa to assay a variety of potential protective measures. These include the use of oil, liquid and powdered extracts of pepper seeds, *Piper guineense,* ginger and cashew, sand, ash, plant materials, paprika and various neem products. For thousands of years, experimental knowledge of the use of botanical pesticides for pest control provided means for crop protection in different parts of the world even before the development of synthetic insecticides. Malik and Naqvi (1984); Su (1990); Dunkel and Sears (1998); Wongo (1998); El-Lakwah *et al*. (2002); Jbilou *et al.* (2006); Mamun *et al.* (2009); Hatil (2009) et c. at their various times and locations had worked with different parts of plant and extracts on stored product pests with encouraging results. Their various reports showed that these plant parts exerted their effects in various ways on the target pests including, insecticidal, repellent, development inhibition and ovicidal. Plant materials used in the control of this important pest of cowpea are cheap and sourced readily unlike the insecticides which come with so many attendant associated problems and health concerns. Moreover, peasant farmers and grain merchants can easily handle plant materials than the insecticides. These are why conventional insecticides are not the answer to the insect problems (Carlos, 2000).

The compounds in neem have demonstrated powerful effects against a very broad spectrum of phytophagous insects that compete with us for food and fibre (Grish, 2008). Neem has shown a variety of toxic manifestations, namely: inhibition of insect growth, deformations, inhibition of ecdysis, outright mortality, inhibition of protein synthesis and inhibition of protein transfer. The wide spectrum of toxic modes of action enhances neem's ability to slow down resistance development in phytophagous insects. Lale and Mustapha (2000), stated that some essential oils are highly lipophilic and therefore have the ability to penetrate the curticle of the insect or mite and that fatty vegetable oils kills insects by flooding their spiracles thus causing asphyxiation. Ofuya, (2002) used different essential oils to protect cowpeas and reported that oils extracted were potent in protecting stored cowpea seeds against infestation and damage by *C. maculatus.* According to his report, adult weevils are rapidly killed and oviposition and subsequent adult emergence may be completely prevented. Some researchers have proved the potentials in the use of neem oil to mitigate the deleterious effects of bean weevil attack on cowpea. Neem kernel extract of 1.69% w/w applied to the cowpea were effective in keeping the bruchids from developing (Lale and Mustapha, 2000). However, its usage has been faced with some challenges especially the problems of foul sulfurous smell and bitter taste (Ojiako and Kayode, 2014) besides the final input cost involved.

There have also been controversies on minimum effective ratios of the oil admixture that can effectively control the bruchids. Ilesanmi and Gunjuola, (2010), tried the following concentrations, 0.5 ml, 1.0 ml and 1.5 ml neem oil/200 g cowpea grains to check their efficacy on bruchids control and reported that the higher the dosage the higher the protection of grains. This work therefore seeks to assay the potency of Palm Kernel oil as a cheap adjunct to neem oil for the control of cowpea bruchid as a panacea for the foul sulfurous odour, bitter taste and high cost of neem oil when used alone. The objectives therefore were: 1) To evaluate the effect of neem oil and palm kernel oil (PKO) extract in the control of *Callosobruchus maculatus* infestation on cowpea and 2) To determine the best combination of Neem and palm kernel oils that will be most effective in the control of cowpea bruchid in stores.

MATERIALS AND METHODS

Location

The experiment was carried out at the Department of Crop Science Teaching and Research laboratory, University of Nigeria, Nsukka ($06^0$52ˈN, $07^0$24ˈE; 447.26 m asl) from February to August 2019.

Source and Preparation of Material

Local, untreated iron bean variety (*Phaseolus vulgaris*) were sourced from the grain reserve bank of the Department of Crop Science University of Nigeria, Nsukka, Enugu state Nigeria. The grains were handpicked to remove damaged ones and contaminants. The selected grains were placed inside polyethylene bags and fumigated against incipient cowpea weevils with phostoxin tablets at 0.83 mg /50 g cowpea. The tablet was sealed in a perforated paper with ten holes and

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placed inside the polythene bag containing the grains. The fumigant was left in the cowpea grain for 3 days. The grains were later exposed for 48 hours to ensure that the phostoxin gas was completely removed.

Neem and palm kernel oil

Technical grade processed neem oil (100 ml) was purchased from a processing company (Company name) at Gudu district, Abuja, Nigeria. Cold pressed technical grade palm oil was also procured from Ugo-grade Technical Company Emene, Enugu, Enugu State, Nigeria. These were stored properly in a cool dry place at a temperature of ± 5 ^{0}C until used.

Insect culture

Adult *Callosobruchus maculatus* were collected from naturally infested stored cowpea from Nsukka main market. Clean cowpea seeds (250 g) were weighed out into plastic breeding containers and adult bruchids were introduced into the container and kept under ambient temperature (30 °C ± 2 °C) and relative humidity (75% ± 5%). Each of the containers had 20 perforations which were covered with muslin cloth to ensure proper aeration and prevent escape of weevils. The grains and bruchids were allowed to stay until emergence of new bruchids which were used for the experiment.

The sexes of freshly emerged bruchids were determined by examining the elytral pattern (Uzuegbu, 2005). The females are usually dark coloured and possess four elytral spots; while the males are pale brown and less distinctly spotted. Furthermore, males have comparatively shorter abdomen and the dorsal side of the terminal segment is sharply curved downwards. In contrast, the females have comparatively longer abdomen and the dorsal side of the terminal segment is only slightly bent downwards.

Preparation of Test Materials

Neem oil (N) and palm kernel oil (PKO) were measured out as follows; Neem oil (0 ml, 1.0 ml, 2.0 mls), PKO (0 ml, 1.0 ml, 2.0 mls), Neem and PKO were also mixed in the ratio of 1N: 1P, 1N: 2P and 1N: 3P. Each mixture was also measured out at the same rate (0 ml, 1.0 ml, 2.0 mls). Phostoxin was applied at the recommended rate of 83 mg/50 g cowpea. The treatments were represented as follows:

N_0P_0 = No neem, No PKO

N_1 = Neem at 1.0 ml

N_2 = Neem at 2.0 ml

1N:1P_1 = 10 ml Neem + 10 ml PKO at 1.0 ml

1N: 1P_2 = 10 ml Neem + 10 ml PKO at 2.0 ml

1N: 2P_1 = 10 ml Neem + 20 ml PKO at 1.0 ml

1N:2P_2 = 10 ml Neem + 20 ml PKO at 2.0 ml

1N:3P_1 = 10 ml Neem + 30 ml PKO at 1.0 ml

1N: 3P_2 = 10 ml Neem + 30 ml PKO at 2.0 ml

P_1 = PKO at 1.0 ml

P_2 = PKO at 2.0 ml

P_t= Phostoxin at 0.2 g/kg cowpea grains.

Bioassay

Fifty gram (50 g) each of disinfected cowpea grains were weighed into 12 perforated plastic containers (500 mls) to which the different appropriate treatments were applied with a syringe. The mixture was shaken thoroughly and laid out on a laboratory bench in a completely randomized design manner with three replications. Ten adult weevils comprising five males and five female bruchids were selected and introduced into each container and the containers were left undisturbed until observation started 24th hour after treatment.

Data collection

i. Mortality count of adult beetle taken at 24 hours, 48 hours and 72 hours after infestation (dead insects were confirmed by poking with office pin).

ii. Number of eggs/ seeds on the 7th day after infestation (this was taken on 20 randomly selected grains).

iii. Number of seeds with eggs per plate (taken on the 7th day of infestation)

iv. Number of emerged adults (dead and alive) on the 1st, 2nd, 3rd week and on the 7th days from the first emergence.

v. Number of emergence holes per grain (taken on 20 randomly selected grains on the 7th day from 1st emergence)

vi. Number of grains with hole. (taken as in number v above)

From the data collected the following calculations were made.

a. $\% \text{ mortality} = \dfrac{\text{Number of dead insects}}{\text{Total number of insect introduced}} \times \dfrac{100}{1}$

b. % Damage (PD) = $\frac{\text{Total number of sampled grains perforated}}{\text{Total number of sampled grains}} \times \frac{100}{1}$

c. Weevil perforation index (WPI) = $\frac{\text{Total number of treated grains perforated}}{\text{Total number of untreated grains perforated}} \times \frac{100}{1}$

A WPI exceeding 50% is regarded as enhancement of infestation by the weevil or a negative ability of the plant material or insecticide tested.

Data Analysis

Data obtained were subjected to analysis of variance (ANOVA) using Genstat System for Window Version 8. Differences amongst treatment means were separated using Fishers least significant difference (F-LSD).

RESULTS

Table 1 shows the mortality rate of *Callosobruchus maculates* at 24 hours, 48 hours and 72 hours after infestation respectively as influenced by different treatments and dosage rates. The treatments differed significantly ($p < 0.05$) in their effect on beetle mortality across the various periods (hours) evaluated except at 72 hours after infestation. It was observed that P_t (phostoxin) had significantly ($p < 0.05$) higher beetle mortality at 24 hours compared to N_0P_0 (0.75) which had the least mortality. Phostoxin (P_t) recorded similar mortality effect at 24 hours after infestation with N_2 and P_2 and which were statistically similar to 1N:1P_2 (1.18) and 1N:3P_2 (1.17). Grains treated with 1N:3P_1 had significantly ($p < 0.05$) higher beetle mortality at 48 hours than P_t, N_2, 1N:1P_2 and P_2 which had the same and least mortality value (0.71).

At 72 hours after infestation, there were no significant differences ($p < 0.05$) in beetle mortality across the various treatments but 1N:1P_1 recorded the highest mortality value, while P_t, N_2 and P_2 had the least mortality. The treatments however recorded significant differences in oviposition. Untreated grains N_0P_0 (1.76) had significantly ($p < 0.050$) higher oviposition count compared to P_t, N_2, 1N: 1P_2, 1N: 3P_2 and P_2, which is statistically similar to other treatments.

The emergence of the cowpea bruchids at 1st, 2nd, 3rd weeks after infestation and 7th day from the first emergence (Table 2) showed no significant difference on the 1st and 2nd week after infestation for all the treatments as there was no beetle emergence (0.00) from all the treatments. However, on the 3rd week after infestation, beetle emergence differed significantly ($p < 0.05$) among the treatments. No treatment (N_0P_0) recorded significantly higher emergence (2.04) than all other treatments. This was followed by P_1 (1.00) though it is statistically similar to the values recorded by the other treatments. On the 7th day from first emergence (DFE), there were significant difference ($p < 0.05$) among the treatments. The control N_0P_0 had significantly ($P < 0.05$) higher bruchid emergence (1.77) than the other treatments except N_1, 1N:1P_1, 1N:3$P_1$and P_1 with which it had statistically similar value.

Effect of treatments on percentage damage, number of adult emergence holes/seed, number of seeds with emergence holes and weevil perforation index at 10th week after infestation (Table 3) showed that untreated grains N_0P_0 (2.36) recorded significantly higher ($p < 0.05$) damage than other treated grains except grains treated with 1N:3P_1 (1.64) and N_1 (1.26) while the least values were obtained from those treated with P_2 and P_t (0.71).

On the number of perforations on grains, untreated grains (N_0P_0) showed significantly ($p < 0.05$) higher perforations (3.89) than all other treated grains. 1N: 3P_1 also recorded significantly ($p < 0.05$) higher number of perforations than P_t and P_2 which had the least number of perforations (0.71).

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Table 1. Effect of Treatments on Mortality and Oviposition of adult Bruchids

Treatments	Mortality (Hrs)			Oviposition
	24	48	72	7DAI
P_t	1.22	0.71	0.71	0.71
N_0P_0	0.75	0.75	0.88	1.76
N_1	0.98	0.79	0.81	1.56
N_2	1.22	0.71	0.71	0.71
$1N{:}1P_1$	0.86	0.77	0.94	1.22
$1N{:}1P_2$	1.02	0.71	0.75	0.71
$1N{:}2P_1$	0.96	0.81	0.83	1.00
$1N{:}2P_2$	1.18	0.73	0.73	0.88
$1N{:}3P_1$	0.85	0.82	0.83	1.17
$1N{:}3P_2$	1.17	0.77	0.75	0.71
P_1	0.89	0.75	0.91	1.22
P_2	1.22	0.71	0.71	0.71
Mean	1.03	0.75	0.80	1.03
F-LSD$_{0.05}$	0.198	0.054	N.S	0.423

Where: P_t: phostoxin, N_0P_0: control, N_1: neem at 1.0 ml, N_2: neem at 2.0 ml, $1N{:}1P_1$:10 ml Neem + 10 ml pko at 1.0 ml, $1N{:}1P_2$:10 ml Neem+10 ml PKO at 2.0 ml. $1N{:}2P_1$:10 ml Neem + 20 ml pko at 1.0 ml, $1N{:}2P_2$:10 ml Neem+20 ml PKO at 2.0 ml. $1N{:}3P_1$:10 ml Neem + 30 ml pko at 1.0 ml, $1N{:}3P_2$:10 ml Neem+30 ml PKO at 2.0 ml. P_1: palm kernel oil (pko) at 1 ml, P_2: palm kernel oil (pko) at 2 ml. Data represent the square root transformed values. DAI = Days after infestation.

Table 2. Effect of treatment on emergence at 1st, 2nd, 3rd weeks and 7th day from first emergence (DFE).

Treatments	Adult emergence			
	Week 1	Week 2	Week 3	7th (DFE)
P_t	0.71	0.71	0.71	0.71
N_0P_0	0.71	0.71	2.04	1.77
N_1	0.71	0.71	0.88	0.88
N_2	0.71	0.71	0.71	0.71
$1N{:}1P_1$	0.71	0.71	0.88	1.00
$1N{:}1P_2$	0.71	0.71	0.71	0.71
$1N{:}2P_1$	0.71	0.71	0.71	0.71
$1N{:}2P_2$	0.71	0.71	0.71	0.71
$1N{:}3P_1$	0.71	0.71	0.88	1.00
$1N{:}3P_2$	0.71	0.71	0.71	0.71
P_1	0.71	0.71	1.00	1.10
P_2	0.71	0.71	0.71	0.71
Mean	0.71	0.71	0.89	0.89
F-LSD$_{0.05}$	NS	NS	0.36	0.526

P_t: phostoxin, N_0P_0: control, N_1: neem at 1.0 ml, N_2: neem at 2.0 ml, $1N{:}1P_1$:10 ml Neem + 10 ml pko at 1.0 ml, $1N{:}1P_2$:10 ml Neem+10 ml pko at 2.0 ml. $1N{:}2P_1$:10 ml Neem + 20 ml pko at 1.0 ml, $1N{:}2P_2$:10 ml Neem+20 ml pko at 2.0 ml. $1N{:}3P_1$:10 ml Neem + 30 ml pko at 1.0 ml, $1N{:}3P_2$:10 ml Neem+30 ml pko at 2.0 ml. P_1: palm kernel oil (pko) at 1 ml, P_2: palm kernel oil (pko) at 2 ml. DAI = Days after infestation. DFE= Day from first Emergence. (Data represent the square root transformed values).

The number of grains with perforations were significantly higher with the untreated (N_0P_0) (2.84) than with other treated grains but did not differ significantly with $1N{:}3P_1$ (1.94) treated grains where P_t and P_2 treated grains recorded the least perforations (0.71). Weevil perforation index (WPI)

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followed the same trend as the number of holes on grains and number of grains with holes. There were significant differences among the various treatments. N_0P_0 (31.49) had significantly ($p < 0.05$) higher WPI values which is similar to $1N:1P_1$ (24.19) while the treatment P_1 and P_2 showed the least index (12.20). The treatments $1N:1P_1$ and $1N:1P_2$ gave the same result for all the observations taken, they did not differ from each other (Table 3).

Table 3. Effect of treatments on percentage damage, number of holes/seed, number of seeds with holes and weevil perforation index at 10th week after infestation

Treatments	%DG	NHLS	NGHL	WPI
P_t	0.71	0.71	0.71	12.20
N_0P_0	2.36	3.89	2.84	31.49
N_1	1.26	1.46	1.46	19.75
N_2	0.96	1.17	1.05	15.70
$1N:1P_1$	0.83	0.88	0.88	13.95
$1N:1P_2$	0.83	0.88	0.88	13.95
$1N:2P_1$	0.96	1.17	1.05	15.70
$1N:2P_2$	0.96	1.05	1.05	15.70
$1N:3P_1$	1.64	2.23	1.94	24.19
$1N:3P_2$	1.14	1.39	1.29	18.00
P_1	1.50	2.00	1.77	22.71
P_2	0.71	0.71	0.71	12.20
Mean	1.15	1.46	1.30	7.96
F-LSD0.05	0.362	0.787	0.482	4.680

P_t: phostoxin, N_0P_0: control, N_1: neem at 1.0 ml, N_2: neem at 2.0 ml, $1N:1P_1$:10 ml Neem + 10 ml pko at 1.0 ml, 1N: $1P_2$:10 ml Neem+10 ml pko at 2.0 ml. $1N:2P_1$:10 ml Neem + 20 ml pko at 1.0 ml, 1N: $2P_2$:10 ml Neem+20 ml pko at 2.0 ml. $1N:3P_1$:10 ml Neem + 30 ml pko at 1.0 ml, 1N: $3P_2$:10 ml Neem+30 ml pko at 2.0 ml. P_1: palm kernel oil (pko) at 1.0 ml, P_2: palm kernel oil (pko) at 2 ml. %DG: percentage damage on grains, NHLS: number of holes on grains NGHL: number of grains with holes, WPI: weevil perforation index. Data represent the square root transformed values.

DISCUSSION

The results obtained from this study showed that the two botanicals, neem oil and palm kernel oil extract and their admixtures can be effective in controlling *Callosobruchus maculatus* (cowpea weevil). As seen from the results, the highest rates of PKO and Neem (P_2 and N_2) exerted the highest mortalities within 24 hours of infestation. This corroborates the report of Emeasor *et al*. (2005) which states that botanical materials provide more effective control of insect pests at higher doses. Chukwulobe and Echezona (2014) also reported that 0.5 g and 1.0 g *Eugenia aromatic* powder were not as effective as 2.0 g in causing mortality of *Tribolium castaneum* in stored root/tuber chips. Results portrayed that the oil mixtures were effective in causing mortality within 24 hours of treatment.

This agreed with the reports of Grish (2008) that toxicity of these materials were expressed within 48 hrs of treatment. Makanjuola (1989) also reported that botanical extracts were toxic to *C. maculatus* within 48 hours of application. The minimum effective rate of neem oil, palm kernel oil extract and their admixtures in the control of the bruchids as seen in this study agreed with that earlier reported by Achio *et al*. (2012) that there was a direct relation between the active material concentration, rate of application and degree of lethal effectiveness. The performance of the botanical oil extracts did not differ with that of P_t (phostoxin) which was the standard positive control. This was a good indication that P_2 and N_2 can be good substitutes for P_t as storage protectants. These were similar to the effects of mixtures especially of $1N:2P_2$ and $1N:3P_2$. The result portrayed by these mixture levels may have been as a result of proper coverage of the grains by the oil extract at that quantity. As expected, however, the least mortality levels at 24 hours was observed in the negative control (no treatment). This agreed with the report of Adebola and Yusuf, (2016).

Mixtures applied at 1ml however had mortality values comparable to the no treatment control.

The effect of treatment on emergence of bruchids at first, second and third weeks of infestation and sevent day from the first emergence showed greater weevil emergence from the no treatment (control) grains. This was however expected as there was no protectant administered on the grains. Emergence started in the control plate on the third week after infestation and it was highest throughout the period of observation. Emergence was not observed at all from P_t, P_2, N_2, $1N:1P_2$, $1N:2P_1$, $1N:2P_2$, $1N:3P_2$. All these treatments totally suppressed beetle emergence from the treated plates. This could be as a result of the larger volumes of the oil to cause asphyxiation by flooding the spiracles, thereby causing death of adult insects, their eggs, larvae and pupae. This is in agreement with the report of Ofuya (2002), Lale and Mustapha, (2000).

On percentage damaged cowpea grains and weevil perforation index (WPI), P_t and P_2 gave the highest protection to the grains. This was followed by $1N:1P_1$, $1N:1P_2$ and $1N:2P_1$ and $1N:2P_2$. This trend was same for the number of perforations, number of grains with perforations and the weevil perforation index. Lower doses of neem and PKO were not very efficient in rescuing the grains from beetle attack and subsequent damage. This corroborate reports by many researchers (Emeasor *et al*., (2005); Chukwulobe and Echezona (2014); Ravi and Gayatri (2007) et. c).

The effect of the different treatments showed different protective abilities of the botanical oils and their admixtures when applied to stored grains. Generally, grains stored with the botanical oils recorded more bruchids mortality, reduced oviposition rate, decreased number of emerged insects and less damaged grains (hence decreased WPI) than the control (N_0P_0).

All parts of the neem tree, *Azadiracta indica* are insecticidal although the seeds possess the largest concentrations of azadirachtin, a steroid; tetranortiterpenoid, and nimbidic acid which possess a wide range of biological activities (Biswas, 2002). The mode of action includes feeding and oviposition deterrence, growth impairment, repellency and toxic insecticidal effects against 400 to 500 insect species in at least10-13 orders (Debashri, 2012). The use of neem oil extracts in storage pest control have been well documented against *C. maculatus* on Bambara groundnut (Obeng, 2014), on cowpea (Maina, 2004) and other stored products, legumes, sorghum, maize, wheat, rice, etc.

CONCLUSION

The study is ongoing so more research should be encouraged to find out the palatability and viability of grains treated with the various admixtures that showed prospects as effective measures of control especially those that has produced results that are comparable with the synthetic chemical (phostoxin) in terms of control of cowpea bruchid, *Callosobruchus maculatus*. Based on the above results, therefore, the following admixtures $1N:1P_1$, $1N:1P_2$, $1N:2P_1$, and $1N:2P_2$, which are next in effectiveness to the sole PKO oil, Neem oil and Phostoxin should further be studied for adoption as storage protectants, especially for *Callosobruchus maculatus*. Further studies will also help to discover the best mixtures in their ratios that will reduce the foul odor and bitter taste associated with neem oil on the grains and their cost effectiveness. Since the use of Neem extracts has been proven to be economically effective, it can be a better choice for farmers in the preservation of stored bean grains. PKO at 2 ml/50 g can also be used as an effective sole control agent as it caused a high percentage mortality on the insect population and is not associated with bitter principles.

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FIELD ASSESSMENT OF JORKEMIL PLUS FOR THE CONTROL OF BLACK POD DISEASE OF COCOA

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ABSTRACT

A fungicide, Jorkemil Plus, with active ingredients Cuprous oxide 62% and Metalaxyl-M 12% was evaluated for its efficacy in the management of black pod disease of cocoa caused by Phytophthora megakarya in Nigeria. The field trials were laid out and conducted on a Randomized Complete Block Design (RCBD) on F_3 Amazon cocoa variety at the Experimental Stations of Cocoa Research Institute of Nigeria (CRIN) at Onigambari (Oyo State), Owena (Ondo State) and Ajassor (Cross River State). This fungicide was applied on the flowers, cherelles and cocoa pods. The fungicide was tried at the experimental stations simultaneously as spray applications at twenty-one (21) days interval. The records on incidence of black pod and pod production were taken at the same interval. The percentage black pod disease incidence by Jorkemil Plus was significantly lower (0.00-7.14%) than that of the control (6.35-29.69%). Cocoa pod production on the targeted cocoa trees during the trial revealed that the application of Jorkemil Plus enhanced cocoa tree yield potential by 18.27-29.78% compared with the reference fungicide (16.00-22.84%).

Key words: Cocoa, Black pod, *Phytophthora,* Fungicide, Cuprous oxide, Metalaxyl-M

INTRODUCTION

Cocoa is a highly prized commodity crop with its beans being a major export commodity for several countries in West Africa (WCF, 2014a; Abbott, 2013; ECA, 2013). Although the crop is native to the upper Amazon region of America, it is cultivated in Central and South America, Southeast Asia and Central and West Africa (WCF, 2014a; 2014b; ICCO, 2010). Cocoa is grown widely in the tropics, specifically in the tropical belt, within 15-20 degrees North and South of the equator (WCF, 2014b). The natural habitat of the cocoa tree is in the lower storey of the wet humid tropics and evergreen rainforest (ICCO, 2013; Orwa *et al*., 2009).

Production of cocoa is constrained everywhere it is cultivated. Among these are ageing trees, declining soil fertility and most especially, pests and diseases. In West and Central Africa, diseases are responsible for the majority of the losses. Black pod disease account for a larger percentage of the losses. *Phytophthora palmivora*, a pan tropical species and *P. megakarya,* an aggressive and extremely destructive species, are responsible for black pod disease (Agbeniyi, *et al.,* 2014; Kolawole *et al.,* 2014; USDA, 2014; Akrofi *et al.,* 2012).

In Nigeria, *P. megakarya* is the predominant species, highly virulent and very destructive (Kolawole and Goss, 2016). In some cocoa growing agro-ecologies, it could cause total loss of cocoa pod if not controlled. It is controlled by cultural practices and application of fungicides, which are mostly copper and metalaxyl-based. The use of fungicides is very popular among farmers because of its quick and relatively effective action. Nevertheless, relying solely on chemical in the control of black pod diseases is not advised. The use of fungicides should be the last resort in the disease management approach (Poole and Arnaudin, 2014). Securing effective control of the disease through fungicide application in the field depends on disease pressure and effectiveness of the fungicide. Therefore, it is of necessity to evaluate fungicides for their effectiveness before usage on cocoa plantations. Cocoa Research Institute of Nigeria (CRIN) is the only government agency in Nigeria saddled with the responsibility to assess fungicides for use on cocoa. Thus, the objective of this work is to evaluate Jorkemil plus, a metalaxyl based fungicide, for its effectiveness in the control of black pod disease of cocoa.

MATERIALS AND METHODS

Trial location and experimental layout

The cocoa plantation for the field trials were the experimental stations of Cocoa Research Institute of Nigeria (CRIN) located at Onigambari (Oyo State), Owena (Ondo State) and Ajassor (Cross River State), Nigeria. The cocoa plantations at the trial stations were purposefully selected based on history of high incidence of black pod disease during main and light cocoa cropping seasons. The experimental plots for this trial comprised of F_3 Amazon cocoa varieties planted at 3.1m x 3.1m spacing and the experimental design was Randomized Complete Block Design (RCBD) with 3 blocks. The treatment plots were demarcated and comprised of 27 cocoa trees per block, separated by guard rows of untargeted cocoa trees. Each treatment was replicated in triplicates per block.

Spray Application

The field application of test fungicide (Cuprous oxide 62% + Metalaxyl-M 12%) was evaluated at concentrations of 30g/15L, 40g/15L and 50g/15L. The spray application was targeted at the flowers, cherrelles and pods on the cocoa trees. An established fungicide known to be very effective in management of black pod disease on cocoa was used as reference (positive control) for test fungicide, while the cocoa stands without fungicide application served as negative control. Five fungicide spraying applications at the early hours of the day were conducted at 21 days' interval between June and November. The trials were simultaneously conducted at the selected locations. Post-treatment records of black pod incidences, number of cherrelles and pod production were taken at regular intervals.

Data Analysis

All data obtained in these trials were subjected to analysis of variance (ANOVA). Means of the treatments were compared using Duncan Multiple Range Test (DMRT) at ($p \leq 0.05$).

RESULTS AND DISCUSSION

The post-treatment data obtained on incidences of black pod disease from the trial Stations showed that there was no significant difference ($p \leq 0.05$) in the management impact of the test fungicide (Jorkemil Plus) and the reference fungicide on black pod disease of cocoa (Table 1). However, there was a significant difference ($p<0.05$) between that of the test fungicide (0.00-7.14%) and the untreated control (6.35-29.69%). The test fungicide applied at 50g/15L was more effective in the management of cocoa black pod disease. Results of the field trial corroborate the earlier findings of Orisajo *et al.* (2011) which reported the efficacy of copper oxide and metalaxyl in the management of black pod disease of cocoa. However, field reports have shown that the most effective and widely used active ingredients against black pod disease are the copper and metalaxyl-based fungicides. Findings from the trial have also shown coherence with the field report, as cuprous oxide 62% +Metalaxyl-M 12% have proven to be very effective in the management of black pod disease.

There was a significant increase in pod production on the cacao plot treated with the test fungicide- Jorkemil Plus (at 30, 40 and 50g/15l water) in all trial locations compared with the untreated control (Table 2). The observed increase in pod production could be attributed to the efficacy of the test fungicide's active ingredients in suppressing black pod incidence on the trial plot. This in turn permitted the expression of the inherent yield potentials of the cocoa trees treated with cuprous oxide and metalaxyl based fungicides such as Jorkemil Plus. The improvement on cocoa pod yield observed is similar to earlier study of Khan *et al*. (2006) which reported yield increase in cocoa occurring as a result of pesticide application. Norgrove (2007) also reported a 60% increase in yield of cocoa pod due to the application of fungicides.

CONCLUSION

Results obtained from this research justifies the recommendation of Jorkemil Plus as an effective fungicide for managing black pod disease of cocoa and for improving pod production, thereby making cocoa business more profitable to the farmers.

Table 1. Effect of Jorkemil Plus on incidence of black pod disease of cocoa at different trial locations

Treatment	Concentration	% diseased pods at different fungicide application						% black pod disease incidence
		1	2	3	4	5	6	
IBADAN								
Jorkemil Plus	30g/15L	0.00a	1.00a	0.00a	0.11a	0.00a	0.22a	1.98
	40g/15L	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00
	50g/15L	0.00a	0.00a	0.00a	0.00a	0.00a	0.00a	0.00
Reference-1	50g/15L	0.00a	0.44a	0.00a	0.00a	0.00a	0.08a	1.22
Control	-	0.00a	0.55a	0.77a	0.00a	0.26a	0.26a	6.35
OWENA								
Jorkemil Plus	30g/15L	0.22b	0.66b	0.22b	0.33b	0.11b	0.30b	4.46
	40g/15L	0.44b	0.44b	0.22b	0.22b	0.11b	0.28b	2.71
	50g/15L	0.11b	0.55b	0.55b	0.44b	0.11b	0.35b	2.19
Reference-1	50g/15L	0.00b	0.55b	0.77b	0.44b	0.00b	0.35b	3.89
Control	-	2.33b	3.00a	2.88a	1.88a	1.66a	2.35a	29.69
AJASSOR								
Jorkemil Plus	30g/15L	0.22b	0.55a	0.11a	0.22a	0.77a	0.37a	4.42
	40g/15L	0.66ab	1.44a	0.11a	0.55a	0.77a	0.70a	7.14
	50g/15L	0.00b	0.22a	0.11a	0.33a	0.22a	0.17a	4.64
Reference-1	50g/15L	3.55a	0.66a	0.22a	0.77a	0.22a	1.08a	12.69
Control	-	3.66a	0.55a	0.33a	1.00a	0.88a	1.28a	19.31

*Means followed by the same letter in the same column are not significantly different according to DMRT ($P \leq 0.05$).

Table 2. Number of cocoa pods produced at each fungicide application at different trial locations

Treatment	Concentration	1	2	3	4	5	Total	Pod Production (%)
IBADAN								
Jorkemil Plus	30g/15L	67	84	135	114	94	494	24.39
	40g/15L	110	122	130	109	109	603	29.78
	50g/15L	47	62	115	96	96	427	21.09
Reference-1	50g/15L	28	48	82	75	75	324	16.00
Control	-	13	21	41	45	117	177	8.74
OWENA								
Jorkemil Plus	30g/15L	112	94	90	62	28	386	19.96
	40g/15L	126	126	97	56	26	431	22.29
	50g/15L	125	121	107	63	32	447	23.11
Reference-1	50g/15L	105	81	109	79	45	419	21.66
Control	-	75	71	51	33	21	251	12.98
AJASSOR								
Jorkemil Plus	30g/15L	97	78	61	69	63	368	21.83
	40g/15L	123	87	59	83	64	416	24.67
	50g/15L	76	67	59	54	52	308	18.27
Reference-1	50g/15L	96	92	63	68	66	385	22.84
Control	-	70	41	37	37	36	209	12.39

*Each value represents mean of three replicates

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IN-VITRO EVALUATION OF DIFFERENT CONCENTRATION OF FUNGICIDES AGAINST FUNGAL ISOLATES OF CABBAGE

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ABSTRACT

Cabbage (Brassica olercea var. capitata) is an eminent vegetable crop that is an important part of human diet all over the world. It forms a major source of vitamins and fibre that is taken in form of vegetables. The potential production of cabbage is mainly restricted by leaf spot disease caused by fungal pathogen. This disease is prevalent in all parts of the tropics where these crucifers are being produced. This makes farmers use fungicides indiscriminately for the management of pathogens, thereby endangering the lives of humans and also causing environmental pollution. Because of this injudicious use, the profits made by farmers do not commiserate with the expenses made through the procurement of fungicides thereby bringing down farmers' profits. An experiment was carried out to find the potency of three fungicides of varied chemistry and different concentrations against mycelia growth of Alternaria brassicicola under in-vitro condition. It was found that Mancozeb 630g/kg + Carbendazim 120g/kg (Green force) and Mancozeb 80%WP (Z- force) completely inhibited the mycelia growth at 400ppm. Thus it was concluded that these two fungicides could be used in field conditions for the management of Alternaria leaf spot at the same concentration, in a sequential manner to avoid environmental pollution and resistance development in the pathogen alongside with increasing the farmers' income.

Keyword: Cabbage, alternaria leaf spot, fungal isolates, identification

INTRODUCTION

Biotic and abiotic factors are the major causal agents of plant diseases. These diseases play a vital role in the decline of products in agriculture. Apart from biotic and abiotic factors, genetic abnormalities also contribute to these declines. Among the biotic factors are fungi, bacteria, viruses, viriods, phytoplasmas, nematodes, parasitic higher plants and protozoans (Agrious, 2005). Gonzalez-Fernandez and Jorrin- Novo (2010) reported that among the plant pathogens that poses serious threat to Agricultural production; the phytopathogenic fungi are the most prominent parasitic organisms as compared to others. Ong (2011) reported also that approximately the presence of approximately 20,000 fungal species of plant pathogen and about 85% of these species are highly pathogenic. They are known to decrease yield worldwide (Boyraz ans Ozcan 2006). In southern Nigeria, crops are frequently infected by pathogens especially fungi due to the weather condition of the region. This attack by these pathogens causes both loss of yield in quality and quantity. Cruciferous vegetables are severely attacked by different species of Alternaria which may be either *A. brassicicola* or *A. brassicacea* or even other species of Alternaria. These pathogens cause leaf spot of these vegetables that belongs to the brassica family. Application of commercial fungicides remains the most convenient and predominant way for disease control. Their use has made it feasible for crop yield enhancement. The efficacy of fungicides is influenced by many biological and environmental factors that directly act on the metabolic activities of the fungal cells (Reinprecht, 2010). Indiscriminate application by farmers who do not have prior knowledge of the content of the fungicides and its application strategies also pose a lot of danger to the consumers and also environment. Also, in some cases, the critical concentration is not effective long-term as the fungi become resistant to those fungicides. The objective of this research was to check the efficacy of different concentrations of fungicides against *Alternaria sp*, the cause of leaf spot of cabbage.

MATERIALS AND METHODS

The vegetable was grown at the department of Crop Science teaching and research farm, Department of Crop Science, University of Nigeria, Nsukka. The basic agronomic practices for the propagation of these vegetables were followed. The heads of infected vegetable (Cabbage) was collected from the field and kept in paper bags. The sample was surface sterilized with 5% Sodium Hypochlorite (NaOCl) solution. Distilled water was used to wash the sample thoroughly for five times. Small pieces of the heads were cut, containing nearly half an infected portion and half healthy section. They were placed on potato dextrose agar (PDA) medium containing streptomycin to avoid contamination by bacteria. Incubation of the plated was carried out at 28 $^oC\pm1^oC$ for one week at 12-hour dark/light photo period (Meena *et al*. 2017). Single spore Isolation technique was used to purify the isolated pathogen culture. It was maintained in PDA slants for future investigations.

Identification of the pathogens

The isolated fungal culture was identified following the conventional taxonomic methods which included the characteristics of the colony and the spores. *Alternaria spp* was identified. The conidia were harvested from the border of isolated culture and placed on the microscopic slide having a drop of lactophenol solution to study the spore characteristics. Checking was done regularly at 24-hours interval for their colony characteristics. The identification was carried out on the basis of description given by the phytopathogen in different manuals and books (Barneth and Hunter, 1998; Gillman and Joseph, 1998).

The pathogenicity test

The identified pathogen isolate was tested for its pathogenicity on healthy vegetables under study to establish its pathogenic nature as per Koch’s postulates. The seed of the vegetable was taken and surface sterilized with 5% Sodium hypochlorite solution and washed thoroughly with distilled water, sown and allowed to grow for six weeks in a bag filled with sterilized top soil. The spore suspension of the identified Alternaria isolated was prepared at 2 x 10^6 colony forming unit (CFU) per milliliter and sprayed on the six week old vegetables. The inoculated vegetable was covered with transparent polythene in order to maintain humidity. Control vegetable was sprayed with distilled water. The symptoms development was recorded at 2, 4, 6, an 8 days after inoculation (DAI). Samples were isolated from the inoculated vegetables and compared with the original culture.

***In-vitro* evaluation of the fungicides against the fungal pathogen**

This experiment was laid out using completely randomized design (CRD) in the Department of crop science Plant pathology laboratory, replicated three times. Three fungicides were evaluated, viz- mancozeb 80%, mancozeb 630g/kg +carbendazim and Azoxystrobin 200g/l + difeconazole 125/l (Z-Force, Green Force and Fungicare respectively) to ascertain their ability to control the pathogen by poisoned food technique (Schmitz, 1930). Amendment of the P.D.A was done on all fungicides with 100, 200, 300, 400 and 500 ppm along with the control. They were paired into sterilized Petri plate and kept for solidification. A seven-day old pure culture of *Alternaria brassicicola* isolate was used for inoculation and 5mm discs were placed in the centre of each plate containing the fungicides along with the control. All the treatments were replicated 3times and they are kept at 28°C ± 1°C sealed with paraffin wax strips. Colony growths in each treatment were recorded 24 hourly until the plate got completely covered with the fungus. Inhibition percentage in the fungicide treatments were calculated over the control by using the formula below.

$$Percentage\ inhibition = \frac{X-Y}{X} X \frac{100}{1}$$

Where X= colony growth in control.

Y= colony growth in fungicide treatment.

Arcsine square root was used to transform the data collected before data analysis

Data analysis

Data collected were subjected to analysis of variance (ANOVA) using GenStat 10th edition release statistical software. Mean separation was done using Fishers least significance test at 5% probability level as described by Obi (2002).

RESULTS

Isolation and identification of pathogen

The isolated fungi formed a dark mycelia colony in appearance due to pigmentation. The colony texture is smooth. The isolated fungi produced hyphae that was initially hyaline which later converted to dark colour septate and branched mycelium. The conidiophores arise singly and bunchy to form vegetative hyphae. The coniodiophore is dark, geniculate and have a swollen base. The basal cell of the conidia is swollen and tapered towards the apex. The morphological descriptions of the colony and conidia of the phytopathogen validates the description given by (Barneth and Hunter, 1998) about *Alternaria brassicicola.*

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Healthy cabbage

Infected cabbage

Pathogenicity test.

The initial symptoms of the inoculated cabbage were observed three days after it was transplanted. The symptoms appeared on the lower leaves and at 8WAT (weeks after transplanting), when the cabbage has started forming head, the dark spot appeared on the cabbage head, the spot coalesced and enlarge rapidly. The fungus was re-isolated using the symptomatic leaves of the inoculated plants. It showed almost the same characteristics to the original culture, thus completing all the criteria of Koch's postulates and confirming the pathogenicity of the isolated *Alternaria Brassicicola* culture to be pathogenic on cabbages.

***In-vitro* evaluation of different concentrations of fungicides against the fungal pathogen**

The in-vitro evaluation of fungicare (Azoxystrobin 200g/l + Difeconazole 125g/l), Green force (Mancozeb 630g/kg + Carbendazim 120g/kg) and Z-force (Mancozeb 80% WP) at 100, 200, 300, 400 and 500 ppm showed that they could all significantly inhibit the growth of *Alternaria brassicicola* Table 2. At 100, 200, and 300 ppm concentrations, Green force showed the maximum inhibition of mycelia growth while Fungicare recorded the minimum inhibition of the mycelia growth. At 400 and 500 ppm concentrations, Green force and Z-force showed total inhibition of mycelia growth followed by fungicare that recorded the 91.29 % and 93.06 % respectively. This proves that all the fungicides possess inhibitory actions against Alternaria brassicicola as all the results are statistically significant. Moreover, Green force and Z-force proves to be more effective against the phyto pathogen as they can inhibit the growth of mycelia at 400 and 500 ppm concentrations.

Table 1. Effect of different concentrations of fungicides on the mycelia growth (cm) on isolated Alternaria brassicicola of cabbage

Treatment	Average mycelial growth (mm) of different concentrations in parts per million					
	100	**200**	**300**	**400**	**(400)**	**500**	**(500)**
Fungi Care	13.85	11.85	10.09	7.84	(2.81)	5.80	(2.42)
Green Force	5.45	4.58	2.07	0.0	(0.22)	0.00	(0.22)
Z-Force	10.43	7.19	4.14	0.0	(0.22)	0.00	(0.22)
control	90	90	90	90	-	90	-
L.S.D (0.05)	**0.757**	**0.625**	**0.265**	**0.628**	**(0.117)**	**0.406**	**(0.087)**
SE	**0.379**	**0.313**	**0.133**	**0.314**	**(0.058)**	**0.203**	**(0.043)**
CV%	**3.8**	**4**	**2.4**	**12**	**(5.4)**	**10.5**	**(4.6)**

Values in parenthesis are square-root transformed values to which LSD is applicable.

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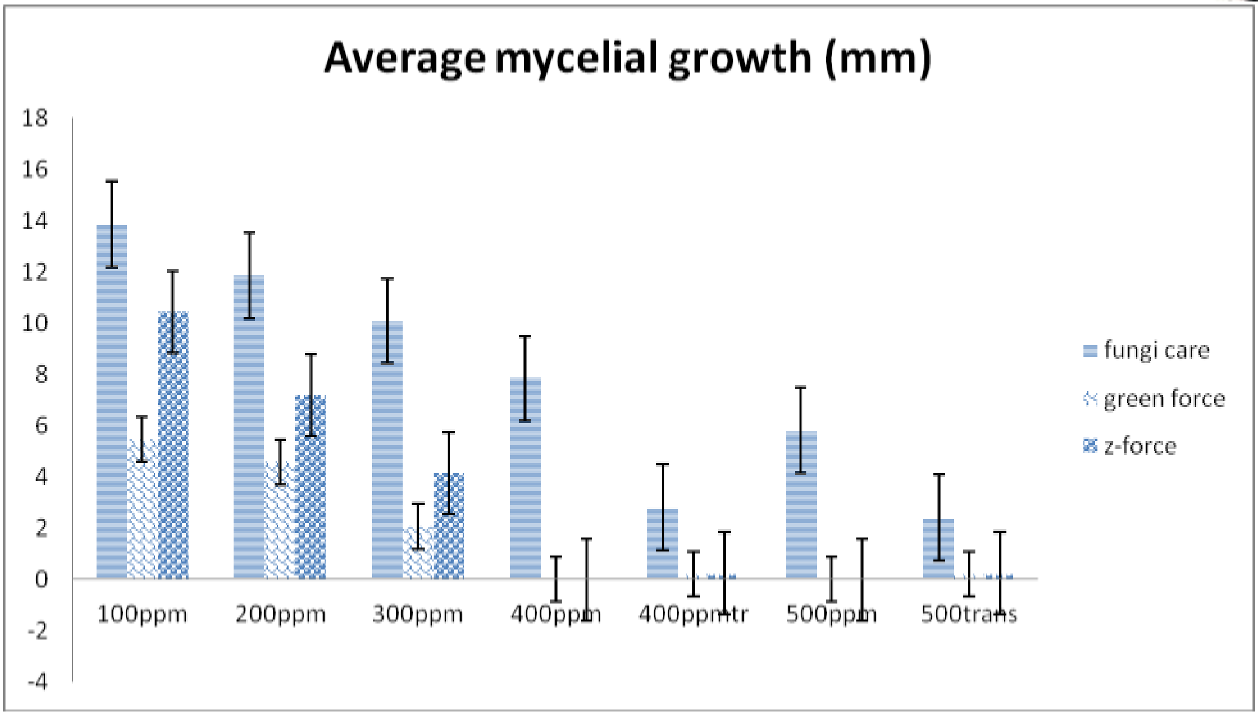

Figure 1. Average mycelia growth

Table 2. Effect of different concentrations of fungicides on the mycelia growth inhibition on isolated Alternaria brassicicola of cabbage

Fungicides treatments	Average mycelial growth inhibition percent (%) of different concentrations in parts per million				
	100	200	300	400	500
Fungi Care	84.61	86.83	88.79	91.29	93.56
Green Force	93.97	94.91	97.7	100	100
Z-Force	88.41	92.01	95.4	100	100
Control	0.00	0.00	0.00	0.00	0.00
L.S.D (0.05)	**0.828**	**0.690**	**0.290**	**0.701**	**0.453**
SE	**0.414**	**0.346**	**0.145**	**0.351**	**0.227**
CV%	**0.5**	**0.4**	**0.2**	**0.4**	**0.2**

DISCUSSION

In this study, the different concentrations of the fungicides used had an inhibitory effect on the mycelia growth of Alternaria leaf spot on cabbage. The fungicide that contains carbendazim and mancozeb had the most effect. However most of the fungicides used did not differ significantly as all of them showed that they can be used to control ALS in *in-vitro* conditions. A similar inhibitory action of Mancozeb and Carbendazim 50%WP was demonstrated by Kumar *et al*. (2017), Jong-hwan *et al*. (2017), Saha *et al*. (2018), and Rajeswari and Balasupramani (2020) on *Alternaria* leaf blight of tomato, ginseng, cabbage, and pigeon-pea, respectively.

CONCLUSION AND RECOMMENDATION

All the fungicides studied were effective in inhibiting the mycelia growth of the isolate. The 400 and 500 ppm concentration of both green force (Mancozeb + Carbendazim) and Z- Force (Mancozeb 80%WP) was more effective as it gives total inhibition at these concentrations. On the basis of these results, I recommend Mancozeb + Carbendazim) and Z-Force (Mancozeb 80%WP) for the *in vitro* control of *Alternaria brassicicola*, that cause leaf spot of cabbages. However, detailed research is needed to solve the long lasting problem for the farmers and also residual analysis is recommended for field trial to ascertain safe consumption for consumers.

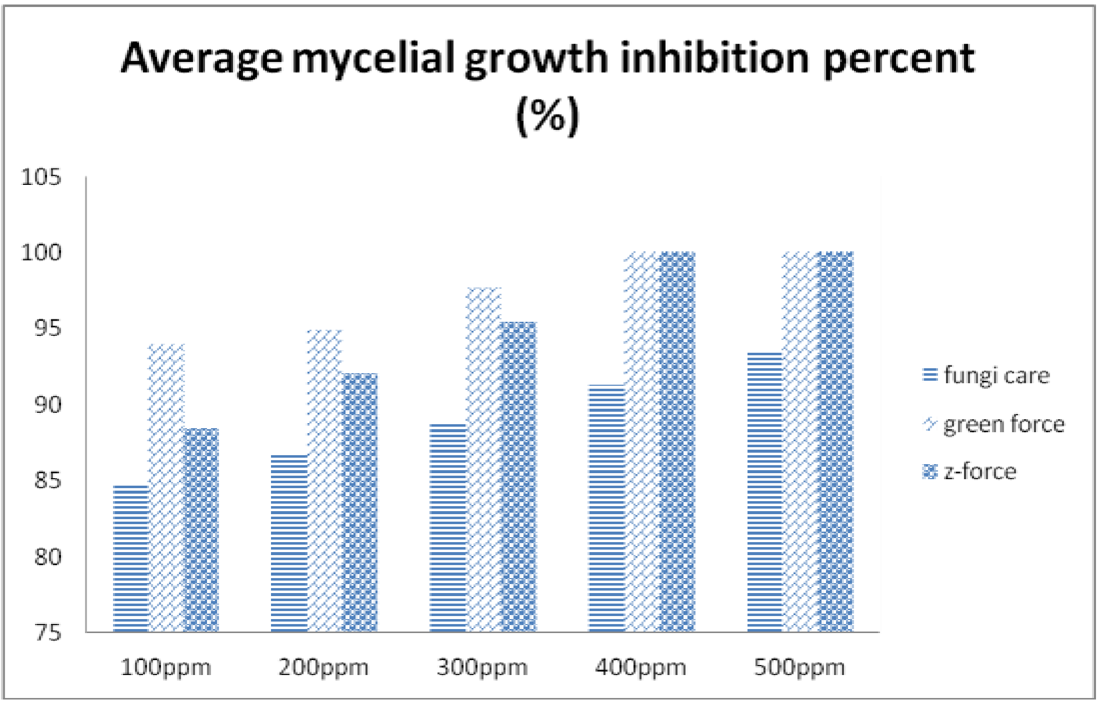

Figure 2. Average mycelial growth inhibition (%)

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PHYTO-SOCIOLOGICAL ATTRIBUTES OF ARABLE WEEDS IN SUNFLOWER PRODUCTION (*HELIANTHUS ANNUUS* L.) IN KANO STATE

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ABSTRACT

Field studies was conducted during the 2018 and 2019 growing seasons at Bayero University Kano (BUK) (Latitude 11° 58.861' N and longitude 008° 25.155' E, altitude 449 m above sea level) and National Horticultural Research Institute (NIHORT). Located at Bagauda in Bebeji Local Government Area of Kano State (Latitude 11^0 33^{1}N and longitude 8^{0}23^{1}E with altitude of 481m above sea level) in the Sudan Savannah of Nigeria in order to determine the Phyto-sociological attributes of arable weeds of the area drylands. Random quadrat method was adopted for the phytosociological studies. In each location, sixty-four plot were randomly selected. In each experimental locations quadrats of 4 m2 size were laid down and hence sum of 124 quadrats were randomly thrown for each location. Within each quadrat area, weeds were identified, counted and weed cover scores were recorded. Weeds were cut at ground level, fresh and dry weights were determined. Pennissetum violaccum, Paspalum tremula, Cassia occidentalis, Ipomea specie, Cynodon dactylon, Cyperus retundus, Acanthuspermum hispidum, and Sida acuta, were the most dominant species in the drylands of Bagauda and BUK that have 5% and above compared to either weeds specie in the locations. Weed density, weed cover scores as well as fresh and dry weight of weed samples from Bagauda were observed to be higher than that of BUK. Morphological characteristics of those weed spp found in Bagauda and BUK were aggressive and can easily dominate the area if not control and lead to low yield of sunflower and other related crops. The study suggested that there is strong need to start an Integrated Biological weed management in the study areas.

Keyword: phyto-sociological attributes, weeds, relative density, relative frequency, Summed ratio, Specie and Quadrant

INTRODUCTION

Sunflower (*Helianthus annuus* L.) belongs to the family Asteraceae order Asterales. It is an important oilseed crop which ranks third after soybean and groundnut as a source of edible oil in the world (Oyinlola *et al*., 2010). The crop originated in North America (anonymous, 2016). Today it has become naturalized in many locations of the tropics and is widely cultivated in Africa. *Helianthus annuus* was introduced into Africa through colonial masters and it was widely cultivated in South Africa. Although statistical data on production level and hectares in Nigeria are not available (Adebayo *et al* 2010), grain yield above 1 t ha-1 has been reported depending on cultivars planted (Olowe *et al* 2005). However, due to its potential and high oil content its cultivation is now rapidly expanding in other agro-ecological zones of Nigeria.

Weed control had been one of the fundamental problems of crop production (Farooq *et al.,* 2008). Weeds left unmanaged caused massive yield losses in sunflower field crops (Jabran *et al.,* 2008 *and Jabran et al.,* 2010). Yield losses in major crops have been reported by several authors. In Nigeria half of the effort devoted to crop production is spent on weed control. Other problems associated with weeds in agriculture include: reduced crop quality by contaminating the commodity interference with harvest; serve as hosts for crop diseases or provide shelter for insects to overwinter, reduced crop quality by contaminating the commodity. Weed drastically reduced sunflower yield to about 70 to 80 percent lost (Anonymous, 1998). Research studies have demonstrated that there was up to 80% yield loss in okra as a result of weed infestation (Aladesanwa and Adejobi, 2007).

MATERIAL AND METHODS

Field studies were conducted during the 2018 and 2019 rainy seasons at Bayero University Kano (BUK) (Latitude 11° 58.861' N and longitude 008° 25.155' E, altitude 449 m above sea level) and National Horticultural Research Institute (NIHORT) at Bagauda in Bebeji Local Government Area of Kano State (Latitude 11^0 33^1 N and longitude 8^0 23^1 E with altitude of 481m above sea level) in the Sudan Savannah of Nigeria. The treatments consisted of three plant spacing (30 cm x 75 cm, 65 cm x 75 cm and 70 cm x 75 cm) and eight weed control methods. These were factorially combined and laid out in split plot design and replicated three times. Spacing was the main plot and weed control methods sub plot. Plot size was 6m × 7m long consisting of six ridges with spacing of 75cm between rows and Alley ways of 1.0 m was allowed between the plots and 2 m between the replicates. A 1 m by 1 m quadrant was randomly thrown in different plots to extrapolate and determine the relative density, relative frequency and summed ratio of weeds present at Bagauda and BUK in 2018 and 2019 rainy season.

Phytosociological Attributes of Weed

The phytosociological attributes of weeds such as relative frequency, relative density and Summed domance ratio were calculated according to the principles of Curtis and McIntosh (1950). The following formulae was used to calculate the relevant phytosociological attributes of weeds were.

$$Relative\ frequency\ = \frac{frequency\ of\ individual\ weed\ specie}{Total\ frequency\ of\ all\ specie} X\ 100$$

$$Relative\ density\ = \frac{density\ of\ individual\ weed\ specie}{Total\ density\ of\ all\ specie} X\ 100$$

$$Summed\ Dormance\ Ratio\ = \frac{relative\ frequency + relative\ density}{2} X\ 100$$

RESULTS AND DISCUSSIONS

Phytosociological Attributes of Weed Species Associated with sunflower

Weed Specie Composition

The results of the study show that, the weed species composition consisted of different species of broad leaved, narrow leaved and sedges in association with the production of sunflower in 2018 and 2019 rainy seasons in the experimental sites are presented in Table 1. The results indicated a total number of thirty-five (35) weed species associated with Sunflower at Bagauda and BUK.

This is in line with Weber et al. (1995) reported 74 weed species in intensified cerealbased cropping systems in northern Guinea savanna of Nigeria under terrestrial condition. Twenty-five (25) species are broad leaved appeared in all the years at both locations. The most dominant species among the broad leaved weeds across the years include *Acanthuspermum hispidum, Amaranthus spinusis, Cassia occidentalis, Euphorbia heterophylla L., Evolvulus alsinoids, Ipomea aquatica, Ipomea furera, Vernonia cinerei, Minosa invisa, and Sida acuta appeared* in both years at both locations. Lado et al., (2016) reported in his results indicated that only three narrow leaved species (Cynodon dactylon, Sorghum halepans and Typha species) consistently appeared in all locations in both seasons indicating their wide spread. These weeds were dominant may be due to rainfall and favorable climatic condition that govern their production in both areas. Farmers has to control weeds to maximize the yield because weeds reduced yield to reasonable percentage. Weeds left unmanaged caused massive yield losses in sunflower field crops (Jabran *et al.,* 2008 *and Jabran et al.,* 2010). This was in line with Das, (2011) and Awodoyin and Akande, (2014) that reported weed is any plant, native or non-native that interferes with crop by competing with crops for limited resources in agroecosystems and has the habit of encroaching where it is not wanted. Weeds develop rapidly and are able to self-pollinate, disperse widely and tolerate wide range of environmental conditions (Akubundu, 1987; Frick and Johnson, 2012). There were 12 narrow leaved associated with sunflower production. The most dominant species are *Cynodon dactylon, Panacum laxum, Paspalum tremula, Pennissetum violaccum,* and *Schwenekia Americana* in 2018 at Bagauda.

Lado et al., (2016) reported that Ten (10) broadleafspecies constituting 42% of the total weed species (Ageratum conyzoides, Azolla pinnata, Eichornia natans, *Hydrilla* speciesIpomea asorifolia, Melochia corchorifolia, Nymphaea lotus, *Phyllanthus* amarus, *Polygonum salicifolium* and *Portulaca oleraceae).* Three sedges are dominant weed species across the experimental years and at both locations. They include *Cyperus ferosta, Cyperus retundus and Kylinga squamulata* in 2018 and 2019 at Bagauda and BUK respectively. Other weed species like *Leunotis nepetipollia* appeared only at BUK in 2018 and 2019 while *Tepprosia linearis* and *Oldenlandia carymbosa* appeared only at Bagauda in 2018 rainy season.

Table 1. Effect of Spacing and weeds Control Method on Weed Specie Composition of Sunflower at Bagauda and BUK in 2018 and 2019 Rainy Season

	Bagauda Level of Occurrence	BUK Level of Occurrence

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Weed specie	2018	2019	2018	2019
Broad leaf species				
Acanthuspermum hispidum	**	***	**	***
Amaranthus spinusis	*	**	*	**
Asphilia Africa	*	*	*	*
Cassia occidentalis	***	***	***	***
Cleom viscosa L.	*	*	*	*
Crotalaria macrocalyx	*	-	*	*
Digitaria horizontalis	*	*	*	*
Euphorbia heterophylla L.	**	**	***	-
Evolvulus alsinoids	***	***	***	*
Imperita cylindrica	*	--	*	-
Ipomea aquatica	**	***	*	*
Ipomea furera	**	**	**	**
Leunotis nepetipollia	_	-	***	**
Vernonia cinerei	***	***	**	*
Metrocarpus villosus	***	***	***	***
Minosa invisa	***	***	*	*
Monechmi citistum	*	-	-	*
Senna abtusifolia L.	*	*	*	*
Sida acuta	*	**	*	**
Tepprosia linearis	*	-	-	-
Tridex procumbens L	*	*	*	**
Narrow leaf species				
Cynodon dactylon	**	**	**	**
Eragrostic arrovirens L.	*	*	*	*
Hydrolea palustris	*	-	*	-
Leucas matinenicensis	*	*	*	*
Mariscus longibracteautus	*	-	*	-
Oldenlandia carymbosa	*	*	-	-
Panacum laxum	*	*	*	**
Paspalum tremula	***	***	***	***
Pennissetum violaccum	***	***	***	***
Phyllatum amarus	*	*	*	-
Physslis ungulate L.	*	*	-	*
Schwenekia Americana	**	**	**	**
Sedges species				
Cyperus ferosta	***	***	***	***
Cyperus retundus	***	***	***	***
Kylinga squamulata	**	**	**	**

- absent, * low occurrence (1–39%), ** moderate (40-59%), *** high occurrence (60-100%)

Relative Frequency

The relative frequency of weed species associated with sunflower at Bagauda and BUK in 2018 and 2019 was presented in Table 2. In 2018 at Bagauda only 4 species recorded relative density of 5 % and above. Among them *Pennissetum violaccum* and *Paspalum tremula* had the highest frequency followed by *Metrocarpus villosus, Evolvulus alsinoids and Cassia occidentalis.* However, in 2019 season in this location up to 7 weed species recorded the relative frequency of 5 % and above. Among which *Pennissetum violaccum* had the highest relative frequency followed by *Paspalum tremula, Cassia occidentalis, Ipomea aquatica, Ipomea furera, Cynodon dactylon, Cyperus retundus* and *Cyperus ferosta*. About 22 weeds species recorded less than 1 % relative frequency in 2018 while 11 species recorded less than 1 % relative frequency in 2019 in this location. However, 6 weed species appeared in 2018 but absent in 2019 they include *Crotalaria macrocalyx, Imperita cylindrica, Monechmi citistum, Tepprosia linearis, Hydrolea palustris* and *Mariscus longibracteautus*. While at BUK only 5 weed species appeared in 2018 but absent in 2019.

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Table 2. Relative Frequency of Weed Specie at Bagauda and BUK in 2018 and 2019 wet season

	Bagauda		BUK	
Weed specie	2018	2019	2018	2019
BROAD LEAF				
Acanthuspermum hispidum	0.7	0.5	4.0	3.0
Amaranthus spinusis	0.8	2.5	2.5	2.0
Asphilia Africa	0.7	1.5	1.5	1.0
Cassia occidentalis	4.0	6.0	2.0	3.5
Cleom viscosa	0.2	2.0	0.5	0.2
Crotalaria macrocalyx	0.2	-	0.5	0.4
Digitaria horizontalis	0.8	0.6	2.0	0.3
Euphorbia heterophylla	3.7	2.5	1.5	-
Evolvulus alsinoids	5.7	2.5	5.0	4.0
Imperita cylindrica	0.8		4.0	-
Ipomea aquatica	0.3	5.0	0.5	2.5
Ipomea furera	2.2	5.0	1.0	5.0
Leunotis nepetipollia	_		5.0	-
Vernonia cinerei	3.2	2.5	0.5	0.2
Metrocarpus villosus	8.7	5.0	10	8.0
Minosa invisa	0.4	0.3		0.1
Monechmi citistum	0.1	-	0.5	0.3
Senna abtusifolia	0.7	0.2	2.0	0.2
Sida acuta	0.2	0.4	2.5	6.0
Tepprosia linearis	0.1	-	0.5	-
Tridex procumbens	0.6	2.0	1.0	3.5
NARROW LEAF	-		-	
Cynodon dactylon	0.4	6.0	0.4	0.5
Eragrostic arrovirens	0.9	0.6	3	0.4
Hydrolea palustris	0.1	-	0.5	0.2
Leucas matinenicensis	2.0	3.5	5.5	3.5
Mariscus longibracteautus	0.1	0.3		-
Oldenlandia carymbosa	0.8	2.5	2.5	1.5
Panacum laxum	0.9	0.3	3.0	-
Paspalum tremula	17.2	15.0	15	10.0
Pennissetum violaccum	32.1	25.0	24.0	25.0
Phyllatum amarus	0.3	-	0.5	0.3
Physslis ungulate	0.2	0.1	0.1	-
Schwenekia Americana	4.8	2.0	2.5	3.0
SEDGES	-			
Cyperus ferosta	0.7	3.5	0.8	5.0
Cyperus retundus	0.7	4.0	2.2	4.0
Kylinga squamulata	3.2	1.5	7	3.0
TOTALS	100	100	100	100

They include *Euphorbia heterophylla, Imperita cylindrica, Hydrolea palustris, Mariscus longibracteautus, Phyllatum amarus.* 24 weed species appeared in all the experimental years and at both locations such as *Acanthuspermum hispidum, Amaranthus spinusis, Asphilia africa, Cassia occidentalis, Cleom viscosa L, Digitaria horizontalis, Evolvulus alsinoids*, *Ipomea aquatica, Ipomea furera, Vernonia cinerei, Metrocarpus villosus, Minosa invisa, Senna abtusifolia L, Sida acuta, Tridex procumbens L, Cynodon dactylon, Eragrostic arrovirens L., Leucas matinenicensis, Panacum laxum, Paspalum tremula, Pennissetum violaccum, Schwenekia Americana, Cyperus ferosta, Cyperus retundus and Kylinga squamulata.*

The relative frequency of weed specie composition at BUK in 2018 and 2019 as presented in Table 2. In 2018 only 7 specie recorded the relative frequency of 5 % and above. These are *Evolvulus alsinoids, Leunotis nepetipollia, Leucas matinenicensis, Paspalum tremula, Pennissetum violaccum* and *Kylinga squamulata.* In 2019 at the

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same location 5 weed specie recorded relative frequency of 5 % and above. These are *Ipomea furera, Metrocarpus villosus, Sida acuta, Paspalum tremula, Pennissetum violaccum and Cyperus ferosta.*12 and 11 weed specie recorded less than 1 % of relative frequency in 2018 and 2019 season respectively in this location.

Relative Density

The relative density of weed species at Bagauda and BUK in 2018 and 2019 season was presented in Table 3. In 2018 at Bagauda *Pennissetum violaccum* had the highest relative density followed by *Paspalum tremula*. However, in same location in 2019 only four weed specie recorded 5 % and above. This include *Pennissetum violaccum, Paspalum tremula, Metrocarpus villosus* and *Evolvulus alsinoids* however in 2019 eight weed species recorded 5 % and above of relative density. They are *Acanthuspermum hispidum, Cassia occidentalis, Ipomea aquatica, Sida acuta, Cynodon dactylon, Paspalum tremula, Pennissetum violaccum* and *Cyperus retundus*. About 24 weed species recorded less than 1 % of relative density in 2018 while 9 specie record less than 1 % relative density in 2019. Only 6 weed species appeared in 2018 and they were absent in 2019 season in this location. They are *Crotalaria macrocalyx, Imperita cylindrica, Monechmi citistum, Tepprosia linearis, Hydrolea palustris and Mariscus longibracteautus.*

The relative density of weed species associated with sunflower at BUK in 2018 and 2019 season was presented in Table 3. At BUK in 2018 only 6 specie had relative density of 5 % and above. This included *Cassia occidentalis, Evolvulus alsinoids, Vernonia cinerei, Metrocarpus villosus, Leunotis nepetipollia, Paspalum tremula* and. In 2019 up to 10 weed species had relative density of 5 % and above in this location. They include *Acanthuspermum hispidum, cassia occidentalis, Sida acuta, Cynodon dactylon, Eragrostic arrovirens, Paspalum tremula, Pennissetum violaccum, Cyperus ferosta, Cyperus retundus and Kylinga squamulata* 17 and 10 weed species had relative density of less than 1 % in 2018 and 2019 season respectively.

Summed Dormancy Ratio

The summed dormancy ratio of weed specie at Bagauda and in 2018 and 2019 season was presented in Table 4. In 2018 season at Bagauda only 5 species recorded summed dormancy ratio of 5 % and above. Among them *Paspalum tremula* had the highest followed by *Pennissetum violaccum and Metrocarpus villosus.* However, in 2019 season in this location up to 12 weed species recorded summed dormancy ratio of 5 % and above. Among which *Paspalum tremula* recorded the highest followed by *Metrocarpus villosus, Pennissetum violaccum, Cyperus ferosta, Schwenekia Americana, Kylinga squamulata, Cyperus retundus, Imperita cylindrica, Evolvulus alsinoids, Cleom viscosa, Monechmi citistum and Acanthuspermum hispidum.* About 13 weed species recorded summed ratio dormancy of less than 1 % in 2018 while 3 weed species recorded less than 1 % summed ratio in 2019 in this location. However, there were species that were appeared in 2018 and were absent in 2019.

Table 4 presented the Summed Dormancy Ratio Associated with Weed at BUK in 2018 wet season in this location. 8 species recorded summed dormancy ratio of 5 % and above. Among these are *Pennissetum violaccum, Paspalum tremula, Kylinga squamulata, Cyperus retundus, Cyperus ferosta, Metrocarpus villosus, Leunotis nepetipollia, and Evolvulus alsinoids.* However, in 2019 at the same location 13 weed species recorded the summed dormancy ratio of 5 % and above. They include *Pennissetum violaccum, Paspalum tremula, Kylinga squamulata, Cyperus retundus, Cyperus ferosta*, *Evolvulus alsinoids*, *Evolvulus alsinoids Digitaria horizontalis, Cassia occidentalis and Acanthuspermum hispidum.* 11 and 6 weed species recorded the summed density ratio of less than 1 % in 2018 and 2019 season respectively.

Table 3. Relative Density % at Bagauda and BUK in 2018 and 2019 wet season

	Bagauda		BUK	
Weed specie	2018	2019	2018	2019

BROAD LEAF				
Acanthuspermum hispidum	1.4	5.5	3.1	6.0
Amaranthus spinusis	0.8	3.0	1.6	4.0
Asphilia Africa	0.7	0.5	1.7	2.5
Cassia occidentalis	4.0	6.0	6.2	5.5
Cleom viscosa	0.2	0.5	0.3	0.2
Crotalaria macrocalyx	0.2	-	0.2	0.5
Digitaria horizontali7	0.8	1.5	0.8	0.4
Euphorbia heterophylla	3.7	3.0	4.0	-
Evolvulus alsinoids	5.7	4.0	5.2	0.2
Imperita cylindrica	0.8	--	0.9	-
Ipomea aquatica	0.3	5.0	0.4	0.6
Ipomea furera	2.2	2.5	2.4	2.5
Leunotis nepetipollia	_	-	5.0	2.0
Vernonia cinerei	3.2	3.5	3.4	0.5
Metrocarpus villosus	8.7	4.5	6.5	3.0
Minosa invisa	0.4	0.2	0.4	0.2
Monechmi citistum	0.1	-	-	0.1
Senna abtusifolia	0.7	0.6	0.8	1.5
Sida acuta	0.2	5.0	0.6	5.0
Tepprosia linearis	0.1	-	-	-
Tridex procumbens	0.6	0.5	0.1	4.5
NARROW LEAF			-	
Cynodon dactylon	0.4	5.0	0.4	7.0
Eragrostic arrovirens	0.9	0.5	0.9	6.0
Hydrolea palustris	0.1	-	0.1	-
Leucas matinenicensis	2.0	0.1	1.9	0.5
Mariscus longibracteautus	0.1	-	0.1	-
Oldenlandia carymbosa	0.8	0.3	-	-
Panacum laxum	0.9	0.5	0.9	2.5
Paspalum tremula	17.2	15.0	9.3	8.5
Pennissetum violaccum	32.1	20.0	27.3	15.0
Phyllatum amarus	0.3	0.1	0.3	-
Physslis ungulate	0.2	0.1	-	0.1
Schwenekia Americana	4.8	2.3	4.9	2.5
SEDGES	-	-	-	
Cyperus ferosta	0.4	5.0	0.4	7.4
Cyperus retundus	0.7	3.0	0.8	5.5
Kylinga squamulata	3.2	3.5	4.0	5.5
TOTALS	100	100	100	100

Table 4. Summed Dormancy Ratio Associated with Weed at BUK in 2018 and 2019 Wet Season

	Bagauda		BUK	
Weed specie	2018	2019	2018	2019

BROAD LEAF				
Acanthuspermum hispidum	1.1	5.0	3.2	6.0
Amaranthus spinusis	0.9	3.2	2.0	4.0
Asphilia Africa	1.2	2.2	1.6	3.2
Cassia occidentalis	2.4	3.0	4.1	9.0
Cleom viscosa	0.3	7.0	0.4	0.8
Crotalaria macrocalyx	0.2	-	0.4	0.8
Digitaria horizontalis	1.2	1.1	1.4	5.0
Euphorbia heterophylla	2.4	3.0	2.8	-
Evolvulus alsinoids	5.2	6.2	5.1	11.0
Ipomea aquatica	0.4	-	0.4	-
Ipomea furera	1.5	3.0	1.7	3.5
Leunotis nepetipollia	_	3.0	5.0	10.0
Vernonia cinerei	1.8	-	1.9	3.2
Metrocarpus villosus	11.9	22.0	8.3	16.0
Minosa invisa	0.5	1.0	0.7	1.4
Monechmi citistum	0.2	5.0	0.3	0.6
Senna abtusifolia	1.1	-	1.4	2.5
Sida acuta	0.7	1.4	1.6	3.2
Tepprosia linearis	0.2	-	-	0.6
Tridex procumbens	1.1	2.2	0.1	
NARROW LEAF	-	0.5	-	0.5
Cynodon dactylon	0.7	1.4	0.9	2.0
Eragrostic arrovirens	1.5	3.0	1.9	3.5
Hydrolea palustris	0.2	-	0.3	-
Imperita cylindrica	1.7	6.0	2.5	5.0
Mariscus longibracteautus	0.4	0.8	0.6	-
Oldenlandia carymbosa	1.3	2.6	1.7	-
Panacum laxum	1.5	3.0	-	3.0
Paspalum tremula	25.5	20.0	12.2	22.5
Pennissetum violaccum	18.9	15.5	19	25.0
Phyllatum amarus	0.3	0.6	0.4	0.8
Physslis ungulate	0.5	1.0	0.6	1.0
Schwenekia Americana	4.2	8.2	3.7	7.5
SEDGES	-		-	
Kylinga squamulata	3.3	6.0	5.8	10.0
Cyprus ferosta	5.0	8.0	10.0	12.0
Cyperus retundus	3.5	6.0	7.0	10.0
TOTALS	100	100	100	100

CONCLUSION AND RECOMMENDATION

The results of the study showed that weed drastically effect horticultural crops thereby reducing yield, increased cost of production, hinder pest and diseases, reduced the value of the produced. *Pennissetum violaccum* and *Paspalum tremula* had the highest frequency, relative density and summed ratio followed by *Metrocarpus villosus, Evolvulus alsinoids and Cassia occidentalis.* Therefore, there is need to control these weeds through integrated weed control to burst horticultural crop production. It's recommended that if these weeds were control the lively hood of farmers would be increased.

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ASSESSMENT OF NUKKAI RIVER BASIN FOR NUTRIENT SECURITY AND WEED FLORAL DIVERSITY: IMPLICATIONS FOR URBAN VEGETABLE PRODUCTION

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ABSTRACT

This research was carried out in Nukkai River Basin (NRB) at the boundary between Ardo-kola and Jalingo local Government areas of Taraba state between 2014 and 2015. Nukkai river basin is naturally divided into four units by the Nukkai Bridge: the upper Nukkai (UN), lower Nukkai (LN) units in Jalingo local government (JLG) area and upper Kofai (UK) and lower Kofai (LK) units in Ardo-kola Local Government (ALG) area. The types of crops grown in each unit were examined, 3-4 farms randomly selected based on the types of crops served as the sampling units. A 1m X 1m quadrat was thrown randomly 3-4 times at about 20m intervals in each of the farms. Weed species within the 1m^2 quadrants were harvested, sorted and identified. Thirteen crop combinations were identified in the Nukkai River Basin of Taraba State. The frequency of occurrence of crops was in the order: Maize> Amaranthus> Rice> Groundnut, Pepper or Tomato> Sorrel> Sugar cane or Onion/Pepper/ Huckleberry> Cassava or Sweet Potato. Between the LGAs, the dominance of farms planted with cereals and root/tuber crops was higher in ALG than JLG, while JLG has more farms cultivating vegetables and other crops (sugarcane and groundnut). An indication that nutrient security potential might be higher in JLG than ALG. Across the units and LGAs, the order Vegetables (43.6%) > Cereals (41.9%) >others (11.3%) > Root/tubers (3.2%) was observed. Seven grasses, four broadleaf and two sedges were identified in the whole of the river basin. Digitaria milanjiana, Portulaca oleracea, Ageratum houstonianum, Ornithogalum caudatum, Echinochloa stagnina and Physalis angulata contributed 77.4% to the weed matrix in ALG. Digitaria milanjiana, Portulaca oleracea, Ageratum houstonianum, Setaria verticillate, Setaria barbata and Physalis angulata contributed 83.0% to the weed matrix in JLG. These weeds need to be monitored for higher productivity of vegetables and enhanced nutrient security in the study area.

Key words: Vegetables, Nutrient security, weed flora, Fadama

INTRODUCTION

Weeds species are the most important, yet most under-estimated of crop pest (Chauhan, 2020). Weed is the most limiting and visible cause of yield loss and a major constrain in Fadama areas (Amare *et al*, 2000). Fadama lands are fertile, supports high biodiversity, reduce risk of crop failure and have more agricultural potential than the adjacent upland (Ingawa, 1998). This weed species, biology, diversity as well as control methods by farmers in Nukkai river basin need to be evaluated for enhanced productivity. In tropical Africa, weed constitutes the major problem in subsistence agriculture and is the major challenge that farmers are facing when growing their crops (Fadayomi, 1996).

Weed control is the dominant labour-demanding occupation of small holder farmers in semi-arid regions of Africa during the cropping season (Akobundu, 2011). Farmers invest large amounts of labour in weeding each season, approximately 35 to 70% of the total agricultural labour need, which limits labour supply for other livelihood operations for small holder farmers (Mashingaidze *et al*., 2019). No single weed management strategy have effectively controlled weed in any cropping system (Ogbimi, 1998). Managing weeds without adequate knowledge of their biology, life cycle, characteristics will limit sustainable control, hence this study surveyed weed flora associated with crops cultivated in the Fadama.

MATERIALS AND METHODS

This research was carried out in Nukkai River Basin (NRB) at the boundary between Ardo-kola and Jalingo local government areas of Taraba state. Taraba state is roughly between latitude $6^0 30"$ – $9^0 36"$ north and longitude $9^0 10"$ – $11^0 50"$ east in north Eastern part of Nigeria. Taraba state have about 2.3 million people. (N.P.C, 2006 population census) inhabiting an estimated land area of about 54,428 km2. Adebayo (2010), divides Taraba into southern, central, northern zone where rain onset starts 16th March, 6th and 26th April respectively. About 75% of Tarabans are involved in farming.

The geological terrain of Jalingo local government is plain with rocky areas, while Ardo-kola is plain with little rocky areas. The climate is tropical, average annual temperature is 25.3°C, the average annual rainfall is 931 mm. (T.A.D.P, 2001). The area under study is broadly divided into four units, the upper and lower Nukkai units (JLG) and upper and lower Kofai units (Ardo-kola Local Government, (ALG) area. Nukkai river basin is naturally divided into four units by the Nukkai Bridge. The four units are characterized by different types of crops grown in the area. About 3-4 farms randomly selected based on the types of crops served as the sampling units. A 1m X 1m quadrat was thrown randomly 3-4 times at about 20m interval in each of the farms. Weed species within the $1m^2$ quadrants were harvested, sorted and identified.

RESULTS AND DISCUSSION

Cropping System of Nukkai River Basin (NRB)

Table 1 shows the thirteen crop combinations identified in Nukkai River Basin of Taraba State. The frequency of occurrence was in the other, Maize> Amaranthus> Rice> Groundnut, Pepper or Tomato> Sorrel> Sugar cane or Onion/Pepper/Huckleberry> Cassava or Sweet Potato. Maize, amaranth and followed by rice were the most dominant crops cultivated in the area (Michael and Aliyu, 20l2). This is because of consumers' preference, and it is one of the major crop and vegetable cultivated in Taraba state. Maize is one of the world top crop, maize provide not only the fast food of Nigerian society breakfast cereals, sweet corn and popcorn but also the staple food for much of the world population in developing countries where it is used to make porridge, bread (Mijindadi and Adegbehnin, 1991). All round the world, maize grain is the basic livestock feed, and the crop can be cut while still green to make silage as a winter feed (Orthmann, 2005).

Table 1. Crops cultivated in Nukkai River Basin of Taraba State

Crop/Group	Upper Kofai		Lower Kofai			ALG	Upper Nukkai		Lower Nukkai			JLG	Total N			rank
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	%AC	
Maize	6	30	5	25	11	55.0	5	25	4	20	9	45.0	20	100	32.2	1
Rice	3	50	3	50	6	100.0	0	0	0	0	0	0.0	6	100	9.6	3
Cereal	**9**	**34.6**	**8**	**30.8**	**17**	**65.4**	**5**	**19.2**	**4**	**15.4**	**9**	**34.6**	**26**	**100.0**	**41.94**	**2**
Sugarcane	0	0	1	50	1	50.0	0	0	1	50	1	50.0	2	100	3.2	6
Groundnut	1	20	0	0	1	20.0	2	40	2	40	4	80.0	5	100	8	4
Others	**1**	**14.3**	**1**	**14.3**	**2**	**28.6**	**2**	**28.6**	**3**	**42.9**	**5**	**71.4**	**7**	**100.0**	**11.29**	**3**
Cassava	1	100	0	0	1	100.0	0	0	0	0	0	0.0	1	100	1.6	7
Sweet potato	1	100	0	0	1	100.0	0	0	0	0	0	0.0	1	100	1.6	7
Root/Tubers	**2**	**100**	**0**	**0**	**2**	**100.0**	**0**	**0**	**0**	**0**	**0**	**0.0**	**2**	**100**	**3.23**	**4**
Tomato/pepper	1	100	0	0	1	100.0	0	0	0	0	0	0.0	1	100	1.6	7
Onion/pepper	1	50	1	50	2	100.0	0	0	0	0	0	0.0	2	100	3.2	6
Pepper	0	0	0	0	0	0.0	2	40	3	60	5	100.0	5	100	8	4
Amaranthus	1	11.1	2	22.2	3	33.3	2	22.2	4	44.4	6	66.7	9	100	14.5	2
Sorrel	0	0	1	33.3	1	33.3	1	33.3	1	33.3	2	66.7	3	100	4.8	5
Huckleberry	0	0	2	100	2	100.0	0	0	0	0	0	0.0	2	100	3.2	6
Tomato	0	0	1	20	1	20.0	2	40	2	40	4	80.0	5	100	8	4
Vegetables	**3**	**11.1**	**7**	**25.9**	**10**	**37.0**	**7**	**25.9**	**10**	**37.0**	**17**	**63.0**	**27**	**100.0**	**43.55**	**1**
Total	**15**		**16**		31	50.0	**14**		**17**		31	50.0	**62**			

Within Ardokola Local Government (ALG) units of the river basin, two cereal crops, onion/pepper and amaranthus were cultivated in both lower kofai (LK) and upper kofai (UK) units. Sugarcane, Sorrel, Huckleberry and tomato were only found in LK while Groundnut, cassava, sweet potato, tomato/pepper mix were only cultivated in UK. Cereal and root/tuber crops were more dominant in UK than LK, while vegetables farms were more in LK than UK. Within Jalingo Local Government (JLG) there were one cereal (UN > LN), sugarcane/groundnut (UN <LN) and four vegetables (UN < LN).

Between the LGAs, the dominance of farms planted with cereals and root/tuber crops was higher in ALG than JLG, while JLG has more farms cultivating vegetables and other crops (sugarcane and groundnut). An indication that nutrient security potential might be higher in JLG than ALG. Across the units and LGAs, the order Vegetables (43.6%) > Cereals (41.9%) >others (11.3%) > Root/tubers (3.2%) was observed. Fadama is generally known for vegetable production in many places because of high and sustained moisture requirement and continuous demand during dry season. The assessment of the spread of farms indicated that maize and amaranthus occurred in all the four units and LGAs; Groundnut, sorrel and tomato in three units; rice and sugarcane in two units, while other crops were observed in only one unit. This reflected effective site selections, especially for rice/sugarcane in the lower units with possible higher moisture content and availability suitable for such crops. The root/tuber crops in the ALG justifies the siting of the cassava processing industry in Ardokola LGA and an oil extracting factory in Jalingo LGA.

Weed Flora

Table 2 shows the different types of weeds identified in all units under study. Seven grasses, four broadleaf and two sedges were identified in the whole of the river basin. In the UK, *Digitaria milanjiana and Ornithogalum caudatum* were the dominant weeds, followed by *Portulaca oleracea, Ageratum houstonianum, Physalis angulata and Setaria barbata*. However, in LK, *Digitaria milanjiana, Portulaca oleracea, Echinochloa stagnina, Ageratum houstonianum.* In the LGA, the order *Digitaria milanjiana, >Portulaca olerace,> Ageratum houstonianum/ Ornithogalum caudatum> Echinochloa stagnina, Physalis angulata> Rhynchospora corymbose/ Setaria barbata/ Heliotropium indicum> Sida cordifolia/ Setaria verticillate> Cynodon dactylon. Digitaria milanjiana, Portulaca oleracea, Ageratum houstonianum, Ornithogalum caudatum*, *Echinochloa stagnina and Physalis angulate* contributed 77.4% to the weed matrix in ALG.

Common purselane (*Portulaca oleracea)* was normally found in amaranthus, onion and sorrel plots (Loux and Berry, 1991). Common purselane is a broadleaf weed, and is normally found in wet areas such as Fadama areas and especially in some irrigated areas (Dowler, 1998). The weed species always do better in areas with continuous supply of water such as Fadama areas, river bands and or irrigated plots (Qureshi, 1989).

In UN, *Setaria verticillata* > *Digitaria milanjiana*> *Setaria barbatal Physalis angulate/ Ageratum houstonianum/ Echinochloa stagnina/ Portulaca oleracea*> *Cyperus iria* order was observed. In LN, the order *Digitaria milanjiana,>Portulaca oleracea/ Ageratum houstonianum* > *Sida cordifolia*> *Cyperus iria/ Setaria barbata/, Physalis angulatel Setaria verticillate*. The order *Digitaria milanjiana,>Portulaca oleracea/ Ageratum houstonianum/ Setaria verticillate* > *Setaria barbata/, Physalis angulate*> *Cyperus iria/ Echinochloa stagnina*. *Digitaria milanjiana, Portulaca oleracea, Ageratum houstonianum, Setaria verticillate, Setaria barbata* and *Physalis angulata* contributed 83.0% to the weed matrix in JLG.

Comparing weed flora between the two LGAs. The dominance of *Digitaria milanjiana*, *Portulaca oleracea,* and *Echinochloa stagnina* in ALG was higher than in JLG, whereas *Ageratum houstonianum, Setaria verticillate, Setaria barbata* and *Sida cordifolia* were more in JLG than ALG. Weeds that were peculiar to ALG alone include *Ornithogalum caudatum, Rhynchospora corymbose, Heliotropium indicum* and *Cynodon dactylon*. *Digitaria*, while *Cyperus iria wa*s found only in JLG units alone.

This trend reflected crop-weed association essentially and ecological requirements Bristly foxtail (*Setaria verticillate)* was the highest weed identified in upper Nukkai and it was normally found in Amaranth, onion, sorrel, pepper/tomato, and onion/pepper plots as reported by (Loux and Berry, 1991).

Table 2. Comparative Assessment of Weed Flora in Nukkai River Basin

Common name		Scientific name	Upper	Lower	ALG			Upper	Lower	JLG			Total	
			Kofai	Kofai	N	%	%AW	Nukkai	Nukkai	N	%	%AW	N	%
Common Purslane	G	*Portulaca oleracea*	4	8	12	54.5	16.0	4	6	10	45.5	14.3	22	15.1
Finger Grass	G	*Digitaria milanjiana*	6	12	18	52.9	24.0	6	10	16	47.1	22.9	34	23.5
Billi (tag), banag (sub),Timsim	AG	*Echinochloa stagnina Beauv*		6	6	60.0	8.0	4		4	40.0	5.7	10	6.9
BillyGoatweed, Tropic Ageratum, Goatweed	BL	*Ageratum houstonianum Mills*	4	4	8	44.4	10.7	4	6	10	55.6	14.3	18	12.4
Bristly Foxtail, East indies Foxtail Grass	G	*Setaria verticillata L. beauv*		2	2	16.7	2.7	8	2	10	83.3	14.3	12	8.3
India helitrope, Turn- Solecorck Comb	BL	*Heliotropium indicum*	2	2	4	100.0	5.3			0	0.0	0.0	4	2.75
Pregnant onion, Maricus Longibacteatus Charm	G	*Ornithogalum caudatum*	6	2	8	100.0	10.7			0	0.0	0.0	8	5.5
Wild cape Goseberry	ABL	*Physalis angulata*	4	2	6	50.0	8.0	4	2	6	50.0	8.6	12	8.3

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Bahama Grass, Bermuda Grass couchgrass	PG	*Cynodon dactylon*		1	1	100.0	1.3			0	0.0	0.0	1	0.7
Rangui	Sedge	*Rhynchospora corymbosa*	2	2	4	100.0	5.3			0	0.0	0.0	4	2.75
Culipass (sub), bala (india) country millow	BL	*Sida cordifolia Linn*	2		2	33.3	2.7		4	4	66.7	5.7	6	4.13
Marry grass, Corn grass	G	*Setaria barbata*	4		4	40.0	5.3	4	2	6	60.0	8.6	10	6.9
Rice flatsedges	Sedge	*Cyperus iria Linn*			0	0.0	0.0	2	2	4	100.0	5.7	4	6.9
Total			34	41	75	51.7	100.0	36	34	70	48.3	100.0	145	100

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Bristly foxtail is a grass weed, and is normally found in wet areas such as Fadama areas and irrigated lands/areas (Akobundu and Agyakwa, 1998).

Common purselane identified in lower Nukkai was normally found in amaranths, onion and sorrel plots (Loux and Berry, 1991). Common purselane is a broadleaf weed, and is normally found in wet areas such as Fadama areas and especially in some irrigated areas (Dowler, 1998). Most of the weed Species identified are Fadama weeds or irrigated land weed species, they are always present in areas with much water (Akobundu and Agyakwa, 1998).

CONCLUSION AND RECOMMENDATION

Thirteen crop combinations were identified in the Nukkai River Basin of Taraba State. The frequency of occurrence of crops was in the order: Maize> Amaranthus> Rice> Groundnut, Pepper or Tomato> Sorrel> Sugar cane or Onion/Pepper/ Huckleberry> Cassava or Sweet Potato. Between the LGAs, the dominance of farms planted with cereals and root/tuber crops was higher in ALG than JLG, while JLG has more farms cultivating vegetables and other crops (sugarcane and groundnut). An indication that nutrient security potential might be higher in JLG than ALG. Across the units and LGAs, the order Vegetables (43.6%) > Cereals (41.9%) >others (11.3%) > Root/tubers (3.2%) was observed. Seven grasses, four broadleaf and two sedges were identified in the whole of the river basin. *Digitaria milanjiana, Portulaca oleracea, Ageratum houstonianum, Ornithogalum caudatum*, *Echinochloa stagnina and Physalis angulata* contributed 77.4% to the weed matrix in ALG. *Digitaria milanjiana, Portulaca oleracea, Ageratum houstonianum, Setaria verticillate, Setaria barbata* and *Physalis angulata* contributed 83.0% to the weed matrix in JLG. These weeds need to be monitored for higher productivity of vegetables and enhanced nutrient security in the study area.

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WEED GROWTH CHARACTERISTICS AS INFLUENCED BY LOCATION AND WEEDING REGIMES UNDER DIFFERENT COCOA (*THEOBROMA CACAO* L.) VARIETIES IN TWO GROWING ECOLOGIES OF NIGERIA

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ABSTRACT

Weed flora is a common problem in any crop field. For the better management of crop, understanding of weed vegetation is obligatory. Cocoa unfortunately is threatened by many constraints among which are weed infestation resulting in significant yield losses. Hence, the present study was aimed at documenting the weeds in cocoa varieties Tc1, Tc2 and F3 Amazon, predict weed growth characteristics in terms of densities, frequencies, importance value and diversities and, to use the predictions for selection of weed control measures that have some desired effects. Thus; a field experiment was conducted in June 2014 in two different agro-ecologies of southwest Nigeria viz: The Cocoa Research Institute of Nigeria (CRIN), Ibadan (Lat. 7° 10′ N, Long. 3° 52′ E,) representing dry forest and CRIN, Owena (7^0 11′ N, 5^0 01′ E) Sub - station, Ondo State, Nigeria representing wet forest. The experiment was a split plot in a Randomized Complete Block Design (RCBD) with three replications per treatment. The varieties (CRIN Tc-1, CRIN Tc-2 and F3 Amazon obtained from the headquarters of CRIN, Idi-Ayunre in Ibadan) were allocated to the main plot and weeding regime (WR) into sub-plots as: WR1. (weedy for 1 month + weeded after for 4 months), WR2. (weedy for 2 months + weeded after for 3 months); WR3. (weedy for 3 months + weeded after for 2 months); WR4. (weedy for 4 months + weeded after for 1 month); WR5.WF (weedfree throughout); WR6.WY (weedy throughout). Plantain was used to provide shade crop for the cocoa stands and was established a year before transplanting cocoa at a spacing of 3 x 3 m, (ditto for cocoa) and three stands of cocoa covering 3 x 6 m = (18 m^2) / treatment was used. Weeds were sampled once from one 50x50cm quadrate per sub-plot for each treatment. The data were analyzed by excel package of simple percentages and weed species diversity (H´) was computed from weed density, according to Pielou (1969). The results showed that: varieties Tc1, Tc2 and F3 has 54,56 and 62 weed types, higher weed flora diversity in WR1, distinctly widespread occurrence of C. odorata, general increase in weed occurrence across experimental sites caused by weed succession and adaptation patterns, dominance of C. odorata and widespread unappreciable weed RIV (≤10%) recorded across the locations. It was therefore concluded that, weed identification studies helps in knowing the existing weeds which can be a clue for their prevention and control, avoid early weed infestation at cocoa establishment, prevent local seeds and whole stem distribution of C. odorata with others like Aneilema aequinoctiale, Asystasia gangetica, Brachiaria deflexa, Digitaria horizontalis, Momordica charantia, Oplismenus burmanii, Sclerocarpus africanus from becoming invasive. Therefore, early weeding planning in cocoa plantations such that weeds don't get to a threshold level is important.

Key words: *Weeding regime (WR), Mean density (no./m^2), Frequency (%), Diversity (H^I)*

INTRODUCTION

No matter what definition is used, weeds are plants whose undesirable qualities outweigh their good points (Dwight, 2009). Certain characteristics are associated with and allow the survival of weeds: abundant seed, production; rapid population establishment; seed dormancy; long-term survival of buried seed; adaptation for spread; presence of vegetative reproductive structures; and ability to occupy sites disturbed by human activities (Dwight, 2009; Abdulraheem, 2018). There are approximately 250,000 species of plants worldwide; of those, about 3% or 8000 species behave as weeds (Dwight, 2009; Akobundu, 1998 and Akobundu *et al.,* 2016). Weeds are troublesome in many ways. Primarily, they reduce crop yield by competing for water, light, soil nutrients, and space. Other problems associated with weeds in agriculture include: reduced crop quality by contaminating the commodity; interference with harvest; serve as hosts for crop diseases or provide shelter for insects; limit the choice of crop rotation sequences and cultural practices; and production of chemical substances which are toxic to crop plants (allelopathy), animals, or humans (Dwight, 2009; Smith, 2016; Abdulraheem, 2018).

Cocoa (*Theobroma cacao* L.) is an important cash crop and major source of income to many smallholder farmers in the forest regions of West Africa. West Africa is currently leading in world cocoa production with about 70 %, while Asia and the Americas contribute about 16 % and 14 %, respectively. Cocoa is the most important cash crop that contributes to national economy in Nigeria. It is estimated that 90 % of worldwide cocoa production comes from smallholdings and most of this production occurs in areas of high biodiversity, of varieties and pest complexes-weeds inclusive.

MATERIALS AND METHODS

The main objectives of this trial was to predict weed growth characteristics in terms of densities, frequencies, importance value and diversities and, to use the predictions for selection of weed control measures that have some desired effects. Thus, a field experiment was conducted in June 2014 in two different agro-ecologies: The Cocoa Research Institute of Nigeria (CRIN), Ibadan (Lat. 7° 10' N, Long. 3° 52' E,) representing dry forest and CRIN, Owena (7^0 11' N, 5^0 01' E) Sub - station, Ondo State, Nigeria representing wet forest. The experiment was a split plot in a Randomized Complete Block Design (RCBD) with three replications per treatment. The varieties (CRIN Tc-1, CRIN Tc-2 and F3 Amazon obtained from the headquarters of CRIN, Idi-Ayunre in Ibadan) were allocated to the main plot and weeding regime (WR) into sub-plots as: WR1.UW1+WA4 (Unweeded in June +Weeded in July, August, September &October), WR2.UW2+WA3 (Unweeded in June &July +Weeded in August, September &October), WR3.UW3+WA2 (Unweeded in June, July &August +Weeded in September &October), WR4.UW4+WA1 (Unweeded in June, July, August &September +Weeded in October) with the two controls which did not vary, the plots were kept weed-free (treatment 5) and weed-infested (treatment 6) throughout. Plantain was used as a shade crop for the cocoa stands and was established a year before transplanting cocoa at a spacing of 3 x 3 m, (ditto for cocoa) and three stands of cocoa covering 3 x 6 m = (18 m^2) / treatment was used. Weeds were sampled once from one 50x50cm quadrate per sub-plot for each treatment. The data were analyzed by excel package of simple percentages;

Weed species diversity (H') was computed from weed density, according to Pielou (1969) as:

$H' = -\sum p_i \ln p_i$ ……………………………………………equation,

where p_i = density of each weed species (no.m^{-2}) and ln= natural logarithm.

Every month, data were taken from each plot for all the treatments. Only weed species with RIV ≥ 10 % will be discussed.

RESULT AND DISCUSSION

Table 1 gives appraisal of weed incidence across the three cocoa varieties (Tc1, Tc2 and F3 Amazon) during the trial in June, 2014. In Tc1 variety, a total of 54 weed types were collected and identified; 26 occurring in Ibadan, 28 at Owena and 12 at both locations. These 54 types cut across 42 species because some of the existing ones in Ibadan are found in Owena. Similarly, in Tc2 variety, 56 types were collected; 27 occurring in Ibadan, 29 at owena and 16 in both. The 56 weed types belong to 40 species. Consequently, in F3 Amazon variety, 62 weeds recorded; 28 were found in Ibadan, 34 at Owena and 16 in both locations; all belonging to 46 species.

Across locations and WR, individual weeds were less abundant in density (0-30 plants/m^2) in Tc1, Tc2 and F3. However, in **TC1** (Table 2)**,** *Chromolaena odorata* and *Desmodium scorpiurus* were distinctly widespread. These were followed by *Aneilema aequinoctiale* and *Oplismenus burmanii* which were appreciably widespread and the fairly widespread *Asystasia gangetica, Brachiaria deflexa, Momordica charantia* and *Sclerocarpus africanus.* Similarly, in **TC2** (Table 3)**,** *Chromolaena odorata* was distinctly widespread, compared to the widespread weeds like *Digitaria horizontalis, Ficus exasperata, Momordica charantia, Pouzolzia guineensis and Tridax procumbens.* In **F3** (Table 4), *Oplismenus burmannii* was distinctly widespread compared to the moderately widespread *Ageratum conyzoides, Digitaria horizontalis, Calapogonium mucunoides, Chromolaena odorata* and *Talinum traiangulare* and widespread *Aneilema aequinoctiale, Asystasia gangetica, Brachiaria deflexa* and *Sclerocarpus africanus.* All other weeds in (tables 2-4) recorded but not mentioned among the three varieties were not widespread. As per relative importance value (RIV) for the varieties, all the weed species were relatively low and similar in abundance (RIV ≤ 10 %) and are not to be discussed as they were not important.

Within locations and WR, generally weeds were neither abundant nor widespread in occurrence in the three varieties. Also within the location and WR but with respect to diversity (H'); in Tc1 variety (Table 2), weed diversity was distinctly high in WR1 (H' =2.33) at Owena, moderately high (H' =1.42 - 2.-04) in other treatments and lowest at WR5 (H' =0.63) in Owena. In Tc2 (Table 3), most diverse weed occurred in WR4 (H' =2.22) at Owena, moderately high (H' =1.07 - 2.08) in others and least in WR3 (H' =0.91) at Ibadan while in F3 (Table 4), the distinctly high weed diversity was in

WR5 (*H´* =2.18) at Ibadan and WR3 (*H´* =2.17) in Owena; moderately high (*H´* = 1.60 - 2.11) in other treatments and least diverse weed flora is in WR6 (*H´* =1.24) at Owena. Table 5 summarizes results on effects of weeding regime (WR) on weed species diversity (*H´*), Most diverse flora, occurrence and most occurred across three cocoa varieties in Ibadan and Owena (June, 2014).

The naming of the weeds (nomenclature) is of paramount importance in any weed identification studies as it helps in informing the farmer on the type of weeds existing in his plantation which can be a clue for their prevention and control (Idrisu *etal*., 2020). Akobundu (1998), Akobundu *et al* (2016) emphasized on proper nomenclature and provides best international guide and information on the taxonomy of weed species and how best they can be identified, classified and written. The diversity and complexity of weed flora in both experimental sites strongly confirm the documented reports of Ayeni *et al.* (1984), Smith (2017), Smith and Onamadi (2007), Smith and Alli (2005), Smith and Alli (2007) on the primary influence of tropical high rainfall and temperature on ecological weed growth and diversity.

The variations in weed species diversity across cocoa varieties, location and weeding regime strongly indicate the predominant influence of environmental factors, viz. soil productivity, crop competitiveness, varietal tolerance and climatic growth conditions of both crop varieties and weeds (Akobundu, 1987; Idrisu *et al*., 2021).

The higher weed flora diversity in WR1 across variety and location in June can be attributed to the prevalent early weed infestation at cocoa establishment; no weeding was done in the first month of cocoa establishment. The distinctly widespread occurrence of *C. odorata,* across varieties and locations during early cocoa establishment (June 2014) was due primarily to local distribution as widely documented in tropical agro-ecologies (Akobundu, 1987; Smith 2001) and weed growth habit (Akobundu *et al.*, 2016). The increase in weed occurrence across experimental sites resulted primarily from weed succession and adaptation patterns to the safe site conditions (Akobundu, 1987; Smith and Fasanmi, 2018; Idrisu *et al*., 2019) in establishing cocoa plantation, especially topsoil disturbance, soil moisture and temperature, impact of solar radiation on shallow weed seedbank, weed seedling emergence and survival of emerged weed seedlings.

Specifically, the overwhelming dominance of *C. odorata* during early cocoa seedling establishment (2014) was primarily due to its tenacity for vigorous regrowth from buds on cut stem-bases during manual weeding under cocoa canopy (Odukwe, 1964; Akobundu, 1987). *C. odorata* is a serious weed in oil palm, cocoa and rubber plants (Odukwe, 1964). The weed was reported to be the most problematic invasive species within protected rainforests (Struhsaker *et al*., 2005), where it prevents the regeneration of tree species in areas of shifting cultivation. Earlier studies specifically identified *C. odorata* as a common weed of cocoa plantations in Owena Local Government Area of Ondo State (Smith, 2000).] Judging from the widespread unappreciable weed RIV (≤10%) recorded across cocoa variety, location and weeding regime during this study, it is evident that none of the weed species encountered was a potential invasive weed problem.

CONCLUSION:

It therefore concluded that:

1. Identification studies help in informing on the type of weeds existing in plantation which can be a clue for their prevention and control.
2. Farmers should avoid early higher weed flora (weed infestation) at cocoa establishment by embarking on early weeding (WR1).
3. Farmers should check widespread occurrence of *C. odorata* by avoiding local distribution of it seeds and whole stem.
4. Farmers should prevent and control weed succession and adaptation patterns by making their safe site conditions unfavorable for them to grow and guide against increase in weed occurrence.
5. Dominance of *C. odorata* should be by preventing it regrowth from buds on cut stem-bases during manual weeding under cocoa canopy or establishment; instead, uproot them because of their problematic invasive nature.
6. Widespread unappreciable weed RIV (≤10%) recorded means none of the weed species encountered was a potential invasive weed problem thus, weeds in cocoa fields should not be allow to get to a threshold level before weeding them.

However, in spite of the inconsistent occurrence of most of the other weed species, *Aneilema aequinoctiale*, *Asystasia gangetica*, *Brachiaria deflexa*, *Digitaria horizontalis*, *Momordica charantia*, *Oplismenus burmanii* and *Sclerocarpus africanus* were apparently present as potential invasive weeds. There is therefore, a strong need to prevent their resurgence during seedling cocoa establishment across cocoa variety, location and weeding regime.

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Table 1: Weed species recorded across the location and weeding regime in cocoa variety TC1, TC2 & F3 (June, 2014)

Weed species TC1	Ib	Ow	Both	Weed species TC2 40spp	Ib	Ow	Both	Weed species F3	Ib	Ow	Both
Ageratum conyzoides	√	√√	√√√	*Abutilon mauritianum*	-	√√		*Acanthus montanus*	-	√√	
Alchornea laxiflora	-	√√		*Ageratum conyzoides*	√	√√	√√√	*Ageratum conyzoides*	√	√√	√√√
Alternanthera pungens	√	-		*Alchornea cordifolia*	√	√√	√√√	*Alchornea laxiflora*	-	√√	
Aneilema aequinoctiale	√	√√	√√√	*Alchornea laxiflora*	-	√√		*Alternanthera pungens*	√	-	
Asystasia gangetica	-	√√		*Alternanthera pungens*	√	-		*Aneilema aequinoctiale*	√	-	
Bidens pilosa	-	√√		*Aneilema aequinoctiale*	√	-		*Aneilema beniniense*	-	√√	
Blepharis masderaspatensis	-	√√		*Aneilema beniniense*	√	√√	√√√	*Asystasia gangetica*	√	√√	√√√
Brachiaria deflexa	√	√√	√√√	*Asystasia gangetica*	√	-		*Bidens pilosa*	-	√√	
Chromolaena odorata	√	√√	√√√	*Axonopus compressus*	√	-		*Blepharis masderaspatensis*	-	√√	
Commelina benghalensis	√	√√	√√√	*Blepharis maderaspatensis*	-	√√		*Brachiaria deflexa*	√	√√	√√√
Commelina diffusa	√	√√	√√√	*Brachiaria deflexa*	√	√√	√√√	*Brachiaria lata*	√	-	
Desmodium scorpiurus	√	√√	√√√	*Calapogonium mucunoides*	√	√√	√√√	*Calapogonium mucunoides*	√	√√	√√√
Digitaria horizontalis	√	-		*Capsicum annuum*	-	√√	-	*Capsicum annuum*	-	√√	
Digitaria nuda	√	-		*Chromolaena odorata*	√	√√	√√√	*Chromolaena odorata*	√	√√	√√√
Euphorbia heterophylla	-	√√		*Combretum hispidum*	√	-		*Colocasia esculenta*	-	√√	
Ficus exasperate	√	-		*Commelina benghalensis*	√	√√	√√√	*Combretum hispidum*	-	√√	
Hewittia sublobata	√	√√	√√√	*Commelina diffusa*	√	-		*Commelina benghalensis*	√	√√	√√√
Ipomoea triloba	√	√√	√√√	*Desmodium scorpiurus*	√	√√	√√√	*Commelina diffusa*	√	√√	√√√
Laportea aestuans	√	√√	√√√	*Digitaria horizontalis*	√	√√	√√√	*Desmodium scorpiurus*	√	√√	√√√
Luffa cylindrica	-	√√		*Digitaria nuda*	√	-		*Digitaria horizontalis*	√	√√	√√√
Mallotus oppositifolius	√	-		*Euphorbia heterophylla*	-	√√		*Digitaria nuda*	√	-	
Mariscus alternifolius	√	-		*Ficus exasperata*	√	√√	√√√	*Euphorbia heterophylla*	-	√√	
Momordica charantia	-	√√		*Hewittia sulobata*	√	√√	√√√	*Ficus exasperata*	√	-	
Newbouldia laevis	-	√√		*Ipomoea batata*	-	√√		*Hewittia sulobata*	√	√√	√√√
Oplismenus burmanii	√	√√	√√√	*Ipomoea involucrata*	-	√√		*Icacina trichantha*	-	√√	
Panicum maximum	√	-		*Ipomoea triloba*	-	√√		*Ipomoea involucrata*	√	√√	√√√

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Table 1 (contd.). Weed species recorded across the location and weeding regime in cocoa variety TC1, TC2 & F3 (June, 2014)

Weed species TC1	Ib	Ow	Both	Weed species TC2 40spp	Ib	Ow	Both	Weed species F3	Ib	Ow	Both
Parquetina nigrescens	-	√√		*Laportea aestuans*	-	√√		*Ipomoea triloba*	√	√√	√√√
Paspalum conjugatum	√	-		*Luffa cylindrica*	-	√√		*Laportea aestuans*	-	√√	
Peperomia pellucida	-	√√		*Mariscus alternifolius*	√	-		*Luffa cylindrica*	-	√√	
Pouzolzia guineensis	-	√√		*Momordica charantia*	√	√√	√√√	*Mallotus oppositifolius*	-	√√	
Rottboellia cochinchinensis	√	-		*Oplismenus burmanii*	√	√√	√√√	*Mariscus alternifolius*	√	-	
Schrankia leptocarpa	-	√√		*Parquetina nigrescens*	-	√√		*Momordica charantia*	-	√√	
Sclerocarpus africanus	√	-		*Paspalum conjugatum*	√	-		*Oplismenus burmanii*	√	√√	√√√
Setaria barbata	√	√√	√√√	*Peperomia pellucida*	-	√√		*Paspalum conjugatum*	√	-	
Sida acuta	√	-		*Platostoma africanum*	√	√√	√√√	*Peperomia pellucida*	-	√√	
Solanum torvum	-	√√		*Pouzolzia guineensis*	-	√√		*Platostoma africanum*	√	√√	√√√
Spigelia anthelmia	√	-		*Rottboellia cochinchinensis*	√	-		*Pouzolzia guineensis*	-	√√	
Spilanthes filicaulis	-	√√		*Sclerocarpus africanus*	√	√√	√√√	*Rottboellia cochinchinensis*	√	-	
Talinum triangulare	-	√√		*Talinum traiangulare*	√	√√	√√√	*Sclerocarpus africanus*	√	√√	√√√
Tephrosia pedicellata	√	-		*Tridax procumbens*	√	-		*Setaria barbata*	√	-	
Thaumatococcus danielli	-	√√		***Total=27+29=56***	**27**	**29**		*Sida acuta*	√	-	
Tridax procumbens	√	-						*Sida garckeana*	-	√√	
Total=26+28=54	**26**	**28**						*Spigelia anthelmia*	-	√√	
								Talinum traiangulare	√	√√	√√√
								Tephrosia pedicellata	√	-	
								Tridax procumbens	√	-	
								Total=28+34=62	**28**	**34**	

√= Weeds present in Ibadan, √√= Weeds present at Owena √√√= Weeds present in both locations - and √ = Weeds present in one of the locations and not in the other &vice versa

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Table 2. Weed growth characteristics as influenced by location and weeding regime in cocoa variety Tc1 (June, 2014)

	Ibadan						Owena						Weed variables				
Weed species	WR1	WR2	WR3	WR4	WR5	WR6	WR1	WR2	WR3	WR4	WR5	WR6	MD	F	RD	RF	RIV
				(no./m^2)					(no./m^2)				no./m^2		%		
Ageratum conyzoides		0.33					0.67	0.67					0.14	25.00	0.02	2.08	1.05
Alchornea laxiflora									2	0.33	0.33	0.33	0.25	33.33	0.04	2.78	1.41
Alternanthera pungens				6.33									0.53	8.33	0.09	0.69	0.39
Aneilema aequinoctiale	1.67	9		9	10.67	0.33			6.33	3.67	0.33		3.42	66.67	0.60	5.56	3.08
Asystasia gangetica	0.67	1	13.33		1	5					1.33		1.86	50.00	0.32	4.17	2.25
Bidens pilosa							2				0.67		0.22	16.67	0.04	1.39	0.71
Blepharis masderaspatensis							3.33	4.67	0.67		1.33	2	1.00	41.67	0.17	3.47	1.82
Brachiaria deflexa	5		1.33	16.33	12.67		0.33				3		3.22	50.00	0.56	4.17	2.36
Chromolaena odorata	3	0.33		0.33	1.67	0.67	2.67	3	7	4.67	3	2.33	2.39	91.67	0.42	7.64	4.03
Commelina benghalensis						1	0.33			0.33	0.33	0.67	0.22	41.67	0.04	3.47	1.76
Commelina diffusa	4.67	1.33	1.67				1					10.33	1.58	41.67	0.28	3.47	1.87
Desmodium scorpiurus	1	0.33			1.67	3.33	4	0.33	1.33		1.67	1.33	1.25	75.00	0.22	6.25	3.23
Digitaria horizontalis	4	8.33	8.67	8.33	2								2.61	41.67	0.45	3.47	1.96
Digitaria nuda			0.33		3.67								0.33	16.67	0.06	1.39	0.72
Euphorbia heterophylla							1.33						0.11	8.33	0.02	0.69	0.36
Ficus exasperata				0.33		2.67							0.25	16.67	0.04	1.39	0.72
Hewittia sublobata		0.33				-		2.33					0.22	16.67	0.04	1.39	0.71
Ipomoea triloba						0.33	0.33		0.67			0.67	0.17	33.33	0.03	2.78	1.40
Laportea aestuans				0.33			0.67	2.67					0.31	25.00	0.05	2.08	1.07
Luffa cylindrica									0.67	0.33			0.08	16.67	0.01	1.39	0.70
Mallotus oppositifolius	0.33												0.03	8.33	0.00	0.69	0.35
Mariscus alternifolius	0.67			0.33		1.33							0.19	25.00	0.03	2.08	1.06
Momordica charantia							1.33	2	0.67	1.67	0.67	3.33	0.81	50.00	0.14	4.17	2.15
Newbouldia laevis								11		0.67			0.97	16.67	0.17	1.39	0.78
Oplismenus burmanii	8.33	16	0.33	4	28.33						16.33	4	6.44	58.33	1.12	4.86	2.99
Panicum maximum	-	0.67											0.06	8.33	0.01	0.69	0.35
Parquetina nigrescens												0.33	0.03	8.33	0.00	0.69	0.35
Paspalum conjugatum					1								0.08	8.33	0.01	0.69	0.35
Peperomia pellucida							0.33	0.33				1.67	0.19	25.00	0.03	2.08	1.06
Pouzolzia guineensis								1.67	3	1.67	1.67	19	2.25	41.67	0.39	3.47	1.93

Table 2 (contd.). Weed growth characteristics as influenced by location and weeding regime in cocoa variety Tc1 (June, 2014)

	Ibadan						Owena						Weed variables				
Weed species	**WR1**	**WR2**	**WR3**	**WR4**	**WR5**	**WR6**	**WR1**	**WR2**	**WR3**	**WR4**	**WR5**	**WR6**	**MD**	**F**	**RD**	**RF**	**RIV**
				(no./m²)					**(no./m²)**				**(no./m²)**		**%**		
Rottboellia cochinchinensis		0.33		1.33		0.33							0.17	25.00	0.03	2.08	1.06
Schrankia leptocarpa									0.33				0.03	8.33	0.00	0.69	0.35
Sclerocarpus africanus	20.33	15.33	18.67	36.67	6	16.67							9.47	50.00	1.65	4.17	2.91
Setaria barbata				2.33		5		5					1.03	25.00	0.18	2.08	1.13
Sida acuta	0.67												0.06	8.33	0.01	0.69	0.35
Solanum torvum									0.33				0.03	8.33	0.00	0.69	0.35
Spigelia anthelmia	0.33	0.33	1	4.33		0.67							0.56	41.67	0.10	3.47	1.78
Spilanthes filicaulis							1.33						0.11	8.33	0.02	0.69	0.36
Talinum triangulare												1.67	0.14	8.33	0.02	0.69	0.36
Tephrosia pedicellata						2.67							0.22	8.33	0.04	0.69	0.37
Thaumatococcus danielli									0.33				0.03	8.33	0.00	0.69	0.35
Tridax procumbens	10.33	20.33		15.33		11.33							4.78	33.33	0.83	2.78	1.81
Mean density (no./m²)	**1.45**	**1.76**	**1.08**	**2.51**	**1.64**	**1.22**	**0.47**	**0.80**	**0.56**	**0.32**	**0.73**	**1.13**					
Frequency (%)	**33.32**	**33.32**	**19.04**	**33.32**	**23.8**	**33.32**	**33.32**	**26.18**	**28.56**	**19.04**	**28.56**	**30.94**					
Diversity (*H*[I])	**2.04**	**1.83**	**1.42**	**1.98**	**1.74**	**2.03**	**2.33**	**2.01**	**1.94**	**1.58**	**0.63**	**1.90**					

[1]WR = Weeding regime (as presented in the Abstract, Materials &Methods and on Table 5 footnote), RD = Relative weed density, RF = Relative frequency of weed occurrence, RIV**=** Weed relative importance value.

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Table 3: Weed growth characteristics as influenced by location and weeding regime in cocoa variety TC2 (June, 2014).

	Ibadan						Owena						Weed variables				
Weed species	**WR1**	**WR2**	**WR3**	**WR4**	**WR5**	**WR6**	**WR1**	**WR2**	**WR3**	**WR4**	**WR5**	**WR6**	**MD**	**F**	**RD**	**RF**	**RIV**
			(no./m^2)						**(no./m^2)**				**no./m^2**	**%**			
Abutilon mauritianum							0.33						0.03	8.33	0.00	0.79	0.40
Ageratum conyzoides			11				24.67		5.33			1	3.50	33.33	0.63	3.15	1.89
Alchornea cordifolia					0.67		0.33			0.33			0.11	25.00	0.02	2.36	1.19
Alchornea laxiflora										0.67			0.06	8.33	0.01	0.79	0.40
Alternanthera pungens				1		1							0.17	16.67	0.03	1.57	0.80
Aneilema aequinoctiale			1.33	2.67		10							1.17	25.00	0.21	2.36	1.29
Aneilema beniniense		2.33							0.67				0.25	16.67	0.05	1.57	0.81
Asystasia gangetica	1.67	0.67	1.67										0.33	25.00	0.06	2.36	1.21
Axonopus compressus					3.67								0.31	8.33	0.06	0.79	0.42
Blepharis maderaspatensis							1				2	0.33	0.28	25.00	0.05	2.36	1.21
Brachiaria deflexa	0.33		1.67	4.67			0.33	30					3.08	41.67	0.56	3.94	2.25
Calapogonium mucunoides			0.33			0.33		1.33	0.67				0.22	33.33	0.04	3.15	1.59
Capsicum annuum							0.33						0.03	8.33	0.00	0.79	0.40
Chromolaena odorata	1.33		0.33	0.67		1.67	0.67	3.33	4	3.33	5.33	2.33	1.92	83.33	0.35	7.87	4.11
Combretum hispidum						22							1.83	8.33	0.33	0.79	0.56
Commelina benghalensis			3.33								0.33		0.31	16.67	0.06	1.57	0.81
Commelina diffusa	0.67			0.67	1.33								0.22	25.00	0.04	2.36	1.20
Desmodium scorpiurus				1		0.67		1.33		1	0.67		0.39	41.67	0.07	3.94	2.00
Digitaria horizontalis	10.67	32	24	15.33	2.33							1.67	7.17	50.00	1.29	4.72	3.01
Digitaria nuda			149.67										12.47	8.33	2.25	0.79	1.52
Euphorbia heterophylla							1					0.33	0.11	16.67	0.02	1.57	0.80
Ficus exasperata		0.33	0.33	0.33		1.67				0.67		0.33	0.31	50.00	0.06	4.72	2.39
Hewittia sulobata					0.33			1	1.33			1	0.31	33.33	0.06	3.15	1.60
Ipomoea batata											1		0.08	8.33	0.02	0.79	0.40
Ipomoea involucrata							0.67			0.33	1		0.17	25.00	0.03	2.36	1.20
Ipomoea triloba								0.67	0.33	0.67			0.14	25.00	0.03	2.36	1.19
Laportea aestuans							0.33		0.67				0.08	16.67	0.02	1.57	0.79
Luffa cylindrica										0.67			0.06	8.33	0.01	0.79	0.40
Mariscus alternifolius	0.67	3		0.33	1.33								0.44	33.33	0.08	3.15	1.61
Momordica charantia		0.33						2.67	0.67	1	1.33	0.67	0.56	50.00	0.10	4.72	2.41

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Table 3 (contd.). Weed growth characteristics as influenced by location and weeding regime in cocoa variety TC2 (June, 2014)

Weed species	Ibadan WR1	WR2	WR3	WR4 (no./m^2)	WR5	WR6	Owena WR1	WR2	WR3	WR4 (no./m^2)	WR5	WR6	Weed variables MD no./m^2	F	RD (%)	RF (%)	RIV
Oplismenus burmanii	1			14.33							1		1.36	25.00	0.25	2.36	1.30
Parquetina nigrescens								0.33				2	0.19	16.67	0.04	1.57	0.80
Paspalum conjugatum				2									0.17	8.33	0.03	0.79	0.41
Peperomia pellucida										1	1.67		0.22	16.67	0.04	1.57	0.81
Platostoma africanum						0.33	0.67					6.67	0.64	25.00	0.12	2.36	1.24
Pouzolzia guineensis							3	0.33	1	2	6	0.67	1.08	50.00	0.20	4.72	2.46
Rottboellia cochinchinensis	1	0.33	0.33	1		3.67							0.53	41.67	0.10	3.94	2.02
Sclerocarpus africanus	9			10.33		0.67					2.67		1.89	33.33	0.34	3.15	1.75
Talinum traiangulare			1							0.33			0.11	16.67	0.02	1.57	0.80
Tridax procumbens	6.33	24.67	1.33	7.33	3	4.33							3.92	50.00	0.71	4.72	2.72
Mean density (no./m^2)	**0.82**	**1.59**	**4.91**	**1.54**	**0.32**	**1.16**	**0.83**	**1.02**	**0.37**	**0.30**	**0.58**	**0.43**					
Frequency (%)	**25.00**	**17.50**	**32.50**	**35.00**	**17.5**	**25.00**	**30.00**	**22.50**	**22.50**	**30.00**	**27.50**	**27.5**					
Diversity (H^I)	**1.74**	**1.11**	**0.91**	**2.04**	**1.74**	**1.62**	**1.11**	**1.07**	**1.77**	**2.22**	**2.08**	**1.94**					

[1]WR = Weeding regime (as presented in the Abstract, Materials &Methods and on Table 5 footnote), RD = Relative weed density, RF = Relative frequency of weed occurrence, RIV**=** Weed relative importance value

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PERFORMANCE OF GARLIC VARIETIES AS INFLUENCED BY DIFFERENT WEED CONTROL METHODS IN BAUCHI STATE, NIGERIA

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ABSTRACT

Field experiment was conducted during 2019 dry season at the Teaching and Research Farm of Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi, to determine the performance of two garlic varieties to different weed control methods. The treatments consist of two (2) garlic varieties: Ex- Sokoto and Ex-Kofa and four (4) weed control methods: Hoe weeding, Herbicides and Aqueous neem leaf extract and a control making a total of eight (8) treatment combinations. The treatments were laid out in a Randomized Complete Block Design replicated three (3) times. Data were collected on growth, yield, yield components and weed indices of weeds. The result of the experiments revealed significant (P≤0.05) variation among the two varieties tested on plant height, fresh bulb weight, cured bulb weight, fresh and cured yield per hectare and fresh weight of weeds. Ex- Sokoto produced taller plants and heavier bulb, higher yield (t/ha) and lighter fresh weed weight than Ex-Kofa. But there was no significant difference on number of leaves, cloves, and weed indices of weeds between the varieties except for fresh weed weight. Where plots with Ex- Kofa gave higher fresh weed weight (263.67g/m^2) and the lowest was obtained from Ex- Sokoto (196.83/m^2). Further, results of the experiment showed significant (P≤0.05) difference among the weed control methods, where hoe weeded treatments, herbicides and neem extract gave better values for almost all the character measured while control plots produced the lowest. Based on the result of this findings therefore, Ex- Sokoto variety of garlic and either hoe weeding, herbicides and or aqueous neem leaf extract may be adopted by farmers for better productivity of garlic in the study area

Key words: Garlic, Varieties, weed control methods, Weed indices

INTRODUCTION

Garlic (*Allium sativum* L.) is an annual vegetable crop of the family alliaceae and genus allium. It is widely recognized as a valuable spice for seasoning and flavouring food and a popular remedy to various ailments and physiological disorder Leech, (2018). Different varieties of garlic exist, which differ in colour, bulb size, clove number and even Sulphur content and bulb yield Usman *etal*., (2016). Yield variations were recorded in different garlic varieties which occur as a result of differences in genetic make-up of the plants environmental factors, agronomic practices among others Weeds constitutes a major problem in garlic production as it competes for both above ground and below ground resources of production which includes: sunlight, water, nutrients etc. weed control remain a major challenge to garlic farmers as it is closely spaced in the field. Hoe weeding is tedious and labour intensive while the use of synthetic herbicide is expensive and indiscriminate use of it is hazardous to human health and environments (Naeem *etal*., 2018 and Ihsan *et al*., 2015). Due to increasing emphasis in organic farming and environmental protection, attention has been shifted towards allelophaty, which is a biological phenomenon by which one organism produces biochemical that influences the growth survival, development and reproduction of another. Allopathy is use in weed control and a promising way to utilize it in weed control is by the use of water extracts of allelopathic plants as herbicides (Dhima *et al*., 2009; Singh *et al*., 2005; White *et al*., 1989). So many researchers have reported the application of allelopathic plant water extracts for weed suppression (Dhima *et al*.,2009; Jamil *et al*., 2009). Plants known to have allellophatic effects includes *Azadirachta indica*, *Eucalyptus spp,* Sorghum (stem, leaves, and root) garlic. etc. (Weston *et al*., 2013; Won *et al*., 2013). Based on this therefore, this experiment was conducted to determine the performance of two garlic varieties as influenced by different weed control methods.

MATERIALS AND METHODS

Field experiment was conducted during 2019 dry season at the Teaching and Research Farm of Faculty of Agriculture and Agricultural Technology,

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ATBU, Gubi Campus Bauchi (10°22′ N, 9°47′E) and 609.3m above sea level, to determine the performance of two garlic varieties under different weed control methods. The treatments consist of two varieties of garlic (Ex-Sokoto, and Ex-Kofa), four weed control methods (herbicides, hoe weeding, aqueous neem leaf extract and a control) making a total of eight treatment combination and these were replicated three (3) times. Garlic bulb selected for planting were separated into their individual cloves and soaked overnight a day to planting as this practice was reported to enhance germination in garlic. Planting was done at a spacing of 20x10cm inter and intra row spacing.

Preparation of the Aqueous Neem Leaf Extract

The neem leaves were obtained from Bauchi State College of agriculture. The leaves were air dried and grounded into powder, the powdered plant material were diluted with water at 1kg to 20liter of water at rate of 40kg/ha (Anwari *et al*. 2003). The extract was applied pre-emergence and at six (6) weeks after emergence**.** Data were collected on plant height, number of leaves, fresh bulb weight, cured bulb weight, number of cloves, fresh yield, cured yield in ton/ha. Weed parameters measured were: number of weeds/m2, fresh and dry weed biomass, weed control efficiency, weed index and the level of weed infestation. All data collected were subjected to analysis of variance (ANOVA) and Duncan multiple range test was adopted in separating the significantly different means.

RESULTS AND DISCUSSION

Plant Height and Number of Leaves of Garlic

The plant height and number of leaves of garlic differed significantly ($p \leq 0.05$) between the two varieties at both weeks after planting, where Ex sokoto gave taller plants than Ex Kofa. However, number of leaves of garlic did not show any significant variation among the varieties (Table 1). This could be due to genetic make-up of the plant and hence they differ in their ability for exploiting environmental factors such as light carbon dioxide water atmospheric humidity nutrients etc. This result is in conformity with the findings of (Rahman *etal*., 2020: Usman *etal*., 2016) who reported variations between garlic varieties in terms of growth parameters. The effect of weed control methods on plant height and number of leaves of garlic was significant ($p \leq 0.05$). where hoe weeding, herbicides application and application of aqueous neem leaf extract produces taller plant while the shorter plant was produced by the control application. This indicates that both hoe weeding, herbicides and neem leaf extract application have no negative effect on plant growth and to same extents have same capability of managing weeds since they produced statistically the same value for the plant height (Table 1). This finding is in agreements with the work of (Cheema *et al.,* 2004) who reported aqueous extracts of sorghum as plant growth promoters and increased yield of wheat by up to 21%

Yield and Yield Components of Garlic

The results obtained on yield and yield components of garlic revealed significant ($p \leq 0.05$) variation on almost all the characters measured except for number of cloves of garlic (Table 2)

Number of Cloves of Garlic

There was no significant difference between the varieties for number of cloves of garlic, however weed control methods significantly influenced number of cloves of garlic, where hoe weeded treatments produced more cloves which is statistically similar with the herbicides and neem leaf extract application, while fewer cloves was from the control application (Table 2). This shows that aqueous neem leaf extract did not suppress the growth of garlic and also formation of bulb and cloves of garlic

Fresh and Cured Bulb Weight of garlic

There was significant difference for both fresh and cured bulb weight of garlic between the varieties, Ex-Soko gave heavier fresh and cured bulb than Ex-Kofa. This could be attribute to the difference in genetic make-up of the varieties, Ex-Sokoto might be having high tendency of utilizing the resources of production and ability to convert it into dry matter. This finding is in agreement with that of Gashaw *et al*. (2020) who reported variation in growth and yield characters of garlic among different varieties of garlic including number of cloves. Further, weed control methods have significantly ($P \leq 0.05$) influenced both fresh and cured yield of garlic. Hoe weeding gave heavier fresh and cured bulb weight of garlic of up to 33g and 19g respectively while the lighter fresh and cured bulb weight (16g) and (9g) respectively was from the control treatment. (Table 2).

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Table 1. Effect of variety weed control methods on plant height and number of leaves of garlic

Treatments	Weeks After Planting					
	4	8	12	4	8	12
Variety						
Ex- Sokoto	28.26^{a}	44.05^{a}	48.67^{a}	4.04	6.14	19
EX- Kofa	26.33^{b}	40.77^{b}	43.73^{b}	3.86	6.62	16
LS	**	**	**	NS	NS	NS
SE±	0.654	0.918	0.700	0.90	0.214	1.343
Weed Control Methods						
Hoe weeding	30.01^{a}	48.23^{a}	48.31^{a}	4.13^{a}	6.89^{a}	18.28^{a}
Herbicides	30.10^{a}	45.15^{a}	47.26^{a}	4.39^{a}	6.81^{a}	18.01^{a}
Neem Leaf Extract	29.14^{a}	44.84^{a}	48.33^{a}	4.41^{a}	6.61^{a}	15.13^{ab}
Control	19.17^{b}	31.45^{b}	40.93^{b}	3.00^{b}	5.23^{b}	11.67^{b}
LS	**	**	**	**	**	**
SE±	0.925	1.298	0.990	0.127	0.303	0.00
Interaction						
V × WCM	**	**	**	NS	NS	NS

V × WCM = Variety x Weed Control Methods

Means followed by the different letter(s) within a treatment group are significantly different using Duncan Multiple Range Test (DMRT

Table 2. Effect of variety and weed control methods on yield and yield component of garlic

Treatments	Number of Cloves	Fresh bulb weight (g)	Cured bulb weight (g)	Fresh Bulb Yield (t/ha)	Cured BulbYield (t/ha)
Variety					
Ex- Sokoto	8.00	28.22^{a}	15.11^{a}	6.299^{a}	4.87^{a}
EX- Kofa	7.33	24.43^{b}	13.87^{b}	4.08^{b}	3.06^{b}
LS	NS	**	**	**	*
SE±	0.928	1.166	0.673	0.504	0.352
Weed Control Methods					
Hoe weeding	11.00^{a}	33.72^{a}	19.06^{a}	7.75^{a}	5.17^{a}
Herbicides	7.00^{b}	29.78^{ab}	5.65^{b}	5.50^{b}	3.879^{b}
Neem Extract	8.00^{ab}	25.73^{b}	14.29^{b}	4.78^{bc}	3.23^{b}
Control	6.00^{b}	16.06^{c}	1.00^{c}	2.7^{c}	1.58^{c}
LS	**	**	**	**	**
SE±	1.313	1.648	0.951	0.712	0.497
Interaction					
VX WCM	**	**	**	NS	NS

V × WCM = Variety x Weed Control Methods

Means followed by the different letter(s) within a treatment group are significantly different using Duncan Multiple Range Test (DMRT

Fresh and Cured Yield of Garlic

Both fresh and cured bulb yield of garlic showed significant ($P \leq 0.05$) variation between the varieties tested, Ex- Sokoto gave higher yield than Ex- Kofa. With regards to weed control methods, hoe weeded treatments produced higher fresh and cured yield of garlic while herbicides and neem leaf extract application produced statistically the same

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yield and lowest yield was from the control treatment. This is supported by the findings of (Kowthar *et al*., 2019) who reported increase in yield of quinoa by the application of aqueous extract of garlic and eucalyptus (Table 2)

Weed control efficiency

There was no any significant difference observed between varieties of garlic tested on weed control efficiency, however, significant difference was recorded between the different weed control methods. Where hoe weeding gave the highest weed control efficiency of (90%), herbicide recorded 59%, neem extract achieved 50% weed control efficiency (Table 3).

Table 3: Effect of variety and weed control methods on Weed Indices of garlic

Treatments	NOW	FWB (gm/2)	DWW (g/m^2)	WCE (%)	WI (%)	WIF (%)
Variety						
Ex- Sokoto	27.17	196.83^b	64.53	47.33	32.00	34 .00
EX- Kofa	23.75	263.67^a	86.08	51.17	33.00	30 .00
LS	NS	**	NS	NS	NS	NS
SE	2.532	21.56	9.59	2.350	2.412	3.09
Weed Control Methods						
Hoe weeding	9.33^c	17.83^c	2.08^c	90.00^a	0.00	12.00^a
Herbicide	19.33^{bc}	215.28^b	72.27^b	59.00^b	25.00^c	24.00^a
Neem Extract	25.00^b	250.68^b	80.52^b	47.00^c	37.00^b	15.13^a
Control	48.17^a	437.20^a	46.25^a	0.00	68.00^a	60.00^b
LS	**	**	**	**	**	**
SE	3.581	30.484	13.558	3.323	3.412	4.368
Interaction						
V × WCM	NS	NS	**	**	NS	NS

V × WCM = Variety x Weed control methods, NOW= Number of weeds, FWB= Fresh weight of weeds, DWW= Dry weight of weeds, WCE= Weed control efficiency, WI= Weed index, WIF= Weed infestation

Means followed by the different letter(s) within a treatment group are significantly different using Duncan Multiple Range Test (DMRT

Weed index

The two varieties of garlic tested showed no significant difference on weed index. But significant variation was observed between the weed control methods on weed index, where herbicides application gave lower weed index (25%) and the higher weed index (68%) was from control treatment. However, application of neem extract gave weed index (37%) (Table 3). Weed index is reduction in yield due to effect of weeds.

Weed Infestation

There was no significant difference ($p \leq 0.05$) with regards to weed infestation between the two varieties, however, significant variation was observed between the weed control methods on weed infestation, where higher weed infestation (60%) occurred with control treatments while lower weed infestation were recorded with hoe weeding (12%) and was statistically the same with herbicides and aqueous neem leaf extract (15%) methods of weed control (Table 3). This indicated the potential of neem leaf extract in reducing the level of weed infestation in garlic is similar to that of herbicides. This has support of the work of (Mishra, 2014; who reported allelophatic effect of neem leaf extract on seed germination and growth of some agricultural crops, (Lawal *et al*., 2011) who revealed suppression of both germination and growth of cowpea as a result of application of neem leaf extract and that of (Xuan, 2004), who reported that neem tree strongly inhibits germination and growth of several species of plants: *Daucus carota, Raphanus sativus, Oryza sativa etc*

Conclusion and Recommendation

Based on the result of this finding, weed control methods had influenced both growth, yield, and weed indices of garlic varieties. Hoe weeding gave better values for the growth and yield of garlic. For weed control methods however, herbicides and aqueous neem leaf extract showed similar potentials in reducing the effect of weed in garlic. Therefore, further research is recommended on the rate, timing of application and selectivity of neem leaf extract in managing weeds as it performed the same with herbicides in managing weeds, hence it showed a great potential as natural herbicides.

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EFFECT OF DIFFERENT METHODS OF WEED CONTROL ON THE GROWTH AND YIELD OF TOMATO (*LYCOPERSICUM ESCULENTUM* MILL.)

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Abstract

Field experiments were carried out at the Federal College of Agriculture, Moor Plantation, Ibadan, Nigeria in 2016 and 2018 to evaluate the effects of different methods of weed control on the growth and yield components of tomato. The treatments consisted herbicide (Pendimetalin), manual weeding using hoe, mulching with grass plant residues, cover crops (life mulching), plastic mulching, while the control was left weedy. Randomized complete block design (RCBD) was used for this experiment with three replicates. Data collected were analyzed using analysis of variance, and significant means were separated by Duncan's multiple range test (DMRT) at 5 % probability. Grass mulching had the highest tomato yield (i.e. No of fruits/plant and weight of fruits/plant) in both years. Yield in grass mulching was significantly higher than other treatments as yield decreased in the order of grass mulching > herbicide > plastic mulching > hoe weeding > use of cover crops > control (weedy check) treatment. In weed control, cover crop had higher weed biomass (45.70 and 40.47g m^{-2}), respectively apart from weedy check which had the highest weed biomass of 90.25, 80.45 g m^{-2}, while plastic mulch had the least weed biomass of 4.45 and 9.15 g m^{-2}.

Key words: Tomato, weed control, mulch, herbicide, hoe weeding

INTRODUCTION

Tomato (*Lycopersicum esculentum* Mill) belongs to the family Solanaceae. It is a popular and nutritive crop ranking next to potatoes in world's vegetable production. It is an important source of minerals and antioxidant such as carotenoids, lycopene, vitamins C, E and phenolic compounds which have a key role in human nutrition in prevention of certain cancer and cadiovascular diseases (Adalid *et al*., 2004).

Tomatoes are consumed in a number of ways, including sun-dreid tomatoes, tomato sauce, tomato juice, tomato soup, tomato ketchup and fresh as salad (Frusciente *et al*., 2007). It is an important cash-generating crop for small scale farmers, and it also provides employment in its production and processing industries (Jiregna *et al*., 2011). Despite this importance, in Nigeria, the average yield is low. The performance of tomatoes under high rainfall and humid conditions of southern Nigeria is poor compared to northern dry savanna environment (NIHORT, 2000).

In many agricultural systems around the world, competition from weed is also one of the major factors reducing crop yield and farmers' income (Knott, 1992). Of all the constraints limiting tomato production, weed seems to have the most deleterious effect causing yield reduction (Sanok *et al*., 1979; Usoroh, 1983, Sinha and Lagoke, 1984). Weeds reduce yield by competing for space, light, water and nutrients thereby weakening crop stands and reducing harvest efficiency (Abbassi *et al*., 2013).

Some weeds can also increase other pest problems by serving as alternative hosts for insects, diseases or nematodes. Weeds appear to have the most deleterious effect causing yield reduction of between 53 and 67 % in Maryland (Sanok *et al*., 1979; Usoroh, 1983; Sinha and Lagoke, 1984), 40 – 82 % in Nigeria (Adigun *et al*., 1993), 70 % in Pakistan (Bakht and Khan, 2014). Adigun (2000) reported that unrestricted weed growth throughout the crop life cycle resulted in 92 – 95 % reduction in tomato fruit yield. The weed control methods practiced in tomato production include cultural, mechanical, chemical and integrated weed management (Ashton and Monaco, 1991).

Since weed seems to have the most deleterious effect causing yield reduction, it is necessary to evaluate different methods of weed control in order to choose the best method; hence, the objective of the project is to determine the effects of different methods of weed control on the growth, yield components and yield of tomato.

MATERIALS AND METHODS

Field experiments were carried out in 2016 and 2018 at the Federal College of Agriculture, Ibadan, southwest of Nigeria (Lat. $7^0$22`30`` N and Long. $3^0$50130``E. Ibadan is characterized by bimodal rainfall distribution pattern with long raining season from March to July, a break in August and a short spell between September and early November.

Soil samples were collected from different points on the farm with Auger at a depth of 0 – 30 cm, air-dried, ground, and bulked for laboratory analyses. The site was cleared manually, ploughed and harrowed twice. The experimental site was marked out with garden line and meter rule. Pegs were used to demarcate the plots and leveled beds were prepared.

The experimental design was randomized complete block design (RCBD), replicated three times. There were six treatments in each replicate. The plot size was 3 x 3 m with alleyway of 0.5 m among the plots and replicates. Total land area used was 236.5 m^2. Treatments used were herbicides (Pedimetalin), hoe weeding, grass mulch, plastic mulch, and control (weedy plot).

The plastic mulch was laid before transplanting of seedlings, which was done through the openings made on it at 50 x 50 cm. herbicide (Pedimetalin) was applied before transplanting. The dried grass was also applied before transplanting leaving a little space for two plants. Hoe weeding was carried out at 3 and 8 weeks after transplanting (WAT). Life mulch was planted 3 WAT, while the control was left un-weeded from time of planting to the end of the experiment.

Tomato R10 Grande cultivar was obtained from certified Seed Store. It was planted in the nursery 6 x 4 m bed size and uniform and vigorous seedlings were transplanted to the experimental field at 5 Weeks after planting (WAP). 4 plants were selected randomly at the center and tagged for data collection.

Data were collected on plant height, leaf length and breath, stem girth, number of branches, number of fruits per plant, fruit length and fruit diameter, number of days to 1st flowering, number of days to 50 % flowering and yield per plot. These were subjected to analysis of variance (ANOVA), while means were separated using Duncan Multiple Range Test (DMRT) at 5 % level of probability.

RESULTS AND DISCUSSION

The soils were slightly acidic in 2016 and 2018 with pH of 5.71 and 6.80, the organic matter and total nitrogen were low (4.85, 6.59g kg and 0.09, 0.38%) respectively, available phosphorus were moderately low with 7.71 and 5.11mg kg, while the exchangeable cation were low. The textural class of the soils sandy (Table 1).

Table 1. Physical and chemical properties of pre-cropping soil

Parameter	2016	2018
pH	5.71	6.80
Available phosphorus (mg kg^{-1})	7.71	5.11
Organic matter (g kg^{-1})	4.85	6.59
Total nitrogen (%)	0.09	0.38
Organic carbon	2.86	3.82
Exchangeable Cation (cmol kg^{-1})		
Na^+	0.44	0.38
K^+	0.26	0.32
Mg^{2+}	0.70	0.29
Ca^{2+}	4.32	1.31
Particle size distribution (g kg^{-1})		
Sand	85.60	85.15
Silt	7.20	8.85
Clay	7.20	6.00
Textural class	Sandy	

Plant height.

In 2016, mulching with grass had the highest plant height (69.90cm) but not significantly different from 67.77 and 64.30 cm in use of herbicide and hoe, respectively. but this was significantly different from the use of cover crops (58.40 cm), which was not different significantly different from plastic mulching (56.90cm). However, the least (45.73cm) plant height was in weedy

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cheek (control) treatment. In 2018, the use of herbicide had the highest (70.20 cm) plant height which was not different significantly from cover crop (65.50cm), plastic mulching (64.92cm), grass mulching (64.40cm), hoe weeding (60.70cm), but significantly different from (54.20cm) in the control treatment which was least in plant height. These results support the findings of Deoteau et al. (1998) who reported mulching as a means of controlling weed, significantly affected the growth of tomato compared to no mulching and the grass mulching conserved sufficient moisture that enhanced the growth of tomato producing tallest plant height and maximum leaf area index (Table 2).

Table 2.: Effect of different methods of weed control on growth parameters of tomato

Treatment	Plant height (cm)		Leaf area index (cm)		No. of branches		Stem girth (cm)	
	2016	2018	2016	2018	2016	2018	2016	2018
Herbicide (Pendimetalin)	67.77a	70.20a	18.40ab	30.30ab	0.33b	5.88a	1.27ab	1.30a
Hoe weeding	64.30ab	60.70ab	18.84ab	37.00a	2.00a	2.27c	1.61a	1.07b
Grass mulching	69.60a	64.40ab	20.28a	36.30a	2.50a	2.60c	1.63a	1.33a
Cover crop (life mulching)	58.40b	65.50ab	17.86ab	25.60b	1.60a	2.43c	1.40ab	1.00b
Plastic mulching	56.90b	64.90ab	18.54ab	33.60ab	1.25a	4.30b	1.34ab	1.30a
Control (weedy check)	45.73c	54.20b	15.39ab	25.90b	0.42b	2.22c	0.84b	0.99b

Means followed by same letter(s) in a column are not significantly different at P < 0.05) by DMRT

Leaf area index (LAI)

The treatment had no significant on LAI of tomato in 2016. From the results, grass mulching had the highest (20.22cm) LAI > hoe weeding (18.84cm) > plastic mulching (18.54cm) > herbicide(18.40cm) > cover crop(17.86cm) > weedy check (15.39cm). In 2018, the treatment had significant effect on LAI of tomato where hoe weeding (37.00cm) was the highest, which was not different significantly from grass mulching (36.60cm) plastic mulching (33.60cm) and herbicide (30.30cm) but different significantly from weedy check and cover crop (25.96 and 25.60 cm) respectively. Plastic mulching, herbicide, weedy check and cover crop are not different significantly from one another with 33.60 > 30.30 > 25.90 > 25.60 cm, respectively.

Number of branches

Different methods of weed control had significant effects on the no. of branches where grass mulching had the highest (2.50) no. of branches which was not different significantly from hoe weeding (2.00) > cover crop > (1.60) plastic mulching (1.25), but the four treatments were different significantly from weedy check (0.42) and herbicide (0.33) in 2016.

In 2018, herbicide had the highest (5.87) no. of branches which was different significantly from plastic mulching, grass mulching, cover crop, hoe weeding and control (weedy check) having values of 4.30, 2.60, 2.43, 2.27 and 2.22, respectively, also plastic mulching 4.30 was different significantly from grass mulching, cover crop, hoe weeding and control values 2.60, 2.43, 2.27, and 2.22 respectively.

Stem girth

The treatments had significant effects on the stem girth of tomato where grass mulching had the highest (1.63cm), which was not different significantly from hoe weeding (1.61 cm), cover crop (1.40 cm), plastic mulching (1.34 cm) and herbicide (1.27 cm), but different significantly from weedy check (0.84 cm) in 2016.

In 2018, the treatments had significant effects on stem girth where grass mulching had the highest (1.33 cm), which was not different significantly from herbicide and plastic mulching with 1.30 cm, but significantly different from hoe weeding, cover crop and the control with values of 1.07 > 1.00 > 0.99 cm, respectively.

Effect of different methods of weed control of reproductive character of tomato

The treatments had significant effects on the no. of days to 1st flower production (Table 3). In 2016 and 2018, the control had the highest (80.15, 83.23 days) to produce the 1st flower which was not significantly different from all other treatments, but different significantly from herbicide which brought out its 1st flower first. The treatments had no significant effects on no. of days to 50 % flower production in 2016 and 2018.

Table 3. Effect of different methods of weed control on reproductive character of tomato

Treatment	No. of days to 1st flowering		No. of days to 50 % flowering	
	2016	2018	2016	2018
Herbicide (Pendimetalin)	70.85b	74.70b	84.45	92.30
Hoe weeding	75.05ab	77.70ab	86.15	91.30
Grass mulching	76.00ab	77.30ab	86.04	92.30
Cover crop (life mulching)	77.45ab	77.00ab	87.05	90.70
Plastic mulching	74.72ab	77.00ab	85.40	90.70
Control (weedy check)	80.15a	83.70a	87.25	90.70
			Ns	ns

Means followed by same letter(s) in a column are not significantly different at P < 0.05) by DMRT

Effect of different methods of weed control on yield and yield components of tomato

Effects of different methods of weed control on yield components are presented in Table 4. The treatments had significant effects on the fruit length in 2016 and 2018. Herbicide treatment had the highest (5.11 cm in 2016 and 5.20 cm) in 2018, which were not different significantly from cover crop (5.01, 5.10 cm), hoe weeding (4.79, 4.80 cm), plastic mulching (4.75, 4.93cm) but different significantly from grass mulching (3.30, 3.40cm) and weedy check (3.41, 3.57cm). Also, the treatments had significant effects on fruit diameter in both 2016 and 2018. Cover crop had the highest (4.57 and 4.23 cm) in 2016 and 2018 respectively which was not different significantly from herbicide (4.32, 4.23cm), plastic mulching (4.20, 4.06cm) and hoe weeding (3.65, 3.73cm), but different significantly from grass mulching (2.80, 2.73cm) and the control (2.51, 2.73cm).

The treatments also had significant effects on the no. of fruits per plant in the years 2016 and 2018 where grass mulching had the highest (4.58, 4.24) no. of fruits per plant. This was not significantly different from hoe weeding (3.42, 3.12), plastic mulching (3.35, 3.30), cover crop (3.33, 3.03), but different significantly from herbicide (2.33, 2.25) and the control (2.42, 2.32), but hoe weeding, plastic mulching, cover crop, the control and herbicide are not different significantly from one another.

Different methods of weed control had significant effects on fruit weight per plant in 2016 and 2018 (Table 4) where grass mulching had the highest (180.95, 175.35 g) fruit weight per plant which was > plastic mulching (128.20, 120.50 g) > hoe weeding (102.91, 100.55 g) > cover crop (121.50, 115.57 g) > control (74.05, 72.97) herbicide and weedy control are not different significantly from one another. Different methods of weed control had significant effects on tomato yield in 2016 and 2018 (Table 4) where grass mulching had the highest yield of 2.86, 2.63 t ha^{-1}. The yield was significantly higher than herbicide (2.41, 2.36 t ha^{-1}) > plastic mulching (2.00, 2.05 t ha^{-1}) > hoe weeding ≈ cover crop (1.91, 1.85 t ha^{-1}) > control (1.39, 1.33 t ha^{-1}). The results conformed with the finding of Kumer *et al*. (1995) who observed that mulching significantly increased the number of fruits per plant compared to weedy check (control).

Effect of different methods of weed control on weed biomass

In Table 5, the highest (98.25, 80.45 g) weed biomass occurred in the control (weedy check) which was significantly higher than all other treatments where plastic mulching had the lowest (4.45, 9.15 g) weed biomass. The order of weed control from the lowest was plastic mulching< grass mulching < herbicide < hoe weeding < cover crop < control (weedy check). This result is in line with the finding of Sanders (2001) who reported that black plastic mulching provides good weed control.

CONCLUSION

It could be concluded from this study that grass mulching has the potentiality to increase the yield of tomato. Farmers in Ibadan may use grass mulching

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in order to increase total yield per unit area of land in tomato production which will result into low weed infestation, weed biomass and effectively control weed of tomato up to harvest.

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Table 4. Effect of different methods of weed control on yield and yield components of tomato

	2016		2018		2016		2018		2016	2018
Treatment	Fruit length (cm)	Fruit diameter (cm)	Fruit length (cm)	Fruit diameter (cm)	No. of pod/plant	Fruit wt/plant (g)	No. of pod/plant	Fruit wt/plant (g)	Yield of tomato (t ha^{-1})	
Herbicide (Pendimetalin)	5.11a	4.32a	5.20a	4.23a	2.33b	74.05c	2.25b	72.93c	2.41a	2.36a
Hoe weeding	4.79a	3.65ab	4.80a	3.73ab	3.42ab	102.71bc	3.12ab	100.55bc	1.91b	1.85b
Grass mulching	3.30b	2.80b	3.40b	2.73b	4.58a	180.95a	4.24a	175.53a	2.86a	2.63a
Cover crop (life mulching)	5.01a	4.57a	5.10a	4.23a	3.33ab	121.50b	3.03ab	115.47b	1.97b	1.87b
Plastic mulching	4.75a	4.20a	4.93a	4.06a	3.35ab	128.20b	3.30ab	120.50b	2.00b	2.03b
Control (weedy check)	3.41b	2.51b	3.57b	2.73b	2.42b	80.35c	2.32b	79.05c	1.39c	1.33c

Means followed by same letter(s) in a column are not significantly different at P < 0.05) by DMRT

Table 5. Effect of different methods of weed control on weed biomass

	2016				2018			
Treatment	Weed density	Fresh weight	Dry weight (g)	Weed species count	Weed density	Fresh weight	Dry weight (g)	Weed species count
Herbicide (Pendimetalin)	20b	30d	10.50cd	6a	24.00b	135.50c	29.33b	7a
Hoe weeding	25b	176.5c	17.05c	6a	27.15b	195.00b	33.61b	7a
Grass mulching	15c	35d	7.13d	3b	20.45b	200.25b	35.25b	9a
Cover crop (life mulching)	32a	225b	45.70b	6a	30.53a	250.57b	40.47b	10a
Plastic mulching	4d	20d	4.45d	3b	6.75c	36.28d	9.15d	3b
Control (weedy check)	40d	441c	98.25a	9a	35.34a	400.37a	20.45a	10a

Means followed by same letter(s) in a column are not significantly different at P < 0.05) by DMRT

EFFECT OF WEED CONTROL METHODS ON WEED PERSISTENCE, GROWTH AND SEED YIELD OF EGUSI MELON IN SOUTHERN GUINEA SAVANNAH AGRO ECOLOGY OF NIGERIA

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ABSTRACT

The experiment was conducted at the Teaching and Research Farm of Kabba College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Kabba campus to study the effect of weed control methods on weed persistence, growth and yield of Egusi melon in southern Guinea Savannah agro ecology of Nigeria. The trial consisted of six treatments laid out in an experimental plot size of 3 m x 3 m each in a randomized complete block design (RCBD), with three replications. The treatments were (WC= plot weedy control, WF=weed free plot, HW4 and 8=hoe weeding at 4 and 8 weeks after sowing (WAS), ATP+HP8= atrazine at 2.5 a i at planting plus hand picking at 8 weeks after sowing, GMAP+HP8= grass mulch at planting plus hand picking at 8 WAS and F= SH3WBS+AP+HP8= application of systemic herbicide (Round up) at 4 l/ha 3 week before sowing (WBS) plus atrazine a day after sowing plus hand picking at 8 WAS). All plots with weed control were better than the weedy plots (control) in growth and yield. The highest yield was recorded in plots with systemic herbicide 3 WBS and atrazine at planting. Plot with grass mulch at sowing plus handpicking at 8 weeks after sowing produced yield higher than plot with weed free and plot with atrazine at planting plus hand picking at 8 WAS. All the weed control plots produced similar weed density, weed fresh weight, weediness of the field and melon canopy cover. The least melon canopy cover occurred in the plots without weed control methods. All the weed control plots produced similar weed control effects compared with weedy plots. For optimum yield of melon, farmers could use round up 3 weeks before sowing + atrazine at planting + hand picking at 8 WAS to enhance melon season-long weed suppression and guarantee profitable melon productivity.

Key words: Egusi melon, weed control, growth, yield, productivity

INTRODUCTION

Melon (*Colocynthis citrullus* L.*)*, popularly known as Egusi-melon is an important crop in African, especially Nigeria. It can tolerate low rainfall. It is cultivated within the savannah and forest vegetation belts (Ekpo *et al.,* 2010). In Nigeria, it is cultivated as sole crop but it could be intercropped with other annual crops. it is cultivated for its seeds which are prepared into condiments used in preparing soup and various dishes (Olaniyi, 2008; NAERLS-PCU, 2005). Melon performs best in a fertile, well drained, loamy soil, medium to near neutral pH, gentle but regular rainfall, interspaced with plenty of sun shine for increase in yield (Olaniyi, 2008). In southern Nigeria, Egusi melon is usually grown mixed with other crops such as cassava and maize by most famers who practice mixed cropping (Ekpo *et al*., 2010). Egusi melon is abundant in Nigeria, where it is cultivated in over an area of 361,000 ha, with yield of about 347,000 tonne per annum (Udensi and Oyeye, 2016). Melon is a short duration or short season crop, it provides food, and most importantly generates income to the farmers early in the season.

The major problem limiting productivity and increased land use for melon cropping system in the southern part of Nigeria is weed. Different weed control methods are used in crop production. Manual weeding is an effective means of controlling weeds (Fischer and Hill, 2004). The predominant method of weed control used by smallholder farmers in Nigeria is hoe weeding (Chikoye *et al*., 2002). Darkwa *et al*. (2001) and Chikoye *et al*. (2002) reported that 25 – 40 people are needed to weed one hectare of maize farm and this may account for 50 – 80 % of total labour budget. The mass migration from rural farm areas to urban centre increases cost of labour (Fischer *et al*., 2004) and also encouraged dependence on herbicides usage (Fischer *et al*., 2004). Delayed weeding causes significant crop losses (Chikoye *et al*., 2004) especially when economic threshold of weed infestation is exceeded. Hoe weeding is uncongenial and laborious (Aluko *et al.,* 2017). However, resource poor farmers have depended on this manual weeding method for a long time. Like many other crops grown in the tropics, melon is susceptible to early weed competition during the

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first 3 to 4 weeks after planting. Weed competition reduces canopy development and predisposes the crop to pest and disease infestation. Absence of weed control in crop farm resulted to crop losses of up to 100% (Nyam, 2005). For full expression of its genetic potentials and improvement in yield capacities, one of the operations in crops production is weed management (Madukwe, 2000). Hand weeding is probably the oldest method of weed control and consists of hand-pulling, hand-slashing and hoeing which have consistently proved inefficient and costly too. In technologically advanced countries, hand pulling is used merely to supplement other improved weed control methods (Kerkhoven, 2003). The use of herbicides for weed control have not only been found effective, but have been proven to be cheap if applied timely and correctly (Chikoye *et al.,* 2001). Similarly, Chikoye *et al.* (2002) have shown that chemical control was cheaper than hoe weeding.

Among pre-emergence herbicides, atrazine and metolachlor at 2.5 kg a.i./ha, fluometuron at 2.0 to 3.0 kg a.i./ha or diuron at 2.0 kg a.i./ha used singly or in combination with alachlor or metolachlorat 3.0 and 2.0 a.i./ha respectively have proved effective for weed control in the humid tropics (Akobundu, 1980). All of these herbicides were also listed as the common herbicides for weed control in the middle belt of Nigeria. The objective of the study was to assess the effect of weed control methods on weed persistence, growth and yield of Egusi melon in Southern Guinea Savannah agro ecology of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research farm of Kabba College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Kabba (Lat. 7.8231^0 N and Long. 6.0732^0 E) in Southern Guinea Savannah agro ecology of Kogi State, Nigeria. The area is characterized by a bimodal rainfall pattern which starts in late March and ends in late July while the short rainy season extends from September to late October after a dry spell in August. The soil order is an Ultisol (Moss, 1957). The site was left fallow for three years after it was cropped to maize and cassava for two years prior to the establishment of the experiment.

Land preparation

The experimental site was slashed and tilled manually using cutlass and hoe, respectively, the land was leveled using a shovel. Soil samples were collected at a depth of 15 cm diagonally across the plot and bulked, and after thorough mixing a sub sample was taken to the laboratory for chemical analysis. The soil of the study site belongs to the Ultisol class with silt 18.1 %, clay 21.6%, sand 60.3% (Sandy clay loam) pH 6.3, TOC 1.57%, TON 0.19 %, 3.41 mg/kg P, 0.26 cmol/kg K, 2.47 cmol/kg Mg and 2.66 cmol/kg Ca (Table 1).

Treatments plan and application

The trial consisted of six treatments laid out in an experimental plot size of 3 m x 3 m each in a Randomized complete block design (RCBD), with three replications. The treatments are WC= plot weedy control, WF=weed free plot, HW4&8=hoe weeding at 4 and 8 weeks after sowing, ATP+HP8= atrazine at 2.5 a i at planting plus hand picking at 8 weeks after sowing (WAS), GMAP+HP8= grass mulch at planting plus hand picking at 8 WAS and F= SH3WBS+AP+HP8= application of systemic herbicide (Round up) at 4 l/ha 3 week before sowing (WBS) plus atrazine a day after sowing plus hand picking at 8 WAS. Planting was done on 1st of April, 2015 at a spacing of 75 cm x 75 cm. Two seeds were sown per hole which was later thinned down to one plant per stand three weeks after planting giving a plant population of 17,778 plants per hectare. The three inner rows were considered the net plot and five plants from the net plot were tagged from which the growth and yield parameters were recorded.

The crops were sprayed with lamdacyahalothrin as Karate (insecticide) and benomyl (benlate) fungicide at the rates of 2 litres and 1.5kg/ha respectively at 6 WAS to protect the plants against insect pests and fungal diseases (Eifediyi and Remison, 2009). Harvesting of the Egusi melon fruits commenced at twelve weeks after planting when the fruits had turned deep green in colour. Harvesting was done by handpicking the mature fruits.

The parameters recorded were vine length, number of leaves per plant, leaf area, yield and yield components. Egusi melon vine length was measured by using a flexible tape rule. Number of leaves was assessed by visual count of the leaves and the leaf area was assessed by the dry weight method. At harvest, the number of fruit per plant was counted and recorded, weight of individual fruit was taken with the use of measuring scale and recorded. The fruits were broken and left for 7 days after which the seeds were extracted and number counted and recorded and weight of seed yield per was recorded. Field evaluation of weed characters

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of the field was conducted by panels of judges consisting of five (5) men, four (4) women and a youth (staff and student). The plots were presented in succession and panel members were allowed to judge the level of weed infestation.

Statistical analysis

Data collected were subject to the analysis of the variance (ANOVA) and treatment means were separated using Duncan Multiple Range Test when the difference between the averages was significant with the threshold of 5%.

RESULTS AND DISCUSSION

The results of the pre-planting soil analysis are presented in Table 1. The soil was sandy, clay, loam and relatively low in nitrogen, phosphorus and exchangeable potassium but slightly acidic. The organic matter level and total porosity were 1.57% and 38.8% respectively. The soil has the fertility potential to support the growth of Egusi melon.

Effect of weed control methods on the growth and yield parameters of Egusi melon are presented in Table 2. Significant differences were observed in all the growth and yield characters evaluated. Vine length of Egusi melon ranged between 283.6 and 103.2 cm. The longest vine length occurred in plots with atrazine at planting plus hand picking at 8 weeks after sowing, this was followed by plots with application of glyphosate (systemic herbicide) before planting plus application of atrazine a day after planting plus handpicking at 8 weeks after sowing (WAS). Plots with weed free then followed. Plots with hoe weeding at 4 and 8 WAS recorded the least value among the treated plots. However, weedy plots (control) recorded the shortest vine length of 103.2cm (Table 2).

Table 1. Pre-planting soil analysis

Properties	Values
Sand (%)	60.3
Clay (%)	21.6
Silt (%)	18.1
Soil texture	Sand clay loam
Soil pH	6.3
Soil bulk density (g/cm^3)	1.56
Total porosity (%)	38.8
Organic matter (%)	1.57
Total N (%)	0.19
Available P (mg/kg)	3.41
Exchangeable cation (cmol/kg)	
K	0.26
Ca	2.66
Mg	2.47

Table 2. Effect of weed control methods on growth and yield parameters of Egusi melon at 8 weeks after sowing

Treatments	Vine length (cm)	Number of leaves/plant	Leaf area(cm3)	Number of fruit per plant	Weight of individual fruit (kg)	Number of seed per fruit	Seed yield per fruit(g)	Yield (t ha^{-1})
WC	103.2c	107.8b	43.8b	2.42b	0.36b	63d	75.6c	1.34c

Weeding Weekly (WF)	276.8ab	232.4a	106.4a	7.48a	1.13a	213a	214.7b	3.82b
HW4&8	262.8ab	236.5a	111.3a	7.44a	1.16a	198b	232.0b	4.12b
ATP+HP8	283.6a	241.3a	116.7a	6.98a	1.24a	194b	235.6b	4.19b
GMAP+HP8	251.3b	227.1a	109.4a	6.04a	1.21a	184c	237.2b	4.22b
SH3WBS+AP+HP8	282.4a	234.6a	114.8a	7.46a	1.26a	208a	277.2a	4.98a

Legend: WC= plot weedy control, WF=weed free plot, HW4&8=hoe weeding at 4 and 8 weeks after sowing, ATP+HP8= atrazine at2.5 a i at planting plus hand picking at 8 weeks after sowing (WAS), GMAP+HP8= grass mulch at planting plus hand picking at 8 WAS and F= SH3WBS+AP+HP8 application of systemic herbicide (Round up) 3 week before sowing (WBS) plus atrazine a day after sowing plus hand picking at 8 WAS.

Numbers of leaves per plant was significantly affected by different weed control method used. Number of leaves produced was highest in plot treated with atrazine at planting plus handpicking of weeds at 8 WAS (241.3 leaves). This was similar to plots treated with hoe weeding at 4 WAS plus handpicking at 8 WAS. Plots with systemic herbicide (Round up) 3 weeks before sowing (WBS) + Atrazine at planting, weed free plots and plots with grass mulch at planting + hand picking at 8 WAS produced similar effects. Plots with no weed control produced the least leaves and the value was significantly inferior to plots with weed control methods.

Leaf area was significantly different due to the weed control method used. Leaf area in melon ranged between 43.8 to 116.7m^2. Plots with atrazine application at planting + handpicking at 8 WAS recorded highest leaf area, this was followed by plots with systemic herbicide at 3 WBS plus hand picking 8 WAS. Plots hoe at 4 WAS also followed. Grass mulch plot recorded leaf area of 109.4m^2 while the least leaf area among the treated plots was recorded in weed free plots. The leaf areas of all the treated plots were significantly better than weedy plots.

The effect of weed control methods on yield parameters of Egusi melon are presented in Table 2. Number of fruits per plant and weight of individual fruit ranged between 2.42 to 7.48 and 0.36 to 1.26 respectively. Plots with weed free, hoe weeding at 4 WAS plus handpicking at 8 WAS, atrazine at planting plus handpicking at 8 WAS and plots with systemic herbicide 3 weeks before sowing + atrazine at planting gave similar number of fruits per plant and individual fruit weight. All these were significantly superior to weedy plots.

Significant differences were observed in the number of seeds per fruit due to the different weed control methods used. Plots with weed free plants recorded the highest number of seeds per fruit but heaviest seeds occurred in plots with systemic herbicide 3 weeks before planting plus atrazine at planting which produced similar numbers of seeds per fruit with weed free plots. Plots with hoe weeding at 4 WAS plus handpicking at 8 WAS and plots with atrazine at planting plus hand pick plots. The highest seeds among the treated plots occurred in plots with grass mulch at planting plus handpicking at 8 WAS. The seed yields of all the treated plots were better than the weedy plots (control).

The highest seed yield per ha was recorded in plots treated with systemic herbicide 3WBP plus atrazine at planting (4.93 t ha^{-1}), this was significantly superior to plots with weed free, hoeing at 4WAS plus handpick at 8WAS and grass mulch at planting plus handpick at 8 WAS that produced similar seed yield per ha. Weedy plots recorded the least seed yield per ha (1.34 t ha^{-1}).

All plots with weed control were better than the weedy plots (control) in growth and yield. This suggested that weed competition in weedy control plots were critical. This is in line with the report of Aluko *et al.* (2017); Ajibola and Modupeola (2014) who reported that weedy control plots suffer critical reduction in growth and yield. Plot with hoe weeding every week (weed free plot) produced lower yield compared to other weed control methods used. The lower yield recorded could be due to constant interfering with the root set up of the crop. Also, flowering distortion during hoeing could lead to premature falls of the flowers which resulted in lower yield of the crop.

The highest yield was recorded in plots with systemic herbicide 3 WBS and atrazine at planting. Chemical weed control has been reported to be effective (Adigun *et al*., 1993; Nazeer *et al.,* 2004 and Korieocha *et al.,* 2011). The combination of this chemical reduced early weed competition, prolonged season weed suppression and improved melon yield.

Plot with grass mulch at sowing plus handpicking at 8 weeks after sowing produced yield higher than plot with weed free and plot with atrazine at planting plus hand picking at 8 WAS. Aluko *et al.,* 2017 opined that mulching plus handpicking reduces weed flushes as a result of mulch barrier, environmental sieve was imposed that prevented weed seeds germination. James (1999) reported that vegetation germinant is eliminated by mulch material used and re-established following the deterioration of mulch materials, this could be responsible for higher yield in mulch plots.

The effect of weed control methods on weed density, wood fresh weight, weediness of the field and melon canopy are presented in Table 3. Significant differences were observed in weed density, weed fresh weight, weediness of the plot were fresh weight and weediness of the plots were highest in plot without weed control. All the weed control plots produced similar weed density, weed fresh weight, weediness of the field and melon canopy cover. The least melon canopy cover occurred in the plots without weed control methods.

Table 3. Effect of weed control methods on weed characters

Treatments	Weed density	Weed fresh weight (g/m2)	Weediness of the fluid (0 -5)	Melon canopy cover (0 – 5)
WC	127a	296.41a	9.63a	3.16b
Weeding Weekly (WF)	02b	4.86d	0.04b	8.41a
HW4&8	21b	42.68bc	1.14b	8.06a
ATP+HP8	18b	34.84c	1.28b	7.89a
GMAP+HP8	27b	45.38bc	2.04b	8.34a
SH3WBS+AP+HP8	26b	53.49b	2.16b	8.27a

Legend: WC= plot weedy control, WF=weed free plot, HW4&8=hoe weeding at 4 and 8 weeks after sowing, ATP+HP8= atrazine at2.5 a I at planting plus hand picking at 8 weeks after sowing (WAS), GMAP+HP8= grass mulch at planting plus hand picking at 8 WAS and F= SH3WBS+AP+HP8 application of systemic herbicide (Round up) 3 week before sowing (WBS) plus atrazine a day after sowing plus hand picking at 8 WAS.

Weedy plants recorded the highest weed parameters and lowest melon canopy cover. This is expected because weed interference is most critical and weed competition with melon was also highest in weedy plots. Thus, reduction in canopy cover and highest weed parameter is in line with the report of Ajibola and Modupeola (2014) that a weedy plot suffered comparable reduction in plant parameters (canopy cover and seed yield. Udensi and Oyeye (2016) also reported a higher weed cover and lowest melon canopy cover and attributed this to severe weed completion.

All the weed control plots produced similar weed control effects compared with weedy plots. All these are expected because of the drastically reduction in weed competition in the weed control plots.

CONCLUSION

Weeds interference significantly reduced crop yield. Reduction in weed pressure through the use of any of the weed control methods evaluated could improve melon yield for higher net return. For optimum yield of melon, farmers could use round up 3 weeks before sowing + atrazine at planting + hand picking at 8 WAS to enhance melon season-long weed suppression and guarantee profitable melon productivity.

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EVALUATING EFFECTS OF COVER CROPS ON WEED ABUNDANCE AND GROWTH OF SWEET ORANGE (*CITRUS SINENSIS* (LINN). (OSBECK) VAR. AGEGE-1) IN A JUVENILE ORCHARD

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ABSTRACT

A field study was conducted at a juvenile sweet orange orchard at the National Horticultural Research Institute Ibadan, to evaluate the effects of cover crops on weed abundance and growth of sweet orange in the orchard. The cover crop tested were; pumpkin (Cucurbita pepo L.) at 1m x 0.5m, egusi melon (Colocynthis vulgaris L.) at 1m x 0.5m , sweetpotato (Ipomoea batatas L. (Lam) at 1m x 1m, akidi (Vigna Sesquipedalis) at 50cm x 75cm, hand slashing (HS) (4 times/year) and no weeding (NW) as control. The spacing for sweet orange was 5m x 5m, with plot size of 10m x 10m. The experimental design was randomized complete block design in four replications. Data collected include ground coverage (GC), weed density, weed biomass and weed control efficiency (WCE), plant height and number of leaves. Data collected were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$. Results obtained revealed that akidi plots recorded significantly higher GC of 91.9% while the lowest (50%) was recorded from egusi melon plots at 12 WAP. Lower weed densities (5.8 and 11.8 no/m^2) were recorded from sweetpotato and akidi plots respectively, while the highest (27.5 no/m^2) was recorded from HS and NW plots. Weed biomass ranged from 122g/m^2 (akidi) to 649.0g/m^2 (NW). The WCE (%) is in the order 78 (akidi) > 72 (sweetpotato) > 71 (pumpkin) > 63 (egusi melon) > 33 (HS). Plant height ranged between 82.7 (sweetpotato) to 55.6 (egusi melon). There were no significant differences between number of leaves and number of branches.

Key words: Cover crop, weed control efficiency, ground coverage, weed suppression, sweet orange

INTRODUCTION

Cover crops are crops planted majorly to manage soil water, soil quality, soil fertility, soil quality, weeds, pests and diseases, biodiversity and wildlife in agro ecosystems (Lu *et al.,* 2000). Farmers grow cover crop types based on their own choice, needs and goals. These are largely influenced by the environmental, biological, social-cultural, and economic factors of the farming and food system within which farmers operates (Snapp *et al.,* 2005). The planting of cover crops when in combination with occasional spot slashing of shrubs, maintain a good view of interrows (Usoroh, 1991). Obiefuna (1989) reported an effective suppression of growth of weed of between 3 to 7 months when plantain was intercropped with 2,500 melons/ha and 5000 melons/ha respectively. Similarly, pumpkin and wide spreading cucurbits were found to significantly suppress weeds in arable crops in Nigeria and South Africa (Nwagwu *et al*., 2000). Michael (2011) evaluating seven cover crops for weed suppression in maize reported that weed suppression was in order akidi > Sweet potato > Melon > Water melon > Fluted pumpkin > pumpkin. The use of cover crops like melon either reduces weed seed germination or smothers the germinated seedlings and established plants. Cover crop stands with higher population density often compete well with weeds during the growth of the cover crops. This competition prevents most germinated weed seeds from completing their life cycle and reproducing. The cover crop reduces weed seed germination if they are left on the soil surface rather than ploughing into the soil as a green manure after their growth is terminated. This is because they form an impenetrable mat that block the light transmittance to the weeds (Teasdale, 1993). Moreso, as the weed seeds is germinating, they run out of stored energy for growth before building the necessary structural capacity to break through the cover crop mulch layer. This is often termed the cover crop smothering effect (Kobayashi *et al*., 2003). Cover crop permits reduction of herbicide input and help in soil fertility maintenance and erosion control (Teasdale, 1996). However, cover crops do not provide complete weed control and have to be augmented with other weed management methods.

MATERIAL AND METHODS

The experimental site was a newly established orchard planted with sweet orange var. Agege-1 budded on Cleopatra mandarin rootstock at National Horticultural Research Institute (NIHORT) Ibadan (07° 24′ 36.88″ N, 003° 51′ 16.05″ E, 213 meters above sea level). Ibadan lies in the derived savanna of South West Nigeria. The soil in the experimental area belongs to the main soil series of Egbeda (Smyth and Montgomery, 1962). They are also classified as Alfisols and Lixisols (Soil Survey Staff, 1990; Okafor, 2016).

The study was carried out in a citrus orchard planted with sweet orange var. Agege-1 budded on Cleopatra mandarin rootstock. The cover crop treatments assigned were; pumpkin (*Cucurbita pepo* L.) at 1m x 0.5m, egusi melon (*Colocynthis vulgaris* L.) at 1m x 0.5m, sweetpotato (*Ipomoea batatas* L. (Lam) at 1m x 1m, akidi (*Vigna unguiculata susp. Sesquipedalis*) at 50cm x 75cm. hand slashing (4 times/year) and no weeding (Weedy check) as control. Sweet orange seedlings were planted to a plot area of 10m x 10m (100m^2), while the spacing for sweet orange was 5m x 5 m. The cover crops were planted at the same time with the transplanting of sweet orange seedlings in the orchard. The experimental design was randomized complete block design with four replications. Data were collected on ground coverage of cover crops, weed density, weed biomass and weed control efficiency, plant height, number of leaves and number of branches.

Weed control efficiency (WCE) was calculated using;

$\mathrm{WCE}\ (\%) = \frac{\mathrm{WDWC} - \mathrm{WDWT}}{\mathrm{WDWC}} \mathrm{X}\ 100$, where WDWC = Weed dry weight in weedy check.

WDWT = Weed dry weight in the treatment (Patel *et al,* 2006). Data collected were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$.

RESULTS AND DISCUSSIONS

Significantly ($p<0.05$) higher ground coverage was recorded from sweet orange plots planted with egusi melon at 6 WAP (Fig. 1). However, at 12 WAP, sweet orange plots planted with akidi recorded significantly ($p<0.05$) higher ground coverage of 91.9%. Sweetpotato plots recorded the highest weed density at 4 WAP of cover crops and at 4 WAT of sweet orange seedlings. Akidi plots had the least weed density of 8.5 plants/m^2 which was statistically ($p<0.05$) lower when compared with no weeding plots, though not statistically different when compared with other cover crop treatments and the hand slashing plots at 12 WAP. At 16 WAP, sweetpotato and akidi plots recorded significantly ($P<0.05$) lower weed densities of 5.8 and 11.8 no/m^2 respectively (Table 1). Significantly least weed biomass (10,122g/m^2) was observed from sweet orange plots planted with akidi at 4 and 16 WAP. The highest weed biomass of 649.0g/m^2 was recorded from the no weeding plots at 16 WAP. The weed control efficiency (WCE) expressed as percentage revealed that, akidi plots recorded significantly higher (78%) WCE, and closely followed by sweetpotato plots (72%). The least WCE (33%) was srecorded from no weeding plots.

Broadleaf weeds dominated in the contribution to weed population during the study. Broadleaf weeds contributed between 34.5% (akidi) and 67.3% in no weeding plots. For grass weeds, highest occurrence of 15.3% was recorded in sweetpotato plots, while 21.8% was recorded from hand slashing plots for sedge weeds. The cover crops contributed lesser weeds with occurrence of 34.5% (akidi), 58.5% (egusi melon) for broadleaf weeds while, egusi melon and sweetpotato plots contributed 5% and 11% for grass weed respectively. Sweetpotato plots contributed least number for sedge weeds. Generally, akidi and sweetpotato plots were the least contributors to the weed population during the period of study (Figure 2). The cover crops (pumpkin, egusi melon, sweetpotato and akidi) used in this study were fast growing, attaining a ground cover of between 50 – 90% at 6 – 12 WAP, and were able to smother weeds early in the orchard. The reduction in weed biomass in cover crop plots may be attributed to early and rapid ground cover by the cover crops, thereby reducing light transmission, soil moisture and nutrient to the weeds during the growth cycle of the companion crops. This also agrees with the earlier report by Olaniyan and Fagbayide, (2005) that early and continuous canopy cover smothers weed and reduces weed/crop competition, particularly for soil nutrients, light and soil water (International Institute of Agriculture (IITA, 1985). Result on weed control efficiency also showed that the lower the weed biomass, the higher the weed control efficiency (Alamu, 2019).

At 1month after transplanting (MAT), there were no significant differences among the growth attributes of the sweet orange seedlings, while at 2 and 4 MAT, sweetpotato plots had statistically ($p<0.05$) taller plants (66.0 cm and 82.7cm) as compared with other treatments. At 2 MAT, lower number of leaves was recorded from no weeding plots. Highest number of leaves was recorded from akidi plots and was statistically ($p<0.05$) higher compared with other treatments. More number of leaves of 43.8 and 53.3 were also recorded from akidi plots at 3 and 4 MAT respectively. However, these values were higher compared with other cover crop treatments and the control. Sweet orange plots planted with akidi recorded more branches at 2 MAT, while egusi melon plots recorded more branches of 6.7 and 8.9 at 3 and 4 MAT. Other treatments had branches that ranged between 7.7 (sweetpotato plots) to 5.2 in no weeding plots. The influences of various cover crops planted (pumpkin, akidi, sweetpotato and akidi) on the performance of test crop might be complicated by factors which included their wider spread to cover the soil surface as was the case with akidi and high biomass generation from pumpkin which reduced the amount of weeds present on the field, their nitrogen fixing ability and soil water conservation due to high crop biomass that cover the surface of the soil (Alamu *et al*, 2018). Care must however be taken in making the choice of the cover crops to be used so that the competition likely to be offered by the cover crop will not have negative influence on the productivity of the main crops. Olaniyan *et al.* (2008) in their preliminary investigation, where cover crops are used for weed control in citrus orchard reported that *Mucuna pruriens* which is an aggressive climber finds its way to the crown of the trees. The authors also reported that this may lead to reduction in the area available for photosynthesis and consequently reduce the fruit yield and quality if it is not properly managed.

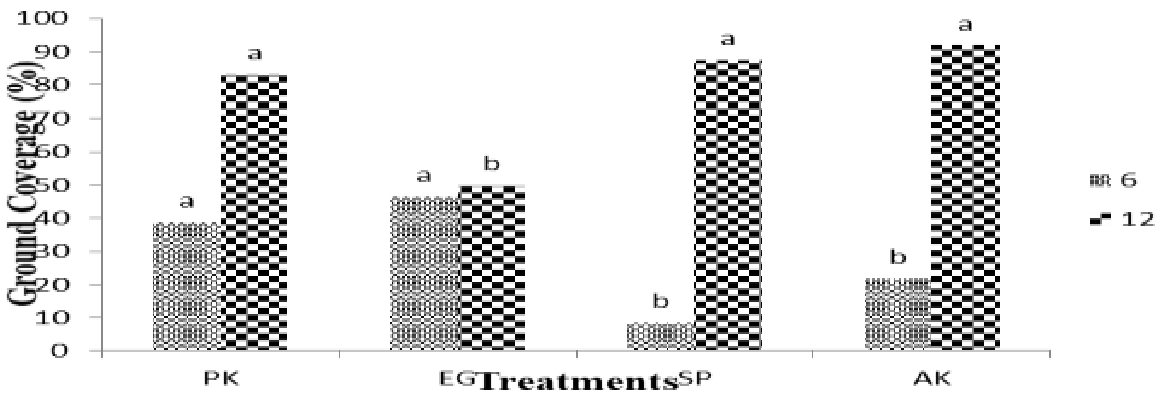

Figure 1: Percent ground cover of the cover crops in sweet orange orchard.

PK – Pumpkin, EG – Egusi melon, SP – Sweetpotato, AK – Akidi. 6, 12. – Weeks after planting. Bars with the same letter(s) are not significantly (P<0.05) different by DMRT

Table 1. Influence of cover crops on weed density (No/m²), weed biomass (g/m²) and weed control efficiency (%) in juvenile sweet orange orchard

	Weed density				Weed biomass				
		Weeks		After	Transplanting				
Treatments	4	8	12	16	4	8	12	16	WCE
Pumpkin	24.5	11.5	15.8ab	25.5a	110.0c	34.0b	73.0bc	184.0c	71.0c
Egusi melon	16.8	13.8	17.5ab	24.3ab	80.0e	61.0b	20.0c	249.0bc	63.0d
Sweetpotato	28.3	11.8	12.8ab	5.8b	90.0d	88.0b	55.0bc	141.0c	72b
Akidi	23.8	10.8	8.5b	11.8ab	10.0f	52.0b	28.0c	122.0c	78a
Hand slashing	22.3	11.5	26.8ab	27.5a	175.0b	154.0ab	251.0a	343.0b	33e
No weeding	22.0	20.3	31.0a	27.5a	180.0a	241.0a	294.0a	649.0a	0.0f

Means followed by the same letter(s) in the same column are not significantly (P<0.05) different by DMRT
No/m² – Number per metre square

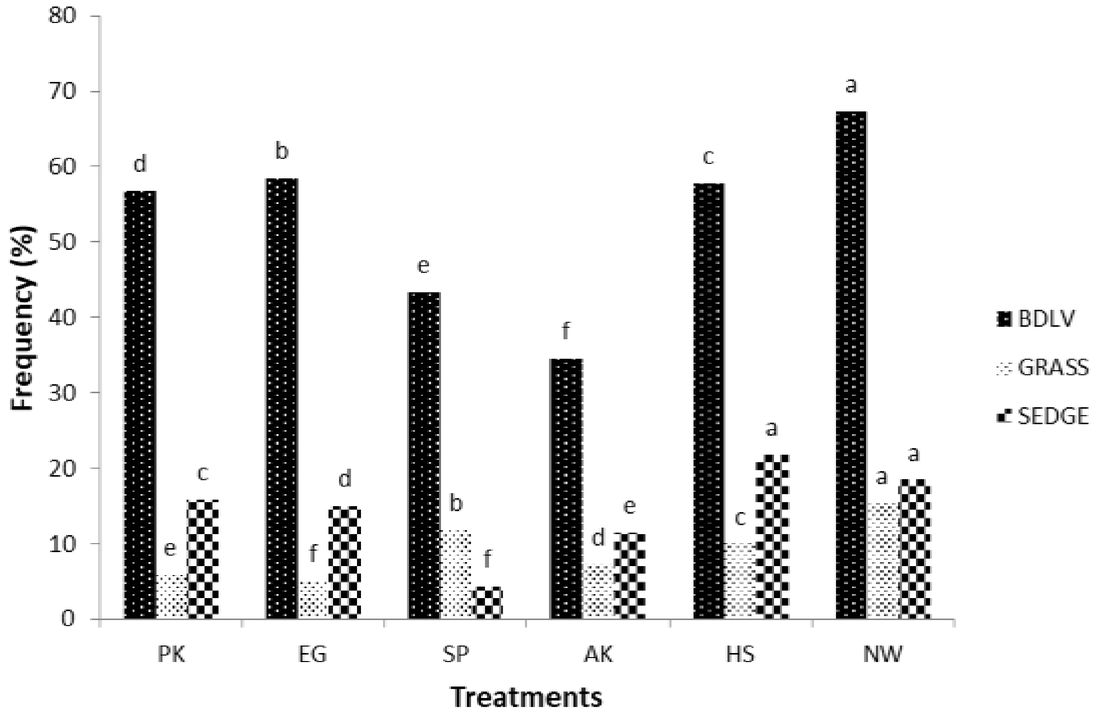

Figure 2: Percentage contribution of weed morphological groups to the weed population as influenced by cover crops in juvenile sweet orange orchard.

PK = pumpkin, EG = egusi melon, SP = sweet potato, AK = akidi, HS = hand slashing, NW = No weeding. BDLV = broadleaf.

Bars with the same letter(s) are not significantly (P<0.05) different by DMRT.

Table 2: Effects of cover crops on sweet orange plant height (cm), number of leaves and number of branches in a juvenile orchard

	Months After Transplanting											
	Plant Height				Number of Leaves				No of Branches			
Treatment	1	2	3	4	1	2	3	4	1	2	3	4
Pumpkin	54.6a	44.1b	64.6a	67.9ab	28.3a	36.3ab	40.1a	49.8a	2.70a	4.50a	5.0a	8.0a
Egusi melon	46.8a	41.3b	51.8a	55.6b	24.5a	30.2b	30.3a	37.8a	3.10a	3.50a	6.70a	8.90a
Sweetpotato	53.0a	66.0a	64.6a	82.7a	35.8a	31.8b	30.7a	51.0a	3.20a	3.80a	5.0a	7.70a
Akidi	48.8a	63.5a	61.3a	73.3a	35.0a	51.3a	43.8a	53.3a	3.60a	3.80a	6.60a	6.60a
Hand slashing	48.3a	62.9a	66.2a	79.7a	33.0a	29.0b	33.5a	41.5a	3.10a	4.0a	4.10a	6.10a
No weeding	49.0a	58.9a	56.8a	70.6ab	27.3a	26.6b	36.9a	36.3a	3.90a	3.0	5.50a	5.20
	2.18	4.73	5.23	3.10	4.54	0.31	0.12	0.10	0.17	0.48	0.41	0.55

Means followed by the same letter(s) in the same column are not significantly (P<0.05) different by DMRT

Cm - Centimetre

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EFFICACY OF BOTANICALS IN THE MANAGEMENT OF CYCAD AULACASPIS SCALE (*AULACASPIS YASUMATSUI*) ON CYCAD PLANT (*CYCAS REVOLUTA*)

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ABSTRACT

The efficacy of four botanicals namely: Azadirachta indica (Neem), Chromolaena odorata (Siam weed), Tithonia diversifolia (Tithonia) and rind of Citrus sinensis (sweet orange) on Cycad Aulacaspis Scale (CAS) on infested Cycas revoluta (cycad plant) was evaluated in the Floriculture garden of the National Horticultural Research Institute Ibadan, Nigeria. Cypermethrin (a synthetic insecticide), was used as positive check and distilled water as control. The treatments were applied weekly as foliar sprays for 10 weeks. CAS attack on cycad was mild on plants treated with citrus rind extracts, neem extracts and cypermethrin; average on Chromolaena and tithonia extracts treated plants and severe in the control plants. Lower damage was recorded on plants treated with citrus rind extracts (12.60%) which was not significantly different from neem extracts (15.10%) and cypermethrin (15.50%) treated plants. However, 100% damage was recorded in the control plants. Orange rind, Azadirachta indica (Neem) and Chromolaena odorata extracts could be considered and used as bioactive candidates for the management of Cycad Aulacaspis Scale.

Key words: Botanicals, Cycad Aulacaspis Scale, *Cycas revoluta*, cypermethrin, management.

INTRODUCTION

Cycad (*Cycas revoluta*) is an important horticultural plant belonging to the family Cycadaceae (Schneider *et al*., 2002). The palm is native to tropical and subtropical regions and can grow in almost any medium, including soil-less ones (Dimkpa, *et al*., 2021). It performs best in sandy, well-drained soil under full sun or partial shade but grows larger leaves in more shaded environment (Dimkpa, *et al*., 2021). It has shiny, dark green leaves which grow out into a feather-like rosette on a thick shaggy trunk (Chamberlain, 1990). Propagation of *Cycas revoluta* is either by seed or clonally by removal of basal offsets. Cycad is used for beautification and in horticultural landscape around homes, institutions, horticultural gardens and offices (Nwaobasi, 2008). Cycad as a horticultural landscape plant is among the highest rated ornamental plants in floriculture business in Nigeria with high cost benefit as reported by Sani *et al*., 2016. However, its production and commercialization is threatened with many factors among which is the infestation by the scale insect, Cycad Aulacaspis Scale (CAS). Cycad Aulacaspis scale (*Aulacaspis yasumatsui* Takagi) is a notorious pest in the family Diaspididae and attack plants in the genera, cycads (Howard *et al.,* 1999). The outbreak of the pest was first noticed in the South-south region of Nigeria in 2014 (Dimkpa *et al*., 2021), and has since spread and caused great havoc in the propagation and multiplication of the plant (Dimkpa *et al*., 2021). A recent outbreak of the pest was observed in South-west region of Nigeria in 2021 causing tremendous damage and huge loss of cycad plants both in the nursery and established landscape plants.

The insect can be transported over short distances by wind and infested plants (Hodges *et al*., 2004). Female cycad scales have a waxy covering and are white or orange in color, while the male cycad scales are orange-brown in color (Weissling *et al*., 1999; Heu *et al*., 2003). A female cycad scale lays egg within 21-35 days of hatching in warmer weather condition, hatching occurs within 8-12 days (CABI, 2018); the life cycle of cycad scale is approximately 35 days from egg to adult and average longevity is 75 days (Howard *et al*., 1999). Newly hatched scales, called crawlers, migrate to the undersides of leaflets or leaves at the base of the petiole where infestation begins. As infestation progresses, the scale insect infest the upper surface of the leaflets, the trunk, seed/cones and the roots of the plant (Heu *et al*., 2003; Howard *et al*., 1999; Weissling *et al*., 1999). Highly infested cycads are almost completely white or snow-covered which eventually turned the leaves brown and crispy making its management difficult (Dimkpa, *et* al., 2021). The damage caused by CAS on cycad plants ranges from chlorotic, yellow-brown leaves, continuous plant sap removal and finally death of the plant (Broome, 2004).

Management practices which include cultural methods (pruning of infested leaves) and the use of insecticides such as Cypermethrin, Lambda-cyhalothrin and methidathion have been adopted in minimizing the spread of this insect. However, these methods have proved not to be the best option for the control of CAS coupled with the deleterious effect of chemicals on plant and human health as well as on biocontrol agents. Therefore, the need for prompt remedial measures to reduce the spread of the insect and at the same time maintain healthy environment. The use of botanicals against diverse insect pests has been employed in pest management in recent times. Botanicals are biodegradable; they reduce environmental contamination and help in maintaining the biological diversity of organisms in the eco-system (Grange and Ahmed, 1998; Isman, 2008). This study therefore aimed at determining the efficacy of indigenous botanicals as well as proven synthetic insecticide in the management of Cycad Aulacaspis Scale (CAS) on *Cycas revoluta*.

MATERIALS AND METHODS

Experiment was conducted in the Floriculture garden of the National Horticultural Research Institute (NIHORT), Idi-Ishin, Ibadan to determine the efficacy of the extracts of indigenous plant parts and synthetic insecticide in the management of Cycad Aulacaspis Scale (CAS) on *Cycas revoluta*. Eighteen (18) potted Cycad seedlings already infested with Cycad Aulacaspis Scale were collected from the nursery in the floriculture garden. Collection of plant materials and preparation of extracts used for the study was done according to the method described by Pitan, *et al. (*2015). Fresh leaves of *Azadirachta indica* (Neem), *Chromolaena odorata* (Siam weed), *Tithonia diversifolia* (Tithonia) and rind of *Citrus sinensis* (sweet orange) were collected, rinsed with distilled water to remove any contaminant and air-dried on a flat surface in the laboratory at room temperature (27± 2ºC) until they are crispy dry. The dried Neem, Siam weed, Tithonia leaves and sweet orange rinds were milled into fine powder separately using an electric blender. From the powder obtained, 100 g of each plant sample was taken and added to 1litre distilled water (10% w/v) in separate plastic containers of 2 litres and allowed to stay for 48 hours after which the extract was vigorously shaken and carefully decanted. The decanted solutions were later passed through the process of filtration using Whatman No 1 filter paper. The filtrates aqueous extracts were taken as stock solution, stored in collection bottles and used for the experiments. Cypermethrin, a standard insecticide (1% v/v) was used as the check. Control plots without any insecticide applications were also maintained. Extracts of *Azadirachta indica*, *Chromolaena odorata*, *Tithonia diversifolia*, sweet orange rind and synthetic insecticide (cypermethrin) were applied weekly as foliar sprays for 10 weeks using a hand sprayer. Control pots without any insecticide applications were also maintained. The pots were arranged in a Complete Randomized Design (CRD) with three replicates according to the six treatments. Efficacy of the botanicals on potted plants were observed and compared with the control pots and the check. The infestation by CAS on the leaves of *Cycas revoluta* before treatment was mild (having 1 - 2 leaves infested) while damage on the plant was assessed after 10 weeks of treatment application using a modified 0-5 rating scale according to Compton (1991) below:

Infestation rating scale

0 leaf infested - No infestation; 1-2 leaves infested - mild infestation, 3-4 leaves infested - average infestation; 5 or more leaves infested - severe infestation.

Damage rating scale

0 wilted - No damage; 1-2 wilted leaves - slight damage; 3-4 wilted leaves - Average damage

5 wilted leaves – Severe damage.

Statistical analyses

Cycad Aulacaspis Scale (CAS) on the plants were scored and transformed using square-root model $\sqrt{(X + 0.5)}$ before analysis of variance (ANOVA). Damage parameters were subjected to one-way ANOVA at 5% probability level. Significant means were separated using Studentized Newman-Keuls test (SNK) with SAS 9.0 statistical package.

RESULTS

Plants used in the study were from three major families namely: Maliaceae, Asteraceae and Rutaceae. The plant parts utilized were the leaves (Neem, siam weed and tithonia) and rind (sweet orange) (Table 1). Treatments application influenced the population of the insects on the foliage and trucks of the plant as well as damage done to the plant (Table 2). Reduced snow covering on the leaves and trucks (signifying reduced CAS population) was observed on plants treated with citrus rind and neem extracts which was similar to what was observed in the cypermethrin treated plants. This was followed by siam weed extract while tithonia leaf extract recorded higher population of the insects with higher snow covering on both sides of the leaves and the truck of the plants used in the study. However, highest CAS population was observed on the control plants.

Table 1: The selected plants utilized in the study

S/N	Common name	Botanical name	Family	Part used
1	Neem	*Azadirachta indica*	Maliaceae	Leaf
2	Siam weed	*Chromolaena odorata*	Asteraceae	Leaf
3	Tithonia	*Tithonia diversifolia*	Asteraceae	Leaf
4	Sweet Orange	*Citrus sinensis*	Rutaceae	Rind

Table 2: Infestation and damage by Cycad Aulacaspis Scale on cycad plants before and after 10 weeks of treatments application

Treatment	Before treatment		After treatment	
	Infestation description	Damage description	Damage Plant (%)	Damage description
Azadiracta indica	Mild	Slight damage	15.10d	Mild
Chromolaena odorata	Mild	Slight damage	45.30c	average
Tithonia diversifolia	Mild	Slight damage	55.10b	average
Citrus sinensis	Mild	Slight damage	12.60d	Mild
Cypermethrin,	Mild	Slight damage	15.50d	Mild
Control	Mild	Slight damage	100.00a	severe

Means in the same column with the same letter are not significantly different ($p > 0.05$) using Studentized Newman Keuls (SNK).

Damage on the plants varied from mild to average (on treated plants) while the control plants were severely damaged. The infestation started from base of the petiole from where it spread to the undersides of the leaflets, this infestation progressed to the upper part of the leaves, making the leaves brownish or chlorotic and eventually become dry and dead. Lower percentage plant damage was recorded on plants treated with citrus rind extracts (12.60%) which was not significantly different from what was obtainable in neem extracts (15.10%) and in the cypermethrin (15.50%) treated plants. Of the botanicals, tithonia extracts recorded higher plants damage (55.10%). However, 100% damage was recorded in the control plants. The effect by CAS infestation was mild on plants treated with citrus rind extracts, neem extracts and cypermethrin; average on Chromolaena and tithonia extracts-treated plants and severe in the control plants.

DISCUSSION

The introduction of the different Cycad species to Nigeria is due to its beautification to the environment as well as its importance as an ornamental/horticultural plant (Nwaobasi, 2008; Chamberlain, 1990). The Cycad Aulacaspis Scale (CAS) is a major constraint to cycad production and commercialization. The invasion of CAS to cycad plants in Nigeria as reported by Dimkpa et al. (2021) has posed danger to cycad species and will cause the extinction of this ornamental/aesthetic plant and negatively affect the cycad-growing industry in the country if necessary action to forestall its effects is not drastically taken. The pest infestation began at the lower surface of the leaves with appearance of snow covering on the leaves and then the trunks which later progresses to the upper parts of the plant. Scale insects has the ability to hide deep in the crevices and roots of the plant with high fecundity and egg production rate which has made the management of the insect difficult (Marler and Moore, 2010). Application of insecticides has been the major measure utilized by florists in the management of CAS. Emshousen and Mannion (2004) reported that systemic insecticides when taken up into the leaves tissues suppress CAS populations; they persist and remain effective deterrents to the target pest.

In this study, citrus rind and neem extracts on application caused high protection to infested CAS plants resulting into lower damage in the plants as observed at the end of the ten weeks' application which was similar to effect in the plants treated with the standard check 'cypermethrin'. Likewise, reduced snow covering on the leaves and trunks (signifying reduced CAS population) was observed on plants treated with citrus rind and neem extracts which was similar to what was observed in the cypermethrin treated plants. However, highest CAS population was observed on the control plants. Weissling (1999) reported that heavily infested plants shows snow covered or heavily white-washed covering on the leaves as the rate of infestation increased. Literatures have shown that orange peels and neem extracts contain bioactive substances which cause mortality, ovicidal, repellence, residual or deterrence effect to insects. Sharaby (1988) reported reduction in egg production and inhibition of egg laying in the potato tuber moth, *Phthorimaea operculella* (Zell.) when moths of either sex were exposed to orange peel extracts. Similarly, Neem extracts had been reported to have adverse effects on survival, fecundity, development and oviposition of insect pests (Charleston *et al*., 2006). Azadirachtin the active ingredient in neem has been found to suppress the activity of ecdyson (juvenile hormone) when in contact with the larvae thereby preventing moulting which eventually lead to the death of the larvae (Seljasen and Meadow, 2006).

As highest CAS population was observed on the control plants in this study, a corresponding increase in damage on the cycad plants was observed. This caused some parts of the leaves to become chlorotic, turned brown, dry with eventual destruction and death of the plants. This observation was similar to report by Heu et al. (2003) that as a result of increased density of the CAS pest, damage resulted into the leaves turning brownish and dried off. CAS sucks sap of the host which resulted into chlorotic yellow-brownish coloration of the leaves preventing photosynthetic activity in the plant which resulted into retarded growth and destruction of the entire plant. The chlorotic coloration of the leaves after infestation as reported by Muniappan *et al*. (2012) was as a result of the toxic substance in the saliva secreted and injected by the scale insect into the plant during the process of feeding.

The effect of CAS infestation on Cycad plants treated with citrus rind and neem extracts was mild; average on Chromolaena and tithonia leaf extracts but severe on the control plants. Damage on the applied plants varied from mild to average and to severe as described by Compton, (1991).

CONCLUSION

Cycad Aulacaspis Scale is a very destructive pest which is of economic importance to ornamental plants especially cycads. Management measures using botanicals can be effective with several applications. Citrus rind and neem extracts are natural plants products that are non-toxic, environmentally safe to human and other beneficial organisms and can be used as substitute to toxic chemical insecticides which has been the major control measures used by florists.

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COST: BENEFIT ANALYSIS OF MICROBIAL AND BOTANICAL INSECTICIDES AGAINST AFRICAN PINK STEM BORER (*SESAMIA CALAMISTIS* HAMPSON) (LEPIDOPTERA: NOCTUIDAE) ON SWEET CORN (*ZEA MAYS* VAR. SACCHARATA L.)

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ABSTRACT:

The study was conducted at Institute for Agricultural Research (IAR) horticultural garden under irrigation in two dry seasons (2019 and 2020). The region is located at Latitude11^{0}11^{1}N and Longitude7^{0}38^{1}E. The research was conducted to evaluate the cost of plant protection using two microbial pesticides: Streptomyces avermitilis (Emamectin benzoate as active ingredient) and Beauveria bassiana, two botanical oil extracts: Karanjin from Karanja (Pongamia glabra) and Azadirachtin from Neem (Azadirachta indica), one synthetic insecticide: Cypermethrin + dimethoate (Lion Guard EC with Cypermethrin 3% and dimethoate 25%) which served as standard check against S. calamistis. The treatments involved two sweet corn varieties; Sweet Corn Yellow, Sugar King F_2 and a non-sweet maize variety; SAMMAZ 52 (Pro-vitamin A maize variety) and also the five (5) pesticides with untreated control laid out in a Randomized Complete Block Design (RCBD) in split plot with three replications on a plots size of 9m^2 (3 m x 3 m). The study showed the profitability of using the botanical extracts (with cost benefit ratio of 1:12 for Azadirachtin and 1:6 Karanjin) and microbial pesticides (with cost benefit ratio of 1:15 for Emamectin and 1:17 for B. bassiana) in the management of S. calamistis on sweet corn.

Key words: Karanjin, Emamectin, Sweet corn, Artificial Infestation

INTRODUCTION

Sweet corn (*Zea mays* var. saccharata L.) also called sugar corn and pole corn is a hybridized variety of maize with high sugar content. It is cultivated for human consumption and is a raw or processed material of the food industry throughout the world. It is popular with the consumer for its unique taste, pleasant flavour and sweetness. Sweet corn contains 5-6% sugar, 10-11% starch, 3% water soluble polysaccharides and 70% water, besides moderate levels of protein and vitamin (yellow varieties) and potassium (Oktem and Oktem, 2005). Sweet corn is one of the six major types of corn, the others being dent corn, flint corn, pod corn, popcorn, and flour corn (Campbell, 2013). Unlike field corn varieties, which are harvested when the kernels are dry and fully mature (dent stage), sweet corn is picked when immature (milk stage) and can be harvested in 75-80 days after planting and eaten as a vegetable, rather than grain (Schultheis, 1994). In Nigeria, most of the maize varieties are eaten green (either boiled, cooked or roasted) (Sani *et al.,* 2013). A gross profit of N 840,521 ($ 1= N 150) and benefit-cost ratio of 1.51 was reported by Sani *et al.* (2013) on sweet corn production which highlights its profitability and potential for high income earnings.

MATERIALS AND METHODS

The cost benefit analysis was carried out to see how economical is the use of the pesticides in controlling *S. calamistis* in sweet corn production using methods described by Shabozoi *et al.* (2011). Cost: benefit ratio is an indicator of the relative economic performance of the treatments and a ratio of more than one indicates the economic viability of the treatment compared with the control treatment.

a) **Cost of Neem oil extract Lha^{-1} (N)=** Volume Lha^{-1} x Price L^{-1}
b) **Cost of Karanja oil extract Lha^{-1} (N)=** Volume Lha^{-1} x Price L^{-1}
c) **Cost of Cypermethrin + Dimethoate) Lha^{-1} (N) =** Volume Lha^{-1} x Price L^{-1}
d) **Cost of Emamectin benzoate Kgha^{-1} (N)=** Quantity in Kg ha^{-1} x Price Kg^{-1}
e) **Cost of *B. bassiana* Kgha^{-1} (N) =** Quantity in Kg ha^{-1} x Price Kg^{-1}

f) **Total income of fresh Sweet corn (Nha^{-1}) =** Total Fresh yield in Kg ha^{-1} x Price Kg^{-1}

g) **Net Benefit (Nha^{-1}) =** Total income – Cost of plant Protection

h) **Benefit of spray (Nha^{-1}) =** Net benefit of spray – Total income of untreated control

i) $$\text{Cost: Benefit ratio} = \frac{\text{Benefit of sprayed treament}}{\text{Cost of plant Protection}}$$

j) $$\text{Return on invetment} = \frac{\text{Total income of treatment}}{\text{Cost of plant Protection}}$$ (Shabozoi *et al.,* 2011)

RESULTS AND DISCUSSION

The microbial pesticides, botanical treatments and the synthetic insecticide were superior financially compared to the untreated control in which sweet corn were heavily attacked by *S. calamistis* (Table 1). Accordingly, treatments other than the control had higher yields which resulted in revenue that exceeded the cost of the plant protection. The cost of plant protection using Cypermethrin+Dimethoate was higher than all of the biopesticides and the botanicals. The best cost: benefit ratio of 1:17 was for *B. bassiana* treatment. It was followed by Cypermethrin+Dimethoate with a cost: benefit ratio of 1:15. Plots sprayed with Emamectin had a cost: benefit ratio of 1:15 while plots sprayed with Azadirachtin had a cost: benefit ratio of 1:12 and Karanjin had cost: benefit ratio of 1:6.

Table 1: Cost Benefit Analysis of the Pesticides used against *S. calamistis*

Variables	Neem oil extract	Karanja oil extract	*Beauvaria bassiana*	Emamectin benzoate	Lion guard	Untreated control
A) Total yield (ton ha^{-1})	8.46	7.22	9.79	9.52	11.43	6.49
B) Total income (₦ ha^{-1})	436,000	312,000	569,000	542,000	733,000	139,000
C) Cost of plant protection (₦ ha^{-1})	15,000	10,000	18,500	19,000	30,000	0
D) Net benefit (₦ ha^{-1}) (B-C)	421,000	302,000	550,500	523,000	703,000	239,000
E) Benefit over untreated control (₦ ha^{-1})	182,000	63,000	311,500	286,000	464,000	-
F) Cost-Benefit ratio (E/C)	1:12	1:6	1:17	1:15	1:15	-
G) Return on investment (B/C)	12.1	31.2	30.8	28.5	24.4	-

In this study, the botanicals Azadirachtin and Karanjin gave the cost benefit ratios of 1:12 and 1:6 respectively, while Emamectin and *B. bassiana* gave the cost benefit ratios of 1:15 and 1:17 respectively. The cost: benefit ratios of botanicals and microbial pesticides calculated in this study are similar to those obtained by Patel *et al.* (1997), who obtained a ratio of 1:14 and 1:13 for botanical (neem extract) and synthetic insecticide (endosulfan) respectively in managing insect pests of pigeon pea. This is because this study analysed only the cost of plant protection and calculated the cost: benefit ratio based on the income of the control treatment. Amoabeng *et al.*, (2014), also reported cost: benefit ratios of between 1:29 and 1:4 for the botanicals Siam weed and tobacco on cabbage pest indicated that, they were biologically effective and resulted in significant return on investment in plant protection. The cost benefit ratio is highly dependent on the commodity price at any particular period and the exchange rate. At the time of this study the exchange rate of Dollar to Naira 1:380 which is not good, but still, not many crops would give that return due to the expensive nature of sweet corn.

CONCLUSION

The study also showed the profitability of using the botanical extracts (with cost benefit ratio of 1:12 for Azadirachtin and 1:6 Karanjin) and microbial pesticides (with cost benefit ratio of 1:15 for Emamectin and 1:17 for *B. bassiana*) in the management of *S. calamistis* on sweet corn.

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SIMULATED CASHEW APPLE MEAT AS A SUBSTITUTE FOR THE VEGETARIANS

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ABSTRACT

Production of simulated cashew meat as a substitute for both meat consumers and vegetarians has come as a way of adding value to wasting cashew apple that has become menace in our cashew farms. Current research on plant-based meat alternatives (PBMAs) is on the increase in food and research communities. However, little is known about cashew apple meat. Despite its high protein content and even low cost, cashew apple remains underutilized in human foods. Consequently, the production of simulated cashew meat could be a way of maximizing cashew apples that has constituted nuisance in most cashew farms. Therefore, this study evaluated the simulated cashew apple meat-like product for its organoleptic acceptability and physicochemical quality. The meat-like substance developed from cashew apple was very similar to the conventional dried meat. Notably, no significant difference was observed when the sensory analysis of the simulated cashew apple meat was compared with that of the conventional dried meat.

Key words: Cashew apple meat, vegetarians, substitute, consumers

INTRODUCTION

Throughout history, humans have considered meat to be an essential part of their diet (Stanford and Bunn, 2001). The consumption of meat has been key for human evolution as it has been linked to the brain growth and development within prehistoric *Homo sapiens* (Williams and Hill, 2017). Globally, beef, pork, and chicken products are the highest in demand, with the United States and Australia topping the charts for the highest annual meat consumption (Ritchie, 2019). Due to an increase in global population and rapid economic development, the last two decades have seen a 58% growth in the global demand for meats. By 2018, approximately 320 tonnes of meat was consumed worldwide and it is predicted that the market will expand 15% by 2027 (OECD/FAO, 2018). However, the inefficiencies of meat production compared to crop harvesting and the negative impacts from the consumption of conventional meats on human health have become topics of concern in recent years (Godfray *et al*., 2018; Marinova and Bogueva, 2019). Due to these increasing concerns, food industries are looking for ways to introduce healthier meat alternatives made from non-animal proteins, but with similar appearances, mouthfeel, and smells to consumer markets (Malav *et al*., 2015). Despite the fact that plant-based meat alternative (PBMA) has become one of the current hottest topics in the academic community, and thus original research articles and review papers outlining different emphasis on this topic have been published (Kumar, 2016). Nevertheless, the research on cashew meat as plant-based meat alternatives (PBMAs) is scanty in literature.

Cashew (*Anacardium occidentale, L*) is a tropical and edible fruit whose genus name *Anacardium* which means "shaped like heart" is derived from the shape of cashew apple. Cashew apple is the pseudo-fruit connected to the real fruit which is cashew nut (Zepka and Mercadante, 2009). Cashew apple is characterized by its fibrous nature and a unique astringent smell. The utilization of this apple is mostly for the production of its juice and wine. The residue made of the skin and the husk called bagasse is frequently used for animal feed or even allowed to waste away. The residue has a dark yellow colour, a fibrous aspect, and a typical astringent aroma due to the presence of tannins which could be a limiting factor for the acceptability of the cashew apple and the juice, especially in foreign countries (Michodjehoun-Mestres *et al*., 2009). Regarding to the use of cashew apple for meat, there are not many researches mentioned. This study therefore focused on the production of a meat-like substance from cashew apples as an alternative source of meat for the vegetarians.

MATERIALS AND METHODS

Cashew apples were collected during its peak season from Cocoa Research Institute of Nigeria, Ibadan and simulated into meat production, the processing was done through the use of different drying techniques to produce cashew apple meat. The biomass composition of the simulated cashew meat was estimated. The products were subjected to organoleptic appraisal and physicochemical analysis.

RESULTS AND DISCUSSION

The result for the biomass composition of the cashew meat (Table 1) revealed that the plant-based meat alternative has high lignin, cellulose and hemicellulose compositions. Also, the organoleptic appraisal of the cashew meat described in Table 2 shows that the cashew apple meat was well-accepted and that there is no significant difference between the simulated meat and the standard (cow-meat). Thereby, suggesting a probable favourable competition between the cashew meat and the conventional dried meat. Apparently, cashew meat substitute has the potential to compete with commercial meat analogues, thereby adding value to the cashew industry.

Table 1. Biomass Composition of Cashew Meat

Composition	%
Cellulose	34.21±31
Hemicellulose	26.23±28
Lignin	36.24±15
Ash	3.32±35

Table 2. Sensory Evaluation of Cashew Meat

Attributes	Samples			
	DC	SM	DM	CM
Color	7.41	6.42	8.34	8.22
Taste	8.52	6.12	8.62	8.54
Flavor	7.63	6.42	7.82	7.22
Texture	8.21	6.12	8.64	8.62
Overall Acceptability	8.14	6.33	8.66	8.42

Key
Dc – Dried chicken, Sm – Dried soymeat, Dm – Dried meat, Cm – Dried cashew meat

Moreover, in the physicochemical characteristics presented in Table 3, the plant-based meat protein's composition was revealed to be 18.71%. Interestingly, this finding is in agreement with the reports of Asgar and Wild that the main component of meat analogues is protein (Asgar *et al*., 2010; Wild *et al*., 2014). The cashew meat is also very rich in crude and non-digestible fibers (14.32% and 82.1% respectively) thus, suitable for good health.

In general, plant-based dietary patterns are associated with health benefits. Vegetarian diets (meat-free dietary patterns) are associated with reduced risks of many health conditions. Vegetarians have lower incidence of type 2 diabetes, obesity, coronary heart diseases and other non-communicable diseases, thus having greater life expectancy (Le and Sabate, 2014; Dinu *et al*., 2017). The Academy of Nutrition and Dietetics (formerly the American Dietetic Association) has recognized that a well-planned vegetarian diet is healthful and nutritionally adequate, being appropriate for human growth and development. Meat-free diets are suitable not only in the prevention but also in the treatment of many diseases (American Dietetic Association, Dietitians Association of Canada (2003); Melina *et al*., 2016; Fresan and Sabate, 2019).

Table 3: Physicochemical Characterization of Cashew Meat

Parameters	Composition %
Moisture	9.33
pH	4.21
Soluble solids (°brix)	0.00±0.01
Reducing sugar	0.54±0.02
Crude protein	18.71
Crude fiber	14.32
Non-Digestible fiber	82.1

CONCLUSION

Developed cashew apple meat has been widely accepted as it has come to add to our satiety value. It is good news to the vegetarians who can as well enjoy their meals with meat from plant origin. Conclusively, in our present societies in Nigeria where daily meat consumption is the social norm, aspiring to drastically reduce meat consumption is a challenging endeavor. More research is needed to better understand the cultural and socioeconomic factors that influence change in dietary patterns.

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COMPARATIVE STUDIES ON SOME BIOCHEMICAL AND MINERAL COMPOSITIONS OF KOLANUT (*COLA NITIDA*) IN NIGERIA

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ABSTRACT

Proximate analysis, phytochemical and mineral compositions of Cola nitida are some of the commonest and basic nutritional investigations carried out on kola nuts in Nigeria. Overtime, several researchers from some part of Nigeria reported different values of proximate analysis, phytochemical and mineral constituents of Cola nitida. In the present study, we analyzed some of the data obtained by these authors on proximate, phytochemical and mineral constituents of kolanuts in Nigeria using data mining software to get a secondary data. This secondary data enabled proper comparison and general overview of Cola nitida's proximate and mineral distribution from some States in Nigeria. In this regard, the result from the proximate analysis's secondary data apparently revealed that the Cola nitida from all the towns reviewed except for Benin in Edo State have high carbohydrate contents. Moreover, other attributes such as ash, lipid and protein contents of these kolanuts are generally low. However, Ilorin in Kwara State has the highest moisture content and the lowest protein content. Sagamu in Ogun State and Ado in Ekiti State have the highest protein values of 15.24±0.58 (% wt/vol) and 15.40 (% wt/vol) respectively. Although the Benin kolanuts have low proximate characteristics however, they are rich in phytochemical constituents especially alkaloids, saponins and tannins. Correspondingly, the Cola nitida in Benin have the highest mineral composition.

Key words: *Cola nitida*, proximate, mineral composition, phytochemicals

INTRODUCTION

Kolanut is an African plant having about 125 species which are all indigenous to Tropical West Africa. Among these species is *Cola nitida*, a kolanut with only two cotyledons. The cultivation of *C. nitida* actually began in Nigeria in the 19th century (Asogwa *et al*., 2006). Kolanut, a masticatory stimulant is an edible fruit, with tremendous medicinal, religious and social values. Although, there is increasing demand of kolanut for its usage in pharmaceutical and food industries for production of drugs, wines, chocolates and non-alcoholic beverages (Beattie, 1970; Ogutuga, 1975; Jarvis, 2002; Dah-Nouvlessounon *et al*., 2015). However, the medicinal importance of kolanuts stems from their pharmacological properties and active chemical constituents such as caffeine, theobromine and kolatin which is somewhat similar to those of coffee and cocoa (Atanda, 2011).

Over the years, the bioactive, mineral and nutritional characterization of kolanuts especially *C. nitida* are often investigated via basic researches such as proximate analysis and phytochemical screening of the kolanuts. Incidentally, several scientific researches have reported different mineral, proximate and phytochemical constituents of *C. nitida* across Nigeria. In spite of the fact that there is extensive research into examining the proximate and phytochemical composition of *C. nitida* in some part of Nigeria nevertheless there is little or no reports on the comparison of these phytoconstituents across Nigeria. Hence, this present study aims at reporting the comparative studies on proximate, mineral and phytochemical constituents of *C. nitida* in some parts of Nigeria.

MATERIALS AND METHODS

A secondary data generated via graph pad prism software from the primary data of proximate, mineral and phytochemical constituents' analysis of *C. nitida* from different research authors in some part of Nigeria were used as itemized below.

- Proximate analysis of *C. nitida* from Benin (Dah-Nouvlessounon *et al*., 2015; Okwunodulu and Ukeje, 2018), Ibadan (Jayeola, 2001), Minna (Ajai *et al*., 2012), Ilorin (Odebunmi *et al*., 2009), Umudike (Okeke, 2015), Ado Ekiti (Dewole *et al*., 2013), Ipetumodu (Adeniyi *et al*., 2017) and Sagamu
- Mineral compositions of *C. nitida* from Benin (Dah-Nouvlessounon *et al*., 2015; Okwunodulu and Ukeje, 2018), Minna (Ajai *et al*., 2012) and Ilorin (Odebunmi *et al*., 2009).

- Phytochemical constituents of *C. nitida* from Benin (Dah-Nouvlessounon *et al*., 2015; Okwunodulu and Ukeje, 2018), Ibadan (Jayeola, 2001), Umudike (Okeke, 2015), Ado Ekiti (Dewole *et al*., 2013) and Akure.

RESULTS AND DISCUSSION

The proximate and mineral analysis of *C. nitida* has been well-studied in many parts of Nigeria. Apparently, the proximate analysis of *C. nitida* as shown in Figure 1 revealed that the kolanuts in most of the towns considered (Benin, Ibadan, Minna, Ilorin, Umudike, Ado and Ipetumodu) are very rich in carbohydrates (CHO) with Ibadan kolanut having the highest CHO while Benin kolanut has low CHO content. Moreover, the moisture contents of kola nuts from Ibadan, Ilorin and umudike are significantly higher than others and this could be attributed in part to the tropical lowland rainforest areas where these kolanuts are grown. In fact, as depicted in Figure 1, Benin and Sagamu kola nuts are generally low in their proximate analysis. However, there is an overall low level of ash, lipids and proteins of *C. nitida* in the towns considered. The low ash and fat contents of these kola nuts is in agreement with earlier report that most tropical fruits have low ash content and are neither rich sources of fats (Ogutuga, 1975).

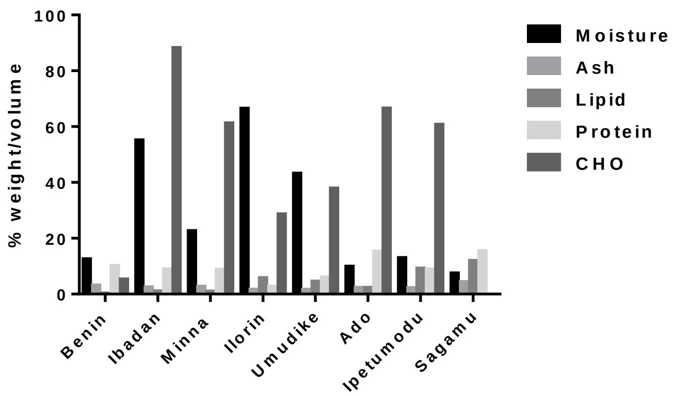

Figure 1. Proximate compositions of *Cola nitida* seeds from some parts of Nigeria

Moreover, kola nuts have been reported to contain traces of essential minerals. Some of these minerals act as sources of macro and micro nutrients needed for the growth, development and metabolic activities of man (Odebunmi *et al*., 2009; Adeniyi *et al*., 2017). Figure 2 markedly revealed the mineral analysis of *C. nitida* from Benin, Minna and Ilorin. It was observed from the result that the Benin kola nuts are richer in calcium, zinc, iron and magnesium than the kola nuts from Minna and Ilorin.

The Phytochemical analysis of the *C. nitida* obtained from investigated towns in Nigeria is presented in Figure 3. Phytochemical analysis is an analysis that reveals the rich bioactive constituents present or absent in kolanuts. These constituents are secondary metabolites such as Alkaloids, Tannins, Flavonoids, Saponins, phenols and Anthraquinones consequently signifying the biological importance and medicinal potentials of the nuts. In this regard, the *C. nitida* from Ado, Benin and Akure has considerable amount of tannins. While the Umudike kolanuts generally have low phytochemical constituents, nevertheless the *C. nitida* from Benin and Ibadan are significantly rich in alkaloids. In addition, Benin kola nuts are relatively high in saponins when compared with the saponin contents of kola nuts from other towns.

Summarily, it is apparent from this study that the distribution of proximate, mineral and phytochemical properties of *C. nitida* in some parts of Nigeria varies from one location to the other.

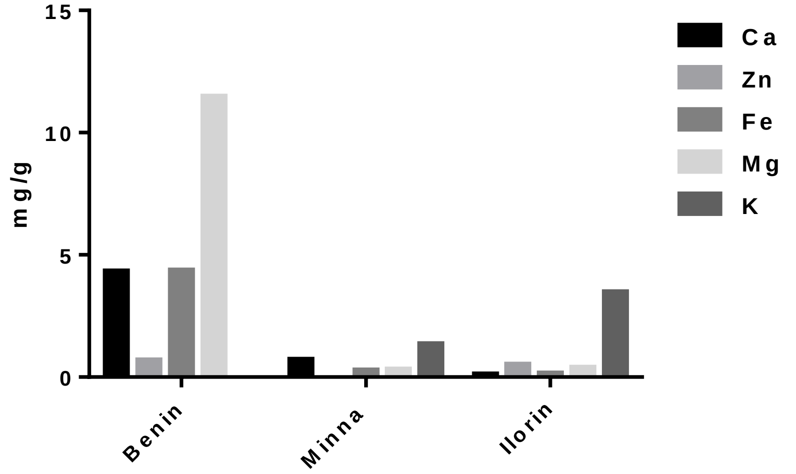

Figure 2. Mineral constituents of *Cola nitida* seeds from some parts of Nigeria

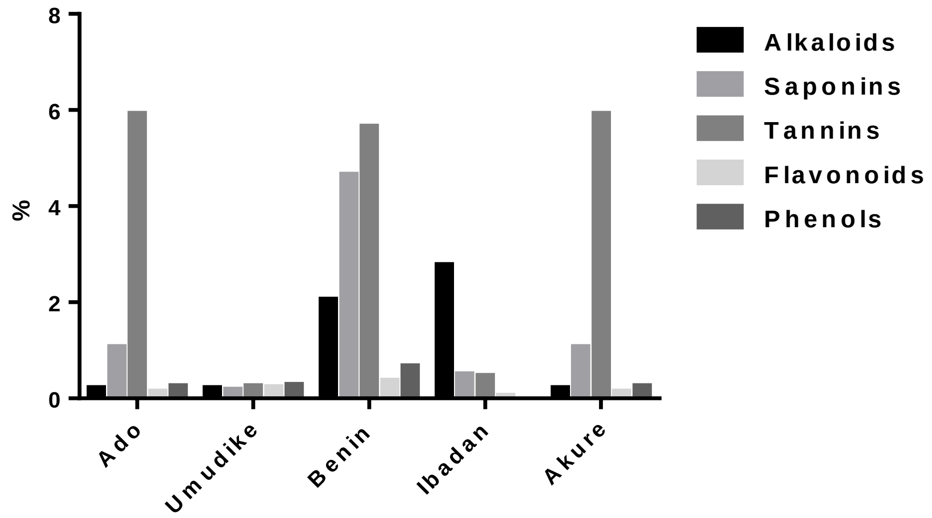

Figure 3. Percentage phytochemical analysis of *Cola nitida* seeds from some parts of Nigeria

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EFFECT OF GERMINATION PERIODS ON PROXIMATE AND ANTINUTRIENT COMPOSITION OF GRAIN AMARANTH (*AMARANTH CRUENTUS*) FLOUR

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ABSTRACT

This study investigated the effect of germination periods on nutritional and antinutritional components of grain amaranth seeds processed into flours. The grain amaranth flour was evaluated at varying germination periods (24hrs, 48hrs and 72hrs) under room temperature (28 ± 0.1°C) for their proximate, minerals and antinutrients. It was found that the periods of germination varied influenced the concentration of various nutrients and antinutrient parameters considered. The highest protein content for amaranth flours after 24hr germination period was (17.37%) which was significantly higher(p<0.05) compared to 48hr (16.73%),72hr (16.05%) and ungerminated amaranth flour (16.06%) which served as control. The values of antinutrient factors which include tannins ranged between (0.154-0.933mg/g), oxalate (0.196-0.520mg/g), phytate (0.210-0.813mg/g) and trypsin inhibitor (0.446-0.856TIU/mg). There was varying degree of reductions in the concentration of antinutrients in amaranth flour across the periods of germination which were significant compared to ungerminated amaranth flour. The phytate in ungerminated amaranth grain flour was (0.813mg/g). This significantly (p<0.05) reduced to (0.286mg/g), (0.226mg/g) and 72hr (0.210mg/g) after 24hr, 48hr and 72hr germination respectively. The reduction in phytate concentration has been attributed to activation of phytase enzyme during germination which breaks down phytic acid thus reducing their concentration.

Key words: Grain amaranth, flours, germination, antinutrients, Phytate.

INTRODUCTION

Diversification of diets in Africa with underutilized and underexploited food crops such as grain amaranth present a viable option and sustainable alternative through which malnutrition problem could be fought through provision of basic and essential nutrients needed for optimum body functions and development, particularly for rural and poor urban households in developing countries where malnutrition is severe and continue to be a big a threat due to its associated consequences (FAO, 2015; FAO,2020; Aderibigbe *et al*., 2020). Amaranth is one such crop which has high potentials to act as alternative food grain in most parts of the world. It is one of the few plants whose leaves are eaten as a vegetable while the grains (seeds) used in the same way as cereals and consumed in various parts of the world.

The amaranth grains are rich in essential amino acid and their amino acid composition is better balanced than in most cereals. The consumption of amaranth grains (seeds) along with other cereals which are low in essential amino acids could be needed to provide a "balanced" source of protein. Amaranth is a good source of riboflavin, vitamin E, calcium, magnesium and iron minerals (Akin-Idowu *et al*., 2017).

Although, grain amaranth as pseudo cereal is rich in essential nutrients needed for growth and development but the interaction between its available basic nutrients and antinutrients to form complexes within food matrixes reduces the bioavailability of its useful and essential nutrients (Njoki *et al.*, 2015). The phytate and trypsin inhibitor in grains for example lowers the sufficient release of minerals and reduces protein bioavability. However, some traditional food processing methods such as soaking, fermentation and germination which also known as malting has been suggested as capable of reducing the antinutrients thereby improving the bioavailability of micronutrients in plant-based diets. Therefore, this study aimed at evaluating the effect of different germination periods as a pretreatment for nutrient improvement in amaranth grains flour.

MATERIALS AND METHODS

Raw material collection

Grain amaranth (*amaranth cruentus*) seeds was collected from the experimental field of National

Horticultural Research Institute (NIHORT), Idi-ishin, Ibadan, Nigeria.

Preparation of germinated grain amaranth flours

The germinated amaranth grain flours were prepared as described by (Sara and Valérie, 2016). The grains were sorted, washed thoroughly and soaked in water at grain to water ratio of 1:3 (w/v) for 24h at room temperature (28±0.1). The water was allowed to drain and grains wrapped in a white cloth and kept at varying periods of 24hrs, 48hrs and 72hrs to germinate. After germination, sprouted grains were thoroughly rinsed in distilled water, then dried at 45–50°C and milled using (Marlex excella electric grinder, model 750). The flour was made into fine powder using a sieved with 0.25mm diameter and stored in air-tight containers.

Analysis of samples

Proximate compositions of samples were determined using (AOAC, 2005). The phytate by (Wheeler and Ferrel, 1971). Oxalate by (Chinma and Igyor, 2007). Tannin by (Ijarotimi 2012) and Trypsin inhibitor determination by (Panta, 2017).

Statistical analysis

The data were analyzed using IBM Statistical Package for the Social Sciences (SPSS) 22. The means and standard deviations of samples in triplicate were calculated. The analysis of variance (ANOVA) was performed to determine significant differences between the means using Duncan test. Statistical significance was set at P<0.05)

RESULTS AND DISCUSSION

The effect of germination periods on proximate composition of amaranth grain flour

The result of proximate composition as influenced by different germination periods are presented in Table 1. The protein content (17.37%) after 24hrs germination was significantly (P<0.05) higher than 48hrs (16.05%), 72hrs (16.73%) and ungerminated flour (16.08%). Germination has been reported to increase protein, this however depend on type of grains (Laxmi *et al*., 2015). The increase in protein during germination was attributed to the release of packed protein in seed structure, when enzymes such as α-amylase break down the starch granules. The activation of protease enzyme during this process detaches protein attached to sugar molecules. Other factor implicated is the occurrence of protein synthesis (Chauha *et al*., 2015). It was opined that the increase or otherwise in protein concentration during germination is a function of the balance between protein synthesis and hydrolysis. The (Bożena and Dariusz, 2012) observed a higher protein concentration (7.40%) after 24hrs germination compared to 48hrs (6.83%) during the germination of bean seed. (Fabiola *et al.,* 2019) reported that a short germination of 24hr is enough to effect significant changes in the nutritional properties of amaranth when he studied the germination effect on nutritional changes in two amaranth species (*Amaranthus quitensis* and *Amaranthus caudatus*).

Table 1. Effects of germination period on proximate composition on grain amaranth flour

samples	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)
Control	8.41±0.01[a]	16.08±0.12[c]	5.75±0.01[d]	2.19±0.01[d]	4.37±0.01[c]	63.28±0.10[b]
24hr germination	7.20±0.01[d]	17.37±0.01[a]	6.75±0.05[c]	2.65±0.01[ab]	4.62±0.01[b]	62.46±0.01[d]
48hr germination	7.51±0.01[c]	16.73±0.01[b]	7.64±0.01[b]	2.47±0.01[c]	4.18±0.02[d]	63.18±0.11[c]
72hr germination	7.70±0.46[b]	16.05±0.56[cd]	8.13±0.20[a]	2.69±0.02[a]	4.97±0.01[a]	63.61±0.11[a]

Values are means ± standard deviation of duplicate determinations. Values with the same superscripts in the same column are not significantly different at P < 0.05.

Proteins are major functional and structural components of all the body's cells and when intake is too low, growth during childhood is compromised (Alles *et al.,* 2014). Adequate protein ingestion is needed to elicit muscle protein synthetic response; this could be achieved by consumption of protein rich food such as germinated grain amaranth for optimization of dietary protein intake, failure of which can result into low physical activities. some proteins are hormones which are chemical message that assist in cell to cell communication. The energy value of germinated amaranth flour after 24hrs germination period (379.61kcal/100g) is significantly ($P<0.05$) higher than 48hrs (375.03mg/100g) and 72hrs (374kcal/100g) respectively. Energy is needed by living beings to perform all vital and necessary body functions. Energy is utilized partly for mechanical work performed by muscles. Diet given in early childhood is marked by high nutrient needs that include notably protein and energy (Dewey, 2013) therefore, quantitative assessment of energy value of raw material to be used in food formulation is very important. The germination of amaranth grain for 24hrs could improve energy value thus make the amaranth grains a good source of complementary food for energy requirement.

The effect of germination periods on antinutrient factors

The result in Table 2 summarizes the effect of different germination periods on antinutrients that includes tannins, phytate, and oxalate and trypsin inhibitor. The value for tannins was between (0.154-0.933mg/100g), oxalate (0.196-0.520mg/100g), phytate(0.186-0.813mg/100g) and trypsin inhibitor(0.446-0.856TIU/mg) respectively. There was a varying degree of reduction in the concentration of antinutrients in germinated amaranth flours across the germination periods. The result showed that level of phytate in ungerminated grain of amaranth flour (0.813mg/100g) was significantly higher ($p<0.05$) compared to what obtained after 24hr (0.286mg/100g), 48hr (0.226mg/100g) and 72hr (0.210mg/100g) respectively. There was a significant reduction in phytate concentration from 0.813mg/100g to 0.286mg/100g) which represents a 64% reduction after 24 hr germination. A similar reduction in phytate concentration after 24hrs germination in pearl millet was observed by (Khetarpaul and Chauhan, 1990). The anti-nutritional factors are secondary metabolites that do affect the nutritional value of foods (Nkhata *et al.,* 2018). However, their concentration can be reduced by the use of traditional food preparation techniques such as soaking and germination (malting).

Table 2: Effects of germination period on antinutrients composition amaranth grain flour

Samples)	**Tannin (mg/100g)**	**Oxalate (mg/100g)**	**Phytate (mg/100g)**	**Trypsin Inhibitor(TIU/mg)**
Control	0.933±0.12[a]	0.520±0.52[a]	0.813±0.81[a]	0.856±0.85[a]
24hr germination	0.273±0.05[b]	0.223±0.21[b]	0.286±0.18[b]	0.460±0.46[c]
48hr germination	0.163±0.05[c]	0.213±0.22[c]	0.226±0.21[c]	0.443±0.59[b]
72hr germination	0.154±0.33[cd]	0.196±0.19[d]	0.210±0.23[cd]	0.426±0.44[d]

Values are means ± standard deviation of duplicate determinations. Values with the same superscripts in the same column are not significantly different at $P < 0.05$.

CONCLUSION

Anti-nutritional factors in foods are responsible for reduction in bioavailability of essential nutrients desirable for proper development and good health. The application of germination technique to reduce anti-nutritional in amaranth grains to induce improvement in concentration of protein and other nutrients could be a good intervention at household level for nutrition security. This study shows that 24hrs germination provided the optimum period for significant improvement in protein value.

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COMPARISON OF PROXIMATE COMPOSITION, SELECTED PHYTOCHEMICAL AND MINERAL CONSTITUENTS OF *ANACARDIUM OCCIDENTALE* (CASHEW) NUT IN SOME NIGERIAN STATES

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ABSTRACT

This study was based on desk review comparison of seven journals on proximate, selected phytochemical and mineral constituents of cashew nuts sourced from Abia, Adamawa, Imo, Enugu and Kogi States in Nigeria. Cashew nuts sourced from Enugu and Adamawa States recorded high carbohydrate content compared with those sourced from other locations (Abia, Imo, Kogi) but recorded a low crude fat content when compared with the ones sourced from other states. Nuts from Enugu State recorded high moisture content compared to others which show not much significant differences. Protein content of cashew nuts from Enugu, Kogi and Adamawa states were relatively low compared to those from other locations. Crude fibre content of nuts from Isiukwuato, Abia State was relatively high compared to those from other states. Ash content compared favourably well across all states except for Kogi where it was relatively low. In Imo State, tannin content of nuts was found to be lower than those sourced from Abia and Enugu states. Alkaloid in cashew nuts from Enugu State was found to be relatively low compared Isiukwuato in Abia and Imo State. Levels of potassium, magnesium and phosphorus of nuts from Enugu State were relatively lower compared to nuts from other states (Imo and Abia).

Key words: Cashew Nuts, Proximate, Phytochemical, Mineral

INTRODUCTION

Cashew plant (*Anacardium occidentale*) is said to be a tropical plant with its origin as the Latin America, specifically North-Eastern Brazil (Dike *et al.,* 2012). The tree belongs to the family *Anacardiaceae* with about 75 genera and 700 species among which the economically known ones are mango and pistachio (Nakasone and Paull, 1998). Cashew tree of all domestically grown tropical fruit trees is the most widely domesticated food plant ahead of mango and pawpaw trees (Daramola, 2013). The nuts are usually dry, hard-shelled and do not split on maturity hence, the seeds are not released (Olife *et al.,* 2013). The nut is about 3cm long and is kidney shaped (Joker, 2003) and the tree is said to be drought resistant and grows well in a variety of soils with tropical climatic condition (Akinhanmi, 2008).

Introduced in Nigeria in the 15th Century, by the Portuguese, cashew nuts are used as a form of afforestation scheme in a bid to control the rate of erosion in Eastern Nigeria (Ohler, 1979) and its cultivation was extensively practiced in Nigeria in the early 1950s which has since increased to about 30 folds between 1990 and 2012 (FAO, 2013a) with Nigeria being one of the largest producers (FAO, 2013b). Planted by directly placing the seeds in the field or by budding, grafting or marcotting (Joker, 2003), cashew plants have variations in physical characteristics such as growth pattern, quality of crop, yield of fruits, colour of apple and size of the nut (Adeigbe *et al.,* 2015). The nuts are of major economic importance hence, special interest in them. Cashew nuts can be processed using several techniques which include: cleaning, soaking, roasting, shelling, drying and peeling (Joker, 2003; Esenwah and Ikenebomeh, 2008). Usually taken as snacks, the cashew nuts are roasted to enhance their flavor (Raji *et al.,* 2011) perhaps because of its nutritional quality such as dietary fiber and health promoting phytochemicals (Olife *et al.,* 2013) which are said to be protective against diseases and sometimes ageing (Burns *et al.,* 2001). Many plants may have generalized standard values of proximate, phytochemical and mineral constituents but due to some factors such as environmental and agronomic conditions; harvest and food processing operations; storage factors; soil types and seasonal change (Figueiredo *et al.,* 2001), these properties may differ especially when sourced from different locations, hence this desk review. The review compares the proximate, some phytochemical and mineral constituents of cashew nuts from selected locations in Nigeria to support these claims and suggest insight on possible panacea.

MATERIALS AND METHODS

A total of seven (7) journals: Nkwocha *et al.,* 2020, Hayatuddeen *et al.,* 2019, Okoroh and Onuoha, 2019, Akujobi *et al.,* 2018, Olalekan-Adeniran and

Ogunwolu, 2018, Okonkwo and Ozoude, 2015, Nwosu *et al.,* 2014 were considered for this desk review cutting across five (5) different states of Nigeria based on their source of cashew nuts. The results of their proximate analysis, some selected phytochemical and mineral analysis were compared based on the state they were sourced from. The results of which were then represented with a bar chat plot for explicit discussion.

RESULTS AND DISCUSSION

Of all the six locations, the moisture content of cashew nuts sourced from Nsukka is the highest (22.49%) and this can be as a result of seasonal change or weather situation with respect to the humidity and temperature of the location and also the post-harvest methods employed which can be of influence not only on the moisture content but also on some other qualitative properties while the moisture contents of cashew nuts sourced from other locations compared favourably well with one another (Fig. 1). The conditions suggested above may also responsible for the low protein content recorded in cashew nuts sourced from Nsukka, Geriei and Ochaja in Enugu, Adamawa and Kogi States respectively (12.60%, 14.26%, 17.37% and 18.25%) with that of Nsukka been the lowest. The protein content (ranging from 24.78% - 34.0%) of nuts from other locations are considerably higher and compared favourably well with some standards such as soybean. This may be as result of weather situation in the area of cultivation which might alter some metabolic process in the plants (Usano-Alemany *et al.,* 2014). The nuts from Gerei, Adamawa state, showed no significant fiber content when compared with nuts from other states which showed some levels of fiber with those from Nsukka, Ochaja and the yellow variety cashew nuts from Okigwe been relatively low (at 1.94%, 1.38% and 187% respectively) as against 2.80%, 2.29% and 6.44% recorded for cashew nuts from Umuahia, red variety cashew nut from Okigwe and the cashew nuts from Isiukwuato. Cashew nuts known to be rich in oil (Akinhanmi, 2008) but the crude fat content of cashew nuts sourced from Nsukka, Enugu State recorded a low percentage at 7.14% when compared to those from other location considered in the review. This difference may be due to seasonal changes, harvest and food processing operation employed during the sample preparation or some storage factors. Some of these factors are likely to be the cause of the low ash content recorded for cashew nut sourced from Ocahaja, kogi State and also the subsequent cause of the high carbohydrate content recorded for sample sourced from Nsukka and Gerei both in Enugu and Adamawa States respectively at 52.3% and 45.78% when compared with the ones sourced from other locations (Fig. 1).

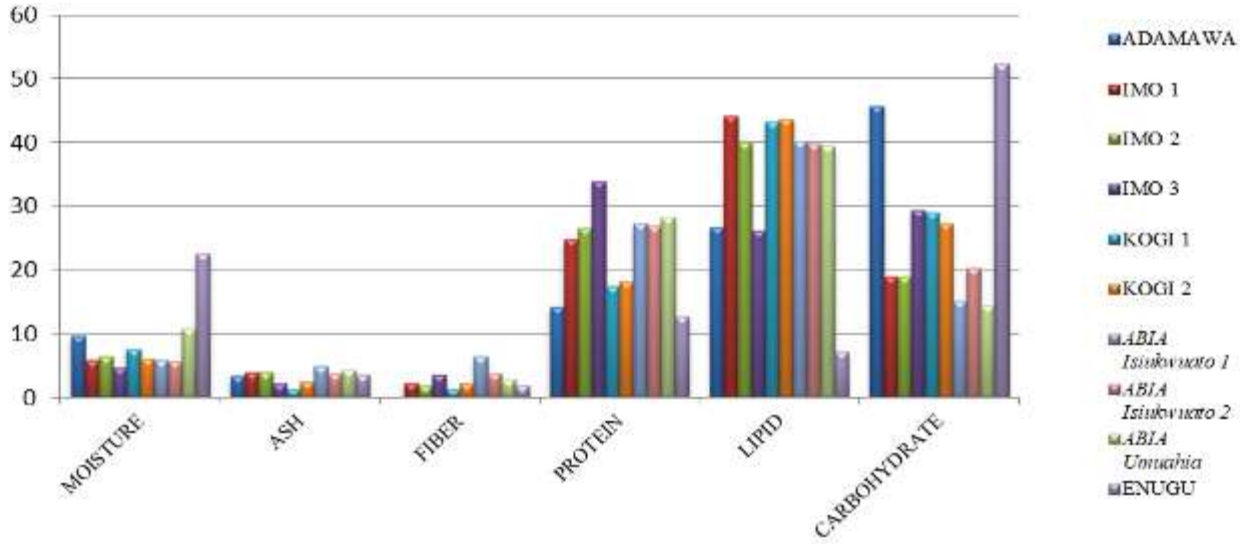

Figure 1. Comparison of the Proximate Compositions of Cashew Nuts sourced from Gerei in Adamawa State, Okigwe in Imo State, Ochaja in Kogi State, Isiukwuato in Abia State, Umuahia in Abia State and Nsukka in Enugu State

Cashew nuts from Isiukwuato, Okigwe and Nsukka were reviewed for the comparison of selected phytochemical constituents which are: phytate, tannin and alkaloid. Nuts (yellow variety of cashew nut) from Okigwe was recorded to have low tannin content (0.1849mg) compared to those from Isiukwuato and Nsukka with 1.75mg, 1.66mg and 0.765mg respectively) but the alkaloid content of the ones sourced from Enugu State is significantly lower (Fig. 2). These significant differences might

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be as a result of the weather situation of the area of cultivation which might subsequently affect the metabolism of these secondary metabolites and can also be as a result of the post-harvest methods employed in the processing of the nuts or as a result of some seasonal or environmental differences. These conditions might subsequently be responsible for the differences and non-uniformity in the selected mineral contents (potassium, magnesium, phosphorus, zinc and iron) of nuts sourced from Nsukka and Okigwe (Fig. 3).

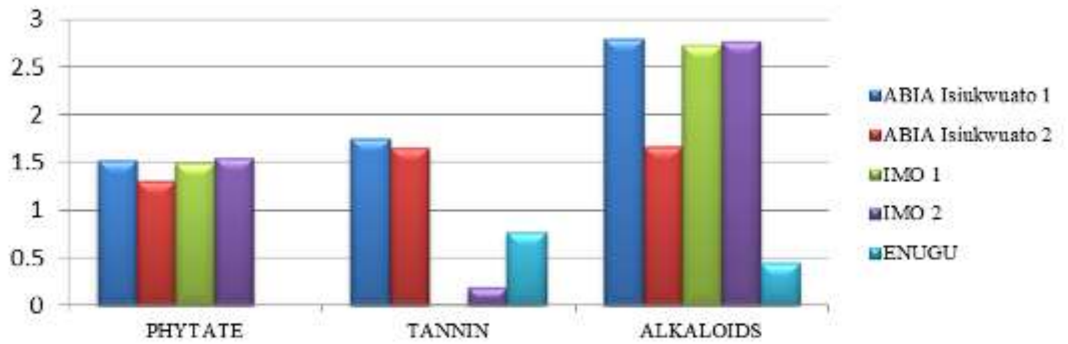

Figure 2. Comparison of the Phytochemical Compositions of Cashew Nuts sourced from Gerei in Adamawa State, Okigwe in Imo State, Ochaja in Kogi State, Isiukwuato in Abia State, Umuahia in Abia State and Nsukka in Enugu State

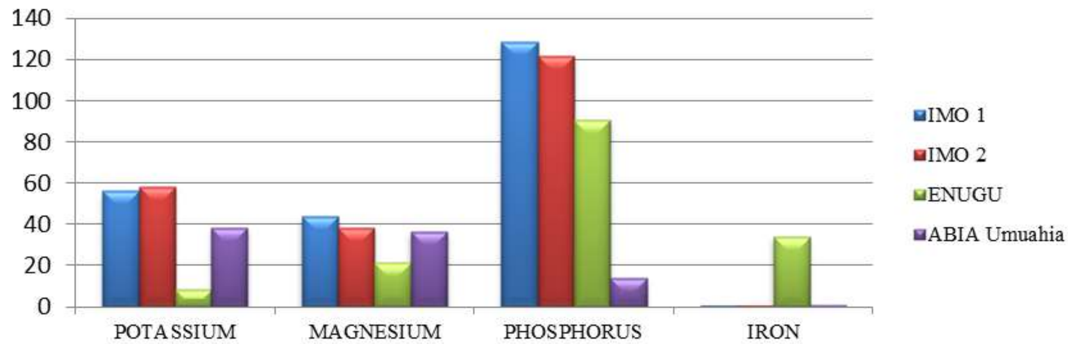

Figure 3. Comparison of Some Selected Mineral Compositions of Cashew Nuts sourced from Gerei in Adamawa State, Okigwe in Imo State, Ochaja in Kogi State, Isiukwuato in Abia State, Umuahia in Abia State and Nsukka in Enugu State

CONCLUSION

This desk review of journals showed that cashew nuts from different location have the tendencies of having different nutritional and medicinal values in terms of their proximate, phytochemical and mineral contents despite the fact that it has been said to able to grow well in tropical climatic conditions (Akinhanmi, 2008). Some of these differences can be based on the post-harvest operations used in their processing and others based on the seasonal or weather and environmental conditions of their plantation locations. There is therefore need for cashew farmers and stakeholders in cashew nut processing in Nigeria to take precautions before, during and after cultivation of cashew plants so as to maintain the quality (most especially chemical properties) of the plant as this remain major reason for its economic importance.

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IMPACT OF VARIOUS PROCESSING METHODS ON THE PROXIMATE COMPOSITION, MINERAL CONTENT AND ANTI-NUTRITIONAL FACTORS OF CASHEW (*ANACADIUM OCCIDENTALIS*) APPLE WASTE

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ABSTRACT

A study was carried out at the Department of Value Addition Cocoa Research Institute of Nigeria, Ibadan, Oyo State, Nigeria to investigate the effect of different processing methods on the Proximate, Mineral and phytochemical screening of Cashew Apple Waste (CAW). Matured and ripe cashew fruits are harvested from cashew plantations of the cocoa research institute of Nigeria, the nuts were detached and the cashew apple was divided into three samples (A, B and C) and were processed using different methods which were blanched, unblanched and fermented. The CAW was then sundried for 5-7 days for proper drying. All the processed CAW were then milled into a fine powder to pass through a 2mm mesh sieve and samples were collected, labelled and were taken to the laboratory for various analysis such as proximate composition, mineral analysis, phytochemical screening and anti-nutritional factors. Result on the proximate composition showed that blanched CAW was significantly ($P<0.05$) higher in all the parameters assayed except for moisture content which was similar. Mineral element composition showed that Ca^{2+}, Fe^{2+}, Mg^{2+}, K^{+} and $PO4^{-}$ were significantly ($P<0.05$) highest in blanched CAW. Phytochemical screening also revealed that flavonoids, alkaloids, tannins, phenolics, saponins, phytates, oxalates and steroids values were higher significantly ($P<0.05$) in blanched CAW. It was therefore concluded that cashew apple waste will exhibit its highest photobiotic potentials and nutrient qualities if it is processed through blanching and the juice mechanically extracted.

Key words: Cashew Apple Waste, Proximate analysis, Mineral composition, Phytochemical screening

INTRODUCTION

The *Anacardiaceae* family has 76 genera divided into five tribes (*Anacardiaceae, Dobineae, Rhoeae, Semecarpeae* and *Spondiadeae*) covering about 600 species (Correia *et al.,* 2006). *Anacardium occidentale* is an abundant tree in the Middle Belt of Nigeria. This species is unique for its antioxidant (Melo-Cavalcante *et al.,* 2003), antigenotoxic, antimutagenic (Melo-Cavalcante *et al.,* 2011), antiulcerogenic (Behravan *et al.,* 2012), anti-inflammatory (Olajide *et al.,* 2004), antibacterial, antifungal and larvicides (Behravan *et al.,* 2012) properties. Also, it is rich in anthocyanins, carotenoids, ascorbic acid (vitamin C), flavonoids and other polyphenols as well as mineral components. After the extraction of the juice, most times we are left with the Cashew Apple Waste (CAW) that is usually discarded. It is a waste obtained after the juice has been extracted from the apple of the cashew fruit after the detachment of the cashew nut. Cocoa Research Institute of Nigeria (CRIN) produces several hectrages of cashew as one of their mandate crops and have been extracting and processing the fruit juice but the CAW, which could be further processed into feed ingredient for livestocks, has always been discarded over the years. There is dearth of information on its utilization as livestock feed but research is recently geared toward assessing its chemical composition to ascertain its phytochemical potentials and then put it to right use. Dos santos Lima *et al.,* (2012) reported that the cashew (pulp) biomass has great potential for bioprocess after pre-hydrolysis and it is a promising raw material for bioethanol production, with 12% of hexoses, and 88% pentoses. CAW could also serve as a good source of sugars for ethanol production. This study is focused on assessing the phytobiotic potentials of cashew apple waste as livestock feed by evaluating its proximate composition, mineral contents and antinutritional factors.

MATERIALS AND METHODS

Location of the study

The investigation was carried out at the Department of Value Addition Cocoa Research Institute of Nigeria, Ibadan, Oyo State, Nigeria.

Sourcing and Processing of Raw materials

Matured and ripe cashew fruits are harvested from cashew plantation of the cocoa research institute of Nigeria, Ibadan in a basket to the production centre. The bad and damage cashew apple were sorted from the good ones, washed with clean water, the nuts detached from the apple. The cashew apple was divided into three samples (A, B and C) and were processed using different methods as stated below.

Sample A: Unblanched Cashew Apple Waste

The properly washed cashew apples were juiced mechanically using a manual mechanical juice extractor fabricated by Cocoa Research Institute of Nigeria (CRIN). The waste were collected and sundried for 5-7 days for proper drying.

Sample B: Blanched Cashew Apple Waste

The cashew apples were placed in a cooking pot with hot water for 10 minutes with intermittent stirring of the apple after which a manual mechanical juice extractor was used to extract the juice and the waste were collected and sundried for 5-7 days for proper drying.

Sample C: Fermented Cashew Apple Waste

The cashew apples were also juiced with the mechanical extractor and the waste were packed in air-tight polythene bag and fermented for 7 days and then were sundried for 5-7 days for proper drying. All the processed CAW were then milled into a fine powder to pass through a 2mm mesh sieve and samples were collected and were well labelled and were taken to the laboratory for the various analysis.

Proximate analysis

The moisture content, ash, crude fibre and crude fat, were determined using the method described by AOAC (1990). The crude protein was also determined by Kjeldahl method. The energy value was determined using an Adiabatic Oxygen Bomb calorimeter (12149 Adiabatic Calorimeter, PARR instrument Co. Illinois USA.

Mineral Analysis

The mineral content of the samples was analyzed by using atomic Absorption spectrophotometer (AAS) for the following metals: Ca, K, Fe, Zn, Mg, PO_4^- and Mn while the Flame Photometer was used in the analyses of K (Ahmed, 2015).

Phytochemical Screening

The samples of cashew apple waste were tested for specific presence of certain phytochemicals according to the method of (Harbone, 1998; Tiwari *et al.,* 2011). Alkaloids were determined using the Wagner's test. Two ml of each of the samples were treated with few drops of Wagner's reagent (iodine-potassium iodide solution). Flavonoids were determined using Alkaline reagent test where two ml of the extracts was treated with few drops of 2mL NaOH. Tannins were obtained with Gelatin test (two ml of the extracts was treated with few drops of 1% gelatin solution containing NaCl). Phenols were determined using the Ferric chloride test while, Triterpenes was determined using the Salkowski's test. Two ml of the extracts was treated with few drops of chloroform and then filtered. The resulting solutions was then treated with few drops of concentrated H_2SO_4, shaken, and allowed to stand for 5 minutes.

Saponins were obtained using the Froth test while glycosides were analysed using the Legal's test where two ml of the samples were treated with few drops of Sodium nitroprusside in pyridine and NaOH. Cyanogenic glycosides (Picrate paper test): Two ml of the extracts was treated with few drops of 10mL water and 1mL dilute HCl. Picrate papers (paper strips dipped in saturated aqueous picric acid previously neutralized with NaHCO3) and suspended above flask containing the solution. The solution was warmed at 45^{o}C for an hour. Phytases (Liebermann-Burchard's test): Two ml of the extracts was treated with few drops of chloroform and then filtered. The resulting solutions were treated with few drops acetic anhydride, boiled and then cooled. Concentrated H_2SO_4 was added after cooling. Amino acids (Ninhydrin test): Two ml of the extracts were treated with few drops of 0.25% w/v ninhydrin and then be boiled for 5 minutes. Vitamins such as acsorbic acid, beta-carotene, thiamin, riboflavin, niacin, were also analysed

Statistical Analysis

The data obtained was subjected to analysis of variance (ANOVA) using Statistical Products for Service Solutions (SPSS) version 21.0. The data obtained were presented as means and standard deviation of the samples. Significant means were separated using the Duncan Multiple Range Test (DMRT) at P≤0.05.

RESULTS

Proximate composition of differently processed CAW

The result of the proximate composition of differently processed cashew apple waste as presented in Table 1. There was no significant (P>0.05) variation in the values of moisture content of the cashew apple waste on the three processing methods used. Crude protein content was however significantly (P<0.05) highest (19.50%) in blanched CAW and lowest (9.75%) in those fermented. Crude fat content was significantly (P<0.05) highest

(2.13%) in blanched CAW and lowest (0.35%) in those that were unblanched. Crude fibre showed significantly (P<0.05) higher mean value of 27.70% in unblanched CAW and lowest (15.17%) in those cashew that were blanched. Crude Ash content was significantly (P<0.05) highest (11.77%) in blanched CAW and lowest (9.90%) in those fermented. NFE content was also higher significantly (P<0.05) in blanched CAW with an average value of 49.07% and lowest (40.67%) in fermented cashew apple waste.

Table 1: Proximate Composition of Cashew Apple waste extracted using different methods

Parameters	Unblanched CAW	Blanched CAW	Fermented CAW	SEM±
Moisture (%)	8.33	8.80	8.33	0.23
Crude protein (%)	12.03[b]	19.50[a]	9.57[c]	1.07
Crude Fat (%)	0.37[c]	2.13[a]	1.47[b]	0.14
Crude Fibre (%)	27.70[a]	15.17[c]	21.57[b]	6.28
Crude Ash (%)	10.53[bc]	11.77[a]	9.90[c]	2.75
NFE (%)	40.67[c]	42.63[b]	49.07[a]	8.76

CAW = Cashew Apple Waste, SEM = Standard Error of Means. Means with same letters are not significantly different (P≤ 0.05) across the rows

Mineral composition of differently processed CAW

The result of the mineral composition of differently processed cashew apple waste as presented in Table 2. Calcium content was significantly (P<0.05) highest (265.00mg/100g) in blanched CAW and lowest (153.33mg/100g) in those samples from unblanched cashew apple waste. Iron content followed the same trend with highest mean value of 10.20mg/100g in blanched CAW and lowest in those samples from unblanched cashew apple waste with an average value of 7.33mg/100g. Zinc content on the other hand was similar (P>0.05) among the various samples. Magnesium content showed significantly (P<0.05) variation with highest (110.00mg/100g) in blanched CAW and least value (70.00mg/100g) in those samples from unblanched CAW. Manganese content showed no significant (P>0.05) variation among the three samples but however the value was higher (0.35mg/100g) in those samples that was fermented. Potassium content was significantly (P<0.05) highest (80.00mg/100g) in blanched CAW and lowest (51.67mg/100g) in those samples from unblanched CAW. Phosphate content was significantly (P<0.05) highest (151.67mg/100g) in blanched CAW and lowest (120.00mg/100g) in those samples from unblanched CAW.

Table 2: Mineral Composition of Cashew Apple waste extracted using different methods

Parameters	Unblanched CAW	Blanched CAW	Fermented CAW	SEM±
Calcium (mg/100g)	153.33[c]	265.00[a]	178.33[b]	24.06
Iron (mg/100g)	7.33[b]	10.20[a]	8.97[c]	3.27
Zinc (mg/100g)	0.30[c]	0.53[a]	1.10[b]	0.06
Magnessium (mg/100g)	70.00[a]	110.00[c]	83.33[b]	23.46
Manganese (mg/100g)	0.02	0.03	0.35	0.03
Potassium (mg/100g)	120.00[bc]	51.67[a]	35.00[c]	22.26
Phosphate (mg/100g)	51.67[c]	80.00[b]	65.00[a]	8.24

CAW = Cashew Apple Waste, SEM = Standard Error of Means. Means with same letters are not significantly different (P≤ 0.05) across the rows

Phytochemical screening of differently processed CAW

The result of the phytochemical screenings of differently processed cashew apple waste as presented in Table 2. Flavonoid content was significantly (P<0.05) highest (388.33mg/100g) in blanched CAW and lowest (140.00mg/100g) in those samples from unblanched CAW. Alkaloids content was also significantly (P<0.05) highest (861.67mg/100g) in blanched CAW and lowest (551.67mg/100g) in those samples from fermented CAW. Tannins values showed significantly (P<0.05) variations with highest mean value (480.00mg/100g) in blanched CAW and least mean value (433.33mg/100g) in fermented CAW. Phenolic, terpinoid and saponins content were significantly (P<0.05) highest (49.00, 520.00 and 240.00mg/100g) in blanched CAW while lowest (30.50, 220.00 and 166.67mg/100g) in those samples from unblanched CAW. Cardiac glycosides and cyanogenic glucosides values showed no significant (P>0.05) variation among the three samples. Phytates and Oxalates content were significantly (P<0.05) highest (75.00 and 20.00mg/100g) in blanched CAW while lowest (6.66 and 65.66mg/100g) in those samples from unblanched CAW. Steroids and Antioxidant inhibitors values were also significantly (P<0.05) highest (94.67and 42.37mg/100g) in blanched CAW while lowest (65.66 and 23.33mg/100g) in those samples from unblanched CAW.

Table 3: Phytochemical screening of Cashew Apple waste extracted using different methods

Parameters	Unblanched CAW	Blanched CAW	Fermented CAW	SEM±
Flavonoid (mg/100g)	140.00^{c}	388.33^{a}	238.33^{b}	32.64
Alkaloids (mg/100g)	583.33^{bc}	861.67^{a}	551.67^{c}	43.22
Tannins (mg/100g)	458.33^{b}	480.00^{a}	433.33^{c}	38.66
Phenolics (mg/100g)	30.50^{c}	49.00^{a}	37.63^{b}	10.24
Terpinoids (mg/100g)	220.00^{c}	520.00^{a}	420.00^{b}	43.24
Saponins (mg/100g)	166.67^{c}	240.00^{a}	208.33^{b}	22.40
Cardiac glycosides (mg/100g)	2.17	2.17	0.67	0.08
Cyanogenic glucos.(mg/100g)	0.47	0.90	0.67	0.26
Phytates (mg/100g)	33.33^{c}	75.00^{a}	51.67^{b}	8.76
Oxalates (mg/100g)	6.66^{c}	20.00^{a}	1.66^{b}	4.37
Steroids (mg/100g)	65.66^{c}	94.67^{a}	80.00^{b}	7.59
Antioxidants (Inhib.) (%)	23.33^{c}	42.37^{a}	29.56^{b}	6.65

CAW = Cashew Apple Waste, SEM = Standard Error of Means. Means with same letters are not significantly different (P≤ 0.05) across the rows

DISCUSSIONS

Proximate composition

Moisture content is one of the most important and widely used measurements in the

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processing, preservation and storage of foods and drugs (Oloyede, 2005). The similarity in the moisture content of the three processed samples is a pointer to the fact that they will have longer shelf life and high storability due to its insusceptibility to microbial attacks. This justifies the practice of storage in dry form by users. Chirife and Fontana, (2008) reported that low water activity can inhibit the proliferation of microorganisms and enzyme activity, leading to increase storability of samples. The higher ash content recorded for blanched CAW showed higher mineral content than those on other samples as ash content of any organic material is a reflection of the mineral content of the material. This finding is supported by the report of (Okpanachi et al., 2016) who observed a high ash content in dry cashew pulp during a laboratory analysis for proximate composition. Many body functions depend on lipids. Lipids provide excellent source of energy and enhance transport of fat-soluble vitamins, insulate and protect internal tissues and contribute to vital cell processes (Pamela *et al.,* 2005). The higher fat content recorded in blanched CAW is a pointer to the fact that this product has the potential to supply livestocks with needed energy. The low crude fibre content observed for blanched CAW is advantageous to the absorption of glucose and fat. Although crude fibre enhances digestibility, its presence in high levels can cause intestinal irritation, lower digestibility and decreased nutrient utilization. Crude fibre in foods or plants is an indication of the presence of non-digestible carbohydrate and lignin. The low value obtained for blanched CAW is considered appropriate and studies have shown that crude fibre aids in reducing peaks of blood glucose following a meal due to delayed gastric emptying (Jones, 1995). The highest protein value recorded among blanched CAW could be as a result of the blanching process that reduces the anti-nutrients and make the protein available. The protein from plant sources have lower quantity, but their combination with many other sources of protein such as animal protein may result in equivalent nutritional value. The higher NFE in fermented CAW could be as a result of the fermentation process as its known to break down higher organic matter to release carbohydrate (Trease and Evans, 2001).

Mineral composition

Calcium content was found to be higher among blanched CAW compared to other samples such as unblanched and fermented CAW. Calcium is necessary for the strong bones and teeth. It is relatively high in cereals, nuts and vegetables (James, 1996; Thomas, 2006). Iron content was also found to be higher among blanched CAW compared to other samples such as unblanched and fermented CAW. It is essential for transport of oxygen in hemoglobin and also involves in energy metabolism. Deficiency of iron results in anaemia. This result obtained shows that it can be used in improving the anaemic condition in iron deficient animals as reported by (Bolt, 1998, Takeri, 2004). Potassium was higher in blanched CAW compare to others samples. Potassium is responsible for nerve action and is very important in the regulation of water and electrolyte balance and acid – base balance in the body. The high level of potassium in blanched CAW is a good indication that its consumption will enhance the maintenance of the osmotic pressure and acid-base equilibrium of the body. Magnesium is essential for enzyme reaction in the metabolism of ingested carbohydrate, example of such enzymes are α-amylases, maltase, sucrase and lactase. It is essential in electrical breakdown of nutrient and other materials within the cells (Bolt, 2008). From this present study, blanched CAW showed higher magnesium content. Manganese is also an essential mineral as it helps the body form connective tissues bones, blood clotting factors and sex hormones. It also plays a role in fat and carbohydrate metabolism, calcium absorption and blood sugar regulation. It helps also to regulate normal brain and nerve function. The study however shows similarity among the manganese content of the various samles. Phosphate was found to be higher among the cashew apple that was blanched and mechanically extracted. This element found more in this treatment is a constituent of bone and teeth, nucleoprotein, phospholipids, enzymes and high energy compounds. (Jones, 1995). Zinc is essential in the activation of certain enzymes, these include dehydrogenase, alkaline phosphatase and carboxypeptidase. Zinc containing organic compounds employed as astringent and anti- fungal agents. Zinc aids wound healing and metabolism of nucleic acid and insulin (Takeri, 2004). It is however found to be higher among the cashew apple that were blanched compared to other samples.

Phytochemical screening

Flavonoids has been shown to possess many pharmacological properties such as: anti-oxidant activities, anti-inflammatory activities, anti-cancer activities and anti- microbial effects, hence, flavonoids may have a contributory effect to its fertility properties and other pharmacological effects the plant possesses (Wu et al., 2003, Verma et al., 2011). Hence the higher flavonoids present in the blanched CAW is of immense advantage to livestocks. The antioxidant activity of flavonoids is efficient in trapping superoxide anion (O_2), hydroxyl (OH), peroxyl (ROO) and alcohoxyl (RO) radicals. Alkaloids are generally toxic to other organisms. They often have pharmacological effects and are used as medications, as antimicrobial, antipyretic, local anesthetic and stimulant, psychedelic, analgesic, antibacterial, anticancer, antihypertension agent, the cholinomimetic, anticholinergic, vasodilator antiarrhythmic, antiasthma and antimalarial. Hence, the presence of alkaloids in the blanched CAW confirms its uses as a potential material in livestock feed. The presence of Tannin in the samples with higher value among blanched CAW comparable to other shows antitumor, hepatoprotective and antioxidant potentials. Alkaloids and tannins may also contribute to the plant's effects as antimalarial, anti-diarrhoea and analgesic agents (Mir, 2013). Phenolic compounds are secondary metabolites in plants that are involved in a number of metabolic pathways and are essential for plant growth and reproduction, and as protecting agents against pathogens. Phenolic compounds may play an important role in preventing chronic illnesses such as cardiovascular disease, certain type of cancers, neurodegenerative disease, and diabetes. Blanched cashew apple gave higher phenolic compound which proves the plant to be a viable phytobiotics which could replace the use of antibiotics in poultry production (Asl Marjan and Hossein, 2008). Blanched cashew apple shows higher saponin content comparable to other samples. Saponins are being used commercially as dietary supplements and nutraceuticals. Saponins are expected to lead to hydrolysis of glycoside from terpenoid and hence reduce the toxicity associated with the intact molecules. (Asl Marjan and Hossein, 2008). Anti-nutrients such as cardiac glycosides and cyanogenic glucosides, phytates, oxalates present in this plant is in low amount such that they do not pose much serious health threat to consumers. Since the levels of these Anti nutrients are not above the lethal dosage approved by standard bodies like National Agency for Food and Drugs Administration and Control (NAFDAC) in Nigeria, consumption of the material by livestocks may be considered to be non-toxic and may not elicit any adverse effect on the nutritional values of the by product (Blessing *et al.,* 2011). Higher level of phytate above that reported in this study for blanched cashew apple waste have been reported to have complicated effects in human and livestock system including indigestion of food and flatulence (Maynard *et al.,* 2004). They have also been known to exert substantial effect on bioavailability of minerals in foods by forming complexes with minerals (such as Ca, Zn and Mg), thereby preventing efficient absorption by the body systems (Oboh *et al.,* 2003). However, extensive and proper processing methods such as blanching is needed to reduce some of these anti-nutrients. Higher oxalate and tanin concentration above that reported in this study in blanched CAW could cause great risk of renal absorption and also possess the ability to chelate divalent minerals and prevent their absorption by the body systems However, the levels of oxalate was reduced to this bearable level because the sample was subjected to heat treatment (Blanching) (Lumu *et al.,* 2011). Steroids are known or have been found as an anti-inflammatory agent, anti-tumor, immunosuppressants and, hepatoprotective, antibacterial, plant growth hormone regulator, anthelminthic, cytotoxic and cardiotonic activity. Been higher in blanched CAW shows that the plant has promising phytobiotic potentials in livestock feeding.

CONCLUSION

Choices of processing method of cashew apple play important roles on the quality of the by product (Cashew apple waste) and bioactivity of the product. Based on the above findings it was concluded therefore that cashew apple waste will exhibit its highest phytobiotic potentials and nutrient qualities if it is processed through blanching and the juice mechanically extracted.

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NUTRITIONAL COMPOSITION OF TWO LOCALLY MADE CONDIMENTS IN NIGERIA

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ABSTRACT

African seasonings are commonly used to enhance the taste of locally made dishes. These various seasonings are gotten from plant sources and could be in form of seeds, roots, bark, or flowers. Fermented food flavoring condiments are usually derived from the fermentative activities of microorganisms on vegetable proteins of legumes or oil seeds, which abound in Nigeria. These condiments, apart from their flavoring properties, also serve as an affordable and ready source of plant protein to the Nigerian populace, whose staple foods are mainly carbohydrate based. This work, therefore aimed at comparing the nutritional values of two local condiments in their raw and processed forms: Parkia biglobosa (parkia seeds, Iru woro, and iru pete) and Citrullus colocynthis (egusi and ogiri). Proximate analyses were carried out on samples of both condiments. Results showed that processed melon seeds (ogiri) had the highest values for protein and moisture content (20.12% and 70.37% respectively) and the lowest values for ash content, fat, crude fibre and carbohydrate (1.01%, 2.12%, 1.92%, and 4.47% respectively), while the unprocessed melon seeds (egusi), had the highest fat content among all the samples. Processed pete had the highest values of ash, fat, fibre, and carbohydrate content when compared with ogiri and Iru woro. Unprocessed P. biglobosa seeds had higher protein, ash, crude fibre, and carbohydrate values (17.47%, 7.91%, 8.72%, and 43.6% respectively), when compared with unprocessed C. colocynthis seeds which had higher moisture and fat contents (43.1%, and 30.51% respectively).

Key words: *Parkia biglobosa,* African parkia seeds, melon seeds, ogiri, iru, fermentation, proximate analysis

INTRODUCTION

African food preparation is not complete without the use of locally available seasonings. Just as salt is important in meal preparation, the addition or omission of some locally made seasonings can make or break a dish. The various seasonings are gotten from plant sources and could be in form of seeds, roots, bark, or flowers. These items follow various preparation procedures from drying and grinding to soaking and leaving whole. Fermented foods constitute a significant component of African diets (Olasupo and Okorie, 2019). Apart from increasing the shelf life and reduction in the anti-nutritional factors, fermentation markedly improves the digestibility, nutritive value and flavours of the raw seeds (Dosunmu et al., 2012). A condiment is defined as a spice, sauce, or other food preparation that is added to food to impart a particular flavor or enhance its taste (example salt). These fermented food condiments are known to be good sources of proteins and vitamins. Indeed, seasonings are an essential key to cooking in Nigeria as no cooking is complete without the addition of one form of seasoning or the other. Seasonings include local and imported brands. Local seasonings can be used singly to cook a special variety of soups. For instance, among the Igbos, *ogiri* is used to cook bitter leaf soup while *iru* or *dawadawa* is used in cooking egusi soup. In addition to the aforementioned benefits of such condiments, they are also employed in dietary strategies to control obesity due to their high fibre, low carbohydrate and fat contents rather than physical exercises (Dosunmu et al., 2012).

Parkia biglobosa

Parkia is a pantropical genus of about 30- 40 tree legume species of considerable evolutionary, taxonomic, biological and economic importance in Africa, Asia and South America. It has several uses including fodder, food, medicine, green manure, fuel and timber (Sabiiti and Cobbina, 1992). The products vary by ethnic groups according to tastes and availability. Citing a number of studies in Togo, Ghana and Nigeria, Campbell-Platt (1993) reported a daily consumption of fermented *Parkia biglobosa* seeds of 1-17g per person in West Africa in central Benin; women reported using between 33g and 66g of locust bean per household per day or 7g – 10g per person. *Iru* is one of the natural sources of plant proteins which gives it a great potential as protein supplement. It is used in the preparation of various delicacies, such as vegetable soups and stews and also a low cost meat substitute that contributes to protein and calories intake by several West African families (Ogunshe and Okereh, 2011).

Figure 1. (a) Unfermented seeds of African locust bean (b) Fermented seeds of African locust bean (Iru) (c) Unfermented melon seeds and (d) fermented melon seeds (Ogiri). Source: Olasupo and Okorie, 2019.

Citrullus colocynthis

Melons are widely grown and consumed in Nigeria. Melon crops provide a source of income to many Nigerians. Melon planting occurs mostly in the Northern portion of the country because the amount of rainfall aids melon growth. For Nigerians, melons are an important source of vitamins such as vitamin A and vitamin C and the seeds are high in protein. Melons are major food crops with several varieties which serves as major food sources (Jacob et al. 2015). The melon crop is scientifically known as *Citrullus colocynthis* and locally known as egusi. Egusi is grown not for its flesh but for its seeds. Only the seeds are edible as the fruit is too bitter. The seeds are eaten in various forms.

Research has proven that the bioactive compounds found in egusi have a protective effect against coronary heart disease and promote the absorption of fat-soluble vitamins as they exhibit antioxidant, antiviral, antidiabetic, hepato protective and cardio protective properties (Acham et al. 2018).

Ogiri is a seasoning native to Nigeria, West Africa. It is a paste of fermented oil seeds. There are many types of Ogiri but the most common varieties are Ijebu, Igbo and Nwan. Its seeds are from West African melons, whose fruit is bitter and inedible. The seeds are covered with a light brown shell which is removed prior to cooking. When de- shelled, the seeds have a creamy white appearance and it is ground into powder that has a consistency of bread crumbs. They are then used to cook very savory stews and served with the staple fufu or pounded yam. Ogiri has an oily grey pasty consistency and a very strong pungent smell. The smell is greatly reduced when frozen. Ogiri is best used in the preparation of egusi soups. It lends a deeper, richer flavor to the dish. This work was aimed at assessing the nutritional values of two locally made condiments in Nigeria; *Parkia biglobosa* & *Citrullus colocynthis* (unprocessed and processed).

MATERIALS AND METHODS

The two condiments used and their seeds were obtained from the market. Iru, ogiri and *colocynth* seeds were obtained from Dugbe market while *Parkia* seeds were obtained from Bodija market. The proximate analysis was carried out at IAR&T central laboratory, Apata, Ibadan, Oyo state.

Proximate Analysis

Proximate analyses were carried out using FAO recommended methods for proximate composition: oven drying for moisture content, Kjeldahl method with 6.25 conversion factor for crude protein, Soxhlet solvent extraction for crude fat, dry ashing for ash and (total or available) carbohydrates by difference.

RESULTS AND DISCUSSION

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Table 1. Proximate analysis results

SAMPLES	PROTEIN%	%MC	%ASH	%FAT	%CRUDE FIBRE	%CHO
Unprocessed parkia	17.47	17.51	7.91	2.44	8.72	43.6
Processed *woro*	12.76	17.1	7.61	2.14	7.25	51.35
Processed *pete*	19	14.69	7.69	2.61	9.79	43.64
Ogiri	20.12	70.37	1.01	2.12	1.92	4.47
Egusi	12.16	43.61	3.07	30.51	4.06	6.06

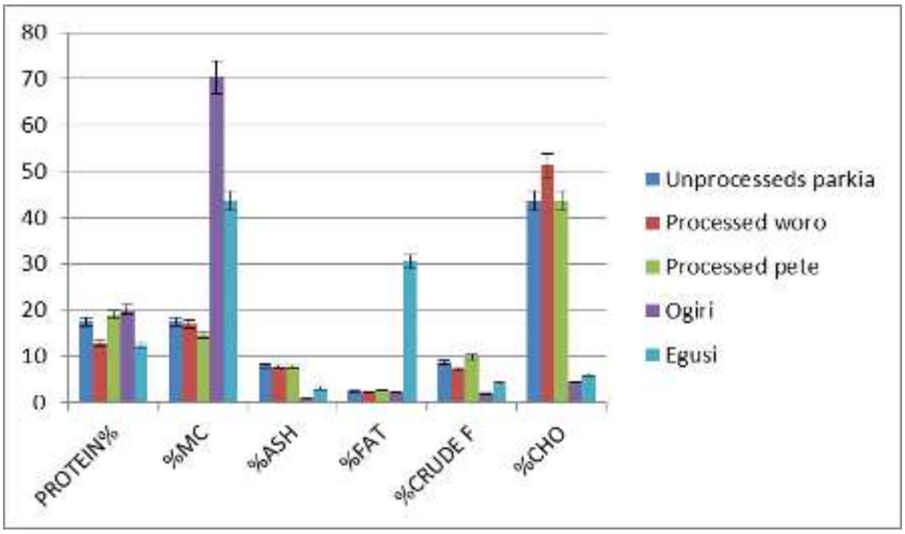

Figure 2. Comparison chart of proximate results of Parkia and melon samples

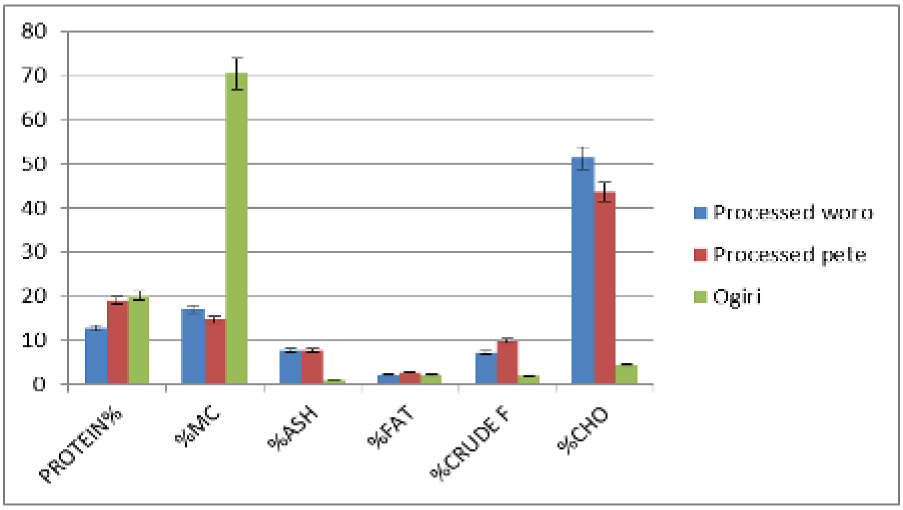

Figure 3. Comparison chart of proximate results of *Iru woro*, *Iru pete*, and *ogiri* samples

From the table and figures above, it was shown that processed melon seeds (ogiri) had the highest values for protein and moisture content (20.12% and 70.37% respectively) and the lowest values for ash content, fat, crude fibre and carbohydrate (1.01%, 2.12%, 1.92%, and 4.47% respectively), while the unprocessed melon seeds (egusi), had the highest fat content among all the samples. Processed *pete* had the highest values of ash, fat, fibre, and carbohydrate content when compared with *ogiri* and *Iru woro.* Unprocessed *P. biglobosa* seeds had higher protein, ash, crude fibre, and carbohydrate values (17.47%, 7.91%, 8.72%, and 43.6% respectively), when compared with unprocessed *C. colocynthis* seeds which had higher

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moisture and fat contents (43.1%, and 30.51%, respectively).

CONCLUSION AND RECOMMENDATIONS

Parkia biglobosa seeds (both unprocessed and processed) and *Citrullus colocynthis* seeds are very nutritious with processed *pete* being more nutritious than processed *woro* seeds, while *ogiri* had high protein content. It is, therefore, recommended that processed (fermented) *Parkia biglobosa* seeds (*pete*) should be consumed more as it is the most nutritious product of the *Parkia* tree. Processing it into powder is also suggested.

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NUTRITIONAL EVALUATION OF YELLOW FLESHED AND RED FLESHED FRUITS OF CHRYSOPHYLLUM ALBIDUM IN NIGERIA

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ABSTRACT

Chrysophyllum albidum is an important but highly underutilized tree crop in Nigeria's food systems. Two varieties, yellow fleshed fruit and red fleshed fruits were considered in this study. Fresh fruits were randomly collected from Eastern parts of the country, and washed to remove dirts. The pulp and the peel were separated and the pulp was stored for analysis. The phytochemical and proximate compositions were determined using standard analytical methods. Phytochemical and antioxidant activity such as total phenol, total flavonoids, total antioxidants, DPPH were significantly higher in yellow fleshed fruit than in red fleshed fruit. Carbohydrate, fat composition, pH value and Brix were higher in red fleshed fruit than in yellow fleshed fruit. This study shows that the yellow fleshed C. albidum, which is less consumed than the red fleshed fruits. are very good source of natural antioxidant and can contribute towards food and nutritional security in Nigeria.

Key words: *Chrysophyllum albidum*, phytochemicals, pulp, nutritional security

INTRODUCTION

Chrysophyllum albidum (African star apple) belongs to the family *Sapotaceae* which is made up of 17 genera and 7 commonly found species (Bada, 1997). The name *Albidum* originated from the white or silvery –grey undersurface of its mature leaves. It is termed star apple because of the star-like arrangement of its seeds as found in an apple (Adu-Baoudu, 2009). It is a tree crop commonly found in the rainforest or the riverine areas of the savanna/rainforest zone. Its distribution spans Central, Eastern and Western Africa (Nigeria, Ghana, Republic of Benin, Uganda, Niger, Cameroun, and Cote d' Ivoire) (Adebayo *et al*., 2011). *C. albidum* is a common tree/shrub in home gardens of Southern Nigeria being a seasonal fruit tree which produces flowers at the end of the rainy season (Oct/Nov) and fruits in the peak of dry season (December to April). However, in parts of the rainforest of South Eastern states of Nigeria, flowering occurs January-February; April-June and September with the variation in its flowering regime making it a good tool for apiculture (Okafor, 1981). Among all the species of *Chrysophyllum* found in Nigeria, C*hrysophyllum albidum* remains a commonly consumed and utilized variety. It is grown for its nutritional and economic value. However, it has been tagged as an endangered, neglected and underutilized fruit tree (Eguagie, 1997). It has been tagged as one of the trees of life and among the top 5 priority indigenous tree crops because of the role it plays in the food systems and economy of rural people in West Africa's humid lowlands (Leakey, 2012). The top priority indigenous tree crops highlighted by Leakey (2012) are *Irvingia gabonensis* (Bush Mango), *Dacryodesedulis* (African Plum or African Pear), *Ricinodendrum heudolotti* (Njangsang in cameron), *Garcinia kola* (Bitter kola) *and Chrysophyllum albidum* (African star Apple). *C. albidum* can be used for wine production, jam, gum making, animal feed production (Makinde *et al.,* 2017). This study therefore aims at evaluating the phytochemical, proximate and antioxidant composition of 2 varieties found in Nigeria.

MATERIALS AND METHODS

Fresh fruits of the red and yellow fleshed varieties were randomly collected from the Eastern states and washed to remove presupposed dirts. Composite sample of each variety was prepared by scraping the pulp of the fruit and separating from its seed with spatula. The pulp was blended thoroughly using a waring blender (model of blender) and divided into two portions. One portion was used for fresh analyses (moisture content, vitamin C, titratable acidity, brix determination), while the other portion was oven dried at 55 °C for 48 h and used for other determinations.

The %pH, Brix and total titrable acidity were measured by standard methods while the total phenolic, flavonoids, total antioxidants and reducing capacity (using Ferric Reducing Antioxidant Power-FRAP and 1,1-diphenyl-2-picryl hydrazyl-DPPH radical scavenging) were determined spectrophotometrically using standard procedures. Proximate analysis was carried out on the samples to determiune the moisture, crude fiber, protein, ash, carbohydrate and crude fat contents. The moisture, crude fiber and ash contents of the

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samples were determined by the method described by Pearson, (1976). The micro-kjedahl method was used to determine crude protein using the methods of AOAC (2000). The protein was calculated using the general factor 6.25 to convert the Nitrogen to protein(AOAC,2000). The percentage total carbohydrate was estimated as the difference between 100 and the sum total of the proximate composition of each sample (Nzikou et al.,2010).

All analyses were carried out in triplicates and data were expressed as means ± standard deviation. Analysis of Variance (ANOVA) was performed to calculate significant difference in treatment means. Fisher test was used in determining the least significant difference(LSD) of the mean. Test of significant was done at 5% probability level (P=0.05).

RESULTS

Phytochemical and proximate compositions of the red and yellow fleshed pulp of *C. albidum* are presented in the tables 1and 2 below, respectively. At p≤0.05, YFP had significantly higher values of total phenolic (1.71 ± 0.06 mg/g), total flavonoid (2.01 ± 0.02 mg/g), total antioxidant (1.04 ± 0.02 mg/g), Vitamin C (0.29 ± 0.11 mg/g), Protein (4.31 ± 0.02 %), Moisture (68.47 ± 0.23 %), crude fibre (1.66 ± 0.01 %) and TTA (1.29 ± 0.08 mg/g) compared to those of RFP while significantly higher values were recorded for RFP for Reducing power (2.10 ± 0.06 mg/g), fat (0.27 ± 0.00 %) and CHO (33.66 ± 1.34 %) when compared with values for YFP. RFP was found to be significantly less acidic (3.80 ± 0.03) than YFP (3.67 ± 0.04). Brix was higher in RFP than in YFP (16.33 ± 0.58^0 and 10.67 ± 1.15^0, respectively) which showed that the YFP is less sweet than the RFP and its corroborated by the low pH value recorded by the YFP. Significantly high values of DPPH inhibition were observed in the YFP (52.03%) compared to the RFP.

Table 1: Phytochemical compositions of yellow- and reddish-fleshed pulp of *C. albidum*

Parameter	Yellow	Red
Total phenolic (mg/g)	1.71 ± 0.06^a	1.58 ± 0.02^b
Flavonoids (mg/g)	2.01 ± 0.02^a	0.85 ± 0.04^b
Reducingpower (mg/g)	1.24 ± 0.01^b	2.10 ± 0.06^a
Total antioxidants (mg/g)	1.04 ± 0.02^a	0.95 ± 0.02^b
DPPH (%)	52.03 ± 0.81^a	27.24 ± 0.56^b
TTA (mg/g)	1.29 ± 0.08^a	0.62 ± 0.03^b

TTA- Total Titratable Acid

Table 2: Proximate composition of yellow and red fleshed pulp of *C. albidum*

Parameter	Yellow	Red
Protein(%)	4.31 ± 0.02^a	4.13 ± 0.02^b
Crude fiber (%)	1.66 ± 0.01^a	1.59 ± 0.01^b
Fat (%)	0.26 ± 0.00^b	0.27 ± 0.00^a
Carbohydrate (%)	21.20 ± 0.16^b	33.66 ± 1.34^a
Ash (%)	4.10 ± 0.10^a	3.94 ± 0.14^a
Vit.C (mg/g)	0.29 ± 0.11^a	0.20 ± 0.00^b
Moisture (%)	68.47 ± 0.23^a	56.40 ± 1.44^b
Ph	3.67 ± 0.04^b	3.80 ± 0.03^a
Brix (%)	10.67 ± 1.15^b	16.33 ± 0.58^a

Means ± standard deviation in the same column with different superscripts are significantly different(p≤0.05)

DISCUSSION

Chrysophyllum albidum fruit pulp is characterized by its colour as the pulp is either yellow or red with the yellow fleshed being sour than the red fleshed. The sour taste can be attributed to higher levels of total phenolics and antioxidants in YFP (1.71 ± 0.06 mg/g and 1.04 ± 0.02mg/g) compared to 1.58 ± 0.02 mg/g and 0.95 ±0.02 mg/g respectively in RFP as shown in table 1. Total flavonoid contents at 2.01 ± 0.02 mg/g as found in YFP is comparable to those found in the pulp of Carpatin (2.22 ± 0.11mg QE/100g) and Andrea (2.87 ± 0.23mg QE/100g) varieties of plum (*Prumus domestica* L.) cultivars as reported by Cosmulescu *et al.* (2015). The total phenols present in both YFP and RFP (1.71 ± 0.06 and 1.58 ± 0.02mg/g) were found to be higher than reported by Mohankumar *et al.* (2019) for the pulp of seven (7) different species of mango (*Mangifera indica* L.) which had values ranging from 0.17 ± 3.79 to 0.56 ± 4.89 mg of GAE/g but lower than that in mandarin pulp (3.90 ± 43.71mg/g) and pulp from different species of clementine (3.11 ± 66.50 to 4.05 ± 123.2 mg/g) (Boudries *et al*., 2012). The levels of the reducing power in both YFP and RFP as shown in table 1 indicates that they have the potentials as good reducing agents in the lipid peroxidation process(Arazo *et al*., 2011) The Vitamin C content in the samples studied (0.29 ± 0.11 and 0.20 ± 0.00mg/g) as shown in table 2 was found comparable to the ascorbic acid content of yellow mombin at 0.27 ± 0.66 mg/g, higher than that in passion fruit at 0.71 ± 2.40 mg/g and pear at 0.0053 ± 0.00 mg/g but lower in that of guava 1.02 ± 0.00mg/g and cashew 2.28 ± 1.68mg/g(Contreras-calderon *et al*., 2011).

Ash content is a quantitative indicator of minerals present. The Ash content in both samples ranged 3.94 ± 0.14 to 4.10 ± 0.10% and were not significantly different but were found lower than 5.73 ± 0.25% as reported in the pulp of *Adansonia digitata* (Sadiq *et al*.,2009) and found higher in the pulp of *Chrysophyllum albidum* 2.29 ± 0.04% reported by (Ibrahim *et al*.,2017).

Fat in both YFP and RFP were quite low when compared to that obtained in the pulp of *C. albidum* 6.97 ± 0.51 reported by (Ibrahim *et al*., 2017) and 6.24% recorded for *Tamarindus indica* (Ishaku *et al*., 2016). The protein content of 4.31 ± 0.02 and 4.13 ± 0.02 found in the YFP and RFP respectively were found higher than 1.53 ± 0.04% found *Adansonia digitate* (Sadiq *et al*., 2009) but lower than that reported for *Chrysophyllum albidum* 7.31 ± 0.46%(Ibrahim *et al*., 2017). Crude fiber aids digestion and both pulps had low values when compared with *Spondias mombin* pulp having 4.2 ± 0.04g/100g (Adepoju 2009). The high moisture content indicates the tendency of the fruit to rot quickly at relatively high temperatures. Carbohydrate content ranged between (21.20 ± 0.16 to 33.66 ± 1.34 %) was higher than 6.43 ± 0.19% as reported by Abraham *et al*.,2019 for fruit pulp of *Balanites aegyptiaca* and lower than that of tamarind pulp 60.02% (Ishaku *et al*.,2016).

This study has shown that the yellow fleshed fruit of *Chrysophyllum albidum* are a rich source of antioxidants showing high levels of flavonoids, phenolics and total antioxidant activity. Therefore, it is suggested that they may contribute to promoting human health as a functional food or a value added ingredient.

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EFFECT OF INCLUSION OF COCOA POWDER ON PROXIMATE COMPOSITION, ANTIOXIDANT AND SENSORY EVALUATION OF UNRIPENED CHEESE MADE FROM SOYABEAN MILK

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ABSTRACT

Unripened soft cheese "warankashi" was made by partially replacing soya milk (SoM) with cocoa powder (CoP) at 0.0%: 100% (A), 2.5%: 97.5% (B), 5.0%: 95% (C) and 7.5%: 92.5% (D) for CoP: SoM respectively. Proximate composition and antioxidants analyses: DPPH, radical scavenging abilities of the cheese were carried out. The sensory evaluation of the samples was done using taste panelists comprising 15 female and 13 male members of staff of the Cocoa Research Institute of Nigeria who are regular consumers of cheese. The proximate chemical components showed significant difference (p<0.05) in protein, crude fat, and total ash content which increased from 4.34% to 5.47%, 16.76% to 26.90% and from 16.15% to 17.44% respectively as the inclusion level of cocoa powder increases. The radical scavenging activities of the cocoa based cheese, FRSA contents also increased from 51.50% to 68.14% and 20.78% to 37.14% respectively as the cocoa powder addition increases. The result of consumer acceptability test shows that sample C (5%: 95%) and D (7.5% :92.5%) were accepted as well as the control sample.

Key words: Warankashi, soya milk, cocoa powder, proximate composition, antioxidants, sensory evaluation

INTRODUCTION

Cheese, a concentrated dairy commodity, either of animal origin or plant origin, is produced by a combination of activities including acid or rennet coagulation or curdling milk, stirring and heating the curd, draining off the whey, collecting and pressing the curd. The cheese is ripened, cured, or aged to develop the flavour and texture (Ayodeji *et al*, 2020, Balogun *et al*, 2016, Lawal and Adedeji, 2013). According to Bodyfelt *et al*. (1988) cheese is a dairy product made by coagulating either whole milk, part-skim (low fat) milk, skim milk, or cream by removing much of the liquid portion while retaining the coagulum and the entrapped milk solids. 'Warankashi' is consumed in its fresh unripened state, fried or used as a meat-analogue in stews and soups. 'Warankashi' is an excellent source of protein, fats and minerals such as calcium, iron and phosphorus, vitamins and essential amino acids, thus making it an important food in the diet of both old and young (Oladipo and Jadesimi, 2012). Cheese made from animal milk is a very good source of animal protein, fat, carbohydrates, ash and moisture and a good source of sodium, potassium and Calcium (Omotosho *et al*., 2011). When it is of plant origin, it also has a very rich nutritional profile.

Cocoa, *Theobroma cacao*, has been widely used in varying applications. Chocolate has been consumed as confection, aphrodisiac, and folk medicine for many years before science proved its potential health benefits (Ackar *et al*, 2013). Cocoa beans are one of the best known sources of dietary polyphenols; the total polyphenol content of the dried fat-free-mass of fresh cocoa beans is around 15–20% and of fermented beans approximately 5% (Wollgast and Anklam 2000). The polyphenol content in cocoa beans depends on their origin and processing, as they are subject to a combination of fermentation and drying treatments, followed by alkalisation and roasting, which affects the polyphenol content and consequently the end product quality (Hii *et al*. 2009). Since cheese of animal origin is costly and rare to come by in developing nations, coupled with its low vitamins C and mineral content, milk was sought from plant origin. This made milk readily available and accessible for the teeming population and her nutrition need. Still, due to effect of processing, milk of plant origin lack capacity to provide adequate mineral content and antioxidants need of the populace. Continous search in solving these nutritional deficiencies gap prompted more research to improve the quality of cheese made from these raw materials. The objective of this project therefore, is to increase utilization of cocoa (cocoa powder) in cheese making, improve presentation and nutritional composition of 'warankashi', an unripened cheese.

MATERIALS AND METHODS

Material Collection and Preparation

Well dried and clean soyabeans was obtained from Oja Oba market in Ibadan while cocoa powder was supplied by the marketing department of CRIN, Ibadan, Nigeria. Alum was obtained from open market in Ibadan and five percent concentration was prepared.

Production of soyabean Milk

Dry, cleaned soyabeans was measured and soaked in water for about six hours before wet milling was done using a hammer mill. Filteration was done through a double-layered muslin cloth, and manually squeezed with a twisting motion to extract most of the milk. The extracted emulsion was pasteurized and stored at 30°C before the production of cheese and used within 24 hours of production.

Production of choco-soy-cheese (cocoa-warankashi) blend

The portion of the sieved milk for warankashi production from the soyabean milk was measured. The variation in the measurement was done according to the method described by Igyor *et al*. (2006). Cheese samples were produced from 1000 mL of soyabean milk with cocoa powder added at varying proportions, to create a ratio of (CoP: SoM) 0:100; 2.5:97.5; 5:95; and 7.5:92.5 (w/w). Alum solution was used as a coagulant. 20 mL of the 5% alum solution was added to each of the milk blends. The method of Ashaye *et al*. (2006) with some modifications was used to produce the cheese. Soyabean milk with cocoa powder blend was transferred into a metal pot. The pot was placed over a slow burning fire and heated till it starts boiling. The milk was kept at the boiling point and the coagulant (20 mL alum solution) introduced until it coagulated and there was a visible separation of curds and whey. The curds and whey were then poured into a clean muslin cloth and the whey was allowed to drain. After a few minutes, the formed curd was placed in a clean container and cut to desired shapes. The cut curd was fried in hot vegetable oil (light frying), allowed to cool and packed in clean air permeable wrappers prior storage on a shelf at room temperature.

Proximate Analysis

The standard method of the AOAC (2000) was used for the analysis of protein percentage, crude fat, ash content, crude fiber, and moisture content. Moisture content was determined after drying at 103 ºC until a constant weight was attained. Protein was determined by the Kjeldahl method (N x 5.84), crude fat was extracted with petroleum ether using Soxhlet apparatus (gravimetric method), ash (gravimetric method), while total carbohydrate quantity was determined by the differences: % carbohydrate = 100- (% protein + % fat + % ash + % crude fiber + % moisture).

DPPH Radical-scavenging activity

Sample Extraction

Five (5) g of fried choco-soy-cheese (warankashi) were uniformly homogenised using the homogenizer with 50 mL of HPLC grade methanol in an ice bath at speed 5 r.p.m for 1 minute and filter under reduced pressure through Whatman No 1 filter paper according to Arabbi *et al*. (2004). The effect of all extracts and standard antioxidants on DPPH radical was estimated according to the method of Blois 1958 reported by Arabbi *et al.* (2004):

DPPH Scavenging Effect %

$$\frac{A_0 - A_1 \text{ x100}}{A_0}$$

Where: A_0 is the absorbance of control and A_1 is the absorbance of extracts or standards.

Free radical scavenging assay

Free radical scavenging activity of cocoa-warankashi samples was determined by the method reported by Re *et al*. 1999. ABTS·+ scavenging effect (%) = ((AB–AA)/ AB) × 100 (2), where, AB is absorbance of ABTS radical + methanol; AA is absorbance of ABTS radical + sample extract/standard. Trolox was used as standard substance.

Sensory Evaluation

Sensory evaluation was conducted using a 9-point hedonic scale and a semi-trained panel comprising 15 female and 13 male members of Cocoa Research Institute of Nigeria familiar with the consumption of cheese. The panelists evaluated the coded samples for colour, taste, flavour, toughness, and overall acceptability. Each sensory attribute was rated on a 9- point hedonic scale (9 = like extremely and 1 = dislike extremely) (Iwe, 2007).

Statistical Analysis

SPSS 20.0 was used to statistically analyze the data obtained from the study. Results obtained in triplicate determinations and subjected to analysis of variance to determine the significant differences among the samples. Means were separated using Duncan test.

RESULTS AND DISCUSSION

The results obtained for the proximate compositions of the samples were significantly different at 95% confidence level (Table 1). The significant difference observed was primarily due to the interaction of cocoa powder with the soya milk used in cheese making. There was an increase in moisture content in all the cocoa-soy cheese samples analysed. The percentage moisture of 18.00% which was the least was observed in the control sample (A: 100 % soy-cheese) and while sample B had the highest moisture content. (CoP: SoM, 2.5: 97.5), 26.48 and thereafter declined for sample C (25.69) and sample D (23.15). There was no significant difference in moisture content of cocoa soy cheese blends B and C. The protein content of the cocoa-soy cheese blends (Table 1) ranged from 16.76% – 26.90%. Sample A had the lowest level of crude protein content, while the highest crude protein content was recorded in sample D. Thus, protein content of choco-cheese increased with increased level of cocoa powder.

Crude fat level ranged from 16.15% – 17.44%. The lowest crude fat content (16.15%) was observed in the control sample (A), while the rest were not significantly different from one another. Fat is important as a source of energy in the human body (Onyeka, 2008). The impact of light frying on the cocoa-soy cheese could partly be responsible for the moderate fat density in the cocoa-soy cheese samples. The ash content in a food material is a measure of mineral elements in food (Balogun *et al*., 2016). It shows a positive increasing trend with the minimum result being 4.34% and highest ash result being 5.47%. This further affirmed the fact that varying inclusion levels of cocoa powder in soya milk was responsible for high mineral content of the cocoa-soy cheese blends. Choco-cheese blends C and D are not significantly different ($p<0.05$) but different from blends B and the control (A).

Table 1: Proximate composition of unripened choco-soy-cheese

Sample	Moisture (%)	Protein (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrates (%)
A	18.00^c	16.76^d	16.15^b	0.00^a	4.34^c	44.75^a
B	26.48^a	21.48^c	17.37^a	0.00^a	5.10^b	29.57^b
C	25.69^a	23.87^b	17.28^a	0.00^a	5.39^a	27.77^c
D	23.15^b	26.90^a	17.44^a	0.00^a	5.47^a	27.04^c

Values are means of triplicate determination, ^{abcd}Values in the same column bearing different superscripts are significantly different ($p<0.05$). Legend: A (0:100), B (2.5:97.5), C (5:95), D (7.5:92.5)

Total carbohydrate content of the cocoa-soy cheese blends ranged from 44.75% - 27.04% among samples with added cocoa powder. The control sample had a value of 44.75%. This result indicated that there was a significant difference ($p<0.05$) among the samples and a decrease in the carbohydrate contents of the cheese samples. This result agreed with the position of Balogun *et al* (2016), as carbohydrate decreased with increasing substitution of cow-soya cheese.

Table 2 shows the result of antioxidant capacities of the choco-cheese samples. The DPPH (2,2-diphenyl-1-picrylhydrazyl-hydrate) scavenging effect analysed on the cheese samples revealed an increasing trend with the control sample having least value. It was observed that the DPPH value increased as the portion of cocoa powder increased in the cheese. Highest value (68.14%) was recorded in sample D (7.5: 92.5). The DPPH scavenging effect was significantly different ($p<0.05$) in all samples. Free radical scavenging activity evaluated as ABTS+ cation scavenging effect [2,2-azinobis (3-ethylenebenzothiazoline-6-sulfonic acid)] also increased across all samples of cocoa-soy cheese. Free radical scavenging activity was highest in sample D, followed by sample C, sample B and least in sample A (100% soy-cheese).

Table 2: DPPH and FRSA content of unripened choco-soy-cheese

Sample	% DPPH	% FRSA
A	51.50^{d}	20.78^{d}
B	64.21^{c}	31.74^{c}
C	66.54^{b}	35.35^{b}
D	68.14^{a}	37.14^{a}

Values are means of triplicate determination, ^{abcd}Values in the same column bearing different superscripts are significantly different ($p<0.05$). Legend: A (0:100), B (2.5:97.5), C (5:95), D (7.5:92.5)

Table 3 presents the sensory mean scores of taste panelist who rated the produced cocoa-soy cheese. There were significant differences ($p<0.05$) observed in all the products implying that, there were variations in the test products. This variation is partly attributed to varying inclusion levels of cocoa powder (CoP: SoM) in the blends and partly due to the nature of soya milk itself. For colour or appearance, control (100% soy cheese) as well as sample D (7.5:92.5) were rated best followed by sample B (2.5:97.5) and sample C (5:95), respectively. The cocoa-soy cheese blend with inclusion level of '7.5:92.5' appeared more like meat analogue 'liver', hence the acceptance. This result was at variance with Aworh and Akinniyi (1989) and Igyor *et al*. (2006) substitution resulting to discolouration and cheese analogue led to reduced acceptability. In terms of toughness, no significant differences exist between all the samples. It is opined that cocoa inclusion in the 'warankshi' blend did not adversely impair the anticipated smoothness, firmness and coherence of produced cocoa-soy cheese. A few respondents remarked on brittleness of control sample but rarely noticed in samples with varying level of cocoa inclusion. For taste, cocoa-soy cheese with highest cocoa inclusion was rated best scoring 6.95 while there was no difference ($p>0.05$) with control (100% soya milk), sample B (97.5% soya milk) and sample C (95% soya milk) respectively whereas, flavor across all made cocoa-soy cheese blends were similar (no significant difference). In terms of overall acceptability, 7.5:92.5 cocoa-soy cheese had the highest rating (7.75), followed by 0:100, control, with mean score (7.55), and cocoa-soy cheese 5: 95 (7.05). Cocoa-soy cheese, 'warankashi', (2.5:97.5) had the lowest score (6.70). This investigation shows consumers' willingness to try out seemingly new products. For all the attributes rated, sample C (5:95) and sample D (7.5:92.5) were accepted as well as the control sample.

Table 3: Sensory evaluation of unripened cheese made from cocoa powder soy-milk blend

Sample	Colour	Taste	Flavour	Toughness	Overall Acceptability
A	7.80[a]	5.35[b]	6.60[a]	7.50[a]	7.55[a]
B	6.75[ab]	6.05[ab]	6.70[a]	7.10[a]	6.70[b]
C	6.45[ab]	5.65[ab]	6.95[a]	6.85[a]	7.05[ab]
D	7.30[a]	6.95[a]	7.20[a]	6.35[a]	7.75[a]

Values are means of triplicate determination, [abcd]Values in the same column bearing different superscripts are significantly different ($p<0.05$). Legend: A (0 :100), B (2.5:97.5), C (5:95), D (7.5:92.5)

CONCLUSION

The results from this study show there was an increase in protein, fat, minerals (ash) and antioxidants level as cocoa inclusion increased. This therefore implies the possibility of creating a new product, cheese analogue, for the populace. The nutritional value discovered in producing 'warankashi' by inclusion of cocoa in soya milk blends will improve the well being of the populace from Nigeria and other developing nations. In conclusion, cocoa can be utilized in making functional cheese for categories of people regulating their carbohydrate intake. This can be served as a snack food or component of a meal. Sample C (5%:95%) and sample D (7.5%:95%) cocoa-soy cheese was acceptable to panelist; hence the inclusion of cocoa powder at 5% or 7.5% should be encouraged in production of cocoa-soy cheese.

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REPLACEMENT OF SKIMMED MILK WITH CASHEW (*ANACARDIUM OCCIDENTALE L.*) KERNEL MILK IN ICE-CREAM PRODUCTION

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ABSTRACT

Cashew kernel milk (CKM) was partially replaced with skimmed milk (SKM) in ice cream production. The recipe of the different formulations was: 10 %, 20 %, 30 %, 40 % and 50 % (v/v) (CKM: SKM), while 100 % skimmed milk ice cream served as control. Samples were evaluated for physicochemical parameters like pH, Titratable acidity (TTA), Total soluble solids (TSS) and microbiological stabilities over 3 weeks' storage period. The proximate and sensory characteristics of samples were determined. The TTA, TSS and pH of the ice creams reduced significantly ($p < 0.05$) during storage but less pronounced in samples containing CKM which is concentration dependent. Results showed range of values of 3.12 - 3.93 % protein, 0.48 - 1.07 % crude fibre, 0.66 - 2.29 % crude fat and 80.1 - 82.15 % moisture content. The bacterial and the fungal counts were within standard recommended for ice creams. Sensory evaluation showed significant differences ($p < 0.05$) among the ice-cream samples up to 20 % above which the taste becomes unacceptable. Cashew kernel milk can therefore substitute skimmed milk in ice-cream production.

Key words: Cashew kernel, DPPH, ice-cream, proximate, skimmed milk

INTRODUCTION

Ice-cream remains one of the most cherished dairy products in the world (Choo *et al*., 2010). Most of the ice-creams available in the market are generally poor in natural antioxidants like vitamin C, colors and polyphenols. It is therefore of interest to explore the possibility of improving the nutritional attributes of ice-cream using ingredients with health benefit like fruits, vegetables, nuts, pulses and fibers in line with consumer expectations. Cashew is a tropical tree crop containing pseudo-apple and sickle shaped nut which has appealing consumer traits like flavor, color and nutritional content, especially vitamin C (Emelike and Akusu, 2019). In Nigeria, cashew kernel has seldom been utilized in other food applications as pea nuts (Aroyeun, 2009) despite the tremendous rise in its yearly production (FAO, 2000). About 60 % of cashew kernels are consumed in form of snacks while a low quantity has been used in the production of differently formulated cashew kernel-based snacks. The remaining unutilized portions have been regarded as wastes because of lack of storage facilities. Ice-cream is made from milk ingredients (milk fat and milk solids-not fat), sugar, water, and other optional ingredients such as flavorings, colors, stabilizers and emulsifiers (Schmidt, 2004). The ice-cream flavor and color are normally generated through adding a small amount (i.e. approximately 0.3 % ice cream mix). Based on the nutritional profiles of cashew kernel milk, this study was developed for it to substitute skimmed milk powder in the production of ice-cream with aim of establishing the effect of its partial replacement on the antioxidant profiles and nutritional contents. Microbial stability and its sensory qualities in comparison with the control were also investigated.

MATERIALS AND METHODS

Sample collection

Cashew nuts used for this study were obtained from the CRIN, Ibadan. The nuts were processed to obtain the kernels following the steps for cashew kernel processing.

Production of Cashew Kernel Milk

Milk production from cashew kernel was carried out as described by Adedokun *et. al*., (2014) with some modifications. Roasted cashew kernel was divided into three equal parts of 450 g each and then soaked in 250 ml of portable water for 6 hours. The water was removed and each portion was blended (using Philips HR2000 blender) into slurry at the ratio of 1:6 (w/v) kernel to water. The slurry was filtered with muslin cloth to separate the milk. The supernatant was removed with water; the milk was skimmed together and concentrated into ¼ of the initial volume. The milk was boiled until frothing stopped. The extracted milk was reserved in the fridge for further use.

Cashew kernel milk /skimmed milk ice-cream Production

Varied levels of cashew kernel milk were used to replace skimmed milk at 10, 20, 30, 40 and 50 % CKM / SKM ratio respectively. All the required ingredients such as milk solid non-fat (MSNF), milk fat (MF), milk blends CKM / SKM, sugar, stabilizer, emulsifier blend (CREMODAN) and water were thoroughly mixed, pasteurized at 80 ^{0}C for 30 s, homogenized in a two-stage process, at 13.8 MPa and 3.6 MPa for 5 min using ULTRA _ TURRAX IKA-T25 digital (Werke Staufen, Germany). The ice-cream mix was then rapidly cooled to room temperature and aged at 4 ^{o}C over-night. No flavor was added to the ice-cream mix prior to freezing to avoid any unrelated flavor impact. The mix was whipped using an ice-cream maker (Kenwood, Model: IM 280, UK) at a constant speed for about 20 min, packaged and stored in the freezer frozen at 20^{o}C.

Physicochemical and Proximate Analysis of Ice-cream mix

The ice-cream mix was subjected to physic-chemical analyses such as, pH, Titratable acidity (TTA) and the Total soluble solids (TSS). The pH of the melted ice-cream samples was measured using a pH meter model: 3505 pH meter, Jenway, UK. The percent titratable acidity was determined as described by A.O.A.C. (2012). The TSS (^{O}Brix)) involves the determination of Total Sugar Level*:* The total sugar level (°Brix) of each ice- cream sample was carried out using refractometric method (Soluble solids) using hand Refractometer (Atago Brix 0-32 % Model TM 1600, Gibertini, Italy). The crude protein, fat content, moisture content, ash, crude fibre were all determined according to standard procedure (AOAC, 2012)

Microbiological Analyses

Five (5) g of melted ice-cream samples and the control were each aseptically homogenized in 10 ml of sterile ringer solution; 3 ml of each of the mixture were plated in the different culture media to obtain the number of CFU/g of product. Moreover, decimal dilutions were plated in the same culture media. The microbial groups investigated were total microbial counts of mesophilic aerobic microorganisms, determined in Plate Count Agar (PCA) medium (Oxoid) and incubated at 30 ^{O}C for 48hours under aerobic conditions; total coliforms in violet red bile Agar (VRBA) (Oxoid, 37 ^{O}C), 24 h under aerobic conditions. Lactic acid bacteria was determined using De Manns Rogosa Agar (MRS); Staphylococci using mannitol salt agar (MSA); Moulds were enumerated using potato dextrose agar (PDA) medium (Oxoid). These were evaluated over a three-week storage period.

Organoleptic property

The sensory characteristics of the ice-cream samples were conducted using an acceptance test. Each analysis was performed by 25 untrained panelists drawn from various academic institutions. Sensory attributes of taste color, flavor, and overall acceptability were evaluated.

Statistical Analysis

Data were generated from the means of triplicate determinations with standard deviations (S.D). Analysis of variance (ANOVA) was carried out using SPSS version 23 for Windows (SPSS Inc., Chicago, IL, USA), and the determination of significant differences among treatment means was conducted under Duncan's multiple range tests ($P \leq 0.05$).

RESULTS AND DISCUSSIONS

Variations occurred in the pH of the ice-creams samples at 21-day storage period as shown in Table 1. Sample G had the highest level of acidity while the least was obtained in Sample F. This could be due to the presence of anacardic acid in G as against lactic acid in F. In the ice-cream mix, Sample B was higher in acidity while Sample C had the least acidity. However, the acidity level in the samples assumed an irregular pattern.

Table 1: Physicochemical properties of Cashew kernel ice-cream mix

Sample	pH	% TTA	TSS (^{0}Brix)	SG
A	5.7	-	2.4	1.009
B	4.2	-	4.0	1.015
C	5.9	-	7.0	1.028
D	4.4	-	7.1	1.029
E	5.5	0.268	7.2	1.042
F	6.4	0.268	16.7	1.075
G	4.1	0.266	17.0	1.076

A – 10 %, B – 20 %, C – 30 %, D – 40 %, E – 50 %, F – 100 % conventional milk, G – 100 % cashew milk, TTA - Titratable acidity, SG - specific gravity, TSS - Total soluble solid

The effects of CKM supplementation in the ice-creams were evident from the TSS values. A direct relationship occurred between the CKM and the sugar contents of the ice-cream. The sugar in milk is lactose which is not as sweet as sucrose in cashew which could be responsible for the higher Brix in CKM ice-creams as against the control. The total soluble solids increase steadily and reached the maximum level at the 50 % inclusion in the mix (Table 1).

Table 2: Proximate chemical compositions of cashew kernel ice-cream

Sample Code	Crude Protein	Crude Fat	Crude Fibre	Total Ash	Moisture content	Dry Matter	CHO
A	3.12	2.66	0.08	3.87	80.17	18.31	13.1
B	3.41	2.49	0.21	3.89	81.89	18.61	11.0
C	3.60	2.43	0.43	3.95	80.06	21.35	12.43
D	3.93	2.29	0.36	3.97	80.97	19.76	11.38
E	2.18	2.07	0.14	3.69	81.31	17.62	13.61
F	3.48	2.69	0.25	3.12	81.39	18.58	13.17
G	3.79	2.42	0.39	3.94	82.15	17.85	10.31

A - 10 %; B – 20 %; C – 30 %; D -40 %; E - 50 %; F – 100 % milk; G – 100 % Cashew Milk, CHO - Carbohydrate

The crude fat in the conventional milk ice-cream (Sample F) was higher than in Cashew kernel milk ice-cream (Sample G) as shown in Table 2. This implies that the latter is a more health-friendly ice-cream than the former, more so that the fat in G is more of unsaturated (Aremu *et. al*., 2006) compared to F that contain more of saturated fatty acid (McCance, and Widdowson, 2002). In the mix, fat content decreases with increase supplementation of CKM (Table 2). Similar results were obtained by Tainara *et al*., (2013) who reported a reduction in percentage fat contents of ice-cream produced from orange by products. The Protein content in G was higher than in F probably due to the inherent high protein content of cashew kernel (Aremu *et. al*., 2006). In the mix, the protein content increased with increasing supplementation up to 40 % (Table 2).

In Table 3, the lowest yeast count, after 21 days was observed in Sample E while the highest was in C. The yeast counts in all the samples fall within the acceptable limit for ice–creams. The presence of staphylococcus species was not detected in any of the samples analyzed. The lactic acid bacteria (LAB) were generally not observed in the samples. The total viable counts (TVC) in the samples were also within the acceptable limit, while there were no indications of mould growth, coliform and staphylococcus presence. These are indications that pasteurization was adequate and the cold storage system effective. This study established the safety of the ice-creams for human consumption. The sensory evaluation (not shown) showed an overall acceptable level of 20 % cashew kernel milk supplementation in the ice-cream according to the panelists.

Table 3: Microbiological profiles of ice-cream from CKM / SKM blends

Samples	Yeast count	Staphylococcus count	LAB Count	TVC	Coliform Count	Mould count (Propagules/ml)
A	7.4x10^5	No growth	No growth	4.95x10^6	No growth	No growth
B	5.99x10^7	No growth	No growth	6.10x10^7	2.02x10^7	No growth
C	6.00x10^7	No growth	No growth	7.82x10^7	2.62x10^7	- (no growth)
D	5.84x10^7	No growth	No growth	5.48 x10^7	2.26 x10^7	No growth
E	3.66 x10^7	No growth	No growth	3.13 x10^5	1.53 x10^7	No growth
F	4.80x10^7	No growth	No growth	3.20 x10^7	7.2 x10^6	No growth
G	6.7x10^6	1.10x10^6	1.19 x10^7	5.38 x10^7	6.5 x10^5	4.22 x10^7

CONCLUSION

CKM addition enhanced the physical, chemical and sensory characteristics of ice-cream. CKM could therefore be used as an easily accessible source of natural food supplement.

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COMPARATIVE STUDY ON THE PROPERTIES OF PLANTAIN AND BANANA FLOUR AND STARCH

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ABSTRACT

Banana based food product is becoming acceptable both in the rural and urban centres, which is also revel among the nutritionist and consumers. In this study, physical properties of banana and plantain flours and starches from different cultivars were investigated for both food and non-food applications. Six unripe but mature banana and 2 plantain cultivars from which physical properties such as pulp colour, starch and flour yield were measured were also used for starch and flour production. The result showed that all the cultivars studied had bright pulp lightness index (L), good colour difference (ΔE) and good Chroma (ΔC). Obino 1 had the least 54.76 L*, 28.81 ΔE and 22.91 ΔC values. The highest starch yield was recorded in the banana cultivars (9.7%-12.5%) while the highest flour yield of 42.1% was recorded in banana Cv. Saro 14. The study reveal that starch and flour can be both be produced from plantain and banana but banana produce more starch and flour than plantain.*

Key words: Starch, Flour, Plantain and Banana.

INTRODUCTION

Banana is a major food crop which is being produced globally, often used for all *Musa* species. Although genetically, most consumed bananas are hybrid of *M. acuminata* (A) and *M. balbisiana* (B). The edible bananas are classified as diploid (AA and AB), triploid (AAA, AAB, and ABB), or tetraploid (AAAA, AAAB, and AABB) (Soares *et al.,* 2011). Nutritionally, the classification is based on sweetness and starch content. While dessert banana converts almost all its starch into soluble sugar at ripening, plantain do not which in turn affects the taste. Therefore, dessert bananas are consumed raw while plantains are consumed cooked, baked, fried, flour, starch etc. The value addition sensitivity in banana/plantain production is becoming acceptable in other to curb post-harvest loss and increase income generation. The main post-harvest product often accepted in Nigeria is banana flour and starch. Starch is affordable and inexpensive raw materials for commercial production and industrial uses (Daudt *et al.*, 2014). Starch is available in large quantities in major plant sources, this includes plantain and banana. The use of banana and plantain starch should be encouraged for commercial production and industrial usage especially in food industrials, animal feeds and bioethanol.

Banana flour is one of the banana-based intermediate food products which traditional and local production is becoming widely acceptable now. Aside the reduction in the crops post-harvest losses, the nutritional value is revel among the nutritionist and consumers. Also, starch is a very important biopolymer in the food industry, where it performs various functions as thickener, binder, disintegrate, stabilizer, texture modifier, gelling and bulking agent. Starch varies greatly in form and functionality between and within botanical species, and even from the same plant cultivar grown under different conditions (Copeland *et al.* 2009). Although fewer cultivars of bananas and plantains are known and been cultivated due to anthropogenic selection. However, the optimal use of the available cultivars for starch and/or flour production is paramount.

Form and functionality of food products which include starch and flour varies between and within botanical species and cultivars. Determination of plantain and banana starch and flour physical properties is important for successful usage for both industrial and household uses. Thus, this study focused on investigating the physical properties of banana and plantain flours and starches of some available banana landraces in Nigeria. It is believed that the information would be relevant for both food and non-food applications of these plantain and banana products.

MATERIALS AND METHODS

Matured unripe bananas and plantains fruits used for this experiment were harvested 85 days after flowering from National Horticultural Research Institute (NIHORT) Project 4 Banana Germplasm field. Six banana cultivars (Saro, TMBX-5, Medium Cavendish, Saro 14, Dwarf Cavendish and Saro 17) and two plantain cultivars (Obino 1 and Agbagba NFC) were used in this study. Pulp colour of the banana and plantain studied were measured using a colourimeter (Chromater CR 410 Konica Minolta, Sensing Inc., Japan) and the values expressed on the lightness index (L*), colour difference (ΔE) and chroma (ΔC) tristimulus scale. The flour and starch were obtained using Pelissari *et al*. (2013) modified protocol, while each study were carried out in triplicates. Data were analysed using descriptive statistics.

RESULTS AND DISSCUSION

The colour characteristics of cultivars pulp are shown in Figure 1. The lightness index (L*) of the pulp was in the range of 54.76 and 74.70 (Figure 1). This result showed that Obino 1 is having the darkest pulp colour (Figure 1). However, the result recorded in study showed that all the cultivars studied had bright colour starch and flour. Mayasti *et al*. (2021) reported bright colour starches from the cultivars studied. The measurement of colour difference (ΔE) was in the range of 28.81 and 49.83 (Figure 1). Based on the ΔE values, the materials can be recommended for use in products requiring a uniform colour except Obino 1 which has the least L* and ΔE values (Figure 1). The chroma (ΔC) is usually regarded as a measure of colour purity (DeMan, 1999) and had been reported to have inverse relationship with particle size (Desalegn and Hailu, 2020; Prasopsunwattana *et al*., 2009). The chroma (ΔC) of the samples pulp were within the range of 22.91 and 30.30 (Figure 1).

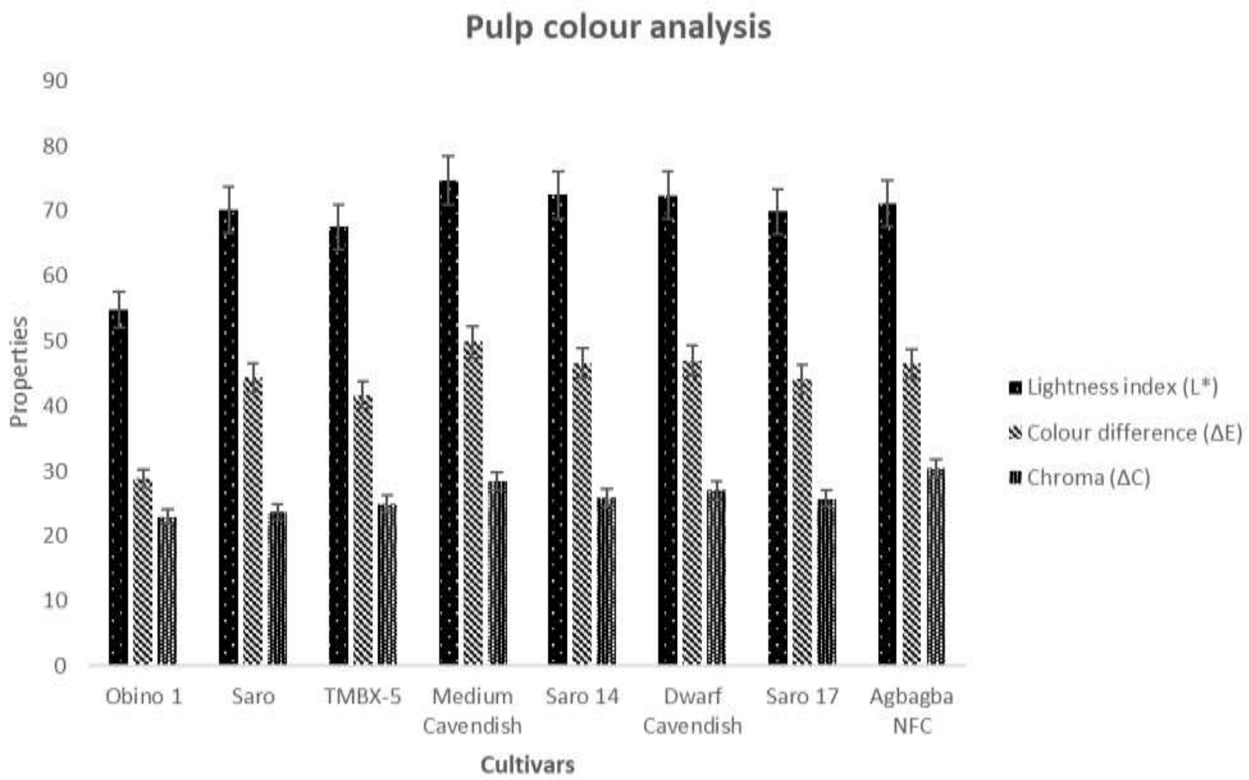

Figure 1: Colour Analysis of the Pulp of the plantain and banana Cultivars studied.

The result of this study showed that higher starch content was extracted from banana cultivars (9.7%-12.5%) compared to plantain (5.6% - 8.7%; Figure 2). The percentage extracted starch yield observed in this study varied slightly from previous studies. Otegbayo *et al.* (2010) reported 14% and 22% starch yield for plantain and banana respectively in the study of the crops starch and physicochemical properties. Daiuto *et al.* (2005) reported that the protocol use in starch extraction often affect the starch extracted quantity and quality. However, banana has been reported to have more extracted starch yield compare to starch yield from plantain cultivars (Eraga *et al.*, 2016; Otegbayo *et al*., 2010).

Also, the highest percentage flour yield (42.1%) was reported in Saro 14 cultivar while the lowest percentage flour yield (23.25%) recorded in this study was observed in Agbagba NFC cultivar (Figure 2). Although, Obino 1 had a closer value of flour yield of 41.18% which had a closer percentage flour yield of 42.1% observed in Saro 14 (Figure 2).

Starch has been reported to vary physicochemical properties within and between species (Zhu, 2014; 2015). Mayasti *et al*., (2021) reported a lowest flour yield in the genotype AAB which plantain (*Musa paradisiaca*) is a AAB genome.

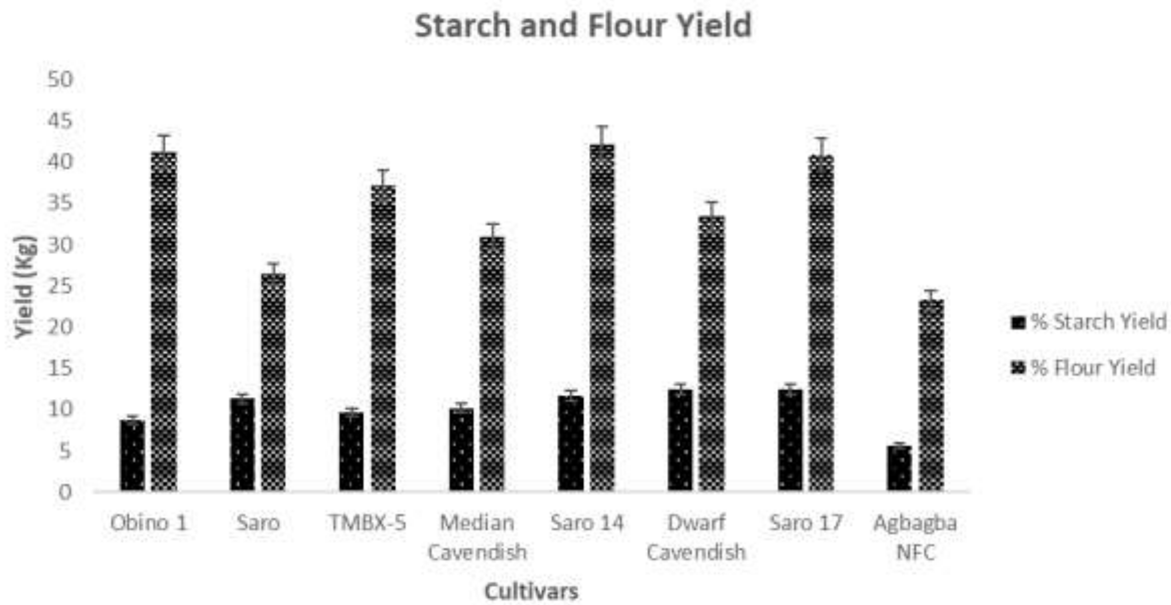

Figure 2: Percentage starch and flour yield of the plantain and banana cultivars studied

CONCLUSION

The utilization of plantain and banana starch and flour is dependent on physicochemical properties. This study showed that the starch and flour extracted the plantain and banana cultivars study had good physical properties. The percentage extracted starch and flour yield was higher in banana compared to plantain extracted starch and flour yield. Generally, the properties and characteristics of the starches and flours showed that they can be used as functional ingredients in food systems for household and industrial uses. However, banana and plantain proper classification is needed so as to group each cultivar in taxons for optimal usage.

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THE EFFECT OF COCOA POWDER AND BANANA FLOUR ON THE ANTIOXIDANT AND SENSORY PROPERTIES OF WHOLE WHEAT BASED BISCUITS

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ABSTRACT

Economically, the development of biscuits from composite flours is advantageous. The production of cocoa powder, banana flour and wheat flour composite biscuit aims at developing a functional food that is relatively cheap and available. This study focuses on the evaluation of cocoa powder, banana flour and wheat flour composite biscuit in the ratios 5:5:90, 10:10:80,15:15:70, 20:20:60, 25:25:50 and 0:0:100 (as the control) respectively. The biscuits samples were evaluated for their antioxidants and sensory properties using standard procedures. The antioxidants properties results ranged as follows: reducing power (1.05-3.54mg/g), total phenol (1.48-3.79mg/g), flavonoid (0.24-6.8mg/g), and total antioxidant. (2.9-9.91mg/g). The sensory evaluation was also carried out for color, flavor, taste, crispiness and overall acceptability; the results were 5.10 -7.80, 4.20-7.50, 2.90 – 7.50, 4.60– 7.40 and 4.50- 7.70 respectively. Interestingly, sample containing 5% whole wheat flour and 10% each of cocoa powder and banana flour was the best in terms of nutritional and sensory qualities.

Key words: Cocoa powder, anti-oxidative potentials, composite biscuits, nutritional quality.

INTRODUCTION

Biscuits are widely consumed convenient, cheap and ready-to-eat snack for all age group in many countries (Adebowale *et.al*., 2012). Biscuits are mainly produced from 100% wheat flour in the past, but there is limited availability of wheat grains in Nigeria due to the unfavorable climatic condition for wheat cultivation and policies such as the ban on the importation. However, Nigeria has climatic conditions that are suitable for tropical crops such as roots, tubers and cereals. Therefore, consumption of biscuits requires development of an adequate substitute for wheat. This is advantageous because it reduces importation cost by encouraging the use of indigenous crops such as cassava, yam, maize and others that are partially substituted for wheat flour (Satin, 1988). The FAO reported that the utilization of composite flour in various food products would be advantageous economically if the importation of wheat could be reduced or even eliminated, and that demand for wheat based products could be met by the use of domestically grown products instead of wheat (Jisha *et al*., 2008). Composite flour as defined by Milligan *et al*. (1981) is a mixture of flours, starches and other ingredients intended in totally or partially replacing wheat flour in bakery and pastry products. In developing countries such as Malaysia, the use of composite flours had a few advantages ranging from saving foreign currency to promoting high-yielding, native plant species to supply of better protein for human nutrition and better overall utilization of domestic agriculture production (Berghofer, 2000; Bugusu *et al*., 2001). Banana is one of the most consumed fruits in tropics and subtropics, and in terms of economical value it is the number five agricultural crop in world trade. The worldwide production of bananas in 2012 was 139.2 million tonnes (FAOSTAT, 2012). Besides, world banana exports are projected to reach almost 17.9 million tonnes in 2011.

Musa spp being one of the cheapest crops to produce and the cost of its production is less than most other staples. Besides being used solely as dessert, banana fruit may be processed into pulp-liquid fruit, canned slice, deep-fried chips, toffees, fruit bars, brandy and etc. (Kachru *et al.,* 1995; Morton, 1987). An estimate of 35% loss of the production of bananas was reported for developing countries (FAO, 1987). This is due to the fact that banana is a climacteric fruit and due to the habit of consuming ripe fruit, large quantities of this commodity are lost during its commercialization and post-harvest handling. A new economic strategy is to process green bananas into dried flour and incorporate the flour into various innovative products so as to encourage consumption of banana and thus contributing to the health of humans (Ovando-Martinez *et al.,* 2009; Ramli *et al.,* 2010). Green banana flour contains up to 61.3-76.5 g/100 g starch on dry basis, a percentage comparable to that in the endosperm of corn grain and the pulp of white potato; apart from starch, Green banana Flour is high in total dietary fiber (6.28-15.54 g/100 g dry basis), which participates in the hypocholesterolaemic effect (Horigome *et al.,* 1992; Mota *et al.,* 2000; Zhang et al., 2005). This is a new economical strategy includes the production of unripe banana flour which are incorporated into various innovative products such as slowly digestible cookies (Aparicio-Saguilan *et al.,* 2007), high-fibre bread (Juarez-Garcia et al., 2006) and edible films.

Cocoa, in recent times has become the target of increased scientific research, due to its pro-health properties (Bogumiła and Jolanta, 2019). Fresh cocoa bean contains about 32–39% water, 30–32% fat, 10–15% protein, 5–6% polyphenols,4–6% pentosans, 2–3% cellulose, 2–3% sucrose, 1–2% theobromine, 1% acids and less than 1% caffeine. Three types of flavonoids dominant in cocoa beans are proanthocyanins (circa: 58%), catechins orflavan-3-ols (circa: 37%) and anthocyanins (circa: 4%) (Khan and Nicod, 2012; Khan *et al*.,2014). The high polyphenol content of cocoa and its wide presence in many food products, makes it particularly interesting both from a nutritional point of view and health (Khan *etal*.,2014; Da Silva Medeiros *et. al*., 2015; Cinquanta *et al*., 2016; Giacometti *et al*., 2016; Tsang *et al*., 2019). Polyphenols are not only antioxidant properties, but also affect sensory properties such as colour and taste (Kothe *et al*., 2013; Zyzelewicz *et al*., 2016; Dabas, 2016; Giacometti *et al*., 2014). The aim of this study is to evaluate the effect of cocoa powder incorporation in banana wheat composite biscuit.

MATERIALS AND METHODS

The banana fruit was purchased from Ologede market, Podo, Ibadan. While the other ingredients such as wheat, coco powder were purchased from Apete market, Ibadan.

Sample preparation

Banana fruits were peeled with a sharp knife and the peels were separated from the flesh using a blunt knife. The flesh of the fruits was then cut into smaller sizes and sundried for 2 days until they attained a constant weight. The peels were then ground with a blender (VTCL, Spark), and the powder sieved through a 500 μm diameter sieve. The powder was then stored in self-sealed paper bags and kept in a cool dry place until utilization.

Formulation of the biscuits

Six samples of the biscuits were formulated. The formulation of the biscuit produced from composite blends of cocoa powder, banana flour and whole wheat flour were in the ratios 5:5:90, 10:10:80,15:15:70, 20:20:60, 25:25:50 and 0:0:100 (as the control) respectively.

Sensory analysis

A consumer acceptance evaluation was performed with a panel of 20 untrained tasters, to whom biscuits were given in random order. Tasters were asked to evaluate different parameters, such as appearance, odor, taste, flavor, texture, overall liking, and purchase predisposition on a 9-point hedonic scale (1-extremely dislike, 9 -- extremely like)

Determination of antioxidant capacity

Sample extraction was done according to the method described by Bloor (2001). Total phenolic content of the extracts was determined colorimetrically, using the Folin–Ciocalteu method as described by Singleton et al. (1999). Total flavonoid content was determined based on the spectrophotometricmethod (Jia *et al*., 1999). Antioxidant Capacity, Ferric Reducing/Antioxidant Power Assays were determined following the methods described by Katalinic *et al.* (2005).

Statistical analysis

The results of chemical, colour, antioxidant and sensory analyses were subjected to one-way analysis of variance (ANOVA) with Duncan's post hoc test at a 95% confidence level. Values obtained by the consumer acceptance test were analyzed by in SPSS software package, version 20.

RESULTS AND DISCUSSION

Sensory Characteristics of Biscuit Samples

The sensory characteristics of biscuit samples are shown in Table 1. The color, flavor, taste, crispiness and overall acceptability ranged from 5.10 -7.80, 4.20- 7.50, 2.90 – 7.50, 4.60– 7.40 and 4.50- 7.70 respectively. The results obtained are significant different at 95% confidence level ($P<0.05$). The colour of the biscuit samples reduced with increased inclusion of the cocoa powder and banana flour, Sample WF had the highest acceptability followed by the sample with 5% inclusion of cocoa powder and banana flour. Similar finding was obtained by Adejumo *et al.,* (2020). However, sensory characteristics are of great importance in the consumers' point of view (Ghadge *et al*., 2008), Higher expectation was therefore placed on the overall acceptability of the composite biscuits. The overall acceptability of samples CBWF5, CBWF10, CBWF25 and WF fell within the like region, while others did not. Among the composite biscuits samples, panelists preferred the sample that its whole wheat flour was substituted with 5% cocoa powder and 10% banana flour.

Table 1: Sensory evaluation of cocoa powder- banana wheat composite biscuits

Samples	Colour	Flavour	Taste	Crispiness	Overall acceptability
CBWF5	6.30^{bc}	5.90^{ab}	6.80^{ab}	7.00^{a}	6.80^{ab}
CBWF10	5.20^{bc}	6.20^{a}	6.00^{b}	6.10^{ab}	6.30^{bc}
CBWF15	5.50^{bc}	4.20^{c}	2.90^{d}	5.10^{b}	4.50^{e}
CBWF20	5.10^{c}	4.50^{bc}	4.00^{cd}	4.60^{b}	4.70^{de}
CBWF25	6.60^{ab}	6.00^{ab}	4.60^{c}	6.10^{ab}	5.60^{cd}
WF	7.80^{a}	7.50^{a}	7.50^{a}	7.40^{a}	7.70^{a}

Mean values having different superscripts within a column are significantly different ($p<0.05$)

Anti-oxidative Potentials

The reducing power of the cocoa powder-banana and wheat flour biscuit ranges between 0.56-4.30 with the CBWF25 having the highest value and CBWF10 was having the lowest value. The total phenolic compounds of the cocoa powder-banana and wheat flour biscuit rangedbetween 1.48 – 3.79 with CBWF15 having the highest value but not higher than the WF. The flavonoids of the cocoa powder-banana and wheat flour biscuit ranges between 0.56-4.30. Sample CBWF20 had the highest value followed by CBWF25.

Table 2: Anti oxidant values obtained for cocoa powder banana and wheat flour biscuit

Samples	Reducing power (%)	Total phenoic compounds (%)	Flavonoids (%)	Total Antioxidants (%)
CBWF5	1.11^{b}	2.60^{c}	3.61^{ab}	5.27^{a}
CBWF10	0.56^{b}	2.40^{d}	0.95^{b}	3.40^{a}
CBWF15	1.82^{b}	3.64^{b}	0.66^{b}	5.69^{a}
CBWF20	1.05^{b}	1.86^{e}	6.80^{a}	4.11^{a}
CBWF25	4.30^{a}	1.48^{f}	3.81^{ab}	2.92^{a}
WF	1.58^{b}	3.79^{a}	0.93^{b}	6.86^{a}

Mean values having different superscripts within a column are significantly different ($p<0.05$)

CONCLUSION

This study has shown from the results obtained that nutrient dense biscuits can be produced by substituting wheat flour with 5% cocoa powder and 5% banana flour. Biscuits produced from 90% wheat flour and 5% cocoa powder and 5% banana flour substitution was most acceptable to the panelist. Thus, consumption of cocoa powder, banana composite and wheat biscuits would increase the anti oxidant intake which help to prevent diseases and increase the utilization of cocoa and banana in developing countries including Nigeria.

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TOXICOLOGICAL PARAMETERS OF ALBINO RAT FED WITH RICH-FIBRE FOOD FROM ORANGE (*CITRUS SINENSIS* LINN.) POMACE, SOYA MEAL AND WHEAT BRAN

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ABSTRACT

The concentration of phenolics and fibres in the orange pomace suggest that it could serve as an ingredient in novel food. Increase in consumers' demand for functional foods with natural origin like pomace is also on the increase. However, the possible toxicological effect has to be investigated. Orange pomace, wheat bran and soyameal of different ratio were subjected to extrusion (5Kg per cycle) at fixed cooking temperature (110 °C) and screw speed (290 rpm). The extrudates were tested on forty male Wistar rats for toxicity for 28 days. Data were analysed using ANOVA at $\alpha_{0.05}$. Tested diets on Wistar rats resulted in lower weight gain which was at variance with control diet. White blood cells, creatine and glucose showed no significant difference between rats fed control and tested diets. The absence of toxic effect on the rat suggested that the food could be consumed for its health promoting benefit in addition to eliminating environmental pollution by orange pomace.

Key words: Orange pomace, soya meal, wheat bran, toxicological parameters

INTRODUCTION

Orange pomace is the waste that remains after processing oranges to juice, wine or other products. The wastes from this processing, including peel, seeds and pulp, which make up nearly 50% of unprocessed fruit, are a possible source of valuable byproducts (Gowe, 2015). Orange pulp is rich in fibre. The fibre has superior quality than others because of the occurrence of minerals, sugars, including bioactive substances like polyphenols, flavonoids and carotenes (Fernandez-Gines *et al*., 2003). The phenolic compounds of citrus pomace could undergo enzymatic oxidation at various stages of processing. Dehydration under suitable conditions enables reduction in water present and water activity in the products. The prevention of oxidative enzymatic reaction and the development of microorganisms prolong the storability of the products (Mhiri *et al*., 2015). Previous work has involved the use of pomace in the manufacture of several intermediates which include the production of compounds and solvents in flavours and colognes, as components in paints, cosmetics and animal supplements. Zaker *et al*., (2016) reported that incorporation of orange pomace up to 10% in cookies preparation increased nutritional value, especially in fibre, physical quality and general acceptance of biscuits. Our previous study developed and characterized the fibre of extruded whole food from orange pomace, soyameal and wheat bran hence this study to evaluate the possible toxicity of the food.

MATERIALS AND METHODS

Sample Preparation

Orange pomace was obtained after juice production from sweet oranges (Agege variety) at the juice processing pilot plant of the National Horticultural Research Institute, Jericho, Ibadan, Oyo State. The pomace was dried at 60 ± 2 °C, ground with a laboratory mill (500 µm) and kept in an airtight 250-micron polyethylene until use. Soyameal and Wheat bran was purchased from an Agro processing supplier, Oluyole Estate, Ring Road, Ibadan, individually ground to 500 µm and packed for further use.

Extrusion cooking

Extrusion cooking was performed according to the modified Huang and Ma (2016) method. Mixtures of wheat bran, soybean meal and orange pomace with different mixing ratios (Table 1). These were the adjudged best in our previous study.

Table 1: Formulations of orange pomace, soyameal and wheat bran extruded

Sample	Orange pomace	Soyameal	Wheat bran
P2	17	44	39
P3	5	80	15
P4	10	80	10

Animal requirements

Ethical consent to animals was obtained from ACUREC(UI-ACUREC/App/2016/027), University of Ibadan before study. Wistar albino rat (*Rattus norvegicus*) of approximate weight of 70- 80 g was used. The animals were obtained from the Department of Veterinary Pathology, University of Ibadan. The venue of the experiment was the Department of Animal Sciences, University of Ibadan. Forty (40) animals were used for the study.

Animal treatment and organ examination

After one week of acclimatization, the 40 rats were separated into four groups as follows: the first group which was control received basal diet while the other three with different ratio of orange pomace, wheat bran and soyameal (17: 39:44, 5:15:80, 10:10:80) % were fed for 3 weeks. The experimental animals were observed closely for up to 21 days, thereafter biological and hematological tests were carried out.

Nutritional evaluation on rats fed with the tested blends

During the experimental period (3 weeks), the consumed diets were recorded every day, and body weights were recorded every week. Nutritional evaluation of various diets was performed by determining body weight gain% (BWG%), feed efficiency ratio (FER), feed conversion ratio (FCR) according to equations described by El-Sayed *et al*. (2014) .

Hematological analysis

About 2 ml of blood samples was taken with heparinized capillary tubes to determine the hematocrit value according to Rodak (1995) method. Total red and white blood cells, Hemoglobin strength, mean corpuscular volume, mean corpuscular hemoglobin concentration and mean corpuscular hemoglobin concentration were estimated by the method reported by Lawal *et al*. (2015).

Method of Euthanasia/Disposition of animals

At the end of the study, animals certified fit were donated to the Zoological garden of the University of Ibadan.

RESULTS AND DISCUSSION

Feed Efficiency/weight gain

At the expiration of the experiment, weight gain and food consumed by the rats fed on the experimental diets were lower than the control (Figure 1). There were no significant differences in food intake between control and tested diets, but weight gain was significantly different. Rat fed with food blend of 17% pomace, 44% soyameal and 39% wheat bran had the highest weight gain while those fed with 5 % pomace, 80% soyameal and 15% wheat bran had lowest weight gain. Lower weight gain from the tested food suggests that the food could be considered to make a difference in the onset and progression of overweight and obesity. This is in line with findings of Keenan *et al*., (2006) that fibre is able to reduce body weight gain or decrease weight gain. This has been attributed to various factors such as soluble fibre, which produces glucagon-like peptide (GLP-1) and peptide TY when fermented in the colon. The two intestinal hormones take part in inducing satiety, decrease energy intake and also decrease metabolizable energy.

Rat fed with control diet were able to digest the diet better than the other tested diets which resulted in increased digestion and absorption of nutrients. Soluble dietary fibre in form of neutral detergent fibre was more in the control diet than the tested diets (Table 2) leading to more absorbed nutrients and weight gain. The same trend was observed in the Feed efficiency ratio and conversion ratio (Figure 2 and 3). The result was comparable with the findings of Rashad and Moharib (2003) of lowered nutritional parameters as a result of high fibre feed fed to rat. The trend could be due to the distribution of soluble and insoluble fibre fraction; hemicellulose, cellulose and lignin present in the tested and control diets.

Hematological parameters

The result of the hematological parameters shows that Packed Cell Volume (PCV) count to be from 35.67 to 37.33% (Table 2) and is within clinical range for rat. The highest PCV was obtained for diet P2 followed by diet P3. No significant difference was observed between the control (P0) and the tested diets. The PCV known as hematocrit (Ht) or (HCT) or erythrocyte volume fraction (EVF) is the percentage (%) of red blood cells in the blood. According to Isaac *et al*. (2013) PCV is involved in the transportation of oxygen and absorbed nutrients. Increased PCV shows better transport and therefore increases the primary and secondary polycythemia.

A higher PCV value for rats fed with the study diet shows that diets are suitable for transporting oxygen and nutrients. The hemoglobin (HGB) value of the albino rat fed the diet P2 (12.63) was the highest, followed by P3, P0 and finally P4. No significant variation ($p > 0.05$) was observed among HGB of rat fed with the food. The result suggests that hemoglobin is sufficient for the albino rats for its physiological function of transporting oxygen to the animal tissues to oxidize red blood cells (RBC). Rats fed control and experimental feed (P0, P2, P3 and P4) were not significantly different. Diet P2 had the highest mean RBC count (6.00×10^{12}) while P4 had the least (5.66×10^{12}). These values are in the laboratory range for rat (Sharp *et al*., 1998) and suggested no toxic effect of experimental diet on the rat.

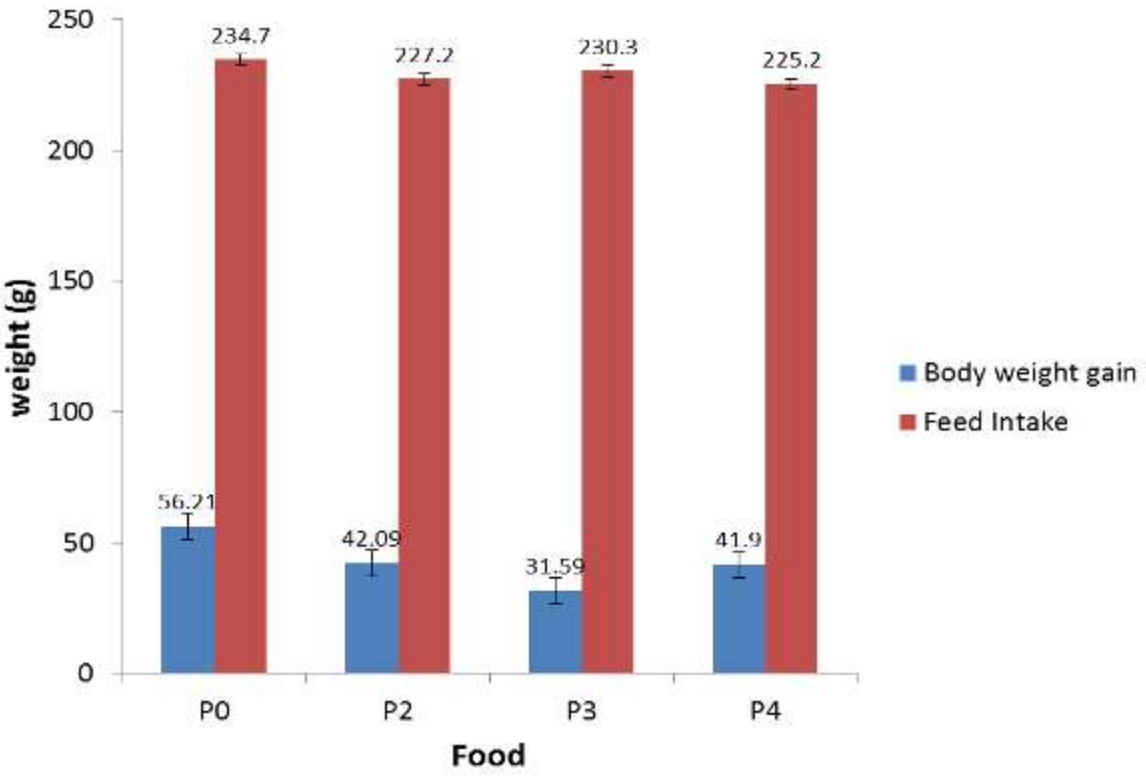
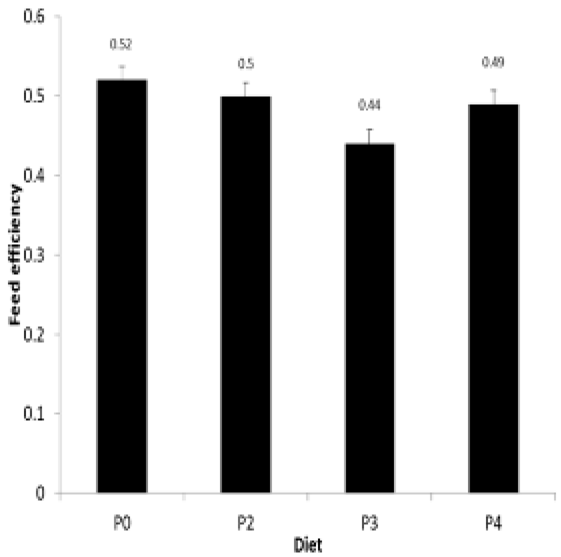


Figure 1: Food intake and Body weight gain by rats fed with control and tested diets



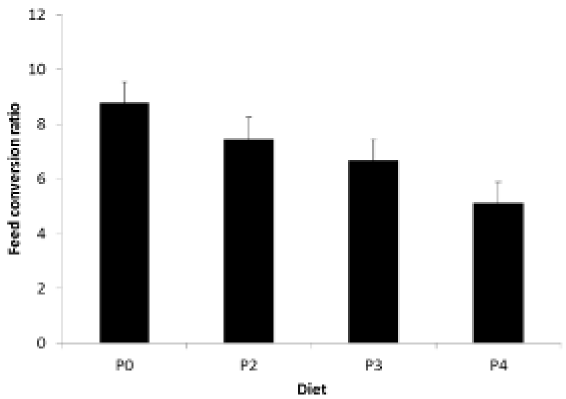


Figure 2: Feed efficiency of control and tested diets Figure 3: Feed conversion ratio of control and tested diets

P0 = control, P2 = 17 % pomace 44% soyameal 39 % wheat bran, P3 = 5 % pomace 80% soyameal 15 % wheat bran, P4 = 10 % pomace 80 % soyameal 10 % wheat bran

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Table 2: Hematological variables of rat fed control and experimental diets

Diet	PCV (%)	HGB (g/dl)	RBC (x 10^{12})	WBC (x 10^9)	Plt	Lym	Neu	Mo	Eos
P0	36.33^a	12.07^a	5.95^a	5283^a	171667^a	65.33^a	30.33^a	1.67^a	2.67^a
P2	37.33^a	12.63^a	6.00^a	5950^a	191000^a	66.33^a	31.00^a	1.33^a	1.33^a
P3	37.00^a	12.33^a	5.96^a	6400^a	156000^a	70.33^a	25.33^a	2.00^a	2.33^a
P4	35.67^a	11.97^a	5.66^a	6100^a	133333^a	66.67^a	30.67^a	1.33^a	1.33^a

Value are mean of three replicates followed by different letters in the same column are significantly different.

PCV – packed cell volume, HGB – Heamoglobin, RBC –red blood cell, WBC – white blood cell, plt – platelet, lym - Lymphocyte, Neu –Neutrophils, Mo -Monocycte, Eos –Eosinophils. P0 = control, P2 = 17 % pomace 44% soyameal 39 % wheat bran, P3 = 5 % pomace 80% soyameal 15 % wheat bran, P4 = 10 % pomace 80 % soyameal 10 % wheat bran.

Red blood cells are used for transportation of oxygen and carbon dioxide in the body (Isaac *et al.* 2013); hence, low red blood cell count signifies a decrease in the level of oxygen transported to the tissues and carbon dioxide returned to the lungs (Soetan *et al*., 2013).

Highest white blood cell (WBC) was recorded for rats fed with diet P3 (6400 x 10^9) which was not significantly different ($p > 0.05$) from other diets. The main roles of white blood cells are defending the body by phagocytosis against attack by foreign organisms, combating infections, production, transportation and distribution of antibodies in the immune response. The result of the study is within the clinical range suggesting that the albino rats were able to generate antibodies in the course of phagocytosis with high degree of resistance to diseases (Soetan *et al*., 2013). It will also encourage their compliance to natural ecology and disease dominant conditions as supported by Iwuji and Herbert (2012).

Platelet count for rat fed with the diets was between 133333 and 191000, the highest from diet P2 while the lowest was from diet P4. There was no significant variation observed among the control and the test diets ($p > 0.05$) The difference in the level could be as a result of variation in the type (dose, structure, soluble, insoluble) of dietary fibre in the diets (Rashad and Moharib, 2003). Table 4.8 also corroborates the findings showing difference in the Dietary fibre fraction. Platelets are involved in blood clotting, the platelet concentration was within the clinical range, suggesting that the process of clot formation (blood clotting) will be quick in the event of an injury in the control diet and on tested diets. Lymphocyte value for the control and test diets were from 65.33 % to 70.33 %. The highest from Diet P3 and lowest from diet P0. No significant variation ($p > 0.05$) obtained from the diets. Maximum neutrophilis were recorded for the blood samples of rats fed P2 (31%), followed by diet P4 (30.67%) while diet P3 had the least (25.33%). No significant variation ($p > 0.05$) was observed among the diets. The result shows no toxic effect on the blood samples of rat fed the experimental diets.

CONCLUSION

The absence of toxic effect on the rat suggested that the food could be consumed for its health promoting benefit in addition to eliminating environmental pollution by orange pomace.

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INFLUENCE OF ALOE VERA AND SILVER THIOSULPHATE FLORAL PRESERVATIVES ON HELICONIA CUT FLOWERS VASE LIFE

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ABSTRACT

The use of floral preservatives has been pertinent to the longevity of cut flowers. This study focuses on the influence of Aloe vera gel solutions and silver thiosulphate solutions used as floral preservative on the vase life of Heliconia cut flowers. The experiment was carried out in the plant physiology laboratory, Floriculture programme, National Horticultural Research Institute, (NIHORT); Ibadan, Nigeria (7°25" N and 3°52" E). Five treatments were used; 0.5 and 1.0 mM silver thiosulphate (ST1 and ST2), 2% and 4% Aloe vera solutions (AV1 and AV2) and water as control (CO). Each treatment was supplemented with 3% w/v sucrose and consists of ten replicates. Fresh Heliconia flowers were harvested early in the morning from the Floriculture garden, washed and uniformly cut as appropriate for the experimental use. The experiment was arranged in a completely randomized design with four replicates. Results showed that there were significant (P<0.05) different in application of the floral preservative treatments the as compared to the control on the vase life of the Heliconia cut flowers as well as other parameters analyzed. Longer vase life (12 days) was recorded for AV1 and AV2 as compared with the control that stayed for 6 days. There was no significant difference in the relative fresh weights of the cut flowers with the different treatments as compared with the control except on day 12. The use of organic floral preservatives such as Aloe vera gel can effectively prolong the vase life of Heliconia vase life as compared with silver thiosulphate.

Key words: Post-harvest, longevity, ornamental cut flowers, organic.

INTRODUCTION

Cut flowers naturally do not have long vase life. Without any form of support, their vase life ranges from 1 – 4 days depending on the plants, its maturity, cultivar, physiological condition, postharvest handling, etc. The reason for its short vase life is because once detached from the parent plant, there is no more supply of any form of nutrients, water and every other essential support causing their flowers and leaves to wilt as a result of unavailable resources that serves as food (Shokalu *et al*., 2018). Other contributory factors include water stress, air embolism, vascular blockage, microbial accumulation and contamination. Heliconias (Golden Torch) are exotic brightly beautiful plants with mostly yellow bracts common in Nigeria and many tropical regions of the world. Heliconia cut flowers have a vase life of about 6 days as they have sturdy bract that help to withstand postharvest handling (Akintoye *et al*., 2018). Silver thiosulphate is an effective ethylene antagonist and such helps to arrest senescence in plants. Aloe vera contains antimicrobial properties. The use of silver thiosulphate (STS) as well as Aloe vera for floral preservatives has been shown to improve the longevity of cut flowers (Adebayo *at al*., 2017, Vehniwal and Abbey, 2019). In Nigeria, cut flower is one of the major industries in floriculture. Therefore, prolonging the vase life of cut flowers has been one of the challenges that is being investigated. The use of floral preservatives has been studied to show that they can promote cut flowers longevity for a period of time by facilitating increased nutrient uptake in the solution, delayed senescence, reduced vascular occlusion and microbial accumulation (Elhindi, 2012; Shokalu *et al*., 2018). Therefore, the aim of this experiment is to evaluate the effect of silver thiosulphate and aloe vera gel preservatives on the longevity of Heliconia cut flowers.

MATERIAL AND METHODS

Plant materials

Heliconia (Golden Torch) flowers were obtained from the floriculture garden in the institute (7°25"N, 3°52"E). Flowering stems of *Heliconia spp.* with four to five open bracts were harvested in the early morning from the floriculture garden. The leaves on the lower section of the stems were removed. The stems were washed under running water to remove dirt. The stems were cut to uniformity of 30 cm and placed in the already prepared floral preservative solution. Vase solutions were not changed throughout the experiment.

Experimental design

Five treatments were used as floral solutions for the study: 0.5 and 1.0 mM Sliver thiosulphate (STS) solutions (STS1 and STS2), 2 and 4% (v/v) *Aloe vera* gel solutions (AV1 and AV2) and water as control (CO). The experiment was arranged in a completely randomized design (CRD) with ten replicates under a temperature of 25 ± 2ºC, 70% relative humidity and 150 µmol m^{-2} s^{-1} light intensity from cool-white fluorescent lamps with a light/dark cycle of 12/12 hours. Data collected was analyzed using Analysis of Variance (ANOVA) while the significant differences among treated means were computed using least significance difference (LSD) test at 5% level of significance.

Relative Fresh Weight and Relative water content

The relative weight was calculated as a ratio, a spike from each treatment was weighed at intervals. Relative water content (RWC) from each sample was determined according to the method described by. To measure the RWC, 2 – 3 excised petals per plant were weighed (fresh weight, FW) and placed in water for 6 hours to allow them reach full turgidity, thus, the turgid weight (TW) was determined. The leaves were then dried at 60°C for 24 hours and their dry weight (DW) obtained. With these, the RWC was calculated using the formula:

%RWC = [(FW – DW) / (TW – DW)] × 100

Vase life

Vase life was determined as the time period for which a spike of cut flower retained 50% fresh flowers. The wilting and bending of the petals is also an index of the vase life of cut flowers.

RESULTS AND DISCUSSION

Relative Fresh Weight:

The fresh weight of the cut flowers showed a declining trend over time in all the treatments. There was no significant difference in the fresh weight of cut flowers up till day 9. By day 12 there was a significant difference (P<0.05) in the cut flowers in respect to the treatments with the lowest value recorded by the control (40.60) and the highest value recorded by AV2 as shown in Figure 1. There was no significant difference among the treatment except the control at day 12. The turgidity of cut flowers is an important factor of their longevity. Treatments of cut flower with lower relative fresh weight tend to lose their turgidity which invariably resulted to their low vase life.

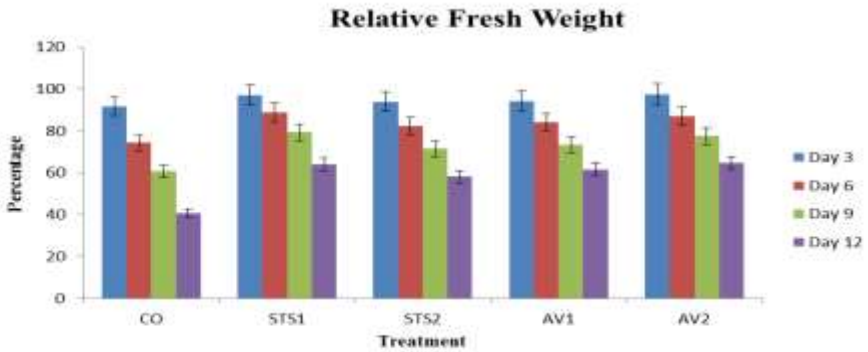

Figure 1: Effect of treatment on the relative fresh weight of Heliconia cut flowers

CO: Tap water (control); STS1: 0.5 mM Silver thiosulphate solution; STS2: 1.0 mM Silver thiosulphate; AV1: 2% Aloe vera; AV2: 4% Aloe vera

Relative Water Content

The relative water content is an also index indicating the water holding capacity of the plant organs and shows the ability of the plant to withstand water stress conditions. Figure 2 shows that there was a significant (P≤0.05) difference in the cut flowers in relation to water content. The AV1, AV2 and STS1 were not significantly different. The highest relative water content value was 51.70 by AV2 while the lowest value was 32.40 by the control. This correlates the report of Shokalu *et al.*, 2019, on the relative water content exhibited by 4% Aloe vera gel solution on the cut flowers of Heliconia.

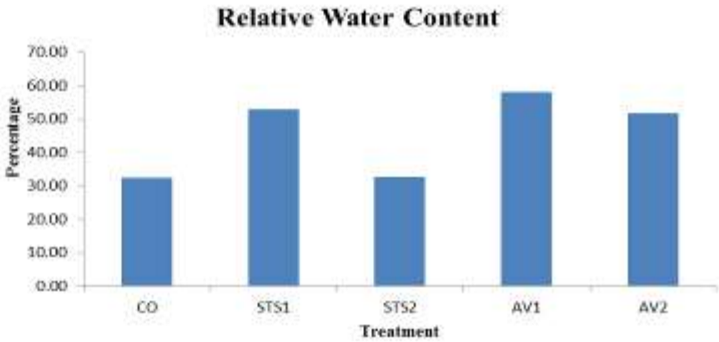

Figure 2: Effect of treatment on the relative water content of Heliconia cut flowers

CO: Tap water (control); STS1: 0.5 mM Silver thiosulphate solution; STS2: 1.0 mM Silver thiosulphate; AV1: 2% Aloe vera; AV2: 4% Aloe vera

Vase life

There was significant difference in the vase life of the cut flowers. As shown in figure 3, CO had a vase life of 6 days while ST1 and ST2 had a vase life of almost 9 days. AV1 and AV2 had the longest vase life compared to other treatments with a vase life of almost 12 days.

The vase life of cut flowers is the most important parameter when considering the longevity of cut flowers. Floral preservation has been very effective in delaying senescence thus extending vase life of cut flowers (Sedaghathoor *et al*., 2020). Loges *et al*., 2013, also reported that the postharvest durability of heliconia was 13 days. In this study, the use of aloe vera and STS solution extended the vase life of Heliconia cut flowers up to 12 days compared to the control.

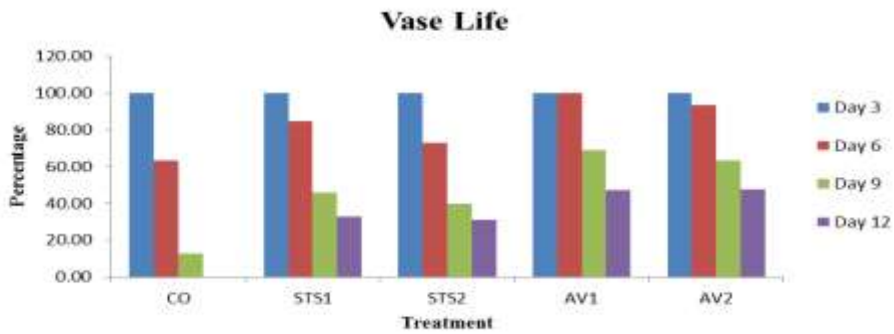

Figure 3: Effect of treatment on the vase life of Heliconia cut flowers

CO: Tap water (control); STS1: 0.5 mM Silver thiosulphate solution; STS2: 1.0 mM Silver thiosulphate; AV1: 2% Aloe vera; AV2: 4% Aloe vera

CONCLUSION

This study has showed that Aloe vera and STS floral preservative solution were effective in improving the longevity of the *Heliconia* cut flowers.

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INDIGENOUS ZERO-ENERGY STORAGE METHODS OF FRUITS AND VEGETABLES IN NIGERIA: A REVIEW

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ABSTRACT

Fruits and vegetables are best consumed as soon as they are harvested, as they tend to quickly decline in freshness, flavour and nutritional qualities under storage conditions. Advances in science and technology has largely benefited the food storage industry as more food, especially fruits and vegetables, can now be stored for much longer while retaining most of their nutritional value as well as their original flavour to satisfy the nutritional requirements of the ever-expanding world population. These storage technologies, apart from being expensive to set up, require a very high energy source garnered from electricity in order to properly function. This is not feasible in a developing country like Nigeria that has poor electricity supply. In order to curb huge post harvested losses usually associated with fruits and vegetables, especially in developing countries like Nigeria, indigenous zero-energy storage methods, that are efficient and effective, are suggested.

Key words: Zero-energy, storage methods, fruits, vegetables

INTRODUCTION

Temperature is the most important limiting-criteria in the storage of fruits and vegetables as varying temperature levels results in rapid respiratory activities, which is the main cause of fruit and vegetable metamorphism (Lei Ji *et al*, 2011). New physical technologies used in the storage of fruits and vegetables are very effective at elongating their shelve life as well as preserving the freshness of these fruits and vegetables. Some examples of these technologies, as highlighted by Lei Ji *et al*. (2011), are: Low Temperature Storage and Fresh-Keeping Technology; which uses continuous and constant low temperature to weaken respiration and prolong storage time, Controlled Atmosphere Storage and Fresh-Keeping Technology; which uses the principle of gas rationing to preserve fruits and vegetables, Pressure Regulating Storage and Fresh-Keeping Technology; which manipulates atmospheric pressure in a storage room to reduce or inhibit microbial activities thus preserving fruits and vegetables, Ionizing Radiation Storage and Fresh-Keeping Technology; which is an advanced technology used in sterilizing fruits and vegetables making and preserving their shelf live in the process. Other examples are Ozone Storage and Fresh-Keeping Technology as well as High-Pressure Electrostatic Field Storage and Fresh-Keeping Technology. These storage technologies, apart from being expensive to set up, require a very high energy source garnered from electricity in order to properly function.

Electricity is gold in Nigeria, especially in rural areas where the bulk of fruits and vegetables are produced. Apart from its epileptic supply, the initial cost of purchasing physical storage facilities such as refrigerators as well as power generating set to power them, coupled with the continuous cost of fuel to run these generating sets as well as spare parts, are very expensive and out of reach to the low-income subsistence fruits and vegetable farmers, making them rely almost solely on indigenous zero-energy storage methods which mimics the principles of those earlier mentioned in order to cut their post-harvest losses. Once leafy vegetables such as African spinach, water leaf, bitter leaf, pumpkin leaf etc are harvested, they deteriorate quickly under warm and dry environmental conditions. In order to curb huge post harvested losses usually associated with fruits and vegetables, especially in developing countries like Nigeria, indigenous zero-energy storage methods that are efficient and effective are discussed below.

MATERIALS AND METHODS

Materials for the review were sourced from secondary data in journals and online.

Indigenous Zero-Energy Fruits and Vegetables Storage Methods

Bulk Ambient Temperature Storage

The vegetables are harvested after which the root is cut off and the stem is gently washed with sterilized water. The washed vegetable is carefully bunched up to about 50 cm diameter and the bunched stem is then dipped unto a bucket of water filled to about three-quarter capacity. A thin black polythene sheet is used to cover the vegetables and the tied closely to the bucket in a way as not to expose the vegetables in any way to conserve moisture. To keep the vegetable moist, water is sprinkled on the leaves daily. The filled vegetable bucket is kept away from sunlight and in the coolest place possible. This technology requires zero-energy and the leafy vegetables can remain fresh for up to 6 days under this condition. (NSPRI, 1982).

Storage in Clay Pots with Jute Bags at Ambient Temperature

Clay pots are washed and placed on a firm support so that their bottom do not touch the ground. Wet jute bags that have been sterilized (through boiling) are placed at the bottom of the pot. A wire gauze is then placed on the bag. The roots of the vegetable are cut and the leafy parts are washed with sterilized water. The washed vegetables are placed on the wire gauze inside the pot. Another layer of wire gauze is placed on the vegetable, which is then followed by another layer of sterilized wet jute bag. The jute bags should be kept moist all the time. (NSPRI, 1982).

Storage in Vegetable Baskets

Well ventilated vegetable baskets made out of raffia are laid with sterilized jute bags after which a wire gaze is placed on the jute bag. The root of the vegetable is cut and the vegetable is washed with portable water. (NSPRI, 1982).

On-farm Shed

A shed, is sited in a section on the farm that is not prone to flooding. The shed, made out of bamboo, should be of dimension 5m x 4m x 3m. Slated bamboo is used to make the sides of the shed to a height of 1.5 m while wire netting is used to complete the other half. The longer side of the shed is constructed in a way so as to face the direction of the wind. Raffia palm is used to make the roof of the shed and the floor can be cemented to make cleaning easy. In more urban areas, concrete can be used to make the floor instead of ordinary cement while timber that has been treated can be used for the sides and corrugated zinc or asbestos are used to make the roof. A 10m x 5m 3m sized shed has enough capacity for up to 10 tonnes of fruits. (NSPRI, 1982).

Pot-in-Pot Evaporative Cooler

A clay pot of about 65 cm in height and 8 mm in thickness is used to completely coat the clay pot and a polythene bag is wrapped around the coated pot. The coated pot is then placed into another pot slightly larger than itself, leaving a space of about 7 cm all around the two pots. Riverbed sand is used to fill the space in between the pots. The sand should be periodically watered to keep moist at all times. Fruits and vegetables are stored inside the inner pot, covered with an appropriate lid and the pot is placed in a cool ventilated place away from sunlight. (NSPRI, 1982).

Metal-in-Pot Evaporative Cooler

The metal-in-pot evaporative cooler is another zero-energy storage method used in developing countries like Nigeria, especially in semi-urban areas. Used beverage tins, large enough to accommodate a substantial quantity of fruits and or vegetable are placed inside a slightly bigger clay pot which has been filled with riverbed sand. The space in between tin and the clay pot is also filled with riverbed sand to serve as an insulator. Fruits and vegetables are stored inside the tin and covered with an appropriate lid. The sand inside the clay pot should be periodically watered to keep moist. The clay pot should be covered with an appropriate lid and placed in a cool dark place away from sunlight. (NSPRI, 1982).

Metal-in-Block Evaporative Cooler

Where large quantities of fruits and vegetables are to be stored using the evaporative cooler zero-energy technology, a metal-in-block evaporative cooler, which is a large-capacity evaporative cooler can be constructed. An area of land that is not flood-prone is selected for the citing the structure. A square metal tank is constructed measuring 1.2m x 1.2 m x 1.2m with a door measuring 63 cm by 51 cm having a thickness of 3 cm on the frontal side. Around this metal tank, a foundation is dug, measuring 1.4 metre square and a depth of 23 cm, after which 23 cm brick blocks are laid around the foundation and 2 cm aggregate concrete is poured into the foundation to make the plinth. Four blocks are placed on the constructed plinth to serve as a base upon which the tank is centrally placed. Blockwork is then built around the metal cube sitting on the plinth with a space of about 10 cm between the cube and the blockwork which is filled with riverbank sand and watered periodically to keep moist. Fruits and vegetables are stored inside the metal cube to minimize post-harvest losses due to spoilage. (NSPRI, 1982).

CONCLUSION AND RECOMMENDATIONS

Considering the huge limitations; inadequate storage infrastructure, inadequate access to finance and especially poor electricity, faced by fruit and vegetable farmers in storing their harvest, especially in developing countries such as Nigeria, cost effective storage methods for fruits and vegetables which are indigenous, efficient and requires zero-energy have been devised by the NSPRI. Although, these indigenous zero-energy methods may not favourably compete with advanced fruit and vegetable storage methods that mentioned earlier which requires huge capital and constant electricity to set up and run, they however, have demonstrated great potentials as they help to store fruits and vegetables for a considerable period of time thereby, significantly reducing post-harvest losses due to spoilage. All levels of government; federal, state as well as local government should, through the relevant agencies and research institutes, priotize the design and fabrication of indigenous storage facilities for fruits and vegetables. Thus, National Centre for Agricultural Mechanization (NCAM) and National Stored Products Research Institute (NSPRI) should be well funded. Efforts of the Federal Government should be geared towards improving rural electrification as well as constructing rural access roads. In conclusion, it is recommended that the role of Agricultural Extension Officers, who are the first contact with farmers, be rejuvenated. This rejuvenation should be coupled with training and re-training on ingenious storage methods for fruits and vegetables.

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POST-HARVEST STORABILITY OF YELLOW PEPPER (*CAPSICUM ANNUUM* L.) AS INFLUENCED BY MATURITY STAGE AND STORAGE MEDIUM

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ABSTRACT

Despite the huge production of yellow pepper, there is scarcity due to high postharvest fruit loss, hence the need to establish appropriate harvest stage (mature green, half ripe and fully ripe) and suitable storage medium (jute bag, plastic basket, and polyethylene bag) to extend shelf life. The experiment was a 3 × 3 factorial in a completely randomized design with three replications. Data were collected on weight loss at four day intervals for 28 days and was calculated as the difference of initial and final fruits weight expressed in percent, postharvest decay was evaluated based on visual observation for decay symptoms at 7 day intervals for 28 days, and shelf-life (time in days the stored fruits show 50% decay after 28 days of storage). Data were analysed using Analysis of Variance. Among the storage media (jute bag, plastic basket, and polythene bag), fruit harvested at half ripe stage lost the least weight (1.12 %, 1.50% and 1.09%) respectively, it also had the least decayed and the most preserved fruits. In all the three maturity stages, the fruits stored in plastic basket although lost the highest weight, but were the least decayed and most preserved. The result suggests that the optimum maturity stage for harvesting yellow pepper would be half ripe stage. Also, plastic baskets should be used as the storage medium for preserving yellow pepper fruits.

Key words: Maturity Stage, Storage Medium, Yellow Pepper, Pepper Fruit and shelf life.

INTRODUCTION

Pepper belongs to the family Solanaceae, genus *Capsicum*. Records show that out of thirty species only five have been domesticated (Nwokem, *et al*., 2010). Fruit features such as shape, size, colour, flavor, spiciness, and so on are used to classify Capsicum species (Bosland, 2012). Among the many varieties grown, yellow pepper is grown in several places of the world. It is among Nigeria's most essential fruit vegetable crops. Despite the huge production of yellow pepper there is scarcity due to high postharvest fruit loss. Most farmers harvest pepper only when it is fully ripe, at this stage of harvest fruits may spoil easily and there will be loss in both quality and shelf life. Different qualities, such as surface colour, fruit firmness, and so on, should be considered as indicator to establish the optimal harvest time Tadesse (2002). Furthermore, several storage materials are used as medium for storage of pepper fruits, but the appropriate material for pepper shelf life harvested at various stages of maturity is not fully established. Hence the need to determine the optimum maturity stage for harvesting yellow pepper and to ascertain the effective and affordable local storage medium for improving the postharvest quality of peppers yellow pepper.

MATERIALS AND METHODS

The yellow pepper seedlings were purchased from local pepper producers in Nsukka market, Enugu State. The seedlings were planted at the Department of Crop Science's Teaching and Research Farm in Nsukka, Nigeria, (U.N.N). The pepper plants' growth was tracked until they reached maturity. The fruits were gathered at three stages of maturity: mature green (MG), half ripe (HR) and fully ripe (FR) and taken for further studies in the Department of Crop Science's Teaching and Research Laboratory at U.N.N. In CRD, the experiment was a three-fold factorial replicated 3 times. The factors were the three stages of maturity MG, HR, and FR and the three storage media (Jute sac, plastic basket and perforated polyethylene bag). Total of 90 clean fruits of a uniform size were used. The fruits were randomly grouped into batches of 30 fruits according to the three maturity stages. Ten fruits out of each were randomly assigned to each of the three different storage media and stored under room temperature for 28 days. Data were collected on weight loss at a 4-day interval for 28 days and was determined by the difference of initial weight and weight at the time of measurement expressed as percentage. Fruits were visually evaluated for signs of deterioration at seven-day intervals for 28 days. Samples that showed decay were recorded and discarded. The shelf-life of the pepper was evaluated and was taken as time when the stored fruits demonstrate 50% postharvest decay after 28 days, a large number of them are regarded to have terminated their lifespan. Using SPSS software version 7, data was subjected to analysis of variance. According to Obi the F-LSD was used to separate the means at 5% of probability (2002).

RESULTS

Table 1 shows that half ripe fruits had the least percentage weight loss (PWL) across the three storage media; jute (3.68%), plastic basket (5.50%) and polythene bag (3.15%). Plastic basket, among the three storage media had the greatest PWL across the three stages of maturity; FR (6.83%), HR (5.50%), and MG (6.38%) while polythene bag had the lowest PWL; FR (4.42%), HR (3.15%), and MG (4.15%). Throughout the storage period the PWL of all the fruits harvested at the three stages of maturity stored in the three media increases progressively. Table 2 shows that Half ripe fruits had the least percentage postharvest decay (PPD) in jute (18.4%), in plastic basket (13.8%) and in polythene bag (27.0%). Basket, among the three storage media had the lowest PPD across the three stages of maturity; FR (24.6%), HR (13.8%), and MG (21.0%) while polythene bag had the highest PPD; FR (44.2%), HR (27.0%), and MG (40.6%). Throughout the storage period the PPD of all the fruits harvest at the three stages of maturity stored in the three media increases progressively. Half ripe fruits had the highest percentage shelf life in jute (59.40%), in plastic basket (85.66%) and in polythene bag (35.72%) (Table 3). Basket, among the three storage media had the highest percentage shelf life across the three stages of maturity; FR (41.78%), HR (85.66%), and MG (56.00%) while polythene bag had the lowest shelf life; FR (15.84%), HR (35.72%), and MG (18.16%). Throughout the storage period, the pepper fruits harvested at the three stages of maturity stored in the three media progressively decreased in their preservability.

Table I: Main effect of storage medium and maturity stage on weight loss of yellow pepper fruits

% Weight loss (days)									
Storage medium	Maturity stage	4	8	12	16	20	24	28	Mean
	FR	2.14	4.02	4.34	5.23	5.90	6.52	7.34	5.07
Jute Sac	HR	1.12	2.78	3.56	3.59	4.37	4.68	5.66	3.68
	MG	1.31	3.86	4.61	4.77	5.37	5.64	6.09	4.52
Plastic	FR	2.31	5.45	7.20	7.26	7.82	8.42	9.38	6.83
Basket	HR	1.50	3.22	5.91	6.03	6.53	7.11	8.18	5.50
	MG	1.99	4.58	6.62	6.86	7.37	8.07	9.08	6.38
Perforated	FR	2.11	2.95	3.98	4.58	5.12	5.84	6.37	4.42
Polythene	HR	1.09	2.56	2.72	3.07	3.66	4.13	4.77	3.15
Bag	MG	1.25	3.57	3.94	4.22	4.86	5.35	5.87	4.15
	LSD(0.05)	0.013	0.013	0.010	0.013	0.572	0.013	0.044	

FR = fully ripe, HR = Half ripe, MG = Mature green, LSD =least significant differences of means ($p < 0.05$).

DISCUSSION

The higher percentage weight loss in pepper fruits harvested at fully ripe stage is the same with findings of Monerizzaman *et al.,* (2009). This could be caused by the rise in transpiration rate which may be aided by worn out epidermal layer (Antonial *et al.,* 2007). Lowest PWL observed in fruits stored in polyethylene bag could be due to the confinement of moisture around the produce by polyethylene bag. This increases the relative humidity, reduces transpiration, and promotes post-harvest decay (Nyanjage, 2005). The higher percentage postharvest decay observed in fully ripe is the same with the report of Ciccarese *et al.,* (2013). This may be as a result of higher rate of respiration, softening of tissues that predispose the fruits to deterioration Bayoumi (2008). The progressive increase in PPD with days could be as a result of accelerated respiration and other catabolic activities which bring about senescence (Ciccares *et al.,* 2013).). The lower percentage shelf life observed in fully ripe as well as in matured pepper could be due to higher respiration rate, plus the presence of immature cuticle without protective wax respectively.

Table 2: Main effect of storage medium and maturity stage on postharvest decay of yellow pepper fruits

Storage medium	Maturity stage	Postharvest decay (days) 0	7	14	21	28	Mean
	FR	00	20	30	45	55	30.0
Jute Sac	HM	00	10	20	27	35	18.4
	MG	00	18	25	40	50	26.6
Plastic Basket	FR	00	13	25	35	50	24.6
	HM	00	07	14	23	25	13.8
	MG	00	10	20	30	40	21.0
Perforated Polythene Bag	FR	00	26	50	65	80	44.2
	HM	00	15	30	40	50	27.0
	MG	00	25	40	50	70	40.6
	LSD(0.05)		4.30	10.07	22.32	24.12	

FR=fully ripe, HR= Half ripe, MG= Mature green, LSD= Least significant differences of means (5%) level.

Table 3: Main effect of storage medium and maturity stage on shelf life of yellow pepper fruits

Storage medium	Maturity stage	%Shelf Life in Days 0	7	14	21	28	Mean
	FR	39.0	32.0	28.0	25.7	22.8	28.84
Jute Sac	HR	70.0	63.0	56.0	56.0	52.0	59.40
	MG	49.0	42.0	38.0	31.5	28.0	37.70
Plastic Basket	FR	53.0	46.9	42.0	39.0	28.0	41.78
	HR	100	93.0	86.0	84.0	65.3	85.66
	MG	70.0	63.0	56.0	49.0	42.0	56.00
Perforated Polythene Bag	FR	26.9	19.9	14.0	11.4	07.0	15.84
	HR	46.7	39.7	32.7	31.5	28.0	35.72
	MG	28.0	21.0	17.8	15.2	08.8	18.16
	LSD(0.05)	23.21	14.01	14.55	11.99	09.45	

FR=fully ripe, HR= Half ripe, MG= Mature green, LSD= Least significant differences of means (5%) level.

CONCLUSION

The study concluded that the optimum maturity stage for harvesting yellow pepper is at half ripe stage. Also the best medium was plastic basket and it appears to be effective in improving the postharvest quality of peppers.

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EVALUATION OF THE EFFECT OF CAPACITY BUILDING ON KNOWLEDGE AND SKILL ACQUISITION ON PLANTAIN POSTHARVEST HANDLING AMONG STAKEHOLDERS IN SOUTHWESTERN NIGERIA

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ABSTRACT

Postharvest losses, caused by poor handling of perishable crops like plantain poses serious threats to food security in Nigeria. Hence, the need for capacity building of stakeholders on improved plantain postharvest handling techniques. The study was carried out at the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria during a stakeholders' workshop organized in partnership with the Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Stakeholders along the plantain value chain were invited from across the southwestern zone and were trained on improved plantain post-harvest handling techniques. Participants were subjected to pre- and post-training knowledge assessment at the beginning and end of the workshop, respectively. Information was obtained from 53 trainees with the aid of structured questionnaire and data were analyzed using descriptive and inferential statistics. Results revealed that majority (71.1%) of the trainees were female with mean age of 44±12 years, educated (90.0%) and were either farmers (20.8%) or traders (20.8%). Post-knowledge mean scores of trainees were higher than their pre-knowledge mean scores in all sessions considered during the training. Estimates of the T-test revealed significant difference in trainees' pre- and post-training knowledge scores for postharvest technology ($t=-3.644$, $p<0.01$); food processing and preservation methods ($t=-1.901$, $p<0.1$) and production of plantain-based composite flour ($t=-5.750$, $p<0.01$). The findings imply that participation in training is a viable tool for improvement of knowledge and adoption of technologies among stakeholders. Therefore, more training should be organized for stakeholders for easy dissemination of improved technologies.

Key words: Perishable crops, plantain, plantain-based composite flour, postharvest handling, pre- and post-evaluation

INTRODUCTION

Plantain (Musa spp.) is a giant herb that is cultivated in humid forest and mid-latitude zone of sub-Sahara Africa (Amah et al., 2020). It is believed to have originated from South East Asia. However, a remarkable diversity of plantain exists in sub-Sahara Africa (Akintade et al., 2016). Plantains are known to be good sources of starch and energy (Dankyi et al., 2007; Akinyemi et al., 2010). It is largely planted by small holder farmers and plays a major role in food security and income generation for millions of poor rural regions around the world especially in African and Latin American countries including Nigeria (Adejoro et al, 2010; Edeoghon and Okoedo-Okojie, 2011; Amah et al., 2020).

However, one of the major constrains of plantain production is post-harvest losses (Ajayi, 2018). According to Atanda et al., (2011), postharvest losses are caused by factors categorized into primary and secondary causes. Primary causes are factors that directly impact the fresh produce to cause deterioration, whereas the secondary causes are indirect factors that facilitate the primary causes to increase deterioration (Atanda et al., 2011). The secondary causes are mostly human decision related factors such as poor harvesting, and inappropriate postharvest handling and management practices that facilitate biological deterioration. In Nigeria, plantain postharvest losses can range from 5% (Adewumi et al., 2009; Olayemi et al., 2012) to as high as 40% (Morris et al., 2019). These losses assume considerable economic and social importance. That is why perishable commodities such as plantain need very careful handling at every stage so that the deterioration of produce is restricted as much as possible during the period between harvest and consumption.

To circumvent such losses, there is need to build the capacity of stakeholders on proper postharvest handling of plantain such as improved storage, value addition and preservation with a view to enhancing the shelf-life and diversifying the product base. To this end, stakeholders along the plantain value chain were trained on plantain postharvest handling techniques and in particular processing of plantain-based composite flour thereafter, the effect of the training on participants' knowledge was evaluated. This study therefore described the socioeconomic characteristics of the trainees; examined the pre- and post-training knowledge of trainees on plantain value addition and lastly determined the change in knowledge of trainees on plantain value addition as influenced by the training.

MATERIALS AND METHODS

The study was carried out at the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria during a stakeholders' workshop organized in partnership with the Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Stakeholders along the plantain value chain were invited from across the southwestern zone and were trained on improved plantain post-harvest handling techniques which include the production of plantain-based composite flour. Participants were subjected to pre- and post-training knowledge assessment at the beginning and end of the workshop, respectively. Information was obtained through the use of structured questionnaire administered to 53 trainees. Data were analyzed using descriptive (frequency, percentage ad mean) and inferential (T-test) statistics.

RESULTS AND DISCUSSION

Socio-demographic characteristics of trainees

As observed on Table 1, majority (71.1%) of the trainees were female which was quite impressive because in the past, trainings of this type were usually male dominated. The mean age of the participants is 44±12 years and most of them (20.8%) were either farmers or traders. More than 90.0% of the trainees have formal education indicating that they would be able to comprehend the teachings and apply the skills acquired during the capacity building and empowerment programme.

Table 1: Socio-demographics characteristics of the trainees

Variable	Percentage	Frequency (n=53)
Sex		
Male	28.3	15
Female	71.1	38
Age		
21-30	15.1	8
31-40	26.4	14
41-50	30.2	16
>50	28.3	15
Mean	44.55	
Standard deviation	12.11	
Marital status		
Married	84.9	45
Single	13.2	7
Widowed	1.9	1
Level of education		
No formal education	5.6	3
Primary education	5.6	3
Secondary education	3.8	2
Tertiary education	85.0	45
Occupation		
Farming	11	20.8
Civil servant	9	17.0
Health worker	8	15.1
Trader/marketer	11	20.8
Lecturing/Research	4	7.5
Teaching	5	9.4
Journalism	1	1.9
Student	3	5.6
Clergy	1	1.9

Expectation from the workshop

Results on Table 2 revealed that more than 80.0% of the trainees looked forward to acquiring skills/knowledge on plantain production techniques (such as how to increase production, tackle production constraints as well as plantain sucker multiplication techniques) during the capacity building programme. Others intended to gain more knowledge on value addition to plantain.

Table 2: Participants' expectation for the training programme

Expectation	Frequency	Percentage
More knowledge /experience on plantain production techniques	39	81.1
Value addition	2	3.8
No response	8	15.1
Total	53	100

Difference between participants pre- and post-training knowledge score for postharvest technology

Estimates of the mean values as displayed on Tables 3-6 shows the difference between the participants' evaluation scores before and at the end of the training, while the t-test values indicate that there was significant increase in the knowledge score on the different modules; postharvest technology (Table 3), food processing and preservation methods (Table 4) and production of plantain-based composite flour (Table 5) before and after the training ($p<0.01$, $p<0.1$ and $p<0.01$, respectively). Combining the scores, results revealed that the trainees acquired significant knowledge during the capacity building workshop (Table 6) which may likely improve their food processing and preservation methods especially for plantain.

Table 3: Difference between participants pre- and post-training knowledge score for postharvest technology

Score type	N	Mean value	Df	t-value	Sig.
Pre-score (before training)	53	2.8491	104	-3.644	0.000
Post-score (after training	53	4.3585			

Table 4: Difference between participants pre- and post-training knowledge score for food processing and preservation methods

Score type	N	Mean value	Df	t-value	Sig.
Pre-score (before training)	53	3.5849	104	-1.901	0.060
Post-score (after training	53	4.2830			

Table 5: Difference between participants pre- and post-training knowledge score for production of plantain-based composite flour

Score type	N	Mean value	Df	t-value	Sig.
Pre-score (before training)	53	3.6321	104	-5.750	0.000
Post-score (after training	53	7.1321			

Table 6: Difference between participants overall score (pre- and post-training knowledge)

Score type	N	Mean value	df	t-value	Sig.
Pre-score (before training)	53	10.0000	104	-4.702	0.000
Post-score (after training	53	15.7736			

CONCLUSION

The study revealed that most of the trainees were educated and economically active, and would be able to comprehend lessons/lectures during the training. At the end of the training, they were able to acquire knowledge on postharvest technology, food processing and preservation methods and particularly the production of plantain-based composite flour. Participation in training is a viable tool for improvement of knowledge and adoption of technologies among stakeholders. Therefore, more training should be organized for stakeholders for easy dissemination of improved technologies.

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TILLAGE, POULTRY MANURE, AND VARIETY EFFECTS ON CARROT (*DAUCUS CAROTA*) STORAGE AT AMBIENT LABORATORY TEMPERATURE

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ABSTRACT

The experiment was carried out at the Laboratory in the Department of Crop Science, University of Nigeria, Nsukka. The study was to evaluate the storage potential of the two carrot varieties, under ambient laboratory temperature. Two carrot varieties (Touchon Mega and kurado) were subjected to a post-harvest study; Six (6) roots were harvested from each treatment combination. It was further divided into two and replicated 3 times, which gave rise to a 2 x 2 x 3 in completely randomised design (CRD). One part of each treatment was dipped in tap water (unsterilized) for 5mins and the second part of each treatment was dipped in saline water (at 10% dilution) for 5mins. (10% of salt was dissolved in water i.e 10g of salt = 100ml of water; which was used for the sterilisation). Weight loss was recorded and the results showed that the roots dipped in saline water could only stay in storage for 3-4 days while roots dipped in tap water stayed up to 9-11 days in storage. From the results of the experiment, it could be concluded that carrots washed with salt should be consumed before the fourth day while those washed with tap water should be consumed before ninth day.

Key words: Carrot, tillage, poultry manure, variety, storage

INTRODUCTION

The modern carrot, a highly nutritious cool season root crop native to Afghanistan, which remains the centre of diversity of *Daucus carota* was domesticated from the wild carrot (Simon *et al.,* 2008). Carrots are a valuable crop, particularly in locations where they thrive, such as Asia and neighbouring towns. The edible section of the carrot, which is effectively a swelling base of the taproot that includes the hypocotyls, is commonly grown annually. It grows mostly in Nigeria's northern regions, and as a result, it has been designated as a northern crop, and has been grown in northern states such as Kaduna, Kano, and Plateau over the years (Orakpo 2010). The crop is so vital that its production and yield should be improved, examined, and given significant research attention; however, this can only be done if the appropriate production and storage variables are available. This can be accomplished by conducting research into the most efficient and improved methods of carrot production and storage.

Carrots are the greatest vegetable sources of all the vitamins and nutrients needed in the body. Carrots help in some of the body's basic functions such as:

1. Boosting immunity (especially among older people).
2. Reducing photosensitivity (Beta-carotene protects the skin from sun damage).
3. Helping to heal minor wounds and injuries: raw carrot or boiled are applied on cuts as an antiseptic to prevent infection.
4. Reducing the risk of high blood pressure.
5. Cleansing the liver and when consumed regularly, can help the liver excrete fats and bile.
6. Fighting bronchitis.
7. Fighting infection (vitamin keeps cell membranes healthy, making them stronger against disease-causing microorganisms.
8. Improving muscle, flesh and skin health.
9. Helping fight anemia.
10. Reducing acne
11. Improving eye health.

Carrots can be stored in the refrigerator for up to a month if stored properly. To prevent condensation from forming, wrap the carrots in a paper towel and then place them in a bag in the refrigerator, or use a perforated plastic bag. Excess moisture will cause them to rot. Cut off carrot greens, place carrots in a container with lid and cover completely in water. Keep container in the refrigerator, changing the water ever 4-5 days.

MATERIALS AND METHODS

Two carrot varieties were harvested from a field experiment for the post-harvest study. The harvested roots were subjected to a post -harvest study in the Crop Science Teaching and Research Laboratory University of Nigeria Nsukka. The study was to evaluate the storability of each variety under varying manure rate and tillage system; and to determine the longevity of the two varieties after soaking in saline water. Six (6) roots were harvested from each treatment combination from the field. It was further divided into two and replicated 3 times, which gave rise to a 2 x 2 x 3(2 varieties, 2 tillage systems and 3 levels of Poultry manure) in completely randomised design (CRD). One part of each treatment was dipped in tap water (unsterilized) for 5mins and the second part of each treatment was dipped in saline water (at 10% dilution) for 5mins. (10% of salt was dissolved in water ie 10g of salt = 100ml of water; which was used for the sterilisation). The roots were put inside a paper bag and was kept in the laboratory and data were collected on weight changes at 2 days' intervals.

RESULTS

The Result of the experiment in Table 1 evidently showed that carrots dipped in tap water could stay more than 10 days while the once dipped in saline water could stay only for less than 6 days. The table also showed a rapid loss of water as the number of days increases in both the sterilized and unsterilized conditions. Significant differences were observed in the 2nd day on tillage while on the effect of manure it was observed in the sterilized condition in all the days (2,4,6days) recorded. The ridge system recorded higher loss of water in value of 38.5% while the bed had 37.4% weight loss in day 10. The table showed that carrots dipped in saline water also had higher percentage weight loss in the ridge tillage system in Day 4 and Day 6 with 18.9% wt loss and 31.0% weight loss respectively; it can also be observed that at Day 8 the carrot had all rotten. At Day10 in the manure, 0t/ha had the highest percentage of water loss with 40.8% weight loss while 5 tons/ha had lowest loss of water with 34.2%wieght loss in the roots dipped in tap water. While those dipped in saline water showed the highest loss of weight in Day 6 with 10tons/ha manure having the highest percentage loss of 32.2%. In the effects of variety Kurado had 39.0% water loss at Day10 which is the highest while Touchon Mega had 36.9% water loss in the carrot dipped in tap water. The table also revealed that the carrots dipped in the saline water showed that Tmega had more loss of weight than kurado with 30.8%.

Table 1 Effects of Tillage system, Manure rates and Variety on the storability of the two carrot varieties

	Dipped in tap water for 5mins					Dipped in saline water for 5mins			
Tillage	**Day 2**	**Day 4**	**Day 6**	**Day 8**	**Day10**	**Day 2**	**Day 4**	**Day6**	**Day 8**
BED	6.1	15.1	22.8	28.9	37.4	6.6	16.5	28.3	0
RIDGE	7.4	17.6	25.9	32.2	38.5	8.3	18.9	31	0
$LSD_{(0.05)}$	**0.911**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Manure									
0tons	6.2	16.3	23.8	30.6	40.8	6.7	17.7	29.7	0
5tons	6.7	16	23.4	28.7	34.2	6.2	14.8	27.2	0
10tons	7.4	16.9	25.7	32.3	38.8	9.4	20.6	32.2	0
$LSD_{(0.05)}$	**NS**	**NS**	**NS**	**NS**	**NS**	**2.13**	**2.8**	**3.4**	**NS**
Variety									
KURADO	6.9	16.3	24.2	30.3	39	7.5	18.2	28.6	0
TMEGA	6.7	16.5	24.4	30.8	36.9	7.5	17.1	30.8	0
$LSD_{(0.05)}$	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS= Not significant

DISCUSSION

Carrots during storage undergo a complex series of physiological and biochemical events involving changes in post-harvest quality (Hewett, 2003). Temperature and relative humidity are important factors that affect the quality and shelf life of vegetable crops. However, most fruits and vegetables are washed with salt (Sodium Chloride) before eating them to kill microorganism which the fruit or vegetables might have contacted during transportation or marketing. This study therefore attempted to answer the storability question of the two carrot varieties. Carrots washed with saline water was observed to shrink and rotten faster than those washed with tap water. They stayed stored in lesser days (5-6days after placement) and those washed with tap water stayed longer (10-12 days after placement). This could be attributed to the effects of osmosis, which states that "water moves from area of low concentration to area of high concentration through a semi-permeable membrane". Water moved from the internal root system of the carrot to the environment which caused shrinkage of the roots. High temperatures are also known to promote enzymatic catalysis and lead to biochemical breakdown of compounds in fruit and vegetables. (Kays, 1999). There was an increasing trend in the weight loss with the

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advancement of storage periods; the rate of weight loss was much higher in carrots washed with saline water when compared with those washed with tap water. Although there was a non-significant difference between the two carrot varieties, Kurado variety was observed to have lower value in all the parameters measured for storability.

CONCLUSION

It can be concluded that, to enhance carrot storage carrots are to be washed with ordinary water. Carrots washed with salt should be consumed before the fourth day while those washed with tap water should be consumed before ninth day.

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SUPPLEMENTATION OF NPK 20:10:10 WITH POTASSIUM AND CALCIUM NITRATE INFLUENCED STORAGE LIFE OF LETTUCE (*LACTUCA SATIVA* L.) IN FOUR POLYETHYLENE COLOUR BAGS

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ABSTRACT

Postharvest storage life of lettuce (Lactuca sativa) in response to rates of inorganic fertilizer and polyethylene bag colours were evaluated during a seven-day storage study. Two field experiments, each comprising four rates of NPK 20:10:10 and supplemented with potassium nitrate or calcium nitrate were conducted. The storage study combined the fertilizer treatments and thus, there were eight rates of inorganic fertilizer (expt.1: 0; 200 NPK 20:10:10 + 200 K-Nitrate; 300 NPK 20:10:10 + 150 K-Nitrate; 300 NPK 20:10:10 Kg/ha; expt.2: 0, 200 NPK 20:10:10+ 200 Ca-Nitrate, 300 NPK 20:10:10 + 150 Ca-Nitrate and 300 NPK 20:10:10 Kg/ha;) and four colors of polyethylene bags (Blue, Green, Red, Translucent and Bare - as control) replicated three times and laid out in a completely randomized design. Data on weight loss were measured for 7 days. Result showed that percent weight loss increased significantly ($p \leq 0.05$) from day 3 till end of storage for the fertilizer treatment. Colour of polyethylene influenced weight changes significantly ($p \leq 0.05$) throughout the study duration. Application of 200 NPK 20:10:10 plus 200 K-Nitrate or Ca-Nitrate kg/ha had the least weight loss. Similarly, lettuce enclosed in green or blue polyethylene bag had better storage life. Biplot graphic analysis suggested that growing lettuce with 200 NPK 20:10:10 plus 200 K-Nitrate or Ca-Nitrate Kg/ha and stored in green polyethylene had better postharvest storage life.

Key words: Supplement; Inorganic fertilizer; Polyethylene bag; Weight loss

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is an important leafy vegetable primarily consumed as salad. In addition, lettuce is also consumed for its medicinal advantage particularly for lowering of blood pressure, maintaining healthy heart and heart related issues, due to it terpenoids, vitamins, flavonoids and phenols contents (Noumedem et.al, 2017). Due to these beneficial uses of lettuce, their cultivation is currently gaining attention in Nigeria. However, their cultivation in Nigeria is to a large extent limited to the northern part of Nigeria; this negatively affects utilization of lettuce in the south due to high cost of transportation and storage loss. In addition, the transporting distance between the north and south also negatively affects the quality of lettuce sold in southern Nigeria. Therefore, it is pertinent that lettuce be grown in the southern Nigeria to reduce both economic and health losses associated with its transportation and poor storage. However, the pre-requisite for its growth in this region is less understood. Schofield et.al (2005) in their findings stated that rib discoloration and rot are the major causes of quality loss in postharvest storage of lettuce. This study therefore, focuses on the storage life of lettuce previously grown under different fertilizer treatments and stored in four color-polyethylene bags.

MATERIALS AND METHODS

The postharvest experiment was conducted under room temperature conditions in September 2020 at the Department of Crop Science, University of Nigeria, Nsukka. Four different colors (Blue, Green, Red and Translucent) of polyethylene bags and bare (control) were used for the storage of the lettuce (see Plate 1). Layout was a factorial experiment in completely randomized design and replicated three times. The treatment combinations for growing the lettuce are as shown in the table 1 below:

Table 1: Fertilizers treatment combinations utilized in the field and evaluated in storage experiment

Fertilizer (Kg)	NPK 20:10:10	+ K-Nitrate	NPK 20:10:10	+ Ca-Nitrate
T0	0		0	
T1	200	200	200	200
T2	300	150	300	150
T3	300		300	

Data collection

Storage parameters measured included weight changes and occurrence and severity of rot during the 7-day period in storage across the different polyethylene colors and the control.

Data analysis

All data collected were subjected to analysis of variance (ANOVA) for factorial experiment in CRD and was executed using GENSTAT 7.3E Discovery edition (GENSTAT, 2007). Significant test for treatment means was by Fisher's Least Significant Difference at 5% probability level.

RESULTS

Cumulative weight loss in lettuce (across 7 days) as influenced by fertilizer rates and supplements and the polyethylene colors used for storage are shown in Table 2. Supplementation with either K- or Ca-nitrate significantly influenced weight loss as from the fifth day of storage, K-nitrate had lower weight loss. Among the fertilizer treatments, weight loss was highest when the lettuce was not fertilized. Polyethylene color bags significantly ($p < 0.05$) affected pattern of weight loss. The bare samples (without the modified atmosphere storage environment) had highest weight loss in contrast to the green color that had the lowest.

The biplot (Fig. 1) revealed the combined effects of fertilizer treatment, fertilizer supplement and the polyethylene color pattern of weight changes in storage. It was evident that all the "T" (Bare and laid on the Table) had the highest and most distinct weight loss of lettuce. Most prominent weight loss was the non-fertilized lettuce that was bare, as seen in the figure, which is the T0 (Table and treatment 0), while GK2 (Green 200 NPK 20:10:10 + 200 K-Nitrate kg/ha) had the least postharvest weight loss.

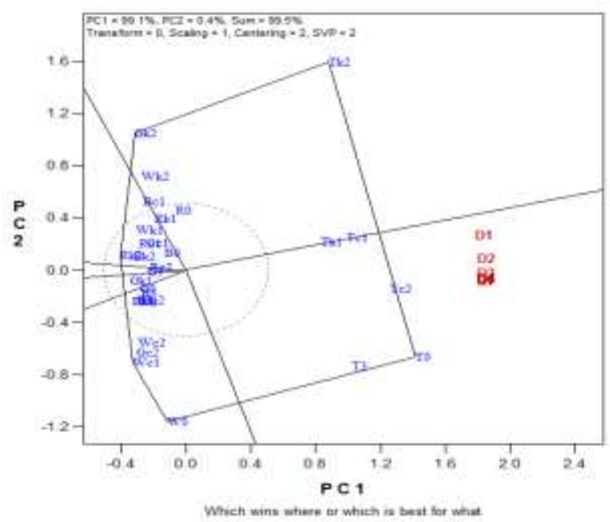

Fig. 1: Biplot showing combined effects of NPK 20:10:10 fertilizer supplemented with K- and Ca- nitrated and stored in four polyethylene colours for seven days.

Plate 1: Experimental layout showing lettuce enclosed in four different polyethylene colours.

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Table 2: Cumulative weight loss (%) of lettuce as influenced by days in storage across supplements, fertilizer levels and polyethylene colors

	Days in Storage						
Supplement	Wtl-1	Wtl-2	Wtl-3	Wtl-4	Wtl-5	Wtl-6	Wtl-7
Ca-Nitrate	5.14	8.97	13.10	15.92	19.63	21.90	24.67
K-Nitrate	5.26	8.99	12.32	15.02	16.31	18.32	20.75
LSD $_{(0.05)}$	NS	NS	NS	NS	2.925	2.881	2.850
Fertilizer (kg/ha)							
T0	6.40	11.73	16.56	20.53	23.08	25.49	28.11
T1	4.68	8.10	11.13	12.93	15.47	17.47	20.39
T2	5.20	8.21	10.80	13.86	16.46	18.19	20.55
T3	4.52	7.88	12.36	14.62	16.67	19.30	21.79
LSD $_{(0.05)}$	NS	NS	3.44	4.16	4.136	4.07	4.03
Color							
Blue	2.19	4.54	5.74	7.20	8.77	10.16	11.79
Green	2.07	3.48	5.04	6.91	7.52	9.65	11.18
Red	2.79	4.29	6.96	7.83	9.00	10.30	12.36
Translucent	1.68	3.30	6.33	7.04	9.03	10.82	12.60
Bare	17.27	29.29	39.48	48.44	55.28	59.62	65.62
LSD $_{(0.05)}$	2.158	3.592	3.850	4.602	4.624	4.555	4.507

NS: Non Significant; Wtl: Weight loss; T0,T1,T2,T3: Fertilizer rates in combination with K- and Ca- nitrate as supplements, See Table 1 for interpretation.

DISCUSSION

Loss of weight in vegetables during storage is caused by water exchange between the internal and external atmospheres, the transpiration rate being accelerated by cellular breakdown (Woods, 1990). The K-Nitrate supplement showed lesser storage weight loss as compared to Ca-Nitrate supplement; this is consistent with the known effect of K on regulation of stomata opening in plants. The fertilizer treatment T1 (200kg of NPK 20:10:10 supplemented with either 200kg K-Nitrate or Ca-Nitrate per hectare) exhibited the least postharvest loss compare to other fertilizer rates. Suggesting that increase in fertilizer level decreased post harvest weight loss in this study and also reduces the rate of chlorophyll dissipation and leaf decay. However, from day 5, decay and rot were observed in some of the samples, especially the red, blue and translucent polyethylene bags.

In conclusion, maximum days of storage for lettuce, under a modified atmosphere storage is 5 days in which the level of greenness and crispiness are still acceptable; storing with green polyethylene with perforation at the edges of the bag to allow minimal respiration (exchange oxygen and carbon dioxide) was more preferably.

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PHYSIOLOGICAL LOSSES IN STORED ONION BULBS AS AFFECTED BY SYSTEM ELEVATION

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ABSTRACT

Onion is a seasonal crop with low storability, but due the high demand of its bulbs throughout the year round, it is usually stored in ambient storage conditions until the harvest of next season crop or for longer period to avoid the glut in the market as well as to ensure its year round availability. This study evaluated the effect of elevation on storage conditions and physiological loss of onion bulbs stored in naturally ventilated cribs Medium-sized of Kano-red onion bulbs were stored in three wooden cribs elevated 500mm, 1000mm and 1500mm above ground level for a period of 90 days. The results showed that elevation significantly ($p<0.05$) affected the storage temperature and relative humidity of the cribs as well as the physiological loss factors of the stored the onion bulbs in the cribs. Under storage conditions, temperature and relative humidity were evaluated, while weight loss, sprouting, rotting, rooting and scale-drying were evaluated under physiological loss. The highest and lowest mean temperature and humidity levels of 28.92°C; 72.56% and 27.74°C; 71.90% were observed in the lowest (500mm) and highest (1500mm) elevated cribs, respectively. The lowest mean per cent weight loss of 2.98% and scale-drying loss of 1.9% were observed in the highest elevated cribs, while the highest mean per cent weight loss of 8.57% and scale-drying loss of 6.4% were recorded in the lowest (500mm) elevated cribs. On the other hand, the lowest mean per cent sprouting of 1.7% and rooting of 0.13% were observed in the lowest elevated cribs, while the highest mean per cent sprouting of 6.9% and rooting of 2.02% were obtained in the highest elevated cribs. The lowest mean per cent rotting loss of 0.71% was recorded in the highest (1500mm) elevated cribs, while the highest mean per cent rotting loss of 1.89% was obtained in the lowest (500mm) elevated cribs. It could be deduced that the lowest mean per cent weight loss and scale-drying loss in the highest elevated cribs could be due to the low temperature and relatively high relative humidity levels associated with the cribs, while the lowest sprouting and rooting losses in the lowest elevated cribs could be due to the high mean storage temperature associated with the cribs. The results suggest that for effective storage of Kano-red onion bulbs under natural ventilation, the structures should be raised higher than 500mm above ground level to facilitate enhance bottom ventilation of the structures.

Key words: Onion bulbs, Natural ventilation storage, Ambient conditions, Physiological loss, Bottom elevation

INTRODUCTION

Onion is a semi-perishable bulb vegetable, which like other vegetables is a respiring commodity. However, when harvested and properly cured, it develops dry skin cover which reduces respiratory, extends its shelf-life and minimizes storage losses (Lawande and Tripathi, 2019). Hence, onion bulbs are usually stored in ambient storage conditions until the harvest of next season crop or for longer period to minimize seasonal glut in the market and to ensure availability of the commodity all year round (Dabhi and Patel, 2017). In a developing country like Nigeria, where cold storage facilities are lacking, high-temperature storage technology is predominantly practiced by farmers using traditional techniques at ambient conditions (Fumen, 2016). In Nigeria, the most popular and best storage variety of onion grown is the 'Kano-red' variety which is locally referred to as *Jan-Kano* (Messiaen and Rouamba, 2004; Fumen, 2016). It is mainly produced during the dry season farming, with the cropping duration being between the months of September and April and the peak harvesting period between the months of March and April (Muhammad *et al*., 2011; Jidda and Benjamin, 2016). Within the two-month harvesting period, onion bulb supply is in surplus that the local market cannot absorb, thereby leading to a seasonal glut situation (Ogunesan, 2012). Like most horticultural crops, onion is susceptible to post harvest losses among which weight loss, rotting, sprouting and rooting rank above others (Jolayemi *et al*., 2018). Hence, despite of the ample production of the bulb vegetable and its wide utilization, onion has a very short postharvest shelf-life with a loss of about 40-

50% before reaching the market (Priya *et al*., 2014; Karthik *et al*., 2016).

Although onion is regarded as a semi-perishable crop, post-harvest losses of 10-12%, 8-10% and 30- 40 % due to rotting, sprouting, and physiological weight loss, respectively, occur during storage (Fumen, 2016; Dabhi and Patel, 2017). To extend the period of availability as well as maintaining bulb quality of stored onion, the metabolic breakdown and microbial deterioration of stored bulbs should be objectively minimized (Dabhi and Patel, 2017). In Nigeria, farmers store onion mostly in naturally ventilated storage structures as per their requirements and availability of material, which have no control of temperature and relative humidity. These storage structures which lack adequate ventilation, neither bottom ventilation nor side ventilation often result in increased storage losses of 50% and above (Fumen *et al*., 2017b; ICAR, 2019). Hence, farmers usually sell their onion stocks within the harvest season at a give-away price due to market glut situation or store for a few weeks in the traditional storage structures and suffer losses (Fumen, 2016). Depending on cultivar, cultural practices, pre-harvest and post-harvest treatments, storage losses under traditional storage structures vary between 30 and 50% for short-term and 50 and 90% for long-term storage (Endalew *et al*., 2014; Petropoulos *et al*., 2016; Chávez-Mendoza *et al*., 2016). The naturally ventilated storage structures results in poor aeration which does not adequately remove heat and moisture from the stored onion bulbs, thereby leading to increase in storage temperature, which in turn adversely affects the product storage physiology and pathology, resulting in higher storage losses and decrease in quality (Tripathi and Lawande, 2016; Dabhi and Patel, 2017).

To achieve and maintain a proper high-temperature storage conditions of 25-30°C temperature and 55%-70% relative humidity (Kukanoor, 2005; Haliru *et al*., 2019), external climatic conditions such as temperature, wind velocity and wind direction as well as internal conditions such as layout, construction type, vent positions and product arrangement are considered to enhance proper circulation of fresh air in a storage structure (Ganguly and Ghosh, 2011; Endalew *et al*., 2014). Poor ventilation often adversely affects the quality and quantity of stored onion through increase in water loss and respiration (Dabhi and Patel, 2017). Use of locally made bamboo structures with improved bottom and side ventilation was found to record minimum onion bulb rot and sprouting losses (Yadav and Yadav, 2012). Storage losses of onion bulbs in aerated basket at room temperature were found to be lower than those in poorly ventilated structures with different roofing materials (Imoukhuede and Ale, 2015; Jolayemi *et al*., 2018). Storability of onion bulbs in a storage structure demarcated into three shelves elevated at 1300mm, 900mm and 500mm above ground level showed that the highest elevated shelf recorded the lowest percent weight loss, while the lowest elevated shelf recorded the highest percent weight loss (Falayi and Yusuf, 2014). Minimum onion bulb bruising and rotting have been observed in fully ventilated structures elevated above the ground with adequate bottom and side ventilation than in conventional storage structures without bottom aeration (Soomro *et al*., 2016).

Although Nigeria is among the world's major onion producing countries and the biggest producing country in sub Saharan Africa (Pasternak *et al*., 2013), lack of adequate storage facilities results in losses of 50-76% annually (Denton and Ojeifo, 1990), thereby leading to scarcity and fluctuation in price of the produce annually (Ogunesan, 2012). The objective of this study, therefore, was to determine how bottom ventilation affects physiological activity of onion bulbs in naturally ventilated storage systems.

MATERIALS AND METHODS

This study was carried out at the Department of Agricultural and Bioresources Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Minna, Nigeria, in 2014. Bulk sample of cured bulbs of *Kano-Red* onion variety was obtained from a local market in Minna, Niger state. The *Kano-red* onion variety is characterized by its marked pungent flavour, high dry matter content, firm and tight outer scales, and closed neck which enable it a longer storage period (Messiaen and Rouamba, 2004). The onion bulb sample was cleaned, sorted and graded into small-sized, medium-sized and large–sized grades of diameter >40.0mm, 40.0-60.0mm and <60.0mm, respectively (Messiaen and Rouamba, 2004; Abd-El Rahman and Ebeaid, 2009). The medium-sized grade was selected for the study.

Nine (9) wooden cribs with storage chambers of dimensions 40 × 40 × 40 mm each were used for this study. The cribs were classified into three classes based on the height of the cribs above ground level (Falayi and Yusuf, 2014). Rectangular shaped cribs were covered with brown fibre net and elevated 500mm, 1000mm and

1500mm above ground level (Plates I, II and III). The brown coloured fibre net of 18mm mesh was used as cover for the storage chambers for base floor, side wall and top ceiling, to allow for uniform air circulation and adequate bottom and side ventilation of the cribs (Soomro *et al*., 2016). For uniformity of storage conditions, proximity of experimental units for easy monitoring, protection of the stored onion bulbs against sun and rain intensity and economy of space, the cribs were sheltered under a naturally ventilated thatched shed (Plate IV).

Plate 1: Rectangular mesh cribs elevated 500mm above ground level

Plate II: Rectangular mesh cribs elevated 1000mm above ground level

Plate III: Rectangular mesh cribs elevated 1500mm above ground level

Plate IV: A cross section of naturally ventilated cribs in a thatched shed

Fourteen kilogram (14kg) weight of onion bulbs at 68.9% moisture content (wb) was loaded into each crib for a storage period of 90 days. Using a digital temperature/humidity measuring device, as adopted by Chávez-Mendoza *et al.* (2016), the storage temperature and humidity of each crib were monitored 5 days per week, at the intervals of 9:00am, 1:00pm and 5:00pm, daily. At the intervals of 14days, losses due to decrease in weight, sprouting, rotting, rooting and scale-drying of the stored onion bulbs in each chamber were evaluated to measure the quality of the stored onion. Storage losses due weight loss (Wl), sprouting loss (Sl), rotting loss (Rttl), rooting loss (Rtl) and scale-drying loss (Scdl) were determined using the following equations (Soomro *et al*., 2016; Shankar *et al*., 2017).

Weight loss (Wl%)

$$Wl(\%) = \frac{Wi-Wf}{Wi} \times 100 \quad (1)$$

Where, wi = initial weight of onion bulbs in a chamber before storage interval and wf = weight of onion bulbs in a chamber after a storage interval.

Sprouting loss (Sl%)

$$Sl\ (\%) = \frac{Nsb}{Nib} \times 100 \quad (2)$$

Where, Nsb = number of sprouted bulb at an interval of inspection and Nib = initial number of bulbs in a chamber before the storage interval.

Rotting loss (Rttl%)

$$Rttl(\%) = \frac{Nrttb}{Nib} \times 100 \quad (3)$$

Where, Nrttb = number of rotting bulb at an interval of inspection and Nib = initial number of bulbs in a chamber before the storage interval.

Rooting loss (Rtl%

$$Rtl(\%) = \frac{Nrtb}{Nib} \quad (4)$$

Where, Nrtb = number of rooting bulb at an interval of inspection and Nib = initial number of bulbs in a chamber before the storage interval.

Scale-drying loss (Scdl%)

$$Scdl\ (\%) = \frac{Nsd}{Nsi} \times 100 \quad (5)$$

Where, Nsd = mean number of dry scales from 3 randomly selected onion bulbs a storage interval and Nsi = mean number of fleshy scales from 3 transversely sliced onion bulbs before storage interval.

Statistical Analysis

Using SPSS 11.5 for Windows, arithmetic mean, standard deviation and coefficient of variance were the statistical tools used in computing and comparing the data generated. Student-Newman-Keul's (SNK) test, was used to determine the effect of elevation on the storage conditions of the ventilated cribs and the physiological loss parameters of stored onion at 5% level of probability (Chukwu and Sunmonu, 2010).

RESULTS AND DISCUSSION

The results of the effect of elevation on mean temperature and relative humidity of naturally ventilated cribs and the mean physiological losses of onion stored in the cribs for the 90-day storage experiment are presented in Table1 and Figures 1-5, respectively.

Effect of Elevation on Temperature and Humidity of Naturally Ventilated Cribs

The result of the effect of elevation on the inside temperature and relative humidity of naturally ventilated rectangular cribs show that both temperature and air relative humidity were significantly ($p < 0.05$) affected by elevation throughout the 90-day storage experiment.

Table 1: Effect of elevation on temperature in naturally ventilated cribs at different storage periods

Elevation (mm)	Mean temperature(°C) and relative humidity (%)							
	July, 2014		August,2014		September, 2014		Total mean	
	(°C)	(%RH)	(°C)	(%RH)	(°C)	(%RH)	(°C)	(%RH)
500	29.20a	71.97a	28.51a	73.86a	29.05a	71.86a	28.92a	72.56a
1000	28.79b	71.70b	27.87b	73.78b	28.21b	71.79b	28.29b	72.42b
1500	28,46c	71.68c	27.30c	72.76c	27.47c	71.26c	27.74c	71.90c
SE±	0.012	0.049	0.011	0.034	0.009	0.028	0.011	0.037

*Mean values with the same letter in a column are not signicantly different at 5% level of probability using Student-Newman-Keul's (SNK) test.

Storage temperature was found to be highest in the lowest elevated (500mm) cribs with a mean temperature of 28.92°C and lowest in the highest elevated (1500mm) cribs with a mean temperature of 27.74°C. During the 90-day storage experiment, storage temperature in the lowest elevated cribs was highest (29.20°C) in the month of July and lowest (28.51°C) in the month of August. While in cribs elevated 1000mm and 1500mm above ground level, storage temperature was highest (28.79°C; 28.46°C) in July and lowest (27.87°C; 27.30°C) in August, respectively. In September, the temperature levels dropped to 28.21oC and 27.47°C, respectively. The results show that there was fluctuation in the storage temperature of the cribs during the storage period. This suggests that the higher a storage structure is elevated above ground level, the lower the storage temperature of the structure, agreeing with Thompson (2002) and Kitinoja and Kader (2003) that increase in altitude lowers air temperature of the affected area and that at every 1km rise in altitude, temperature drops by 10°C. Ganguly and Ghosh (2011) stressed that storage structures elevated 1500mm above ground level have colder outside air flow into them to replace the inside warm air, thereby keeping the structures cooled.

The effect of elevation on relative humidity of the naturally ventilated cribs was also significant ($P<0.05$) as the highest air humidity levels of 71.97%, 73.86% and 71.86% were found in the lowest elevated (500mm) cribs, while the lowest air relative humidity levels of 71.68%, 72.76% and 71.26% were observed in the highest elevated (1500mm) cribs. The effect however fluctuated during the study period as the air relative humidity levels were relatively low (71.97%, 71.70% and 71.68%) in the month of July, high (73.86%, 73.78% and 72.76%) in the month of August and low (71.86%, 71.79% and 71.26%) in the month of September. The result suggests that elevating a storage structure high above ground level has a significant cooling effect on the storage conditions of the storage products, with moderate air relative humidity. This corroborates the report of Cantwell and Kasmire (2002) that elevating storerooms 500mm above ground level prevents them from soil moisture effect and dampness.

Effect Elevation on Physiological Losses of Stored Onion in NaturallyVentilated Cribs

The results of effect of elevation of naturally ventilated cribs on physiological losses of stored onion bulbs are presented in Figures 1-5. The results show that elevation significantly ($p < 0.05$) influenced physiological losses in the stored onion bulbs. The result shows that the lowest mean per cent weight loss of 2.98% was observed in the highest elevated (1500mm) cribs, while the highest mean per cent weight loss of 8.57% was recorded in lowest elevated (500mm) cribs. This suggests that the lowest elevated (500mm) cribs with higher temperature levels recorded the higher per cent weight loss while the highest elevated (1500mm) cribs with lower temperature levels recorded the lower per cent weight loss. The result is in conformity with the report of Watkins and Nock (2012) and Sohany *et al*. (2016) that moisture loss from onion bulb is greater at room temperature of more than 27˚C.

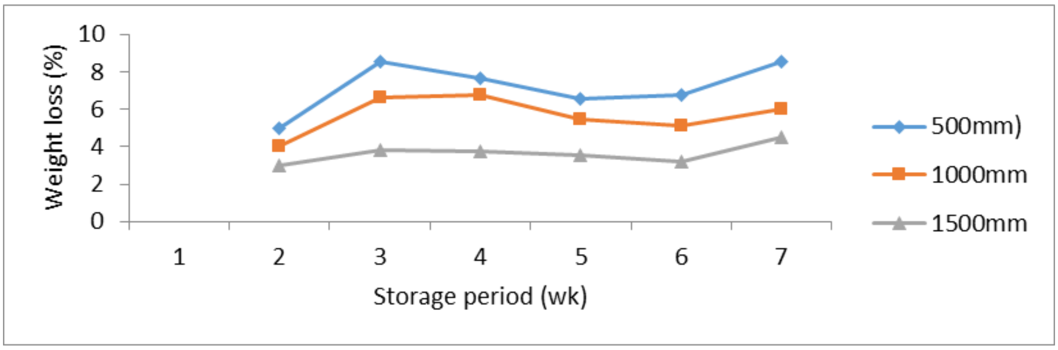

Figure 1: Effect of elevation on mean per cent weight loss

With reference to Table 1, the highest temperature levels were observed in the lowest elevated (500mm) cribs. The high mean per cent weight loss in these cribs could be attributed to the high temperature levels associated with the cribs (Sohany *et al*., 2016). This could also be attributed to the high transpiration and respiration due to the comparatively high temperature and optimum relative humidity in the cribs (Endalew *et al*., 2014). Storage of onion in a storage structure with adequate bottom and side aeration can result in high reduction in physiological loss in weight (Mangaraj *et al*., 2017).

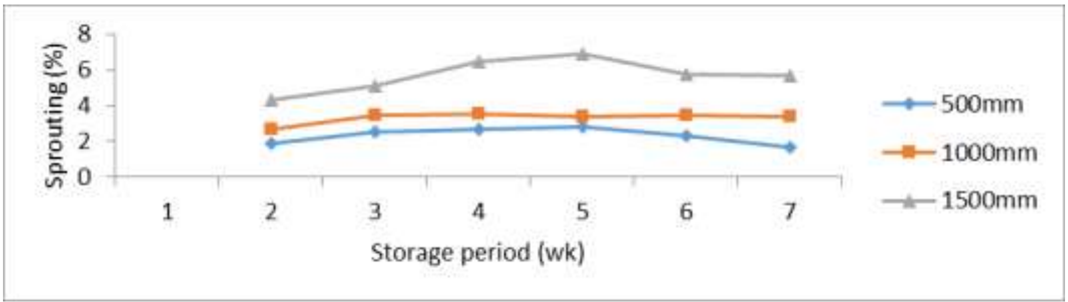

Figure 2: Effect of elevation on mean per cent sprouting loss

Figure 2 shows that the lowest elevated (500mm) cribs maintained the lowest mean percent sprouting of 1.7%, while the highest elevated (1500mm) cribs maintained the highest mean per cent sprouting of 6.9%. The result depicts that storage of onion in high temperature stores suppresses bulb sprouting. Reference to Table1, the lowest sprouting loss in the lowest elevated cribs could be attributed to the high mean storage temperature levels in the cribs, while the highest mean per cent sprouting in the highest elevated cribs could be as a result of the moderate temperature levels associated with the cribs. This conforms to the reports by Singh (2012), Sohany *et al*. (2016) and Fumen *et al*.(2017a) that the combination of moderate temperature (9-18°C) and high relative humidity (> 75%) favours rapid bulb sprouting, while the combination of high temperature (> 32°C) and moderate relative humidity (<60%) suppresses bulb, thereby extending the dormancy period of stored onion bulbs.

Figure 3 shows that the highest elevated (1500mm) cribs maintained the lowest mean per cent rotting loss of 0.71%, while the lowest elevated (500mm) cribs recorded the highest mean per cent rotting loss of 1.89%. The results suggest that onion bulb rotting is higher in hot and humid storage conditions, thereby conforming to the report that hot and humid storage conditions are susceptible to the growth of black mold (*Aspergillus niger*), bacterial soft rot (*Pseudomonas gladioli*) and other storage diseases which cause bulb rotting in stored onion (Sohany *et al*., 2016; Jidda and Benjamin, 2016).

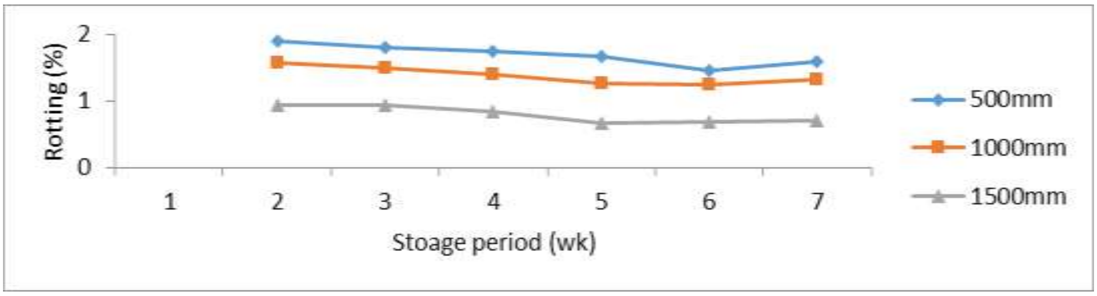

Figure 3: Effect of elevation on mean per cent rotting loss

In Table 1 above, the highest elevated (1500mm) cribs maintained moderate temperature and humidity levels, while the lowest elevated (500mm) cribs maintained the highest temperature and humidity levels. Thus, the lowest mean per cent rotting loss of 0.71% in the highest elevated cribs could be attributed to the moderate temperature levels associated with the cribs. The high mean percent bulb rotting loss in the lowest elevated cribs could be attributed to the high temperature and high humidity levels associated with the cribs (Singh, 2012; Fumen *et al*., 2017a).

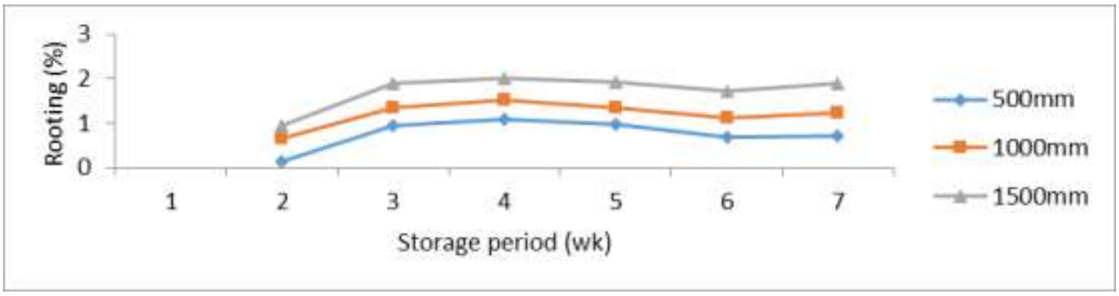

Figure 4: Effect of elevation on mean per cent rooting loss

In Figure 4, the lowest elevated cribs recorded the lowest mean per cent rooting loss of 0.13%, while the highest mean per cent rooting loss of 2.02% was obtained in the highest elevated cribs. Reference to Table1, the result suggests that the lowest mean percent rooting loss recorded in the lowest elevated cribs could be attributed to the high temperature levels associated with the cribs, while the highest percent rooting loss in the highest elevated cribs could be attributed to the intermediate temperature and high relative humidity levels associated with the cribs. This result conforms to the report that a combination of moderate (10-20°C) temperatures and high (> 75%) relative humidity favours rooting loss in stored onion bulbs (CIGR, 1999).

In Figure 5, the lowest mean per cent scale-drying of 1.9% was recorded in the highest elevated cribs, while the highest mean per cent scale-drying loss of 6.4% was obtained in the lowest elevated cribs. With reference to Table1, the highest temperature levels were recorded in the lowest elevated cribs, while the lowest temperature levels were maintained in the highest elevated cribs. The result suggests that the lowest mean per cent scale-drying loss in the highest elevated cribs could be attributed to the low temperature and humidity levels associated with the cribs, while the highest mean per cent scale-drying loss in the lowest elevated cribs could be attributed to the high temperature levels associated with the cribs. The result conforms to the report by Fustos (1997) that scale-drying in stored onion is minimized rapidly at low temperature and moderate (<60%) air relative humidity.

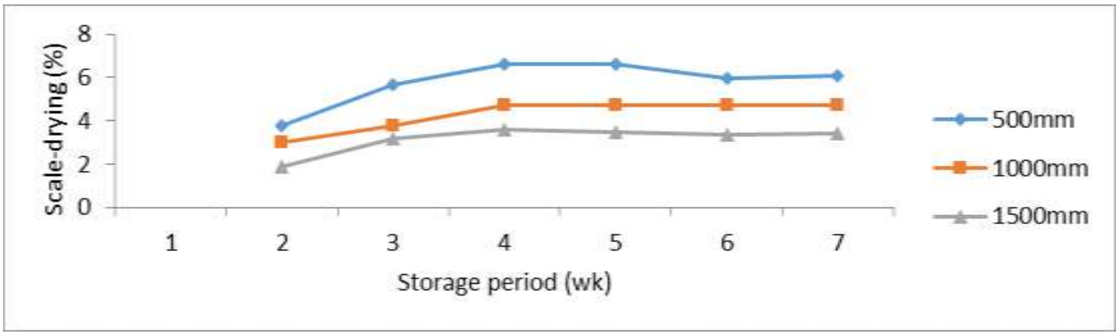

Figure 5: Effect of elevation on mean per cent scale-drying loss

CONCLUSIONS

Effect of elevation of naturally ventilated cribs on storage conditions and physiological loss in stored onion bulbs was evaluated. Medium-sized of *Kano-red* onion bulbs were stored in three wooden cribs elevated 500mm, 1000mm and 1500mm above ground level for a period of 90 days. Bottom elevation significantly ($p<0.05$) influenced the storage conditions of the cribs as well as the physiological loss in the stored onion bulbs. The highest mean storage temperature and relative humidity were observed in the lowest (500mm) and highest (1500mm) elevated cribs, while the lowest mean temperature and relative humidity were both observed in the highest elevated (1500mm) crib. The mean per cent weight loss of the stored onion was lowest (2.98%) in the highest elevated (1500mm) crib and highest (8.57%) in lowest elevated (500mm) crib. The lowest mean percent bulb sprouting of 1.7% was recorded in the lowest elevated (500mm) cribs, while the highest (6.9%) was obtained in the highest elevated (1500mm) crib. While the lowest mean per cent rotting loss of 0.71% was observed in the highest elevated (1500mm) crib, the lowest elevated (500mm) crib recorded the highest mean per cent rotting loss of 1.89%. The mean per cent rooting loss was lowest (0.13%) in the lowest elevated crib and highest (2.02%) in the highest elevated crib. The lowest mean per cent scale-drying of 1.9% was recorded in the highest elevated cribs and the highest (6.4%) in the lowest elevated crib. The study suggests that raising storage structures higher than 500mm above ground level reduces the storage temperature and increases the relative humidity of the structure, thereby minimizing weight loss, bulb rotting and scale-drying in stored onion.

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ANTIOXIDATIVE AND ANTIFUNGAL EFFECTS OF COFFEE HUSK PASTE ON THE SHELF LIFE QUALITY OF SMOKED TILAPIA (*SAROTERODON GALILEA*)

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ABSTRACT

Antioxidative and antifungal effects of different concentrations of coffee husk paste were tested on smoked tilapia (saroterodon galilea) stored for 4 weeks at ambient temperature of approximately 28^{0}C. Five bathes of eviscerated, brined fish fillets were each coated with 0%(A), 1.0%(B), 2.0%(C), 3.0%(D), and 4.0%(E) coffee husk paste and smoked in a gas oven. The cooled stored fillets were then examined and analysed periodically after every week of storage. Gradual decrease in the values of the two antioxidative indicators: thiobabituric acid (TBA) and peroxide value (PV) as the level of coffee paste increased, shows that rancidity of fish tissue is been retarded by the coated coffee husk paste. Antioxidative activity of coffee paste was in this order: B<C<D<E. Higher and steady increase in the rate of rancidity of fillet than all other treatments were noticed in the control (0%) as storage days increased. This was indicated by the TBA values. At the end of the fourth week, lowest value of TBA (0.41) was obtained in treatment E (5%). Although this was higher than the value obtained after the second week. Similar trend was also observed for the peroxide values of the same treatment. This might be due to slight increase in the moisture content of the samples at the stage of storage. Colony count of fungal growth on fish fillets was lowest (4.10 x 10^4) on treatment E as against A (0%) and other lower concentrations at day 21. At the end of the study, least fungal growth (6.02 x 10^4) was recorded on E, thus indicating highest antifungal activity of coffee husk paste on fish fillets. Results of sensory evaluation however show least preference for treatment E. This was as a result of poor appearance (2.46) and flavor (3.18), although lowest value (3.14) was recorded for the degree of rancidity. Thus, coffee husk paste exhibited antioxidative and antifungal actions on the smoked fish and could be used to extend the shelflife of smoked fish.

Key words: Rancidity, Shelflife, Ambient temperature, Fillet, *Saroterodon galilea*

INTRODUCTION

Protein consumption per head in any developing or underdeveloped countries in concernedly low when compared to other developing countries of the world (Maeve *et al*., 2017). Minimum daily protein consumption per head should not be below 0.8 grams of protein per kilogram of body weight (WHO/ FAO/ UNU (2007). Animal protein is and still remain the better source of protein in the class of food (https://www.webmd.com). Sources of animal protein are many depending on the level; of development of any countries livestock sector. However, fish as a source of animal protein remains an excellent source due to some reasons. Fish has been reported to contain very high level of sulphur containing amino acids such as: cysteine, methionine and lysine. Such amino acids as mentioned above a grossly lacking in legumes and most cereal based diets (https://www.healthline.). In Nigeria, fish still remains the cheapest source of animal protein when compare to other sources of animal protein (particularly meat).

Fish has two major sources of supply: the capture and culture fishery. Fish from either of these sources easily spoil as a result of oxidative rancidity (particularly fat fish) if not properly cared for during processing and preservation. This is because fish is an easily and highly perishable commodity most especially at temperate regions of the world (Nigeria inclusive). Fish protein undergo spontaneous rancidity within 24 hours' postmortem (Ames *et al.,* 1993). The occurrence poses a major setback for the artisanal sector of most underdeveloped countries of the world, as negligible proportion of the catch is finally gets to the market in good condition. This undoubtedly reduces their average daily income realizable from their business.

Coffee is one of the most popular beverages, is consumed by millions of people every day. This is as a result of the concentration of important polyphenolic compounds like cinnamic acids, benzoic acids, flavonoids, proanthocyanidins, stilbenes and lignin. Most of these compounds possess antioxidatative properties (Rice *et.al,* 1996). Studies have also shown that coffee pulp obtained from deshelling (dry pulping) the ripe coffee beans equally contain significant proportion of polyphenolic compounds. However, some of these compounds of have been detected to be antinutritional in nature. This thus deters its utilization as animal feedstuff. Coffee byproducts proportion is about 50% (dry matter) of the world coffee production, and about 2.8 million tonnes of this pulp was reportedly produced between 1989-1990 (Perraud-Gaime, 1995). Despite the high global production of this husk, Hamzat (2011) reported that coffee pulp and husk usually constitute a major pollutant of lakes and rivers around the coffee processing sites (farms and industries). Hence, coffee pulp is hitherto facing serious disposal problem. Coffee husks and pulp, which comprises nearly 45% of the cherry, are one of the main by-products of coffee agro-industry and might be a valuable material for several purposes, including extraction of caffeine and polyphenols. Coffee pulp contains 23.3 % (DM) in the following proportions: 3.4% fiber, 2.1 % protein, 1.5 % ash, non-protein and organic components like tannins, sugars, caffeine, chlorogenic acid and caffeic acid. Additional phenolic compounds such as flavan-3-ols (monomer and proanthocyanidins), hydroxynamic acid (caffeolquinic acid, caffeolquinic acid derivates and p- c oumaroylquinic acid), flavonols and anthocyanidins were present in the pulp. Tannins and caffeine extracted from coffee were found to inhibit *Staphylococcus aureus*, *Vibrio parahaemolyticus, V. cholerae,* and *Salmonella*.

Synthetic antioxidants, widely known and have being in use for long is today being discouraged. This is as a result of the health implication of synthetic products. This thus necessitates the need to search for alternative preservative materials which could effectively tackle the problem of spoilage of seafood and frozen products which are highly perishable. In seafood like fish, oxidative rancidity and microbial proliferation are the two major sources of spoilage.

MATERIALS AND METHODS

Fish sample

Twenty-five kilogrammes of table size fresh tilapia (*saroterodon galilea*) was purchased from a local artisanal fishermen Odo-Ona village, Ibadan. and brought to the experimental site where it was immediately eviscerated by removing the intestine and gills through cutting of the abdominal region of each fish. They were thoroughly washed in clean water. Fish fillets were then dipped in 15% sodium chloride (brine) solution for 3 minutes after which it was drained. The processed fish were divided into five batches into sterilized clean stainless container and labeled A, B, C, D and E.

Coffee hush paste

Dry processed coffee husk sample was collected from Value Added Research Department of Cocoa Research institute of Nigeria, Ibadan. Five kilogramme of the dried sample of the husk were thoroughly grinded using local pepper milling machine and then milled into finer particles using local grinding stone to form a powder. 0 to 5% concentration of coffee husk paste were made by adding 1litre of water each into 100, 200, 300 and 400gms of powder coffee husk in different containers. This solution is then mixed together thoroughly to form paste. Each of the pastes were then pore on each of the five batches of fish in the containers with the exception of sample A (control). The paste is now mixed with the fishes to cover all the entire surfaces of the fish.

Smoking of fish

A gas oven with a regulated temperature of 60^0C. Smoking was done for about two hours with four turning times.

Storage and sampling of fish sample

Each bathes of the fish were allowed to cool down so as to avoid steam effect. Each bathes (A, B, C, D and E) were later packaged into air-tight black polythene bags and stored at ambient temperature of about 30^0C for four weeks. At the end of the fourth week, samples were then subjected to visual observation for fungal growth and sensory evaluation. Chemical and microbiological evaluations were later carried out on the samples in the laboratory.

Chemical analysis

Protein, lipid, moisture content, Thiobarbituric acid (TBA) and the peroxide value of samples were determined.

Microbiological analysis

Visual examination of fish samples was done weekly and data from each batch were taken accordingly. Mould counts of sample were determined.

Sensory evaluation

Four (4) member panel comprising of well experienced taste panelist, was composed to examine the samples. To facilitate unbiased examination, all samples were rinsed in clean water and covered with aluminum foil and then heated for about 25 minutes in gas oven at a temperature of 70^0 C. Each batch were later presented one after the other in a regular order before each of the taste panelists after cooling down of samples to room temperature. Panel members were to score each sample for: appearance, saltiness, juiciness, flavor, rancidity (off flavour) and the general acceptability of samples, base on a 5-point hedonic scale.

Statistical analysis

Analysis of variance was used to analyze the data obtained. Duncan Multiple range test was employed in determining the differences in means.

RESULTS

The effects of different concentrations of coffee husk paste on the examined qualities of the smoked tilapia samples are shown on table 1- 6. Different levels of coffee husk past have imparted certain degrees of antioxidative and antifungal effects on the smoked fish fillets. Moisture contents of all the smoked samples decreased progressively as days of storage increases, until after the fourteenth day. Thus rise in the moisture content was however absent in treatment E. Percentage water activity of the smoked fish samples also followed the same trend as in the moisture content. Highest rate (0.12) of reduction in the water activity was obtained in the sample with the highest coffee paste concentration.

Levels of thiobabituric acid (TBA) increased in all the fish samples, with highest value (0.89) in A (control) and least (0.41) in E (4%). The difference between the initial TBA values was equally highest (0.48) in A and least (0.03) in E, in this order A> B >C >D >E. Initial peroxide values (rancidity indicator), have trends closely similar to that of the TBA. Initial peroxide value was lowest in treatment D (3%), while that of B (10.9) was the highest. Trend of these values changed after the third week of storage. Peroxide values which increased across table till the end of the third week gradually decreased till the end of the storage period. At the end, highest value (8.0) of peroxide value was found in A as against the least (4.2) value in E. Final values obtained in all the coffee husk treated samples have no regular trend. All treated samples were however lower than that of the control. Results of the physical examination of the treated fish shows highest (14.6×10^4) in the control and least value (6.02×10^4) of colony count was found in E. Assessment of samples by taste panelists (Table 6) shows least (2.46) value for appearance in E. Best appearance (5.62) was recorded for treatment C. For rancidity, sample A had the highest (4.66) value and the least (3.14) activity was found in E. Treatment C had the best (5.44 and 6.42) values respectively for flavor and general acceptability. Treatment A scored least for flavour while had least value for general acceptability.

Table 1: Effects of Coffee husk treatment on moisture content of fish sample

Storage period (days)	Moisture content (%) A	B	C	D	E
7	42.1	34.1	34.1	28.3	21.5
14	33.2	30.3	30.2	25.2	19.5
21	34.3	31.6	32.8	27.1	16.2
28	36.2	33.4	34.6	17.4	12.6

Table 2: Effects of Coffee husk treatment on water activity of fish sample

Storage period(days)	Water activity (%) A	B	C	D	E
7	0.72	0.63	0.61	0.60	0.52
14	0.69	0.61	0.57	0.58	0.47
21	0.70	0.60	0.55	0.55	0.43
28	0.77	0.63	0.56	0.52	0.40

Table 3: Effects of Coffee husk treatment on thiobabituric acid value of fish sample

Storage period (days)	TBA Value A	B	C	D	E
7	0.41	0.40	0.28	0.35	0.38
14	0.46	0.44	0.31	0.33	0.35
21	0.61	0.51	0.34	0.36	0.37
28	0.89	0.77	0.50	0.53	0.41

Table 4: Effects of Coffee husk treatment on peroxide value of fish sample

Storage period (days)	Peroxide Value A	B	C	D	E
7	10.5	10.9	8.6	8.0	6.4
14	13.2	13.2	12.4	11.6	9.0
21	18.5	18.2	17.2	16.2	12.8
28	17.2	16.8	16.1	15.3	12.0

Table 5: Effects of Coffee husk treatment on mould colony count of fish sample

Storage period (days)	Mould colony count ($x10^4$) A	B	C	D	E
7	2.1	3.3	3.0	2.7	3.2
14	4.3	4.1	3.5	3.2	4.6
21	6.7	5.9	5.2	4.6	4.1
28	14.6	10.1	12.2	10.3	6.2

Table 6: Effects Sensory evaluation of Coffee husk paste treatment on smoked fish sample

Treatment / Parameter	A	B	C	D	E
Appearance	5.32	5.16	5.62	3.16	2.46
Saltiness	3.10	3.46	3.77	3.46	3.59
Juiciness	5.14	4.41	3.62	3.22	3.71
Rancidity	4.66	4.28	3.42	3.28	3.14
Flavour	5.04	3.20	5.44	4.23	3.18
General Acceptability	3.24	5.46	6.42	3.81	3.26

DISCUSSIONS

Poverty and disease incidence are closely related and hence management of either of them should be done together. Fish is said to be one of the food of the poor people. This is because it is relatively cheaper than meat. This consequently makes cheaper protein sources like fish much more relevant in this global pandemic period. One of the proffered solutions to lowering the spread of corona virus is the maintenance of good hygiene among the citizen of any country. By avoiding or preventing the accumulation of all environmental pollutants, such as sewage effluents, industrial wastes as well as agricultural byproducts, good hygiene would be maintained. Hence an environment voids of diseases which could predispose people to health related problems like corona could be provided. Coffee farmers and fish processors could contribute to the alleviation of infections like corona. Lockdown, which is one of the global measures to reduce the spread of covid 19, has negative effects on almost every aspect of human life, most especially the industrial and agricultural sector of the economy. The aftermath of which is mass retrenchment of workers and considerable cutdown in the income per head of citizen. If smoke fish shelf life could be extended simply by the application of coffee husk as natural preservative, consumption of contaminated fish products by people would be prevented. Coffee farmers in turn will have their income raised. In conclusion, increase in coffee farming, which will indirectly increase coffee husk production and utilization may be a right step in the right direction.

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A REVIEW ON LACTIC ACID SYNTHESIS FROM CASHEW APPLE JUICE: A SOURCE OF INTERNATIONAL MARKET FOR NIGERIA

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ABSTRACT

The conversion of agro-residues into various value-added products is attracting global attention. Cashew (Anacardium occidentale) apple juice is an interesting low-cost substrate for microbial production of lactic acid. The juice is highly rich in reducing sugars (fructose and glucose), vitamins, minerals and some amino acids. In Nigeria, the goal of cashew tree cultivation is mostly directed towards nut production. This exposes the cashew apple to natural decomposition and wastage. Although, research works on utilization of cashew apple juice as a substrate for lactic acid production abound, its potential as an alternative source of income to the Nigeria government is still sketchy. This paper provided information on the procedural approach for lactic acid production vis-à-vis its prospects in income generation to the Nigerian government.

Key words: Cashew, lactic acid, reducing sugars, vitamins, amino acids

INTRODUCTION

Cashew (*Anacardium occidentale*) is an important evergreen perennial tree plant belonging to the family Anacardiaceae. It is cultivated in many African countries such as Nigeria, Tanzania, Ivory Coast, Mozambique, Benin and the Tropical countries such as Vietnam and India (Daramola, 2013). Cashew apple is a pseudo fruit of the cashew tree to which the cashew nut is attached. Cashew apple juice contains reducing sugars such as glucose, fructose and sucrose. It is also a very good source of vitamins, amino acids and minerals. The goal of the cashew tree cultivation is directed towards nut production. The nuts represent only 10% of the total fruit weight, and large amounts of cashew apples are lost in the field after nut removal (Rabelo *et al*., 2009). The use of cashew apple as a source of high value-added products may represent an important source of national income (Azevedo and Rodrigues, 2000).

Lactic acid (2-hydroxypropanoic acid), $CH_3CHOHCOOH$, was first discovered in sour milk by the Swedish chemist Scheele in 1780 (Datta and Henry, 2006). It is the most globally synthesized hydroxycarboxylic acid. Lactic acid has a wide documented history of use in the food, pharmaceutical, health and textile industries. It is widely used in the production of sweets, pickled foods and as a raw material in the manufacture of important emulsifiers for the baking industry. Lactic acid also functions as an important metabolite in most living organisms, from anaerobic prokaryotes to humans. Due to its inherent hydroxyl and carboxyl groups, it can be easily converted into useful chemicals such as pyruvic acid, acrylic acid, 1,2-propanediol, and lactate ester (Fan *et al*., 2009). Over the last few years, the demand for lactic acid has greatly increased due to its applicability in the production of biodegradable and biocompatible polymer, polylactic acid (PLA) (Abdel-Rahman *et al*., 2013). Lactic acid is produced by both prokaryotic and eukaryotic organisms. It is the simplest hydroxyl carboxylic acid with an asymmetrical carbon atom that confers optical activity. Lactic acid is found naturally in two optical forms, D-(-) and L-(+)-lactic acids. L-lactic acid is the preferred isomer in food and pharmaceutical industries, since elevated levels of the D-isomer are harmful to humans (Hofvendah and Hahn–Hägerdal, 2000; Bouguettoucha *et al*., 2009).

In relation to the foregoing, many studies have been carried out in order to explore the cashew apple juice as a cheaper source of carbon in fermentation processes for the production of bio-products such as lactic acid (Honorato *et al*., 2007), biosurfactant (Rocha *et al*., 2006) and oligosaccharide (Rabelo *et al*.,2009). Although, there are reviews on lactic acid production through cashew apple juice utilization as a substrate, its potential as a reliable source of income to the Nigerian government is yet to be considered. Hence, this paper attempts to provide information on the procedural approach for lactic acid production vis-à-vis its prospects in income generation to the Nigerian government.

Production of Lactic Acid

Lactic acid can be produced by chemical synthesis or microbial fermentation. However, the latter has some desirous advantages over the former such as the use of cheap raw materials like molasses, starchy waste, cellulosic and other carbohydrate rich materials (Vishnu *et al.,*2000). Another significant advantage is the production of a pure form of lactic acid, whereas, chemical synthesis only provides a racemic mixture of D- and L-lactic acids (Randhawa *et al*.,2012).

Chemical Synthesis of Lactic Acid

The stepwise procedure for chemical synthesis of lactic acid is based on lactonitrile. Initially, hydrogen cyanide is added to acetaldehyde in the presence of a base to make lactonitrile. The reaction occurs optimally at high atmospheric pressures in liquid phase. The crude lactonitrile is separated from the reaction medium and then purified by distillation. The lactonitrile is hydrolyzed to lactic acid using either concentrated sulphuric acid or hydrochloric acid. Apart from the lactic acid, ammonium salt is also produced alongside. Through esterificaton, the lactic acid combines with methanol to yield methyl lactate. The methyl lactate is then hydrolyzed by water in the presence of acid catalyst to produce methanol and lactic acid (Boontawan *et al*., 2011).

Microbial Fermentation

The fermentation process is characterized by a microbial degradation of carbohydrate into metabolites such as lactic acid, citric acid and ethanol (Yasmine, 2002). The carbohydrate material has to be hydrolyzed into fermentable simple sugars via a process that breaks down the alpha-glycosidic bonds. Alpha-amylase (EC3.2.1.1), Beta-amylase (3.2.1.2), and glucoamylase (EC 3.2.1.3) are well known amylolytic enzymes that catalyze the hydrolysis of alpha-glycosidic bonds in starch and other related saccharides (Ying *et al*.,2014). The efficiency of lactic acid fermentation activities is determined by the microorganism used, substrate, and operational conditions. Well-known fermentation approaches that are employed in lactic acid production include batch, fed-batch and continuous batch fermentations (Hofvendahl *et al*., 2000).

Application of Lactic Acid

In the pharmaceutical industry, lactic acid is used as an electrolyte in many parenteral or intravenous solutions that are prepared to replenish the bodily fluids. It is also used in large number of mineral preparations which includes tablets, prostheses, controlled drug delivery systems and surgical sutures (Wee *et al*., 2006). In the food industry, lactic acid is used as an acidulant due to its mild and palatable acidic taste and as preservative and pH regulator. As a result of its bactericidal activity, it is used as an inhibitor against bacteria growth in food processing. Lactic acid is also very effective in preserving and extending the shelf life of dairy products (Wee *et al*.,2006).

Lactic acid is considered an indispensable material in the chemical industry as a result of its desirable properties. It contains two reactive functional groups, a carboxylic group and a hydroxyl group. It functions as a descaling agent, neutralizer, chiral intermediate, cleaning agent and metal complexing agent. Lactic acid also finds applicability in the cosmetic industry where it is used as a moisturizer and skin brightening agent. The moisturizing effect is attributable to lactate's water-retaining capacity, and the skin-lightening action is caused by tyrosinase formation inhibition (Vijayakumar *et al*.,2008). Lactic acid is currently used as a feedstock monomer in the polymer industry for the production of polylactic acid (PLA). PLA, a biodegradable polymer, has numerous applications in activities such as food packaging, mulch film, trash bags and protective clothing (Vink *et al*., 2010).

Economic Benefits of Lactic Acid Production from Cahew in Nigeria

Agricultural development and the production of value-added products from farm residues are powerful tools to boost the economy of a nation, particularly a developing country like Nigeria. The issue of cashew apple losses on farm is of an immense importance in the efforts to propose an alternative source of income to the Nigerian government. After removing the cashew nut, the cashew apples are thrown away or dumped, where they undergo natural decomposition in the soil. This represents a waste of resources incurred during the different phases of cashew propagation and harvesting.

The wide application of lactic acid in various industrial processes corresponds to its higher demand. It is a high value-added product that has been gaining market share with each year (Albuquerque *et al*., 2015). The global consumption of lactic acid has been roughly estimated as 130,000-150,000 metric tons per year (Wee *et al*., 2006). The three largest consumer markets in the world are the United States, followed by China and Western Europe (Komesu *et al*., 2017). As stated here, Nigeria can improve its economy by taking advantage of the large global markets available to lactic acid production.

CONCLUSION

The use of cashew apple as an agro-source for lactic acid production would not only boost the Nigerian economy but also indirectly provide a cost-

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effective protocol to manage environmental pollution associated with cashew farming. At the same time, the rate of unemployment that has maintained a rising trend for several years in Nigeria would be significantly reduced.

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ORGANOLEPTIC PROPERTIES OF SOME ACCESSIONS OF SWEETPTATO ROOTS

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ABSTRACT

Sweetpotato is an underutilized crop with a high potential to improve food security and nutrition, especially through harnessing sweetpotato accession with high vitamin content and dry matter which will help in filling gap of nutrition and food in security. This research was developed in order to determine the organoleptic properties of selected accession of sweetpotato. The accessions were purchased at the point of harvest from Osun State University Teaching and Research Farm; University of Ibadan Teaching and Research Farm and from Local Farmers in Offa Kwara State. The accessions were washed, peeled, steamed and presented to 50 trained panelists in the laboratory of the Department of Agronomy, College of Agriculture, Osun State University, Ejigbo to determine the organoleptic properties (taste, flavor, texture, appearance, colour of peel and flesh and overall acceptability. Data collected were subjected to analysis of variance at 5% probability. For the organoleptic evaluation Offa accession was extremely liked due to the appearance, colour and taste among other qualities.

Key words; sweetpotato accessions, local farmers, organoleptic, offa accession

INTRODUCTION

Sweetpotato (*Ipomoea batatas* L.) is an important root crop grown in more than 100 countries worldwide (Osiru *et al*., 2009). In sub-Saharan Africa (SSA), it is cultivated in an area of about 3.22 million hectares with an annual production of 14.65 million tonnes which is about 12% of the world total production (FAOSTAT, 2015). Sweetpotato is grown for food, feed and income generation in many countries in Sub Saharan Africa (Low, *et al*., 2009). It is an important food security crop, often crucial during famine due to its excellent drought tolerance and rapid production of storage roots (Mukhopadhyay *et al*., 2011). It is a crucial crop in rural and marginalized communities including many HIV affected and women-headed households in eastern and central Africa (Johanson and Ives, 2001). It has supported more people per unit area than any other crop (Okada *et al*., 2002). In addition to serving as an important complementary food crop, It supplements household income through formal and informal trading at both rural and urban markets, thereby contributing to the alleviation of widespread food shortages and poverty for the majority of rural communities who are dependent on this crop (Mwanga and Ssemakula, 2011). Sweetpotato is a crop plant whose large, starchy, sweet-tasting storage roots are an important root vegetable (Woolfe. 1992). In 2008, Nigeria ranked second in sweetpotato production in Africa, with an annual production output of 2.6 million metric tonnes. While in global sweetpotato production, Nigeria was ranked third (FAO, 2008). These figures have changed in the last decade. Currently, Nigeria is the first largest producer of sweetpotato in Africa with 3.46 million metric tonnes annually (Udemezue, 2019).

MATERIALS AND METHODS

The experiment was conducted at the Laboratory of the Department of Agronomy, Osun State University Teaching and Research farm, Ejigbo Campus, Osun State Nigeria which lies between Longitude 4, 18°13.76"E and Latitude 7, 52°28.37"N during rainy season. Twenty-six (26) accessions of sweetpotato, collected from the University of Ibadan, Oyo State; local farmers in Offa, Kwara State and Teaching and Research Farm Osun State University, Ejigbo, were evaluated for the research (Table 1). The experimental materials were laid out in a Complete Randomized Design (CRD) with five replicates.

The sensory evaluation was carried on the taste, texture, appearance, colour of peel and flesh, flavour and overall acceptance of 26 accessions of sweetpotato roots. Mature tuberous root of each variety were washed and cooked for 15minutes. Each bag containing the sweetpotato roots were labeled and immersed in a pot of boiling water for 15 minutes. A sample of each accession was allowed to cool down and served among a taste panel for rating. The taste panel consisted of 50 people, and each person tasted a set of coded samples. After each tasting, the panelists rinsed their mouths thoroughly with clean water. Each consumers' rate for taste, texture, flavour and overall acceptability of the boiled sweetpotato tuberous roots was noted.

Organoleptic Evaluation

Fifty (50) randomly selected panelists drawn from Osun State University were used. Panelists who are familiar with the sensory properties of boiled sweetpotato roots assessed the prepared boiled sweetpotato for colour of peel and root, taste, texture, and flavor, overall acceptability, and the degree of likeness, using a 4-point Hedonic scale and 7-point Hedonic scale, Where:

1 = Very soft (texture); Poor (taste and flavor); Dislike very much (Overall acceptability).

2 = Soft (texture); Fair (taste and flavor); Dislike extremely (Overall acceptability)

3 = Hard (texture); Good (taste and flavor); Dislike moderately (Overall acceptability).

4 =Very hard (texture); Excellent (taste and flavor); Neither like or dislike (Overall acceptability).

5 = Like moderately (Overall acceptability).

6 = Like very much (Overall acceptability).

7 = Like extremely (Overall acceptability).

Statistical Analysis

Descriptive analysis was adopted, and data collected were subjected to Analysis of Variance at 5% probability.

Table 1. Accessions of Sweetpotato, Skin Colour and Flesh Colour

S/N	Sweet potato Accessions	Skin Color	Flesh Color	S/N	Sweet potato Accessions	Skin Color	Flesh Color
1	Bodija	Cream	Cream	**14**	Usman	Cream	Cream
2	Ladele	Cream	Cream	**15**	Offa 1	Cream	Cream
3	Omini	Dark Purple	Cream	**16**	Molete	Cream	Cream
4	Dammy	Purple	Pale Orange	**17**	Felicia NN	Cream	Cream
5	PK5	Purple	Cream	**18**	Felicia	Cream	Cream
6	PK3	Cream	Cream	**19**	Ojoo	Cream	Cream
7	Offa 2	Cream	Cream	**20**	Kin J	Purple	Cream
8	Oja Oba	Cream	Cream	**21**	BD	Cream	Cream
9	Doris	Cream	Cream	**22**	Orita	Cream	Cream
10	Yau	Cream	Cream	**23**	BV	Cream	Cream
11	Mother’s Delight	Cream	Cream	**24**	PK66	Purple	Cream
12	Ex-igbariam	Cream	Cream	**25**	PK55	Purple	Cream
13	Sango	Cream	Cream	**26**	BD	Cream	Cream

RESULTS AND DISCUSSION

Table 2 revealed that 70% of the respondents were between the ages of 15-30. The mean age of the respondent was 24.5 which implies that majority of the respondents were in the middle age. In addition, the distribution of the respondents by sex showed that majority (59.40%) were female compared to male (40.6%).

Taste evaluation

The response of the panelist on the selected sweetpotato accessions tested shows most of the accessions had sweet taste. Offa2 had excellent taste. Bodija, Ladele, PkS. Pk3, Doris, Yau, Mother’s Delight, Ex-Igbariam, Offa, Molete, Felicia NN. BD. and PK55 had good taste while Omini, Dammy, Oja Oba, Sango, Felicia, King J, Orita, BV and PK66 had fair taste, Ojoo had poor taste as shown in Figure 1.

Texture Evaluation

Figure 2 presents the variations in texture as described by the panelists, where most of the accessions were soft in texture. Bodija, Pk5, Mother’s Delight, Sango, Offal, Molete, and Felicia had hard texture. Ladele, Omini, Dammy, Pk3, Offa2, Oja Oba, Doris, Yau, Ex- Igbariam, Usman Felicia NN, Ojoo, King J, BD, BV, and Pk66 had soft texture. Orita, Pk55 had very soft texture.

Table 2: Socio economic characteristics of consumers

Characteristics		Frequency	Percentages (%)
Age			
0-15		5	10
15-30		35	70
30-45		7	14
45-60		3	6
Mean±Sd:	**24.5±10.11**		
Sex			
Male		13	40.60
Female		19	59.40

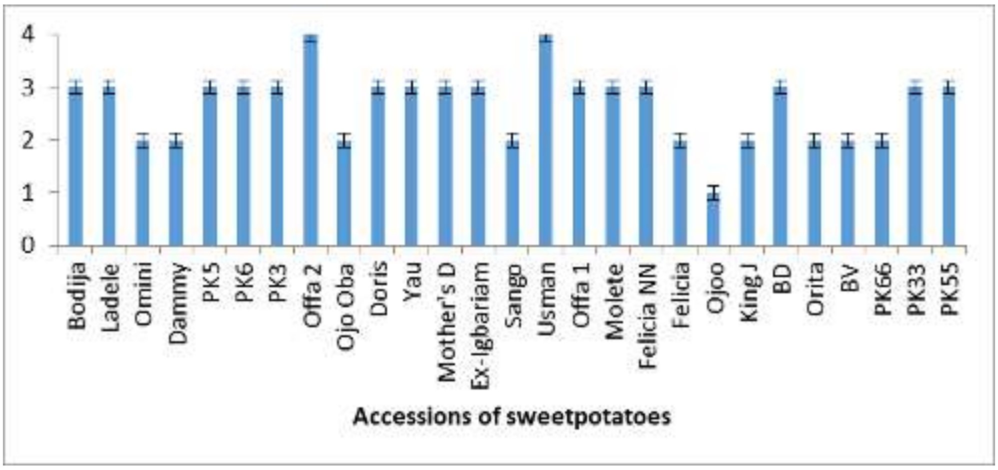

Figure 1: Taste of 26 accessions of sweetpotatoes.

Key: 1 = Poor; 2 = Fair; 3= Good; 4= Excellent

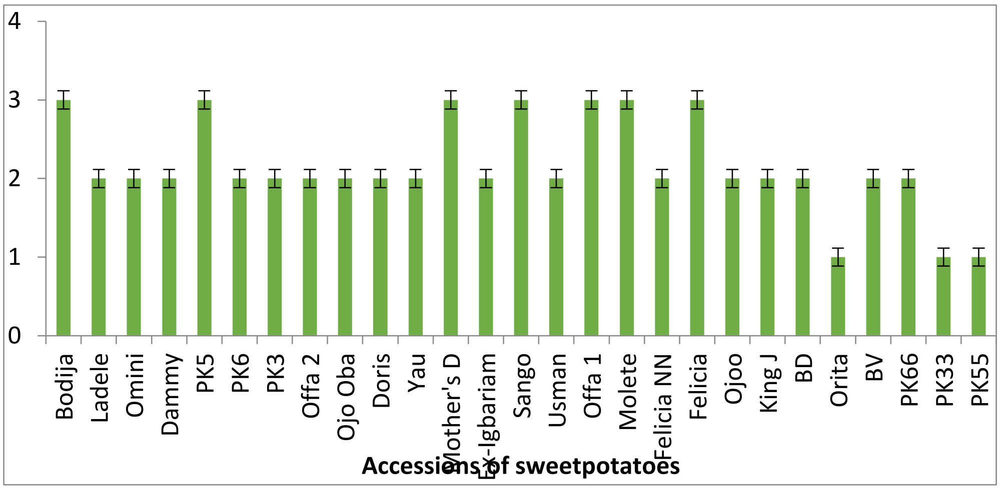

Figure 2: Texture of 26 accessions of sweetpotato

Key: 1 = Very soft (texture); 2 = Soft (texture); 3 = Hard (texture); 4 =Very hard (texture)

Flavour Evaluation

The outcome of the response of panelists on flavour of twenty-six accession of sweetpotato where most of the accession had good flavour. Usman accession had excellent flavour, Bodija, Ladele, Pk5, Pk3, Offa 2, Doris, Orita, Yau, Ex-Igbariam, Mother's Delight, Offa, Molete, Felicia NN, Felicia, and BV accession had good flavour. Omini, Dammy, Oja Oba, Sango, and PK 66, accession had fair flavour, Ojoo had poor flavour as shown in Figure 3.

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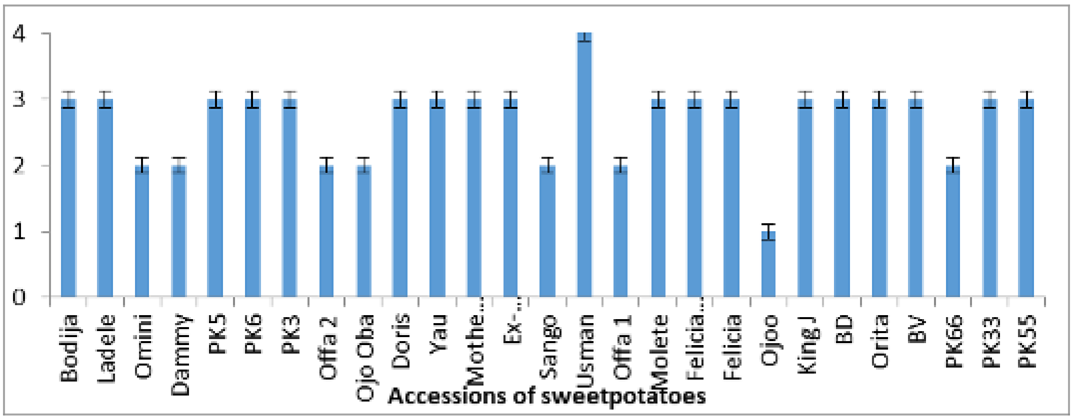

Figure 3: Flavour of 26 accessions of sweetpotato

Key: 1 = Poor; 2 = Fair; 3= Good; 4= Excellent

Appearance

The appearance of twenty-six accession of sweetpotato evaluated were good. Pk6, Pk3, Yau, and Felicia NN accessions had appealing appearance, while Ojoo had poor appearance as shown in Figure 5.

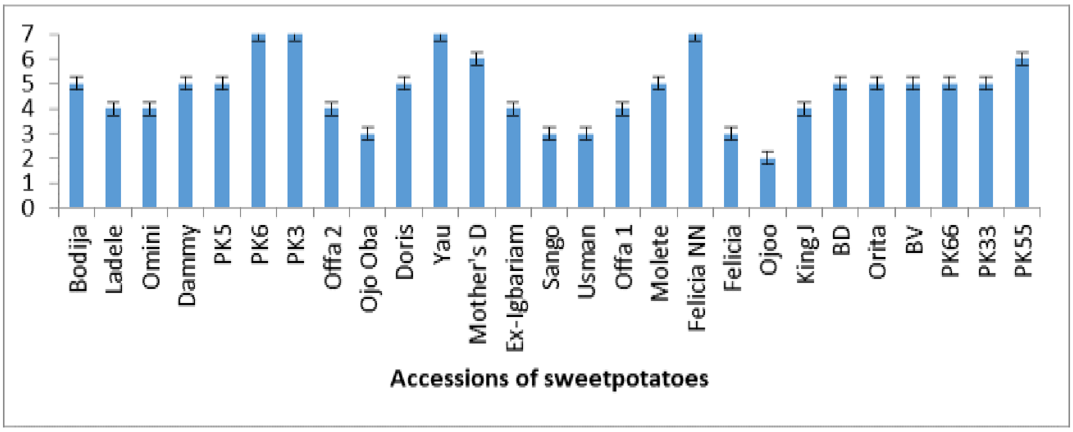

Figure 5: Appearance of 26 accessions of sweetpotato

Key: 1 = Dislike very much; 2 = Dislike extremely; 3 = Dislike moderately; 4 =Neither like or dislike; 5 = Like moderately; 6 = Like very much ;7 = Like extremely

Overall acceptability

The result obtained from the response of panelists showed that the acceptability of the accessions varied from each other where Offal had the highest acceptability rate, the accession was extremely liked, followed by Ladele, Felicia NN, BV accessions which were liked very much, accessions with the lowest rating are Ex-Igbariam and Sango which were disliked moderately (Figure 6).

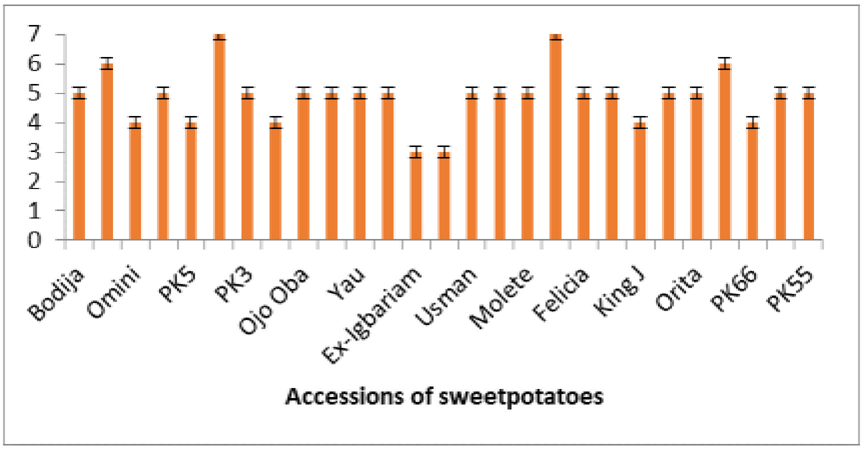

Figure 6: Overall acceptability of 26 accessions of sweetpotato

Key: 1 = Dislike very much; 2 = Dislike extremely; 3 = Dislike moderately; 4 =Neither like or dislike; 5 = Like moderately; 6 = Like very much; 7 = Like extremely

DISCUSSION

One of the world's greatest challenges is to secure adequate food that is healthy, safe and of high quality for all (Hunter and Fanzo, 2013). Sweetpotato is a nutritious food, low in fat and protein, but rich in carbohydrate. Both tubers and leaves are good sources of antioxidants (Teow *et al*., 2007). Sweetptato is grown for its multipurpose use. Both the root and vines are used for human food and animal feed. There has been a great deal of breeding effort focusing on developing sweetpotato varieties fortified with minerals for human consumption and not on vine yield. The mean age of the respondent was 24.5 which implies that majority of the respondents were youths, which implies they are willing and ready to try new products. Hence, the demand for new varieties to enhance nutrition and flexibility/diversity.

Several studies have shown that there are varieties with a potential of producing both root and forage (Lukyu and Agili, 2013). Therefore, the exposure of households to new varieties of sweetpotato will help to improve the livelihood of farmers, food security and nutrition of the rising populace. This was also supported by (Almekinders and Hardon, 2006) who reported that dissemination of dual purpose varieties could help improve the livelihood of herdsmen. Colour variability and taste of OFSP in relation to its acceptability is a prevalent problem which needs urgent intervention. Therefore, there is need to improve on the root and develop acceptable products needed to combat the prevailing hunger with increased population while improving profit maximization for farmers.

CONCLUSION AND RECOMMENDATION

Sweet potato is rich in diversity with colours ranging from cream to purple and orange. Majority rated offa accession with excellent taste with hard texture. While the flavor of Usman was preferred to others. The appearance of PK5, PK6, PK55, Felicia NN and Yau was also liked very much compared to others. Conclusively, PK6 and Felicia NN was accepted by majority. Conclusively, more enlightenment need to be conducted on the production, diversity and nutritional benefits of sweet potato accessions, both for the elites and rural community who may not be familiar with its availability and production.

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CAPACITY BUILDING ON AFRICAN BUSH MANGO (*IRVINGIA SPP.*) PRODUCTION AND PROCESSING IN SOUTHEAST NIGERIA: AN ASSESSMENT OF PARTICIPANTS' KNOWLEDGE

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ABSTRACT

Building the ability of stakeholders to follow appropriate procedures for production and processing of African bush mango is important for improved production/processing and increased income. This study thus assessed knowledge gained by participants during a capacity building programme on Irvingia spp. production and processing in Imo and Abia states. Stakeholders selected for the training were from an earlier need assessment/situation analysis conducted in Imo and Abia states. Aspects of the training taught were from propagation to field maintenance as well as processing using a manual Irvingia decorticator. Data was collected from stakeholders using structured questionnaire and analyzed with descriptive and inferential statistics (t-test). Most of the participants were male (54.6%), married (86.9%), and had up to 13 years of Irvingia production experience. However, 86.9% of the stakeholders were not aware of the manual Irvingia decorticator. The t-test result showed a significant difference in participants' pre and post knowledge assessment carried out. This implies an increase in knowledge of the subject matter was observed among the participants; this is expected to lead to improved production and processing of Irvingia kernels.

Key words: African bush mango, processors, producers, knowledge assessment, *Irvingia* manual decorticator

INTRODUCTION

African Bush Mango (*Irvingia spp.*) is a tropical African fruit tree that is highly valuable and an important Non-Timber Forest product in West and Central Africa (including Nigeria) with large production and economic potentials. It contributes to alleviating the food, nutritional and health needs of the people particularly in Africa (Okolo et al, 1995, Chadare et al, 2010, Ahenkan and Boon, 2011, Sossa-Vihotogbe et al, 2012). The fruit tree also plays a prominent role in the livelihoods of both urban and rural dwellers in and around the world (Tabuna, 2000). There are two types- the bitter and sweet Irvingia (*Irvingia wombulu* and *Irvingia gabonensis)* but the bitter type has more value and commands higher price in international/regional trade. *Irvingia* species are highly medicinal and used as thickener for soups mostly relished by people in Southern Nigeria. They are also used in the cosmetic industry (Lesley and Brown, 2004). African bush mango is mostly found growing in the wild and its commercial production is limited (Lowe et al, 2000). This is the reason for having more people involved in its collection than production thus; it is important to train *Irvingia* producers/collectors how to propagate the crop for optimum production.

Irvingia spp kernels are obtained by cracking the nuts which involves separating the kernels from the dried nuts. Processors make use of stone and knife to manually crack the nuts to obtain the kernels; a method which leads to injury of the processors' fingers as well as drudgery. This method also leads to reduction in the quality and quantity of African bush mango kernels available for sale by the processors. As a result, it is important to find a means of processing the nuts in a way that will retain the quality and quantity of kernels obtained (Busari et al, 2019). Studies such as Diabano, 2009, Busari et al, 2019 have carried out research on the design, fabrication and evaluation of performance of mechanical *Irvingia* nut crackers. Diabano 2009's study showed that moisture content of the Irvingia nuts did not affect cracking ability of the nuts. On the other hand, Busari et al, 2019 noted that cracking efficiency of the mechanical nut cracker was higher when the nuts used were of lower moisture content. The National Horticultural Research Institute, Mbato outstation, Okigwe designed and fabricated a manually operated *Irvingia* decorticator to reduce the drudgery associated with processing *Irvingia* nut and increase its market value. Owing to the fact that African bush mango processors are faced with these identified challenges, it is crucial to conduct capacity building activity on the use of this manually operated decorticator in a bid to introduce it to processors in the area.

Capacity is the ability of someone or a group of people to do something following appropriate procedures (UNDP, 2002). According to the Farmer-to-farmer blog (2015) of agrilinks.org, "capacity is the ability of people, organizations, and society as a whole to manage affairs successfully, to achieve goals and to satisfy the rights or expectations of citizens, customers and other stakeholders". Capacity of individuals can be developed by improving competence in both technical and soft skill which in turn contributes positively to effectiveness (Farmer-to-farmer blog, 2015). It involves the transfer of new knowledge, skills and competencies to individuals or groups in order to carry out their activities more efficiently and resourcefully (Yanseen et al, 2015). Learning and training (or capacity building) in agriculture (horticulture) contributes to poverty reduction by equipping farmers and other stakeholders with knowledge and skill required by them to raise their productivity and income (Ogundele et al, 2012) thus achieving improved livelihood. Capacity building and training are important components of research-for-development (Gordon and Chadwick, 2007). There are 3 levels of capacity building which are individual, organizational/institutional and societal (Kumari and Khanduri, 2019). It is important that training/capacity building activities should be on the needs/demand of the individuals/groups to be trained. Thus, arising from a needs assessment/ situation analysis on the African bush mango value chain carried out earlier in some states in Southern Nigeria (Abia, Imo and Rivers states), capacity building on the production and processing of *Irvingia spp*. was identified as an area of intervention. The situation analysis revealed that stakeholders (producers and processors) had limited access to improved seedlings and processing method considering the economic and health benefit of African bush mango kernels traded in the study area and beyond. As a result, a capacity building activity was conducted for selected stakeholders during which an assessment of knowledge gained on the propagation and processing of Irvingia fruits using *Irvingia* manual decorticator (processing machine/ nut cracker) was carried out.

MATERIALS AND METHODS

Participants were trained in two different locations- Mbato, Okigwe in Imo state and Abia state. The locations are accessible to the African bush mango producers and processors who were trained. Participants for the training (*Irvingia* producers and processors) were those present during the situation analysis earlier conducted. They were contacted through the Agricultural Development Programmes in Imo and Abia States. Also in Imo state, participants were from the neighbourhood of the National Horticultural Research Institute's sub-station at Mbato, Okigwe. The training covered four aspects:

- Propagation of Irvingia
- Seed extraction
- Nursery establishment and management
- Field establishment and other management practices
- Processing *Irvingia spp*. using the manually operated *Irvingia* decorticator

Practical demonstration was done and the participants had the privilege of hands-on experience on the use of the manually-operated *Irvingia* decorticator. To assess the immediate change in knowledge of individuals trained on the subject matter, knowledge gained was evaluated before and after the training and analyzed using the t-test.

RESULTS AND DISCUSSION

Profiling the participants' socio-economic characteristics, the study (Table 1) showed that 165 participants were trained in Imo and Abia states; however, only 130 completed pre and post evaluation questionnaire retrieved from the participants trained were found analyzable. A larger percentage of the participants were males (54.6%), married (83.9%) with average family size of 7 household members (6.6±2.3) and age of 50 years (49.5±11.7) respectively. Most of them had at least secondary education (65.4%) with an average of 13 years (12.8±9.6) of farming experience. Also, more than half of the participants (63.8%) belong to an association. This is supported by the study of Chah et al, 2014 which found that 56% of Irvingia farmers in Enugu state (part of southern Nigeria) were males, having on the average, a household size of 6 members and 16 years of experience in Irvingia farming. A sizeable proportion was not aware of the manual *Irvingia* decorticator (86.9%). However, 79.2% registered their willingness to use the manual decorticator. This implies that most of the stakeholders in *Irvingia* value chain trained were married, educated and experienced farmers. They were not aware of the manually operated *Irvingia* decorticator but were willing to use it for processing *Irvingia* nuts.

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Table 1: Socio-economic characteristics of participants

Variable	Frequency	Percentage	Mean (standard deviation)
Sex			
Female	71	54.6	
Male	59	45.4	
Marital Status			
Married	109	83.9	
Single	13	10.0	
Others	8	6.1	
Educational status			
No formal education	2	1.5	
Primary six	26	20.0	
Secondary School	38	29.2	
Tertiary	47	36.2	
Others	17	13.1	
Age			49.5(11.7)
Family size			6.6(2.3)
Years of experience			12.8(9.6)
Membership of association			
Yes	83	63.8	
No	47	36.2	
Awareness of manual Irvingia decorticator			
Yes	17	13.1	
No	113	86.9	
Willingness to use manual Irvingia decorticator			
Yes	103	79.2	
No	6	4.6	
Uncertain	21	16.2	

Source: Field survey 2018

Pre and Post Knowledge Assessment of participants

There was an increase in the overall mean scores of participants when their knowledge was assessed using the pre and post evaluation questionnaire (4.4±2.3 versus 5.3±2.5 for pre and post scores respectively) (Table 2). The t-test result showed significant difference in the knowledge of participants before and after the training sessions (t=4.1, p=0.000). This revealed that participants' knowledge increased after the training. This agrees with the finding of Olajide-Taiwo et al, 2018 who found a significant difference in the pre and post knowledge assessment of participants during a training programme on ginger and turmeric production techniques in Oyo state, Nigeria. Thus, the training programme is expected to lead to the use of improved seedlings for production and manual *Irvingia spp* decorticator which will increase *Irvingia spp* production, processing and ultimately income of the stakeholders.

Furthermore, participants stated that apart from the process of seed extraction taught as well as the practical demonstration on the use of the manual *Irvingia* decorticator, they benefitted from the training sessions on cultivation of *Irvingia*, and its medicinal and industrial uses among others.

Table 3: Pre and Post Knowledge Assessment of participants

Score	Mean	Standard Deviation	Std error Mean	Df	T value	Sig level
Post score versus Pre score	0.9	2.6	0.2	129	4.1	.000
Post knowledge score	5.3	2.5	0.2			
Pre knowledge score	4.4	2.3	0.2			

Source: Field survey, 2018

CONCLUSION AND RECOMMENDATION

This study assessed the change in knowledge of participants during the capacity building programme on production and processing of African bush mango (*Irvingia spp*.) held in Imo and Abia states. Capacity building is important for enhanced sustainable development while a pre and post training knowledge assessment is required to establish the immediate change in knowledge of the participants as a result of the training. Most of the participants were male (54.6%), 65.4% had at least secondary education, 86.9% were married while most of them had 13 years of experience also, 89.6% were not aware of *Irvingia spp.* manual decorticator. Findings revealed a significant difference in participants' knowledge in the pre and post knowledge assessment conducted. Moreover, the participants stated that they are willing to make use of the knowledge gained during the training. This is expected to improve Irvingia production and processing in the study area. In order to assess the outcome of knowledge gained during the capacity building programme, monitoring of the participants is imperative.

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ECONOMICS OF *INVIRGIA WOMBOLU* "OGBONO" KERNEL PROCESSING IN OGBADIBO LOCAL GOVERNMENT AREA OF BENUE STATE, NIGERIA

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ABSTRACT

The study examined the economics of invirgia wombolu "Ogbono" kernel processing in Ogbadibo Local Government Area of Benue state, Nigeria. Multistage and random sampling techniques were used to select 100 respondents for the study. Data were collected with the aid of structured questionnaire and personal interview. Analyses of data were achieved using descriptive statistics, cost and return and multiple regression and Likert-scale model. The result of the study shows that Ogbono kernel processing was a profitable business with a net return on investment value of about 57k for every ₦1.00 invested in the business. Females (62%) were mostly involved in the processing exercise than males (38%) with average age of 35 years and have 15 years of experience in processing with an average annual income ₦125, 500.00 from the business. More so, high cost of Ogbono fruit and labour had affected the farmers 'output. Though the observed constraints such as injury sustained during cracking of the kernels and high cost of labour had seriously affected the processing of Ogbono kernel in the area. It was therefore recommended that the farmers should form a cooperative society to enable them attract the attention of both government and non-governmental organization that can intervene by providing and training the farmers on any available modern processing technique. This cooperative society will also help them to get meaningful financial assistance from government or other non-interest based financial institutions.

Key words: irvingia wombolu, "ogbono", processing, gross margin, profitability.

INTRODUCTION

Irvingia gabonensis and *Irvingia wombolu* commonly known as African mango, bush mango or wild mango is an important Non-Timber Forest Products (NTFPs) that has been a valuable source of income to the rural people and the urban poor in Nigeria. It belongs to the family *Irvingia*ceae (Arowosoge, 2017). There are seven listed species of the *Irvingia* genus; six of which are native to tropical Africa and one species native to South-east Asia. Of the six species native to tropical Africa only two are economically important: *Irvingia gabonensis* var. *gabonensis*, and *Irvingia gabonensis* var. *excelsa* which was renamed to be *Irvingia wombolu* (Harris, 1996). The two are very similar with the exception that *Irvingia gabonensis* has a sweet edible pulp (mesocarp) and the stone is usually split to reveal its kernel which is the product that is used for soup thickening in most parts of Nigeria but the kernel is less slimy while *Irvingia wombolu* has a bitter inedible pulp and the fruit stone is also extracted to produce the kernel which is often known as '*Ogbono* which is slimier (Okafor, 1975). It is worthy of note that in Nigeria, both the pulp and dry kernel of *Irvingia gabonensis* are traded while only the dry kernel of *Irvingia wombolu* are traded. However, *Irvingia wombolu* kernel commands more price and demand due to the high slimy consistency produced in soup making when compared with *Irvingia gabonensis* kernels (Awe et al, 2012). *Irvingia* trees are a valuable source of income for West and Central African farmers. The fruits are sold, but by far the most important product is the kernels, which fetch a price several times higher than the fruits. The trade in kernels not only benefits the producers financially, but also generates income for traders (Babalola and Agbeja, 2009).

Ogbono is a wonderful soup thickener and flavouring ingredient in many parts of Nigeria and Africa in general, it is a very lucrative source of income and essential raw materials for the pharmaceutical industries and most importantly, potential foreign exchange earnings. Joseph (1995) listed the potential industrial applications of *Irvingia* kernel oil/fat to include cooking oil, margarine, perfume, soap and pharmaceuticals. The pulp can be used for the preparation of juice, jelly and jam. The kernel is also used in making fatty paste called "dika", which is the major ingredient in making of "Gabon Chocolate" or "dika bread" (Ugwumba *et al*., 2013). Irvingia shells are used as fire wood materials when fully dried.

Irvingia species can be found in the forests (wild) and can be domesticated in the farms or gardens. Irvingia fruit, for fresh eating and for their kernels could be picked from forests, farms or gardens.

Many families depend on picking of irvingia fruit as supplementary source of income for their survival, and some families use to buy from others or people that picked and don't want to process them. Picking of irvingia fruit from the field takes place between December to April for *Irvingia wombolu,* May to July for *Irvingia gabonensis*. Pickers of irvingia fruit are mostly children and women, and few young and adult males. The women and children are sometimes restricted to pick from nearby farms and nearby village forests only. While the adult and young males are involved in picking from any available forests or farms, which could be daily, two or three days intervals or even on weekly basis. Sometimes the fruit are processed in the forests or in the farms to reduce the load weight when carrying it home, however, women and children usually feel more comfortable when processing irvingia fruit at home than in the bush or farms for security reasons (Ladipo et al., 1996). Processing of "Ogbono" kernel is seasonal and so, the processors engage in other employments such as trading, farming and art work.

Processing of irvingia kernels in the study area is highly constrained by many factors particularly the use of traditional processing techniques. This situation made it necessary for this study to determine the economics of *invirgia wombolu* "Ogbono" kernel processing with the following objectives; to describe the socioeconomic characteristics of the "Ogbono" kernel processers in the study area; establish the profitability of "Ogbono" processing in the area; and identify constraints to processing.

MATERIALS AND METHODS

The study was carried out in Ogbadibo Local Government Area (LGA) Of Benue State, Nigeria in 2021. It is one of the 23 LGAs of Benue State and among the nine LGAs in agricultural Zone C. Ogbadibo LGA is made up of three districts which are Otukpa, Orokam and Owukpa. It Consists Of 16 Communities which include Ai-Oono 1, Ai-Oono 2, Ai-Oono 3, Olachagbaha, Ai-Oodo 1, Ai-Oodo 2, Orokam 1, Orokam 2, Orokam 3, Itabono, Ehaje 1 and Ehaje 2. The LGA covers an area of about 598km^2. The estimated population was 130,988 people in 2006 population census. The area is located between latitudes 7^o5^1E 21^{11}N and longitudes 7^o38^1 60^{11} E . It is bounded in the north by Olamaboro LGA of Kogi state, Isi-Uzo LGA of Enugu state to the south, to the west by Udenu and Igbo-Eze North LGA of Enugu State and Okpokwu LGA of Benue state to the east. The people produce crops like cassava, yam, beniseed, bambara nut, melon, oil palm, palm wine, Ogbono, groundnut and so on. Multistage and random sampling techniques were used to select 100 respondents for the study. The first stage involved the selection of ten communities out of the thirteen communities in the area. Stage two entailed a selection of two (2) villages from each of the ten selected communities to get 20 villages. Finally, five Ogbono kernel processing farmers from each of the 10 villages were selected to obtain a total of 100 respondents. Primary data were collected using copies of questionnaire which were administered to the respondents and oral interview.

Analytical models

Descriptive statistics such as means and percentages were used to analyze data on socioeconomic characteristics of the respondents. Gross margin and Multiple Regression analysis was used to explain the profitability of the enterprise while Likert-scale was used to analyze the constraints.

GM=TR-TVC

NPI (Profit) =TR-TC (TVC+TFC)

Where

GM= Gross Margin (N), TR=Total Revenue (N), TC= Total cost, TVC=Total Variable Cost (N)

and NPI=Net Processing Income (Profit)

The multiple regression models used to establish the profitability of the enterprise is implicitly given as:

OOKP =f(COf, COL, PRT)

Explicitly, the model is given as:

$OOKP = \beta_o + \beta_1 COf + \beta_2 COL + \beta_3 PRT + e$

Where

COf= Cost of Ogbono fruit, OOKP= output of Ogbono kernel Processing (kg), COL=cost of labour

PRT=processing technology (dummy: traditional method=0, improve technology=1) and e_i=error term

Four functional forms of regression model (linear, exponential, semi-log and double-log) were tried with the data. The one that gave the best fit in terms of value of co-efficient of multiple determinations and number of significant variables was chosen as the lead equation. The functional forms are given as:

Linear: $OOKP = \beta_o + \beta_1 COf + \beta_2 COL + \beta_3 PRT + e$, Exponential; $\log OOKP = \beta_o + \beta_1 COf + \beta_2 COL + \beta_3 PRT + e$, Semi-log: $OOKP = \beta_o + \beta_1 COf + \beta_2 COL +$

β_3PRT+e and Double-log: log OOKP = $\beta_o+\beta_1$COf + β_2COL + β_3PR +e

Likert –scale model

$$X = \frac{ns}{N}$$

Where

n=number of respondents, s= Likert scores and N= total number of population

Decision rule; reject for factors scored ≤2.5 otherwise accept.

RESULTS AND DISCUSSION

Result presented in table 1 shows that majority of the irvingia kernel processors were females (62%), and 38% were males, indicating that females were more involved in Ogbono kernel processing than males in the area which is collaborated by the findings of Ugwumba et al, 2013 that females are more in the processing of Ogbono kernel than their male counterpart. The average age of the farmers was 35years, which is a good mean age for meaningful Ogbono kernel processing; also, majority (61%) of the farmers were married and 24% were single and the average household size was 13 members. Again, greater percent (64%) and (24%) had secondary and tertiary education respectively. The mean for experience in processing was 15 years and all (100%) the farmers used both family labour and hired labour. Most of the farmers (58%) had no contact with any extension agents concerning Ogbono kernel processing technique while 42% of them had actually been in a discussion with extension agents and none of the respondents (100%) belongs to any Ogbono co-operative organization. Again, all the respondents (100%) sourced Ogbono fruit both from the forest and farms while engaging the traditional processing technology (100%) only. However, the average annual farm income from Ogbono kernel processing was N125, 500.00.

Gross margin analysis was adopted in analyzing costs and returns in Ogbono kernel processing in the area. Results obtained in table 2 shows a gross margin, net processing income and net return on investment values of ₦ 458, 650.25; ₦ 312, 150.00 and 0.5685 each. The net return on investment value of 0.5685 implies that the respondents returned about 57k for every ₦1.00 invested in the business implying that Ogbono kernel processing is a profitable business in the study area (Table 2).

The four forms of multiple regression analyses were employed to estimate Ogbono kernel processing output. From the values of estimated parameters such as coefficient of multiple determination, R^2 and number of significant parameters, double-log function was therefore chosen and result is presented in table 3. Cost of fruit was negatively signed and statistically significant at 1% level, this implied that the variable negatively influenced the output of Ogbono kernel processing in the area; this means that the higher the cost of Ogbono fruit purchased the lesser the output of the kernel processed. This is because increase in cost of a produce usually; result to decrease in the quantity demanded of the same produce. Thus, the aprior expectation was met. Again, cost of labour was negatively signed and statistically significant at 5% level, meaning that increase in the cost of hiring labour will lead to decrease in the quantity of Ogbono kernel processed. Hence, the aprior expectation was met. However, processing technique was positively signed and statistically significant at 1% level, this is because the farmers used majorly traditional processing technique involving machetes, knives, basins and dried wood which have enabled them to achieve their level of output in the business. That is, this method of processing has good relationship with the output of Ogbono kernel and had positively influenced the income of the farmers. Thus, the aprior expectation was met. Meanwhile, the high value of R^2 implied that the independent variables examined significantly caused about 86.8% change in the output of Ogbono kernel processing in the area. The remaining 13.2% was due to error. The F-statistics value of 341.31 was significant at 1% level and so, confirmed the overall significance of the regression analysis. Durbin- Watson statistic value of 2.01 indicated absence of autocorrelation among the factors observed.

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Table 1: Socio-economic characteristics of the irvingia wombolu kernel farmers

Variables	Frequency	Percentage (%)	Mean
Gender			
Male	38	38	
Female	62	62	
Age			
≤20	16	16	
21-30	22	22	
31-40	41	41	35.5
41-50	21	21	
51 and above	0	0	
Marital status			
Married	61	61	
Single	24	24	
Divorced	5	5	
Separate	10	10	
Household size			13
≤10	26	26	
11-15	46	46	
≥16	28	28	
Occupation of respondents			
Educational attainment			
No formal education	0	0	
Primary education	12	12	
Secondary education	64	64	
Tertiary education	24	24	
Years of processing experience			15.5
≤10	8	8	
11-15	52	52	
16-20	24	24	
≥21	16	16	
Source of labour			
Family labour	100	100	
Hired labour	100	100	
Members of ogbono social organization			
Yes	0	0	
No	100	100	
Contact with extension agents	42	42	
Yes	58	58	
No			
Source of ogbono fruit			
Forests	100	100	
Farm/garden	100	100	
Both forests and farm	100	100	
Processing technology			
Traditional	100	100	
Improved processing technology	0	0	
Annual ogbono processing income			125,500
≤N50,000.00	7	7	
N51,000.00-N100,000.00	13	13	
N101,000.00-N150,000.00	13	13	
N151,000.00-N200,000.00	41	41	
≥N201000.00	26	26	

Source; field survey, 2021

Table 2. Estimated cost and benefit of Ogbono kernel processing

Variable	Unit value	Average quantity value	Amount (N)
Total Revenue (TR)			861,250.25
Variable costs:			
ogbono fruits	10,000/50kg bag	28 50kg bags	280,000
Labour	2000/manday	10manday	20,000
Transport	66,000	66,000	66,000
Miscellaneous expense			36,600
Total variable costs (TVC)			402,600
Fixed cost:			
Knife	1,300	5	6,500
Matchet	3000	6	18,000
Wheel barrow	16,000	3	48,000
Basket/basin	500	16	8,000.25
Storage container	6,000	11	66,000
Total fixed cost (TFC)			146,500.25
Total cost (TC=TVC+TFC)			549,100.25
Gross margin (GM=TR-TVC)			458,650.25
Net Processing Income (NPI) = TR-TC			312,150.00
Net Return On Investment (NROI) =NPI/TC)			0.5685

Source: Field survey, 2021. N= number of respondents

Table 3: Estimates of Ogbono kernel processing output

Variables	Linear	Exponential	Semi-log	Double-log
Constant	-6.703 (-3.28)	2.0160 (6.38)	-580.80 (-6.20)	2.88760 (9.00)
COF	0.0182 (213.56)**	-0.0601 (9.22)**	-12.8800 (6.45)**	-1.8435 (24.21)* **
COL	-0.0277 (1.95)**	-0.0042 (-3.11)	-214.3013 (3.13) **	-0.3172 (2.09)**
PRT	0.0342 (0.64) ***	0.0564 (0.55) **	-63.25 (-0.30) **	0.6701 (0.93) ***
R^2	0.778	0.5735	0.781	0.868
$\bar{R}^2$	0.598	0.480	0.612	0.772
F-statistics	1152.13	10.33	40.62	341.31
Durbin-Watson- statistics	2.05	1.04	1.35	2.01

Source: Field survey, 2021. *and**=significant at 1% and 5% probability level each

Table 4, shows factors that significantly militated against Ogbono kernel processing in the area include, finger wounds when cracking the kernels(x=3.75) which usually occur when the fruit slicing target is missed or when the machete is wrongly placed on the fruit, high cost of labour (x=3.46) that could be associated with high inflation rate in the country or scarcity of young people in the business as a result of the high level of drudgery involved. Rough and stained palms when handling the monocarp (x=3.44) that is always slimy and yellowish in colour, lack of capital (x=3.28) associated with poor level of income in the area, waist pains, shoulder pain, others (x=3.20), and high cost of transportation (x=2.74) in the country.

CONCLUSIONS AND RECOMMENDATIONS

Ogbono kernel processing was a profitable business with net return on investment value of about 57k for every N1.00 invested in the business though so tedious because of the traditional processing technique that was majorly engaged in the study area. Females were mostly involved in the processing exercise than males with average age of 35 years and have good years of processing experience of 15 years, while, the average annual income from the business was N125, 500.00. More so, high cost of Ogbono fruit and labour had affected the farmers'output, however, the traditional processing technique used had enabled the farmers to achieve their certain level of output. Among the various constraints experienced by the respondents in the processing of Ogbono in the study area are injury encountered during cracking, high labour cost, stained palms etc. It was therefore recommended that the farmers should form a cooperative society to enable them attract the attention of both government and non-governmental organization that can intervene by providing the farmers with any available modern processing technique. This cooperative society will also help them to get meaningful financial assistance from government or other interested based financial institutions.

Table 4: Factors Constraining Ogbono kernel processing

Factors	Mean score	Decision
Finger wounds when cracking the kernels	3.75	Accept
High cost of labour	3.46	Accept
Rough and stain palms when handling the mesocarp	3.44	Accept
Lack of capital	3.28	Accept
waist pains, shoulder pain, and others	3.20	Accept
High cost of transportation	2.74	Accept

Source: Field survey; 2012.

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DISSEMINATION OF COCOA POD HUSK TECHNOLOGY AS A PART- SUBSTITUTE FOR MAIZE IN POULTRY FEED IN CRIN ADOPTED VILLAGE AND SCHOOL

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ABSTRACT

One of the major objectives of Cocoa Research Institute of Nigeria (CRIN) is to investigate the effective utilization of the crops and their by-products, and the feasibility of small-scale production of such end-use products. Based on this objective, cocoa pod husk (CPH) is one of the major by-products of cocoa and has been utilized effectively by CRIN through its inclusion in poultry feeds. The adopted village and school concept was a collaboration between Agriculture Research Council of Nigeria (ARCN)/West Africa Agricultural Productivity Programme (WAAPP) and CRIN. The poultry project in the CRIN adopted village and school is to encourage secondary school students to develop interest in agriculture and for farmers to increase their livelihood activities by reducing the cost of buying layers' mash. This technology was demonstrated in CRIN adopted village such as Aba-Agbo Community in Oyo state, and CRIN adopted school such as Mamu Community Comprehensive High School in Ogun state. The inclusion of CPH in layers' mash reduced the quantity of maize in the formulated feed by 20% (most especially in layers' mash). This was demonstrated by feeding equal number of birds with conventional feed (control) and CPH-based diet for 16 months (experimental). The result revealed that about N495 was saved on every 25kg of CPH-based feed, compared to conventional feed. Egg production was also similar to that of control. This resulted in a significant decrease in feed cost on CPH-based feed when compared to conventional feed, thereby increasing the farmers' profit margin. However, COVID-19 pandemic which eventually led to lockdown nationwide, posed some challenges such as theft of experimental eggs and birds as well as transportation restrictions to the project. In conclusion, the idea of substituting quantity of maize with CPH in poultry diets reduces the production cost and increased farmers' income. It is recommended that CPH may be used as a part- substitute for maize in poultry feed.

Key words: Farmers, Students, CPH, Poultry feed, Adopted Village and School.

INTRODUCTION

Cocoa-Pod Husk (CPH) is a by-product of cocoa and it forms about 80% of the cocoa fruit. It is essentially a waste product except for the negligible amount used in the manufacture of local soap and feeding of livestock (Eghosa *et al.*, 2010). CPH is usually an under-utilized agro-waste from cocoa, which could serve as good nutritional source for monogastric animals (Adeyeye *et al*, 2017). It is estimated that 0.8 to 1.0 million tons of CPH is generated annually in cocoa farms in Nigeria (Ojeniyi, 2006). Very little of the potentials locked up in this by-product have been exploited (Egbe and Olubamiwa, 1989). However, CPH can be incorporated into layers' diets to serve as a substitute or reduce the quantity of maize. The inclusion of CPH in layers' mash will reduce quantity of maize by 20%, thereby reducing the ever soaring cost of maize. The increase in the price of conventional feed ingredients, especially maize constitutes the primary cause of the rise in animal feed production cost, subsequently making animal protein cost very high (Adeyeye *et al*, 2017). The replacement of one or more major ingredients in conventional feed will significantly reduce the production cost of animal feed thereby increasing access to animal protein (Adeyeye *et al.*, 2017). According to Agunbiade and Olubamiwa (2002), CPH contains protein, energy and fibre, which are important ingredients of livestock feed.

Commercial poultry production provides easily accessible and affordable meat and eggs. About 80% of the world population gets most of their basic nutrients like proteins, fats and vitamins from meat and eggs (FAO, 2009). Presently, in Nigeria and other developing countries, despite the recent relatively rapid expansion in the livestock industry, protein consumption is 75% below the FAO requirement (Ibe, 2000). High cost of animal production results in high cost of animal protein thereby reducing the affordability of animal protein. Therefore, reducing the cost of animal production by using by-products from crops will greatly increase the affordability of animal protein.

The demand for maize increases yearly due to rising population and urbanization, as well as the growing poultry and fish industrial sectors of the economy (Djim koffi *et al.*, 2020). Maize being one of the major ingredients used in producing animal feed is exposed to several production risks, ranging from the disastrous effects of army worms, destruction of several maize farms by grazing cattle, farmers/ herders clashes and effect of climate change and so on. These factors combined have led to a sharp increase in the price of maize, which forms the major ingredient in poultry feed. Hence, a way to curtail the rising cost of feed would be by substituting some quantity maize with CPH, which is almost cost free.

The Agricultural Research Council of Nigeria (ARCN) in collaboration with Cocoa Research Institute of Nigeria (CRIN) initiated the adopted village and school concept in year 2009. The West African Agricultural Productivity Programme (WAAPP) embraced the idea and used it to reposition technologies development and dissemination in all research institutes in the country. This led to the establishment of different intervention projects such as poultry, fishery and arable crops production. The projects were demand driven by the host communities irrespective of the institutional mandates. The major purpose of these projects is to disseminate developed technologies in research institutes to farmers in nearby communities and to encourage youth involvement in agriculture. So to demonstrate this, the inclusion of CPH to replace 20% maize was carried out by CRIN with following specific objectives:

- to encourage the inclusion of CPH in poultry feed formulation,
- to inspire students' interest in agriculture from their tender age,
- to increase the income of farmers by reducing cost of poultry production,
- to encourage students and teachers to be job creators.

MATERIALS METHODS

The study was carried out in Mamu Comprehensive High School in Ogun state and Aba Agbo community, in Oluyole Local Government Area, Oyo state. Both school and the village fall within 5km range to the headquarter of CRIN as stipulated by ARCN. Mamu Comprehensive High School was purposively selected because it represents the school the poultry experiment was conducted and Aba Agbo was purposively selected because of their strong willingness to adopt technologies developed by CRIN. A participatory approach was adopted, with the beneficiaries (Agricultural Science students in Mamu Secondary School and farmers in Aba-Agbo) assisting in feeding the birds, water-supply, as well as providing partial security over the poultry pen. CRIN, in collaboration with ARCN built the poultry house and put battery cages. CRIN supplied the birds, vaccines, partial labour, security including other logistics. The Principal and Agricultural Science Teachers in the School organized students to ensure maximum participation and cooperation. The spaces for the poultry houses were provided by the school authority and farmers with the approval of the village head in Aba-Agbo.

Eighty (80) point-of lay birds (18 weeks) Bovan Brown breed were stocked in two different cages, forty (40) birds per cage. They were fed with conventional feed till 20 weeks to attain optimum laying capacities, after which the two categories of birds were fed differently with CPH-based diet and the conventional feed. Data were taken daily on eggs production, feed consumption, and vaccination in both categories. The results observed were explained using graphs, tables and charts.

Processing of CPH

Disease free and fresh cocoa pod were harvested, broken with the use of a club, after which the cocoa beans and placenta were removed. The husks were chopped into smaller sizes to hasten the drying process. Thereafter the husks were sundried to attain a moisture content of about 10%. The dry processed husks were reduced to smaller particles and stored in sacks on wooden pallets until it was later mixed by formula into the compounded feed.

RESULTS AND DISCUSSION

Table 1 shows the feed formulation for both conventional and CPH-based feed. It can be observed that 20% of the maize in the convectional feed was replaced by CPH in the feed. The 20% of 45 kg is 9kg, so 9kg CPH was included in CPH-based feed unlike in the conventional feed.

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Table 1: Feed formulation table for the conventional feed and CPH fortified feed

S/N	Ingredient (conventional)	Percentage	Ingredient (CPH-based)	Percentage
1	Maize	45	Maize	36
2	CPH	-	CPH	9
3	Soya meal	10	Soya meal	10
4	Wheat offal	12	Wheat offal	12
5	Limestone	8.6	Limestone	8.6
6	Bone meal	2.0	Bone meal	2.0
7	PKC (Palm kernel cake)	6.5	PKC	6.5
8	Groundnut cake	15	Groundnut cake	15
9	Premix	0.25	Premix	0.25
10	Toxin binder	0.15	Toxin binder	0.15
11	Salt	0.3	Salt	0.3
12	Super liv	0.05	Super liv	0.05
13	Lysine	0.15	Lysine	0.15

Source: field survey, 2020

Calculations based on price differences between conventional feed and CPH-based feed

Calculation for conventional feed

Price of conventional feed per 25kg bag is N 4,900 (conventional feed comes in a 25kg standard bag)

Price of maize per kg is N220

But in a 100kg of conventional feed, maize constitutes 45kg (check in table 1)

Hence, N220 x 45kg = N9,900

Since there are four 25kg bags in a 100kg bag of feed

Therefore 9,900 / 4 = N2,475

This means that the share cost of maize in a 25kg bag (which costs N4,900) of feed is N2,475, while the share cost of other ingredients isN2,475 (i.e. N4,900 –N2,475)

By this calculation, maize makes up to half or 50% of the cost of a 25kg bag of conventional feed

Calculation for CPH fortified feed

In a CPH-based feed, 20% of maize is substituted with CPH.

20% of 45kg (45kg being the quantity of maize in a 100kg of conventional feed) is 9kg

45kg – 9kg = 36kg

Market price of maize (at the time of execution) was N220 per kg.

N220 x 36kg = 7,920

Since there are four 25kg bags in a 100kg bag of feed as shown above

Therefore 7,920 / 4 = 1,980

This means that the share cost of maize for a 25kg bag of CPH-based feed is N1,980, which is against the original cost of N2,475 for a 25kg bag of conventional feed.

Therefore, a 25kg bag of CPH-based feed is cheaper by N495 (i.e. N2,475 –N1,980) than a 25kg bag of conventional feed

Production record for both conventional and fortified feed with CPH

Table 2 shows the eggs laid by birds fed with conventional feeds and CPH-based feed. It can be observed that egg production dropped significantly in July, 2020 (659), December, 2020 (670) and January, 2021(443), this was due to the diversion of the money realized from sale of eggs to other school projects by the school principal, so birds were not fed properly. This finding corroborates Hagger *et al*. (1989) that found out that feed is the most important single cost item in egg production of laying birds and a reduction in feed consumption will affect the laying capabilities of birds. It can also be observed that egg production increased significantly in February, 2021 (1,268) this was due to intervention by CRIN to supply feeds and some multivitamins to the birds. So egg production peaked up again. Jeroen Visscher, |(2017) confirms that high performance laying birds needs a perfect feeding strategy to maintain the diserable laying performance level.

Table 2: Production record for both conventional and fortified feed with CPH

S/N	Month	No of bird fed with regular feed(control)	No of egg laid per month	No of bird fed with CPH-based feed	No of egg laid per month	Total no of bird	Total of egg laid (Pulled)
1	November, 2019	40	31	40	30	80	61
2	December, 2019	40	392	40	390	80	782
3	January, 2020	40	770	40	769	80	1,539
4	February, 2020	40	885	40	884	80	1,769
5	March, 2020	40	770	37	760	77	1,530
6	April, 2020	37	602	36	598	73	1,200
7	May, 2020	37	450	36	446	73	896
8	June, 2020	37	535	36	534	73	1,069
9	July, 2020	33	329	35	330	68	659
10	August, 2020	33	558	35	562	68	1,120
11	September, 2020	33	671	35	679	68	1,350
12	October, 2020	33	810	35	825	68	1,635
13	November, 2020	33	669	33	667	66	1,336
14	December, 2020	33	340	31	330	64	670
15	January, 2021	33	225	31	218	64	443
16	February, 2021	33	635	31	628	64	1,268

Source: field survey, 2020

Chart showing eggs laid by birds fed with conventional feeds and CPH-based feed

Figure 1 shows the result of the egg laid by birds fed with conventional feeds and CPH fortified feed. It can be seen that the difference between the two feeding ingredients is almost marginal. This finding is corroborated by Ashade *et al.* (2010), who observed that 100% maize substitution with CPH had no significant effect on the survival, weight gain, and feed conversion ratio at a reduced cost in the diet of laying birds.

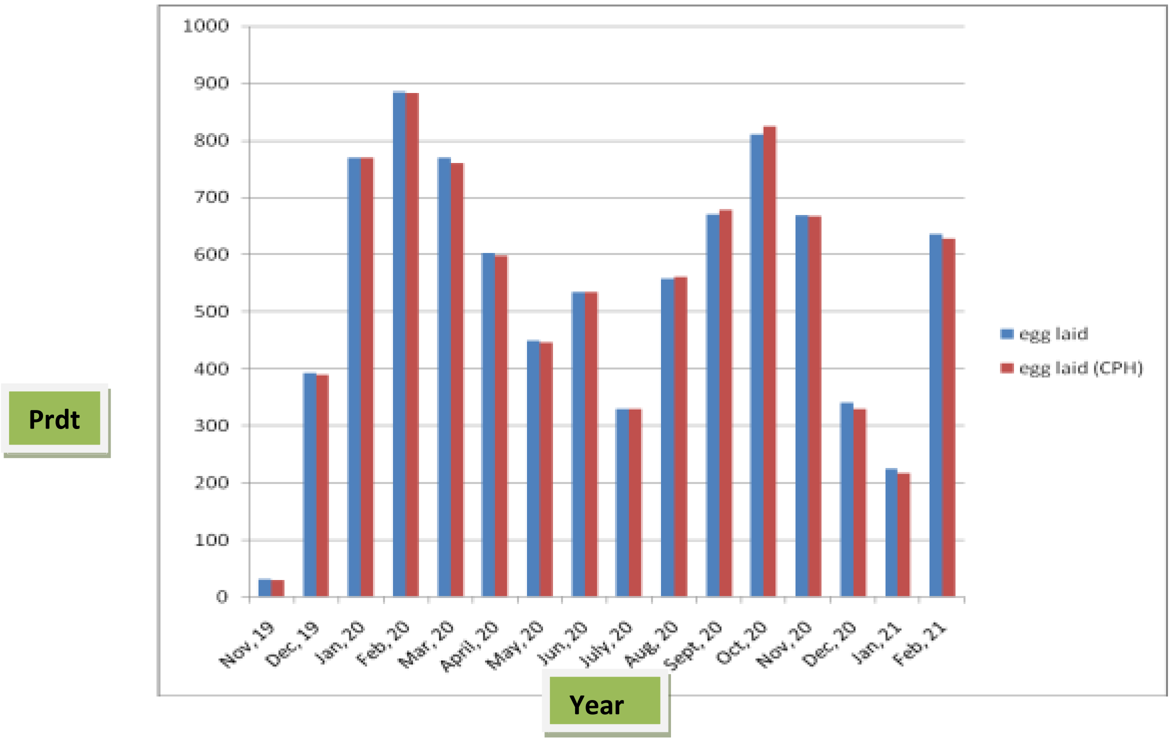

Figure 1: Bar chart showing eggs laid by birds fed with conventional feeds and CPH-based feed

Legend: Prdt represents Egg Production

Pulled eggs laid by both birds fed with conventional and CPH-based feed

The figure 2 shows the egg laid by birds fed with the conventional feed and CPH based feed between November, 2019 and February, 2021.

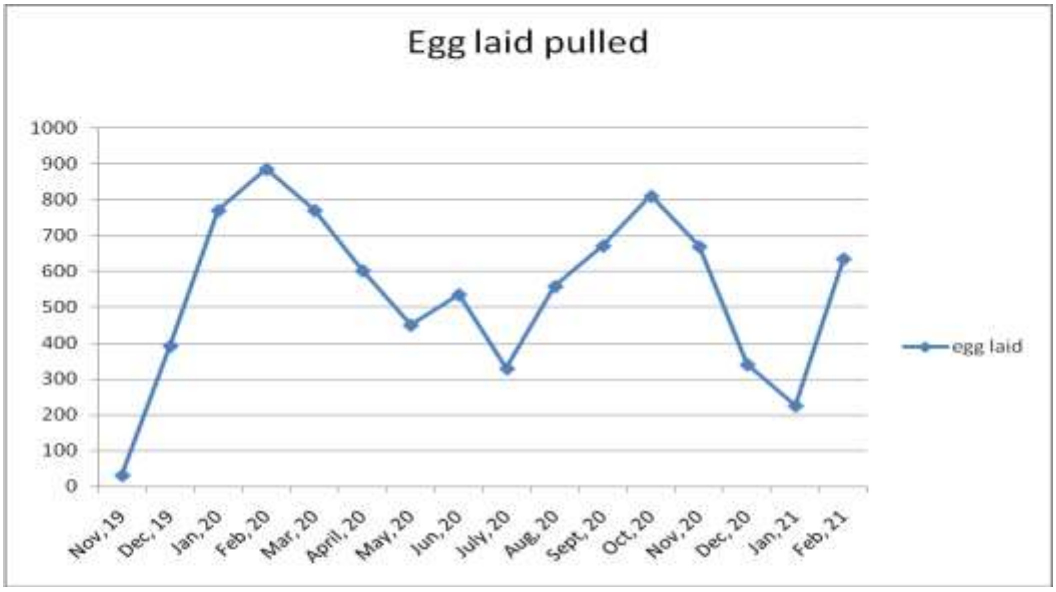

Figure 2: Pulled eggs laid by both birds fed with conventional and CPH-based feed

Source: field survey 2020

CONCLUSION AND RECOMMENDATIONS

The results showed that 20% of maize in conventional feed was successfully replaced by CPH without any significant difference in the production capability of laying hen. This can considerably reduce the cost of production in poultry business, thereby increasing the profit margin of farmers. It is recommended that poultry farmers should embrace the use of CPH to replace the recommended proportion of maize in their compounded feed. Also, more schools and communities should be encouraged to adopt this programme.

Picture of a student feeding the birds

CRIN researchers with students during renovations

Visit to CRIN adopted village (Aba-Agbo) by Students on industrial training

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EFFECT OF CAPACITY BUILDING ON KNOWLEDGE ACQUISITION AMONG PLANTAIN AND PINEAPPLE VALUE CHAIN STAKEHOLDERS IN DELTA STATE, NIGERIA

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ABSTRACT

Capacity building and training is imperative to improve performance of actors in agricultural/horticultural value chain. This is because improved knowledge may translate to enhanced efficiency. The study examined effect of capacity building and training on stakeholders' knowledge acquisition in plantain and pineapple value chain in Delta State. Stakeholders were randomly selected from communities in four Local Government Areas of the state (Ika South, Ukwuani, Ndokwa West and Ndokwa East). Structured interview schedule was used to collect information from 400 participants out of which 354 were found usable. Participants' knowledge in various aspects of plantain and pineapple value chains taught with practical demonstration were determined. Data collected was analyzed using descriptive statistics, T- test and linear regression. Results showed that 88.7% of the participants were male, 81.6% were married, most (34.2%) were within 31-40 years' age group and 91.9% had secondary and tertiary level of education. Majority of the respondents had farming as their primary occupation (85.3%) and 59.6% and 33.9% of the respondents had 1-10 years' experiences in plantain and pineapple value chain respectively. Overall total mean pre and post training score of the participants was 0.41±8.462 and 15.49±1.55 respectively. T-test result showed a significant difference (t = 27.774, p = 0.00) in participants' overall knowledge after training. Educational qualification of the participants significantly affected knowledge gained in the training. The study recommends scaling out of the training to other areas in which the country has comparative advantage in the production of the commodities in order to improve competitiveness of the value chains.

Key words: Capacity building, Knowledge, Plantain, Pineapple, value chain

INTRODUCTION

Plantain and Pineapple are important fruit crops and have high economic value (USDA, 2012). Nigeria has comparative advantage in the production of the commodities; production figure of plantain in 2019 was 3,182,872 tons from 506,766 hectares (FAO, 2021). Plantain is in high in demand and its cultivation is attractive to farmers due to relatively lower labour requirements for production compared to cassava, maize, rice and yam (Kayode *et al*., 2013). Pineapple production on the other hand, could help to ensure food security, job creation, and launch the country on the path of self-sufficiency, and help in improving lives and health of the populace (All Africa, 2011). Nigeria ranked 7th on the list of world producers, as well as the leading pineapple producer in Africa with a production capacity of 1,671,440 tons from 200,911 hectares in 2019 (FAO, 2021). Despite the aforementioned potential of the country in plantain and pineapple value chain, Nigeria production of the commodities remains low when compared to other producing nations (Adegbite and Adeoye, 2015 and Adeoye, 2015). One of the factors that may be responsible for the low performance is lack of technical knowledge on the use of improved technologies in the commodities value chains.

Capacity building is one of the approaches that may be used to achieve poverty alleviation (Rola-Rubzen and Gabunada, 2003). According to Olajide-Taiwo *et al* (2018), training is crucial to equip stakeholders in good agricultural practices and skills. Capacity development is a process of change in which people, organizations and institutions improve their performance and strengthen their capacity in response to changing circumstances (Kumari and Khanduri, 2019). Most of the empirical research/Socio economic research in Plantain and Pineapple value chain has been on economics of production, marketing of the commodities (Adegbite and Adeoye (2015), Adegbite *et al*, (2014). There are very few empirical studies on the effects of capacity building and training on stakeholders' capacity to improve Plantain and Pineapple commodity value chain. The objective of the study is to determine the effect of capacity building on knowledge acquisition among plantain and pineapple value chain actors in Delta State. Specifically, the study describes the socio economic characteristics of the respondents; determine the pre and post training knowledge about plantain and pineapple value chain and determine the factors responsible for knowledge acquisition through capacity building/training among the respondents.

MATERIALS AND METHODS

The study was conducted in Delta state, Nigeria. It is situated in the South-South geo-political zone with a population of 4,112,445. The state has a total land area of 16,842 square kilometers (6,503 sq mi). Delta State consists of 25 Local Government Areas. A total number of 400 trainees were selected from farmers' and youth organization in 4 local governments noted for plantain and pineapple production using multistage sampling technique. But, 354 questionnaires were found useful for the study. Aspects of theoretical and practical demonstration on Plantain and Pineapple value chain covered were: Rapid multiplication Technique of Plantain and Banana sucker production; Managing Pests and Diseases in Plantain production, Management of Plantain wastes, Pineapple value addition, Water Resources Management for Plantain and Pineapple, Profitability of Plantain and Pineapple value added products and Basic Book Keeping for good business management. Data on socio-economic characteristics and other farm specific variables were collected from the farmers. Knowledge of the respondents about the training content was determined before and after training. Data were analysed using descriptive statistics such as frequencies, means and percentages for socio-economic characteristic of the farmers and their production activities. T test was used to examine significant difference in the knowledge level of the participants before and after the training. Linear regression was used to examine factors responsible for knowledge acquisition through capacity building and training among the respondents.

RESULTS AND DISCUSSION

Most of the participants were male (88.7%) while 11.3% were female, married (81.6%) and within 31-40 years of age (34.2%). Majority of the trainee had secondary and tertiary level of education (91.9%) indicating that they may appreciate significance of training in improving performance along commodity value chain. A large number of the respondents had farming as their major occupation (85.3%). Approximately 60% and 33.9% of the respondents had 1-10 years of experience in plantain and pineapple farming respectively. The dominant source of planting materials was from the open market (49.7%) (Table 1).

T test showing Difference between Post and Pre training knowledge score among the respondents

The mean overall score of pre-training evaluation was 0.41±8.46 while that of post training evaluation was 15.49±1.55 (Table 2). This shows that the mean knowledge of participants increased after the training. Moreover, there was a significant difference in the overall pre and post training scores of the participants as revealed in the t-test result ($t=27.74$, $p=.000$). This indicates that knowledge/skills were acquired by the participants in the course of the training programme. Skills learnt are expected to be put to productive use by the participants. Similarly, Olajide-Taiwo *et al.* (2018) also found significant difference in the knowledge of participants trained on ginger and turmeric production techniques indicating that knowledge gained may be utilized to improved production of the commodities.

Factors responsible for knowledge acquisition through capacity building/training among the respondents

Result of the linear regression analysis (Table 3) showed that the educational level of participants had a positive relationship with knowledge acquisition and was statistically significant (Table 3). The positive relationship showed that an additional year in school may lead to increase in the knowledge acquisition of the participants in plantain and pineapple value chain. Wongnaa *et al* (2019) also found a positive and significant relationship between educational level of farmers and vegetable production in Ghana. The coefficient of age was negative and statistically significant at 5%. This implies that the more advanced in age the respondent are, the less knowledge they may acquire through training.

Table 1: Socio economic Characteristics of the Respondents (n = 354)

Variable	Category	Total	Percentage
Sex	Female	40	11.3
	Male	314	88.7
Marital Status	Married	289	81.6
	Single	56	15.8
	Widowed	9	2.5
Age (years)	20-30	49	13.8
	31-40	121	34.2
	41-50	108	30.5
	51-60	51	14.4
	61-70	22	6.2
	>70	3	0.9
Educational level	No formal	7	1.7
	Primary	3	0.8
	Secondary	174	49.2
	Tertiary	151	42.7
	Choose not to say	20	5.6
Major occupation (Farming	No	52	14.7
	Yes	302	85.3
Years of experience in Plantain production	1-10	211	59.6
	11-20	60	16.9
	21-30	13	3.7
	31-40	3	0.9
	Choose not to say	67	18.9
Years of experience in Pineapple production	1-10	120	33.9
	11-20	9	2.5
	21-30	37	10.5
	31-40		
	Choose not to say	188	53.1
Sources of Planting Materials	NIHORT	16	4.5
	Open market	176	49.7
	Missing	162	45.8

Table 2: T test showing Difference between Post and Pre training knowledge score among the respondents

Variables	Mean	Std Deviation	Std error Mean	T value	DF	Sig level
Mean pre knowledge score	0.41	8.462	0.534			
Mean post knowledge score	15.49	1.55	0.98			
Post score versus Pre score	15.076	8.599	0.543	27.774	353	0.000

Table 3: Linear Regression showing factors responsible for knowledge acquisition through capacity building/training among respondents

Variables	Coefficient	Std error	T	p
Constant		4.614	3.239	0.001
Age	-0.138	0.045	-2.131	0.034*
Sex	0.033	1.543	0.518	0.605
Primary Occupation (Farming)	-0.047	1.873	-0.757	0.450
Educational qualification	0.131	1.020	2.022	0.044*

*Significant @ 5% level

CONCLUSION AND RECOMMENDATIONS

The importance of capacity building and training in ensuring improved performance and sustainability

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of agricultural/horticultural value chain cannot be over emphasized. The study showed that most of the participants in plantain and pineapple value chains in Delta state were male, within the active age group and is farmers with 1-10 years' experience in the commodities value chain. There were significant differences in the knowledge gained by the participants on all the aspect taught after the training. Educational qualification was found to have significant relationship to the total post training score/knowledge gained by the participants. The study recommends intensification of the training and scaling out of the training opportunities to other areas of comparative advantage in Plantain and Pineapple value chain to improve the contribution of the commodities to food security, economic empowerment, employment generation and sustainable livelihood.

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EFFECT OF TRAINING WORKSHOP ON PARTICIPANTS' KNOWLEDGE ON GINGER AND TURMERIC VALUE CHAIN IN OYO STATE

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ABSTRACTS

Training workshop is an essential ingredient in improving stakeholders' knowledge along agricultural value chain. The study assessed effect of exposure to training workshop on participants' knowledge on ginger and turmeric value chain in Oyo state. Participants were selected with the assistance of the Agricultural Development Programme (ADP) in Oyo State. Data were collected from 83 respondents using interview schedule and analyzed using descriptive and inferential statistics. Majority (65.1%) were male, married (83.1%), within 50-59 years (30.7%) with 1-10 household members (69.9%) and most (54.2%) had tertiary education. Respondents were mostly farmers (59%), however, few (8.4%) were producing ginger while none was cultivating turmeric. Only 5% and 4% of the participants had earlier been trained on ginger and turmeric production respectively. There was an increase in mean knowledge score from 0.70 ±1.488 to 6.73±2.209 and 1.33±2.415 to 8.04±1.984 for ginger and turmeric production respectively after exposure to training. Likewise, post training knowledge mean score (5.77±2.177) was higher than pre training mean score (1.54±2.307) in economics of production of the two commodities. Results of the T-test reflects a significant difference in participants pre and post knowledge score in ginger (t = 21.98, p = 0.000) and turmeric (p = 21.664, p = 0.000) production, economics of production (t = 13.871, p = 0.000), processing (t = 19.563, p = 0.000) and overall (t =25.376, p = 0.000) along the value chain. Capacity building of horticultural stakeholders is indispensable for sustainable food security and health in this era of climate change.

Key words: Economic, youth involvement, value addition, value chain

INTRODUCTION

Ginger (*Zingiber officinale*) and Turmeric (*Curcuma longa*) are important spices both locally and globally (Amadi *et al*, 2018; Chidiebere and Ibe, 2018). They are well known at both local and international markets due to their numerous nutrition and health benefits. Ginger and Turmeric are important crops and farmers should be encouraged to invest in commercial production of both crops because of their potentials to improve health, income and economic levels of farmers (Chidiebere and Ibe, (2018, Amadi et al, 2018). Nigeria is the third largest producer of ginger in the world (VCA Ginger in Nigeria, 2020). The worth of ginger exported by Nigeria in 2016 was worth $8.2 million representing 9.6% of total world export (Workman, 2017). Nigeria ginger is highly rated in the international market due to its pungency and high rate of oleoresin oil. According to Amadi *et al*, 2018, Nigeria has potential in turmeric production considering the favourable soil and climatic conditions in the country. One of the difficulties facing Nigerian ginger sector is high post-harvest losses (VCA Ginger in Nigeria, 2020). Amadi *et al*, 2018 also stressed that a lot need to be done, especially in processing of turmeric to achieve food security. Thus to benefit maximally from ginger and turmeric, value addition is germane. In order to minimize post-harvest losses and ensure that food safety practices are adhere to, there is the need to build the capacity of interested youth, women and men along the value chain. Previous research efforts on Ginger and Turmeric are on economics of production and marketing (Sambo *et al* 2019, Chidiebere and Ibe, 2018). There is little information on effect of training on knowledge of stakeholders along the commodities value chain. The present study therefore described the socio economic characteristics of trainee and examine effect of training on participants' knowledge on ginger and turmeric along the value chain.

The specific objectives are:

i. To determine the socio economic characteristics of trainees
ii. Assess the effect of the training workshop on participants' knowledge

MATERIALS AND METHODS

The study was conducted at Saki zone of the Oyo State Agricultural Development Programme (ADP) in Oyo state. The zone was chosen due to the availability of favourable climatic conditions to support the growth of the selected spices. Two hundred and ten participants were contacted with the assistance of the Oyo state ADP. Selection cut across Saki west, Atisbo, Orelope, Kajola, Olorunsogo, Iwajowa, Orelope, Saki East, Saki west and Irepo communities under Saki zone of the ADP. Targeted beneficiaries were farmers' organization, women, youth and ADP staff. Participants were assessed and trained on technical knowledge on production, processing, nutrition and health benefits, record keeping as well as economics of ginger and turmeric. This was done to determine the gap and gain in knowledge before and after the training respectively. Data were collected from 100 respondents using interview schedule, however, 83 (83%) questionnaires that were found useful out of the 100 questionnaire prepared for the study were analyzed using both descriptive and inferential statistics.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Respondents

Most participants at the training workshop were male (65.1%) and married (83.1%). This is an indication that more men participated in the training workshop. Greater proportion of participants were within 50-59 years (30.7%) while majority (54.2%) having tertiary education. Most of the respondents have 1-10 members in their respective households (69.9%). Many (59%) were farmers but only 8.4% were producing ginger while none was cultivating turmeric. A considerable proportion (39.8%) of the producers had more than 20 years of farming experience and belong to farming association (60.2%). Only 5% and 4% of the participants had been trained on ginger and turmeric production before NIHORT training workshop (Table 1).

Pre and post knowledge assessment of participants

Considering the mean knowledge scores of participants before and after training, there was an increase in knowledge mean score from 0.70 ±1.488 to 6.73±2.209 and 1.33±2.415-8.04±1.984 for ginger and turmeric production respectively. Participants' knowledge mean score in value addition also reveal a change from 2.27±4.469 to 14.18±4.260. Likewise post training knowledge mean score (5.77±2.177) was higher than pre training mean score (1.54±2.307) in economics of production of the two commodities. The result indicated that the participants experienced a positive change in skill and knowledge after exposure to the training workshop. This could also be attributed to the fact that participants were involved in hands-on practical experience during the training exercise. Layade et al (2018) observed increase in knowledge score among participants after a training session on mango value chain among horticultural stakeholders.

T-test analysis of pre and post knowledge assessment in ginger and turmeric value chain

Results of the T-test reflects a significant difference in participants pre and post knowledge score in ginger production ($t = 21.98$, $p = 0.000$), turmeric production ($p = 21.664$, $p = 0.000$), economics of production of ginger and turmeric ($t = 13.871$, $p = 0.000$), processing of ginger and turmeric ($t = 19.563$, $p = 0.000$) and overall ($t = 25.376$, $p = 0.000$) along the value chain (Table 3). In a related study, Olajide-Taiwo et al, 2018 observed a significant difference in trainees' pre and post knowledge score after participating in training activities.

CONCLUSION AND RECOMMENDATION

Most participants were male, married, had tertiary education with 1-10 family members. Few participants were involved in ginger production while none was cultivating turmeric as at the time of the training workshop. Along the value chain, post knowledge assessment score was higher than the pre knowledge assessment score. Significant differences exited between pre and post knowledge mean score on the selected commodities along the value chain indicating that the training was beneficial to the participants. To ensure that training of participants translate to action that can lead to sustainable food security and health in the era of climate change, there is the need for follow up on participants for feedback as well as impact assessment in the nearest future.

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Table 1: Socioeconomic Characteristics of Respondents (N=83)

Items	Variables	Frequency	Percentage
Sex	Male	54	65.1
	Female	29	34.9
Age	< 20	3	3.4
	20-29	8	9.1
	30-39	18	20.1
	40-49	19	21.6
	50-59	27	30.7
	60 & Above	9	10.2
	Preferred not to say	4	4.5
Educational qualification	No formal education	11	13.3
	Primary	13	15.7
	Secondary	14	16.9
	Tertiary	45	54.2
Marital status:	Married	69	83.1
	Single	14	16.9
Family size	1-10	58	69.9
	11-20	5	6.0
	No response	20	24.1
Farming experience	1-5	9	10.8
	6-10	16	19.3
	11-15	15	18.1
	16-20	10	12.0
	> 20	33	39.8
Farmers association	No	33	39.8
	Yes	50	60.2
Main occupation	Civil Servant	18	21.7
	Farming	49	59.0
	Student	6	7.2
	Trading	7	8.4
	Unemployed Youth	3	3.6
Ginger production	Yes	7	91.6
	No	76	8.4
Turmeric production	No	83	100.0
Previous training in Ginger	Yes	4	95.2
	No	79	4.8
Previous training in Turmeric	Yes	3	3.6
	No	80	96.4

Table 2: Pre and post training mean score of respondents along ginger and turmeric value chain

S/N	Items	Pre-knowledge mean score	Post knowledge score
1.	Ginger production	0.70±1.488	6.73±2.269
2.	Turmeric production	1.33±2.415	8.04±1.984
3.	Economics of production (ginger and turmeric)	1.54±2.307	5.77±2.177
4.	Processing of ginger and turmeric	2.27±4.469	14.18±4.260

Table 3: T-test analysis showing difference in Pre and Post Knowledge score of respondents along ginger & turmeric value chain

Ginger & turmeric value chain	Mean	Standard Deviation	t-value	p-value
Ginger production	6.04	±2.501	21.988	0.000
Turmeric production	6.71	±2.822	21.664	0.000
Economics of production of Ginger and Turmeric	4.229	±2.778	13.871	0.000
Ginger and Turmeric processing	1.191	±5.776	19.563	0.000
Ginger and turmeric along the value chain	1.697	±6.09	25.376	0.000

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TRAINING NEEDS ON GARDENING FOR JUNIOR SECONDARY IN NIHORT ADOPTED SCHOOLS

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ABSTRACT

Training needs is one of the crucial steps towards identifying the area of farmers' interest, design and development of curriculum that can best suit to the existing real conditions of farmers. Therefore, training is needed on garden for both the trainers, student and every farmers or individual involve in agriculture for efficient and effective improvement in agriculture and in knowledge on maintenance of gardens. Fifty students from each of the Senior Secondary School 2 students in the three adopted schools were randomly sampled to assess the students' sources of information on gardening and students' training needs areas in the school gardening activities. Results revealed that 62% have heard of school garden which is as a result of various intervention programs from NIHORT, while 38.0% were ignorant of the school garden probably because of lack of interest. However, Majority of the student (91.3%) were eager to be trained on horticultural school garden, while 8.7% were not interested in the training at all. The study concluded that training student on planting and harvesting of crops as well as livestock management in school/home garden will increase their interest in gardening from tender age; thereby sharing the knowledge from the training with their friends and families. This will increase gardening/agricultural practices in schools and homes in Nigeria. Hence, availability of adequate safe food for Nigerians.

Key words: Gardening, schools, adopted villages, training needs

INTRODUCTION

Agriculture is a key sector in Nigeria's economy and provides an important source of food and income to a large number of households, most of which are located in rural areas. Subsistence is the dominant agricultural management system in Nigeria, with most agricultural activities being carried out to produce food for household consumption and in some cases to sell at local markets or to neighbours. Production activities focus on the crop especially horticultural crops, livestock, fisheries sub-sectors and etc. Some farmers, mostly women grow small quantities of vegetables and fruits, mainly for household consumption, with small surpluses being sold in local markets. Some schools and home compounds are set up as gardening for raising horticultural crops and ensuring that children are involved in school and home gardening.

School gardening was coined out of home gardening (Gautam *et al*., 2002). Home gardening as a concept refers to the cultivation of small portion of land which may be at the back of a home or within a walking distance from home (Odebode, 2006). It is this concept of cultivation of land at the back of home or within a walking distance for the purpose of meeting multipurpose family and households needs. Home gardens is the intimate, multi-storey combination of various trees shrubs; annual and perennial and crops; herbs, spices, medicinal plants in association with fish and domestic animals around homestead on the same land unit, in a spatial arrangement or on a temporal sequence (Eyzaquirre and Linares, 2004; Kumar and Nair, 2004)

In Nigeria, great diversity exists in farmers' access to extension services, as well as the quality of services provided. To have an impactful and productive extension training services, the audience must be interested in the content of the training. This necessitates needs assessment evaluation before the training. Training needs is one of the crucial steps towards identifying the area of farmers' interest, design and development of curriculum that can best suit to the existing real conditions of farmers. Caffarela (2002) noted that a systematic process of farmers' training must include needs assessment, goal and objectives setting, organizing instructional methods and techniques, monitoring and evaluation.

Furthermore, training is needed on garden for both the trainers, student and every farmers or individual involve in agriculture for efficient and effective improvement in agriculture and in knowledge on maintenance of gardens (school and home garden). Meenambigai and Seetharaman (2003) asserted that training is the most singular factor affecting individuals' attitude, productivity, improvement, minimization of risks. So, adequate training is essential for farmers to acquire necessary knowledge and skills in different aspects of farming. It is therefore imperative that secondary school students are organized and given adequate training through agricultural extension to ensure that they are well informed and adequately skilled on gardening (both school and home gardening).

Objectives of the study were to:

- Identify the personal characteristics of the students
- Identify the students' sources of information on gardening in junior secondary school.
- Assess students' training needs areas in the school gardening activities.

MATERIALS AND METHODS

The study was carried out in Ibadan, Oyo state. The sampling involved a purposive selection of three adopted schools of National Horticultural Research Institute Ibadan: Baptist Grammar School, Idi-ishin, Oba Abass Aleshinloye Grammar School, Eleyele and Urban Day Secondary School Jericho. Fifty students from each of the Senior Secondary School 2 students in the three adopted school were randomly sampled for the study. Structured questionnaire was used to elicit information from the students. The total number of respondents sampled from the three schools was one hundred and fifty. Descriptive statistics such as frequencies and percentages were used to analyze the data collected.

RESULTS AND DISCUSSION

The respondents sex was male 57.3% and female 42.7%, there are more male than female in the senior students in the secondary school (Table 1). Thus there were more male in the study area. This finding was corroborated by (Nweke et al. (2002). About three quarter of them being 15-17 age bracket 76.7%. They are young, agile and still under the guide of parents /guardians. This implies that these students were still in their economic active age which could result in a positive effect on training. This result agrees with the findings of Kainga and Seiyebo (2012) who observed that the age has great influence on training because of their flexibility to new knowledge or ideas. Three schools were sampled to ascertain their knowledge in school garden and 62.0%. This is an indication that students have a good knowledge of what horticulture is and is not. Kettlewell and Henry, 2009) opined that prior knowledge acts as a lens through which we view and absorb new information. It is like knowing where one wants to go before the start of a journey. Individual goals and interest produce motivation, that is, a person is directed towards a particular activity which is aimed at accomplishing goals or exploring interest. This finding agrees with Gillie and Gillie (2003) who argued that making informed and considered career decisions has benefits which indicated that they have heard of school garden this may be as a result of various intervention programs from NIHORT while 38.0% were ignorant of the school garden probably because of lack of interest. However, Majority of the student (91.3%) were eager to be trained on horticultural school garden while 8.7% were not interested in the training at all. Garden training in this areas will increase their school income as asserted by Ajayi (2008). It is clear that training is an essential resource which will direct knowledge and skill toward production (Adesoji et al, 2006). This indicates that garden activities in the study area are still in need of training that has to be provided in order to boost their level of production and also increase their standard of living. In the school of more than half (59.3%) of the respondents there is school garden where they can practice what they would be trained on. Schools without garden (40.7%) can kick start their school garden after training. There is need for the training as most (39.3%) of the school garden are functioning. This may be as a result of lack of adequate knowledge of gardening activities. Although 55.3% of the respondents are involve in school garden activities. However, majority (90.7%) of the respondent are willingness to participate in school garden training.

Table 1: Personal Characteristics of selected secondary school student

Parameter	Frequency	Percent
SEX		
Male	86	57.3
Female	64	42.7
AGE		
12-14	18	12.1
15-17	115	76.7
18-20	17	11.3
CLASS	150	99.9
Have you heard of school garden training before?		
NO		
YES	57	38.0
	93	62.0
Do you like to be train in garden (horticultural) farming practices?		
NO	13	8.7
YES	137	91.3
Do you have school garden?		
NO	61	40.7
YES	89	59.3
In your own opinion, is your school garden functioning?		
NO	91	60.7
YES	59	39.3
Are you willing to participate in school garden training?		
NO	14	9.3
YES	136	90.7
Are you involved in the school gardening activities?		
NO		
YES	67	44.7
	83	55.3

Source: School survey, 2021

Table 2: Information sources of selected secondary student

Sources of Information	Frequency	Percent	Frequency	Percent
	NO		YES	
Research Institute	62	41.3	88	58.7
Radio	59	39.3	91	60.6
Television	47	31.3	103	68.7
Extension	84	56.0	66	44.0
Friend	47	31.4	103	68.7
Relatives	61	40.7	89	59.3
Teachers	32	21.4	118	78.7
Young farmers club	78	52.0	72	48.0

Source: School survey, 2021

The students learn more in the school through their teachers. The student assesses information through their teachers (78.7%) and friends (68.7%). This implies that if a student is trained, he/she can share the information with friends and family (Table 2). Mass media (Television: 68.7%; Radio: 60.6%). This implies that adaptation strategy using teacher, friends, television and radio are likely produce more result because it is most prevalent source of information in the study area. This finding is consistent with that of Yekini (2010) who recognized that popularity of local radio stations stems from a sense of proximity with the listening community. Radio has proven useful in communicating agricultural technologies to farmers and garden activities with the objective of increasing agricultural production (Nwankwo and Orji, 2013) is also a good information source for the student with wider coverage. Bringing in practical agricultural training to the school where close to 80% information can be assessed by the student trough their teacher who can pass the information to the students under their tutelage is the most effective source of information of the respondents. There is need to strengthen in the young farmer's club (48%) in the secondary school in order to build the student interest in agriculture. The least mode of information assessment is through extension services 44.0%. Similarly, Mala (2012) observed that regular contact with extension agents lead to a significant knowledge gain by farmers. This is a cogent reason for this study to intensify on the Extension Services of research institute and other relevant agencies. Extension enables farmers to take up new innovations, to improve their production and income, and to protect the environment. However, to achieve optimum production in horticultural activities, smallholder farmers including students working in the school garden can benefit from tailored training as part of agricultural extension. (Table 3)

Table 3: Agricultural training needs of secondary school student

Training Need	Highly Needed		Moderate Needed		Not Needed	
	freq	%	Freq	%	Freq	%
Land clearing	96	64.0	30	20.0	24	16.0
Harrowing	69	46.0	55	36.7	26	17.3
Ploughing	68	45.3	52	34.7	30	20.0
Planting	112	74.7	26	17.3	12	8.0
Watering	94	62.7	39	26.0	17	11.3
Weeding	76	50.7	51	34.0	23	15.3
Manuring	84	56.0	49	32.7	17	11.3
Harvesting	101	67.3	37	24.7	12	8.0
Storage	93	62.0	39	26.0	18	12.0
Livestock management	107	71.3	30	20.0	13	8.7
Feed production	100	66.7	36	24.0	14	9.4
Marketing	87	58.0	39	26.0	24	16.0

Source: School survey, 2021

Training is acquisition of the best way of utilizing knowledge and skill (Sajeev and Singha, 2010; Training in these areas will increase their school income as asserted by Ajayi (2008). Assessment of the training of student on agricultural activities will give opportunity of handling the aspect of training intervention required by the audience. The student training needs on agricultural practices shows that planting 74.7%, livestock management 71.3%, Adeyemo and Onikoyi, (2012) reported that poultry production outnumbered other all forms of livestock production in Nigeria, this is because it requires less space and can be raised mainly on compounded rations which is available in animal feed store compared to other livestock. and harvesting (67.3%), rank high among the agricultural activities whose training are highly needed among secondary school students while harrowing 36.7% and ploughing 34.7% are moderately needed. This may be because of the small size land available for gardening in the school, which can be easily handled manually without the use of machineries. Training the students will put them through a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation presently and in future as this will increase their student interest in agriculture or improving productivity of their school or an organization (Rahman and Khatun, 2018). The training of the gardening activities will be done based on the need assessment will give room for effective training that requires a clear picture of how the trainees will need to use information after training in place of local practices i.e. their schools what they have adopted before or intending to adopt in their situation (Rahman and Khatun, 2018).

CONCLUSION

Training needs assessment is crucial for effective and impactful training that will increase knowledge, skills and translate to increase productivity. Training student on planting and harvesting of crops as well as livestock management in school/home garden will increase their interest in gardening/agriculture from tender age; they will also share the knowledge from the training with their friends and families. This will increase gardening/agricultural practices in schools and homes in Nigeria. Hence, availability of adequate safe food for Nigerians.

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SOCIO-ECONOMIC CHARACTERISTICS ON KOLA FARMERS' KNOWLEDGE AND ITS REHABILITATION TECHNIQUES PRACTICES IN EDO STATE, NIGERIA

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ABSTRACT

The study examined the socio-economic characteristics of Kola farmers' knowledge and its rehabilitation techniques practices in Edo State, Nigeria. Data were obtained using interview schedule, frequency, percentage, mean, graph, multinomial logistics, regression and standard deviation. The results showed a weak and poor extension services ranking (4.71%), with inadequate finances (4.07%), high cost of labour (3.88%), time consuming (3.55%), poor skills (3.03%) and pests and diseases (1.76%). However, Kola farmers should see Good Agricultural Practices (GAPs) and extension contact visits as best alternative to bridge the knowledge gap in increasing kola yield and farmers' income.

Key words: Knowledge, practises, rehabilitation and techniques.

INTRODUCTION

Kola nuts have been an important trade item in the West Africa region for many years. The kola nuts are valued in many cultures as a sign of friendship and peace and are consumed (broken) at reunions, during meetings, ceremonies and festivals. It is also the only stimulant allowed and consumed by religious faithful (Asogwa *et al.,* 2006). Kola is an important economic cash crop to a significant proportion of Nigeria population who are involved in kola farming, trading and industrial utilization. Nigeria currently produces 70% of world kola nut with an annual production of 200,000 metric tonnes of fresh nuts, mostly in the South West and surrounding boundary of South-South Nigeria.

The potential and importance of kola as a cash crop cannot be over emphasised due to its contribution to the economy of Nigeria GDP (Opeke, 1992). Due to increase in domestic market for kola arising from the expansion of sales of Cola beverages and other products containing kola nuts and the by- products, recent discoveries of their potential industrial uses has enhanced the market prospects for kola. Despite the huge success of Nigeria ranking in kola production in Africa, kola farmers' production still remains poor due to farmer's socio economic characteristics, old kola farm plantation that need Good Agricultural practices (GAPs), and the long gestation of maturity. The main objective of this study was to evaluate the socio economic characteristics of kola farmer's production, while the specific objectives examined the socio economic characteristics of kola farmers in the study area and examine the constraints faced by kola farmer's on rehabilitative techniques in study areas.

Hypotheses of the study

There is no significant relationship between the farmer's socio economic characteristics and their knowledge on kola farm rehabilitation technology.

There is no significant difference among the constraints faced by kola farmer's rehabilitation techniques.

MATERIALS AND METHODS

Study Area:

The research was conducted in Owan district Local Government of Edo State which comprises both Owan West and Owan East with the following communities namely; Uhonmora, Ozalla, Uzebba, Aviose, Opuje, Emai, Ojavun, Ikaho, Otuo and Iki. The communities were purposively selected because of its large numbers of kola farmers in the study areas. Data were obtained using interview schedule, descriptive, frequency, percentages, mean, graphs, multinomial logistic regression and standard deviation.

RESULTS AND DISCUSSION

The age distribution of kola farmers in the study area shows that majority of the respondents are aged 51 – 60) years old, while the least age of the respondents falls between less than 30 years of the respondents (Table 1) These findings indicate that farmers in the age bracket of 51 – 60 years old are very active in kola farming, since most of the kola farmers inherited their kola farms from their parents.

Table 1. Distribution of age of kola farmer's respondents

		Owan west		Owan East		Total	
		Freq	%	Freq	%	Freq	%
Age (categories)	>= 30	7	8.14	7	7.07	14	7.57
	31-40	12	13.95	8	8.08	20	10.81
	41-50	24	27.91	31	31.31	55	29.73
	51-60	28	32.56	33	33.33	61	32.97
	61-70	10	11.63	13	13.13	23	12.43
	>70	5	5.81	7	7.07	12	6.49
	Total	86	100.00	99	100.00	185	100.00

Source: Field survey, 2020

Educational level of respondents reveals that 46.49% has secondary education qualification, while 27.57% has primary education, 14.59% has tertiary education and the least has 11.35% with no formal education (Table 2). These findings imply that the educational status of respondents in the study area fall between average, and this can facilitate their adoption on their effectiveness on training.

Table 2. Respondents' education distribution

		Owan west		Owan East		Total	
		Freq	%	Freq	%	Freq	%
Education	No formal education	12	13.95	9	9.09	21	11.35
	Primary education	25	29.07	26	26.26	51	27.57
	Secondary education	35	40.70	51	51.52	86	46.49
	Tertiary education	14	16.28	13	13.13	27	14.59
	Total	86	100.00	99	100.00	185	100.00

Source: Field survey, 2020

Majority of the respondents falls between household size of 5-8 persons (51.35%), followed by 4 and below (32.43%), 9- 12 persons (10.27%) and the least of household size of respondents is 5.95% (Table 3).

Table 3. Household size of respondents of kola farmers

		Owan west		Owan East		Total	
		Freq	%	Freq	%	Freq	%
Household size (range)	4 & below	31	36.05	29	29.29	60	32.43
	5-8	42	48.84	53	53.54	95	51.35
	9-12	6	6.98	13	13.13	19	10.27
	>12	7	8.14	4	4.04	11	5.95
	Total	86	100.00	99	100.00	185	100.00

Source: Field survey, 2020

Marital status of respondents shows that majority (78.92%) of respondents are married, while 4.32% were single, 2.70% divorced and 14.05% are widower. This implies that most of the respondents who were married were involved on farming activities. This also indicates the family cohesion has great influence in improving family supports and livelihood of the respondents.

Table 4. Marital status of kola farmers' respondents

		Owan west		Owan East		Total	
		Freq	%	Freq	%	Freq	%
Marital Status	Married	68	79.07	78	78.79	146	78.92
	Single	6	6.98	2	2.02	8	4.32
	Divorced	2	2.33	3	3.03	5	2.70
	Widower	10	11.63	16	16.16	26	14.05
	Total	86	100.00	99	100.00	185	100.00

Source: Field survey, 2020

Table 5 shows the sex distribution of respondents which indicate the male respondents has (62.70%) than the female with (37.30%). This result confirmed the findings of Ele et al; (2013), Shaibu et al; (2017); Olaoye et al; (2011) which reported that male counterpart involves more in Agricultural activities in Nigeria than female counterpart.

Table 5. Gender distribution of kola farmers

		Owan west		Owan East		Total	
		Freq	%	Freq	%	Freq	%
Gender	FemaleMale	34	39.53	35	35.35	69	37.30
	Total	52	60.47	64	64.65	116	62.70
		86	100.00	99	100.00	185	100.00

Source: Field survey, 2020

Membership of association has a greater influence on agricultural activities of which 81.62% of the respondent farmers belong to one association or the others, while 18.38% do not belong nor has interest in joining any membership of association (Table 6). This implies that low membership can lead to low response on participation on training adoption of new technology.

Table 6. Membership of respondents of kola farmers' association

		Owan west		Owan East		Total	
		Freq	%	Freq	%	Freq	%
Membership of association (dummy)	Non- member	18	20.93	16	16.16	34	18.38
	Member	68	79.07	83	83.84	151	81.62
	Total	86	100.00	99	100.00	185	100.00

Source: Field survey, 2020

Table 7 shows the significant of respondent's knowledge of different rehabilitation technology. This finding further revealed that fertilizer application is necessary after coppicing with total mean of significant of (4.54%), followed by coppicing (4.51%), Cutting of old moribund of kola tree (4.32%), Removal of chupon (4.30%), Fertilizer application (4.27%), Use of motor saw for coppicing operation (4.17%), Pruning (4.08%), Application of fungicides/insecticides (4.07%), Coppicing of kola tree above 30-60cm from ground level (4.03%), Ring weeding (3.99%), and painting stump after coppicing prevent diseases with less of significant mean of (3.98%) respectively. This finding prove or shows that fertilizer application shows more significant preference among all the rehabilitation technology on knowledge and least preference on painting of coppiced kola trees.

Table 7. Knowledge of kola farm rehabilitation technology practice

Technologies	Owan west		Owan East		Total	
	Mean	SD	Mean	SD	Mean	SD
Fertilizer is necessary after coppicing	4.43	0.7	4.63	0.5	4.54	0.6
Coppicing is a best practices KFRT	4.47	0.6	4.56	0.6	4.51	0.6
Cutting of old moribund kola trees is best form of rehabilitation	4.42	0.5	4.23	0.5	4.32	0.5
Removal of chupon is best practices of kola rehabilitation	4.29	0.5	4.31	0.5	4.30	0.5
Fertilizer rehabilitation boost kola rehabilitation	4,28	0.5	4.26	0.6	4.27	0.5
Motor saw is the best tools to used to carry out coppicing operation	4.19	0.4	4.15	0.4	4.17	0.4
Pruning can be done once or twice a year	4.16	0.4	44.00	0.3	4.08	0.3
Application of fungicides and insecticides is good for kola rehabilitation	4.08	0.4	4.06	0.3	4.07	0.4
Coppicing kola tree above ground level of 30cm to 60cm is good for kola rehabilitation	4.01	0.3	4.04	0.3	4.03	0.3
Ring weeding should be done 2 to 3 times annually	4.01	0.3	3.98	0.4	3.99	0.4
Painting surface kola tree prevent diseases	3.99	0.4	3.98	0.4	3.98	0.4

Source: Field survey; 2020

Table 8: shows the constraints limiting respondent's adoption on kola rehabilitation technologies. Findings of the results shows the possible constraints facing the adoption constraints to kola rehabilitation technologies. The pooled results reveal all the constraints listed in the above serious based on mean benchmark of 2.50. The major constraints include lack of week and poor extension services (mean = 296), inadequate finance (mean =3.05), high cost of labour (mean =296), time consuming (mean 2.82), lack of knowledge/ poor skills (mean =2.63) and lack of pests and diseases (mean =2.01). The weak and poor extension services, as major constraints may be as a result of the fact that respondents do not have sound formal education, since their educational level still fall below average of (46.49%).

Table 8. Constraints limiting respondent's adoption on kola rehabilitation technologies

Constraints	Owan west		Owan East		Total	
	Mean*	SD	Mean*	SD	Mean*	SD
Weak and poor extension services	3.44	0.5	3.38	0.5	3.41	0.5
Inadequate finance	3.05	0.6	3.05	0.6	3.05	0.6
High cost of labour	2.98	0.5	2.95	0.5	2.95	0.5
Time consuming	2.78	0.5	2.86	0.5	2.82	0.5
Lack of knowledge/poor skills	2.67	0.5	2.59	0.6	2.63	0.5
Pests and diseases	2.07	0.6	1.95	0.5	2.01	0.6

Source: field survey, 2020

Test of hypothesis

Relationship between the farmer's socio- economic characteristics and their adoption of kola farm rehabilitation technology (Logistic regression).

Ho1: There is no significant relationship between the farmer's socio-economic characteristics and their adoption of kola farm rehabilitation technology.

Ho2: There is no significant difference among the constraints to farmer's adoption on kola farm rehabilitation techniques.

Table 9. Parameter Estimates of determinants of farmers' adoption of kola rehabilitation technologies

Parameter	B	Std. Error	Wald Chi- Square	df	Prob. Level.
Constant	0.463	40.8373	0.009	1	0.924
Age	0.025	0.0262	0.908	1	0.341
Education	-0.188	0.3090	0.370	1	0.543
Gender	0.425	0.5339	0.632	1	0.426
Household size	0.201*	0.1030	3.810	1	0.051
Association of membership	0-.109	0.06895	0.025	1	0.875
Farming experience	-0.030	0.0422	0.502	1	0.479
Output before training					
Farm size	-0.123	0.3289	0.140	1	0.708
Perceived relevance of	-0.055	0.0740	0.553	1	0.457
technologies	0.040	0.1066	0.139	1	0.710

Source: field survey, 2020

Table 10. Constraints to farmer's adoption on kola farm rehabilitation techniques

Constraints	**Mean rank**
Pests & Diseases	1.76
Lack of knowledge & skills	3.03
Time consuming	3.55
High cost of labour	3.88
Inadequate finance	4.07
Weak and poor extension services	4.71

Source: field survey, 2020

The result of hypothesis test on the significant difference on constraints to farmer's adoption of kola farms rehabilitation techniques. Statistically, the results have shown the weak and poor extension services rank the highest with mean (4.71), followed by inadequate finance (4.07), high cost of labour (3.88%), time consuming (3.55%), poor skills (3.03) and pests and diseases with (1.76%) respectively. These results indicate that extension services need to be intensify adoption techniques to kola farmers at the right time through the Ministry of Agriculture and Research extension outreach centres in the state; since extension information is part of educational baseline for adoption of new technology.

CONCLUSION AND RECOMMENDATION

From the findings, kola farmers' knowledge on kola farm rehabilitation technology (KFRT) reveals that they really have knowledge and practical skills on the Good Agricultural practices (GAPs), but find it difficult to continue on the practices despite its impact on both yield and finance on the kola farmers. Majority of respondents see poor extension services, time, finance, labour, poor skills, pests and diseases, low cooperation of kola farmers that ought to connect them fully with government in term of support compared to other tree/cash crops such as; Cocoa, Coffee, Cashew and groundnuts among others. This would have contributed to effective adoption of the technology that was later discontinue due to constraints been faced by the kola farmers in the study area. There is needed to form a formidable kola farmers' association (KFA) in the study area of Edo State. This will also expose the kola farmers to different measures of awareness from (CRIN) and various groups within the association in other to assist the farmers to access both information and credit facilities that will enhance their production and their standard of living. Also, there is need for sensitization and mobilization of relevant stakeholders in kola industry to established Farmers – Field Schools that will bring kola farmers from different locations to understudy a specific

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technology using their knowledge so as to re-activate old kola moribund plantations from extinction. Indigenous knowledge system should be incorporated in the new modern teaching of kola rehabilitation technology practices that will enhance low kola farmers' participation for easy understanding and adoption of the technology. Finally, Kola farmers should see Good Agricultural practices (GAPs) as the sole alternative with knowledge application as the only way to increase kola yield and better income.

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ASSESSMENT OF THE KNOWLEDGE OF TERTIARY INSTITUTION STUDENTS ON THE PURPOSE OF EXCURSION

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ABSTRACT

Excursion tour is a vital educational tool that complements classroom knowledge. The study assessed knowledge of tertiary Institution students on the purpose of excursion tour. One of the tertiary Institutions that came for excursion tour to National Horticultural Research Institute in 2021 were purposively selected due to their large number. Random sampling technique was used to select 30% out of the 319 students. Questionnaire was used to elicit information and data were analyzed using frequency and percentages. Majority (58.9%) of the students were between 21-25yrs, 71.1% female, 95.6% were interested in horticulture as a career. Majority (87.8%) agreed that excursion is an educational tool, increases students' knowledge (93.3%), helps to meet new people (85.6%), helps students to learn more and inspired by what they see (80.0%). Most of the respondents (74.4%) disagree that excursion does not help to develop cooperative attitude and does not assist in development of initiatives and leadership skills (68.9%). The Institute was rated excellent and very good by 51.1% and 22.2% respondents respectively. The students are quite knowledgeable on the importance of excursion. Relevant organizations should continue to support excursion on a regular basis to improve academic performance and promote students' interest in horticulture for sustainable food security and health in the era of climate change.

Key words: Excursion, knowledge, Tertiary Institutions, NIHORT

INTRODUCTION

One type of informal learning experience, more commonly known as educational excursion, is valued by many educators for its potency to increase interest and enhance information that is being taught inside the classroom (Hudak, 2003). Educational excursion is a progressive method of learning by which the student goes through the necessary learning experiences under the leadership and guidance of the teacher (Shakil et al., 2011). Carolyn (2009) admit that taking pupils outside the comfort of the classroom can be a daunting step for some teachers, but admits strongly that field trips provide unique opportunities to apply learning to the real world. Excursion tour is a journey into the land of knowledge for the purpose of acquiring practical knowledge and skill for a specified operation or occupation (Nwakor, 2006). It is helpful in physical, mental, social and emotional development of students.

Excursion visit has the tendency to complement classroom learning and impart practical knowledge of students. Excursion by students is a common routine that is embedded in the curriculum of most schools. In pursuit of better and satisfactory student performance in agricultural science in Secondary Schools examination in Nigeria, West African Examination Council (2006) recommended students' visitations to well established government and private experimental and commercial farms, agricultural research institutes and other institutions related to agriculture. It is very essential to find out whether students are knowledgeable about the purpose of excursion. The study assessed excursion knowledge among students on educational tour to National Horticultural Research Institute (NIHORT).

The specific objectives were to:

i. determine the personal characteristics of students
ii. assess students' knowledge about excursion
iii. ascertain students feed-back after excursion

MATERIALS AND METHODS

The 300 Level students of one of the tertiary Institutions in Nigeria that came for excursion tour to National Horticultural Research Institute (NIHORT) in 2021 were purposively selected due to their large number. Three hundred and nineteen students from the school came in three batches of 110, 150 and 130 within a month. Random sampling technique was used to select 30% of the students from each of the group and questionnaire was administered to elicit information from them. Only 90 questionnaires that were properly filled were analyzed using frequency and percentages.

RESULTS AND DISCUSSION

Personal Characteristics of the Respondents

Majority (58.9%) of the students were between 21-25yrs, 71.1% were female and 57.8% major in Biology. Majority (95.6%) were interested in horticulture, 55.6% indicated interest in horticulture as a career choice while only 32.3% had previously visited agricultural organization (Table 1). More female than male could be an indication that more female enrolled in the selected school than boys. Educational excursion is a good way to create interest about a subject or a course, the educational visit may result in students' interest in horticulture. Horticulture is a unique field due to the arrays of crops within its scope. This could be one of the reasons why majority of the student indicated interest and significant proportion also affirmed readiness to choose horticulture as a career. This could probably reduce the erroneous believe by some people about horticulture as a field dealing with ornamental plants alone.

Table 1: Personal Characteristics of the Respondents

	Variable	Frequency	Percentage (%)
Age	16-20	22	24.4
	21-25	53	58.9
	26-35	15	15.5
	Sex		
	Male	26	28.9
	Female	64	71.1
Course of study	Integrated/biology	8	8.9
	Biology/chemistry	19	21.1
	Biology	52	57.8
	Integrated science/Computer	2	2.2
Students interest	Interest in horticulture	86	95.6
	Interest in the excursion	86	95.6
	Career choice in horticulture	50	55.6
	Previous visit to agricultural organization	29	32.3

Respondents Knowledge about Excursion

Majority (87.8%) of the respondents agreed that excursion is an educational tool, increases students' knowledge (93.3%), helps to meet new people (85.6%) and helps students to learn more and inspired by what they see (80%). On the other hand, 84.4% and 74.4% disagreed that excursion helps in the development of creative faculties and does not help to develop cooperative attitude respectively, while 68.9% disagreed that it does not assist in development of initiatives and leadership skills (68.9%) (Table 3). On the other hand, respondents disagree that excursion does not help to develop cooperative attitude (74.4%) and development of initiatives and leadership skills (68.9%) respectively (Table 3). The results indicated that the students are knowledgeable about the significance of excursion. This is in line with the work of Carolyn (2009), who admits strongly that field trips provide unique opportunities to apply learning to the real world. It buttresses the work of Nwakor (2006) that excursion is a journey into the land of knowledge for the purpose of acquiring practical knowledge and skill for a specified operation or occupation.

Distribution of Respondents on Feedback on Excursion

Table 4 shows that majority (77.6%) agreed they would like to visit NIHORT again for their excursion. The Institute was rated excellent, very good and good by 51.1%, 22.2%, 6.7% respondents respectively while staff of the institute that attended to them were also rated as excellent, very good and good by 48.9%, 20.0%, 6.7% respondents respectively. Majority (70.0%) affirmed that their expectations on the excursion was met. This is an indication that the staff that attended to the students are competent and skillful in passing appropriate information across to the audience. Exposure of students to the arrays of technologies generated in the Institute and receptive environment may also boost the interest of students in revisiting the Institute in the nearest future.

Table 3: Distribution of the Respondents based on their Knowledge about Excursion

S/N	Statement	Agreed freq. (%)	Disagreed freq. (%)	I don't know freq. (%)
1.	Excursion as an exciting education experience	79 (87.8)	6 (6.7)	5(5.6)
2.	Increase in students' knowledge	84 (93.3)	3(3.3)	3(3.3)
3.	Horticulture does not increase desires to try new things	9 (10.0)	79 (87.8)	2(2.2)
4.	It creates chance to meet new people	77 (85.6)	6(6.7)	2(2.2)
5.	Development of creative faculties	9 (10.0)	76(84.4)	3(3.3)
6.	Proper utilization of leisure	16(17.8)	62 (68.9)	3(3.3)
7.	It does not help in developing cooperative attitude	10 (11.1)	67 (74.4)	7(7.8)
8.	It does not assist in development of initiative and leadership skills	20(22.2)	62(68.9)	3(3.3)
9.	Students learn more and get inspired by what they see	72(80.0)	8(8.9)	-
10.	It provides opportunity for development of aesthetic sense	74(82.2)	3(3.3)	-

Source: field survey, 2021

Table 4: Respondents feed-back

Variable	Frequency	Percentage (%)
Willingness to visit NIHORT on another excursion	70	77.85
NIHORT rating by students		
Excellent	44	48.9
Very good	18	20.0
Good	6	6.7
Missing system	22	24.4
Staff rating by students		
Excellent	46	51.1
Very good	20	22.2
Good	6	6.7
Poor	1	1.1
Missing system	17	18.9
Expectation from excursion met	63	70.0

Source: field survey, 2021

CONCLUSION AND RECOMMENDATION

The students are quite knowledgeable on the importance of excursion, interested in horticulture and gave a positive feed-back about NIHORT after the excursion visit. More excursion should be carried out by educational Institutions. Relevant organizations should continue to support practical knowledge impartation among students by allowing students to come for excursion on a regular basis, this is to improve academic performance and promote students' interest horticulture for sustainable food security and health in era of climate change

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ATTITUDE OF COCOA FARMERS TOWARDS COCOA REHABILITATION TECHNIQUES IN SOUTHERN NIGERIA

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ABSTRACT

Government intervention is essential for achieving rapid economic growth on agriculture. Cocoa improvement practices such as cocoa rehabilitation programme is essential for increase yield and improvement of social economic status of peasant farmers. Therefore, the attitude of cocoa farmers to cocoa rehabilitation in southern Nigeria was investigated. 300 cocoa farmers were sampled through a multistage sampling procedure. Data obtained were described using frequency and percentage, and analyzed using chi-square at p≤ 0.05. Results revealed 12.0% of the farmers are non-adopter, 21.0% adopted only one technique while 67.0% of the farmers adopted at least two of the technique. Attitudes such as training is important in cocoa rehabilitation {$\overline{X}$ =4.69}, cocoa rehabilitation reduces pests attacks {$\overline{X}$ =4.54} and cocoa rehabilitation is a solution to low yield {$\overline{X}$ =4.49} showed a favorable attitude. While attitudes such as cocoa rehabilitation does not promote cocoa beans yield {$\overline{X}$ =1.77}, and cocoa rehabilitation does not improve moribund cocoa trees performance {$\overline{X}$ =1.30} revealed unfavorable attitude. However, the hypothesis showed a significant relationship between some selected socio-economic characteristics and the attitude of cocoa farmers in the study area. These variables include, member of organization (0.674), House hold size (0.541), source of information (0.624) and number of cocoa farms acquired (0.521). The study concluded that cocoa farmers have both positive and negative pre-disposed attitudes to cocoa rehabilitation techniques used in the study area.

Key words: attitude, cocoa farmers, economic growth.

INTRODUCTION

Cocoa is a commodity crop relevant to most developing economy as it's produced by more than fifty developing countries across Asian, Africa, and Latin America (Ogunleye and Oladeji, 2007). It is a perennial tree crop grown in tropical climate, native of the Americas but which are now widely cultivated in West Africa. Studies revealed that about 5-6 million cocoa farmers exist worldwide, while 40-50 million people depend on cocoa for their livelihood (Adebiyi, 2020). Obviously, Nigeria was the second leading producer of cocoa in the world in 1965 but due to a combination of factors such as ageing of cocoa trees, ageing cocoa farmers (Adebiyi and Okunlola, 2009) and inadequate fund to acquire inputs (Sanusi and Oluyole, 2006). These aforementioned predicaments made cocoa production dwindling over time and Nigeria is currently the fourth world producer which is 367,000 tonnes after Cote d'Ivoire, Ghana and Indonesia (World Atlas, 2018).

The need to increase cocoa beans yield becomes paramount as Nigerian Government and the World Bank embarked on Cocoa improvement projects such as promotion of adoption of cocoa rehabilitation techniques which commence in 1999 under National Cocoa Development committee with the objective of rehabilitation of old and moribund cocoa trees in all 14 Cocoa producing states. This has yielded positive results of cocoa farmers have adopted various cocoa rehabilitation techniques transferred to them.

Cocoa rehabilitation techniques were considered to be the restoration of the yields to the peak level by the systematic replacement of inferior trees (Adebiyi *et al*., 2018. It can also be described as the process whereby unproductive cocoa farms or plantations can be made productive by extending the economic life of the trees through replacement of the old trees with improved younger cocoa tree (CRIN, 2001). Sequel to the above, this study was designed to determine attitude of cocoa farmers toward the practice of cocoa rehabilitation techniques and how it affects their participation in the scheme.

Hypothesis of the study

There is no significant relationship between some selected socio-economic characteristics of the respondents and their attitude towards cocoa rehabilitation techniques

MATERIALS AND METHODS

Smallholder cocoa farmers in Southern Nigeria were considered for this study. A multi-stage sampling procedure was used for the selection of respondents. From 10 cocoa producing states in Southern Nigeria; Ondo, Cross-Rivers and Oyo States were purposely selected because of their level of involvement in the Federal Government Cocoa Rehabilitation Programme. This was followed by purposive selection of two local governments and two communities where farmer's organizations participated in cocoa intervention programme. Finally, 25 small holder cocoa farmers were randomly selected using table of random numbers among the farmers in any of cocoa group they belong such as Cocoa Farmers Association of Nigeria and Cocoa Association of Nigeria. Thus a total of 300 respondents were selected and interviewed in this study. Structured interview schedule was used to collect data for the study. Frequency counts and percentages were used to describe the data while Pearson Product Moment Correlation was used to test the relationship between the attitude of cocoa farmers and their socio-economic characteristics. Attitude of cocoa farmers toward rehabilitation techniques was depended variable and was measured on a 5-poits Likert type scale.

RESULTS AND DISCUSSION

The ability of cocoa farmers to practice cocoa rehabilitation techniques introduced to them will determine the volume of cocoa production. Figure 1 shows 88.0% practiced cocoa rehabilitation techniques as few (12%) of the respondents did not adopt any of the techniques.

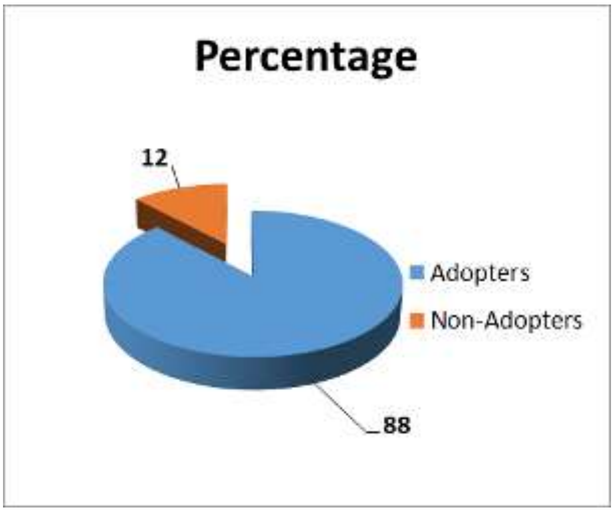

Figure 1: Distribution according to adoption

Multiple responses Source: Field Survey, 2017

The distribution of respondents by household size as shown in figure 2 reveals that some 49.9% of the respondents had household size of 1 - 5 persons, 47.0% of the respondents had household size of 6 - 10 persons while (3.3% and 0.3%) of the respondents had household size of 11 - 15 and greater or equal to 16 persons respectively. The mean household was 5 persons; this implies that the majority of the respondents have a moderate household size which could lead to access to farm labour (Oluyole, etal; 2013) stated that the larger the household size, the more family labour available for agricultural production.

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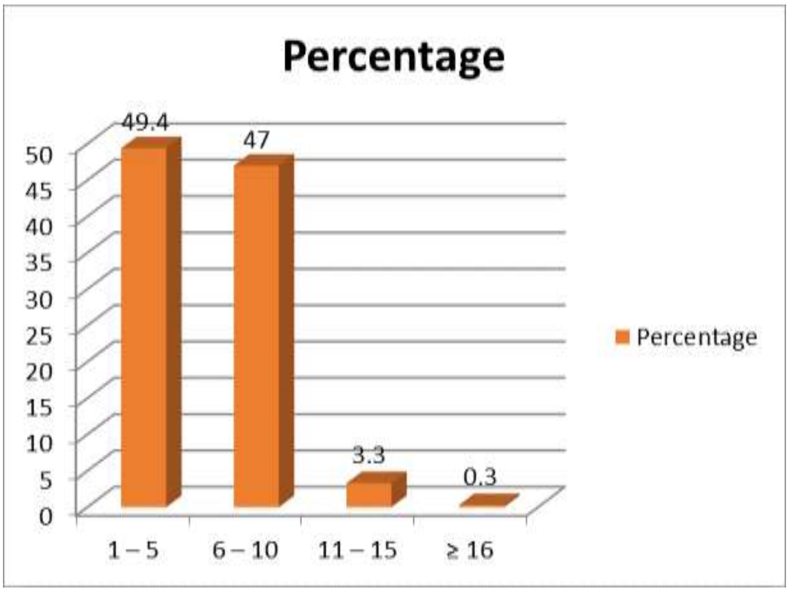

Figure 2: Distribution of the Respondents according to their household size

Mean = 5, Source: Field Survey, 2017

From Figure 3, the mean cocoa farms acquired were 3.3. The finding shows that, more than half (54.0%) of cocoa farmer acquired more than three cocoa farms, while 46.0% of the respondents claimed they have between one and two cocoa farms. This showed that apart from the cocoa farms the respondents acquired through inheritance which is too small to make the ends meet, some of them acquired more cocoa farms through purchased, leased, rent and share cropping. Adebiyi *et al.* (2013) supported that land fragmentation has made many cocoa farmers who view farming a career option to acquire more farms in addition to the one inherited from their father.

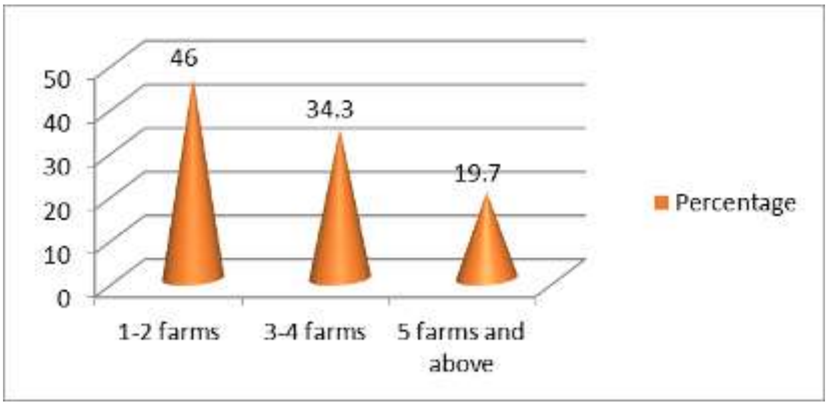

Figure 3: Distribution according to the number of cocoa farms acquired

Mean = 3.3. Source: Field Survey, 2017

Table 1 shows the distribution of respondents according to their membership in social group. The findings revealed that majority of the farmers (87.3%) were participants of social groups, it was also revealed that 51.3% were ordinary member, 36% of them were executive member, while, few (12.7%) of them were not member of social group. The implication is that farmers will be informed of new innovations introduced to their community. This agrees with the findings of Adebiyi *et al.* (2018) who discovered that being a member of group has a positive and significant relationship with adoption of new technology.

Table 1: Distribution of the Respondents according to membership of social group

Membership	Frequency	Percentage (%)
Non- Membership	38	12.7
Ordinary member	154	51.3
Member of executive	108	36
Total	300	100

Source: Field Survey: 2017

Table 2 revealed that State, Ministry of Agriculture (77%), Research Institutions (70.7%) and Cocoa Association of Nigeria/Cocoa Farmers Association of Nigeria (CAN/CFAN) (66%) were the most frequent source of information on planting under old cocoa trees as claimed by the respondents, Input Agency (60%), Radio/TV (59.7%), Extension Agent (53.3%), Friend/Neighbours (51.7%) and Non-Governmental Organization (NGO) (48.3%) were also sources of information on planting under old cocoa trees. This is in line with assertion of Akinnagbe and Ajayi (2012) on assessment of farmers' benefits derived from Olam Organization's Sustainable Cocoa Production extension activities in Ondo State, those cocoa farmers have improved knowledge and skill acquisition in their production as well as economics gains in terms of yield and income.

The Table further reveals that State Ministry of Agriculture (69.7%), Radio/TV (69%) and CAN/CFAN (63.7%) were the major sources of information on gapping up to cocoa farmers. However, the State Ministry of Agriculture (83.7%) and Research Institution (74.3%) are the major sources of information on coppicing. Information is germane to adoption as the medium and source determines the sustainability of any innovation introduced to farmers. Farmers depend on information that would help them to solve their production problems. This supports the findings of Famuyiwa *et al*. (2014) who found that innovative nature of some technologies affects its movement. Okunlola and Akinwalere (2019) also affirmed that source of information influence adoption of improved techniques in tree crop management.

Table 2: Respondents' sources of information on cocoa rehabilitation techniques

Rehabilitation techniques	Radio /TV		Ext. Agent		Input Agency		Friend/ Neighbour		Res. Institute		Min. of Agric.		CAN/ CFAN		NGO/Private Org.	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Planting under old trees	179	59.7	160	53.3	180	60	155	51.7	212	70.7	231	77	198	66	185	61.7
Gapping up	207	69	154	51.3	164	54.7	184	61.3	161	53.7	209	69.7	191	63.7	173	57.7
Phased farm replanting	2	0.7	6	2	2	0.7	3	1	86	28.7	8	2.7	4	1.3	6	2
Complete farm replanting	125	41.7	132	4.4	190	63.3	114	38	206	68.7	251	83.7	171	57	91	4.3
Coppicing	2	0.7	74	24.7	11	3.7	18	6	223	74.3	188	62.7	23	7.7	41	13.7

Multiple responses
Source: Field Survey, 2017

Table 3 reveals that the respondents have both positive and negative pre-disposition towards the practice of cocoa rehabilitation techniques. The respondents were positive pre-disposed to attitudes such as rehabilitation had promoted yield of cocoa trees ($\overline{X}$ = 4.38), adoption of cocoa rehabilitation enhanced my standard of living ($\overline{X}$ = 4.30), cocoa rehabilitation increased yield of cocoa trees ($\overline{X}$ = 4.38), reduced pest attack on cocoa farms ($\overline{X}$ = 4.54), rehabilitation is a solution to low yield ($\overline{X}$ = 4.49), training is important in cocoa rehabilitation techniques ($\overline{X}$ = 4.69), rehabilitation improves moribund cocoa trees ($\overline{X}$ = 4.44).

Inversely, respondents were negatively pre-disposed to attitude such as rehabilitation does not promote cocoa bean yield ($\overline{X}$ = 1.77) adoption of rehabilitation has not enhance my income ($\overline{X}$ = 1.55), rehabilitation is complex to practice ($\overline{X}$ = 1.59), rehabilitation is not a solution to reduction in output ($\overline{X}$ = 1.47). These attitudes have negative pre-disposition and were all categorized as

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unfavourable attitude. The negative attitude towards cocoa rehabilitation techniques could be traced to low awareness, inadequate information, unavailability of planting materials and chemical inputs required in cocoa rehabilitation techniques. This is in consonance with Bisanda et al. (1998), who identified lack of knowledge and collateral as major constraints to obtain credit.

Table 3: Distribution of respondents according to their attitude about cocoa rehabilitation techniques

Cocoa Rehabilitation Techniques	Mean	Remark
Training is important in cocoa rehabilitation techniques (p)	4.69	Favourable
Cocoa rehabilitation reduces pests attack on my farm	4.54	Favourable
Cocoa rehabilitation is a solution to low yield of my cocoa farm (p)	4.49	Favourable
Cocoa rehabilitation is not difficult to practice (p)	4.49	Favourable
Cocoa rehabilitation has increased yield of my cocoa tree (p)	4.48	Favourable
Cocoa rehabilitation improves moribund cocoa trees in my farm (p)	4.44	Favourable
Cocoa rehabilitation has promoted cocoa beans yield (p)	4.38	Favourable
Cocoa rehabilitation promotes farm sanitation (p)	4.33	Favourable
Cocoa rehabilitation encourages management practices in my farm (p)	4.32	Favourable
Adoption of cocoa rehabilitation has enhanced my standard of living (p)	4.30	Favourable
Cocoa rehabilitation does not promote cocoa bean yield (N)	1.77	Unfavourable
Cocoa rehabilitation does not promote farm sanitation (N)	1.62	Unfavourable
Rehabilitation is complex to practice (N)	1.59	Unfavourable
Adoption of cocoa rehabilitation has not enhanced my standard of living (N)	1.55	Unfavourable
Cocoa rehabilitation does not reduce pest and diseases attack (N)	1.53	Unfavourable
Cocoa rehabilitation is difficult to promote (N)	1.49	Unfavourable
Cocoa rehabilitation is not a solution to reduction in cocoa output (N)	1.47	Unfavourable
Training is not important in capacity building (N)	1.47	Unfavourable
Cocoa rehabilitation does not encourage soil management practices (N)	1.43	Unfavourable
Cocoa rehabilitation does not improve moribund cocoa trees’s performance (N)	1.30	Unfavourable

Grand Mean = 2.98, High attitude ≥ grand mean = Favourable., Low attitude < grand mean = Unfavourable.
Source: Field Survey, 2017.

Table 4 revealed that membership of organization (r=0.674; p= 0.05) had the highest correlation coefficient with attitude of cocoa farmers toward rehabilitation techniques. The indication is that various organizations farmers belonged create awareness about cocoa rehabilitation programme and this is capable of stimulating their interest to participate in the programme.

There was a positive (r=0.624; p 0.05) and significant relationship between the farmers’ attitude and source of information. This implies that information available to cocoa farmers determines their level of participation. However, household size (r=0.541; p 0.05), and number of cocoa farm acquired (r=0.521; p 0.05) shows a positive and significant relationship with attitude of farmers toward cocoa rehabilitation.

Table 4: Relationship between some selected socio-economic characteristics of the respondents and their attitude toward cocoa rehabilitation techniques (n=300)

Variable	r- value	Decision
Member of organization	0.674*	Significant
House hold size	0.541*	Significant
Number of cocoa farm acquired	0.521*	Significant
Source of information	0.624*	Significant

*Significant at 0.05 levels
Source: Field Survey, 2017.

CONCLUSION

Cocoa rehabilitation which is an intervention programme of federal government to rejuvenate moribund cocoa farms has brought about increase in cocoa beans yield. However, there is need to consider positive attitude exhibited by the respondents in order to enhance participation in the programme. The favorable attitude revealed in this study revealed that, cocoa rehabilitation techniques practiced by cocoa farmers has brought about increase in their farm yield which results to the promotion of their socio economic status. Based on this findings, it is recommended that various stakeholders in cocoa industry should be encouraged to work together with cocoa farmers in order to solve farmers' problem in a more integrated and holistic approach.

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ASSESSMENT OF ADOPTION OF IMPROVED AGRICULTURAL PRACTICES AMONG HOME GARDENERS AT NEIGHBORHOOD COMMUNITIES OF NATIONAL HORTICULTURAL RESEARCH INSTITUTE (NIHORT), MBATO, OKIGWE IMO STATE

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ABSTRACT

Assessment of adoption of improved agricultural practices among home gardeners at neighborhood communities of National Horticultural Research Institute (NIHORT), Mbato, Okigwe Imo state was conducted in 2018. Combination of purposive and multi-stage random sampling techniques was used to select 64 farmers as sample size. Primary data were collected using structured questionnaire and oral interviews and analyzed with both descriptive and inferential statistical tools such as percentage, frequency table and 4- point Lickert scale. Result of data analysis shows that greater number of females (51.6%) practiced home garden activities than males (48.4%), the farmers had average age of 39 years, and average annual income was about N38,000.00, from home garden activities only. Meanwhile, all the farmers were aware of all the examined improved agricultural practices such as use of irrigation, crop rotation, fertilizer, pesticide and herbicide. With the exception of vertical farming and use of drones, however, use of manual irrigation, crop rotation, fertilizer and improved seeds was outstanding. While, some notable factors such as inadequate finance, and inadequate or lack of access to loan, significantly constrained adoption of improved agricultural practices in the area. It was therefore recommended that both state and local government as well as nongovernmental organization should offer farmers soft loan to enable them meet up with cost of adequate adoption of improved agricultural practices; also, NIHORT Mbato, local and state government should have sent adequate trained extension agents to the area, to intimate the gardeners on the current needs of improved agricultural practices.

Key words: awareness, adoption, improved agricultural practices, home garden

INTRODUCTION

Globally, agricultural productions have shifted from conventional and traditional farm practices to more diversifying and market oriented crops production. The need for fruit and vegetables production has been tremendously recommended in every part of the world (FAO, 2009). In the recent times, people growing both staple and non-staple crops within their surroundings have increased significantly. Home garden production is a wonderful aspects of agriculture that concerns with the cultivation of multipurpose and multi-storied trees and crops combined with animal husbandry around a homestead (Galhena, 2013). According to Uzokwe, *et al. (*2016) home gardens are of vital importance for the socio-economic development of subsistent and resource poor communities. It is an important source of supplementary income in the family (Adeoye *et al*., 2018). It is a sustainable agro system that meets various households needs such as food, medicine, ornamental purposes among others (Oritz-sanchez *et al*, 2015). According to FAO (2006), some vegetables and fruit varieties are grown in traditional gardens which lack improved know-how and depend on limited means for their upkeep. However, increased home garden production could play an important role of reducing reliance on food assistance and imports, and enhancing overall agricultural development (Hailu, 2008). Increased vegetables and fruit cultivation has been enhanced by the use of modern agricultural technologies. Though, traditional knowledge of farming is mainly utilized in home garden practices in the study area, the importance of improved agricultural production technologies in achieving sustainable increases in food production cannot be overemphasized. A good example for Africa to leverage on is the green revolution model in Asia and Latin America where significant economic growth has been achieved through the introduction and adoption of improved agricultural production technologies, mainly improved seeds, irrigation, fertilizers, pesticides, herbicide and farm arrangement (Hailu, 2008). Farmers are currently replacing their traditional crop cultivars with the new innovations including the improved varieties, in many cases with hybrid varieties (Eisses and Chaikam, 2002). By extension crop that provide higher economic returns, thus provide better livelihood opportunities. There is little or no information on the awareness and adoption of improved agricultural technologies in home garden practices in the study area, hence the objective of the study to assess the adoption of improved agricultural practices among home gardeners. Specifically, the study tends to; describe the socio-economic characteristics of the home gardeners, ascertain whether the farmers are aware of new agricultural practices, determine the level of adoption of improved agricultural practices and identify factors militating against adoption.

MATERIALS AND METHODS

The study was carried out in the neighbourhood communities of National Horticultural Research Institute (NIHORT), Mbato, Outstation, Okigwe local government area of Imo state, Nigeria in 2018. Five communities (Aku, Agbobu, Umulolo, Umuowa-ibu and Okigwe urban) that surround the Institute were surveyed. Okigwe is the third largest city, after Orlu and Owerri. The local government lies between $5^0 30^0$N to $5^0 57^0$N and $7^0 40^0$E to $7^0 55^0$E with population of 132,237(2005 census). Okigwe has a land mass of 1,824km^2 and less than 13km distance from Abia State University, Uturu. The people of Okigwe cultivate crops such as cucumber, watermelon, cassava, yam, maize, garden egg, telfairia, cocoyam, orange, plantain, etc. Combination of purposive and multi-stage random sampling techniques was used to select 64 farmers as sample size for the study. Primary data were collected using structured questionnaire from the sampled farmers.

RESULTS AND DISCUSSION

Result of data analysis in table 1 shows that greater number of females (51.6%) practiced home garden activities than males (48.4%) in the area. This is in line with the findings of Kabir *et al.* (2008) that women are mostly involved in home garden production and management-related activities. Increased involvement of women in a broad range of home garden production and management activities is not only beneficial for sustaining their own socioeconomic well-being, but also, imperative for sustaining the livelihoods of their communities (Sayma, *et al* 2010).

The farmers' average age was 39 years, which is very good for decision taking on early adoption of improved technologies in active home garden production. This is true because, young farmers are expected to be more innovative and risk taking (IFAD, 2020). Meanwhile, greatest percent (78.1%) of the sampled farmers are married with average family size of 10 members; this implies that the farmers are mature enough with good family size that can propel them to adopt any improved agricultural technologies which could increase their level of farm output in order to meet up with households needs. More so, large household size is commonly expected to increase adoption, as it is used as a proxy for labour availability in places with labour market imperfections. Although, the exact effect depends on whether the technology is labour saving or increases labour needs (Munguia and Llewellyn, 2020). However, their level of education was poor with majority (45.3%) and (35.9%) were only able to have secondary and primary education respectively, while only (18.8%) got tertiary education. This low level of education would affect their level of knowledge, acceptance and adoption of improved agricultural technologies, which in turn will affect their level of farm output. This is because; good level of education is expected to affect technology adoption positively since new technologies require an understanding of the expected returns from a new technology (Huffman 2020). High level of education among the farmers would likely make them more responsive to many agricultural extension programmes and policies (Agwu *et al*.,2008). Meanwhile, the farmers have spent an average of 14 years in home garden production which would enhance their level of knowledge on traditional home garden activities. Agwu *et al*., (2008) reported that long farming experience is an advantage for increased home garden productivity and could encourage rapid adoption of farm innovations. Data in table 1 also, shows that each farmer's farm size is less than a hectare. Home garden cultivation is usually done on small land area around the homestead (FAO, 2014). This has resulted to poor average annual income of about N38,000.00, from home garden activities, which might hinder them from meeting up with costs associated with adoption of improve technologies. This is because, IFAD, (2020) has reported that high annual home garden income is expected to positively affect the adoption of new practices that require up-front cash investments such as use of improved seeds or fertilizers.

Data analysis in table 2 reveals that all (100.0%) of the farmers knew about improved seeds, while only 59.4% had used them. This is poor level of adoption. Mundlak, *et al*, (2004) has noted that most of improved seeds are high input responsive with higher economic returns compared to local varieties. All (100%) of the farmers interviewed in this study knew about manual irrigation system, which is necessary because of irregular and uneven pattern of rainfall throughout the year, especially during critical growth period of the crops. And so, 90.7% of them had been using it.

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This is good level of adoption considering the facts that; irrigation has become necessary in order to avoid crops failure and meet up with pressure on growing food demand and provide low cost food to an increasingly world populations (Giordano, *et al*, 2017). Meanwhile none of the farmers studied or interviewed used mechanized system of irrigation on their home garden activities even when 60.9% of them were aware of that. Verma (2006) has stated that mechanized irrigation system enhances the productivity of home gardens due to timeliness of operations and precision in the application of water. One hundred percent (100.0%) of farmers were aware of pesticide use in home garden, since, pests were notable problems that need to be removed, however, it was adopted by 28.8% only. This very poor level of adoption could be as a result of having very poor knowledge about pesticide, poor income or simply avoided to avert risk. Nevertheless, Kroening and Frishel, (2016) has reported that pesticide can increase production in the gardens and fields by reducing loses caused by insects, diseases and weedy species. Similarly, 100.0% of farmers had knowledge of herbicide, and, it was applied by 21.8% of them, which is very poor level. This could be attributed to the fact that Gianessi (2013) had opined that herbicide reduces manual weeding, that is time-consuming, physically demanding, and often detrimental to the farmers 'health and well-being. Furthermore, all (100%) of the farmers were cognizant of fertilizer use, which improves soil fertility, that sustains plant growth and optimize crop yield, thus, 71.9% of the farmers had used fertilizer in their home gardens. This good level of fertilizer use may have been necessitated by increased yields and higher profit return from produce sales. IAEA/FAO, (2020) noted that advancing food security and environmental sustainability in home garden systems requires an integrated soil fertility management approach such as use of fertilizer, organic inputs, among others, that maximizes crop production and minimizes the mining of soil nutrient reserves. Seventy-five (75%) of farmers were aware of farm and crops arrangement and it was practiced by 43.8% of them. This is very poor level of adoption considering the facts that farm and crops arrangement exposes the orderliness and beauty of home garden and crops, and facilitates post planting activities such as weeding, spraying of pesticide and liquid plant food, farm observation, harvesting of crops, among others. Again, all (100%) of the farmers were aware of electricity but none of them used it, due to total power failure in the area. This lack of electricity could be a significant constraint to adoption of improved technologies, growth and productivity of home garden; in that it induces growth in the rural economy including agriculture by bringing about higher agricultural income and improved opportunities for nonfarm labour (Gilberto, 2012). Over ninety percent (90.7%) of farmers were aware of crop rotation, and 84.4% of them rotated crops in their home gardens. Crop rotation helps to maintain soil structure and nutrient levels and to prevent soil borne pests from getting a foothold in the garden (Rudolph *et al*, 2020). Finally, none of the farmers know about vertical farming such as hydroponics, aquaponics, aeroponics and use of drone in home garden production, because these new technologies were yet to be introduced in the area. These new technologies could have been a helpful answer to frustrations with traditional home garden practices. This is because, it provides longer growing capacity, less water consumption, and improved crop predictability due to controlled environment which aims at optimizing crop growth and yield (Birky and Jeff,2016). Benke and Tomkins, (2017) has noted that the main advantage of utilizing vertical farming technologies is the increased crop yield that comes with a smaller unit area of land requirement.

It was found from the result in table 3 that inadequate finance (x=3.45) and inadequate or lack of access to loan (x=3.42), were notable adoption constraining factors; that can impede increased investments in home garden, particularly in the identification and promotion of improved agricultural technologies and practices (AASR, 2016). This is because, resource endowments (including various wealth indicators and access to off-farm income) are significantly correlated with higher adoption of home garden related practices (IFAD,2020). Lack of modern power production equipment (x=3.35), such as cultivators, irrigation sprinklers, hedge trimmers, mini tractors, etc was found to be militating against adoption practices in the area. FAO, (2021) stated that sustainable home garden production with the use of modern power equipment that reduces drudgery can contribute significantly to the development of value chains and food systems as it has the potentials to render postharvest, processing and marketing activities more efficient, effective and environmentally friendly. Lack of processing and storage facilities (x=3.34), was identified as an impediment to use of improved agricultural practices in home garden, in that it effects farmers income, as they were often compelled to sell their produce at very low prices to avoid much losses due to post harvest spoilage. TNUA, (2015), opined that processing and storage provides employment and higher income through price advantages. Pests and diseases attack (x=3.31), was observed as a problem. Due to the fact that they affect food crops, causing significant losses to farmers and threatening food security (FAO, 2021). Small available land (x=3.26), that could not accommodate the use of power equipment on home garden production was also a problem. Mehari and Abera, (2019), stated that as the area of the gardens is limited, the improved agricultural activities undertaken inside the gardens will also be minimal, thus, the output. Poor produce prices (x=3.20), due to glut, uncontrolled market price system and poor purchasing power of the consumers in the area was seen as a challenge. This is because, high produce price is known to stimulate more food production including fruit and vegetables that can generate new jobs and improve welfare (FAO,2011). High cost of inputs (x=3.17), as a result of poor income and high level of inflation rate in the country would hamper adoption of improved agricultural practices in home gardens. Because if the cost of input rises then the cost of production will also increase and it will tend to reduce urge to produce and create some cut in production and so, less need of the improved product. Changes in rainfall pattern and other weather conditions (x=2.88), affects adoption of improved practices in home garden. As it increases crop diseases incidents, uncertainties, risks and causes drastic reductions in soil fertility (Kashaigili *et al.,* 2014). Inadequate extension services (x=2.85), was noted as a constraint to adoption of improved agricultural technologies. This agrees with, Dideon-Abbeam, *et al.,* (2018), that adequate extension services would have been the major channel for disseminating information on improved agricultural technologies to home gardeners, and it is expected to increase garden productivity and revenue, reduce poverty and minimize food insecurity.

CONCLUSION AND RECOMMENDATION

From the findings of this study it was concluded that farmers were aware of all the examined improved agricultural practices on home garden activities, with the exception of vertical farming and use of drones. However, use of manual irrigation, crop rotation and fertilizer, was outstanding in the area, which is followed by use of improved seeds. While, farm and crop arrangement, pesticide and herbicide use, were very poorly adopted. Use of mechanized irrigation system, electricity or solar power, vertical farming and use of drone were not adopted at all. Nonetheless, some notable factors such as inadequate finance, inadequate or lack of access to loan, lack of modern power equipment and lack of processing and storage facilities significantly constrained adoption of improved agricultural practices in the area. It was therefore recommended that both state and local government as well as non-governmental organization should offer farmers soft loan to enable them meet up with cost of adequate adoption of improved agricultural practices. More, so, NIHORT Mbato, local and state government should send adequate trained extension agents to the area, to intimate the gardeners on the unavoidable needs of improved agricultural practices.

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Table 1: Socio-economic characteristics of farmers

Socioeconomic variables	Frequency	Percentage(%)	Mean
Sex			
Male	31	48.4	
Female	33	51.6	
Age			
≤30	15	23.4	
31-40	21	32.8	
41-50	20	31.3	39.15
≥50	8	12.5	
Marital status			
Single	14	21.9	
Married	50	78.1	
Separated	0	0.0	
Divorce	0	0.0	
Family size			
≤10	51	79.7	
11-15	12	18.8	10.00
≥16	1	1.6	
Level of education			
No formal education	0	0.0	
Primary education	23	35.9	
Secondary education	29	45.3	
Tertiary education	12	18.8	
Years of home garden production			
≤10	22	34.4	
11-15	18	28.1	
16-20	12	18.8	14.41
≥21	12	18.8	
Farm size(hectare)			
≤1	64	100.0	
Annual home garden income			
≤N30,000.00	29	45.3	
N31000.00-N40000.00	16	25.0	
N41000.00-N50000.00	12	18.8	
N510000.00-N60000.00	1	1.6	
≥N61000.00	6	9.4	N37,585.94

Source: Field Survey Analysis, 2018

Table 2: Improved Agricultural Practices in the study area

Improved technologies	Awareness		Adoption	
	frequency	Percentage(%)	Frequency	Percentage (%)
Improved seeds	64	100.0	38	59.4
Irrigation				
Mechanized	39	60.9	0	0.0
Manual	64	100.0	58	90.7
Pesticide	64	100.0	18	28.1
Herbicide	64	100.0	14	21.8
Use of fertilizer	64	100.0	46	71.9
Farm and crops arrangement	48	75.0	28	43.8
Electric or solar power	64	100.0	0	0.0
Crop rotation	58	90.7	54	84.4
Vertical farming	0	0.0	0	0.0
Hydroponics	0	0.0	0	0.0
Aquaponics	0	0.0	0	0.0
Aeroponics	0	0.0	0	0.0
Use of drones	0	0.0	0	0.0

Source: Field Survey Analysis, 2018

Table 3: Factors Militating against Adoption of Improved Agricultural Technologies

Factors militating against adoption	Mean	Standard deviation
Inadequate finance	3.45	.50
Inadequate or lack of access to loan	3.42	.66
Small available land	3.26	.71
Inadequate extension services	2.85	.77
Lack of processing and storage facilities	3.34	.78
Pests and diseases attack	3.31	.68
Poor produce prices	3.20	.59
Lack of modern power equipment	3.35	.65
High cost of inputs	3.17	.74
Changes in rainfall pattern and other weather conditions	2.88	.81

Source: Field Survey Analysis, 2018

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PARTICIPATION CONSTRAINTS OF UNEMPLOYED GRADUATES IN OYO STATE CASHEW FARMING

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ABSTRACT

Cashew tree is of economic importance grown commercially in some areas in Nigeria such as Oyo state for its apple and especially the nuts. Over the years, cashew farming has experienced a decline due to reduction in cashew farmers and senile cashew trees. The goal of this paper is to identify and proffer solutions the constraints in cashew farming peculiar to unemployed graduates in Oyo state. Some selected areas where considered in Oyo state where data on socio economic character, awareness of cashew tree and its importance and constraints of graduates' involvement in cashew farming were collected using questionnaires. 90 respondents were considered in the survey. Data was analyzed using SPSS statistical package. Result showed that 46% of the unemployed graduates were between the ages of 28-31 years. The study also showed that 85.6% knows the economic importance of cashew while 91.1% knows cashew farming as profitable. Lack of fund ranked first of the constraints to cashew farming. Majority of the graduates are aware of the importance of cashew. Zero or single digit interest loans or grants should be given to the unemployed graduates so as to encourage them in participating in cashew farming thereby increasing its production.

Key words: Cashew, unemployed, constraints, farming, graduates, production

INTRODUCTION

Cashew tree (*Anacardium occidentale* L.) is a popular specie of the Anacardiceae family (Subbarao *et al*., 2011). Commercial farming of cashew started in 1953 (Akinwale and Esan, 1989) but now cultivated in about 20 states in Nigeria with Kogi, and Oyo state among the heavy producers. It is among the important edible nuts with high demand in the world market with Nigeria among its leading producers. The tree brings substantial income to both the farmers and the local buyers (Elijah, 2015). Cashew is mostly ventured into for its wood, apple and more importantly the nut (Adeigbe, *et. al*., 2015).

There is a noticeable decline in the yield of cashew in most growing areas in Nigeria due to decrease in the number of cashew farmers over time (Hammed *et. al*., 2008) and increase in moribund cashew trees. Globally, Nigeria contributes about 2.52 percent share of the total export of cashew nut in world market which is low compared to the contributions of other cashew producing countries (FAOSTAT, 2019). Nigerian cashew nut value chain has not been fully exploited, despite its money making potentials. (Adesanya *et. al*., 2021).

Oyo state is a major cashew producing state in Nigeria with high population of its graduates seeking for employment or a sustainable source of income. Therefore, the objective of this study is to:

1. Understand the constraints of unemployed graduates in Oyo state to cashew farming.
2. Identify ways of increasing youths or graduates' engagement in cashew farming.

MATERIALS AND METHODS

The study was conducted in Oyo State with the coordinate 8.1574° N, 3.6147° E which is located in South Western Nigeria. It is the 5th ranked most populated state in Nigeria with a population of about 7,840,864. The vegetation pattern of Oyo State is that of rain forest in the south and guinea savannah in the north. Some selected areas were considered due to their dense population and high numbers of graduate youth. Purposive sampling was also used in selecting 90 respondents as they are either job-seeking graduates or unemployed but running a not too sustainable business before participating in the survey. Data were collected using questionnaires. The data collected were socio-demographic characteristics of the respondent, awareness on cashew tree and its importance and constraints to graduates participation in cashew farming. Data obtained were analyzed using SPSS statistical package (version 22) and subjected to descriptive statistics such as frequency table and percentage.

RESULTS AND DISCUSSION

The table 1 on socio-economic characteristics of the unemployed graduates showed that 59.3% are male while 40.7% are female. 46% were between the ages of 28-31 years, 23.3% were between the ages of 32-35 years while 22.2% were between the ages of 24-27 years which implies that majority are still in their very active youthful age which gives them an advantage of success if engaged in cashew farming. 58.2% are single while 41.8% are married. 55.6% had B.Sc. qualification and 34.5% had M.Sc. qualification which shows that majority of the graduates has highly invested in their education.

Table 1: Socio-economic characteristics of the respondents

Socio-economic characteristics	Frequency	Percentage
Sex		
Male	54	59.3
Female	37	40.7
Age		
20 – 23	2	2.2
24 – 27	20	22.2
28 – 31	42	46.7
32 – 35	21	23.3
36 – 39	5	5.6
Marital Status		
Single	52	58.2
Married	38	41.8
Academic qualification		
National Certificate of Education (NCE)	3	3.3
Bachelor of Science (B.Sc.)	50	55.6
Master of Science (M.Sc.)	31	34.5
Other	6	6.6

Source: Field survey: 2021

The table 2 on distribution of respondents by their awareness of Cashew tree and its importance showed that 98.8% can identify or are aware of what a cashew tree is which indicate that cashew tree is a well-known tree. 100% of the respondent knows what a cashew nut is which showed that cashew nut is a popular nut among the graduates. 85.6% knows what a cashew apple is. 93.3% knows cashew as a crop of economic importance, also 85.6% is aware of cashew to be a major export commodity in Nigeria which indicates that importance of cashew both as an economic crop and a major export commodity is well known. 91.1% knows cashew farming to be profitable. 64.4% knows Nigeria as one of the leading producers of cashew nut while 35.6% are not aware.

Table 3 shows the constraints to graduates participation in cashew production and value chain. Lack of fund ranked 1st of all the constraints to cashew production considered as it is one of the discouraging factors when considering plantation farming. Insecurity ranked 2nd of the constraints which is a major problem being currently faced by Nigerian farmers. Pilfering which is one of the major problem encountered by cashew farmers ranked 3rd. Little or no knowledge in cashew farming ranked 7th and 3 to 4 years wait before fruiting was ranked least (11th) of all the constraint.

Table 2: Distribution of respondents by their awareness of Cashew tree and its importance

Awareness of Cashew tree and its importance	Aware	Not aware
Can you identify a cashew tree?	88 (97.8)	2 (2.2)
Do you know what a cashew nut is?	90 (100)	0 (0.0)
Do you know what a cashew apple is?	77 (85.6)	13 (14.4)
Do you know that cashew tree is of economic importance?	84 (93.3)	6 (6.7)
Do you know that cashew nut is a major export commodity in Nigeria?	77 (85.6)	13 (14.4)
Do you believe that cashew farming is profitable?	82 (91.1)	8 (8.9)
Do you know that Nigeria is one of the leading producers of cashew nut?	58 (64.4)	32 (35.6)

Source: Field survey, 2021. Value in parentheses ( ) are percentages

Table 3: Constraints to graduates participation in cashew farming

Constraints to Cashew farming	Severe	Not Severe	Not a Constraint	WMS	Rank
Lack of fund	67(74.4)	20(22.2)	3(3.3)	1.71	1st
Availability of land to farm	48(53.3)	28(31.1)	14(15.6)	1.38	5th
Little or no knowledge in cashew farming	38(42.2)	38(42.2)	14(15.6)	1.27	7th
Little to no understanding on the value of crop	26(28.9)	45(50.0)	19(21.1)	1.08	9th
The 3 to 4 years wait before fruiting	20(22.2)	40(44.4)	30(33.3)	0.89	11th
Poor knowledge of its value chain	40(44.4)	33(36.7)	17(18.9)	1.26	8th
Little to no knowledge about marketing of cashew products	37(41.1)	42(46.7)	37(41.1)	1.29	6th
Little to no knowledge about processing, processing machines or equipment	47(52.2)	34(37.8)	9(10.0)	1.42	4th
Insecurity	61(67.8)	22(24.4)	7(7.8)	1.60	2nd
Access to labour	29(32.2)	38(42.2)	23(25.6)	1.07	10th
Pilfering (theft)	51(56.7)	28(31.1)	11(12.2)	1.44	3rd

Source: Field survey, 2021. WMS-Weight Mean Score.

CONCLUSION

Larger population of the job hunting graduates are still in their very youthful age, well-educated and unemployed for about an average of 4.98 years. Creating job opportunities for this population by engaging them in cashew production will help increase the decline experienced in cashew production and output thereby serving as job opportunity and a major source of sustainable income for the unemployed youths. Cashew tree, its nuts and apples are well known as a profitable economic and export crop in Nigeria, therefore necessary trainings and empowerment must be adopted to help monetize this knowledge thereby increasing cashew production. Government should work in partnership with commercial banks and bank of agriculture in giving zero or small interest loans to graduates or youths who wants to engage in farming activities such as cashew farming since it is a capital intensive project. Regular dissemination of information on cashew farming and processing, farm security and anti-theft lectures should be passed via mass media, social media and seminars by research institutes such as Cocoa Research Institute of Nigeria whose one of its mandate crops is cashew.

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ASSESSMENT OF EMERGING PRODUCTION CONSTRAINTS ENCOUNTERED IN CASHEW PRODUCTION IN KOGI STATE, NIGERIA

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ABSTRACT

Cashew production has contributed greatly to Nigeria economic growth, unfortunately its production is faced with so many constraints that if not urgently addressed it can make cashew production to go into extinction. This study therefore examined emerging constraints facing cashew production in two local governments area of Kogi State, North central Nigeria. Data were obtained through structured questionnaire administered to 60 randomly selected cashew farmers from the study area. Data were analysed using descriptive and inferential statistics. The result revealed that majority of the respondents were male (70%), married (73.3%) with mean age of 48years. Majority (81.7%) had formal education, 50% had between 1-5 persons in their household, and 45% had farm size of between 6-10ha. Major production constraints are lack of access to credit facilities (mean =2.70 ranked 1st), price fluctuation (mean 2.68 ranked 2nd), farmers-herders' clashes (mean 2.60 ranked 3rd) and sharp practices of middle men (mean 2.59 ranked 4th). Respondents accessed inputs such as cashew nuts (95%), cashew seedlings (78%) from research institute (CRIN), farm implements (100%), chemical (90%), fertilizer (60%) from friends and family, input dealers and farmers' cooperatives society respectively. Majority of the respondents (58.3%) had negative attitude towards cashew production constraints. Chi-square analysis revealed a significant relationship between level of education (X^2= -11.622, P=0.011), primary occupation (X^2=7.360, P=0.061) and constraints faced in cashew production. It is therefore necessary for both government and non- government organizations to help in policies formulation that will reduce cashew production constraints

Key words: Assessment, Cashew Farmers, Production Constraints

INTRODUCTION

The Cashew plant, *Anacardium occidentale*, belongs to the family of Anacardiaceae is a native of central and South America with its main centre of variation in eastern Brazil. Its importance as an agricultural commodity lies in the values derivable from its fruit (nut) and apple. products from the whole fruit include the edible kernel, cashew nut shell liquid (C N S L) and the apple which can be consumed fresh as well as prepared into syrup, jams, jellies, beverages or candied fruits (Opeke, 2005) Cashew nut production trends have varied over the decades. Currently, 75 to 80% of cashew nuts produced in Nigeria are exported, as only very few companies are involved in local processing of the produce (Aliyu and Hammed, 2008).

The annual world production of cashew nuts was about 3,186,039 tons and Nigeria was rated the second among the top ten producers with 660,000 tons making the sector a major contributor to Nigeria's non-oil GDP. Vietnam is the highest producer with 961,000 tons (FAOSTAT, 2010). The estimated export value varies from US$ 25- 35 million annually, and supplements the income of about 50,000 farmers and an additional 55,000 people who are employed down its value chain (Nugawela and Oroch, 2005; Adeigbe *et al*., 2015). Out of 2.6 million tonnes of raw cashew nuts produced in the world, 42% of it come from Africa out of which 90% is exported while only 10% is left for domestic consumption.

Nigerian nuts have consistently served the Indian and Vietnamese cashew factories and in recent years have added the Brazilian market. The kernels are well accepted in the United State of America and Western Europe because of the high quality of the produce (Aliyu and Hammed, 2008). The constraints militating against cashew production are production constraints biotic, environmental, breeding, climatic and land; marketing constraints and processing constraints. Production constraints results from damages from different insect species at different stages of production. These result into high loss of yield. It attacks the leaf causing black leasion on petioles or the leaf surface. it also attacks the stem which appears as a discolored and lesion which also occurs on fruits and developing nuts. In situation of high infestation of these insect on a farm. It eats up the whole shoot and it dies or the entire tree looks burnt. This brings about great loss of income to farmers (Aliyu, 2010).

According to Agbongiarhuoyi *et al.* (2015), cashew grows almost everywhere in Nigeria with production spanning across 27 out of 36 States in all the geo-political zones. Irrespective of the predominance of this crop in many states, yield per hectare is not encouraging. There is abandonment and significant decline in yield of cashew production in most growing areas of Nigeria as a result of discovery of crude oil by federal government in early 1970s (Hammed *et al.,* 2008).

According to Agada and Sule (2020) The problems of cashew production include; old trees, deforestation, low yield varieties, dominance of small holdings and wild varieties, land acquisition, high cost of inputs, climatic conditions, diseases and pests, fire outbreaks, post-harvest losses, infrastructural constraints, poor qualities, market price of the product and the competition amongst the local buying agents. Apart from this, several authors had worked on the problems facing cashew production in Nigeria. for instance, Aliyu and Hammed (2008) worked on constraints to cashew production in Nigeria. Agbongiarhuoyi *et al.* (2015) considered factors associated with low yield of cashew among farmers in growing areas of Nigeria. Also, Oluyole *et al*. (2015) investigated constraints in cashew production among cashew farmers in Southwestern Nigeria. While Uwagboe *et al.* (2010) considered constraints of farmers in cashew production, a case study of Orire L.G.A of Oyo state Nigeria.

In order to solve some of these cashew production constraints, Cocoa Research Institute of Nigeria (CRIN) with research mandate in cocoa, kola, cashew, coffee and tea has recommended some cashew production technologies that if farmers adhere strictly to it will reduce some of these production constraints. These are regular pruning, maintenance of recommended spacing (6m x 6m or 9m x9m), cashew rehabilitation techniques, replacement of death/ missing stands, prompt harvesting of ripe cashew apples, regular weeding and planting of improved varieties of cashew nuts and seedlings

The main objective of the study was to assess the constraints limiting cashew production among farmers in Kogi- State. The specific objectives were to describe socioeconomic characteristics of the respondents, ascertained some agronomic practices, identify constraints to cashew production, identify sources of input and determine attitudes of farmers towards cashew production constraints. The hypothesis of the study was stated in the null form; there is no significant relationship between socioeconomic characteristics of the respondents and the constraints to cashew production.

MATERIALS AND METHODS

A multi-stage sampling procedure was used to select respondents for the study. Stage1: Kogi State was randomly selected from North Central. Stage 2: two Local Government Areas (LGAs) noted for cashew production were chosen. These are Dekina and Ankpa. Two villages per LGA where cashew is well produced were selected. Stage 3: Fifteen farmers were selected in each village to make a total number of sixty respondents. A list of cashew farmers was obtained from the Tree Crop Units (TCU) in the State ministry of Agriculture. A structured interview schedule was used for field data collection from cashew farmers in the study areas. Descriptive statistics and chi-square were used in data analysis. The variables were measured at 0.05 Level of probability.

RESULTS AND DISSCUSSION

The socioeconomic characteristics of the respondents

The socioeconomic characteristics of the respondents are shown in Table 1. The result revealed that greater percent (70%) of the respondents are male while 30% were female. This result is in agreement with Uwagboe *et al.* (2010) who found out that 84.5% of cashew farmers in orire local government area of Oyo State are male. The result also shows the mean age of farmers as 48 years with 73.3% married. It indicates that farmers are still very energetic and they are still in their productive age. Also, the greater numbers of married farmers in the study areas is as a result of the tedious nature of cashew farming that cannot be done alone. The mean household size was 9.7 persons. The implication of this is that farmers with higher numbers of household size tends to enjoy cheap labour for farm enterprise. This is in agreement with Onuk *et al.* (2013) who explained that household labour help in solving labour related issues on farm. Eighty-two percent of the respondents had primary school leaving and above, it shows that greater percentage of the respondents can read and write, this may be as a result of influxes young school leaver into the profession. According to the table, 66.6% of the respondents cultivated above 5 hectares while the mean farm size is 11.1hectares. This result contradicts the result of Agbongiarhuoyi *et al.* (2015) where only 47% of farmers had above 5 hectares

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Table 1: Distribution of respondents based on socioeconomic characteristics n=60

Variable	Frequency	Percentage	Mean	Std
Age(years)				
20-30	7	21.7	48.1	14.1
31-40	13	25.0		
41-50	15	18.3		
51-60	11	16.7		
Above 61	14	22.3		
Sex				
Male	42	70		
Female	18	30		
Marital Status				
Single	6	10.0		
Married	44	73.3		
Divorced	3	5.0		
Widowed	7	11.7		
Religion				
Christianity	28	46.7		
Islam	29	48.3		
Traditional worship	3	5.0		
Hose hold size(numbers)				
1-5	30	50.0		
6-10	19	31.7	9.7	
11-25	6	10.0		
Above 15	5	8.3		
Level of education				
No formal education	11	18.3		
Primary	14	23.3		
Secondary	18	30.3		
Tertiary	17	28.4		
Primary occupation				
Farming	25	46.7		
Business	11	18.3		
Civil servant	17	28.3		
Artisan	4	6.7		
Farm size(hectares)				
1-5	20	33.3	11.1	
6-10	27	45.0		
11-15	8	13.3		
Above 15	5	8.3		

Source: Field survey, 2021

Utilization of some agronomic practices

The distribution of respondents based on utilization of some cashew agronomic practices is indicated in Table 2. The result show that 60%, 45% and 41.7% of the respondents regularly practicing timely harvesting of cashew nuts, regular pruning and recommended planting spacing with mean scores of 1.53, 1.35 and 1.27 respectively. The result of regular pruning and timely harvesting is in tandem with the work carried out by Agada and Sule (2020) where 89.5% of cashew farmers pruned regularly and 100% of cashew farmers harvest regularly. Also, 78.3% and 58.3% occasionally practiced gapping up/suppling of death stands and use of improved cashew seedlings/nuts while 73.3% never practiced cashew rehabilitation technique. Cashew rehabilitation technique is the process of making unproductive cashew plantation to be productive by increasing its economic life span. It is a new technology so efforts should be geared towards training of famers on how to carry it out.

Table 2: Percentage distribution of the respondents based on agronomic practices

Agronomic practices	Regularly		Occasionally		Never			
	Freq	%	Freq	%	Freq	%	Mean	Rank
Regular pruning	27	45.0	27	45.0	6	10.0	1.35	2nd
Gapping up/suppling	7	11.7	47	78.3	6	10	1.00	6th
Cashew rehabilitation	3	5.0	13	21.7	44	73.3	0.32	7th
Control of pest and diseases	23	38.3	24	40.0	13	21.7	1.17	5th
Timely harvesting	36	60.0	21	35.5	3	5.0	1.53	1st
Use of improved seedlings& nuts	21	35.5	35	58.3	4	6.7	1.28	3rd
Recommended plant spacing	25	41.7	20	33.3	15	25	1.27	4th

Source: Field survey, 2021

Constraints encountered in cashew production

Table 3 presents the various production constraints faced by cashew farmers and their corresponding degree of severity. Constraints such as no access to credit facility (76.7%), price fluctuation (70%), farmers-herders' clashes (66.7%) and sharp practices of middlemen (65.0%) were found to be major constraints faced by the respondents. Credit is very important in cashew production as farmers need money to purchased so many things like improved seedlings/nuts, agrochemicals, some farm equipment, paid wages to laborers. Akinbode (2013) explained that it is difficult for farmers to get loan from banks as a result of stringent and high interest rate demanded by commercial bank. In addition, transportation problem (73.3%), unavailability of labour (66.6%), irregular rainfall (55.0%) and prolonged draught (53.3%) were considered as minor constraints affecting cashew production in the study areas. This result is similar to the report of Oluyole *et al.* (2015) who found out that farm activities, age of farm , inadequacy of labour, access to market information and inadequate credit are part of many challenges of cashew production in Nigeria In clear term, no access to credit facilities, price fluctuation, and farmers-herders' clashes ranked 1st, 2nd, and 3rd respectively as the most serious production constraints facing cashew production while transportation problem(13th), and irregular rainfall (14th) ranked least among production constraints in this study.

Sources of inputs

Table 4 shows that majority (95% and 78%) of the farmers got their cashew nuts and cashew seedlings respectively from research institutes (CRIN) while only 10% farmers got their cashew nuts from input dealers and 40% got cashew seedlings' from family and friends. Eighty percent (80%) of the farmers got fertilizer from input dealers while 60% of farmers got it from farmers' cooperatives society. Majority (90%) of farmers got chemicals from input dealers while only 10% got same chemicals from cashew farmers association of Nigeria (CFAN). All the farmers got farm implements from friends and family. The major sources of loan to farmers is friends and relatives (88%), and farmers' cooperatives (64%) while only 9% farmers procure loan from agric bank. High interest rate and collateral security demanded by agric banks discouraged farmers from taken loan from the bank

Table 3: Percentage distribution of respondents based on constraints encountered in cashew production

Constraints	Major Freq	Constraint %	Minor Freq	Constraint %	Not a Freq	Constraint %	Mean	Rank
No access to credit	46	76.7	10	16.7	4	6.7	2.70	1st
Unavailability of labour	16	26.7	40	66.6	4	6.7	2.20	12th
Transportation problem	11	18.3	44	73.3	5	8.3	2.10	13th
Land tenure systems	27	45.0	30	50.0	3	5.0	2.41	7th
Prolonged drought	26	43.3	32	53.3	2	3.4	2.39	9th
Soil erosion	23	38.3	31	51.7	6	10.0	2.27	10th
Irregular rainfall	16	26.7	33	55.0	11	18.3	2.08	14th
Unstable govt.policy	21	35.0	31	51.7	8	13.3	2.26	11th
Theft	31	51.7	22	36.7	7	11.7	2.40	8th
Sharp practices of middlemen	39	65.0	14	23.3	7	11.7	2.59	4th
Price fluctuation	42	70.0	15	25.0	3	5.0	2.68	2nd
Pests and diseases	34	56.7	24	40.0	2	3.3	2.53	5th
Farmers-herders clashes	40	66.7	14	23.3	6	10.0	2.60	3rd
Inadequate information	37	61.7	14	23.3	9	15	2.49	6th

Source: Field survey, 2021

Table 4: Percentage distribution of respondents based on sources of input

			Inputs			
Sources	Fertilizer	Cashew nuts	Cashew seedlings	Chemicals	Loan	Farm implements
Research Institute(CRIN)	0.0	95.0	78	0.0	0.0	0.0
CFAN	0.0	0.0	0.0	20.0	0.0	0.0
Input dealers	80.0	10.0	0.0	90.0	0.0	25.0
Farmers cooperatives	60.0	0.0	0.0	0.0	64.0	10.0
Agric bank	0.0	0.0	0.0	0.0	9.0	0.0
Friends and family	0.0	0.0	40.0	0.0	88.0	100

Multiple responses Source: Field survey, 2021

Farmers attitudinal disposition to cashew production constraints

The results of farmers' attitudinal disposition to cashew production constraints is shown in table 5a. According to the table, all the farmers (100%) agreed that credit facilities are readily available to farmers; 78%, 63.3% and 80% also agreed that unstable government policies affect cashew production, farm labour is not cheap and affordable and farmer-herders' clashes are big challenges to cashew production respectively. However, 75%, 71.6%, and 86.6% disagreed with the statement that information on GAP are readily available, pest and diseases do not affect cashew production and it is cheap to transport cashew nuts

Farmers level of attitudinal disposition to cashew production constraints

Farmers attitudinal disposition was categorized into positive and negative (Table 5b). This was determined as the mean attitude scores was computed and used as the benchmark, such that respondents whose scores are below the mean attitude scores were categorized as negative attitudinal disposition, while scores equal to or greater than the mean score were categorized as having positive attitudinal disposition. The result shows that majority (58.3%) of the respondents had positive disposition to cashew production constraints while 41.7% had negative disposition

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Table 5a: Farmers attitude towards constraints encountered in cashew production

Statement on attitudes	SA F (%)	A F (%)	U F (%)	D F (%)	UD F(%)
Credit facilities are not readily available	35 (58.3)	25(41.7)	Nill	Nill	Nill
Unstable govt. policies	9 (15.0)	38 (63.0)	3 (5.0)	8 (13.3)	2(3.3)
Farm labour is not cheap and affordable	14(23.3)	24(40.0)	16 (26.7)	3(5.0)	3(5.0)
Pilfering is a problem	12(20.0)	31 (51.7)	12 (20.0)	4(6.7)	1(1.7)
Farmers –herders clashes are big challenges	45(75.0)	3 (5.0)	10 (16.7)	1 (1.7)	1 (1.7)
Information on GAP is readily available	1 (1.7)	4(6.7)	10 16.7	15(25.0)	30(50.0)
Pests and diseases do not affect cashew	9(15.0)	6(10.0)	2 3.3	20(33.3)	23(38.3)
Middlemen make more gain than farmers	44(73.3)	5 (8.3)	1 1.7	5(8.3)	5(8.3)
Climate change is not a problem	21(35.0)	23 (38.3)	5 8.3	5(8.3)	6(10)
It is cheap to transport cashew	4(6.7)	4 (6.7)	Nill	26(43.3)	26(43.3)

Source: Field survey, 2021

Table 5b: Categorization of farmers' level of attitude towards constraints in cashew production

Categorization	Frequency	Percentage
Negative	35	58.3
Positive	25	41.7
Total	60	100

Source: Filed Survey 2021. Minimum =10.00. Maximum =31.00. Mean =20.27. Standard Deviation =4.43. N =60

Hypothesis testing

Chi-square result of the relationship between respondents selected socioeconomic characteristics and constraints to cashew production as revealed in table 6. It shows a significant relationship occurred between educational level (X^2 =-11.622; P< 0.011), primary occupation (X^2= 7.360; P< 0.061) and constraints to cashew production. It implies that education inversely influences constraints faced by respondents. The implication of this is that the more educated farmers experienced lesser constraints as compared to those who are not educated. in other to solve emerging constraints faced by cashew farmers, education is very important. Also, the positive significant relationship between primary occupation and constraints indicates that respondents whose primary occupation is farming are more constraint in their farming activities compared with those who took farming as their secondary occupation. However, Marital status and Religion did not have any significant relationship with constrains to cashew production.

Table 6: Chi-square analyses between respondents' socioeconomic characteristics, attitude and constraints in cashew production

Variable	X^2	Df	r-value	p-value	Decision
Marital status	3.573	3	-	0.311	NS
Religion	1.195	2	-	0.550	NS
Education	-11.622	3	-	0.011	S
Primary occupation	7.360	3	-	0.061	S

Source: Field survey, 2021

CONCLUSION AND RECOMMENDATION

The study concludes that cashew farmers are still in their productive age. Farmers frequently utilized most cashew agronomic practices. This study had revealed array of constraints facing cashew farmers which might affect cashew production in commercial purposes these include; lack of access to credit, price fluctuation, farmers-herders' clashes, sharp practices of middlemen, price fluctuation etc Based on the importance of cashew production and its products to Nigerian populace, it is therefore necessary to encourage cashew farmers so that production can be increased. Farmers need to be encourage by making available for them credit facilities as most of them depend on personal savings and money gotten from family and friends to finance their farming operation. Inputs should be subsidized by government and made available to farmers in large quantity so that farmers can be motivated to continue and increase production.

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ASSESSMENT OF THE CONSTRAINTS TO PLANTAIN PRODUCTION IN IDO LOCAL GOVERNMENT AREA OF OYO STATE

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ABSTRACT

The study examined constraints to plantain production among farmers in Ido Local government area of Oyo State. A total of 120 plantain farmers were sampled and data was gathered with the use of a structured questionnaire. The results revealed that 63.1% of the respondents were male and about 59% had tertiary education. Major benefits that respondents derived from plantain were, as a source of food (76.2%) and income (75.4%). Moreover, constraints faced by the respondents were cost of planting materials (68.9%), bad road network (63.1%), high transportation cost (60.7%), among others. The study thus recommends that training opportunities should be made available for the plantain farmers in the identified areas, especially on ways of generating planting materials.

Key words: Carbohydrate, export, high labour cost, starch

INTRODUCTION

Plantain (*Musa paradisiaca*) is one of the staple foods in developing countries mostly in Western and Central Africa. Globally, it considered important after rice, wheat, and maize with respect to gross value of production (FAO 2018). It is estimated that about 70 million people in West and Central Africa obtain more than 25% of their carbohydrates from plantains, making it a major energy food in these areas. Seven of the top 10 plantain producing countries globally are in Africa. Ghana, Cameroun Nigeria and Guinea and Côte d'Ivoire are in West Africa. Despite the huge potentials offered by plantain, Nigeria is not prominent among plantain-exporting countries as the production is mostly for local consumption (Akinyemi et al., 2008). Cameroun exports approximately 4.31 million tons of plantains yearly followed by Ghana with an average annual export volume of 3.95 million tons (FAO 2018). The sustained production of plantain in Nigeria is limited by several factors like pests and diseases, low technology adoption and environmental factors, especially among smallholder farmers. However, there is a need to continuously boost plantain production through innovative concepts together with continuous training and capacity building for farmers to assist them understand new concepts and apply new knowledge in farming (Ibitoye and Onimisi 2013). Thus, to improve agricultural productivity, farmers' competencies need to be up scaled through appropriate intervention and trainings that could lead to improvement in their skill, knowledge and attitude. For this to be successful, farmers' training needs or shortfall in knowledge, skills and abilities must be assessed. This study was therefore designed to access the constraints to plantain farmers in Ido Local Government Area of Oyo State.

MATERIALS AND METHODS

The study was conducted in Ido local Government Area of Oyo State, which is in the South-west Geopolitical Zone of Nigeria. The local Government has a land area of 986km2 and a total population of 103,261. The population of the study was the plantain farmers in Ido Local Government Area, Oyo state. Multi –stage sampling technique was used in selecting the respondents. The first stage was a selection of Odo-Ona Apete within Ido Local Government Area. The second stage involved the random selection of 120 plantain farmers. A structured questionnaire was used to elicit information from the plantain farmers on their personal characteristics, benefits of plantain, training needs and constraints to plantain production in Ido Local Government Area of Oyo state. The variables considered are:

Age: The age of respondent was measured in actual years.

Sex of respondents: This was categorized into male and female measured by assigning scores of 1 to male and 2 to the female respondent.

Marital status: The marital status of the farmers was categorized as single, married, divorced, widowed, separated with 1, 2, 3. 4, and 5 assigned respectively.

Sources of information on plantain production: It was measured based on 2-point scale: yes =1, No = 2.

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Benefits derived from plantain production: It was measured based on 3-point scale: major =1, moderate = 2, minor = 3.

Constraint to plantain farmers: This was measured was based on 4-point scale: very severe =1, severe =2, moderate = 3, not severe = 4.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Respondents

Table 1 shows the frequency distribution of respondents according to their socio-economic characteristics. This table reveals that there were more male plantain farmers in the study area and that most of them (76.1%) are married. This agrees with the findings of (Edeoghon et al. 2008), that agriculture is mostly practiced by married people to make ends meet and cater for their children. Furthermore, the result shows that 38.0% of the respondents were in middle age ranging from 40-49 years and about 59% of them have tertiary education. Educated farmers have more access to information on farm improvement techniques and credit than non-educated farmers, education affords farmers the ability to think and make necessary decision associated with their farming enterprises, (Barmon et al. 2012). The results also revealed that 37.7 percent of farmers has spent 6-10 years in farming, which is relatively long time in farming and therefore should equip them with better knowledge pf farming (Alexander et al. 2018). Moreover, farm size of most of the respondents (54.2%) was between 1 and 5 acres while 43.4% of the respondents was involved in mixed cropping. Large farm size increases agricultural productivity, improves farmers' technicality, resource use efficiency as well as easy adaptation to climate change (Onubuogu et al. 2014). Almost half (45.9%) of the respondents were members of farmers' association. At harvest, 59% of the farmers harvest plantain when it is mature and unripe; (28.7%) of the respondents sell their products to the wholesalers, while (36.1%) feed the stem of plantain to animals after harvest. Also, 46.7% of the farmers consume the produce does not meet grading standard.

Constraints Faced by Plantain Farmers

The constraints experienced by plantain farmers (table 2) show that most plantain farmers face very severe constraints, some of which are cost of planting materials (68.9%), bad road network (63.1%), high transportation cost (60.7%), high labour cost (50.8%). Previous studies such as Idumah et al (2016) and Akinyemi et al. (2013) had also identified high cost of labour as a major constraint faced by plantain producers in Nigeria Also, few of the respondents experienced severe constraints such as timely availability of suckers (36.9%), inadequate market information (34.4%) and non-availability of improved planting materials (32.0%). Moreover, climate change and limited productive land were moderately severe constraints faced by few of the respondents (29.5% and 28.7% respectively) in the course of plantain production. The study identified high cost of planting material as major constraints to plantain production in the area and recommends training opportunities on ways of generating planting materials.

Table 1: Socio-economic Characteristics

Variable	Frequency	Percentage
Sex		
Male	77	63.1%
Female	43	36.2%
Marital status		
Married	105	86.1%
Single	11	9.0%
Widowed	3	2.5%
Separated	1	0.8%
Age in years		
<30	20	16.2%
30-39	28	22.9%

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40-49	47	38.6%
50-59	19	15.6%
60 and above	6	4.9%
Educational status		
Primary education	12	9.8%
Secondary education	36	29.5%
Tertiary education	72	59.0%
Years of experience		
1-5	42	34.3%
6-10	46	37.7%
11-15	23	18.8%
15-20	9	7.4%
Farm size (acres)		
1-5	66	54.2%
6-10	35	28.7%
11-15	19	15.5%
Association affiliation		
Cooperative society	44	36.1%
Farmers association	56	45.9%
Stage of harvest		
Mature unripe	72	59.0%
Mature ripe	33	27.0%
Mature fully	10	8.2%
Unripe	5	4.1%
Sales after harvest		
Assemblers	25	20.5%
Wholesalers	35	28.7%
Retailers	15	12.3%
Processors	9	7.4%
Consumers	36	29.5%
Use of Plantain stem after harvest		
Feed to animals	44	36.1%
Incorporate into soil	39	32.0%
Burn off	23	18.9%
Making of rope or weaving material	14	11.5%
Low grading standard of produce		
Sell at lower price	40	32.8%
Household consumption	57	46.9%
Feed to animals	23	18.9%

Source: field survey, 2020

Table 2. Constraints Facing Plantain Farmers

Constraints	Very severe	Severe	Moderately severe	Not severe
Cost of planting materials	84(68.9%)	20(16.4%)	4(11.5%)	2(1.6%)
High transportation cost	74(60.7%)	31(25.4%)	10(8.2%)	5(4.1%)
Pest and disease infestation	59(48.4%)	31(25.4%)	15(12.3%)	15(12.3%)
Bad road net work	77(63.1%)	28(23.0%)	9(7.4%)	6(4.9%)
Timely availability of suckers	47(38.5%)	45(36.9%)	26(21.3%)	2(1.6%)
Non-availability of improved planting materials	42(34.4%)	39(32.0%)	31(25.4%)	8(6.6%)
Inadequate post-harvest handling practices	56(45.9%)	31(25.4%)	34(19.7%)	9(7.4%)
Inadequate storage facilities	56(45.9%)	37(30.3%)	20(16.4%)	7(5.7%)
High cost of farm chemical procurement	54(44.3%)	34(27.9%)	27(22.1%)	5(4.1%)
Inaccessibility in fertilizer procurement	46(37.7%)	33(27.0%)	29(23.8%)	12(9.8%)
Inadequate market information	44(36.1%)	42(34.4%)	27(22.1%)	7(5.7%)
High labour	62(50.8%)	30(24.6%)	17(13.9%)	11(9.0%)
Limited production land	37(30.3%)	34(27.9%)	35(28.7%)	14(11.5%)
Harvest failure	32(26.2%)	30(24.6%)	33(27.0%)	25(20.5%)
Climate change	22(18.0%)	31(25.4%)	36(29.5%)	31(25.4%)

Source: Field survey, 2020

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RURAL YOUTHS' PARTICIPATION IN COMMUNITY DEVELOPMENT ACTIVITIES: A CASE STUDY OF OLUYOLE YOUTHS' COUNCIL, IDI AYUNRE, OYO STATE, NIGERIA

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ABSTRACT

This study investigated rural youths' participation in Community Development (CD) activities in Oluyole Local Government Area of Oyo State. One hundred and ten youths were selected for the study through a multistage sampling procedure. Structured interview schedule was used for data collection. The data were analyzed using frequency counts, percentage, weighted mean and mean score ranking. Results show that most of the respondents were male (56.4%), married (64.5%) and aged between 26 – 30 years old (51.8%). Attendance and punctuality at community development meetings ranked highest amongst CD activities with weighted mean score (WMS) of 3.50 and 3.65, respectively. Participation at planning stage of CDAs recorded WMS of 2.94, implementation stage (3.14) and evaluation stage (2.75). Constraint militating against youths' participation in community development activities included poor monitoring which recorded the WMS of 5.60, poor team spirit (4.80), and funds' mismanagement (3.57), gender bias (3.05). The study concluded that participation in CDAs by youths in the study was at average level.

Key words: CDA, Rural youth, WMS, Constraint

INTRODUCTION

Rural youths' have a great role to play in community development in Nigeria as they are being considered to be the active working group. The youth at present, constitute about 60% of Nigeria's population and have over the years made significant contributions to National Development (Vision 2010 report, 2005). The concept of youth has been defined by Nwachukwu (2008), as the period in an individual life which comes between the end of childhood and entry of adulthood. The United Nation defined youths as individuals between the lower age of 17 years and upper age limits of 39 years. Youth, the state of being young, is a transitional period in personality development that bridges the years between childhood and adulthood (D`Souza, 1970). The age bracket varies among authorities ten to twenty years (Shingi et al., 1980) and 10-30 years (Anonymous, 2000). In some societies, as long as one remains a bachelor or spinster one is a youth! Youths possess unique capabilities; dynamism, strength, adventure, ambition, hilarity etc. (Udah, 2001; Waldie, 2004; Akwiwu et al., 2005). One eminent problem Nigeria is facing today is how to tackle income disparity between urban and rural centers especially in youth situations.

Youths have a solution to the problem, if they will mobilize their fellow youths to embark on community development and self-help projects that will make them compete among themselves and other youths around the world. Already some communities in Nigeria have formed their Youth's Community Development Associations (YCDA) long ago for the improvement of their living conditions. The various governments in Nigeria have in the past introduced various community development programmes for the benefit of all citizens irrespective of sex. Programmes includes: Directorate of Food, Road and Rural Infrastructure (DFRRI), National Agricultural and Land Development Authority (NALDA), National Directorate of Labour (NDL), Small and Medium Enterprises (SME) etc. However, these programmes seem to have achieved little. Unfortunately, the present situation makes it even more difficult to explore youths' full potential in community development. In order to stimulate the interest of our youths' in community development; government has to put in place certain measures that will make youths' to be self-developed, independent, motivated, spirit of leadership and self-employed in order to contribute to development of their community and this will in turn help to have the courage of sense of belonging, leadership skills anywhere they found themselves.

Community development is the process whereby some citizens mobilize their members so as to map out a strategy of improving their community through collective efforts. Collective efforts mean the ability to have full participation of members to be able to make use of their local resources in order to improve their living condition and standard. But the United Nations (1963)

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defined community development "as the process by which efforts of the people themselves are united with those of the government authorities to improve the economic, social and cultural conditions of the communities to integrate them into the life of the nation and to enable them to contribute fully to national progress". Therefore, the United Nations definition of community development implies the participation of both the community and the government. Hillman (1960) has however defined community development as the method of helping local communities to become aware of their resources in such a way to satisfy some of their needs and in so doing, acquire the attitudes, experiences, and cooperative skills for repeating this process using their own initiatives.

Community Development, according to Ajayi (1995) and Hanachor (2012), is a social process by which human beings can become more competent to live with and gain some control over local conditions and the changing world. Sustainable community development cannot take place through force or order, but is most likely to happen when all actors participate and share their ideas, visions and responsibilities equally and democratically in steering and implementing their community or village development activities (Ajayi, et al, 2006). According to Emeka (2012), one approach in creating sustainable rural development is through giving the main actors (villagers living in the community) an equal opportunity to think and plan their own future. This underpins the need for effective leadership at the local community levels in order to harness the efforts of the rural people towards their own development.

Youths are great assets in the society. This is true because youths have played a great role and are still playing an important role in community and rural development. Many Nigerian youths lives in the rural areas and have being trying their best to improve their status through the community development programmes/Activities. The issue is that youths need to participate actively in community development as they will one day become self-sufficient. Youths have realized the importance of self-help projects in improving the way of life and living standards of their communities. Youth's participation cannot be over emphasized as youths are deeply involved in self-help projects in various local governments in Nigeria. However, Ekong (2003) argued that the youth have been active participant in the happening of their own destiny as well as building the development of the nation.

Participation or involvement of youths' in community development activities is a way of increasing their skills, knowledge, confidence, self-reliance and opportunity to collaborate and engage in sustainable development (Nelson and Wright, 1997, Akinbile et al, 2008; Kyle, 2009). Generally, the participation of youth in community development activities in Oluyole local government area in Oyo state, it is important in order to keep them together to love one another in the community. Since the communities throughout the state are faced with extensive growth pressure, significant socio-demographic changes and a growing youth population it at an alarming rate due mainly to the new nature of the State. Such condition suggests an important role for the youth to play in local planning and decision making (Unite Nation, 2002). The involvement of youth and their active collaboration with adult contribute to the local community development, while presenting opportunities for personal self-growth, skill enhancement and leadership development. It is also evident that successful youth or adult partnership encourages youth to develop the capacity to serve in organization and can actively become a community leader. Therefore, the United Nation (2002), posit that, youth participation is known to be prerequisite for overall development of community. This study is centered on the facts that youth are pivotal in the development of society which can be positive or negative. Some of the positive impacts of youth's participation in community development activities majorly in Oluyole Local Government Area are;

1. some of the schools in the LGA were dilapidated, as a result of compliment the effort of State Government in making sure school structure are made conducive for learning, the organization consulted a number of companies in the area to render help in this regard, out of all, Rom Oil Mills Nigeria Limited responded positively by renovating St. Martins Catholic School at Orile Odo Village to Modern School.
2. Clearing the bushes, cleaning of water channel and waste indiscriminately dumped by the major road sides in some part of LGA,
3. Training of youths in different skills such as computer training, hair dressing, make up and barbing, vulcanizing, embroidery, welding, catering services and fashion designing,

4. Organizing empowerment programme for the youths in computer training, hair dressing, make up and barbing, vulcanizing, embroidery, welding, catering services and fashion designing.
5. Reducing unemployment rate by securing employment for over 120 youths in the LGA.

These goals can only be achieved through the combined and collective efforts of all those who share the conviction that rural community development must be accorded a high priority in our drive for poverty alleviation and national self-sufficiency. To help bring a rural community to action, it is necessary for individuals and groups to provide good leadership. When good leadership is provided, the people participate voluntarily in the accomplishment of stated objectives. The approach to rural community development is always through local leaders who not only act as pioneers of projects but also help in influencing and motivating their people to action. For any rural community development to be successful, influential local leaders must be involved else they might undermine the progress of such programmes. Therefore, any agency or organization coming up with a development programme for the community must initially "clear" with these influential local leaders, a process otherwise referred to as legitimization. It is saddening to recall that rural community development was neglected by successive governments since colonial rule in Nigeria. For instance, according to Adebisi, (2009) while the colonial government concentrated their development projects such as roads, schools, hospitals, and pipe-borne water around the major cities and built network of roads to areas where they exploited our natural resources, the rural areas were completely left out.

Statement of the problem

The development and success of any community in rural or urban area majorly depends on the types or the categories of youths' in that particular community. Youth, the state of being young is a transitional period in personality development that bridges the years between childhood and adulthood. Many youths' in some community used their useful time, power, connection, knowledge and resources for something that are not useful for themselves or for the community. It is in this context that this study is aiming at evaluating the level of youths' participation in the community development activities of their area, examine the factors that are associated with their participation in CD activities, assessing their source of fund for execution of CD activities, and investigate the constraints of youths' participation in Community Development Activities in the study areas of Oyo State Nigeria.

Objectives of the Study

The broad objective of this study is to investigate the Rural Youths' Participation in Community Development Activities: A Case Study of Oluyole Local Government Areas of Ibadan, Oyo State.

Specific Objectives are to

- Identify the personal characteristic of youths' in the study area,
- Evaluate the level of youths' participation in community development activities,
- Examine the factors associated with youths' participation in CD activities in study area,
- Determine the constraints of youths' participation in CD activities.

The Research Hypothesis of the Study

The following null hypothesis will be used to test for the relationship between the dependent variable and independent variable of the study;

- There is no significant relationship between the age of respondents and level of participation,
- There is no significant relationship between the educational status of respondents and level of participation in community development activities,
- There is no significant relationship between the sources of fund for community development activities and the participation in the activities.

MATERIALS AND METHODS

Sampling Procedure

The study was conducted in Ibadan, Oyo State, precisely in Oluyole Local Government Areas of the State. The study area lies on the latitude 7^0 and 24^1 north and longitude 3^0 and 55^1 east of the glober axis with seasonal period of wet (Rain) and dry (Harmattan). This study area is a rain forest zone in the tropical region of the south western area of Nigeria covering an area of approximately 4,000 square kilometers. The major occupation of the people in the area is farming as Nigeria is a country with very rich cultural background in agricultural practices, rain-fed farming. Oyo state is bounded by Ogun, Kwara, Osun and Ekiti State, in the South, North, West and East respectively. The State has thirty-three Local Government Areas (33 LGAs) of which the study area which is Oluyole LGA is one among the LGAs of the State with population of 203,461 both male and female (NPC, 2006). There are 10 wards in Oluyole LGA and these wards divided into two sectors, namely, Idi-Ayunre Sector and Olode Sector.

Sampling Size

The population of the study consisted of all the youths' male and female in the selected communities or villages which made up of Oluyole Youth Council in Oluyole Local Government Area of the State.

Data Collection and Analysis

Data were collected only from among the youths' both male and female of oluyole youths' council for the study with a set of well-structured and validated questionnaire schedule with items based on the objectives of the study. Items discussed were centered on the specific objectives of the study. Trained extension officers were used to assist in the interview and administer questionnaire for data collection in the study areas. Descriptive statistic was employed to analysis the data gathered from the respondents. Descriptive statistic such as frequency distribution, Percentages, means and standard deviation was used to explain the socio economics characteristic of the respondents. Independent variable that was measured included in socio economic characteristic of respondents such as age, sex, religions, level of education etc. level of participation of youths' in community development activities was measured on a four-point rating scale of Highly Active (HA); Moderately Active (MA); Active (A); and Inactive (I).

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents;

Tables 1 revealed that many (56.4%) of the respondents were male while 43.6% were female. This indicates that the both male and female youths in the study area were fairly represented in the study. However male youths who took part in the study were slightly more than female youths. This finding concurs with Mukarumashana *et al.* Youths generally need proper harnessing so that they can maintain reliable status quo in their locality. It is easier for them to speak with one voice when they are brought together. This is why mobilisation yields progress. The entirety of youths in both urban and rural areas needs to be mobilized for proper impact to be felt in their communities (Adesope, 2007).

Age of respondents

Many (51.8%) of the respondents as shown in Table 1 were aged between 26-30years, 19.1% were aged between 31-35years while 15.5%, 12.7% and 0.9% of the respondents were aged between 20-25years, 36-40years and 41-above respectively. The sex distribution gave room for a balanced opinion from both sexes of the respondents and going by definition of youth as a person aged between 12 and 30 years by the Vision 2010 Report (2005).

Marital Status of respondents

Table 1 revealed that majority (64.5%) of the respondents were married while 35.5% were single

Religion of the respondents

50.9% of the respondents were Christians while 49.1% were Muslims. This implies that the respondents are evenly distributed across the two religions.

Level of Education of respondents

Table 1 show that majority (60%) of the respondents had secondary level of education, 31.8% had tertiary level of education, while 6.4% had primary level of education and 1.8% had no formal education. Findings clearly shows that majority of the youth had at least acquired basic education. Also the finding implies that a high percentage (secondary plus tertiary level) of the respondents was literates and could give relevant information on the subject matter.

Occupation of the respondents

Table 1 indicates that 43.6% of the respondents were artisans, 12.7% were civil servants, 10.9% were engaged in farming activities, 10.9% were students while 9.1% were engaged in teaching and 13.6% did not have any specific occupation. This implies that most of the sampled youths were artisans.

Table 1: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage (%)
Gender		
Male	62	56.4
Female	48	43.6
	110	100
Age		
20-25	17	15.5
26-30	57	51.8
31-35	21	19.1
36-40	14	12.7
41 And Above	1	0.9
Marital Status		
Single	39	35.5
Married	71	64.5
	110	100
Religion		
Islam	54	49.1
Christianity	56	50.9
Education		
No Formal Education	2	1.8
Primary School Education	7	6.4
Secondary School Education	66	60.0
Tertiary Education	35	31.8
Occupation		
None	14	12.7
Teaching	10	9.1
Artisan	48	43.6
Farming	12	10.9
Civil Servant	14	12.7
Student	12	10.9
Organization Type		
Nil	15	13.6
Oluyole youth organization	88	80.0
Youth amiable	2	1.8
Youth enlightment forum	2	1.8
Tokolase ladies club	1	.9
RAHIS	1	.9
Ifedola youth of Adungbee	1	.9
Years of being in an Organization		
1-3	42	38.2
4-6	64	58.2
7-9	4	3.6

Source: Field survey 2018.

Organization type of respondents

Majority (80%) of the respondents as shown in Table 1 below belong to Oluyole youth organization, 1.8% belong to Youth amiable organization, 1.8 belong to Youth enlightment forum while 0.9% belong to Tokolase ladies club, RAHIS, Ifedola youth of Adungbee respectively and 13.6% did not have any specific the organization type. The importance of the youths to national development is without doubt because the various programmes directed at them by government at various times gives credence to this (Agumagu et al., 2006).

Year of being in an Organization

Table 1 show that 58.2% of the respondents have joined the organization between 4-6 years while 38.2% and 3.6% had joined the organization between 1-3 years and 7-9 years respectively.

Level of Youths' Participation in CDA;

Table 2 below revealed the level of youths' participation in community development (CD)

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activities. The results show that punctuality to community development activities is ranked 1st with mean score (3.65). This might be as a result of the fact that majority of the respondent are literates and also married which makes them have regards for punctuality. Attendance of CD meetings was ranked 2nd, association participation in CD activities and association partnership with other association in carrying out CD activities were ranked 3rd while participation in CD activities was ranked 5th. Participation helps youths in planning and acting together for the satisfaction of their felt needs through organized efforts to acquire skills and the concepts required for their effective participation in the problem solving process (Jibowo, 1992; Akinbile et al., 2006).

Table 2: Level of youths' participation in community development activities

	Highly Active Freq* (%*)	Moderately Active Freq* (%*)	Active Freq* (%*)	Inactive Freq* (%*)	Mean Score	RANK
1. Punctuality in CD activities	77 (70.0)	28 (25.5)	5 (4.5)	0 (0.0)	3.65	1st
2. Attendance of CD meetings	66 (60.0)	33 (30.0)	11 (10.0)	0 (0.0)	3.50	2nd
3. Organizing orientation training to sensitize the youths'	56 (50.9)	27 (24.5)	21 (19.1)	6 (5.5)	3.21	3rd
4. Partnership with other association in carrying out CD activities	44 (40.0)	45 (40.9)	21 (19.1)	0 (0.0)	3.21	3rd
5. Clearing of road side bushes in major roads	37 (33.6)	57 (51.8)	16 (14.5)	0 (0.0)	3.19	5th
6. Participation in planning stage	20 (18.2)	74 (67.3)	5 (4.5)	11 (10.0)	2.94	8th
7. Participation in implementation stage	36 (32.7)	58 (52.7)	11 (10)	5 (4.5)	3.14	6th
8. Participation in supervision stage	25 (22.7)	59 (53.6)	15 (13.6)	11 (10.0)	2.89	10th
9. Participation in Evaluation stage	10 (9.1)	68 (61.8)	27 (24.5)	5 (4.5)	2.75	11th
10. Empowerment programme for the youths'	33 (30.0)	38 (34.5)	34 (30.9)	5 (4.5)	2.90	9th
11. Rehabilitations of some road	40 (36.4)	43 (39.1)	22 (20.0)	5 (4.5)	3.07	7th
12. Government role in meeting the needs of the association on implementation activities	24 (21.8)	42 (38.2)	28 (25.5)	16 (14.5)	2.67	12th

Source: Field survey 2018. Freq*= Frequency, %* =Percentage

Factors Associated with Youths' Participation in CDA

Table 3 below revealed the factors associated with of youths' participation in CD projects. The results show that Technical Know-how about the activities was ranked 1st with mean score (4.48) this might be as a result of majority of the youths' being educated. Collaboration with members was ranked 2nd with mean score (4.11) while level of awareness, assigned responsibilities and challenges during and after the activities were ranked 3rd, 4th and 5th respectively with mean score 3.75, 3.47 and 3.35.

Table 3: Factors Associated with youths' participation in community development project

	Strongly Agreed Freq* (%*)	Agreed Freq* (%*)	Disagreed Freq* (%*)	Strongly Disagreed Freq* (%*)	Mean Score	RANK
1. Awareness	83 (75.5)	27 (24.5)	0 (0.0)	0 (0.0)	3.75	3rd
2. Assigned responsibilities	57 (51.8)	48 (43.6)	5 (4.5)	0 (0.0)	3.47	4th
3. Technical Know-how	60 (54.5)	33 (30.0)	17 (15.5)	0 (0.0)	4.48	1st
4. Area of specialization	39 (35.5)	61 (55.5)	10 (9.1)	0 (0.0)	3.26	8th
5. Contribution	48 (43.6)	56 (50.9)	0 (0.0)	6 (5.5)	3.33	7th
6. Form of motivation	42 (38.2)	63 (57.5)	0 (0.0)	5 (4.5)	3.34	6th
7. Challenges	44 (40.0)	60 (54.5)	6 (5.5)	0 (0.0)	3.35	5th
8. Collaboration	33 (30.0)	66 (60.0)	11 (10.0)	0 (0.0)	4.11	2nd
9. Assistance from governmental and non-governmental agencies	33 (30.0)	61 (55.5)	11 (10.0)	5 (4.5)	3.11	9th
10. Coordination	33 (30.0)	60 (54.5)	11 (10.0)	6 (5.5)	3.09	10th

Source: Field survey 2018, Freq*= Frequency, %* =Percentage

The constraints of youths' participation in community development activities;

Table 4 shows the constraints of youths' participation in community development activities. The data below revealed that negative effects of traditions (mean score = 5.70) was ranked 1st. This implies that a community development activity was believed to have negative effects on tradition and culture of the people, thus limiting youths' participation. Poor monitoring (mean score = 5.60) was ranked 2nd, poor team spirit (mean score = 4.80) was ranked 3rd while unemployment (mean score = 4.10) and level of awareness (mean score = 3.97) were ranked 4th and 5th respectively.

SUMMARY

Majority of youths' participated in the community development activities of the study area were in their active year of age with average age of 30 years; many of them had secondary school education which makes them to participate actively in community development activities such as planning, initiation, implementation and evaluation stages. Poor funding, inadequate sensitization, inadequate awareness, improper implementation of activities, government policy, political instability was the major constraint which make some of the youths' not to participate actively in the community development activities.

CONCLUSION AND RECOMMENDATION

Youths generally need proper harnessing so that they can maintain reliable status quo in their locality. This study indicates that both male and female youths in the study area were fairly represented in the study. The average age of respondent in this study is 29.5 approximately 30 years of age, which means that the respondents were young enough to participate in the development activities in their areas. The youths' in the area contribute meaningfully in the initiation, planning and implementation of various activities going on in their community. Some of the respondents were married which enable them to know the gravity of team work spirit. Findings clearly shows that majority of the youth had at least acquired basic education. Also the finding implies that a high percentage (secondary plus tertiary level) of the respondents was literates and could give relevant information on the subject matter. Majority of respondents were self-employed which gives room for higher participation in CDA because they were independent people. Majority were in one organization or the other before coming together and formed the youths' council which give room for some of them having experience of unity, target and spirit of development of their community.

Table 4: Constraints of Youths' participation in community development activities

	Very High Freq* (%*)	High Freq* (%*)	Low Freq* (%*)	Very Low Freq* (%*)	Undecided Freq* (%*)	Mean Score	RANK
1. Unemployment	38 (34.5)	50 (45.5)	17 (15.5)	5 (4.5)	0 (0.0)	4.10	4th
2. Level of awareness	23 (20.9)	61 (55.5)	26 (23.6)	0 (0.0)	0 (0.0)	3.97	5th
3. Mismanagement of funds for the activities	6 (5.5)	56 (50.9)	43 (39.1)	5 (4.5)	0 (0.0)	3.57	6th
4. Members were not carried along in the execution	10 (9.1)	38 (34.5)	62 (56.4)	0 (0.0)	0 (0.0)	3.53	7th
5. Poor team spirit	5 (4.5)	22 (15.5)	61 (55.5)	10 (9.1)	12 (10.9)	4.80	3rd
6. Political undertone	26 (23.6)	17 (15.5)	46 (41.8)	21 (19.1)	0 (0.0)	3.44	8th
7. Insufficient source	10 (9.1)	17 (15.5)	68 (61.8)	15 (13.6)	0 (0.0)	3.20	12th
8. Poor implementation	21 (19.1)	5 (4.5)	63 (57.3)	21 (19.1)	0 (0.0)	3.24	11th
9. Gender bias	10 (9.1)	6 (5.5)	74 (67.3)	20 (18.2)	0 (0.0)	3.05	16th
10. Unequal participation of stakeholders	0 (0.0)	21 (19.1)	57 (51.8)	26 (23.6)	6 (5.5)	2.85	23rd
11. Incompatibility of government	26 (23.6)	11 (10.0)	45 (40.9)	28 (25.5)	0 (0.0)	3.32	9th
12. Poor monitoring	11 (10.0)	18 (16.4)	47 (42.7)	34 (30.9)	0 (0.0)	5.60	2nd
13. Negative effects of traditions	12 (11.0)	17 (15.5)	37 (33.6)	44 (40.0)	0 (0.0)	5.70	1st
14. Self-centeredness of some leaders	10 (9.1)	28 (25.5)	33 (30.0)	39 (35.5)	0 (0.0)	3.08	15th
15. Lack of Interest	5 (4.5)	12 (10.9)	54 (49.1)	39 (35.5)	0 (0.0)	2.85	23rd
16. Illiteracy	17 (15.5)	12 (10.9)	26 (23.6)	55 (50.0)	0 (0.0)	2.92	21st
17. Scarcity and problem of land resources	11 (10.0)	33 (30.0)	10 (9.1)	56 (50.9)	0 (0.0)	2.99	19th
18. High cost of labour	5 (4.5)	30 (27.3)	20 (18.2)	55 (50.0)	0 (0.0)	2.86	22nd
19. Inadequate communication infrastructure	6 (5.5)	23 (20.9)	22 (20.0)	48 (43.6)	11 (10.0)	2.68	25th
20. Interference by opposition groups	15 (13.6)	34 (30.9)	28 (25.5)	33 (30.0)	0 (0.0)	3.28	10th
21. Disagreement between the local leaders	16 (14.5)	12 (10.9)	43 (39.1)	39 (35.5)	0 (0.0)	3.05	16th
22. Political Instability	16 (14.5)	12 (10.9)	54 (49.1)	28 (25.5)	0 (0.0)	3.15	14th
23. Lack of appropriate mechanism	10 (9.1)	23 (20.9)	32 (29.1)	39 (35.5)	6 (5.5)	2.93	20th
24. Religious crisis	16 (14.5)	12 (10.9)	44 (40.0)	38 (34.5)	0 (0.0)	3.05	16th
25. Lack of cooperation among stakeholders	17 (15.5)	23 (20.9)	32 (29.1)	38 (34.5)	0 (0.0)	3.17	13th

Source: Field survey 2018, Freq*= Frequency, %* =Percentage

The fact that majority of the respondent were learned, married and self-employed makes them to participate actively, effectively and efficiently in the community development activities in the area of study. Collaboration with others in the community made a meaningful impact in the community development activities through robbing minds together make them to achieve greater high of community development activities in their community. However, unemployment, problem of

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insufficient fund, gender bias, poor team spirit, communication problem, poor level of awareness, political instability all these hinder the progress of development activities in the community which made some of the youths' not to part take in such activities.

Recommendations

1. Youths' should be motivated and encouraged to be more serious and have stable mind to learn, emulate, and ability to be a good leader, coordinator, supervisor, in order to be useful to their community.
2. Greater efforts should therefore, be geared towards encouraging the rural youths to be organized into groups so as to facilitate development of their community to greater high through both governmental and non-governmental agencies.
3. Responsibility should be assigned to youths' in order to know their level of competence, experience and leadership quality.
4. Young one should be encouraged and be carried along to see how their elder are doing thing so as to be moved and encouraged in order to have the mind of community development whenever they attained such age in life.
5. Local leaders should be educated on attribute of youths' as regards their participation and involvement in community development activities which has nothing to do with culture, norms and belief of the area.
6. Community leader should be sensitized on the role, importance and participation of youths' in the development of community.
7. Government should encourage youths on education and other apprentice work in order not to joined bad wagon, because ideal hand is devil workshop.
8. Provision of social amenities and infrastructural facilities such as good roads, stable electricity, and drinkable water, rehabilitation of school and construction of new building where necessary for the community.
9. The stakeholder should be encouraged to take active role in the development of the area where situated.
10. Provision of employment for the youths' in the area.
11. Empowerment scheme for youths' in the area should be organized.

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ASSETS ACQUISITION AMONG BENEFICIARIES OF VILLAGE ALIVE DEVELOPMENT INITIATIVES IN KWARA STATE, NIGERIA

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ABSTRACT

Access to credit facilities has been identified as the direct solution to increasing investment in agriculture in Nigeria. To improve people's lives substantively, there is need to enable the poor to have access to credit and financial services which will be based on empirical findings that indicate basic financial services such as savings, credit, money transfer and insurance. This study assessed the impact of Village Alive Development Initiative on assets acquisitions among beneficiaries in Kwara State, Nigeria. A total of 319 beneficiaries were selected for the study using multi-stage sampling procedure. Primary data were collected using well-structured questionnaire, Descriptive statistics and Pearson Product Moment correlation (PPMC) were used for data analysis. The results of PPMC show that high loan rate (0.035), bank systems (0.040), tractor for land preparation (0.032), inadequate irrigation facilities (0.001) and little training/workshop (0.042) at $p<0.05$ were the factors that significantly influenced the growth in beneficiaries' enterprises and the constraints they are faced with. This implied that VADI beneficiaries are more informed now that agriculture should be seen as agribusiness and not just a leisure, hence, reliance on family labour should be shunned. The study concluded that VADI programme has helped in improvement of saving culture and high purchasing power of the beneficiaries. It was recommended that government policies more like VADI should be put in place to alleviate poverty

Key words: VADI, beneficiaries, constraints, assets acquisition, purchasing power

INTRODUCTION

One of the factors attributed to a declining productivity of the agricultural sector is farmers' limited access to credit facilities (Oruonye and Musa, 2012; Etonihu *et al.,* 2013). Access to credit facilities has also been identified as the direct solution to increasing investment in agriculture in Nigeria. Credit is a vital factor in agricultural production and in many cases may be limiting factor in small-scale agriculture especially in Nigeria (Salami and Aramowo, 2013). The small scale rural farmers' need for credit is more acute because their access to finance is lowered by their low productivity and wide spread poverty in the rural farm sector. The idea of enabling the poor to have access to credit and financial services is based on recent empirical findings which indicate that basic financial services such as savings, credit, money transfer and insurance can make a substantial positive difference in improving poor people's lives (Mahember, 2001; Dupas and Robinson, 2013). OECD (2010) contends that providing access to credit and financial services will stimulate the independence and self-development of poor households and micro-entrepreneurs. This will improve poor people's economic condition and their quality of life in the face of numerous uncertainties. Access to finance and financial services determines the capacity of an enterprise in a number of ways, especially in the choice of technology, access to markets, and access to essential resources which in turn greatly influence the viability and success of a business (Wole, 2009). He further states that securing capital for business start-up or business operations is one of the major obstacles every entrepreneur faces particularly those in the MSMEs sector. According to Sacerdoti (2005), among the reasons for lack of access to credit in Sub-Saharan Africa are SME‟s inability to provide accurate information on their financial status, lack of collateral, high loan default ratio, high cost of credit, and weak legal and judicial systems. Others include, long physical distance to the nearest financial services provider, lack of infrastructure and socio-economic and demographic characteristics that make them less creditworthy. Indeed, most small and mediums enterprises are unable to provide the needed collateral to support any large scale borrowing. Gaining access to credit and financial services is therefore a critical step in connecting the poor to a broader economic life and in building the confidence for them to play a role in the larger community (Dzisi and Obeng, 2013). It is assumed that credit will be used for productive purposes and would generate additional income for borrowers. Thus, the provision of credit came to be perceived as an important mechanism for reducing poverty (Stewart *et al.,* 2012).

Objectives of this study were to: examine the effect of VADI loan on assets acquisitions among beneficiaries; identify the constraints to the VADI programme; examine the relationship between growth in assets acquisition and challenges faced by the beneficiaries.

MATERIALS AND METHODS

Kwara State situated in the Savannah region of Nigeria. The region is characterized by favourable weather with annual rainfall of 400-1400mm (LNRBDA, 2015). As a result of this, the zone has a great potential for food production as farming is the predominant occupation of the people in the region, where farmers grow crops like maize, cassava, rice, sweet potatoes, soybean, sorghum, egg-plant, okra, water melon, Corchorus etc. The study area for this study consisted of Ifelodun and Ilorin South Local Government Areas (LGAs) of Kwara State. Multi stage sampling procedure was employed for the study. The first stage was stratified selection of seventy 70% of the community groups (Falokun-Oja, Apa-Ola, Elerinjare, Igbo-Owu, Omomere-Oja, and Ilota) that were involved in the VADI programme. The second stage is selection of 75% credit groups in the selected communities while the third stage involved selection of all the beneficiaries in the communities that were pre-selected (Table 1). Questionnaire was used to collect primary data for the study. Frequency distribution, percentages, mean scores and Pearson's Product Moment Correlation (PPMC) were used for data analysis.

Table 1: Sampling Procedure and Sample Size

Selected communities	Total number of credit group	75% percent credit group selected	Total number of participants
Falokun-Oja	5	4	65
Apa-Ola	5	4	50
Elerinjare	4	3	61
Igbo-Owu	5	4	47
Omomere-Oja	3	2	33
Ilota	6	5	63
Total	**28**	**21**	**319**

Source: Field work, 2018

RESULTS AND DISCUSSION

Assets Acquisitions among Beneficiaries

The results showed that beneficiaries have more access to food stuff (M=2.44), they experienced increased savings (M=2.43), access to farm inputs (M=2.07), increased income (M=2.14), access to fertile land for cultivation (M=2.29), available market for produce (M=2.09), access to health care facilities (M=2.00), payment of children school fees (M=1,95) and entrepreneurial knowledge & skill competency (M=1.89). Considering financial assets VADI has contributed moderately to increased income (73.4%) and purchase of building material/rent (71.2%). On physical assets, purchase of transport for product distribution (61.4%), on social assets, there has been more network and contact with other entrepreneurs, on human assets, there has been more access to education (80.9%) and on natural assets, there has been more access to irrigation facilities (79.6%) and safe drinking water (69.6%). Also, there were high contributions to saving to meet basic needs (50.8%), purchase of food (48.2%) and more access to food stuffs purchase (48.2%) among beneficiaries. However, in the purchase of electronic, payment of utility bills and purchase of television, 63.8%, 74.3% and 85.9% respectively were indifference as regards the contribution of VADI. The results shows tremendous effect on the financial, physical, social, human and natural assets as they were all shown to have positive increase in the lives of the beneficiaries. The whole effects/benefits that VADI members had derived from the programme cannot be overemphasized. The beneficiaries now enjoy those benefits that they had no or little access to before the advent of the programme. However, the least ranked benefit was the access to family labour (MS=1.02). The implication of the above was that VADI has made the farmers understood that agriculture should be seen as agribusiness and not just a leisure hence, reliance on family labour should be exiled and the beneficiaries are advised to employ hired/paid labour to work on their farm.

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OECD (2010) contends that providing access to credit and financial services will stimulate the independence and self-development of poor households and micro-entrepreneurs.

Table 2: Distribution of the Beneficiaries by their Assets Acquisitions

Contributions of VADI to Assets Acquisitions	No contribution (%)	Indifferent (%)	Moderately contributed (%)	Highly contributed (%)	Mean score	Rank
Financial Assets						
Income		20 (6.3)	234 (73.4)	65 (20.4)	2.14	4
Saving to meet basic needs		24 (7.5)	133 (41.7)	162 (50.8)	2.43	2
Access/purchase of food stuff		12 (3.8)	153 (48.0)	154 (48.2)	2.44	1
Payment of medical bills		90 (28.2)	210 (63.0)	28 (8.8)	1.82	18
Payment of children school fees		61 (19.1)	214 (67.1)	44 (13.8)	1.95	10
Payment of building materials/house rent	4 (1.3)	60 (18.8)	227 (71.2)	28 (8.8)	1.87	15
Payment of television	13 (4.1)	274 (85.9)	32 (10.0)	-	1.06	26
Purchase of electronics	18 (5.6)	237 (74.3)	60 (18.8)	4 (1.3)	1.16	25
Payment for utility bills	8 (2.5)	218 (68.3)	81 (25.4)	12 (3.8)	1.30	24
Physical Assets						
Purchase of farm machinery equipment	17 (5.3)	68 (21.6)	113 (35.4)	120 (37.8)	2.05	7
Purchase of processing facilities	25 (7.8)	60 (18.8)	110 (34.5)	124 (38.9)	2.04	8
Purchase of farm inputs	13 (4.1)	73 (22.9)	112 (35.1)	121 (37.9)	2.07	6
Purchase of transport for product distribution	16 (5.0)	79 (24.8)	196 (61.4)	28 (8.8)	1.74	20
Rentage of land for cultivation and shop for marketing	13 (4.1)	65 (20.4)	121 (37.9)	120 (37.6)	2.09	5
Access to health care facilities	18 (5.6)	81 (25.4)	104 (32.6)	116 (36.4)	2.00	9
Social Assets						
Networks and contact with other entrepreneurs	8 (2.5)	36 (11.3)	255 (79.9)	20 (6.3)	1.90	12
participation in social gathering	36 (11.3)	109 (34.2)	145 (45.5)	29 (9.0)	1.52	23
satisfaction as an entrepreneur	4 (1.3)	56 (17.6)	235 (73.7)	24 (7.5)	1.87	15
Decision making ability	8 (2.5)	45 (14.1)	238 (74.3)	28 (8.8)	1.90	12
Membership of farmers associations	8 (2.5)	42 (13.2)	237 (74.3)	32 (10.0)	1.92	11
Human Assets						
Educational attainment	20 (6.2)	41 (12.9)	258 (80.9)		1.74	20
Entrepreneurial knowledge & skill competency	16 (5.0)	29 (9.1)	249 (80.9)	25 (7.8)	1.89	14
Access to family labour	88 (27.6)	154 (48.3)	61 (19.1)	16 (5.0)	1.02	28
Access to hired labour	100 (31.3)	114 (35.7)	96 (30.2)	9 (2.8)	1.04	27
Experience in related enterprises	16 (5.0)	56 (17.5)	235 (73.7)	12 (3.8)	1.76	19
Natural Assets						
Access to safe drinking water	12 (3.8)	81 (25.4)	222 (69.6)	4 (1.3)	1.68	22
Access to water for irrigation farming	20 (6.3)	12 (3.8)	254 (79.6)	33 (10.3)	1.84	17
Access fertile land for cultivation	17 (5.3)	36 (11.3)	105 (32.9)	161 (50.5)	2.29	3

Source: Field survey, 2019

Constraints faced by VADI Beneficiaries

Constraints encountered among respondents were in the size of loan available to the farmers (48.3%) that was too small, delay in bank deposit (30.4%) and terms of repayment which was very short (27.6%). However, few respondents (15.7%) agreed that there was delay in loan disbursement and high interest rate with 5.0% (Table 3). Mohan (2008) opined that agribusiness is seasonal and the inputs needed for the production should be made available before the cropping season is full blown so as to ensure optimal yield from the production and return on investment.

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Table 3: Constraints Faced by VADI Beneficiaries

Constraint	Frequency	Percentage (%)
High interest rate	16	5.0
Delay in the disbursement of loan	50	15.7
Delay in bank deposit	97	30.4
Terms of repayment very short	88	27.6
Uncultured behavior of VADI officers towards client	21	6.6
Loan size too small	154	48.3

Source: Field survey, 2019

Relationship between growth in assets acquisition and challenges faced by the beneficiaries.

The result in table 5 indicates the Pearson Product Moment Correlation (PPMC) analysis showing relationship between growth in beneficiaries' enterprise and their level of constraints. The finding revealed that there were significant relationships between constraints to enterprise growth and high loan rate (**r** =0.035), bank system (**r** =0.04), tractor for cultivation (**r** =0.032), inadequate irrigation facilities (**r** = 0.001), inadequate shea butter facilities (**r** = 0.017) and little training /Workshop (**r** = 0.042).

Table 4: Correlation Analysis between the Growth in Beneficiaries' Enterprise and their Level of Constraints

Variables	r – value	Remark
High loan rate	0.035	Significant
Bank systems	0.040	Significant
Tractor for cultivation	0.032	Significant
Inadequate irrigation facilities	0.001	Significant
Inadequate shea butter facilities	0.017	Significant
Little training /Workshop	0.042	Significant

Source: Field survey, 2019

CONCLUSION AND RECOMMENDATION

The study concluded that VADI scheme has helped in increased assets acquisition of the beneficiaries. However, the programme is faced with challenges in the size of loan available to the farmers which was considered to be too small, delay in bank deposit and the bottleneck of timely disbursement due to banking system. Therefore, the following recommendations were made:

- Government policies more like the VADI intervention should be promoted to enable the farmers improve on their assets acquisition.
- More farmers' cooperative groups should be encouraged to ensure that their members are taken care of and reduce reliance on the government.
- There should regulation policy to ensure loan is made available to farmers at the right time and lowest rate to ensure maximum production.

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AWARENESS OF ICT IN INFORMATION TRANSFER AMONG COFFEE FARMERS FOR SUSTAINABLE PRODUCTION IN KOGI STATE

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ABSTRACT

The study investigated awareness of ICT in Information transfer among coffee farmers for sustainable production in Kogi State, Nigeria. The population of the study consisting of 71 coffee farmers in three local governments. Seventy-one pieces of questionnaire were administered with 61 returned rates making 87.14%. The questionnaires were analysed using descriptive analysis (frequency counts and percentages). The study revealed that radio, phone and television are the common ICT gadgets available for use by coffee farmers in Kogi state while projector, computer, GIS are rarely available. The study therefore recommended that Federal government should provide soft loans to acquire those ICT facilities that are not available for farmers to be able to be at par with their counterpart in developed world and also to enjoy benefits that comes with the usage of ICTs tools in solving famers problems. This will indirectly improve standard of living and increase productivity of coffee farmers in Nigeria.

Key words: ICT, Information transfer, Coffee farmers, Kogi State, Awareness

INTRODUCTION

Information and Communication Technology (ICT) is defined by the World Bank as any device, tool or application that allows the exchange or collection of data through interaction and/or transmission. It includes anything ranging from radio to satellite imagery, mobile phones or electronic money transfers. The application of ICTs in agriculture is often regarded as e-agriculture (FAO, 2020). The power of ICT in this era has opened new channels of knowledge management that could play vital roles in meeting the dominant challenges related to sharing, exchanging and disseminating knowledge and technologies. Today ICTs have been recognized as a key agent in changing the agricultural and knowledge services. More so, farmers (Coffee farmers inclusive) could access relevant information through ICT at any point in time, and this enables them to create jobs with development agencies and other farmers, and ultimately yield higher agricultural productivity (Ramli *et al*., 2015, Abdullah and Samah, 2013). These claims were supported by Kale *et al*. (2015) that ICT provides timely information on what, when, where, why and howssss to produce and sell agricultural products. Furthermore, ICT-based market information systems have a proven track record for improving the rural livelihoods in middle income earners of developing countries where they have been introduced. These findings are consistent with De Silva and Ratnadiwakara, (2008) who found that there is likelihood of reductions in business cost with the use of ICT. The use of ICT enables farmers to access appropriate and current information in agriculture. This provides likelihoods for younger generation-agro based entrepreneurs to established their own network and websites regardless of time and place (Bhalekar *et*. *al*., 2015; Pande and Deshmukh, 2015; Ramli *et al*., 2015; Singh *et al*., 2015a; Singh *et al.,* 2015b). Consequently, they could publicize their goods both in national and international markets. This assertion is in accordance with Bhalekar *et*. *al*., (2015) that ICT could be used to secure food traceability and reliability that has been an emerging issue concerning farm products and diseases. Besides, new agricultural and rural business such as e-commerce, real estate business for satellite offices, rural tourism, and virtual cooperation of small-scale farms are initiated. Similarly, Yimer (2015) indicates that ICT furnish up-to-date knowledge and information on agricultural technologies, best practices, markets, price trends, and weather conditions.

The areas in which ICT can be deployed in coffee farming are: online services for information on coffee. online interaction facility to interact with nearest research station like CRIN, agriculture and allied departments for advice on current schemes, projects, varieties etc. Information on all sources of agricultural credit and crop insurance and their terms and conditions. Information sharing mechanisms among coffee farmers, extension workers and researchers. Online information on market prices of coffee, online monitoring and information sharing on all agricultural development projects in the country, online weather forecasting and its impact on coffee, on a weekly basis, including early warning systems. E-commerce through connections between traders, retailers, and other farmers. Information on availability and rates of agricultural inputs on coffee seeds, fertilizers, pesticides, machinery etc. and on all governmental and non-governmental organizations working directly or indirectly in the agricultural sector. The ICT devices that help facilitating farming activities include radio, television, cellular phones, computers, tablets, hardware and software, satellite systems (Munyua and Adera 2009; Pande and Deshmukh 2015). In the same way, (Yimer, 2015; Munyua and Adera 2009) reports that radio is extensively used to inform users on agricultural topics, including new and upgraded farming techniques, production management, and market information. According to Ramli *et al*, (2015), ICT is an effective solution to problems that militate against the development of agricultural industry, such as weak marketing linkages, poor information management, low productivity, low income and lack of diversity. Hence it is imperative to keep the farmers with lucrative and remunerative agriculture through ICT. In this context new and advanced ICT tools such as internet and mobile phones have great potential to facilitate technology transfer to farming community. Through ICT tools, people in rural areas can connect with the local, regional and national economy and access markets, banking/financial services and also farm based services.

Objectives of the Study

The major objective is to find out the awareness of ICT in Information transfer among coffee farmers in Kogi State, Nigeria. The specific objectives are to:

1. Find out types of ICT available for use by coffee farmers in Kogi State, Nigeria
2. Investigate the accessibilities of ICT facilities by coffee farmers in Kogi State, Nigeria
3. Find out sources of awareness of ICT usage among coffee farmers, Kogi State, Nigeria.
4. Determine benefits of using ICT in coffee farming

Research Questions

1. What are the types of ICT facilities available for use by coffee farmers in Kogi State?
2. Where do you access ICT facilities?
3. What are the sources of awareness of ICT usage among coffee farmers in Kogi State?
4. What are the benefits of using ICT facilities in coffee farming?

MATERIALS AND METHODS

Coffee farmers in Iyamoye, Kogi state were investigated. 71 pieces of questionnaire in three local governments were administered and 61 returned making 87.14% Returned rate. Returned questionnaire were sent for analysis and interpretation of data using descriptive analysis such as frequency counts and percentages.

RESULTS AND DISCUSSION

In Table 1, ICTs available for use by coffee farmers at Iyamoye are radio 26 (42.6%) which carried the highest number, followed by phone 14 (23.0%), also cassette 8 (13.1%), E-bulletin 7 (11.5%), and GIS and projector carried the least 2 (3.3%). This is supported by Yimer, 2015; Munyua and Adera 2009 who reported that radio is extensively used to inform users on agricultural topics, including new and upgraded farming techniques, production management, and market information. Khattar, (2017) also stated that ICTs are now being used by farmers to disseminate farming activities across the globe.

From the Figure 1 below, Coffee farmers access ICT majorly from workplace which is their farm and home. This means ICTs facilities used by Iyamoye farmers were used mostly for their farming activities. This is supported by Bhalekar *et. al*. (2015); Pande and Deshmukh, (2015).

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Table 1: Types of ICT facilities available for use by coffee farmers in Kogi State

ICT facilities	Rarely Available	Moderately Available	Available	Not Available
Radio	12 (19.7%)	15(24.6%)	26 (42.6%)	8(13.1%)
Television	7(11.5%)	16(26.2%)	11(18.0%)	26(42.6%)
Phone	17(27.9%)	16(26.2%)	14(23.0%)	13(21.3%)
Computer	55(90.2%)	2(3.3%)	4(6.6%)	60(98.4%)
Cassette	49(80.3%)	4(6.5%)	8(13.1%)	60(98.4%)
Recorder	51(83.6%)	4(6.6%)	4(6.6%)	2(3.3%)
GIS	57(93.4%)	2(3.3%)	1(1.6%)	1(1.6%)
Projector	58(95.1%)	2(3.3%)	1(1.6%)	0%
E-bulletin	41(67.2%)	7(11.5%)	6(9.9%)	7(11.5%)

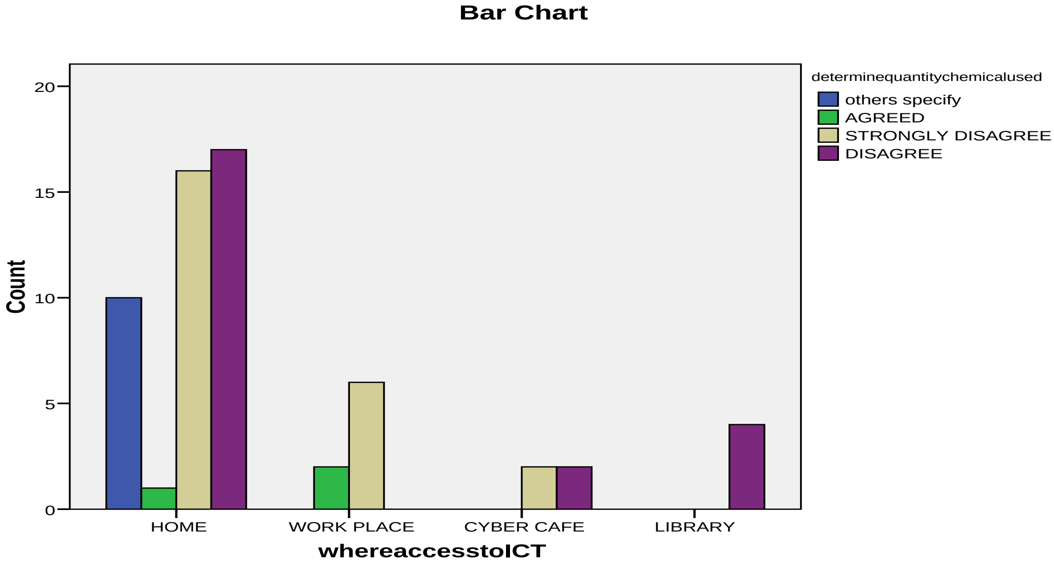

Figure1: Farmers' accessibility to Information Communication Technologies (ICTs)

Table 2 revealed sources of awareness of ICT tools among coffee farmers in Kogi State, the table revealed that CRIN (60.7%) carried the highest percentage, extension agents (16.4%) and NGOs (11.5%). It can be inferred from here that despite paucity of research fund Cocoa Research Institutes of Nigeria is performing her duty of reaching out to all farmers in Nigeria. Which means all mandate crops are being touched especially, coffee. Also, extension agents from CRIN are performing their roles of reaching out to coffee farmers at Iyamoye, Kogi state in particular.

Table 2: Sources of awareness of ICT among coffee farmers in Kogi State

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	EXTENSION AGENT	10	16.4	16.7	16.7
	CRIN/ RESEARCH INSTITUTE	37	60.7	61.7	78.3
	NGOs	7	11.5	11.7	90.0
	FARMERS ORGANIZATION	6	9.8	10.0	100.0
	Total	60	98.4	100.0	
Missing	System	1	1.6		
Total		61	100.0		

The following are the benefits of using ICT among coffee farmers in Kogi State (Table 3): Increase productivity (52.2%), saves time (34.4%) and reduction of risk (11.5%). These claims are supported by Ramli *et al.* (2015) and Abdullah and Samah, (2013), that farmers (Coffee farmers inclusive) could access relevant information through ICT at any point in time, and this enables them to ultimately have higher yield of agricultural productivity. Also, these claims were supported by Kale *et al.* (2015) that ICT provides timely information.

Table 3: Benefits of using ICT for Information Transfer in Kogi State

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SAVES TIME	21	34.4	35.0	35.0
	INCREASE PRODUCTIVITY	32	52.5	53.3	88.3
	REDUCE RISK	7	11.5	11.7	100.0
	Total	60	98.4	100.0	
Missing	System	1	1.6		
Total		61	100.0		

CONCLUSION AND RECOMMENDATIONS

It was discovered that coffee farmers in Iyamoye Kogi state still lack behind in using ICT in transferring information. That is low level of use of ICT among coffee farmers, this indirectly must have led to low productivity. It was also discovered that few that have this ICT do not know the benefit of using it, hence they lack ICT knowledge. Based on the above discovery, it is therefore recommended that:

1. Since availability does not connote usability, ICT training should be organised to coffee farmers in Iyamoye. This will help the farmers to learn how to use the available ones profitably.

2. Regular visit of extension officers is needed so as to always remind them the importance and usage of ICT facilities in their farming activities.

3. Special recognition and ICT subsidy loan should be provided by government for coffee farmers in Iyamoye. This will help them in purchase of these ICTS that are not available as it has been discovered that benefits of it will improve the standard of living of coffee farmers, improve productivity and increase food production in Nigeria.

4. Therefore, since this study found that ICT has a low level of use among coffee farmers, it infers that taken into cognizance all the benefits of use of ICT as earlier explained, there is urgent need by coffee farmers in Kogi state to start using ICTs so as to increase output. Special recognition and ICT subsidy should be given to coffee farmers so as to boost ICT use.

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COVID-19 PANDEMIC: A DRIVING FORCE FOR DIGITAL TRANSFORMATION IN AGRICULTURAL RESEARCH INSTITUTE LIBRARIES IN NIGERIA

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ABSTRACT

Covid-19 pandemic has shifted organisation's such as research institute libraries activities to less of physical engagement as measures especially social distancing are to be ensured for safe practices in the libraries. Researcher's information needs which is always enormous and current demands that opportunity for contact is maintained by libraries and researchers. This demands library services needs to be transformed digitally through the deployment of digital tools. Digital transformation of the library services ensures convenience and ease of access by the researchers. This is imperative for effective productivity as accesses to information increases innovation in agricultural practices. It is required of the research institute to provide adequate funding for the acquisition of digital tools and opportunities for staff training to ensure the digital tools are deployed effectively in a bid to achieve the library goals and objectives even admist the Covid-19 pandemic.

Key words: Covid 19, Digital tools, Digital transformation, Agricultural research institutes, libraries

INTRODUCTION

Coronavirus disease (Covid-19) pandemic is a novel virus that has been ravaging the whole world since it time of identification on 31st December, 2019 in Wuhan, Hubei city of China (WHO, 2020). It spread did not affect only developed countries but as well as developing country such as Nigeria. The Covid-19 virus is a virus that can spread quickly, highly contagious with high mortality rate compare to other contagious disease. Based on the recommendation of the World Health Organisation (WHO) in a bid to curtail it spread among people social distancing, lock down, quarantine and isolation are key things expected of countries, organisation, as well as individuals to abide with. Organisations, such as the agricultural research institute libraries with the sole responsibility of meeting the diverse and daily information needs of the library users, are expected to take the advantage digital tools offers in ensuring physical contact is reduced. Agricultural research institute as an organisation relevance in the era of the Covid 19 pandemic can be ensured through digital transformation. Covid 19 pandemic as pose a major challenge to accessing of information from the research libraries as certain measures had to be put in place specially to reduce the number of researchers that may want to use the library at a time in a bid to maintain social distancing as well as avoid crowding within the library. Thus, in a bid to ensure the research library being still consulted, there is need for the deployment of technological facilities for running library services leading to digital transformation of the library.

According to Mazurek (2019), digital transformation (DT) can be regarded basically as organisation change. This is implemented through the deployment of technological facilities in areas that includes operation models, models of cooperation regarding the internal and external environment, provision of services, technology used information management. Digital transformation involve library making use of digital technologies and its supporting features to provide opportunity for library users to relate, interact, collaborate with the library and gets the needed information without having the need to be physically present within the library. For the research community through digital transformation, there has been predominantly large number of information resources that are available online as well as opportunity for knowledge dissemination electronically. Digital transformation positions the library such as the agricultural research institute libraries to shift it services provision electronically by ensuring library services can be rendered online. Library services in which technology can be deployed into Webopac, digitization, building of institutional repository linked to the library website, social media pages on different platforms, electronic referencing, selective dissemination of information, document delivery and much more. The implementation of such service will increase the confidence of researcher to see the relevance of the library especially in during this pandemic era of Covid-19.

The uptake of digital technologies to mediate human interaction, digitization of print documents and opportunities to have a personalised channel such as email, social media pages have provided avenue for library to leverage in the satisfaction of diverse information needs of the library users especially in this era of Covid-19 where physical contact is expected to be minimal. There is therefore need for the library to acquire digital tools as well train staff to effectively use the digital tools to promote digital transformation of the research libraries.

According to Verhoef et al (2019) digital transformation is driven by three predominant factors. First, the wide entrance of the World Wide Web (WWW) as well its acceptance and use globally, including a significant number of accompanying technologies such as SEO, Web 2.0, smartphones, broadband internet speech recognition, cloud computing, crypto currencies, Internet of Things (IoT) and online payments platforms) which have increased sporadically and have given opportunity for activities to be done electronically. Second, change in competition dramatically due to the presence of new technologies. As regards library being the provider of relevant information, for examples internet and web sites providers, telecommunications operators; E-journals and E-book providers and so on are trying to take the advantage of the web to provide information and reduce the patronage of the library for needed information. Third, the behaviour of the consumer such the library clientele is changing as a response to the digital revolution.

Digital transformation and innovation in digitization are made possible by digital technologies and are boosted by researchers' expectations, as well as by prospects of greater economic and social benefits. Successful digital transformation comes not only from implementing new technologies but also from transforming organizations to take advantage of the possibilities that new technologies provide, and requires digital resources. Major digital transformation initiatives are centered on re-envisioning customer experience, operational processes, and business models (Kohli and Melville, 2019)

There are many external factors forcing transformative change in libraries, such as shifts in scholarly communication and how research is published and disseminated, technology that allows users to access information without intermediation, user demands for access to new types of scholarly information (e.g. data sets, multimedia resources), and accelerated globalization. Learners and researchers have new demands due to the complexities of blended learning, experiential learning, distributed learning and the concomitant need for mobile content delivery, increased focus on research data management and data mining, and increased options for disseminating research (Anuradha, 2018).

DIGITAL TRANSFORMATION AND LIBRARY SERVICES IN AGRICULTURAL RESEARCH INSTITUTE IN NIGERIA

Digital technologies can be employed to facilitate the following services within the library.

1. **Web-OPAC:** The catalogue of a library provides access to the holdings of a library. Through the catalogue library users can search for information materials to determine if it available within the collection of the library. Web OPAC (Online Public Access Catalogue) allows the library to host her catalogue on the web there by ensuring access is provided from any location and at any time. Researchers then have the opportunity to determine if a particular information material they intend to consult in the research library is available, through checking the Web OPAC of the institute online. This will help a researcher to be sure that a particular resource he or she intend to consult is available or not, thereby avoiding the risk of exposure to crowd as well as saving time and cost.
2. **Digitisation:** This can be regarded as the process of converting print information material into electronic readable format. Digital tools such as scanner and necessary software on the computer system can be used. It ensures that information materials that are available in print format needed by library are digitised for access electronically.
3. **Web 2.0:** This is associated with web applications that facilitate participatory information sharing, inter-operability, users' centred design and collaboration on the World Wide Web (Verma and Verma, N.D). Furthermore, with. Web 2.0, the holdings of the library become virtual collection and library become without wall. Library use the Web 2.0 in a bid to share information and receive feedback from thereby building knowledge as understanding is sustained in a real time. Such tools that facilitate this real time communication includes blogging, social media, wikis, multimedia sharing, audio blogging and pod

casting and so on. Library service that can be well integrated is reference service as two ways communication must be sustained between the librarians and the library users.

4. **Selective Dissemination of Information (SDI):** This is an activity of the library, in which the librarians seek to understand and determine the information needs of the various researchers of the library based on their research area, topic of interest and so on. The researcher's profile is generated by making a list of needed information to be filled by the researcher and sent to their mail. Availability of information materials that matches the areas of the researchers are also delivered electronically.
5. **Institutional Repository:** Institutional repository is a service-based activity of the library in which research breakthroughs (findings) generated by staff and researchers of research institute are presented in seminars, symposium and workshops. These information resources are captured and stored on the library website for wider access and use by information seekers. Such information resources are presented in portable document format (PDF) and stored on the institutional repository. The institutional repository serves as back up for archiving the seminar presentation. Publications of the staff and researchers belonging to the research institute are stored in the repository of each institute.

CONCLUSION AND RECOMMENDATION

Agricultural researchers are individuals whose contributions are important to sustainable practices of agriculture in nations of the world such as Nigeria. Researchers need access to current information in order to be aware of new practices for improvement int agricultural practices globally and how they can implement it locally as well as contribute their own findings, such information are contained in the collections of the research libraries.

Covid 19 pandemic has changed the way information is being accessed as there is need for less physical gathering. Therefore, engineering information services provision through digital technology is key to ensuring the consultation of the research libraries in Nigeria. Leading to better and sage information service provision of the library and improved agricultural practices in the nation at large.

In a bid to achieve digital transformation for research library service provisions, the following recommendations shall be made.

1. Improvement in library personnel training through exposure to current trends in library practices, ICT based services provision and much more. This will ensure research librarians are abreast of development in library practices and how they can implement it in their library especially in Covid 19 pandemic era. Likewise, opportunities for havd on experience with digital tools increases the potential of it being deployed in the research library settings

2. Provision of funds for the acquisition of digital tools needed to ensure effective and efficient digital transformation in the research library.

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AWARENESS AND COPING STRATEGIES TO COVID-19 PANDEMIC BY COCOA FARMERS IN ONDO STATE OF SOUTHWESTERN NIGERIA

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ABSTRACT

The study investigated the awareness and coping strategies to the COVID-19 pandemic by cocoa farmers in Ondo State of Southwestern Nigeria. Random sampling technique was used to select cocoa farmers in the study area. A total of fifty cocoa farmers (respondents) were purposively selected from Ile-Oluji/Oke-Igbo local government area. Information was collected from the selected farmers with the aid of well-structured questionnaires and the data retrieved from forty-six cocoa farmers collected were analysed with descriptive statistics and chi-square analysis. The result of the analysis showed that 76.1% of the respondents are above the age of 41 years, 78.3% are males while 76.1% are married. Similarly, 78.3% of the cocoa farmers have 4-6 children in the household, 26.1% had secondary education, 43.5% have 16 to 20 years farming experience while 73.9% lived in condominiums or housing units where residents are herded together thereby predisposing them to the risk of the contagion. Majority of the respondents (96%) were aware of the occurrence of corona virus, 69.6% of the respondents coped by relying on less expensive food during the lockdown, 56.5% reduced their food consumption due to income loss, 63% reduced the number of meals eaten daily while 67.4% reduced the portion or size of meal daily during COVID-19. The chi-square test also revealed that there is significant relationship between farmers' awareness and coping strategies to covid-19, the quality and type of food they consumed.

Key words: COVID-19 pandemic, Farmers' awareness, coping strategies, Ondo state, Nigeria

INTRODUCTION

Cocoa is one of the most important perennial tree crops grown in tropical climates around the equator. It is also a highly valuable economic tree crop because it provides employment and income to the farmers, raw materials for industries and foreign exchange for producing countries such as Nigeria (Afolayan, 2020). Here, it is worth noting that cocoa is a major cash crop of the tropical forest, most notably in West Africa where export earnings from its sales forms a major part of national economies (Mayhew and Perry, 1998). However, the matter of cocoa and Nigerian government's handling of it is both complex and bizarre, to say the least. To begin with, prior to political independence in 1960, agriculture was the mainstay of the Nigerian economy; it was also the major source of foreign exchange earnings for the country. However, the discovery of oil in the 1970s led to a shift of emphasis from the agricultural sector to petroleum. With particular reference to the cocoa economy, the undue dependence by government on oil has led to a decline in export-led growth coming from cocoa.

But it is not only government neglect that has hampered the cocoa industry in Nigeria. On the contrary, the decline in cocoa productivity has been exacerbated by other factors, a few of which are outlined below:

i. majority of cocoa farmers lack the technical know-how on modern methods of agricultural practices;
ii. most young people are unwilling to engage in farming or replace their ageing parents who are either incapacitated or weak to engage in farm work;
iii. there is mass exodus of farmers from rural to urban areas in search of the better life;
iv. there is high cost of agricultural labour, prevalence of pests and crop diseases;
v. most of the cocoa plantations are old while a majority of cocoa processing factories are decrepit, neglected and not functioning, and
vi. there is lack of incentives or financial aids to cocoa farmers, etc. (CRIN, 2003; Akinnagbe and Ajayi, 2010; Afolayan, 2020).

The factors highlighted above are not exhaustive. However, the point needs to be made, which is that the case with cocoa is not altogether that of gloom, misery or despair. On the contrary, even with the dependence on oil and the neglect of the agricultural sector by various Nigerian administrations, cocoa remains the major non-oil export that still generates high income for the country. This is the point made by Afolayan (2020), Akinwale (2006) and Ibiremo *et al.* (2011) when they averred that in Nigeria, cocoa is a key export crop with revenue of at least 34 billion derived annually from the export of cocoa beans alone, besides revenue from cocoa by-products like butter, cake, liquor and powder. Indeed, cocoa is only second to crude oil as the major revenue earner for Nigeria.

The contribution of cocoa to Nigeria's economy: a historical perspective

Nigeria ranks among the top six cocoa beans producers in the world. And as indicated already, after oil, cocoa is the country's most important agricultural export product. Indeed, cocoa is a household cash crop and key agriculture produce in Nigeria. Cocoa is consumed locally and also exported internationally to generate foreign exchange for the country. Statistics show that Nigeria produced 367,000 tonnes of cocoa in 2017, and that out of the 161,285.72 metric tonnes of agricultural produce exported, cocoa export alone accounted for 33,294 tonnes (NEPC, 2018). Again, the total income from non-oil products exported by Nigeria in 2019 was US$1,870.677 million; out of this, cocoa exports alone amounted to US$394.798million. No other agricultural export crop has contributed to Nigeria's GDP like cocoa. Besides being a major foreign exchange earner for the country, the cocoa sub-sector provides employment both directly and indirectly, to many youths in the country. Cocoa is also an important source of raw materials to many industries in the cocoa value chain in the country.

Historically, cocoa is said to have been first cultivated in the Delta region before spreading to Western Nigeria around 1890 where ecological conditions and the soil type encourages cocoa growing and cultivation. It is generally agreed that all the states in southwestern Nigeria are cocoa producing states, with the only exception being Lagos, which according to Afolayan (2020), does not produce cocoa in "commercial quantity." But of all the cocoa producing states in Nigeria, Ondo State is the largest with its output capacity of about 77,000 tons per annum (Oluyole, 2005).

The covid-19 global pandemic had a negative impact not only on the cocoa sub-sector but on the agricultural sector generally. In the main, the pandemic exposed many rural farmers to debilitating health problems, and by restricting human and vehicular movement, led to low agricultural productivity, which in turn led to low income for farmers and their households. It is common knowledge that the COVID-19 pandemic led to the collapse of many national economies. To minimize the impact on the livelihood of their citizens, many governments all over the world initiated various fiscal interventions to alleviate the suffering caused by the pandemic. But as with many government policies, in Nigeria, many households, micro, small and medium enterprises affected by COVID-19 did not benefit from the credit facility or stimulus package announced by the national government through the Central Bank of Nigeria in March, 2019. Usually too, rural farmers and their households are the worse off as neither government nor local authorities extend help or fiscal assistance to them in time of need. As with other cocoa producing states in Nigeria, cocoa farmers in Ondo state experienced great hardship during the peak period of the global pandemic. The pandemic did not only affect farmers' health or farming activities but also their livelihood. Hence, this study examined the coping strategies of cocoa farmers in Ondo state during the COVID-19 global pandemic. Well-structured questionnaires were administered to 50 cocoa farmers to collect primary data on farmers' socio-economic characteristics, awareness and coping strategies during the pandemic. The objectives of the study are: (i) to determine the socio-economic characteristics of cocoa farmers in the study area, and (ii) to identify the awareness and coping strategies of cocoa farmers in the study area during COVID-19.

MATERIALS AND METHODS

The study was carried out in South-western Nigeria, which is one of the six geopolitical zones in the country. Ondo state is one of the states in South-western Nigeria, made up of 18 Local Government Areas and the chief cocoa producing state in Nigeria. The state lies between longitudes 4"30" and 6" East of the Greenwich Meridian, 5"45" and 8" 15" North of the Equator. The state is bounded in the North by Ekiti/Kogi State; in the East by Edo State; in the West by Oyo and Ogun States and in the South by the Atlantic Ocean. Ile Oluji/Oke-Igbo LGA was purposively selected. Well-structured questionnaires were administered to fifty cocoa farmers in six villages/towns out of which forty-six were used for the analysis due to the fact that not all the questionnaires were completed. Data retrieved from the information collected was analysed with descriptive statistics and chi-square analysis. In the study, the null hypothesis and alternative hypothesis are generally stated as: Ho: No relationship between the awareness of cocoa farmers and their coping strategies during covid-19 pandemic.

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H1: There is a relationship between the awareness of cocoa farmers and their coping strategies during covid-19 pandemic.

RESULTS AND DISCUSSION

Table 1 shows the socioeconomic characteristics of cocoa farmers in the study area during the pandemic. The table shows that 76.1% of the respondents are above the age of 41 years, 78.3% while males and 76.1% are married. Again, 26.1% of the respondents had secondary education, 43.5% had 16 to 20 years farming experience, 78.3% had 4-6 children in the household while 73.9% lived in condominiums or living conditions that brought people in close proximity to each other. Such living conditions are risk factors for the spread or transmission of COVID-19 since the possibility of contracting the contagion increases with contact or people sharing common facilities such as conveniences and rooms. It follows from the foregoing that because of their lifestyle and economic deprivation cocoa farmers are among the most vulnerable populations to COVID-19 pandemic.

Table 1: Socioeconomic characteristics of cocoa farmers in Ondo state

Variables	Frequency	Percentage
Age		
18-25	1	2.2
26-33	4	8.7
34-41	6	13
>41	35	76.1
Total	46	100
Gender		
Male	36	78.3
Female	10	21.7
Total	46	100
Marital Status		
Single	11	23.9
Married	35	76.1
Total	46	100
Educational Status		
No formal education	15	33
Primary education	11	23.9
Secondary education	12	26.1
Tertiary education	8	17.4
Total	46	100
Farming Experience		
1-5	2	4.4
6-10	11	23.9
11-15	13	28.3
16-20	20	43.5
Total	46	100
Type of accommodation		
Hut	1	2.2
Bungalow	3	6.5
Face-to-face	34	73.9
Self-contained room	8	17.4
Total	46	100
Children in the household		
1-3	8	17.4
4-6	36	78.3
7-10	2	4.4
Total	46	100

Source: Field Survey, 2021

Table 2 shows the awareness and coping strategies of cocoa farmers in the study area. It shows that 96% of the respondents were aware of the existence of corona virus, 69.6% relied on less expensive food for their daily meal during the lockdown, 56.5% reduced their food consumption due to income loss, 63% reduced the number of meals eaten daily while 67.4% reduced the portion

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or size of meal for their daily meal during COVID-19. This could be as a result of low income or sale, reduced farm activities, inability to purchase food items due to lockdown or restrictions in movement.

Table 2: Coping strategies of Cocoa Farmers during Covid-19 Pandemic

Variables	Frequency	Percentage
Awareness of Corona Virus (COVID-19)		
Yes	44	96
No	2	4
Total	46	100
Relied on less expensive food during lockdown		
Every day (7days)	32	69.6
3-6 days	13	28,3
0-2 days	1	2.2
Total	46	100
Borrowed food from friends during COVID-19		
Every day (7days)	6	13
3-6 days	3	6.5
0-2 days	37	80.4
Total	46	100
Reduced number of meals during the lockdown		
Every day (7days)	29	63
3-6 days	16	34.8
0-2 days	1	2.2
Total	46	100
Reduced portion or size of meals		
Every day (7days)	31	67.4
3-6 days	14	30.4
0-2 days	1	2.2
Total	46	100
Coping strategies with income loss		
Relied on savings	12	26.1
Relied on off-farm income	3	6.5
Reduced food consumption	26	56.5
Relied on income from farming	5	10.9
Total	46	100

Source: Field Survey, 2021

Table 3 shows the result of the chi-square test analysis on the relationship between the awareness of cocoa farmers and the coping strategies adopted by farmers during the pandemic. The Table shows that there is significant relationship between the awareness of cocoa farmers about covid-19 and their reliance on less expensive food, coping strategies with income loss, reliance on support/palliatives received as well as the type of support received during covid-19.

Table 3: Results of Chi-Square analysis showing the relationship between cocoa farmers' awareness and their coping strategies during covid-19 pandemic

Variables	df	Chi-square value($\chi 2$)	p value
Reliance on less expensive food	3	14.388***	0.002
Coping with income loss	5	22.519***	0.000
Palliatives supplied	1	7.161***	0.007
Reliance on support	2	16.013***	0.000
Type of support	3	21.271***	0.000

*** Significant at 1%   Source: Field Survey, 2021

CONCLUSION AND RECOMMENDATION

The study assessed the awareness and coping strategies to COVID-19 pandemic by cocoa farmers in Ondo State of Southwestern Nigeria. The findings showed that despite the long neglect that the cocoa sub-sector has experienced, cocoa has remained a resilient agricultural product, and one that has contributed immensely to the growth of the Nigerian economy. The findings further revealed that the impact of COVID-19 on farmers and farming activities was dire and grim. However, it is heartwarming that the cocoa industry was able to withstand the negative effect of the pandemic, which threatened to kaput the past efforts of committed individuals and governmental agencies. The cocoa sub-sector has remained vibrant and continues to contribute to the nation's economic growth and revival. To restore cocoa to the enviable state it occupied in pre-independent Nigeria, it is recommended that government, stakeholders and other concerned organisations make concerted effort to resuscitate cocoa production and marketing in the country. This way the nation's tottering economy will be revived and the country will regain its past economic glory.

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SIGNIFICANCE OF DEVELOPMENT COMMUNICATION TO SOCIAL CHANGE

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ABSTRACT

The focal point of this study is to investigate Significance of Development Communication to Social change. Secondary method of data collection which entails the review of journals and publication related to the subject was adopted in data collection. Findings from the study revealed that the components of development communication were used in the implementation of projects and involved members in the implementation of the project. Absence of participatory communication in some of the projects did not help implementers understand the challenges the community goes through in maintaining such developmental projects thus come together to find solutions to them. By facilitating mutual understanding and by building trust among stakeholders, communication becomes of critical value in fostering participation and social change. The study therefore recommends that project planners should design and adopt appropriate development communication model towards sustaining projects for project implementers and communities so as to get the desired social changes that come with such projects.

Key words: Development communication, Social change, Social development, Significance

INTRODUCTION

Development communication refers to the use of communication to facilitate social development (Kamarah, 2011). Development communication engages stakeholders and policy makers, establishes conducive environments, assesses risks and opportunities and promotes information exchange to create positive social change via sustainable development. Development communication techniques include information dissemination and education, behavior change, social marketing, social mobilization, media advocacy, communication for social change, and community participation. Development communication has not been labeled as the "Fifth Theory of the Press", with "social transformation and development", and "the fulfillment of basic needs" as its primary purposes (Abiona, 2019). Jamias articulated the philosophy of development communication which is anchored on three main ideas. Their three main ideas are: purposive, value-laden, and pragmatic (Bella, 2013).

Chadha, D. (2015) expanded the definition, calling it "the art and science of human communication applied to the speedy transformation of a country and the mass of its people from poverty to a dynamic state of economic growth that makes possible greater social equality and the larger fulfillment of the human potential". Melcote and Steeves (2016) saw it as "emancipation communication", aimed at combating injustice and oppression. The term "development communication" is sometimes used to refer to a type of marketing and public opinion research, but that is not the topic of this article.

The emphasis on participation in development also implies increased attention to communication, because there can be no participation without communication. Communication is central to this task in many ways; thus, it enables planners, when identifying and formulating development programmes, to consult with people (the stakeholders) in order to take into account their needs, attitudes and traditional knowledge (Diouf, 2014). Development communication is the only way project beneficiaries can become the principal actors to make development programmes successful (FAO, 2016). Communication for Development (ComDev) or development communication can be defined as the planned and systematic use of communication through inter-personal channels, ICTs audio-visuals and mass media for social change. Development is about change, and if development initiatives of any kind are to be sustainable they should start with mechanisms that ensure broad participation by all those who have some interest in the intended change (Mefalopolus, 2018). In ComDev, rural people are at the centre of any given development initiative and so communication is used in this sense for people's participation and community mobilization, decision making and action, confidence building for raising awareness, sharing knowledge and changing attitudes, behaviour and lifestyles (FAO 2016). According to Adedokun et al. (2010), communication is expected to be used to facilitate community participation in a development planning initiative. The objective of this study is to investigate the significant of development communication to social change. The specific objectives are;

i. To determine is communication influence in sustaining development projects.
ii. To find out the importance of The use of Communication in Involving Communities in development projects.

Development Communication in Africa

The African school of development communication sprang from the continent's post-colonial and communist movements in the late 1960s and early 1970s. Anglophone Africa employed radio and theatre for community education, adult literacy, health and agricultural education (Kamlongera, 2013, Mlama, 2011).

In 2014, the FAO project "Communication for Development in Southern Africa" was a pioneer in supporting and enhancing development projects and programs through the use of participatory communication. The FAO project, placed under SADC, developed an innovative methodology known as Participatory Rural Communication Appraisal (PRCA), which combined participatory tools and techniques with a strong communication focus needed to enhance projects results and sustainability. FAO and SADC published a handbook on PRCA that was used in projects around the world.

The radio maintained a strong presence in research and practice into the 21st century. Radio was especially important in rural areas, as the work of the non-governmental organization Farm Radio International and its members across sub-Saharan Africa demonstrated. Knowledge exchange between development partners such as agricultural scientists and farmers were mediated through rural radio (Hambly, 2013).

Participatory development communication

The evolution of the participatory development communication school involved collaboration between First World and Third World development communication organizations. It focused on community involvement in development efforts and was influenced by Freirean critical pedagogy and the Los Baños school (Besette, 2014).

Development Communication or Communication for Development

The World Bank actively promotes this field through its Development Communication division and published the *Development Communication Sourcebook* in 2008, a resource addressing the history, concepts and practical applications of this discipline. World Bank tends to espouse and promote the title "Development Communication" while UNICEF uses "Communication for Development". The difference seems to be a matter of semantics and not ideology since the end goals of these global organizations are almost identical to each other. Communication for Development (C4D) goes beyond providing information. It involves understanding people, their beliefs and values, the social and cultural norms that shape their lives. It includes engaging communities and listening to adults and children as they identify problems, propose solutions and act upon them. Communication for development is seen as a two-way process for sharing ideas and knowledge using a range of communication tools and approaches that empower individuals and communities to take actions to improve their lives. World Bank defines Development Communication "as an interdisciplinary field, is based on empirical research that helps to build consensus while it facilitates the sharing of knowledge to achieve a positive change in the development initiative. It is not only about effective dissemination of information but also about using empirical research and two-way communications among stakeholders" (Development Communication division, the World Bank).

Examples of Development Communication across the Globe

One of the first examples of development communication was Farm Radio Forums in Canada. From 1941 to 1965 farmers met weekly to listen to radio programs, supplemented by printed materials and prepared questions to encourage discussion. At first, this was a response to the Great Depression and the need for increased food production in World War II. Later the Forums dealt with social and economic issues. This model of adult education or distance education was later adopted in India and Ghana (Besette, 2014). Radio DZLB was the community broadcasting station of UPLB College of Development Communication. It was a forerunner of the school-on-air (SOA) concept that provided informal education for farmers. DZLB hosted SOAs on nutrition, pest management and cooperatives.

DZLB aired educational programming for farmers and cooperatives. Established in 2009, Global South Development Magazine has been a recent example of development communication in practice. Instructional television was used in El Salvador during the 1970s to improve primary education. One problem was a lack of trained teachers. Teaching materials were improved to make them more relevant. More children attended school and graduation rates increased.

In the 1970s in Korea the Planned Parenthood Federation succeed in lowering birth rates and improving life in villages such as Oryu Li. It mainly used interpersonal communication in women's clubs. Oryu Li's success did not recur in all villages. The initial effort had the advantage of a remarkable local leader and visits from the provincial governor. A social marketing project in Bolivia in the 1980s tried to get women in the Cochabamba Valley to use soybeans in their cooking. This was an attempt to deal with chronic malnourishment among children. The project used cooking demonstrations, posters and broadcasts on local commercial radio stations. Some people tried soybeans but the outcome of the project was unclear.

In 1999 the US and DC Comics planned to distribute 600,000 comic books to children affected by the Kosovo War. The books were in Albanian and featured Superman and Wonder Woman. The aim was to teach children what to do when they find an unexploded land mine left over from Kosovo's civil war. The comic books instruct children not to touch and not to move, but instead to call an adult for help. Since 2002, Journalists for Human Rights, a Canadian NGO, has operated projects in Ghana, Sierra Leone, Liberia, and the Democratic Republic of the Congo. JHR works directly with journalists, providing monthly workshops, student sessions, on the job training and additional programs on a country by country basis.

Cuban Media and Education – In 1961, the year of education, the well known literacy campaign was initiated. Television and radio played a complementary role in the dissemination of literacy training programs. Live coverage of literacy worker and students was used to dramatise and this was reinforced on radio and in newspapers (Besette, 2014).

Social change

Social change involves alteration of the social order of a society. It may include changes in social institutions, social behaviours or social relations. Social change may refer to the notion of social progress or socio-cultural evolution, the philosophical idea that society moves forward by evolutionary means. It may refer to a paradigmatic change in the socio-economic structure, for instance the transition from feudalism to capitalism, or hypothetical future transition to some form of post-capitalism (Anderson, 2017).

Social Development

Social Development refers to how people develop social and emotional skills across the lifespan, with particular attention to childhood and adolescence. Healthy social development allows us to form positive relationships with family, friends, teachers, and other people in our lives.[1] Accordingly, it may also refer to social revolution, such as the Socialist revolution presented in Marxism, or to other social movements, such as Women's suffrage or the Civil rights movement. Social change may be driven through cultural, religious, economic, scientific or technological forces (Smith, 2014).

Types of changes

Social changes can vary according to speed and scope and impetus. Some research on the various types of social change focuses on social organizations such as corporations.

Different manifestations of change include:

- Fabian change - gradual and reformist incremental amelioration after the manner of the Fabian Society
- radical change[] - improvements root and branch in the style of political radicalism
- revolutionary change - abrupt, radical and drastic change, with implications of violence and of starting afresh (perhaps most popular as a political bogeyman)
- transformational change - a New-age version of radical change, and thus difficult to define
- continuous change, open-ended change - change (allegedly) for the sake of change
- top-down change - reliance on leadership
- bottom-up change - reliance on the huddled masses

MATERIALS AND METHODS

The methodological approach chosen for any piece of research is designed to provide proper data to answer the research questions and to attain the research objectives. The research is an exploratory type which investigates a phenomenon in which the researcher has little knowledge about. Exploratory research is usually undertaken when the research issue is badly understood. Cooper and Schindler (2003) argued that when the area of investigation is new or unclear, or if the research variables cannot be clearly defined, the researcher needs to follow an exploratory design in order to serve the purpose of the study and learn something new about the phenomenon. The study adopted a case study approach since it seemed more appropriate as this helps to understand complex issues through analysis of a number of events or conditions and their relationships. Case study is a strategy that explores in-depth a program, an event, a process or one or more individuals (Creswell, 2003).

RESULTS AND DISCUSSION

This section presents the analysis of findings and discussions base on the data collected from the field on the role communication plays in sustaining development projects. Analysis was run using SPSS version 25 and the following results were obtained.

Table 1: Communication influence in sustaining development projects.

SN	**Statement**	**N = 150 Mean (Std.)**	**Remark**
1	Communication is essential in sustaining development projects	2.53 (1.12)	Accepted
2	Communication has no influence in sustaining development projects	2.86 (1.20)	Accepted
3	Communication is partially important in terms of sustaining development projects	2.94 (1.25)	Rejected
	Total	**2.59**	Accepted

Source: Field survey, 2021. Mean magnitude: X ≥ 2.5 = Accepted, X ≤ 2.5 = Rejected

Results on Table 1 showed that communication has positive influence in sustaining development projects. The analysis indicates that respondents accepted on items 1 and 2, but rejected on item 3. The Grand mean 2.59 indicates that communication has positive influence in sustaining development projects.

In the context of this study a project is defined as an intervention that addresses a particular problem. Communication's influence on sustaining these projects is what the study set out to achieve. The development projects that have been implemented in the selected communities were investigated and it was realized that rural electrification and rural water supply were the major projects that have been implemented in the past few years. The study therefore concentrated on these two types of projects. The survey indicated that government and NGOs as well as development partners were involved in the provision of these projects.

Table 2: Importance of the use of communication in involving communities in development projects

SN	**Statement**	**N = 150 Mean (Std.)**	**Remark**
4	Communication important during implementation of projects	2.53 (1.12)	Accepted
5	Communication is important before implementation of projects	2.86 (1.20)	Accepted
6	Communication is important after implementation of projects	2.94 (1.25)	Accepted
	Total	**2.77**	Accepted

Source: Field survey, 2021. Mean magnitude: X ≥ 2.5 = Accepted, X ≤ 2.5 = Rejected

Results on Table 2 showed importance of the use of communication in involving communities in development projects. The analysis indicates that respondents accepted on items 4, 5 and 6. The Grand mean 2.77 indicates the importance of the use of communication in involving communities in development projects.

The study explored the use of communication before during and after the implementation of the projects under study. As indicated by FAO (2005), participatory communication approaches can bring together different stakeholders and groups into conversation with each other, and enable the poorest and most marginalized to have a powerful or influential voice in the decision and activities concerning their well-being. From the information gathered through interviews with respondents and focus group discussion, majority agreed that there was communication whilst a few people said there was absence of communication between implementers and communities before and during the implementation of the projects under study.

CONCLUSION AND RECOMMENDATIONS

The purpose of this paper was to explore the significance of development communication to social change. Qualitative research method, including document reviews, semi-structured interviews and a focus group were used to collect data. To identify the significance of development communication to social change the study first considered whether the three components of development communication thus social mobilization, advocacy and behaviour change communication were used to involve people before, during and after the implementation of projects. The study established that the components of development communication were used in the implementation of projects and involved members in the implementation of the project. Absence of participatory communication in some of the projects did not help implementers understand the challenges the community goes through in maintaining such developmental projects thus come together to find solutions to them. By facilitating mutual understanding and by building trust among stakeholders, communication becomes of critical value in fostering participation and social change.

Furthermore, the study revealed that participatory communication approaches can bring together different stakeholders and groups into conversation with each other, and enable the poorest and most marginalized to have a powerful or influential voice in the decision and activities concerning their well-being.

RECOMMENDATIONS

Based on the significance of development communication to social change, the study recommends as follows;

i. Firstly, project planners should design and adopt appropriate development communication model towards sustaining projects for project implementers and communities so as to get the desired social changes that come with such projects.
ii. Development communication should be all encompassing and should carry all along to as to achieve the desired social change that it comes with.
iii. Project implementers should adopt the social mobilization element of development communication by reaching out to opinion leaders who have the tendency to reach out to a large number of community members to inform them about the projects. This will help all members to become aware of the projects as these leaders have greater influence on the people.
iv. Development Communication should be used to raise awareness on the importance of members of communities playing their aspect of the social contract as this will enable the sustenance of social change that development communication brings.

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THE IMPORTANCE AND USE OF INFORMATION COMMUNICATION TECHNOLOGIES (ICTs) IN THE DISSEMINATION OF INFORMATION FOR IMPROVING CASHEW (*ANACARDIUM OCCIDENTALE* L.) PRODUCTION IN NIGERIA

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ABSTRACT

The study reviewed the importance and use of ICTs in the dissemination of information for improving cashew production in Nigeria. The impact of ICTs in cashew production was extensively discussed, its benefits to weather and climate change, diseases and pest, market price as well as creation of new business opportunities were examined. Challenges facing the use of ICTs in cashew production was also looked into and finally recommendations were made that cashew farmers should be trained in the use of ICTs tools and soft loans to purchase ICTs equipment should be made available by government to cashew farmers.

Key words: ICTs use, Information dissemination, cashew production, cashew farmers, Nigeria

INTRODUCTION

Information has been identified as an important factor in improving agricultural production of any nation. It also serves as a very important tool for decision making. Human beings need information to be able to make informed decisions on any meaningful thing. Thus, for any development to take place especially in cashew production, relevant, efficient, and effective information need to be sought by cashew farmers. This therefore means that the agricultural sector needs timely and up-to-date information with the use of Information Communication Technologies (ICTs) (Ronke, 2005). There is hardly a field of human activity today that has not been touched by the use of ICTs. Information Communication Technologies comprise those mobiles devices and applications that help the processing, management, and exchange of information with a target audience. They include traditional telecommunications such as television, radio, video, cell phones and other smart devices and several modern technologies such as computers and the internet, sensors, Geographic Information Systems and satellites. Essentially, the purpose of ICT is to transfer information from one point to another. ICTs are essential to access digital information, whether online or offline. Their impact depend on which specific technology is used and also on farmers' level of literacy. Short message services (SMS), voice messages, short video trainings, audio messages, social media interventions and virtual extension platforms. All these can improve farmer-to-farmer and farmer to expert's information sharing. In many circumstances ICTs, like mobile phones, increase access to information by cashew famers in developing countries. Cashew farmers can achieve higher crop yields, as they get access to timely and better-quality information on their products and services as well as environmental and market conditions. ICTs promote learning, which can facilitate technology adoption among cashew farmers, but can also alert on early warning systems through better quality data and analysis. The use of ICTs has allowed the agriculture sector to surge ahead and change the way famers cultivate, harvest, and distribute agricultural commodities. The use of ICTs in agriculture quickens agricultural and rural development by adopting innovative ways to improve the existing information and communication processes. It has helped address several challenges associated with the traditional form of agriculture.

In fact, agriculture has changed as ICTs have become increasingly critical to farmers. Research showed that those farmers who have used ICTs in agriculture have increased their production. Similarly, those who have used the e-services, e-commerce applications also increased their income (Chapman and Slaymaker, 2002, Sideridis, 2010). The use of mobile phones by farmers in India led to reduction in price dispersion and also lead to perfect adherence to the law of one price (Jensen, 2007). In India, farmers obtain information about pesticides use and application as well as market details from internet (Meera *et al*., 2004). The study conducted in South Africa showed that mobile phones have given a positive impact on farmers' income (Aker and Mbiti, 2010).

Economic importance of Cashew (*Anacardium occidentale*) in Nigeria

Anacardium occidentale is a tree crop which originated from Brazil and it's an evergreen nut bearing tropical plants generally single-trunked of

12 cm. It is multipurpose tree crop with great economic importance to third world countries including Nigeria. The cashew tree has been cultivated for food and medicine for many years and its fruits are of economic value. This includes apple, nut, kernel and wood. Cashew apple is edible food rich in vitamin C. It can be dried, canned or eaten fresh from the tree. It can also be squeezed for fresh juice, which can then be fermented into cashew wine, cashew nut is consumed as roasted and salted nuts. In confectionery and bakery products, finely chopped kernels are used in the production of sweets, ice creams, cakes, and chocolates and as a paste to spread on bread (Akinwale, 2000). The kernels are well accepted in the United States of America and Western Europe because, of the high quality of the produce (Aliyu and Hammed, 2008). Cashew nut shell liquid is a dark liquid, which is extremely caustic. It is an important and versatile industrial raw material. It is used as raw material for phenolic resins and friction powder for the automotive industry. It is also used in molding of acid-resistant paints, polishes, enamels, and black lacquers which is used for decorating vessels. It can also be used in the production of insecticides and fungicides. In traditional medicine, it has been used in treating leprosy, elephantiasis, psoriasis, ringworm, warts, and corns (Akinwale, 2000). The cashew wood is also used for furniture and fishing boat (Adeigbe *et al*., 2015). Currently, large amount of cashew nuts produced in Nigeria are exported, as only very few companies are involved in local processing of the produce. The Cashew industry also provides jobs and employment for women and smallholder farmers and has a total annual trade worth N 24 billion, thus making the sector a major contributor to Nigeria's non-oil GDP (Akinwale, 2000). There are lots of challenges facing cashew production in Nigeria, these include diseases such as floral shoot die-back, twig die-back and root rot of cashew seedlings, climate change and marketability which ICTs assisted information dissemination could help to solve.

Benefits of using ICT in cashew Production in Nigeria

Internet has created a room for farmers to get latest information on market. Internet can increase many opportunities in cashew production. By using the internet, cashew farmers will get information about their production from different markets within and outside Nigeria. Similarly, it will help them to obtain information on new method to increase their goods and services. In addition to the internet is mobile phone. Mobile phone has reduced the gap among traders and farmers and same time farmers directly can communicate with buyers and customers to find the good price of their product. Mobile phones have created a new business opportunity for farmers and has given them access to information about market, health and weather condition. The mobile phones technologies can directly connect cashew farmers and buyers without any disturbances. Farmers have another advantage of mobile phones they do not need to go to market but directly communicate and ask the price of their production. In this context they save their money, time and energy (Muto, *et al*., 2011, Lee *et al*., 2013). Television can disseminate scientific and agricultural knowledge among cashew farmers with the discussion of agricultural experts. Cashew farmers can get information by watching the agriculture related programs on television (Murty and Albino, 2012). Radio was the more effective source of dissemination of agriculture information among famers (Abbas *et al*., 2009, Bolorunduro *et al*., 2004). Okwu *et al*. (2007). Radio provides information among rural farmers about marketing, weather, environmental, diseases, water management and pest monitoring to increase the productivity of agriculture in their country. Radio can broadcast new approaches, ideas, research findings and scientific information in cashew production.

Challenges associated with using ICT in Cashew Production in Nigeria

Singh *et al*. (2015) reported some existing issues of ICT use in agriculture to include inadequate accessibility of ICT services to rural farmers, lack of basic skills of using ICT facilities in agriculture, inability of government to deliver adequate ICT knowledge to farmers. Access to the internet and telecommunications are mostly limited to urban areas in many developing countries while the rural areas remain untouched with new technology (Kale *et al*., 2015). Inadequate, and unstable power supply, cost of hardware and software are very high (Kale *et al*., 2015; Wyche and Steinfield, 2015). Unreliability and poor connectivity of the internet, and regular barriers to power distributions could be a major constraint to ICTs usage among cashew farmers in Nigeria. In view of the foregoing, it is clearly understood that inadequate basic ICT skills posed a serious challenge towards reaping the impact of ICT for agricultural growth.

CONCLUSION AND RECOMMENDATIONS

From the foregoing, we can see that cashew is a valuable economic tree. The crop provides food,

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income and also a source of livelihood that create job opportunities for relevant stakeholders. Despite all these benefits, there are lots of challenges facing cashew farmers along value chain in Nigeria. These challenges can be managed if cashew farmers can get accurate and up to date information through the use of ICTs. It is therefore recommended that:

1. Cashew farmers should develop interest in the use of ICTs and should be trained by IT expert in the use of sophisticated ICTs tools.

2. Government should assist them with soft loans to purchase some of these ICTs equipment.

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RAINFALL ATTENUATION OF MILLIMETER WAVE TECHNOLOGY AND AGRICULTURAL RESEARCH INFORMATION DISSEMINATION IN NIGERIA

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ABSTRACT

The attenuation of millimeter waves radio signal by rain and its implication on the dissemination of agricultural research in Nigeria was investigated. The data was collected from the Tropospheric Data Acquisition network (TRODAN), the International Institute for Tropical Agriculture (IITA), Bowen University Iwo and the Federal University of Technology, Akure. The rainfall rates were measured at 5 and 1-minutes integration time and the Lavergnat and Gole model was used for the conversion of the measured 5 minute to equivalent 1-minute values. The International Telecommunications Union (ITU) - Radio sector (R) 530-17 recommendation was used obtain the specific and path attenuation. The results revealed that as the percentage of time deceases from 1 to 0.0001%, the rainfall rate increases and vice versa. The specific attenuation frequency threshold at the 0.01% exceedance was 120 and 150GHz and it ranged from 11.81 to 35.05dB/km and 20.54 to 35.63dB/km respectively. The clear signal band path attenuation frequency threshold at 20km path length was 40 and 45GHz and it ranged from 168.23dB to 92.11dB. These results suggest the inclusion of the estimated attenuation values by radio propagation engineers in communication equipment designs for Nigeria.

Key words: Rainfall rate, millimeter wave, rain induced attenuation, radio signal, agricultural research

INTRODUCTION

Millimeter wave is the highest radio frequency band in practical use. It is the next band above microwave and lies between 30-300 GHz of the electromagnetic spectrum. It is characterized by narrow beamwidth, wide bandwidth spectrum and high frequency re-use potential (Chittimoju and Yalavarthi, 2021). Millimeter wave is the ideal candidate for certain applications such as provision of higher data rates in supporting applications such as Internet calls (Voice-Over-IP), local network remote access, inter- active audio-visual conferencing, wireless internet access of high speed, multimedia information broadcasting and file transfer (Karipidis, 2021).

At the millimetre wave frequency bands, attenuation by rain is considered the most crucial limiting factors that impairs the performance of fixed terrestrial wireless systems (Abayomi *et al*., 2019). Communication links reliability, availability and performance is adversely affected by the absorption and scattering of radio signals by rain which causes a decrease in the amplitude of the propagated signal (Shrestha *et al*., 2019) and leads to cross talk. Though a methodological approach has been developed by the International Telecommunications Union (ITU) - Radio sector which is useful for radio signal attenuation prediction due to rain on any terrestrial paths, however, in the tropical climate, the model does not perform well because of its dependence on temperate climates based data (Melloda *et al*., 2007). With the increase in spectrum occupancy of the volumes of agricultural research information in Nigeria and higher bandwidth demand to accommodate them, the need to explore the attenuating effect of rain on the carrier technology has become imperative.

MATERIALS AND METHODS

The data used for this study was sourced from the Tropospheric Data Acquisition Network (TRODAN), a project put forward by the Nigerian Centre for Atmospheric Research (CAR); the International Institute for Tropical Agriculture (IITA), Federal University of Agriculture, Akure and Bowen University, Iwo. The equipment used was with rain gauge of 5 minutes' resolution. The accuracy is up to 1 inch/hr: ±1% while the operating temperature is from 0° to +50°C.The study area covers all the agro-ecological zones of Nigeria with the exception of the sahel savanna and the duration of the study was averaged to five years. Table 1 shows the features of the study sites. The Lavergnat and Gole Model (equation 1) was used for the 5 to 1-minute integration time conversion; the specific attenuation, Y_R (dB/km) also referred to as attenuation per unit distance was determined with equation (2). The path attenuation, $A_{0.01}$ (dB) at 0.01% exceedance, the equivalence of 99.99% radio signal availability, was obtained at the maximum recommended path length of 60km by ITU-R (ITU-R 530-17, 2017) and 20 km for millimeter wave radio equipment deployment as shown in equation 2.

$$Q_c\left(r, t\right) = K^{\xi-1} Q_c\left(rk^{\xi-1}, kt\right) \quad (1)$$

Where $Q_c(r,t)$ is the cumulative probability function of rain rate r that would be obtained with a rain gauge having an integration time t.

$$\gamma_R = kR^{\alpha} \quad (2)$$

k and α = functions of frequency (GHz) ranging from 1GHz to 1000 GHz and R is the rainfall rate in mm/hr

$$A_{0.01} = \gamma_R d_{eff} = \gamma_R dr \; dB \quad (3)$$

where d_{eff} is the effective path length.

RESULTS AND DISCUSSION

Annual rainfall rates cumulative distribution

The variation of the yearly cumulative distribution of the averaged 1-minute integration time rainfall rate over the agro-ecological zones are shown in Figure 1(a - f). It can be observed from the figure that as percentage of time of rainfall rate exceedance decreases from 1 to 0.0001%, the rainfall rate increases and vice versa. In effect, the higher the rainfall rate, the higher the annual failure rate of millimeter wave radio equipment.

Rainfall attenuation of signal per unit distance

The specific attenuation was calculated for both for the horizontal and vertical polarization of the millimeter radio waves by rain. As shown in Table 2, the specific rain attenuation threshold across the zones was 120 GHz or 150 GHz. As observed, there is a slight difference between the specific attenuation at the horizontal polarisation and the vertical polarisation. In the Derived Savanna zone, the maximum specific attenuation predicted by ITU-R was 30.56 dB/km which differed from attenuation of 29.78 dB/km derived from measured rainfall by 0.78 dB/km. On the other hand, at the Humid Forest zone, the maximum predicted value of specific attenuation by ITU-R was 33.52 dB/km and it differed from the attenuation of 35.91 dB/km derived from measured rainfall by about 2.30 dB/km. Other zones follow the same trend, however with variation in the differences in specific attenuation due to rain.

Estimating path attenuation of millimeter radio wave

The path attenuation across all the zones was plotted at their frequency threshold of 120 GHz and 150 GHz respectively and the maximum recommended path length of 60km by ITU-R and 20 km for millimeter radio equipment deployment. As deduced from in Figures 2, the maximum frequency for clear signals transmission at 120 and 150GHz frequency threshold is 40 and 45 GHz and respectively. The clear signal band path attenuation frequency threshold at 20km path length ranged from 168.23dB to 92.11dB. The transmitted signal suffers from overlap beyond these frequency bands.

CONCLUSION

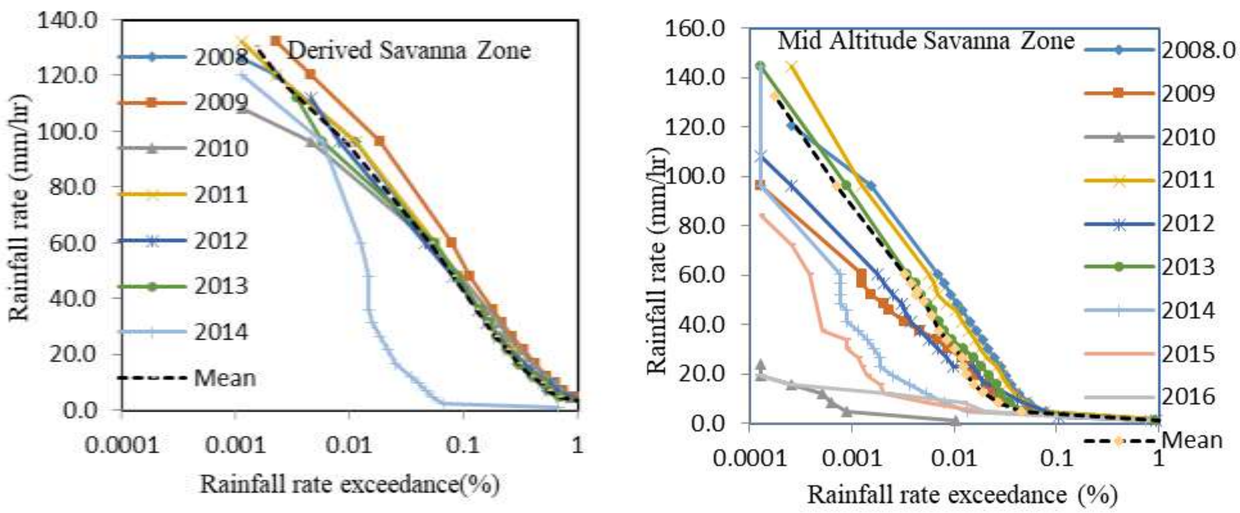
Rainfall constitutes a major impairment on the dissemination of agricultural research information through the use of millimeter wave radio technology; it impairs the effective utilization of the available huge bandwidth. There is an inverse relationship between the percentage exceedance and the rainfall rate across the agro-ecological zones. The specific attenuation threshold is 120 and 150GHz while the clear signal band frequency threshold is 40 and 45GHz. Hence for effective dissemination of agricultural research information in Nigeria during rainfall, the clear signal band frequency threshold should be used for the design of communication equipment for Nigeria inorder to forestall failures.

Table 1. Features of the study sites

Sites	Coordinates	Altitude	Average Annual rainfall (mm/yr)	Agro-ecological zone
Jos	9.93 °N, 8.89°E	1280	812.40	Mid altitude savanna
Minna	9.61 °N, 6.56 °E	223	910.08	Southern Guinea Savanna
Yola	9.23 °N, 12.46 °E	260	532.30	Southern Guinea Savanna
Nsukka	6.86 °N, 7.40 °E	259	1442.68	Derived Savanna
Anyigba	7.63 °N, 7.29 °E	420	476.85	Derived Savanna
Eburumiri	6.61 °N, 7.35 °E	359	1295.63	Derived Savanna
Makurdi	7.73 °N, 8.54 °E	140	734.38	Derived Savanna
Mowe	6.90°N, 3.58°E	116	685.90	Derived Savanna
Ogbomosho	8.11°N, 3.41°E	306	498.50	Southern Guinea Savanna
Iwo	7.63°N, 4.19°E	224	854.50	Derived Savanna
Bauchi	10.63°N, 10.08°E	600	1030.60	Northern Guinea Savanna
Akure	6.89°N, 4.89°E	194	1567.70	Humid forest
PortHarcourt	4.75 °N, 7.00 °E	468	1684.13	Humid forest
Minjibiri	11.75°N, 8.66°E	477	501.60	Sudan Savanna

Table 2. Specific attenuation values at 120 GHz and 150 GHz

Location	Freq (GHz)	ITU-R		Estimate	
		Horiz. (dBkm^{1})	Vertical (dBkm^{-1})	Horiz. (dBkm^{-1})	Vertical (dBkm^{-1})
Nsukka	120	27.70	27.41	29.78	29.46
Eburumiri	120	29.48	27.19	29.59	29.26
Iwo (Osun)	120	22.95	21.81	21.81	21.06
Ogbomosho	150	24.27	24.10	20.54	20.41
Mowe	150	17.36	17.26	23.13	22.97
Akure	150	23.25	23.09	35.63	35.32
Port Harcourt	120	33.52	33.14	29.91	28.60
Yola	120	29.63	29.31	15.21	15.09
Bauchi	150	18.14	18.04	30.81	30.55
Jos	120	28.86	28.55	11.85	11.77
Minna	120	29.85	29.52	35.05	34.64
Makurdi	120	29.91	29.58	20.23	20.05
Anyigha	120	30.56	20.00	15.30	15.18
Kano	150	18.03	17.93	26.93	26.72



(a) (b)

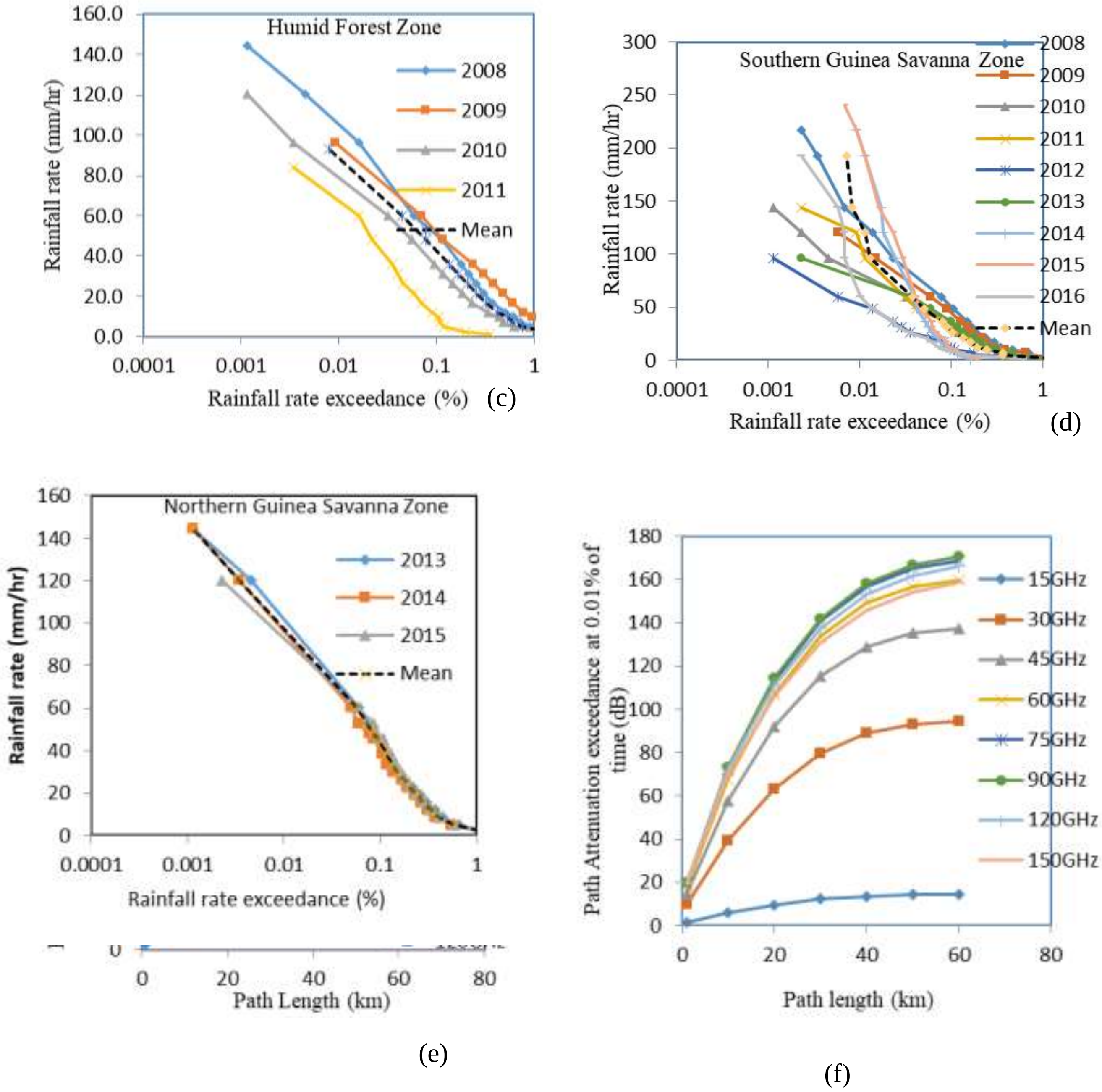


Figure 1. Annual cumulative distribution of rainfall rates (a-f)

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PERCEPTION AND INFORMATION NEEDS OF SMALLHOLDER HORTICULTURISTS ON CASHEW SEEDLINGS VALUE ADDITION: LESSONS FROM KWARA STATE, NIGERIA

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ABSTRACT

Knowledge of high-quality seedling production is a significant way to assist tree crop farmers achieve improved profitability in their enterprise. This is because quality seedlings as well as variety selection set the maximum performance level for tree crop plants. Being key players in the seedling production industry, this study examines the perception and information needs of smallholder horticulturists on cashew seedlings value addition in Kwara State, Nigeria. A two-stage sampling technique was used in selecting twenty-three horticulturists across the state. Structured interview schedule was used in collecting data which was analyzed using frequency counts, percentages, means and chi-square analysis. The results show that 73.9% of the respondents were between the ages of 41 and 50, mostly males (91.3%) and were married (95.7%). All the respondents had formal education with average years of experience in horticulture as 21.2 years. They had positive perception towards cashew seedlings value addition initiative (WMS =3.25) and high information needs on the initiative (WMS =1.86). It was recommended that tailor made advisory services should be packaged by extension organizations and other stakeholders for horticulturists in the areas of information needs indicated so as to enhance their use of the initiatives in seedling production. Also, youths should be educated to appreciate horticulture enterprise as a viable job option.

Key words: cashew, seedlings, plant nurseries, orchards, value addition

INTRODUCTION

In Nigeria, horticulturist are important service providers in tree plant seed sub-sector. The actors in the horticultural businesses are responsible for seedling inputs in tree crop production. Most nursery operations are carried out by horticulturist. Seedling production enterprise contributes to income generation and socio-economic development of a country (Eko et. al., 2021). Successful plant production is dependent on the viability of the available planting materials. Viable seedlings are achieved through good nursery management techniques and skills of the operators. Plants that are poorly managed in the nursery usually struggle to perform well once planted out in the field. In order to enhance the performance of planting materials, adding value that can improve their viability is important to maximize the potentials of the seedling sub-sector. Characteristics such as trueness to variety, survival rate, purity, vigor, and appearance are important feature attainable through value addition during seedling production. To achieve great yield potentials, farmers must use high-quality, healthy and vigorous seedlings. Seeds and seedlings are noted as the foundation of agriculture especially as it relates to crop production. Hence, for sustainable crop production, seeds and seedling production have been receiving prime attention in agricultural research and technology development. For instance, research efforts have provided technologies in improved seed varieties, use of biodegradable packs, standardized operational procedures etc. These technologies have modernized most farming's day-to-day operations.

In tree crop plant expansion, cashew is receiving special attention because of its current demand globally. In Nigeria, cashew industry is becoming a major contributor to the nation's non-oil GDP. Nigeria exported cashew nuts (both in-shell and shelled) valued at N13.71 billion in the first quarter of 2021 (National Bureau of Statistics, 2021). The industry is also a vibrant employer, providing about 600,000 jobs. Cashew farming is quite popular with a total land area of 320,00 hectares being used for the cultivation of the crop. Cashew is cultivated in more than 27 states in Nigeria and has high potential to increase production beyond any of the competitors like cocoa and palm. Despite these great potentials, cashew industry maybe unable to attain its full potential if quality planting materials are not available to the farmers. Therefore, nursery operators have vital role to play in the provision of viable and quality cashew seeds and seedlings. To meet this task, access to requisite information on proper handling of seedlings and value addition is a sure way to guarantee good planting material distribution in the subsector. In order to articulate training programmes that can improve the knowledge of actors in the nursery businesses, it is important to investigate their information needs for curriculum development. It was against this background that this present study was carried out to examine the perception and information needs of smallholder horticulturists on cashew seedlings value addition in Kwara State, Nigeria. To establish this aim, the following objectives were considered;

1. determine the socioeconomic characteristics of the smallholder horticulturists;
2. examine their perception of cashew seedlings value addition and
3. identify the information needs on cashew seedlings value addition.

MATERIALS AND METHODS

The study was carried out in Kwara State, Nigeria. Kwara State covers eight percent of the total land area of Nigeria; that is, an area of 74,256 km^2. The state has a tropical climate, with a total population of 3,192,893 (National Bureau of Statistics, 2018) and a density of 66 people km^{-2}. The state is typically agrarian. Eighty percent of the population reside in rural areas and 90% of the population are farmers (Yusuf *et al*., 2016). The climate, vegetation pattern and soil make the state suitable for cultivation of a wide variety of tree crops of which cashew takes the lead. The state has 16 Local Government Areas (LGAs). The Agricultural Development project (ADP) classified the 16 LGAs into 4 agricultural zones, 23 blocks and 184 cells in consonance with ecological characteristics and cultural practices. The population for the study comprises all horticulturist in Kwara State. A two-stage sampling technique was used to select twenty-three smallholder horticulturists across the state. The first stage involved the purposive selection of six local government area in the state based on the availability of horticultural businesses in the areas. The second stage was an aided-selection of twenty-three horticulturists in the selected LGAs. Snowballing approach was used to locate the them. This selection approach was used because there are no organized horticulture systems in the state. Structured interview schedule was used to collect data for the study. Data were summarized and presented using frequency counts, percentages, mean and standard deviations. The socioeconomic profile of the horticulturists including sex, marital status and educational attainment were measured in a nominal scale. Data on age, years of experience in nursery operations/horticultural enterprise and household size were measured on an interval scale. perception on cashew seedlings value addition was measured using five-point likert scale of 5= Strongly agreed, 4= Agreed, 3= Undecided, 2= Disagreed and 1= Strongly disagreed. The frequency values on the Likert scale were added to obtain 15 and a mean score of 3; hence variables with mean scores of 3 or above were regarded as positive perception while mean scores below 3 were considered as negative. The information needs on cashew seedlings value addition initiative was measured using four-point likert-type scale of 2= Highly needed, 1= Needed and 0=Not needed.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents

Data in Table 1 reveals that a notable proportion of the respondents (73.9%) falls between the age bracket of 41-50 years. This age group, since they are relatively young have the tendency of positively responding to innovations that could enhance their business. Majority (91.3%) of the respondents were males. Horticultural enterprise like other farming businesses is labour intensive, especially the nursery plant management routines, making men play leading roles in the horticultural industry. A major proportion (95.7%) of the respondents are married. Being married gives a sense of responsibility that makes individuals seek information to improve their business performance (Olabanji and Fabiyi, 2021). All the respondents are educated at secondary and tertiary levels. Estruk and Oren (2014) mentioned that education enables easier access to information from various sources and facilitates knowledge generation out of those sources. More than two-third (78.3%) of the respondents have 6-10 household size with an average of 7 persons. Household size has been linked to the availability of 'own' labour that could be of assistance in the developing the enterprise. Averagely, the respondents hold 21.2 years of experience in horticultural ventures and majority (78.3%) have not received extension contacts in the last 2 years. This is below the Food and Agricultural Organization (FAO) recommendation that farmers are expected to be visited at least once in every two weeks, or a minimum of 15 extension contacts in a farming season (Idrisa and Ogunbameru, 2012).

Table 1: Distribution of respondents based on socioeconomic characteristics

Socioeconomic Variables	Frequencies	Percentages	Mean
Age of Respondents			
Less than 30	01	4.4	
31-40	04	17.3	44.2 years
41-50	17	73.9	
Above 51	01	4.4	
Sex			
Male	21	91.3	
Female	02	10.0	
Marital Status			
Single	01	0.0	
Married	22	95.7	
Educational Status			
Secondary	04	17.3	
Tertiary	19	82.6	
Household Size			
1-5	05	21.7	7 persons
6-10	18	78.3	
Years of experience			
Less than 10	01	4.4	
11-20	03	13.0	
21-30	17	73.9	21.2 years
31 and above	02	8.7	
Contact with extension workers in the last 2 years			
Yes	05	21.7	
No	18	78.3	

Perception of cashew seedlings value addition initiative

Data on Table 2 shows that the respondents have positive perception towards cashew seedlings value addition initiative (WMS =3.25). Positive perception is a pointer to acceptance of an innovation and this could impact adoption positively. The Table also shows that the standard deviations were all less than 1.0 indicating that the respondents' individual scores as regards their perception on the cashew seedling value addition initiative are more closely related.

Table 2: Distribution of the respondents according to their perception of cashew seedling value addition initiative

Perception Statements	WMS	Std. Dev	Decisions
Too much investments will be required to implement the value addition initiative	2.72	0.680	Negative
Adding values to my seedlings can give me hedge over competitors	3.01	0.731	Positive
In order to sustain my income in cashew seedling production, value addition will be helpful.	4.45	0.543	Positive
Activities other than the normal routine will be stressful	3.12	0.812	Positive
Additional cost of production may not be appreciated by buyers	3.17	0.634	Positive
Asides the normal practices, I want to do other things to increase the pleasure in my work.	3.16	0.411	Positive
A lot of awareness will be needed to make customers see difference in value added seedlings and the normal one	2.85	0.833	Negative
I believe that I can increase the margins of my production through the initiative.	3.11	0.759	Positive
Adding value seedling will show unique trait that will enhance patronage from buyers	3.68	0.556	Positive
The initiative can improve cashew seedling production across board	3.21	0.785	Positive
Cumulative average	3.25	0.674	POSITIVE

Information Needs on Cashew Seedlings Value Addition

Data on Table 3 shows that the respondents require high information needs on various aspects of the initiative (WMS =1.86). Wilson (2000) perceives information seeking behaviour as the purposive seeking for information as a consequence of need to satisfy some goals.

Table 3: Distribution of the respondents according to their information needs

Information Needs	Extremely Needed	Highly Needed	Moderately Needed	Not Needed	WMS	Decision
Systemic treatments of developing seedling	5 (21.7)	9 (39.1)	07 (30.5)	2 (8.7)	1.74	Required
Improvement of seedlings material attributes (e.g., dormancy status, water relations and morphology)	10 (43.5)	7 (30.4)	5 (21.7)	1 (4.3)	2.13	Required
Improvement of seedlings performance attributes (e.g., root growth potential, hardiness to frost, and resistance to stress)	7 (30.5)	6 (26.1)	5 (21.7)	5 (21.7)	1.65	Required
Grafting of good performing seedlings	14 (60.9)	5 (21.7)	3 (13.1)	1 (4.3)	2.39	Required
Genetic traits considerations	5 (21.7)	6 (26.1)	5 (21.7)	7 (30.5)	1.39	Not Needed
Sourcing for foundation seed (registered) for seedlings production	5 (21.7)	5 (21.7)	6 (26.1)	7 (30.5)	1.35	Not Needed
Proper nutrient management	7 (30.5)	7 (30.5)	4 (17.3)	5 (21.7)	1.70	Required
Treatment of seeds before sowing	6 (26.1)	8 (34.8)	6 (26.1)	3 (13.0)	1.74	Required
Application of improved nutrient solutions	8 (34.8)	7 (30.5)	6 (26.1)	2 (8.7)	1.91	Required
Sourcing for biodegradable packs	16 (69.6)	5 (21.7)	2 (8.7)	0 (0.0)	2.61	Required
Cumulative average					1.86	Required

CONCLUSION AND RECOMMENDATIONS

The study concludes that the positive perception of the respondents on the initiative is a good pointer that adoption of improved practices is possible in the area. However, poor extension contacts with horticulturists could be a setback in meeting their information needs. It was therefore recommended that more extension service should be provided to the horticulturist, tailor made advisory services should be packaged by extension organizations and other stakeholders in the areas of information needs indicated. Also, people should be enlightened on the profitability potential of value addition on seedlings as an enterprise. This could encourage youths to go into the business thereby sustaining livelihood at the same time reducing unemployment.

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INFORMATION SOURCING BY VEGETABLE FARMERS IN OKIGWE LOCAL GOVERNMENT AREA, IMO STATE NIGERIA

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ABSTRACT

Information is key to enhanced productivity in any life endeavour. In vegetable production availability of the required information could make a difference in the outcome of the production activity. Information sourcing by vegetable farmers in Okigwe Local Government of Imo State has scarcely been documented hence this study. The research, therefore, assessed information seeking by vegetable farmers in the Local Government Area. A structured questionnaire was designed and used to elicit responses for vegetable farmers in 20 out of the 22 autonomous communities of the Local government area. Two (2) difficult to access autonomous communities were left out. Five farmers were purposely chosen from each community and the questionnaire administered to them totaling 100 questionnaires only were filled, returned and analyzed. The result shows that there are more female (54%) than male farmers (41%) of all the farmers were aged between 20 and 49 years (59%) were married and 60% had more than primary school education. The farmers grew various vegetables but telfairia (ugu) and okro topped the list and the farmers were small-holders with plots less than I hectare of land. The highest sources of information to the farmers were from colleagues (36%) and NIHORT (31%). Information sourcing was more at the beginning of the farming season (47%) and when a problem arises (42%) and they sourced information more on vegetable seed (43%) and fertilizer use (34%). Lack of funds (41%) and insecurity (39%) constituted the major constraints to the farmers. It is recommended that agricultural extension services be intensified by the government extension agents in the communities and NIHORT as a research institute should establish out- reaches to the communities.

Key words: Information sourcing, vegetable farmers, Okigwe L.G.A.

INTRODUCTION

Information is key to any productive activity as one cannot successfully act beyond the level of information at his disposal in agriculture, access to adequate information is very necessary to increase output (Mgbada, 2006). Availability of sufficient information to farmers helps them bridge the gap occasioned by their lack of knowledge in various aspects of agricultural production. Fagbola (2015) asserts that relevant knowledge can aid farmers in the high production of horticultural crops. Also, Oladele (2011) concurs that lack of agricultural knowledge and information is a key factor that has greatly limited agricultural advancement in developing countries. Oladunjoye et al. (2015) reported that improper utilization of research information in agriculture has been one of the causes of low crop yield in Sub-Saharan Africa. In Nigeria specifically, Aina, Kaniki and Ojiambo (1995) identified low utilization of research information as one of the major problems affecting agricultural transformation in Nigeria. Thus, Taiwo Oyaniran (2020) reported that lack of financing for small-scale farmers and inefficient transport system affects vegetable farmers in remote areas.

The increasing yield of vegetables is very important because of the role vegetables play in the health and wealth of humans. Vegetables are natural sources of vitamins, minerals and sometimes fats and oils Ezeibe (2011). Ugwuoke et al (2015) reported that vegetables supply essential micronutrients in human nutrition that act as preventive agents to several ailments. Vegetables are produced and consumed in large quantities, especially in Southern Nigeria. Ugwuoke et al. (2015) According to Enete and Okon (2010) vegetable production (Fluted pumpkin) has become a major occupation of many small scale producers in both rural and semi-urban communities in Abia state. An increase in vegetable production may improve food security and offer employment opportunities to the populace, especially women who form a substantial production community. (Mlozi, 2003).

The potentials of vegetable production for wealth creation has been documented by Ugwuoke et al. (2015) who reported that vegetable production offers a significant opportunity for poor women to earn a living as producers and marketers. F.A.O. (2006) also noted that there has been a rise in production of vegetables in general induced by growing public demand driven by the enhanced consumer of the dietary and health benefits of fresh vegetable consumption for instance, Hart et al. (2005) noted that in Nigeria, vegetable consumption of rage of 59-130 person/day is far below the recommended average for healthy living. It is, therefore, imperative to increase the production of vegetables in Okigwe L.G.A to create and improve the health of the inhabitants of the area. One of the ways of improving production is by sourcing information from the appropriate sources. This study investigates the sourcing of information by vegetable farmers in the Okigwe Local Government Area of Imo State, Nigeria.

MATERIALS AND METHODS

The study was carried out in the Okigwe Local Government Area of Imo state. Okigwe lies between latitudes 5^0 30' North to 5^0 57' North and longitudes 7^0 40'E to 7^0 5S' East with and has a population of 132,237. The Local government area consists of twenty-two autonomous communities. With the assistance of the ADP agents in those autonomous communities, 5 questionnaires were purposively distributed to prominent vegetable farmers is identified by the agent. Questionnaires were not distributed to two far-thing autonomous communities because of their accessibility. Thus a total of 100 questionnaires were distributed and the return rate was 95 percent as five of the questionnaires were not returned. The structured questionnaire sought information on the demographic characteristics of the respondents, types of vegetables grown, farm size, where they source information, when information is sourced, types of information sourced etc. The results were analyzed and presented in frequency counts and percentages.

RESULTS AND DISCUSSION

A total of 100 research questionnaires were distributed and 95 were filled and returned giving a percentage of 95%. The Socio-economic characteristics of Respondents are presented in tables 1,2,3 below.

The result shows that there were more female (approximately 57%) vegetable farmers than male ones (approximately 43%). This is understandable because vegetable crops are regarded as belonging to women while such crops like yam are the preserves of men.

Table 1: Gender of respondents

Gender	Frequency	Percentage of respondent
M	41	43.16
F	54	56.84
	95	100.00

Table 2 shows that majority of the vegetable farmers in the L.G.A fall between 20-59 years of age. This age range could be considered energetic and productive. However, further analysis shows that some (approximately 16%) of the respondents face between the age brasher of 20-25 years of age. This age is when some young people, through full of energy but are lethargic to physical agricultural production preferring to migrate to cities to look for white-collar (jobs or any jobs at all).

Table 2: Ages of Respondents

Age Range	No Respondents	Percentage of Respondent
20-29	15	15.79
30-39	19	20.00
40-49	34	35.79
50-59	21	22.11
60 <	6	6.32
		100

The result presented in Table 3 shows that almost 59% of the respondents are married, another 24.21% widowed, while 7.37% are divorced and about 10% (9) are still single. This implies that vegetable production is not discriminatory to marital status. And this could be as a result that it offers the producers returns that encourage all to participate. However, the distribution of respondents shows that married people contributed almost two-thirds (58.95%) of the respondents followed by widows and widowers, (about a quarter of the respondents while the singles and divorced make up the rest.

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Table 3: Marital Status of Respondents

Marital Status	No of Respondents	Percentage of Respondents
Married	56	58.95
Widowed	23	24.21
Divorced	7	7.37
Single	9	9.47
	95	100

Source: Field Survey, 2021.

Table 4 describes the distribution of the educational qualification of the respondents. The result shows that 38(40%) of the respondents had only the First School Leaving Certificate. Another 26.32% had the Secondary School Certificate. A combined percentage of 28.42% of N.D/ NCE, HND and B.Sc was found to be growing vegetables in Okigwe L.G.A. It was also revealed that about 5% of the respondents had no formal education.

The result shows that since some of the respondents had no formal education (45%) have low education, information seeking by them may be deterred. However, as the result indicates that more than half of the respondents are literate, they would seek or source information that will improve their vegetable production techniques. This may also diffuse into the communities. In all, the correspondents are both youthful and educated and most likely seek for information to assist them in their endeavours.

Table 4: Educational Qualification of Respondents

Educational Qualification	Number of Respondents	Percentage of Respondents
FSLC	38	40.00
WAEC/GCE	25	26.32
National Diploma/ Nigeria Certificate of Education	14	14.74
HND/BSC	13	13.68
None of the above	95	5.26
Total	95	100

Source: Field Survey, 2021

Table 5 shows that most respondents grew more than one vegetable but the more common vegetables grown were okra by almost two-thirds of the respondents and Ugu, by more than two-thirds of the respondents and a combination of other vegetables by others. It is obvious from the results that a respondent grows both okra, ugu, Amaranthus, pepper and melon, though it should be noted that these two vegetables (Okra and ugu) are compliments. This result agrees with Enete and Okon (2010) who confirmed that fluted pumpkin (ugu) has become a major occupation of many small scale producers in both rural and semi-urban communities in Abia State.

Table 5: Types of vegetables grown by Respondents

Types of vegetable Grown	No. of Respondents	% of Respondents
Okra	56	58.90
Fluted pumpkin (ugu)	60	63.16
Pepper	21	22.11
Tomatoes	20	21.05
Melon	25	26.32
Green (Amaranthus)	22	23.16
Garden Egg	15	15.79
Other Vegetables	4	4.21
Total	223*	224.60*

*There were multiple responses. Source: Field Survey, 2021.

The study showed that farm size among the respondent ranged from small plots of 1-5 plots of land (35.79) to bigger farmers who owned 1-acre farms (27.37%) and farmers who owned about a hectare of the vegetable farm (27.37). Respondents in this survey fall into the small-holders, category with the characteristic of small farm size (Table 6).

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Table 6: Farm size of the respondent

Farm size	No. of Respondents	% of Respondents
1 hectare	35	36.84
1 acre	24	25.26
1-5 plots of land	34	35.79
6 – 10 plots of land	2	2.11
Total	95	100

Source: Field Survey, 2021.

Table 7 shows the sources of information by respondents. As expected, there were multiple responses as vegetable producers in the Okigwe Local Government Area sourced their information from more than one source. NIHORT was the highest (30.53%) Institutional source of information. Another institutional source of information was from the ADP (15.79) is (through the agents in the community) and 12.63% sought their information from the farmers' co-operative society. The university as a source of information was the least used by the respondent; this could be as a result of no University around Okigwe where they could go. The Abia State University in nearby Uturu has its Agriculture Faculty in Umuahia, which entails a cost to travel to. Workshops and Seminars was another source of information for the vegetable farmers in Okigwe L.G.A. as about 15% of respondents said they get their information from that source. Social Media (4.21%) and Radio/TV Programmes (8.42%) also contribute as sources of information to the surveyed vegetable farmers.

However, the highest source of information for the vegetable farmers in Okigwe L.G.A. area of Imo State is from personal contact with their colleagues. This practice is forth with possible misinformation as (35.79%) they can only give as much as they have. The remedy to this is to ensure that adequate and correct information is made available to the farmers.

Table 7: Where Respondent seek information from

From where do Respondents Seek Information	No. of Respondents	% of Respondents
Agricultural Development Programme (ADP)	15	15.79
University	2	2.11
NIHORT	29	30.53
Farmers Co-operative Society	12	12.63
Workshops/Seminars	14	14.74
Personal Contracts with Colleagues	34	35.79
Social Media (Agric. Platform)	4	4.21
Radio/TV Programme	8	8.42
Total	**118***	**124.24***

*There were multiple responses. Source: Field Survey, 2021.

Time of Seeking Information

The time of seeking information by the respondents is presented in Table 8. The farmers (47.36) seek information most at the beginning of the farming season while another good proportion (42.10%) are reactionary and therefore firefights, only seeking information when a problem exists. A percentage of respondents (10.53%) just seek information perfunctorily.

Since the need to gather information is to help improve production, farmers should be encouraged to being to source information easily as this source would prepare them better for the farming season.

Table 8: When respondents seek information

When do you seek Information	No. of Respondents	Percentage
Before the beginning of the farming season	45	47.36
In the middle of the farming season	10	10.53
When there is a problem at the farm	40	42.10
Total	95	400

Source: Field Survey, 2021.

Table 9 reveals that a high percentage of the farmers (43.17%) seek information on vegetable seed, another 34.34% of the respondents seek information on fertilizer, including types, sources, application, and price. Vegetable growers in the area offer to have become accustomed to the varieties they have as less than one-fifth (16.67%) seek information on vegetable varieties. However, the result of the survey shows that the agronomy of the vegetables and marketing them are the least areas where the respondents seek information. This suggests that any information being passed to the farmers should major on seeds, availability, costs, and general information on vegetable seeds. Another information the farmers may consider important would be fertilizer.

Table 9: Type of information sought by vegetable farmers

Type of Information Sought Respondents	Number of Respondents	Percentage
Information Vegetable varieties	17	16.67
Information of vegetable seeds	44	43.14
Information on fertilizer use	35	34.34
Information Marketing	3	3.16
Information on Agronomy	3	3.16
Total	**102***	**100**

*Multiple Responses. Source: Field Survey, 2021.

Constraints to information seeking by the Okigwe Vegetable Farmers

The result shown in Table 10 indicates that vegetable growers in Okigwe L.G.A of Imo State encounter various challenges in sourcing information. The greatest constraint faced by the vegetable growers is lack of adequate finance, this could be to travel to sources of information. Another constraint faced by the vegetable grows is security. Security of lives in some parts of the country has been a challenge and farmers out of fear do not move around these days as much as in the past few years.

Vegetable farmers in the L.G.A. also are challenged by accessibility to sources of information perhaps as a result of poor roads. Improved infrastructure and government taking the required information closer to the farmers would be great assistance to them. Least of the challenges faced by the vegetable producer's non-existent power supply particularly for those who source information from the radio and television sets.

Table 10: Challenges (Constraints) to information seeking by Respondents.

Challenges (Constraint)	No. of Respondents	Percentage
Inadequate fund	39	41.01
Insecurity	37	39.00
Accessibility to sources of information	12	12.63
Power Supply	7	7.36
Total	95	100.00

Source: Field Survey, 2021.

SUMMARY

This study investigates information-sourcing among vegetable growers in Okigwe Local Government Area of Imo State of Nigeria.

The demographic characteristics of the farmers were captured by the research instrument. The result shows that the vegetable growers are more of females (54%), aged between 20 and 59 years of age, more of married people (59%).However, about a quarter of the respondents are widowed and less than 20% are either divorced or single. Most of the vegetable producers are educated to varying levels. The table shows that 40% but are only Primary School Leavers, 26% are Secondary School Leavers, about 15% are with the National Diploma or NCE. It is interesting to note that about 14% of the respondents are graduates, driven to vegetable production perhaps by joblessness.

The results also showed that the respondents grew an assortment of vegetables but Telfairia (Ugu) and okra, are the two major ones grown by the respondents. The farmers are mainly small-holders, with farm size ranging from few plots of land to 1 hectare of land as the largest farm size. The vegetable growers in Okigwe L.G.A. as seen from the results sourced their information through personal contact with Colleagues, from NIHORT Sub-station in the L.G.A, A.D.P, and Workshops in that order. The result shows that close to 50% of the surveyed vegetable farmers begin seeking the information at the beginning of the farming season. Another 42% start seeking information when there is a problem at the farm. The major information they seek is on vegetable seeds and fertilizer use, though some (about 17%) vegetable growers also seek information regarding better yielding vegetable varieties. The major constraints faced by the farmers are inadequate funds, insecurity in sourcing information. Accessibility to sources of information and power supply are also constraints but to a lesser degree.

CONCLUSION

Adequate information of the right time is crucial to improving the productivity of vegetable growers.

The availability of the right information at the right time. This study has shown that the vegetable growers source information more from their co-producers, and the closest research institute (NIHORT). The study also revealed that they start seeking information both at the beginning of the season and when a problem arises. However, they are constrained by a lack of funds to source the desired information and the information sought by these producers is more on vegetable seeds and varieties.

RECOMMENDATIONS

Based on the results of the study, the researcher makes the following recommendations

(1) In view of the challenges to accessing the desired information on seeds, the research institute should establish closer links with the vegetable growers in the different communities.

(2) The government should make extension services with the right information, should be made more available to the vegetable growers in the Okigwe Local Government.

(3) Agricultural loan facilities should also be made available to these small scale vegetable farmers.

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COFFEE FARMERS' INFORMATION SOURCES ON COFFEE PRODUCTION TECHNOLOGIES UTILIZATION IN KOGI STATE

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ABSTRACT

Coffee is an important cash crop and has contributed greatly to gross domestic product of Nigeria economy. The study was conducted to assess the information sources to coffee farmers on coffee production technologies utilization in Kogi State. More specifically, it examined the socioeconomic characteristics of the farmers, identified various sources of information by coffee farmers on coffee production technologies utilization and determine levels of coffee production technologies utilization among coffee farmers. A set of pre- tested questionnaire was used to gather information from 100 farmers that were selected through multistage sampling procedure from two local governments where coffee was grown in commercial basis. The result revealed that most (90%) male dominated coffee farming, 74% were literate and mean age of farmers was 41.4 years. The major sources of information on coffee production technologies utilization was from input dealers (68%). very few farmers (26%) had contact with extension agent. The result also revealed overall categorization of farmers into level of utilization of coffee production technologies with majority (61%) indicating low level of utilization. There was significant relationship between age (X^2 =8.61, p=0.01), sex (X^2 =14.19, p=0.00), and extension contact (X^2 = 14.19, p = 0.00) and coffee production technologies utilization. It was concluded that extension agent should improve on their contact with farmers which will lead them to get information form the right source

Key words: Cocoa farmers, Information, production technologies, utilization

INTRODUCTION

Coffee is one of the important commercial plantation crops grown in Nigeria which is ranked second in value only to oil as a source of foreign exchange in many of the major producing countries, Nigeria inclusive (Opeke, 2005). The two most important species of cultivated coffees in Nigeria are Arabica coffee (highland coffee) and Robusta coffee, lowland coffee (Agbongiarhuoyi et al., 2006). Over 80% of coffee from developing countries particularly Nigeria, is produced by small scale farmers who lack adequate technical education and are faced with low market prices leading to poor management, poor productivity and abandon farms. In about 50 countries of the world, almost 25million farmers depend on coffee as a mean of survival (Cague et al., 2009). Coffee channel of production and marketing provide employment for millions of people throughout the world. Despite the facts that coffee production can boost the country's revenue, coffee production is fast declining because farmers are no longer interested in its production in Nigeria (Ayoola et al., 2012). On that basis, Cocoa Research Institute of Nigeria (CRIN) with research mandate on cocoa, kola, coffee, cashew, and tea has recommended some coffee production technologies that can help coffee farmers to boost their production if adhere strictly to it. Some of these recommended coffee production technologies are; site selection/land preparation, use of improved coffee varieties, shade management, planting period and spacing (3m x3m), control of pest/insect and pathogens, regular weeding, coffee rehabilitation, gapping up of missing/death stands, regular pruning, appropriate fertilizer application and timely harvesting/processing (CRIN, 2018). Uwagboe et al. (2006) as quoted by Adeogun et al. (2010) stated that the best way to pass information on new technologies and innovations to a larger proportion of farmers is through personal contacts such as visits from extension agents. According to Israel and Wilson (2006) and Oto and Shimayohol (2011), developing an understanding of extension sources and channels used by clients to obtain information is a pre-requisite for efficient educational programming because messages that go unheard or unseen cannot lead to change. The awareness and utilization of these coffee production technologies will not only increase farmers' income but also improve their standard of living. Hence, this study assessed the information sources to coffee farmers on coffee production technologies utilization

The specific objectives are to:

(1) Determine the socioeconomic characteristics of the respondents

(2) Investigate the sources of information on coffee production technologies utilization

(1) Examine the level of utilization of coffee production technologies

Hypothesis of the study.

There is no significant relationship between socioeconomic characteristics of the respondents and sources of information on coffee production technologies

MATERIALS AND METHODS

A multistage sampling procedure was used to select farmers for the study. The first stage involves the selection of Kogi State because it is the highest producer of coffee Robusta in Nigeria. The second stage involves random selection of two (2) Local Government Areas which are Kabba-Bunu and Ijumu as a result of their prominence in coffee production. Two (2) villages were purposively selected from each local government due to coffee production activities in large quantity making a total of four (4) villages. Twenty-five (25) farmers were randomly selected in each village to make a total of sample size of one hundred (100) respondents. Data for the study was collected through the use of well-structured questionnaire and interview schedule. Descriptive statistics such as frequency counts, percentages and means were used to analyze the objectives while the hypothesis was tested with chi-square

RESULTS AND DISCUSION

Socioeconomic characteristics

The socioeconomic characteristics of respondents are shown in table 1. The result shows greater percentage (90%) of the respondents were male while only 10% were female. It means that more males were into coffee farming in the study areas. It shows that coffee farming is very tedious activity that can be carried out by male. This is in agreement with Oladipupo et al. (2010) that farm work is mostly being carried out by men because they have strength to withstand the rigours of farming activities. The result also shows that 85% of the respondents were married with mean ages of 41.4 years. The implication of this is that coffee farmers in the study area are still in their productive and energetic age. The mean household size for the farmers was 7.8 persons. Household size provides cheap labour for agricultural purposes. The table also revealed that farmers' extension contact was very low with majority (74%) not having contact while only 26% had contact. This result is in tandem with Famuyiwa et al. (2014) that 84.3% of farmers had no extension contact. When farmers have regular contact with extension agent, then there will be information flow. Farmers will present their production problems to extension agents likewise extension agents bring information on new technologies to farmers. when there is a gap between extension agent and farmers, there will be lack of information and consequently affecting adoption of new technologies by farmers

Table 1: Distribution of respondents by socioeconomic characteristics

Variables	Frequency	Percentage	Mean
AGE			
<30	16	16	
31-40	17	17	41.4 years
41-50	30	30	
51-60	25	25	
Above 61	12	12	
SEX			
Male	90	90	
Female	10	10	
MARITAL STATUS			
Single	10	10	
Married	85	85	
Divorced	3	3	
Widowed	2	2	
RELIGION			
Christianity	51	51	
Islam	45	45	
Traditional worship	4	4	

HOUSEHOLD SIZE			
1-5	33	33	
6-10	45	45	7.8 persons
11-15	16	16	
16-20	6	6	
Extension Contact			
Yes	26	26	
No	74	74	
Total	100	100	

Sources: Field Survey 2021.

Table 2 shows level of education of the respondents that 26% of respondents had no formal education while 29% of the respondents had primary education, 30% are school certificate holders, and 15% attended tertiary institutions. It shows that 74% of the respondents can read and write. There is high level of literacy among farmers in the study areas this will to greater extent influenced them positively in adopting new technologies.

Table 2: Distribution of the respondents based on level of education

Farmers educational status	Frequency	Percentage
No formal education	26	26
Primary education	29	29
Secondary education	30	30
Tertiary education	15	15
Total	100	100

Source: Field Survey; 2021.

Tables 3 shows that majority (68%) get information from input dealers, 15% get information from coffee farmers' association of Nigeria, 19% get information from extension agents while only 20% get information from research institutes. information, according to oxford dictionary is facts provided or learned about something or someone. It shows that farmers did not get information from the right sources. This will affect their utilization of coffee production technologies. This result is in agreement with the findings of Adeogun et al. (2010) that majority of farmers obtained information on rehabilitation technique through radio which is not the best source to obtain such information. Information on coffee production technologies is best gotten from research institute (CRIN) because it involves training of farmers on the best way to practice it.

The results in table 4a show mean rank order of farmers' utilization of coffee production technologies with regular pruning(mean=2.64) ranked 1^{st}. It follows by gapping up of missing/death stands (mean= 2.63), shade management (mean = 2.43), planting distance (mean =2.29), with ranked 2^{nd} ,3^{rd}, and 4^{th} order of utilization. Other coffee production technologies utilized by farmers are timely harvest/processing (mean =2.16) which ranked 5^{th}, use of improved coffee varieties (mean =2.14) which ranked 6^{th} it follows by control of pest insect and pathogens (mean =2.06), site selection (mean =2.03), appropriate fertilizer application (mean =2.01) and coffee wet processing method (mean =1.06) ranked 7^{th}, 8^{th}, 9^{th} and 10^{th} order of utilization.

Table 3: Distribution of respondents by sources of information on coffee production technologies

Farmers sources of information	Frequencies	Percentages
1 Extension Agent/ADP	19	19
2 Input dealers	68	68
3 Coffee farmers' association	15	15
4 Other association	11	11
5 Radio and Television	6	6
6 Research institutes(CRIN)	20	20
7 Newspapers	5	5
8 Friends and neighbor	8	8

Multiple responses. Source: Field Survey 2021.

Table 4a: Mean rank order of farmers' utilization of coffee production technologies

Coffee production technologies	Mean	Rank
Site selection	2.03	8th
Use of improved coffee varieties	2.14	6th
Shade management	2.43	3rd
Planting distance(3x3)	2.29	4th
Control of pest insect and pathogens	2.06	7th
Gapping up of missing/death stands	2.63	2nd
Regular pruning	2.64	1st
Appropriate fertilizer application	2.01	9th
Timely harvest/processing	2.16	5th
Coffee wet processing method	1.06	10th

Source: Field Survey 2021.

Farmers level of utilization of coffee production technologies was categorized into low and high (Table 4b). This was determined as the mean level of utilization scores were computed and used as the benchmark, such that respondents whose scores are below the mean level of utilization scores were categorized as low utilization, while scores equal to or greater than the mean score were categorized as having high utilization. The result shows that majority (61%) of the respondents had low utilization of coffee production technologies while only 39% had utilization of coffee production technologies. The low utilization of coffee production technologies could be as a result of not getting information from the right sources

Table 4b: Level of utilization of coffee production technologies

Interpretation	Frequency	Percentage
Low	61	61
High	49	39
Total	100	100

Source: Field Survey 2021.

Hypothesis testing

Chi-square result of the relationship between respondents selected socioeconomic characteristics and information sources to coffee production technologies as revealed in table 5. It shows a significant relationship occurred between age (X^2 = 8.61; P< 0.01), Sex (X^2= 10.19; P< 0.00), and extension contact (X^2=14.19; P=0.00) and information sources to coffee production technologies. It implies that age directly influences

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information sources to coffee production technologies. The younger farmers are still very energetic and can go a long way in searching for information that will improve their production. On significant relationship between sex and information sources, women are constrained to stay at home to take care of the family whereas his male counterparts enjoy more freedom to get information anywhere that will improve their coffee production. Also, on significant relationship between extension contact and information sources, the more contact of extension agent with the farmers the more they may likely get information on coffee production technologies and vise vasa. From the findings, extension contact with farmers was low which resulted to low utilization of coffee production technologies.

Table 5: Chi square showing test of significant relationship between some selected socioeconomic characteristics and sources of information on coffee production technologies utilization

Socioeconomic characteristics	X^2	Df	P-value	Decision
Age	8.61	2	0.01	S
Marital status	2.99	2	0.23	N S
Religion	5.30	3	0.15	N S
Sex	10.19	1	0.00	S
Extension contact	14.19	3	0.00	S
Household size	3.88	3	0.28	N S

Source: Field Survey 2021.

CONCLUSION AND RECOMMENDATION

The study revealed that most coffee farmers are male and are still very active in farming business. It also revealed that most of them are literate i e they can read and write. There was low extension contact with farmers as the study revealed that most coffee farmers were not visited by extension agent. The major sources of information on coffee production technologies was through input dealers. There was low utilization of coffee production technologies, this may be as result of not getting information from the source. There was significant relationship a between age, sex, extension contact and coffee production technologies utilization. Extension agent should increase their visit to coffee farmers so that they can get information from the right source this will increase the utilization of this technologies among coffee farmers

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COLLABORATIVE RESEARCH OUTPUTS ON ORNAMENTAL PLANTS IN HORTSON PROCEEDINGS: 2009-2020

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ABSTRACT

Ornamental plants have the ability to enhance the entire ambience and improve the topography of a place. Although they are grown basically for decorative and aesthetic purposes, they also have nutritive and medicinal properties. The proceedings of Horticultural Society of Nigeria (HORTSON) of the years 2009-2020 was selected as the source of citation data for this study. Articles on ornamental plants published were analysed. Data collected from the articles included: types of ornamental plants researched, number of citations, number of author(s), authors' affiliation, and pattern of authorship. Descriptive statistics were used to analyse the data. The result of the study revealed high degree of collaboration among horticultural scientists in the research institutes, Universities and colleges of agriculture. The authorship pattern shows majority of joint authorship. Contributions from various research Institutes in Nigeria was the highest (59.7%) followed by authors from Universities (21.3%). National Horticultural Research Institute had the highest contributions (96.8%) among other research institutes. While Federal University of Agriculture, had the highest contributions among other universities (66.6%).

Key words: Ornamental; Collaboration; Citations; Authorship; Nigeria

INTRODUCTION

Collaboration is working together as a team to achieve a purpose. "Authorship is one aspect that plays a great role in information dissemination and communication. Authors' contribution to the field of knowledge could be viewed from different patterns, such as single authorship, joint authorship and multiple authorship'' (Aliyu, 2011). The authorship pattern analysis elucidates the work of Scientists contribution to the number of papers at a certain time. (Sankar and Srinivasa ,2012). Singh and Singh (2018) investigated the trends in authorship pattern and author collaborative in the Biotechnology research field. Their study revealed that the researchers in Biotechnology move towards team research or group research rather than solo research. Viswanathan and Tamizhchelvan (2016) examined authorship productivity and collaborative nature on spacecrafts research outputs during the period 2000 and 2014.The result of their study revealed that most of the researchers in this field preferred a collaborated work. There has not been any bibliometric documentation on ornamental horticulture in Nigeria.This study aims to find out the trend of research collaboration in the field of ornamental horticulture.

MATERIALS AND METHODS

The Proceedings of Horticultural Society of Nigeria (HORTSON) of the years 2009-2020 was selected as the source of citation data for this study. Articles on ornamental plants published were analysed. Data collected from the articles included: types of ornamental plants research, number of citations, number of author(s), authors' affiliation, and pattern of authorship. Descriptive statistics were used to analyse the data.

RESULTS AND DISCUSSION

A total number of forty-four (44) papers were published in the HORTSON Proceedings on ornamental plants/landscape between 2009 to 2020. No HORTSON Proceedings was published in 2013. There was no research article on ornamental plants/landscape in the HORTSON Proceedinsg of 2010. Year 2019 had the highest number of publications on ornamental plants/landscape (Table 1). Papers with three authors had the highest number of publications (Table 2). Table 3 shows authors with frequency count of five or more on Ornamental/Landscapes. Table 4 indicates that National Horticultural Research Institute (NIHORT) contributed the highest number of authors 122 (96.8 %) among the research institutes from 2009-2020. Federal University of Agriculture Abeokuta contributed the highest number of authors 30 (66.6 %) among the universities in Nigeria (Table 5, 6). The following ornamental plants were identified in HORTSON proceedings in years 2009-2020: *Heliconia* (cv. 'Golden Torch') Flowers, *Begonia semperflorens,* Sunflower *(Helianthus anuus* L.), *Callitris mantis* (cypress-pine), *Senna fistula* (Golden shower), Flamingo flower (*Anturrium andraenum* L.), Marigold (*Tagetes spp*), Purple rose periwinkle (*Catharantus roseus* L.), Heliconia (cv. "golden torch") and Duranta (*Duranta erecta*)

Table 1: Number of papers per year on Ornamental/Landscapes

S/No	No. authors (unit)	No. of articles
1	Single	2
2	Two	4
3	Three	11
4	Four	8
5	Five	7
6	Six	7
7	Seven	2
8	Eight	1
9	Ten	1
10	Twelve	1
Total		44

Table 2: Pattern of authorship in Ornamental/Landscape Research

Year	Total no of papers
2009	Seven
2010	None
2011	Three
2012	Two
2014	Five
2015	Three
2016	Two
2017	Nine
2018	Six
2019	Nine
2020	1
Total	44

Table 3: HORTSON proceedings authors with frequency count of five or more on Ornamental/Landscapes (2009-2020)

S/N	Author	frequency count
1	Akintoye, H. A	15
2	Shokalu, A.O.	14
3	Adebayo, A. G.	12
4	Olatunji, M. T.,	12
5	Aina,O.O.	7
6.	James.I.E.	6
7.	Fade-Aluko	6
8.	Okoyo,M.E	5
9	Igberaese,P.O.	5
10	Olosunde, O.M.	5

Table 4: Research contribution on Ornamental/Landscapes by research institutes in HORTSON proceedings from 2009 to 2020*

S/N	AUTHORS'AFFLIATION RESEARCH INSTITUTES	2009	2010	2011	2012	2014	2015	2016	2017	2018	2019	2020	Total
1	National Horticultural Research Institute /SW	11	-	8	-	3	1	1	36	36	21	5	122
2	Forestry Research Institute of Nigeria	1	-	-	-	-	-	-	-	-	-	-	1
3	Institute of Agricultural,Research and Training,Moor Planation,Ibadan	-	-	-	-	-	-	-	3	-	-	-	3
	Total	12	-	8	-	3	1	1	39	36	21	5	126

*The proceeding of 2013 was not published.

Table 5: Research contribution on Ornamental/Landscapes by Universities in HORTSON proceedings from 2009-2020

AUTHORS'AFFLIATION UNIVERSITIES	2009	2010	2011	2012	2014	2015	2016	2017	2018	2019	2020	Total
University of Port-Harcourt, Port Harcourt	-	-		-						2	-	2
Ignatius Ajuru University of Education, Port Harcourt		-		-						1	-	
Federal University of Agriculture, Abeokuta	4	-	4	-	13	-	-	2		7	-	30
Adekunle Ajasin University, Akungba Akoko,Ondo State	-	-	-	-	-	-	-	-	-	1	-	1
University of Benin, Benin City	-	-	-	-	-	-	-	-	-	1	-	1
Federal University Dutse-Jiga State	-									3	-	3
Nasarawa State University, Shabu-Lafia, Nigeria	-								1	-	-	1
Fountain University,Osogbo	2	-	-	-	-	-	-	-	-	-	-	2
Federal University of Technology,Minna	-	-	-	-	-	-	-	-	-	3	-	3
Babcock University,Ogun State.										1	-	1
Total	6	-	4	-	13	-	-	2	1	19		45

Table 6: Research contribution on Ornamental/Landscapes by Polytechnics, College of Forestry, Colleges of Agriculture & Colleges of Education from 2009-2020

AUTHORS'AFFLIATION COLLEGE OF FORESTRY, COLLEGES OF AGRICULTURE & COLLEGES OF EDUCATION	2009	2010	2011	2012	2014	2015	2016	2017	2018	2019	2020	Total
Federal college of Agriculture, Akure								6		3	-	9
College of Agriculture, Lafia, Nasarawa State									2	-	-	2
Federal college of forestry,Ibadan	4	-	-	2	-	-	-	-	-	-	-	6
Federal college of forestry mechainzation,Kaduna.				3		6	4			3		16
Federal college of Agriculture, Moor plantation ,Ibadan								2		1		3
Federal college of Agriculture,Ishiagu								3				3
Safe Environmental watch and Health Awareness Initiative,Keffi-Nasarawa State										1		1
Total	4	-	-	5	-	6	4	11	2	8		40

CONCLUSION

The study revealed collaboration of authors from research institutes, universities and colleges of agriculture working together on ornamental plants. The highest numbers of research articles were published in 2019.The scientists in the field of ornamental horticulture need to work more on other ornamental plants and also collaborate with foreign authors.

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INVOLVEMENT IN SHARP PRACTICES AMONG RESEARCH PERSONNEL IN AGRICULTURAL RESEARCH INSTITUTES OF SOUTH WESTERN NIGERIA

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ABSTRACT

Agricultural research is saddled with the responsibility of addressing the monumental challenges of agriculture to ensure that its diverse benefits translate into increased productivity and improvement in the living conditions of stakeholders. Greater efficiency, transparency and accountability in research is required as sharp practices do not only tarnish the credibility and integrity of the researcher and research institution, they affect the multitude of the citizens as food and health policies for the citizenry are based on evidence of agricultural research. The study was undertaken to assess the involvement in sharp practices of research personnel in agricultural research institutes in south western Nigeria. Both quantitative in form of questionnaire and historical were used for data collection. Multistage sampling procedure was used to select a sample of 30 respondents in the study area. The result of the findings was analysed using descriptive statistics such as frequency and percentages. The study revealed that 48.0 % of the respondents were between the age of 30 and 39, 64.0% were male and majority (92.0%) were married. The result further revealed that 40.0% of respondents were in the senior research cadre and majority (84.0%) were aware of fabrication of data as a sharp practice. Only 12.0% were involved in extrapolation of data. Ethical standards should be vigorously adhered to in order to limit sharp practices among research personnel.

Key words: Research misconduct, Horticulture, Agricultural Policy, Nigeria

INTRODUCTION

Agriculture apart from being the catalyst for economic growth provides food, clothing, employment, tourism for the over 160 million people in Nigeria and significantly contributes to the alleviation of poverty and promotes international competitiveness (Food and Agriculture Organization, 2012). Agriculture remains the economic base for Nigeria as it significantly contributes to poverty reduction and sustainable development; provides 35.1%in 2019 (World Bank Report, 2020) percent of employment and is a major determinant of aggregate economic growth, accounting for 42 percent of GDP growth (NBS, 2006). Despite the country's huge dependence on the oil and gas sector agriculture is its mainstay offering important investment opportunities at all levels of economic and sustainable rural and national development (Aminu and Anono, 2012). In Nigeria as well as other developing countries, most agricultural production comes from small-scale farms and low-income farmers. These farmers reside in rural areas, where they depend directly or indirectly on agriculture for their livelihood (FAO, 2012). The food security and nutritional status of Nigerian households therefore depend on agricultural production.

Agricultural research for development

Agricultural Research for Development (ARD) is a multi-dimension's research that addresses the agricultural development challenges of developing and emerging countries (SFIAR Award 2021 - Guidelines). The agricultural domain includes crop production and animal husbandry, agro-forestry, fisheries and aquaculture, agribusiness and related enterprises, animal and human health related issues, as well as the sustainable management of the natural sources on which farming depends and the socio-cultural and bio-diverse landscapes, food systems and ecologies in which it is embedded (SFIAR Award 2021 - Guidelines). Research which is the process of arriving at dependable solutions to problems through a planned and systematic collection, analysis and interpretation of data is the bedrock of policy formulation (Amzat and Ogundiya, 2010). Research is the most important tool for advancing knowledge, for promoting progress and enabling man to relate more effectively to his environment, to accomplish his purpose and to solve his conflicts (Okoro, 2013).

ARD provides technological, economic and institutional knowledge and innovations contributing to sustainable development by solving the food and nutrition challenges confronting the human society. The thrust of agricultural research therefore is in solving problems of poverty, hunger, food and nutrition security by improving productivity and income; minimizing the effects of pests- weeds, insects, pathogens, nematodes on crops and livestock and the prevention and correction of adverse environmental effect. A policy which is a plan of action adopted by a Government in order to influence the trend of events in order to achieve a set of objectives () is usually based on theoretical and empirical evidence from research. The evidence from research are crucial in evaluating, modifying or changing policies in order to address the established problems.

National Agricultural Research Systems (NARS)

These are the building blocks of the global ARD system. They include various stakeholders such as National Agricultural Research Institutions (NARIs), Universities, NGOs, Extension services, farmer's organisations, farmers, private sector with the primary responsibility for generating, adapting and transferring technologies that farmers need to ensure food security and equitable, sustainable development. NARIs often occupies a prominent position in expressing national research priorities and in setting up and implementing the national research agenda.

The agricultural sector, however, faces monumental challenges such as adaptation to the vagaries of climate change, crop production to meet the needs of the biofuel industries as well as for food security, nutrition, biosecurity. The solutions however lie veiled in the complexity of the findings of research efforts in the midst of limited resources. The contribution of the agricultural sector to the accelerated and transformative growth initiative requires focused effort in tackling and responding to identified challenges and opportunities which requires a core of competent researchers to generate knowledge to achieve sustainable natural resource utilization, manage biodiversity conservation; develop risk-management strategies for agricultural production to address natural disasters, climate change and disease and pest outbreaks; improve production systems, post-harvest and processing technologies to enhance nutrition, food security and safety. One of the objectives of agricultural development therefore is to maintain and retain a cadre of qualified, experienced, motivated and competent agricultural R&D personnel that can achieve the long-term goals of food security and poverty alleviation, international competitiveness in agriculture and enhancement and sustainability of the natural resource base. This would ensure that important policies to address these challenges facing the human society are formulated from the evidence and findings of these seasoned crop of research personnel.

Sharp practices (scientific or research misconduct)

Sharp practices in research which could be regarded as research or scientific misconduct is defined as the intentional distortion of the research process by fabrication of data, text, hypotheses or methods from another researcher's manuscript form or publication or distortion of the research process in other ways (Wikidoc, 2012). Also refers to an intentional fabrication, falsification or plagiarism in proposing, performing or reviewing research or in reporting research results which must be proven by sufficient evidence. Sharp practices include breaches of confidentiality and authorship or publication violations.

Research results are reported as manuscript or theses given to a mentor as representing the result of experiments; reports submitted such as progress reports in renewal applications; application for continuing years of an approved project; preliminary data in new grant applications and as abstracts, posters, oral presentations or preliminary reports presented at scientific meetings.

This is the similar trio- fabrication, falsification and plagiarism (referred to as "FFP" in international discussion.

Sharp practices in research include:

Fabrication The practice of generating data without performing the relevant research; i.e. making up results and recording or reporting them**.**

Falsification Manipulating research materials, equipment or processes or changing or omitting data or results such that research is not accurately represented in the research record.

Plagiarism The appropriation of another person's ideas, processes, results or words without giving appropriate credit.

Citation plagiarism Also known as citation amnesia, bibliographic negligence or disregard syndrome is the willful or negligent failure to appropriately credit other or prior discoveries so as to give an improper impression of priority.

Plagiarism fabrication The act of taking an unrelated figure from an unrelated publication and reproducing it exactly in a new publication with the claim that it represents new data.

Self-plagiarism Also known as recycling fraud is the reuse of significant, identical or nearly identical portion of one's work without acknowledging that one is doing so or without citing the original work. Articles of this nature are referred to as duplicate or multiple publication.

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Ghost writing When the real author is not listed as an author

Suppression of research The failure to publish significant findings due to the results being averse to the interests of the researcher or his/her sponsors.

Extrapolation of data

Sabotaging others research

Guest authorship where there is stated authorship in the absence of involvement

Honorary authorship Listing an individual as an author as a sign of respect or gratitude.

Gift authorship Listing an individual as an author as a personal or professional favor or for reciprocal co-author arrangement.

Prestige authorship Listing an individual with a high degree of notoriety as an author to give the publication more visibility or impact.

Massaging data picking and choosing data that support your argument while ignoring those that do not (Bornmann, 2013.*)*

Consequences of sharp practices in Agricultural Research

The enormousity of the consequences that can happen when flawed research is added to the body of knowledge or is used in policy formulation cannot be overemphasized. It is in line with these that this study was undertaken to examine the aforementioned sharp practices as detrimental in achieving the objectives of agricultural research.

The general objective of the study is to ascertain involvement in sharp practices among research personnel in agricultural research institutes in South Western Nigeria. The specific objectives of the study are to:

1. Identify the personal characteristics of research personnel in the study area;
2. Ascertain research personnel's awareness of sharp practices in research;
3. Determine the respondents' involvement in sharp practices;

MATERIALS AND METHODS

Study area

The study was carried out in National Horticultural Research Institute (NIHORT), Ibadan South Western Nigeria. NIHORT Ibadan started as "The National Fruit and Vegetable Research and Development Centre (NFVRDC)" with the assistance of UNDP/FAO project NIR/72/007. By the Federal Government Agricultural Research Institute Establishment Decree Order No. 35 of June 1975, the center metamorphosed into the "National Horticultural Research Institute (NIHORT)" along with other Agriculture Research Institutes. With the promulgation of decree No. 5 in January 1977, the Institute came under the National Science and Technology Development Agency (NSTDA). In January 1980, the Science and Technology Bill of 1980 transferred the Institute to the Ministry of Science and Technology. However, since 1996, it has been under the Federal Ministry of Agriculture and Rural Development. Following the Agricultural Research Council of Nigeria Act 1999 (hereinafter referred to as "the principal Act to further the advancement of research, training and extension in the agricultural Research, the Institute thus came under the Agricultural Research Council of Nigeria (ARCN) in 2006.

A multi-stage sampling technique was used to select the respondents for the study. The first stage involved a purposive selection of one (1) out of the three (3) agricultural research institutes (ARIs) in the south western zone of Nigeria. NIHORT was randomly selected.

The second stage involved a purposive sampling of the Research personnel in the institute. Research personnel on research cadres Research Officer 1 to Assistant Directors were selected for the study. Research Officer 11 who are still newly employed and Research Directors were excluded from the study.

The third stage involved a random selection of 40% of officers from the selected cadre (RO 1 to Assistant Director of Research). Thirty Research personnel were therefore randomly selected for the study.

Data for this study was collected through the use of structured questionnaire and were analyzed using descriptive statistics such as frequency and percentage counts to describe the variables in the specific objectives of the study.

RESULTS AND DISCUSSION

Personal characteristics of respondents

Results in Table 1 showed that 48.0% of the respondents were between the ages of 30 – 39 while 36.0% were between the age brackets of 40 – 49. This implies that most of the respondents are still energetic and with young mind for agricultural research. Also, 64.0% of the respondents were male while only 36.0% were female. This indicates that there are more males than females which may be attributed to the physical nature of agricultural

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research coupled with very frequent travels of researchers.

The study also showed that 92.0% of the respondents were married while only 8.0% were single. This showed that a very large proportion of the respondents were married and therefore are responsible and settled individuals which is a crucial attribute required for success in research. Findings from the study also revealed that 96.0% of the respondents have less than 9 persons in their households. This indicates that a very large proportion of the research personnel have small family size with a limited number of persons who depend on them. The study revealed that only 12.0% of the respondents had only BSc degree; 48.0% had MSc, 8.0% had M Phil and 32.0% had PhD degree. This result is an indication that the respondents are academically progressive which could be attributed to higher qualifications being a pre-requisite for progression in research career. Majority (40.0%) of the respondents were in the Senior Research cadre. 20.0% of the respondents were in the Research Officer 1 cadre with 32.0% in the Principal Research cadre. Only 4% were in the Chief Research cadre; 4.0% in the Assistant Director cadre. No Director was involved in this study.

Table 1: Percentage distribution on Personal characteristics of respondents

Variables	Percentage
Age	
30-39	48.0
40 – 49.	36.0
Sex	
Male	64.0
Female	36.0
Marital Status	
Single	8.0
Married	92.0
Family Size	
Less than 9 persons	96.0
Above 9 persons	4.0
Academic Qualification	
B Sc degree;	12.0
M Sc, degree;	48.0
M Phil degree;	8.0
P hD degree.	32.0
Research Cadre	
Senior Research cadre	40.0
Research Officer 1 cadre	20.0
Principal Research cadre	32.0
Chief Research cadre	4.0
Assistant Director cadre.	4.0

Respondents' awareness of sharp practices in research

The result (Table 2) reveals that 84.0% of respondents are aware of fabrication of data, Plagiarism, Falsification of data, Extrapolation of data, while 72.0% are equally aware of Suppression of data and Self-plagiarism as types of sharp practices in research. This is an indication that respondents are very much aware of sharp practices that goes on in research. This is in line with the studies of Bamigboye and Oladosu (2015) who opined that 68% of farmers were aware of sharp practices involved in Agricultural mechanization.

Table 2: Respondent's awareness of sharp practices in research

	Sharp practice	Rank	Percent*
1	Fabrication of data	*1*	*84*
2	Plagiarism	*1*	*84*
3	Falsification of data	*1*	*84*
4	Extrapolation of data	*1*	*84*
5	Suppression of data	*5*	*72*
6	Self-plagiarism	*5*	*72*
7	Sabotaging others research	*7*	*68*
8	Guest/ Honorary authorship	*8*	*64*
9	Massaging data	*9*	*60*
10	Withdrawal of publication	10	50
11	Ghost writing	11	4

*multiple responses

Respondent's involvement in sharp practices

The result shows (Table 3) that 28.0%, 16.0%,12.0% are involved in withdrawal of publication, guest/honorary authorship, massaging data and extrapolation of data respectively. The result indicated that the involvement of researchers in sharp practices is not so high though they are involved.

Table 3: Respondent's involvement in sharp practices

	Sharp practice	Rank	Percent*
1	*Withdrawal of publication*	*1*	*28*
2	*Guest/Honorary authorship*	*1*	*28*
3	*Massaging data*	*3*	*16*
4	*Extrapolation of data*	*4*	*12*
5	*Self-plagiarism*	*5*	*8*
6	*Suppression of data*	*5*	*8*
7	*Ghost writing*	*5*	*8*
8	*Plagiarism*	*8*	*4*
9	*Falsification of data / result*	*8*	*4*
10	*Sabotaging others research*	*8*	*4*
11	*Fabrication of data*	-	-

*multiple responses

CONCLUSIONS

The study established that there were few female research personnel in the National Horticultural Research Institute and that a large proportion of research personnel at large are relatively young which implies that research has a promising future. The study also revealed that although the level of awareness of the diverse sharp practices in research among research personnel is high; their level of involvement in these sharp practices is very low.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

1. More females should be encouraged in the field of agriculture and in agricultural research particularly;

2. Penalties should be attached to research misconduct and sharp practices;

3. The NARIs /ARCN should encourage research personnel to regard success in research as key to citizens wellbeing and not merely for promotional benefits or for career progression.

Researchers themselves have a duty to conduct themselves with integrity in their research work. Integrity should be second nature to researchers. Integrity is vital to fostering trust that researchers have in one another and the trust that society places in the result of their research. Research institutes are responsible for paying attention to integrity in research practice

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CLIMATE CHANGE INFORMATION SOURCES AND CHALLENGES ON COCOA INSECT PESTS AND DISEASES CONTROL AMONGST SMALLHOLDER FARMERS IN CROSS RIVER STATE, NIGERIA

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ABSTRACT

Access to viable information by farmers in this era of climate change is very crucial to cocoa production. The study therefore examines the various sources of information available to farmers on climate change and their challenges on Cocoa Insect Pest control amongst smallholder cocoa Farmers in Cross River State. Multi stage sampling procedure was used to select 132 respondents from three local Government Areas (Etung, Boki and Ikom). Interview schedule and questionnaire administration for data collection on personal characteristics of the cocoa farmers, sources of climate change information, types of agro-climatic change information, quantity of cocoa beans in bags produced by farmers, constraints encountered in coping with climate smart adaptation strategies. Data were analysed using descriptive statistics such as frequencies and percentages while inferential statistics used was Pearson Product Moment Correlation (PPMS). Results revealed that 12.9% were below the age of 30 years, 56.8% of them were between the ages of 31-50 years, 25.8% of the respondents were between the ages of 51-70 while only a few 4.5% were between the ages of 71-90. The mean age of the respondents was 45 years. Their major information source is from friends and family with 23.5% and the major constraint was high cost of pesticides 88.7% in climate change adaptation. The highest constraint of the respondents was high cost of pesticides 88.7%. Frequency of climate change information obtained on insect pest and diseases of respondents positively correlated with their constraints encountered in adapting to climate change strategies ($r = 0.361$, $p < 0.05$). In conclusion, the study has shown that majority of the respondents' major channel of information was family and friends not through extension agents and CRIN. Therefore, there is the need for an urgent strengthening of extension arm of CRIN and Nigeria in general.

Key words: Climate change, constraints, information channels, Cocoa farmers

INTRODUCTION

Climate change is defined as change in the state of the climate over time, either due to natural variability or as a result of human activities resulting to most of the global warming that persist over an extended period typically decades (IPCC,2011). Globally, climate change has been described as an important determinant of abundance and distribution of species and it possesses potential threat to environment and agricultural production which has implications on livelihood of farmers.

Information and communication are essential ingredients in the transfer of developed technologies such as climate change adaptation strategies designed to boost agricultural production. In order for farmers to benefit from such, they must first have access to the technologies and learn how to effectively utilize same in their farming systems and practices (Ani and Baba, 2009). Extension agents play a major role in transferring information on climate change and improved agricultural practices to the end users through media and participatory training approach. It serves as a source of advice and assistance for farmers in order to respond proactively to climate change and improving their production and marketing (Adams, 1988). The level of public awareness on issues related to climate change in Nigeria is considered to be low (BNRCC, 2011), however access to specific weather information, early warning systems and forecast technologies can also help farmers to develop and readjust coping or adaptation strategies (Otitoju and Enete, 2016)

Prior to the discovery of oil and gas, the agricultural sector was the backbone of the Nigerian economy though it has been affected by climate change. However, there is dearth of information on the farmers' perception on climate change affecting agricultural productivity, such as changes in weather patterns and extreme weather impacts on livestock and crop production. Understanding farmers' knowledge and sources of information will help improve on current economic, social and environmental risk polices mitigating and adapting to climate change (Deressa, 2009). The challenges of climate change such as increasing temperature, change rainfall pattern, soil depletion, pests and disease have negative resultant effect on agricultural activities thus posing new risk challenges to food production (Neate, 2013). These adverse events and challenges have led to reduce income, fall in farm practices and welfare of farming households (Lawal, 2016). Farming activities shudders such as heavy rains, flood, price and income fluctuations both eccentric and covariate in nature are globally predominant and they are particularly arduous to small-scale farmers in developing countries. Therefore, farmers' attitudes and opinions towards climate change can help improve policies and decision-making at local level. Consequently, the principal focus of this research paper is on the challenges faced by farmers through the investigation of farmers' knowledge on channels of information, types of agro-climate change information and the effects of climate change on spread of insect pests and diseases which pose threats to increased cocoa production.

Objectives of the study

This study has the following objectives:

i. To identify farmers' personal characteristics in the study area.

ii. To examine the sources of information on climate change.

iii. To identify the types of climate change information available to farmers

iv. To find out the constraints in the utilization of climate change information.

MATERIALS AND METHODS

A multi-stage sampling procedure was used in the selection of the local government areas, communities and the cocoa farmers. In stage 1: Three (3) Local Government Areas (LGA) were selected. In Stage 2: Three (3) communities were selected based on contiguity and proximity to the farmers' centers as follows**:** 1) Etung LGA: Ajassor, Etomi and Effraya, (2) Ikom LGA: Okundi, Ekonde and Akparabong and 3) Boki L.G.A: Olom, Nsadop and Iruan. Stage 3: In the communities, farmers were selected from Etung LGA Fifty (50) farmers, Boki LGA Forty-two (42) while in Ikom LGA Forty (40) farmers were selected giving a total of 132 cocoa farmers.

RESULTS AND DISCUSSION

Table 1 revealed the personal characteristics of the respondents as majority (81.1%) of the respondents were males while 18.9% were females. This implies that men in the study area were more involved in cocoa production than the women which support Uwagboe and Agbongiarhuoyi, (2020), where most cultures in Nigeria limit women in acquiring land for tree crops cultivation which however affects their technology adoption. Respondents' age revealed that, (12.9%) were below the age of 30 years, (56.8%) of them were between the ages of 31-50 years, (25.8%) of the respondents were between the ages of 51-70 years while (4.5%) were between the ages of 71-90 years. The mean age of the respondents was 45 years, as farmers below the mean age were seen younger, while those above the mean age were older farmers. In all, (69.7%) were within mean age of the respondents which corroborates the findings of Akinbile and Ndaghu (2005) where, most farmers were between the ages of 20-50 years and very active farmers to seek information on climate change. All the farmers had one form of the formal education based on the number of years spent in school (37.1%) of the respondents had primary education, (44.7%) of them attained secondary education while (18.2%) had tertiary education, totaling (77.2%) which corroborates the findings of Edeoghon *et al.,* (2008) that education is a panacea to boost agricultural production.

Table 1: Personal characteristics of respondents (N=132)

Sex	Frequency	Percentage	Mean
Male	107	81.1	
Female	25	18.9	
Age			45.0 years
11-30	17	12.9	
31-50	75	56.8	
51-70	34	25.8	
71-90	6	4.5	
Years spent in school			
1-6	49	37.1	
7-12	59	44.7	
13-18	24	18.2	

Source: Field Survey, 2019

Table 2 shows the farmers response on their channels of climate change information which help in taking decisions on when and type of crop to plant and ditto the kind of animal production to engage in. The climate change information gives scientific direction on the kind of practice in every farming season. Farmers received climate change information from different sources such as relatives

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(23.5%), fellow farmers (21.9%), CRIN channel (15.2%), extension agents (9.8%), NIMET (6.8%), Radio channels(9.1%),phone messages(7.6%),television(6.1%) this is contrast tothe findings of Csoto (2010), where radio, extension services and television were majorly used in rural areas to access climate, especially radio information resulting from the affordability and size of the gadget as been able to fix up in the clothing pockets.

Table 2: Respondents' sources of climate change information

Channels	Frequency	Percentage
Friends and family	31	23.5
NIMET	9	6.8
CRIN	20	15.2
Radio	12	9.1
Television	8	6.1
Phone	10	7.6
Fellow farmer	29	21.9
Extension Agent	13	9.8
Total	132	100.0

Source: Field Survey, 2019

Table 3 indicates types of agro-climate change information accessed by farmers in the study area. Based on these findings, farmers accessed different forms of information on climate change in order to allow them to take decisions on how to effectively control insects' infestation and diseases and infection. This table highlights the percentage of respondents who accessed different kinds of climate change information, (66.7%) of the respondents have access to early warning signals information, (68.9%) seasonal rainfall, (56.0%) seasonal temperature forecast, (32.6%), insect pest, diseases prevalence and drought (28.0%). These various types of climate change information stated above are required by farmers on how to adapt and mitigate climate change effects which has posed a very big threat to food security and achievement of agricultural diversification programme (Chukwuji, *et al*., 2019). It takes information to make a right or an informed decision. In the face of the threats posed by climate change to the world especially Nigeria, there is need for adequate and timely information to be given out to the public. This information will help the people especially the vulnerable to build capacity for adaptation and or mitigation of the effects of climate change. Idoma and Mamman (2016) in their study revealed that early warning signals, rainfall prediction, drought prediction, adaptation technology, food aid, temperature change are needed climate change information and knowledge which require sharing between scientists, farmers, policy makers and community institutions in order to enhance practical adaptation at the grassroots level.

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Table 3: Types of Agro-climate information received on insects' pest and diseases of cocoa

Types of information	Yes		No	
	Frequency	Percentage	Frequency	Percentage
Early warning signals	88	66.7	44	33.3
Seasonal rainfall prediction	91	68.9	41	31.1
Seasonal temperature forecast	74	56.0	58	44.0
Insect pest and diseases population data	43	32.6	89	67.4
Drought	37	28.0	95	72.0
Climate change impact zones in Cross River State	57	43.2	75	56.8

Source: Field Survey, 2019

Table 4 reveal that the most critical constraint among the respondents in coping with climate change in the study area was high cost of pesticides (88.7%), financial constraints was (83.3%), inadequate climate change information (54.5%), high labour cost as very serious constraint responses was (75%), the constraint of respondents on emerging pests was (41.7%), which could have adverse effects on cocoa production and reduce yield leading to low income.

Table 4: Challenges encountered in coping with climate smart adaptation strategies

Constraints	**Very serious**		**Serious**		**Not serious**	
	Frequency	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
High cost of pesticides	117	88.7	13	9.8	2	1.5
Labour cost	99	75.0	32	24.2	1	0.8
Financial problem	110	83.3	19	14.4	3	2.3
Inadequate climate change information	72	54.5	36	27.3	24	18.2
Emerging or new pest problem	55	41.7	34	25.8	43	32.6

Source: Field Survey, 2019

Table 5 shows that channels of climate change information obtained on insect pest and diseases of cocoa by respondents, positively correlated with the constraints encountered in adapting to climate change strategies ($r = 0.361$, $p < 0.05$). This is an indication that channel of climate change information obtained had significant relationship with farmers' constraints encountered in adapting to climate change strategies. According to Mark (2008) some of the direct impacts of climate change on agro-climatic conditions include alteration in rainfall and temperature, growing seasons, planting and harvesting calendars, water availability, pest, weed and disease populations. However, the findings of Onyeneke (2010) indicated majority of smallholder farmers' suffered knowledge gap in coping with climate change adaptation strategies due to lack of adequate information on climate change, while Nwaru (2004) and Aderinto *et al*. (2009) in a different study observed that poor financial position of the peasant farmers compels them to produce on a very small scale and so earn relatively small income.

Table 5: Correlation between climate change information sources and challenges encountered by farmers in adapting to climate change strategies

Variable	R	P	Decision
Climate change information on insect pest and diseases	0.361	0.000	Significant

*Pearson Product Moment Correlations. Source: Field Survey, 2019

CONCLUSION AND RECOMMENDATIONS

This study examined the various sources of information available to farmers on climate change and their challenges on Cocoa insect pest control amongst small-holder's cocoa farmers in Cross River State. This investigation revealed more men in the active mean age of 45 years obtain information on climate change than women, despite that the farmers involved had different forms of formal education as determined by the number of years spent in school, however secondary sources of information from co-habitat have been the major channel of climate change information and prominent amongst the sources of information is that of seasonal rainfall prediction, while in addition is the high cost of pesticides. There is an indication that channel of climate change information obtained had significant relationship with farmers' constraints encountered in adapting to climate change strategies. Therefore, there is the need for an urgent strengthening of extension arm of institutions of relevance as a channel of information on cocoa climate change making the power of information incontrovertible

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A REVIEW ON SOME MEDICINAL POTENTIALS OF GUAVA

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ABSTRACT

Guava (Psidium guajava) is a well-known tropical tree abundantly grown for fruit. Many countries have a long history of using guava for medicinal purposes. This plant is used for the treatment of diarrhea, dysentery, gastroenteritis, hypertension, diabetes, caries and pain relief and improvement in locomotors coordination. Its leaf's extract is being used as a medicine in cough, diarrhea, oral ulcers and in some swollen gums wound. Its fruit is rich in vitamins A, C, iron, phosphorus and calcium and minerals. It contains high content of organic and inorganic compounds like secondary metabolites such as antioxidants, polyphenols, antiviral compounds, anti-inflammatory compounds. The phenolic compounds in guava help to cure cancerous cells and prevent skin aging. The presence of terpenes, caryophyllene oxide and p-selinene produces relaxation effects. Guava leaves contain many compounds which act as fungistatic and bacteriostatic agents. Guava has a high content of important antioxidants and radio-protective ability. Quercetin is considered as most active antioxidant in the guava leaves and is responsible for its spasmolytic activity. Its ethyl acetate extract can stop the germ infection and thymus production. Guava possesses anti-viral, anti-inflammatory, anti-plaque and anti-mutagenic activities. Guava extract shows antinociceptive activity and is also effective in liver damage inflammation and serum production.

Key words: Medicinal potentials, chemical properties, *Psidium guajava*

INTRODUCTION

The guava (*Psidium guajava L.*) tree belonging to the *Myrtaceae* family, is a very unique and traditional plant which is grown due to its diverse medicinal and nutritive properties. Guava has been grown and utilized as an important fruit in tropical areas like India, Indonesia, Pakistan, Bangladesh, and South America. Different parts of the guava tree - roots, leaves, bark, stem, and fruits, have been employed for treating stomachache, diabetes, diarrhea, and other ailments in many countries. Guava belongs to phylum *Magnoliophyta*, class Magnoliopsida and Myrtaceae family (Dakappa *et al.,* 2013). It has about 133 genera and more than 3,800 species. *Psidium guajava* and all it's parts have an old history of medicinal value (Nwinyi *et al.,* 2008). The plant is well known by a common name "Guava" in English, guayabo in Spanish, goyaveandgoyavier in French, guyabaorgoeajaab in Dutch, goiaba and goaibeira in Portuguese and jambubatu in Malaya. Pichi, posh and enandi are the names commonly used in Mexico and America (Morton, 2004). Guava plant grows widely in the tropic areas because it is a plant that can be grown on a big range of soils (Jiminez-Escrig, 2001). In Mexico guava is one of very important crop which is cultivated over 36,447 acres and production is about 192,850 tons. According to records the first money-making guava planting was reputable around 1912 in Florida at Palma Sola (Morton, 2004). In this review we describe the botany, ecology and medicinal value of this useful plant.

General uses of Guava

The guava fruit contains vitamin A, C, iron, phosphorus and calcium. It has more vitamin C than the orange. The fruit contains saponin, oleanolic acid, lyxopyranoside, arabopyranoside, guaijavarin, quercetin and flavonoids. Ascorbic acid and citric acid are the major ingredients of guava that play important role in anti-mutagenic activity. The skin of fruit contains ascorbic acid in very high amount; however, it may be destroyed by heat. The strong pleasant smell of fruit is credited to the carbonyl compounds. Guava fruit contains terpenes, caryophyllene oxide and p-selinene in large quantity which produce relaxation effects. The flavonoid content is higher in the methanolic extract of the guava. There are 41 hydrocarbons 25 esters, 13 alcohols and 9 aromatic compounds in guava. Titratable acidity and the total soluble solids are present in fruit. Guajadial is also present in guava.

Essential oil is present in leaves which contain α-pinene, limonene, β-pinene, isopropyl alcohol, menthol, terpenyl acetate, caryophyllene, longicyclene and β-bisabolene. Oleanolic acid is also found in the guava leaves]. Leaves have high content of limonene about 42.1% and caryophyllene about 21.3%. Leaves of guava have a lot of volatile compounds.

The bark includes 12–30% of tannin and one source declares that it includes tannin 27.4%, or polyphenols, resin and the crystals of calcium oxalate. Tannin is also present in roots. Leukocyanidins, gallic acid and sterols are also present in roots. Carbohydrates with salts are present in abundance. Tannic acid is also its part.

If guava fruit is healthy, then its leaves are super healthy. Some of the benefits of guava leaves includes - it helps in stopping diarrhea, reduce cholesterol level, helps in losing weight, helps to manage blood sugar levels, helps to fights cancer, helps in good vision, used for healing acne and helps in improving your skin texture. Guava leaves can either be boiled in hot water and consumed or made tea using them. Either of these will benefit you in many ways.

Guava leaves for healthy hair

Hair fall is a result of an unhealthy scalp. Guava leaves can help stop hair fall and strengthen your scalp because of their anti-inflammatory, antimicrobial and antioxidant properties. It is also being used in scalp related problems and dandruff.

It is also rich in vitamin B & C that helps in nourishing and aids in hair growth. So if you have a guava tree in your garden, then don't pile up those leaves or burn it, instead make it a point to make a paste out of it and gently apply it on your scalp. This will fight hair fall and help strengthen your scalp.

Guava leaves tea

If green tea is considered healthy and ayurvedic, then guava leaf tea is even healthier and this can be consumed if you are having abdominal pain, watery stools etc. All you need to do is to add guava leaves to boiling water and boil for 20 minutes. Then strain the water and allow it to cool for 5 minutes. Make sure it is at least lukewarm when you are consuming it. Also, this must be consumed on an empty stomach and you may find instant relief once you've followed the steps carefully.

Guava fruit is rich in most essential nutrients. The fruit is packed with fiber, vitamins, and minerals. It may help in diabetes treatment, protect heart health, boost immunity, and improve digestive health.

Medicinal importance of Guava

Psidium guajava L. is consumed not only as food but also as folk medicine in subtropical areas all over the world due to its pharmacologic activities (Deguchi and Miyazaki, 2010). Guava is frequently employed in numerous parts of the world for the cure of a lot of sickness like diarrhea reducing fever, dysentery, gastroenteritis, hypertension, diabetes, caries, pain relief and wounds. The countries which have a long history of using medicinal plants are also using guava at big level like Mexico, Africa, Asia and Central America. With its medicinal uses it is also used as food and in the preparation of food products. It is also used in house construction and toys making. Guava contains high content of organic and inorganic compounds like secondary metabolites e.g. antioxidant, polyphenols, antiviral compounds and anti-inflammatory compounds. Guava has a lot of compounds which have anti cancerous activities. It has a higher number of vitamins and minerals. Phenolic compounds like flavonoids also find an important place in the guava. Lycopene and flavonoids are important antioxidants. They help in the cure of cancerous cells and help to prevent skin aging before time (Manikandan and Anand, 2016). Guava can affect the myocardium inotropism. Guava skin extract can control level of diabetes after 21 days' treatment (Rai *et al.,* 2010).

Medicinal uses of Guava parts

Leaves: The decoction or infusion of the leaves is used as febrifuge, antispasmodic and for rheumatism in India (Hernandez, 1971). The leaves are used in USA as an antibiotic in the form of poultice or decoction for wounds, ulcers and tooth ache (Heinrich, 1998; Leonti et al., 2001). Bronchitis, asthma attacks, cough, pulmonary diseases could be also treated with guava teas (Batick, 1984; Khan and Ahmad, 1985).

Fruits: Guava fruit is rich in most essential nutrients. The fruit is packed with fiber, vitamins, and minerals. It may help in diabetes treatment, protect heart health, boost immunity, and improve digestive health.

Bark: The bark in the form of decoction and poultice is used as an astringent in the treatment of ulcers wounds and diarrhea in Philippines while in Panama, Bolivia and Venezuela, the bark is used in treatment of dysentery and skin ailments. In the form of decoction and poultice, it is used to expel the placenta after childbirth and in infections of the skin, vaginal hemorrhage wounds, fever, dehydration and respiratory disturbances (Gutiérrez *et al.*, 2008).

Root: The root is used in West Africa as a decoction to relieve diarrhea, coughs, stomach ache, dysentery, toothaches, indigestion and constipation; while in Philippines, Fiji and South Africa, the roots are used in the form of decoction and poultice as an astringent in ulcers wounds and in treatment of diarrhea (Gutiérrez *et al.*, 2008).

Whole plant: In general, the whole plant or it shoots are used in the form of infusion, decoction and paste as skin tonic in Tahiti and Samoa and as analgesia in painful menstruation, miscarriages, uterine bleeding, premature labor and wounds (Gutiérrez *et al.*, 2008).

Medicinal Chemical Properties of Guava

Here are some medicinal chemical properties of guava leaves:

Antimicrobial activity

Guava has a high antimicrobial activity. Guava leaf's extract doses can reduce the amount of cough due to its anti-cough activity. Aqueous, chloroform and methanol extract of leaves can reduce the growth of different bacteria. Due to its anti-cough activity it is recommended in the condition of cough (Jaiarj, 1999).

Antidiarrheal activity

Diarrhea is one of most common and well recognized health problem and a global issue. It is very common even in developed countries. It is estimated that about 2.2 million people die annually by diarrhea; most of them, are children or infants.

Anti-inflammatory activity

Extract of guava in ethyl acetate can stop the germ infection and thymus production. It can act as anti-viral agent. It is used as anti-inflammatory agent for skin.

Antioxidant activity

Antioxidants are molecules which retard the oxidation process. The oxidation reactions may produce free radicals which damage the cells by starting various chain reactions. Free radicals which damage the cells cause cancer and many other diseases. Antioxidants terminate the free radicals and stop the chain reactions. Examples of antioxidants include beta-carotene, lycopene, vitamins C, E, and A and other substances. Oxidative reaction is one of most important destructive reaction. Free radical's damage is responsible for a lot of disorders in human like nervous disorders, inflammation, debates and viral infections. When drugs are metabolized in body the free radicals are produced. Sometimes the environmental changes and hormones become the reason of free radical production. These free radicals are responsible for all the oxidation reactions.

Guava contains high amount of antioxidants and anti-providing nutrients which are essential not only for life but also help to control the free radical activities. It also has a variety of phytochemicals which are beneficial for human health like diabetes, obesity and high blood pressure. There are two common methods by which antioxidants neutralize free radicals that is DPPH and FRAP assay. Extracts of guava in water and organic solvents have a large quantity of antioxidants which can stop the oxidation reaction. The concentration of these compounds become high with the increase in concentration. Pink guava also has a high antioxidant activity.

Guava is highly rich in antioxidants which are helpful in decreasing the incidences of degenerative diseases such as brain dysfunction, inflammation, heart disease, cancer, arteriosclerosis and arthritis. In fruits, the most abundant oxidants are polyphenols and ascorbic acid.

CONCLUSION

Guava is a traditional remedy for a number of ailments. Preliminary research suggests that compounds in guava leaf extract may have a positive effect on a range of illnesses and symptoms, including menstrual cramps, diarrhea, the flu, type 2 diabetes, and cancer. However, scientists need to carry out further studies in humans to confirm and better understand these findings. *Psidium guajava* (guava) is well known tropic tree grown in tropic areas for fruit. It is found to be effective in diarrhea, dysentery, gastroenteritis, hypertension, diabetes, caries, pain relief, cough, oral ulcers and to improve locomotors coordination and liver damage inflammation. The fruit is rich in vitamins (A & C), iron, phosphorus and calcium and minerals. The phenolic compounds in guava help to cure cancerous cells and prevent skin aging before time. The leaves contain many fungistatic and bacteriostatic agents and important oxidants. Its ethyl acetate extract contains quercetinwhich can stop the germ infection and thymus production. Guava possess anti-viral, anti-inflammatory and anti-oxidant activities which can be useful for the prevention and treatment of diseases.

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A REVIEW ON SOME POTENTIALS OF GINGER (*ZINGIBER OFFICINALE* ROSCOE) AND PRODUCTION IN NIGERIA

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ABSTRACT

Ginger (Zingiber officinale Roscoe) a spice crop is a member of the family zingiberaceae and sub family zinigeradeae. It is a monocotyledonous crop which produces rhizomes that serve as the ginger for commerce. Although the exact centre of origin is not known with certainty, it is believed to have originated from south East Asia and has been grown in India and China for centuries. Presently ginger is cultivated throughout the humid tropical areas of the world. Ginger is considered the most widely used spice globall. Ginger enters international markets in three primary forms; fresh (green) ginger, preserved ginger and dried ginger. The dried ginger has more commercial importance compared to preserved or fresh ginger. Ginger have so many health benefits, it is used in treating ailment such as such as arthritis, cramp, rheumatism, constipation, fever and infectious diseases. The economic part is the underground rhizome, which is pungent and aromatic and used for culinary purposes in ginger bread, biscuits, cookies, candy, jam, alcohol, cakes, puddings, ginger ale, curry powders, soft drinks, soups, prickles and a lot of other products. It is in view of the above the potentials of the plant are reviewed.

Key words: Ginger, health benefits, rhizome, dried, fresh

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) a spice crop is a member of the family *zingiberaceae* and subfamily *zinigeradeae.* It is a monocotyledonous crop which produces rhizomes that serve as the ginger for commerce. Although the exact centre of origin is not known with certainty, it is believed to have originated from south East Asia and has been grown in India and China for centuries. Presently ginger is cultivated throughout the humid tropical areas of the world. Ginger is considered the most widely used spice globally (FAO, 2008).

Uses

The economic part is the underground rhizome, which is pungent and aromatic and used for culinary purposes in ginger bread, biscuits, cookies, candy, jam, alcohol, cakes, puddings, ginger ale, curry powders, soft drinks, soups, prickles and a lot of other products (Nauman *et al*., 2010) Ginger enters international markets in three primary forms; fresh (green) ginger, preserved ginger and dried ginger. The dried ginger has more commercial importance compared to preserved or fresh ginger. Aromatic spices are prepared by harvesting and drying the mature rhizome while the fresh ginger, consumed as a vegetable, use for making Ginger juice etc is harvested when immature or mature (Modupeola *et al*., 2012) Dried ginger is used directly as a spice and also for the preparation of ginger oil and ginger oleoresin. It is also valued as a medicinal plant widely used throughout the world to address a wide range of human ailments such as arthritis, cramp, rheumatism, constipation, fever and infectious diseases (Ali *et al*., 2008)

Botany

Ginger is an erect perennial herb usually cultivated as an annual, whitish or off coloured in appearance and which is much appreciated throughout the world. The plant reaches a height of 3 to 4 feet, the leaves growing 6 to 12 inches long. It is extensively cultivated in the tropics (Kaushal *et al*., 2007)

Ginger Production in Nigeria

Ginger (*Zingiber officinale Rosc*) is one of the most important spices grown in Nigeria. It was traditionally grown in the Ginger savannah region of Kaduna, particularly in southern Kaduna (Areas like Kachia, Kubacha, Kafanchan, Kwoi and Zankwa), research however has shown that it can equally do well in the rain forest region. Among the crops predominantly cultivated. In Southern Kaduna is ginger and is one of the most economically beneficial crops in southern part of Kaduna state. Ginger is produced in states namely: Kaduna, Nasarawa, Benue, Niger and Gombe with Kaduna as the major producer. Ginger cultivation in Nigeria dates back to 1927 and it is believed to have Asian origin. Ginger was introduced to Africa and the Caribbean by the Colonial Masters; and it is now cultivated throughout the humid tropics Although Nigeria ranks first globally in terms of land area devoted to ginger cultivation (56.23% of the total), it ranks third in terms of quantity of ginger produced, accounting for 12.54%of global production According to Food and Agriculture Organization in 2018, Globally, ginger production was estimated at over 3.3 million metric tons with India; China; and Nigeria as the world leaders. Nigeria produces and export good quality ginger; that contains less fiber which is generally preferred by Western countries. Ginger production, processing and marketing are big businesses that guarantee high returns on investment (Meadows, 1998).

AGRICULTURAL PRACTICES

Source of Planting Material

Seed rhizomes should be carefully preserved free from pests and diseases which are collected from organically cultivated farms (most preferable) or any farm, Research institutes or trusted dealers should be used for planting.

Land Preparation/Planting

Proper land clearing, ploughing and harrowing is important in the cultivation of Ginger, as it encourages the proferation of ginger roots for maximum exploitation of soil nutrients and moisture. The seed rate varies from 1500-2500kg/ha, planting can be done using planting hoes as the rhizome setts which are cut into pieces weighing between 20-30g are placed in the soil and well covered, this is the minimum weight of ginger recommended for planting, although other researchers recommends something higher,115 – 230g.majority of farmers ensure that each of the rhizomes setts has at least 23 eye buds means they are aware of the implication of such in successful ginger production and might have gained this knowledge from practical (Nwaogu *et al* , 2014).

Varieties

Studies have shown that most farmers in Nigeria preferred the black ginger this is also known as Monkey fingers and the yellow ginger (elephant foot), the black ginger is more pungent than the yellow ginger, but yield slightly less.

Mulching

Mulching the ginger beds with green leaves enhances the germination of seed rhizomes and the addition of organic matter to the soil and also conserves moisture during the later part of the cropping seasons (NIHORT, 2014). The first mulching is to be done with green leaves at 10-12t/ha at the time of planting. It is to be repeated at 5t/ha at 3 months after planting. This helps to moderate the soil temperature which needs to be maintained at 28-32^{o}C during the first three months after planting for good rhizome growth. Mulching should be done up to a thickness of 5cm with long lasting mulch material (NIHORT, 2014)

Soil Fertility Management

Organic manure such as green manure, compost wood ash or farmyard manure should be applied to return the nutrient removed from the soil by the crops as well as to improve the water and nutrient holding capacity of the soil by the crops. The amount of fertilizer required for a particular crop depends on the initial fertility status of the soil; fertilizer is best applied by broadcasting in two applications 300kg of NPK 15:15:15 is recommended /ha of ginger, applied in split applications half at planting and half at 4-6 weeks after planting (Olasanta, 1994). Farmyard manure or compost at 5-6 t/ha may also be applied as a basal dose at planting. Organic fertilization is very important to agriculture as the constant use of synthetic fertilizers over the years poses threat to human lives, Optimum growth and yield of plants require nutrients, as deficiency in nutrients results in stunted crop growth and poor yield (Modupeola *et al., 2012)*

Weed Control

Uncontrolled weed growth in ginger plots or farm may reduce rhizome yield by up to 76% compared to weeded plots or farms. The critical period for weed removal in ginger is 8-16 weeks after planting. This means the crop should be free from serious weed competition during the period. Manual weeding is done 4-6 weeks after planting and subsequent roughing. Weed growth after 20 weeks of planting does not affect rhizome yield much (Paul *et al*.,1988)

Pest and Disease

Disease and pests of ginger are rare when ginger is grown in fertile soils. However, high relative humidity and low soil fertility predispose it to the attack of leaf spot disease which, at the advanced stage, may tear the leaves into shreds and finally lead to premature death of the plant. To prevent the disease, select fertile soil and apply balanced fertilizer, plant early and mulch adequately to prevent soil splash on the leaves. Other diseases like fusarium, yellow and soft rot are rare. There is hardly any known pest of economic importance of ginger, although, root knot nematode (*meloidogyne incognita*) is said to be a common pest of ginger (Tabin *et al*., 2015)

Harvesting and Yield

The crop is ready for harvest in about eight to ten months depending on the maturity of the variety. When fully matured, leaves turn yellow and starts to dry up gradually, clumps are lifted carefully with a spade or digging fork and rhizomes are separated from dried leaves, roots and adhering soil. The average yield of fresh ginger per hectare varies with varieties ranging from 15 to 25 tons (Elliot, 2008).

Storage of Ginger

After setting aside planting material for the next season, ginger rhizomes are split and dried soon after harvest. Small quantities of ginger can be stored in covered pits, or in baskets covered with saw dust. Large quantities can be best stored in heaps under the shade of the tree and covered with dry grass, or in well-ventilated huts. The rhizomes should be sorted periodically to remove rotten ones. Seed rhizomes can also be stored in pits dug in the ground under the shade of tree provided there is no chance for water to enter the pits (Paul *et al*., 1998)

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THE USE OF NATURAL HERBS AMONG POULTRY FARMERS IN OKENE LOCAL GOVERNMENT AREA OF KOGI STATE, NIGERIA

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ABSTRACT

The study was conducted to examine the use of natural herbs among poultry farmers in okene local government area, of Kogi state Nigeria. 100 poultry farmers were randomly selected and Data were collected through well structured questionnaire and interview schedule. The data were analyzed using descriptive statistic and logit regression. The result revealed that the model age of the farmers is 41-50years, while the mean age is 39years. Majority (90%) of the farmers attended formal educational and engage in poultry farming on a small scale. The result further revealed that age, level of education, poultry experience, flock size and access to veterinary services had positive and significant influence on the use of natural herbs by poultry farmers to manage and prevent poultry diseases are indeed effective and reliable based on the farmers' perception. Support and encouragement on the use of natural herbs by poultry far mers' provision of credit facilities will go a long way in improving the use of natural herbs for poultry's diseases control among poultry farmers in the study area.

Key words: Natural Herbs, Diseases, Poultry farmers, Okene, Kogi

INTRODUCTION

Poultry industry in Nigeria occupies a prominent position as a major source of supply of animal protein to the citizens. Over the years, the growth of poultry industry has followed a pattern closely dictated by the economic fortunes of the country. (USDA, 2013) however over the years, a synthetic antibiotic has been the main stay of the industry in terms of disease prevention, treatment and growth promotion of the animals. Furthermore, antibiotic resistance (AR), which is defined as the ability of an organism to resist the killing effects of an antibiotic to which it was normally susceptible, has become an issue of global interest. Thus, using antibiotics in animals may raise the risk of transmitting drug resistant bacteria to humans either by direct infection or by transferring resistance genes from agriculture into human pathogens. This has made some poultry farmer or poultry industry to turn to the use of natural herbs for disease prevention and treatment. (Tulobaeu, 2016), therefore, this study aims to assess the use of natural herbs among poultry farmers in Okene local government Area of Kogi State with specific objective, describe the socio – economic characteristics of poultry farmers in the study area; assess the prevailing diseases in poultry production in the study; assess the extent of usage of natural herbs in the study area; determine the factors that influence the use of natural herbs in the study area; and examine the perception of farmers on the efficacy of natural herbs treatment of poultry diseases in the study area.

MATERIALS AND METHODS

This study was conducted in Okene Local Government Area of Kogi State. This study area is within the northern guinea savannah ecological zone of Nigeria. It lies between latitude $7^0 30^I$N - $7^0 30^I$N and longitude $6^0 10^I$E - $6^0 16^I$E of the equator with an area of 328km2 and a population of 320, 260 (NPC 2006). The area has two distinct seasons in a year, the wet and dry seasons. The wet season span between April to October, while the dry season is between the months of November to March. The area has an average maximum temperature of 31^0c, and an average minimum temperature of 24^0c with annual rainfall is usually between 1, 100mm and 1, 300mm. the main occupation is cotton weaving is traditional craft, others engage in pet trading such as yam, cassava, corn (maize) sorghum, beans, peanuts (Groundnuts) palm oil and kernels and cotton grown in the surrounding area by the Ebira people. Animal husbandry is also practice in the area.

Sampling technique and Sample Size

The following technique was used to draw sample of 100 respondents from the L.G.A. purposive sampling technique was used to select individual respondents and 10 villages, (10) were involved in Okene L.G.A for the study. The distribution of questionnaire in the study area was based on the available number of poultry farmers in each village.

Data Collection

The primary data was obtained through the use of well structured questionnaire and oral interview. Secondary information on the other hand was obtained from journals, articles, documents of the local government, book and internet.

Data Analysis

Data collected was analyzed using both descriptive and inferential statistics. Descriptive statistics such as frequency, percentage and means was used to achieve objectives (i), (ii), (iii), and (iv) whereas logit regression was used to achieve objective (iv) of the study.

Model Specifications

Model for descriptive statistics

Percentage (%) = Observed frequency x 100/Total No mean (X) = Ɛ x /n

Where

Ɛ = Summation

X = Individual Observation

N = No of Observation

Model for logit regression analysis

$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_nX_n + e$ ………

Y = use of Natural herbs/ alternative medicine (use =1, non use =0)

X1 = Age (yrs), X2 = Sex, X3 = Level of education, X4 = Marital Status, X5 = Years of experience in poultry production (yrs), X6 = Production Scale (Large, Small), X7 =Flock Size (No), X8 = Household Size (No), e = Error Term, B_0 = Constant, $B_1 – B_7$ = Regression Coefficient

RESULTS AND DISCUSSION

Analysis of the socio-economic characteristics of the poultry farmers in the study area

Table 1 shows that the mean age of the farmers was 39years. 10% of the farmers did not have formal education while 90% of the farmers acquired various forms of education. This implies that the farmers are educated enough to know the different types of herbs for various poultry diseases, their usage efficacy and implications. 90% of the farmers practice small scale farming with average flock size of 240 birds. 50% of the respondents have between 6-10 household sizes with a mean of 7%. This implies that farm operations in the study area will depend mainly on family labour particularly with me moderate flock.

Prevailing poultry disease in the study area

Ten (10) poultry diseases were reported by the respondents to be prevalent in the study area (Table 2). The commonest ones in order of prevalence include coccidiosis (100%), fowl cholera (90%), Newcastle disease (82%), fowl pox (81%), Gumboro (73%) and CRD (57%). Similar observations were reported by Atteh (2004), Mishra et al. (2010) and Lawal and Oyegbami (2010) that coccidiosis, fowl cholera, Newcastle disease, Fowl pox, Gumboro and CRD were responsible for over 71% of the total cause of mortality in poultry farming.

Extent of usage of Natural Herbs for various poultry disease

Table 3 shows that most of the poultry farmers use natural herbs mostly for coccidiosis (93%) fowl cholera (88%), Newcastle disease (80%), fowl pox (76%), Gumboro (64%) and CRD (51%). All the poultry farmers interviewed used plants natural herbs to treat poultry diseases. Farmers used these plants because they are readily available and at low or no cost at all. Locally available, easily accessible and culturally appropriate and are therefore readily understood. It is believed that natural herbs (traditional drugs) do not produce side effect.

Determinants of the use of Natural herbs by poultry farmers in the study area

Age, level of education, poultry farming experience, flock size and access to veterinary services had positive and significant influence on the use natural herbs by poultry farmers (Table 4). This implies that a unit increase in any of these socio-economic variables will lead to a unit increase in the use of herbal medicine to treat diseases in poultry farming in the study area. Furthermore, cox and snell R square of 0.49 indicate that 49% of the various in the use of herbal medicine in poultry production were influenced by the socio-economic characteristics of the farmers.

Table 1: Socio-economic Characteristics of the poultry farmers in the study area

Characteristics	Frequency	%	Means
Age (years)			
30 – 40	60	60	
41 – 50	25	25	
51 – 60	10	10	39
> 61	5	5	
Sex			
Male	65	65	
Female	35	35	
Marital Status			
Married	70	70	
Not Married	30	30	
Educational Level			
Tertiary	30	30	
Secondary	40	40	
Primary	20	20	
No Formal Education	10	10	
Poultry Farming Experience (years)		%	
1-10	50	50	
11 – 20	30	30	13
> 21	20	20	
Household Size (in number)			
1 – 5	40	40	
6-10	50	50	7
> 11	10	10	
Flock Size (in number)			
1 – 200	50	50	
201 – 400	30	30	240
> 400	20	20	
Membership Association			
Yes	20	20	
No	80	80	
Access to veterinary services			
Yes	60	60	
No	40	40	

Table 2: Prevailing poultry diseases in the study area

Prevailing Poultry Diseases	Frequency	%	Rank
Coccidiosis	100	100	1st
Fowl cholera	90	90	2nd
Newcastle disease	82	82	3rd
Fowl pox	81	81	4th
Gumboro	73	73	5th
CRD	57	57	6th
Pullorum	49	49	7th
Powl typhoid	47	47	8th
Helminthosis	42	42	9th
Lousiness	25	25	10th

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Table 3: Extent of usage of Natural Herbs for various poultry diseases

Natural Herb Used	Diseases Cured	F	%	Rank
Bitter leaf, Water, Moringa	Coccidiosis	93	93	1st
Pawpaw, Pepper, Scent Leaf, Water, Lime water, Aloe vera, Moringa, Green tea, Thyme	Fowl Cholera	88	88	2nd
Bitter Leaf, Scent Leaf, Sorghum, Guava Leaf, Akintola Leaf	Newcastle Disease	80	80	3rd
Palm Oil, Goat Weed, Cassava Leaf, Shea Butter	Fowl pox	76	76	4th
Olive Leaves, Turmeric, Tagiri, Lime Water	Gumboro	64	64	5th
Ginger, Oregano, Green Tea, Moringa, Paw paw	CRD	51	51	6th
Pepper, Sorghum	Lousiness	40	40	7th
Pumpkin leaf, Banana pod, Cassava Leaf, Lime, Water	Helminthosis	37	37	8th
Akintola Leaf, Lime Water, Moringa	Fowl Typhoid	17	17	9th
Moringa, Garlic Powder, Bitter Leaf, Water	Pollurum	10	10	10th

Table 4: Determinants of the use of natural herbs by poultry farmers in the study area

Characteristic	Coefficient	Standard Error	T – stat
(Constant)	.9835	.21877	4.4957
Age	.03282	.01198	2.7395**
Sex	.07412	.04921	1.5061
Level of Education	.23152	.08012	2.8896**
Marital Status	.04206	.02940	1.4306
Poultry production Exp.	.05123	.01945	2.6339**
Flock Size	.40121	.14349	2.7960**
Household Size	.05331	.03472	1.5354
Membership of Association	.21234	.14120	1.5038
Access to Veterinary Services	.00891	.00329	2.7082**
Log Likelihood		-162.04	
Cox and Snell Square		0.4931	

** = significant at 0.05

Farmers perception of the Effectiveness of natural herbs in poultry farming.

The use of local methods of managing and preventing poultry diseases are indeed effective and reliable or dependable (Table 5). The farmers generally preferred and had more confidence in their local methods because the materials needed are readily available, affordable and easy to employ.

Table 5: Farmers' perception of the effectiveness of natural Herbs in poultry farming

Perception	Frequency	%
Highly Effective	59	59
Effective	30	30
Undecided	5	5
Ineffective	4	4
Highly ineffective	1	1

CONCLUSIONS

From the findings of this study, poultry farmers in the study area use different natural herbs medicine to prevent or treat various poultry diseases ranging from coccidiosis, fowl cholera, Newcastle disease, fowl pox, Gumboro, CRD, etc with high level of effectiveness.

RECOMMENDATIONS

i. The following recommendation were made: the veterinary doctors and extension agents should support and encourage the use of natural herbs medicine among poultry farmers

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ii. The local government should support by granting loans to the poultry farmers, to enable them expand their production capacity.

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INVESTIGATING THE TRADO-MEDICINAL USE OF MUSTARD SEED AMONG HOUSEHOLDS IN SOUTH-WEST NIGERIA

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ABSTRACT

Studies on the use of alternative medicine in Nigeria are on the rise and this could be the antidote to reducing the country's rate of incidences of terminal diseases among both the young and the old. The present study investigated the various medicinal use of mustard seed among households in South-West Nigeria. The study ascertained the socio-economic characteristics of households using mustard seeds, determined the level of awareness and usage of mustard seed among respondents, ascertained the frequency of use of mustard seed among respondents in South-West Nigeria; and determine to perception of respondents on mustard seed in the study area. The study was carried out in South-West, Nigeria and sixty-four households were purposively from Lagos, Ogun and Ondo State.

Key words: Mustard Seed, Alternative medicine, South West, Nigeria.

INTRODUCTION:

Mustard is the common name for several herbaceous plants in the genera *Brassica* and *Sinapis* of the Brassicaceae family, and in particular *Sinapishirta* or *Sinapis alba* (white or yellow mustard; sometimes classified in *Brassica*), *Brassica juncea* (brown or Indian mustard), and *Brassica nigra* (black mustard), all three of which produce small mustard seeds that can be used as a spice and, by grinding and mixing them with water, vinegar, or other liquids, be turned into a condiment also known as mustard. The seeds are also pressed to make mustard oil, and the edible leaves can be eaten as mustard greens. Mustard has been called the third most important spice after salt and pepper (Downey, 2003). Mustard seeds are very rich in phytonutrients, minerals, and anti-oxidants, and are an excellent source of essential B-complex vitamins such as folates, niacin, thiamin, riboflavin, pyridoxine (vitaminB-6), and pantothenic acid. These B-complex groups of vitamins help in enzyme synthesis, nervous system function and regulating body metabolism. Mustard seeds contain flavonoid and carotenoid antioxidants such as carotenes, zeaxanthin, and lutein. In addition, the seeds contain a small amount of vitamin antioxidants such as vitamin-A, C, and Vitamin-K. Mustards are rich source of health benefiting minerals. Calcium, manganese, copper, iron, selenium and zinc are some of the minerals especially concentrated in these seeds.

MATERIALS AND METHODS

The study was carried out in South-West, Nigeria. A multi stage sampling technique was used to select three states in South west; these are Ondo, Ogun and Lagos State. A purposive sampling technique was used to select areas where mustard seed is commonly used. Twenty-one households were selected from Lagos and Ogun State while twenty-two house-holds were sampled in Ondo State. These makes a total of sixty-four household sampled for the study. Data were obtained with the aid of a simple structured questionnaire which had been previously validated by experts in the field of extension. The reliability of the questionnaire was 70.5 %. Data were subjected to descriptive and inferential statistics

RESULTS AND DISCUSSION

Socio economic characteristics of respondents

Table 1 revealed that the mean age of the respondents is 41.2 This implies that majority of the respondents in the study area are within the middle age category and have the ability to try out relatively new innovations or practices. More than half (53.8%) of the respondents had between 1-6 years of formal education. 66.2% of the respondents are likewise married. This could imply that their marital status could aid or reduce the usage of mustard seed as decision taken by individuals to use or not use mustard seed could be influenced by family or spouse's preferences. 44.1% of the respondents are Christians and Muslims alike hence, there is no disparity of religion in the use of mustard this negates the a priori expectation that Christians will likely use mustard seed more than any other religion. The mean income of respondents is ₦27,986 monthly as majority (42.1%) and (34.5%) of the respondents are artisans and civil servant respectively which could be as a result of the new minimum wage salary scale. Concussively respondents in the study area could afford to purchase mustard seeds for use.

Table 1: Socio-Economic characteristics of Respondents (N=145)

Socioeconomic characteristics	Frequency (%)	Mean Score
Age		
<31	37 (25.5)	
31-50	72 (49.7)	
51-70	31 (21.4)	41.2
>70	5 (3.4)	
Sex		
Male	67 (46.2)	
Female	78 (53.8)	
Educational Level		
None	5 (3.4)	
1-6	78(53.8)	
7-12	14(9.7)	
>12	48 (33.1)	
Marital Status		
Single	37 (25.5)	
Married	96(66.2)	
Widow	3(2.1)	
Seperated	9(6.2)	
Religion		
Christianity	64 (44.1)	
Islam	64(44.1)	
Traditional	17(11.7)	
Primary Occupation		
Farming	11 (7.6)	
Civil/Public Service	50 (34.5)	
Artisan	61(42.1)	
Trading	23 (15.9)	
Monthly Income(₦)		
10,000-49,999	115(79.3)	
50,000-89,999	15(10.3)	
≥90,000	15(10.3)	₦27,986

Source: Field Survey (2020)

Awareness of mustard seed

Table 2 shows that majority (88.3%) is aware of mustard seed and 26.9% of the respondents with source of awareness from their place of worship. It can be deduced from the results that respondents in the study area are aware of mustard seed. This is further expected to have positive influence on its use.

Table 2: Respondents Awareness of Mustard Seed (N=145)

	Frequency (%)
Awareness of Mustard Seed	
Yes	128 (88.3)
No	17 (11.7)
Sources of Awareness	
Radio	12 (8.3)
Television	30 (20.7)
Friends/Neighbours	13 (9.0)
Family/Relatives	22 (15.2)
Place of Worship	39 (26.9)
Motor park	29 (20.0)

Source: Field Survey (2020)

Use of mustard seed among respondents

Table 3 shows that 61.4% of the respondents used mustard seeds. However, there were variations in frequency of use as 22.5% of the respondents used mustard seed on daily basis, 46.1% used it on weekly basis, while 31.4 used mustard seed monthly. With respect to the type of mustard used, the brown type was prominent as 48.3% of the respondents indicated its use. Other types of mustard seeds used by the respondents include: black (31.5%) and yellow type (20.2%). The major forms of use were raw and powdery form, with most (55.1%) indicating preference for raw form, while 44.9% preferred it in powdery/blended form.

Table 3: Respondents Usage of Mustard Seed (N=145)

	Frequency (%)	Rank
Usage of Mustard Seed		
Yes	89 (61.4)	
No	56(38.6)	
Frequency of Usage		
Daily	20 (22.5)	3rd
Weekly	41 (46.1)	1st
Monthly	28 (31.4)	2nd
Types of Mustard Used		
Black Type	28 (31.5)	
Brown Type	43 (48.3)	
Yellow Type	18(20.2)	
Forms of Usage		
Raw form	49(55.1)	
Powdery/Blended	40 (44.9)	

Source: Field Survey (2020)

Constraints to use of mustard seed

Result in Table 4 revealed the constraints militating against the use of mustard seed. Cost (41.4%) and Non determinant of dosage (31.0) ranked first and second, respectively. The cost of mustard seed being a constraint could be associated with its low level of production in Nigeria which invariably influences its market price in. Other constraints to use of mustard seeds are: Its non-availability (13.1%) and fear of getting original seed (2.1%), while inadequate information on its usefulness ranked least constraint to use of mustard seed.

Table 4: Respondents Constraint to usage of Mustard Seed (N=145)

Constraints	Not constraint	Mild constraint	Serious constraint
Non availability/scarcity	95(65.5)	31(21.4)	19(13.1)
It is expensive	53(36.6)	32(22.1)	60(41.4)
Scarcity	87(60.0)	55(37.9)	3(2.1)
Inadequate information on its usefulness	116(80.0)	29(20.0)	0(0.0)
Non determinants of dosage			
Fear of getting original seed	69(47.6)	31(21.4)	45(31.0)
	59(40.7)	55(37.9)	3 (2.1)

Source: Field Survey (2020) *multiple responses

Trado-medicinal use of mustard seed

According to Sri Wahjuni *et.al* (2019), the use of traditional medicine is considered to be 'safer' than using synthetic drugs. Experience also proves that not all synthetic drugs are able to overcome various health problems optimally. Data on Table 5 reveals several illnesses that mustard seed cured. More than half (61.8%) of the respondents attested to the effectiveness of mustard in regulating blood sugar, 59.6% and 53.1% of the respondents opined that it was effective in treating arthritis and body pain, respectively. This is in consonance with the finding of Yadav and Kumari (2013) who opined that the linoleic acid found in mustard seed have been proven to be effective in treatment for rheumatism and arthritis. Other ailments that could be treated with mustard seed as identified the respondents were headache (50.0%), stomach ache (50.0%) and menstrual pain cramp (47.6%).

Table 5: Percentage of distribution of trado-medicinal use of mustard seed

Diseases/ sickness	Freq.	%
Regulation of blood sugar	37	61.4
Infertility	30	31.0
Menstrual pain and cramp	29	47.6
Arthritis	19	59.6
Ulcer	25	42.1
Body pain	32	53.1
Malaria	24	39.3
Headache	30	50.0
Cough	24	39.3
Stomach ache	36	50.0
Eye problem	19	31.0
Migraine	25	42.1
Fibroid	23	37.6
Insomnia	17	28.7

Source: Field Survey (2020)

CONCLUSION

The study found that respondents in the study area were young, educated and low income earners. The study also established a high level of awareness of mustard seed among respondents. The study also found variations in usage ranging from daily, weekly and yearly. The study revealed that several illness ranging from low blood sugar, arthritis and body pain, headache stomach ache and menstrual pain cramp were treated with mustard seed. Despite the benefits accrued from its use, certain factors such as non-availability or scarcity of mustard seed and cost were major constraints to use of mustard seed

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ETHNO BOTANICAL QUALITY OF *MORINGA OLEIFERA* (LINN TREE) IN KAUGAMA LOCAL GOVERNMENT AREA OF JIGAWA STATE, NIGERIA

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ABSTRACT

The study focuses on the ethno botanical uses of Moringa oleifera in Kaugama Local Government Area of Jigawa State, Nigeria. Well-developed structural questionnaires (100) were randomly administered on respondents from five (5) selected villages which include; Viz Yalleman (east), Turmi (north)Hadin (south), Marke (west) and Kaugama main town (Kofar arewa, Fada and B/Kasuwa). Data collected were analyzed using simple descriptive statistic. The study revealed that majority of the respondents were female (80%), while male was made up of 20%. Most of the respondents involved in Moringa oleifera cultivation were above 40 years old (70%). Hence, Government should assist in improving the cultivation of Moringa oleifera in a mechanized way.

Key words: Ethno botanical, Quality, Jigawa State, *Moringa oleifera*, medicinal uses

INTRODUCTION

Moringa (*Moringa oleifera* Lam) is the most widely cultivated species of the monogenetic family "Moringaieae" (Order: Brassicals) that includes 13 species of trees and shrubs distributed in sub Himalayan range of India, Sri Lanka, north eastern and south western Africa (Fahey, 2005). Today it has become localized in many locations in the tropics and is widely cultivated throughout African countries as well as Burma, Singapore, Mexico and Malaysia (Fahey 2005). Moringa species is one of the world's most useful plants and is a fast growing tree cultivated throughout the tropics for human food, livestock forage, medicine, and dying and water purification. The tree is known by several names in different countries, but is most popularly called the "drum sticks tree" for its pods that are popularly used by drummers and the: horse radish tree" for the flavor of its roots (Palada and Chang, 2003). Moringa is one of the world's most nutritious crops. Ounce for ounce, the leaves of—Moringa have more beta-carotene than carrots, more protein than peas. More vitamin C than orange, more calcium than milk, more potassium than banana, and more Iron than spinach. This tree is becoming a vital source of nutrition in this region, where most of the world's poor people live. The multiple uses of Moringa have attracted the attention of many people in the world today (Palada and Chang, 2003). The tree can be found growing naturally at elevations of up to 100m above sea level. It can grow well on hill sides but is more frequently found growing on pastureland or in river basins. It is a fast growing tree and has been found to grow 6-7m in one year in areas receiving less than 4000mm mean annual rainfall (Odee, 1998). *Moringa oleifera* is an important and miraculous tree. The relative ease with which it is propagated through both sexual and asexual means and its low demand for soil nutrients and water after being planted makes its production and management easy. Introduction of this plant into farms with bio dense environment can be beneficial for both the owner of the farm and the surrounding eco-system (Foidi et al., 2001).

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Kaugama Local Government area of Jigawa State, Nigeria. Kaugama is a Local Government Area in the north of Jigawa State, Nigeria. Its headquarters are in the town of Kaugama. It has an area of 883 km^2 and a population of 127,956.

Data Collection

A total of 100 questionnaires were randomly administered to some selected villages: Yalleman (east), Turmi (north), Hadin (south), Marke (west) and Kaugama main (K/Arewa, Fada, B/Kasuwa). All the questionnaires were returned successfully.

Data Analysis

The data obtained was subjected to simple descriptive statistics such as percentages and frequency distribution

RESULTS AND DISCUSSION

Table 1 indicates that females are more engaged in *Moringa oleifera* activities in the study area. Female has the highest value (80%) followed by male with (20%). Similar finding was obtained by Palada and Chang (2003). Table 2 shows that 10% of respondents are within the range of 15-25 years old, while 70% are above 46 years old. Majority of the respondents are married (55%), while 40% widowed in the study area (Table 3).

Table 1: Sex

Sex	**Respondents**	**Percentage (%)**
Male	20	20
Female	80	80
Total	100	100

Source: Field survey 2021.

Table 2: Age

Age	Respondents	Percentage (%)
15-25 years	10	10
26-35 years	20	20
46-above	70	70
Total	100	100

Source Field survey 2021.

Table 3: Marital status

Marital status	Respondents	Percentage (%)
Married	55	55
Divorce	2	2
Single	3	3
Widowed	40	40
TOTAL	100	100

Source: Field survey 2020

Table 4 indicates how the people obtain *Moringa oleifera* plants. It was discovered that 35% of the people obtained if by cultivation, 65% by purchasing, while none obtained from the forest. From all indications, people get *Moringa oleifera* from purchasing. The study revealed that 50% of the respondents in the study area uses *Moringa oleifera* for food, while 20% use it for medicine, and 28% for water purification (Table 5). This means that *Moringa oleifera* plants are widely used for both consumption and non-consumption purposes. This indicate that *Moringa oleifera* is widely acceptable and highly utilized in the northern parts of the country.

Table 4: Method of obtaining

Method of obtaining	Respondents	Percentage (%)
Purchase	65	65
Cultivation	35	35
Obtaining from forest	0	0
TOTAL	100	100

Source: Field Survey 2021

Table 5: Uses of *Moringa oleifera* in study area

Uses	**Respondents**	**Percentage (%)**
Food	50	50
Medicine	20	20
Fuel wood	1	1
Fence	1	I
Water purification	28	28
TOTAL	100	100.

Source: Field survey 2021.

In Table 6, it was observed that 85% of the respondents highly utilized leaves as a source of food leaves, while 15% uses fruit/pod. This means that the respondents in the study area use fruit/pod for water purification to substitute alum. This agrees with similar finding of Fahey (2005). Table 7

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indicates parts of *Moringa oleifera* plants mostly used as medicine by man. It was discovered that the leaves had the highest percentage with 35%, Bark 10%, Seed 2%, Root 25%, while fruit had at least 28% due to the water purification to substitute alum.

Table 6: Perception of *Moringa oleifera* as sources of food

Plants part	Respondents	Percentage (%)
Leaves	85	85
Fruit/Pod	15	15
Flower.	0	0
TOTAL	100	100.

Sources: Field Survey, 2021

Table 7: Parts of *Moringa oleifera* plants mostly used as medicine by man

Parts and medicine	**Respondents**	**Percentage (%)**
Leaves	35	35
Bark	10	10
Seed	2	2
Root	25	25
Fruit	28	28
Total	100	100

Source: Field survey 2021

CONCLUSION

In conclusion, *Moringa oleifera* (Linn) is used for food, medicine, fuel wood, water purification and curing some diseases in Kaugama Local Government Area, Jigawa State, Nigeria

RECOMMENDATIONS

Based on the finding of the study, the following recommendations are to be considered by the Government and non-governmental organizations:

- Provision of improved seedlings to the farmers,
- Encouragement of the farmers through provision of loans for enhanced production of *Moringa oleifera* production,
- Training of farmers in the study area on Good Agricultural Practices involved in *Moringa oleifera* production.
- Mechanization cultivation of *Moringa oleifera*.

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COMMON MEDICINAL PLANTS USED AS HERBS AND THEIR PACKAGING FOR EFFECTIVE UTILIZATION AND STORAGE

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ABSTRACT

This study represents an attempt to document information on the common medicinal plants used in Nigeria. These plants can be used as remedies for different aliments in our homes. The study identified 325 species and 95 families of plants being used by most of the people in Nigeria for the treatment of various common diseases. The medicinal uses are varied and the plant parts that are used ranged from leaves, roots, stem, bark to fruits only, or a combination of two or more in a species or with those of other species. Enduring and sustainable conservation efforts should be made to safeguard these important medicinal plants by processing and packaging it so that it can be stored and sold without losing its efficacy.

Key words: Medicinal plants, Herbs, Package, Utilization Storage

INTRODUCTION

Herb plants constitute an effective source of both traditional and modern medicine. These plants have been shown to have genuine utility and about 80% of the rural population depends on them as primary health care (Akinyemi, 2000). Herb plants have been used as sources of remedies for the treatment of many diseases since ancient times and people of all countries of the world including Nigeria have this old tradition. Despite the remarkable progress in synthetic organic medicinal products of the twentieth century, over 25% of prescribed medicines in industrialized countries are derived directly or indirectly from plants (Newman *et al.,* 2000). Up to 80% of the Nigeria population uses medicinal plants as remedies (Hostellmann and Marston, 2002).

According to the World Health Organization (WHO), the definition of traditional medicine may be summarized as the sum total of all the knowledge and practical, whether explicable or not, used in the diagnosis, prevention and elimination of physical, mental or social imbalance and relying exclusively on practical experience and observation handed down from generation to generation, whether verbally or in writing. In Africa, traditional medicine made use herbs from plants and this plays an important role in the health of millions of people. Traditional medicine has been described by the WHO as one of the surest means to achieve total health care coverage of the world's population. Of the 2, 500,000 higher plant species on earth, more than 80,000 are medicinal. India is one of the world's 12 biodiversity centres with the presence of over 45000 different plant species. The use of traditional medicine in various therapies by the indigenous population over the world cannot be overemphasized, according to the World Health Organization (WHO), as many as 80% of the world's people depend on traditional medicine for their primary healthcare needs. Due to poverty, ignorance and unavailability of modern health facilities, most people especially rural people are still practice traditional medicines for their common day ailments. (Khan, 2002).

There is increase in the use herbal plants among the present generation of people because of benefits of derived from the use. (Cox, 2005). The older generation is showing more interest in this valuable science of healing although the youths are not left out. All over the world, several ethnobotanical studies focusing on medicinal plants have been documented (Singh and Singh, 2001; Wang et al., 2002; Cox, 2005; Kumar et al., 2005; Pei, 2005). In Nigeria, information about ethnobotanical studies has also been documented (Gill, 1992; Sofowora, 1993; Igoli et al., 1999: El-Ghani, 2016). Studies have shown that 325 species and 95 families of medicinal plants were recognized as being used by most of the people in Nigeria for the treatment of various common diseases. Fabaceae has the largest number of species (42), followed by Asteraceae (22), Euphorbiaceae (20), Acanthaceae (13) and Apocynaceae (12). The largest genera were Euphorbia (6 species), Cola and Hibiscus (5 species for each), Albizia, Acacia, Combretum and Ficus (4 species for each), Acalypha, Allium, Clerodendrum and Cleome (3 species for each).

Studies also revealed that traditional medicinal practices have a wide acceptability among the Nigerian people, probably because they believe in its effectiveness. The medicinal uses are varied and the plant parts that are used ranged from leaves, roots, stem, bark to fruits only, or a combination of two or more in a species or with those of other species.

This paper presents common medicinal plants used for local herbs and how to package them using modern ways. This documentation of medicinal uses of African plants is becoming increasingly urgent because of the rapid loss of the natural habitat for some of these plants due to anthropogenic activities. The following are the common medicinal plant used for local herbs:

Moringa: Moringa is energy booster, strengthens immune system, and has antibiotic properties, cures headaches, asthma, reduces arthritic pains and inflammations and restrict tumor growth.

Aloe vera: It has an amazing properly of water retention in its leaves that help in certain conditions such as constipation, and poor body immunity.

Ginger: It plays a vital role in digestion and also helps in controlling blood pressure. It also helps during menstruation.

Mint: It keeps the digestive system running and boost immunity. It also helps in keeping the mosquitoes away.

Spinach: It has riboflavin and beta carotene that improve cardiovascular and nervous system.

Partminger (Cury leaf, Efirin): It is used in soup making and salad. The leaves are widely believed to aid digestion. The crushed leaf paste can stop nose bleeding.

Lemon grass (Kooko-oba): It is easily cultivated and made into herbal tea and making pepper soup. It is used to relieve thrush (yeast infection) and an ingredient in black soap and body cleanser.

Roselle: There are two flowering varieties, the red and the white. The white flower is used for making soup and the red flowers are used for making hibiscus tea usually called "zobo". It lowers blood pressure and cholesterol. It destroys cancer cell.

Bitter leaf (Ewuro): Many Nigerians uses it as medicinal component of their diets. It is bitter, as name implies, but this can be reduced by crushing it and washing the leaves and boiling before the leaves are cooked as bitter leaf soup or added as garnish to enhance the flavour of stew. Traditionally, it is used to treat fever, malaria, hepatitis, diarrhea, dysentery and cough. It is rich in vitamin and mineral that helps to reduce blood sugar drastically, repairs the pancreas and kidney.

Bitter Kola: The fruit, when added to other herb/vegetable, helps to remedy many aliments in our body.

***Adensonia digitata* (luru):** The powered leaves are very high in vitamin, calcium, phosphorus, potassium protein and lipids. It is antimalaria, antiviral, anti-oxidant and anti-inflammatory.

***Iruingia gabonesis* (Bush Mango Ogbono):** It is used for making soup that helps persons with over weight, reduce abdominal fat, lower cholesterol and reduce chance of developing heart disease, cancer, stroke, kidney failure and high blood pressure.

***Garcinia kola* (Orogbo):** It has analgesic /anti-inflammatory effect. It prevents glaucoma.

Different types of packing herb plants

The plant parts that are used as herb are principally the roots, leaves and stems. These plant parts of the herb should the identified, removed and processed. The processing involves, removal of dirt by washing, drying and sorting. Drying should be done at room temperature or electric oven. The processed parts can be package in the following ways.

1. **Nylon:** Rhizome, root, tuber and leaves can be packaged in transparent nylon.
2. **Bottle:** liquid or powder herbs can be packaged in sealed bottles.
3. **Plastic Container:** The seeds or fruits can be stored in transparent container with cover,
4. **Paper container**: can also be used for powder herb and fruits
5. **Capsulated: T**his is quite expensive

Safety and efficacy of packaged herb

Safety and efficacy depends upon storage, packaging and handling of raw material, quality control during the process of production of herbal medicine, and their self life time, preservative used and pesticide residue etc. For all these reasons, it is evident that the raw herbal requires a series of extended studies aimed at establishing the safety and efficacy of raw herbal by changing or improving the methods of storage and handling of raw herbs used. Exposure to light, oxygen and microbes have direct effect on the shelf life of the herbs. Air oxidizes the raw herbs whereas light decomposes the herbs as a result of which stability is reduced. Raw herbs need to be carefully studied to select suitable packaging material so that products are compatible with the material and retain properties. Herbals may be stored under conditions that prevent contamination and deterioration. The effects of atmosphere, moisture, heat and light should be taken into consideration so that the active constituent of herbs remains stable for a longer period of time. Changes in colour, odour and taste physical structure are the indications for the deterioration of medicinal constituents of the herbs. Contamination and deterioration can be prevented by proper storage methods which ensure the safety and efficacy of finished herbal products. Before the storage of herbs, they must be cleaned, washed in order to remove earthy material and other contaminants and dried properly.

Steps involved for proper storage of herbs

· Identification by naked eyes

· Washing of herb parts- Washing of herb parts like stem barks, roots, leaves, stems may be done with potable water.

· Drying of herb parts

· Removal of microbes from herb parts

Sterilization of herb parts

Sterilization of herb parts, which needs to be stored, may be done by any of the methods below as applicable:

· Dry heat sterilization,

· Steam sterilization,

· Sterilization by radiation like infra-red radiation, UV rays, X-rays and Gama rays, Alpha radiations and Beta radiation.

· Chemical method – Gaseous sterilization like ethylene oxide.

Temperature for storage of herb parts

All the herb parts may be stored at a cool place (any temperature) between 8^0 - 25^0C. Herb parts must be protected from moisture, freezing, light and excessive heat for preventing decomposition. There are no guidelines for proper storage of herb parts till date. It is only the proper handling, packaging and storage of herb parts which can preserve the safety, efficacy and quality of herbs. Exposures to air, moisture, light, dust etc. are harmful and should be restricted to maximum extent.

Each lot of herbs packaged should bear a label with following details: Name of herb, part (root, stem, bark, leaf, flower, rhizome etc), Inspection status (tested/rejected/approved), date of arrival and consignment number, test report number and date, time of collection, best use before date, batch no., and geographical region of collection.

CONCLUSION

Herbs may be stored under controlled temperature, pressure, air and light etc in order to retain the active constituents of the herbs in different stores with proper labeling after packaging with specific packing material for different parts of the medicinal herbs. In this way, safety, efficacy and quality of the herb shall be maintained.

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ASSESSMENT OF NUTRIENT COMPOSITION AND PHYTOCHEMICALS IN EXTINCT INDIGENOUS LEAFY VEGETABLES OF SOUTHWESTERN, NIGERIA

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ABSTRACT

Southern Nigeria is blessed with diverse indigenous leafy vegetables that are rich in nutrients and phytochemical which are going into extinction from our diets because of lack of literature on their usefulness. The present research assesses phytochemicals, vitamins, minerals, proximate, beta carotene and chlorophyll in eight leafy vegetables namely: Yanrin (Launea taraxacifolia), Gboro (Solanum notrifolium), Gbagba (Solanium aethiopicum), Oguma (Solanum Scabrum), Odu (Solanium americanum), Morogbo (Sesamum radiatum), Efinrin (Ocium gratissimum), Curry (Colocasia rotis). Recommended procedures were used in the analyses. Phytochemical analysis showed all eight vegetables contained flavonoids, tannis and alkaloids while all except Solanum scabrum and Ocium gratissimum did not contain saponin. Vitamin C content ranged between 23.25±0.75mg/100g and 14.14±0.69mg/100g, Vitamin B_1 0.149±0.003 and 0.06±0.008ma/100g; Vitamin B_6 0.7425±0.0005 and 0.315mg/100g. Mineral analysis revealed high level of calcium and potassium 282.2 to 71.0mg/100g and 920.0 to 450mg/100g respectively, magnesium was between 122.0 and 19.79ma/100g, sodium 66.64 and 10.0mg/100g and iron 10.1 and 0.85mg/100g. Beta-carotene content showed 258.49±3.86 and 96.45±3.86µg/100g while chlorophyll a was 31.51±0.02mg/g tissue and 5.23 ±0.20mg/g tissue and chlorophyll b was 28.65±0.06mg/g tissue and 4.72±0.20mg/g tissue. The results revealed that eight leafy vegetables are good sources of nutrients and phytochemical that can be used to cure or prevent some diseases.

Key words: Nutrient Composition, Phytochemical, Beta-carotene, Chlorophyll

INTRODUCTION

Nature provides us with diverse fruits and vegetables that are used for food and healing (Kimura and Rodriguez-Amaya, 2003; Znidarcic *et al.,* 2011). In Southwestern Nigeria some of the vegetables that are used as food by earlier settlers are now termed as weeds and are no more part of our diet despite the health benefit that are in these vegetables. There are wide varieties of indigenous fruits and vegetables found in Africa, which are good sources of nutrients, vitamins, antioxidants, minerals and proteins (Odhav *et al.,* 2007). Some of these fruits and vegetables are mainly used by inhabitants for medicinal purposes (Eifediyi *et al*., 2008). A vegetable is any edible plant or its parts, intended for cooking or eating raw. Leafy vegetables constitute important functional food components by contributing vitamins, minerals and biologically active compounds which are associated with dietary activities

Plants make an amazing variety of plant pigment molecules which may have physiological or biological functions (Brian, 1997). Three types of pigments present during the aging of leaves are chlorophyll, carotenoids and anthocyanins. These food pigment in the leafy vegetables are sources of powerful antioxidants; which helps body scavenge free radicals, thereby limiting the damage to cell membrane DNA and protein structures in the cell (Druesne-Pecollo *et al*., 2010). Leafy vegetables contained essential macro minerals and micro minerals. The amounts required in the body are not an indication of their importance. Some of the functions these elements are helps muscles to relax and contrast, proper fluid balance, and nerve transmission and muscle contraction.

In-sufficient research in the overall assessment of the nutritive and health benefits of leafy vegetables presently studied may be a major cause of them going into extinction. Therefore, the present study assessed the nutrient composition and phytochemical in extinction indigenous leafy vegetables of southwest, Nigeria.

MATERIALS AND METHODS

Samples of eight indigenous leafy vegetables were collected on a single day at the Botanical garden, The Polytechnic, Ibadan: *Yanrin (Launea taraxacifolia), Gboro (Solanum notrifolium), Gbagba (Solanium aethiopicum), Oguma (Solanum Scabrum), Odu (Solanium americanum), Morogbo (Sesamum radiatum), Efinrin (Occium gratissimum)* and Curry *(Colocasia rotis)* between 7:30am and 8:30am. Location was to ensure the vegetables were exposed to the same condition. After collection, 100g of each vegetable was weighed, stored in transparent plastic bags, covered with aluminum foil, identified at Nigerian Horticultural Centre (NIHORT), Ibadan, Oyo State, Nigeria and taken to the laboratory. The vegetables were washed under running water, dried on paper towels, cut into small pieces, and homogenized for subsequent trituration. Extraction of beta-carotene, chlorophyll and digestion of minerals from the vegetable was performed on the same day of collection. Proximate composition and water soluble vitamins were determined. Phytochemical screening of crude extract was carried out using standard procedures. The method by AOAC 2005 was used for mineral analysis, beta-carotene, chlorophyll, proximate composition and water soluble vitamins. Minerals were determined by Atomic Absorption Spectrophotometer (model 400 Perkin Elmer Analyst), Flame Photometer for the analysis of sodium and potassium and Sp 30 UV visible Spectrophotometer (Pye Unicam, Cambridge) for the analysis of beta-carotene and chlorophyll.

RESULTS

Results of the analysis were presented in figures below:

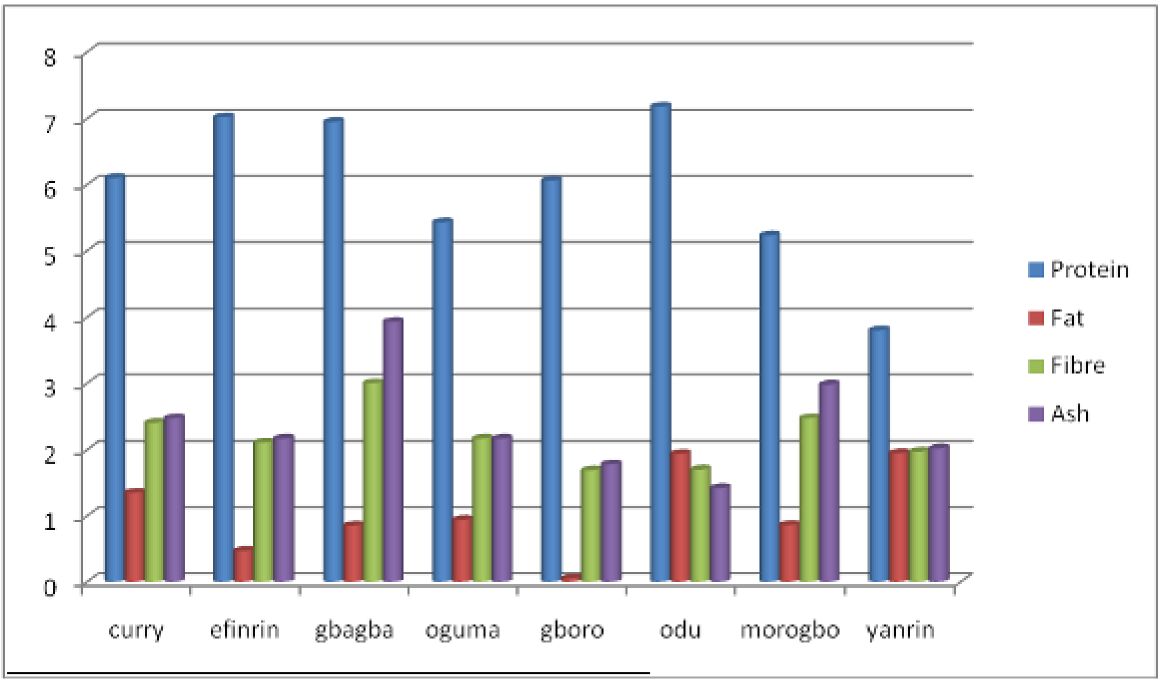

Figure 1: Proximate analysis of eight leafy vegetables in percentage (%)

Moisture content of eight leafy vegetables ranged between 84±1.00 and 78.0±1.00 curry had highest content and *oguma* least, this was not captured in the figure as it will affect the visibility of other parameter. *Odu*, *efinrin* and *gbagba* showed highest protein content while *yanrin* had least content. *Yanrin* and *odu* showed highest fat content and *gboro* had least content. *Gbagba* and *morogbo* had highest content of fibre while *odu* and *gboro* were lowest. *Gbagba* had highest ash content and *odu* lowest (Fig. 1).

The eight samples analysed produced β-carotene of mean 184 and 98 for OCC and AOAC respectively. The β-carotene in OCC and AOAC, with SD of 61 and 28, respectively (Fig. 2, 3).

Eight samples used in the two instruments produced total carotene of mean 15.98 and 15.36 for OCC and AOAC respectively. The mean of total carotene in OCC is slightly higher than AOAC, with the p-value of 0.0894 there is no statistically significant different between Open Column Chromatography and AOAC methods in analysing chlorophyll content. Therefore, the Open Column method of analysis is better than AOAC method (Fig. 4).

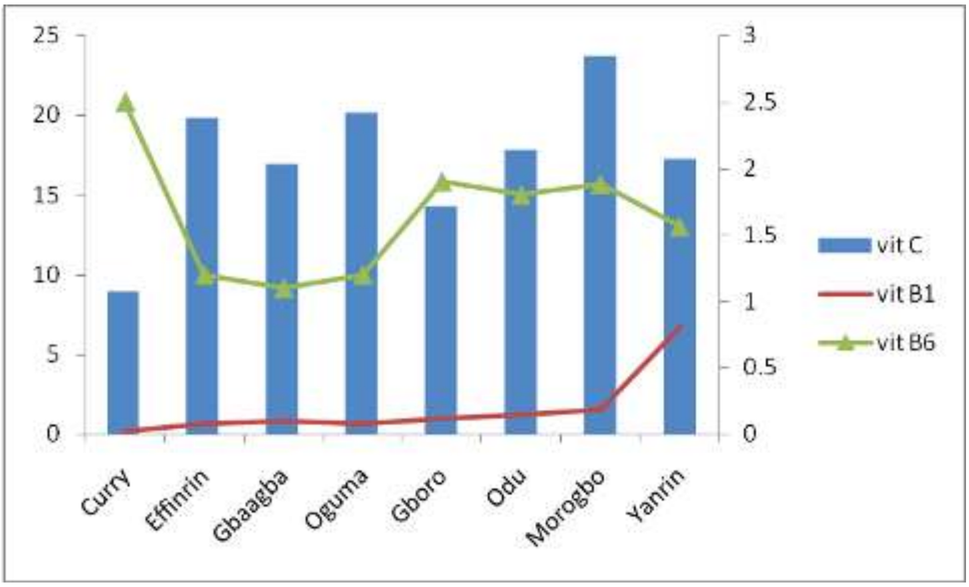

Figure 2: Water soluble vitamins in mg/100g

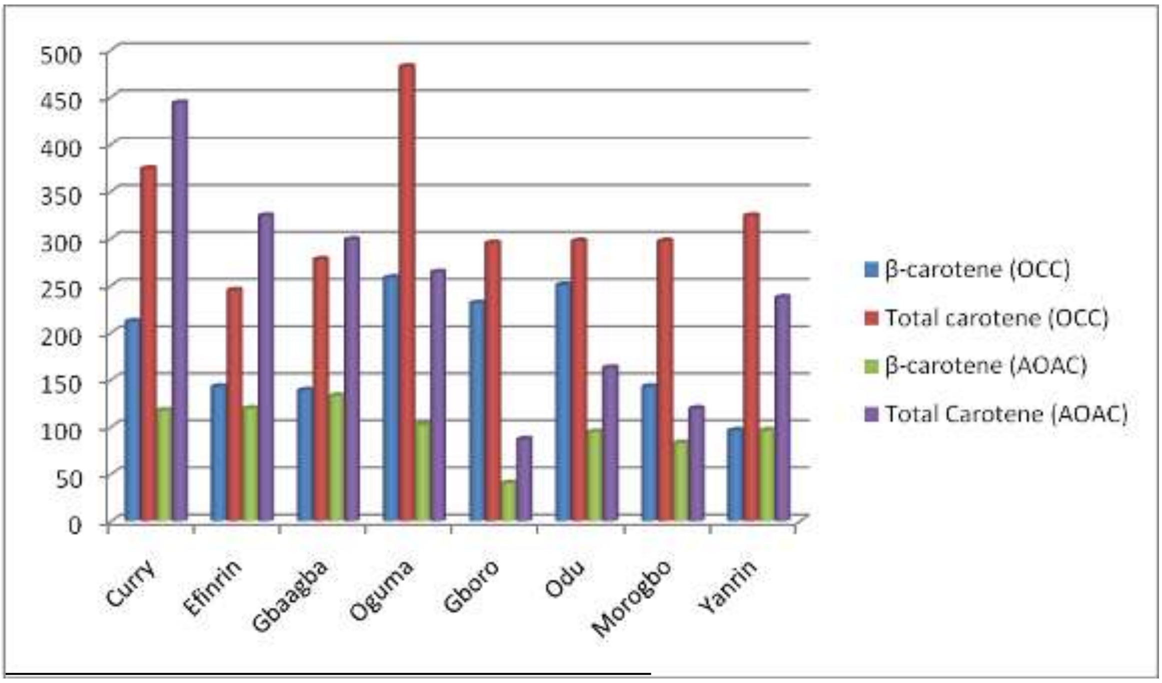

Figure 3: Beta-Carotene and total carotene content of selected vegetables (Open Column Chromatography (OCC) and AOAC methods) in µg/100g

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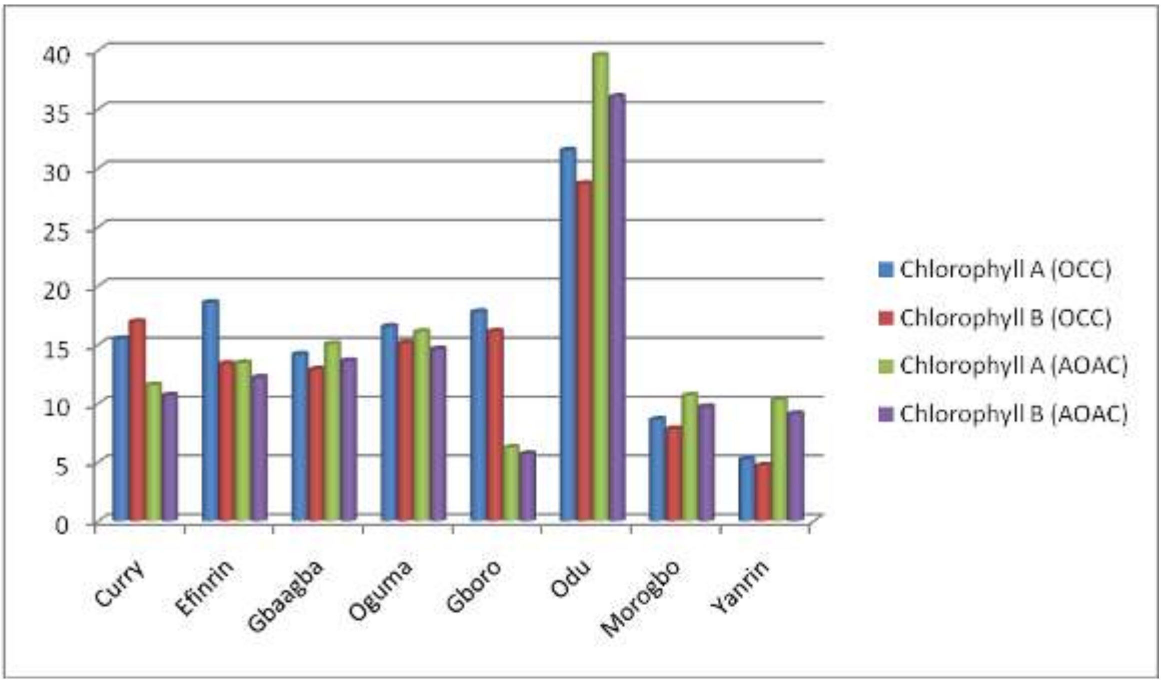

Figure 4: Concentration of chlorophyll A and B in selected vegetables (Open Column Chromatography and AOAC methods) in mg/g tissue

DISCUSSION

Vitamin C contents of the eight leafy vegetables are appreciable and fall between the acceptable recommendation range with the lowest in curry and highest in *morogbo*. Vitamin C ranged between 8.34 and 23.25mg/100g this was lower to the one reported by Adeguwa *et al*. (2011) on processed vegetables which ranged between 49.3 mg/100gto 104.1 mg/100g which may be due to the processing. Also at variance with vitamin C content obtained in the study of Lisiewskwa *et al.* (2006). *Morogbo* that is regarded as weed in most localities in the southwest had highest concentration of vitamin C and thiamine (Vitamin B_1), curry showed lowest concentration while *efinrin* had highest concentration of pyroxidine (Vitamin B 6) and was lowest in *oguma*.

Moisture contents in all the vegetables was very high, this is an indication that the vegetables will be very low in dry matter content hence, would be a good source of microelements. *Efinrin, gbagba* and *gboro* showed highest percentage of protein content while least values were observed in *oguma* and *morogbo.* Fat content was highest in *odu*, curry and *yanrin*, these vegetables are odourous and this is indicative of the presence of essential oils that have been observed in this vegetables. High significant value of fat in all vegetables analysed is an indication that they are good for consumption in keeping the body warm. Fats in food samples keeps the body warm even twice as that of carbohydrate. The presence of appreciable content of crude fibre and ash content showed that the vegetables were very good for consumption.

In comparing the concentration of beta-carotene and total carotene recovered from the two methods Open column method (96.45 to 258.49µg/100g; 244.99 to 482.26 µg/100g) was better than Association of Analytical Chemists (AOAC) method (40.52-133.1µg/100g to 119.6 to 443.68µg/100g) of analysis. The total carotene concentration was in agreement with the recovery in the work of Kimura and Rodriguez-Amaya (2003). It was at disparity with the range recovered in the research of Ahamad *et al*., 2007 though some of the vegetables were not leafy and High Performance Liquid chromatography was used which may be responsible for the result since it is a rapid, efficient and sensitive technique for carotenoid analysis. Podsedek, 2007 was of the opinion that leafy vegetables are indeed a rich source of beta-carotene which the present study confirmed.

AOAC method of analysis was better in the recovery of chlorophyll a than the open column method while open column method was better for the recovery of chlorophyll b. The result of the present study was lower than the content of both the chlorophyll a and chlorophyll b in the work of

Znidarcic *et al*. (2011); while the content were higher than that of Lisiewskwa *et al*. (2006). Chlorophyll a had higher content than the b variant in the present study.

CONCLUSION

The eight extincting leafy vegetables were rich in phytochemical, soluble vitamins, beta-carotene and chlorophyll. This is an indication that the vegetables had great potentials to improve human health and can be used to synthesis useful drugs that can cure diverse diseases. It is, therefore, recommended that the vegetables should be cultivated and that the populace should re-introduce it to our diet.

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UNDER UTILIZED CROP: A REVIEW OF AGRONOMIC POTENTIALS OF *CORCHORUS CAPSULARIS* FOR FOOD SECURITY IN NIGERIA

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ABSTRACT

Many vegetable crops are underutilized despite their high nutritional values. Corchorus capsularis is hardly grown in Nigeria but only limited to its natural occurrence as weed in farmlands during rainy season. The cooked leaves form a slimmy sticky sauce which is consumed with starchy balls made from sorghum, millet and maize. In other parts of Africa, it is used to prepare several recipes in combination with pumkin, sweet potato, cocoyam leaves and cowpea. Due to its fast growing habit, draught tolerance and high nutrient it can serve as good alternative to Ceratotheca sesemoides. This paper, therefore, document agronomic potentials of C. capsularis being an orphan crop and its benefits in order to enhance food security in Nigeria.

Key words: *Corchorus capsularis*, under utilized crop, food security, agronomic potential

INTRODUCTION

Corchorus capsularis (white jute), an erect annual herb up to 1m tall with branches, globose fruits and it probably originates in southern China. It was brought from there to India and Bangladesh where, till today, its production is centred. In the late 18th and early 19th century the crop was brought to many other tropical countries, but only in Brazil has the introduction been successful. The failure of the crop in other countries than Brazil has been attributed to a wrong choice of cultivars and labour constraints. In tropical Africa it is reported as a wild or cultivated vegetable in many countries. It is a leading leaf vegetable in Côte d'Ivoire, Benin, Cameroon, Sudan and Zimbabwe. White jute is also cultivated as a leaf vegetable in the Caribbean, Brazil, India, Bangladesh, China, Japan, Egypt and the Middle East. It is cultivated for jute production in Asia (India, Bangladesh, China) but in Africa it is of no importance as a fibre crop, although the fibre may be used domestically as firewood. The fibre of *Corchorus capsularis* is less fine, soft and lustrous than that of *Corchorus olitorius*. The former is usually whitish, whereas the latter is yellowish to reddish (Fondio and Grubben, 2011).

USES

White jute is used as a leafy mucilaginous vegetable. When cooked the leaves form a slimy sticky sauce, comparable to okra. In Nigeria this sauce is found suitable for easy consumption of starchy balls made from cassava, yam or millet. A powder prepared from dried leaves is used to prepare this sauce during the dry season. The immature fruits, called bush okra, are also dried and ground to a powder for the preparation of this slimy sauce. In East Africa several recipes exist, it can be cooked with cowpeas, pumpkin, cocoyam leaves, sweet potato, meat, and flavoured with peppers and lemon. Root scrapings are used in Kenya to treat toothache, a root decoction as a tonic, leafy twigs in Congo against heart troubles, an infusion from the leaves is taken in Tanzania against constipation, and seeds in Nigeria as a purgative and febrifuge. *Corchorus capsularis* leaves contain antioxidative phenolic compounds, of which 5-caffeoylquinic acid is the most important. Some ionone glucosides have also been isolated from the leaves; they showed inhibitory activity on histamine release from rat peritoneal exudate cells induced by antigen-antibody reaction (Ohtani *et. al.,* 1995)

LIFE CYCLE

Growth of *Corchorus capsularis* is fast. In short day conditions flowering starts about a month after emergence and continues for 1–2 months, depending on type and conditions. The flowers are usually self-pollinated, but cross-pollination up to 10% occurs. After about 3–4 months, the fruits are ripe, the leaves drop and the plant dies (Burkill, 2000).

CULTIVATION

Most farmers have no access to improved seed, but harvest from the wild. For a good seed yield of 25 g per plant, a spacing of 50 cm between and within the row is recommended. Commercial seed production may be 600 kg/ha. The seed is ripe when all the leaves have dropped. For own on-farm seed production, the stems with fruits are harvested, and after drying in the sun they are kept until the next season. In villages in the north of Côte d'Ivoire, the women conserve the fruits in the kitchen above the fireplace. Fruits on abandoned plants in the field also still contain viable seed until the next rainy season. These fruits open at the onset of the rains and the seeds spread. Well-dried seed keeps a high germination capacity for several years. One g contains about 470 seeds. Fresh and sometimes old seed shows dormancy caused by impermeability of the seed coat. This is a major problem for Jew's mallow cultivation. To suppress the dormancy, it is recommended that the seed tied in a piece of cotton cloth be immersed for 5 seconds in almost-boiling water before sowing. Another method is scarification with sandpaper (Mwaikambo, 2006).

In traditional field cultivation, the farmers broadcast seed without any consideration concerning the optimal density. Peri-urban vegetable farmers produce Jew's mallow on beds in monoculture. Direct sowing is mainly applied for once-over harvest by uprooting or low cutting at soil level. Sowing is done in lines 30–50 cm apart and with spacing 10–15 cm in the rows. For the more common harvesting by repeated cuttings, 10–20 g seed per 10 m² is sown in a nursery in well-loosened soil. When the seedlings are 5–10 cm tall, they are transplanted at a spacing of 10–20 cm in the row and 30–50 cm between the rows (Norman, 1992)

HARVESTING

The first harvest by cutting shoots 20–30 cm long may take place 4–6 weeks after transplanting at a height of 10–20 cm above the ground. This cutting stimulates the development of side shoots. Subsequently every 2–3 weeks a cutting may take place, in total 2–8 cuttings. For a once-over harvest from a direct sown crop the plants are uprooted or cut at ground level when they are 30–40 cm tall, 3–5 weeks after emergence and before development of fruits. The plants are bundled for marketing. In intercropping systems farmers tend to harvest at irregular intervals.

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COMPARATIVE STUDY ON BIOGAS COMPOSITION USING COW DUNG AND EUCALYPTS (*EUCALYPTUS CAMALDULENSIS. DEHNH*) WASTE IN SUDANO - SAHELIAN REGION OF NIGERIA

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ABSTRACT

The rising cost of conventional fuel necessitates exploration of other cheap, renewable and sustainable energy sources especially in Sudano-Sahelian region of Nigeria. Eucalyptus is one of the common tree species in the region, it leaves falls every day littering the environment and most times burnt after cleaning the environment which in turn emits CO_2. Hence study was carried out on biogas production using cow dung, eucalyptus wastes and mixture of cow dung/eucayptus to evaluate quality of biogas produced. Locally made digesters (10 L plastic buckets) were used, slurries were prepared at mixing ratio, waste to water (cow dung 3kg: 3000cm^3, eucalyptus 1kg: 5000cm^3 and mixture 2kg: 4000cm^3). For each sample digesters were fed in triplicates and subjected to anaerobic digestion for 6 weeks. Mean values of weekly biogas produced was measured using water displacement. Cow dung has the highest total volume of biogas produced (9416.34cm^3), mixture of cow dung/eucayptus (5793.33cm^3) and then eucalyptus (3780cm^3). Data obtained were subjected to (ANOVA) which shows no significant difference among the substrates used at ($P<0.05$). Biogas produced was also analyzed using NDIR Gas analyzer which revealed percentage of gases that comes with methane and caloric value. Methane content/caloric value recorded were 53.35% /249.58 KJ/m^3, 34.79% / 125.98 KJ/m^3 and 34.58% / 124.60 KJ/m^3 for eucalyptus, mixture of cow dung/eucayptus and cow dung respectively. Temperature recorded during the period was between 29.1^{o}C - 32.1^{o}C. This research has shown that biogas produced from eucalyptus has substantial methane content than cow dung and mixture of cow dung/eucayptus.

Key words: *Eucalyptus camaldulensis*, composition, biogas, cow dung.

INTRODUCTION

The use of fossil fuels as primary energy source has led to global climate change, environmental degradation and human health problems (Adeniran *et al.,* 2014). Also, improper waste management is one of the major problems confronting every development. This is because increase in industrial, commercial, agricultural and environmental activities has resulted in the generation of large quantities of wastes (Adeniran *et al.,* 2014). These wastes, when not properly managed contribute to unhygienic environmental conditions that breed pathogenic microorganisms (Ogbene *et al.*, 2019). Apart from the health implications, wastes make an environment unpleasant and unattractive. However, these wastes can be managed properly by conversion into useful and more environment-friendly forms called biogases. Biogas typically refers to a gas produced by the breakdown of organic matter in the absence of oxygen (Anunputtikul and Rodtong, 2004). It is a renewable energy source, like solar and wind energy. Furthermore, biogas can be produced from regionally available raw materials and recycled waste and it is environment friendly and carbon IV oxide (CO_2) neutral. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material, and crops (Kaygusuz and Kaygysuz, 2002).

Biogas is a flammable gas produced when organic materials are fermented under anaerobic condition (Sagagi *et al.,* 2009). It contains methane and carbon (IV) oxide with traces of hydrogen sulphide and water vapor. It burns with pale blue flame and has a calorific value of between 25.9-30J/m^3 depending on the percentage of methane in the gas. The gas is called by several other names, such as: dung gas, marsh gas, gobar gas, sewage gas and swamp gas (Dangoggo and Fernando, 1986). In biogas production, the conversion of complex organic matter to methane and carbon dioxide is possible mainly by the actions of different group of microorganisms, with the microbial community of biogas comprised essentially of bacteria and fungi and other groups of protozoan (Idi *et al.,* 2020) The essential microbial complex is comprised of hydrolytic bacteria, fermenting bacteria, acetogenic bacteria and methanogenic bacteria and these groups of microorganisms have been reported to establish synthrophic relationships where the later members of the food chain depend on the previous for their substrate but may also have significant metabolic products (Eze and Agbo, 2010).

A non-dispersive infrared sensor (NDIR sensor) is a simple spectroscopic sensor often used as a gas detector. It is non dispersive in the sense of optical dispersion since the infrared energy is allowed to pass through the atmospheric sampling chamber without deformation. The main components of an NDIR sensor are an infrared source (lamp), a sample chamber or light tube, a light filter and an infrared detector. The IR light is directed through the sample chamber towards the detector. In parallel there is another chamber with an enclosed reference gas, typically nitrogen. The gas in the sample chamber causes absorption of specific wavelengths according to the Beer–Lambert law and the attenuation of these wavelengths is measured by the detector to determine the gas concentration. I.e. The gas is pumped (or diffuses) into the sample chamber, and gas concentration is measured electro-optically by its absorption of a specific wavelength in the infrared (IR). The detector has an optical filter in front of it that eliminates all light except the wavelength that the selected gas molecules can absorb. (Korotcenkov, 2013)

Eucalyptus camaldulensisDehnh is widely planted as an exotic in many parts of Nigeria. It is the most widely planted tree species in semi-arid and arid environments it is very strong, durable and useful timbers which can be put to a wide variety of uses. Much attention has been focused on biomass from grass. However, *Eucalyptus* species is one of the most promising types of cellulose feedstock for biogas production due to its high cellulose content (Yu *et al*., 2010). In addition, these biomasses do not form human and animal food sources. *In Nigeria, it is largely grown for the production of fuel wood, poles and posts and also in mixture with other tree species such as Azadirachta indica (Neem), for the establishment of shelterbelts. (*Midgley *et al., 1989).*

MATERIALS AND METHODS

Samples Collection

Cow dung was collected in a clean bag from Kofar marke area of Sokoto and transported to Sokoto Energy Research Center, Usmanu Danfodiyo University Sokoto, Nigeria. *Eucalyptus camaldulensis. Dehnh* waste was collected in a clean bag from Savanna Forestry Research Station Samaru – Zaria, Kaduna Stateand transported to Sokoto Energy Research Center, Usmanu Danfodiyo University Sokoto, Nigeria where it was sun dried for 7 days and pulverized into powder using mortar and pestle (Galbe M. and Zacchi G. 2007).

Pretreatment of Eucalyptus Waste

The grinded powdered sample of the Eucalyptus waste was put in a polythene bags and buried underground for 14days to mesorize (Nnaji 2015).

Preparations of Slurry

Three thousand gram (3000 g) of fresh cow dung was mixed with 3000 ml of water in a ratio of 1:1. The mixture was agitated thoroughly. One thousand gram (1000 g) of pulverized Eucalyptus was mixed with 5000 ml of water in a ratio of 1:5. For the mixture, one thousand five hundred grams (1500 g) of the fresh cow dung and five hundred grams (500 g) of pulverized eucalyptus was mixed with 4000 ml of water in a ratio of 2:4. All were agitated thoroughly and transferred into separate digesters (10 litters) and tightly covered with silicon sealant and araldites to create anaerobic condition. Each sample was replicated 3 times (kigozi *et al.* 2014), (Sagagi *et al.,* 2009) and (Akhator *et al.,* 2016). pH of the slurries was also taken before and after digestion.

Measurement of Biogas Production

Volume of biogas production was measured using measuring cylinder by water displacement method. Mean values of weekly biogas production were taken as shown in plate 1, together with the temperature variations for 6 weeks' retention time (Oghenefejiri *et al.,* 2016).

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Plate 1: Set- Up of Locally Made Rubber Digesters

Non Dispersive IR Gas Analysis

Biogas samples (4000cm^3) were collected using two urine bags (2000cm^3) that were connected to two separate digesters for each of the three samples and was taken to Department of Chemical Engineering, Ahmadu Bello University, Zaria for NDIR analysis using Gas Analyzer (Gasboard-3100P). The analyzer measured concentration of CO, CO2, CH4, H2 and O2 in the sample simultaneously and also calculated caloric value automatically.

Gas analysis was carried out according to manufacturer's instruction, where biogas sample was pumped into the sample chamber and gas concentration was measured electro-optically by absorption of specific wavelength in the infrared (IR). The IR light was directed through the sample chamber towards the detector. The detector has an optical filter that eliminates all light except the wavelength that the selected gas molecule can absorb. Ideally other gas molecules do not absorb light at this wavelength, and do not affect the amount of light reaching the detector. The detector measures the attenuated signal depending on the amount of gas absorption and it is proportional to the measured gas concentration (Barati 2017) and (Rajaefar *et al.,* 2017).

Analysis of Variance

The data collected were subjected to ANOVA using Minitab 17 and mean differences in total gas yield were separated using least significant difference (LSD) at P<0.05 level which shows there is no significant difference in the volume of biogas produced from cow dung, eucalyptus and mixture of cow dung/eucalyptus

RESULTS AND DISCUSSION

The result obtained from the biogas production as shown in Table 1, indicates that highest biogas yield recorded was from cow dung (6376.34cm^3) at week 3, followed by Eucalyptus waste (2383.33cm^3) at week 4 and then mixture (2259cm^3) at week 3. This trend shows that the production potentials of the samples differ, which is in agreement with the work of Baki, *et al.,* (2004) and Arinze, *et al.,* (2005). Low biogas yield recorded from eucalyptus waste could be due to high lignin content and the nature of the substrates. However, low biogas yield observed in the first week for cow dung, first and second week for eucalyptus and mixture could be due to lack of activity of methanogenic bacteria and at those weeks the development of such bacteria was not completed. The volume of biogas yield for Mixture at week four start decreasing unlike other samples which could be due to mixing effect from the two different samples. Similarly, at 5th week, a decline in the biogas yield was recorded and this is due to the lower activity of bacteria which results due to shortage of ingredients needed for it survival.

Table 1: Weekly Biogas Produced (cm^3)

Retention time (weeks)	Cow dung	Eucalyptus	Mixture	Average Temp. (^0C)
1	53.67±0.08	NGP	NGP	29.1
2	2950.33±0.99	NGP	134.33±0.35	31.1
3	6376.34±8.56	681±0.14	2259±0.14	31.5
4	36±0.11	2383.33±4.12	1700±0.00	30.6
5	NGP	622±75.0.36	1700±0.14	31.2
6	NGP	93.67±0.17	NGP	32.1
Total	9416.34	3780.00	5793.33	

Results are mean of triplicate ± SD; NGP= No Gas Production

Result of ANOVA (Two way) for the biogas produced as shown in Table 2 revealed p-value as 0.346 which is greater than (0.05), hence there is no significant difference ($P<0.05$) in the biogas yield from the three different samples, thus the volume of biogas produced from the three samples are the same.

Table 2: Analysis of Variance (ANOVA) for Biogas Produced

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Period (WK)	5	29005487	5801097	7.74	0.000
Sample	2	1628037	814019	1.09	0.346
Error	46	34498521	749968		
Lack of Fit	10	34494723	3449472	32696.42	0.000
Pure Error	36	3798	106		
Total	53	65132045			

Different gases are produced during the production of biogas from cow dung, Eucalyptus and mixture, the gas analyzer (Gasboard-3100P) used has the capacity of detecting only five different gases, and these include: CO, CO_2 CH_4, O_2 and H_2 as shown in table 3 below. Biogas generated from Eucalyptus leaves recorded highest methane content (53.35%) which is the target composition and lowest come from cow dung (34.58%). which is in agreement with the work of Joao, *et al.,* (2011). This could be due to the nature, and composition of Eucalyptus species. The gas analyzer (Gasboard-3100P) also measured calorific value of the biogas.

Table 3: Percentage Composition of Some Gases in the Biogas Produced

Sample	Percentage composition (%)			
	CO	CO_2	CH_4	H_2
Cow dung	0.03	9.97	34.58	0.46
Eucalyptus	0.26	11.48	53.35	0.00
Mixture	0.00	10.84	34.79	1.11

The results as obtained from the NDIR Gas analyzer as shown in Table 4 indicates higher heating values of the biogas produced from *Eucalyptus camaldulensis. Dehnh* (249.58KJ/m^3) and lowest from Cow dung (124.60KJ/m^3). The Eucalyptus leaves contain highly nutritious rich organic substances that are suitable for sustaining microbial life in an anaerobic fermentation process, and transform substrates into biogas. These results were in accordance with the work of Joao, *et al.,* (2011). High caloric value is due to high methane content from the biogas produced from Eucalyptus, and this shows the potentiality of biogas generated from Eucalyptus leaves as a cooking gas.

Table 4: Caloric Values of Biogas Production from the Substrates

Sample	Caloric value (KJ/m^3)
Cow dung	124.60
Eucalyptus	249.58
Mixture	125.98

pH of the sample is another factor that affects biogas production. pH value is of paramount importance especially during digestion to provide enable environment for the production of the biogas. Table 5 shows the pH values before and after of the substrate samples. However, the optimum pH range for biogas production has been reported as 6.0 – 7.8 before digestion and 5.6 – 7.8 after digestion. (Garba and Sambo 1992). Based on this the results of pH as shown in table 5 above indicates the samples used in this research were having pH which provides favorable environment for effective bio digestion of the substrate. The pH values were in agreements with the work of Garba and Sambo (1992).

Table 5: pH values of the substrates

Samples	Before digestion	After digestion
Cow dung	7.12±0.01	5.14±0.01
Eucalyptus	7.83±0.01	6.73±0.01
Mixture	6.71±0.01	5.79±0.01

Results are mean of triplicate ± SD

CONCLUSION

Total volume of biogas recorded for 6 weeks' retention time were (9416.34cm^3), (5793.33) and (3780.00cm^3) for cow dung, mixture and eucalyptus respectively, indicating that all the substrates used in the study were good candidates for biogas generation. Furthermore, ANOVA (Two way) for the volume of biogas produced revealed *p*-value as 0.346 hence no significant difference ($P<0.05$) in the biogas yields recorded for the three different substrates. ND-IR analysis revealed high methane content and caloric value from eucalyptus (53.35%) (59.65Kcal/m^3) and least from cow dung (34.58%) (29.78Kcal/m^3). This has shown the quality of biogas generated from leave litters of *Eucalyptus camaldulensis. Dehnh is superior compared to other subtrates used*. pH of the substrates recorded were within the recommended value of 6.0 – 7.8 before digestion and 5.6 – 7.8 after digestion. This has proven the noble potentiality of the said plant as source of biogas which has not been well exploited in the study area.

RECOMMENDATIONS

The use of biological waste materials is receiving attention for their effectiveness in biogas production because of less or zero emission of carbon. Therefore, based on this research, the following further works are recommended:

1. Research on the applications of biogas produced by the substrates.
2. More research on the activities of microorganisms that perform the action of biodegradation during biogas production.
3. Large scale production of efficient digesters, cylinders and burners for domestic activities
4. Similarly, based on the observations and encouraging results from this research, use of Eucalyptus wastes for biogas generation should be given more attention in areas where the wastes are in abundance.

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CLIMATE CHANGE AND THE FUTURE OF APPLE PRODUCTION (*MALUS DOMESTICA*): CASE OF MARONDERA DISTRICT, MASHONALAND EAST PROVINCE, ZIMBABWE

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ABSTRACT

This paper analyses the potential impacts of climate change on apple production in Marondera District, Zimbabwe. The Climate Change Wizard online tool was used to make historic and mid-century projections on temperature (ºC) and precipitation (mm) the major drivers of crop production in the country. The A2 scenario extracted from Special Report on Emission Scenarios (SRES) was used. The scenario was run using four different models to project monthly outputs. The model outputs were related to the observations made on the flowering of an 18year old apple orchard. It was observed that the flowering season for the apple cultivars is commencing earlier than previously. The projections show an increase in annual precipitation, increasing mean monthly maximum and minimum temperatures. Marondera will thus be characterized by hot summers and warmer winters as shown by increasing minimum temperatures around May to August. The increasing temperatures will make the environment unsuitable for apple production in the near future. It will also have a negative impact on the expansion of apple production in the country as region one is also shrinking due to climate change.

Key words: climate change, apples, temperature, precipitation, projections, flowering

INTRODUCTION

Modern satellite data suggest that about 50-83 % of the land surface has been physically transformed by human activities (Bologna, 2008). Global warming has been attributed to human induced activities, which include the production and use of fossil fuels and land use (UNFCC, 2008). The warming of Earth's climate is clear as evidenced from increases in global average air and ocean temperatures, sea level rise and melting of ice and snow in the arctic (IPCC, 2007). Reports on current scientific research indicate that projected events are becoming more likely than before.

The current climate records for Zimbabwe, shows some considerable spatial and temporary variability which have been characterized by no specific trends in rainfall patterns, intensities and distribution (Unganai 2009). There has been an increase in the occurrence of extreme weather events, the cyclones (Eline and IDAI) and droughts (Mutasa 2008) across the country. Records from July 2012 from the Zimbabwe Met Offices recorded temperature as low as -3ºC (http://www.chronicle.co.zw/) in May when the maximum effect of winter is normally expected in June and July. Zimbabwe as compared to other African countries is highly vulnerable in the world due to widespread poverty and limited coping strategies (UNFCC, 2007). This is because Zimbabwe is heavily dependent on rain fed agriculture and climate sensitive resources (Chaguta, 2010).

The country was divided into five agro ecological regions based on rainfall patterns rainfall patterns and crop productivity (Vincent and Thomas, 1960). Agro-ecological zones, as defined by FAO (1978), are land areas representing unique combinations of homogenous agro-climate, ecology, soil units and agricultural activities Natural Region I (NRI) covered approximately 2% of the land area and had the highest rainfall. It was an area of specialized and diversified farming with plantation forestry, fruit and intensive livestock production with tea, coffee and macadamia nuts being grown in frost-free areas. Natural Region II (NRII) covered about 15% of the land area, receiving lower rainfall than Region I. Nevertheless, it was suitable for intensive farming based on crops or livestock production. The remaining natural region from III to V covered a range of farming from semi-intensive farming to extensive respectively. However, current studies on Zimbabwe's agro ecological regions indicate a shift in the agro-ecological zones, which has been attributed to climate change (Zimbabwe Meteorological Services Department, 2002; Chikodzi *et al.,* 2013). The increase in temperatures and unreliable rainfall has seen the shrinking of NRI and NR11 and the expansion of NRIII. Stations like Chinhoyi, Chibero and their surroundings previously in NRII were moved to (NR III) Government of Zimbabwe (2020).

Apples best grow where temperatures do not rise above 25°C for them to have a good flavour. In Zimbabwe these temperatures are best approximated in Nyanga. However, NRII, specifically Marondera, has the potential for apple and other deciduous fruit tree production in the country by virtue of its cooler climate. Apple and any other fruit research in Zimbabwe are relevant to support the countries' food and nutrition policy which was launched May 2013, horticulture recovery plan 2020. The Policy aims to ensure adequate food and nutrition security in Zimbabwe for all people at all times. Statistics show that one out of every three children is chronically malnourished, 25% of all deaths of children under the age of five are attributed to nutritional deficiencies and 47% of women are anemic.

Apple *(Malus domestica/Malus pumila),* Maepuru [S], Ama Apula [N] is classified under the group of pome fruits in the same family with pears and quince. Apples have a dormant winter period that requires cold temperatures for the tree to properly break dormancy in spring. Apples are grown from late winter (July to August) blossom and harvested from November through to late March in Zimbabwe. The fruits require a period of chilling (exposure to temperature of 7.2°C) during the winter period for them to flower adequately. Varieties that require 500 or less of chilling hours for them to flower are called low chilling requirement apples. These cultivars are best suited in areas such as Marondera, Rushinga, Domboshawa, Harare and areas with similar microclimates. The cultivars that need chilling hours of 500 to 800 hours are called medium chilling requirement apples, while those that require 800 to 1200 chilling hours are called high chilling requirement apples.

There has been some positive progress in Nyanga lately as reported by the Apple Association of Zimbabwe (www.freshplaza.com) that apple farming has changed the lives of people with about 170ha under production, about1 200 individuals employed and about 8000 households being supported. Past studies on apples by the Horticulture Research Institute also proved that Marondera was a site closely comparable to Nyanga and could be exploited for apple production. It was also proved high chilling apple varieties could thrive in Marondera, though with special treatment of dormancy breaking chemicals such as Dormex (mineral oil) or winter oil (DNOC 3%) in June/July. The main objective of this study was to assess the potential impact of climate change on the future of apple production in Marondera District, Zimbabwe.

MATERIALS AND METHODS

Study Area: Climate change projections were made for Marondera, Mashonaland East Province of Zimbabwe. Marondera is in the highveld, latitude 18° 11' longitude 31° 28' E. Marondera is classified under Natural region IIb at an altitude of 1630 - 1800m above sea level. The observations were done at the Horticulture Research Institute (HRC). Historically the province was characterised by a subtropical climate, which was well suited for the cultivation of wide range of temperate and sub-tropical crops. The average minimum temperatures range from 5.1°C to 14.2°C in January. HRC has a mean average day-length of 13.2 hours in summer to 11.1 hours in winter. HRC is also characterised by ground frost during the months of June and July with sporadic devastating frosts occurring in September. Rainfall averages 873 mm per year, temperature mean maximum are form 19.5°C (July) to 24.6°C (January). Hot summer is between September and December. October is the hottest month of the year with maximum temperatures above 30°C.

Modeling: The Climate Change Wizard Application (Nature Conservancy 2009) was used to make projections. The wizard allows the user to choose a country or state and both access how climate has changed over time and to project what future changes are predicted to occur in a given area. Users can view historic temperature and rainfall maps from anywhere in the world, view future prediction of temperature and rainfall around the world based on scientifically vetted model projections and view and download climate change maps.

A polygon was drawn on the map to pre-define Marondera district. Parameters to be used for projections were selected, the monthly temperature and precipitation. The historical projections were averages during 1961-1990 period and future projections were made for the mid-century period from 2046-2065. The A2 emission scenario (IPCC 2007) was used. The A2 scenario family describes a very heterogeneous world were the underlying theme is self-reliance and preservation of local identities. In this analysis, four different models, GFDL-CM2.1, IPSL-CM4, MICROC3.2, and CGCM3.1 were run to come up with an ensemble average. The models are from

USA, France, Japan and Canada respectively. It has been observed that when a number of models are used, the average of these models performs better than any individual model (Santer *et al*., 1990).

Projections were made on:

i. Average low temperature
ii. Hottest temperature ºC
iii. Coldest temperature ºC
iv. Number of cold days (% of time that daily maximum temperature values are below the reference period (1961-1990).
v. Number of cold nights
vi. Number of warm days
vii. Number of warm nights
viii. Total Precipitation, rainfall mm

An inventory of apple cultivars growing in Marondera was created at HRC in 2008 taking note of the name, origin, physical and fruiting characteristics. A total number of 26 apple cultivars were observed over a period of 6 years from 2008 to date. Since the trees were old (about 18 years), observations were made only on the time of flowering as they had already reached their full yield potential. Early apple varieties we had Anah, Mayan, Elah and Michal of Israeli Origin. These cultivars normally flowered from the 4th week of July getting onto full bloom in the 1st week of August. Yields ranged from45-50 kg per tree (Anna and Mayan) and about 50-60 kg/tree (Ellah).

Table 1: Apple cultivars observed at HRC and their origin, flowering times, fruiting times and total yield (kg) per tree of the high chilling apple cultivars

High chill apple cultivars (sprayed with a dormancy breaking hormone for them to induce bud break)			
Golden Delicious	West Virginia, USA	1st week of October to 3rd week of October	**Fruits:** From October to February **Yield:** 60 to 90 kg/tree
Fuji	Japan	1st week of September to 4th week of September	**Fruits:** From September to February **Yield:** 60- 80 kg/tree
Mollies Delicious	Europe	1st week of September to 4th week of September	**Fruits:** From September to February **Yield:** 50-60 kg/tree
Jomured and Starking	Europe	1st week of September to 4th week of September	**Fruits:** From September to February **Yield:** 25-30 kg/tree
Royal gala	New Zealand	3rd week of September to 1st week of October	**Fruits:** From October to February **Yield:** 50-60 kg/tree
Goldjorn and Primicia	USA	1st week of September to 4th week of September	**Fruits:** From September to February **Yield:** 20-30 kg/tree
Majorie pie	USA	1st week of September to 4th week of September	**Fruits:** From September to February **Yield:** 30- 45 kg/tree

RESULTS

Apple observations

Overally the observations made indicate early flowering across the different cultivars. The trees go into flowering about two weeks earlier than their historic performance. The flowering season has shrunk by about 2-3 weeks for all the cultivars. The low chilling cultivars continue to come into flower first and the high chilling last. There is however a decrease in the number and quality of flowers during the season especially for the high chilling varieties. This has resulted in reduced fruits per tree and thus low yields.

Modelled Results

The total projected annual precipitation for the mid -century is expected to increase to 923mm from 912mm. The monthly precipitation is evenly spread with the winter season receiving the least precipitation. The projected monthly rainfall shows a decrease from September to December as compared to the historical average. It is projected that the highest mean monthly precipitation will still fall in January (225mm) showing an increase from the historical average (213mm).

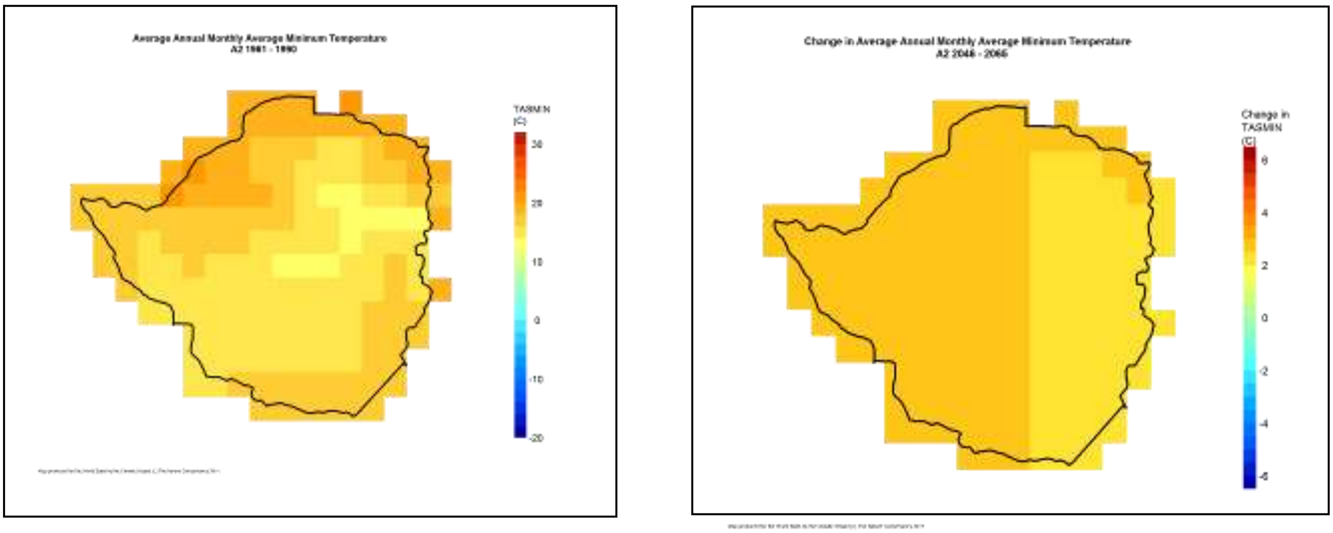

Figure 5: The historical and mid-century mean minimum temperature (ºC) projections for Marondera district

There is an overall increase in the minimum and maximum temperatures as we progress into the mid -century. The historical mean maximum annual temperature is projected to increase by about 2.7 ºC to 26.60 ºC. October will be the hottest month with about 30 ºC. The historical mean minimum annual temperature is projected to increase by about 2.46 ºC in the mid-century to 14.01 ºC. It is projected that the historical month receiving lowest minimum temperature will shift from June to July (Figure 3). The increase in temperatures is also illustrated in (Figure 2) as shown with the gradation from the lighter yellow colouration to deep orange.

The historical minimum temperature for June, July and August was 6.63 ºC, 5.80 ºC and 7.78 ºC respectively. Minimum temperature projections for the same months show an increase to over 8 ºC. The number of cold days, (% of time that daily maximum temperature values will be below the reference period is projected to decrease from 10% to between 2-4%. The number of cold nights (% of time that daily minimum temperature values will below the reference period is projected to decrease from about 10% to between 1 -3% for all the months. The decrease by 1% takes half the proportion.

DISCUSSION

The increasing winter minimum temperatures for June, July and August to over 8 ºC by mid-century has got negative impacts on apples because they need to be exposed to temperatures below 7.2 ºC for bud break. The increasing annual precipitation is good for apple production and other agricultural crops. However, both increasing temperatures and precipitation can increase the incidences of pests and diseases on apples. Studies in India have shown an increasing number in sprays from 4 -12 per year to control pests resulting economic loss (Signh and Sharma, 2016). With a warmer climate, the region will shift more to the production of sub-tropical fruits rather than temperate fruits. The high chilling requirement apples will not perform well under a warm environment even with special chemical treatments because they would not have received enough chilling to trigger bud break. Such environmental cues may result in misalignment between flowering, pollination and fruiting. Although the projected minimum monthly temperatures will be warmer the chilling hours in other instances will be triggered by extreme events such as the scenario recorded in Marondera in July 2012. The minimum temperatures went as low as -3ºC during early winter. These low temperatures can trigger the low chilling varieties to flower early because they would achieve enough chilling earlier. However, these flowers are prone to mid to late winter temperature extremes which will most times destroy the early flowers before fruiting.

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CONCLUSIONS AND RECOMENDATIONS

From the observations and model projections, it can be concluded that in the near future most apple cultivars growing at the Horticultural Research Centre might fail to thrive. The critical parameter of minimum monthly temperature during winter May to August might fail to meet the requirements needed for achieving enough chilling hours sufficient for bud break. Apples need to be exposed to a temperature of About 7.2 ºC for chilling.

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ASSESSMENT OF HEDGE PLANT NEEDS AND MANAGEMENT FOR CLIMATE RESILIENCE IN TARABA STATE, NORTH-EAST NIGERIA

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ABSTRACT

The survey of hedge plants status and management was carried out Taraba State, in 2006, with the aim identifying the nature, promoters, effects, management practices in the face of increasing climate change. Two hundred structured questionnaires were distributed in six local government areas to elicit relevant information with 83 % return rate. Simple statistics and percentage were used to analyze the data. Results showed that Majority were male (74.4 %) and single (56.9 %), aged 20-30 years old (41.4 %), followed by teenagers (24.8 %) most of whom were applicants (38.8 %) or civil servants (33.3 %). About 97 % are literate, majorly NCE/HND and Secondary school leavers. Horticultural flowers, trees and shrubs were planted by 46.3 %, 38.3 % and 15.4 % of the respondents respectively for beautification and landscaping (47.3 %) and protection of boundary (25.5 %). A higher number of sampled persons planted 1-3 types of hedges (35.5 %), raised from stem cuttings (40 %) and seedlings (37.0 %) at the cost of N20-200/ propagule (85.5 %). Challenges facing hedgerow plants were majorly insect pest, drying out of the plant and fire outbreak as indicated by 32.9 %, 26.2 % and 18.3 % of the respondents respectively. This basic management practices of pruning and watering during dry season were carried out by 79.4 % and 62.6 % respectively. With the involvement of the educated youths and economic potential of raising seedlings, enhanced hedgerow planting culture could be sustained with minimal adverse effect of climate change in the study area.

Key words: Hedge plants, climate, resilience, management

INTRODUCTION

Climate change is a challenge of global dimension that continues to reduce the resource base of any ecology quantitatively and qualitatively. Working against nature, in terms of deforestation for urbanization and industrialization with several fallouts from such unmitigated practice aggravate climate change. Tree planting, afforestation, reforestation and hedge planting are part of the remedies. A hedge is a well arranged shrubs and/or shrublets or short trees, similar species, planted closely together to give a linear strips of vegetation that perform a variety of valuable functions, in a blended scenario where individuality gives way for integrated view of plant set (Hessayon, 1992; Brun and Dinius, 2015). Wilton *et al*. (2014) identified nine sustainable ecosystem services of hedge plants that guarantees a) improvement in water quality, urban air quality, crop water availability, crop pollination, shelter provision for crops and livestock on one hand and b) mitigating flood risk, soil loss/erosion, crop pest impact, climate change on the other hand.

Hedges are known to store more carbon than cropped land mitigating climate change. Trees store more carbon than shrubby hedges because of greater above ground biomass than shrubs and add more carbon into the soil through higher leaf and small branch litter fall. Carbon is sequestered both in woody growth above ground and in roots, leaf litter and other soil organic matter at and below ground level. To have any significant impact upon greenhouse gas levels, carbon needs to be locked up within the hedges and soil over the long-term (Devon, 2014). Hedge plants serve for protection, enhanced security, wind breaks, privacy screens, environmental beautification and management; they make public parks and houses more conducive for relaxation and enjoyment (Okunlola, 2013; Armstrong, 2000; Okunlola, 2013, Mathews *et al*., 2014). After the establishment of hedges plants, maintenance requires watering, weeding, trimming/pruning. The efficiency of hedge plant in playing above-mentioned roles depend on to hedge structure, hedge density, woody species and age. (Devon, 2014)).

In the study area, little information is available on the types, nature and potential of hedge plants to deliver the afore-mentioned soil-water-environmental sustainability services, hence the need to survey the state, for hedge plant need, management practices and challenges which will help the planers and environmentalists harness potentials of hedges for better livelihood.

MATERIALS AND METHODS

Taraba state was zoned into four based on agro-vegetation criteria which could affect hedge plants performance: Semi-temperate zone of Mambila plateau, Forest zone, Southern zone and Northern zone. Six local government areas: Jalingo, Lau, Sardauna, Gassol, Donga and Kurmi were selected. Data were collected with questionnaires, distributed randomly and proportionately to Jalingo, Sardauna (40 each); Gassol, Donga, Kurmi and Lau (30 each) giving a total of 200, out of which 166 were retrieved. Analysis was based on total response to each item and expressed in percentages.

Socioeconomic characteristics of Hedge Plant Users

Table 1 shows socioeconomic characteristics of respondents using hedge plants in Taraba State. A good number (41.4 %) were 20-30 years old, followed by teenagers (24.8 %) and those between 30-40 years. Beyond teen age, the percentage of people that planted hedge plants decreased with age. Fewer older people were involved. Majority were male (74.4 %) and single (56.9 %). About 38.8 %, 33.3 % and 13.9 % of the respondents were applicants, civil servants and farmers respectively. Traders were the least involved. Ninety-seven percent of the respondents have acquired one form of education or the other. The order NCE/HND >Secondary > ND > Degree >Primary > Illiterate was observed. The higher involvement of youths, male, singles and unemployed reflected quest for aesthetic surrounding, high energy and time required for the establishment of the hedge plants which adults, including older farmers and traders could not afford.

Table 1: Socioeconomic characteristics of respondents using hedge plants in Taraba State

Variables	Groups						Total
Age (yrs)	<20	20-30	30-40	40-50	>60		Total
N	39	65	34	16	3		157
%	24.8	41.4	21.7	10.2	1.9		100
Gender		Male		Female			Total
N		122		42			164
%		74.4		25.6			100
Occupation	Farmer	Trader	C. servant	Yet to emp.			Total
N	23	14	55	64			165
%	13.9	8.5	33.3	38.8			100
Marital Status		Single		Married			Total
N		91		69			160
%		56.9		43.1			100
Education Q	Illiterate	Primary	Secondary	ND	NCE/HND	Deg.	Total
N	5	11	36	27	68	17	164
%	3.0	6.7	22.0	16.5	41.5	10.4	100

Status of hedge plants

The status of hedge plants, utilization, management and challenges in Taraba State is presented in Table 2. Horticultural flowers, trees and shrubs were planted by 46.3 %, 38.3 % and 15.4 % of the respondents respectively for beautification and landscaping (47.3 %), protection of boundary (25.5 %), feeding livestock (17.0 %) and privacy screening (10.3 %) within a compound. Ornamental hedges are a very important part of environmental beautification and management; they make public parks and houses more conducive for relaxation and enjoyment (Day and Loveys, 1998; Okunlola, 2013). Other usage of hedge plants includes provision of shelter/shade for individuals/ family (36.4 %) and construction of local buildings (31.5 %). Its industrial potential of raising electric poles was the least (11.1 %). About 21.0 % sourced fire wood from the hedge plants around them.

Most hedge plants are raised from stem cuttings (40 %) and seedlings (37.0 %). Less than 25 % of the respondents raised theirs from seeds and leave. This reflects the possible low survivability and unavailability of seeds and leave propagules. Most hedge plants are propagated vegetatively. Propagation of hedges by cuttings is an and common technique in horticultural science (Odusanya *et al.*, 2019). Hedge plant choices based on their ease of propagation and early establishment is recommended. Successful

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seedling establishment is largely dependent on the capacity of seedling to rapidly initiate roots (Anthony and Douglass, 2005). Rooting through asexual methods of propagation is commonly used (Manica *et al*., 2000; Awan *et al*., 2012; Qadri *et al*, 2018). Haider *et al*. (2015) reported the rate of multiplication through cuttings is higher than for any other vegetative propagation techniques, with the exception of micro-propagation.

About 39.9 % and 28.2 % of the respondents indicated that private sellers and government institutions were the major sources of propagules, followed by friends (19.6 %). Higher percentage of the respondents (43.7 %) paid N20-30/ propagule, while 20.9 % each paid N50-100 or N100-200/propagule. This shows the potential of hedgerow plant propagule as viable business. A higher number of sampled persons planted 1-3 types of hedges (35.5 %), followed by those that planted 3-4 types (24.5 %). The plot size hedged were majorly 2 plots (37.9 %) and 3-5 plots (27.3 %). This was closely followed by those having < 1 plot (19.3 %). The low percentage of individuals that hedged large plots (11.8 %) reflected ownership; amount of planting materials required. Small to moderate plots are easier to be hedged in comparison with large plots. The number of stands/area was in order 20-50 (41.9 %) > less than 20 > 50-100 > 100-200 >500 > 200-500. With about 69.4 % planting <= 50 stands/plot reflected plot size, hedge type and plant spacing. The diversity and density of hedgerow plants reflected needs, purpose and establishment requirements (Haider *et al*., 2015).

Challenges facing hedgerow plants were majorly insect pest, drying out of the plant and fire outbreak as indicated by 32.9 %, 26.2 % and 18.3 % of the respondents respectively. This basic management practices of pruning and watering during dry season were carried out by 79.4 % and 62.6 % respectively. This could be attributed to the nature of hedge plants and scarcity of water (Heritage, 2021). Water is required by plants all year round but mainly between April and the end of September. Trees, shrubs and hedges planted less than five years ago require water to encourage root growth into the surrounding soil to enable the plants to establish and flourish.

Established trees, shrubs and hedges do not generally need watering because they have far spread roots and it is best if they can reach and survive on their own through rainfall. Excessive drought conditions could result in slow growth rate, leaf drop or even die-back so watering in these extreme circumstances is recommended (Odusanya *et al*., 2019). A good number depended on rainfall. About 66.5 % protected the hedge plants using chemical method with insecticide, while 33.5 % used biological method. The reflected the strategic handling of the most important challenge, insect pest that can easily be controlled with synthetic chemicals.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Most hedge plants are horticultural flowers, trees and shrubs were planted by 46.3 %, 38.3 % and 15.4 % of the respondents respectively. Beautification and landscaping (47.3 %) and protection of boundary (25.5 %) were the main purposes. A higher number of sampled persons planted 1-3 types of hedges (35.5 %), raised from stem cuttings (40 %) and seedlings (37.0 %) at the cost of N20-200/ propagule (85.5 %). Challenges facing hedgerow plants were majorly insect pest, drying out of the plant and fire outbreak as indicated by 32.9 %, 26.2 % and 18.3 % of the respondents respectively. This basic management practices of pruning and watering during dry season were carried out by 79.4 % and 62.6 % respectively. Government should provide insecticides, education on managing fire outbreak and dry season maintenance to general populace at local and state levels for harnessing the potentials of hedgerow plants in the study area.

Table 2: Status of hedge plants, utilization, management and challenges in Taraba State

Variables	Groups						Total
Types of hedges	Shrubs	Tree	Flowers				Total
N	25	62	75				162
%	15.4	38.3	46.3				100
Purpose	Protection	Privacy screen	Beautification	Feeding animals			Total
N	42	17	78	28			165
%	25.5	10.3	47.3	17.0			100
Use	Fire wood	Local building	Electric pole	Shelter			Total
N	34	51	18	59			162
%	21.0	31.5	11.1	36.4			100
planting material	Seed	Stem	Leave	Seedling			Total
N	28	66	10	61			165
%	17.0	40.0	6.1	37.0			100
Sources of propagules	Friend	Govt. Inst.	Private Seller	Around			Total
N	32	46	65	20			163
%	19.6	28.2	39.9	12.3			100
Price of propagules	N10	N20-30	N50-100	N100-200	>200		Total
N	17	69	33	33	6		158
%	10.8	43.7	20.9	20.9	3.8		100
Number of hedge types /user	1	1-3	3-4	5	>5		Total
N	23	55	38	21	18		155
%	14.8	35.5	24.5	13.5	11.6		100
Land area	< 1 plot	2 plots	3-5 plots	5-10 plots	>10 plots		Total
N	31	61	44	6	19		161
%	19.3	37.9	27.3	3.7	11.8		100
Stands /area	< 20	20-50	50-100	100- 200	200 – 500	>500	Total
N	44	67	28	11	3	7	160
%	27.5	41.875	17.5	6.875	1.875	4.375	100
Problems	Fire	Insect	Drying out	Leave Shed	Tree Fall		Total
N	30	54	43	23	14		164
%	18.3	32.9	26.2	14.0	8.5		100
Pruning		Yes		No			Total
N		127		33			160
%		79.4		20.6			100
Watering in dry season		Yes		No			Total
N		102		61			163
%		62.6		37.4			100
Hedge protection		Chemical method		Biological method			Total
N		107		54			161
%		66.5		33.5			100

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AN ASSESSMENT OF THE CAUSAL FACTORS OF CLIMATE CHANGE ON FOOD SECURITY: THE WAY FORWARD IN NIGERIA

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ABSTRACT

This paper examines an assessment of the causar factors of climate change and food security. The discursed on climate change and food security have been a major concerned among other global environmental challenges in recent time. Climate change is more to natural than anthrpogenic factors. There exists a corrolation between climate climate, food production and food security and sustainable development of these variables. The differential in food production and pace of food security from region to region is a function of the level of science and technology, innovation and development of the nations involved in food production in commercial scale. The objectives of the paper are to examine the causar factors of climate change and food security and these 2 indices constitutes the conceptual issues of the the study. The study revealed that climate change is caused by both natural and anthrpogenic factors and food security is a function of a combination of factors such as: the quantum of food production, demand and supply for agricultural products, nature of science and technology, innovation and development. The study, therefore, recommends that on climate change, there should be the need for human interferance and control of the effects of: burning and less dependence fossil fuels, greenhouse gases, depletion of ozone layer, environmental degardation, rise in carbon dioxide concentration and practice of afforestation of the earth atmosphere while on food security there is the need for: absolute security in Nigeria on life and property, increase in food production via commercial agriculture, marketing and improved storage facilities, scheme on comparative cost advantage, improved technology, flood control, government incentives and improved budgetry allocation on agricultural products for sustainable development of the teeming population of Nigeria.

Key words: Assessment**,** Causar Factor, Climate Change, Food Security, Nigeria and Way-Forward.

INTRODUCTION

At present the concerned of environmental consultants, health practitioners and agricultural scientists in recent time is how to combat the ramvanging threats of climate change, food production and food security among other environmental challenges as pollution, waste management, erosion, flood, health and increase in human population among other global challenges. Climate change results from changes in climatic variations of the indices of high temperature and global warming (Oyediran *et al*., 2001; Wright and Nebel, 2002; Orimoogunje, 2010). It has been recognized that climate change is a global problem of unique character that could affect every aspect of life on the planet. Secondly, it issues reach far beyond atmospheric and ocean science and thirdly, it issues are increasing pivotal in determining environmental and economic well-being. Furthermore, no matter the level of uncertainties in the knowledge of the characteristics and future trends of climate, climate change and sea level rise will have significant impacts globally, regionally and locally creating problems for sustainable development and resource management (Oyediran *et al*., 2001; Wright and Nebel, 2002; Orimoogunje, 2010; Fadejin, 2010; Agbebaku, 2016). At a global view, while some regions produced food surplus due to their pace of science and technology, innovation and advancement, others produced food deficits owing to their levels of development, financial aids, innovation and level of insecurities. To this end, while areas with harvest surplus have the technology to preserved and ensures food security and sustainability of their agricultural products, the reserves in the case in areas with poor technology and low production and insecurity challenges (Gradi *et al*., 2015; Olayiwola and Arowosegbe, 2021; FAO, 2021). However, in a broad perpecstives, these inadequacies in food in security could be attributed to natural and anthropogenic factors. Food security has been a challenge to primary producers of agricultural crops and government mainly in the developing nations in recent time in the last two decades (Olayiwola and Arowosegbe, 2021). This could be due to a combination of factors such as: (a)poor technology, (b)weak marketing board, (c)inadequate commercial farming, (d)insecurity, (e)envioronmental degradation, (f)epidermic (g)poor human attitude, (h)annual fire outbreak (i)poor government intervention and assistance, (j)poor budgetry allocation, (k)soil infertility (i)differentials in climatic variables among other variables (Ayoade, 2002; Ajadi, Adeniyi and Afolabi, 2011; Olayiwola and Arowosegbe, 2021).

For instance, in Nations such as the United State of America and Sweden, 15% and 9% respectively of their population goes into agriculture and they produced surplus and export for sustainbale development for their teeming population and future use because they have the technology, engaged in research, engaged in commercial production, government assistance and above all have a scheme for agricultural production in place. In essence, the aimed of food security on agricultural crops is the ability to preserved and stored the harvested products without scarity for present and future demands and supply and at a-fixed price whenever the supplied of these products are demanded. But the reverse of these benefits and measures cannote be said in developing Nations in general and Nigeria in particluar as the food supply cannote be guarantee in as much as the price and security of the farmlands where these items area coming from. In addition to these challenges is the issue of: (a) poor technology, (b) less research and development, (c)land tenure challenge and sustenance production, (d) poor government assistance (e) poor scheme on agricultural production and (f)insecurity among others (Oyediran *et al*., 2001; Gradi *et al*.,2015; Clucas *et al*.,2018; Olayiwola and Arowosegbe, 2021). However, there exists a correlation between climate change and food production and food security as the combination of the indices of a favorable climatic conditions enhances food production and possibly food security and vice-versa. There is no doubt that climate plays a crucial role in foof production and harvest of these products needs to be protected for sustainable uses and development hence the concerned of food security accrossed the globe to meet and equate with the demand and supply of these product with the ever increasing population (Orimoogunje, 2010; Olayiwola and Arowosegbe, 2021; FAO, 2021). In view of the above, there is the need for the cross-examination of the causar factors of climate change and food security in Nigeria and examines the ways forward. This informed the reason for this research as the research gap is meant to ascertain the causar factors of climate change and food security and examines ways forward in Nigeria. In order to achieve this, the sole objective of this paper is to examine the causar factors of climate change and food security in Nigeria.

MATERIALS AND METHODS

This paper is purely an experimental survey and a combination of content analysis of articles from journal publications and field survey. The study utilises evidence mainly from secondary sources and observed information from field survey. Primary information was sourced from established survey of literature. Secondary data were sourced mainly from existing literature, academic journals, conference papers, theses, internet materials and archival sources. In a nutshell, secondary data will be sourced from documentary materials from established sources. The descriptive and purposive sampling techniques was used for this study.

CONCEPTUAL ISSUES

Climate Change: This connotes changes in the indices of climatic variables of the earth atmosphere. This concept is used to explain changes in the earth’s climatic system like the theories of polar wandering and continental drift, relief hypothesis, carbon dioxide and variations in polar radiation. In view of these theories and models, climate change is mainly concerned with changes due to an increase in average atmosphere temperature. The incessant features of desert encroachment, glacier melting, irregular wind and wave patterns, environmental in-balance and challenges, tsunamis, drought, overflow of riverbank, epidermis-outbreak and ocean surge are clear indicators that the ecosystem is affected by climate changes. Climate change is a function of environmental challenges and in-balance in the ecosystem (Oyediran *et al*., 2001; Ayo, 2009; Thomas, 2009; Amina, 2013; Agbebaku, 2016). In another perspective, climate change is attributed directly or indirectly to human impact and activities that alters the composition of the physics and chemistry of the global ecosystem and of the natural variability observed over some comparable time periods (IPCC, 2017 as cited by Thomas, 2009). It is now a global concern that the impact of climate change today has been speed up due to increase in human population and spread of socio-economic activities such as; (a) industrialization, (b)agriculture, (c)commerce and mining, (d) technology and (e) man’s quest for comfortability and sustainable development. At the global level, climate change wound directly or indirectly affect (i)food production, (ii) human health and (iii) envioronmental degradation such as: erosion and floods, wind and wave pattern, drought and desertification, settlement and pollution spread among others (Oyediran *et al*., 2001; Ayoade, 2002; Ayo, 2009; Amina, 2013; Agbebaku, 2017).

Food Security: Agriculture was the most important sector in Nigeria before independence in 1960. It accounted for more than 50% of the GDP and more than 75% of export earnings. However, in recent time and due to persistence increase in population growth and the need to sustain the growing population, most agricultural lands have been taken over or reduced for cultivation of agricultural crops hence the inflation of food price, food scarcity and food insecurity. To this end, where the few havested crops are cannot be guaranttee of their presevation owing to poor storage facilities or where government fails to do the needful to meet future demand and supply the challenge of food security comes to play (Ajadi *et al*., 2011; Gradi *et al*., 2015; Agbebaku, 2015; Clucas *et al*., 2018; Olayiwola and Arowosegbe, 2021).

CAUSAL FACTORS OF CLIMATE CHANGE ON FOOD SECURITY

Climate Change: The studies of Oyediran et al (2001), Ayo (2009 as cited by Thomas, 2009), Cunningham and Cunningham (2015) and Agbebaku (2017) revealed that the combination of burning fossil fuels, excessive heat, increase in average temperature, greenhouse gases, heat waves and global warming are major determinants and causar factors of climate change globally. In Africa and Nigeria in particular, hot weather and high temperature as well as wind and wave variabilities are added factors to these global threats in recent time. On the other hand, global warming is caused by deficiencies of greenhouse gases, depletion of ozone layer, dependence on fossil fuel, rise in carbon dioxide concentration and the practice of deforestation. Findings have revealed that global warming is a global phenomenon and experienced in all regions of the globe. For instance, while climate change is caused mainly by the combination of the indices of high temperature and global warming such as the long-term deleterious effects of burning fossil fuels, excessive heat, increase in average temperature, greenhouse gases, heat waves, deficiencies of greenhouse gases, depletion of ozone layer, dependence on fossil fuel, rise in carbon dioxide concentration and the practice of deforestation of the earth atmosphere. Studies have revealed that global warming is largely anthropogenic and there have been a steady rise in used of fossil fuels by man in the past few decades and this have caused an increase in the earth's temperature causing to climate change. Studies have revealed that in the next two decades (probably between 2030 and 2050) that climate change is expected to cause approximately 250, 000 additional deaths per year due to the effect of global warming. These can be felt from the incessant cases of malnutrition, malaria, diarrhea and heat stress. Climate change signified more danger to developing nations like Nigeria and others. These have resulted to about 75% of epidermis diseases or disasters related deaths and environmental challenges of the ecosystem (Wright and Boorse, 2011; Thomas, 2009; Ayo, 2015; Agbebaku, 2017).

Food Security: Studies have revealed that a combination of factors such as (a)urban growth and development (b) attitude of youth towards farming, (c) insecurity (d) land tenure/fragmentation system (e) environmental degradation, and (f) poor government aids to farmers are some of the major reasons and challenges responsible for food insecurity in Nigeria. For instance, the challenge of urban growth and development have drastically reduced the sized of farmlands majorly in human settlement habited areas thereby assembling pressure on agricultural products. There has been a shift of the attitude of youths towards farming as most of them ends up doing white-collar, skilled and miniate jobs as against farming. Furthermore, the indequacies of government to do the needful via: provision of presevation or storage facilities, agricultural loans, fertilizers, chemicals, herbicides and subsisdies as well as the activities of insecurities on the land via; kidnapping, banditary, boko-haram and fulani herdmen are added advantages to reduction in food production hence the threat of food security in Nigeria (Ajadi, Adeniyi and Afolabi, 2011; Gradi, Panagos, Van Liedekerke, Bosco and Brogniez, 2015; Olayiwola and Arowosegbe, 2021).

EFFECTS OF CLIMATE CHANGE ON FOOD SECURITY

Climate Change: Scientists have projected that the effects of climate change could cause the polar regions of the Northern Hemisphere will heat up more than other areas of the planet, and glaciers and sea ice will shrink as a result of global warming. However, the effects of climate change could be observed where (a) storms are expected to be more frequent and more intense in a warmer world. Water will also evaporate more rapidly from soil, causing it to dry out faster between rains. Some regions might actually become drier than before.

Overall, higher latitudes are projected to receive more rainfall, and subtropical areas are projected to receive less (b) weather patterns are expected to be less predictable and more extreme. Storm tracks are projected to move toward the poles, shifting wind, rainfall, and temperature patterns. Heat waves will continue to become more frequent and intense, a trend already observed. Hurricanes, violent storms that draw their force from warm ocean water, are likely to become more severe. The intensity of hurricanes has already increased (c) warming temperatures are already causing significant changes to mountain glaciers around the world, ice sheets in Greenland and the Antarctic, and polar sea ice in the Arctic. From Europe to Africa to Asia to North America, mountain glaciers have receded over the 20th century, and melting is becoming more rapid (d) as the atmosphere warms, the surface layer of the ocean warms as well, expanding in volume and thus raising sea level. The melting of glaciers and ice sheets, especially around Greenland, further swells the sea. Rising sea level will complicate life in many island and coastal regions. Storm surges, in which winds locally pile up water and raise the sea, will become more frequent and damaging. Erosion of cliffs, beaches, and dunes will increase (Oyediran et al, 2001; Thomas, 2009; Ayo, 2009; Cunningham and Cunningham, 2015; Agbebaku, 2017; IPCC, 2017).

In the past two decades in Lagos, Nigeria, studies have revealed that the Bar Beach on Victoria Island has been experiencing ocean surges, flooding kilometers of residential and commercial estates and destroying valuable properties. In addition, the recent flood disasters of 2012 from the over flows of Ladgo Dam in Southern Cameroun into Nigerian rivers and land masses caused more havoc of environmental degradation and challenges in the country. The menace from the flooding covered about 2/3 states in Nigeria, the floods lasted for about two months in some parts of the country. The aftermath effects were the loss of human life, property, agricultural farm lands and products. In addition, there were severe cases of soil erosion, and collapse of socio-economic activities among others that worth trillions of naira. The National Emergency Management Agency (NEMA) states that Nigerian lost about N2.29 trillion to damages caused by these widespread flood in recent time. Findings further revealed that over 3.8 million persons were displaced. The agency further stated that the estimated loss was equivalent to 1.4 per cent of Nigeria Gross Domestic Product. From that incidence 363 deaths were recorded, 5,851 injured, 3,891, 394 people were affected and 3,891,530 were displaced (Owuru, 2012; Ige, 2012; Okechukwu, 2013; Agbebaku, 2015, 2017).

Food Security: In Nigeria, 53% of the population are engaged in agriculture practices yet there is deficit in food production, supply and presevation hence the challenge of food security and dependence on foreign supply to meet with demand. In addition to these indices is the issue of insecurity of their farmlands as well as the citizenry themselves. Agricultural system, food production and security at globe scale is in-line with the climatic patterns and variables of weather and climate of the area. The positive variables such as: (a)humidity (b)trosposheric temperature (c)temperature over ocean (d)sea surface temperature (e)ocean heat content and (f)temperature over land to climate change results to tropical agricultural systems while the negatives variable such as: (a)sea ice (b)snow cover (c)glaciers results to temperate agricultural system. In most states of the North, the positive has led to environmental inbalance, inadequate water and poor soil nutrients for crop cultivation. These effects have resulted to dry and hard nature of the soils (red ferralite), rainfall hardly seeps into the soil due to high temperature but flows across the surface. The implications are the consistent use of traditional and systematic methods, mechanize-irrigation and use of fertilizer applications to revamp the soil nutrient to increase agricultural output. The variation in climatic patterns led to the ease of the production of cereals crops and animal husbandry in the region. In Southern region, the differential in soils (hydro-morphic and juvenile) and climatic patterns have led to variance in crops production as more of roots and tuber crops are cultivated in the region. In addition to these challenges are poor technology on crops presevative measures, poor seedlings, insecticides and herbicides subsidices and annual floodings (Thomas, 2009; Fadejin, 2010; Ige, 2012; Ayo, 2014; Gradi *et al*., 2015).

THE WAYS FORWARD FOR COMBATING CLIMATE CHANGE AND INCREASE IN FOOD SECURITY IN NIGERIA

Climate Change: Though climate change is more of natural than anthropogenic factors. But there should be the need for human interferance on the control of the effects of: (a) burning and less dependence fossil fuels, (b) greenhouse gases (c) depletion of ozone layer (d) control rise in carbon dioxide concentration and (f) practice of afforestation of the earth atmosphere.

Food Security: There is the need for: (a) absolute security in Nigeria (b) increase in food production via commercial agriculture, marketing and improved storage facilities (c) scheme on comparative cost advantage (d)improved technology (e) flood control (f)government incentives and improved budgetry allocation on agricultural products for sustainable development of the teeming population of Nigeria.

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IMPACT OF ENVIRONMENTAL INTERACTIONS ON TEA PRODUCTIVITY IN THE CHANGING GLOBAL CLIMATE

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ABSTRACT

Tea (Camellia sinensis) is an important beverage crop cultivated in the tropics and subtropics. Tea production impart meaningfully on the economy of several tea-producing countries in Africa and the world generally. Environmental holdbacks, particularly water deficiency due to inadequate or poorly distributed rainfall, limit tea productivity in most of the tea-producing countries in the world. Both atmospheric and intracellular CO2 concentrations are greatly influenced by stomata conductance, which is highly responsive to water availability. Consequently, the CO2 available for assimilation is determined by leaf water status, giving a clear picture about the interrelationship existing between whole-plant photosynthetic capacity and water availability. Agrochemicals with chemical fertilizers used on tea plantations kill many soil-borne beneficial flora and fauna. It has therefore been predicted that global climate change will furthermore have a considerable adverse impact on tea production in the near future. Exhaustive resolution of increasing concerns regarding the quality of tea in this changing climate therefore lies mainly in the effective management of the various environmental conditions that directly or indirectly affect tea productivity.

Key words: Tea, productivity, environmental interaction, climate

INTRODUCTION

Tea (*Camellia sinensis*) belong to the family *Theaceae* and was discovered by the Chinese around 2700BC. It's the most expensively popular nonalcoholic beverage consumed in the world, ranked second after water as the most consumed drink globally and cultivated in 5continents in the world. Besides being a traditional beverage, tea has a more significant role as a health drink. It is produced in 50 countries, with major producers being China, India, Kenya, Sri Lanka, Vietnam, Turkey, Indonesia and Iran. There are over 200 species reported so far of which tea plant is the most economically important. Presently, world production of tea stands at 5.56 million tons, with plantation coverage of 3.80 million hectares (Chen *et al.*, 2007; FAO 2014).

The tea plant is an evergreen woody/bush plant which when under cultivation, is kept at a low level to facilitate harvesting the young shoots, the part from which tea beverage drink is made. The crop attains a height of up to 15 m in the wild. In cultivation, however, the tea plant is maintained at 0.6-1.0 m tall to facilitate harvesting of the leaves (Famaye *et al.*, 2006; de Costa *et al.*, 2007).

Tea has a productive lifespan of over 100 years, but its peak production period is between the 30th and 50th year and can also be grown in low land and high land. Commercially grown teas are hybrids of two distinct ecotypes: The Assam-type (var. *assamica*) and the China-type (var. *sinensis*). The tea plant (*Camellia sinensis*) leaves are light green, short stalked, coriaceous, alternate, lanceolate, serrate margin, glabrous or pubescent beneath, varying in length from 5 - 30cm and about 4cm width. Flowers are white fragrant, 2.5 - 4cm in diameter, found in solitary or in clusters of two or four. Flowers bear numerous stamens with yellow antherand produce brownish red capsules. Fruit is a flattened, smooth, rounded trigonous three celled capsule, seed solitary in each, size of a small nut ((FAO, 2014; de Costa *et al.,* 2007).

ENVIRONMENTAL REQUIREMENTS FOR TEA PRODUCTION

Environmental and climatic conditions determine the rate of shoot expansion and tea yield. Various components of the environment influence the growth and productivity of tea to a different extent in Nigeria. Light, carbon(iv)oxide (CO_2) concentration, temperature and water availability are the most important factors determining tea productivity.

Effect of light environment

The rate of photosynthesis in fully expanded mature leaves of tea shows an asymptotic response to increasing light intensity. Reported values for saturating light intensities range from 600-800 $\mu molm^{-2}s^{-1}$up to 1200-1500 $\mu molm^{-2}s^{-1}$of photosynthetic active radiation. The genotype environment interaction, the effect of light supply, and the stages of the pruning cycle are factors responsible for such variation. This declines during the latter part of the pruning cycle in parallel with an increase in dark respiration rate (Mohotti, 2004).

In a greenhouse experiment, the optimum light intensity for CO2 assimilation was lower for young growing leaves (250 μmolm^{-2}s^{-1}) than that for mature leaves (500 μmolm^{-2}s^{-1}). Because the tea plant originated as an under-storey plant in tropical rainforests, its photosynthetic apparatus is adapted to function with maximum capacity under shade condition. Parameters such as photosynthetic light capture, electron transport, photochemical and non-photochemical energy quenching and carboxylation have shown that the entire photosynthetic apparatus of the tea plant is shade-adapted. The optimum shading level for tea yield is 30-40% (Gamage *et al.*, 2007).

Effect of CO_2 concentration

Variation in the atmospheric CO2 concentration is at least averagely responsible for the spatial and temporal leaf differentiation in tea. In addition, it's important for determining the productivity of tea in response to long-term climate change. A positive, linear correlation has been observed between instantaneous and CO2 concentration. Photosynthesis can be raised temporarily up to 40-60 μmolm^{-2}s^{-1}by CO2 enrichment up to 1500 μmolmol^{-1}around 30 μmolm^{-2}s^{-1}is reached at 1000-1200 μmolmol^{-1}(intracellular CO2) in mature field-grown tea. The corresponding values for young greenhouse-grown tea are 7-10 μmolm^{-2}s^{-1}and 500-600 μmolCimol^{-1}, respectively. The CO_2 response curve of mature field-grown tea is dependent on the shade and harvestable shoot supply levels (Mohotti, 2004).

Apart from the effect of atmospheric CO_2 concentration, intracellular CO_2 concentration is also greatly influenced by stomata conductance, which is highly responsive to water availability. Consequently, the CO2 available for assimilation is determined by leaf water status, and thus the whole-plant photosynthetic capacity is interrelated with water availability.

Effect of temperature

The growth of the tea plant is highly affected by temperature ranges. Tea productivity is sensitive to increased average monthly temperatures, and sustained periods of higher temperatures reduce tea yield. Tea grows well within an air temperature range of about 18-25ºC. It has also been reported to survive within the range of 18-40ºC. Air temperatures below 13ºC and above30ºC have been found to reduce shoot growth. With increasing temperature above the threshold to the optimum temperature, shoot initiation rate increases and thereafter decreases with a further temperature rise up to the maximum value. The threshold temperature for tea shoot extension has been found to vary from 2-7ºC to 15ºC. Interestingly, threshold temperature for shoot extension is 2-3ºC higher than that for shoot initiation and development (de Costa *et al.*, 2007).

The thermal duration determined the growing of tea buds and it need to accumulate about 150ºC-days above a threshold temperature of 12.5ºC to expand the leaves and 450-500ºC-days to produce a harvestable tea shoot. This parameter is needed to determine plucking rounds for different periods of the year. The thermal duration requirement for producing a harvestable tea shoot (three leaves and a bud) varies from 330-370ºC-days at high elevation to 500-600ºC days at low elevation in Sri Lanka (de Costa *et al.*, 2007).

Water availability

Tea growth is mainly controlled by water availability. Drought is responsible for a 14-20% reduction in yield and 6-19% mortality of tea plants. In addition, under drought conditions, photo-inhibition could reduce source capacity and thereby impose a source-limitation on tea productivity. Although the total annual rainfall in most of the rain-fed growing areas is sufficient for tea production, its uneven distribution throughout the year often limits annual tea yield. Under such conditions, the distribution of rainfall throughout the year is distinctly bi-modal due to the seasonality of monsoons and, consequently, these areas experience a continuous dry period of about 2-3 months (Cheruiyot *et al.*, 2008).

In temperate regions that experience less than adequate rainfall, tea plantations must receive additional water from irrigation. Soil water is responsible for shoot extension, leaf area, stem diameter, internode elongation and the numbers of lateral branches of woody plants, including tea, are greatly influenced by soil water deficits. Water uptake is mainly determined by the maximum rooting depth and the water available within the root zone. Tea is generally considered to be a shallow-rooting plant. Wind also have effect on some of the tea-growing regions, especially at high altitudes, experience periods of high wind speeds during certain times of the year. High wind speeds generally tend to increase transpiration rates from extensive tea canopies and thereby accelerate the development of soil water deficits during dry periods. To counter these adverse effects of high wind speeds, wind breaks and shelter belts consisting of several rows of different tree species are being used in tea growing areas. However, reducing wind speed by sheltering increases canopy resistance to water vapour. Daytime temperature of the canopy increases (by 1-2ºC) because of the greater resistance to heat transfer from the canopy to the surrounding air (Carr, 2000; de Costa *et al.*, 2007).

Therefore, sheltering is beneficial for tea plants growing in cooler regions where atmospheric temperature is closer to the threshold temperature for shoot growth, under irrigation and in areas with significant advection of hot dry air onto tea fields from the surrounding areas. Air humidity also have a high ambient vapour pressure deficit also reduces shoot growth in tea even when the soil is irrigated. The critical vapour pressure deficit affecting the growth of tea shoots has been reported to be about 1.2-2.3kPa. Usually, shoot extension is less sensitive to dry weather than leaf expansion. The ambient exerts a significant influence on the transpiration rate of a crop by controlling the water vapour pressure gradient between the leaf sub-stomata chamber and the outside air. A greater leaf-air vapour pressure deficit results in a higher transpiration rate and consequently decreases (Vadez *et al.*, 2014).

Use of Agrochemicals

The chemical inputs applied on tea plantations have had a deadly effect on soil biodiversity while simultaneously polluting river water, killing fish, and harming the animals and people who depend on the rivers for water. Agrochemicals used on tea plantations kill many of the microorganisms that live in soil. Studies have shown that as much as 70 percent of soil biota has been lost on tea plantations as compared to nearby natural habitat, especially in areas that workers and machinery pass over. The use of chemical fertilizers has resulted in a decline in soil fertility. Pesticides used include synthetic pyrethroids, which is quite toxic to fish and downstream organisms (Senapati *et al.*, 2002).

Degradation of Soil

Researchers have found that tea plantation soil contained between one-third and one-half the number of earthworms per square meter as the nearby natural forest soil. However, most earthworms found in tea plantations were not native species to the area (Senapati *et al.*, 2002).

Soil degradation includes factors that reduced cation exchange (a measure of a soil's ability to hold stores of nutrients and release them to plants), reduced water absorption and retention, increased acidity of the soil, nutrient leaching, and accumulation of natural toxins from tea leaves which can begin to alter microorganism soil communities (Senapati *et al.*, 2002),

CONCLUSION

The tea plant very sensitive to prevailing weather conditions across the globe. There are some specific environmental/soil requirements needed for its cultivation and productivity. Besides other environmental factors, CO2 concentrations are greatly influenced by stomata conductance, which is highly responsive to water availability. The CO2 available for assimilation is as a result, determined by leaf water status, giving a clear picture about the interrelationship existing between whole-plant photosynthetic capacity and water availability. In addition, under drought conditions, photo-inhibition could reduce source capacity and thereby impose a source-limitation on tea productivity. Agrochemicals and chemical fertilizers used on tea plantations kill many soil-borne beneficial flora and fauna. Holistic resolution of increasing concerns regarding the quality of tea in this changing climate therefore lies mainly in the effective management of the various environmental conditions that directly or indirectly affect the crop's productivity.

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AWARENESS OF THE ENVIRONMENTAL USE OF CASHEW IN IBADAN METROPOLIS: A CASE STUDY OF AGBOWO-BODIJA

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ABSTRACT

One of the pressing environmental issues affecting the world is climate change. Studies have shown that trees provide shading and cooling effects thus leading to a reduction in the accumulation of carbon dioxide (CO_2) in the atmosphere. The study accessed the awareness of Ibadan residents on the environmental benefits of cashew. Agbowo-Bodija was purposively sampled because of its dense population and climate condition that is favourable for the propagation of cashew. A total of 60 respondents were used for this study and vital information on their socio-economic characteristics was collected using well-structured questionnaires. Descriptive statistics were used to analyze the data collected. The result shows that the majority of the respondents are youths (81%) with men of 33.87, the male gender is predominant in the study area (55%) and all the respondents (100%) have a form of formal education. The awareness result shows that majority believes the climate is changing as a result of carbon emission and deforestation. All the respondents believe the tree helps the environment but 34% have no idea where to get cashew seed or seedlings. It is therefore important to encourage schools and institutions to educate people on urban afforestation. CRIN should enlighten people on the environmental use of cashew trees in urban areas and how to get improved cashew seed/seedlings.

Key words: Cashew, environment, awareness, climate change, urban area

INTRODUCTION

Cashew (*Anacardium occidentale L.*) is a tropical tree crop (Nair, 2010), wildly known species of the Anacardiaceae family (Subbarao *et al*., 2011) which is commercially cultivated for its wood, apple and most especially the nut (Adeigbe *et al*., 2015). It is a perennial and evergreen fruit tree with a wildly spread canopy (Toschi *et al*., 1993) which makes it a suitable shade plant. Besides being a shade plant, it also serves as an ornamental tree that is wildly used to control soil degradation (Elijah, 2015). The cashew apple is a rich source of a composite mix of antioxidants, glucose, mineral salts organic acids and vitamin C which is about 4 to 7 times higher than orange (Campos, 2002). It has been observed that consumption of cashew nuts helps in the prevention of cancer, diabetes, weight gain, gallstone, migraine and some heart disorders (Vyavahare *et al.,* 2020). The cultivation of the cashew trees preserves and restores the environment. The planting of cashew is a sustainable remedy for reducing human activities on tree species (Tandjiékpon *et al.,* 2003).

Climate change is gradually rising as one of the most significant universal issues affecting the world (Kangalawe and Lyimo, 2013). Recent studies show that the accumulation of carbon dioxide (CO2) in the atmosphere has increased. CO2 holds heat in the atmosphere leading to an increase in the temperature of the earth surface (Buchdahl, 1999) which contributes to global warming. Besides cooling and shading characteristics provided by tree canopies, rigorous planting of trees to trap CO2 from the atmosphere could help reduce the increasing CO2 accumulation in the atmosphere. Trees are a very important carbon sink and also reduce the effect of climate change in the urban areas thereby controlling the accumulation of CO2 and other atmospheric pollutants (FAO, 2010).

Trees are a principal part of the terrestrial habitat (Lowman, 2009). Trees poise the soil, prevent erosion, control desertification, contribute to climate control and play a major role in the preservation of biodiversity and ecosystem equilibrium (Bellefontaine, 2012). One of the major sources of sustenance in our environment is trees as they provide food, beverages, wood, medicines, wax, fodder, fuel, fertilizers, fibre, rubber and paper (Seth, 2004).

Trees in the urban ecosystem are known to beautify the environment, have a good shade

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effect, releases water vapour to the environment via evapotranspiration, purifies the air and reduce carbon emission problems (Yilmaz, 2007). One of the major ways of reducing the effect of climate change is planting trees around the compound at home, privately owned properties open public spaces (Ferrini, 2014). Deliberate planting of shade trees in home areas have been observed to supply considerable energy, long-run cost savings, provides some health benefits and increasing the general environmental quality of the urban area (Akbari, 2001).

So much attention has been placed on the economic importance of cashew crops with little attention on the environmental benefits of the crop. The multipurpose function of cashew trees, most especially the environmental importance makes it a tree suitable and encouraged to be grown in urban areas. Therefore, the objective of this study is to understand the willingness of households to grow cashew in urban areas.

MATERIALS AND METHODS

The study was conducted in Agbowo-Bodija, Ibadan metropolis of Oyo state. The state lies between the derived savannah and rain forest ecological zone of Nigeria. The study area lies between the latitude 7.376736o N and the longitude 3.939786o E. The average annual temperature is 25.9 °C in Ibadan with about 1467 mm rainfall yearly. The whole Ibadan metropolis comprises 11 local governments and it is the capital city of Oyo state. Agbowo-Bodija was purposively sampled because of its dense population and climate condition that is favourable for the propagation of cashew. Agbowo-Bodija was purposively sampled because of its dense population and climate condition that is favourable for the propagation of cashew. A total of sixty respondents were purposively selected for this study based on their location which is Ibadan. A structured questionnaire containing open-ended and closed-ended items was used to interview the respondents. The socio-economic characteristics were analyzed using descriptive analysis techniques such as frequencies, percentages, mean and standard deviation.

RESULTS AND DISCUSSION

Table 1 shows that the majority of the respondents (55%) are male and the age group of 20-35 years were 81.7%. The mean age is 34 years and this shows that the majority of the respondents in the study area are in their productive age and are economically active. This also implies that the majority of the respondents are youth and are capable of taking decisions on their own.

The majority of the respondents are married (51.7%) and all the respondents have formal education (100%). About 26.7% of the respondents were self-employed, 23.3 percent were privately employed and 23.3% of the respondents are public employed. The implication is that majority of the respondents are productive and in their economic age, the decision to plant cashew can be manifested.

Table 2 shows respondent responses to awareness of environmental benefits of cashew trees and climate change. The majority (96.7%) of the respondents agreed that the climate is changing. 51.7% and 61.7% believed that carbon emission and deforestation respectively are responsible for climate change. All the respondents (100%) know that trees help the environment and they are aware that trees can be planted. The majority of the respondents know all the propagation methods of cashew, however, 56.7% have no idea where to get cashew seeds or seedlings. 60 percent of the respondents are aware of the health benefit of cashew tree bark while 61.7% are aware of the cashew leaf health benefit.

TABLE 1: Socio-economic characteristics of the respondents

Socio-economic characteristics	Frequency	Percentage	Mean	Standard deviation
Sex				
Male	33	55.0		
Female	27	45.0		
Total	60	100		
Age				
20 – 35	49	81.7		
36 – 51	5	8.3		
52 – 67	4	6.7		
Above 67,	2	3.3	**33.87**	**11.89**
Total	60	100		
Marital Status				
Single	29	48.3		
Married	31	51.7		
Total	60	100		
Academic qualification				
Formal	60	100.0		
Informal	0	0.0		
Total	60	100		
Occupation				
Self Employed	16	26.7		
Public Employed	14	23.3		
Retired	5	8.3		
Privately Employed	14	23.3		
Unemployed	1	1.7		
Student	10	16.7		
Total	60	100		

Source: Field survey, 2021

TABLE 2: Selected responses on awareness of Cashew tree and its importance

Do you believe climate is changing?	**Frequency**	**Percentage**
Yes	58	96.7
No	2	3.3
What do you think is responsible for the climate changing		
carbon emission	37	61.7
Deforestation	31	51.7
Source of knowledge on how trees help the environment		
Personal experience	34	56.7
School	43	71.7
Tree planting experience		
Do you know trees can be planted	60	100.0
Do trees help the environment	60	100.0
Do you know where to get cashew seed or seedling?		
Yes	23	38.3
No	37	61.7
Where can you get cashew seed or seedling?		
CRIN (Cocoa Research Institute of Nigeria)	7	11.7
Farmers	10	16.7
No Idea	34	56.7
Would you prefer Cashew seedling or seed		
Seed	17	28.3
Seedling	23	38.3
Both	20	33.3
Cashew health benefits awareness.		
Back	60	100.0
Leaf	37	61.7

Source: Field survey, 2021

CONCLUSION

This study was conducted to assess the awareness of people on the environmental benefits of cashew trees. Cashew as a major cash crop in Nigeria economy has not received the needed attention on the benefits it can accrue to the environment of urban areas and the positive effect it can have on the climate of a densely populated area. Households in urban centres are advised to consider planting cashew trees as this would alleviate the level of environmental degradation in the metropolis and serve as a shade for comfort and recreation. It is, therefore, important to encourage schools and institutions to educate people on urban afforestation. CRIN should enlighten people on the environmental use of cashew trees in urban areas and how to get improved cashew seed/seedlings.

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CLIMATE CHANGE ADAPTATION AND MITIGATION STRATEGIES ADOPTED BY COCOA FARMERS IN CROSS RIVERS STATE AGAINST PESTS AND DISEASES

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ABSTRACT

The survey aimed at understanding the strategies adopted among cocoa farmers in adapting and mitigating the effects of climate change on pests and diseases prevalence in Cross River State. A multi stage-sampling procedure was used to select 60 respondents from Bendeghe Local Government Area (LGA) and 60 respondents from Ikom LGA, both in Cross River State. Results showed that 96% of the respondents are aware that climate change has a negative effect on cocoa production as a result of high incidence of pest and diseases and that the effect ranges from high to moderate. Majority of the respondents in the study area adopted various adaptation strategies to mitigate the effects of climate change on pests and diseases prevalence. High level of awareness, adaptation and coping strategies adopted by farmers made them less vulnerable to the adverse effects of pests and diseases as a result of the change in climate.

Key words: Mitigation, Adaptation, Pests and Diseases, Climate change, Cocoa farmers

INTRODUCTION

Nigeria has a tropical climate with two precipitation regimes: low precipitation in the North and high precipitation in parts of the Southwest and Southeast (Huma, 2019; Nkechi et al., 2016). The impact of climate change on food supply varies significantly by region and the risk is generally believed to be more acute in developing countries (Okeniyi et al., 2021). Over 70% of the country's population is engaged in agriculture as their primary means of livelihood (Shiru et al., 2018; Nkechi et al., 2016). Nigeria climate has been changing, evident in increases in temperature; variable rainfall; rise in sea level and flooding; drought and desertification; more frequent extreme weather events; affected fresh water resources and loss of biodiversity. Agriculture produce in Nigeria is mainly rain fed and unpredictable rainfall variation makes it difficult for farmers to plan their operations (Anabaraonye et al., 2019; BNRCC, 2011). Evidence from literature and past studied has revealed that the present global warming has influenced agricultural productivity leading to declining food production. Oyekale et al. (2009) and Oseni (2011) showed that climate change greatly affects cocoa production both in hot and wet seasons and during irrigation. According to Raufu et al. (2015), three major phases mostly affected by climate change during field operations include nursery seedlings, field establishment and processing phases. However, the level of public awareness on issues related to climate change in Nigeria is considered low (BNRC, 2011). Mitigation and adaptation are the two main responses to climate change, "Mitigation refers to measures that may either reduce the increase in greenhouse emission or increase terrestrial storage of carbon", while adaptation refers to all the responses of climate change that may be used to reduce vulnerability" (Ifeanyi-obi and Nnadi, 2014). Study showed that Nigerian farmers on their own and with the help of governmental and other intervention agencies are already adapting to climate change using several methods (Ifeanyi-obi and Nnadi, 2014). The adoption of existing and new technologies for adapting to climate change and variability is a high priority for many ecological regions in Nigeria. This includes crop diversification, the adoption of drought-tolerant and early maturing varieties of crops, water harvesting for irrigation, mulching of young seedlings (Okeniyi et al, 2021; Halder, 2019). Climate change also affects bio-physiological processes of both the crop and the rate of development of cocoa pests and pathogens which may result in low cocoa yield (Okeniyi et al., 2021).

MATERIALS AND METHODS

The study was carried out in Cross River State. Two high cocoa producing Local Government Areas were selected for the study. Multi-stage random sampling technique was employed in the selection of 120 respondents from the two purposively selected Cocoa producing Local Government Areas. The selected Local Government Areas include Etung and Ikom. Random sampling was used to select two villages from each of the two LGAs (Etung LGA: Bendeghe and Last motor) and (Ikom: Ajassor 1 and Ajassor mission). Thirty farmers were randomly selected from each of the villages making a total of one hundred and twenty

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respondents. Structured questionnaire was used to elicit information from the selected respondents. The information collected from the respondents was analysed using descriptive statistics to describe the socio economic characteristics of the farmers.

RESULTS AND DISCUSSION

The socio-economic characteristics of the respondents in the study area are described in Figure 1. The ages of the farmers ranges between 30 years to over fifty years. Those within the ages of 30 to 50 years were relatively young being 67% of the total population studied while 21% were over 50 years. The implication of this according to Okeniyi et al., 2021, is that the substantial percentage of cocoa farmers in Cross River state are relatively young which is good for cocoa production.

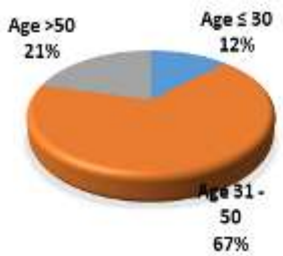

Figure 1: Percentage age distribution of the respondents

75% of the farmers are male while 25% are female this is an indication that men are more involved in the cocoa farming in the study area than the women.

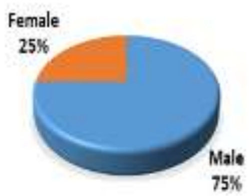

Figure 2: Percentage gender distribution of the respondents

75% of the respondents in the study area are married, 13% single, 8% widowed and 4% divorced. This is a good indication that family labour will be readily available which will reduce the cost of hiring labour.

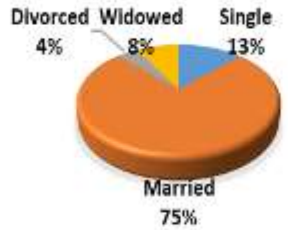

Figure 3: Marital status of the respondents

Majority of the farmers in the study area are 88% are highly experienced on farm work as the proportion has been engaging in cocoa farming for not less than 10 years. Only 12% of the sampled farmers have less than 10 years cocoa farming experience.

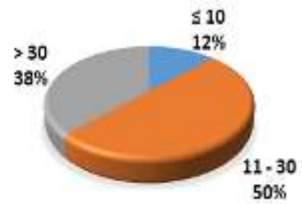

Figure 4: Years of cocoa farming experience

82% of the cocoa farmers in the study area are formally educated though only 17% had tertiary education while 40% completed secondary education. All this are good indicators towards awareness on the effect of climate change and its adaptation.

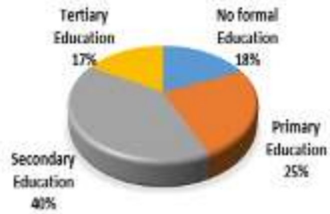

Figure 5: Percentage educational level of respondents

35% of the respondents were of the opinion that climate change resulted in high incidence of pests and diseases, 8.33% believed that the increase in drought experienced was as a result of climate change while 25% understood climate change to have resulted in decline in yield, 18.33% said it resulted into crop failure, 4.17% believed it resulted in excessive rainfall, 23% said it causes high heat waves while 2.5% said it resulted in flooding (Figure 6).

Figure 6: Farmers' perception on climate change

64.2% of the farmers from the sampled area got to know about climate change through radio/television, 19.2% from extension agents, 5% from friends and 11.6% from farmers' association. (Figure 7)

Figure 7: Respondents sources of information on climate change

Result showed that 77.5% of the farmers perceived that climate change negatively imparted on cocoa production while 22.5% perceived the effect to be positive (Figure 8).

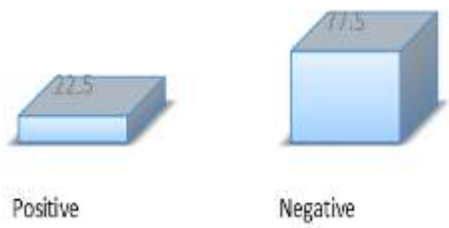

Figure 8: Respondents perception on the effect of climate change on pests and diseases

Effects of climate change on disease prevalence

The result of the study showed that climate change has negatively impacted on Pests and Diseases in the study area. For Black pod disease, 72.1% of the total respondents indicated that change in climate resulted in high incidence of black pod disease, 12.9% indicated that the effect on black pod disease is moderate, 10.4% considered it to be low while 4.6% of the respondents believed the incidence of black pod disease to be low (Figure 9). For Cocoa Swollen Shoot disease, 52.1% of the respondents indicated climate change has no effect on CSSV and so they considered it to be normal. 18.8% believed that climate change had effect on CSSV prevalence but the effect is low, 20.8% considered its effect as moderate while 8.3% indicated that climate change's effect on CSSV prevalence is high (Figure 9). 70.8% of the respondents indicated that the incidence of die back was high as a result of change in climate when compared to the previous years, 10.67% believed that the effect of climate change on die back was moderate, 12.5% considered the effect as low while 6% of the farmers were of the opinion that it was normal (Figure 9). Most of the respondents (64.6%) believed that climate change increased the incidence of Cherelle wilt when compared to the previous years, 15.4% considered its effect to be moderate, 15% considered it low while 5% considered it as normal (Figure 9). For Nematode infection, 32.9% of the respondents believed that infection prevalence increased due to climate change, 29.2% considered it to be moderate, 17.5% considered the rate of infection due to climate change to be low while 20.4% considered it to be normal (Figure 9). 62.5% of the respondents indicated that climate change has greatly influenced the prevalence of stem canker in the plantation, 20.1% considered its effect on Stem canker as moderate 7% believed it prevalence to be low while 10.4% considered the effects on stem canker as normal (Figure 9). Majority of the respondents (72.9%) were of the opinion that climate change had greatly increased the prevalence of yellowing and shedding of leaves in cocoa plantation. 10% of the sampled farmers considered the effect to be moderate, 6.7% considered it as low while 10.4% believed that the rate of yellowing and shedding of leaves remained normal (Figure 9) This report is in tandem with submission of cocoa farmers in Abia State that climate change resulted in high incidence of diseases (Okeniyi et al., 2021).

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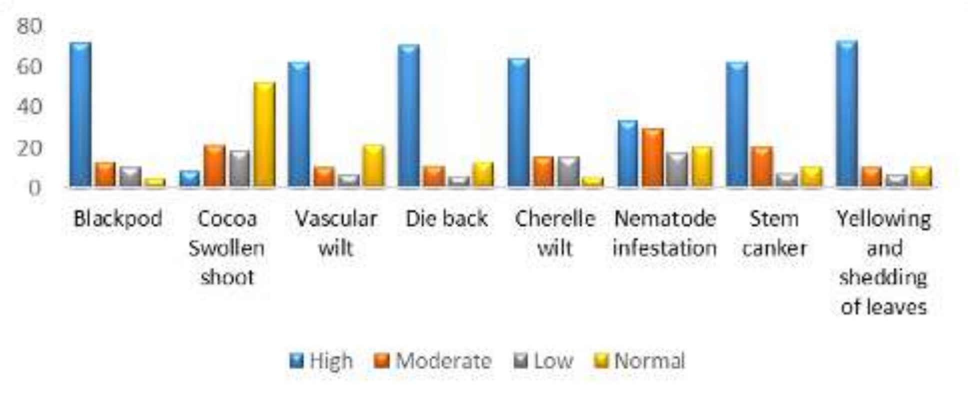

Figure 9: Effects of climate change on Diseases prevalence

Effects of climate change on Pests prevalence in cocoa plantation

67.9% of the respondents indicated that climate change increased the population of Stem borer in the field, 17.1% considered the population has been moderate, 7.5% of the farmers considered it to be low while 7.5% also considered the population of Stem borer due to climate change to be normal (Figure 10). For Pod borer 57.5% of the total respondents were of the opinion that population of Pod borer had increased as a result of climatic change. 25% of the farmers considered the population of Pod borer as moderate, 15.4% considered it to be low while 12.5% indicated that the population of pod borer remained normal (Figure 10). Mirid prevalence due to climate change was considered to be high by 64.6% of the respondents, 18.3% of them considered it to be moderate, 15% of the farmers were of the opinion that Mirid prevalence in the plantation was low while 2.1 % of the total respondents considered it to be normal (Figure 10). 77% of the respondents attributed the prevalence in termite infestation to be due to climate change when compared to previous years, 10% considered the predominance to be moderate, 6.7% believed that termite infestation was low while 6.3% considered it to be low (Figure 10). 64.6% of the farmers indicated that the population of leaf defoliator was greatly increased as a result of change in climate, 15% considered the population of leaf defoliator to be moderate, 18.3 considered it to be low while 2.1% of the respondents believed that the population is normal (Figure 10).

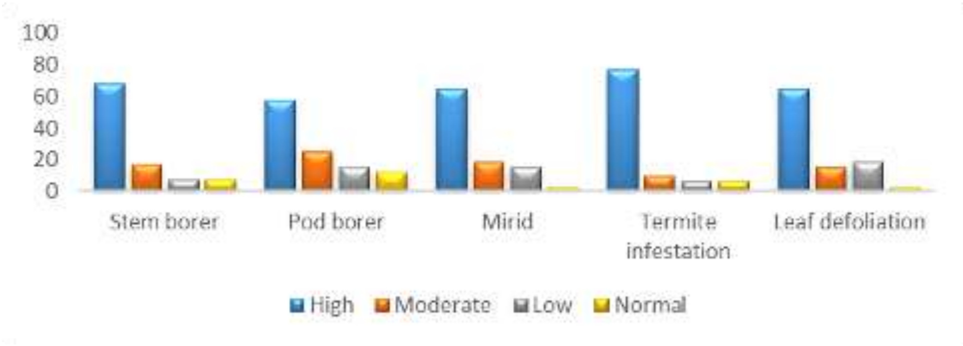

Figure 10: Effects of climate change on Pests prevalence in cocoa plantation

Strategies adopted in mitigating the effect of climate change on Cocoa Plantation

From the result, cocoa farmers in Cross Rivers State adopt different methods to adapt and mitigate the effect of climate during field establishment. 39.2% of the farmers reduced the planting distance in order to ensure that a larger percentage of the seedlings survives. 10.8% of the respondents adopted planting in-situ, 14.2% intercrop with other crops in order to minimize loss, 23.3% planted cassava as shade crop instead of plantain because it is believed that plantain itself cannot survive the effect of climate change. 12.5% of the respondents planted their seedlings in water logged area (Figure 11).

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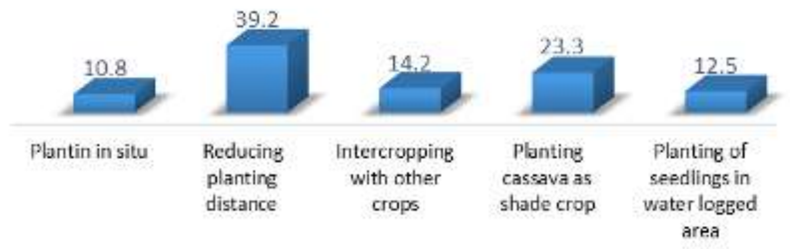

Figure 11: Methods adopted during establishment

Farmers in the study area adopted several methods in mitigating the effect of climate change in their plantation during the farming season. 29.2% harvested rain water for irrigation during the dry period. 25% of the respondents planted drought tolerant cocoa plants, 12.5% mulch the plant to conserve soil water, 10.8% dug well, 5.8% sank borehole while 16.7% conserve soil water (Figure 12).

Figure 12: Adaptation methods adopted by farmers

Mitigation and adaptation methods adopted on the field

In mitigating the effects of climate change on Pests and Diseases among farmers in Cross Rivers State, 35% of the respondents increased the use of chemicals, 16.7% planted resistant varieties, 15% carried out pruning of trees in order to reduce shade, while 25% of the respondents combined more than one chemical during spraying (Figure 13).

Figure 13: Methods for mitigating and adapting to pests and diseases

Most of the farmers in the study area are of the opinion that climate change had greatly affected yield and as such had to mitigate its effect. 33.3% of the respondents applied foliar fertilizer in order to increase yield, 29.2% applied liming, 25% make use of organic amendments while 12.5% of the respondent make use of inorganic fertilizer (Figure 14).

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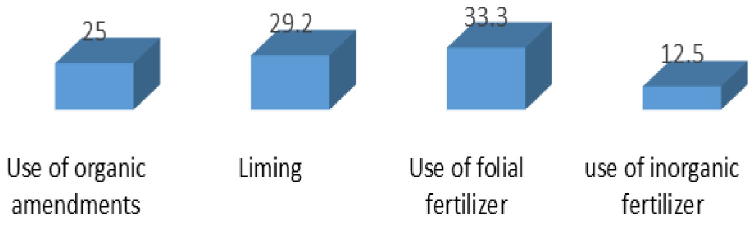

Figure 14: Methods for mitigating and adapting decline in yield

CONCLUSION

This study has revealed the need to incorporate the knowledge and experiences of farmers and indigenous people into the adaptation strategies developed by researchers and disseminate such back to farmers in a more robust way. This will help farmers to develop skills to address the effects of climate change which will allow for more comprehensive measures.

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INTRA AND INTERSPECIFIC INHERITANCE STUDY OF ANTHOCYANIN PIGMENTATION IN THREE SELECTED CROSSES OF EGGPLANT SPECIES

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ABSTRACT

A study to determine the inheritance pattern of purple anthocyanin pigmentation on plant shoot, corolla colour and fruit colour of two eggplant species was undertaken at NIHORT, Ibadan, Nigeria in 2013/14. Three selected crosses comprising of two intraspecific crosses Solanum aethiopicum x Solanum aethiopicum (NHS10-22 X NHS10-83), Solanum melongena x Solanum melongena (NHS10-4 X NHS10-49) and interspecific cross Solanum aethiopicum x Solanum melongena (NHS10-22 X NHS10-49) were generated to obtain their F_1, backcrosses and the F_2 generation. The results obtained showed that all the F_1 plants had purple pigmented shoots and backcrossing to the first parents and Chi-square test of goodness of fit of the F_2 data fit the 1:1 and 3:1 ratio, respectively. The phenotypic expression and segregation of the corolla colour revealed that the F_2 data fits 3 white corolla: 1 white corolla with purple tint colour ratio for the intraspecific cross NHS10-22 X NHS10-83 and 3 purple corolla: 1 white corolla ratio for interspecific cross NHS10-4 X NHS10-49. For fruit colour at physiological maturity, the interspecific cross NHS10-4 X NHS10-49 F_2 data fits 3 purple fruit: 1purple stripped fruit with green/white background and at full maturity the F_2 data fits 3 golden yellow: 1yellow fruit colour. Finally, in this study, the $F_1$and F_2 progenies from the two intraspecific crosses (NHS10-22 X NHS10-83and NHS10-4 X NHS10-49) and interspecific cross (NHS10-22 X NHS10-49) revealed that the mode of inheritance of purple anthocyanin pigmentation on the plant shoot, corolla colour and fruit colour at physiological and full maturity are majorly monogenic and simply inherited.

Key words: Intraspecific cross, interspecific cross, Inheritance, anthocyanin pigmentation, phenotypic expression, segregation

INTRODUCTION

Eggplant is an important vegetable crop in the world and belongs to the Solanaceae family. The fruit is classified as a non-climacteric berry, which can grow to various sizes, shapes and colour depending on the genotype. Violet is one of the most common colours: the result of anthocyanins in the epicarp by the presence of chlorophyll pigments in the layers found under the skin (Daunay *et al.*, 2004). For the exploitation of the potentials and the genetic improvement, the gene- character relationship is essential to plant breeders as genes are the building blocks from which new varieties are developed. In eggplant purple anthocyanin pigmentation is a common decimal in the plant qualitative morphology. Anthocyanins are colored water-soluble pigments belonging to the phenolic group which often give red, blue or purple coloration in plants. Yong et al., 2019 reported the total anthocyanin content in fresh purple eggplant and black eggplant peel to be 2.1 and 3.9 mg/g, respectively. The most common anthocyanin linked to purple pigmentation in eggplant is nasunin which is a potent antioxidant and free radical scavenger that has been shown to protect cell membranes from damage.

The colour of shoots, flowers and fruits is caused by the presence of different kinds of pigment belonging to the phenylpropanoid and terpenoid classes whose three major groups are chlorophylls, carotenoids and anthocyanins (Silvia *et al*., 2009). Anthocyanins are an important group of naturally occurring polyphenolic compounds derived from the phenylpropanoid biochemical pathway (Koes *et al*., 2005). They are members of the flavonoid class of plant secondary metabolites and are soluble pigments. Early genetic studies of anthocyanin coloration in eggplant (Halstead, 1918; Nolla, 1932) deal primarily with genes which control the presence or absence of pigmentation in the fruit. Genes involved in anthocyanin coloration are classified into two functionally distinct groups viz; basic colour genes which are required to be in the dominant condition for the development of anthocyanin in the fruit and modifier genes which are hypostatic to the basic colour genes and which quantitatively or qualitatively alter anthocyanin colour (Tigchelaar *et al*., 1968). The objective of the

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current study was to determine the inheritance pattern of two intraspecific crosses of two species of eggplant and their interspecific cross.

MATERIALS AND METHODS

Between 2013 and 2014, crossing blocks were set up in Vegetable Research field of National Horticultural Research Institute (NIHORT), Ibadan, Nigeria with four parental accessions consisting of two species *Solanum aethiopicum* (NHS10-22 and NHS10-83) and *Solanum melongena* (NHS10-4 and NHS10-49). Two selected intraspecific NHS10-22 X NHS10-83 and NHS10-4 X NHS10-49 crosses and one interspecific NHS10-22 X NHS10-49 cross were generated. The F_1crosses along with their backcrosses and F_2 plants generated were used to examine the inheritance pattern of anthocyanin pigmentation on three selected traits. The phenotypic expression and segregation of purple anthocyanin pigmentation on young shoot plants, corolla flower colour, fruit colour at physiological and full maturity were observed in the generation of the selected crosses

RESULTS

Phenotypic expression and segregation of plant shoot purple anthocyanin pigmentation in generations of three selected eggplant crosses are shown in Table 1. In crosses NHS10-22 x NHS10-83 (*S. aethiopicum* x *S. aethiopicum*), NHS10-4 x NHS10-49 (*S. melongena* x *S. melongena*) and NHS10-22 x NHS10-49 (*S. aethiopicum* x *S. melongena)*, all the F1 plants had purple pigmented shoot and backcrossing to the P_1 parents gave the ratio 1 purple:1 green while the Chi-square test for F_2 data gave a goodness of fit to the expected 3 purple shoot: 1 green shoot.

The phenotypic expression and segregation of flower colour in generations of three selected eggplant crosses are presented in Table 2. In cross NHS10-22 x NHS10-83, the Chi-square test of goodness of fit to 3 white corolla flower: 1 white corolla flower with purple tint ratio. White corolla colour is associated with green colour of plant shoot. In the inter specific cross NHS10-22 x NHS10-49, the backcrosses and F_2 data fit the 1:1 and the 3:1 ratio, respectively. Purple colour of fruit is dominant over green inherited in 3:1 ratio.

Furthermore, the phenotypic expression and segregation of fruit colour at physiological maturity in generations of three selected eggplant crosses are presented in Table 3. Chi-square test of goodness of fit of the F_2 data in cross NHS10-4 x NHS10-49 also gave a good fit to 3 purple fruits: 1 purple striped fruit with green/white background. Also Chi-square test of goodness of fit of the F_2 data in the same cross NHS10-4 x NHS10-49 at full maturity of fruit also gave a good fit to 3 golden yellow fruits: 1 yellow fruit (Table 4).

DISCUSION

The results of inheritance pattern of plant shoot purple pigmentation, flower colour, fruit colour at physiological and full maturity for 3 selected crosses viz; NHS10-22 x NHS10-83, NHS10-4 x NHS10-49 and NHS10-22 x NHS10-49 showed defined trends which are in agreement with earlier Mendelian reports. The phenotypic expression and segregation observed in all F_2 populations of the 3 selected crosses above for plant shoot purple pigmentation displayed monogenic inheritance pattern in the genetic ratio 3:1 which indicated that purple shoot colour was governed by a single dominant gene. Similar ratio of 3:1 monogenic inheritance gene action observed for cross NHS10-22 x NHS10-83 (white flower x white flower) F_2 populations was also governed by a single dominant gene (white corolla dominant over white corolla with purple tint). It appeared that presence of purple pigmentation is a requirement for white corolla with purple tint to be expressed. The inter-specific cross NHS10-22 x NHS10-49 (white flower x purple flower) F_2 data fit 3:1 monogenic inheritance gene action governed by a single dominant gene (purple corolla dominant over white/ white with purple tint). Similar ratio for flower colour was reported on inter-specific cross *S. melongena* x *S. indicum* by Wanjari and Khapre (1977) and monogenic form of inheritance was reported by Rangaswamy and Kadam Bavananasundran (1973) on inter-specific cross *S. indicum* x *S. melongena*. The fruit colour segregation at physiological and full maturity of fruit in cross NHS10-4 x NHS10-49 also fit 3:1 monogenic inheritance gene action governed by a single dominant gene (purple fruits over purple striped fruit with green/white background at physiological maturity and golden yellow fruits over yellow fruit at full maturity of fruit). However, Daunay et al. (2004) working on *Solanum melongena* reported that anthocyanin presence (vs its absence) is under monogenic dominant gene control. The monogenic inheritance is also in agreement with More and Patil (1982) on inheritance of some characters in brinjal cross, but Khapre *et al.* (1988) working on inter-specific cross *S. melongena* x *S. indicum* reported interaction of 3 non-allelic genes for fruit colour inheritance.

CONCLUSION

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The study revealed that the inheritance pattern of plant shoot pigmentation, flower colour, fruit colour at physiological and full maturity of fruit are majorly monogenic and simply inherited.

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Table 1: Phenotypic expression and segregation of plant shoot purple anthocyanin pigmentation in generations of selected eggplant crosses

Cross and generation	Observed number of plants		TOTAL	Expected Ratio	χ^2	P≤0.05
	Purple pigmented shoot	Green shoot				
NHS10-22 x NHS10-83						
NHS10-22	0	109	109			
NHS10-83	115	0	115			
F_1	118	0	118			
F1 x NHS10-22	92	107	199	1:1	$1.131^{n.s}$	0.288
F_1 x NHS10-83	206	0	206			
F_2	254	90	344	3:1	$0.248^{n.s}$	0.618
NHS10-4 x NHS10-49						
NHS10-4	0	106	106			
NHS10-49	118	0	118			
F_1	115	0	115			
F_1 x NHS10-4	104	98	202	1:1	$0.178^{n.s}$	0.673
F_1 x NHS10-49	200	22	222			
F_2	238	82	320	3:1	$0.067^{n.s}$	0.796
NHS10-22 x NHS10-49						
NHS10-22	0	109	109			
NHS10-49	118	0	118			
F_1	120	0	120			
F_1 x NHS10-22	112	97	209	1:1	$1.077^{n.s}$	0.299
F_1 x NHS10-49	215	0	215			
F_2	214	75	289	3:1	$0.140^{n.s}$	0.708

Table 2: Phenotypic expression and segregation of corolla colour in generations of selected eggplant crosses

Cross and generation	Observed number of plants			TOTAL	Expected ratio	χ^2	P≤0.05
	Purple corolla	White corolla	White corolla with purple tint				
NHS10-22 x NHS10-83							
NHS10-22	0	109	0	109			
NHS10-83	0	115	0	115			
F_1	0	104	14	118			
F_1 x NHS10-22	0	196	0	196			
F_1 x NHS10-83	0	170	26	196	??	??	??
F_2	0	186	68	254	3:1	0.425 $^{n.s}$	0.514
NHS10-4 x NHS10-49							
NHS10-4	106	0	0	106			
NHS10-49	118	0	0	118			
F_1	115	0	0	115			
F_1 x NHS10-4	201	0	0	201			
F_1 x NHS10-49	196	0	0	196			
F_2	289	0	0	289			
NHS10-22 x NHS10-49							
NHS10-22	0	109	0	109			
NHS10-49	118	0	0	118			
F_1	0	0	116	116			
F_1 x NHS10-22	0	118	112	230	1:1	0.157 $^{n.s}$	0.692
F_1 x NHS10-49	114	42	60	216	1:1	0.667 $^{n.s}$	0.414
F_2	222	40	34	296	3:1	0.00 $^{n.s}$	1.000

Table 3: Phenotypic expression and segregation of fruit colour at physiological maturity in generations of selected eggplant crosses

Cross and generation	Observed number of fruit colour at physiological maturity				TOTAL	Expected ratio	χ²	P≤0.05
	Purple fruit	Green fruit	Purple striped fruit with green/white background	Cream Fruit				
NHS10-22 x NHS10-83								
NHS10-22	0	109	0	0	109			
NHS10-83	0	115	0	0	115			
F_1	0	118	0	0	118			
F_1 x NHS10-22	0	199	0	0	199			
F_1 x NHS10-83	0	199	0	0	199			
F_2	0	267	0	0	267			
NHS10-4 x NHS10-49								
NHS10-4	0	0	106	0	106			
NHS10-49	118	0	0	0	118			
F_1	114	0	0	0	114			
F_1 x NHS10-4	180	0	5	0	185			
F_1 x NHS10-49	192	0	11	0	203			
F_2	220	0	70	0	290	3:1	$0.115^{n.s}$	0.735
NHS10-22 x NHS10-49								
NHS10-22	0	109	0	0	109			
NHS10-49	118	0	0	0	118			
F_1	0	116	0	0	116			
F_1 x NHS10-22	0	221	0	6	227			
F_1 x NHS10-49	0	228	0	2	230			
F_2	0	271	0	9	280			

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Table 4: Phenotypic expression and segregation of fruit colour at full maturity in generations of selected eggplant crosses

Cross and generation	Observed number of plant fruit colour at full maturity				TOTAL	Expected ratio	χ²	P≤0.05
	Orange	Brick red	Golden yellow	Yellow				
NHS10-22 x NHS10-83								
NHS10-22	0	109	0	0	109			
NHS10-83	0	115	0	0	115			
F_1	0	118	0	0	118			
F_1 x NHS10-22	0	199	0	0	199			
F_1 x NHS10-83	0	199	0	0	199			
F_2	0	267	0	0	267			
NHS10-4 x NHS10-49								
NHS10-4	0	0	0	106	106			
NHS10-49	0	0	118	0	118			
F_1	0	0	114	0	114			
F_1 x NHS10-4	0	0	180	5	185			
F_1 x NHS10-49	0	0	192	11	203			
F_2	0	0	220	70	290	3:1	$0.115^{n.s}$	0.735
NHS10-22 x NHS10-49								
NHS10-22	109	0	0	0	109			
NHS10-49	0	0	118	0	118			
F_1	116	0	0	0	116			
F_1 x NHS10-22	221	0	6	0	227			
F_1 x NHS10-49	228	0	2	0	230			
F_2	271	0	9	0	280			

HERITABILITY STUDIES AND INTER-CHARACTER ASSOCIATION IN SOME TEA (*CAMELLIA SINENSIS L. O. KUNTZE*) GENOTYPES IN NIGERIA

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ABSTRACT

*Tea (Camellia sinensis) is an important medicinal crop. Its young leaves are processed as tea for human consumption due to its health and nutritive values. Tea is grown in all the continents of the world and serves as major economic crop for some countries like China, Kenya, India and Nigeria. Knowledge of inter character association in tea is required for its improvement to suit specific purpose and demand. This research work was carried out to study inter-character association of various morphological and agronomic parameters. The experiment was laid in Randomize Complete Block Design (RCBD). The phenotypic correlation analysis shows that plant height showed significant positive correlation with number of leaves 0.73**, number of branches 0.74**, harvestable point 0.49*, stem diameter 0.70**, leaf breadth 0.54* and yield/plant 0.40*. Yield showed significant positive genotypic correlation to all the characters except caffeine with value of 0.38. Meanwhile, fewer characters showed significant environmental correlation than both genotypic and phenotypic correlations. Plant height had significant positive environmental correlations with number of leaves 0.64, number of branches 0.57** and stem diameter 0.41*. Plant heightand number of leaves combined high heritability with moderate genetic advance 70.95, 30.25 60.17, 34.85 respectively. Qualitative analysis showed variability for all characters except leave petiole colour and mature leaf colour. Therefore, there is presence of character association among the traits studied.*

Key words: Character, Association, Heritability, Germplasm and Correlation

INTRODUCTION

Tea is an important crop based on its health and economic benefits (Xia et al. 2020). It originated from China and spread to all continents of the world. Its medicinal use was first reported by the Chinese (Mandal 2007). It remains the oldest non alcoholic caffeine containing crop in the world and its consumption is next to that of water. According to Oloyede et al. (2014), consumption of green tea may help reduce the risk of cardiovascular disease and some form of cancer, reduce blood pressure, improve antibacterial and antiviral activities and promote oral health. Crop improvement depends greatly on the extent of variability to which selection for further development can be made by the breeders. Tea yield is a quantitative character simply because it is influenced by many other characters. Knowledge of inter-character association is important to know the extent at which one character is affecting other characters either positively or negatively. To determine the extent of relationship between two characters, correlation analysis is employed which the result may be positive or negative. Correlation produce is highly effective when selecting superior genotypes (Akinyele and Osekila, 2006). It is important to note that when there is positive association between major yield components simultaneously, selection becomes difficult. Therefore, the objective of the work is to investigate inter-relationship of tea yield attribute in view of identifying the traits contributing to its yield.

MATERIALS AND METHODS

Thirty-four genotypes of tea (*Camellia sinensis*) were obtained from Cocoa Research Institute of Nigeria tea germplasm and they have their origin from China except C143, C318 and and C357 that were originated from Kenya

Location of the experiment: The experiment was carried out in 3 environments (1) Cocoa Research Institute of Nigeria headquarters Onigambari, Ibadan latitude 7°12' N, longitude 3°51' E. and altitude 457m above sea level. The land preparation was done manually using hoe and cutlass and Randomized Complete Block Design was employed. The experiment included three blocks, each containing 34 single-row plots, representing each of the tea genotypes. The Spacing of 0.6 m X 1.0 m within and between rows with 12 plants per plot (7.2 m^2), making the total land area to be 870.4 m^2. Weeding and other cultural maintenance practices were done as and when necessary. The scoring of the qualitative traits was done according to IPGRI now (Biodiversity international) descriptor for tea.

Quantitative Characters

Internodes length (cm) Measured with meter rule between 3rd and 4th nodes

Length of mature leaf (cm) Measured with meter rule from leaf base to the apex

Width of mature leaf (cm) Measured with meter rule at the middle of the leaf

Plant height (cm) Measured from ground level to the tip of the plant

No of branches Recorded by counting number of branches

Shoot weight (g) Measured using electric weighing balance

Stem diameter Measured at the ground level with vernier caliper

Number of leaves Recorded by counting number of leaves

Number of flower buds Recorded by counting number of flower buds

Data analyses

Data were subjected to analysis of variance and means were separated using Duncan Multiple Range Test (Duncans, 1955) at 5% probability level (P$\leq$ 0.05). Genotypic and phenotypic variances were determined according to Okelola *et al.,* (2007). The Variance components were used to compute the genotypic and phenotypic coefficient of variability, heritability (in the broad sense) and genetic advance according to the method of Burton (1952), (Johnson *et al.*, 1955) and (Kumar *et al.*, 1985). Other analyses carried out were Correlation, Genotypic Coefficient of Variability $\{100 * \left(\frac{\delta g}{N}\right)\}$ and Phenotypic coefficient of variability $\left\{100 * \left(\frac{\delta ph}{N}\right)\right\}$ Where δph and δg are the phenotypic and genotypic standard deviations respectively and $\boxed{N}$ is the grand mean of the character under consideration.

The genotypic and phenotypic variances were calculated according to (Adewale *et al.*, 2010).

$$MSe = \delta^2\text{e}$$

$$MSy = \delta^2\text{e} + r\delta^2\text{g}$$

Genotypic variance $(\delta^2\text{g}) = \frac{Msy - Mse}{r}$ where error mean square (MSe) = error variance (δ^2e)

Phenotypic variance ($\delta^2\text{p}) = \delta^2\text{e} + \delta^2\text{g}$,

r = number of replicates.

Heritability was calculated in its broad sense.

$$Hb(\%) = \frac{\delta^2\text{g}}{\delta^2\text{p}} x100$$

Genetic Advance was also estimated using

$$G.A = \frac{\delta^2\text{g}}{\delta^2\text{p}} kx100$$

Where k = selection differential of 2.06 at 5% selection intensity according to (Adewale *et al.*, 2010). Estimates of genotypic and phenotypic correlation coefficients among the characters were obtained using the formula of Miller *et al., (*1958)

$r_{x,}y = \frac{Cov(x, y)}{\sqrt{(\delta x)^2(\delta y)^2}}$

.where

r_x,y is either genotypic or phenotypic correlation between variable x and y;

Cov (x,y) is the genotypic or phenotypic covariance between two variables;

δx is the genotypic or phenotypic variance of the variable x;

δy is the genotypic or phenotypic variance of the variable y.

Environmental correlation coefficients were determined according to Falconer (1996).

Quantitative Characters

Internodes length (cm) Measured with meter rule between 3rd and 4th nodes

Length of mature leaf (cm) Measured with meter rule from leaf base to the apex

Width of mature leaf (cm) Measured with meter rule at the middle of the leaf

Plant height (cm) Measured from ground level to the tip of the plant

No of branches Recorded by counting number of branches

Shoot weight (g) Measured using electric weighing balance

Stem diameter Measured at the ground level with vernier caliper

Number of leaves Recorded by counting number of leaves

Number of flower buds Recorded by counting number of flower buds

Qualitative Characters

Leaf apex habit	Observation
Leaf venation	Observation
Immature leaf colour	Observation
Mature leaf colour	Observation
Leaf size	Observation
Leaf shape	Observation

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Leaf base shape	Observation
Leaf margin	Observation
Leaf Petiole colour	Observation

RESULTS

Morphological characterization

The qualitative characters evaluated for each tea genotypes used in this study are presented in table 1 below. The leaf shape was lanceolate for all the genotypes except for NGC 55, 357 and NGC 47. The leaf base shape for the genotypes was attenuate apart from NGC 55 which was round. The leaf margin varies from biserrulate to serrulate and finally to entire for NGC 6 and C357. All the genotypes evaluated were indifferent in terms of leaf petiole colour which was green as well as mature leaf colour which was dark green. All the genotypes had medium leaf size except for genotype C357 with large leaf size. The leaf apex habit was between straight and recurve while the leaf venation for the genotypes evaluated ranged between indistinct and distinct. However, the immature leaf colour showed a vast range of variability from dark green observed in NGC 40 to green in NGC 6 and lastly to yellowish brown in NGC55.

Table 1. Qualitative description of tea genotypes

S/N	Genotypes	Leaf shape	Leaf base shape	Leaf margin	Leaf petiole Colour	Leaf size	Leaf apex habit	Leaf venation	Immature leaf colour	Mature leaf colour
1	NGC48	Lanceolate	Attenuate	Biserrulate	Green	Medium	Recurved	Indistinct	Deep Green	Dark green
2	NGC29	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Deep Green	Dark green
3	NGC23	Lanceolate	Attenuate	Biserrulate	Green	Medium	Recurved	Distinct	Deep Green	Dark green
4	NGC24	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Indistinct	Deep Green	Dark green
5	NGC8	Lanceolate	Attenuate	Serrulate	Green	Medium	Straight	Indistinct	Deep Green	Dark green
6	NGC6	Lanceolate	Attenuate	Entire	Green	Medium	Straight	Distinct	Green	Dark green
7	NGC45	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Deep Green	Dark green
8	NGC41	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Indistinct	Deep Green	Dark green
9	NGC18	Lanceolate	Attenuate	Serrulate	Green	Medium	Straight	Distinct	Deep Green	Dark green
10	NGC38	Lanceolate	Attenuate	Biserrulate	Green	Medium	Recurved	Distinct	Deep Green	Dark green
11	NGC46	Lanceolate	Attenuate	Biserrulate	Green	Medium	Recurved	Distinct	Deep Green	Dark green
12	NGC40	Lanceolate	Attenuate	Serrulate	Green	Medium	Straight	Indistinct	Dark green	Dark green
13	C143	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Distinct	Greyish green	Dark green
14	NGC49	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Distinct	Deep Green	Dark green
15	NGC37	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Indistinct	Deep Green	Dark green
16	NGC51	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Greyish green	Dark green
17	NGC27	Lanceolate	Attenuate	Biserrulate	Green	Medium	Recurved	Distinct	Greyish green	Dark green
18	NGC26	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Distinct	Greyish green	Deep green
19	NGC25	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Distinct	Greyish green	Dark green
20	NGC55	Ovate	Rounded	Serrulate	Green	Small	Straight	Indistinct	Yellowish brown	Dark green
21	NGC54	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Indistinct	Deep green	Deep green
22	NGC53	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Green	Dark green
23	C357	Ovate	Attenuate	Entire	Green	Large	Recurved	Distinct	Deep green	Dark green
24	NGC13	Lanceolate	Attenuate	Serrulate	Green	Medium	Straight	Distinct	Deep green	Dark green
25	NGC17	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Grayish green	Dark green
26	NGC22	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Distinct	Greyish green	Deep green

27	NGC42	Lanceolate	Attenuate	Biserrulate	Green	Medium	Recurved	Distinct	Deep green	Dark green
28	NGC50	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Indistinct	Grayish green	Dark green
29	NGC19	Lanceolate	Attenuate	Biserrulate	Green	Medium	Straight	Distinct	Deep green	Dark green
30	NGC15	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Brown	Dark green
31	NGC12	Lanceolate	Attenuate	Biserrulate	Green	Medium	Recurved	Distinct	Grayish green	Dark green
32	NGC32	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Deep green	Dark green
33	NGC47	Ovate	Attenuate	Serrulate	Green	Medium	Recurved	Indistinct	Deep green	Dark green
34	C318	Lanceolate	Attenuate	Serrulate	Green	Medium	Recurved	Distinct	Deep green	Dark green

Heritability

Estimate of mean, phenotypic variance, genotypic variance, environmentalvariance, phenotypic coefficient of variability, genotypic coefficient of variability, heritability and genetic advances expressed as percentage of the mean in three environments are presented in Table 2. Tea genotypes showed considerable variation for plant height, number of leaves, number of flower buds, as well as number of branches. The genotypic variance ranged from 0.03 for caffeine to number of leaves (2193.23). Phenotypic variance also followed similar trend with genotypic variance. The phenotypic variance ranges between caffeine and number of leaves with 0.09 and 2149.29 respectively. The genotypic coefficient of variation from 2.76% for crude fibre to 54% for number of flower buds. Meanwhile, phenotypic coefficient of variation ranges from 3.69% for protein to 92.83% for number of flower bud. The mean value also ranges from 2.19 for caffeine to 164.87 for number of leaves. Considering heritability and genetic advance simultaneously, plant height, number of leaves combined high heritability with moderate genetic advance. Internodes length, leaf length, leaf breadth, crude fibre and caffeine had moderate heritability and low genetic advance. It was noted that the yield/plant combine low heritability and low genetic advance while high genetic advance and moderate heritability was observed for number of flower buds.

Phenotypic Correlation

The Phenotypic Correlation Coefficients of thirteen character of tea are presented in Table 3 below. Plant height showed positive significant correlation with number of leaves (0.73**), number of branches (0.74**), harvestable point (0.49*), stem diameter (0.70**), leaf length (0.46*), leaf breadth (0.54*) and yield/plant (0.40*), while it showed insignificant correlation with internodes length (0.37) and number of flower bud (0.30). The number of leaves (NL) exhibited significant positive correlation with number of branches (0.83**), harvestable point (0.45*), stem diameter (0.68**), number of flower bud (0.45*) and yield/plant (0.57**). Number of branches also showed positive correlation with harvestable point (0.54*), stem diameter (0.65**) and yield/plant (0.48*.)

Harvestable point was significantly correlated to stem diameter (0.41**), leaf breadth (0.42) and yield/plant (0.61**). There was positive correlation among stem diameter and the following traits; leaf breadth (0.67**) and yield/plant (0.44*). Internodes length showed no significant correlation to all the characters measured. Also, the leaf length showed no significant correlation to all the characters measured except for plant height (0.46*). It was observed that leaf breadth showed no significant correlation to number of flower bud and yield/plant with the following values (0.25) and (0.34) respectively. The number of flower bud was only significant to number of leaves (0.45*) among all the traits observed. Protein and crude fibre showed positive significant correlation to caffeine with values of 0.40* and 0.42* respectively.

Genotypic Correlation

The results of genotypic correlation among thirteen characters in tea are presented in Table 4. Generally, more characters showed genotypic correlation among themselves than the phenotypic correlation. It was observed that plant height showed strong positive genotypic correlation to all characters with the values of 0.87**, 1.08**, 0.85**, 1.06**, 0.72**, 0.64**, 0.69**, 0.56* and 1.65** for number of leaves, number of branches, harvestable point, stem diameter, internodes length, leaf length,

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leaf breadth, number of flower bud and yield/plant respectively. Similarly, number of leaves showed positive genotypic correlation for all the characters except for internodes length, protein, crude fibre and caffeine with the correlation coefficients of 0.30, 0.29, 0.01 and 0.05 respectively. The results also showed that number of branches was positively correlated with harvestable point 0.58**, stem diameter 1.37**, leaf length 0.81**, leaf breadth 0.58** and yield/plant 1.27. The number of branches was not significantly correlated with internodes length 0.14 and number of flower bud 0.38. It was also observed that harvestable point exhibited negative genotypic correlation with internodes length -1.04**. Harvestable point was positively correlated with stem diameter, leaf breadth, number of flower bud, yield/plant, protein and crude fibre with the genotypic correlation coefficients of 1.61**, 0.64**, 0.68**, 0.57**, 0.58** and 1.12** respectively. Also, stem diameter was positively correlated with leaf breadth 1.25**, number of flower buds 0.73**, yield/plant 3.06**, protein 0.49*, crude fibre 0.43* and caffeine 1.01**. It was found that internodes length was negatively correlated with yield/plant -0.66** and crude fibre -0.47*. The leaf length showed positive correlation with number of bud 0.53**, yield//plants, 0.46* but showed significant negative correlation with protein -0.54* and crude fibre -0.66**. Number of flower buds showed positive genotypic correlation for protein 0.72**, and crude fibre 0.43*. Yield/plant exhibited significant genotypic correlation for protein 0.61** crude fibre 1.36** and caffeine0.91**. Protein exhibited positive genotypic correlation for crude fibre 0.55** and caffeine 0.85**. Finally, positive genotypic correlation exists between crude fibre and caffeine with value of 0.79**.

Environmental correlation

The environmental correlation coefficients among thirteen characters are presented in Table 5. Generally, fewer characters showed significant environmental correlation than both the genotypic and phenotypic correlations. Environmental correlations of plant height were highly significant and positively correlated with number of leaves 0.64**, number of branches 0.57** and stem diameter 0.41* It was observed that there was no significant environmental correlation between harvestable points for all possible combined characters except for number of leaves 4.09**. Leaf breadth, number of flower bud, yield/plant and crude fibre showed no significant environmental correlation to all the characters. Stem diameter showed significant environmental correlation to leaf length 4.64**. It was noticed that caffeine recorded positive environmental correlation to number of branches and crude fibre with values of 1.07** and 0.41*, respectively. The PH (0.40*, 1.68**), NL (0.57**, 1.09**), and NB (0.48*, 1.27**) were phenotypically and genotypically correlated with yield, respectively.

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Table 2: Estimate of Means, Phenotypic and Genotypic Coefficient of Variability, Phenotypic, Genotypic, Environmental and Genotype by Environment Variance, Heritability in broad sense and Genetic Advance Expressed as percentage of the mean of thirty- four tea genotype

Character	Mean	Phen var	Gen var	G x L var	Envr var	PCV	GCV	Heritability	Genetic advance
Plant height (cm)	71.05	216.27	153.45	19.86	42.96	20.70	17.43	70.95	30.25
No of Leaves	164.87	2149.29	1293.23	14.31	841.76	28.12	21.81	60.17	34.85
No of Branches	22.09	37.80	15.18	4.11	18.50	27.84	17.64	40.16	23.03
harvestable point	9.59	11.01	2.84	6.13	2.04	34.60	17.57	25.80	18.39
Stem Diameter (mm)	12.67	2.41	1.19	0.24	0.98	12.24	8.61	49.41	12.46
Internodes length(cm)	3.35	0.19	0.07	0.03	0.14	12.89	8.02	38.73	10.29
Leaf length (cm)	8.75	2.00	0.82	0.05	1.13	16.17	10.37	41.16	13.71
Leaf Breadth (cm)	3.49	0.21	0.10	0.08	0.04	13.15	8.85	45.30	12.27
No of flower bud	12.53	135.29	45.81	81.74	7.74	92.83	54.02	33.86	64.75
yield/plant (g)	4.16	4.85	0.37	2.65	1.83	52.94	14.63	7.64	8.33
Protein%	20.69	0.58	0.34	0.22	0.02	3.69	2.83	58.86	4.47
Crude fiber%	9.13	0.18	0.06	0.10	0.01	4.60	2.76	35.91	3.41
Caffeine%	**2.19**	**0.09**	**0.03**	**0.06**	**0.01**	**13.66**	**7.68**	**31.59**	**8.89**

Table 3: Phenotypic Correlation coefficient among eleven quantitative characters of tea genotypes

Phen cor	NL	NB	HP	SD (mm)	IL(cm)	LL (cm)	LB(cm)	NFB	yield/plant (g)	Protein %	Crude fibre%	Caffeine %
PH(cm)	0.73**	0.74**	0.49*	0.70**	0.37	0.46*	0.54*	0.30	0.40*	-0.08	-0.08	0.09
NL		0.83**	0.45*	0.68**	0.18	0.28	0.27	0.45*	0.57**	0.07	-0.05	0.13
NB			0.54*	0.65**	0.21	0.34	0.32	0.30	0.48*	0.11	-0.07	0.11
HP				0.41*	-0.07	0.30	0.42*	0.34	0.61**	0.13	0.29	0.11
SD (mm)					0.28	0.26	0.67**	0.33	0.44*	0.21	0.17	0.37
IL(cm)						0.12	0.22	0.05	-0.02	0.07	-0.11	0.04
LL (cm)							0.36	0.16	0.09	-0.25	-0.15	0.24
LB (cm)								0.25	0.34	0.12	0.35	0.27
NFB									0.15	0.24	0.15	0.22
yield/plt (g)										-0.02	0.01	-0.01
Protein%											0.36	0.40*
Crude fibre%												0.42*

**, * significant at P≤ 0.01 and P≤ 0.05

N= 204

Plant Height (PH), Number of Leaves (NL), Number of Branches (NB), Stem Diameter (SD), Harvestable Points (HP), Internodes Length (IL), Leaf Length (LL), Leaf Breadth (LB), Number of Flower Bud (NFB) and Yield/plant

Table 4: Genotypic Correlation coefficient among eleven quantitative characters of tea genotypes

Gen cor	NL	NB	HP	SD (mm)	IL(cm)	LL (cm)	LB(cm)	NFB	yield/plant (g)	Protein%	Crude fibre%	Caffeine %
PH(cm)	0.87**	1.08**	0.85**	1.06**	0.72**	0.64**	0.69**	0.56**	1.68**	-0.06	-0.15	-0.19
NL		1.25**	0.70**	1.06**	0.30	0.48*	0.58**	0.66**	2.09**	0.29	0.00	0.05
NB			0.58**	1.37**	0.14	0.81**	0.58**	0.38	1.27**	0.33	-0.06	0.15
HP				1.16**	-1.04**	0.31	0.64**	0.68**	0.57**	0.58**	1.12**	0.10
SD mm)					0.26	0.31	1.25**	0.73**	3.06**	0.49*	0.43*	1.01**
IL(cm)						-0.39	0.05	-0.20	-0.66**	0.27	-0.47*	-0.25
LL (cm)							-0.07	0.53*	0.46*	-0.54	-0.66**	0.12
LB (cm)								0.68**	1.29**	0.39	1.03**	0.38
NFB									0.02	0.72**	0.43*	0.08
yldplt(g)										0.61**	1.36**	0.91**
Protein%											0.55**	0.85**
Crude fibre%												0.79**

**, * significant at P≤ 0.01 and P≤ 0.05

Plant Height (PH), Number of Leaves (NL), Number of Branches (NB), Stem Diameter (SD), Harvestable Points (HP), Internodes Length (IL), Leaf Length (LL), Leaf Breadth (LB), Number of Flower Bud (NFB) and Yield/plant

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Table 5: Environmental Correlation coefficient among eleven quantitative characters of tea genotypes

Envr cor	NL	NB	HP	SD (mm)	IL(cm)	LL (cm)	LB(cm)	NFB	yield/plant (g)	Protein%	Crude fibre%	Caffeine%
PH(cm)	0.64**	0.57**	0.22	0.41*	0.01	-0.10	0.19	0.20	0.19	0.01	0.01	0.11
NL		0.56**	4.09**	0.36	0.88**	-0.07	-0.01	0.21	0.30	-0.02	-0.07	0.11
NB			0.15	0.26	-0.03	-0.01	0.06	0.10	0.09	0.86**	-0.02	0.97**
HP				0.04	-0.11	-0.04	0.03	0.00	0.28	-0.08	-0.08	-0.11
SD mm)					0.00	4.63	-0.08	0.18	0.03	0.12	0.09	0.14
IL(cm)						-0.11	0.09	0.07	-0.09	-0.06	-0.02	-0.03
LL (cm)							0.19	-0.07	0.02	-0.19	-0.05	-0.04
LB (cm)								-0.03	0.13	0.12	-0.06	-0.10
NFB									-0.02	0.05	0.02	-0.08
yld/plt(g)										-0.03	-0.18	-0.26
Protein%											0.05	0.14
Crude fibre%												0.41*

**, * significant at P≤ 0.01 and P≤ 0.05

Plant Height (PH), Number of Leaves (NL), Number of Branches (NB), Stem Diameter (SD), Harvestable Points (HP), Internodes Length (IL), Leaf Length (LL), Leaf Breadth (LB), Number of Flower Bud (NFB) and Yield/plant

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DISCUSSION

The significant phenotypic correlation of yield/plant with plant height, number of leaves, number of branches, harvestable point and steam diameter suggest that these characters possessed greater practical values for selection than component characters.

The significant positive plant height and number of branches implies that tea plant with good height tend to produce more harvestable leaves from the buds of the new branches. Positive phenotypic correlation between number of leaves and number of branches implies that tea plant with more number of branches produce more leave directly increasing the yield since the first two new leaves and the bud is harvested as yield. It is pertinent to say that positive correlation between harvestable point and leaf breadth also determined the quantity of yield harvested. The positive correlation between plant height and stem diameter showed that plant with good height and strong stem tends to produce more yield. Plant height, number of branches, harvestable point and stem diameter were phenotypically and genotypically correlated with the yield/plant. The characters that are genotypically correlated but not phenotypically correlated will not be of practical value in selection, since selection is often based on the phenotypic performance of the characters (Adebisi *et al*., 2004)

The significant negative genotypic correlation between internodes length and yield /plant indicate that the longer the internodes length the lower the yield/plant. Similarly, harvestable point is negatively correlated with internodes length i.e. the longer the internodes length the fewer the bud harvested. This may be due to the effect of partitioning of assimilates between the internodes and bud (harvestable point). Characters with moderate to high value of genotypic coefficient of variability such as number of flower bud might be further improved through varietal selection (Aremu 2005; Omoighi *et al.,* 2006). Therefore, genotypic coefficient of variability gave information on the genetic variability present in the various quantitative characters; it is not enough to offer full scope to estimate the variation that is heritable or environmental. Hence along with PCV and GCV estimates, the estimation of heritability and genetic advance became necessary. (Janaki *et al*., 2017). The low heritability value obtained for yield/plant was a confirmation of Adebisi *et al*., (2004) who reported low heritability for grain yield in soya bean. As yield is a product of complex characters liable to have more environmental influences compared to all other traits. Characters that are highly heritable are important to a plant breeder as they enable him to base his selections reliably on the phenotypic performance and extent to which improvement is possible through selection (Priyanka *et al*., 2017). High heritability observed for plant height, number of leaves, number of branches and leaf breadth indicated that the expression of these traits was more of genotype than environmental effects and therefore, there is possibility of positive response to selection Joshi (1986).

The nine qualitative characters studied confirmed that relationship exists among the studied characters of the genotypes. Leaf shape, leaf margin, leaf size, leaf apex habit and leaf venation seems to be controlled by few genes action. Adeoluwa and Kehinde (2011) found out in their work that some variations in okra such as leaf colour and spine in the fruits surface are inherited in a simple fashion. For leaf petiole colour and mature leaf colour, the gene controlling these traits are probable dominant as no variation was expressed among the genotypes.

CONCLUSION

There is presence of association among the traits studied which led to the resultant variability. Therefore, further improvement of tea is possible in Nigeria.

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CORRELATION AND PATH COEFFICIENT ANALYSES OF YIELD-RELATED TRAITS IN CACAO (*THEOBROMA CACAO* L.)

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ABSTRACT

The cacao tree (Theobroma cacao L.) produces the cocoa bean, a major source of foreign exchange earnings for most West African countries and many smallholder farmers. Declining yield of cacao is a major limitation to cocoa production in Nigeria. This study aimed at determining the correlations of the phenotypic traits that were related in the yield of the cacao genotypes. Nine cacao hybrids were produced from some high-yielding parents in the research farm of Cocoa Research Institute of Nigeria, Ibadan and evaluated in the field in Owena (7^0 11'N, 5^0 1'E), Ondo State, Nigeria. Character Correlations and Path Coefficient Analysis were used in the description of the performance of the genotypes. The study concluded that significant genotypic and phenotypic correlations existed among many of the pairs of the fruit and bean characters with one another and with pod index, suggesting the contribution of these characters either positively or negatively to growth and yield in the cacao genotypes, and that fruit and bean traits are determinants of yield in cacao.

Key words: Cacao, Genotypes, Correlation, Phenotypic traits, Path coefficients

INTRODUCTION

The importance of the cacao crop is very enormous to farmers and government in the producing countries. Cocoa bean, the main ingredient used in the manufacture of chocolate, other beverages, is the major product obtained from the cacao tree. Declining yield is, however, a limiting factor in cacao cropping in Nigeria (Adenuga *et al*., 2018). The cocoa bean yield is the primary focus of any cacao farming venture, and is indicated essentially in the 'pod index', which refers to the number of cocoa pods (fruit) required to produce one kilogramme (1kg) of dry cocoa beans. Among other factors, cocoa bean yield is influenced by variety and age of plant (Goenaga *at al*., 2018). A number of factors are, therefore, observed to be correlated with pod index in cacao.

Correlation is a measure of the degree of relationship between variables and a plant breeder should know whether the improvement of one character will result in simultaneous change in other characters through estimates of inter character correlations (Falconer, 1989). Estimates of genotypic, phenotypic and environmental correlations among characters can provide the basis of planning of more efficient breeding programmes. A positive genetic correlation between two desirable traits simplifies the breeder's job of crop improvement. As yield, being a complex and polygenic trait, is influenced even by fluctuations in environmental factors, a knowledge of the nature and magnitude of the traits that influence yield in cacao can provide a basis for genotype selection many characters that improve yield. Beyond the influence of climate, an often complex inter-relationship of plant traits is an important determinant of yield in cacao (Adenuga *et al*., 2018). This study was therefore carried out to understand the association among yield and the related traits in cacao so as to improve on the crop.

MATERIALS AND METHODS

Nine new early-bearing cacao hybrids produced at the Cocoa Research Institute of Nigeria which fruited at the Owena sub-station (7^0 11'N, 5^0 1'E) of the Institute, with harvest period ranging from 104 through 124 weeks after field ploanting (Table 1) were used this study. Thirty (30) individual seedlings were established per genotype as ten (10) seedlings per plot in three (3) replications in a Randomized Complete Block Design (RCBD). Prior to fruit harvest, data were collected (at three months' interval) on plant height, stem diameter, number of leaves, time to jorquette, jorquette height, tree circumference, fruiting and cherelle wilt. Five uniformly matured and ripe cocoa pods were harvested per genotype in each of three replications, giving a total of fifteen pods (fruits) per genotype. The time to fruit harvest (being the time of fruit maturation) was recorded in weeks. Each fruit was weighed, and the fruit length and width measured using a vernier calliper. The fruits were carefully broken and pod husk thickness was estimated as the difference between the outer (ridge to ridge) and the inner diameter of the fresh pod husk using the venier calliper. The number of rows, number of beans per row and number of beans per pod was counted and the weight of the beans was recorded per fruit, while the weight of one bean was recorded as the average of the weight of ten beans randomly selected per fruit. The beans from each fruit were extracted and fermented in trays. The beans were weighed after fermentation and the weight recorded per fruit and per individual bean as the average of ten fermented beans weighed. The fermented beans were sun-dried, and the pod value recorded as the weight of the total dried beans obtained per fruit. The weight of one dried bean was also recorded as the average of the weight of ten dried bean per fruit. Dried bean length and width were recorded by as an average of the values of ten dried beans using the vernier calliper. Pod index was calculated from the weight of dried beans from each pod as the number of pods required to produce one kilogramme of dry cocoa beans. In all, a total of fourteen quantitative traits were used to assess the nine genotypes. The means from the sampling unit per genotype were used to estimate the phenotypic, genotypic and environmental correlation coefficients using the formula of Miller *et al*. (1958) thus:

$$\mathbf{r}(\mathrm{x,y}) = \frac{\mathrm{Cov\,(xy)}}{\sqrt{(\delta \mathrm{x})^2 . (\delta \mathrm{y})^2}}$$

Where $r_{(x,y)}$ is either genotypic or phenotypic or environmental correlation between variables x and y;

$Cov_{(xy)}$ is the covariance of variables x and y;

$(\delta_x)^2$ is either the genotypic or phenotypic or environmental variance of variable x;

$(\delta_y)^2$ is either the genotypic or phenotypic or environmental variance of variable y.

The significance of the correlation coefficients was tested using the non-directional probability in the software of Lowry (2009). The direct and indirect Path Coefficients were calculated to reveal the strength of the relationship among pod index and the yield-related characters by solving a series of simultaneous equations as suggested by Dewey and Lu (1957)

RESULTS

The phenotypic correlation coefficients among fourteen vegetative and fruit characters of the nine cacao hybrids are presented in Table 1. Plant height was positively and significantly correlated with stem diameter (0.83), tree circumference (0.60), presence of fruits (0.46), fruit width (0.41) and pod index (0.56), but negatively correlated with time to fruit harvest (-0.47). Time to jorquette was positively ($P \leq 0.05$) correlated with time to fruit harvest, (0.43) and fruit weight (0.53) but negatively correlated with pod index (-0.40). Presence of fruit was positively significantly correlated with cherelle wilt (0.57) and pod thickness (0.96). Cherelle wilt was positively significantly correlated with pod thickness (0.55). Time to fruit harvest was positively significantly correlated with fruit weight (0.41), fruit length (0.71), but negatively correlated with fruit width (-0.91) and pod index (-0.83). Number of beans per row was negatively correlated with pod index (-0.71).

Table 1: List of nine cacao genotypes used in the study

S/N	Genotypes	Pedigree	Weeks to Harvest
1	P_1 x P_{10}	($T_{82/27}$ x $T_{12/11}$) x ($T_{65/7}$ x $T_{57/22}$)	122
2	P_1 x P_{11}	($T_{82/27}$ x $T_{12/11}$) x ($T_{53/5}$ x $N38$)	117
3	P_2 x P_{10}	(P_7 x $T_{60/887}$) x ($T_{65/7}$ x $T_{57/22}$)	124
4	P_3 x P_{10}	($T_{86/2}$ x $T_{9/15}$) x ($T_{65/7}$ x $T_{57/22}$)	114
5	P_3 x P_{11}	($T_{86/2}$ x $T_{9/15}$) x ($T_{53/5}$ x $N38$)	105
6	P_5 x P_9	($T_{86/2}$ x $T_{22/28}$) x ($T_{65/7}$ x $T_{22/28}$)	117
7	P_6 x P_{10}	($T_{65/7}$ x $T_{9/15}$) x ($T_{65/7}$ x $T_{57/22}$)	104
8	P_7 x P_8	(P_7 x P_{A150}) x ($T_{101/15}$ x N_{38})	117
9	P_7 x P_{10}	(P_7 x P_{A150}) x ($T_{65/7}$ x $T_{57/22}$)	114

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The genotypic correlation coefficients among fourteen vegetative and fruit characters of the nine cacao hybrids are presented in Table 2. Plant height was positively significantly (P≤0.01) correlated with stem diameter (2.84), time to jorquette (1.29), tree circumference (2.29), presence of fruit (2.24), fruit width (27.68), pod thickness (19.82), and pod index (4.27) but negatively correlated with number of leaves (-1.62), jorquette height (-1.06), cherelle wilt (-4.09), time to fruit harvest (-2.19), fruit weight (-1.07), fruit length (-0.47) and number of rows (-0.82). Time to jorquette was also highly significantly (P≤0.01) correlated with the rest of the characters except jorquette height. The highly significant correlations of time to jorquette with these characters was however negative with fruit width (-9.98), number of rows (-0.53) and pod index (-0.99). Jorquette height was significantly (P≤0.05) correlated with the rest of the characters except fruit weight, fruit length and pod thickness. The highly significant correlations of jorquette height with these characters was however negative with presence of fruit (-0.68), Cherelle wilt (-1.42), time to fruit harvest (-0.41) and number of rows (-0.41). Tree circumference was positively significantly (P≤0.01) correlated with fruit width (7.96), pod thickness (1.84) and pod index (0.72) but negatively correlated with cherelle wilt (-1.27), time to fruit harvest (-0.42) and number of rows (-0.37). Presence of fruit was positively significantly (P≤0.01) correlated with cherelle wilt (0.57), pod thickness (10.60), and pod index (0.47) but negatively correlated with fruit length (-0.47). Cherelle wilt was also positively significantly (P≤0.01) correlated with time to fruit harvest (0.54), pod thickness (9.52) and pod index (0.54) but negatively correlated with fruit width (-3.76). The correlation of pod index was negative with each of time to fruit harvest (-1.09), fruit weight (-0.75), fruit length (-0.92) and number of beans per row (-0.56). Fruit width was positively correlated with pod index (12.26).

The environmental correlation coefficients among fourteen vegetative and fruit characters of the hybrids are presented in Table 3. Plant height showed positively significant (P≤0.05) correlations with stem diameter (0.65), number of leaves (0.63), jorquette height (0.54), tree circumference (0.42) and cherelle wilt (0.60). Stem diameter showed positively significant (P≤0.05) correlations with number of leaves (1.13), tree circumference (0.98) and cherelle wilt (0.64). Time to jorquette was negatively significantly (P≤0.01) correlated with tree circumference (-0.86) and cherelle wilt (-0.44). Jorquette height was positively significantly correlated with cherelle wilt (0.73) but negatively correlated with time to fruit harvest (-0.55). Tree circumference had positively significant correlations only with the presence of fruit (0.37) and cherelle wilt (0.91). Presence of fruits had positively significant correlation only with cherelle wilt (0.63), but a negative correlation with pod thickness (-0.92). Cherelle wilt was positively significantly (P≤0.01) correlated with number of rows (0.40) but negative correlations with pod thickness (-0.58) and pod index (-0.79). Time to fruit harvest was negatively significantly correlated with number of rows (-0.43). Fruit weight was negatively correlated with number of rows (-0.78). Fruit width and number of beans per row were negatively significant with pod index (-0.39 and -0.90 respectively).

The direct and indirect path coefficients that estimate the strength of the relationship between pod index and the vegetative and fruit characters using the genotypic correlation values is presented in table 4. Fruit length had the largest positive direct effect (4.5487) on pod index, with its largest indirect effect through time to jorquette (1.6755). The largest negative indirect effect of fruit length on pod index is through time to fruit harvest (-7.5772). Cherelle wilt also had a notably large positive direct effect (3.5830) 0n pod index, with its largest indirect effect also through time to jorquette (5.0864). The largest negative indirect effect of cherelle wilt on pod index is through time to fruit harvest (-4.5974). Time to fruit harvest had the largest negative direct effect (-8.5137) on pod index, with its largest indirect effect through fruit length (4.0484). The negative direct effects of jorquette height (-0.4375), and plant height (-0.2087) on pod index are also noteworthy. Jorquette height had its largest indirect effect also through time to fruit harvest (3.4906). Though the number of characters used in the path coefficient analysis was large, the residual factor was 1.7558.

DISCUSSION

The mutual association among characters is often expressed by the phenotypic, genotypic and environmental correlations (Searle, 1961 and Ariyo, 1989). Phenotypic correlation is a composite of genotypic and environmental correlations. In this study, the genotypic correlation coefficients were in most cases higher than the corresponding phenotypic correlation coefficients and the environmental correlation coefficients. This has been ascribed to reduced values of environmental correlations between the corresponding characters implying reduced influence by the environment (Searle, 1961). This implies that the genotypic factor had a greater contribution in the development of the character association (Arshad *et al*., 2006). The low values of the environmental correlation coefficients imply that the phenotypic correlation coefficients would be good indicators of genotypic correlation coefficients (Ariyo, 1995).

Selection of the genotypes based only on inter-character associations which are genotypically correlated but not phenotypically correlated may not be of practical value since selection is mostly based on the phenotypes of the characters. Such a selection will be unrepeatable and unreliable (Ariyo, 1995). This applies to the pairs of characters that exhibited this kind of relationship in the study, such as stem diameter, fruiting and wilted fruits with pod index.

The significant genotypic and phenotypic correlations of many of the pairs of the vegetative and fruit characters with one another and with pod index suggested that these characters contributed either positively or negatively to growth and yield in the cacao genotypes. Such inter-character associations can therefore be used as criteria for selection of the genotypes that particularly exhibit good yield. This relationship applies to plant height, time to jorquette, time to fruit harvest, fruit length and fruit width with pod index. Significant correlations of yield-related characters in young cacao plants were reported by Santos *et al* (2018).

The direct and indirect relationships between pod index and the vegetative and fruit characters of the nine cacao genotypes indicated that plant height, jorquette height, fruiting, time to fruit harvest, fruit weight and fruit width all had a negative direct effects on pod index. These relationships are very desirable. It implies that an inverse relationship exists between each of these traits and pod index, i.e. an increase in the value of each of these results in a corresponding reduction in the pod index. Since pod index refers to the number of cocoa pods required to produce 1.0kg of dry cocoa beans (Wood and Lass, 1985), the lower the value, the more desirable the genotype. Any character whose incremental value will reduce the numerical value of pod index is therefore of utmost importance.

The valuable negative indirect effects of these plant traits on pod index include their effects through fruiting, cherelle wilt, fruit length and fruit width (for plant height); fruit wilt, fruit weight and fruit width (for jorquette height); plant height, stem diameter, time to fruit harvest and fruit length (for fruiting); stem diameter, tree circumference, fruiting and fruit weight (for time to fruit harvest); stem diameter, jorquette height, tree circumference, time to fruit harvest and pod thickness (for fruit weight); and plant height, time to jorquette, cherelle wilt, fruit length and pod thickness (for fruit width). Each of plant height, jorquette height, fruiting, time to fruit harvest, fruit weight and fruit width can therefore be considered along with any or all of each of the other traits that enhance their negative expression in the screening or selection of these cacao genotypes for desirable pod index. Initial increase in the tree circumference can result in better yield (pod index), when tree circumference is considered in association with jorquette height, fruiting, cherelle wilt, fruit length and fruit width, which all had negative indirect correlations with pod index. The other traits such as stem diameter, time to jorquette, cherelle wilt, fruit length and pod thickness which had positive direct effect on pod index (which is not desirable in this context) can also be considered in conjunction with the traits which had negative indirect effect on pod index. The significant value of the residual factor in spite of the large number of characters used in the path coefficient analysis may be due to the fact that correlations are mere estimates, and may also be due to rounding-off errors.

CONCLUSION

Significant association existed among most traits under consideration, and such traits significantly determined yield as indicated by pod index in cacao. These traits, therefore, are important for consideration in further yield improvement procedures in cacao.

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Table 2: Phenotypic correlation coefficients among fourteen vegetative and fruit characters of nine cacao hybrids used in the study

Character	S D	N L	TTJ	JH	TC	FRT	WLT	TFH	Frt Wt	Frt Lt	Frt Wth	P T	Rows	P. I.
P H	0.83**	0.25	0.10	0.21	0.60**	0.46*	-0.06	-0.47**	-0.09	-0.27	0.41*	0.36	-0.01	0.56**
S D		0.40*	-0.09	0.37*	0.55**	-0.06	-0.41*	-0.45*	-0.01	-0.09	0.48**	-0.17	-0.05	0.36
N L			-0.17	0.09	0.35	-0.09	-0.16	-0.09	-0.23	0.05	0.13	-0.18	0.33	0.06
TTJ				0.11	-0.10	0.25	0.30	0.43*	0.53**	0.29	-0.69**	0.30	-0.27	-0.40*
JH					0.14	-0.32	-0.28	-0.36	0.19	-0.07	0.27	-0.33	-0.30	0.09
TC						0.23	0.01	-0.25	-0.05	-0.08	0.30	0.15	-0.08	0.29
FRT							0.57**	0.03	-0.15	-0.26	-0.10	0.96**	0.25	0.25
WLT								0.30	0.21	-0.15	-0.32	0.55**	0.01	-0.12
TFH									0.41*	0.71**	-0.91**	0.10	-0.05	-0.83**
Frt Wt										0.18	-0.35	-0.17	-0.64**	-0.62**
Frt Lt											-0.66**	-0.11	-0.29	-0.63**
Frt Wth												-0.19	0.04	0.73**
P T													0.14	0.21
Rows														0.15
Bns/Row														-0.71**

NB: df= 25; * and ** = Significance at 0.05 and 0.01 respectively. The values without asterisk are not significant

PH= Plant Height; SD= Stem Diameter; NL= Number of Leaves; TTJ= Time to Jorquette; JH=jorquette Height; TC= Tree Circumference; FRT= Presence of Fruit; WLT= Cherelle Wilt; TFH= Time to fruit harvest; Frt Wt= Fruit Weight; Frt Lt= Fruit Length; Frt Gt= Fruit Girth; PT= Pod Thickness; Bns/Row= Number of Beans per row; P. I. = Pod Index

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Table 3: Genotypic correlation coefficients among fourteen vegetative and fruit characters of nine cacao hybrids used in the study

Character	S D	N L	TTJ	JH	TC	FRT	WLT	TFH	Frt Wt	Frt Lt	Frt Wth	P T	Rows	P. I.
P H	2.84**	-1.62**	1.29**	-1.06**	2.29**	2.24**	-4.09**	-2.19**	-1.07**	-0.47**	27.68**	19.82**	-0.82**	4.27**
S D		-0.93**	0.49**	0.70**	-0.23	-0.49**	-2.51**	-0.90**	-0.02	0.27	14.46**	0.88**	-0.48**	0.96**
N L			0.11	0.42	-0.72**	-0.52	-1.34**	-0.25	-0.46*	0.21	5.06**	1.13**	0.42*	0.24
TTJ				0.15	1.25**	0.84**	1.70**	0.78**	1.21**	0.56**	-9.98**	2.39**	-0.53**	-0.99**
JH					0.75**	-0.68**	-1.42**	-0.41*	0.15	0.09	1.57**	0.12	-0.41*	0.78*
TC						0.14	-1.27**	-0.42**	-0.08	-0.14	7.96**	1.84**	-0.37*	0.72*
FRT							0.57*	0.03	-0.25	-0.47**	-0.05	10.60**	0.30	0.47**
WLT								0.54**	0.31	-0.28	-3.76**	9.52**	-0.33	0.54**
TFH									0.44*	0.89**	-9.17**	0.66**	-0.02	-1.09**
Frt Wt										0.24	-4.85**	-0.42	-0.61**	-0.75*
Frt Lt											-9.89**	-1.21**	-0.30	-0.92**
Frt Wth												-17.20**	2.56**	12.26**
P T													1.37**	0.38
Rows														0.11
Bns/Row														-0.56**

NB: df= 25; * and ** = Significance at 0.05 and 0.01 respectively. The values without asterisk are not significant

PH= Plant Height; SD= Stem Diameter; NL= Number of Leaves; TTJ= Time to Jorquette; JH=jorquette Height; TC= Tree Circumference; FRT= Presence of Fruit; WLT= Cherelle Wilt; TFH= Time to fruit harvest; Frt Wt= Fruit Weight; Frt Lt= Fruit Length; Frt Gt= Fruit Girth; PT= Pod Thickness; Bns/Row= Number of Beans per row; P. I. = Pod Index

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Table 4: Environmental correlation coefficients among fourteen vegetative and fruit characters of nine cacao hybrids used in the study

Character	S D	N L	TTJ	JH	TC	FRT	WLT	TFH	Frt Wt	Frt Lt	Frt Wth	P T	Rows	P. I.
P H	0.65**	0.63**	-0.04	0.54**	0.42*	0.18	0.60**	-0.25	0.24	-0.32	-0.15	-0.29	0.22	-0.16
S D		1.13**	-0.32	0.17	0.98**	0.33	0.64**	0.13	0.00	-0.38	-0.35	-0.30	0.33	-0.07
N L			-0.33	-0.22	1.17**	0.48**	0.69**	0.61**	0.15	-0.14	-0.29	-0.41	0.24	-0.14
TTJ				0.09	-0.86**	-0.28	-0.44**	0.06	-0.18	0.09	-0.17	0.10	-0.06	0.04
JH					-0.44	0.26	0.73**	-0.55**	0.33	-0.29	0.22	-0.51	-0.14	-0.84
TC						0.37*	0.91**	0.16	0.01	-0.02	-0.30	-0.06	0.30	-0.16
FRT							0.63**	0.11	0.16	0.13	-0.18	-0.92**	0.12	-0.14
WLT								-0.31	0.09	-0.03	-0.10	-0.58**	0.40*	-0.79**
TFH									0.29	0.22	0.09	-0.07	-0.43*	0.02
Frt Wt										0.02	0.23	-0.27	-0.78**	-0.35
Frt Lt											0.22	0.07	-0.27	-0.17
Frt Wth												0.10	-0.31	-0.39*
P T													-0.09	0.26
Rows														0.24
Bns/Row														-0.90**

NB: df= 25; * and ** = Significance at 0.05 and 0.01 respectively. The values without asterisk are not significant

PH= Plant Height; SD= Stem Diameter; NL= Number of Leaves; TTJ= Time to Jorquette; JH=jorquette Height; TC= Tree Circumference; FRT= Presence of Fruit; WLT= Cherelle Wilt; TFH= Time to fruit harvest; Frt Wt= Fruit Weight; Frt Lt= Fruit Length; Frt Gt= Fruit Girth; PT= Pod Thickness; Bns/Row= Number of Beans per row; P. I. = Pod Index

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Table 5: Direct and indirect path coefficients between pod index and twelve vegetative and fruit characters of nine cacao hybrids

Indirect effects through other plant characters

	Direct effect	PH	SD	TTJ	JH	TC	FRT	WLT	TFH	Frt Wt	Frt Lt	Frt Gt	PT	Corr with Pod index
PH	**-0.2087**		1.4382	3.8597	0.4637	0.6822	-6.3551	-14.6547	18.645	4.4176	-2.1379	-2.7851	0.9052	4.27
SD	**0.5064**	-0.5928		1.4661	-0.3062	-0.0685	1.3902	-8.9934	7.6623	0.0826	1.2282	-1.4549	0.0402	0.96
TTJ	**2.992**	-0.2693	0.2481		-0.0656	0.3724	-2.3832	6.0912	-6.6407	-4.9956	2.5473	1.0042	0.1092	-0.99
JH	**-0.4375**	0.2212	0.3545	0.4488		0.2234	1.9292	-5.0879	3.4906	-0.6193	0.4094	-0.158	0.0055	0.78
TC	**0.2979**	-0.4780	-0.1165	3.7400	-0.3281		-0.3972	-4.5505	3.5758	0.3303	-0.6368	-0.8009	0.084	0.72
FRT	**-2.8371**	-0.4675	-0.2481	2.5133	0.2975	0.0417		2.0423	-0.2554	1.0321	-2.1379	0.005	0.4841	0.47
WLT	**3.583**	0.8537	-1.2711	5.0864	0.6212	-0.3783	-1.6171		-4.5974	-1.2799	-1.2736	0.3783	0.4348	0.54
TFH	**-8.5137**	0.4571	-0.4558	2.3338	0.1794	-0.1251	-0.0851	1.9348		-1.8166	4.0484	0.9227	0.0301	-1.09
Frt Wt	**-4.1286**	0.2233	-0.0101	3.6203	-0.0656	-0.0238	0.7093	1.1107	-3.7460		1.0917	0.4880	-0.0192	-0.75
Frt Lt	**4.5487**	0.0981	0.1367	1.6755	-0.0394	-0.0417	1.3334	-1.0033	-7.5772	-0.9909		0.9951	-0.0553	-0.92
Frt Gt	**-0.1006**	-5.7774	7.3226	-29.8601	-0.6868	2.3711	0.1419	-13.4723	78.0706	20.0236	-44.987		-0.7855	12.26
PT	**0.0457**	-4.1369	0.4456	7.1509	-0.0525	0.5481	-30.0732	34.1106	-5.619	1.734	-5.504	1.7306		0.38

PH= Plant Height; SD= Stem Diameter; TTJ= Time to Jorquette; JH=jorquette Height; TC= Tree Circumference; FRT= Presence of Fruit; WLT= Cherelle Wilt; TFH= Time to fruit harvest; Frt Wt= Fruit Weight; Frt Lt= Fruit Length; Frt Gt= Fruit Girth; PT= Pod Thickness
Residual effect = 1.7558

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VARIATION IN FRUIT TRAITS OF FOUR ACCESSIONS OF SABA *(SABA SENEGALENSIS)* FROM KOGI STATE, NIGERIA

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ABSTRACT

This study was undertaken to evaluate morphological variations in Saba fruits sourced from Kabba, Okoro, Unosi and Oforachi in Kogi State. The morphological variation in fruits was evaluated by sampling fruits and assessing their characteristics. Five fruits per accession were selected for this study and were replicated five times. The experiment was a completely randomized design (CRD). Results of the analysis of variance revealed variability in most fruit traits of Saba across the accessions. Oforachi and Okoro accession had the widest fruit base shape of 5.0 (IPGRI, 1995) which did not differ statistically from the value (4.8) recorded from Unosi accession. The widest fruit circumference (25.3 cm), widest diameter (7.8 cm), heaviest fruit weight (283.0 g) and thickest pulp (1.0 cm) were obtained in Oforachi accession. Values for fruit circumference and fruit diameter obtained in this accession were not statistically different from 25.0 cm and 7.4 cm obtained in Kabba accession, respectively. Kabba accession gave the longest fruit length (14.0 cm), heaviest fresh weight of seeds with mucilage (148.6 g) and pulp weight (99.6 g). The diversity found between locations is vital for selection and domestication of this wild species. This could provide basis for genetic improvement of Saba.

Key words: Accession, *Saba senegalensis*, fruit traits, variability

INTRODUCTION

Human cultivates a number of plant species with different direction of use – seeds, fruits, roots, leaves etc. Market requirements enforce fruits to be attractive for consumers, traders and for processing industry according to appearance, size and weight (Todorova, 2007). Quantitative fruit characters – length, diameter, pericarp thickness, average weight and usable part are of great importance in describing of fruits and genotypes (varieties), respectively. They also have strong effect for economic significance of each variety. Saba is gaining popularity and may soon take its place in domestic and international market. The fruit is highly prized and in parts of Africa, they are important to the rural economy and are openly hawked in the cities (TPD, 2020).

Saba senegalensis (A.DC.) Pichon is an African indigenous large, woody plant that belongs to the family Apocynaceae (Arbonnier, 2000). In Nigeria, it is found largely in North central and Southern parts of the country (Baiyeri *et al.,* 2019). It is a climber that usually seeks support from other plant species to rest upon and grow. The species growing in various ecological conditions (from 100 mm to 1300 mm annual rainfall). It is known as 'Utu' by the Igbo of southeastern Nigeria, 'Ibo' by Okun-Yoruba of north central Nigeria (Baiyeri *et al.,* 2019). *Saba senegalensis* has the potential to contribute in feeding and treating hundreds of diseases in rural populations (Sarr *et al*., 2018). The pulp is tasty, sweet sour with yellow colour when ripe and can be consumed as such or can be processed into puree, nectar and jams (Arbonnier, 2000; Tanor, 2001). The fruit is rich in vitamin A, vitamin C, dietary fiber and contains minerals such as potassium, magnesium and calcium (Fatim *et al.,* 2019).

Earlier studies focused on biochemical evaluation of Saba fruit pulp but not on fruit characterization and as such there is limited information on the characterization of Saba fruit in Nigeria. Therefore, the main aims of this study was to investigate the natural variation in fruit traits of Saba. Furthermore, to identify accession with specific fruit traits that will increase the market value, encourage the cultivation of this wild species and prevent it from going into extinction.

MATERIALS AND METHODS

Fully matured *Saba senegalensis* fruits (Fig. 1) for this experiment were harvested from the wild in four Local Government Areas (LGAs) purposively selected, they are Kabba in Kabba Bunu LGA, Okoro in Ijumu LGA, Unosi in Ajaokuta LGA and Oforachi in Igala Mela/Odollu LGA of Kogi State. The experiment was a completely randomized design (CRD). Five fruits per accession were selected for this study and were replicated five times. This corresponds to a total of 100 fruits sampled used for assessing and analyzing morphometric data for Saba. The fruits were cut into two halves and the measurements taken. De-pulping was done by pouring the seeds containing mucilage in a cloth and saw dust added, folded and squeezed gently till the pulp is removed from the seeds. The seeds were poured in a basket rubber with smaller mesh size compared to the size of seeds, washed in a bowl filled with clean water and used for other measurements. Most of the measurements taken were done as stated in descriptors for avocado (IPGRI, 1995).

Figure 1: *Saba senegalensis* whole fruit and yellowish fruit pulp with seeds

Data collection

Fruit apex position, fruit base shape, fruit shape and seed shape were determined using descriptors for Avocado as described by IPGRI (1995). Fruit circumference (cm) was measured round the fruit from the apex to the base using measuring tape, fruit length was determined in cm by measuring the fruit from the apex to the base using measuring tape, fruit diameter was measured in cm at the broadest part of the fruit by a measuring tape, fruit weight was determined in (g) by weighing each fruit with sensitive scale and the average recorded, pulp thickness was taken using a Vernier caliper, fresh weight of seeds per fruit with mucilage was determined in gram by using weighing balance, pulp weight was calculated by subtracting the weight (g) of seed with mucilage from the weight of seed without mucilage and the average recorded (pulp + seed – seed), according to De Smedt *et al.* (2011). Fresh seed weight per fruit without mucilage was determined in gram by using weighing balance and the average recorded and number of seeds per fruit were counted and the average also recorded.

Data analysis

Data were collected across the accessions and subjected to the analysis of variance (ANOVA) in completely randomized design (CRD) using GENSTAT Discovery edition 3 Release 7.22 DE (GENSTAT, 2008). Significant treatment means were compared using least significant difference (LSD) at 5 % level of probability.

RESULTS

The fruit traits varied with the accessions except fruit apex position, fruit shape, fresh seed weight per fruit without mucilage and number of seeds per fruit (Table 1). Oforachi and Okoro accession had the widest fruit base shape of 5.0 which did not differ statistically from the value (4.8) recorded from Unosi accession while the thinnest (2.4) was obtained in Kabba accession. The widest fruit circumference (25.3 cm), widest diameter (7.8 cm), heaviest fruit weight (283.0 g) and thickest pulp (1.0 cm) were obtained in Oforachi accession. Value for fruit circumference and fruit diameter obtained in this accession were not statistically different from the value (25.0 cm and 7.4 cm) obtained in Kabba accession, respectively. Kabba accession gave the longest fruit length (14.0 cm), heaviest fresh weight of seeds with mucilage (148.6 g) and pulp weight (99.6 g) while the shortest fruit circumference (19.0 cm), fruit length (11.0 cm), diameter (5.6 cm), least fruit weight (113.0 g), tiniest pulp (0.6 cm), least fresh weight of seeds per fruit with mucilage (58.2 g) and least pulp weight (33.4 g) were attributed to Unosi accession.

DISCUSSION

The differences in fruit traits studied may be related to the variability between the four studied accessions, climatic conditions and nature of the soil in each location of collection. Todorova (2003) established that the systematic factors manifest a proven effect on the phenotypic variability of length, diameter, weight and usable part of the fruit. Stoffella *et al.* (1995) report similar results for fruit weight in Bell peppers. The fruit length and fruit diameter obtained in this study varied from (11.0 to 14.0 cm and 5.6 to 7.8 cm) respectively. These were similar with the report of Sarr *et al.* (2018) who observed that the fruit of *Saba senegalensis* is a globose shell, 7 to 10 cm long, 6 to 8 cm wide. Also, fruit length recorded in this work varied from 11.0 to 14.0 cm, fruit weight ranges from 113.0 to 283.0 g, weight of pulp varies from 33.4 to 99.6 g and number of seed per fruit ranged from 25.0 to 47.8. The results are similar to the findings of Nafan *et al.* (2013) who reported that the length of Saba fruit varied from 6.7 to 12.3 cm; the weight of the whole fruit ranged from 173.8 to 491.14 g; the weight of the pulp varied from 63.47 to 216.53 g and the number of nuts by fruit swung from 10 to 45. The weight of pulp observed in this present study is lower when compared to the value obtained in their study.

Table 1: Effect of accession on fruit traits of *Saba senegalensis*

ACCESSION	FAP	FBS	FC	FL	FD	FW (g)	PT	FS	SWM	PW	SWWM	NSPF
KABBA	5.0	2.4	25.0	14.0	7.4	265.0	0.8	4.4	148.6	99.6	49.0	47.8
OFORACHI	5.0	5.0	25.3	13.0	7.8	283.0	1.0	2.2	132.6	89.8	42.8	31.2
OKORO	5.0	5.0	23.0	12.0	6.8	199.0	0.7	3.4	110.6	72.0	38.6	40.2
UNOSI	4.8	4.8	19.0	11.0	5.6	113.0	0.6	3.4	58.2	33.4	24.8	25.0
LSD (0.05)	NS	0.4	3.0	1.7	0.9	88.0	0.1	NS	58.0	40.0	NS	NS

FAP=fruit apex position, FBS=fruit base shape, FC=fruit circumference, FL=fruit length, FD=fruit diameter, FW=fruit weight, PT=pulp thickness, FS=fruit shape, SWM= seed weight with mucilage, PW=pulp weight, SWWM= seed weight without mucilage and NSPF= number of seeds per fruit.

CONCLUSION

It was evident that differences existed in fruit traits of four accessions of *Saba senegalensis* from Kogi State, Nigeria, indicating great potential for domestication of this crop. This information could provide basis for genetic improvement of this wild species.

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FRUIT QUALITY OF TWELVE SELECTED TOMATO GENOTYPES IN SOUTH WESTERN NIGERIA

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ABSTRACT

Physicochemical and chemical properties are very important in the determination of fruit quality in tomato. Twelve selected tomato genotypes were established at the Vegetable research field of National Horticultural Research Institute, Ibadan, Nigeria. Wholesome ripe fruits were selected for each genotype and all laboratory analysis were carried out following standard procedures. The results revealed significant variation for all the physicochemical and chemical properties examined in the twelve tomato genotypes. NHSL4, NHSL11, NHSL20 and NHSL21 had the highest lycopene content, ranging from 0.32 to 0.35 mg/100g out of the twelve genotypes; NHSL20 and NHSL21 had the highest beta-carotene (0.27mg/100g each respectively); NHSL12 and NHSL20 recorded the highest Vitamin C (0.151 and 0.148 mg/g respectively) while the highest value for fruit firmness (5.03 Pascal) was recorded for NHSL11. In conclusion, NHSL4, NHSL11, NHSL21, NHSL20 and NHSL12 with highest carotenoid content, Brix, Vitamin C and firmness can be selected as genotypes with high quality fruits for health and commercial purposes. They can be used for crop improvement in future breeding programme.

Key words: Breeding, physicochemical, tomato, lycopene, quality

INTRODUCTION

Tomato is one of the vegetable fruits consumed worldwide. This is due to its ability to reduce the incidence of chronic degenerative diseases such as some types of cancer (Giovannucci, 1999) and cardio-vascular diseases (Pandey *et al*., 1995). It has been reported that tomato fruit contains 92.5 – 95 % water and 5 – 7.5 % dry matter (DM). The DM consists of 48 % sugars (glucose and fructose), organic acids, 13 % citric and malic acids; minerals mainly N, P and K (18 %) and small fractions of vitamins and anti-oxidant pigments (e.g. lycopene) (Carvalho, 1980). Lycopene, ascorbic acid (vitamin C) and potassium contents are part of nutritional value derived from tomato and they are of great importance to human health (Caliman, 2010). Vitamin C which is useful for the prevention of scurvy and maintenance of skin and blood vessels can also be found in fruits (tomato) and vegetables in form of ascorbic acid and is equally important to human health (Lee and Kader, 2000). Due to the health benefits derived from tomato and its importance to human well-being, studying the level of the physico-chemical and chemical properties in different genotypes cannot be over-emphasized. The objectives of the study were, therefore, to determine the variation in the quality of properties in fruits of twelve selected tomato genotypes and to select genotypes with best fruit quality in terms of physical and nutritive content.

MATERIALS AND METHODS

Twelve genotypes of tomato selected from an on-going breeding programme were used in this study. These were established on the Vegetable field of National Horticultural Research Institute, Ibadan using a completely randomized block design with three replications. The spacing used was 0.5 m between plants and 0.6 m within rows with 12 plants per plot. Wholesome fruits used for the study were harvested on sampled plants at red ripen stage. Each sample used for the analysis comprised of 2 - 4 fruits depending on the fruit size of each genotype. The samples used were cut, freeze-dried, powdered and stored at -20°C for determination of the physicochemical properties.

Determination of physicochemical properties in tomato at red ripen stage:

Total Titratable acidity (TTA) (%): This was obtained by titrating 5 ml of sample powder with 0.1 N NaOH up to pH 8.1. The result was expressed as grams of citric acid per 100 g of dry sample weight (AOAC, 2000).

Brix or Total Soluble Solid (TSS) (°C): Total soluble solids (TSS) were determined for each sample according to AOAC (2000) method using an Atago DR-A1digital refractometer (Atago Co. Ld., Japan) at 25 ° C and expressed as percentage.

Fruit firmness: The fruits firmness for the twelve tomato genotypes was measured by the use of manual fruit penetrometer by pressing the tip of the penetrometer on the side of the fruit until the reading was taken. This was done on three fruits per genotype and the average measurement was recorded. The result obtained was subjected to analysis of variance while means were separated using Duncan's Multiple Range Test (DMRT).

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Determination of the chemical properties in tomato at red ripen stage

Beta-carotene: About 0.5 g of homogenous sample was extracted with 5 ml cold Acetone and 5 ml ethanol, until the total loss of pigmentation. 3 ml of distilled water was added which was later partitioned with 10 ml petroleum ether. The ether phase was passed through Neutral Alumina (activity III) packed column. The column was eluted with petroleum ether and the first band was collected into 25 ml volumetric flask. The extract was read at 450 mm, to determine beta-carotene content calculated were as follows:

$$C(\mu g/g) = \frac{A \times \text{Volume (ml)} \times 10^4}{A1\ \% \times 1\ \text{cm} \times \text{sample weight (g)}}$$

Where A = Absorbance, A1 % = absorption coefficient of beta –carotene in PE (2592) (Rodriguez-Amaya and Kimura, 2004).

Lycopene: Out of the stored dry samples, 0.5 g was extracted with 5 ml cold Acetone and 5 ml ethanol, until the total loss of pigmentation. 3 ml of distilled water was added which was later partitioned with 10 ml petroleum ether. The ether phase was passed through Neutral Alumina (activity III) packed column. The column was eluted with petroleum ether and the first band was collected into 25 ml volumetric flask. The extract was read at 510 mm, to determine lycopene content calculated were as for beta-carotene.

Total carotene = Lycopene + beta carotene.

Vitamin C: Five ml of standard solution of ascorbic acid was pipetted into 100 ml conical flask. 10 ml of oxalic acid was added and the solution titrated against the dye (V_1 ml) until a pink colour persisted for 15 seconds. The dye consumed is equivalent to the amount of ascorbic acid.

The amount of vitamin C in analyzed samples was determined by titration using the method described by Pongracz *et al*., (1971) with slight modifications. About 0.5 g of each sample was soaked for 10 min in 40 ml meta-phosphoric acid-acetic acid (2 % w/v). The mixture was centrifuged at 3000 rpm for 20 min and the supernatant obtained was diluted and adjusted with 50 ml of bi-distilled water. 10 ml of Oxalic acid was added to 5 ml of the mixture above. 10 ml of this mixture was titrated to the end point with dichlorophenol-indophenol (DCPIP) 0.5 g/L. The volume of the dye used was recorded as (V_2 ml):

$$\text{Ascorbic acid (mg/100g)} = \frac{0.5\ \text{mg} \times V_2 \times 50\ \text{ml} \times 100}{V_1 \times 5\ \text{ml} \times W}$$

Where W = sample weight (Pongracz *et al*., 1971).

RESULTS

Tomato fruits of 12 genotypes were estimated for important physicochemical and chemical characteristics. The analysis of variance for these properties of 12 tomato genotypes is presented in Table 1. There were significant differences for all the parameters observed in this study. Table 2 presents the descriptive statistics for the physicochemical and chemical properties in twelve selected tomato genotypes. The TTA (%) content ranged between 0.05 to 0.22 %. The highest content was observed in NHSL2 while the lowest was recorded in NHSL14. The average value for TTA was 0.08 %. Brix or Total Soluble Solid (TSS) (0^o) content also varied and ranged from 4.07 to 5.77 mg/100g. The highest Brix was recorded in NHSL11 (5.77 mg/100g) while the least was observed in NHSL13 (4.07 mg/100g). Beta-carotene content in 12 tomato genotypes ranged from 0.07 to 0.27 mg/100g. The highest β-Carotene content was recorded in NHSL21 (0.27mg/100g) followed by NHSL20 (0.27mg/100g) which were statistically similar to each other while the least content was recorded in NHSL19 (0.07 mg/100g). The range of lycopene content was between 0.15 to 0.35 mg/100g with the highest recorded in NHSL4 (0.35 mg/100g) followed closely by NHSL11 (0.34 mg/100g) which were statistically similar while the least was recorded in NHSL23 (0.31 mg/100g). The Vitamin C content observed in the tomato genotypes at full ripen stage ranged from 0.088 to 0.151 mg/g. NHSL12 (0.151 mg/g) recorded the highest Vitamin C content while the least content was obtained in NHSL13 (0.088 mg/g).

The firmness of 12 selected fruits at five days after harvesting at full ripeness was measured by manual fruit penetrometer by pressing the tip of the penetrometer on the side of the fruit until the reading is taken. This was done on three fruits per genotype. The readings showed variation across the 12 genotypes under studied. The highest fruit firmness (very firm) was recorded in NHSL11 (5.03 Pascal), followed by NHSL14 (4.80 Pascal) while the lowest firmness (very soft) was observed in NHSL4 (3.23 Pascal).

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Table 1: Analysis of variance of physicochemical and chemical properties of 12 genotypes of tomato

	TTA (%)	Brix (0°)	B/Carotene	Lycopene	Vit. C
Rep	15.24 x 10^{-5}	11.94x10^{-3}	3.13 x 10^{-5}	3.0x10^{-5}	1.81x10^{-5}
Genotype	0.007**	0.663**	0.025**	0.023**	0.001**
Error	65.14x10^{-5}	6 x 10^{-3}	15.12x10^{-5}	6.31x10^{-5}	1.09x10^{-5}
CV	32.81	1.67	6.747	3.115	2.682

TTA: Total titratable acidity; B/Carotene: β–Carotene; Vit. C: Vitamin C

Table 2: Descriptive statistics for the physicochemical properties and firmness in twelve selected tomato genotypes

Property	Mean	Coefficient of Variation (%)	Range
TTA (%)	0.08	32.81	0.05 - 0.22
Brix (0°)	4.71	1.67	4.07 - 5.77
B-Carotene (mg/100g)	0.18	6.75	0.05 - 0.27
Lycopene (mg/100g)	0.26	3.12	0.15 - 0.35
Vitamin C (mg/g)	0.12	2.68	0.08 - 0.15
Firmness (Pascal)	4.12	20.54	3.23 - 5.03

DISCUSSION

Physicochemical and chemical properties are very important when determining the quality of tomato fruits. The significant differences observed among these parameters in tomato genotypes is an indication that there is wide variability within the genotypes and this enhances large scope of selection in future breeding programme. Four (NHSL4, NHSL11, NHSL20 and NHSL21) out of twelve genotypes in this study had high lycopene content while two (NHSL20 and NHSL21) had high beta-carotene content. These two are the total carotene recorded in this study and these contain anti-cancer agents which help in the fight against cancerous diseases. This is an indication that consumption of these genotypes can reduce the risk of cancerous diseases. This is in conformity with the work of Frusciante *et al.*, 2007 who studied the antioxidant nutritional quality of tomato. NHSL12 and NHSL20 had high Vitamin C content which helps in the fight against scurvy and maintenance of skin. This implied that these two tomato genotypes can help in reduction of the risk of scurvy in human and in maintenance of human skin.

The firmest fruit was NHSL11 followed by NHSL14. This indicated that these genotypes can store longer under room temperature and can be selected for the preparation of salad due to low moisture content. This is in conformity with the work of Lesage and Destain, 1996 who worked on measurement of tomato firmness by using a non-destructive mechanical sensor.

CONCLUSION

NHSL4, NHSL11, NHSL21, NHSL20 and NHSL12 with highest carotenoid content, brix, vitamin C and firmness can be selected as fruits with high quality for health and commercial purposes. These can be used for crop improvement in future breeding programme.

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FRUIT CHARACTERISTICS OF PEPPER ACCESSION IN FOREST AGRO-ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

Due to absence of improved varieties and lack of pure seed supply are among major challenges of production. Therefore, the study is to evaluate performance of pepper accessions for environmental adaptability and high yielding. Thirty-one pepper accessions were planted in randomized complete block design (RCBD) with three replicates during the year 2020. The seeds were raised in the nursery and transplanted to the field at five weeks after sowing. The accessions were grown in the field with spacing 50 cm by 50cm. Data were collected on growth and yield attributes of pepper accessions. Data collected were subjected to analysis of variance and significant means were separated using Least Significant Difference at P≤0.05. Pepper accession varied significantly in term of vegetative growth and yield trait. In conclusion pepper accession V11R1 had the highest yield follow by V4R2-1, V17R2, V1R2-1 and V3R3-3. These can be used for crop improvement in future breeding programme.

Key words: Growth, pepper accession, fruit characteristics yield, Rainforest agro-ecological zone of Nigeria

INTRODUCTION

Pepper (*Capsicum annuum L)* belongs to the family *solanaceae*, under the genus *Capsicum* (Russo, 1996). The crop is a native of Tropical South America especially Brazil which is thought to be the original home of Peppers (Islam *et al*., 2010). The genus Capsicum contains about 20 species but the popularly cultivated species are sweet pepper (*C. annum*) and hot pepper (*C. frutescens*) both serving as a food and cash crops in Nigeria and other countries. Pepper yields obtained by peasant farmers in Nigeria are often very low (Adigun, 2001). Pepper thrives in a wide range of soil types, but good drainage is essential. Is the most precious and valuable form of spices in the world (Usman, 2019). It is the 3rd most added ingredient in food among the wide range of spices, India is one of the largest producers of pepper, after China and Vietnam. Pepper has played a pivotal role in India's international trade and it is said that the Europeans came to India primarily for this pepper spices (Grubben, 2004). It is also used in industry as an ingredient for numerous foodstuffs, and also in certain cosmetic and pharmaceutical products (Grubben and El Tahir, 2004).

The world fresh chilli and sweet pepper production was 27.6 million tons in 2010, to which West Africa contributed 888,400 tons or 3.2%. In 2011, it was estimated that Nigeria produced 50% of total production in Africa (Adesina *et al,* 2014) and ranked 8th while Ghana ranked 13th producing country in the world (FAOSTAT, 2012). However, farmers use to grow mostly local selections, because there are shortages of improved varieties. Most farmers produce seeds from harvested fruit or source from local markets. Such seed lots are often mixed with different varieties and the impurities harboring pathogens. Thus, the objective of this study is to evaluate performance of pepper accessions for environmental adaptability and high yielding.

MATERIALS AND METHODS

The field trial was carried out during dry (October 2020 – March 2021) seasons at block 3 Vegetable Research Field of the National Horticultural Research Institute (NIHORT), Ibadan (Latitude 7° 22' N and Longitude 3° 50' E at 234m above sea level), located in the forest agro-ecological zone of Nigeria. The experimental site had been under continuous cultivation for many years. Top soil was collected and sterilized by heating to 100^{0}C in a metal drum and was allowed to cool. The sterilized soil was filled into nursery trays after which seeds of pepper accession were sown. Regular watering and monitoring was carried out in the nursery for five weeks. The trial was laid out in randomized complete block design (RCBD). The treatments consisted of 31 pepper lines. The land was ploughed and left for two weeks to allow buried weeds to decay and ploughed followed by harrowing. Pepper seedlings were transplanted at 5 weeks after sowing (WAS) at the spacing of 50 x 50 cm. The plot size was 2 x 2 m, alley of 1.0 m within plots and 1.0 m between replicates. NPK 20 10 10 at the rate of 15g per plant (two splits) was applied 8 weeks after transplanting. Weeding was carried at 4 weeks' interval Cypermethrin was applied at 2ml to 1 liter of water to control insect.

Data were collected from five randomly selected tagged plants within the plot for growth and yield attributes; plant height, number of leaves, number of fruit per plant, fruit weight, fruit length, fruit width, pedicle length, number of seeds/ fruit and seed weight All data collected were subjected to the analysis of variance (ANOVA) using Gen-Stat Discovery Edition 4 (2013). Significant means were separated using least significant difference (LSD) at five per cent (5%) level of probability ($P \leq 0.05$).

RESULTS AND DISCUSSION

The result in table 1 shows significant difference among the treatments in plant heights the tallest plant height was recorded from variety NHTatase (51.30 cm) followed by V6R3-4 (47.90 cm) followed by V12R3-4 (45.20cm). The shortest plant height was attained from variety V1R2-1 (16.70 cm) at 6 WAT. This result is in agreement with the works of MARC (2005), which reported that varieties Weldele and Melka Zala showed the tallest plant height of 61 and 62 respectively among the evaluated varieties at three locations. The significant variation of plant height in pepper accession maybe attributed to genetic potential as well as environmental factor and ability to absorb nutrients. This result is in agreement with work done by Eghaarevba and Law-Ogbomo (2007) El-Tahomy et al, Alizadeh and Carapetian (2006) Vos and Frinking 1997 and Mastro (2007) who reported significant differences in plant height in other crop due to genetic and environmental condition.

There were significant differences among the treatments at 2 and 6WAT (Table 3). Pepper accession tagged with V2R1-1 and V11R1-1 had the highest number of leaves (29.00 and 87.00) while V12R1-1 and V13R3-2 recorded least value of 6.36 and 22.50 respectively. In contrary at 4WAT, V6R3-1 had the highest value while V12R3-6 and V12R1-1 had the lowest number of leaves of 12.08. Significant differences were observed among the evaluated pepper accessions for some of the quality and yield trait. Table 4 shows that V11R1-1 had significantly higher fruit length, fruit width, number of seeds, pedicle length, fruit yield in gram and fruit yield in ton/ha, except in number of fruits and seeds weight. Fruit length was significantly differed among the pepper accessions. V11R1-1 had the longest fruit length (69.1cm) followed by V17R2-1 (61.5cm) and V4R2-1(56.8cm) while the shortest fruit length was recorded in T26.

Fruit width had highly significant effect among the pepper accessions. The highest fruit width was produced by V11R1-1 (177.4cm), followed by T2 (128.5cm) and T28 (124.4cm) while T26 had the least fruit width. Similarly, number of fruits was significantly differed among the pepper accessions. NH TATASE had highest number of fruits per five plants (81.0) while the least number of fruits per five plants was recorded from T26. The variations in fruit development among accession could also be due to the temperature stress of the growing environment and the capability of each variety to withstand the stress specially on the reproductive development, which is more sensitive to high temperature stress (day and night temperature) than vegetative development. This result is inline with the work of Sato (2005), who reported that, the reduction of fruit set under moderately elevated temperature stress was mostly due to a reduction in pollen release and viability in tomato plant. Number of seeds had highly significant effect among the pepper accession. The highest number of seeds (1642.0) was recorded from V11R1-1, follow by V17R2-1 (1380) and V1R2-1 (1149.0) respectively while the least number of seeds per five plants was observed from T26. This report was inline with Russo (2003) and Aleemulah *et al*. (2000), who observed positive relationship between seed number and pod size, where fruit weight increased linearly with seed number in sweet pepper. Pedicel length was highly significant differ among the accession. V11R1-1, V5R3-2 and V17R2-1 produced the longest pedicel length of 38.9cm, 37.3cm and 32.3cm respectively whereas T26 produced the shortest pedicel length. The pepper seed weight had significant effect among the accession. The highest seed weight (20.94g) was obtained from V1R1-2, followed by V17R2-1 and V4R2-1 and the least seed weight was gotten from T26. Bosland and Votava (2000) reported that, in some cultivars of chili pepper seed, it contains up to 60% of the dry weight of the fruit which makes it an important economic part of the crop. There was significant variation in the fruit weight/g and fruit weight in tons/ha observed among the pepper accession. V11R1-1 V1R2-1 and V17R2-1 respectively recorded the highest fruit weight while least fruit weight was observed from T26. The significant differences in fruit yield among the pepper accessions may be due to genetics and environmental factors (Wasiullah *et al*., 2003 and Tsegaye *et al*., 2007).

CONCLUSION

There is variation in vegetative growth, fruit quality and fruit yield characters in the pepper accession during the late cropping season. Thus, based on the findings of present investigation, it can be

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concluded that pepper accession V11R1-1 recorded highest fruit yield during late cropping season. Accession V4R2-1, V17R2, V1R2-1 and V3R3-3 yielded relatively well. These can be used for crop improvement in future breeding programme.

Table 1: Effect of plant height on pepper accessions during dry season

	Plant height (cm)		
Accessions	2WAT	4WAT	6WAT
T1	9.85	19.34	26.80
T2	11.08	13.36	16.70
T3	11.69	15.95	23.80
T4	10.89	16.10	32.00
T5	9.17	18.83	40.00
T6	9.71	18.17	36.10
T7	9.67	18.32	35.60
T8	8.25	10.14	32.70
T9	8.83	16.35	33.50
T10	8.69	14.83	24.00
T11	7.92	17.10	36.40
T12	14.53	26.97	47.90
T13	9.08	22.67	41.60
T14	7.17	14.22	27.30
T15	9.08	17.99	38.10
T16	11.97	16.89	39.50
T17	14.17	26.40	45.20
T18	6.48	11.38	30.20
T19	8.00	21.47	24.50
T20	12.58	23.83	36.70
T21	13.44	20.08	28.40
T22	7.30	10.67	31.30
T23	18.78	23.72	41.00
T24	16.44	22.18	39.20
T25	11.50	19.23	29.00
T27	13.39	17.80	41.60
T28	12.27	23.22	36.70
T29	8.67	16.27	25.80
T30	6.11	14.83	51.30
T31	10.50	19.18	39.80
$LSD_{(0.05)}$	5.88	9.18	19.78
Sig	**	*	NS

Table 2: Effect of number of leaf on pepper accessions during dry season

	Number of leaf		
Accessions	2WAT	4WAT	6WAT
T1	15.63	26.72	37.50
T2	16.48	26.00	50.20
T3	10.57	25.50	35.80
T4	29.00	32.34	44.50
T5	7.67	19.50	44.80
T6	15.17	40.58	55.40
T7	11.08	35.67	87.00
T8	9.40	24.45	40.50
T9	12.28	25.00	39.70
T10	13.33	21.75	52.00
T11	9.25	22.14	45.00
T12	10.67	19.43	35.30
T13	10.94	22.32	39.60
T14	7.58	12.58	22.50
T15	7.00	21.22	43.10
T16	11.56	18.09	26.40

T17	10.81	25.33	43.40
T18	6.67	12.08	29.90
T19	10.00	12.83	35.00
T20	11.25	21.08	61.30
T21	11.15	29.61	68.00
T22	6.36	12.08	38.20
T23	17.17	34-00	68.80
T24	10.62	19.22	55.80
T25	14.44	29.75	57.40
T27	13.58	23.08	44.00
T28	15.75	32.83	68.40
T29	6.58	33.58	50.50
T30	9.08	19.08	52.90
T31	7.83	20.44	41.00
$LSD_{(0.05)}$	6.24	15.13	20.10
Sig	**	*	**

Table 3: Effect of yield attributes on pepper accessions during dry season

Accessions	Fruit Length cm	Fruit Width cm	Number of Fruit	Number of Seed	Pedicel Length cm	Seed Weight G	Fruit weight g	Fruit Weight ton/ha
T1	9.9	88.9	20.7	364.0	11.4	1.68	65.7	2.63
T2	34.5	128.5	30.0	1149.0	20.8	5.20	72.6	2.90
T3	2.8	16,5	1.0	67.0	2.6	0.25	7.8	0.31
T4	6.9	22,0	10.0	202.0	3.4	0.72	22.0	0.88
T5	10.0	143.4	24.0	393.0	16.6	1.90	53.3	2.73
T6	12.9	53.3	13.5	381.0	12.2	1.81	38.7	1.55
T7	69.1	177.4	44.0	1642.0	38.9	3.06	228.0	9.12
T8	29.3	71.0	20.0	911.0	12.7	3.09	72.8	2.91
T9	7.2	68.6	11.5	627.0	6.8	0.99	42.9	1.72
T10	5.9	25.0	5.0	57.0	3.9	0.38	13.1	0.52
T11	12.1	98.6	18.0	692.0	12.1	2.60	94.2	3.77
T12	25.7	65.4	7.5	201.0	10.4	1.43	38.5	1.54
T13	8.5	45.0	12.5	208.0	9.4	0.96	44.9	1.80
T14	5.2	32.1	8.0	213.0	3.5	2.83	33.8	1.35
T15	3.2	59.7	20.3	414.0	13.5	1.87	57.1	2.28
T16	2.4	21.3	3.0	58.0	2.1	0.35	6.4	0.25
T17	8.6	117.8	14.0	277.0	9.5	1.07	51.5	2.06
T18	15.3	84.1	20.0	670.0	12.2	2.95	92.8	3.71
T19	3.8	23.1	4.0	68.0	4.6	0.32	13.5	0.54
T20	7.1	110.5	13.0	306.0	9.3	20.94	27.6	1.11
T21	27.3	43.1	41.5	694.0	18.7	2.63	50.7	2.03
T22	12.4	57.2	15.0	305.0	8.0	0.96	23.9	0.96
T23	50.1	62.6	54.0	1034.0	37.3	5.31	84.8	3.39
T24	14.3	61.2	17.0	481.0	9.1	2.26	60.9	2.44
T25	10.1	47.7	14.5	302.0	9.5	1.09	37.3	1.49
T26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T27	56.8	109.6	40.7	914.0	30.1	6.84	176.0	7.04
T28	61.5	124.4	33.7	1380.0	32.3	7.87	163.4	6.54
T29	18.1	43.6	25.3	392.0	10.6	2.42	75.9	3.03
T30	20.9	36.9	**81.0**	912.0	2.6	0.25	71.3	2.85
T31	0.0	0.0	0.0	0.0	11.3	3.78	0.0	0.0
$LSD_{(0.05)}$	25.31	72.42	26.84	723.7	19.36	3.09	63.74	2.60
SIGN	**	**	**	**	**	**	**	**

T1=V1R1- 1, T2=V1R2-1, T3= V1R2-2, T4=V2R1-1, T5= V7R1-2, T6= V6R3-1, T7= V11R1-1, T8= V3R3-3, T9= V13R3-3, T10= V12R3-3, T11= V13R3-5, T12= V6R3-4, T13= V12R3-2, T14= V13R3-2, T15=V25R3-2, T16=V6R3-3, T17=V12R3-4, T18= V12R3-6, T19= V12R3-5, T20= V1R1-2, T21= V20R2-1, T22=V12R1-1, T23=V5R3-2, T24= V10R1-1, T25=V2R2-1, T26=V17R2-1, T27= V4R2-1, T28= V17R2-1, T29=NHRodo, T30= NHTatase, T31= NHSombo.

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BIOCHEMICAL PROPERTIES OF F5 BREEDING LINE OF *CAPSICUM ANNUAL* (VAR NSUKKA YELLOW PEPPER)

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ABSTRACT

Nine accessions of fully ripe tomato fully ripened Nsukka yellow peppers from nine F5 breeding lines were harvested and analyzed for their physico-chemical properties including pH, Total Titratable Acidity (TTA), Total Soluble Solids (TSS), β-carotene, Vitamin C, Capsaicin and Piperin. The highest pH was recorded in 59-2-1-5 variety, (5.62) while the lowest was 31-1-3-5 (5.06). The Vitamin C content was observed to be high in 34-1-2-5 variant (86.06mg/100g) and the least being 06-5-5 variant (33.90mg/100g). Among the various lines, the highest TTA value was found in 53-1-2-5 breeding line (0.31%) and others lines are of same values (0.16%). Among all the accessions, 59-2-1-5 had the highest capsaicin value of 0.86 mg/g, follow by 59-3-1-5 variant with 0.85 mg/g whilst the lowest value was reported in D2-1-5. The highest β-carotene was found in 59-3-1-5 variety, with 6849.29 µg/100g while the lowest was 06-5-5 of value (3801.44 µg/100g). The Piperin content was recorded to be high in 34-1-2-5 variant (66.70 mg/100g) and the least being D2-5-5 variant (20.32 mg/100g). Midst the breeding lines, 63-1-2-5 had the highest brix value of 9.08% and the least is 06-5-5 line of 6.58%. Most of the generational lines showed better performance than their parents and thus can be selected for further breeding work. In conclusion generational lines; 59-3-1-5, 34-1-2-5, 63-1-2-5 and 59-2-1-5 obtained from the various parents were found to have more desirable traits compared to their parents.

Key words: Nsukka yellow pepper; variant lines; pH; capsaicin, piperin

INTRODUCTION

One of the most practical ways of managing free radical activity in the body is through diet. Dietary antioxidants may play an important role in protecting against cell damage caused by free radicals by acting as radical scavengers, reducing agents and quenchers of singlet oxygen formation, and by forming complexes with pro-oxidant metals (Ademoyegun *et al*., 2013).

Carotenoids impart orange and red colors in vegetables. The carotenoids in peppers include capsanthin and carotene. Nsukka yellow pepper is predominantly yellow color of peppers, and the carotene is formed by *α*- and *β*-carotene, zeaxanthin, lutein and *β*-cryptoxanthin (Anyaoha *et al*., 2019). Beta-carotene is a hydrocarbon carotenoid found widely in the chloroplasts of higher plants, and exercises pro-vitamin A and powerful antioxidant activities. Carotenoids' cancer-preventive activities have been associated with their antioxidant properties. Perera and Yen reported that consumption of carotenoid-rich foods reduces the incidence of several disorders such as cancers, cardiovascular diseases, age-related macular degeneration, cataracts, diseases related to compromised immune function, and other degenerative diseases.

Phenols function as antioxidants with properties similar to vitamins C and *β*-carotene, and have received extensive study. A wide variety of spice-derived phenolic compounds, such as capsaicin, possess potent antimutagenic and anticarcinogenic properties (Adetula and Olakojo 2006). Phenolic compounds cannot be produced by the human organism and are acquired mainly through diet. Knowledge about the nutritional and therapeutic role of dietary phenolic antioxidants is essential for development of functional foods, which are conventional foods with augmented health benefits (Ademoyegun *et al*., 2011).

Ascorbic acid is a required human nutrient, and functions primarily as an antioxidant in biological systems, preventing common degenerative processes. Testing of ascorbic acid derivatives on cancer cells showed ascorbic acid esters to have promising anticancer activity. Ascorbic acid as found in most fruits and vegetables also protects against heart disease, high cholesterol, high blood pressure and cancer (Idowu-Agida *et al*., 2011).

Nigeria is one of the principal centers of origin and domestication of the genus *Capsicum*. Some variants in Nigeria are known and used primarily in certain regions. For example, *Nsukka yellow pepper* variants are common, grown in Eastern part of Nigeria. *Nsukka yellow pepper* fruit is known to be an excellent source of aromatic favor. Hot chili peppers are widely consumed in Nigeria, with an average annual per capita intake of approximately 7 to 9 kg, making it the second most consumed vegetable after tomatoes. Such a widely consumed vegetable with various potential health benefits merits characterization of its bioactive compounds content to better understand their possible applications and increase consumer awareness of these benefits (Baiyeri *et al*., 2016). The present study objective was to quantify polyphenols, carotenoids and ascorbic acid levels, and measure capsaicin level of *Capsicum annum var Nsukka yellow* Genotypes commonly grown in Eastern zone, Nigeria.

MATERIALS AND METHODS

All analyses carried out were of standards procedures and performed in triplicate.

Statistical Analysis

All parameters carry out among genotypes were subjected to a one-way Analyses of Variance (ANOVA) using IBM SPSS Statistics 20 software and means were separated using Least Significant Different Test (LSD).

RESULTS AND DISCUSSION

pH and Total Titratable Acidity (TTA)

The lowest pH value for the samples analysed was 5.06 (31-1-3-5 variant), however the highest value was 5.62 which was higher than the values with 5.62 (59-2-1-5 variant). This is an indication of stronger acidity in the samples worked on than the samples worked on by Antonious et al., (2009), however, this gave rise to the second least TTA, a higher pH is expected to give rise to a lower TTA value, but this was not the case in the 31-1-3-5 line, and this might be due to other factors. A higher pH should give rise to a lower TTA. This was due to the lower percentage of citric acid present in this line. The highest TTA value was recorded in 53-1-2-5 0.31% but was significantly different ($P > 0.05$) from the others hybrid (0.16 to 0.20%) (Table 1.).

Total Soluble Solids (TSS)

The highest TSS (9.08%) was observed in 63-1-2-5, whilst the lowest was observed in 06-5-5 (6.58%). The highest TSS observed in 63-1-2-5 might be due to the high carbohydrate (sugars and nonsugars) content. Significant differences ($P < 0.05$) were detected in the TSS values among the various breeding lines (Table 1). However, no significant differences ($P > 0.05$) were detected among the total soluble solid values of 53-1-2-5 and 31-1-3-5 lines, also no significant differences ($P > 0.05$) were detected among the total soluble solid values of 59-3-1-5, 59-2-1-5 and D2-5-5 lines which might be due to similar carbohydrate content in these samples. The lowest observed TSS was in 06-5-5 (6.58%), which implies low carbohydrate content and the conversion of acids to sugars in the glycolytic pathway.

Carotenoids are fat-soluble antioxidants found in many fruits and vegetables and are required for human epithetlial cellular differentiation. Carotenoids content in the studied *Nsukka yellow* accession genotypes ranged from 3147.63 to 6849.27 µg/100 g sample (Table 1). No differences (p > 0.05) were identified among four lines of accession, the carotenoid levels in 53-1-1-5, 31-1-3-5, D2-5-5 and D2-1-5. Carotenoids are terpenoid compounds formed by the condensation of eight isoprene units. Specific chemical groups present at the chain terminus determine carotenoid chromophore properties and allow their classification into two families based on color: red and yellow/ orange. *Capsicum* fruit owe their intense coloring to carotenoid pigments, which coincides with the high carotenoid content observed here in all nine studied genotypes. Ademoyegun *et al*., stated that carotenoids can act as antioxidants, with functions that include protection of membranes against damage by free radicals and retardation of ageing processes. In their analysis of carotenoids content in mature *C. chinense* fruit from 63 accessions, Antonious *et al*., found that accession PI-355817 (from Ecuador) contained the highest *β*-carotene concentrations (8,000 µg/100g fresh fruit). 59-3-1-5 accession line can be identified as potential candidates for mass production of antioxidants with health-promoting properties. Differences in carotenoids content are probably due to the influence of genotype and maturity stages. Carotenoids are known to play an important role in preventing oxidative damage, which is caused by free radicals in age-related diseases such as cancer. Most current carotenoids research is focused on their probable function as lipid antioxidants, which can protect against oxidation and other destructive processes mediated by singlet oxygen and free radicals, although more specific immune system effects are also receiving attention.

Peppers have the highest ascorbic acid content of the vegetables; for example, consumption of 100 g fresh weight of peppers provides 100% - 200% of the recommended dietary allowance of ascorbic acid. Ascorbic acid content in the nine studied *Nsukka yellow* genotypes ranged from 33.90 to 86.06 mg/100 g sample (Table 1). The genotype had the highest level is 34-1-2-5 and the 06-5-5 the lowest. The high ascorbic acid content of peppers is one of their primary nutritional qualities. Factors such as genotype, environment and fruit maturity affect levels of ascorbic acid and other nutritional compounds.

Table 1. pH, total soluble solid, titriable acidity, β – carotene and Vitamin C (ascorbic acid) content of Nsukka yellow breeding lines pepper fruits

BREEDING LINES	pH	TOTAL SOLUBLE SOLID	VITAMIN C	BETA-CAROTENE	TITRICABLE ACIDITY
59-3-1-5	5.50 ± 0.10a	7.67 ± 0.14c	49.00 ± 1.00b	6849.27 ± 39.60a	0.16 ± 0.02c
53-1-2-5	5.35 ± 0.05b	8.08 ± 0.14b	43.00 ± 1.00c	5439.81 ± 30.86b	0.31 ± 0.03a
06-5-5	5.54 ± 0.04a	6.58 ± 0.13d	33.90 ± 2.07d	3801.44 ± 46.51d	0.16 ± 0.02c
59-2-1-5	5.62 ± 0.03a	7.67 ± 0.15c	56.59 ± 2.32b	4938.27 ± 38.58c	0.16 ± 0.02c
31-1-3-5	5.06 ± 0.06d	8.08 ± 0.16b	37.54 ± 1.60	5389.39 ± 81.00b	0.16 ± 0.02c
63-1-2-5	5.41 ± 0.01b	9.08 ± 0.17a	47.00 ± 1.40c	4633.44 ± 70.50c	0.16 ± 0.01c
D2-5-5	5.39 ± 0.03b	7.50 ± 0.25c	39.80 ± 1.41d	5666.64 ± 65.37b	0.16 ± 0.02c
34-1-2-5	5.24 ± 0.04c	7.50 ± 0.25c	86.06 ± 2.02a	3147.62 ± 45.21e	0.17 ± 0.01c
D2-1-5	5.17 ± 0.06c	6.83 ± 0.14d	50.78 ± 2.45b	5395.55 ± 38.34b	0.20 ± 0.02b

Ascorbic acid levels were low in all the studied genotypes, which coincides with reported high in ascorbic acid content as some pepper fruit varieties. Carotenoids, ascorbic acid, flavonoids, phenolic acids and other chemical constituent concentrations increase as peppers. These authors concluded that the high variability in ascorbic acid content among breeding samples may have been due to differences in growing conditions, maturity and particularly post-harvest handling. In the study of the mature fruit of 63 *C. chinense* accessions by Antonious *et al*., they reported that accessions PI-152452 (Brazil) and PI-360726 (Ecuador) contained the highest ascorbic acid concentrations (1.2 and 1.1 mg·g−1 fresh fruit, respectively).

Capsaicin is an important parameter in peppers that indicate the hottest of pepper, Nsukka yellow pepper of breeding line 59-2-1-5 had the highest pungent value of 0.86 mg/g, follow by 59-3-1-5 variant of 0.85 mg/g and lowest value with D2-5-5 (0.42 mg/g) (Figure 1**)**. *Nsukka yellow* pepper is containerized aromatic pepper. The piperin in pepper is responsible for the flavor with a distinct aroma, which enhance is accessibility. The breeding line with highest piperin is 34-1-2-5 with value 66.70 mg/g and lowest is D2-5-5 with 20.32 mg/100g valve (Figure 1**)**. From the research results their no distinct relationship or correlation between the capsaicin and piperin in *Nsukka yellow pepper*. These accessions were identified as potential candidates for mass production of antioxidants with health promoting properties.

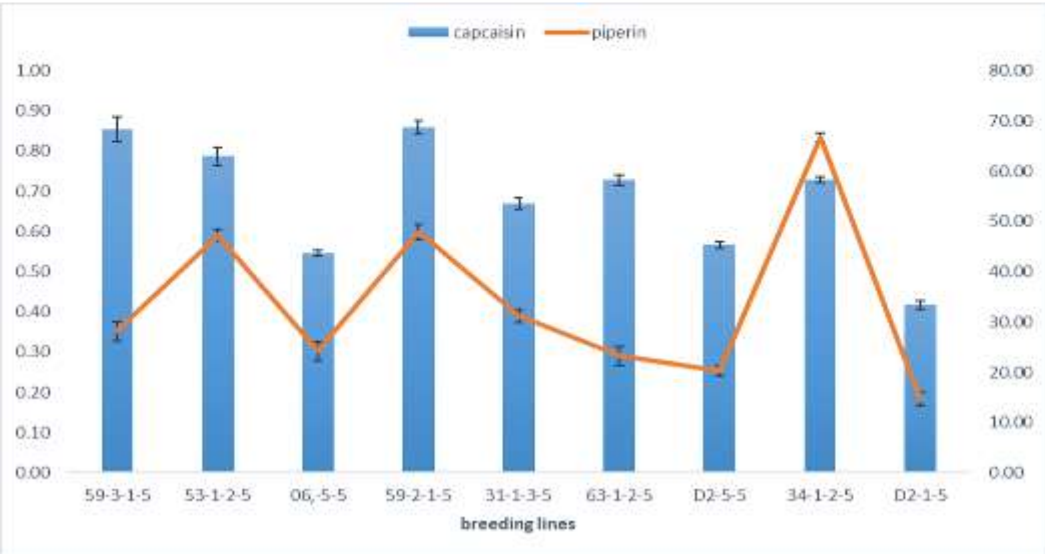

Figure 6: Capcaisin and Piperin contents of nine breeding lines of Nsukka yellow pepper

CONCLUSION

In terms of vitamin C, 34-1-2-5 was superior as compared with others. This is an indication that 34-1-2-5 had high vitamin C content which can meet the daily uptake of by man. 34-1-2-5 breeding line had the highest content of vitamin C and piperin as compared with all the others. The fruits with the highest content of capsaicin were the lines of 59-2-1-5 and 59-3-1-5, an indication of high levels of pungency as compared to that of the other lines, which was also seen in the β-carotene for the line 59-3-1-5. The offspring performed better than their parents and possessed traits which can be used in further breeding works.

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ASSESSMENT OF THIRTY ACCESSION OF PEPPER (*CAPSICUM ANNUM* AND *C. FRUTESCENS*) IN SOUTHERN NIGERIA FOR SEEDLING AGRONOMY AND EMERGENCE

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ABSTRACT

Pepper is an important vegetable crop and played significant role in development of food in Africa. However, the production in Southern Nigeria is still short of what is demanded therefore there is need to increase and advance pepper research and production through quality and vigorous seeds for higher yields. This study was conducted at the screen house in vegetable research of National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. Pepper were collected from agro-ecology zone of Nigeria and sorted into thirty accessions. The seeds were sown into nursery trays, watered and monitored for six weeks at nursery before hardened. Data were collected on daily emergence from six – fifteen DAS, plant height and number of leaves were recorded at transplanting. Data collected were subjected to analysis of variance and means were separated using LSD. The results showed significant different among pepper accessions. Acc 30 had the tallest seedling (14.2cm), while highest number of leaves was recorded in Acc 27 (12.67). Highest percentage germination rate was recorded and observed in Accession 30, which also germinated rapidly and attained 90% germination at 6 DAS, then obtain total germination percentage of 100% at 8DAS, therefore Acc 30 can be considered for further study.

Key words: germination%, vigour, pepper accession, seedling

INTRODUCTION

Pepper generally originates from Central America. *Capsicum annum* is from middle America (Mexico) while *Capsicum frutescens* (Bosland *et al.,*1993, Khali *et al* 2019) is from the northern half of south America to part of central America and Caribbean area. Pepper played a significant role in food production in Africa. Pepper is one of the most important vegetable crops in the world (FAOSTAT, 2018). There is need to increase production as indicated by the demand for pepper throughout the year. Germplasms collection and screening for desirable traits are essential for crop genetic enhancement (Idowu-Agida and Ajayi 2012). It is mainly used for adding flavour and imparting the pungency to cooked vegetables and meals. Pepper is often described as the "king of spices," and it shares a place on most dinner tables with salt (Alabi, 2006).

The vast majority of crops produced in world agriculture begin with the sowing of a seed to establish a new plant in the field. Successful seedling establishment is the first critical step for crop production, and determines the success or failure of the future harvest (Finch-salvage *et al*., 2015). Seeds germinate best at 25-30°C. Optimal temperatures for productivity range between 18-30°C. Peppers are tolerant to a wide range of soil conditions. However, fertile medium loams and well-drained soils with a pH of 5.5-6.8 are generally considered most suitable (Brandenberger *et al*., 2012). Seed quality is an essential trait for crop production and food security, particularly during the increasing uncertainty due to climate change (Finch-salvage *et al*., 2015). There is need to increase and advance horticultural crops for research and production. This study therefore investigate thirty accessions of pepper collected from Southwest Nigeria for seedling emergence and field establishment.

MATERIALS AND METHODS

The experiment was conducted at the screen house of Vegetable Research (NIHORT), Ibadan, Nigeria. Seeds were extracted from long cayenne and hot pepper collected from thirty locations respectively of agro- ecologies of South West Nigeria. The seeds were air-dried, bulked, and packaged as accession from each location. Top soil was collected and sterilized by heating to 100^{0}C in a metal drum and was allowed to cool. The sterilized soil was filled into perforated nursery trays. Thirty accessions of pepper seeds were sown in nursery trays filled with steam-sterilized top soil. Twenty seeds were counted and sowed from each accession at 2cm depth, regular watering and monitoring was carried out in the nursery for six weeks. The following data were collected during the early growing stage; seedling emergence counts, seedling height (cm) was determined as the distance between the soil surface and the uppermost collar using meter rule and number of leaves, germination percentage was computed as: Germination percentage = $\frac{(No\ of\ emerged\ seedling)}{No\ of\ seed\ sowed} x100\%$

Analysis: Data recorded were subjected to Analysis of Variance (ANOVA) using the Genstat 12th edition package while means were separated using least Significance Difference (LSD) at 5% probability level. Treatments means were considered significantly different at *p*<0.05.

RESULTS

The mean maximum number of leaves (12.67) was observed in Accession 27, followed by Accession 30 (10.69), and Accession 29 which had the same value with accession 28 (10.33). Similarly, the tallest seedlings were observed from Accession 30 (14.17cm) and Accession 10 (12.67cm) (Table 1). However, lowest number of leaves (4.67) was observed in Accession 26 followed by Accession 25 and Accession 24 with the same mean value (5.33). Meanwhile, the shortest seedling was observed in Accession 24 (Table 1).

Table 1: Effects of Thirty accessions of pepper on seedling height and number of leaves at Transplanting

Accessions	seedling height (cm)	No of leaves
Acc1	10.08	6.67
Acc2	7.83	9.67
ACC3	11	8
ACC4	8.5	6.67
ACC5	10	6
ACC6	8.9	7
ACC7	11.33	8
ACC8	5.5	6
ACC9	11.83	8.67
ACC10	12.17	8.67
ACC11	10.67	6.33
ACC12	10	7.67
ACC13	8.17	6.67
ACC14	9	6.33
ACC15	8	7
ACC16	9.17	9
ACC17	10	9.67
ACC18	6.67	6.33
ACC19	6.83	7.33
ACC20	9.17	7.33
ACC21	9.83	6.67
ACC22	9	8.33
ACC23	6.67	7
ACC24	4.83	5.33
ACC25	5.17	5.33
ACC26	5.38	4.67
ACC27	5.13	12.67
ACC28	6.67	10.33
ACC29	6.33	10.33
ACC30	14.17	10.67
LSD (0.05)	4.19	3.38
sig	**	**

Acc = Accession, highly significant (p< 0.001) = **

Highest percentage germination rate was recorded from Accession 30, it germinated rapidly and attained 90% germination at 6 DAS, then obtain total germination percentage of 100% at 8DAS (Table 2). The lowest germination was observed in Accession 8 and 9 which had 5% (Table 2).

Table 2: Germination percentage of thirty pepper accessions at 6,8,10,12 and 14 DAS

	Seedling germination percentage (%)				
Accession	**6th DAS**	**8th DAS**	**10th DAS**	**12th DAS**	**14th DAS**
ACC1	0	15	15	15	15
ACC2	0	05	05	05	05
ACC3	55	75	90	90	90
ACC4	20	50	85	85	85
ACC5	0	25	65	65	65
ACC6	0	40	65	85	85
ACC7	0	0	10	10	10
ACC8	0	0	0	05	05
ACC9	0	0	05	05	05
ACC10	0	25	40	45	45
ACC11	60	95	95	95	95
ACC12	0	0	10	35	35
ACC13	40	55	55	55	55
ACC14	0	30	30	30	30
ACC15	0	0	15	15	15
ACC16	0	15	20	30	30
ACC17	0	15	35	35	35
ACC18	0	0	05	05	15
ACC19	0	05	20	20	20
ACC20	5	40	60	60	60
ACC21	0	0	25	40	45
ACC22	0	30	35	35	35
ACC23	0	0	1	25	25
ACC24	0	10	15	15	15
ACC25	0	20	20	20	20
ACC26	0	0	10	10	10
ACC27	0	0	15	30	30
ACC28	0	35	35	35	35
ACC29	0	0	40	55	55
ACC30	90	100	100	100	100

DAS= Days After Sowing, Acc = Accession.

DISCUSSION

In the study, accession 30 gave the highest seedling, and was the second accession with more leaves which are indications of good seedling vigour. Vigour is the properties of seed that determines the potential level of activities and performance of seeds during germination and seedling emergence (ISTA 2015; Finch-salvage 2016). These results conformed with the findings of (Jeremi Kolodziejek 2017), who reported that, both shoot biomass and root biomass of the seedling from the seeds on the primary umbel were significantly higher than those of the seedlings from seeds on the secondary umbels. In addition, the total percentage germination differed significantly (p-value<0.01) than others, also has rapid germination, similar results were found by Ajala *et al.,* (1985) and Jeremi Kołodziejek (2017) who observed that seed mass and germination percentage of *Angelica archangelica* were higher in seeds on the primary umbel than in those on secondary, tertiary, and quaternary umbels. This can be attributed to seeds because seeds carry the full genetic compliment of crop production and improvement (Perry 1980).

The study revealed that accession 2, 8 9 and Acc 18 emerged lately, it does not emerge until 12th DAS with poor germination rate, number of leaves and seedling height respectively, which might have been as a result of aging during storage. Sheppard *et al., (*1995), reported that seeds undergo aging during storage, the extent of which depends on the moisture content and temperature. The deterioration manifested by aged seeds includes reduced emergence. This is similar to the findings of Jeremi, (2000) who suggested that seed size can affect germination percentage as well as seedling establishment, growth survival and can be due to their sources and vigour. Powell *et al.* (1984) and Finch-salvage (2015) also reported low vigour grain of legume seeds due to increased leakage of solutes that attract fungi, and the presence of dead tissue that provides a food base for infection.

CONCLUSION

In conclusion, it was discovered that variation existed among the thirty accessions of pepper under the present study. When selections of new accessions are the objective in future breeding and agronomy work, Acc 30, Acc11 and Acc29 can be considered.

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GENETIC VARIABILITY STUDY FOR YIELD AND RELATED TRAITS IN SELECTED AMARANTH (*AMARANTHUS SPP*) ACCESSIONS

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ABSTRACT

Seventeen amaranth (Amaranthus spp.) accessions were planted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta to determine their genetic variability for yield and related traits as well as contribution of each character to variation. The field experiment was laid out in randomized complete block design with three replications. Data were collected on plant height (cm), number of leaves, leaf length (cm), leaf width (cm), stem girth (mm), 1000-seed weight (g) and seed yield (kg/plant). Analysis of variance revealed that the seventeen amaranth accessions differed significantly with respect to all characters except leaf width. The first principal component analysis (PCA) had the highest contribution of 34.1% to the total variation. The small difference between the phenotypic coefficient of variation and genotypic coefficient of variation observed for most characters indicated that the variability was primarily due to genetic differences. Meanwhile, heritability was highest for number of leaves (H_B = 95.62) and was lowest for leaf width (H_B = 6.10). It was concluded that variability exist among the seventeen amaranth accessions used in this study and number of leaves with high estimate (95.62%) of Broad-sense heritability could be used as a criterion for selection in a future breeding programme.

INTRODUCTION

Amaranth is an herbaceous annual belonging to the family *Amaranthaceae* that originated from central and South America. The genus *Amaranthus* consists of approximately 60 species worldwide which is characterized by a high degree of diversity and a wide spectrum of adaptability to different agro ecological conditions (Snezana *et al.,* 2012; Malaghan *et al*., 2018). The cultivated amaranths are utilized as leafy vegetables, food grains and forage crops in diverse geographic areas (Stallknecht and Schulz-Schaeffer, 1993; Popa *et al*., 2010). Amaranth leaves are rich in dietary fiber, protein, vitamins and minerals (Shukla *et al.,* 2004). The seeds are rich in protein (17–19%) with very good balanced amino acids, particularly lysine, which is often limited in other cereal grains (Popa *et al*. 2010; Oduwaye *et al*., 2016).

The first step in the development of high yielding varieties is assessing the genetic variability of available genotypes for yield and its components (Rahman *et al*., 2016). This information will guide in choosing genotypes to be included in a breeding programme. Genetic parameters, such as, co-efficient of variation, heritability and genetic advance provides information on the extent of variability and efficiency of selection of genotypes based on their phenotype, in a diverse population. Hence, this study was carried out to determine genetic variability among seventeen Amaranth accessions.

MATERIALS AND METHOD

Seventeen accessions of amaranth used for this study were collected from the Nigeria Institute of Horticultural Research (NIHORT), Ibadan. These include; NGB01234, NG/SA/DEC/07/0423, NGB0124g, NGB01276, NG/AO/11/08/042, NG/SA/DEC/07/0412, NG/AA/03/11/010, NG/AO/11/08/039, NG/AA/MAY/09/027, NG/TO/02/12/154, NHAM15, NHAM22, PI477913, PI576460, PI576478, PI576454 and PI511719. The experiment was conducted between Nov 2014 and February 2015 in the Teaching and Research Farm of Federal University of Agriculture, Abeokuta (Latitude 7°15′ North, Longitude 3°25′ East and altitude 159 m above sea level) within the Forest – Savannah transition zone in Southwestern Nigeria. The experiment was laid out in a randomized complete block design with three replicates. The Amaranth seedlings were transplanted to the main field 3 weeks after sowing in a double row plot at a spacing of 50cm by 25cm. Weeding was done manually and no fertilizer was applied. A total of 16 plants were maintained in each plot and data were collected on five selected plants for Plant height (cm), stem girth (mm), leaf length (cm), leaf width (cm), number of leaves/plant, 1000-seed weight (g) and seed weight (g). The data collected were subjected to analysis of variance (ANOVA) to test for significance among the accessions. Genotypic coefficient of variability (GCV), Phenotypic coefficient of variability (PCV) and heritability (broad sense) were calculated (mohsin *et al*.., 2009). Also, contribution of each character to variation was determined using principal component analysis.

RESULTS AND DISCUSSION

There were significant differences among the seventeen amaranth accessions for number of leaves, stem girth, plant height, leaf length, 1000-seed weight and seed yield (Table 1). This suggests that there is sufficient variation in the materials studied.

Table 1: Mean squares of seven traits measured in seventeen Amaranth Accessions

Source of variation	Block (df = 2)	Accession (df = 16)	Error (df = 32)
Number of leaves	91.29**	506.16**	22.19
Stem girth (mm)	3.91*	5.33**	0.93
Plant height (cm)	212.45*	296.86**	54.01
Leaf length (cm)	0.80	2.47**	0.61
Leaf width (cm)	11.80	15.50	14.55
1000-seed weight (g)	0.01	0.02**	0.00
Seed yield (kg/ha)	0.07	3.43**	0.24

The means, variances, phenotypic coefficient of variation, genotypic coefficient of variation and broad sense heritability of seven traits in seventeen accessions of amaranth were presented in Table 2. The values of phenotypic coefficient of variation were higher than those of genotypic coefficient of variation for all the traits studied. Similar results in amaranth were reported by Ramesh *et al*., (2013) and Lokeshkumar & Murthy, 2017. Number of leaves (32.37) and seed yield per plot (30.24) showed high estimates of GCV revealing that emphasis should be given on these characters during selection of improved genotypes because these characters have high range of genetic variation, hence, a better scope of improvement through selection. It is not possible to determine the amount of variation that is heritable with GCV alone. The GCV together with heritability estimates would give reliable indication of the expected amount of improvement through selection (Johnson *et al.,* 1955).

Table 2: Estimates of variances, phenotypic coefficient of variation, genotypic coefficient of variation and heritability

Character	Mean	Phenotypic variance	Genotypic variance	EV	PCV	GCV	Heritability %
Number of leaves	39.24	167.72	161.32	7.40	33.10	32.37	95.62
Stem girth (mm)	5.93	1.78	1.47	0.31	22.48	20.43	82.63
Plant height (cm)	57.87	98.95	80.95	18.00	17.19	15.55	81.81
Leaf length (cm)	6.74	0.82	0.62	0.20	13.45	11.69	75.49
Leaf width (cm)	3.92	5.17	0.32	4.85	57.95	14.32	6.10
1000-seed weight	0.45	0.00	0.00	0.00	13.96	12.75	83.33
Seed yield (kg/ha)	3.41	1.14	1.06	0.08	31.38	30.24	92.88

The fact that most of the traits evaluated had relatively high estimates of broad-sense heritability confirmed that there existed a large genetic differences among the accessions and that the traits can be used as selection criteria in future breeding programme. The result also indicated that the effect of the environment on the expression of most characters was low. However, high heritability estimate of 95.62% and 92.88% recorded for number of leaves and seed yield respectively indicated a large contribution from genetic factors compared to environmental factors. The knowledge of genetic variation and relationships among accessions will help breeders in developing appropriate breeding strategies to solve problems of low yield in amaranth.

Table 3 presents the eigen values, variance proportion and factor scores of yield and related traits in seventeen accessions of amaranth. The output of the PCA revealed that different characters contributed differently to total variation. The first four component axis had 2.731, 1.860, 1.158 and 0.868 eigen values respectively and together accounted for 82.7% of total variation.

The characters that contributed significantly to variations in the PC1 include 1000-

seed weight, plant height, stem girth and number of leaves. In PC2, seed yield, leaf length, leaf width and plant height were the most effective traits. Thus, the characters associated with these principal components should be used in differentiating the Amaranth accessions.

Table 3: Eigen values, variance proportion and factor scores of yield and related traits in seventeen accessions of amaranth

	PC1	PC2	PC3	PC4
Eigen value	2.731	1.860	1.158	0.868
Proportion (%)	0.341	0.232	0.145	0.109
Cumulative (%)	0.341	0.574	0.719	0.827
Character				
Number of leaves	0.443	-0.075	-0.041	0.491
Stem girth (mm)	0.532	0.237	-0.084	-0.026
Plant height (cm)	0.438	0.463	-0.101	0.153
Leaf length (cm)	-0.005	0.602	0.267	-0.243
Leaf width (cm)	-0.241	0.316	0.555	-0.112
1000-seed weight (g)	0.370	-0.238	0.475	-0.120
Seed yield (kg/ha)	0.237	-0.445	0.518	-0.135

CONCLUSIONS

The current study has shown that variability exists among the seventeen amaranth accessions and such variation or much more could exist among the entire collections of this accessions being held at NIHORT. High genotypic coefficient of variation and high heritability is helpful in making selection of superior genotypes. Number of leaves with highest broad-sense heritability estimate can be used as selection criterion for amaranth improvement.

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VARIABILITY EVALUATION OF QUALITATIVE TRAITS AMONG OKRA (*ABELMOSCHUS ESCULENTUS* (L) MOENCH) GENOTYPES IN SOUTH WEST NIGERIA

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ABSTRACT

The study was conducted on okra (Abelmoschus esculentus (L.) Moench) collected from National Horticultural Research Institute, Ibadan. Twenty (20) genotypes of Okra were evaluated in a randomized complete block design with three (3) replicates to assess the degree of genetic variability and qualitative traits among the genotypes in 2019 and 2020 cropping seasons. The results revealed that the okra genotypes had significant variation in days to first flowering, plant height, fruit length, fruit width, internode length, and number of pods per plant. Mean performance for pod per plant shows that Prof x Clemson-59 produced the maximum number of pods per plant which was significantly higher among the other genotypes, followed by Prof x Clemson-9, LD88, and 47-7. Variability for pod yield per plant had its traits correlation effect mainly with pedicel length, plant height, days to first flowering and fruit width. This indicates that a selection procedure base on these traits may be effective in improving fruit yield. Prof x Clemson-59 with early days to first flowering and high pod yield per plant could be utilized in hybridization for future Okra breeding programmme for developing superior varieties.

Key words: Okra, variability, correlation and Pods yield per plant

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) belongs to the family *Malvaceae*. The fruits are a green capsule containing numerous white seeds when immature and the upright plants and flowers give okra an ornamental value. Okra fruit varies in fruit shape which could be angular or circular (Chaudhary *et al*., 2006 and Varmudy, 2011). It is a very important vegetable crop grown in tropical and subtropical parts of the world. It's proposed to be originated in Tropical Africa and it is native to North Eastern Africa in the area of Ethiopia and Sudan from where it extensively spread to Asia, America, Southern Europe, and other countries (Aladele *et al*., 2008 and Anyaoha *et al*., 2018). It is self-pollinated, mainly propagated by seeds with a duration of 3 to 4 months. It is a rich source of fats, fibres, proteins, carbohydrates, minerals, and vitamins. The unripe green finger-like seed capsule of okra, usually called "pod," is processed and consumed as stews, salads, soups, sliced, boiled, and fried vegetables. (Barrett, 2013; Duzyaman, 1997).

Okra is a traditional crop in southern, western, and northwestern Nigeria. The crop is cultivated from landraces over the years in the country. Geographic distances and environmental differences are the two major causes of genetic diversity among plant populations (Anyaoha *et al*., 2018; Alade *et al.,* 2008). Evolutionary forces like selection, mutation, migration, and genetic drift are the basis of crop genetic diversity. In this regard, morphological characterization involves both the quantitative and qualitative traits' performance of plants under study. Progress and gain from the selection in any breeding program depend upon the magnitude of useful variability present in the population and the degree to which the desired traits are heritable. (Adeoluwa *et al*., 2011 and Rahman *et al*., 2012)

In Nigeria, despite the increase in demand for okra cultivars that present good quality and high yield, the yield of okra is still low (2.7 t/ha) compared to other countries such as India (10.50 t/ha), Sudan (10.2t/ha), Egypt (15.7 t/ha), Pakistan (7.6 t/ha), Saudi-Arabia (11.5 t/ha) and Ghana (5.5 t/ha) (Varmudy *et al*., 2011, and Oyelade, et al., 2003) Therefore, it is essential to study the variability and the quantitative traits of the different Okra genotypes for yield and crop improvement programme (Ariyo, O.J. 1990). This study was carried out to assess the degree of genetic variability and qualitative traits among twenty okra genotypes to provide input for okra variety, crop improvement program and its conservation in Nigeria.

MATERIALS AND METHODS

The research was conducted at the research farm of the National Horticultural Research Institute, Ibadan (Latitude 7 ° 24’ 26” N, and longitude 3°50’43” E), during 2019 and 2020 wet season. Ibadan has bimodal rainfall distribution, which peaks in June/July and September. (Olaniyan et al 2001). Twenty Okra genotype were selected for this study from The National Horticultural Research Institute (NIHORT) Ibadan. Selection was based on fruit traits such as shape, size and colour of fully-developed fruit

Experimental Design:

The experiment was laid out in Complete Randomized Block Designed in 3 replications. The seeds of the Okra were planted three (3) per hole. Plants were spaced 60 cm between and within rows. Plants were thinned down to one per stand, three weeks after seedling emergence, giving a total plant population of approximately 27, 778 plants/ ha. Agronomic maintenance carried out included manual weeding at two weeks after planting; NPK 15:15:15 fertilizer was applied in split at 60 Kg/ha first at three weeks after planting and later at flowering.

Data Collection:

Data was collected on three (3) plants per genotype per plot on the following agro- morphological quantitative traits according to (IPGRI, 1998) descriptors for Okra (Abelmoschus esculentus (L.) Moench) on the following agronomic attributes: Number of days to flowering, plant height (cm), number of pods per plant, internode length (cm), fruit length (cm) and fruit width (cm).

Data analysis

Each genotypes, the mean values of the data collected were subjected to Analysis of Variance to determine significant differences of the traits using Duncan Multiple Range Test (DMRT) at 5% probability level.

The relationship among the fifteen traits were investigated for each environment using phenotypic correlation coefficients between traits X and Y (rp XY) calculated from mean values of traits using the procedure outlined by Miller *et al.* (1958) thus

rpXY = $\frac{CoVpXY}{\sqrt{((\delta 2gX)(\delta 2gY))}}$

Co VXY = Phenotypic covariance of traits X and Y

$\delta^2 gX =$ Phenotypic variance of Traits X

$\delta^2 gY =$ Phenotypic variance of Traits Y

RESULTS AND DISCUSSIONS

The result of the analysis of variance showed that highly significant (P<0.01) genotypes effect was observed for days to first flowering, plant height, internode length, and number of pods per plant (Table 1). Fruit length and pedicel length were also significantly (P<0.05) different among the genotypes. Non-significant (P>0.05) genotype effect was observed in fruit width. The result suggests the presence of variation among the twenty genotypes evaluated except for traits that were not significant. The presence of wide genetic variability provides an indication of a better scope for genetic improvement. Similar results were reported by other workers (Ariyo, O.J. 1990; Ade-Oluwa and Kehinde, 2011; Binalfew *et al*., 2016) who also investigated genetic variability in okra and found significant cultivar effect in all the studied traits.

Table 1: Mean squares of traits evaluated in twenty genotypes of okra

Source variance	DF	Days to first flowering	Fruit length (cm)	Fruit width (cm)	Pedicel length (cm)	Internode Length (cm)	Plant height (cm)	No pods Per plant
Block	2	39.18	0.02	0.28	0.21	2.69	97.38	2.55
Accessions	19	7.99**	5.89*	3.31	0.61*	10.53**	238.87**	0.68**
Error	38	0.94	0.78	0.27	0.10	0.43	1.94	0.19

Days to first flowering: The result of the mean performance shows significant variations among the genotypes studies pertaining to days to first flowering. (Table 2). The result revealed that genotypes; Prof x Clemson-59 and 47-4 significantly had the earliest days to first flowering at 46 days but genotype Benue Local had late days to first flowering at 61 days. The differential performance of the genotypes to flowering may have been influenced by their unique genetic characteristics. The results are supported by previous works (Rahman *et al*., 2012; Demelie *et al*., 2015; Anyaoha *et al*., 2018).

Table 2: Mean performance of morphological traits studied on twenty-five accessions of pepper for quantitative traits

Accessions	Days to first flowering	Plant Height (cm)	Fruit length (cm)	Fruit width (cm)	Pedicel length (cm)	Internode length (cm)	Number of pods per plant (cm)
Ld88	57.65abcd	59.00abcd	8.95ab	8.65ab	2.90abc	7.00cde	5.52cd
Ik11	49.15defghi	71.00ab	8.80bcd	12.15a	2.75abcd	11.82a	1.50cd
Prof 10	55.12abcde	34.00f	6.41d	11.35ab	1.60de	5.90cde	2.00cd
Clemson	60.45ab	42.55cdef	10.65abc	9.50ab	2.50abcd	8.75bcd	2.50cd
Prof 2	50.79cdefg	42.50cdef	10.50abc	7.95b	2.20abcde	8.10bcde	3.50cd
Iwo	47.00hi	55.00abcde	10.45abc	7.60b	1.75cde	6.80cde	2.00cd
47-7	46.00i	40.50cdef	6.39d	8.45ab	1.7cde	8.35bcde	5.00cd
Ik7	59.00abc	49.20cdef	8.75bcd	9.60ab	1.80bcde	11.75ab	3.00bcd
Mb 1	53.90bcdef	44.70cdef	8.40bcd	10.05ab	2.6abcd	6.00cde	1.50cd
Benue Local	61.65a	40.95cdef	9.35bcd	8.05b	2.15abcde	5.60cde	2.00cd
Prof x clemson-9	55.66abcd	73.60a	7.00cd	7.50b	2.0bcde	7.50cde	5.60cd
Prof x clemson-34	48.70efghi	38.00ef	10.40abc	8.15ab	1.8bcde	7.50cde	2.50cd
Prof x clemson-27	53.57cdefgh	38.75ef	10.15abc	10.15ab	1.25e	7.00cde	3.50ab
Prof x clemson-19	55.70abcd	59.75abc	9.15bcd	10.05ab	2.50abcd	5.60cde	2.50cd
Prof x clemson-95	47.7ghi	40.75cdef	9.35bcd	8.45ab	2.20abcde	5.75cde	2.00cd
Prof x clemson-33	47.70ghi	39.50def	9.65bcd	8.60ab	1.7cde	7.85cde	1.00d
Prof x clemson-34	53.50cdefgh	46.50cdef	9.56bcd	9.4ab	2.60abcd	4.70e	3.00bcd
Prof x clemson-59	46.00i	39.70def	13.85a	10.60ab	3.3ab	7.90de	7.50ab
Prof x clemson-35	54.00bcdefg	48.60cdef	8.30bcd	9.35ab	3.0ab	4.95de	3.50bc
Prof x clemson-29	55.50abcde	55.00abcde	10.40abc	10.25ab	2.80abc	9.00b	4.00bcd

Mean with the same alphabets within the column are not significant different at 5% probability level from one another

Plant height (cm): Table 2 shows that significant genotypes effect was observed for plant height. Maximum height (73.60 cm) was recorded in Prof x Clemson-9, whereas Prof 10 (34.60 cm) gave the minimum height. Khan *et al*. (2002) and Mohammed *et al.* (2017) also reported significant differences for plant height among okra varieties evaluated.

Internodes length (cm): Fruit internodes showed significant genotype effect. The genotype Ik11 and Ik7 had the maximum internode length at 11.82cm and 11.75 respectively while the minimum occurred in the Prof x Clemson-34 and PROF x CLEMSON-35 at 4.7 and 4.95 respectively. (Table 2). The study also revealed that internode length has positive correlation with fruit yield per plant. This result is in line with the findings of Raji *et al.* (2002) and Akortkar *et al*. (2010).

Fruit width (cm): No significant genotype effect was recorded with respect to fruit width. It showed that the genotypes did not differ in fruit width. However, the genotype Ik11 recorded the largest width of (12.15cm) and Prof 10 (11.35cm) whereas the least was observed in the Prof x Clemson-9 (7.50cm). (Table 2). Khan *et al*. (2002) and Temam *et al*., 2020 also observed a non-significant cultivar effect on fruit size in their study.

Fruit length (cm): Significant genotype effect was observed in the fruit length. The genotype Prof x Clemson-59 had maximum fruit length of (13.85 cm) and Clemson had (10.65cm) while the minimum occurred in the 47-7 (6.39 cm). (Table 2). However, the fruit length for plots sown with Clemson, Prof 2 and Prof x Clemson-34 were not statistically different indicating that they did not differ in terms of fruit length. This result is in line with the findings of Chaudhary *et al.* (2006) and Akortkar *et al*. (2010).

Number of pods per plant: Number of pods per plant showed significant effect among the okra genotypes. Table 2 revealed that genotype Prof x Clemson-59 produced the maximum number of pods which was significantly higher among the genotypes evaluated. The number of pods per plant produced by Prof x Clemson-9, LD88, and 47-7 were 5.60, 5.52, and 5.00, respectively. This result suggest that these three genotypes possessed similar fruiting potentials. This finding corroborates the reports of other authors; (Bello *et al*., 2006; Akortkar, et al., 2010; Rahman *et al*., 2012 and Simon et al. 2013) who also had significant effect of number of pods per plant in different okra cultivars. However, this result contradicts the findings of Khan *et al*. (2002) who had noted a no significant effect of cultivar on number of pods per plant in Pakistan.

Correlation: Expressive significant phenotypic correlation coefficient was observed for most of the traits studied (Table 3). The phenotypic correlations between pedicel lenght and number of pods per plant was positive and significant (r = 34*). The result also shows that the correlation between days to first flowering (r = 0.08), fruit width (r = 0.09) and plant height (r = 0.30) with number of pods per plant was positive but negatively with fruit length (r = -0.07). Days to first flowering had significant and positive correlation with plant height (r = 0.48**) and number of pods per plant (r = 0.08). This result showed that early flowering genotype have advantage over late flowering ones as it allows for a longer duration of fruiting which ultimately influences number of pods per plant. Ariyo, O.J. (1990); Mihretu *et al.,* 2014 and Anyaoha *et al*. (2018) also reported a positive relationship between number of pods per plant and days to flowering, fruit length and plant height. The positive association of number of pods per plant with pedicel length (r = 0.34*), days to first flowering (r = 0.08), fruit width (r = 0.09) and Plant height (r = 0.30) indicates that genotypes with these traits may be selected for increase in okra fruit yield.

Table 3: Correlation Coefficient between traits in 20 Okra genotypes evaluated

Traits	Days to first Flowering	Fruit Length (cm)	Fruit Width (cm)	Pedicel Length (cm)	Internode Length (cm)	Plant Height (cm)	No of pods Per Plant (cm)
Days to First Flowering	1.00	0.18	0.22	0.25	-0.13	0.48**	0.08
Fruit Length	0.18	1.00	0.07	0.34*	-0.11	0.14	-0.07
Fruit Width	0.22	0.08	1.00	0.29	0.15	-0.04	0.09
Pedicel Length	0.25	0.34*	0.29	1.00	-0.02	0.19	0.34*
Internode Length	-0.13	-0.14	0.15	-0.02	1.00	-0.16	0.23
Plant Height	0.48**	0.12	-0.04	0.19	-0.16	1.00	0.30
No of fruit Per Plant	0.08	-0.07	0.09	0.33*	0.29	0.30	1.00

**. Correlation is significant at the 0.01 level. *. Correlation is significant at the 0.05 level.

CONCLUSION

Significant ($P \leq 0.01$) variations were observed among the okra genotypes for all the morphological quantitative traits studied. The result revealed wide variation for days to first flowering, plant height, fruit length, fruit width, pedicel length, internode length and number of pods per plant. It also revealed the relationship between number of pods per plant and its components as they affect pod yield. It shows the superiority of Prof x clemson-59, Prof x clemson-9, LD88, and 47-7 in terms of early days to flowering, fruit length, fruit width and yield potentials under South West Nigeria and soil condition. This genotypes could be utilized in hybridization for breeding programmes for development of superior okra varieties. Hence, the result of this study is an indicator for the presence of a higher chance to develop okra varieties that could be highly preferred by farmers, consumers and for further plant breeding program through selection/ crossing of okra genotype.

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GENETIC ANALYSIS OF THE SEEDS CHARACTERISTICS AND PLANT GROWTH HABITS OF ROBUSTA COFFEE (*Coffea canephora* P. Ex Fr.) ACCESSIONS

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ABSTRACT

Coffee is one of the most economic important tree crops worldwide. Response to selection and success of hybridization in Coffee depends majorly on the natural diversity and how well the magnitude of the genetic diversity is harness for future improvement. This study was conducted to estimate some genetic parameters of the seeds and growth habits of young plants of Robusta coffee accessions in order to provide baseline information for breeding programs. The experiment was conducted in a Randomized Complete Block Design with three replications at Owena, Ondo State of Nigeria. Cherries of coffee accessions collected from different farm locations were characterized before processed for onward planting. Fifteen qualitative and quantitative agro-morphological traits were evaluated and data were taken on the plants for two consecutive years. Result of the analysis revealed that phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) across all the traits. High phenotypic coefficients of variation were observed in seed traits and plant growth habit traits. High PCV was recorded in leaf number (103.72); fruit shape (49.42) and the lowest PCV in leaf length (30.08) and dried seed weight (12.67). High GCV were observed in leaf number (75.34) and fruit shape (41.22) whereas, lowest GCV were recorded in plant height (22.34) and fresh cherry weight (8.51). Heritability estimations for all traits ranged from medium in plant height (32.72) to relatively high in fruit shape (69.57). These findings revealed a high genetic variability for most of the morphological traits coupled with high heritability for most of the traits which can be utilized in future coffee improvement programs.

Key words: Coffee accessions, Seeds characterization, Coefficient of variation, Broad sense heritability, Genetic diversity

INTRODUCTION

Coffee is one of the most important tree crops worldwide. One of the utmost decisions to be taken by farmers is the choice of variety to plant that will produce the best results and this has always been a challenge to farmers. Coffee growers have been selecting plants with specific traits for many years either consciously or unconsciously with the aim of achieving high productivity. With this effort made by farmers, it is of priority to identify available cultivars for selection of desirable traits in coffee breeding programme (Cubry*et al*., 2008). According to Partelli*et al*. (2019, 2020), efforts of selection and identification of cultivated cultivars of coffee, had led to development of new coffee genotypes in the recent past with some desirable traits. However, much is still needed to be done to identify cultivars with desirable agronomic characteristics and well adapted to different environmental conditions as this will bring about competitiveness, sustainability and increase in coffee production. This necessitate determinant of level of variation among the cultivated robusta coffee, identification of homogeneous genotypes and those with stable traits among the cultivars for commercial coffee production (Gichimu and Omondi, 2010).

Coffea canephora is an allogamous and diploid species, with self-incompatible gametophyte (Tran *et al.* 2017; Moraes*et al.* 2018). This inferred that C. *canephora* is of natural reproduction, which makes propagation of coffee by seeds to be of highly diverse, wherein each plant may differ from others in relation to its architecture, shape and size of grain and leaves, maturation pattern, and susceptibility or tolerance to biotic and abiotic factors, among others. The magnitude of genetic variability present in the coffee population determines the success of the breeding program for crop improvement. Getachew *et al.* (2017) evaluated genetic parameters in Arabic coffee and reported significant variations on growth characters among the accessions. Genetic variability in a population can be achieved by introducing new genetically diverse lines in to the population. It is important to increase variability in the population in order to bring the genetic improvement in the characters for economic benefits. In view of this, concerted efforts were made in this study for ex-situ collection of robusta coffee accessions, in order to consolidate on increase in genetic diversity of existing genotype of robusta coffee in Nigeria. Therefore, it is imperative to characterize the available robusta coffee accession for future selection and improvement programme. Evaluation of the collected accessions for genetic variability would be of use in future for improvement purposes.

MATERIALS AND METHODS

Plant materials

A total number of 15 *Coffea canephora* accessions were collected and used for this study, of which 3 were from CRIN coffee germplasm as a check and the remaining 12 were collected from various coffee farms. Ripe coffee cherries were harvested from heavy-bearing healthy trees for seedlings establishment and for onward transplanting into the field. Each accessions collected were numbered and named based on the location of collection. Pulps were removed with the use of pestle and mortar after fermentation. After then the parchment coffee seeds were air dried under the shade until ready for planting at pre-nursery. Harvested coffee cherries were characterized before process into seeds. The experiment was conducted at CRIN Owena substation in Ondo State under rain fed condition, in randomized complete block design with 3 replications and six plants per plot representing population of each accession.

Data collection and analysis

Data on 15 agro-morphological parameters were taken for two years. Among data recorded, 13 were quantitative traits and the remaining 2 parameters were qualitative traits and scored based on physical observation as described in descriptors of coffee by International Plant Genetic Resources (IPGR) (1997). Data were recorded on: plant height; stem girth; leaf number; internodes length; number of plagiotropic branches; leaf length; leaf width; colour of matured fruit; fruit width; fruit length; fruit shape; fresh cherry weight; dried seed weight; germination % and days to 50% germination. Data of 15 different characters' traits were subjected to statistical analysis. Analysis of variance (ANOVA), was generated from data, using SAS 9.1.3 Version (2004). Multivariate analysis (MANOVA) was performed from the variance components, in which the following parameters were estimated for each characters: phenotypic variance (PV); genetic variance (GV); environmental variance (EV); genotypic coefficients of variation (GCV); phenotypic coefficient of variation (PCV); environmental coefficient of variation (ECV); heritability estimates in broad sense (H^2b) and expected genetic advance (GA); and genetic advance as percentage of mean (GAM%). Cluster analyses were performed using word method to plot hierarchical clustering.

Genotypic and phenotypic variation was calculated based on the formula given by (Singh and Choudhary, 1985). Phenotypic coefficient of variation (PCV %) and genotypic coefficient of variation (GCV %) were estimated following the formula given by (Sivasubramanian and Madhava, 1973). It was categorized as follows Less than 10% = low, 10-20% = Moderate, More than 20% = High. Heritability (H^2b) was estimated based on the formula given by (Falconer, 1981). Heritability was classified as low (below 30%), medium (30-60%) and high (above 60%) as suggested by (Johnson *et al.,* 1955). According to Singh (2001), heritability values greater than 80% are regarded as very high value, from 60-79% moderately high; 40-59% as medium and values less than 40% as low. Estimation of genetic advance Genetic advance (GA) and percentage of mean (GAM) and selection intensity (k) at 5% (2.06) was used in accordance with the formula described by (Johnson *et al*., 1955). Genetic advanced was classified as between 0% and 10% for low, 10% and 20% for intermediate, and more (>20%) for high, following the formula given by (Johnson *et al*., 1955: Juangsamoot*et al*., 2012).

RESULTS

The result of analysis showed genetic variations in plant morphological traits, with phenotypic variance (PV) being higher than the genotypic variance (GV) in all the traits for the two years combined (Table 1). The highest phenotypic variance value recorded was for leaf number (103.72), number of plagiotropic branches (95.13), internodes length (56.36), and stem girth (45.84), likewise the intermediate phenotypic variance was leaf length (30.08), leaf width (34.87); and plant height (39.06). Highest genetic of coefficient of variation was expressed by leaf number (75.34), number of plagiotropic branches (51.89), similarly intermediate genetic coefficient of variation (GCV) was observed in plant height (22.34), stem girth (31.44), internodes length (32. 87) and leaf length (22.96). Heritability estimates in broad sense ranges from medium in plant height (32. 72) to high in fruit shape (69. 57) for all the fifteen traits. Genetic advance as percentage of mean ranged from intermediate (10.84) to high (70.82).

Genetic variability was observed among the seed traits (Table 1). The value of phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters studied.

Fruit shape (49.42%) shows high phenotypic coefficient of variation while dried seed weight (12.67%) shows lowest phenotypic coefficient of variation. Intermediate to high phenotypic coefficient of variation was observed in seed width (21.88%), length of seed (21.38%), and days to 50% germination (15.59). Genotypic coefficient of variation recorded value ranging from 8.51% (fresh cherry weight) to 41.22% (fruit shape). Low to high genotypic coefficient of variation was exhibited by fruit colour (10.19%), dried seed weight (9.35%), seed width (13.84%), and length of seed (21.38%), germination percentage (18.61%), and days to 50% germination (10.84%).

Broad sense heritability was estimated from PCV and GCV values. It is observed that heritability ranged from 33.33% in length of seed to 69.57% in fruit shape. High heritability was recorded for germination percentage (65.16%). Moderate heritability was revealed by dried seed weight (54.39%), days to 50% flowering (48.37%), seed width (40.00%) and fresh cherry weight (38.25%). Genetic advance estimated shows value range from low to intermediate of genetic advance for seed character which was 0.11 for seed weight to 12.59 for germination percentage. Low genetic advance value was recorded on fruit colour 0.75, fresh cherry weight 7.84, fruit shape 1.54, dried seed weight 3.38, length of seed 0.12, and days to 50% germination 7.82. Genetic advance as percentage of means magnitude value ranges from intermediate to high with values ranged from 10.84% for fresh cherry weight to 70.82% in fruit shape. Intermediate genetic advance as percentage of means was observed in fruit colour (15.74%), dried seed weight (14.20%), germination percentage (14.32%), length of seed (14.68%), days to 50% germination (14.68%), and seed width (18.03%).

The relationships among the 15 robusta coffee accessions based on the quantitative traits were assessed as shown by clustering (Fig.1). The result revealed 15 robusta coffee accessions were distinct from each other with some grouped based on morphological similarity. Cluster dendrogram constructed based on morphological traits to estimate the diversity among the fifteen coffee accessions, grouped them into three main clusters. Cluster group 1 comprises of five accessions which shows that (33.3%) of the accessions were of shortest plant height, cluster group 2 comprises of six accession representing (40%), of the accessions that are of tallest plant height, while cluster group 3 comprises of four accessions representing (26.7%) of the accessions that are of moderate plant height.

DISCUSSION

Improvement programme in crops depends majorly on the magnitude of genetic variability and heritability of traits studied. Coefficient of variation studied indicated that phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the traits. Getachew *et al*. (2017) reported same in Arabica coffee, implying the influences of environmental factor on all the traits, with low genetic variability. Similar finding was reported in *C. arabica* by Resende *et al*. (2001) and in C. *canephora* by (Bayisa and Ney, 2017). Bhadru *et al.* (2012), also reported same finding in rice. Genetic diversity is reliant on the heritable variation within and between populations as it is useful in predicting genetic gain from selection (Paikhomba *et al*., 2014), as increase in heritability contribute to increases in genetic gain (Mckeand *et al*., 2008). This study was able revealed moderate to high heritability in the traits studied suggesting that the traits studied are heritable. Moderate to high heritability would guarantee transfer of heritable characters to their offspring by parents (Jansson, 2005). This gives high level of confidence in the phenotypic values which serve as a guide for the genetic value in selection of the accessions for improvement programme. High to moderate genetic advance as percentaage of mean revealed by all traits indicated that all the traits are under genetic control suggesting that selection from them can be achieved through their phenotypic performance. Also moderate to high genetic advance as percentage of mean is a useful indicator of the progress that can be expected as result of exercising selection on the pertinent population. High heritability value together with good genetic advance as percentage of means value, would give a more reliable index for selection with desirable characteristics (Ajmal *et al*., 2009: Johnson *et al*., 1955). Clustering due to morphological traits shows that such accessions are morphologically similar, with low genetic variation within the accessions. Similar grouping based on similar morphological traits has been reported in *C. canephora* (Aluka, 2013) and in *C. arabica* (Gesseseet *al*., 2015). Close proximity observed among the accession from CRIN germplasm (M36) from south west and farmer's varieties (DAC and ORA1) collected from north central of Nigeria explained the similarity and relationship between the accessions, implying there is likely possibility of being related genetically. This required stringent evaluation of these accessions using molecular markers. Deductively, this finding has suggested that morphological traits could be used to select superior accessions without assessing of the yield components, this has been reinforced by report of Freitas*et al*. (2007) on coffee. Moreover, this study is in agreement with the previous work stating that morphological diversity is more important factor rather than variation in geographical origin as an indicator of genetic diversity in coffee (Bayetta, 2001). However, the use of morphological markers to studied genetic divergence in coffee is of equally important as it has been reported by (Gichimu and Omondi, 2010; Guedes *et al*. 2013: Baba Nitsa *et al*. 2020) which also provide genetic information and opportunity for plant breeders to develop new high-yielding crop varieties (Govindaraj *et al*., 2014).

Conclusion

Result obtained from this study was able to emphatically establish the important of morphological parameters for genetic evaluation and grouping of accession into mean full cluster for identification of best accession with desired heritable traits. Information from this study will guide in the management and planning for coffee improvement strategies in Nigeria. Further study is needed to explore more accessions and also to relate the observed diversity to other traits with the aim of identifying best parental for breeding programs. The traits could be incorporated into intensive molecular characterization for quality related traits (caffeine content) and use of coffee plants for aesthetics value.

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Table 1: Genetic parameters estimates of fifteen agro-morphological traits of C. *canephora* accessions

Trait	FC	FCW	FS	DSW	SW	LOS	Germ%	DG50%	PH	SG	LN	IN	LL	LW	NPB
GAM%	15.74	10.84	70.82	14.2	18.03	14.68	14.32	16	26.32	44.44	112.73	39.5	36.1	36.57	58.31
GA	0.78	7.84	1.54	3.38	0.11	0.12	12.59	7.82	13.85	0.23	42.39	1.02	6.05	2.76	2.44
h^2	56.2	38.25	69.57	54.39	40	33.33	65.16	48.37	32.72	47.06	52.76	34.02	58.26	50.91	29.76
ECV %	9	10.81	27.26	8.56	16.95	12.35	13.6	11.2	32.04	33.35	71.29	45.78	19.44	24.43	79.73
GCV %	10.19	8.51	41.22	9..35	13.84	12.35	18.61	10.84	22.34	31.44	75.34	32.87	22.96	24.88	51.89
PCV %	13.6	13.76	49.42	12.67	21.88	21.38	23.05	15.59	39.06	45.84	103.72	56.36	30.08	34.87	95.13
EV	0.2	61.16	0.35	4.14	0.01	0.01	30.63	31.79	284.27	0.03	718.62	1.39	10.61	3.4	11.15
GV	0.26	37.88	0.8	4.94	0.01	0.01	57.29	29.78	138.23	0.03	802.69	0.72	14.81	3.53	4.72
PV	0.47	99.04	1.15	9.08	0.02	0.03	87.92	61.57	422.5	0.057	1521.31	2.11	25.42	6.93	15.87
Mean	4.97	72.33	2.17	23.77	0.59	0.81	40.68	50.34	52.63	0.52	37.61	2.58	16.76	7.55	4.19

Fruit colour= FC); Fresh cherry weight = FCW; Fruit shape = FS; Dried Seed weight = DSW; Seed width = SW; and Length of Seed = LOS; Germination percentage = Germ %; Days to 50% germination = D50%Germ; Plant height = PH; Stem girth = SG; Leaf number = LN; Internodes length = IN; Leaf length = LL; Leaf width = LW; and Number of plagiotropic branches = NPB

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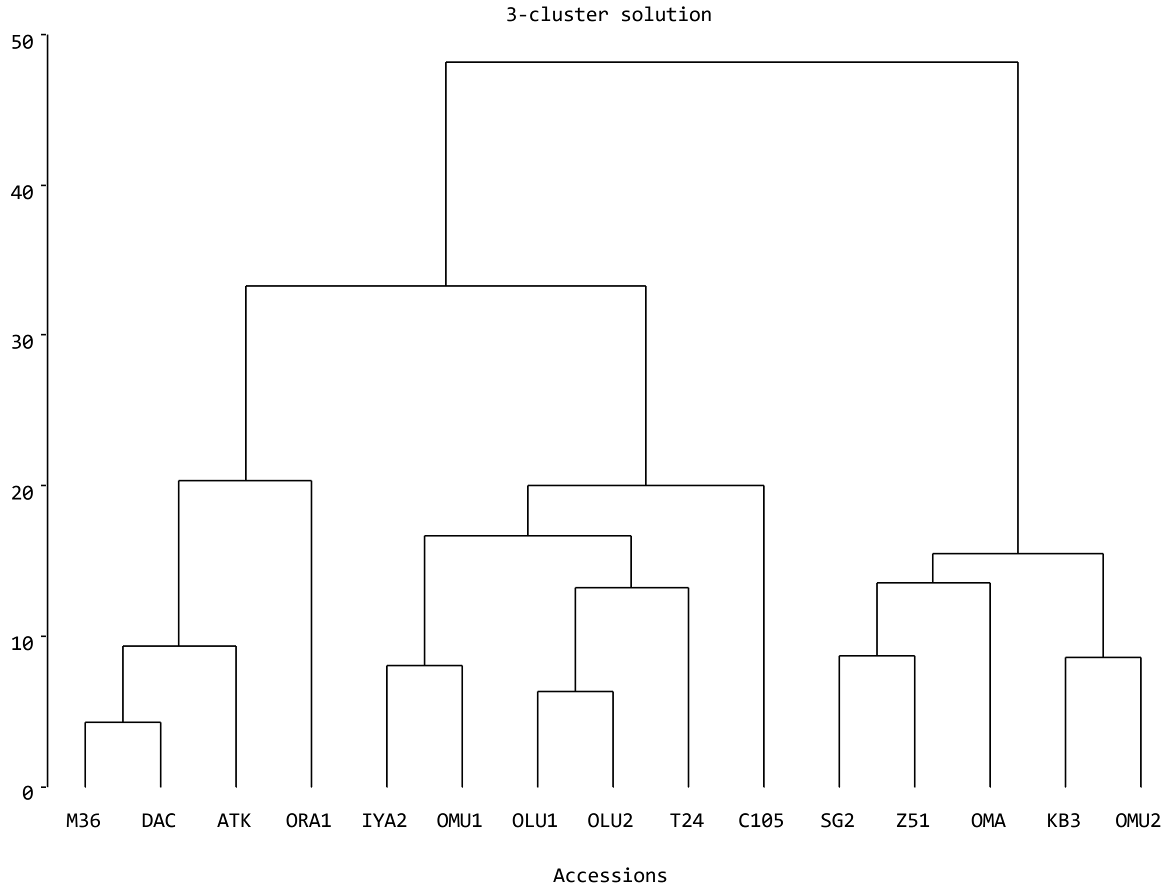

Figure 1: Dendrogram of accessions of C. *canephora* evaluated based on 15 agro-morphological traits

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INFLUENCE OF LEAF RELATIVE WATER CONTENT ON THE GROWTH OF COCOA DURING THE EARLY ESTABLISHMENT PERIOD IN NIGERIA

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ABSTRACT

Nine cocoa clonal materials AMAZ 15, MAN 15, UF 676, ICS 95, PA 150, SCA 6, N 38, SPEC 54 and IMC 47 were selected from 25 clones at the International Cocoa Clonal Germplasm of Cocoa Research Institute of Nigeria, Ibadan. After self-pollinated, the resultant true-to-type seeds were raised into seedlings and transplanted into a field in Ibadan. Data were collected on the Plant height, Stem diameters and Leaf Relative Water Content (LRWC) to determine the influence of LRWC on the growth performances of these cocoa materials over two separate dry and wet seasons in the first two years of establishment. There was variation in the performances of the variables measured with SCA 6 and PA 150 have higher growth values than some clones like N 38, ICS 95 and AMAZ 15.

Key words: Cocoa, establishment, plant height, stem diameter, relative water content

INTRODUCTION

Cocoa is a tropical crop that grows in areas with high annual rainfall and its production is prone to periodic drought due to seasonal rainfall patterns that sometimes include a long dry season. In West Africa where over 70% of the global cocoa beans are produced, the cocoa plant is still majorly grown as a rainfed crop with its vegetative and reproductive growth mainly controlled by a range of environmental factors. At some levels of water stress and high temperature conditions, cocoa shows adaptations to various physiological levels for its survival and growth. For dry weather to affect cocoa plant, the amount of rainfall must lead to a soil water deficit and ultimately to a plant water deficit situation. Despite the fact that drought negatively impacts the survival and growth of the crop (Abo-Hamed *et al*., 1985, Razi *et al*., 1992, Belsky and Siebert, 2003) selection of cocoa clones based on how they respond physiologically to drought has been meagre (Zuidema *et al*., 2005) and very little research has been directed towards the identification and development of drought tolerant traits in the cocoa germplasm (Balasimha *et al*., 1988, Bae *et al*., 2008). In fact, much of the little research work on how cocoa react to stress are carried out under artificial stress conditions of which the results of plants response may not be representative of the crop response in the field conditions. Therefore, on-the-site research is needed to gain basic understanding of the effects of drought stress on cocoa and reduce the chances of crop failure since such experience is needed to ensure improvement of crop and soil water management to develop drought tolerant cultivars (Ayegboyin, 2012). This present experiment was then carried out to study the effect of leaf relative water content on the plant height and stem diameter in young cocoa trees across two different dry seasons and two wet seasons in Ibadan, Nigeria.

MATERIALS AND METHODS

Nine cocoa clonal materials namely AMAZ 15, MAN 15, UF 676, ICS 95, PA 150, SCA 6, N 38, SPEC 54 and IMC 47 were selected from the 25 cocoa clones established at the International Cocoa Clonal Germplasm of Cocoa Research Institute of Nigeria, Ibadan. Hand pollinated seeds of the nine selected clones were produced and later raised into seedlings which were true-to-type with their parental clones. Five stands per cocoa clone were planted in 3 replications to make up 135 experimental cocoa stands established on the field using a completely randomized block design. The plant height, stem diameter and leaf relative water content (LRWC) were determined for the cocoa plants during the 1st two years of establishment which cut across 2 dry seasons and 2 wet seasons. The plant height and stem diameter were measured in-situ. While the height of cocoa was measured with 1-meter rule, the stem diameter was determined with the aid of a digital vernier caliper. The LRWC was determined in the laboratory using various procedure. First, about 20 leaf discs of diameter 10mm per disc were removed from each sample leaf and the fresh weight (FW) of the discs was determined. Later, 40ml of distilled water was added to the discs in each petri-dish and left to float for specific temperature for complete 24 hours to allow them reach full turgor and their turgid weight (TW) was determined. The discs were then transferred into clean brown envelopes before

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being dried in the oven at 65⁰C for 3hrs to determine their dry weights (DW). The LRWC plant was then calculated in % using the method of Turner (1981) while all the procedures adopted had been fully explained in Ayegboyin, 2012.

RESULTS AND DISCUSSION

There were significant clone season interactions at 6, 15 and 18 MAT, representing later part of the 1st dry season and full 2nd dry season after establishment. Values were not significant (NS) at 9, 12, 21 and 24 MAT (1st and 2nd wet seasons). This shows that cocoa growth during the experimental period varied with seasonal water availability while clones are prone to varied osmotic adjustment during water deficit. SCA 6 and PA 150 plant heights were significantly higher than those of the N 38 during the 1st and 2nd dry seasons which is an indication that some cocoa clones tolerate soil water deficit than the others (Table 1).

Table 1: Mean plant height during the first two years of establishment (cm)

	Months After Transplanting (MAT)							
	1st dry season		1st wet season		2nd dry season		2nd wet season	
	3	6	9	12	15	18	21	24
AMAZ 15	40.3	63.2	77.3	94.7	128.4	138.2	155.2	183.7
ICS 95	41.1	63.2	80.6	95.7	127.5	141.2	162.2	185.2
IMC 47	44.0	66.3	81.2	98.9	129.0	139.0	163.2	184.8
MAN 15	45.2	68.0	79.2	95.6	130.3	150.0	167.3	187.2
N 38	39.0	62.6	80.6	95.0	129.1	142.2	167.3	190.0
PA 150	47.3	70.0	85.3	100.0	135.3	157.3	168.3	198.2
SCA 6	45.0	71.9	88.3	102.2	136.3	159.8	168.2	195.2
SPEC 54	42.5	69.3	80.3	98.3	133.3	151.1	165.2	187.5
UF 676	40.5	64.9	79.3	97.1	128.2	141.2	167.3	184.4
P = 0.05	NS	5.0	NS	NS	6.4	7.9	NS	NS

Values represent the means of three replicates (two trees per replicate) while NS means Not Significant

The stem diameters of cocoa across all seasons showed genotypic differences between clones. There were significant clone*season interactions in the dry seasons with SCA 6 and PA 150 having significantly higher stem diameter than ICS 95 and N 38 at 6 and 18 MAT (Figure 1). This confirms that increase in cocoa stem diameters had similar features with increase in the cocoa plant heights with both parameters showing the influence of genes and environmental factors on their performances (Balasimha, 2011).

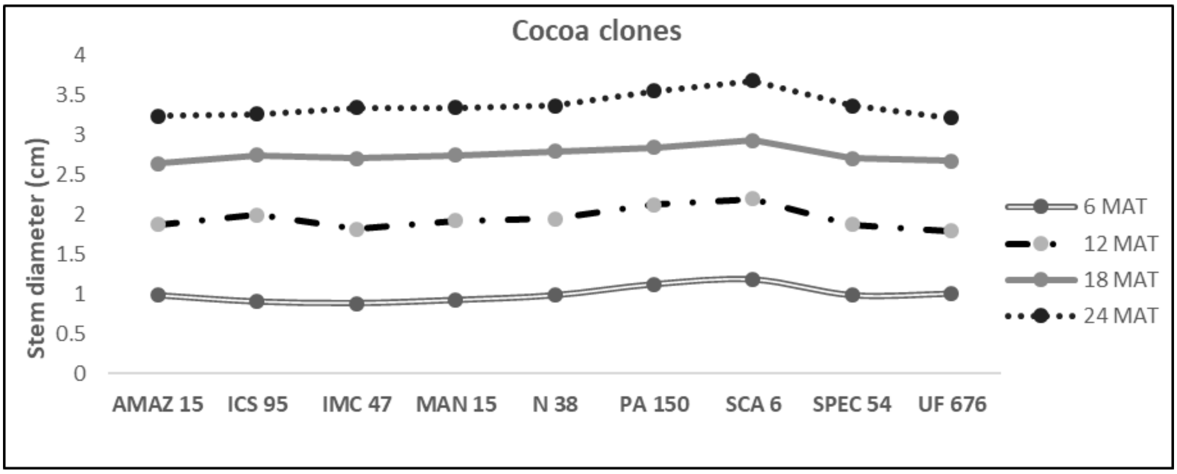

Figure 1: The stem diameters of cocoa clones during the 1st two years of establishment. Values represent the means of three replicates (two trees per replicate) and MAT means Months After Transplanting.

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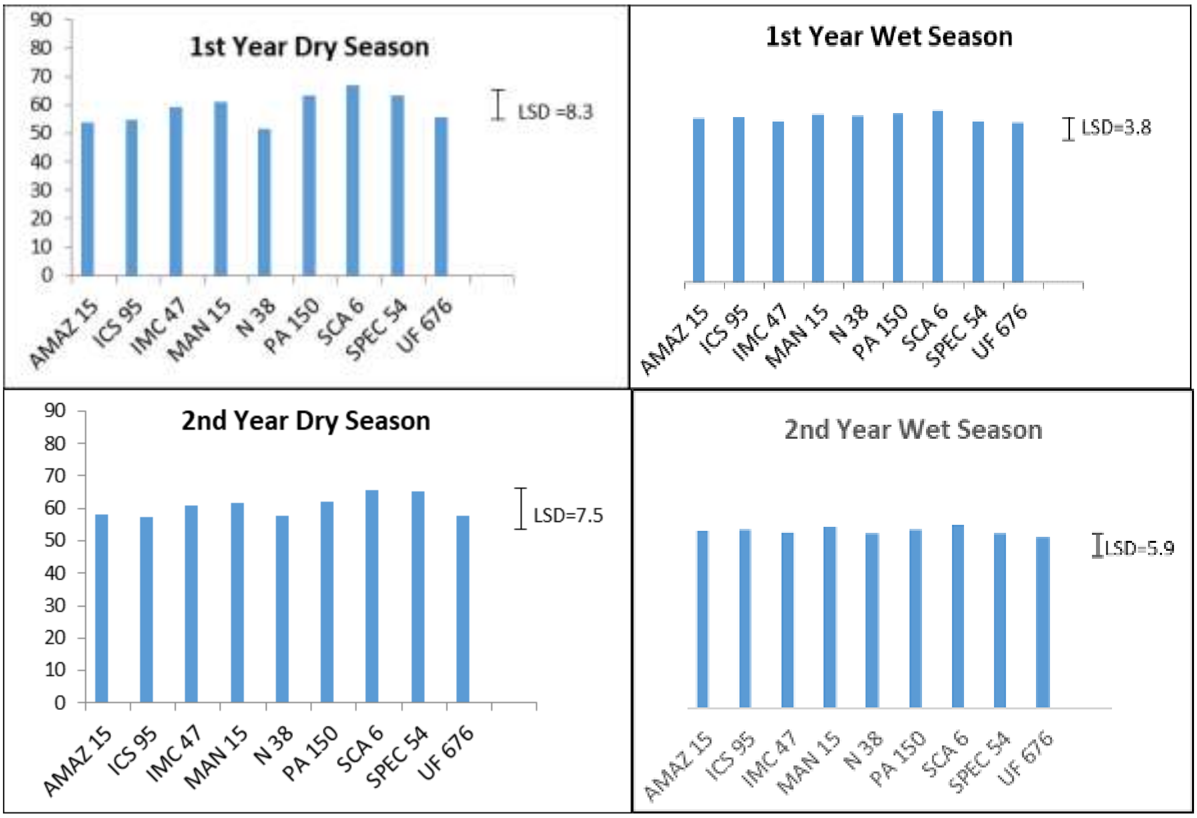

Figure 2: Leaf Relative Water Content (LRWC) of cocoa clones during the 1st two years of establishment. Values represent the means of three replicates (two trees per replicate) and two measurements. Bars shows the Least Significant Differences (LSDs).

The LRWC showed significant cocoa clone*season interactions during the 1st and 2nd year dry seasons with SCA 6 and PA 150 having significantly higher values than ICS 95 and N 38 at 6, 9, and 15 MAT. Wet seasons recorded higher LRWC values than dry seasons thereby revealing varied osmotic adjustment by cocoa clones during water deficit. The values of cocoa LRWC were not significantly different among clones during the two wet seasons. Similar reports of relative decrease in LRWC among cocoa clones during dry season condition had been made by Abo-Hammed *et al.* (1985), Balasimha *et al*. (1988) and Ayegboyin (2012). Although, Abo-Hammed *et al*. (1985) reported LRWC of 80 % as the lowest value in cocoa, the present study in Nigeria showed that overall highest LRWC in cocoa was 79% which is similar to those obtained in Ghana by Acheampong (2010). One explanation to this is that since Nigeria and Ghana shared almost similar climatic features, the LRWC of cocoa is not only dependent on genetic and seasonal variability, but also on many other climatic factors like temperature and relative humidity which are determinants of water potential of cocoa trees. This reports confirms the position of Balasimha (2011) that LRWC of cocoa cultivars is not only genetic but also dependent on soil-water potential, air relative humidity and daily mean temperature. The ability to keep the LRWC high during the period of water deficit might be one of the traits responsible for SCA 6 and PA 150 to maintain normal activities like photosynthesis and produced significantly higher plant heights and stem diameters than N 38 during dry seasons. This confirms that for plant cells to exhibit normal activities and growth during growth, its leaves must maintain high turgor under low plant-water availability while such turgor pressure are governed by osmotic adjustment (Chimenti *et al*., 2002; Martínez *et al*., 2007).

The sustenance of a reasonable growth in dry seasons by some cocoa clones showed that those cocoa trees had relatively enough LRWC for optimum leaf turgor despite soil water deficit situation during those dry seasons. One explanation for this is that due to their genetic capabilities, the soil water deficit in dry seasons could not affect the provision of enough plant-water potential sufficient to avoid significant loss of water from the leaves in such cocoa clones. This confirms the fact that while LRWC and many other metabolic processes are negatively affected during increase intensity of drought (Balasimha, 1985), the reduction of plant water potential is not a product of loss of soil water in plant (Martínez et al., 2007). The present study showed that cocoa LRWC, plant height and stem diameter were not just a function of genetic capabilities but are influenced by many environmental factors such as weather and soil conditions of an area (Ayegboyin[1], 2019). The superior performance of SCA 6 and PA 150 than some other clones showed that these clones were less affected by water stress. Such drought tolerant clones possess stronger abilities to maintain some good photosynthetic rates under many precarious conditions that negatively affect other clones (Ayegboyin, 2019).

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EFFECTS OF SHADE AND WATER STRESS ON GROWTH OF TWO VARIETIES OF COCOA (*THEOBROMA CACAO* LINN.)

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ABSTRACT

An experiment was carried out between December 2019 and April, 2020 at the screen house of Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta. The experiment was conducted to evaluate the effects of shade and water stress on growth of two varieties of cocoa. It was a 2 x 2 x 2 factorial experiment. Factor-1 was shade provision: Shaded and un-shaded, factor-2 was volume of water supplementation: 600mls/plant/week (no stress), and 150 mls/plant /week (stressed) and Factor-3 was cocoa variety: CRIN TC-1 and CRIN TC-2. The experiment was laid out in Completely Randomized Design replicated three times. The effects were monitored by collection of data on growth components which include, plant height, stem girth, total leaf area and dry matter production of leaf, stem and root. Data generated were subjected to Analysis of Variance and means separated using Least Significant Differences (p<0.05). Shade significantly enhanced stem girth and leaf area of cocoa in the nursery. Cocoa grown under shade had significantly (p<0.05) thicker stem girth, larger leaf area surface and higher root weight value compared to those without shade. Cocoa that received 600mls/plant/week water had significantly (p<0.05) taller, thicker girth, larger leaf area surface as well as higher leaf, stem and root weight compared to those that received 150 mls/plant/week. Variety CRIN TC-1 had significantly taller plant compared to CRIN TC-2 while CRIN TC-2 was superior with respect to stem girth and higher root weight value compared to CRIN TC-1. The interaction of shade x water supplementation rate x variety significantly affected growth of cocoa. CRIN TC-1 that received 600mls/plant/week grown under shade produced the tallest plant with larger leaf area surface. This study indicated the importance of shade and the supply of 600mls/plant/week water for growing of cocoa during the dry season. CRIN TC-1 is recommended as better cocoa variety.

Key words: Cocoa variety, Water stress, Shade, Growth

INTRODUCTION

Cocoa is one of the most important tropical crops in the world. Africa contributes 75% of the world's cocoa production and production is cantered in West Africa with Ivory Coast (2,034,000 t/ha), Ghana (883,652 t/ha), Nigeria (328,263 t/ha) and Cameroon (295,028 t/ha) being the first, second, fifth and sixth respectively in the world rankings of producers (FAOSTAT, 2017). Cocoa powder is used in baking cakes, biscuits, cocoa beverage, cocoa mixes, other confectioneries, baking, dairy products, including ice cream, soft drinks and in pharmaceutical and food preparations (Opeke, 2005).

Cocoa growth is highly sensitive to water and light availability (Zuidema *et al.*, 2005; Carr and Lockwood, 2011). Gateau-Rey et al. (2018) explained that drought stress can have substantial negative impacts on plant growth until the death of plant up to 15%. Drought stress has detrimental effects on the growth and yield of cocoa are well documented (Gateau-Rey *et al.,* 2018; Schroth *et al.,* 2016). Under drought stress, Medeiros *et al.* (2012) reported that the inflow of water reduces due low water avail-ability in soil, which potentially affects the physiological processes dependent on turgor pressure because of low water status in plant. Drought stress also inhibits the activity of enzymes, such as nitrate reductase (Mandi *et al.,* 2018). Then, it also causes the degradation of photosynthetic pigment, such as chlorophyll. The degradation in the concentration of photosynthetic pigments causes damage in photochemical activity. The present study aimed to examine the effect of shade and drought stress on the growth of cacao two cocoa varieties.

MATERIALS AND METHODS

The experiment was carried out at the at the screen house of Centre of Excellence in Agriculture Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta, Nigeria. This research was conducted from December 2019– April 2020. Each polybag was fulfilled with 3 kg soil. It was 2 x 2 x 2 factorial experiment, Factor 1 was shade at 2 levels (Shaded and un-shaded), factor 2 was irrigation volume at two levels 600mls/plant/week (no stress), and 150 mls/plant /week (stressed) and Factor 3 was cocoa variety at two levels (Crin T-c 1 and Crin T-c 2). Average monthly temperature ranges between 34.3- 36.80C in the shaded area and 41.2-44.50C in the un-shaded area (Figure 1). The average monthly relative humidity ranges between 41-46 % for the shaded area and 10-31% for the un-shaded area (Figure 2) while Average monthly light insolation ranges between 750 and 946 Lux for the shaded area and 18460-32600 lux for the un-shaded area (Figure 3). Data on shoot height, number of leaves, stem girth, number of branches were collected on at two-week interval. Dry matter accumulation was determined at 20 weeks after sowing (WAS) by carefully uprooting one plant per plot in and oven dried to constant weight at a temperature of 750 C. Data collected were subjected to Analysis of Variance (ANOVA) using GENSTAT (12th Edition) and treatment means separated using Least Significance Difference (LSD) at 5% probability.

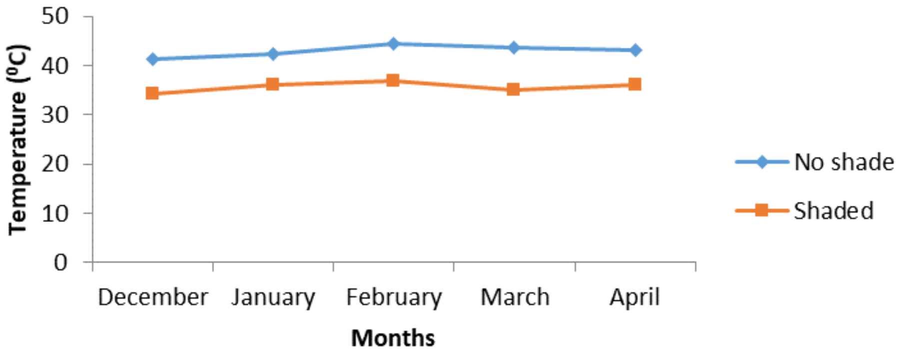

Figure 1: Average monthly temperature

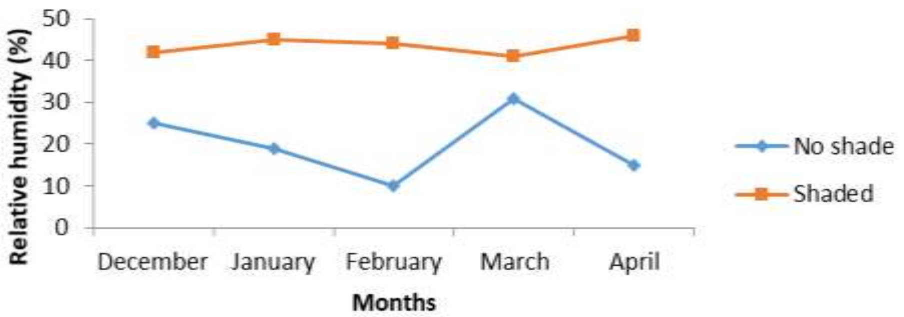

Figure 2: Average monthly relative humidity

Figure 3: Average monthly insolation

RESULTS

Vegetative growth

Shade does not significantly influence plant height of cocoa. Although not significant, shaded seedlings were taller than the one without shade (Figure 4). However, the effect of irrigation volume had profound effects on plant height of cocoa was significant. Plants that were irrigated with

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600mls/plant/week were significantly taller compared to those that received 150mls/plant/week from 8-20 WAS (Figure 5). Also, Crin-Tc 1 variety were significantly taller compared to Crin-Tc 2 from 8-20 WAS (Figure 6).

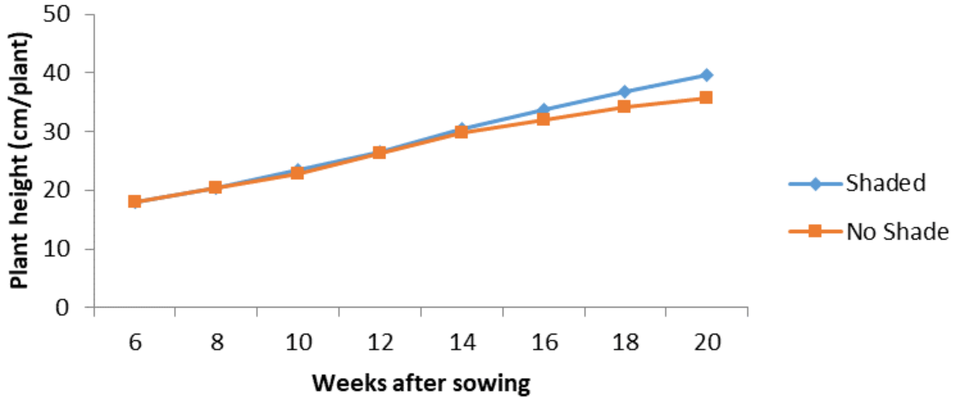

Figure 4: Plant height of cocoa as affected by shade

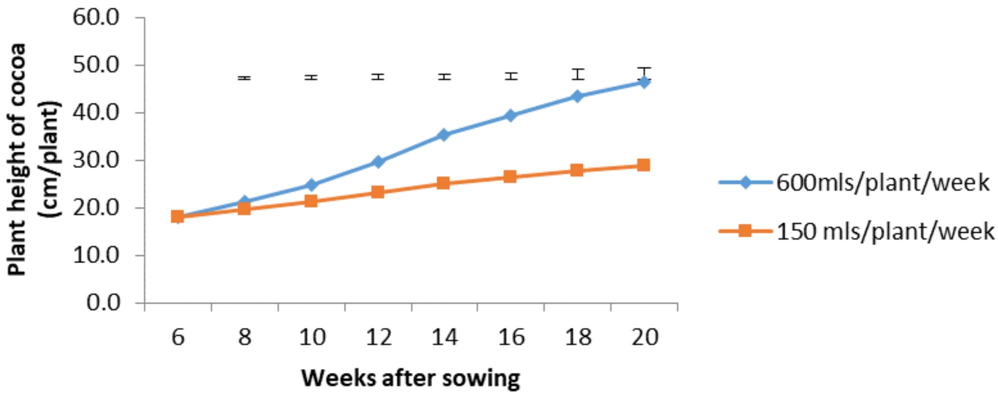

Figure 5: Plant height of cocoa as affected by irrigation rate

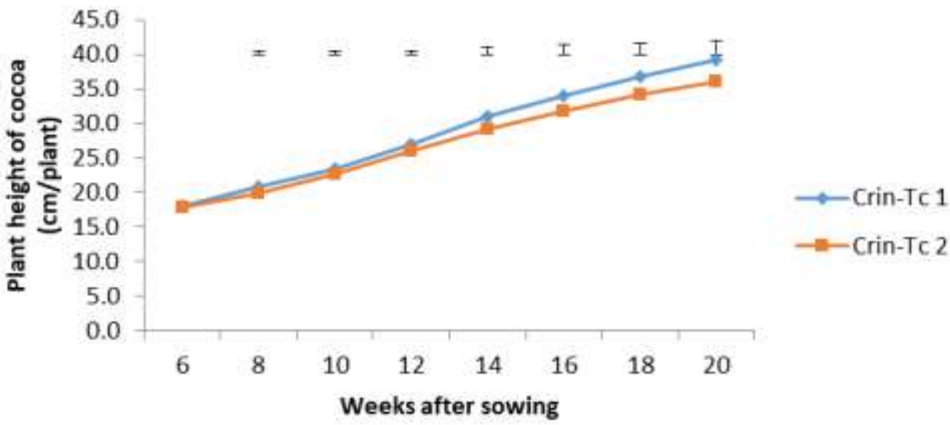

Figure 6: Plant height of cocoa as affected by variety

The interaction of shade x irrigation volume x variety was significant on plant height of cocoa from 14-20 WAS. Cocoa raised with water volume of 600mls/plant/week were significantly taller irrespective of shade and variety compared with those that received 150mls/plant/week. Crin-Tc 1 variety irrigated with 600mls/plant/week raised under shade were tallest compared with other treatment while the shortest plant height was recorded in Crin-Tc 2 irrigated with 150mls/plant/week with shade (Table 1).

Table 1: Interaction of shade, irrigation rate and variety on plant height of cocoa

Treatments			Plant height of Cocoa (cm/plant) Weeks after transplanting							
Shade	Water rate	Variety	6	8	10	12	14	16	18	20
No-Shade	600mls/plant/week	Crin-Tc 1	18.2	22.4	24.8	30.3	36.0	38.3	41.2	43.0
		Crin-Tc 2	17.8	20.3	24.1	29.4	35.4	39.2	42.9	45.5
	150 mls/plant/week	Crin-Tc 1	17.9	19.6	21.3	23	24.9	26.3	27.6	28.5
		Crin-Tc 2	17.9	19.1	20.8	22.2	22.9	23.7	24.7	25.4
Shaded	600mls/plant/week	Crin-Tc 1	18.0	21.2	25.9	30.3	36.9	43.0	49.2	54.1
		Crin-Tc 2	18.0	20.7	24.6	28.6	32.6	36.6	40.0	43.1
	150 mls/plant/week	Crin-Tc 1	18.0	19.8	21.8	23.9	26.3	28.0	29.3	30.8
		Crin-Tc 2	18.0	19.7	21.3	23.5	25.7	27.5	28.7	30.4
		LSD	0.5	0.91	1.12	1.52	2.67*	3.08*	3.78*	4.76*

Stem diameter of cocoa was influenced by shade significantly. Cocoa seedlings grown under shade had wider stem girth from 8-20 WAS compared to those without shade (Figure 7). Similarly, the effect of irrigation volume significantly influenced stem girth of cocoa. Cocoa seedling irrigated with 600mls/plant/week had significantly wider stem girth compared to seedlings that received 150mls/plant/week from 10-20 Weeks after Sowing (WAS) (Figure 8). Crin-Tc 2 variety elicited significantly wider stem girth compared to Crin-Tc 2 from 12-18 WAS (Figure 9). The interaction of shade x irrigation volume x variety was not significant on stem girth of cocoa. Although not significant, cocoa seedlings raised under shade and received application of 600mls/plant/week had wider stem girth (Table 2).

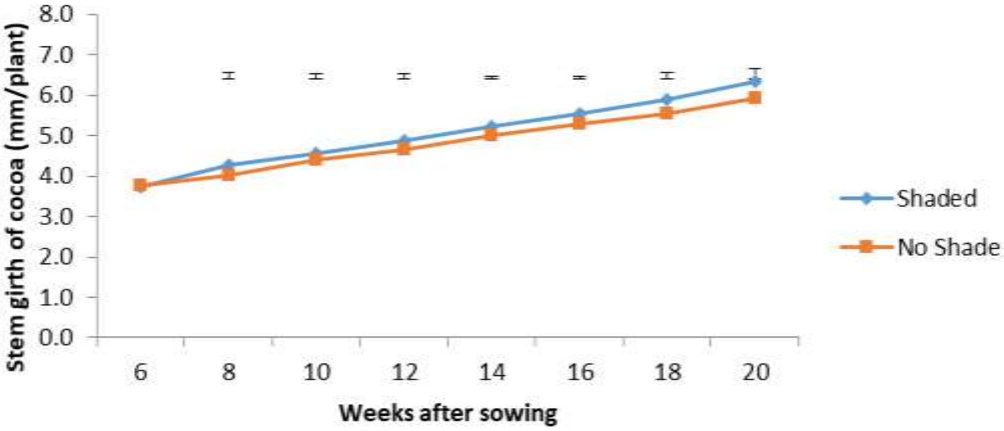

Figure 7: Stem girth of cocoa as affected by shade

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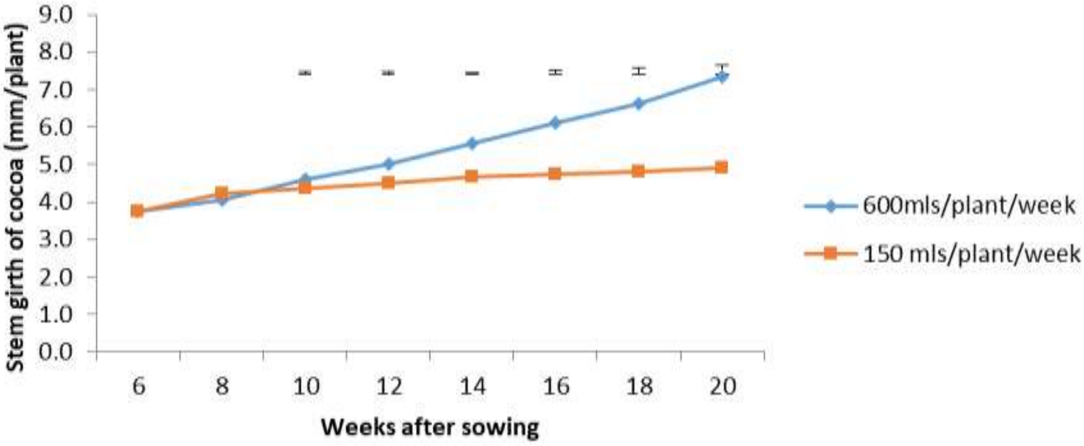

Figure 8: Stem girth of cocoa as affected irrigation rates

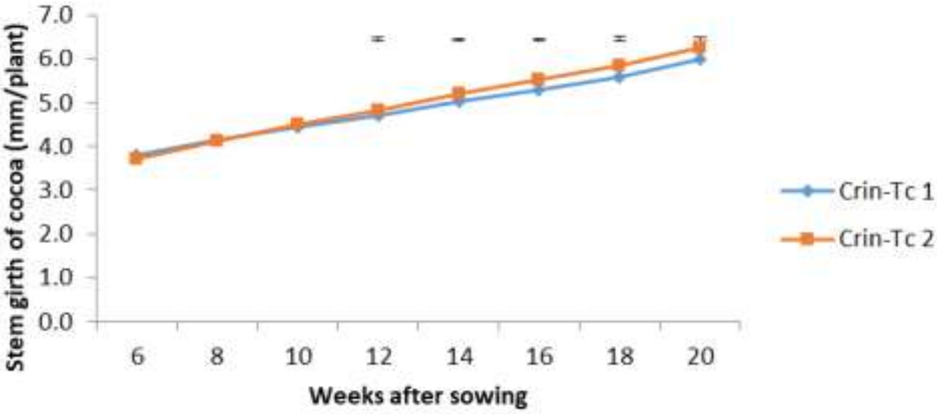

Figure 9: Stem girth of cocoa as affected by variety

Table 2: Interaction of shade, irrigation rate and variety on stem girth of cocoa

Treatments			Stem girth of Cocoa (mm/plant) Weeks after transplanting							
Shade	Water rate	Variety	6	8	10	12	14	16	18	20
No-Shade	600 mls/plant/week	Crin-Tc 1	3.8	3.8	4.5	4.8	5.3	5.8	6.3	7.0
		Crin-Tc 2	3.7	3.8	4.3	4.8	5.4	6	6.4	7.2
	150 mls/plant/week	Crin-Tc 1	3.8	4.2	4.3	4.5	4.5	4.6	4.6	4.6
		Crin-Tc 2	3.8	4.3	4.5	4.6	4.7	4.8	4.8	4.9
Shaded	600 mls/plant/week	Crin-Tc 1	3.8	4.4	4.8	5.2	5.7	6.2	6.6	7.5
		Crin-Tc 2	3.7	4.2	4.8	5.3	5.9	6.4	7.1	7.7
	150 mls/plant/week	Crin-Tc 1	3.7	4.2	4.2	4.4	4.6	4.7	4.7	4.9
		Crin-Tc 2	3.6	4.3	4.4	4.6	4.8	4.9	5.0	5.2
		LSD	0.2	0.27	0.16	0.16	0.11	0.14	0.23	0.32

Shade significantly influenced leaf area of cocoa. Cocoa seedlings raised under shade had significantly higher leaf area value from 12-20 WAS compared to those without shade (Figure 10). Cocoa seedlings irrigated with 600mls/plant/week had significantly higher leaf area value compared to those that received 150mls/plant/week from 8-20 WAS (Figure 11). However, variety does not influence leaf area of cocoa (Figure 12).

The interaction of shade x irrigation volume x variety was significant on leaf area of cocoa from at 8, 10, 18 and 20 WAS. Generally, Cocoa seedlings raised under shade and received 600mls/plant/week had significantly higher leaf area value compared with those that received water volume of 150mls/plant/week (Table 3). Crin-Tc1 raised under shade and received 600mls/plant/week had significantly higher leaf area value while the least leaf area value was recorded in Crin-Tc 1 raised without shade irrigated with 150mls/plant/week (Table 3)

Dry matter production

The effect of shade was significant on dry root weight of cocoa seedlings. Seedlings resided under shade had higher dry root weight value compared to those without shade (Table 4). The effect of irrigation volume was significant on dry leaf, stem, root and total weight of cocoa seedlings. Cocoa seedling that received 600mls/plant/week of water had significantly higher dry leaf, stem, root and total weight compared to seedlings that received 150mls/plant/week (Table 4). The effect of variety was significant on dry root weight of cocoa. Crin-Tc 2 variety had significantly higher root dry weight compared to Crin-Tc 1 (Table 4).

The interaction of shade x irrigation volume x variety was not significant on dry weight of cocoa seedlings. Although not significant, cocoa seedlings raised under shade and received application of 600mls/plant/week had higher dry weight compared to those raised without shade (Table 5).

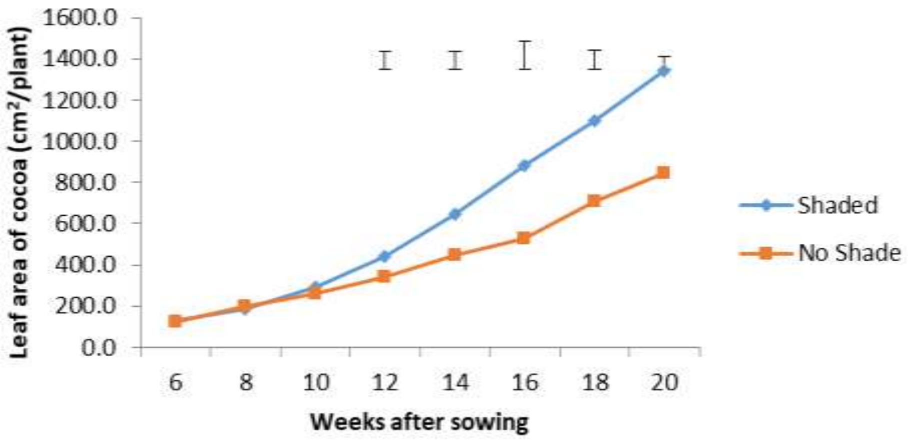

Figure 10: Leaf area of cocoa as affected by shade

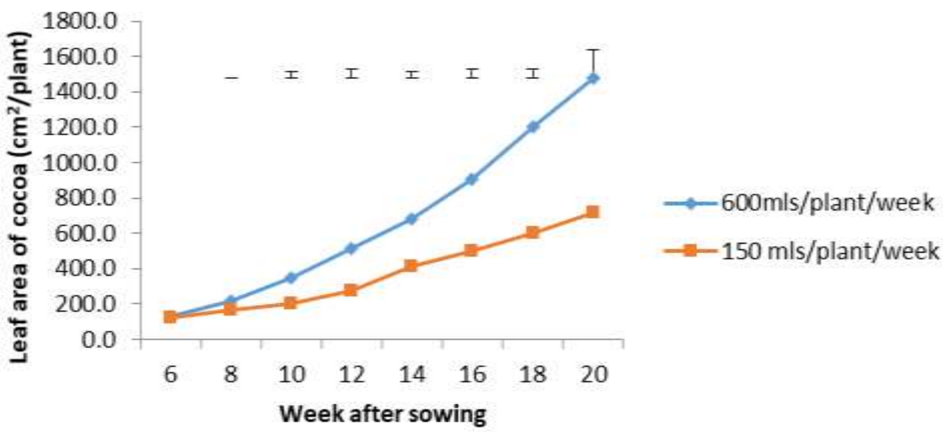

Figure 11: Leaf area of cocoa as affected irrigation rates

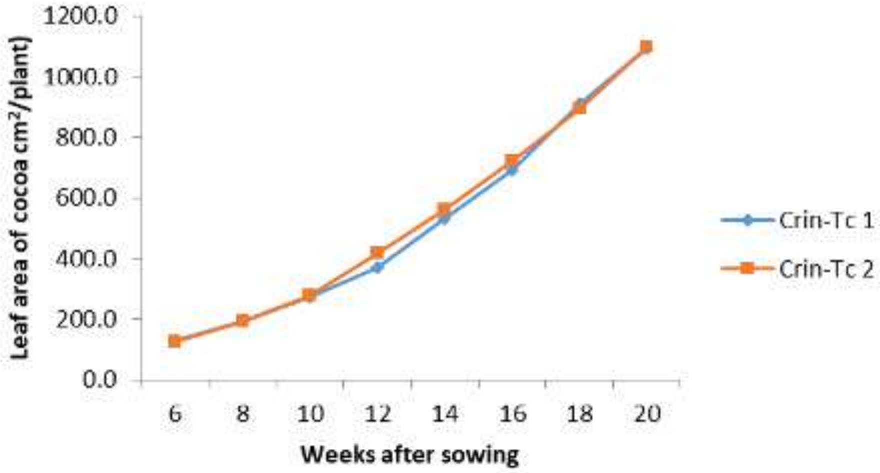

Figure 12: Leaf area of cocoa as affected by variety

Table 3: Interaction of shade, irrigation rate and variety on leaf area of cocoa

Treatments			Leaf area of Cocoa (cm²/plant) Weeks after transplanting							
Shade	Water rate	Variety	6	8	10	12	14	16	18	20
No-Shade	600 mls/plant/week	Crin-Tc 1	128.1	234.8	333.4	487.6	628.3	776.6	1109.3	1324.5
		Crin-Tc 2	134.8	230.2	325.2	454.5	620.4	775.5	1034.0	1249.8
	150 mls/plant/week	Crin-Tc 1	123.0	177.8	199.3	203.8	253.5	277.2	333.6	340.5
		Crin-Tc 2	113.2	163.1	177.6	230.2	282.5	291.7	353.2	399.5
Shaded	600 mls/plant/week	Crin-Tc 1	138.2	224.5	387.9	504.6	714.5	993.5	1312.3	1665.5
		Crin-Tc 2	119.0	188.6	346.8	603.2	749.9	1091.3	1358.3	1661.2
	150 mls/plant/week	Crin-Tc 1	122.7	141.3	170.1	285.0	526.6	712.5	892.6	980.1
		Crin-Tc 2	136.9	189.0	262.3	381.5	590.6	727.4	815.0	948.4
		LSD	28.00	50.78*	64.58*	97.20	85.97	130.66	98.54*	161.68*

Table 4: Effects of shade, irrigation rate and variety on dry weight of cocoa

Treatments	Dry weight of cocoa (g/plant) Plant parts Leaf	stem	Root	Total weight
Shading				
Shaded	2.83	2.92	1.06	6.80
No Shade	2.73	2.38	0.93	6.03
LSD	0.535	0.980	0.081*	1.220
Irrigation Volume				
600 mls/plant/week	3.39	3.25	1.15	7.79
150 mls/plant/week	2.17	2.04	0.83	5.04
LSD	0.440*	0.523*	0.178*	0.857*
Variety				
Crin-Tc 1	2.71	2.50	0.95	6.17
Crin-Tc 2	2.85	2.79	1.03	6.67
LSD	0.196	0.406	0.057*	0.517

Table 5: Interaction of shade, irrigation rate and variety on dry weight of cocoa

Treatments			Dry weight of cocoa (g/plant) Plant parts			
Shade	Water rate	Variety	Leaf	stem	root	total
No-Shade	600 mls/plant/week	Crin-Tc 1	3.24	2.53	0.99	6.76
		Crin-Tc 2	3.55	3.08	1.10	7.73
	150 mls/plant/week	Crin-Tc 1	1.90	1.78	0.79	4.46
		Crin-Tc 2	2.23	2.11	0.82	5.16
Shaded	600 mls/plant/week	Crin-Tc 1	3.24	3.50	1.15	8.13
		Crin-Tc 2	3.55	3.89	1.35	8.55
	150 mls/plant/week	Crin-Tc 1	1.90	2.20	0.87	5.32
		Crin-Tc 2	2.23	2.06	0.85	5.22
		LSD	0.600	1.001	0.187	1.330

DISCUSSION

Optimal growth performance in the two cocoa varieties was obtained with shade. Opeke (2005) had earlier reported that provision of good shade enhances survival of cocoa seedlings during the dry season. He further reported that shade protect Cocoa plant from harmful effects of direct insolation and minimize the risk of leaf and branch scorch by establishing a more equitable eco-climate through the reduction of high intensity, temperature and air movement. This was in agreement with Olatunde *et al.* (2014) who attributed the better performance of the Cocoa seedlings grown under 50% shade on the high assimilation rate of the cocoa seedlings under this condition.

Adequate water provision in this study was found to be very critical for survival and growth of cocoa. Plant that received higher irrigation rate of water had better growth performance. Water deficit inhibits plant growth by reducing water uptake into the plant cells thus alters the rheological properties of the cell wall. Consequently, inhibition of growth by water deficit occurs prior to inhibition of photosynthesis or respiration (Hummel et al., 2010). This was in agreement with findings of Suzuki *et al*., (2014) who reported that among the abiotic stress, drought and heat stresses affects new cacao the most.

The interaction of shade and adequate water were critical for optimal growth of cocoa. Cocoa seedlings grown with shade and supplied with adequate moisture were superior to those grown under moisture and Heat stress. This indicated the complimentary role of shade in reduction of evapotranspiration rate from the leaf and soil of cocoa.

CONCLUSION

Apparently, from the results obtained from this study, shade is important for the growth of cocoa during the dry season period. Adequate moisture of 600mls/plant/week is necessary for optimal growth of cocoa and Crin Tc-1 as a better variety.

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PRIMARY HARDENING OF MICROPROPAGATED PLANTAIN (*MUSA* SP. AAB CV. AGBAGBA) ON DIFFERENT GROWTH SUBSTRATES FOR FOOD SECURITY

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ABSTRACT
In Nigeria, there is increase in the demand for healthy and uniform micropropagated plantain plantlets especially during the start of the rainy seasons. Attempt has been made in this study to use different growth substrates to assist in the mass propagation and adequate supply of micropropagated plantain plantlets all year round. The growth substrates used were sawdust only, sawdust: top-soil (1:3), and sawdust: top-soil (3:1). At 21 days after treatment, the results showed that the percentage survival of the micropropagated plantlets was highest in sawdust only (100%) and highly significant when compared to the other substrates sawdust: top-soil (1:3) and sawdust: top-soil (3:1) both recorded 99% survival of the plantain plantlets. The average plant height was (124 mm) sawdust only> (105 mm) sawdust: top-soil (1:3)> (102 mm) sawdust: top-soil (3:1) while the average number of leaves was (8) sawdust: top-soil (1:3)> (7) sawdust only and (7) sawdust: top-soil (3:1). We therefore concluded that the use of sawdust only as a substrate for hardening of plantain plantlets will yield better results and produce well primary hardened plantain plantlets.

Key words: Plantain, plant tissue culture, sawdust, fruits, hardening chamber.

INTRODUCTION
Plantain (*Musa* sp. AAB cv. Agbagba) belongs to the family Musaceae. They are perennial monocotyledonous fruits grown in many tropical areas. The total world production of plantain and banana reached 70.8 metric tons in the year 2006 (FAO, 2007). The fruits are used both as staple food and dietary supplements (Assani *et al*., 2001). Generally, plantain cultivars are good sources of carbohydrates, proteins, vitamins and minerals. However, many pests and diseases are threatening the production plantain cultivars. In order to augment conventional breeding and to avoid constraints imposed by pests and pathogens, transgenic and *in* vitro approaches are being considered (Jain and Swennen, 2004). Plant tissue culture or micropropagation of plantain and banana has been extensively used for rapid production of high quality, disease-free and uniform planting material irrespective of the season and weather. However, a large scale application of this technology is hindered by high mortality experienced by micropropagated plantain plantlets when transferred into *ex vitro* conditions. During *in vitro* conditions, plantain plantlets grow under special conditions in relatively air-tight vessels i.e. air humidity is higher and irradiance is lower than in conventional culture (Uzaribara *et al*., 2014). High mortality is observed upon transfer of micro shoots to *ex vitro* conditions as the cultured plants have non-functional stomata, weak root system and poorly developed cuticle (Mathur *et al*., 2008). Primary and secondary hardening is an integral and vital activity of the whole process of tissue culture technology. Improper hardening leads to the failure of whole technology. Success in hardening is a must for the survival of micropropagated plantain plantlets to meet urgent demand for food security (Sukanya Parkhe *et al*., 2018, Radeshyam and Subramani, 2008). In this study, the role of formulated growth medium for acclimatization (primary hardening stage) of micropropagated plantain plantlets was investigated.

MATERIALS AND METHODS
Area of study and source of materials
This study was carried out at the Biotechnology Research Unit, National Horticultural Research Institute (NIHORT), Ibadan. The micropropagated plantain plantlets were collected from Biotechnology Unit of NIHORT, Ibadan.

Micropropagated plantain primary hardening experiment
The micropropagated plantain plantlets were subjected to primary hardening treatment using different formulated substrates i.e. sawdust only, sawdust + top-soil (1:3) ratio, and sawdust+top-soil (3:1) ratio. Eleven micropropagated plantain plantlets were used per treatments in a round tray placed in a humidity chamber with relative humidity of 75% and temperature of 35^{o}C for 21 days.

Data Analysis
The experiment was laid out in a completely randomized design in three replicates. Data were subjected to Analysis of Variance (ANOVA) and means were separated using SPSS version 23,

Duncan's Multiple Range Test at P < 0.05. The experiment was repeated twice.

RESULTS AND DISCUSSION

Effect of different growth substrates on the average plant height of micropropagated plantain seedlings after acclimatization experiment

The effect of different substrates on the survival and growth of the plantain plantlets were shown in Figure 1. The average height of the plantain plantlets in all the treatments used were initially 101 mm. After 21 days of treatment, the plantain plantlets with treatment of sawdust only had the highest average plant height of 124 mm as compared to the ones of sawdust +soil 1:3 which was 105 mm and sawdust +soil 3:1 which was 102 mm (Fig. 1). This agrees with the findings of Baiyeri *et al*., (2005) who concluded that banana plantlets at pre-nursery stage had the highest survival rate in mixture of sawdust only as compared to that of rice hull. However, Fornkwa *et al*., (2015) concluded that the treatment (substrate) biochar: soil: sand can be a better substrate for acclimatization of some plantain varieties in terms of leaf, stem and root development.

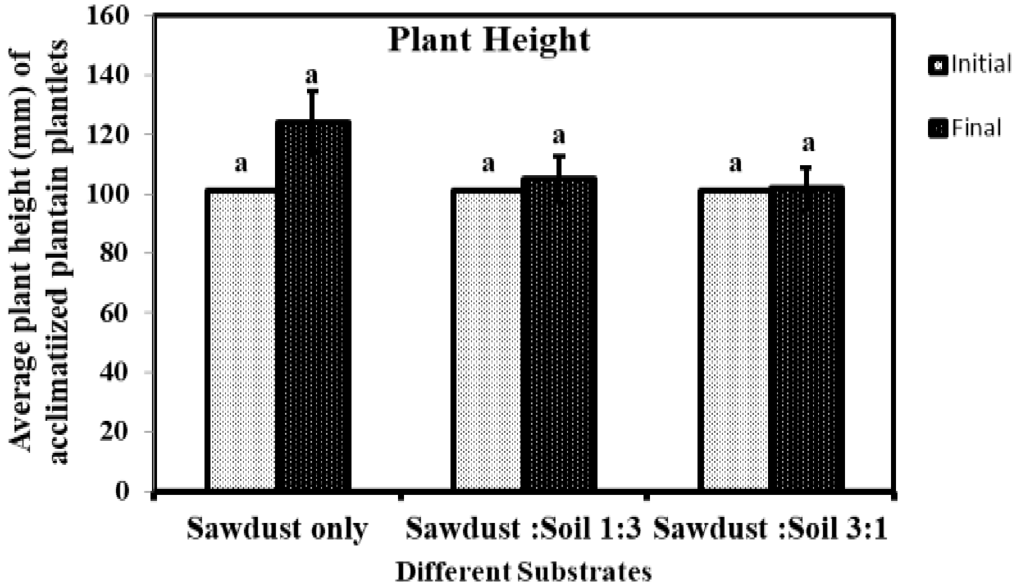

Figure 1: The effect of different growth substrates [sawdust only, soil+sawdust (1:3) soil+sawdust (3:1)] on average plant height (mm) of the acclimatized plantain plantlets showing the initial average plant length compared to final average plant length after 21 days of treatment.

Effect of different substrates on the number of leaves of tissue culture plantain seedlings after acclimatization experiment

In Fig 2, the plantain plantlets hardened on with sawdust: top- soil 1:3 had more average leaves of 8 when compared with the other substrates sawdust only was average of 7 leaves and sawdust+soil 3:1 was also average of 7 leaves. This is in line with the fimdings of Fornkwa *et al*., (2015) who concluded that sawdust alone as a substrate was not sufficient for the developments of more leaves on plantain seedlings during acclimatization.

Effect of different substrates on the percentage survival of tissue culture plantain seedling after acclimatization experiment

In Fig 3, the plantain plantlets hardened on both sawdust only and sawdust: top-soil (1:3) were having the percentage survival of plantlets after 21 days which was 99% as compared with those in sawdust only which had the highest percentage survival of plantlets of 100% after 21 days. Ubalua and Okorafor (2013) reported 100% survival rate of sweet potato plantlets grown on sterile substrates (river sand, saw dust, rice mill waste, river sand/rice mill waste, river sand/saw dust, saw dust/rice mill waste and jiffy peat) and 58% survival rate on unsterilized substrates. Sawdust is an ingredient that can keep the soil loose, which in turn enables the roots to spread out easily thus, giving it more breathing space and aeration. Consequently, better plant growth is achieved in sawdust growth medium. Kiran *et al*. (2018) as well as Ubalua and Nsofor (2017) also reported that acclimatization and growth of in vitro raised plantlets are highly correlated with the substrate porosity.

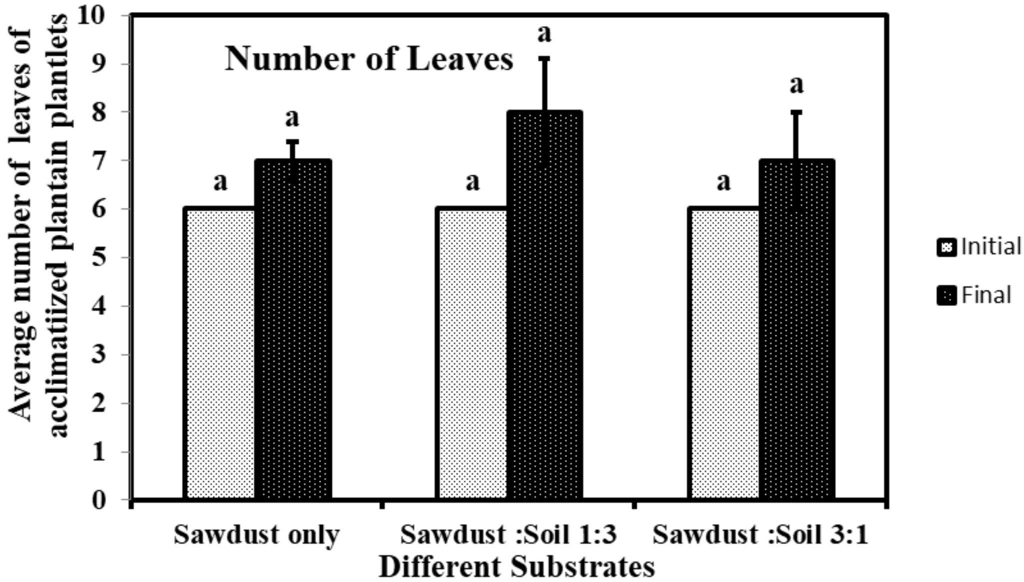

Figure 2: The effect of different growth substrates [sawdust only, soil+sawdust (1:3) soil+sawdust (3:1)] on average number of leaves of the acclimatized plantain plantlets showing the initial average plant length compared to final average plant length after 21 days of treatment.

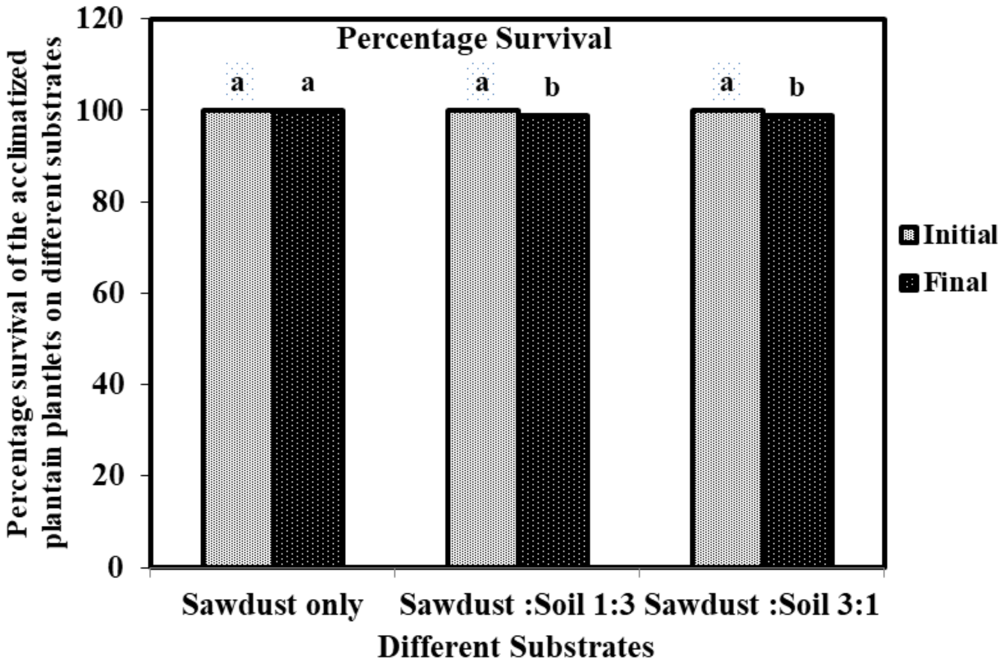

Figure 3: The effect of different growth substrates [sawdust only, soil+sawdust (1:3) soil+sawdust (3:1)] on percentage survival of the acclimatized plantain plantlets showing the initial average plant length compared to final average plant length after 21 days of treatment.

CONCLUSIONS

It is clear that the use of sawdust as substrates for primary hardening of micropropagated plantain plantlets enhanced and promoted better growth and survival of the plantlets because it had better air-permeability and also had appropriate retention. This substrate was suitable because the roots are not disturbed and it induces the growth of the leaves faster. The improved rooting and acclimatization achieved by this work could be used to optimize the secondary hardening of the plantain plantlets.

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ACCLIMATISATION OF TISSUE CULTURE PINEAPPLE PLANTLET USING SEMI-AUTOTROPHIC HYDROPONICS TECHNIQUE IN COMPARISON WITH OTHER CONVENTIONAL SUBSTRATES

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ABSTRACT

This research is aimed at optimizing the protocol for acclimatization of tissue cultured pineapple plantlets. Previously conventional substrates consisting of top soil mixtures have produced low yield and low survival rate of the tissue culture plantlets. Semi-Autotrophic Hydroponics (SAH) technique is being compared with Sawdust (SD) and Topsoil (TS) as a suitable method of acclimatization and further rooting of the plantlets. The experiment was conducted at the department of Biotechnology and Tissue Culture, National Horticultural Research Institute, Jericho-Idishin, Ibadan. Feb 2021 – April 2021. The crown of Ananas comosus (pineapple) was extracted and was cultivated in MS media. The plantlets were sub-cultured twice, after which they were taken into the hardening chamber. The plantlets were acclimatized in sterile substrate- Semi-Autotrophic Hydroponics substrate and other unsterile substrates – Topsoil (TS), Sawdust (SD), Sawdust and Topsoil (3:1) and Sawdust and Topsoil (1:3). 100% survival rate was observed for the plantlets grown SAH media as compared to the ones acclimatized on Topsoil and Sawdust combinations. The SAH media also enhanced further rooting of the plantlets, and there was significant increase in plant height. In conclusion, SAH media is a very effective media for the hardening and the acclimatization of micro-propagated plantlets.

Key words: Semi-Autotrophic Hydroponics, Acclimatization, Tissue Culture, Micro-propagation.

INTRODUCTION

Acclimatisation is an important step in the micro-propagation of plants. During in vitro culture, plantlets grow under special conditions in air tight vessels, thereby increasing humidity and controlling the temperature, unlike conventional culture (Yaya *et a*l., 2015). The aseptic environment in vitro reduces stress of pathogenic organisms. Quite a number of micropropagated plants do not survive the transition from in vitro environment to the field due to change in temperature, humidity and lightning (Hazarika, 2003). The ultimate success of tissue cultured plants on a commercial scale depends is the ability to transfer the clean plantlets from a controlled, aseptic environment to land successfully while maintaining a low cost and high survival rate. During the process of Tissue Culture, plantlets are handled with utmost care in a stable and well controlled atmosphere. The culture media serves as the nutrient source for the growing plantlet. The temperature, light and humidity of the laboratory are also controlled to suit the need of the plantlet. The transfer of tissue culture plantlets from the lab to soil usually leads to them being exposed to abiotic stresses, like altered temperature, light intensity, and humidity conditions, and biotic stresses, like soil microflora. The transfer of tissue culture plantlets from laboratory to soil needs to be slow and stepwise. This process is known as acclimatisation, which is the adaptation of organisms to a new environment.

Problem Statement

Various unsterilized substrates have been tried in the past for the acclimatization of micro propagated plantlets, leading to poor survival rate and poor yield. Ubalua and Okorafor (2013) reported 58% survival rate for sweet potato plantlets grown on unsterilized substrates. There is therefore need to develop a low cost easily accessible technology that would produce clean, virus free, sterile plantlets in large quantity within a short period of time, hence the introduction of the Semi-Autotrophic Hydroponics (SAH) Technology. This is a novel technology that is low-cost, licensed and rapid alternative method for the acclimatization of tissue culture cultivated plantlet and successful transfer to field. (Pelemo *et al*., 2019).

MATERIALS AND METHODS

The experiment was carried out at the tissue culture laboratory of National Horticultural Research Institute, Ibadan, Nigeria. Pineapple crowns were obtained from the research field of National Horticultural Research Institute. The crowns were sterilized with 50% Clorox (Sodium Hypochlorite 5.2%, (15mins)), 20% Clorox (10mins) and rinsed with sterile distilled water. Sterile crowns were cultured in the prepared medium which comprised of Murashige and Skoog (MS) (1962), supplemented with macro and micro elements, vitamins (Nitsch and Nitsch, 1965), 3% sucrose and 0.1 g/L myo-inositol. Cultures were incubated at 25

± 2°C for duration of four weeks for shooting and rooting induction.

Tissue Culture Media Composition

- Full MS (Murashige and Skoog) Media
- Vitamins
- 30% Sucrose
- 0.1g/L Myo-inositol
- 0.02g/L Cysteine
- Hormones

Hardening and Acclimatization in SAH Media

Clean, mature virus free plantlets were transferred into SAH (Semi-Autotrophic Hydroponics) Media for acclimatization to take place. SAH nutrient solution is added fortnightly to enhance growth. 15 micro-propagated plantlets were used per SAH container.

SAH Media Composition

SAH substrate consists of Nitrogen (N), Phosphorus (P) and Potassium (K) in the ratio 1:1:1

Nutrient Solution A: 35.4g of Solution Calcium Nitrate in 15L of distilled water

Nutrient Solution B:

- 14.7g of Magnesium Sulphate
- 4.08g of Potassium Monophosphate
- 15.5g of Potassium Nitrate
- 0.02g of Ferrous Sulphate

Make up to 15L with distilled water

Nutrient Solution C:

Mix 500ml of Solution A and 500ml of Solution B + 2litres of water to form Solution C

Note that Solution B must be kept in a black keg or container to prevent oxidation of iron compounds.

Hardening and Acclimatization in Saw Dust and Soil Mixtures

The micro-propagated plantain plantlets were subjected to primary hardening treatment using different formulated substrates i.e. Sawdust only, sawdust + top-soil (1:3) ratio, sawdust+top-soil (3:1) ratio and top soil only. Ten micro-propagated plantain plantlets were used per treatments in a round tray placed in a humidity chamber with relative humidity of 75% and Temperature of 35°C.

RESULTS AND DISCUSSION

There was a significant effect of substrate on root length, plantlet height and leaf number ($p<0.05$) for the acclimatization period (Table 1). Mean values for all substrate combinations were illustrated in figure 1. There was a significant increase in Plant Height for the substrate SAH, as against other substrates. The plantlets in SAH, SD and SD:TS 1:3 showed a significant increase in root length, with SAH having the highest value, followed by SD. The plantlets in SAH also had 100% survival rate as against SD:TD 3:1 which had 50% survival. It was demonstrated that pineapple acclimatization was the most efficient in Semi Autotropic Hydroponics media, because the growth yield increased significantly compared to the conventional method in sawdust and topsoil under the same environmental conditions (Fig. 2 and 3). These finding are in agreement with the findings of Ariadne *et al*. (2015) who agreed that the use of SAH with in vitro rooted plants increased efficiency in the 'transfer from culture' process, because it improved the survival percentage and facilitated management of them.

Table 1: Showing Least Squares Means for the plant growth parameters

SUBSTRATE	PLANT HEIGHT		NO OF LEAVES		ROOT LENGTH	
	Day 1	Day 15	Day 1	Day 15	Day 1	Day 15
SAH	5.33 ± 0.3*	7.5 ± 0.3*	6.67 ± 0.6	8.83 ± 0.6	1.15 ± 0.1*	1.38 ± 0.1*
SD	4.33 ± 0.3	5.15 ± 0.3	6.33 ± 0.6	7.83 ± 0.6	0.82 ± 0.1*	0.88 ± 0.1*
TS	4.45 ± 0.3	5.30 ± 0.3	7.00 ± 0.6	7.5 ± 0.6	0.33 ± 0.1	0.61 ± 0.1
SD:TS 1:3	3.50 ± 0.3	3.72 ± 0.4	5.00 ± 0.6	6.33 ± 0.7	0.38 ± 0.1*	0.42 ± 0.1*
SD:TS 3:1	4.42 ± 0.3	5.05 ± 0.3	7.50 ± 0.6	7.83 ± 0.6	0.37 ± 0.1	0.42 ± 0.1

LSD for plant height: 1.412, LSD for no leaves: 2.652, LSD for Root length: 0.9864

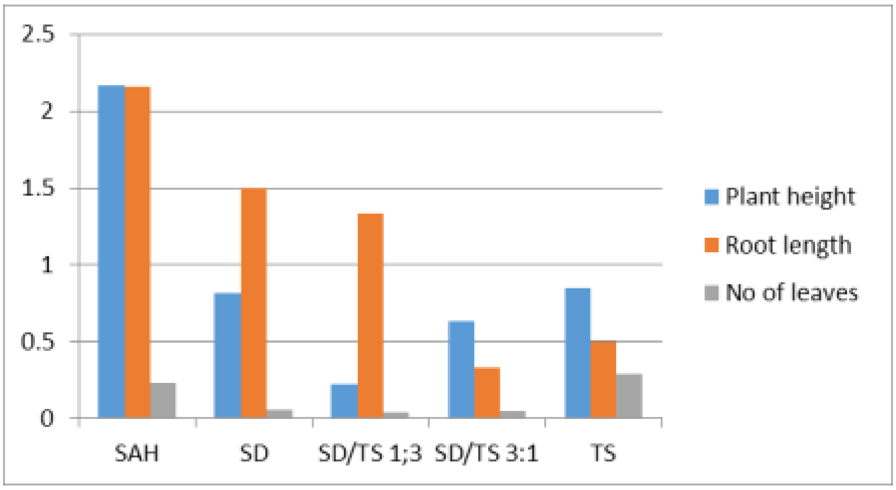

Figure 1: showing the mean difference between the growth parameters

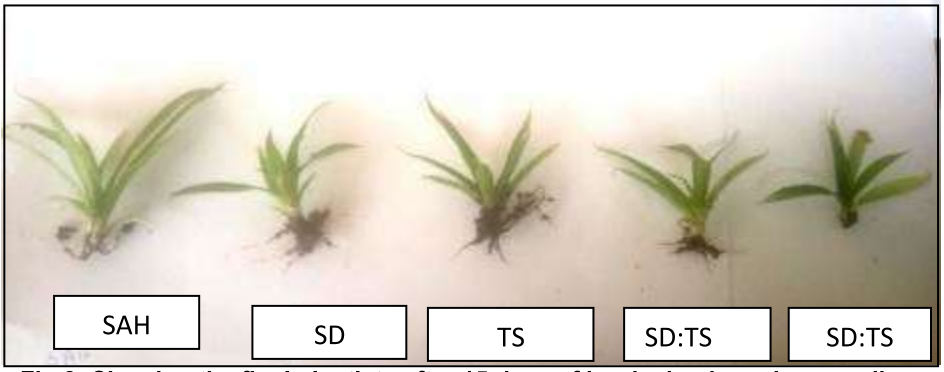

Fig 2: Showing the final plantlets after 15 days of hardening in various media. SAH: Semi autotrophic hydroponics, SD: Saw dust alone, TS: Top soil alone

Fig 2: (a) Tissue Culture pineapple plantlets (b) SAH culture pineapple plantlets

CONCLUSION

The substrate Semi Autotrophic Hydroponics (SAH) presents the best condition for the acclimatization and growth of the tissue culture pineapple seedlings.

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BIOTECHNOLOGY APPLICATIONS FOR EFFICIENT MASS PRODUCTION OF PLANTAIN (*MUSA* SP. AAB CV. 'AGBAGBA'), PINEAPPLE (*ANANAS COMOSUS* VAR. SMOOTH CAYENNE), AND UGU (*TELFAIRIA OCCIDENTALIS*) FOR FOOD SECURITY IN NIGERIA

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ABSTRACT

The National Horticultural Research Institute (NIHORT) has the mandate to produce large scale plantain suckers, pineapple suckers, and other horticultural crops using Plant Tissue Culture technique (micropropagation) and Temporary Immersion Bioreactor System (TIBS). The conventional field split-corm technique and PIFF (macropropagation) method for low-cost plantain multiplication is also used to complement plantain production effort. Recently, a new technology called Semi-Autotrophic Hydroponics (SAH) was introduced to assist mass propagation of horticultural crops. An average of 1,024 plantain tissue culture planting materials and 40,000 pineapple tissue culture planting materials were realized at 28 weeks after culture. For plantain tissue culture, the average number of suckers regenerated using TIBS was thrice what was realized in conventional tissue culture at the same period. Consequently, the application of biotechnology for efficient mass production of disease-free horticultural crop planting materials for food security in Nigeria is essential.

Key words: Plantain and Banana, Murashige and Skoog medium (MS), suckers (planting materials), hormones, plant tissue culture

INTRODUCTION

There is urgent need to supply enormous numbers of healthy and uniform planting materials to local and commercial farmers. The traditional methods of horticultural crop propagation especially plantain, banana, and pineapple cannot meet this demand. Fortunately, the National Horticultural Research Institute (NIHORT) has the mandate for these crops. Hence, the Biotechnology Research Unit, NIHORT, Ibadan employs micropropagation or plant tissue culture methods widely known for large scale clonal propagation to meet some of the Institute's crop mandate which include varieties of fruits, citrus, vegetables, spices and ornamentals. Plant tissue culture is a process of *in vitro* aseptic culture of cells, tissues, organs or a whole plant under controlled environmental and nutritional conditions with the aim to produce clones of the parent or explants. It has made possible the mass production of desired traits with disease-free and uniform plantlets. The technique thus brings farmers the great benefits of high-quality planting materials all year round. Some of the achievements of using biotechnology applications for efficient mass production of plantain (*Musa* sp. AAB cv. 'Agbagba'), pineapple (*Ananas comosus* var. smooth cayenne), and *Telfairia occidentalis* for food security in Nigeria are hereby reported.

MATERIALS AND METHODS

Conventional plant tissue culturing

Plantain (*Musa* sp. cv. Agbagba) conventional plant tissue culturing

Plantain sword suckers are gotten from the Institute's germplasm field collections. They were thoroughly washed under running tap water for at least 1 hour. The explants were collected from the sword suckers and brought to the laboratory for further tissue culture preparatory work. The plantain explants were cultured aseptically following the methods of Akinyemi *et al.* (2018).

Pineapple (*Ananas comosus* var. smooth cayenne) conventional plant tissue culturing

Fresh pineapple crowns were collected from the Processing Unit, NIHORT. The explants were initiated, sub-cultured and multiplied following the methods of Akin-Idowu et al., 2014. The subculturing was done aseptically to avoid contamination and loss of the explants.

Ugu (*Telfairia occidentalis*) conventional plant tissue culturing

Embryo of *Telfairia occidentalis* were cultured on media in test tubes and allowed to develop shoots and roots. Sub-culturing was done at 21 days after the first culture. Nodal cuttings were taking from the regenerated plantlets and transferred into fresh media in other test tubes for proliferation steps following the methods of Akinyemi and Esuola (2012).

Temporary Immersion Bioreactor System (TIBS)

Plantain and pineapple in Temporary Immersion Bioreactor System (TIBS)

Regenerated tissue culture plantain and pineapple plantlets were placed in MS liquid medium containing appropriate hormones and vitamins in TIBS jars. The TIBS was set-up to run automatically.

RESULTS AND DISCUSSION

Plantain, pineapple, and Ugu conventional plant tissue culturing

An average of 1,024 plantain tissue culture plantlets and 40,000 pineapple tissue culture plantlets were realized at 28 weeks after culture (Fig. 1A-B). In addition, the biotechnology unit has developed successful protocols for mass multiplication of plantain, banana, pineapple, and ugu plantlets (Fig. 2A-J).

Plantain and pineapple in Temporary Immersion Bioreactor

The average number of plantain and pineapple suckers produced using the TIBS liquid medium set-up after 21 days were three-fold and ten-fold respectively, when compared to the conventional tissue culture placed on agar solidified MS media. This result is useful as it rapidly produces disease-free planting materials to meet the high demand by farmers in order to generate more income in the face of the current prevailing adverse climatic conditions (Fig. 2B). For plantain tissue culture using TIBS, the average number of suckers regenerated is thrice what is realized in conventional tissue culture at 28 weeks after culture.

Semi-Autotrophic Hydroponics (SAH)

The backbone of the micropropagation process lies in the successful rooting and hardening of the tissue culture-derived plantlets. Semi-Autotrophic Hydroponics has been successfully used in the acclimatization of rootless pineapple tissue culture-derived plantlets (Fig 2G).

Challenges in plant tissue culture laboratory

The major challenges faced are incessant power failure or irregular electricity power supply, lack of constant running tap water; need to maintain a sterile laboratory environment, and access to quality chemicals and consumables. For biotechnology applications to be successful, the provision of constant electricity is non-negotiable.

CONCLUSIONS

Biotechnology application is very important as it complements conventional plant production practices for sustainable Agriculture in Nigeria. The Plant Tissue Culture Laboratory, NIHORT is well equipped to handle production of plantain, pineapple, *Telfairia occidentalis* plantlets, and plantlets of other horticultural crops. This is very useful for meeting the needs for clean planting materials by farmers. We recommend for policy on the adoption and use of these healthy planting materials by local and commercial farmers for better livelihood and reduction in transfer of diseases.

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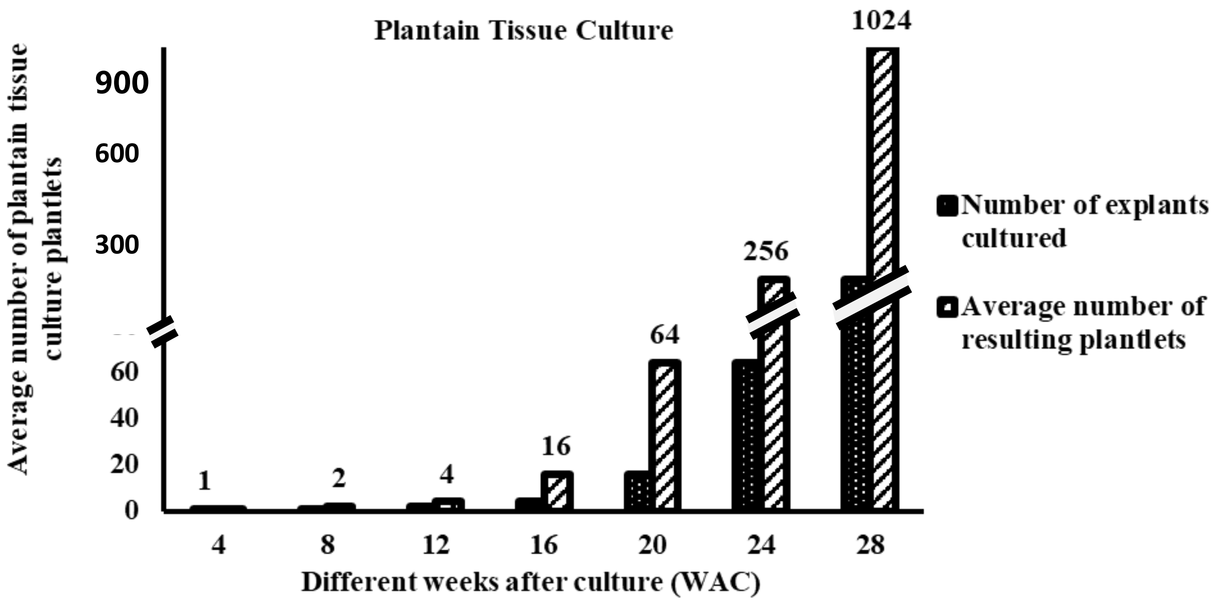
(A)



(B)

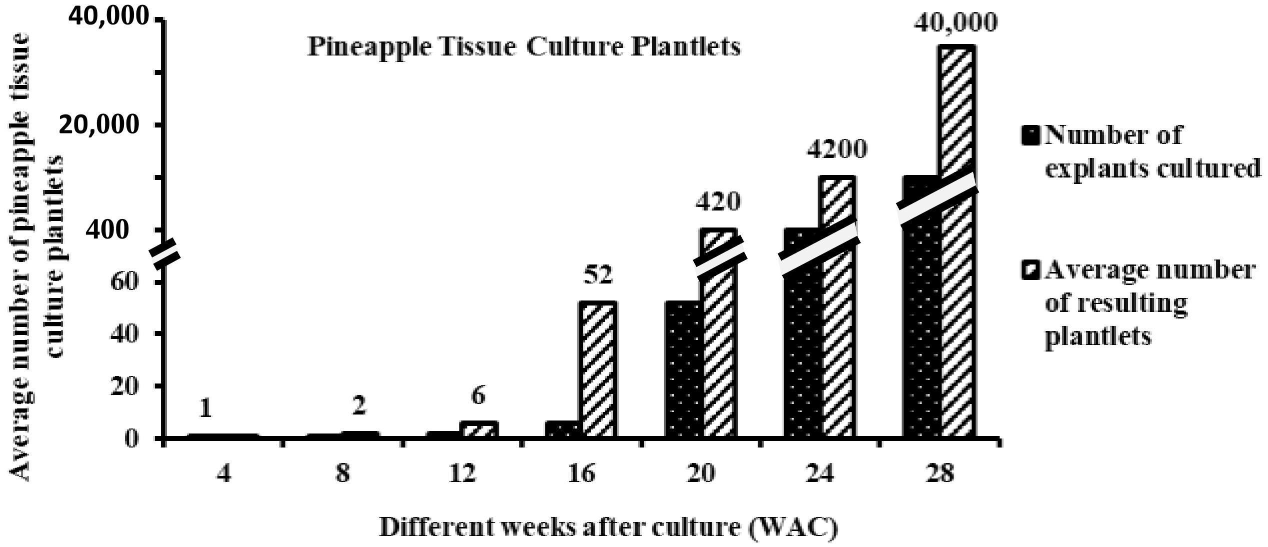


Figure 1(A-B): Average number of plantlets realised in plantain and pineapple tissue culture at different weeks after culture (WAC) at the Tissue Culture Laboratory, NIHORT.

Figure 2: Plant tissue culture activities at the Biotechnology Research Unit, NIHORT, Ibadan. (A). micropropagation of plantain (*Musa* sp. cv. Agbagba) plantlets with multiple shoots 21 days after culture (B). Temporary Immersion Bioreactor Systems (TIBS) for plantain and pineapple (C). macropropagation of plantain in the humidity chamber (D). micropropagation of pineapple (*Ananas comosus* var. smooth cayenne) plantlets with multiple shoots 21 days after culture (E). acclimatization of rooted pineapples in topsoil, F. rootless pineapples in tissue culture medium (G). rootless tissue culture pineapple plantlets rooted in the Semi-Autotrophic Hydroponics (SAH) medium (H). *Telfairia occidentalis* embryo germination (I-J). *Telfairia occidentalis* plantlets in tissue culture medium.

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EVALUATION OF SEASON EFFECT AND ROOTING HORMONE APPLICATION ON AIR LAYERING OF *SYZYGIUM MALACCENSE* [L.] MERR. & PERRY IN ISHIAGU EBONYI STATE NIGERIA

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ABSTRACT

Air layering is a method of macropropagation technique which still finds its relevance in the present day domestication and routine plant multiplication efforts of fruit trees, including Malay apple (Syzygium malaccense: Myrtaceae family). There is dearth of information concerning propagation of S. malaccense by air layering in Ishiagu derived savanna agroecological zone of southeast Nigeria. Therefore, field trial of season effect and 1-Naphthalene Acetic Acid (NAA) rooting hormone application on air layering of S. malaccense was conducted in Ishiagu field condition. The treatments comprised two seasons (dry and wet seasons weather) and five NAA concentrations (0.01, 0.02, 0.04, 0.08% and control – zero NAA) which were arranged in a factorial experiment in randomized complete block design and replicated three times. Number and length (mm) of adventitious roots formed were assessed at eight weeks after girdling. Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$*. The result indicated that branches of S. malaccense air layered during wet season produced longer and more adventitious roots (2.3±0.96 and 3.9±1.60, respectively) than the dry season air layered branches (1.6±0.67 and 1.9±0.48, respectively). The 0.02% NAA induced more number of roots (3.6±2.82) than the control (no NAA) (2.5±0.50), while the least (1.9±0.65) was produced by 0.08% NAA. Highest root length was however, produced by control (4.6±1.30), and followed by 0.02% NAA (3.2 ± 0.55). In Conclusion, 0.02% NAA proved to enhance root initiation in air layering of Syzygium malaccense in both dry and wet seasons.*

Key words: Air layering, phenology, rooting hormone, plant propagation, *Syzygium malaccense*

INTRODUCTION

Fruit trees constitute important biological resources in many agro-ecological systems and forest ecosystems all over the world. This is evident by the fact of these species long time economic and ecological impacts in nature (Altieri, 2000; Mithofer, 2005). Fruits are full of nature's rich in essential nutrients, antioxidants, dietary fibres and health benefits for ready use by humans and animals without alternation in most cases, unlike vegetables and other edible agriculture and horticulture produce that may require necessary pre-treatments, like heating, sometimes before consumption (FAO, 2017; Bioverity International, 2019). The tropics, more than any other region of the world is endowed with great diversity of fruit tree species that have provided humans with basic food and nourishment for ages since the domestication of beneficial wild plants (Kulnlein *et al*., 2009).

Syzygium malaccense is a species of tropical fruit tree belonging to the Myrtaceae family; native to Southeast Asia and the Oceania, including Australia and New Guinea. It has been introduced throughout other parts of the tropics (including Nigeria where it is known simply as "local apple"). The *S. malaccense* has a number of English common names. It is known as a Malay rose apple, or simply Malay apple, mountain apple, Otaheite apple, pink satin-ash (Whistler and Elevitch, 2006; Christenhusz *et al.,* 2018). The combination of tree, flowers and fruit has been praised as the most beautiful of the *Syzygium* genus. The fruit is oblong-shaped and dark red in color, although some species have white or pink skins. The flesh is white and surrounds a large seed. Its taste is bland but refreshing. Jam can be prepared from it by stewing the flesh with brown sugar and ginger (Keay, 1989; Orwa *et al.,* 2009).

Air-layering is a technique that has been widely used in domestication of indigenous fruit trees in west and central Africa in capturing the attributes of elite trees within genetically diverse wild populations, so avoiding the long, slow process of tree breeding. The natural tendency of some plants to strike roots when their branches come into contact with soil forms the basis of propagation by layering. However, there is little research work available on air layering of *Syzygium malaccense* in southeast Nigeria. The goal of this research work is to contribute to the promotion and domestication of local fruit production in the sub-region. Specific objectives therefore included: to determine amenability of *S. malaccense* to air layering propagation in the study location; to evaluate effect of growth hormone (NAA) application on adventitious root induction of air-layered *S.*

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malaccense; to determine optimum growth hormone (NAA) concentration for best rooting ability in air layered *S. malaccense*.

MATERIALS AND METHODS

The experiment was conducted at Tree Crops Nursery of Federal College of Agriculture (FCA), Ishiagu Ebonyi State, in the derived savanna agroecological zone of southeast Nigeria. The College lies along 05˚55'N latitude, 007˚33'E longitude and elevation of 59 m above sea level with average annual rainfall of 1735.7 m and average annual temperature of 29.4 ˚C and mean relative humidity of 69% during dry season. The basic weather data of Ishiagu location is shown in Table 1. The treatments consisted of two seasons: dry (March) period and wet (July) period; and five 1-Naphthalene Acetic Acid (NAA) concentrations (0.01, 0.02, 0.04, 0.08% NAA and control – zero), which were arranged as factorial experiment in Randomized Complete Block Design ((RCBD) and replicated three times. There were three (3) tree stands representing the three blocks/replicates. Branches (1.0 ± 0.2 cm in diameter) were girdled by cutting a 5 cm wide ring of bark to expose the cambium at the proximal end. Moistened mixture of river sand and saw dust (1:1; w/w) was tied around the girdled part using polythene sheet. The growth medium held in the polythene sheet around the girdled portion was kept moist by injecting 100 ml of distilled water into it twice a week using hypodermic syringe. The experiment was monitored for eight weeks after girdle operation when the air layered part has developed noticeable adventitious roots. Measurements on percent adventitious root formation, root length (mm) and number of root per successful air layered branch were taken. Statistical analysis of data was performed by use of descriptive statistics and Analysis of Variance (ANOVA). Separation of treatment means for significant effect was done by the use of Least Significant Difference (LSD) at p≤0.05.

Table 1: Mean basic weather data across different months in Ishiagu southeast Nigeria†

Months	Rainfall (mm)	Min temperature (˚C)	Max. temperature (˚C)
January	0.0	23	34
February	0.0	25	34
March	45.1	26	35
April	158	25	33
May	250.3	23	32
June	220.8	24	31
July	304.9	23	29
August	210.2	24	29
September	293.6	24	30
October	279.7	24	31
November	42.5	24	32
December	0.0	23	33

†Main flowering period of *Syzygium malaccense* is January – March and May.

RESULTS AND DISCUSSION

Effect of NAA rooting hormone application and season of propagation on root length of air layered Syzygium malaccense

The results in Table 2 indicated that the wet season produced longer roots than the dry season, while the various hormone concentrations used in the experiment indicated that 0.02% NAA was better than all the rooting hormone concentrations, with exemption of control (zero NAA). Even in dry season, the 0.02% concentration of the NAA growth hormone still produced more extended roots than other treatment concentrations. The zero NAA concentration however, produced significantly longer adventitious roots at p≤0.05 in both dry season and wet season trials than other concentration of the rooting hormone. This is in consonance with Ogbu *et al.* (2019) report in the domestication study of *Pentaclethra macrophylla* by marcotting across different dry and wet seasons. Dhillon and Mahajan (2000) reported that wet season was the best time for air layering in *S. malaccense* in respect of rooting success and survivability. Besides the favourable moisture availability during the wet season that tend to sustain adventitious root production, the physiology of tree growth phases shows (Table 1) that *S. malaccense* undergoes active vegetative growth cycle during this wet season period than dry season. The period between January and March coincides with the reproductive cycle of the Malay apple, with minor blooming on May (Keay, 1989). Thus, when tree undergoes period of reproductive cycle, anti-auxin substances are released that make active vegetative growth to be suspended and the buds appear to enter state of dormancy (Awodoyin and Olaniyan, 2000). Hence, shoots air layered or collected for stem cuttings at such reproductive phase may largely be unresponsive or slow to formation of adventitious roots due to inhibiting endogenous factors (Jaenicke and Beniest, 2002; Hartmann *et al.,* 2007; Chadha, 2009). This may offer additional reason for the relative poor adventitious root formation observed among stems air-layered during dry season (i.e. period of reproductive growth).

Table 2: Root length (mm) of air layered *Syzygium malaccense* treated with different NAA concentrations across two seasons in Ishiagu derived savanna zone of Southeast Nigeria

	Naphthalene acetic acid (NAA) concentrations (%)					
Season	Control (zero)	0.01	0.02	0.04	0.08	Mean
Dry (March)	3.3±5.70	1.6 ± 0.23	2.6 ± 0.62	0.7± 0.23	1.6± 0.47	1.6 ± 0.67
Wet (July)	5.9±10.00	2.3 ± 0.47	3.7 ± 0.47	2.0 ± 0.81	1.0± 0.40	2.3 ± 0.96
Mean	4.6±1.30	1.9 ± 0.35	3.2 ± 0.55	1.4 ± 0.65	1.8± 0.30	

Value = mean±SD; r=3, LSD (0.05) treatment combinations = 1.11; LSD (0.05) NAA concentrations = 0.78
LSD (0.05) Seasons = 0.52.

Effect of NAA rooting hormone application and season of propagation on number of roots of air layered Syzygium malaccense

The result on Table 3 indicated that wet season produced longer roots than the dry season. The various hormone treatments used in the experiment also indicated that 0.02% NAA rooting hormone was the best among the other treatment concentrations. Even in the dry season the 0.02% concentration of the NAA growth hormone still produced more number of roots than other concentrations. The wet season was more preferable for rooting of air layered shoots of *S. malaccense* because moisture availability is one of the essential conditions for successful air layering among other endogenous factors like the species phenology, as earlier explained (Hartmann et al. 2007, Ogbu *et al.,* 2019). Callus formation was observed in both seasons in all the treatment concentrations. However, root initiation was more in wet season due to relatively low temperature coupled with higher humidity compared to dry season. Moreover, the presence of inflorescences (when tree undergoes period of reproductive cycle during dry season), which exert anti-auxin retarding influence on vegetative growth activities (Awodoyin and Olaniyan, 2000; Ogbu and Okocha, 2018), might have contributed to the observed low adventitious root formation in the dry season than wet season.

Table 3: Number of roots of air layered *Syzygium malaccense* treated with different NAA concentration across two seasons in Ishiagu derived savanna zone Nigeria

	Naphthalene acetic acid (NAA) concentrations (%)					
Season	Control (0.00)	0.01	0.02	0.04	0.08	Mean
Dry (March)	2.0±3.50	2.0 ± 0.00	1.6 ± 0.47	1.3± 0.47	2.6± 0.47	1.9 ± 0.48
Wet (July)	3.0±4.70	4.3 ± 1.24	5.6 ± 1.24	4.6± 0.47	1.3± 0.47	3.9 ± 1.60
Mean	2.5±0.50	3.1 ±1.15	3.6 ± 2.82	2.9± 1.65	1.9± 0.65	

Value = mean±SD; r=3, LSD (0.05) treatment combinations = 1.51, LSD (0.05) NAA concentrations = 1.06,
LSD (0.05) Seasons = 1.73

CONCLUSION

The result of the study indicated that air layering method is a potential, viable and economical method of vegetative propagation of *Syzygium malaccense.* Air layering is relatively simple and very easily adopted by farmers due to high success rate and low mortality. From the results obtained by air layering of the fruit tree *S. malaccense,* it can be concluded that wet season enhanced air layering of the species more than dry season. The hormone treatments proved successful in inducing adventitious root as 0.02% NAA was more effective in promoting root formation in both seasons than other concentrations used in experiment.

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THE EFFECTS OF ROOTING HORMONES ON CALLUS DEVELOPMENT AND PLANT SURVIVAL OF MARCOTTED AFRICAN STAR APPLE (*GAMBEYA ALBIDA*)

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ABSTRACT

A field experiment was carried out in the Teaching and Research Farm of Delta State University, Asaba Campus to evaluate the effects of different rooting hormones on marcotted Gambeya albida. A Completely Randomized Design with three replicates was used to assess the impact of Honey, IBA 1000 ppm, IBA 500 ppm and Control on callus production and pant survival. Vegetative variables evaluated included number of survival of marcotted stem after severance from the tree, number of stems with callus, propagule survival and callus growth were assessed. The study showed that there were significant differences between the Rooting hormones. The result obtained for number of successful marcots showed that IBA 1000 ppm had the highest percentage of successful marcots with 4.30 (38%), while Control had 1.91 (18%) at 12 weeks after severance from the tree. This study has shown that callusing can be influenced by the use of rooting hormone. Since, an increase in success was obtained for IBA, higher concentrations should be exploited in further studies. The success achieved showed that it is possible to regenerate propagules of African cherry through the use of rooting hormones especially, Indole-3 Butyric acid.

Key words: Rooting hormones, Marcotting, African star apple.

INTRODUCTION

In Nigeria, *Gambeya albida* is classified among the endangered tree species (Ojeifo and Okonta, 2008), with a high possibility of going into extinction in the near future. The gestation period of *G. albida* seeds or propagated propagules is very long having a long phase of about 10-12 years before its first fruiting. Also, the plant apical demance (25 – 37m) discourages planting and makes harvesting difficult (Don and Boateng, 2014). Furthermore, the availability of seed is seasonal. The use of marcotting technique has been widely used in the domestication of indigenous fruit trees in west and central Africa, such as *Dacryodes edulis, Cola spp, Chrysophyllum spp*. (Anegbeh, Ladipo and Tchoundjeu, 2005). Marcotting provides the best opportunity to multiply valuable trees for cultivations (Simmons and Leakey, 2000). Application of growth regulators helps to accelerate callus development and rooting, especially with the use indole-3-butyric acid (Leakey, 2000). The objective of this study is to determine the effects of rooting hormones on marcotts of *G. albida* for the regeneration clonal propagules.

MATERIALS AND METHODS

The experiment was conducted in the Teaching and Research Farm of Delta State University, Asaba Campus, Asaba. Asaba is located in Oshimili South Local Government Area of Delta State. The study area is located at longitude 6^0 49" E and latitude 6^0 14" N. It's a region of moderate rainfall. Rainfall season is between April and October with a mean annual rainfall of 1000 -1800mm. Four treatments were replicated three times, and each plots consisted of 16 pots. Callused marcotted stems, after severance, were arranged in Completely Randomized Design and spaced 50cm by 50cm on the field. The experiment was carried out using four different treatments which were honey and IBA at 1000ppm, 500ppm and control (without hormone). Marcots were set on a matured *Gambeya albida* plant which has fruited over ten years. Marcotting involved the removal of a ring of bark 4cm wide from a selected branch. The treatments were applied to the wounded branches after the removal of the bark with a budding knife. Ball of earth weighing about 400-600g, which comprised topsoil, sawdust and organic manure was wrapped around the injured portions. Thereafter, the soil medium was wrapped with a polyethylene sheath. Both ends of the sheath were tied with a thread. Marcots were severed at 5cm from the point of marcot at 12 weeks after marcotting and potted into a polyethylene pots and filled with top soil. These were placed in the nursery and watered daily, to enable the development of the callus into roots. Vegetative variables were collected fortnightly from 6 to 12 weeks before and after planting which included number and percentage of survival of marcotted stems before and after severance of macottsfrom the tree, Number and percentage of stems with callus Callus rating (1-5, where 1 represents No Callus while 5 represents Very High Callusing). The data collected were subjected to Analysis of Variance and the treatment means were separated using Least Significant Difference at 5% level of probability.

RESULTS

The results obtained in this study showed that the number of survival of marcotted stems after severance from the tree was generally influenced by the different rooting hormones, with IBA having the highest value at week 12 when compared to other hormones. There was significant difference between the treatments. IBA at 1000ppm produced the highest values of survival. The lowest value was obtained for control (Fig. 1).

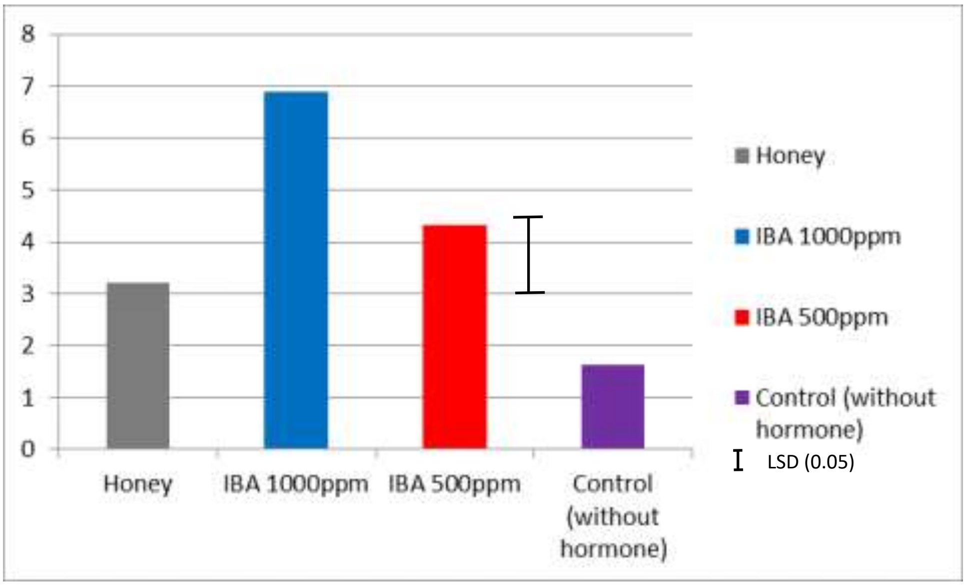

Figure 1: Effects of Rooting Hormones on the number of survival of marcotted stems after severance from the tree

Callusing was generally influenced by the different rooting hormones, the highest was 1BA at 1000 ppm attaining a maximum value of 4.30 (38%) at 12 weeks after marcotting when compared to other hormones. There was a general increase in the number of stems with callus with preceding weeks and with the different rooting hormones from 6-12 weeks after marcotting, except for honey which has a decreased value of 2.02 (18%) at week 12. The result showed that there was a significant difference between the treatments. IBA 1000 ppm had the highest values after marcotting, while the lowest values were obtained for control (Table 1).

Table 1: Effects of Rooting Hormones on number and percentage of Stems with Callus after Severance from the Tree

Rooting hormones	Weeks after Marcotting			
	6	8	10	12
Honey	1.63 (20)	1.79 (18)	2.50 (23)	2.02 (18)
IBA 1000ppm	2.90 (36)	3.32 (34)	3.50 (32)	4.30 (38)
IBA 500ppm	1.87 (24)	2.89 (29)	2.99 (28)	3.00 (26)
Control(without horrmone)	1.43 (20)	1.60 (19)	1.90 (17)	1.91 (18)
LSD (0.05)	0.20	0.18	0.60	0.91

The number of survival of marcotted stems after severance from the tree showed that the treatments were generally influenced by the different rooting hormones, with IBA1000 ppm and control having the highest and lowest values respectively throughout the study (Table 2). Callus size was generally influenced by the different rooting hormones, and was highest with 1BA 1000 ppm

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attaining a maximum value of 3.70 (34%) at 12 weeks after marcotting. The untreated marcotted stem (control) consistently had lowest number of callus size than the other treatments throughout the period of study. The results indicated that there was significant difference between the treatments throughout the period of study (Table 3).

Table 2: Effects of Rooting hormones on the number and percentage of survival of marcotted stems after severance from the tree

Rooting hormones	Weeks after Marcotting			
	6	8	10	12
Honey	2.32 (23)	1.91 (21)	1.52 (19)	2.30 (21)
IBA 1000ppm	3.46 (34)	2.90 (32)	2.91 (35)	3.70 (34)
IBA 500ppm	2.93 (29)	2.63 (29)	1.58 (23)	3.42 (32)
Control (without hormone)	1.90 (14)	1.39 (18)	1.58 (23)	2.02 (13)
LSD (0.05)	0.32	0.83	0.91	1.41

Table 3: Effects of Rooting Hormones on the Callus Size (1-5) and percentage after Severance from the Tree

Rooting hormones	Weeks after Marcotting			
	6	8	10	12
Honey	1.62	0.99	1.25	1.33
IBA 1000 ppm	3.00	3.00	3.36	3.91
IBA 500 ppm	2.99	2.91	3.00	3.12
Control (without hormone)	1.01	2.13	2.21	2.30
LSD (0.05)	0.50	1.11	1.03	1.33

The results obtained from the study showed that an increase in the application of rooting hormones had effect on the number of stems with callus; callus size, number of survival of marcotted stems before severance from the mother plant and number of survival of marcotted stems after severance from the mother plant.

DISCUSSION

Some studies shown that callus formation follows the pathway of rooting, and newly formed callus cells have the possibility to be a group of fast-dividing root primordium-like cells (Che *et al*., 2007). Callus, a precursor of roots of marcotted stems of *Gambeya albida* was most successful with the application of rooting hormone Indole 3-butyric acid. At the point of severing the marcots which was 12 weeks after initiation of study, healing had taken place in most of the marcots and many had developed evident callus. These were the tools used as indicator of marcots survival. The results obtained from the study showed that an increase in the application of rooting hormones had effect on the number of stems with callus; callus size and number of survival of marcotted stems before and after severance from the mother plant.

It was observed from the study that cuttings callused relatively `well at all concentrations and in control plot, but very little in the use of Honey. The best results were obtained with IBA 1000 ppm and IBA 500 ppm with 3.91(38%) and 3.12 (30%) of successful marcots respectively. Though, honey had a stimulatory effect, and resulted in low callusing. According to the experiment conducted by Don and Boateng, (2014) claimed that the use of different IBA concentrations of 25, 50, 100, 200 and 300 ug/ml (which is equivalent to ppm) on marcotted *Gambeya albida* did not enhance rooting. This may be due to the low concentration of rooting hormone used. This study showed that *Gambeya albida* has potential for vegetative propagation by marcotting and better results can be obtained with the use of rooting hormone. The use of rooting hormones initiated early callusing and promotes early root growth and the earlier the root grows, Therefore, high concentrations of indole3-butyric acid should

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be evaluated for the vegetative propagation of *G. albida*.

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THE INFLUENCE OF CYTOKININ ON THE GROWTH AND PERFORMANCE OF *IXORA* SPP. CUTTINGS IN THE GUINEA SAVANNA AGRO-ECOLOGY OF NIGERIA

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ABSTRACT

The experiment was carried out at the Horticultural Nursery of Crop Production Department of Federal University of Technology, Minna. Single red and yellow ixora (*Ixora coccinea*) were used in this study. Ixora cuttings were obtained from matured parent plants at School of and Agricultural Technology (SAAT) Complex of Federal University of Technology, Minna. cuttings were dipped in natural hormone concentration (coconut water) and then planted into polythene pots filled with top soil. The study lasted for thirteen weeks. Beginning from March 2015, routine weeding was carried out manually, by hand picking and insects were controlled using Laraforce all through the experiment. Data were collected on the following morphological parameters viz: sprout count and leaf count from 4 to 13 WAP, at weekly intervals. At 13WAP, the experiment was terminated by collecting leaf samples for dry matter determination. All data collected were subjected to analysis of variance engaging SAS software package 2008 and the means were separated using Duncan Multiple Range Test (DMRT) at 5% level of Probability. The analytical result showed that there was a significant difference between the hormone treatments. Hardwood cuttings dipped in natural hormone (coconut water) and planted immediately (0hrs) produced significantly higher effect on parameters viz: number of leaf and sprout count with red ixora having a significantly higher effect than yellow ixora. It is therefore recommended that for mass propagation of Ixora (*Ixora coccinea*) cuttings in the guinea savanna agro-ecology of Nigeria, hardwood of red ixora dipped for zero hour in natural hormone (coconut water) should be used.

INTRODUCTION

Ixora which is a native of tropical Asia and Africa is now common in all Eastern pantries, both in its wild state and as a cultivated garden shrub. It flowers almost throughout the rainy season. A revolution, according to McGregor and Stice (2008), is occurring in the export of horticultural products from developing countries since overall, high value products including horticulture, livestock, fish, and organic products) now make up 66% of all developing countries of agricultural product export. It is common to find people associating the purchase of flowers with luxury. With increased prosperity in Nigeria, the amount of cut flowers purchased per household increase (Koshioka and Amano., 1998).

Globally, horticulture has become a leading sector for poverty reduction in developing countries. The value of world production of floriculture products is estimated at approximately €100 billion and around 10% of this production enters international trade. Trade in floriculture products will increase by 3.5% annually to 2012 (Leonhardt, 2006). About half of the existing nurseries in Nigeria were set up in the recent past (Ellis *et al.,* 2003), an indication that the industry is growing more in recent times. Ornamental plants such as ixora is in high demand for landscaping, bouquet making and wreath as well as cut flowers in Nigeria, Ghana, Italy, Germany and other parts of the world. Yet, these economically important ornamental plants have a low genetic and physiological capacity for adventitious root formation and, therefore, limit their commercial production. Such ornamental plants have been popularly termed as "difficult-to-root". Economically, the demand for these ornamentals necessitate that the difficult-to-root phenomenon be solved. Since the growth medium relates to every cultural practice in the production of nursery crops in containers, the selection and preparation of the medium is extremely important and could pay great dividends in terms of plant growth and quality (Hall, 3003). There is no universal or ideal rooting mixture for cuttings. An appropriate propagation medium depends on the species, cutting type and propagation system (McDonald *et al.,* 2002).

Ixora *coccinea* is an evergreen shrub that blooms in rainy seasons spectacularly in the landscapes of the Guinea Savanna Region of Nigeria. Due to the rise in temperature with reduced relative humidity during dry season, it makes the successful propagation of *ixora 000000atnacinea* almost impossible to be raised; due to insufficient water. However, this leads to poor vegetative sprouting from the cuttings (Hartmann *et al.,* 2002). This thus, necessitates provision of micro-climate by shedding. In the quest of achieving a successful propagation of *Ixora coccinea*, it becomes imperative to utilize adequate materials and methodologies that would ensure successful rooting and growth of *Ixora coccinea* stem cutting.

Global warming affects the growth of most ornamental crops today. Growing conditions such as sunlight, water, temperature, soil and fertilizer have deviated from the past trends (Blazich, 2006). Agricultural production under this situation has increasingly threatened human and animal health. It becomes very important to provide possible solution's in curtailing this drastic climatic change. It has been scientifically proven that plants utilize carbon-iv-oxide (CO_2) to carry out photosynthetic activities, and in this process, oxygen (0_2) that is required by man and animals, is been released as its bye product (Iganberdiev and Lea, 2002). Ixora is a shrubby evergreen plant that is well adapted to different agro-ecological zones, particularly, the semi-arid and arid zones. This makes it useful in the landscaping thereby serving as a huge CO^2 sink. In order to achieve a successful propagation of Ixora (*Ixora coccinea*), it becomes imperative to provide available materials and techniques that could ensure successful rooting of this plant when propagating it vegetatively.

In the context of above, this experiment is designed to: 1) Assess and compare the performance of red and yellow Ixora (*Ixora coccinea*) under varying treatments of coconut water as a natural hormone and 2) Determine the ixora specie that performs best under natural hormone treatments

MATERIALS AND METHODS

Study Location: The experiment was carried out in the beginning of March 2015, in the horticultural nursery of crop production department, school of agriculture and agricultural technology of Federal University of Technology Minna, Niger State of Nigeria. The geographical location is latitude 6^0 30'E and longitude $9^0$40'N, which lies at the Southern Guinea Savanna zone of Nigeria.

Materials

The following materials were used for the implementation of this research work are:

Ixora cuttings, Coconut water, Beaker, Secateurs, Shading material (Sac), Wooden pole for shading, Measuring tape and rule, Polythene container, Top soil, Rope for security

Types of Ixora Cuttings and Mixtures

Hardwood and softwood of red and yellow ixora was used for experimental work. The cuttings were collected from a 3 years old parent plants. The planting material and hormone mixtures are as follows:

Red hardwood control (RHC), Read softwood control (RSC), Red hardwood + 12 hours coconut water (RH12), Red softwood + 12 hours coconut water (RH12), Red hardwood + 24 hours coconut water (RH24), Red softwood + 24 hours coconut water (RH24), Red hardwood +fresh hours coconut water (RH0), Red softwood + 0 hours coconut water (RS0), Yellow hardwood control (YHC), Yellow softwood control (YSC), Yellow hardwood + 12 hours coconut water (YH12), Yellow softwood + 12 hours coconut water (YS12), Yellow hardwood + 24 hours coconut water (YH24), Yellow softwood + 24 hours coconut water (YS24), Yellow hardwood + fresh hours coconut water (YH0), Yellow softwood + 0 hours coconut water (YS0).

Source of Planting Material

The cuttings of red and yellow ixora (*Ixora coccinea*) for the experiment were collected from established parent plant within School of Agriculture and Agricultural Technology (S.A.A.T.) in Gidan Kwanu Campus of Federal University of Technology, Minna.The natural hormone (coconut water) was derived from a matured coconut fruit purchased from kure ultra-modern market.

Propagation

The red and yellow ixora (*Ixora coccinea*) cuttings were obtained from school of Agriculture Complex of Federal University of Technology, Minna. The length was 15 centimetres. Secateurs was used in cutting the Ixora and the leaves were removed gently to avoid injuries, thereby inhibiting its exposure to pests and insects attack. The two types of cuttings were softwood and hardwood. The cuttings were planted by inserting each single Ixora plant-tip into polythene container. Planting was done immediately the cuttings were obtained and dipped in coconut water. The planting process was also done by gently inserting the moist cuttings into the media therein.

Experimental Design

The experiment was 2x2x4 factorial design arranged in a Completely Randomized esign (DRD) and replicated three times.

Data Collection

Data was recorded at weekly interval as from four weeks after Ixora cuttings were planted. The data was collected on the following growth parameters viz:

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Leaf number: The number of leaves were counted and recorded from the oldest leaf at the base of the shoot to the youngest at the top of the plant.

Number of Sprouts: The sprouts were counted and recorded from the base of the plant to the top.

Leaf dry Matter: Leaf samples of red and yellow ixora (*Ixora coccinea)* were collected from each treatment on the field and were taken to the laboratory. The fresh weight of ixora leaf sample were determined using electric weighing balance. After then, the leaf samples of red and yellow ixora were packed, labelled and kept at 70^{0}C for 72 hours in the oven. The oven dried ixora leaf samples were unpacked and leaf dry weight was determined using electric weighing balance after 72 hours of oven drying. According to Okalebo *et al.,* 2002, dry matter was calculated mathematically, thus: Dry Matter (%) $(\%) = \frac{Dry\ weight}{fresh\ weight}\ x\ 100$

Statistical Analysis

The data collected on growth parameters were statistically analyzed using the analysis of variance (ANNOVA) for the complete randomized design while means were separated by Duncan's Multiple Range Test (DMRT) at 5% level of probability. The analysis was perfected with SAS software package.

RESULTS AND DISCUSSION

The results in table 1 shows the effect of varying hormone treatments of coconut water on leaf count of ixora. The varying hormone treatments have significant effect on leaf count of both red and yellow ixora at 6,8,9,10 and 11 WAP, where red ixora produced significantly the highest number of leaves while yellow ixora significantly produced the least number of leaves respectively. The varying hormone treatments had significant effect on the leaf count at 6,7,10,11 and 12WAP. Where ixora cuttings dipped in coconut water and planted immediately produced significantly the highest number of leaves although statistically similar to control and ixora cuttings dipped in hormone for a period of 12hours while ixora dipped in hormone for a period of 24hours significantly produced the least number of leaves. With regards to wood of ixora, there was no significant difference on the leaf count at 4-5WAP but that was not the case at 6-13WAP, where significant difference was observed on the leaf count. Hardwood significantly produced the highest number of leaves while softwood significantly produced the lowest number of leaves at 6-13WAP respectively.

Furthermore, the results in table 2 shows the effect of varying hormone treatments of coconut water on sprout count of ixora. The varying hormone treatments had significant effect on sprout count of both red and yellow ixora at 7,8,9,10 and 13WAP. With regards to ixora species, red ixora significantly produced the highest number of sprout while yellow ixora significantly produced the lowest number of sprout at 7,8,9,10 and 13WAP respectively. The varying hormone treatments had a significant effect on sprout count at 5 and 9WAP only, where ixora dipped inhormone and planted immediately (0hrs) significantly produced the highest sprouts though statistically similar with ixora cuttings dipped in hormone for a period of twelve hours (12hrs) and ixora cutting dipped in hormone for a period of twenty-four hours (24hrs). control produced significantly, the lowest sprout. With regards to wood of ixora, there was no significant difference in number of sprout at 4WAP only, but that was not the case at 5-13WAP where significant differences were observed. Hardwood significantly produced the highest number of sprouts while softwood significantly produced the lowest number of sprout at 5-13WAP, respectively.

CONCLUSION /RECOMMENDATION

The practical approach to enhance successful multiplication f ornamental plants is through the use of growth hormones (Greensil, 1975). The study showed that there was a significant difference between the hormone treatments. Hardwood cuttings dipped for zero hour in coconut were (natural hormone) produced significantly higher effect on parameters viz: leaf dry matter, number of leaf and sprout count with red ixora having a significantly higher effect than yellow ixora. It is, therefore, recommended that for mass propagation of ixora (*Ixora coccinea*) cuttings in the guinea savanna agro-ecology of Nigeria, hardwood of red ixora dipped for zero hour in natural hormone concertation (coconut water) should be used. Also, further study should be carried out during the dry season so as to compare the effect of coconut water on the same varieties of ixora cuttings as this research work was carried out in the rainy season.

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TABLE 1. Leaf count of ixora species as affected by different treatments of coconut water as natural hormone

Treatments	WEEKS AFTER PLANTING (WAP)									
Species	4	5	6	7	8	9	10	11	12	13
Red Ixora	3.29ᵃ	5.38ᵃ	9.75ᵃ	11.25ᵃ	17.67ᵃ	29.88ᵃ	21.88ᵃ	25.13ᵃ	28.83ᵃ	31.96ᵃ
Yellow Ixora	1.75ᵃ	2.13ᵃ	5.17ᵇ	8.08ᵃ	12.33ᵇ	12.96ᵇ	15.92ᵇ	20.00ᵇ	22.63ᵃ	25.35ᵃ
SE+	0.63	0.92	1.09	1.15	1.13	1.66	1.57	1.74	2.16	2.36
Hormone Treatment										
Control	2.25ᵃ	4.25ᵃ	8.42ᵃᵇ	9.17ᵃᵇ	14.67ᵃ	15.92ᵃ	18.50ᵃᵇ	21.00ᵃᵇ	21.92ᵃ	24.92ᵃᵇ
0hrs	283ᵃ	5.08ᵃ	10.03ᵃ	12.25ᵃ	16.58ᵃ	19.42ᵃ	22.08ᵃ	26.85ᵃ	30.08ᵃ	34.25ᵃ
12hrs	2.75ᵃ	3.58ᵃ	8.33ᵃᵇ	10.50ᵃᵇ	15.00ᵃ	18.03ᵃ	20.25ᵃᵇ	24.00ᵃᵇ	27.67ᵃ	33.58ᵃ
24hrs	2.25ᵃ	2.08ᵃ	4.08ᵇ	6.75ᵇ	12.25ᵃ	12.25ᵃ	14.75ᵇ	18.67ᵇ	21.25ᵃ	22.42ᵇ
SE+	0.89	1.29	1.54	1.63	2.35	2.35	2.22	2.46	3.06	3.34
Wood										
Softwood	2.63ᵃ	2.79ᵃ	4.96ᵇ	6.71b	9.92ᵇ	1021ᵇ	11.21ᵇ	12.21ᵇ	14.25ᵇ	16.67ᵇ
Hardwood	2.42ᵃ	4.17ᵃ	10.50ᵃ	12.63ᵃ	19.58ᵃ	22.63ᵃ	26.58ᵃ	31.92ᵃ	36.21ᵃ	40.92ᵃ
SE+	0.63	0.92	1.09	1.15	1.59	1.66	1.57	1.74	2.16	2.36
Interaction										
Var.xHorm.	Ns	ns	ns	ns	ns	ns	*	*	*	*
Var.xWood	Ns	ns	ns	ns	ns	ns	Ns	ns	ns	ns
Horm.xWood	Ns	ns	ns	ns	ns	ns	Ns	ns	ns	ns
Var.xHorm.XWood	Ns	ns	ns	ns	ns	ns	*	*	*	*
CV (%)	122.4	119.56	68.82	58.35	52.85	49.53	40.71	37.72	42.01	40.15

Mean followed by the same letters in a column are not significantly different (P≤ 0.05) by DMRT.

KEY: * = Significantly different, ns = Not significant, SE± = Standard Error, CV= Coefficient of Variables, Nil = Control, Hrs = Dipping hours of ixora cuttings in coconut water

TABLE 2. Sprouts count of ixora species as affected by different treatments of coconut water as natural hormone

Treatments	WEEKS AFTER PLANTING (WAP)									
Species	4	5	6	7	8	9	10	11	12	13
Red Ixora	11.79ᵃ	13.67ᵃ	15.00ᵃ	13.96ᵃ	15.79ᵃ	17.50ᵃ	14.58ᵃ	14.92ᵃ	14.33ᵃ	15.25ᵃ
Yellow Ixora	10.63ᵃ	11.38ᵃ	11.08ᵃ	10.96ᵇ	10.88ᵇ	11.88ᵇ	9.71ᵇ	11.29ᵃ	11.71ᵃ	10.05ᵇ
SE+	0.89	0.78	0.9	0.93	.089	0.98	0.88	1.33	0.99	0.9
Hormone Treatment										
Control	10.25ᵃ	10.33ᵇ	11.83ᵃ	11.33ᵃ	12.17ᵃ	12.83ᵇ	12.00ᵃ	11.83ᵃ	11.17ᵃ	11.08ᵃ
0hrs	12.42ᵃ	15.00ᵃ	15.42ᵃ	14.25ᵃ	14.58ᵃ	17.83ᵃ	12.83ᵃ	14.00ᵃ	14.17ᵃ	14.83ᵃ
12hrs	11.83ᵃ	12.83ᵃᵇ	12.67ᵃ	12.58ᵃ	12.92ᵃ	13.75ᵃᵇ	12.08ᵃ	12.67ᵃ	12.08ᵃ	13.50ᵃ
24hrs	10.33ᵃ	11.92ᵃᵇ	12.25ᵃ	11.67ᵃ	13.67ᵃ	14.33ᵃᵇ	11.67ᵃ	13.92ᵃ	14.67ᵃ	11.17ᵃ
SE+	1.25	1.1	1.28	1.32	1.25	1.38	1.35	1.88	1.39	1.27

Wood										
Softwood	1038[a]	11.13[b]	11.00[b]	10.21[b]	1.00[b]	12.50[b]	9.83[b]	9.75[b]	10.96[b]	9.67[b]
Hardwood	12.04[a]	13.92[a]	15.08[a]	14.71[a]	15.67[a]	16.88[a]	14.46[a]	16.46[a]	15.08[a]	15.63[a]
SE+	0.89	0.78	0.9	0.93	0.89	0.98	0.88	1.33	0.98	0.9
Interaction										
Var.xHorm.	Ns	ns	ns	Ns	ns	ns	ns	ns	*	ns
Var.xWood	Ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns
Horm.xWood	Ns	*	ns	Ns	ns	ns	ns	ns	ns	ns
Var.xHorm.xWood	Ns	ns	ns	Ns	ns	ns	ns	ns	ns	ns
CV (%)	38.7	30.39	33.9	36.71	32.53	32.52	35.61	49.59	37.1	34.71

Mean followed by the same letters in a column are not significantly different (P≤ .05) by DMRT

KEY: * = Significantly different, ns = Not significant, SE± = Standard Error, Scv = Coefficient of Variables, Hrs = Dipping hours of ixora cutting in coconut water

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ADENINE SULPHATE-NAPHTHALENE ACETIC ACID COMBINATION ENHANCES *IN-VITRO* ROOTING OF PINEAPPLE (*ANANAS COMOSUS L.*) PROPAGATION

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ABSTRACT

In vitro micropropagation is recognised and has been employed in the mass production of healthy and homogenous planting materials. Pineapple (*Ananas comosus*) is one of the economically important fruit crops of the tropics. Poor survival rates during hardening and acclimatization have been identified as one of the problems affecting the micropropagation technique. This work therefore, evaluated the synergetic effects of rooting hormones Naphthalene acetic acid (NAA) and Idole-3-butyric acid (IBA) with Adenine sulphate (AdS) on the rooting attributes of tissue culture derived pineapple. Rooting was induced by subculture of established plantlets into ½ strength of MS medium (Murashige and Skoog) supplemented with NAA (1.0, 2.0 mg/l), IBA (1.0, 2.0 mg/l) and AdS (50, 100 mg/l). The control was treated with neither any hormones nor the AdS but subculture on ½ MS only. Five plantlets were used per treatment with three replicates. Root emergence was first observed with medium combination of ½ MS supplemented with 2.0mg/l NAA and 50mg/l AdS at 14days. Medium combination of MS supplemented with 2.0mg/l NAA with 50mg/l and 100mg/l AdS showed a highly established root system with mean root length and root number (15.2cm, 7.68cm and 11.8cm, 7.3cm) respectively. Thus, NAA perform better than IBA and addition of AdS enhanced proliferation and rooting growth parameters of pineapple plantlets.

Key words: Tissue culture, Pineapple, Adenine sulphate, Naphthalene acetic acid, Indole butyric acid.

INTRODUCTION

Tissue culture micropropagation is recognised and has been employed in the mass production of healthy and homogenous planting materials**.** Micropropagation of pineapple plants has many advantages over conventional methods of vegetative propagation. For example, this technique could allow for an efficient and rapid increase of selected varieties. The conventional way of producing healthy and high-quality pineapple is time-consuming. Conventional methods of obtaining materials from the sucker, crown, and slips of the pineapple take up to and/or more than 18 months after the fruit is harvested. Furthermore, imported plant material is very costly. In addition to that, the multiplication rate of pineapple is slow when using conventional propagation method, this causes inability to meet the high demand for pineapple planting materials. Nevertheless, these constraints can be overcome through plant tissue culture technique where the mass quantity of *in vitro* clonal pineapple can be produced within a short period. Tissue cultured pineapples have similar physical and chemical properties when compared to conventionally grown plants (Jackson *et al*., 2016).

Adenine sulphate (AdS) has been used in other plant species like *Musa paradisiaca*-plantain (Akin-Idowu *et al.,* 2020), *Trifolium repens* L. (Gabriela Vicaş, 2011), *Stevia rebaudiana* Bertoni (Kamram *et al.,* 2014), *Jatropha curcas* L. (Medza *et al.,* 2010) with a beneficial effects on multiplication particularly when in combination with cytokinins. However, little to nothing is known about auxins in synergy with AdS for optimum root formation. Formation of adventitious root is a complex process that is influenced by multiple endogenous factors such as phytohormones and as well as environment (Xuan *et al*., 2008). Survival rates during hardening and acclimatization have been identified as one of the problems affecting the pineapple micropropagation technique. This study was therefore carried out to access the potential synergistic influence of Auxins (NAA and IBA) with AdS combination for optimum adventitious root formation of tissue culture derived pineapple.

MATERIALS AND METHODS

Plant Materials

Pineapple crowns (Smooth Cayenne) were used as explants source. The experiment was conducted at the Biotechnology unit of the National Horticultural Research Institute (NIHORT) Headquarters, Ibadan. Surface sterilization process was carried out according to the method of (Akin-Idowu et al., 2014) with slight modifications. The explants were regenerated and subsequently multiplied on proliferation media according to the established protocol of the Laboratory. Root was induced by subculture of established proliferated plantlets into ½ strength of MS medium (Murashige and Skoog) supplemented with NAA, IBA and AdS as shown in the Table 1 with each treatment consisted of five plantlets in three replicates. Root data taken include root number (RN), root Length (RL-cm) and root Thickness (RT-mm with the aid a digital Vernier Calliper).

Table 1. Composition of treatment groups with other media components is as follows; Ascorbic Acid 5ml, Sucrose 30g, Myinositol 0.125g, Agar 8.0g/L, at pH 5.8.

Treatment	Group
T1	No hormone, No AdS
T2	1.0ml IBA+50mg/L AdS
T3	2.0ml IBA+100mg/L AdS
T4	1.0ml NAA+ 50mg/L AdS
T5	2.0ml NAA+100mg/L AdS

RESULTS AND DISCUSSION

Root Induction/Emergence

Plant growth regulators are vital in plant tissue culture since they play an imperative part in stem elongation, apical dominance and root emergence. The success rate of plant tissue culture depends on the choice of the nutrient medium. Saad and Elshahed, 2012 affirmed that the cells of most plant cells can be grown in cultured media. The ratio of the auxin to the cytokinin determines the type of culture established or regenerated, while Auxins on one hand promote both cell division and cell growth cytokinin on the other hand promote cell division. A high auxin to cytokinin ratio generally favours root formation, whereas a high cytokinin to auxin ratio favours shoot formation. An intermediate ratio favours callus production. The influence of AdS is known in tissue cultures as many plant species and types of vegetative tissues show superior effect when combined with different levels of cytokinin and auxin (Zapartan, 2001). In this study, the effects of AdS were well observed in treatment T4 (Table 2) the highest roots mean number and root length with well established root system (Figure 1). Abdel *et al.,* 2013 reported contrary results in which different auxin types and concentrations and different media strength were evaluated on the induction and proliferation of adventitious root on two cultivars of pineapple. According to these authors, IBA performed better than NAA at equal concentrations, except 1.0 mg/L, both of the cultivars (Smooth Cayenne and Morris) produced longer roots on IBA than NAA. But percentage rooting was approximately the same for IBA and NAA. Although the authors only compared different concentrations of auxins and cytokinins on Smooth Cayanne and Morris on root induction, but did not include AdS in their study. In this present study, 1.0mg\L NAA +50mg\L AdS would be recommended for Smooth Cayanne based on root number and root length and days of root emergence (Figure 1). This was in tandem with Abdel *et al*. (2013) as suggested based on the root length results they got for Smooth Cayanne.

Table 2. Mean root induction and elongation rate. RN-Root numbers, RL- Root Length, RT-Root thickness

Treatment	RN	RL(cm)	RT(mm)
T1	8.85±1.59	8.85±1.59	0.29±0.01
T2	7.89±1.21	6.41±1.18	0.41±0.08
T3	13.19±2.71	6.46±0.65	0.40±0.10
T4	15.21±5.38	7.68±2.86	0.54±0.18
T5	11.83±2.25	7.08±1.23	0.30±0.10

Figure 1. ***In vitro* root development. A) Induction of root system at 14days after subculture. B) Root elongation after 4wks of induction (C&F) Root formation and elongation Pattern after 6wks of induction (D&E) Root no and length before hardening process.**

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EVALUATION OF VEGETATIVE PROPAGATION TECHNIQUES ON *COFFEA CANEPHORA* GENOTYPES

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ABSTRACT

To improve the stability and productivity of coffee plants, many strategies for Robust coffee propagation could be applied. The goal of this study was to compare alternative propagation procedures for establishing coffee plantation. The stability and production capacity of cutting propagation procedures was investigated in this study. For optimum cutting development, vertical orthotropic branch stem cuttings were collected and dipped in rooting media, inserted into the well-prepared bed, and covered with nylon. For data collection, the rooted cuttings were transferred into the field, laid in Complete Randomized Block Design with three replicates. Variation in morphological characteristics was determined using analysis of variance and multivariate analysis. On the basis of morphological characters, differences between genotypes were detected. Plant height, number of leaves, stem girth, and number of plagiotropic branches were the key characters that contributed considerably to the variances, according to the findings. Plant height and the number of leaves were positive association. Plant height and number of leaves were identified as important variables in this study that might be used in genotype selection in a breeding program.

Key words: Coffee genotypes, vegetative, seeds and techniques of propagation

INTRODUCTION

The establishment of coffee plantation is crucial, and this necessitates the use of healthy and vigorous seedlings. Because Robusta coffee is self-incompatible, it must be cross-pollinated (Hetzel, 2015; Moraeset al., 2018). Seeds from cross-pollinated species have a wide range of genetic diversity and are genetically distinct from parent trees. However, farmers and coffee breeders all over the world have been propagating coffee through seeds for a longer time (Van der Vossen, 2001) including germplasms (Koo *et al*., 2004). Through vegetative propagation techniques, an effort has been made to establish coffee plantation. Angelo *et al*. (2018) advocate shoot grafting or cutting as the optimum technique of vegetative proliferation in Robusta coffee. Cutting/grafting is a method of plant propagation that employs the vegetative section of the plant to produce new plants that are identical to the parent plant. Cuttings ensured maximum homogeneity, decreased the time required for conventional breeding, and produced genotypes with vigour and desired features (Partelli *et al*., 2014). Cuttings also provided a distinct maturation and duration period (Martins et al., 2019; Partelli *et al*., 2019, 2020). Stem cuttings in Robusta coffee plants could serve two purposes either as rootstock for grafting or for establishment of coffee plantation/research purposes. According to Syafaruddin*et al*. (2014), Robusta coffee developed through grafting techniques were found to be stable and high yield when compared to those propagated by seeds. The advantage of grafting over cuttings is the vigour given to the scion by the rootstock. Grafting provide strong root system that could serve as a drought tolerant and disease resistant to scion (Bittenbender*et al.,* 2001).

The age of the mother tree, stem juvenility, plant regulator concentration, seasonality, and environmental variables during rooting growth all influence adventitious root formation (De Oliveira *et al*., 2015; Stuepp *et al*., 2017). As a result, callus must be generated and developed into adventitious roots in order for stem cuttings to grow successfully. Cutting should be collected from young branches that are in good condition and free of disease (Wendling *et al*., 2014). De Oliveira et al. (2015) discovered that soft wood cutting with a node outperformed woody cutting with a node in *C. canephora*. Few studies have been conducted on propagation procedures that will improve the establishment and performance of coffee plants. As a result, this research was conducted to determine the vegetative propagation technique that could be used in Robusta coffee genotypes and offer a foundation for good growth and production increase.

MATERIALS AND METHODS

Stem cutting were collected from orthotropic branches that were vertical, softwood stem cutting was taken at about 7-10 cm long, with a pair of leaves cut into two. The cuttings were planted in growing medium. The stem cuttings were planted vertically in a mixture of sawdust and top soil at a ratio of 1:1. The cuttings of each genotype were planted on well prepared bed, covered with white nylon to create a semi microclimate for cutting development. Shaded nursery is the best for cutting production.

Data were collected on plant height, stem girth, number of leaves, number of plagiotropic branches, leaf length and leaf width.

Data Analysis

Data were subjected to analysis of variance (ANOVA) to determine the significant variation that exits among the characters in respect to the genotypes while multivariate analyses were computed with the use of SAS statistical software version 9.1.3 (2008), to evaluate the relative contribution of each character to the phenotypic variation and the level of their associations.

RESULTS AND DISCUSSION

Table 1 summarizes the results of the RCBD experiments in terms of characters studied. Analysis of variance revealed significant variations among the genotype ($p<0.001$). For Number of plagiotropic branch (NPB) and Leaf Length (LL), the block genotype connection exhibited significant variation ($P< 0.001$). Plant height, number of leaves, number of plagiotropic branches, and leaf length were all significantly different between genotypes. Other parameters were also not different significantly.

Table 1: Analysis of variance of eight genotypes of coffee

Source	DF	PH	SG	NL	NPB	LL	LW
Rep	2	168.35	10050.98	832.95	17.87	0.87	3.67
Block (genotype)	16	124.89	0.87	2.71	91.46**	17.62**	2.37
genotypes	7	3121.13**	8170.46	1845.49**	125.86**	14.07**	84.24
Error	43	217.80	9272.26	309.95	13.20	3.14	2.33
Total	68	34027.92	621197.30	41789.16	3076.10	501.49	202.14
C.V %		23.00	506.74	44.35	40.67	12.26	26.01

Where Plant height = (PH), Stem girth = (SG), Number of plagiotropic branch = (NPB), Number of lea = (NL), Leaf length = (LL) and Leaf width

Result of the principal components in Table 2 showed characters with eigenvalues greater than 1 contributed variation observed among the 8 genotypes of coffee. The first principal component accounted for (29 %) of the total variation. Leaf length, leaf width, plant height and leaf number among others characters contributed to the variation in the first PC. Similarly, number of leaves, number of plagiotropic branches, plant height and stem girth contributed significantly to variation observed in the second PC which amount to (22 %). In the third PC stem girth, leaf length1, leaf width 1, and leaf length 2 were the most characters that contributed to the variation indicated. The three PCs contributed (64 %) of the total variation observed among the genotypes. Plant height, number of leaves, stem girth, and number of plagiotropic branches were the most significant characters that contributed to the variations observed in PCs, based on significant contributions of each character to the variations observed in PCs. As a result, because these characters contribute significantly to variance, they could be used to select genotypes. The findings of this investigation corroborated Kitilaet's (2011) report on coffee arabica.

Table 2: Eigenvectors, eigenvalues, proportion %, and cumulative variance % of the characters studied

	Prin1	Prin2	Prin3
PH	0.38	0.43	-0.34
SG	0.07	0.28	0.84
NB	0.11	0.49	0.04
NL	0.25	0.53	-0.06
LL	0.47	-0.33	0.14
LW	0.47	-0.29	-0.01
Eigenvalue	2.31	1.79	1.03
Proportion %	0.29	0.22	0.13
Cumulative variance %	29	51	64

Where Plant height = (PH), Stem girth = (SG), Number of plagiotropic branch = (NPB), Number of leaf = (NL), Leaf length1 = (LL) and Leaf width = (LW)

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The correlation study in Table 3 indicated positive relationship between plant height and leaf number, implying that an increase in leaf number contributed to an increase in plant height. This could be due to a higher number of leaves exposed to photosynthetic activities, implying an increase in carbohydrate production by plants. Similarly leave width was positively correlated with leaf length, implying that increase in leaf width could lead to increase in leaf length.

Table 3: Linear correlation coefficient of the characters studied on coffee

	PH	SG	NB	NL	LL	LW2
PH	1.00	0.00	0.36	0.53**	0.15	0.16
SG		1.00	0.21	0.24	0.08	-0.03
NB			1.00	0.25	-0.07	-0.02
NL				1.00	0.06	-0.04
LL					1.00	0.23
LW2						1.00

Where Plant height = (PH), Stem girth = (SG), Number of plagiotropic branch = (NPB), Number of leaf = (NL), Leaf length = (LL) and Leaf width = (LW)

CONCLUSION

The necessity of stem cutting in the establishment of coffee plantations for early seedling growth and stability was revealed by this study. Leaf number was found to contribute to plant vigour, which resulted in early plant stability at the juvenile stage. As a result, it is recommended to establishing coffee by cuttings for rapid growth and yield.

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RED *COLA NITIDA* SEEDLINGS AS INFLUENCED BY PLANT GROWTH SUBSTANCES

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ABSTRACT

Effect of plant growth substances on the growth and development of red C. nitida seedlings was investigated in Cocoa Research Institute of Nigeria (CRIN) Headquarters. Two (200) hundred nuts were collected from CRIN Headquarters scarified and pre-germinated before transplanting into polythene pots. The study was carried out using randomized complete block design. Hormonal treatments of 50mg/L,100mg/L and 200mg/L of different concentrations of gibberellic acid, indo-3- acetic acid, kinetic acid and 20% coconut water were applied to C. nitida seedlings at 4 weeks after planting and subsequently at 2 weeks' interval for 96 weeks. The control seedlings were sprayed with distilled water. Each treatment was replicated thrice. Morphological parameters, fresh and dry weight of root, shoot leaves and whole plant were determined. Root/shoot ratio, shoot water/shoot dry matter, shoot dry matter content and leaf area ratio were carried out. The data collected was subjected to analyses of variance (ANOVA) separation of means using Duncan Multiple Range Test (DMRT). 50mg/L GA_3 induced plant height (117.38 cm), stem girth (1.81cm), number of branches (21.83) and leaf area (167.71cm) except for number of leaves where 50mg/L kinetin had the highest (132.83), respectively. Similar result was obtained for fresh weight of root, shoot, leaves, root length and fresh weight of whole plant with 50mg/L GA_3 having the highest value (77.10 g, 125.93 g, 84.87 g,52.67cm and 281.23 g) and the result not significant at 5% level of probability except for fresh weight of leaves. 100mg/L GA_3 had the height in dry weight of root, shoot and dry weight of whole plant. The highest root/shoot ratio and shoot water/shoot dry matter was enhanced by 100mg/L GA_3 while shoot dry matter and leaf area ratio was produced by 50mg/L GA_3 respectively. Plant growth hormones of low concentration 50mg/L GA_3 elicited the highest growth in C. nitida seedlings when compared to the control.

Key words: Plant hormones, Red *C. nitida* seedlings, Morphological parameters.

INTRODUCTION

Kola nut (*Cola nitida)* also known as gbanja or goro) is the seed kernel of a large African tree grown commercially around the world. It originates from the Congo and throughout West Africa, but today, it is cultivated in Jamaica, Indonesia and South America. In Nigeria, Kola is the second most important indigenous cash crop. It is estimated that the country currently produces 70% of world's kola nuts with an annual production of 250,000 metric tons of fresh nuts mostly from south-west (Oludemokun, 1983). Kola nut serves as stimulant for the consumers and also for industrial uses as beverage and cough syrup made from its juice. Kola nut and kola by-products are noted for many industrial and domestic uses thereby contributing immensely to local and foreign exchange earning of the country. The nuts are nutritious, containing nearly 1% protein, 1.35% fats and 45% starch. (Quarcoo, 1973). Kola nut is being used as an alternative natural medicine in Europe and America. It also has industrial usage for the production of drugs, soft drinks, wines, candies, beverages, animal feed formulation, liquid soap and dyes (Beattie 1970; Daramola, 1978).

Despite the economic importance of kola stated above, the rate of uniformity in germination and its slow growth rate is a major challenge. Therefore, this study is aimed at boosting its growth and development as well as unifying the kola seedlings using plant growth regulators. Plant growth regulators in low concentration regulates growth, differentiation and development, either by promotion or inhibition (Naeem *et al*. 2004), and allows physiological processes to occur at their normal rate (Gulluoglu 2004). Among PGRs, auxin and gibberellin play vital role in regulating developmental processes within plant bodies (Gou *et al*. 2010). Auxin promotes cell elongation, especially of shoots, and induces apical dominance and rooting, while gibberellin helps in cell growth of stem, leaves and other aerial parts by causing cell elongation, and increase in internodal length. A higher concentration of gibberellins increases plant growth (Bora and Sarma 2006) while higher concentration of auxin inhibits it (Hussain *et al.* 2010). Thus, only low doses of auxin are effective in growth promotion (Vwioko and Longe 2009). The different concentrations of GA had significant effect on growth in mustard (Akter *et al.* 2007). Baydar (2000) reported that oil synthesis increases with increasing dose of GA in safflower. Like gibberellins, auxins are effective in increasing oil yield. Farooqui et al. (2005) reported that indole acetic acid (IAA) application increases oil yield enormously in *Cymbopogon martinii* and *Cymbopogon winterianus.* Faizanullah et al. (2010) reported that judicious application of growth hormone increases seed yield in linseed. However, seeing the potential effects of plant growth hormones on *C. nitida* plant, there are possibilities to investigate the influence of these PGRs on different growth parameters. The present study was aimed with the objectives of i) evaluating the effect of plant growth regulators on seedlings growth and development and ii) determining the yield components of *C. nitida* nut.

MATERIALS AND METHODS

Raising nuts for seedlings

The experiment was carried out Cocoa Research Institute of Nigeria (CRIN) Headquarters, Ibadan, Oyo State. A total of two hundred red *C. nitida* nuts were obtained from mature fresh pods from Cocoa Research Institute of Nigeria Headquarters. Nuts extraction was achieved by splitting matured pods with a sharp knife, the nuts were soak and washed in water to remove the testa on them. Five seed boxes of (90x60x30cm) size each was filled with a mixture weathered sawdust and topsoil (ratio 50:50). A shade was erected for the pre-nursery to prevent the seeds from desiccation and cultural practices such as weeding, watering and spraying of pyrinex 0.5L/1L of water against termite infestation was carried out. The bulk soil taken from the site (0-15cm depth) was sieved to remove stones and plant debris and 2.5kg of the sieved soil was placed into a polythene bag (25cmx13cm). The nuts were first pre-germinated in the nursery before transferring into the polythene pot.

Pre- soil analysis

Soil samples was randomly collected from 0-15cm depth on the site, mix thoroughly and the bulked sample was taken to the laboratory, air dried and sieved to pass through a 2mm screen for chemical analysis. The soil pH (1:1 soil/water) was determined using pH meter. Organic matter was determined by the wet oxidation method (Walkley and Black, 1934). Soil phosphorus (P) was extracted by the BrayP1 and measured by the Murphy blue coloration and determined by Spectronic 20 at 882um (Murphy and Riley, 1962). Soil potassium (K), calcium (Ca), and magnesium (Mg) was determined with flame photometer, Mg was determined with an Atomic Absorption Spectrophotometer. The total Nitrogen (N) was determined by the microjedah method (AOAC, 1990).

Nursery Establishment

Kola seedlings were transplanted into polythene bag, one per pot arranged in a randomized completely block design (RCBD) replicated three times. The parameters such as plant height, number of leaves, leaf area, stem girth and number of branches was recorded from four weeks after germination. The treated plants were spray every 2 weeks with 50ppm, 100ppm and 200ppm of IAA, Kinetin, GA_3 and 20% coconut water while the control was watered with distilled water. Growth parameters were measured every four weeks for 96 weeks (2years) after planting. Weeding was done at three months after planting and repeated at 6, 9, 12, 15 and 18 months. At 96 weeks after planting, the seedlings were carefully removed from the polythene bags for the measurement of the fresh shoot, root and leaves. Furthermore, dry matter yield was taken after oven dried in an oven at 60^{O}c for 2h.

Total fresh and dry weights determinations

Total fresh weight per plant was estimated as the sum of the leaf, stem and root. Fresh weight was determined at the expiration of the nursery stage. The organ was weigh with a H72 mettler balance. After weighing, they were put in an envelopes and oven-dry for the determination of the dry weights. The plant organ was oven dried at 60^{o}c for 24 h to constant weight. Leaves stem and root dry weights were summed up to give the total dry matter production per plant.

Shoot and Root ratio:

The treated and the control plants obtained were divided into shoot and roots after which they were dried separately in the oven at 60^{0}C for 24h and their different weights were measure using a weighing balance. The shoot and root ratio was calculated using the formula below.

$$\textbf{Shoot–Root Ratio} = \frac{\text{Dry weight of Root}}{\text{Dry weight of Shoot}}$$

Leaf Area Ratio:

Leaves of treated and control plant were measured using a meter rule. Bigger and smaller leaves were measured multiply by the correction factor, 0.67 before taking the mean. The leaf area ratios were calculated using the formula shown below:

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$$\text{Leaf Area Ratio} = \frac{\text{Leaf Area total}}{\text{Dry weight of whole plant}}$$

Shoot water and Shoot dry matter contents:

The fresh weights of shoots from the harvested treated and control seedlings was recorded, replicated three (3) times after which the shoot was dried in an oven for 24h at 60°C and their dry weight be calculated using the following formula:

$$WC = \frac{Wf - Wd}{Wf}$$

Where:

Wc = Shoot water content

Wf = Shoot fresh weight.

Wd = Shoot dry weight.

The percentage shoot dry matter content was obtained using the formula below:

$$DC = \frac{\text{Shoot dry weight}}{\text{Shoot fresh weight}} \times 100$$

Statistical analysis

The average data obtain for the physiological and growth parameters and soil chemical composition of kola seedlings for the two experiments were analyzed using ANOVA. The treatment means were compared using a Duncan Multiple Range Test at the 5% probability level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Soil analysis before planting

The initial physical and chemical properties of the soils are presented in Table 1. Based on the established critical levels for the soil in South-Western Nigeria, the soil was acidic (5.70). The soil organic matter and organic carbon were 17.83 and 30.74 while that of sawdust were 12.12 and 20.90 respectively. The soil nitrogen and sawdust values were 1.011 and 0.017 while the available P was 9.07 mg/kg for soil and 5.36mg/kg for sawdust. The exchangeable K value for soil and sawdust were 0.66cmol/kg and 0.34cmol/kg. The values for Ca, Na, Mg and Mn for soil are 0.37cmol/kg, 0.46cmol/kg, 0.18 cmol/kg, and 0.05cmol/kg, while that of sawdust were; 0.34cmol/kg, 0.16 cmol/kg, 0.12 cmol/kg, and 0.04cmol/kg, respectively. The soil is sandy loam in texture, belonging to Onigambari series: an Alfisol.

Table 1: Physicochemical characteristics of the soil before planting

Soil properties	value	Sawdust physical value
Sand	82.00%	-
Silt	14.00%	-
Clay	4.00%	-
Texture class	sandy loam	-
Chemical properties		
P^H (H_20)	5.70	3.75
Organic carbon	17.83	12.12%
Organic matter	30.74%	20.90%
Total Nitrogen	1.011%	0.017%
Available P	9.07mg/kg	5.36 mg/kg
Exchangeable bases		
K^+	0.66cmol/kg	0.34 cmol/kg
Ca^{++}	0.37cmol/kg	0.16 cmol/kg
Mg^{++}	0.18cmol/kg	0.012 cmol/kg
Mn	0.05cmol/kg	0.04 cmol/kg
Exchangeable acidity		
Al^{3+}	0.107cmol/kg	-
H^+	0.084cmol/kg	-
ECEC	1.753	-
Base saturation	95.29%	

There were increases in plant height of seedlings of *C. nitida* subjected to hormonal treatment and the controls as the number of months after planting increased. (Table 2). The highest value of the plant height of 137.7cm was obtained at 24 MAP in seedlings treated with gibberellic acid at 50mg/L, followed by seedlings treated with 50mg/L kinetin (111.32cm) and the least mean value was obtained for the control (61.09cm). There were no significant differences at 24MAP between plant heights of the treated seedlings and control. Increased in stem girth were observed at different concentrations of plant hormones and the control as the number of months after planting increased. The highest mean value of stem girth was recorded in 50mg/L gibberellic acid (1.88) at 24MAP. This was followed by 100mg/L gibberellic acid (1.83) and the least was obtained for the control (1.26). However, no significant differences were observed among the treated and the control. The positive results of GA_3 treatments are similar to that obtained by Islam *et al.* 2010 who found that at 70 days after sowing, 1.0mg/L GA_3 gave more plant height (44.29cm) which was statistically different from those of 2.0mg/L GA_3 and 0.50mg/L which gave plant height of Black gram (42.26cm and 42.06cm), respectively. Islam *et al.* 2004 observed that 0.664mg/L GA_3 enhanced plant height significantly in Lentil. These results also conform to those of Geekiyanage *et al.* 2006 and Sasaki, (1989). Similar results of plant height stimulation were observed by Currah & Thomas (1979) upon application of 100mg/L GA_3 on carrot plant. Spraying of kinetin on Datura innoxia plant at 1mg/L, 5mg/L and 10mg/L was found to cause increased vegetative growth (Abdel-Rahman & Abdel- Aziz, 1983). Similarly, GA_3 spraying was found to stimulate production of flowers in lettuce (Metzger, 1988). Biddington & Dearman (1987) also observed that GA_3 application increased the growth of bean and leaf length of lettuce (Olympios, 1976). An increase in stem girth was observed by Kadiri (1991) in his studies with *Abelmoschus esculentus* and *Lycopersicon esculentus* treated with various concentrations of GA_3 and 2, 4-D. The role of GA_3 has been highlighted in both somatic embryogenesis and organogenesis resulting in cell division and elongation (Al-khayri *et al.,* 1992; Komai et al., 1996; Molvig and rose, 1994 and Geekiyanage *et al.,* 2006). Ebofin *et al.* (2004) similarly recorded enhancement in leaf number and plant height in *Prosopis africana* and *Albizia lebbeck*. This might explain why GA_3 increased plant height and stem girth.

Table 2: Mean plant height (cm) and stem girth of red *C. nitida* seedlings treated with different concentrations of plant growth substances ranged between 4MAP to 24MAP

	4MAP		8MAP		12MAP		16MAP		20MAP		24MAP	
Treatments	Plant height	Stem girth	Plant height	Stem girth	Plant height	Stem girth	Plant height	Stem girth	Plant height	Stem girth	Plant height	Stem girth
50mg/L IAA	25.61^{ab}	0.77^{a}	39.64^{abc}	0.84^{a}	52.21^{abcd}	1.00^{ab}	59.01^{abc}	1.18^{ab}	79.09^{abc}	1.31^{abc}	102.34^{a}	1.45^{a}
100mg/L IAA	23.52^{ab}	0.76^{a}	36.17^{abc}	0.92^{a}	44.61^{abcd}	1.01^{ab}	51.77^{abc}	1.20^{ab}	62.41^{abc}	1.40^{abc}	78.94^{a}	1.53^{a}
200mg/L IAA	21.19^{ab}	0.77^{a}	30.84^{abc}	0.91^{a}	43.08^{abcd}	1.04^{ab}	51.96^{abc}	1.20^{ab}	61.76^{abc}	1.52^{abc}	72.94^{a}	1.60^{a}
50mg/L GA_3	38.23^{a}	0.77^{a}	53.05^{a}	1.10^{a}	76.34^{a}	1.29^{a}	80.95^{a}	1.39^{a}	103.87^{a}	1.76^{a}	137.70^{a}	1.88^{a}
100mg/L GA_3	28.83^{ab}	0.89^{a}	42.60^{abc}	0.92^{a}	51.98^{abcd}	1.01^{ab}	58.25^{abc}	1.17^{ab}	72.75^{abc}	1.62^{ab}	108.73^{a}	1.83^{a}
200mg/L GA_3	27.06^{ab}	0.64^{a}	37.98^{abc}	0.72^{a}	46.77^{abcd}	0.77b	56.54^{abc}	0.91^{bc}	68.55^{abc}	1.15^{bc}	83.60^{a}	1.45^{a}
50mg/L KT	24.04^{ab}	0.83^{a}	40.12^{abc}	0.85^{a}	62.61^{ab}	0.84^{b}	73.14^{ab}	1.02^{bc}	94.66^{ab}	1.29^{abc}	111.32^{a}	1.47^{a}
100mg/L KT	21.10^{ab}	0.74^{a}	23.71^{bc}	0.87^{a}	27.55^{cd}	0.93^{b}	32.61^{bc}	1.07^{abc}	44.76^{bc}	1.24^{abc}	72.77^{a}	1.51^{a}
200mg/L KT	26.27^{ab}	0.73^{a}	49.32^{ab}	0.87^{a}	62.14^{abc}	1.04^{ab}	65.30^{abc}	1.13^{abc}	80.96^{abc}	1.33^{abc}	98.03^{a}	1.45^{a}
20% C.W	29.06^{ab}	0.72^{a}	28.64^{bc}	0.89^{a}	40.46^{bcd}	0.87^{b}	45.83^{abc}	1.11^{abc}	58.21^{abc}	1.30^{abc}	79.57^{a}	1.52^{a}
Control	19.69^{b}	0.63^{a}	23.09^{c}	1.07^{a}	25.65^{d}	0.87^{b}	31.23^{c}	0.88^{c}	37.50^{c}	1.02^{c}	61.09^{a}	1..26^{a}

Means followed by the same letters on the same columns are not significantly different at 5% probability level using Duncan Multiple Range Test. IAA- Indole-3-acetic acid, GA_3 Gibberellic acid, KT- Kinetin, C.W- Coconut water, MAP- months after planting

Increase in number of leaves of the treated and control of *C. nitida* seedlings were observed as the number of months after planting (MAP) increased. Significant differences were obtained for 8, 12, 20 and 24 MAP except for 4 and 16MAP. The highest number of leaves at 24MAP was recorded for seedling treatments with 50mg/L gibberellic acid (142.67), followed by 100mg/L gibberellic acid (111.44) and 50mg/L IAA (111.44) respectively the least was obtained in control (41.89). Increased in number of branches were obtained in all the treated and control *C. nitida* seedlings as the number of months increased. Significant differences were observed in all the hormone treatments when compared to the control. With respect to the hormone treatments at 24MAP, the highest number of branches was obtained for seedling treatment of 50mg/L gibberellic acid (13.89). This was followed by 100mg/L gibberellic acid (12.67) and the least was recorded for control (7.33). The highest leaf area at 24MAP was recorded for seedlings treatment of 50mg/L gibberellic acid (163.44), followed by 50mg/L kinetin (158.53) and the least was obtained for control (72.80). This result obtained was not significant when compared to the control (Table4). Similar results were obtained by

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Alamu and Mc David (1979), in their studies with tannin (*Xanthosoma sagittifolium*) where they observed that application of GA_3, auxin and cytokinins increased the number of leaves of the plant by promoting the development of auxillary leaf systems. The observation of Usman *et al.* (2005) in explants of *halimii* whereby the highest number of leaves was observed at 75mg/L NAA treatment results shows that low concentration of 50mg/L GA_3 gave the highest number of leaves which was significantly different from that of control in *C. nitida* seedlings.

Table 3: Mean number of leaves and branches of red *C. nitida* seedlings treated with different concentrations of plant growth substances ranged between 4MAP to 24MAP

	4MAP		8MAP		12MAP		16MAP		20MAP
Treatments	Number of leaves	Number of branches	Number of leaves	Number of branches	Number of leaves	Number of branches	Number of leaves	Number of branches	Number of leaves
50mg/L IAA	6.73^{a}	1.42^{a}	13.17^{ab}	1.50^{bc}	13.20^{ab}	2.92^{ab}	45.25^{a}	6.08^{b}	84.17^{ab}
100mg/L IAA	4.99^{a}	1.67^{a}	18.67^{ab}	4.08^{ab}	20.83^{ab}	4.08^{ab}	45.50^{a}	8.42^{ab}	63.67^{ab}
200mg/L IAA	6.23^{a}	0.83^{a}	13.54^{ab}	2.75^{abc}	22.08^{ab}	2.92^{ab}	38.33^{a}	5.08^{b}	53.42^{ab}
50mg/L GA_3	5.76^{a}	1.58^{a}	22.57^{ab}	5.17^{a}	31.75^{a}	5.17^{a}	66.00^{a}	12.57^{a}	111.76^{a}
100mg/L GA_3	6.22^{a}	0.83^{a}	23.92^{a}	3.75^{abc}	32.92^{a}	4.33^{ab}	63.08^{a}	8.08^{ab}	93.00^{ab}
200mg/L GA_3	4.99^{a}	0.50^{a}	8.08^{ab}	2.33^{abc}	14.83^{ab}	2.25^{ab}	26.17^{a}	5.08^{b}	35.25^{b}
50mg/L KT	7.97^{a}	0.75^{a}	18.33^{ab}	3.42^{abc}	22.08^{ab}	2.83^{ab}	35.25^{a}	6.00^{b}	69.92^{ab}
100mg/L KT	6.48^{a}	1.63^{a}	14.00^{ab}	2.92^{abc}	16.58^{ab}	3.58^{ab}	24.25^{a}	4.47^{b}	33.00^{b}
200mg/L KT	5.22^{a}	1.00^{a}	16.42^{ab}	3.08^{abc}	19.58^{ab}	3.00^{ab}	24.25^{a}	4.67^{b}	44.00^{ab}
20% C.W	8.02^{a}	1.00^{a}	6.83^{ab}	1.25^{bc}	15.25^{ab}	3.25^{ab}	61.17^{a}	9.08^{ab}	49.58^{ab}
Control	3.69^{a}	0.42^{a}	5.08^{b}	0.96^{c}	5.87^{b}	1.72^{b}	18.08^{a}	3.58^{b}	27.17^{b}

Means followed by the same letters on the same columns are not significantly different at 5% probability level using Duncan Multiple Range Test IAA- Indole-3-acetic acid, GA_3 Gibberellic acid, KT- Kinetin, C.W- Coconut water, MAP- months after planting

Table 4: Mean leaf area of red *C. nitida* seedlings treated with different concentrations of plant growth substances ranged between 4MAP to 24MAP.

Treatments	4MAP	8MAP	12MAP	16MAP	20MAP	24MAP
50mg/L IAA	47.56^{a}	64.72^{a}	55.27^{ab}	65.64^{a}	68.74^{ab}	144.42^{a}
100mg/L IAA	37.56^{a}	38.54^{a}	40.87^{b}	45.47^{a}	55.22^{ab}	97.25^{a}
200mg/L IAA	39.03^{a}	39.09^{a}	39.87^{b}	40.03^{a}	54.07^{ab}	73.75^{a}
50mg/L GA_3	40.06^{a}	71.82^{a}	73.55^{a}	78.32^{a}	85.48^{ab}	163.44^{a}
100mg/L GA_3	36.94^{a}	43.35^{a}	51.77^{ab}	58.07^{a}	73.79^{ab}	133.32^{a}
200mg/L GA_3	26.33^{a}	37.61^{a}	39.55^{b}	39.55^{a}	55.85^{ab}	116.45^{a}
50mg/L KT	46.31^{a}	49.81^{a}	49.55^{b}	49.70^{a}	53.33^{ab}	158.53^{a}
100mg/L KT	34.08^{a}	34.15^{a}	45.67^{b}	55.55^{a}	55.75^{a}	143.48^{a}
200mg/L KT	45.99^{a}	46.99^{a}	49.10^{ab}	58.51^{a}	91.26^{ab}	155.84^{a}
20% C.W	39.14^{a}	42.71^{a}	42.85^{b}	46.30^{a}	63.56^{ab}	104.24^{a}
Control	39.26^{a}	33.65^{a}	33.72^{b}	37.32^{a}	50.90^{b}	72.80^{a}

Means followed by the same letters on the same columns are not significantly different at 5% probability level using Duncan Multiple Range Test, IAA- Indole-3-acetic acid, GA_3 Gibberellic acid, KT- Kinetin, C.W- Coconut water, MAP- months after planting

Table 5 shows the fresh weight of root, shoot, leaves, fresh root length and fresh weight of whole plant of the treated seedlings of *C. nitida* and controls. Significant differences were obtained among the treated *C. nitida* seedlings from those of the controls except for fresh weight of leaves and root length (Table 5). The highest fresh weight of shoot at 24MAP was observed in seedlings treated with 50mg/L gibberellic acid (153.37), followed by 100mg/L gibberellic acid (144.83) and the least mean value was observed for control with value (32.03) respectively. Root fresh weight shows that seedlings treated with 50mg/L gibberellic acid had the highest (67.57), followed by 100mg/L gibberellic acid (61.70) and the least was obtained for the control (15.33) respectively and result highly significant. (Table 5). However, 50mg/L gibberellic acid had the highest (282.10) in fresh weight of whole plant root, this was followed by 100mg/L gibberellic acid (267.50) and the least was observed in controls (60.77) respectively. (Table5). This result is contrary with Heijari *et al.* (2005) who reported seedling diameter, shoot fresh weight, root fresh weight and root length were hampered by low MJ concentration in Scots pine. Similar observations were reported by Zhang *et al.* (2002). However, morphological characters were strongly inhibited by increasing MJ concentration. Results similar reported by Koda, (1999) Salicylic Acid (SA) is a growth regulator which participates in the regulation of physiological processes in plants. It stimulates flowering in a range of plants, increases flower life, controls ion uptake by roots and stomatal conductivity Bhupinder *et al.* (2003). Application of SA also significantly increased dry weights of root and top part of barley and soybeans. The mechanism of salicylic acid was reported by Oata (1975) and Pieterse and Muller (1977) who concluded that salicylic acid induced flowering by acting as a chelating agent. This view was supported by Raskin *et al.* (1987) who confirmed that salicylic acid functioned as endogenous growth regulators of flowering and florigenic effects.

Table 5: Mean fresh weight of root, shoot, leaves, root length and fresh weight of whole plant of red *C. nitida* seedlings treated with different concentrations of plant growth substances ranged between 4MAP to 24MAP

Treatments	Fresh weight of Root	Fresh weight of shoot	Fresh weight of leaves	Fresh Root Length	Fresh weight of whole plant
50mg/L IAA	39.30^{ab}	94.87^{abc}	39.37^{a}	33.43^{a}	173.73^{abc}
100mg/L IAA	30.53^{ab}	53.23^{bc}	19.53^{a}	37.93^{a}	103.30^{abc}
200mg/L IAA	30.53^{ab}	58.27^{bc}	28.87^{a}	32.17^{a}	138.77^{abc}
50mg/L GA_3	67.57^{a}	153.37^{a}	28.87^{a}	36.17^{a}	282.10^{a}
100mg/L GA_3	61.70^{a}	144.83^{ab}	60.97^{a}	37.40^{a}	267.50^{ab}
200mg/L GA_3	25.33^{ab}	35.53^{c}	14.07^{a}	32.00^{a}	74.93^{c}
50mg/L KT	31.25^{ab}	89.33^{abc}	37.43^{a}	32.43^{a}	158.00^{abc}
100mg/L KT	27.50^{ab}	43.67^{c}	18.00^{a}	38.13^{a}	91.20^{bc}
200mg/L KT	42.60^{ab}	52.97^{bc}	23.00^{a}	37.90^{a}	118.57^{abc}
20% C.W	29.50^{ab}	50.80^{c}	27.47^{a}	35.30^{a}	105.77^{abc}
Control	15.33^{b}	32.03^{c}	13.40^{a}	28.93^{a}	60.77^{c}

Means followed by the same letters on the same columns are not significantly different at 5% probability level using Duncan Multiple Range Test. IAA- Indole-3-acetic acid, GA_3 Gibberellic acid, KT- Kinetin, C.W- Coconut water, MAP- months after planting

Table 6: Mean dry weight of root, shoot, leaves and dry weight of whole plant of red *C. nitida* seedlings given hormonal treatment of different concentrations at 24MAP

Treatments	Dry weight of Root	Dry weight of shoot	Dry weight of leaves	dry weight of whole plant
50mg/L IAA	15.22^{abc}	38.18^{abc}	15.12^{bc}	68.51^{bc}
100mg/L IAA	14.27^{bc}	22.26^{bc}	8.36^{c}	45.43^{c}
200mg/L IAA	14.27^{bc}	25.08^{bc}	12.55^{bc}	51.57^{c}
50mg/L GA_3	30.01^{ab}	60.24^{ab}	40.57^{ab}	141.06^{ab}
100mg/L GA_3	36.27^{a}	81.10^{a}	53.14^{a}	170.51^{a}
200mg/L GA_3	11.65^{bc}	19.93^{bc}	7.56^{c}	41.76^{c}
50mg/L KT	14.37^{bc}	37.16^{abc}	15.79^{bc}	67.44^{c}
100mg/L KT	16.36^{abc}	22.26^{bc}	9.22^{c}	47.84^{c}
200mg/L KT	20.12^{abc}	25.06^{bc}	11.51^{bc}	55.69^{c}
20% C.W	13.65^{bc}	32.22^{bc}	12.54^{bc}	44.42^{c}
Control	7.53^{c}	11.61^{c}	6.36^{c}	28.80^{c}

Means followed by the same letters on the same columns are not significantly different at 5% probability level using Test Duncan Multiple Range. IAA- Indole-3-acetic acid, GA_3 Gibberellic acid, KT- Kinetin, C.W- Coconut water, MAP- months after planting.

Table 6 shows the dry weight of root, shoot, leaves and fresh weight of whole plant of the treated seedlings of *C. nitida* and controls. Significant differences were obtained among the treated *C. nitida* seedlings from those of the controls. The highest dry weight of root, shoot, leaves and dry weight of whole plant for seedlings given hormone treatments at 24MAP was observed in seedlings treated with 100mg/L gibberellic acid, simply followed by 50mg/L gibberellic acid and the least was observed for control. (Table6). Quaderi *et al.* (2006) reported that IAA increases dry matter by increasing photosynthesis activity in mungbean. Ibrahim *et al.* (2007) reported that the application of bioregulators (GA_3, IAA, benzyl adenine, ancymidol) significantly increased the total dry weight of shoot system in fababean.

Table 7 shows the root- shoot ratio, shoot water and shoot dry matter and leaf area ratio of the treated seedlings of *C. nitida* and controls. Significant differences were obtained in all the parameters tested among the treated *C. nitida* seedlings from those of the controls. The highest shoot- shoot content and leaf area ratio given hormone treatments at 24MAP was observed in seedlings treated with 200mg/L kinetic acid with mean value of 0.78 and 12.19. 100mg/L GA_3 had the highest in shoot water and shoot dry matter with value 60.90, followed by 20% coconut water and the least was observed in control with value 48.36. (Table 7). Mukhtar, (1993) obtained a similar result of increased shoot- root ratio and leaf relative water content for seedlings of *Abelmoschus esculentus* treated with single 100ppm GA_3 treatment and a combination of 100ppm GA_3 + 15% coconut milk at 9 weeks after sowing. Currah and Thomas, (1979) obtained a similar finding of increased shoot-root ratio of carrot plant (*Daucus carota* L.) treated with 100ppm GA_3. Stuart and Cathay (1961) and Akhtar *et al.* (2008) explained that increases in shoot-root ratio by hormones treatments are due to the fact that they enhance the stem elongation plants. In addition, cytokinins such as those contained in coconut water, 6-benzylaminopurine (BAP) also facilitate cell division and sprouting. (Pan, 2001). Quaderi *et al.* (2006) reported that IAA increases dry matter by increasing photosynthesis activity in mungbean. Ibrahim *et al.* (2007) reported that the application of bioregulators (GA_3, IAA, benzyl adenine, ancymidol) significantly increased the total dry weight of shoot system in fababean.

Table 7: Mean root/shoot ratio, shoot water and shoot dry matter, shoot dry matter content and leaf area ratio of red *C. nitida* seedlings given hormonal treatment of different concentrations at 24MAP

Treatments	Root/Shoot Ratio	Shoot water/shoot dry matter	Leaf Area Ratio
50mg/L IAA	0.40^{ab}	52.21^{ab}	1.64^{c}
100mg/L IAA	0.60^{ab}	55.77^{ab}	2.82^{bc}
200mg/L IAA	0.73^{a}	52.46^{ab}	1.64^{c}
50mg/L GA_3	0.47^{ab}	54.36^{ab}	1.18^{c}
100mg/L GA_3	0.45^{ab}	60.90^{a}	1.35^{c}
200mg/L GA_3	0.50^{ab}	55.69^{ab}	4.35^{b}
50mg/L KT	0.46^{ab}	58.82^{a}	3.64^{bc}
100mg/L KT	0.78^{a}	58.98^{a}	12.19^{a}
200mg/L KT	0.77^{a}	53.66^{ab}	2.82^{bc}
20% C.W	0.49^{ab}	60.60^{a}	3.23^{bc}
Control	0.31^{b}	48.36^{b}	1.15^{c}

Means of the same letters on the same columns are not significantly different at 5% levels of probability using Duncan multiple range test

IAA- Indole-3-acetic acid, GA_3 Gibberellic acid, KT- Kinetin, C.W- Coconut water, MAP- months after planting.

The present study clearly showed that among various plant growth substances applied, gibberellin, 50mg/L at low concentration had most pronounced stimulatory effect on growth components, which might be due to their effect on physiology of plant (Naeem *et al.* 2004). Gibberellin promotes growth by stimulating cells for quick division, as well as elongation, by increasing mechanical extensibility and plasticity of cell wall, which is followed by hydrolysis of starch to sugar, resulting in reduced water potential and allowing water to enter inside the cell.

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EFFECT OF DIFFERENT NURSERY MEDIA ON THE SEED GERMINATION AND SEEDLING DEVELOPMENT OF TWO SPECIES OF BUSH MANGO (*IRVINGIA GABONENSIS*) IN OKIGWE SOUTH-EASTERN NIGERIA

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ABSTRACT

Potted experiments was conducted at National Horticultural Research Institute Mbato Okigwe South eastern Nigeria during fruiting season of 2019 and 2020 to evaluate the effect of different nursery media on the seed germination and seedling development of two bush Mango (Irvingia gabonensis) species. In doing this, from the Bush mango conservation area in Mbato, freely felled fruits from the two species of Irvingia trees were picked separately, depulped to expose the nuts containing the seeds and shade dried for 3 days. Top soil (Ts), Saw dust (Sd), Poultry manure (Pm), Woodcharcoal(Wc) and Irvingia peel (Ip) and their 50% portion mixture namely; Ts x Sd, Ts x Wc, Ts x Pm, Ts x Ip, Sd x Wc, Sd x Pm, Sd x Ip, Wc x Pm, Wc x Ip, and Pm x Ip. A total of 5 sole nursery growth media and 10 of their mixtures giving 15 treatments per specie of the Bush mango constitutes the experiment. For each of the treatment 30 poly bags (25cm x I8cm) were filled, I5 each for the two variety (V_I & V_2) and placed under a tree shade. The I5 polybags were arranged 5 per roll replicated 3 times in a Completely Randomized Design (CRD). Each of the polybags were planted to a depth of 5cm with one seed of the respective variety and watered once in three (3) days using watering can. Germination and Cotyledon emergence started to strive from the third week and with eye observations, Log Books bi-weekly records were taken on percentage emergence, shoot heights, number of shoot/leaves leaf lengths, breadths and stem girths. Data generated were subjected to ANOVA and pertinent means were separated using fishers LSD at 5% level. There was no seed emergence on treatments Ip x Wcv_2, Ip x Pmv_1 and Ip x Pmv_2 throughout (2-14WAS) the trial period. Treatments Tsv_1; Tsv_2; Sdv_1; Sdv_2; Ts x Wcv_1; Ts x Pmv_1; Ts x Pmv_2; Ts x Sdv_1; Ts x Sdv_2; Pm x Sdv_1 and Pm x Sdv_2 were earliest at 4WAS for seed emergence records of 3,3; 3,6; 3; 4,3 ;4,5 and 4,6 out of 45 samples, respectively. At 14WAS Treatment Ts x Pm with record of 44 out of 45 samples giving 97.7% seed emergence was the highest. It was followed by Ts x Sd at 95.5% and 93.3% by Sd and the least 2 out of 45 samples at 4.4% for treatments Ip; Wc; Pm; Ts x Ip, Ip x Wc and Ip x Sd respectively. Treatment Ip x Sdv_2 as an unsuitable nursery media, had delayed seed emergence till 12WAS and at 14WAS the seedling wildered and diminished. Shoot height was highest at 39cm on Tsv_1 on the 14WAS and least at 5.8cm on treatment Wc x Pmv_1. Number of leaves was highest at 9.2 on Ts x Pmv_2 and least at 1.0 on Ts x Pmv_1. At 14WAS lengths and breadths of leaves were highest at 16.7cm on Tsv_1 and 6.1cm on Ts x Pmv_2 and least at 2.7cm on Ipv_2. Shoot stem girth was highest at 0.53cm on Ts x Pmv_2 and least at 0.21cm on treatment Wc x Pmv_2. The implication of this trial result is that for a tremendous earliest day at 8WAS to seed germination, nursery media Sawdust should be used. Then for a sustained pot-bound seedling production with good number of leaves and sizable girths Topsoil mixture with poultry manure (Ts x Pmv_2) is advised. Any media mixture involving Irvingia peels waste gave delayed and little results and in some cases wildered just at the end of the trial.

Key words: Bush mango, media, germination, *Irvinga*, seedlings, seeds

INTRODUCTION

Irvingia is one of the three genera in the family Irvingiaceae (Okafor,1975, Rundel, 2016). With 2n-28 chromosomes profiling, Irvingia comprises 7 species; 6 in tropical Africa and 1 in South east Asia (PROTA,2007). Bush mango, Dika nut tree, Sauvage, Chocolatier and Ogbono is the various names of *Irvingia*. (Harris, 1996). Currently, it is called African Wild Apple. The origin of species is traceable to wild humid low-land rainforest of central African and West Africa characterized with Ultisols (Van Dyke,1997). It is popularly found in the Tropical Rainforest of Garbon and in the Derived Savannah belts of Southern Nigeria (Okafor,1983, Nzekwe,1995). Okigwe, Imo State in South-eastern Nigeria soil is classified as Ultisols (Mbagwu,1992; Okpara *et al.*, 2012; Okpara *et al.*, 2017; Okpara *et al*,2018; Okpara *et al*, 2020). In this part of Southern Nigeria, *Irvingia* has two distinct forms namely, *Irvingia gabonensis* var gabonensis with sweet edible pulp and *Irvingia gabonensis* var excels (wombolu) with bitter inedible pulp (Okafor,1975; Vihotogbe, 2012). The two types have trees and seedling that looks identical but their fruits mesocarp or pulp taste clearly and steadily different from the other(Vihotogbe, 2016). Their DNA analysis suggests that these two (2) taxa are clearly and genetically distinct and that their genome do not hybridize even when planted in close isolation distances (PROTA,2007). They two species flowers separately. The inedible bitter, *I. wombolu,* fruits during dry season months of December to March while the sweet and edible type fruits during raining season from April to August. These days, may be for climate change, their fruiting months' over-laps into the other. Both species are called African Bush Mango Tree (Vihotogbe, 2016). They are large, long-lived, evergreen tropical tree of 10 to 50 meters high with gestation period of 10 – 15 years (Okafor,1975; Harris,1996; Vihotogbe, 2016). NIHORT Mbato Okigwe has over two (2) hectares of land area of conservation of these species. The fruit falls freely from the tree top upon maturity. The fruit in the wild is classified as one of the major Non-Timber Forest Products(NTFPs) are usually picked from tree base by farmers and rural locals as important component of rural livelihood (FOA, 2015; Rundel, 2016). *Irvingia* fruit has been described as ellipsoid, to cylindrical drupe, occasionally near spherical 4-6.5cm x 4-6.5cm x 3.5 – 6cm smooth, green when ripe ,pulp bright orange, soft, juicy with few fibres ,stone woody,1 seeded with epigeal germination (PROTA,2007).The most valued part of the *Irvingia* species which is also traded internationally across Europe is the fruit seed n called kernel that is popularly used as a thickener for soup and stew making (Ejiofor,*et al.,* 1987; PROTA, 2007; Vihotogbe, 2012; Rundel, 2016). Other uses of *Irvingia* is the tree as a hard timber, the bark used as anti poison, anti dysentery and the fruit pulp for dye making (PROTA, 2007). The increasing local and international market demand of the kernels causes on over exploitation of trees in natural habitat and their result in poor regeneration in their postulated genetic diversity in Nigeria, Cameroun and Garbon (Vihotogbe, 2012). Before now the common source of new seedling stock of *Irvingia* is the forest (Tchoundeu *et al.*,1997). Today with new innovative from trials over time, growth media such as soils, saw mill waste, animal waste, kitchen waste, plant residue/waste and their mixtures can be harnessed and tapped to regenerate through seedling nursery of tree plant to create, replenish, expand and sustain plantations. Different nursery media affects sprouting and germination as well as seedlings differently. Raising planting materials on growth media is another method of ex-situ conservation of genetic materials (Hunter and Heywood, 2011). This involves collecting and placing growth media in empty cans, trays, pots, polybags, and other sizeable receptacles. Agricultural productivity increase is only possible with use of yield-enhancing technology (CCIA, 2019). Top soil is commonly used in germination of seeds but when used alone are very poor growth media (Baiyeri & Aba 2012). The use of Organic materials mix soils provides better root-substrate relation than conventional Topsoil (Baiyeri & Aba,2012). One of the most important criteria for successful rooting is a reliable rooting medium (Akintoye, *et al.,* 2012). To evaluate from the arrays of Topsoil, Poultry manure, Sawdust, Wood charcoal, Irvingia peel waste and their mix with a view of coming up with recommendation is what informed this trial.

MATERIAL AND METHODS

Potted experiments were conducted at National Horticultural Research Institute Mbato Okigwe South eastern Nigeria during fruiting season of 2019 and 2020 to evaluate the Effect of Different Nursery Media on the Seed germination and Seedling Development of two Bush Mango (*Irvingia gabonensis*) Species. The station lies on latitude 05^0 33^1N and longitude 07^0 23^1E and altitude of 130 meters above sea level. Okigwe is characterized by undulating dissected plains and soils derived from shale and sandstone, classified as ultisol. NIHORT Mbato Okigwe has over two (2) hectares land area of conservation of these two species namely *Irvingia gabonensis* var *gabonensis* and *Irvingia gabonensis* var wombolu also known as I*rvingia wombolu*. They two species flowers separately. The inedible bitter *I. wombolu* fruits during dry season months of December to March while the sweet and edible type fruits during raining season from April to August. These days, their fruiting over-laps into the other. From the conservation area some tree stands were selected and tagged according to species for fruit pickings. Freely felled fruits from the two species of Irvingia trees were picked separately, depulped to expose the nuts containing the seeds and shade dried for 3 days. Top soil (Ts), Saw dust (Sd), Poultry manure(Pm), Wood charcoal (Wc) and *Irvingia* peel(Ip) and their 50% portion mixture namely; Ts x Sd, Ts x Wc, Ts x Pm, Ts x Ip, Sd x Wc, Sd x Pm, Sd x Ip, Wc x Pm, Wc x Ip, and Pm x Ip. A total of 5 sole nursery growth media and 10 of their mixtures giving 15 treatments per specie of the Bush mango constitutes the experiment. For each of the treatment 30 poly bags (25cm x I8cm) were filled, I5 each for the two variety (V_I & V_2) and placed under a tree shade. The I5 polybags were arranged 5 per roll replicated 3 times in a Completely Randomized Design (CRD). Each of the

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polybags were planted to a depth of 5cm with one seed of the respective variety and watered once in three (3) days using watering can. Germination and Cotyledon emergence started to strive from the third week and with eye observations and Log Books Bi-weekly records were taken on percentage emergence, shoot heights, number of shoot/leaves leaf lengths, breadths and stem girths. Data generated were subjected to ANOVA and pertinent means were separated using fishers LSD at 5% level.

RESULTS AND DISCUSSIONS

Tables 1 shows the Bi-weekly (till the 14wks) data collections on shoot emergence and percentage of the 45 samples each for the 15 treatments for two varieties investigated. Also taken was bi-weekly data for heights, number of leaves, leaf lengths and breadths and stem girths of the samples. There was zero seed emergence at 2WAS across all the treatments and varieties investigated. At 4WAS there was significant (P< 0.05) difference on treatments with records for earliest weeks to seed emergence. That seed emergence was observed beyond 2WAS sowing agrees with Okafor (1997) findings. Treatments Tsv_1; Tsv_2; Sdv_1; Sdv_2; Ts x Wcv_1; Ts x Pmv_1; Ts x Pmv_2; Ts x Sdv_1; Ts x Sdv_2; Pm x Sdv_1 and Pm x Sdv_2 were earliest to seed emergence records of 3,3; 3,6; 3; 4,3 ;4,5 and 4,6 out of 45 samples respectively. Of all the earliest to seed emergence records, treatments Sdv_2; Ts x Sdv_2 and Pm x Sdv_2 with records of 6; 5 and 6 seed emergence were significantly (p<0.05) higher than others. These other treatments not mentioned at 4WAS were observed with zero seed emergence.

At 6WAS, treatments Ts x Wcv_1 at 16 sample seed emergence was significantly (p<0.05) higher than other treatments. It was closely followed by treatments Sdv_2 and Ts x Sdv_2 each at 15 sample emergences and the least (3) each for treatments Wcv_1; Pmv_2 and Wc x Pmv_1 respectively. It is worthy of note that treatments Ipv_1; Ipv_2; Wcv_2; Pmv_1; Ts x Ipv_1, Ts x Ipv_2 ;Ip x Wcv_1; Ip x Wcv_2;Ip x Pmv_1;Ip x Pmv_2;Ip x Sdv_1; Ip x Sdv_2 and Wc x Pmv_2 all recorded zero seed emergence at the 6WAS.

At8WAS. Treatment Sdv_2 (Sawdust v_2) with 33 out of 45 for seed emergence was significantly (P<0.05) higher than 27 recorded for treatment Pm x Sdv_2 and 18 also recorded for treatment Tsv_1(Topsoil). The least was 2 seed emergence recorded for treatments Wc x Sdv_1 and Pmv_2. At this time or interval for expectant seed emergences, an average observer will label treatment Saw dust(Sdv_2) as the earliest with highest number for seed emergence. This may be true with NIHORT reports of 1997,2000,2005 and 2018 that acclaimed sawdust as the best for Irvingia spp germinations.

At 10 WAS the following treatments maintained zero seed emergence :-Ipv_1, Ipv_2; Wcv_2; Ts x Ipv_1, Ts x Ipv_2; Ip x Wcv_1, Ip x Wcv_2; Ip x Pmv_1, Ip x Pmv_2; Ip x Sdv_1, Ip x Sdv_2 and Wc x Pmv_2. Poultry treatment (Pmv_1) at 10 WAS recorded its ever seed emergence of 3 samples out of 45. Treatment Wc x Pmv_1 with 3 seed emergence at 6WAS recorded zero emergence and zero shoot at 10WAS.This wildering and diminishing of seedling after emergence recorded for treatment Wc x Pmv_1 suggests that the nursery media mixture was poor in giving the seedling the physical support the soil gives(Ekpo and Sita,2010).Still on 10 WAS, treatment Sawdust(Sdv_1) with 36 samples though not significantly(P<0.05) different was lower than treatments ,Ts x Pmv_1(39) which was significantly higher than other samples with seed emergences. The least (2) was recorded for treatment Wc x Sdv_1.

At 12 WAS, treatments IpV_I, Ipv_2; Wcv_2; Ip x Wcv_I, Ip x Wcv_2; Ip x Pmv_I, IIp x Pmv_2 and Ip x Sdv_2 maintained zero seed emergence even at I2 WAS in this trial. Some other treatments were observed at I2WAS with their first ever seed emergence and it includes treatments, Ts x Ipv_I, Ts x Ipv_2; Ip x Wcv_I; Ip x Sdv_1; Wc x Pmv_1, Wc x Pmv_2 with sample records of 4, 3; 2; 4; and 3,4 respectively. This trends of poor and delayed seed emergence could be attributed to poor aeration, nutrient and water balance that is inherent with these soil, sawdust, wood charcoal, *Irvingia* peel and poultry manure mixtures thus making these features as Akintoye *et al.* (2012) put it as unreliable nursery media. It is worthy of note here that at 8WAS Sawdust(Sdv_I) with 33 out of 45 samples was with superior significant(p<0.05) for earlier and numerical seed emergence higher than other treatments. Sawdust use here can be likened to a yield-enhancing technology which CCIA, afdb.org/affm (2019) affirmed as the surest ways to increasing agricultural productivity. This lead (33) by treatment sawdust at 8WAS increase at decreasing trend (36) at I0 WAS, was at this same interval running neck-to-neck with treatment Topsoil and poultry manure (Ts x Pmv_1;)at 39 without significant(P,0.05) difference even to the I4WAS.

At I4WAS this trend of seed emergence numerical margin without significant (P<0.05) difference even with percentage (%)comparison, continued from the I2WAS into the I4WAS with 39(86.6%) samples each for treatments Tsv_I; Tsv_2; and Pm x Sdv_I.

Fourthy -42(93.3%) out of 45 samples each was recorded for Sdv_1, Sdv_2, Ts x Wcv_1, Ts x Sdv_l, 43 (95.5%) for Ts x Sdv_2 only and lastly ,44(97.7%) samples out of 45 each for Ts x Pmv_1 and Ts x Pmv_2.The least of 2(4.4%) samples each was recorded for treatments Ipv_2, Wcv_l, Pmv_l, Ts x Ipv_2, Ip x Wcv_l, and Ip x Sdv_l. It is also at I4WAS that treatments Ipv_2 and Ip x Sdv_l recorded 2 (4.4%) samples as their first ever seed emergence. It is also worthy of note that treatment Ip x Sdv_2 with 4(8.8%) samples emergence at I2WAS lost it all (0%)to wildering at I4WAS probably to what Ingram *et al*. (2009) described as unsustainable nursery media.

Table 1 also shows data on shoot / seedlings heights from 2 – I4WAS following seed emergence of the two variety of Bush mango; *Irvingia gabonensis* and Irvingia *wombolu*. At 2WAS there was no seed emergence across all treatment which agrees with Okafor (1997).

At 4WAS, treatments that recorded seed emergence were significantly(P<0.05) earliest to shoot/height expression compared to others at later weeks after sowing(WAS). This includes treatments; Tsv_l; Tsv_2; Sdv_1, Sdv_2; Ts x Wcv_1; Ts x Pmv_1; Ts x Pmv_2; Ts x Sdv_1, Ts x Sdv_2; Pm x Sdv_1 and Pm x Sdv_2 with emerged seed shoots/seedlings height records of 3.8cm,3.0cm; 2.9cm,2.5cm; 2.6cm; 2.4cm,2.5cm; 2.2cm,2.1cm; 2.6cm and 2.9cm, respectively. There was no significant (P<0.05) difference for these recorded values.

At 6WAS,Shoots/seedlings heights was significantly(P<0.05) high at 6.1cm and 5.9cm on treatments Ts x Pmv_1 and Ts x Pmv_2 and least at 2.1cm for treatment Wc x Pmv_1..This trend continued till the 14WAS wherein treatments Tsv_l;Tsv_2 significantly(P<0.05) recorded highest heights of 39cm and 37cm and was followed with records of 29.1cm,29.0cm, 28cm,and 27cm for treatments Sdv_1; Ts x Sdv_2; Ts x Pmv_2; Sdv_1; and Ts x Sdv_1..That the top soil at 14WAS here gave highest seedling heights also confirms soil as universal best anchor for seedlings and crops (FOA,1981; Mbah,1996). The top soil as a nursery growth media stand the best with respect to 'pot – bound' or prolonged stay of seedlings in the nursery. The least for shoot/seedling heights was 5.8cm for treatment Wc x Pmv_1.Treatments that recorded Zero seed emergence also recorded zero shoot/seedling heights.

Table 1 also shows the number of shoot /seedling leaves from 2 – I4WAS following seed emergence of the two variety of Bush mango; *Irvingia gabonensis* and Irvingia *wombolu*. At 2WAS there was no seed emergence across all treatment which agrees with Okafor (1997).

At 4WAS. treatments that recorded seed emergence were significantly (P<0.05) earliest to shoot/seedling leaves expression compared to others at later weeks after sowing(WAS). This includes treatments; Tsv_l; Tsv_2; Sdv_1, Sdv_2; Ts x Wcv_1; Ts x Pmv_1; Ts x Pmv_2; Ts x Sdv_1, Ts x Sdv_2; Pm x Sdv_1 and Pm x Sdv_2 with emerged shoot/seedling number of leaves records of 1.1, 1.2; 1.3, 1.1; 1.5; 1.6,1.7; 1.3 ,1.4; 1.9 and 2.0, respectively. There was no significant (P<0.05) difference for these recorded values.

At 6WAS, shoot/seedling number of leaves were significantly (P<0.05) high at 3.2,3.0;3.0; and 3.0 for treatments Ts x Wcv_1, Ts x Wcv_2;Tsv_1 and Tsv_2 and least at 1.9 on treatment Wc x Pmv_1.This trend also continued till the 14WAS wherein significant(P<0.05) highest number of leaves of 9.2 and 8.1 was recorded for treatment Ts x $Pmv_1$and Ts x Pmv_2.This was followed without any significant(P<0.05) difference by treatments, Tsv_1 ;Tsv_2; Ts x Wcv_1 and Ts x Wcv_2 at 6.4;6.6;6.0; and 5.8 number of leaves. That treatment Topsoil poultry manure mix gave numerical lead in the number of leaves agrees the fact that poultry manure is rich in Nitrogen that readily enhances vegetative growth (Yagodin,1982; Munoz *et al.,* 2004; Baiyeri *et al*., 2012.). The least number of leaves per seedlings was observed at I.0 and 2.0 leaves for treatments Pmv_1 and Ipv_2.

Table 2 shows three (3) measured seedlings growth parameters that included leaf lengths, leaf breadths and stem girths only. At 2WAS there was no seed emergence across all treatment which agrees with Okafor (1997). At 4WAS treatments with earliest weeks to seed emergence recorded earliest to shoot emergence for expression of leaves for data collections that did not significantly (P< 0.05) vary among one another. The leaf lengths sequence of 3.3cm; 3.I cm; 2.2cm, 3.5cm; 3.9cm; 3.5cm,4.0cm; 3.9cm,4.0cm;.3.7cm and 3.9cm for treatments Tsv_l; C; Sdv_1, Sdv_2; Ts x Wcv_1; Ts x Pmv_1; Ts x Pmv_2; Ts x Sdv_1, Ts x Sdv_2; Pm x Sdv_1 and Pm x Sdv_2 respectively.

At 6WAS shoot/seedling leaf lengths were significantly(P<0.05) high at 8.1cm, 7.3cm; 6.9cm and 6.7cm for treatments Pm x Sdv_2; Ts x Pmv_2; Ts x Wcv_1 and Ts x Sdv_1 and least at 2.9cm for treatment Wcv_1.PROTA(2007) reported a range of 4.5 -8cm lengths of leave blades. The trend generally continued till the 14WAS that significant(P<0.05) high leaf lengths of 16.7cm, I5.6cm; I5.5cm; 15.0cm and I3.4cm were recorded for treatments Tsv_1; Ts x Sdv_1; Ts x Wcv_1; Ts x Pmv_2 and Pm x Sdv_2 and the least(2.7cm) for treatment Ipv_2 that coincidentally emerged seed for the first time at same interval of 14WAS.This suggest that Ipv_2 as a treatment is not a sustainable nursery media (Akintoye *et al*., 20I2).

Table 2 also shows that at 2WAS there were data to take across all the treatments but there was for leaf breadths at 4WAS and at 6WAS. Just like as it was in its complimentary leaf lengths records, leaf breadths were at 6WAS significantly (P<0.05) high at 4.8cm, 4.7cm; 4.0cm; 3.4cm and 3.3cm for Pm x Sdv_2; Ts x Wcv_1; Ts x Sdv_2; Ts x Pmv_l and Sdv_1.The least value was 1.8cm on treatment Wcv_1.The generally continued through to the I4WAS with significant(P<0.05) high records of 6.1cm; 5.9cm and 5.Icm for Ts x Pmv_1 ; Ts x Sdv_1 and Tsv_2 and the least(I.9cm) each for Ipv_2 and Pmv_1. PROTA (2007) reported a range of 2 -4 cm breadths of leave blades.

Table 2 also shows data on stem girths with the indication that at 2WAS, there were no to take across all the treatments but there at 4WAS through to the I4WAS. At 4WAS although there were significant (P<0.05) difference, treatments with earliest days to seed emergence recorded earliest stem girths data collections. Thus, at 4WAS, treatments Tsv_l;Tsv_2; Sdv_1, Sdv_2; Ts x Wcv_1; Ts x Pmv_1; Ts x Pmv_2; Ts x Sdv_1, Ts x Sdv_2; Pm x Sdv_1 and Pm x Sdv_2 recorded 0.25cm, 0.26cm, 0.3cm,0.3cm,0.25cm,0.25cm,0.3cm,0.3cm,0.25cm. 0.27cm and 0.28cm respectively. The trend generally continued from the 6WAS to the 14WAS wherein significant(P<0.05) high stem girths of 0.53cm, 0.51cm, 0.48cm,0.47cm and 0.46cm for treatments Ts x Pmv_1, Tsv_l; Ts x Sdv_2, Sdv_1 and Ts x $Wcv_1$and least (0.22cm) was recorded each for treatments Ipv_2 and Wc x Pmv_2 respectively.

CONCLUSIONS/RECOMMENDATIONS

The uptake of this trial result is that for a tremendous earliest day at 8WAS to seed germination, nursery media Sawdust should be used. Then for a sustained pot-bound seedling production with good number of leaves and sizable girths, Topsoil mixture with poultry manure (Ts x Pmv_2) is hereby recommended. Any media mixture involving *Irvingia* peels (waste) gave delayed and little results and in some cases, an already emerged seedling wilders and diminishes just at or near the end of the trial. Finally, these days, the fruiting seasons of the two *Irvingia* species over laps into the other. This appears to suggest a climate change effect which also opens doors for hybridization and other comparative trials involving the two species.

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Table 1. Shoot emergence and other growth parameters of Bush Mango (*Irvingia gabonensis*)

S/N	TREATMENTS	BI-WEEKLY SEED EMERGENCE								SHOOTS HEIGHTS(cm)							NUMBER OF SHOOTLEAVES						
`		2 wk	4 wk	6 wk	8 Wk	10wk	12wk	14wk	%	2 wk	4 Wk	6 wk	8 wk	10 wk	12 wk	14 wk	2 wk	4 wk	6 Wk	8 wk	10wk	12 wk	14 wk
1	Tsv_1	0	3	12	18	24	36	39	86.6 *	0	3.8	5.1	8.0	14.2	21.	39**	0	1.1	3.0	2.7	5.4	5.2	6.4*
2	Tsv_2	0	3	9	15	21	33	39	86.6*	0	3.0	4.9	7.4	13	20.1	37**	0	1.2	3.0	2.5	5.2	4.9	6.6*
3	Ipv_1	0	0	0	0	0	0	0	0.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Ipv_2	0	0	0	0	0	0	2	4.4	0	0	0	0	0	0	3.9	0	0	0	0	0	0	2.0
5	Wcv_1	0	0	3	5	9	6	2	4.4	0	0	3.5	5.5	7.4	5.9	4.0	0	0	1.1	2.0	3.0	4.2	5.1
6	Wcv_2	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Pmv_1	0	0	0	0	3	3	2	4.4	0	0	0	0	4.4	6.8	10.1	0	0	0	0	1.8	3.1	1.0
8	Pmv_2	0	0	3	2	3	7	5	11.1	0	0	4.0	5.0	7.0	12.5	18.0	0	0	1.0	1.6	2.9	5.8	5.4
9	Sdv_1	0	3	9	21	35	42	42	93.3**	0	2.9	4.2	7.5	16.2	22.0	27*	0	1.3	2.5	2.6	3.3	3.5	3.6
10	Sdv_2	0	6	15	33*	36	39	42	93.3**	0	2.5	3.9	7.6	15.4	20.5	29.1*	0	1.1	2.7	2.8	3.1	3.2	3.4
11	Ts x Ipv_1	0	0	0	0	0	4	3	6.6	0	0	0	0	0	4.5	14.0	0	0	0	0	0	3.0	4.0
12	Ts x Ipv_2	0	0	0	0	0	3	2	4.4	0	0	0	0	0	4.1	8.3	0	0	0	0	0	3.1	3.9
13	Ts x Wcv_1	0	3	16	18	30	42	42	93.3**	0	2.6	4.9	9.6	17.0	20.5	24	0	1.5	3.2	2.8	4.6	5.1	6.0*
14	Ts x Wcv_2	0	0	12	21	30	36	36	80.0*	0	0	4.6	10.0	16.1	19.06	22	0	0.0	3.0	2.5	4.2	5.3	5.8
15	Ts x Pmv_1	0	3	12	15	39	42	44	97.7**	0	2.4	6.1	11.4	15.5	18.2	26.0*	0	1.6	2.9	2.8	6.2	7.0	8.1*
16	Ts x Pmv_2	0	4	9	14	38	44	44	97.7**	0	2.5	5.9	11.6	15.0	19.0	28.0*	0	1.7	2.7	2.4	6.0	7.3	9.2*
17	Ts x Sdv_1	0	4	12	21	24	36	42	93.3**	0	2.2	5.3	11.0	14.1	17.1	27*	0	1.8	2.6	3.1	4.1	4.5	4.9
18	Ts x Sdv_2	0	5	15	18	27	33	43	95.5**	0	2.1	5.0	10.9	14.8	18.0	29*	0	1.3	2.7	3.3	4.1	4.5	4.9
19	Ip x Wcv_1	0	0	0	0	0	2	2	4.4	0	0	0	0	0	4.7	8.5	0	0	0	0	0	2.0	2.5
20	Ip x Wcv_2	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Ip x Pmv_1	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Ip x Pmv_2	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Ip x Sdv_1	0	0	0	0	0	0	2	4.4	0	0	0	0	0	0	7.8	0	0	0	0	0	0	2.0
24	Ip x Sdv_2	0	0	0	0	0	4	0	0.0	0	0	0	0	0	5.1	0	0	0	0	0	0	1.0	0
25	Wc x Pmv_1	0	0	3	0	0	3	3	6.6	0	0	2.1	0	0	2.9	5.8	0	0	1.9	0	0	3.0	4.0
26	Wc x Pmv_2	0	0	0	0	0	4	4	8.8	0	0	0	0	0	3.1	7.6	0	0	0	0	0	3.1	3.9
27	Wc x Sdv_1	0	0	9	2	2	33	36	80.*	0	0	3.2	7.3	9.5	13.7	17.8	0	0	2.6	2.7	3.5	3.7	4.2
28	Wc x Sdv_2	0	0	6	5	18	27	33	73.3	0	0	3.0	7.1	8.8	12.1	20.0	0	0	2.3	2.9	3.3	3.8	4.0
29	Pm x Sdv_1	0	4	9	5	21	39	39	86.6*	0	2.6	3.0	6.1	12.0	16.3	22	0	1.9	2.8	3.0	3.6	4.9	4.5
30	Pm x Sdv_2	0	6	12	27*	27	30	33	73.3	0	2.9	4.8	6.4	11.3	17.1	20.00	0	2.0	2.4	2.7	3.8	5.0	4.1
LSD	(5%)	Ns	2.0	3.5	3	8	9	5	11.11	Ns	Ns	1.9	4.2	5.7	4.9	10.0	Ns	Ns	0.9	1.2	2.0	3.2	4.1

Table 2. Shoot growth parameters of Bush Mango (*Irvingia gabonensis*)

	TREATMENT	LENGHTS OF SHOOTS LEAVES (cm)							BREADTHS OF SHOOTS LEAVES (cm)							STEM GIRTHS OF SHOOTS (cm)						
		2 wk	4 Wk	6 wk	8 Wk	10 Wk	12 wk	14 wk	2 wk	4 wk	6 Wk	8 wk	10 Wk	12wk	14 Wk	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk	14 wk
1	Tsv$_1$	0	3.3	5.2	11.3	13.4	14.2	16.7**	0	2.1	3.1	3.5	4.4	5.1	5.0*	0	0.25	0.3	0.34	0.4	0.42	0.51*
2	Tsv$_2$	0	3.1	5.1	10.5	13.0	14.0	15.5**	0	1.8	2.9	3.7	4.5	5.0	5.1*	0	0.25	0.3	0.35	0.39	0.41	0.50*
3	Ipv$_1$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Ipv$_2$	0	0	0	0	0	0	2.7	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0.22
5	Wc$_1$	0	0	2.9	6.0	8.6	9.0	7.5	0	0	1.8	3.3	1.5	1.1	2.1	0	0	0.20	0.26	0.30	0.33	0.24
6	Wc$_2$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Pmv$_1$	0	0	0	0	6.3	8.9	7.0	0	0	0	0	1.2	3.1	1.9	0	0	0	0	0.25	0.34	0.31
8	Pm$_2$	0	0	5.9	8.4	10.1	11.5	12.2*	0	0	2.6	3.8	4.6	4.1	3.9	0	0	0.26	0.30	0.33	0.39	0.40
9	Sdv$_1$	0	2.2	6.5	10.1	12.0	10.4	9.3	0	1.7	3.3	4.1	5.0	4.3	4.1*	0	0.30	0.31	0.35	0.40	0.43	0.46
10	Sdv$_2$	0	3.5	6.3	11.0	12.2	10.1	9.1	0	2.0	3.0	4.3	4.9	4.1	3.9	0	0.30	0.32	0.36	0.40	0.44	0.47*
11	Ts x Ipv$_1$	0	0	0	0	0	5.1	10.1*	0	0	0	0	0	4.8	4.5*	0	0	0	0	0	0.21	0.31
12	Ts x Ipv$_2$	0	0	0	0	0	5.0	11.1*	0	0	0	0	0	4.1	4.4*	0	0	0	0	0	0.22	0.33
13	Ts x Wcv$_1$	0	3.9	6.9	11.8	12.0	14.3	15.5**	0	2.0	4.7	5.9	6.2	5.6	5.1*	0	0.25	0.30	0.34	0.39	0.42	0.46
14	Ts x Wcv$_2$	0	0	7.0	10.7	12.4	14.0	14.9**	0	0	4.0	5.5	6.0	5.4	5.0*	0	0	0.26	0.31	0.35	0.39	0.41
15	Ts x Pmv$_1$	0	3.5	7.3	10.5	12.2	13.1	14.9**	0	1.8	3.4	3.9	4.3	5.6	6.1**	0	0.25	0.35	0.40	0.43	0.47	0.53*
16	Ts x Pmv$_2$	0	4.0	7.0	9.9	13.1	13.0	15.0**	0	2.1	3.1	4.1	4.5	5.8	6.0**	0	0.30	0.36	0.40	0.44	0.48	0.51*
17	Ts x Sdv$_1$	0	3.9	6.7	8.8	9.2	9.5	15.6**	0	2.2	3.9	4.4	4.5	5.1	5.9**	0	0.3	0.28	0.39	0.41	0.44	0.47*
18	Ts x Sdv$_2$	0	4.0	6.5	8.2	9.1	9.3	15.0**	0	3.1	4.0	4.1	4.2	5.3	5.7**	0	0.25	0.30	0.37	0.40	0.43	0.48*
19	Ip x Wcv$_1$	0	0	0	0	0	9.6	5.3	0	0	0	0	0	0.4	0.31	0	0	0	0	0	0.3	0.24
20	Ip x Wcv$_2$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Ip x Pmv$_1$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	Ip x Pmv$_2$	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Ip x Sdv$_1$	0	0	0	0	0	0	3.2	0	0	0	0	0	0	3.0	0	0	0	0	0	0	0.23
24	Ip x Sdv$_2$	0	0	0	0	0	3.0	0	0	0	0	0	0	3.8	0	0	0	0	0	0	0.26	0
25	Wc x Pmv$_1$	0	0	6.5	0	0	2.7	4.9	0	0	2.5	0	0	2.9	3.3	0	0	0.21	0	0	0.28	0.23
26	Wc x Pmv$_2$	0	0	0	0	0	2.5	6.3	0	0	0	0	0	2.4	4.8*	0	0	0	0	0	0.24	0.21
27	Wc x Sdv$_1$	0	0	6.6	9.2	9.6	8.5	8.1	0	0	4.1	4.2	4.5	4.9	4.2*	0	0	0.26	0.31	0.36	0.34	0.32
28	Wc x Sdv$_2$	0	0	6.5	9.0	9.4	8.3	8.0	0	0	3.9	4.0	4.1	5.1	4.5*	0	0	0.25	0.30	0.35	0.33	0.30
29	Pm x Sdv$_1$	0	3.7	7.9	9.7	9.1	10.2	13.4*	0	2.2	4.6	5.0	3.4	4.0	3..8	0	0.27	0.31	0.34	0.39	0.40	0.31
30	Pm x Sdv$_2$	0	3.9	8.1	9.5	9.0	10.4	13.0*	0	2.4	4.8	4.9	3.1	3.9	3.5	0	0.28	0.32	0.36	0.40	0.41	0.33
LSD	(5%)	Ns	Ns	3.0	5.3	5.0	4.6	4.8	Ns	Ns	1.9	2.1	2.3	1.9	2.0	Ns	0.5	0.11	0.10	0.085	0.09	0.12

NS = Not Significant *Significant **High Significant

EVALUATION OF DIFFERENT PRE-TREATMENT METHODS ON THE GERMINATION POTENTIAL OF *PIPPER GUINEENSE* (SCHUMACH. & THONN.) SEEDS IN NORTHERN GUINEA SAVANNA ZONE OF NIGERIA

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ABSTRACT

A study was carried out to determine the effect of pre-germination treatments on growth of Pipper guineense at Savanna Forestry Research Station Samaru, Zaria. The treatments include seeds with removed pericarps sown in river sand, seeds with removed pericarps sown in top soil, seeds with unremoved pericarps sown in river sand and seeds with unremoved pericarps sown in top soil. The experiment was laid out in a completely randomized design with five replications. The results of germination test show significantly ($P \leq 0.05$) higher germination percentage among all treatments combinations. Seeds with removed pericarps sown in top soil recorded the highest (95%) germination followed by seeds with unremoved pericarps sown in top soil (52.9%), seeds with removed pericarps sown in river sand (39.6%) while seeds with unremoved pericarps sown in river sand (19.6 %) had the lowest germination. Similar trends were observed with seedling heights and number of leaves with seeds having removed pericarps sown in top soil (4.08cm and 3.30) recording highest seedling height and number of leaves and this was followed by seeds with unremoved pericarps sown in top soil (3.64cm and 2.56), seeds with removed pericarps sown in river sand (3.44cm and 1.46) while seeds with unremoved pericarps sown in river sand (2.64cm and 1.32) had the lowest seedling height and number of leaves respectively. The above findings have shown the potential of all the pre-germination treatments especially seed with removed pericarps sown in top soil as most effective mechanism to break the dormancy of the seed in order to initiate germination and growth for efficient plantation establishment and conservation.

Key words: Pre-germination treatment**,** *Pipper guineense*, Germination, Potential

INTRODUCTION

Forests provide products for different uses at households and industrial levels (Appiah 2009). These products are grouped into timber and non-timber products (NTFPs). Although timber products are highly valued worldwide, the NTFPs which play an important role in sustaining livelihoods of communities living around forest areas, but have been given minimum attention. The contribution of non-timber Forest resources to the rural economy is known to be substantial but this cannot be quantified because of reliable data that are lacking. Lack of knowledge about the resources themselves and the demand for and value of these products make sound knowledge on the management planning extremely difficult. Precise information on the abundance, distribution, variation ecology, reproductive biology, traditional and new method of propagation of these non-wood forest resources are grossly inadequate (Gbile and Soladoye, 1995).

It is true that many of the major crops of the world are produced in areas outside their place of origin and Nigeria with the rest of Africa are not exceptions in this respect. It is equally true however, that at least 2,000 indigenous, food plants exist in various parts of the continent, many have been used for thousands of years but are now little appreciated. Most have not been assessed for their potential and they receive very scanty attention of Researchers and bodies that promote research in Nigeria, spice crops such as *Piper guineense, Ocimum graticimum* and so on are crops that receive very poor attention, (Adedipe, 1993).

Another factor affecting our indigenous species like *Piper guineense* is the issue of inadequate policy guidelines and lack of practicable conservation measures regarding the research, development and its initialization. Thus, at present, greater attention is paid to the development of exotic crops to the neglect of the indigenous ones. This has then led to the under-utilization of the potential species.

Today, *Piper guineense* constitutes part of the Nigerian crops that are fast disappearing from our natural vegetation and it should be noted that this crop has an important role to play in the food and chemical extractive security of our people. Food security can be defined as the access by all people at all times to enough food for an active, healthy life and it depends on both the availability of food and the ability to acquire it. Increasing food security involved increasing food supplies in addition to increasing income of the rural poor. There is a great potential for this disappearing crop i.e. *Piper guineense* and all other disappearing crops in general in the mixed crop farming system. If food and fibre production on continuous basis must be ensured in Nigeria, there is the need to conserve and re-cultivate some of these disappearing crops urgently. The value of some of these plants is better appreciated in their role in alternative medicine. There is then the need to prevent the loss of bio diversity (Okojie, 1993).

Piper guineense or African black pepper, a climbing perennial plant of the family Piperaceae, is used as spice, food preservative, insecticide, herbal medicine, and as fragrance in the cosmetic industry (Nwozo *et al.,* 2011). It is used for the treatment of cough, bronchitis, intestinal diseases, and rheumatism (Sarah *et al*., 2011). *Piper guineense* stimulates the digestive enzymes, lowers lipid peroxidation, prevents oxidative damage, and inflammation (Ogunniran, 2009). *Piper guineense* is a spice plant from the family Piperaceae and from genus piper. It is a West African spice plant commonly called Ashanti pepper. It is known as Uziza in Igbo and Iyere in Yoruba. Other common names are Benin pepper, Guinea pepper and false cubeb. Spices generally are parts of various plants cultivated for their aromatic pungent or otherwise desirable substances. They consist of rhizomes, bulbs, flower bud, fruit, seed, and leaves. They usually are categorized into tiny wild fruits, nuts, herbs, and leafy vegetables. *Piper guineense*, a spice plant from the class Magnoliopsida, order Piperales and family Piperaceae, is an important plant that has culinary, medicinal, cosmetic and insecticidal uses (Juliani *et al*. 2013, Besong *et al.* 2016). The plant is found in tropical regions of central and West Africa, where it is semi-cultivated in countries like Nigeria, especially in the southern parts (PURSEGLOVE et al. 1981). It is known in Nigeria as 'Uziza' (Igbo), 'Iyere' (Yoruba) and 'Masooro' (Hausa). Other common names are Ashanti pepper, Guinea pepper, Benin pepper and false cubeb. *Piper guineense* is an important source of various nutrients and phytochemicals such as proteins, carbohydrates, vitamins, minerals, fat, alkaloids, steroids, lignins, glycosides, saponins, flavonoids, tannins and phenolic compounds. It is also known to have antibacterial, antioxidant, anti-inflammatory, hepatoprotective, fertility, aphrodisiac, anticonvulsant and larvicidal properties (ECHO *et al*., 2012, Okoye and Ebeledike 2013, Nwankwo *et al*., 2014, Besong *et al*., 2016, Ukpai *et al*., 2017).

Germination is key to the successful regeneration and propagation of plants. The condition where an intact, viable seed fails to germinate under favourable conditions is known as dormancy (Bewley, 1997). The intensity of dormancy could be influenced by the species, genome and the type of dormancy (Zoghi *et al.,* 2011). Common methods that have been suggested to break physical dormancy in seeds include scarification by nicking, hot water and acid treatments, stratification (Vandenbeldt, 1992). However, very little effort has been directed towards using this indigenous tree in afforestation programs. The main problem encountered in propagating seedlings of most indigenous trees for afforestation programs in arid and semiarid areas is as a results of dormant seeds (Bewley, 1997). Seeds of such species need to be subjected to some chemical or physical treatment to break dormancy and obtain uniform germination (Hossain *et al.,* 2005).

Extinction is an irreversible process and so, we must not allow this native species to become extinct. This crop and many others can become extinct in a few decades if no proper attention is paid to the problem and so, desired attention should be given to these crops by the appropriate authorities. Therefore, this study investigates the seed germination of *Piper guineense* in different soils: top soil and river soil.

MATERIALS AND METHODS

Study Area

The study was carried out at Savanna Forestry Research Station Nursery, Samaru (11^0 11" N, 07^0 38" E and 686m above sea level) Zaria.

Treatments and Experimental Design

The treatments consisted of four pre-germination methods (removed pericarp/River Sand, removed pericarp/topsoil, not-removed pericarp/River Sand and not-removed pericarp/topsoil) which were replicated five times in a completely randomized design with 40 seeds per replicate which resulted in a total of 200 seeds per treatment. A total of 800 seeds were used for the whole experiment.

Sowing of seed

Fresh seeds of *Piper guineense* used for this study were purchased from Ojoo market (Ibadan, Nigeria) and were identified and authenticated at the Forest Herbarium Ibadan (FHI), Forestry Research Institute of Nigeria. Sieved top soil collected from Teak plantation and thoroughly washed river sand were filled into 10 germination boxes each, measuring 90cm x 45cm x 30cm. Forty (40) seeds each were sown in germination boxes according to the treatments combination resulting in a total of 20 germination boxes used for the experiment. Each treatment replicate was thoroughly watered every other day and kept for a period of two weeks, and the number of seeds that germinated per treatment were recorded. After germination, 15 randomly selected seedlings were transported into each polythene pots filled with top soil and river sand according to the treatments. The growth of seedlings was observed for four weeks, and constantly watered to avoid dryness.

Data collection and analysis

Data collected includes number of germinated seeds from each treatment, and cumulative average recorded after two weeks, while data on seedling height and number of leaves were obtained from five randomly selected plants and their cumulative average recorded after four weeks. Germination percentage was computed using the formula below.

$$\text{Germination \%} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

All data collected were subjected to analysis of variance (ANOVA) using SAS software package. Mean differences among treatments were separated using Least Significant Difference (LSD) at *P*=0.05

RESULTS AND DISCUSSION

The results of effect of different pre-germination treatments on germination and growth of *Pipper guineense* seeds and seedlings are discussed below.

Effect of Pre-germination treatments on seed germination of *Pipper guineense*

There were significant ($P \leq 0.01$) differences in germination of *P. guineense* seeds subjected to different pre-germination treatments 2weeks after sowing (Table 1). Seeds with removed pericarp (67.3%) recorded significantly ($P \leq 0.05$) higher germination than seeds with unremoved pericarp (36.3%). Similarly, seeds planted in top soil (73.9%) had significantly ($P \leq 0.05$) higher germination than seeds planted in river sand (29.6%) respectively.

Table 1: Effect of pre-germination treatments on germination of *Pipper guineeense* seeds

Treatment	Germination (%)
Seed Pericarp	
Removed	67.3a
Not Removed	36.3b
SED±	3.369
Soil Type	
River sand	29.6
Top soil	73.9a
SED±	3.368
Interaction	
Seed Pericarp*Soil Type	**

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using LSD
**= Significant at ($P \leq 0.01$)

Interaction between seed pericarp and soil type on germination of *Pipper guineense* seeds

The interaction between seed pericarp and soil type on germination of *P. guineense* 2WAS is presented in table 2. There was significant interaction of the two seed pericarp with the two soil type on the germination of *P. guineense* 2weeks after sowing. Seeds with removed pericarp sown in top soil (95.0%) recorded significantly ($P \leq 0.05$) higher germination than other three treatments. This was followed by seeds with unremoved pericarp sown in top soil (52.9%) which also recorded significantly ($P \leq 0.05$) higher germination than seed sown in river sand with removed pericarp (39.6%) and seed sown in river sand with unremoved pericarp (19.6%). The germination recorded from seed sown in river sand with removed pericarp was also significantly ($P \leq 0.05$) higher than seed sown in river sand with unremoved pericarp.

Table 2: Interaction between seed pericarp and soil type on germination of *Pipper guineense* seeds

	Germination (%)	
	Seed Pericarp	
Treatment	Removed	Not Removed
Soil Type		
River sand	39.6c	19.6d
Top soil	95.0a	52.9b
SED±	4.763	

Means followed by same letter(s) in the same column and row are not different statistically at *P=0.05* using LSD

Effect of Pre-germination treatments on seedling height of *Pipper guineense*

There were significant ($P \leq 0.01$) differences in seedling height of *P. guineense* seeds subjected to different pre-germination treatments 4weeks after

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sowing (table 3). Seeds with removed pericarp (4.8) recorded significantly ($P \leq 0.05$) higher seedling height than seeds with unremoved pericarp (3.8). Similarly, seeds planted in top soil (3.7) had significantly ($P \leq 0.05$) higher seedling height than seeds planted in river sand (3.9) respectively. There was no significant ($P \geq 0.05$) difference in seedling height resulting from the four different treatment combinations.

Table 3: Effect of pre-germination treatments on seedling height of *Pipper guineeense*

Treatment	Seedling Height (cm)
Seed Pericarp	
Removed	4.8a
Not Removed	3.8b
SED±	0.236
Soil Type	
River sand	3.9b
Top soil	3.7a
SED±	0.236
Interaction	
Seed Pericarp*Soil Type	NS

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using LSD
NS = Not significant

Effect of Pre-germination treatments on number of leaves of *Pipper guineense*

Significantly ($P \leq 0.05$) higher number of leaves were observed on *P. guineense* seedling subjected to different pre-germination treatments 4weeks after sowing (table 4 and figure 3). Seeds with removed pericarp (3.0) recorded significantly ($P \leq 0.05$) higher number of leaves than seed with unremoved pericarp (2.4). Also, seeds planted in top soil (3.7) had significantly ($P \leq 0.05$) higher number of leaves than seeds planted in river sand (1.7) respectively. There was no significant ($P \geq 0.05$) difference in number of leaves resulting from the four different treatment combinations.

Table 4: Effect of pre-germination treatments on number of leaves of *Pipper guineeense* seedling

Treatment	Number of Leaves
Seed Pericarp	
Removed	3.0a
Not Removed	2.4b
SED±	0.193
Soil Type	
River sand	1.7
Top soil	3.7
SED±	0.193
Interaction	
Seed Pericarp*Soil Type	NS

Means followed by same letter(s) in the same column are not different statistically at *P=0.05* using LSD NS = Not significant

CONCLUSION

The results of this study shows that seeds of *Piper guineense* germinate better in top soil than river sand because of variations in seedlings heights and number of leaves produced. Also, the removal and non-removal of pericarps influences the growth rate, height and leaf production of the plant. It was found that *P. guineense* seeds with removed pericarps have higher rates of germination and quicker growth rates than seeds with unremoved pericarps. The combined effect of the two factors on germination and growth of *P. guineense* seeds shows that seeds with removed pericarps that were sown in top soil perform significantly better than other treatments combination. Hence, can be adopted to break its dormancy for better seedling establishment.

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RELEVANCE OF NUT FLOATATION TEST AND SOWING MEDIUM TO THE GERMINATION OF CASHEW (*ANACARDIUM OCCIDENTALES* L.)

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ABSTRACT

Seed nuts play a vital role as planting material in the production of rootstocks and seedlings for cashew plantations establishment. One of the major challenges faced by cashew nursery operators and farmers is low seed germination and this always contributes to the losses encountered in nursery management. This study was focused at investigating the effects of seed viability test on the germination of three cashew biotypes using three sowing media. The experiment was carried out at the nursery unit of the Cocoa Research Institute of Nigeria, Ibadan. Two hundred nuts Jumbo, Medium and Small cashew biotypes were used for floatation test in water. The same nuts were used for seed germination assessment in pre-germination chamber by sawdust, in polythene bags filled with top soil and in-situ using completely randomized experimental design. Jumbo biotype recorded the highest percentage cashew nut floatation in water (62.33%) while the least floated nuts (19%) were observed in Small biotype. Mean days to germination of the floated and sank nuts sown In-pot medium across all the three biotypes (with a range of 14.7 – 17.4) were lower than those sown in Pre-germination chamber and In-situ. The percentage of floated nuts that germinated was very high in Jumbo (53% - 58%) and least in Small biotype (37% - 40%). This study concludes that cashew nut sown in pot medium tends to germinate faster than the nuts sown in pre-germination chamber and in-situ. In addition, nut floatation in water is not an appropriate test for cashew viability determination because good percentage (37% - 58%) among the floated nuts will germinate.

Key words: Cashew germination, Nut floatation test, Seed viability, Pre-germination

INTRODUCTION

Cashew (*Anacardium occidentale* L.), an important edible nut crop, is cultivated in the tropical region of Africa, India, and Brazil, (Wickramasinghe, 2002). The nut is a basic input and is vital to the propagation of cashew; in the production of rootstocks and seedlings for plantations establishment. To grow plants from seed, some knowledge of the quality and germination requirements of the seed is required. Not all fruits will produce seed and not all seed produced will be viable. There are a number of quick tests that can be conducted on seed to determine whether or not the seed is potentially viable. Insect damaged seed and shriveled seed is unlikely to germinate. Fruits with no seed within will also not germinate (Seed notes, 2000). There are several ways for testing seeds viability; these include scarification, cutting test, excised embryo technique, biochemical and chemical method such as acid pre-treatment (Agbogidi *et al*., 2007), colour method, transparency, and germination method as well as floatation technique (Singh *et al*., 2011). However, floatation method is the fastest way of testing seeds viability, which is based on the observation that empty or nonviable seeds float while viable seeds sink or settle down to the bottom of the container (Bello and Gada, 2015; Pamela, 2012). Adeyemi and Hammed (2001) conducted a preliminary study on the effects of floatation test on the germination of two Iwo cashew selections and reported that the germination of floaters was as good as sinkers. Their study was limited to the varieties that were available as at the time the experiment was conducted (Iwo Selection) and only one sowing method (in-situ). Therefore, this is study was aimed at investigating the effects of seed floatation viability test and three sowing media on the germination of three cashew biotypes that are currently cultivated by farmers in Nigeria.

MATERIALS AND METHODS

The study was carried out between May and August, 2020 at the nursery unit of Cocoa Research Institute of Nigeria (CRIN) (latitude 4°- 14°N and longitude 3° - 14°E), Oyo State, South Western Nigeria. The three cashew biotypes; Jumbo, Medium and Small nut sizes produced in the current season with no sign of damage, insect pest attack or disease symptoms were collected from the cashew germplasm of the Institute. Two hundred nuts randomly selected from each biotype were introduced into a bucket fill with ordinary water at room temperature to separate and count those that sink in water from the floating ones and for data taken. The nuts that sank in water and those that floated were separately used for germination evaluation by using three different sowing media / environment; Pre-germination chamber using sawdust in a chamber, In-pot (polythene bag filled with top soil) and In-situ (on the farm land). Data were collected from each of the treatment categories on number of seeds germinated and days to germination after sowing. Data collected on cashew nut floatation test and germination were analyzed using descriptive statistics, while days to germination data were analyzed by variance (ANOVA) technique using SAS.

RESULTS AND DISCUSSION

The percentage cashew nut floatation in water varied widely across the biotypes (Fig. 1) with highest floatation (62.33%) recorded in Jumbo the while the least floatation (19%) was observed in Small biotype. Reverse was the case for the nuts (seeds) that sank in water. Small boitype recorded the highest sinkers percentage (81%) followed by Medium (65.33%), while least sinkers (37.67%) were observed in Jumbo. From this trend, it appears that there is simple relationship between cashew nut sizes and their floatation in water. Large cashew nuts tend to float more in water than smaller nut sizes and vice versa for cashew nuts sinking in water.

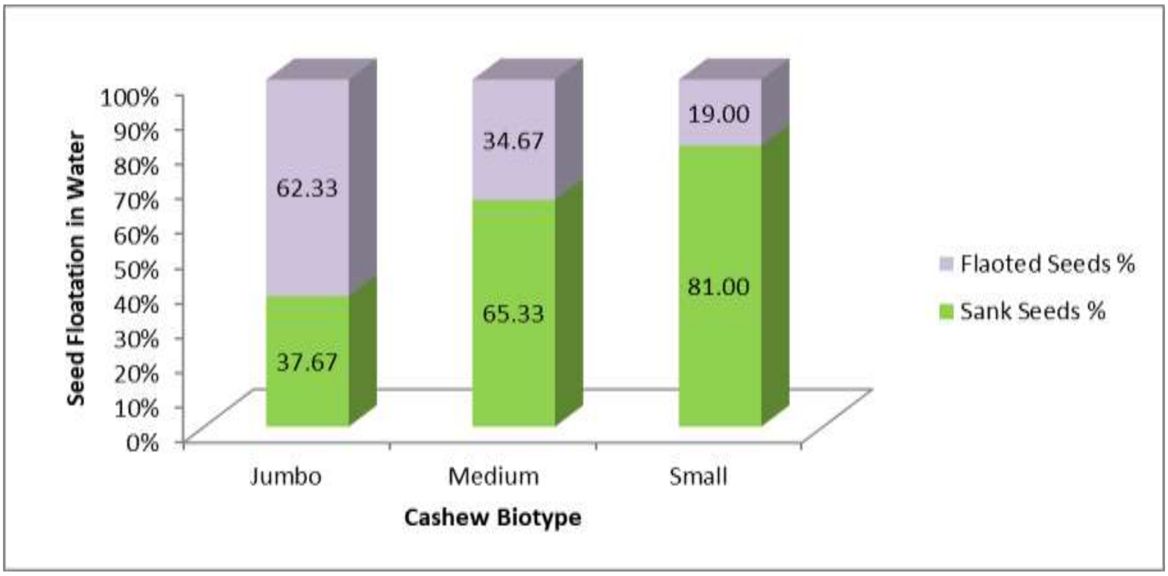

Figure1. Percentage of cashew nuts floated and sank during viability test of three cashew biotype

The summary statistics of the ANOVA for days to germination of the three cashew biotypes sown in three media is presented in table 1. The effect of germination medium as a main effect was highly significant (P≤0.001) on the days to germination. Interaction between nut floatation in water and germination medium was significant (P≤0.05) while biotype by germination medium interaction was highly significant (P≤0.001). From table 2, variation was observed in the days to germination of floated / sank nuts with respect to sowing medium with the highest Coefficient of Variation (27.19%) observed in Medium nuts that sank in water, while lest CV (11.72%) was observed in Medium nuts that floated in water. This indicates that Medium cashew nuts that sank in water are most sensitive to the sowing medium, while the floated nuts of the same biotype are least sensitive to sowing medium. The mean days to germination of the floated and sank nuts sown In-pot medium across all the three biotypes (with a range of 14.7 – 17.4) were lower than those sown in Pre-germination chamber (10.30 – 23.55) and In-situ (17.65 – 22.0). This implies that cashew nuts sown In-pot medium (polythene bags filled with top soil) tends to germinate faster than the nuts sown in Pre-germination chamber and In-situ for both sinks and floated nuts as compare to other sowing medium.

The results of cashew seed germination with respect to those that sank and floated in water as well as the three media for seed sowing across the treatments is presented in figure 2. First, there appears to be no significant difference in the germination percentage of cashew nuts sown In-pot, Pre-germinated in chamber using sawdust and In-situ across all the treatments. Furthermore, germination of cashew nuts that sank in water were very high in all the biotypes (77% - 90%) with no significant variations observed across the sowing media. It is noteworthy to report that the percentage of floated nuts that germinated was highest in Jumbo (53% - 58%) and least in Small biotype (37% - 40%). Adeyemi and Hammed (2001) made similar observation in their reports.

Table 1. Analysis of variance for germination days of three cashew biotypes sown in three media

Source variation	Degree of Freedom (df)	Days to Germination
Floatation in water	1	0.61
Germination Medium	2	2466.28***
Biotype	2	16.43
Floatation in water*Germination Medium	2	68.41*
Biotype *Floatation in Water	2	7.9
Biotype*Germination Medium	4	98.62***
Error	688	4.08
Mean		19.29
CV%		21.19

*, *** = Significant at P≤0.05 and 0.001

Table 2. Mean days to germination of three cashew biotypes used in floatation test and sown in different media

	Jumbo nuts		Medium nuts		Small	
	Sank	Floated	Sank	Floated	Sank	Floated
In-pot Medium	16.50±0.87	15.40±0.84	14.70±0.93	17.35±0.80	15.80±1.10	15.35±0.30
Pre-germination Chamber	21.30±0.94	19.30±0.84	20.90±1.06	21.30±0.81	22.50±1.16	23.55±0.94
In-situ	20.75±1.08	22.0±0.68	21.80±0.89	17.65±0.82	21.60±1.21	18.85±0.73
SD	2.63	3.76	3.87	2.20	3.64	4.12
CV%	13.48	18.89	27.19	11.72	18.23	21.40

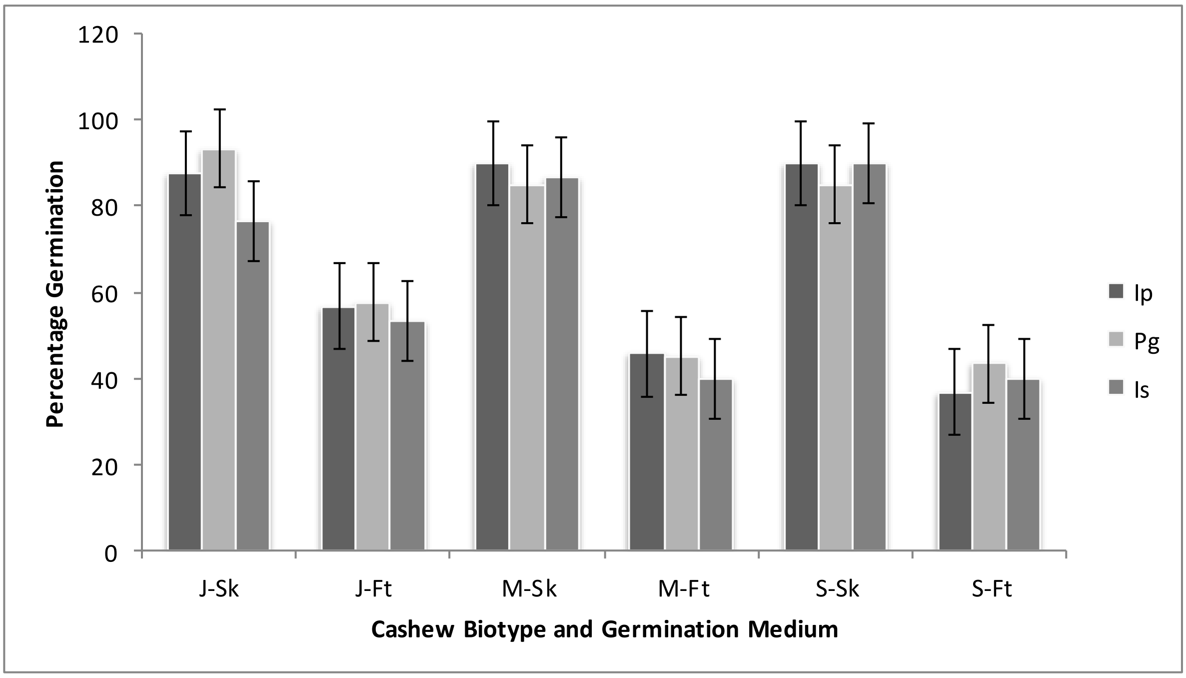

Figure 2. Percentage germination of floated and sank nuts of three cashew biotypes in different sowing media

J-Sk = Jumbo-Sank, J-Ft = Jumbo-Floated, M-Sk = Medium-Sank, M-Ft = Medium-Floated, S-Sk = Small-Sank, S-Ft = Small-Floated, Ip = In-pot medium, Pg = Pre-germination chamber, Is = In-situ

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EFFECT OF DRYING METHODS ON SEED GERMINATION OF BLACK NIGHTSHADE (*SOLANUM NIGRUM*)

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ABSTRACT

Drying operation is a critical step in the post-harvest processing of black nightshade seeds. This study was carried out to investigate the influence of drying methods on seed germination of this vegetable. Fruits of one accession of black nightshade were harvested at physiological maturity and extracted immediately after harvest and dried using three drying methods thereafter subjected to germination test. Traits assessed were germination percentage and emergence index. The results of analysis of variance revealed that the effect of drying method was highly significant (P<0.01) on germination percentage and emergence index of black nightshade seeds. Germination percentage of sample dried under shade using electric fan was significantly outstanding (65.06%). The germination value (46.7%) for sample dried with seed dryer was significantly higher than the value (31.7%) of sample dried with sun. Moreover, <70% germination percentage observed suggest that black nightshade seeds need treatment to break the dormancy before planting. These results support conclusion that shade drying of black nightshade seeds would enhance germination and speedy emergence.

Key words: Emergence index, germination, vegetable, traits

INTRODUCTION

Black Nightshade (*Solanum nigrum* L.) is one of African indigenous vegetables belonging to Solanaceae family. However, production of this mainly constrained by lack of quality seeds occasioned by methods of seed harvesting, processing and storage. Adebooye and Opabode (2005) reported that non-availability of improved seeds constitutes a major constraint to the cultivation and productivity of indigenous leaf vegetables (ILVs) of Africa. Drying operation is a critical step in the post-harvest processing of black nightshade seeds however; seed quality can be reduced during drying due to injury caused by unfavorable drying conditions. Black nightshade fruits harvested at physiological maturity usually contain high moisture of 60 to 70% hence the sooner the seed is extracted; cleaned and dried the better will be the quality. Germination and vigor are crucial aspects of seed quality therefore germination tests are used worldwide to determine the maximum germination potential of a seed batch under optimum conditions while speed of emergence of seedlings is one of the oldest seed vigour concepts. The objective of this study therefore was to compare three drying methods with a view to identify the best method suitable for a successful and cost effective production of biologically viable black nightshade seeds.

MATERIALS AND METHODS

Seed Production and processing

Fruits of one accession of black nightshade were harvested at physiological maturity stage during the growing season of 2015 and extracted immediately after harvesting. The extraction was done by hand to minimize mechanical damage. The extracted seeds were spread on absorbent cloth for six hours and thereafter partitioned into three equal parts (100g) and the samples were packed inside cloth bags.

Conduct of the experiment

The experiment was conducted at the Seed Testing laboratory (STL) of NACGRAB in July 2015 in a completely randomized design with five replications, in 3 x 3 factorial design. The factors were (i) Drying methods: shade-drying with an electric fan at room temperature, mechanical seed dryer at 30^{o}C and sun-drying (ii) Drying time: 3days, 6 days and 9 days.

One hundred seeds from each sample were drawn and evaluated for standard germination test according to ISTA rules (ISTA, 2003) in five replicates. Germination Index (GI) was calculated by taking the germination counts at 5, 7 and 9 days after planting using the following formula:

$$GI = \frac{\text{No of germinated seed}}{\text{Days of first count}} + \ldots + \frac{\text{No of germinated seed}}{\text{Days of final count}}$$

Statistical Analysis

Data on germination percentage were subjected to analysis of variance (ANOVA) using Statistical Analysis Software, SAS Version 9.1 (SAS, 1990). Pertinent means were separated by the use of the least significant difference (LSD) at 0.05 level of probability.

RESULTS AND DISCUSSION

The results of analysis of variance revealed that the effect of drying methods was highly significant ($P<0.01$) on germination percentage and emergence index of black nightshade seeds (Table 1). Somado, *et al*., (2006) also observed variation in germination performance of rice varieties due to drying methods when compared with the efficiency of sun-, shade-, silica gel- and conventional room drying on seed quality of rice.

Table 1. Mean squares from analysis of variance for standard germination test (STG) and germination index (GI) of black nightshade seeds evaluated using three drying methods

Source of variation	Degree of freedom	Standard germination (%)	Emergence index (days)
Replication	4	39.1ns	0.2ns
Drying method (DM)	2	4321.1**	1.5**
Drying time (DT)	2	5186.4**	1.4**
DM*DT	4	826.3**	0.8**
Error	32	84.1	0.1
Total	44	572	0.3
R^2		0.9	0.8
CV		19.1	4.1
Mean		48	7.5

*, **, Significant at probability level of 0.05 and 0.01, respectively; ns = Not Significant

Effect of drying methods on germination and emergence index of black nightshade seeds

Shade drying at room temperature using electric fan gave the best germination (65.1%) and lowest emergence index (7.3 days) among the three methods (Table 2). Drying using seed dryer at 30°C also showed tendency to enhance early germination (7.4 days) however, the germination performance was significantly lower (46.7%) when compared to shade drying method (Table 2). Sun drying gave the lowest germination (31.7%) and highest (7.9 days) germination index indicating that this method is not suitable for drying black nightshade seeds (Table 2). Moreover, in all the three methods used, the germination counts were below 65% which could be attributed to an innate dormancy in black nightshade seeds.

Table 2. Germination and Emergence index of black nightshade seeds as affected by drying methods and time.

Source of variation	Standard germination (%)	Emergence index (days)
DRYING METHOD		
Sun drying	31.7c	7.9a
Seed dryer	46.7b	7.4b
Shade drying	65.1a	7.3b
LSD	**6.8**	**0.2**
DRYING TIME		
Three Days	27.6c	7.5b
Six Days	64.0a	7.8a
Nine days	52.4b	7.2c
LSD	**6.8**	**0.2**

Means with the same letter are not significantly different at P= 0.05

In conclusion, the study identified shade drying method as the most effective method in enhancing germination of black nightshade seeds.

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PRELIMINARY INVESTIGATIONS INTO POLYEMBRYONY IN NIGERIAN LOCAL MANGO LANDRACES AND THEIR PERFORMANCE IN POTTING BAGS

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ABSTRACT

This study was carried out at NIHORT Ibadan as preliminary studies towards enhancing availability of improved mango seedlings for orchard establishment. Hence the evaluation of early germination in the pre-nursery, multiple seedlings incidence and early growth and development of seedling in poly-pots was carried out. Ripe Mango fruits were collected and depulped, air dried and cut open to remove the seed from the stone. The seeds were planted in cured sawdust and irrigated in alternate days. Treatments used were V_1 (Ogbomosho), V_2 (Otutu) and V_3 (land race) cultivars Twenty seeds (20) were planted per plot and replicated three times. The seedlings were transplanted into poly-pots at (8WAS) after the pinkish young levels had turned green. Data collected were (1.) Early germination percentage (2) polyembryo incidence (3) seedlings performance. Ogbomoso and Land race gave highest early germination (100%) and multiple seedlings incidence (5), while land race had the tallest (46.20 cm) and branch (1) in the nursery to enhance multiple grafting of different rootstocks on the same seedling. Each of the rootstock studied had good agronomic performance and are therefore recorded for production of mango rootstock.

Key words: *Mango, germination, polyembyo and cultivar*

INTRODUCTION

Mango (*Mangifera indica* L.) belongs to the family *Anacardiaceae*,(Minja *et al*., 2017). It is a popular fruit in the world; common in tropical and subtropical part of the world, (Shah *et al*., 2010), ranking 15 among other fruits(Francoise, 1986). India is the world leading producer while Nigeria is the highest producer in Africa (Mitra, 2016). Good planting materials are required for orchard expansion. In Nigeria, different varieties are grown, these include Otutu, Opioro, Ogbomoso, land race or cherry etc. Among these varieties, some are characterised with higher tolerance to pest, disease, and drought, waterlogged and other environmentally oriented stress factors. Mango has good tap roots systems which helps it to withstand high wind speed, drought. With these, carriage of heavy fruit production is ensured. According to Baita *et al*. (2010), graft wood results in vigorous trees, high fruit yield or small trunk. Restricted growth and poor fruit yield are all functions of poor rootstock types compatibility with graft wood from a desired mother tree, (Baita *et al*, 2010). Mango is a highly cross-pollinated and allopolyploid in nature. Therefore, it is necessary to keep desirable cultivars available. Vegetative propogation can play a significant role especially through grafted seedling production. This requires selection of "mango rootstocks that are fast growing and with high graftwood seedlings compatibility. This enhances effective grafting and availability of quality seedlings for field establishment.

MATERIALS AND METHODS

This study was carried out at NIHORT Ibadan Ripe Mango fruits were collected and depulped, air dried and cut open to remove the seed. The seeds were planted in cured sawdust and irrigated in alternate days. Varieties planted were V_1 (Ogbomosho), V_2 (Otutu) and V_3 (land race), Twenty (20) seeds each were planted per pot using CBD replicated three times. The seedlings were transplanted into poly-pots at 8WAS Data collected were early germination percentage, polyembryo incidence and growth of seedlings in the poly-pot.

RESULTS AND DISCUSSION

The result of the germination showed that, V_1 (Ogbomosho) had the least early percentage germination (25%) while V3 (Landrace) had the highest percentage early germination. as shown in Table 1. Ali and Elozeiri (2017) stated that moisture content and rehydration can affect germination of mango seeds because, seeds having inherent more moisture content attain saturation upon rehydration hence triggers germination earlier than other seeds with low inherent moisture content. The overall result of the germination showed that, V_1 (Oghomosho) and V_3 (Landrace) gave the highest percentage germination (100%) respectively, while V_2 (Otutu) gave the lowest percentage germination (55%). This may be as a result of variation in seed deterioration time among the varieties. early deteriorating time Mahasin & Mustafa, (2015) observed that mango seeds deteriorate 4 weeks after sowing, but this period of deterioration may differ from one cultivar to the other.

Table 1: Early Germination Percentage of Mango Rootstocks Seeds at 15 days after sowing (DAS) and at 36 DAS

Varieties	2WAS	4WAS
V_1Ogbomosho	25%	100%
V_2- Otutu	30%	55%
V_3- Landrace	60%	100%

V_1- Ogbomosho, V_2- Otutu, V_3- Landrace, DAS- Days after sowing.

The results on polyembryo incidence on mango rootstocks under evaluation revealed that V_1 and V_3 have higher number of polyembryo incidence than V_2. (Table 2). These implies that, a farmer can use a small area, same number of seeds, labour and cultural practices to produce more number of seedlings for market in V_1 and V_3 than V_2, that is why farmers focus on enterprises with more economic returns. From our observation, during germination of seedlings, only one or two seedlings emerged simultaneously, there after other seedlings continue to emerge at different intervals sometimes about 2, 3 and 4 after the emergence of the first emerged seedlings.

Table 2: Range of poly embryo incidence across three varieties of mango rootstocks

Varieties	Range of polyembryo per seed (multiple seedlings)
V_1 – Ogbomosho	1-5
V_2- Otutu	1-4
V_3- Landrace	1-5

The result of influence of mango rootstock varieties on the early growth of seedlings in the poly-pot (Table 3) revealed that, V_3 gave the highest (46.20 cm) plant height followed by V_2 (29.80 cm) while V_1 gave the least plant height (24.50 cm). This can be attributed to the cultivar having early growth vigour than some other cultivars, (Getulio *et al*., 2003) stated that one of the most important features in selecting mango rootstock seedlings is vigour, early root establishment/spared, early thickening of the stem and other desired traits.

Table 3: The influence of mango varieties on the early growth and development of seedlings in poly-pots nursery at 12 weeks after transplanting

Varieties	Plant Height (cm)	Stem Girth (mm)	No. of leaf	No. of Branch
V_1 - Ogbomosho	24.50	5.05	9.60	0.00
V_2- Otutu	29.80	7.09	8.66	0.00
V_3- Landrace	46.20	6.39	13.20	1.00

V_2 had the thickest stem girth (7.09 mm) followed by V_3 (6.39 mm) and V_1 (5.05 mm). Considering the importance of stem girth in attaining "graft-ability" and its eventual implication on number of seedlings produced, V_3 and V_2 are highly recommended due to the early attainment of graft-able girth. Stem girth is a useful indicator of seedling vigour, (Getulio *et al*., 2003).

Number of leaves is a pointer to the level of leaf production by cultivars. Factors affecting high production of leaves in seedlings include plant vigour, soil fertility status, proper irrigation and pest/disease management. The highest number of leaves was recorded in V_3 (13) followed by V_1 (9) whereas the least number of leaves was gotten from (V_2 with (8) number of leaves. Branching was observed in V_3 (land race) only. Photosynthesis helps growth of crops and improves assimilation of photosynthates which leads to drymatter accumulation, (Seyyed and Reza, 2012). More branching can increase ground cover and reduce weed density by shading the weed seed in the seed bank and dominating the emerged ones, (Aluko and Tee, 2015).

CONCLUSION

Ogbomoso and Land race gave highest early germination and multiple seedlings incidence, while land race had the thickest stem girth and tendencies of branching in the nursery to enhance multiple grafting of different rootstocks on the same seedling. Each cultivar of mango rootstocks under study has their desire traits, from germination to multiple seedling incidence and early performance in the nursery, therefore, with good agronomic practices, the cultivars can be used for this purpose at this level.

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PERFORMANCE OF FIVE CULTIVARS OF MANGO GRAFTED ON OGBOMOSHO ROOTSTOCKS

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ABSTRACT

An experiment was carried out to evaluate the performance of five cultivars of mango on Ogbomosho rootstocks at the National Horticultural Research Institute, Ibadan. The test cultivars were Ogbomosho, Tommy Atkins, Edward, Kent and Saigon evaluated over five years. The experiment was a randomized complete block design with five replications. Data collected were plant height, number of leaves, stem girth, primary branches, secondary branches, canopy cover, number of fruits and fruit yield. Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using LSD at 5% probability level. Results from this study showed that significant varietal differences existed among the varieties of mango evaluated in terms of plant height, number of leaves, stem girth, number of fruit and fruit yield. Kent was observed to be significantly taller than other varieties right from the first year (2016) to the last year of observation (2021). Ogbomosho, Tommy Atkins and Edward produced the highest number of leaves. Kent and Edward did not produce fruit in the first three years of transplanting, fruits were observed in the fourth year of transplanting. Meanwhile, Ogbomosho, Tommy Atkins and Saigon produced comparable number of fruit at early stage of transplanting but later Saigon produced significantly higher number of fruit. In 2020 and 2021, Saigon and Ogbomosho produced 23 and 15 fruits respectively while Kent and Edward produced 6 and 5 respectively. At the last year of observation, Ogbomosho mango variety produced significantly higher fruit yield (4.5 kg) while no significant difference existed in fruit yield of other mango varieties. It can then be concluded that Ogbomosho, Tommy Atkins and Saigon are early fruiting varieties but Kent produced bigger fruits at first fruiting.

Key words: Mango cultivars, Tommy Atkins, Edward, Kent, Saigon, rootstocks.

INTRODUCTION

Mango *(Mangifera indica)* belongs to the family Anacardiaceae. It is indigenous to Asia, India in particular. Mango is widely cultivated in many tropical and subtropical regions. It is the most extensively exploited fruit for food, juice, flavour fragrance, and colour. It is also an outstanding source of vitamin A and C apart from normal minerals and other vitamins (Sadhu, 1999). Mangos are delicious, sweet, juicy and refreshing. They are a great fruit to use when cooking in the kitchen, especially because they can be used equally for savoury and sweet dishes. According to the National Horticulture Board, there are about 1500 varieties of mango across the subcontinent of India (www.finedinninglovers.com). Number of mango varieties varies from one country to another. There are over 400 varieties of mango in Florida (toptropicals.com.> articles > fruit. Mango fruits vary in characters or quality such size, colour, taste, shape, juice content, fibre content among others. Ten best mango cultivars are Alphonso, Kesar, Langra, Chaunsa, Badam, Safeda, Totapuri, Neelam, Dasheri and Himsagar. Many cultivars of mango are available across Nigeria. There exist about 15 cultivars of mango in NIHORT. These include Ogbomosho, Tommy Atkins, Kent, Edward (Haden × Carabao), Saigon (Vietnanese tropical mango variety, most highly consumed fruit in the world with sweet flavor and succulent) alohatropical.com., Palmer, Julie, Lippen, Governor, Johnbull, Peach and Haden. Among the local cultivars of mango in Nigeria, Ogbomosho is the most popular due it sweetness, juicy content and low fibre. It is also adopted as rootstock material for it adaptability to our soils and poly-embryonic nature suitable for rapid multiplication. Ogbomosho, Tommy Atkins, Kent, Edward and Saigon are desirable cultivars that attract high demand from mango growers. It is then pertinent to evaluate their performance, most especially yields for accurate prediction for potential growers. Mangos are also classified as early-season (Bombay Yellow, Malda, Pairi and Saflar), early to mid-season (Langra, and Rajapuri) and mid-season (Alampur, Alphonso, Bangalora and Dusehri) types (www.producebook.com). Mangos are also classified as sweetest (Carabao), largest (Keitt) and smallest (Anwar Ratol). The genus Mangifera contains several species that bear edible fruits. Most of the fruits belong to the species *Mangifera indica.* The other edible Mangifera species generally have lower quality fruits and are commonly referred to as wild mangos (Bally, 2006).

MATERIALS AND METHODS

The experiment was carried out at National Horticultural Research Institute, Ibadan located in the forest savanna transition zone of Nigeria ($7^{0}40^{1}$ N, $3^{0}84^{1}$ E and 194m above sea level) between 2016 and 2021. The test cultivars were Ogbomosho, Tommy Atkins, Edward, Kent and Saigon which were all grafted on Ogbomosho rootstocks. The rootstock seedlings were raised from carefully selected stones of test rootstock cultivars (Ogbomosho) in the year 2015. The seedlings were grafted in 2016 and transplanted to the permanent field of plot size 10 m x 10 m. The experiment was laid out in a randomized complete block design (RCBD) with five replications. Major cultural activities carried out were weeding and pruning of rootstock outgrowths at regular intervals. Data collected were plant height, number of leaves, stem girth, primary branches, secondary branches, number of fruits, fruit weight and canopy cover. Data collected were subjected to statistics analysis using analysis of variance (ANOVA) and significant means were separated with LSD at 5% probability level.

RESULTS AND DISCUSSION

Results of the analysis of variance (ANOVA) showed that significant differences existed among the varieties of mango evaluated in terms of plant height through the period of observation (Table 1). Kent grafted on Ogbomosho was observed to be significantly taller (89.64 cm, 176.00cm, 190.60cm, 304.00cm and 391.40cm) than other varieties right from the first year (2016) to the last year of observation (2021), except that Tommy Atkins was taller than Kent in the year 2019, but it was not significantly different from Kent. Ogbomosho grafted on Ogbomosho was the shortest among the five varieties of mango grafted on Ogbomosho (Table 1). Significant varietal difference also existed in the number of leaves produces by the mango varieties evaluated. During the period of observation for number of leaves produced by theses varieties (i.e. 2017 and 2019), Ogbomosho, Tommy Atkins and Edward produced the highest number of leaves while Kent and Saigon had the lowest number of leaves (Table 2). Unlike number of leaves, Kent had the widest stem girth of 24.43cm, 48.94cm and 56.71cm in 2017, 2018 and 2019 respectively. Saigon had the lowest stem girth (17.48cm) in 2017, in 2018 Ogbomosho, Edward and Saigon had the lowest stem girth while no significant difference existed in stem girth of all the varieties of mango evaluated except Kent that has significantly higher stem girth than others (Table 2). Like stem girth, Kent had significantly higher canopy cover (364.40 cm) than other varieties of mango grafted on Ogbomosho rootstock (Table 2).

Table 1: Plant height of five mango varieties grafted on Ogbomosho rootstocks

Variety	Plant height (cm)				
	2017	2018	2019	2020	2021
Ogbomosho	39.78c	92.42c	158.20c	199.00c	248.00c
Tommy Atkins	61.42b	104.10b	210.00a	245.00b	0.00d
Kent	89.64a	176.00a	190.60ab	304.00a	391.40a
Edward	45.75c	67.22d	136.80c	244.40b	278.00b
Saigon	45.27c	86.50c	183.20b	211.60c	262.20bc
$LSD_{0.05}$	11.08	11.46	22.84	29.95	25.61

Table 2: Number of leaves, stem girth and canopy cover of five mango varieties grafted on Ogbomosho rootstocks

Variety	Number of leaves/plant			Stem girth (cm)			Canopy cover (cm)
	2017	2018	2019	2017	2018	2019	2021
Ogbomosho	58.80ab	112.00	285.40a	19.59bc	30.29c	40.07b	238.00c
Tommy Atkins	54.80ab	125.00	317.20a	21.80ab	38.05b	45.34b	269.40bc
Kent	37.40bc	48.92	154.40c	24.43a	48.94a	56.71a	364.40a
Edward	68.40a	136.60	202.80b	22.39ab	30.83c	44.97b	301.00b
Saigon	19.00c	128.80	138.80c	17.48c	26.93c	43.27b	208.00c
$LSD_{0.05}$	24.16	Ns	33.83	3.68	6.35	6.63	61.79

Kent and Edward did not produce fruit in the first three years of transplanting, fruits were observed in the fourth year of transplanting (i.e. 2020). Meanwhile, Ogbomosho, Tommy Atkins and Saigon started fruiting from first year after transplanting, but in 2017 no significant variation

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existed in the number of fruits they produced (3, 4 and 4 respectively). In 2018 and 2019, Saigon produced significantly higher number of fruit (7 and 12 respectively) than both Ogbomosho and Tommy Atkins that produced 4 fruits each in 2018 then 8 and 7, respectively in 2019 (Figure 1). In 2020 and 2021, Saigon and Ogbomosho produced significantly higher number of fruit (23 and 15 respectively) which were comparable to each other while Kent and Edward produced the least number of fruit (6 and 5 respectively) which were also not significantly different form each other. The same trend observed in the number of fruit produced by the mango varieties in 2020 was also observed in 2021 (Figure 1).

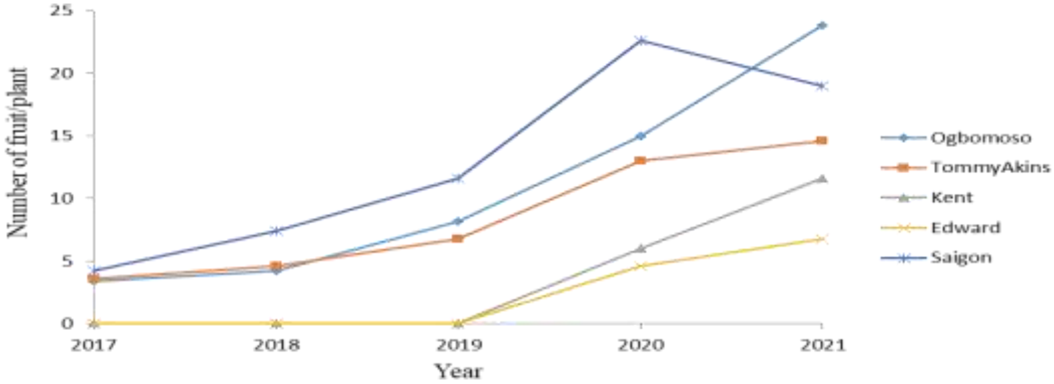

Figure 1: Number of fruit produced by five mango varieties grafted on Ogbomosho rootstock

In 2017 and 2018, Tommy Atkins and Saigon mango varieties produced comparable fruit yield of 0.78 kg 0.71 kg respectively while Kent and Edward produced no fruit. In 2019 Saigon variety produced significantly higher fruit yield of 2.2 kg followed by Ogbomosho and Tommy Atkins which produced comparable fruit yield of 1.6 kg and 1.5 kg respectively while Kent and Edward are yet to produce fruit at this time (Figure 2). In 2020, Kent mango variety grafted on Ogbomosho root stock produced significantly higher fruit yield (7.7 kg) than all other varieties of mango grafted on Ogbomosho root stock, meanwhile no significant difference existed in fruit yield of other mango varieties grafted on Ogbomosho root stock. Unlike in 2020, Ogbomosho mango variety grafted on Ogbomosho root stock produced significantly higher fruit yield (4.5 kg) in 2021 while no significant difference existed in fruit yield produced by other mango varieties grafted on Ogbomosho rootstock (Figure 2).

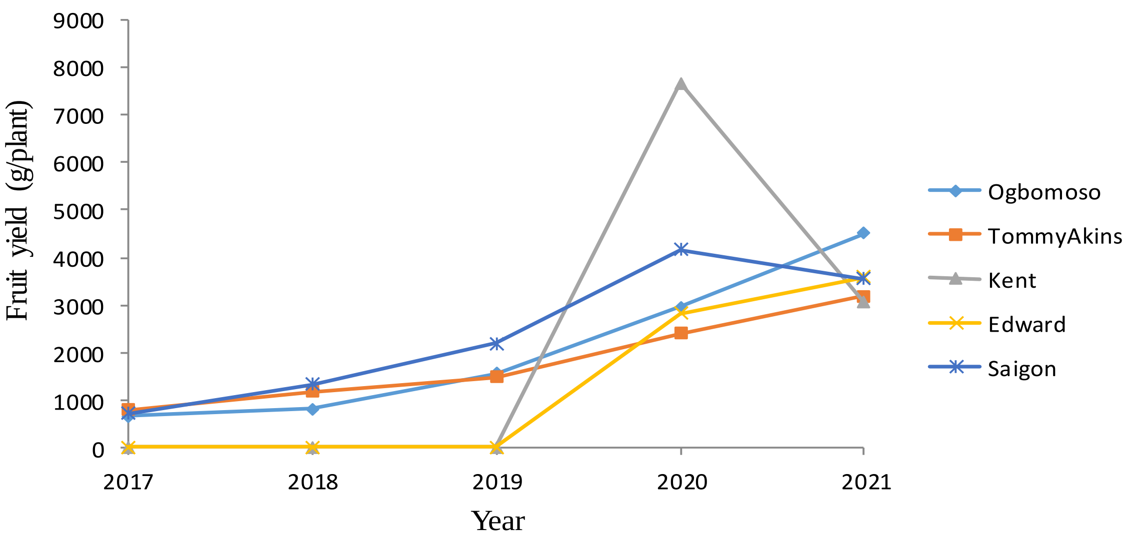

Figure 2: Fruit weight of five mango varieties grafted on Ogbomosho rootstock

The variation observed in growth and yield of these varieties of mango may be attributed to the genetic variation among the varieties responding to the climatic conditions. The findings of this study are supported by the idea that yield is highly variable factor depending upon the cultivars and age of plants, climatic conditions, incidence of pests and diseases. Majority of the workers had the idea that yield potential was a varietal character. The increase in yield in terms of weight might be either due to the large sized fruits or due to more number of fruits per plant. Similar results were obtained by Kumar and Singh (2005), Sinha *et al*., (2007) and Kundu *et al*. (2009).

CONCLUSION

It can then be concluded that Ogbomosho, Tommy Atkins and Saigon are early fruiting varieties but Kent was taller with broader canopy cover and produced bigger fruits at first fruiting. These varieties can be selected depending on the traits of interest for breeding and production purposes.

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GERMINATION AND MORPHOLOGICAL GROWTH PERFORMANCE OF KOLA PLANTLETS (*COLA NITIDA,* VENT. SCHOTT & ENDL.) AS INFLUENCED BY BIOTYPE-COLOUR, METHOD AND SCARIFICATION INTENSITY OF SEED

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ABSTRACT

The cultivation of Cola nitida nuts has decreased worldwide over time due to its pronounced dormancy and uneven germination among several other factors. A study was therefore initiated to look at the ways of breaking the dormancy in order to improve the seed germination. The experiment was conducted in the screen house to determine the effects of biotype-colour, method and intensity of scarification of Cola nitida seed on germination and morphological growth of the resultant plantlets. It was a 3 x 2 x 3 factorial experiment in completely randomized design with three replicates. It involved seed biotype-colour at 3 levels (white, pink and red), scarification-method at 2 levels (epicarp-scraping and epicarp line-cutting), scarification intensity at 3 levels (single, double and triple epicarp scarification) and the controls (untreated white, pink and red seeds) totaling 21 treatments combinations. Sowing carried out after treatment application. Data collected on percentage germination, morphological growth performance and dry matter content were subjected to analysis of variance and means separated using Duncan's Multiple Range Test ($p \leq 0.05$). Germination of between 3.33% and 6.66% was observed early at 2 Weeks After Sowing (WAS) in the white kola seeds scraped once as well as pink and red kola seeds cut twice. At 20 WAS, white, pink and red kola seeds scraped once gave germination of between 96.6 and 100% while the untreated nuts of white, pink and red recorded low germination of between 40 and 60%. Seedlings raised from white kola seeds scraped thrice had the highest plant height value (37.6 cm) followed by those from red kola nuts scraped once with height value (35.1 cm) while seedlings raised from untreated white and red seeds had lowest height values of 12.6 cm and 19.9 cm, respectively. In conclusion, epicarp of white seeds of C. nitida, should be treated to single, double and triple line-cutting or scraping, pink seeds should be treated to single scraping while epicarp of red nuts should be treated to single, double and triple scraping before sowing for improved germination and early seedling growth.

Key words: Scarification method, Scarification intensity, Epicarp scraping, Epicarp line cutting, Seed-biotype colour, Seed dormancy, Seed germination

INTRODUCTION

Kola (*Cola nitida)* is one of the several tropical tree crops in the genus *Cola* and family *Sterculiaceae* (Oladokun, 1985). The genus kola comprises about 125 species (Onomo *et al*., 2006). However, the two most common and useful fruit producing species within the genus are *Cola nitida* (Vent.) Schott and Endl. and *Cola acuminata* (P. Beauv.) Schott and Endl. The former being of much more economic importance than the latter (Russell, 1955; Eijnatten, 1973). Its cultivation has been well established in countries like Carribean Island, Mauritius, Sri Lanka and Malaysia (Ashiru, 1973). In Nigeria the cultivation is ecologically limited to the rain forest zones of Southwest and riverine areas of Southern region as well as areas historically co-habited by the Yorubas or people from Yoruba extraction, for example some parts of Niger state of Nigeria (Ndagi *et al*., 2012). For several years, kola nuts served as an important article of internal trade in Nigeria and some other parts of Africa, mainly in the South Eastern and Western region where it serves as the main livelihood of many farmers and traders (Sundstrom, 1966). Kola nuts from both wild and cultivated trees of *C. nitida* are marketed fresh or cured (Burkill 1961). Kola nut is perhaps second only to oil palm in importance in the list of indigenous cash crops in Nigeria. According to FAOSTAT (2019), Nigeria produces 161,135 M/ton (52.59%) followed by Cote D'Ivoire 60,066 M/ton (19.6%), Cameroon 50,518 M/ton (16.49%), Ghana 25,303 M/ton (8.26%) and Sierra Leone 8,773 M/ton (2.86%) of the total world production. The use of kola nut, like coffee, tea and cocoa, is of immense benefits in local and industrial application. In spite of the immense benefits of kola, some debilitating factors have been limiting its production in Nigeria. Among these constraints are delayed germination, poor field establishment, poor agronomic practices and ageing kola farms (Adebiyi *et al*., 2011), which led to discouragement in its cultivation by farmers. Therefore, investigating the effects of seed biotype-colour, method and intensity of scarification on germination and growth performance of kola plantlets will elucidate information on appropriate method of improving germination and growth performance of the crop.

MATERIALS AND METHODS

Fresh kola seeds of same mother plant (*Cola nitida*) were sourced from a local market in Olugbo Odeda, Ogun State, South Western Nigeria. Seeds smaller than 15g or infested / infected with insects / diseases were discarded. Seeds of 15g and above, in weight were used for this study. The seeds were separated into three biotypic colours – red, pink and white. The experiment was conducted in the screen house of the College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta, Ogun State Nigeria (Latitude 7^0 15'N Longitude 3^0 25'E). The experiment was a 3 x 2 x 3 factorial laid out in a completely randomized design with three replicates.

Factor-1 includes kola seed biotype-colour at 3 levels (white, pink & red). Factor- 2 includes method of scarification at 2 levels: (Epicarp-line-scrapping, Epicarp-line-cutting). Factor-3 includes intensity of scarification at 3 levels: (Single-epicarp-mark, Double-epicarp-mark & Triple-epicarp-mark). Fresh sawdust was collected and filled into 50cl containers which had earlier been perforated underneath to allow for excess water drainage. After preparing the seeds in accordance with the treatments, they were sown inside the plastic cups at seeding rate of one seed per cup, horizontally on their sides at a sowing depth of about 4-5 cm. The saw dust was watered to wet for two weeks before planting to allow for partial weathering and moisture percolation in to the medium. Ten seeds were sown per treatment giving 180 seeds per replicate which amounted to 540 treated nuts plus 90 untreated nuts giving a total of 630 nuts for the whole experiment. Watering was carried out daily, early in the morning and evening to prevent the plant from water stress. Data were collected on weekly Germination percentage, Plant height (cm), Stem diameter (mm), Number of leaves, Leaf area (cm^2) and dry matter yield (g/plant) were subjected to Analysis of Variance procedures and treatment mean comparisons were carried out with Duncan multiple range test ($p \leq 0.05$) using CoStat (CoStat, 1996).

RESULTS

Germination

Germination was observed as early as 2 WAS on pink and red seeds cut twice with 6.66% each, white seeds scraped once, white seeds cut once and twice, pink and red seeds cut once with 3.33% each. All other treatments recorded no germination. At 8 WAS, white, pink and red biotype kola seeds scraped once and white and pink biotype seeds cut once attained more than 50% germination, all other treatments had between 10.0% and 46.6% germination and the differences were significant at $P < 0.05$. At 20 WAS, (beyond which no germination was observed) pink seeds scraped once had 100% germination followed by white and red seeds scraped once with 96.6% each, white, pink and red seeds cut twice had germination of 93.3% each, pink seeds cut once and red seeds scraped twice each had 90.0% germination. while untreated white, pink and red kola seeds had germination percentage of 60.0%, 40.0% and 40.0%, respectively. The differences were significant at $p \leq 0.05$ (Table 1).

Plant Height (cm)

At 16 WAS, red kola seeds scraped once gave seedlings of highest height value of 33.1cm followed by seedlings raised from white and red seeds scraped thrice with 29.1cm and 28.1cm, respectively. All other treated seeds gave seedlings of between 11.0cm and 25.7cm. Compared to the seedlings raised from red seeds scraped once with tallest seedlings, the seedlings raised from untreated white, pink and red seeds had 44.1%, 83.3% and 65.8% reduced plant height values and the differences were significant at $p \leq 0.05$. At 20 WAS, seedlings raised from white kola seeds scraped thrice had highest height value of 35.9cm followed by those of red seeds scraped once with 34.8cm, red seeds scraped thrice with 32.5cm, pink seeds scraped once and pink seeds scraped thrice with 31.0cm and 30.3cm, respectively. The plant height of seedlings raised from all other treated seeds was between 20.7cm and 28.8cm. Seedlings raised from white seeds scraped thrice had height advantages of 45.6%, 68.5% and 65.7% compared to seedlings raised from untreated white, pink and red seeds of *C. nitida*, respectively, in the pre-nursery (Table 2).

Table 1: Effects of colour, method and intensity of scarification on percentage germination of seeds of *C. nitida* with time in the pre-nursery

	Weeks After Sowing									
Treatments	2	4	6	8	10	12	14	16	18	20
White kola seeds scraped once	3.33a	13.3a	26.6abc	63.3a	90.0ab	96.6a	96.6a	96.6a	96.6a	96.6ab
White kola seeds scraped twice	0.0a	3.33ab	13.3bcd	30.0bcd	50.0c-f	66.6b-e	76.6abc	76.6bcd	76.6abc	76.6bc
White kola seeds scraped thrice	0.0a	0.0b	6.66cd	20.0cd	43.3d-g	70.0a-d	80.0abc	80.0a-d	80.0abc	86.6abc
White kola seeds cut once	3.33a	13.3a	40.0a	56.6ab	73.3a-d	80.0abc	83.3abc	83.3a-d	83.3abc	86.6abc
White kola seeds cut twice	3.33a	6.66ab	10.0bcd	23.3cd	53.3c-f	66.6b-e	86.6abc	86.6abc	86.6abc	93.3abc
White kola seeds cut thrice	0.0a	0.0b	3.33d	13.3d	36.6efg	46.6de	73.3abc	73.3cd	73.3bc	73.3c
Pink kola seeds scraped once	0.0a	6.66ab	16.6bcd	56.6ab	83.3abc	93.3ab	96.6a	96.6a	96.6a	100a
Pink kola seeds scraped twice	0.0a	0.0b	10.0bcd	30.0bcd	63.3a-e	70.0a-d	76.6abc	80.0a-d	80.0abc	83.3abc
Pink kola seeds scraped thrice	0.0a	3.33ab	10.0bcd	30.0bcd	50.0c-f	56.6cde	63.3c	76.6bcd	76.6abc	80.0abc
Pink kola seeds cut once	3.33a	6.66ab	23.3a-d	56.6ab	76.6a-d	76.6abc	83.3abc	90.0abc	90.0ab	90.0abc
Pink kola seeds cut twice	6.66a	10.0ab	20.0a-d	36.6a-d	70.0a-d	83.3abc	86.6abc	93.3ab	93.3ab	93.3abc
Pink kola seeds cut thrice	0.0a	0.0b	3.33d	16.6d	23.3fg	40.0e	73.3abc	73.3cd	73.3bc	80.0abc
Red kola seeds scraped once	0.0a	13.3a	30.0ab	60.0a	93.3a	96.6a	96.6a	96.6a	96.6a	96.6ab
Red kola seeds scraped twice	0.0a	3.33ab	23.3a-d	46.6abc	73.3a-d	83.3abc	86.6abc	86.6abc	86.6abc	90.0abc
Red kola seeds scraped thrice	0.0a	6.66ab	6.66cd	26.6cd	60.0b-e	66.6b-e	70.0bc	76.6bcd	86.6abc	86.6abc
Red kola seeds cut once	3.33a	6.66ab	23.3a-d	46.6abc	76.6a-d	80.0abc	83.3abc	83.3a-d	83.3abc	83.3abc
Red kola seeds cut twice	6.66a	6.66ab	10.0bcd	26.6cd	66.6a-e	76.6abc	90.0ab	90.0abc	90.0ab	93.3abc
Red kola seeds cut thrice	0.0a	0.0b	3.33d	10.0d	16.6g	46.6de	66.6bc	66.6d	66.6c	73.3c
Untreated white kolanuts	0.0a	0.0b	0.0e	30.0bcd	60.0d-g	60.0e	60.0c	60.0e	60.0c	60.0d
Untreated pink kolanuts	0.0a	0.0b	0.0e	20.0cd	30.0efg	30.0ef	40.0cd	40.0e	40.0d	40.0e
Untreated red kolanuts	0.0a	0.0b	0.0e	20 .0cd	30.0fg	30.0f	30.0d	30.0e	40.0d	40.0e

Note: Means with same letter(s), same column, are not significantly different (P<0.05).

Table 2: Plant height (cm) of seedlings of *C. nitida* as affected by biotype colour, method and intensity of scarification of the seeds sown in the pre-nursery

	Weeks After Sowing			
Treatments	16	18	20	22
White kola seeds scraped once	23.5abc	23.9abc	25.4abc	26.9ab
White kola seeds scraped twice	25.7ab	28.1abc	28.8abc	29.4ab
White kola seeds scraped thrice	29.1ab	31.0ab	35.9a	37.6a
White kola seeds cut once	23.0abc	25.2abc	26.6abc	26.4ab
White kola seeds cut twice	24.2abc	28.7ab	29.8abc	30.1ab
White kola seeds cut thrice	17.3bc	19.3bc	24.4abc	26.1ab
Pink kola seeds scraped once	24.1abc	27.6abc	31.0abc	30.9ab
Pink kola seeds scraped twice	23.5abc	24.9abc	26.9abc	27.6ab
Pink kola seeds scraped thrice	25.1abc	28.0abc	30.3abc	31.1ab
Pink kola seeds cut once	16.7bc	19.9abc	20.4bc	20.9b
Pink kola seeds cut twice	23.0abc	24.0abc	24.5abc	24.8ab
Pink kola seeds cut thrice	11.1c	17.6bc	20.0c	21.8b
Red kola seeds scraped once	33.1a	34.2a	34.8ab	35.1ab
Red kola seeds scraped twice	22.3abc	23.2abc	23.5abc	24.7ab
Red kola seeds scraped thrice	28.1ab	29.1ab	32.5ab	33.3ab
Red kola seeds cut once	21.7abc	22.4abc	22.7abc	23.2ab
Red kola seeds cut twice	20.3abc	21.7abc	22.8abc	24.5ab
Red kola seeds cut thrice	11.0c	13.7c	20.7bc	23.9ab
Untreated white kolanuts	18.5bc	19.2bc	19.5cde	19.9bc
Untreated pink kolanuts	5.5d	7.4d	11.3de	12.6c
Untreated red kolanuts	11.3cd	11.8cd	12.3de	12.6c

DISCUSSION

Germination of *C. nitida* usually takes long time, sometimes up to one year to reach a reasonable percentage. Mechanical hindrance has been implicated for delay in germination of C. nitida (ibikunle and Mackenzie, 1975). Breaking this mechanical barrier allows better respiration with concomitant physiological activities. Removal of testa, scarifying of the cotyledons or breaking the adhesive force that held the two cotyledons together will remove the mechanical barrier and enhance germination (Ibikunle and Mackenzie, 1974). This breaking of the nitida effect by way of scarification of the cotyledons which form the basis of this research work was a success. It was observed that germination occurred at 2 weeks after sowing for treated white, pink and red biotype nuts, where pink and red kola seeds cut twice recorded the highest percentage germination, but, not significantly different from other treated seeds. While the untreated white, pink and red coloured nut were yet to germinate. This is in contrast with the report of oladokun (1998), that white seeds germinated earlier, followed by pink and red nuts in that order. This was verified in this study whereby no germination was observed for the untreated white pink and red kolanuts at 2weeks after sowing, whereas treated white, pink and red kolanut had 3.33%, 6.66% and 6.66% mean germination respectively. A combined effect of colour, method and intensity of scarification was influential on plant height at the pre-nursery. Seedlings derived from white kola seeds scraped thrice had the tallest plant height and significantly different from others, however, seedlings derived from white kola seeds cut thrice had more number of leaves, but statistically not significant, seedlings derived from pink kola seeds scraped once had the widest stem girth but statistically not significant.

CONCLUSION

Under similar conditions, white kola seeds scraped once and pink kola seeds scraped once would germinate faster than red kola seeds scraped once. Pink kola seeds scraped once can attain 100% germination. Seedlings derived from white kola seeds scraped thrice would grow more vegetative at the pre-nursery. Kola nut colour, scarification method and intensity of scarification interacted to induce germination to the tune of 96.6% - 100%. White kola seeds scraped once and thrice and pink kola seeds scraped once and thrice should therefore be recommended for early germination of kola seeds and growth performance. Regardless of nut colour, kola nuts should therefore be scraped once or singly for improved germination and subsequent seedling growth.

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PERFORMANCE OF TOMATO (*LYCOPERSICON LYCOPERSICUM* Mill.) GENOTYPES UNDER MOISTURE STRESS AT BAGAUDA, KANO STATE

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ABSTRACT

Huge loss of tomato yield is being experienced in recent years due to erratic rainfall and desertification in environments prone to drought as a result of climatic changes. Tomato varieties are required to increased production in ecologies prone to drought. It is vital to screen, identify and select drought tolerant genotype(s) useful for breeding of drought tolerant tomato varieties. Screen house experiment was conducted in completely randomized design with three repetitions under water stress during dry season. Thirteen traits were measured on five plants for plant height, number of branches, number of leaves, leaf length, leaf width, leaf area, number of flowers, number of marketable fruits, number of non-marketable fruits, total number of fruits per plant, average fruit weight, Biomass and fruit yield. The results showed that, Tom 6, Tom 25 and Tom 28 genotypes performed better under moisture stress for biomass, number of fruits per plant, number of marketable fruits and fruit yield per plant. Based on the rank summation index, Tom 6, Tom 28, Tom 21, Tom 61 and Tom 64 stand out to be superior genotypes under moisture stress condition which can be selected for breeding and higher fruit yield under moisture stressed environment.

Key words: Drought, moisture, stress, tomato, dry season

INTRODUCTION

Tomato (*Lycopersicon lycopersicum* MILL.) is one of the most cultivated and consumed vegetable throughout the world and second after potato (*Ipomia batatas* L.) (FOASTAT, 2005). Tomato is very rich in minerals, vitamins, essential amino acids and high level of lycopene anti-oxidants. In Nigeria, the major production areas of tomato lie between latitudes 7. 5^{o}11' and 13.0^{o} N longitude in the Sahel-Sudan Savannah. Despite its wide cultivation and importance for improved health and as source of income generation, drought stress is one of the major causes of fruit yield reduction in the Sahel and Sudan agroecologies due to short seasoned erratic rainfall and increment of temperature from climate change. Jurekova *et al*. (2019) observed that declined soil water contents tend to reduce leaf area in tomato genotypes. Significant reduction of plant height was observed for plants under water stress (Jasmina *et al.,* 2013). Fruit length, fruit diameter and average fruit weight were affected by soil moisture stress at 40% field capacity (Nahar and Ullah 2012). Significant differences for number of fruits per plant, plant height, number of leaves and average fruit weight were observed under water stress (Oliveira *et al*. 2021). The available varieties in the country are very intolerance to drought. Screening is a pre-requisite for selection of tomato under moisture stress. Hence sourcing and screening of tomato germplasm for the identification of genotypes tolerant to drought is required for increased production and productivity of the crop. Such materials will be useful for predetermined breeding programme to develop tomato genotypes that can produce economic fruit yield in a drought prone environment. The study was conducted to screen tomato genotypes under moisture stress so that drought tolerant genotype(s) would be identified and use as starting materials in the tomato drought tolerance breeding program.

MATERIALS AND METHODS

Sixty-five tomato genotypes were evaluated using a completely randomized design in three repetitions in the screen house at the National Horticultural Research Institute, Bagauda research farm (11°33´N latitude and 8°23´E longitude of the equator) in the Sudan savanna during the 2012 dry season. The climate of the region is characterized by mean of annual rainfall of 830mm with mean daily temperature ranged from 18.4^{o}C to 45^{o}C. Seedlings were raised in nursery and transplanted into pots about 30 days after sowing. Non-stress plants were irrigated with 900mm of water a week, while stressed plants were irrigated with 300mm of water a week. The treatments were imposed two weeks after transplanting. Data were measured on three plants for plant height, number of branches, number of leaves, leaf length, leaf width, leaf area, number of flowers, number of marketable fruits, number of non-marketable fruits, total number of fruits per plant, average fruit weight, Biomass and fruit yield. Data obtained were analyzed using JMP Pro 14. For the purpose of selection, Rank Summation Index (RSI) according to Malumba and Mock (1978) was generated from each trait. The index was formed by ranking each trait in descending order. Finally, the values assigned to each trait was added, thereby obtaining the sum of the ranks, which indicates the classification of the genotypes (Cruz and Carneiro, 2003). Rank Summation Index as computed by Malumba and Mock (1978) will be estimated as follows:

$$RSI = \sum_{i=1}^{n} R_i \, s$$

Where,

RSI = Aggregate performance of a genotypes using the ranking of each of the desired traits

R_i = Rank of the mean of each of the desired traits

RESULTS AND DISCUSSION

Mean Performance

The mean performance revealed highly significant (P≤0. 01) differences among the genotypes for plant height, number of branches, number of leaves, number of fruits per plant and number of marketable fruits while significant (P≤0. 05) variation was observed for leaf length, leaf width and leaf area (Table 1); indicating the presence of considerable genetic variability in the studied genotypes which is prerequisite for any crop improvement. Akhoundnejad (2020) reported significant differences among three genotypes for fruit length, diameter and average fruit weight under drought stress while Oliveira *et al*. (2021) observed significant differences for number of fruits per plant, plant height, number of leaves and average fruit weight. Non-significant differences were recorded for number of flowers per plant, biomass, number of non-marketable fruits average fruit weight and fruit yield per plant. Phenotypic differences were observed across the sixty-five tomato genotypes under moisture stress for studied traits. Tom 18 was taller (38.67cm) and Tom 42 was shorter plant (5.42cm) among the genotypes (Table 1). It was observed that, Tom 18 produced highest number of branches (7.17) followed by Tom 11 while minimum number of branches (0.67) were noticed in Tom 30. Similar results were published by Amalia Tetrani Sakya *et al*., 2020. Maximum number of leaves per plant was recorded for Tom 11 (11.83) while minimum was observed in Tom 35 (2.33). Tom 59 showed longer leaf (6.65cm) and wider leaf (4.05cm). Shorter and narrow leaves were noticed in Tom 42 and Tom 35 (Table 1) with values of 1.63cm and 0.88cm, respectively. Results revealed that, there was strong correlation between leaf length and leaf width; the longer the leaf the wider the leaf (Table 1) among the genotypes. Tom 59 also revealed maximum leaf area (4.20cm^2), because of its longer and wider leaves compared to other genotypes. Whereas minimum leaf area was recorded in Tom 37 (0.63cm^2). The results corroborated with findings of Mohammad *et al*. 2012 and Oliveira *et al*. 2021. Tom 25 recorded heavy (81.67g) biomass per plant, followed by Tom 15 (71.67g); whereas, Tom 37 showed minimum biomass per plant (3.33g). The result showed that, Tom 25 recorded high number of fruits per plant (60.33) followed by Tom 3 and Tom 1 with values of 34.33 and 29.33, respectively. Tom 25 also recorded high number of marketable fruits per plant (59.00) whereas minimum number of marketable fruits per plant was noticed in Tom 35 (0.67). Highest number of non-marketable fruits per plant (1.67) were observed in Tom 28, Tom 31 and Tom 28. Thirty-one genotypes revealed no single non-marketable fruit per plant, indicating that imposed drought stress does not affect their fruit quality among the genotypes. Similar results were reported by Oliveira *et al*. 2021 for significant differences of number of fruits per plant under drought stress. Tom 54 showed medium fruit weight followed by Tom 16 (11.67g), Tom 64 (11.13g) and Tom 61 (11.04g). Amalia Tetrani Sakya *et al*. 2020 observed non-significant variation for biomass and significant for number of fruits per plant among the evaluated genotypes under drought stress. Minimum average fruit weight was observed in Tom 30 with value of 0.56g. The result for fruit yield per plant shows that Tom 6 and Tom 28 recorded highest fruit yield per plant of 133.33Kg and 106.67Kg. Tom 35 revealed minimum fruit yield per plant (1.67Kg), indicating susceptible to moisture stress. These results contradict the results of Amalia Tetrani Sakya *et al*., 2020 for average fruit weight and fruit yield per plant (Akhoundnejad, 2020). Both researchers reported significant variations for average fruit weight and fruit yield per plant.

Rank Summation Index

For the purpose of selection, Rank Summation Index (RSI) according to Mulamba and Mock (1978) was used to determine the rankings of the genotypes with regard to their overall performance based on twelve agronomic traits under moisture stress (Table 2). Based on number of branches per plant, biomass, number of fruits per plant and fruit yield per plant, the results revealed that genotypes with higher index recorded low number of branches per plant, biomass, number of fruits per plant and fruit yield per plant, indicating to be drought sensitive genotypes, whereas genotypes (Tom 6, Tom 28, Tom 21, Tom 62 and Tom 64) with lower index values showed high number of branches per plant, biomass, number of fruits per plant and fruit yield per plant revealing drought tolerance genotypes (Table 2). Similar findings were observed by Vieira Nascimento *et al.* (2020), Finzi *et al.* (2020) and Oliveira *et al*. (2021).

CONCLUSIONS

The genotypes revealed significant variation for most of the traits studied under moisture stress, indicating sufficient genetic variability among the genotypes from which selection can be imposed. Considering biomass, number of fruits per plant, number of marketable fruits and fruit yield per plant; Tom 6, Tom 25 and Tom 28 genotypes performed better under moisture stress. Rank summation index revealed that Tom 6, Tom 28, Tom 21, Tom 61 and Tom 64 stand out to be superior genotypes based on high number of branches per plant, biomass, number of fruits per plant and fruit yield per plant indicating tolerance to drought.

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Table 1: Mean performance of agronomic traits under moisture stress at Bagauda during 2012 dry season

Genotype	PHT (cm)	NBPP	NL	LL (cm)	LW (cm)	LA (cm^2)	BM (g)	NFRPP	NMFR	NNMFR	AFW (g)	FRYPP (Kg)
TOM 1	37.83	6.00	11.67	4.30	2.65	1.78	51.67	29.33	29.00	0.33	2.51	73.33
TOM2	34.83	3.17	10.17	5.57	3.30	2.85	56.67	8.67	8.33	0.33	6.53	55.00
TOM 3	31.00	4.00	9.83	4.43	3.20	1.90	30.00	34.33	34.33	0.00	2.38	81.67
TOM 4	32.50	2.67	10.33	5.40	3.20	2.68	45.00	9.33	9.00	0.33	5.90	61.67
TOM 5	36.83	4.33	10.50	5.62	3.43	3.01	43.33	23.33	22.67	0.67	3.86	95.00
TOM 6	18.83	3.33	4.833	3.40	1.95	1.62	38.33	15.33	15.33	0.00	5.84	133.33
TOM 7	29.17	5.33	10.17	4.37	2.65	1.91	40.67	14.67	14.00	0.67	5.07	76.67
TOM 8	25.67	4.00	6.50	3.88	2.60	2.35	35.00	10.33	9.00	1.33	4.84	75.00
TOM 9	30.83	3.67	9.83	5.47	3.63	3.10	40.00	7.67	7.67	0.00	6.83	53.33
TOM 10	36.17	4.00	11.33	5.07	3.42	2.69	30.00	9.67	9.33	0.33	7.20	73.33
TOM 11	37.67	7.00	11.83	5.52	3.42	2.93	38.33	12.00	12.00	0.00	6.02	73.33
TOM 12	19.58	3.00	6.50	4.68	2.53	2.77	28.33	5.00	5.00	0.00	3.94	31.67
TOM 13	26.00	6.50	9.67	5.25	3.02	2.46	61.67	14.33	13.667	0.67	7.28	96.67
TOM 14	35.33	2.67	10.50	5.18	3.55	2.85	56.67	6.33	6.00	0.33	3.86	53.33
TOM 15	17.83	2.83	6.17	4.03	2.58	1.70	71.67	7.00	6.33	0.66	8.36	61.67
TOM 16	27.92	5.33	8.50	4.65	3.15	2.44	48.33	5.33	5.00	0.33	11.67	65.00
TOM 17	30.25	2.50	8.00	5.35	3.42	2.84	43.33	9.000	8.67	0.33	7.75	73.33

Table 1 continues

Genotype	PHT	NBPP	NL	LL (cm)	LW (cm)	LA (cm^2)	BM (Kg)	NFRPP	NMFR	NNMFR	AFW (g)	FRYPP (Kg)
TOM 18	38.67	7.17	10.83	5.30	3.25	2.70	50.00	16.00	14.67	1.33	4.33	73.33
TOM 19	29.58	5.17	10.50	5.50	3.65	3.12	45.00	6.67	6.33	0.33	4.49	45.00
TOM 20	30.17	2.67	9.00	5.60	3.20	2.90	43.33	10.33	10.33	0.00	5.00	51.67
TOM 21	37.67	5.67	10.67	5.95	3.50	3.25	45.00	12.67	12.33	0.33	6.78	88.33
TOM 22	24.17	3.50	8.17	5.63	3.48	3.05	13.33	6.33	5.67	0.67	6.39	45.00
TOM 23	38.50	3.00	9.83	5.42	3.42	3.00	18.33	9.67	9.67	0.00	5.57	60.00
TOM 24	30.67	3.67	9.33	4.88	3.25	2.46	35.00	3.33	3.33	0.00	3.19	16.67
TOM 25	28.25	4.33	10.17	3.93	2.60	1.62	81.67	60.33	29.00	1.33	1.40	76.67
TOM 26	19.25	3.00	6.17	3.27	1.93	1.01	20.00	3.00	2.30	0.66	4.17	25.00
TOM 27	14.33	1.67	5.67	2.38	1.58	0.64	10.00	11.00	11.00	0.00	1.42	23.33
TOM 28	23.08	4.00	7.17	5.08	3.27	2.68	70.00	14.00	12.33	1.67	6.67	106.67
TOM 29	21.92	3.17	6.00	4.12	2.92	1.97	10.00	6.33	6.33	0.00	7.92	65.00
TOM 30	8.83	0.67	3.67	3.07	2.03	1.60	11.67	1.00	0.67	0.33	0.56	1.67
TOM 31	26.42	4.17	8.33	6.17	3.42	3.27	8.33	5.00	3.33	1.67	5.45	48.33
TOM 32	14.17	2.17	3.83	2.87	1.88	1.26	6.67	1.67	1.67	0.00	4.72	11.67
TOM 33	22.25	2.00	7.17	4.57	2.73	1.97	20.00	6.67	6.33	0.33	3.27	25.00
TOM 34	22.67	1.17	6.33	4.08	2.42	1.56	11.67	3.00	3.00	0.00	5.58	23.33

Table 1 continues

Genotype	PHT	NBPP	NL	LL (cm)	LW (cm)	LA	BM	NFRPP	NMFR	NNMFR	AFW	FRYPP
TOM 35	7.33	0.83	2.33	1.85	0.88	0.76	13.33	0.67	0.67	0.00	0.83	1.67
TOM 36	18.33	1.17	6.00	4.63	2.75	2.06	18.33	4.67	4.33	0.33	4.31	21.67
TOM 37	17.75	1.67	5.33	2.10	1.25	0.63	3.33	6.33	6.33	0.00	1.52	10.00
TOM 38	29.92	3.00	8.67	4.87	3.03	2.33	15.00	5.00	3.33	1.67	5.46	45.00
TOM 39	26.17	5.83	8.67	3.68	2.25	1.38	13.33	10.33	9.66	0.67	7.09	71.67
TOM 40	13.58	2.00	4.67	2.88	1.50	1.04	6.67	4.67	4.33	0.33	5.90	43.33
TOM 41	29.50	2.50	8.33	5.17	3.52	2.84	8.33	11.33	11.34	0.00	5.07	60.00
TOM 42	5.42	1.00	2.67	1.63	1.10	0.84	11.67	2.67	2.67	0.00	1.88	15.00
TOM 43	24.48	3.67	6.67	5.10	3.15	2.55	28.33	4.67	4.67	0.00	4.44	33.33
TOM 44	21.33	3.83	5.67	2.88	2.05	1.49	5.00	10.67	9.67	1.00	1.17	25.00
TOM 45	22.33	1.00	6.67	4.00	2.58	1.65	11.67	3.00	2.67	0.33	2.59	23.33
TOM 46	29.28	2.50	7.67	4.80	3.05	2.27	21.67	6.67	6.33	0.33	7.33	41.67
TOM 47	23.42	1.67	7.33	5.05	3.13	2.51	16.67	5.33	5.00	0.33	7.06	41.67
TOM 48	30.58	1.50	7.67	4.85	3.05	2.29	16.67	5.67	5.67	0.00	5.14	43.33
TOM 49	13.50	1.17	4.33	3.92	3.00	2.27	20.00	2.67	2.67	0.00	6.89	26.67
TOM 50	26.25	1.33	7.50	6.38	3.95	4.05	25.00	6.00	6.00	0.00	9.78	61.67
TOM 51	23.75	1.33	6.67	4.95	3.45	2.77	21.67	2.67	2.66	0.00	0.63	5.00
TOM 52	30.33	1.50	9.17	4.50	2.73	2.03	13.33	5.00	4.67	0.33	8.18	50.00

Table 1 continues

Genotype	PHT	NBPP	NL	LL (cm)	LW (cm)	LA	BM	NFRPP	NMFR	NNMFR	AFW	FRYPP
TOM 53	30.92	4.92	9.50	4.92	2.97	2.43	29.33	9.67	9.00	0.66	6.94	66.67
TOM 54	22.50	2.17	7.67	6.45	3.82	3.82	31.67	6.00	6.00	0.00	12.08	83.33
TOM 55	24.25	4.33	7.50	6.00	3.73	3.53	25.00	2.00	2.00	0.00	6.67	11.67
TOM 56	31.83	2.50	8.17	6.52	3.72	3.79	16.67	5.67	5.67	0.00	6.47	40.00
TOM 57	24.33	1.33	6.17	5.12	3.15	2.52	5.00	2.67	2.67	0.00	5.00	20.00
TOM 58	31.92	1.67	7.67	5.95	3.32	3.25	13.33	4.67	4.67	0.00	7.14	36.67
TOM 59	25.33	1.67	7.17	6.65	4.05	4.20	33.33	5.67	5.66	0.00	6.65	56.67
TOM 60	26.50	3.00	8.17	5.58	3.27	2.83	11.67	3.67	3.67	0.00	3.21	20.00
TOM 61	26.58	1.17	5.50	5.07	2.77	2.67	35.00	4.33	4.33	0.00	11.04	68.33
TOM 62	37.00	2.00	8.17	5.18	3.25	2.61	16.67	13.00	13.00	0.00	7.03	88.33
TOM 63	17.08	1.00	7.00	4.17	2.47	1.78	15.00	6.00	6.00	0.00	9.85	58.33
TOM 64	25.83	1.17	7.83	5.03	2.97	2.42	40.00	7.67	7.33	0.33	11.13	81.67
TOM 65	25.00	3.17	7.83	5.62	3.32	2.94	10.00	5.67	5.33	0.33	5.29	31.67
Mean	25.86	3.00	7.75	4.70	2.91	2.38	27.87	8.82	8.49	0.33	5.55	50.82
CV	36.33	57.59	31.82	32.90	32.80	46.81	114.21	110.04	114.85	38.47	70.55	85.51
SE±	7.67	1.41	2.01	1.26	0.78	0.91	25.99	7.93	7.96	0.65	3.20	35.48
Level of significant	**	**	**	*	*	*	NS	**	**	NS	NS	NS

PHT = Plant height, NBPP = Number of branches per plant, NL = Number of leaves, LL = Leaf length, LW = Leaf width, LA = Leaf area, BM = Biomass, NFRPP = Number of fruits per plant, NMFR = Number of marketable fruits, NNMFR = Number of non-marketable fruits, AFW = Average fruits weight and FRYPP = Fruit yield per plant

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Table2: Rank summation Index for twelve agronomic traits of sixty-five tomato genotypes under moisture stress at Bagauda during 2012 dry season

Genotype	PHT	R	NBPP	R	NL	R	LL (cm)	R	LW (cm)	R	LA	R	BM	R	NFRPP	R	NMFR	R	NNMFR	R	AFW	R	FRYPP	R	RSI
TOM 1	37.83	3	6.00	4	11.67	2	4.30	46	2.65	46	1.78	49	51.67	7	29.33	3	29.00	2	0.33	16	2.51	56	73.33	13	259
TOM2	34.83	9	3.17	24	10.17	9	5.57	14	3.30	21	2.85	17	56.67	5	8.67	24	8.33	24	0.33	16	6.53	25	55.00	29	231
TOM 3	31.00	13	4.00	15	9.83	11	4.43	44	3.20	27	1.90	49	30.00	24	34.33	3	34.33	2	0.00	35	2.38	57	81.67	9	295
TOM 4	32.50	10	2.67	33	10.33	8	5.40	18	3.20	27	2.68	26	45.00	8	9.33	21	9.00	19	0.33	18	5.90	29	61.67	22	296
TOM 5	36.83	6	4.33	11	10.50	5	5.62	10	3.43	14	3.01	13	43.33	10	23.33	3	22.67	3	0.67	9	3.86	50	95.00	4	150
TOM 6	18.83	51	3.33	22	4.833	54	3.40	52	1.95	55	1.62	50	38.33	15	15.33	4	15.33	3	0.00	34	5.84	30	133.33	1	391
TOM 7	29.17	22	5.33	7	10.17	7	4.37	42	2.65	44	1.91	46	40.67	12	14.67	4	14.00	4	0.67	9	5.07	37	76.67	8	247
TOM 8	25.67	32	4.00	13	6.50	41	3.88	49	2.60	44	2.35	37	35.00	15	10.33	12	9.00	16	1.33	5	4.84	40	75.00	9	316
TOM 9	30.83	12	3.67	16	9.83	8	5.47	15	3.63	8	3.10	11	40.00	12	7.67	20	7.67	20	0.00	32	6.83	21	53.33	24	218
TOM 10	36.17	7	4.00	13	11.33	2	5.07	25	3.42	13	2.69	23	30.00	18	9.67	14	9.33	15	0.33	15	7.20	14	73.33	9	179
TOM 11	37.67	3	7.00	3	11.83	1	5.52	13	3.42	13	2.93	14	38.33	13	12.00	8	12.00	8	0.00	31	6.02	26	73.33	9	150
TOM 12	19.58	44	3.00	19	6.50	38	4.68	34	2.53	44	2.77	19	28.33	18	5.00	36	5.00	34	0.00	31	3.94	43	31.67	38	440
TOM 13	26.00	26	6.50	3	9.67	7	5.25	17	3.02	31	2.46	27	61.67	4	14.33	4	13.667	4	0.67	8	7.28	13	96.67	2	153
TOM 14	35.33	6	2.67	24	10.50	3	5.18	17	3.55	8	2.85	15	56.67	4	6.33	22	6.00	24	0.33	14	3.86	42	53.33	21	220
TOM 15	17.83	44	2.83	23	6.17	37	4.03	39	2.58	40	1.70	40	71.67	2	7.00	18	6.33	18	0.66	10	8.36	8	61.67	15	331
TOM 16	27.92	19	5.33	5	8.50	12	4.65	32	3.15	23	2.44	27	48.33	4	5.33	31	5.00	31	0.33	13	11.67	3	65.00	13	217
TOM 17	30.25	12	2.50	23	8.00	18	5.35	15	3.42	12	2.84	15	43.33	6	9.000	14	8.67	14	0.33	13	7.75	9	73.33	8	166
TOM 18	38.67	1	7.17	2	10.83	1	5.30	15	3.25	18	2.70	18	50.00	3	16.00	3	14.67	3	1.33	5	4.33	36	73.33	8	120
TOM 19	29.58	13	5.17	4	10.50	2	5.50	13	3.65	7	3.12	10	45.00	3	6.67	16	6.33	16	0.33	12	4.49	34	45.00	21	163
TOM 20	30.17	11	2.67	20	9.00	7	5.60	11	3.20	19	2.90	13	43.33	4	10.33	9	10.33	8	0.00	24	5.00	31	51.67	17	202
TOM 21	37.67	2	5.67	3	10.67	1	5.95	7	3.50	8	3.25	8	45.00	3	12.67	5	12.33	4	0.33	12	6.78	16	88.33	2	75
TOM 22	24.17	26	3.50	11	8.17	10	5.63	8	3.48	8	3.05	9	13.33	27	6.33	16	5.67	21	0.67	7	6.39	20	45.00	19	215

Table 2 continues

Genotype	PHT	R	NBPP	R	NL	R	LL (cm)	R	LW (cm)	R	LA	R	BM	R	NFRPP	R	NMFR	R	NNMFR	R	AFW	R	FRYPP	R	RSI
TOM 23	38.50	1	3.00	13	9.83	2	5.42	10	3.42	9	3.00	9	18.33	19	9.67	9	9.67	7	0.00	22	5.57	22	60.00	12	162
TOM 24	30.67	6	3.67	9	9.33	3	4.88	20	3.25	14	2.46	19	35.00	4	3.33	34	3.33	32	0.00	22	3.19	36	16.67	38	256
TOM 25	28.25	11	4.33	4	10.2	1	3.93	31	2.60	30	1.62	32	81.67	1	60.33	2	29.00	2	1.33	5	1.40	40	76.67	6	168
TOM 26	19.25	32	3.00	11	6.17	27	3.27	33	1.93	36	1.01	38	20.00	14	3.00	33	2.30	39	0.66	7	4.17	32	25.00	28	356
TOM 27	14.33	35	1.67	22	5.67	30	2.38	37	1.58	37	0.64	41	10.00	32	11.00	5	11.00	5	0.00	20	1.42	38	23.33	30	342
TOM 28	23.08	25	4.00	6	7.17	19	5.08	14	3.27	12	2.68	13	70.00	1	14.00	2	12.33	3	1.67	2	6.67	16	106.67	1	131
TOM 29	21.92	29	3.17	8	6.00	27	4.12	27	2.92	23	1.97	27	10.00	31	6.33	12	6.33	10	0.00	19	7.92	8	65.00	8	236
TOM 30	8.83	36	0.67	39	3.67	34	3.07	31	2.03	33	1.60	30	11.67	26	1.00	38	0.67	38	0.33	8	0.56	39	1.67	38	425
TOM 31	26.42	13	4.17	5	8.33	5	6.17	5	3.42	9	3.27	7	8.33	31	5.00	21	3.33	28	1.67	2	5.45	22	48.33	14	171
TOM 32	14.17	32	2.17	14	3.83	32	2.87	32	1.88	32	1.26	32	6.67	32	1.67	36	1.67	36	0.00	17	4.72	26	11.67	33	379
TOM 33	22.25	27	2.00	15	7.17	18	4.57	23	2.73	25	1.97	26	20.00	13	6.67	10	6.33	10	0.33	7	3.27	28	25.00	25	250
TOM 34	22.67	24	1.17	27	6.33	23	4.08	25	2.42	28	1.56	28	11.67	25	3.00	28	3.00	28	0.00	16	5.58	19	23.33	26	321
TOM 35	7.33	33	0.83	34	2.33	31	1.85	31	0.88	33	0.76	33	13.33	21	0.67	34	0.67	34	0.00	16	0.83	33	1.67	34	398
TOM 36	18.33	27	1.17	27	6.00	24	4.63	22	2.75	24	2.06	24	18.33	14	4.67	22	4.33	23	0.33	7	4.31	26	21.67	27	295
TOM 37	17.75	27	1.67	17	5.33	26	2.10	29	1.25	30	0.63	32	3.33	31	6.33	11	6.33	10	0.00	15	1.52	30	10.00	31	300
TOM 38	29.92	8	3.00	8	8.67	3	4.87	18	3.03	18	2.33	20	15.00	18	5.00	19	3.33	25	1.67	2	5.46	20	45.00	14	196
TOM 39	26.17	13	5.83	2	8.67	3	3.68	25	2.25	26	1.38	27	13.33	19	10.33	5	9.66	5	0.67	3	7.09	10	71.67	5	166
TOM 40	13.58	26	2.00	13	4.67	24	2.88	25	1.50	27	1.04	27	6.67	26	4.67	19	4.33	21	0.33	5	5.90	17	43.33	13	266
TOM 41	29.50	8	2.50	9	8.33	3	5.17	10	3.52	7	2.84	9	8.33	25	11.33	3	11.34	3	0.00	12	5.07	20	60.00	8	120
TOM 42	5.42	27	1.00	25	2.67	24	1.63	25	1.10	26	0.84	27	11.67	21	2.67	23	2.67	22	0.00	12	1.88	25	15.00	25	307
TOM 43	24.48	16	3.67	5	6.67	17	5.10	11	3.15	12	2.55	13	28.33	6	4.67	18	4.67	17	0.00	12	4.44	21	33.33	18	176

Table 2 continues

Genotype	PHT	R	NBPP	R	NL	R	LL (cm)	R	LW (cm)	R	LA	R	BM	R	NFRPP	R	NMFR	R	NNMFR	R	AFW	R	FRYPP	R	RSI
TOM 44	21.33	22	3.83	4	5.67	20	2.88	23	2.05	24	1.49	24	5.00	23	10.67	3	9.67	3	1.00	2	1.17	24	25.00	20	194
TOM 45	22.33	21	1.00	23	6.67	17	4.00	21	2.58	22	1.65	23	11.67	20	3.00	20	2.67	20	0.33	4	2.59	23	23.33	20	253
TOM 46	29.28	8	2.50	7	7.67	8	4.80	17	3.05	14	2.27	19	21.67	10	6.67	7	6.33	7	0.33	4	7.33	8	41.67	13	129
TOM 47	23.42	18	1.67	10	7.33	13	5.05	12	3.13	13	2.51	14	16.67	12	5.33	14	5.00	14	0.33	4	7.06	9	41.67	13	154
TOM 48	30.58	6	1.50	12	7.67	8	4.85	15	3.05	13	2.29	17	16.67	12	5.67	10	5.67	10	0.00	8	5.14	17	43.33	12	149
TOM 49	13.50	19	1.17	17	4.33	17	3.92	18	3.00	13	2.27	17	20.00	11	2.67	17	2.67	17	0.00	8	6.89	11	26.67	16	200
TOM 50	26.25	9	1.33	14	7.50	10	6.38	4	3.95	3	4.05	3	25.00	8	6.00	7	6.00	7	0.00	8	9.78	6	61.67	7	102
TOM 51	23.75	15	1.33	14	6.67	13	4.95	12	3.45	6	2.77	9	21.67	9	2.67	16	2.66	17	0.00	8	0.63	18	5.00	18	171
TOM 52	30.33	6	1.50	12	9.17	2	4.50	14	2.73	15	2.03	15	13.33	12	5.00	12	4.67	12	0.33	4	8.18	6	50.00	10	135
TOM 53	30.92	5	4.92	2	9.50	1	4.92	12	2.97	11	2.43	12	29.33	5	9.67	3	9.00	3	0.66	2	6.94	8	66.67	6	79
TOM 54	22.50	13	2.17	7	7.67	6	6.45	3	3.82	3	3.82	3	31.67	4	6.00	6	6.00	6	0.00	6	12.08	2	83.33	3	71
TOM 55	24.25	12	4.33	2	7.50	7	6.00	3	3.73	3	3.53	4	25.00	6	2.00	14	2.00	14	0.00	6	6.67	7	11.67	14	95
TOM 56	31.83	4	2.50	5	8.17	1	6.52	2	3.72	3	3.79	3	16.67	6	5.67	7	5.67	7	0.00	6	6.47	8	40.00	8	71
TOM 57	24.33	10	1.33	9	6.17	8	5.12	6	3.15	7	2.52	8	5.00	11	2.67	12	2.67	12	0.00	6	5.00	10	20.00	11	112
TOM 58	31.92	3	1.67	6	7.67	5	5.95	2	3.32	3	3.25	3	13.33	8	4.67	9	4.67	9	0.00	6	7.14	5	36.67	8	70
TOM 59	25.33	7	1.67	6	7.17	5	6.65	1	4.05	2	4.20	2	33.33	3	5.67	7	5.66	7	0.00	6	6.65	6	56.67	6	61
TOM 60	26.50	4	3.00	3	8.17	1	5.58	2	3.27	3	2.83	3	11.67	7	3.67	9	3.67	9	0.00	6	3.21	8	20.00	9	69
TOM 61	26.58	3	1.17	6	5.50	5	5.07	3	2.77	6	2.67	3	35.00	2	4.33	8	4.33	8	0.00	6	11.04	3	68.33	4	62
TOM 62	37.00	1	2.00	4	8.17	1	5.18	2	3.25	3	2.61	3	16.67	4	13.00	2	13.00	2	0.00	6	7.03	4	88.33	1	35
TOM 63	17.08	5	1.00	6	7.00	3	4.17	4	2.47	5	1.78	5	15.00	4	6.00	5	6.00	5	0.00	6	9.85	3	58.33	3	59

Table 2 continues

Genotype	PHT	R	NBPP	R	NL	R	LL (cm)	R	LW (cm)	R	LA	R	BM	R	NFRPP	R	NMFR	R	NNMFR	R	AFW	R	FRYPP	R	RSI
TOM 64	25.83	**3**	1.17	**5**	7.83	**1**	5.03	**2**	2.97	**3**	2.42	**3**	40.00	**1**	7.67	**4**	7.33	**4**	0.33	**3**	11.13	**2**	81.67	2	38
TOM 65	25.00	**3**	3.17	**2**	7.83	**1**	5.62	**1**	3.32	**2**	2.94	**2**	10.00	**3**	5.67	**4**	5.33	**4**	0.33	**3**	5.29	**3**	31.67	4	35

PHT = Plant height, NBPP = Number of branches per plant, NL = Number of leaves, LL = Leaf length, LW = Leaf width, LA = Leaf area, BM = Biomass, NFRPP = Number of fruits per plant, NMFR = Number of marketable fruits, NNMFR = Number of non-marketable fruits, AFW = Average fruits weight, FRYPP = Fruit yield per plant, R = Rank and RSI = Rank summation index.

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VULNERABILITY OF OKRA GROWTH INDICES TO DIFFERENT MOISTURE REGIMES IN A FOREST SAVANNAH TRANSITION ZONE OF NIGERIA

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ABSTRACT

Uneven distribution of rainfall and limited water resources calls for an irrigation management and scheduling scheme that enable crops cope better with the variable and changing climate. The experiment studies the effects of moisture stress conditions on two Okra cultivars (Ibadan local and Jokoso). The moistures stress conditions vary from continuous flooding (FLD), wetting after three days (W3D), wetting after five days (W5D), wetting after seven days (W7D), and wetting after ten days (W10D). The experimental design was a Completely Randomize Design (CRD)fitted into split plot with three replications. The agronomic parameters (leaf width, leaf length, plant height, numbers of leaves and leaf area) and yield data (weight, fruit diameter, fruit length) were subjected to analysis of variance and treatment means separated using Least significant different. Okra growth and fruit yield were significantly ($p<0.05$) affected by moisture conditions, it significantly ($p<0.05$) affect fruit yield characters with FLD recorded highest fruit weight of 13.97g and 0.87g for Ibadan Local and Jokoso correspondingly while W7D recorded 0.78g for Ibadan Local and 0.00g for Jokoso. Also, FLD recorded highest fruit diameter in Jokoso with 6.43cm and 2.63cm for Ibadan Locals while W7D recorded 2.23cm for Ibadan Local and 0.0cm for Jokoso. The trend for Fruit length was similar with FLD producing longest fruits in Ibadan Local with 5.51cm and 4.67cm for Jokoso while W5D produced 4.62cm in Ibadan Local and 3.00cm in Jokoso. It could be concluded from the study that moisture conditions such as FLD, W3D and W5D were suitable for growth and fruit yield of okra cultivars; Ibadan Local and Jokoso in the study area while moisture stress beyond W5D appeared detrimental.

Key words: Okra, Moisture stress, growth indices, flooding

INTRODUCTION

Agricultural crops are watered periodically during the growing season, either by natural rainfall or by irrigation. In the intervals of each watering, soil moisture stress sometimes becomes severe and limits plant growth and development. This is particularly true in rain-fed agricultural areas where the amount of rainfall is insufficient for the plant to complete growth, and also in irrigated agricultural areas where the amount of available water is limited. Most of the studies have indicated that even brief water shortage is likely to interfere with the normal function of vital processes of plants, thereby to influence their vigor and productivity. Timing of water stress during crop growth and development is an important factor in determining the magnitude of the effect of stress (Begg and Turner (1976), Kramer, (1983).

Generally, annual crops are particularly sensitive to stress at a critical stage of development (Kramer,1983). Salter and Goode (1967) suggested that most of the determinate crops are sensitive to water stress especially at the time of floral initiation and during flowering and, to a lesser extent, during fruit and seed development. In indeterminate and perennial crops, in which vegetative growth and reproductive processes overlap, the situation is not very clear. (Begg and Turner, 1976). Due to the economic importance of Okra in food security, it is crucial to understand how drought conditions potentially affects okra yield under climate change and to explore appropriate adaptation measures to maintain or increase okra production. Previous studies indicate that irrigation is the most efficient adaptation measure to mitigate the negative effects caused by drought in crop production (Li*et al*., 2005; Olesen*et al*., 2011; Ji*et al*., 2012).

However, due to the uneven distribution of rainfall and limited water resources calls for an irrigation management and scheduling scheme that accounts for effects of actual soil water content to better cope with the variable and changing climate. Although okra is usually grown as an annual plant, it is a perennial plant. In this crop, after short vegetative development, reproductive growth including flower opening and fruit development, and vegetative growth occur concurrently. In such crops, the relationship between the stage of plant growth and effect of water deficit is not clearly understood yet. This experiment was conducted to analyze the responses of two okra cultivars to moisture stress conditions in a forest-savanna transition zone of Nigeria.

MATERIALS AND METHODS

Experimental site Descriptions

The experiment was conducted in a screen house at Federal University of Agriculture, Abeokuta (FUNAAB) behind College of Environmental Resources Management (COLERM), located between Latitude 7° 2' 23'' N and Longitude 3° 4' 03'' E. The study area is characterized by a tropical climate with distinct wet and dry seasons. The wet season is associated relatively with the prevalence of the moist maritime southerly monsoon from Atlantic Ocean and the dry season by the continental North Easterly harmattan winds from the Sahara Desert. The area is located within a region characterized by bimodal rainfall pattern (April to July being the wettest months, followed by August to October). The annual rainfall ranges between 1400 and 1500mm in Abeokuta ant its environs. Isolated and scanty rains usually start in mid-March and steadily increase to reach the peak values in July followed by a short break in August. The dry season is normally from October to March and often characterized by hot days.

Experimental Procedure

The experimental crop used was two Okra varieties (Ibadan Local and Jokoso) obtained from National Horticultural Research Institute (NIHORT), Ibadan. Top soil collected from the FADAMA wetlands of the university was sieved to fine particle before filled into plastic pots. Eighteen (18) plastic pots were used, they were pierced at the bottom before use to enable free drainage of water. 3kg of sieved soils were measured to into each plastic pot. The plastic pots containing soil was watered and left for a day, after which seeds of two (2) okra varieties (Ibadan Local andJokoso) were planted in each plastic pot and they were arranged in a Completely Randomized Design (CRD) fitted into split plot with three replicates. The experiment was laid in 5x2 factors consisting of five water regimes and two varieties of okra. The moisture conditions are flooding (FLD) (the plastic pots were kept flooded throughout the crop growth period), wetting after three days (W3D) (the plastic pots were kept flooded at three days interval throughout the crop growth period), wetting after five days (W5D) the plastic pots were kept flooded at five days interval throughout the crop growth period), wetting after seven days (W7D) the plastic pots were kept flooded at seven days interval throughout the crop growth period), and wetting after ten days (W10D) the plastic pots were kept flooded at ten days interval throughout the crop growth period). while the two varieties used were Ibadan Local and Jokoso. Three weeks after planting the plants were thinned to one per pot and weeded manually. Herbicide was applied in the screen house for the protection against pests and diseases.

Data collection and analysis

The data set for number of leaves, plant height, leaf area and fruit yield characters were subjected to analyses of variance (ANOVA) using SAS software package 9.1 (SAS Institute, 2003). Comparison among the treatments combination were carried out at 0.05% probability level and treatment means were separated using Least Significance Difference (LSD).

RESULTS AND DISCUSSION

Plant height of okra (Ibadan local)

The difference in plant height of the Ibadan local and Jokoso at 3,4,5,6 and 7 weeks after plant (WAP) is shown in Table 1. The plant height of the Ibadan Local was significantly different at all sample occasions. The plant height at 3WAP ranged from 15.63cm in W10D, followed by 17.23cm in W3D, then by 17.37cm in W5D, followed by 17.90cm in W7D while the highest plant was obtained in FLD with 19.17cm. Equally the plant height at 5WAP ranged from 21.03cm in W10D followed by22.47cm in W7D, followed by 23.93cm in W5D and 25.67cm in W3D while the highest value was obtained in FLD with 27.97cm. Also the plant height at 7WAP ranged from 24.47cm in W10D, followed by 25.20cm in W7D, followed by 28.87cm in W5D and 34.03cm in FLD while the highest value was obtained in W3D with 35.63cm.

Plant height (Jokoso)

Also from Table 1, the plant height of Jokoso was statistically significant at all sampled occasions. The plant height at 3WAP ranged from 11.00cm in W10D, followed by 14.00cm in W7D, then 14.83cm in W3D while the tallest plant with 16.33cm was obtained in FLD. Similar pattern was observed at 7WAP when the plant height was from 19.00cm in W10D, 32.83cm in W5D while the tallest plant with 42.17cm was obtained in FLD.

Leaf area of Okra (Ibadan local)

The difference in the leaf area of the Ibadan local and Jokoso at 3,4,5,6, and 7 weeks after plant (WAP) is shown in Table 2. The leaf area of the okra varieties was significantly difference at all sample occasions. The leaf area of the Ibadan Local at 3WAP increased from 38.67cm^2 in W10D, followed by 57.69cm^2 in W7D, then 60.83cm^2 in W5D, and 74.87cm^2 in FLD while the highest value was obtained in W3D with 76.64cm2. Also the leaf area of the okra variety at 7WAP ranged from 144.05cm^2 in W10D, followed by 181.95cm^2 in W5D, followed by 182.22cm² in W7D and 224.23cm^2 in FLD while the highest value was obtained in W3D with 298.51cm^2.

Leaf area of Okra (Jokoso)

Table 2 also revealed that the Leaf area of Jokoso at 3WAP increased from 21.25cm^2 in W10D, then 35.34cm^{2}in W7D and 40.30cm^{2}in W5D while the largest area of 42.92cm^{2}was obtained in FLD. The leaf area recorded at 5WAP were in the order, 170.48cm^2 in FLD followed by 160.42cm^2 in W5D, then 147.50cm^2 in W7D and 135.45cm^2 in W3D while the least value of 106.23cm^2 was obtained in W10D. Again, at 7WAP it ranged from 78.83cm^{2}in W10D, then 140.33cm^2 in W3D and 183.33cm^2 in W5D while the largest value of 249.75cm^{2}in FLD. The result implies that the leaf area of Jokoso and Ibadan local was not influenced by moisture stress of less than 7 days, this may be due to the nature of okra plants to survive under moderate water supply, this agrees with Lawlor and Leach (1985) who opined that a decrease in leaf area is majorly a common effect of drought.

Number of leaves of Okra (Ibadan local)

The difference in number of leaves of the Ibadan Local and Jokoso at 3,4,5,6 and 7 weeks after plant (WAP) is shown in Table 3. The number of leaves of the okra variety was significantly different at all sample occasions. The number of leaves of Ibadan Local at 3WAP in FLD, W3D and W5D are the same with 6.00 leaves while the number leaves in W5D and W7D was 5.00. Equally the number of leaves at 5WAP ranged from 4.67 leaves in W10D and W7D, followed by 8.00 leaves in W5D and W3D while the highest value of 8.67 leaves was obtained in FLD. Also the number of leaves at 7WAP ranged from 2.67 leaves in W10D and W7D, followed by 3.67 leaves in W5D, while the highest value was obtained in FLD and W3D with 5.00 leaves.

Number of Leaves Okra (Jokoso)

Also from Table 3, the number of leaves of Jokoso at 3WAP were 4.67 leaves in FLD and W7D, 4.33 leaves in W5D, 4.00 leaves in W10D while W3D had 3.67 leaves. The observations at 5WAP shows that FLD had highest number of leaves with 6.67 leaves, followed by W5D with 6.33 leaves, then W10D with 6.00 leaves while the lowest value of 5.67 leaves was obtained in W3D and W7D. At 7WAP, FLD again had highest number of leaves with 9.00 leaves, followed by W5D and W7D with 7.00 leaves, then W3D with 6.33 leaves while the least value of 2.33 leaves was recorded in W10D. Generally, number of leaves of both varieties showed high resilience to moisture stress conditions of wetting intervals of three, five and seven days (i.e. W3D, W5D and W7D).

Soil temperature of Okra (Ibadan local)

Table 4 shows the soil temperature data recorded for the growing seasons, it was differed considerably at various stages of the crop growth. The soil temperature trend for Ibadan local at 3WAP from the table shows that W7D had 32.33^{o}C, followed by 31.53 ^{o}C in W10D, then 30.93 ^{o}C in W3D and 30.80 ^{o}C in FLD while the least temperature of 30.67 ^{o}C was obtained in W5D. Also at 5WAP the highest temperature of 37.90 ^{o}C was obtained in W7D followed by 37.87 ^{o}C in W10D, then 34.40 ^{o}C in W3D and 34.27 ^{o}C in W5D while the least temperature of 33.27 ^{o}C was recorded FLD. Equally at 7WAP the highest temperature of 31.27 ^{o}C was obtained in W10D followed by 30.43 ^{o}C in W7D, then 28.03 ^{o}C in FLD and 28.00 ^{o}C in W3D while the least temperature of 27.87 ^{o}C was obtained in W5D.

Soil temperature of Okra (Jokoso)

The soil temperature trend for Jokoso at 3WAP from the table shows that FLD had 31.37^{o}C, followed by 31.17^{o}C in W10D, then 30.93 ^{o}C in W7D and 30.57^{o}C in W5D while the least temperature of 30.47 ^{o}C was obtained in W3D. Also at 5WAP the highest temperature of 34.30 ^{o}Cwas obtained in W10D followed by 31.07 ^{o}C in W5D, then 30.80 ^{o}C in W7D and 30.63^{o}C in W3D while the least temperature of 30.27 ^{o}C was recorded FLD. Equally at 7WAP the highest temperature of 27.23^{o}C was obtained in W10D followed by 26.87^{o}C in W7D, then 26.77^{o}C in W5D and 26.53^{o}C in W3D while the least temperature of 26.17 ^{o}C was obtained in FLD. The range of temperature observed fell within the optimum temperature required for optimum crop production (Downes, 1972). For instance, Downes (1972) indicated that air temperature above 30^{o}C during vegetative stage delayed floral development, particularly initiation of panicle meristem. Consequently, the vegetative phase became longer than usual.

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Table 1: Effect of Moisture Stress Conditions on the Plant Height of Ibadan local and Jokoso in Abeokuta

Ibadan Local

Moisture stress	3WAP	4WAP	5WAP	6WAP	7WAP
FLD	19.17±1.89	21.00±2.00	27.97±2.66	31.67±2.51	34.03±1.27
W3D	17.23±0.91	19.17±2.02	25.67±1.27	32.87±1.51	35.63±1.01
W5D	17.37±0.32	17.00±3.12	23.93±1.00	29.67±1.59	28.87±1.16
W7D	17.90±1.47	17.60±2.51	22.47±1.96	24.33±2.76	25.20±0.95
W10D	15.63±1.50	14.33±1.89	21.03±4.13	23.30±2.46	24.47±2.29
LSD	2.43**	4.28**	4.49**	4.05**	2.59**

Jokoso

3WAP	4WAP	5WAP	6WAP	7WAP	8WAP
16.33±4.04	20.67±6.43	29.00±9.64	36.67±12.42	42.17±12.77	47.50±11.76
14.83±4.54	19.83±5.01	25.67±7.23	31.67±7.23	39.17±6.79	40.50±8.26
14.50±5.68	18.33+5.78	23.67+5.5	25.83±5.39	32.83±6.79	35.50±5.07
14.00±1.32	17.67±2.52	21.50±2.29	24.33±1.53	30.50±5.89	32.67±9.17
11.00±1.50	13.17±1.04	16.00±2.00	17.83±2.25	19.00±3.00	20.50±3.78
6.96**	8.42**	11.06**	12.69**	14.07**	14.71**

Table 2: Effect of Moisture Stress Conditions on the Leaf Area of Ibadan local and Jokoso

Ibadan Local

Treatment	3WAP	4WAP	5WAP	6WAP	7WAP
FLD	74.87±11.58	187.33±26.82	220.98±27.59	213.39±30.50	224.23±25.44
W3D	76.64±5.33	211.17±89.14	262.67±137.19	295.03±168.52	298.51±158.34
W5D	60.83±20.29	167.10±102.84	210.23±102.01	240.43±115.81	181.95±11.17
W7D	57.69±19.31	87.31±1.22	120.03±3.56	144.33±18.50	182.22±3238
W10D	38.67±13.40	94.02±51.32	102.40±50.18	136.24±50.66	144.05±49.33
LSD	27.31**	120.34**	146.72**	173.83**	139.32**

Jokoso

3WAP	4WAP	5WAP	6WAP	7WAP	8WAP
42.92+24.56	112.20±57.61	170.48±34.17	220.75±91.97	249.75±127.11	245.08±149.91
35.42±21.88	71.38±33.56	135.45±20.27	147.42±15.04	140.33±18.58	150.00±16.70
40.30±27.52	61.70±36.44	160.42±44.71	185.92±50.38	183.33±44.17	193.60±57.76
35.34±8.07	93.32±46.88	147.50±15.77	176.42±15.44	199.50±36.65	190.50±39.32
21.25±5.81	41.76±5.63	106.23±46.44	94.25±94.25	78.83±13.60	121.50±14.31
35.82**	72.78**	62.93**	87.16**	115.01**	135.75**

LSD: Least Significant difference was observed from WAP: weeks after planting;

FLD: Flooding of the plant every day. W3D: Irrigating every three days.
W5D: Irrigating every five days. W7D: Irrigating every seven days. W10D: Irrigating every ten days. **: Significant at 0.05

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Table 3: Effect of Moisture Stress Conditions on the Number of Leaves of Ibadan local and Jokoso

	Ibadan Local					Jokoso					
Treatment	3WAP	4WAP	5WAP	6WAP	7WAP	3WAP	4WAP	5WAP	6WAP	7WAP	8WAP
FLD	6.00±0.00	7.67±0.58	8.67±0.58	5.00±1.00	5.00±1.73	4.67±0.58	6.67±0.58	6.67±0.58	8.33±1.53	9.00±3.61	9.33±4.93
W3D	6.00±0.00	7.33±0.58	8.00±2.00	6.00±1.73	5.00±2.00	3.67±0.58	5.33±1.52	5.67±0.58	7.00±0	6.33±1.53	6.33±1.15
W5D	6.00±0.00	7.67±1.15	8.00±2.00	4.33±0.58	3.67±0.58	4.33±0.58	5.00±0	6.33±0.58	5.33±0.58	7.00±3.00	8.67±3.79
W7D	5.00±0.00	6.33±1.15	4.67±0.58	3.33±0.58	2.67±0.58	4.67±0.58	6.67±0.58	5.67±1.53	5.67±1.53	7.00±3.61	6.00±4.36
W10D	5.00±1.00	6.67±0.58	4.67±0.58	3.00±1.00	2.67±0.58	4.00±0.00	5.33±0.58	6.00±0	4.00±0	2.33±0.58	3.00±1.00
LSD	0.81**	1.56**	2.44**	1.94**	2.30**	0.94**	1.49**	1.49**	1.82**	4.99**	6.30**

Table 4: Effect of Moisture Stress Conditions on the Soil Temperature Trends

	Ibadan Local					Jokoso					
Treatment	3WAP	4WAP	5WAP	WAP6	7WAP	3WAP	4WAP	5WAP	6WAP	7WAP	8WAP
FLD	30.80±0.70	30.63±2.15	33.77±1.04	32.17±0.38	28.03±0.21	31.37±0.90	28.37±0.23	30.27±0.50	29.47±0.35	26.17±0.06	27.43±0.40
W3D	30.93±1.03	29.27±0.67	34.40±1.15	32.03±0.23	28.00±0.36	30.47±0.58	27.93±0.28	30.63±1.10	29.77±0.57	26.53±0.15	27.53±0.40
W5D	30.67±0.15	29.13±0.57	34.27±0.21	32.77±0.75	27.87±0.90	30.57±0.89	27.93±0.12	31.07±0.76	30.00±0.34	26.77±0.15	27.47±0.45
W7D	32.33±0.68	30.33±0.15	37.90±1.40	33.27±0.47	30.43±0.55	30.93±0.42	27.5±0.06	30.80±0.50	30.43±0.21	26.87±0.40	28.60±0.26
W10D	31.53±0.23	31.17±0.61	37.87±0.21	34.33±0.67	31.27±0.29	31.17±0.35	29.73±0.51	34.30±1.04	31.07±0.15	27.23±0.38	29.63±0.40
LSD	1.17**	1.95**	1.72**	0.97**	0.95**	1.18**	0.53**	1.49**	0.65**	0.49**	0.71**

Presented in Table 5 are the yield characteristics of okra cultivars for both Ibadan Local and Jokoso. There was significant difference in fruit diameter, fruit length and number of fruits in all samples of the fruit harvested. The fruit weight of Ibadan Local ranged between 0.87g in FLD and 0.78g in W7D while forJokoso cultivar it ranged between 13.97g in FLD and 0.00g in W7D. Fruit diameter of cultivar Ibadan Local ranged between 2.63cm in FLD and 2.23cm in W7D while forJokoso cultivar it ranged between 6.43cm in FLD and 0.00cm in W7D. The fruit length of Ibadan Local ranged between 5.51cm in FLD and 4.62cm in W5D while for Jokoso cultivar it ranged between 4.67cm in FLD and 3.00cm in W5D. The mean number of fruits for both cultivars; Ibadan Local and Jokoso was 0.67 fruits across all moisture conditions that produce yield.

Table 5: Effect of moisture stress conditions on okra cultivars fruit diameters, fruit lengths, fruit weight and number of fruit

	Ibadan Local				Jokoso			
Treatment	FRW	FRD	FRL	FRN	FRW	FRD	FRL	FRN
FLD	0.87±1.50	2.63±4.56	5.51±9.54	0.67±1.15	13.97±12.23	6.43±5.81	4.67±4.16	0.67±0.57
W3D	1.00±1.73	2.68±4.65	8.64±14.96	0.67±1.15	4.94±8.56	3.34±5.78	1.83±3.18	0.33±0.58
W5D	0.85±1.47	2.25±3.90	4.62±8.00	0.67±1.15	7.67±13.27	2.83±4.91	3.00±5.19	0.67±1.15
W7D	0.78±1.34	2.23±3.87	3.81±6.60	0.67±1.15	0.00	0.00	0.00	0.00
W10D	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00	0.00	0.00	0.00
LSD 0.05	2.47**	6.93**	16.72**	1.88**	7.772**	6.002**	16.253**	1.151**

CONCLUSION

It could be concluded from the study that moisture conditions such as flooding (FLD), wetting after three days (W3D), wetting after five days (W5D) and wetting after seven days (W7D) were suitable for growth and fruit yield of Ibadan Local while moisture stress from wetting after ten days (W10D) appeared detrimental. Contrastingly, Jokoso cultivar showed high tolerant to flooding (FLD), wetting after three days (W3D) and wetting after five days (W5D) while moisture conditions from wetting after seven days (W7D) appeared detrimental to its growth and fruit yield quality. Also, the results have shown that reduced level of water to the plant has an increasing negative effect on the early growth, development, yield and plant survival depending on the magnitude of excess or deficit of the water. Wetting after three days (W3D) was shown to give maximum performance for Ibadan Local while flooding (FLD) gave maximum performance for Jokoso cultivar. The results of thisstudy suggest that using these two okra cultivars (Ibadan Local and Jokoso) as a crop in water-limited environments, may enable farmers of these regions to use deficit irrigation, preventingshort-term decreases in gas exchange and plant growthwhen soil dries, and improving irrigation efficiency. It is recommended that this could be further verified using different genotypes in fieldexperiments for asustainable agriculture.

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EFFECTS OF TIME OF SEED COLLECTION AND SOWING ORIENTATION ON SEEDLING EMERGENCE AND EARLY SEEDLING GROWTH OF STEP TREE (*TERMINALIA MANTALY* H. PERRIER)

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ABSTRACTS

Terminalia mantaly commonly called Step tree is an important ornamental plant widely used for avenue planting and provision of shade in the landscape. It Commercial seedling production remains low due to poor germination thereby negatively affecting its availability for environmental gratification. This study was conducted to investigate the best sowing orientation for seeds collected during dry and wet season for optimum emergence and seedling growth. Step tree seeds collected in wet and dry seasons were sown using three sowing orientations: Horizontal, vertical upward, and vertical downwards. Treatments were arranged in Completely Randomized Design (CRD) with four replications. Data collected on number of days to seedling emergence, plant height(cm), number of leaves, root length(cm), root fresh weight(g), root dry weight (g), shoot fresh weight (g) and shoot dry weight (g) were subjected to Analysis of Variance (ANOVA) and means were separated using Least Significant Difference(LSD) at 5% level of probability. The results of the experiment revealed that seeds collected in dry season and sown in horizontal orientation had the highest (73 %) seedling emergence, tallest seedling (97.3 cm) and highest (0.06 g) dry matter accumulation than other treatments. It was therefore concluded that time of collection of seed and sowing orientation affected emergence and early growth of Step tree. Seeds collected in dry season and sown in horizontal position were considered better for optimum emergence and early seedling growth of Terminalia mantaly.

Key words: Seed orientation, *Terminala mantaly*, germination percentage, environmental beautification.

INTRODUCTION

Terminalia mantaly commonly called Step tree is an ornamental evergreen plant with conspicuous layered branches. Leaves are smooth, bright green when young, in terminal rosettes of 4-9 unequal leaves on short-thickened stem. It belongs to the family Combretaceae (Tanzania Tree Seed Agency, 2004) and it is widely distributed globally. *Terminalia* trees can tolerate light to moderate shade, when young but thereafter, they should receive full overhead sunlight for optimal growth (Veenendaal *et al*. 1999). *Terminalia* trees are able to grow at high altitude; most species perform well at altitude less than 2000 m a.s.l. The climate in which *Terminalia* grows varies from area with year round rain for species occurring in forest areas (>2000 mm per annum) to seasonal with moderate rainfall (<1,200 mm per annum) for those occurring in savanna zones (Tanzania Tree Seed Agency, 2004).

It can be propagated naturally by seeds but could also be raised through vegetative methods. Step trees are planted in several countries be it tropical and sub-tropical regions primarily for ornamental purposes as avenue plants, shade providing tree, noise reduction and as containerized/bonsai tree. It is also useful as a source of high quality hard timber for carpentry, joinery, building, flooring, ply wood manufacturing (Singapore Flora and Fauna web,2019) and in a mixed crop system "taungya" agri-silvicultural system in which they provide shade and play a major role in increasing soil fertility (Nichols *et al*., 2001; Norgrove and Hauser, 2002). Furthermore, members of the genus *Terminalia spp* are among some of the plants most widely used for medicinal purposes in Africa (Masoko *et al*., 2005).

Step tree seeds vary in the length of time they remain viable. The seeds can be stored in sealed containers at 2-4 degree Celsius for one year, adding to its suitability for commercial exploitation (Grolez and Wood, 2001). Seeds of *Terminalia mantaly* undergo a period of dormancy before germination occurs. The seeds are covered by a hard protective coat, the physical dormancy ends when the seed coat is opened through different process such as mechanical abrasion, nicking or soaking water (Tanzania Tree Seed Agency, 2004). Most often, for some species of *Terminalia*, seeds are pre-treated by soaking in water for 12-46 hour. The physiological dormancy of *Terminalia* seed end within two weeks after sowing and is followed by epigeous germination which lasts two to five weeks. Pricking out should be done early enough to avoid disturbing the rapidly developing taproots (Lemmens *et al*., 1995).

Groulez and Wood (2001) reported that seed orientation affects greatly seedling emergence. However, information about proper seed orientations is scanty. To ensure good germination, rapid emergence and quality growth performance, seeds must be placed in a position and in an environment with adequate supply of nutrients and water from the soil.

This study was carried out to investigate the best time for collection of seeds and sowing orientation for optimum seedling emergence and growth of *Terminalia mantaly* in the commercial ornamental plant nursery.

MATERIALS AND METHODS

Trials were conducted in the experimental nursery of Horticultural Department, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria during the dry and wet seasons of the year 2019 and 2020, respectively. The site is located on Latitude 7'15 ° N, Longitude 325 ° E and altitude 100 m above sea level with annual mean temperature ranging from 26.90 ° C to 29.20 ° C. Fresh seeds of Step trees were collected from randomly selected mature plants at the Federal University of Agriculture, Abeokuta. Then, from the seed lots in each season, 1,500 viable ones were selected and sown in a polythene bags (20 cm x12 cm) filled up with sawdust at 1 seed/pot. Treatments were seeds sown using horizontal (seeds sown flat) orientation, vertical up-wards (sown with stalks placed upwards) and vertical down-wards (sown with stalks placed down) orientations laid in a Completely Randomized Design (CRD) with four replications. Each replicate had 25 seeds per replicate.

Data were collected on germination percentage (%), days to 1st emergence, plant height, number of leaves, root length, root fresh and dry weights. All data were subjected to analysis of variance (ANOVA) using Statistical Analysis Software (SAS) and the treatment means separated using Least Significant Difference (LSD) test at P=0.5% level of probability.

RESULTS AND DISCUSSION

Effect of sowing orientation on percentage germination of seeds of step tree was significant (P=0.5) in dry season only at 4 and 10 weeks after sowing (Table 1). Seeds of step tree sown in a horizontal orientation had highest (33 and 73%) germination percentage at 4 and 10 WAS respectively. Then, followed by those sown in a vertical downward (24 and 58 %) and vertical up (28 and 67 %) positions. There was no significant difference in percentage germination of seeds sown in either vertical up or vertical downward position. However, for seeds collected during the wet season, statistically similar germination percentage value was recorded for seeds sown in the three sowing orientations. (Table 1).

Table 1: Effect of sowing orientation on the germination percentage of step tree in wet and dry season

Treatments	Percentage germination (%) 4WAS	10WAS
	Wet season	
Vertical up	18.0	33.8
Vertical down	18.3	31.0
Horizontal	15.0	36.3
LSD	NS	NS
	Dry season	
Vertical up	28.0	67.0
Vertical down	24.0	58.0
Horizontal	33.0	73.0
LSD	8.19	10.11

WAS = Weeks After Sowing, NS = not significant. LSD =Least Significant Difference at P=0.5 %

Effect of sowing orientation on height of strep tree seedlings was not significant (P=0.5) for seeds collected during dry and wet seasons, except at 4 and 6 WAS during wet season (Table 2). Tallest seedlings were observed from seeds collected during wet season sown in horizontal position at 4 (9.9 cm) and 6 (11.3 cm) WAS, followed by those sown in vertical down (9.10 cm)

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and vertical up (7. 9 cm) orientations, respectively. Production of leaves by step tree seedlings was not affected by sowing orientations in either dry or wet season (Table 3). Sowing orientation had no significant effect on root length, dry root and shoot weight irrespective of the time of collection of seeds (Table 4). This could be linked to the age of harvest of seedlings for data collection and being a tree with slow growth of seedlings. This could mean that the seedlings collected and sown in wet season had better moisture as rain fed compared to those of dry season which were irrigated.

Table 2: Effect of sowing orientation on height (cm) of step tree in wet and dry season

Treatments	4WAS	6WAS	8WAS	10WAS
			Wet season	
Vertical up	7.72	9.15	10.39	11.47
Vertical down	8.96	10.13	11.57	11.78
Horizontal	9.85	11.34	12.17	13.18
LSD	1.67	2.18	NS	NS
			Dry season	
Vertical up	4.99	5.66	6.30	6.82
Vertical down	3.65	4.73	5.45	5.92
Horizontal	5.15	6.10	6.89	7.52
LSD	NS	NS	NS	NS

WAS = Weeks After Sowing, NS = not significant. LSD =Least Significant Difference at P=0.5 %

Table 3: Effect of sowing orientation on number of leaves of step tree in wet and dry season

Treatments	4WAS	6WAS	8WAS	10WAS
			Wet season	
Vertical up	4.0	5.5	6.5	7.3
Vertical down	3.4	5.3	7.0	7.5
Horizontal	2.9	5.3	6.2	7.2
LSD	0.9	NS	NS	NS
			Dry season	
Vertical up	2.3	3.2	4.9	6.3
Vertical down	2.2	3.6	5.2	6.5
Horizontal	2.4	3.3	5.4	7.7
LSD	NS	NS	NS	NS

WAS = Weeks After Sowing, NS = Not Significant, LSD =Least Significant Difference at P=0.5 %

Table 4: Effect of sowing orientation on root length, fresh root weight and dry root weight (g) of step tree in dry and wet season

Treatments	Root length (cm)	Fresh root weight (g)	Dry root weight (g)
		Wet season	
Vertical up	12.9	0.2	0.1
Vertical down	14.8	0.2	0.1
Horizontal	13.3	0.2	0.1
LSD	NS	NS	NS
		Dry season	
Vertical up	0.2	0.6	0.1
Vertical down	0.1	0.6	0.1
Horizontal	0.3	0.7	0.1
LSD	NS	0.1	NS

WAS = Weeks After Sowing, NS = Not Significant, LSD =Least Significant Difference at P=0.5 %

CONCLUSION

Sowing seeds of step tree in horizontal orientation enhanced seeds emergence and early seedling growth. Seeds of step tree collected during dry season performed better in terms of germination and seedling growth.

Therefore, it is recommended to collect seeds of *Terminalia mantaly* during dry season and sow in a horizontal orientation for optimum seedling emergence and early growth in the nursery.

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RESPONSE OF COFFEE GENOTYPES AND PROCESSING METHODS ON SEEDS GERMINATION AND SEEDLING GROWTH IN NIGERIA

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ABSTRACT

Seeds for seedling production of coffee have hitherto being processed using mortar and pestle. Increasing demand for coffee seeds and seedlings in Nigeria calls for some better alternatives to produce higher and quality seeds. In view of the above, ripe cherries of coffee of 3 genotypes were harvested viz: open pollinated, C2 and C4 which were processed using mortar and pestle (MT); manually operated pulper (MN) and motorised pulper(NCAM). These were evaluated in 3 x 3 factorial combinations laid out in Completely Randomised Design in three replicates. There were 27 treatment units in all. The treatments are: Mortal & pestle for OP, C2 and C4 (MTOP, MTC2 &MTC4); CRIN Manual Driven Pulper (MN) for the three genotypes (MNOP, MNC2 & MNC4) and NCAM motorised pulper (NCAMOP, NCAMC2 & NCANC4). The seeds generated were sown in a 50:50 soil/sawdust mixture under a 50% natural shade of palm fronds. Data were taken on Day to 50% germination; percentage germination and growth of generated seedlings (height, Stem diameter, number of leaves and leaf area) from each treatment. There was significant difference($P \leq 0.05$) on days to 50% germination in the order: MNC2(92.33)>MTC4(89.33)>MNC4(88.0)>NCAMOP(83.67>MTC2(79.67)>MTDE(77.0)>MNOP(75.67)>NCAMC2(0)>NCAMC4(0)- an indication that 50% germination was not attained by NCAM processed C2 and C4 seeds. On percentage germination, there was no significant difference ($P \leq 0.05$%). However, percentage germination for MNOP, MTC2 and NCAMOP were respectively 56.2, 54.33 and 54.01. The other treatments had germination below average (33-49.84%). The growth parameters viz; Length x Width (L x W) of leaves and plant height were significantly different with NCAMC4 and NCAMC2 being outstanding (404.57cm^2) and (297.12cm^2), the least being from MTC2, MNOP, MNC4, NCAMOP and MTOP in that order with value ranging between 143.64cm^2 to 200.72cm^2. Plant height followed similar pattern while other growth parameters of stem diameter and number of leaves were not significantly different. Manually operated pulper, mortal & pestle processed seeds germinated better probably because of less damage to the seeds while NCAM motorised pulper processed seeds got the least germination due to damage on seeds' endosperm except for NCAMOP where seeds size was the smallest, hence undamaged. Growth was better in NCAMC2 and C4 probably because seeds were scarified thereby encouraging faster germination and growth. CRIN manually operated pulper promoted higher germination as against NCAM motorised pulper which needs further adjustment based on variation in berries and seeds sizes.

Key words: coffee, genotypes, pulpers, seeds, germination, growth

INTRODUCTION

Coffee is one of the agricultural products that is of economic importance and serve as a means of income to farmers (Muleta, 2007). In Nigeria, many farmers established their coffee plantation using seedlings derived from seeds. Coffee cherry is a drupe containing two flat seeds which are used for propagation. Germination of the coffee seeds under field condition is defined as emergence of seedling from soil, with radicle extending downward. Report had revealed that presence of patchment delay early germination of coffee seeds and its removal will hasten germination. Da-Silva *et al.* (2004) carried out studies on the mechanism and regulations concerning coffee seed germination. It was observed that parchment causes the cell wall not to expand on time or making surrounding endosperm from being inactive.

Coffee cherries can be processed after harvest by the removal of both the pulp and husk either by dry, wet or semi-dry method. Mucilage is removed by fermentation, followed by washing or machines processes Brando and Brando (2015). Selmar *et al* (2006) reported that germination process of coffee seeds starts after post-harvest processing which involved removal of fruit flesh (pulp) either manually or mechanically. They further corroborated their findings through the use of germination-specific isocitrate lyase (ICL) test with b-tubulin, a maker for cell division or elongation Selmar *et al.,* (2006).

Traditionally, the exocarp (pulp) is manually removed during seed processing by farmers as it is widely being practiced and believed to be devoid or at least reduces seed damage. Traditional coffee processing method of de-pulping requires soaking of cherries, use of mortar and pestle or even matching or tramping on cherries to remove pulp. This is followed by separation of pulps from the beans (scooping) and drying of beans. The process is however very tedious with attendant drudgery and low work rate, specifically separation of pulp (scooping) is very difficult and discouraging. Damage is a very vital index to be considered in seed production approach. Improved process of pulping coffee cherries using mechanical methods with the aim of reducing labour, time and cost should be focused for the purpose of increasing coffee production (Weinberg *et al.*, 2001). According to Murthy and Naidu (2011), removal of pulp from fresh berries; using a pulper is one process to achieve increased coffee seed production. The use of machine has been immemorial for increased efficiency and for large scale production with little or no drudgery. Proper understanding of coffee seed germination will help in improvement of agricultural activities and increase in production of coffee needed for international market. Work done on coffee seed germination with regards to seed production using mechanical pulper is very scarce considering the economic important of coffee crop in the world market. In Nigeria, some mechanical pulpers (motorized and manual) have been developed toward processing coffee seeds (*C. canephora* pierre ex Froehner.and *Coffea arabica* L.) for planting. The purpose of this study is to determine the effectiveness of these pulpers for coffee seeds production compare to the usual traditional manual method of mortar and pestle. Findings from this study will provide basic information needed for large scale viable coffee seeds production.

MATERIALS AND METHODS

Ripe matured Robusta coffee cherries were harvested from three genotypes and sorted to obtain good ones at CRIN Headquarters plantations. Harvested cherries were de-pulped using manually-operated mechanical pulper and I.C engine powered mechanical pulpers while the traditional manual method of mortar and pestle commonly used was the control. The standards procedures of wet processing method of soaking, depulping and separation of pulp were followed. Wet coffee beans obtained were air dried for about one week good (undamaged) seeds were selected and sown on pre-nursery seedbed mixed with 50:50 topsoil and sawdust mixture.

The drum pulper consists of a perforated cylinder rotating against an adjustable plate and a fixed plate where depulping (through abrasion force) and separation take place respectively. The cylinder is rotated by hand through a handle joined to a wide flywheel. The engine powered pulper is a screw shaft rotating inside a cylinder lined with metal plate and operated by a medium petrol engine. Depulping occurred through rupturing and shearing actions of the cylinder, screw and plate. The pulp was then separated manually from the beans. Equal weights of each genotype of cherries were fed into the pulpers at the appropriate feed rates and machine speeds which were pre-determined before the actual operations. Manual depulping using mortar and pestle was done by pouring the soaked cherries inside the mortar and using the pestle to press out the seeds. Each treatment was replicated thrice. The treatments are designated as follows: Mortal & Pestle (MT) for OP, C2 and C4 (MTOP, MTC2 &MTC4); CRIN Manual Driven Pulper(MN) for the three genotypes (MNOP, MNC2 & MNC4) and motorised pulper (NCAM)also for the three genotypes (NCAMOP, NCAMC2 &NCAMC4). Equal weights of 20g of seeds from each treatment were sown on pre-nursery bed in Completely Randomized Design (CRD). The sown seeds were watered at every other day. Weeding was done as and when due and shade provided using palm fronds. The pre-nursery was protected from rodents and lizards by fencing it round during the experimental period. Data were taken on germination count at 3 days' intervals 2 months after sowing. Healthy and well grown germinated seeds were transplanted (at one seed per bag) into black polythene bags filled with forest topsoil and arranged under the shade in a complete randomized design (CRD). Watering and weeding were carried out at regular intervals. Data were taken on plant morphology of height, leaf length by width, leaf number and stem diameter at monthly intervals for the period of 4 months. Data collected were analysed using SAS, Version 9.1. Means that were different were separated using Duncan Multiple Range Test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Both the seed germination rate and percentage were affected by de-pulping methods and genotypes as indicated by Tables 1 and 2. This was also true of agronomic characters such as leaf number and plant height, but these were not significantly different as in Tables 3 and 4. But, both C2 and C4 genotypes showed the highest means of about 9.7 and 11cm respectively for leaf numbers and plant height for NCAM, while genotype DE had the lowest mean values of 8.6 and 9.3cm for these agronomic parameters and the method of pulping. Engine powered (motorized) pulper were

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significantly different from other methods in respect to germination rate, having the least mean of 29.67 for NCAMC2. However, germination percentage was not different significantly for all the treatments while NCAMC2 had the lowest mean of 33%. Genotype OP had the highest mean of 44 and 54% for engine powered (motorized) pulper (NCAM) in terms of germination rate and percentage respectively. Manually operated mechanical pulper(MN) gave the highest germination rate of 65.3 and germination percentage of 56.2% for OP genotype. The implication is that germination rate was somehow affected by methods of pulping while percentage germination was not seriously affected by the three pulping methods studied. Manual pulper (MN) showed the best performance for germination rate and percentage. This may be as a result of removal of parchment and the endocarp layer by the machine which had been earlier reported as a factor to improve germination by Rosa *et al* (2005) and Da-Silva *et al* (2004). Genotypes can also determine both the rate and percentage of germination; this may be due to variation in genotypes sizes which may be affected by the clearance of the pulping unit of the machine, resulting in possible bruises and damage to the seeds. Although, pulping methods tested did not seriously affect agronomic characters, the trend of response by the genotypes in the nursery indicated that engine powered pulper may have best developmental quality which is also affected by the genotype itself (probably seed size).

Table 1: comparism of seeds germination percentage

Treatments	Means
MNOP	56.1986a
MTC2	54.3322a
NCAMOP	54.0114a
MNC4	49.8430a
MTC4	48.5491a
MNC2	47.9575a
NCAMC4	45.3128a
MTOP	42.9153a
NCAMC2	33.0025a

Means that do not share a letter are significantly different.

Table 2: comparism of seeds germination factor

Treatments	Means
MNOP	65.3333a
MTC4	61.3333ab
MNC4	58.6667ab
MTC2	58.6667ab
MTOP	52.3333abc
MNC2	51.3333abc
NCAMOP	44.0000abc
NCAMC4	39.0000bc
NCAMC2	29.6667c

Table 3: Comparison of number of leaves (NL)

Treatments	Means
NCAMC2	9.72222a
NCAMC4	9.66667a
MNOP	9.55556a
MTC4	9.27778a
MTOP	8.58824a
NCAMOP	8.55556a
MNC4	8.33333a
MNC2	8.23889a
MTC2	7.94444a

Means that do not share a letter are significantly different.

Table 4: Comparison of plant height (PH)

Treatments	Means
NCAMC2	11.6222a
NCAMC4	11.0444ab
MTOP	10.3778ab
MTC4	9.6667ab
MNC4	9.5111ab
MNC2	9.3556ab
NCAMOP	9.2778ab
MNOP	8.7667ab
MTC2	7.9333b

** Means that do not share a letter are significantly different.

CONCLUSION

Manually operated pulper (MN), mortal & pestle (MT) processed seeds germinated better probably because of less damage to the seeds while NCAM motorised pulper processed seeds got the least germination due to damage on seeds' endosperm except for NCAMOP where seeds size was the smallest and were undamaged. Growth was better in NCAMC2 and C4 probably because seeds were scarified thereby encouraging faster germination and growth. CRIN manually operated pulper promoted higher germination as against NCAM motorised pulper which needs further adjustment based on variation in berries and seeds sizes experienced in the study.

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Plate A: Coffee seeds in the pre-nursery

Plate B: Coffee seedlings in the nursery

SEEDLING EMERGENCE AND GROWTH OF ORCHID TREE (*BAUHINIA MONANDRA)* AS AFFECTED BY SOWING ORIENTATION AND MEDIUM

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ABSTRACT

Orchid tree (Bauhinia monandra) is a shrub widely used for provision of shade and environmental beautification. This studywas carried out at the Federal University of Agriculture Abeokuta, Ogun State, Nigeria in 2017 to determine the effect of sowing orientation and medium on seedling emergence and growth of orchid tree (Bauhinia monandra) seedlings. Treatments were sowing orientations (vertical and horizontal) and media (sawdust, topsoil and river sand) in a factorial arrangement laid out in Completely Randomized Design (CRD) with five replications. Data collected on seedling emergence and growth were subjected to Analysis of variance procedures (ANOVA) and treatment means were compared using Duncan's multiple range test (DMRT) at 5% probability level. Effect of sowing orientation on the emergence and height, number of leaves and weight of Orchid tree seedlings was not significant. Seeds sown in sawdust medium had highest percentage of emerged seedlings and dry weight. This study has shown that the germination percentage and seedling growth of B. monandra improves significantly when sown in sawdust and topsoil. Thus, floriculturist can use sawdust as an alternative medium to topsoil for commercial production of seedlings of orchid tree.

INTRODUCTION

Bauhinia monandra also known as orchid tree is a flowering plants in the subfamily Caesalpinioideae and family Fabaceae with a pan tropical distribution. There are about 300 species of this genus found in tropical and subtropical climates usually in most types of vegetation ranging from evergreen lowland rain forest to mountain forest, savanna, dry deciduous forest to swamp forest on various soils. The genus includes trees, vines, and shrubs that are frequently planted for their showy flowers and ornamental foliage. *Bauhinia monandra* is a small to medium-sized deciduous fast-growing shrub or tree with a round, symmetrical, moderate dense crown to 10 m tall. In dry forests, the size is much smaller. The bark is pale grey brown, fairly smooth to slightly fissured and scaly. The twigs are slender, light green, slightly hairy, and angled, becoming brownish grey. Leaves are simple, alternate, basecordate to rounded, apex of lobes acute, ovate blades and long (1.5 – 4 cm) petiole.

Orchid-Tree is festooned with many showy and delightfully fragrant, five-inch-wide blossoms, the narrow purple, pink, and lavender petals arranged to closely resemble an orchid. It has 6-10 flowered racemes in terminal panicles and are a beautiful sight to see, creating a vivid splash of color in the landscape. The flowers are followed by 12-inch-long, slender, brown, flat seed pods which usually persist on the tree for few months. The pods should be collected when they are brown before they dehisce. The seeds are extracted by drying the pods in the sun to release seeds (Orwa*et al* 2009). Seeds of *B.* species possess an undeveloped rudimentary embryo that requires an extended period of high temperature for breaking the dormancy.

Many species are widely planted in the tropics as ornamental tree in parks, gardens and homesteads, and along avenues for its showy fragrant, purple flowers. *B. monandra* is useful as food and medicine for man and animals, source of edible gum, dyestuff, tannins, linolenic, oleic and mytristic fatty acids particularly in India, Vietnam, China and several other countries.

Seedling emergence and growth of plants are affected by many factors. Orientation of seeds and other plant propagules is known to influence the germination and seedling growth (Thapliyal, 1979). For example, maximum germination and better emergence of seeds of *Balanites aegyptica* were achieved in a horizontal position (Elnour and Massimo 1995) while Sal (*Shorea robusta*) seeds placed in an inverted position had the best germination and emergence than in horizontal or upright position (Sharma and Purohit, 1980). Depth of sowing and growing medium was also important for optimum seedling emergence and growth of *Polyalthia longifolia* (Olosunde, 2015). Too shallow or too deep placement would affect both seed germination and seedling vigour (Singh and Wilson, 1974; Masilaijnani and Dharmalingam, 1998). In general, incorrect position, growing medium and depth of seeding could delay or suppress seed germination and seedling emergence adding to sowing expenses. Therefore, the present study was conducted to determine the best sowing orientation (positioning) and medium for emergence and growth of *B. monandra* seedlings to enhance its commercial production.

MATERIALS AND METHODS

The experiment was carried out in 2017 at the Horticultural Nursery, Federal University of Agriculture Abeokuta (7° 15N and 3 ° 25 E), Ogun State, Nigeria. Brown mature pods collected from the mature *B. monandra* trees at the Federal University of Agriculture, Abeokuta were broken to get 1000 seeds. Then six hundred (600) seeds were randomly selected and planted in vertical and horizontal positions in three different media

The experiment was laid out in 2 x 3 factorial arrangement in a Completely Randomized Design (CRD) with 5 replications. The factors were sowing orientation (horizontal and vertical) and growing media (top soil, river sand and sawdust) giving a total of six treatment combinations. There were thirty-seven litres calibrated pots and twenty seeds were planted in each pot. Pots were filled with topsoil, river sand and sawdust to 3 litre points and a ruler was used to determine 2 cm height. Then, seeds were evenly sown horizontally on their sides and vertically by making the tip of the seed upright and covered with different media to predetermined point on the pots (2 cm height). Seedling emergence was determined using the formula derived by Fakorede and Agbana, 1983 as adopted by Olosunde, (2015).

Seedling emergence percentage: $\frac{\text{Number of seedlings emerged}}{\text{Number of seeds planted}} \times \frac{100}{1}$

Three representative plants were tagged for observation. Data were collected on number of days to emergence, seedling height, number of roots, length of the longest root, fresh and dry weight of root and shoot. Three plant samples per treatment were carefully removed from the growing medium by placing them under flowing water to wash off the medium particles from the roots. Then, fresh root and shoot samples were oven dried at 70 ºC to constant weight before weighing with the aid of the sensitive scale to obtain the dry weights. The data collected were subjected to analysis of variance (ANOVA) treatments means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

RESULTS AND DISCUSSION

Effect of sowing orientation on percentage emergence, height, number of leaves, length of longest root and dry matter accumulation of *B. monandra* seedlings was not significant ($p \leq 0.05$). However, percentage seedling emergence, height and number of leaves of *B. monandra* were significantly influenced by different growing media (Tables 1, 2). Highest (65, 70 and 76%) seedling emergence was recorded from seeds sown in sawdust, followed by those sown in river sand (56, 60 and 65%) and then those sown in topsoil (50, 54 and 58%) at 8, 11 and 14 days after sowing (DAS). Conversely, seeds sown in topsoil medium had tallest (27 – 30 cm) seedlings, followed by seeds sown in sawdust (22 - 26 cm) and least in river sand (20 – 22 cm) at 4 and 14 weeks after sowing (WAS). Seedlings from seeds sown in topsoil and river sand produced more (3 – 9) leaves than those sown in sawdust (3 - 8) across the sampling period. Differences in the growing media had no significant effect on the length of longest root and dry matter accumulation of *B. monandra* irrespective of the sowing orientation.

Effect of sowing orientation x medium interactions on percentage of seedling emergence, height and number of leaves of *B. monandra* was significant (Table 1). Generally, seeds sown in sawdust either in vertical or horizontal position had more emerged seedlings compared to other treatments. However, similar percentage seedling emergence was observed from seeds planted in river sand or sawdust medium. Conversely, tallest seedlings with more leaves were recorded from seeds sown in topsoil either in vertical or horizontal position and least in river sand medium. Seedlings grew in river sand and sawdust at both sowing orientations were similar in terms of height and production of leaves. Length of longest root and shoot dry weight of *B. monandra* was not significantly affected by sowing orientation and medium (Table 2).

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Table 1: Seedling emergence and height of *B. monanda* as affected by sowing orientation and sowing medium

		Seedling emergence (%) Days after sowing					Height (cm) Weeks after sowing					
Orientation	Growing media	2	5	8	11	14	4	6	8	10	12	14
Vertical	Topsoil	41.0 a	47.0 a	56.0 ab	58.0 ab	61.0 ab	27.3 a	29.1 a	29.8 a	29.9 a	30.2 a	30.3 a
	Sawdust	49.0 a	62.0 a	67.0 a	73.0 a	80.0 a	23.3 a	24.5bc	25.0ab	25.5abc	25.8abc	26.1ab
Riversand		38.0 a	46.0 a	54.0 ab	56.0 b	60.0 ab	20.4 a	20.7 c	21.5 c	21.7 c	21.9 c	22.8 b
Horizontal	Topsoil	34.0 a	44.0 a	46.0 b	50.0 b	55.0 b	26.9 a	28.1ab	28.8ab	29.0ab	29.3ab	29.9 a
Sawdust		49.0 a	56.0 a	64.0 a	67.0 ab	72.0 ab	21.5 a	22.0 c	22.7 c	24.8bc	24.9bc	25.2 b
River sand		41.0 a	49.0 a	58.0 ab	64.0 ab	70.0 ab	20.0 a	20.7 c	21.4 c	21.9 c	22.1 c	22.1 b
Orientation												
Vertical		42.7 a	51.7 a	59.0 a	62.3 a	67.0 a	23.67 a	24.80 a	25.42 a	25.73 a	25.95 a	26.18 a
Horizontal		41.3 a	49.7 a	56.0 a	60.3 a	65.7 a	22.81 a	23.59 a	24.31 a	25.23 a	25.47 a	25.93 a
Growing media												
	Topsoil	37.5 a	45.5 a	50.5 b	54.0 b	58.0 b	27.10 a	28.61 a	29.29 a	29.50 a	29.75 a	30.11 a
	Sawdust	49.0 a	59.0 a	65.5 a	70.0 a	76.0 a	22.39 b	23.28 b	23.84 b	25.14 b	25.35 b	25.64 b
	River sand	39.5 a	47.5 a	56.0 ab	60.0 ab	65.0 ab	20.22 b	20.70 b	21.46 b	21.79 c	22.04 c	22.42 c

Means followed by same letter(s) in a column within the same factor are not significantly different

Table 2: Number of leaves, root length and total dry weight of *B. monandra*as affected by sowing orientation and medium

Orientation	Growing media	Number of leaves Weeks after sowing 4	6	8	10	12	14	Total dry weight (g)	Length of longest root (cm)
Vertical	Topsoil	3.0 a	4.0 a	6.0ab	8.0 a	9.0 ab	11.0 a	1.06 a	20.88 a
	Sawdust	3.00 a	4.0 a	5.0 c	6.0 b	7.0 c	8.0 b	1.18 a	19.58 a
	Riversand	3.0 a	4.0 a	5.0 bc	6.0 b	8.0 bc	9.0 b	1.08 a	20.20 a
Horizontal	Topsoil	3.0 a	4.0 a	6.0 a	8.0 a	10.0 a	11.0 a	0.90 a	18.68 a
	Sawdust	3,0 a	4.0 a	5.0 c	6.0 b	7.0 c	8.0 b	1.20 a	19.12 a
	Riversand	30 a	4.0 a	5.0 bc	6.0 b	7.0 c	8.0 b	1.08a	20.44 a
Orientation									
	Vertical	3.0 a	4.0a	5.0a	7.0a	8.0a	9.0a	1.11a	20.22 a
	Horizontal	3.0 a	4.0 a	5.0 a	7.0a	8.00a	9.0a	1.06a	19.41 a
Growing media									
	Topsoil	3.0 a	4.0 a	5.0 b	6.0 b	7.0 b	9.0 a	0.98a	19.35 a
	Sawdust	3.0 a	4.0a	5.0 b	6.0 b	8.0 b	8.0 b	1.19a	20.32 a
	River sand	3.0 a	4.0a	6.0a	7.0a	9.0.a	9.0a	1.08a	20.22 a

Means followed by same letter(s) in a column within the same factor are not significantly different

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EFFECT OF PRE-PLANTING TREATMENTS ON GERMINATION AND EARLY SEEDLING GROWTH OF YELLOW PLUM (*XIMENIA AMERICANA*) IN DADIN KOWA, GOMBE STATE

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ABSTRACT

The research was conducted at the Horticultural Technology Department Site of the Federal College of Horticulture Dadin kowa, Gombe State. The effects of pre-planting treatments on germination and early seedling growth of Ximenia americana were studied in 2020 rainy season. The experiment was laid out in a completely randomized design (CRD) with four treatments replicated four times. A rate of 1.2kg/pot (244.8kg/ha.) 0.25ton/ha. of dried and ground cow and bull droppings and top soil 1.5kg/pot (306kg/ha.) 0.31ton/ha. Was mixed with river sand at 1.6kg/pot (326.4kg/ha.) 0.33ton/ha and river sand only at 4.8kg/pot as control were applied as the potting mixtures in equal proportion (1:1:1). With the spacing of 7x7m for Ximenia americana tree fitted into the design. The treatments consisted of seeds scarified with fire, seeds soaked in normal tap water for 24 hrs, seeds boiled in hot water and untreated seeds serving as control. Growth parameters such as number of days to first seedlings germination, germination rate and germination percentage were investigated for 3 weeks while plant heights (cm), leaf counts, stem collar girths (cm) were investigated at 12 weeks at 2weeks interval and seedlings vigour index (SVI) was calculated at the end of the 12 weeks' period. The result showed that seeds soaked in normal tap water for 24 hrs was the first to germinate in 7 days followed by seeds boiled in hot water in 10 days, seeds scarified by fire in 12 days and untreated seeds germinated last between the treatments in 14 days respectively. Seeds soaked in normal tap water for 24hrs has the highest germination percentage of 87.5%. followed by seeds boiled in hot water with 75%, seeds scarified by fire had 62.5% and untreated seeds with the least of 50%. The result also revealed that seeds soaked in normal tap water for 24hrs was still the highest in means of plant height (48.0 cm), leaf count of (33) and stem collar girth of (3.0cm) and seedlings vigour index (4200) respectively. Analysis of variance indicated a significant difference at 5% level of probability (P=0.05) on number of days to first seedlings germination (LSD = 1.16), germination percentage (LSD = 6.41), plant height (LSD = 2.47) and stem collar girth (LSD = 2.94). This result indicated that soaking Ximenia americana seeds in normal tap water for 24hours should be adopted for quick germination and early seedlings growth of Yellow plum by breaking the seed dormancy to produce more seedlings in nurseries by researchers/farmers for seedlings multiplications in plantations for food production, solving the problem of unemployment, soil erosion control, industrial uses and to save the crop from extinction in Africa.

Key words: Dormancy, seed coats, germination, *Ximenia americana*

INTRODUCTION

Ximenia americana, commonly known as sour plum, yellow plum, sea lemon or Tsada in Hausa language is a small sprawling tree of woodlands native to Australia and Asia. Ximenia is a genus of flowering plants in the family Olacaceae.The generic name honours Francisco Ximenez,.a Spanish priest.The specific name is the latin form of 'American'(Wikipedia,2021).The tree grows as a bush –forming shrub/small tree to between a height of 2m-7m(6.5-23feet).The leaves are oval shaped ,bright green and have a strong smell of almonds,simple ,alternate or clustered on spur shoots of 2.5-8cm having a lanceolate (spear-like)to elliptic shape and retuse at the apex with a texture similar to leather.

The trunk has a diameter of less than 10cm which is used as kitchen hand tools and the wood is used as fuel wood. The bark has a colour of dark brown to pale grey together with the roots are used as dyes. The sour sweet fruits about 1.5-4 cm long have orange fleshed resembling plum and vary in colour from dark red to brown to bright orange with sour sweet flavour. Equally, it can be eaten raw and are used to make a sour preservatives or an intoxicating drinks. In Asia, the young leaves are cooked as a vegetable. Flowering and fruiting varies between locations, but flowering typically occurs in the dry season. However, the leaves also contain Cyanide and need to be thoroughly cooked and should not be eaten in large amounts (International Cyanide Management Institute, 2009). The seeds kernel contains oil which is edible and used for cooking, hair care etc. The seeds contain 10 fatty acids, 7unsaturated yielding a total unsaturation of 92.42%. The oil contain essential fatty acids of Linoleic (1.34%) Linolenic (10.31%), Arachidonic (0.60%) and varying levels of unsaturated higher fatty acids, specifically

Eicosatrienoic (3.39%), erucic (3.46%) and Nervonic (1.23%) acids, yellowish green or brown at maturity (Wikipedia, 2021).

Ximenia americana oil is also known particularly for its anti-inflammantory properties local medicines and cosmetics. The non drying oil is suitable for soap making and lubrication, lips and dry skin cares, softening leather, soothes dermatitis and eczeama skins (The illustrated encyclopedia of essential oil,1995). The presense of active ximenynic acid has been shown to be beneficial for the skin, it is also used as soap. A mostly solitary tree dispersed in open country, savannahs, gallery forest along coastal areas, in the under storey of dry forests, in dry woodlands or on river banks, drought resistant. It requires an altitude of 0-2000m, mean annual temperature is 14-30^{0}C, rainfall 300-1250mm, soil type is poor and dry, including clay loam and sands. The tree starts flowering in September to December and fruiting through out the year (World Agroforestry, 2021)

The tree is propagated by seeds and cuttings, regenerates naturally from seed and coppice, fresh seed should be sown for good germination, can also be used for life fencing purposes. The tree contributes to better crop yields as it reforms organic matter to the soil, thus improving the water holding capacity of the soil preventing soil erosion. Growth of trees depends on the environmental and genetic factors. The leaves are green during drought which can be emergency fodder to grazing livestock when grasses dry up. scarcity of all types of its value.Some valuable species are becoming rare, and some endangered in their wild habitats (World Agro forestry, 2021).The seed is orthodox and should be stored at low moisture content and as cold as possible and for short term storage ,the seeds can be stored moist,It is essential for the successful moist storage of orthodox seeds that the seeds are ventilated frequently, furthermore, the Dormancy and pretreatment can be done by removing of the seed coat prior to germination or sterilization of the seeds (e.g by immersion in sodium hypochlorite for 5 minutes) can increase germination (Pritchard et al., 2004). Pre-germination treatments become necessary to enhance its quick germination. However, to get the seeds emerged within few days required breaking the seed dormancy through seed coat treatment, hence the need of this study in view of importance of the crop.

MATERIALS AND METHODS

This research work was conducted at Horticultural research and training site of the Federal College of Horticulture Dadin Kowa, Gombe state. The research area is located at latitude 11^0 30^{1}N and longitude 10^0 20^{1}E in the Northern guinea savannah. The annual rainfall of the area is 760 – 850mm with mean daily temperature ranges from 30^{0}c – 36^{0}c and the soil type of the area is loamy (Kowal and Knabe, 1973). The experimental design was laid out in a completely randomized design with four treatments replicated four times, each treatment with 2 medium size polythene pots (4x4x2).

The potting mixture has the ratio of one part of top soil to one part of cow and bull droppings to one part of river sand (1:1:1) mixed together for treatments A, B and C that is seeds that were pre-treated and river sand only for treatment D serving as control. 32 seeds were sown in all the polythene pots for the whole treatments and replications. Each treatment has 8 polythene pots stacked at the experimental site (6x7 metres) the treatment were: scarified seeds with fire (T_1), seeds soaked in normal tap water for 24hrs (T_2), seeds boiled in hot water (T_3) and un-treated seeds serving as control (T_4). Dried and grounded cow and bull droppings was applied at the rate of 1.2kg/pot (244.8kg/ha) 0.3 ton/ha. Top soil 1.5kg/pot (3.06kg/ha) 0.3ton/ha was mixed with river sand at 1.6kg/pot (326.4kg/ha) 0.33ton/ha and river sand only at 4.8kg/pot as control under Espacement of 7x7 meters for Yellow plum fitted into the design. Zero fertilizers were adopted in control (T4). The seeds were tested by floatation to determine the viability. Growth parameters such as number of days to first seedlings germination, germination rate and germination percentage were investigated for 3 weeks at 3 days' interval while plant heights (cm) leaf counts, stem collar girths (cm) were investigated for 12 weeks at 2 weeks' interval and seedlings vigour index (SVI) was calculated at the end of the 12 weeks' period. The data collected was analyzed using genstat and the means were separated by least significant difference (LSD) at 5%.

RESULTS AND DISCUSSION

The Effects of Pre- planting treatments on germination and early seedling growth of *Ximenia americana* were represented in table 1, where treatment B (seed soaked in normal tap water for 24 hours was the first to germinate in 7 days between the treatments on number of days to first seedlings germination. This is followed by seeds boiled in hot water, seeds scarified by fire and untreated seeds. Table 2 shows the influence of seed coat treatments on germination percentage where seeds soaked in normal tap water for 24 hrs has the highest germination percentage of 87.5%. This is followed by seeds boiled in hot water, seeds scarified by fire and untreated seeds with the least percentage of 50%.

Table 1: Number of days to first seedling germination of *Ximenia americana*

Treatment	No. of days
A=T1: seeds scarified with fire	12.0
B=T2: seeds soaked in normal tap water for 24hrs	7.0
C=T3: seeds boiled in hot water	10.0
D=T4: untreated seeds (control)	14.0
LSD (5%)	1.16

LSD = Least significant difference, NDFSG = Number of days to first seedlings germination.

Table 2: Germination percentage for 3 weeks' period after 1st germination of *Ximenia Americana* seedlings

Treatment	Emergence percentage
T1	62.5
T2	87.5
T3	75.0
T4	50.0
LSD (5%)	6.41

LSD = Least significant difference, GP = Germination percentage

Table 3 shows the effects of pre-planting treatments on plant height of *Ximenia americana* where the treatments differed significantly with the control through out the period of sampling. At 2 weeks after sowing (WAS), taller seedlings were recorded on seeds soaked in normal tap water for 24 hrs and still up to 4,6,8 and 10 WAS, the same treatment was leading in taller seedlings up to 12 weeks where the same treatment produced taller seedlings of 48.0cm followed by seeds boiled in hot water, seeds scarified by fire and untreated seeds respectively. The effects of pre-planting treatments on number of leaves on *Ximenia Americana* seedlings is represented in table 4. The results show that higher number of leaves of 33 at 12WAS was achieved with the seeds soaked in normal tap water for 24 hrs followed by seeds boiled in hot water, seeds scarified by fire and untreated seeds respectively.

Table 3: Effects of pre-planting treatment on cumulative mean plant heights (Cm) of *Ximenia americana* for 12 weeks at 2 weeks' interval

Number of Weeks						
Treatments	2WAS	4WAS	6WAS	8WAS	10WAS	12WAS
T1	4.0	7.1	12.0	16.0	23.0	32.0
T2	6.6	12.0	20.0	28.0	39.0	48.0
T3	58	10.0	14.0	20.0	27.0	36.0
T4	3.0	5.0	9.0	12.0	18.0	24.0
LSD (5%)	0.34	0.60	0.97	1.35	1.89	2.47

LSD = Least significant difference, PH = Plant height (cm), WAS= weeks after sowing

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Data on table 5 shows the effects of pre-planting treatments on stem collar girths at 2, 4, 6, 8 and 10 WAS where higher collar girths was produced by seeds soaked in normal tap water for 24 hrs of 2.6cm followed by seeds boiled in hot water, seeds scarified by fire and untreated seeds respectively. While at 12 WAS seeds soaked in normal tap water for 24 hrs was still leading the trend with 3.0cm collar girth compared with the other treatments, this is followed by seeds boiled in hot water, seeds scarified by fire and untreated seeds which differed significantly at P=0.05. The priority of pre-planting treatments is perhaps due to soaking the seeds in normal tap water for 24 hrs due to imbibitions through the hard seed coat of *Ximenia americana* that enhanced the seed germination and early seedlings growth than the other treatments adopted in this research.

Table 4: Effects of pre-planting treatments on cumulative mean number of leaves of *Ximenia americana* for 12 weeks at 2 weeks' interval.

Number of Weeks						
Treatments	2WAS	4WAS	6WAS	8WAS	10WAS	12WAS
T1	5.0	8.0	12.0	14.0	17.0	20.0
T2	8.0	12.0	18.0	24.0	29.0	33.0
T3	6.0	10.0	14.0	16.0	19.0	22.2
T4	4.0	6.0	8.0	10.0	14.0	17.5
LSD (5%)	0.73	0.15	1.65	2.04	2.51	2.94

LSD = Least significant difference, NL = Number of Leaves, WAS= weeks after sowing

Table 5: Effects of pre-planting treatments on cumulative mean stem collar girths (Centimetre) for 12 weeks at 2 weeks' interval of Ximenia americana

Number of Weeks						
Treatments	2WAS	4WAS	6WAS	8WAS	10WAS	12WAS
T1	0.4	0.7	1.1	1.4	1.7	2.0
T2	0.9	1.5	1.9	2.1	2.6	3.0
T3	0.7	1.2	1.5	1.9	2.3	2.6
T4	0.3	0.5	0.6	1.1	1.3	1.7
LSD (5%)	0.08	0.14	0.15	0.19	0.24	0.29

LSD = Least significant difference, SCG = Stem collar girth (cm), WAS= weeks after sowing

CONCLUSION AND RECOMMENDATION

Based on the results of this experiment, soaking of the hard seed coats of *Ximenia americana* in normal tap water for 24 hrs performs better in its germination and early seedlings growth as per the parameters measured above. It was considered to be the best treatment out of the four treatments adopted in this research. It is, therefore, suggested that farmers and researchers should soak the hard seeds for 24 hrs prior to sowing to break the dormancy and thus enhancing germination and early seedlings growth of *Ximenia americana*

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SEEDLING GROWTH AND NODULATION AMONG DIFFERENT ACCESSIONS OF AFRICAN YAM BEAN (*SPHENOSTYLIS STENOCARPA* HOCHST EX. A. RICH) HARMS

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ABSTRACT

Seedling growth and nodulation in African yam bean were studied in a potted experiment at the experimental farm of the Department of Agronomy, Michael Okpara University, Umudike. The experiment involved twelve (12) accessions of African yam bean, which were sourced from five locations, namely: Abia, Enugu, Ebonyi, Kogi and Benue states. The experiment was laid out in a completely randomized design and replicated three times. Data were collected on the following parameters: number of leaves, number of nodules, plant height, root dry weight, shoot dry weight, nodule weight and total dry matter. These parameters were recorded at 3, 6, 9 and 12 weeks after planting. Data collected were subjected to analysis of variance using the GLM module of SAS, while mean separation was done using least square difference at 5% level of significance. Correlation analysis was done to show relationship among traits. The results showed that at 3, 6, 9 and 12 WAP, most of the traits studied were significant (p<0.05). The results further showed that as the plants progressed from 3,6, 9 and 12 WAP, there were significant increases in most of the traits measured. It further revealed that at 12 WAP, Nsukka accession gave significantly higher number of leaves, number of nodules and root dry weight. Similarly, Onicha accession gave significantly higher shoot dry matter and total dry matter, while Igbo-Etiti accession gave plant height. On the other hand, the accessions, Ogbadibo and Ikwuano gave significantly lower values for most of the attributes studied. From the correlation analysis, shoot dry weight had strong positive relationship with total dry matter weight. Accessions such as Nsukka and Onicha with higher agronomic attributes, especially at 12 WAP are encouraged for further selection and improvement studies to ensure improved and sustained production of African yam bean.

Key words: Seedling growth, nodulation, genetic potentials, Agronomy

INTRODUCTION

The African yam bean- *Sphenostylis stenocarpa* (Hochst ex. A. Rich) Harms, locally known and identified as "Odudu" among the Igbos, "Sese" among the Yorubas and "Girigiri" among the Hausas, of the family *Fabaceae,* is a well-known West African leguminous crop (Duke *et al.,* 1997). It is believed to have originated from Ethiopia. Both wild and cultivated types occur in Tropical Africa as far south as Zimbabwe, throughout West Africa from Guinea to Southern Nigeria (Baudoin and Mergeai, 2001; GRIN, 2009). It is a vigorous, herbaceous leguminous plant, growing and adaptable throughout tropical Africa (Poster, 1992). It is a vigorous, climbing vine, reaching 1.5 – 2 m in height with trifoliate leaves; the leaflets being up to 14 cm in length and 5 cm broad (Adewale *et al.,* 2010). The stems may be prostrate or climbing and range from 1 m to 3 m in length (Adewale and Odoh, 2013). The crop is mostly cultivated on a small scale throughout tropical Africa and it is especially suited to lowland conditions, though it can be grown up to 1,800 m. It performs well on almost all soils, provided they are slightly acidic; i.e. pH 5.0-6.5 (Baudoin and Mergeai, 2001). It is propagated by seeds or tubers (Adewale *et al.,* 2010). The duration of the crop cycle ranges between 150 – 300 days. In Southern Nigeria, it is usually interplanted with yams and other twining beans and usually trained up with long stakes (Ene-Obong and Okoye, 1992).

Based on its nutrient composition, ripe seeds contain an average 2.1% protein, 1.2% fat, 74.1% carbohydrates and 5.7% fibre, of which the calculated percentages relate to dry matter (Arogundade *et al.,* 2014). The tubers contain an average of 11-19% fibre, of which the calculated percentages also relate to dry matter (Baudoin and Mergeai, 2001). The amino acid content of the protein is similar to that of the soybean, though rather higher in histidine and iso-leucine. The energy content of the seeds per 100 g dry matter is 1, 640 KJ (Utter 2007). The seeds are also rich in minerals such as potassium, phosphorus, calcium, Iron and Zinc, but low in sodium and Copper (Utter, 2007). The dry seeds serve as a source of protein in various food preparations. Therefore, they can be used to fortify other foods low in protein to address protein malnutrition among the susceptible population. The bean has been touted for use in

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addressing the problem of food insecurity in Africa because they are indigenous (Klu *et al.,* 2000). Similarly, it currently serves as a security crop due to its potentials to meet year-round protein requirements, if grown on a large scale. The tubers are cooked and eaten in the same manner as potatoes, which they resemble in flavor. The tubers are regarded as an important source of starch and protein in tropical Africa (Baudoin and Mergeai, 2001).

The plant has a large genetic variation (Klu *et al.,* 2000) with new accessions investigated recently (Baiyeri *et al.,* 2018). The crop also nodulates profusely and probably has very high ability to fix nitrogen (Oboh *et al*., 1998), thereby helping to replenish soil nitrogen. It is therefore an important crop which merits significant consideration for land reclamation. The nitrogen-fixing symbiosis makes it possible for the nitrogen that is supplied by the rhizobia to the legumes replace the expensive and chemical industrial fixed nitrogen (Otsoseng *et al.,* 2012). The AYB enjoys a symbiosis with bacteria that naturally fix nitrogen from the air (Busson, 2001).

Despite its rich nutrient base and its capacity to serve as a security crop, AYB is still being regarded as an underutilized crop owing to the poor distribution and utilization of its rich genetic and nutritional resources. Recent studies have mainly emphasized on the nitrogen fixing ability of AYB with little or no attention given to the nodule formation and how they influence seedling growth and total yield of AYB; hence, the backbone of the study. AYB is a potential crop that needs to be explored and developed because of its biological nitrogen fixation ability and adaptability to a variety of soils. Therefore, the main objectives of the study were to: determine the growth and seedling development in AYB and to determine the nodulation pattern among various accessions of AYB.

MATERIALS AND METHODS

The research was conducted at the research farm of Department of Agronomy, Michael Okpara University of Agriculture, Umudike from April – August, 2009. It is located at latitude 05^{0}29'' North and longitude 07^{0}33'' East (Nwokocha and Onwuka, 2002). It has an altitude of 122 m (400 Ft.) above sea level. It falls within the humid rainforest zone of West Africa, which is characterized by a long duration of rainfall. Twelve accessions of AYB were sourced from five locations, namely: Enugu, Ebonyi, Kogi, Abia and Benue states. The seeds were sown at a depth of 3-4 cm to allow for early germination and emergence. The experiment was a potted experiment and was laid out in completely randomized design (CRD) which was replicated three times. Well perforated polythene bags were filled with well composed soil comprising top soil, organic manure and sharp river sand mixed in the ratio of 3:2:1, respectively. Each plot comprised of 12 poly bags and 12 accessions, giving a total of 144 bags per replication and a total of 432 poly bags used in the experiment. Seeds were sown at the rate of two seeds per hole, with spacing distance of 0.5 m x 0.8 m. Data were collected at three weeks' intervals of 3, 6, 9 and 12 weeks after planting (WAP) on the following parameters: number of leaves, number of nodules, plant height, root dry weight, shoot dry matter weight and total dry matter weight. Weeding was done at weekly intervals and the accessions were staked at 3 WAP. This was done after destructive sampling of which the whole plant is being harvested after wetting the soil. The root region was subsequently immersed in a bucket of water and washed gently, then excised from the shoot region and later oven dried. This was done at 3, 6, 9 and 12 weeks after planting (WAP). Analysis of variance was performed on plot means using GLM module of SAS software on plot means. Separation of means was done using Fishers' Least square difference (F-LSD) at 5% level of significance.

RESULTS AND DISCUSSION

According to Bareke (2018), seedling growth is the developmental period of the young plant from time germination is completed until it can manufacture enough food through photosynthesis to sustain growth. The seedling root (radicle) is the first structure to emerge from the seed during germination. From the results obtained, it was observed that Nsukka accession gave significantly ($p<0.05$) higher number of leaves at 9 and 12 WAP. It was statistically similar to Ikwuano accession for this attribute. For plant height, similar result was obtained at 3 WAP, of which Nsukka accession gave significantly higher result (Table 1). However, it was statistically similar to Onicha accession at 6 and 9 WAP and statistically similar to Igbo-Etiti accession at 12 WAP for same trait (Tables 2,3). At 9 and 12 WAP, it was observed that Nsukka accession also recorded significantly ($p<0.05$) higher number of nodules (Tables 3, 4). It was statistically similar to Isuikwuato and Dekina accessions. It differed slightly at 3 and 6 WAP, with Igbo-Etiti and Isuikwuato accessions recording higher results. For nodule weight, there were no significant weight differences (p>0.05) at 3 WAP. However, at 6 and 9 WAP, Tarka accession gave significantly higher nodule weight while Ogbadibo accession gave higher result at 12 WAP. For root dry weight and shoot dry weight, it was observed that especially at 6 WAP, Nsukka accession gave significantly (p<0.05) higher results. It recorded higher result at 12 WAP for root dry weight, while Onicha accession gave higher result for shoot dry weight. Similar result was recorded for total dry weight of the plant, with Onicha accession recording significantly (p<0.05) higher results at 9 and 12 WAP, while Nsukka accession gave higher result at 6 WAP. It was statistically similar to Isi-Uzo accession at 3 WAP. In contrast, it was observed that Ogbadibo and Ikwuano accessions gave lower results for most of the agronomic traits estimated especially at 9 and 12 WAP. This development especially with Nsukka and Onicha accessions which gave higher significant results, especially at 9 and 12 WAP could be as a result of the rich genetic resource and high adaptive potentials of these accessions. Assefa and Kleiner (1997) recorded similar trend with some accessions having more pronounced dominance over others in expression of major agronomic and yield attributes in some accessions of AYB.

Table 1: Means of the seedling growth and nodulation attributes among different accessions of African yam bean at 3 WAP

ACCESSIONS	NL	NOD	PH (cm)	NODWT (g)	RDWT (g)	SDWT (g)	TDWT (g)
IGBO-ETITI	5.00	4.00	32.06	0.00	0.07	0.49	0.56
NSUKKA	7.67	2.33	33.50	0.00	0.09	0.47	0.57
OGBADIBO	5.33	2.33	14.67	0.00	0.04	0.27	0.31
IKWO	6.33	4.00	22.83	0.00	0.08	0.42	0.49
ISI-UZO	5.67	0.67	17.22	0.00	0.04	0.34	0.72
TARKA	6.67	1.67	19.50	0.00	0.04	0.36	0.40
IKWUANO	5.67	0.33	17.77	0.00	0.04	0.27	0.30
ONICHA	5.33	2.33	27.72	0.00	0.10	0.40	0.50
ABAKALIKI	6.33	2.00	25.37	0.00	0.07	0.34	0.41
ISUIKWUATO	5.67	0.67	24.44	0.00	0.09	0.35	0.44
KWANDE	5.67	3.00	31.61	0.00	0.09	0.47	0.56
DEKINA	6.00	2.00	25.94	0.00	0.09	0.34	0.42
F-LSD$_{(0.05)}$	2.00	NS	11.52	NS	0.04	0.16	NS

Where; NL= Number of leaves, NOD= Number of nodules, PH= Plant height, NODWT= Nodule weight, RDWT= Root dry weight, SDWT= Shoot dry weight, TDWT= Total dry weight.

Table 2: Means of the seedling growth and nodulation attributes among different accessions of African yam bean at 6 WAP

ACCESSIONS	NL	NOD	PH (cm)	NODWT (g)	RDWT (g)	SDWT (g)	TDWT (g)
IGBO-ETITI	12.00	6.33	63.45	0.06	0.36	1.56	2.00
NSUKKA	16.00	5.67	59.22	0.04	0.40	2.42	2.90
OGBADIBO	11.67	6.00	49.03	0.08	0.28	1.60	2.00
IKWO	11.00	4.00	46.11	0.09	0.25	1.29	1.57
ISI-UZO	10.33	4.33	37.78	0.02	0.14	1.23	1.41
TARKA	11.00	5.00	49.91	0.07	0.34	1.75	2.12
IKWUANO	11.67	5.67	25.77	0.04	0.26	1.16	1.48
ONICHA	12.67	6.00	66.59	0.03	0.35	2.00	2.38
ABAKALIKI	14.00	5.00	50.22	0.05	0.25	1.72	1.89
ISUIKWUATO	12.33	7.00	45.77	0.02	0.25	1.54	1.86
KWANDE	13.33	6.33	49.22	0.05	0.31	2.00	2.58
DEKINA	12.67	6.33	54.78	0.05	0.35	1.47	1.91
F-LSD$_{(0.05)}$	NS	NS	10.77	NS	NS	0.69	0.84

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Where; NL= Number of leaves, NOD= Number of nodules, PH= Plant height, NODWT= Nodule weight, RDWT= Root dry weight, SDWT= Shoot dry weight, TDWT= Total dry weight.

Table 3: Means of the seedling growth and nodulation attributes among different accessions of African yam bean at 9 WAP

ACCESSIONS	NL	NOD	PH (cm)	NODWT (g)	RDWT (g)	SDWT (g)	TDWT (g)
IGBO-ETITI	28.00	8.00	82.39	0.13	0.86	9.64	10.62
NSUKKA	38.00	12.00	106.77	0.13	1.11	4.94	6.18
OGBADIBO	24.00	5.67	99.83	0.81	1.00	7.67	9.63
IKWO	29.00	12.67	102.83	0.49	0.72	7.07	8.28
ISI-UZO	31.00	6.76	83.55	0.12	0.66	8.55	9.33
TARKA	21.00	9.67	96.00	0.81	0.84	9.13	10.14
IKWUANO	30.00	8.33	96.33	0.24	0.88	3.89	5.06
ONICHA	28.00	7.67	124.72	0.29	0.93	11.33	12.55
ABAKALIKI	33.00	7.33	101.50	0.31	1.06	3.90	6.27
ISUIKWUATO	30.00	12.00	99.49	0.34	0.75	4.88	5.97
KWANDE	29.00	12.00	82.33	0.28	0.96	9.43	10.67
DEKINA	28.00	11.00	114.75	0.62	1.21	6.58	10.31
$\text{F-LSD}_{(0.05)}$	NS	1.77	NS	0.01	0.11	1.29	1.55

Where; NL= Number of leaves, NOD= Number of nodules, PH= Plant height, NODWT= Nodule weight, RDWT= Root dry weight, SDWT= Shoot dry weight, TDWT= Total dry weight.

Table 4: Means of the seedling growth and nodulation attributes among different accessions of African yam bean at 12 WAP

ACCESSIONS	NL	NOD	PH (cm)	NODWT (g)	RDWT (g)	SDWT (g)	TDWT (g)
IGBO-ETITI	48.00	11.00	154.63	0.29	1.28	14.95	16.53
NSUKKA	62.00	19.67	134.72	0.36	1.96	8.08	10.37
OGBADIBO	42.00	10.00	98.25	1.59	1.64	11.36	14.59
IKWO	54.00	17.33	121.83	0.79	1.22	13.93	15.73
ISI-UZO	62.00	13.33	120.80	0.32	1.02	11.40	12.75
TARKA	38.67	15.00	107.08	0.33	1.44	12.25	14.02
IKWUANO	62.00	13.67	123.09	0.49	1.24	9.69	11.42
ONICHA	51.00	15.00	115.19	0.42	1.25	15.93	17.60
ABAKALIKI	59.00	10.33	109.35	0.58	1.46	10.40	12.44
ISUIKWUATO	55.00	16.00	126.34	0.75	1.18	12.00	13.93
KWANDE	55.00	16.67	124.83	0.58	1.26	13.43	15.26
DEKINA	51.00	18.00	105.15	0.95	1.76	12.07	14.57
$\text{F-LSD}_{(0.05)}$	0.56	4.19	3.00	0.05	0.11	1.06	1.11

Where; NL= Number of leaves, NOD= Number of nodules, PH= Plant height, NODWT= Nodule weight, RDWT= Root dry weight, SDWT= Shoot dry weight, TDWT= Total dry weight.

Furthermore, the result showed that the number of leaves, plant height, nodule weight, root dry weight, shoot dry weight and total dry weight of the plant increased significantly from 3 WAP to 12 WAP. This agrees with the findings of Assefa and Kleiner (1997) and Otsoseng *et al*. (2012) on Jicama (*Pachyrhizus erosus* (L.)), a relative of African yam bean which showed significant increase in foliage, fresh and dry matter weight, number of leaves per plant, main stem length, nodes and internodes of the main stem. In terms of nodulation pattern in the plant, it was also observed that as the growth of the plant progressed from 3 WAP to 12 WAP, the nodules became bigger, with corresponding increase in their weights. It also follows similar trend for root dry matter, even as they increased progressively from 3 WAP to 12 WAP. This conforms with the report of Crespi and Galvez (2000). It was also observed in the course of the study that root nodules decreased progressively in number from 3 WAP to 12 WAP, with corresponding increase in nodule weight. This could be that the root nodules kept merging progressively to form edible root tubers (Crespi and Galvez, 2000). From the correlation analysis, plant height had a negative correlation with number of nodules (r = -0.585*), while shoot dry weight had a strong positive correlation with the total dry matter weight (Table 5). This implies that, an increase in plant height resulted in reduction in number of nodules. In contrast, an increase in shoot dry weight gave a corresponding increase in the total dry matter weight. This agrees with the findings of Otsoseng *et al.* (2012) of which they explained that increase in number of leaves, number of root nodules, stem girth and shoot weight influenced positively the total biomass of the plant.

Table 5: Correlation analysis showing relationship among seedling growth and nodulation attributes

Correlations							
	NL	**NOD**	**PH**	**NODWT**	**RDWT**	**SDWT**	**TDWT**
NL	1	0.248	0.329	-0.36	-0.147	-0.461	-0.569
NOD		1	0.112	-0.192	0.284	-0.103	-0.126
PH (cm)			1	-0.585*	-0.225	0.15	0.034
NODWT				1	0.31	-0.066	0.135
RDWT					1	-0.498	-0.351
SDWT						1	0.975**
TDWT							1

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Where; NL= Number of leaves, NOD= Number of nodules, PH= Plant height, NODWT= Nodule weight, RDWT= Root dry weight, SDWT= Shoot dry weight, TDWT= Total dry weight

CONCLUSION

African yam bean, though under exploited and less popular among notable food crops and legumes, is gradually gaining ground in terms of recognition as a good source of food protein with protein percentage exceeding that of the well-known cowpea (Baudoin and Mergeai, 2001). Currently, the crop is being cultivated as a root vegetable, though on a small scale, despite its protein-rich nutrient base (Gruneberg *et al.,* 2003). From the results obtained, the accessions Nsukka and Onicha gave significantly higher values for number of leaves, plant height, root dry weight, shoot dry weight and total dry matter weight of the plant. These accessions thus provide promising potentials to exhibit higher yield and productivity, and are therefore recommended for further improvement studies so as to greatly harness their potentials to boost production and wider availability. With regards of number of nodules and nodule weight, Nsukka and Isuikwuato accessions gave significantly higher values. Selection and further improvement studies on these accessions could improve the potentials of AYB to efficiently produce root tubers which are highly relished alternatives to other starchy root products such as potatoes, especially in the tropics. However, the results have shown that nodulation is low in AYB compared to some popular legumes such as cowpea and mungbean. Therefore, concerted effort should be made to increase nodulation in AYB; as further studies and research work would ensure optimum utilization of the great nutrient potentials of this crop, as this would ensure increased food security and improved productivity.

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YIELD PARAMETERS AND YIELD OF IRISH POTATO (*SOLANUM TUBEROSUM* L.) VARIETIES AS AFFECTED BY CULTIVARS AND SOWING DATE IN THE SUDAN SAVANNA OF NIGERIA

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ABSTRACT

Field experiment were conducted in the Sudan Savanna of Nigeria during the 2017/2018 dry season at the research farms of National Institute for Horticultural Research, Bagauda (11^{0}53'N 8^0 14'E, 440m above sea level) and Institute of Agricultural Research Ahmadu Bello University Kadawa, Kano state (11^{0}39,08^0 02'E, 500m above sea level) to determine yield parameter sand yield of Irish potato as affected by cultivars and sowing date in the sudan zone of Nigeria. The treatment combinations consisted of five Irish potato verieties (Nicola YL, Nicola GL, Bertita Ditta and marabet L and four levels of sowing date (early November, middle November, end of November end middle December) respectively treatments were laid down in a split plot design with three replications. The varieties were assigned to the main plots and sowing dates to the sub plots. All agricultural practices for dry season production of Irish potato were observed the data collected were subjected to analysis of variance (ANOVA) using SAS version statistically, the result obtained from measured yield parameter and yield were taken from sampled plants. The parameters measured include; number of tubers per plant, tuber weight per plant (Kg) and tuber yield in Kg/ha. The result based on comparison between five varieties of Irish potato and four levels of sowing dates showed that variety and sowing date have statistically significant effects. Varieties Nicola GL and Nicola YL, when sown in the middle of November had higher yield.

Keywords: Sudan Savanna, Irish Potato Varieties, Sowing Dates and Yield.

INTRODUCTION

Irish Potato (*Solanum tuberosum* L.) is an annual, herbaceous, tuber crop of the Solanaceae family that contains all the essential food ingredients required for maintaining proper health (FAO, 1986). The potato plant produces swollen underground tubers when mature. Potato has its region of origin in the high plains of the Andes Cordillera where the Incas cultivated the plant largely for food. In Africa, it was not cultivated until the end of the 19th century that potato was imported from Europe by missionaries and thereafter by colonial administrations (Raemaekers, 2001). Irish potato was introduced into Nigeria early in the 20th Century by European miners in Jos Plateau (Obighesan, 1976). In Nigeria, the area under potato cultivation during 2014 stands at 142, 600 ha of land with an average production of 1,184, 865 metric tons (Muhammad et al., 2018; Ugonna et al., 2013). Over 85% of potato produced in Nigeria comes from Jos plateau (Muhammad et al., 2015). Jos Plateau has a high altitude and thus a cool climate, which is favorable for the development of the crop in the area (Obighesan, 1976). Being a hardy plant, potato is cultivated the world over under different growing conditions. Irish potato has a shorter growing cycle of about 95 days than most other root crops in the tropics (Wuyep et al., 2013).

MATERIALS AND METHODS

Field experiments were conducted in Sudan savanna of Nigeria during 2017/2018. Dry season at the two locations National Institute for Horticultural Research, Bagauda (11^{0}53'N 8^0 14'E, 440m above sea level) and Institute of Agricultural Research Ahmadu Bello University Kadawa, Kano state (11^{0}39,08^0 02'E, 500m above sea level) respectively. Treatments consisted of five varieties of Irish potatoes (namely: Nicola YL, Nicola GL, Bertita, Ditta and Marabel) with four levels of sowing dates (early November, middle November, end of November and middle December) for each of the locations. They were laid down in a split plot design with three replications with variety in main plots and sowing date in sub plots. Before sowing, each of the experimental sites was cleared, harrowed, demarcated and prepared in ridges of total plot size of 150 m^2. It was further divided into three replications with an alley of 2 m between them. Replications were transformed into main plots of 10 m × 1 m with an alley of 1 m between them. Main plots were further divided into sub plots of 1 m × 2.5 m containing six rows of 3-m length. Seed tubers of uniform size were treated with soil-borne disease-preventing chemical and sown at a depth of 5 cm and 20 cm between stands. Planting was carried out on 7th November 2017. First farrow watering was on sowing and at weekly intervals, and was stopped 2 weeks before harvesting; weed and pest control were followed. Harvesting was carried out on 14th February 2018 using hoe to uproot the tubers from the soil. Data were collected at harvest on yield attributes (number of tubers per plant, tuber weight per plant (kg) and tuber yield kg/ha. in kg/ha) were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1976) using a SAS. Significant means of treatments were separated using LSD All-Pairwise Comparisons Test.

RESULTS

Table1 shows the Effect of variety and sowing date on number of tubers per plant of Irish potato (*Solanum tuberosum* L.) at Bagauda, Kadawa and combined. At both locations and combined effects on numbers of tubers produced per plant were highly significantly affected by variety. Nicola YL and Nicola GL produced higher number of tubers per plant (kg). They were followed by Ditta, Marabel and Bertita, which respectively produced almost similar number of tubers per plant. Sowing date shows insignificant effect on number of tubers per plant produced. Potato sown at middle of November produced higher number of tubers per plant. Other sowing dates produced similar number of tubers per plant. Interaction between variety and sowing date shows insignificant effect on number of tubers produced per plant.

Table 2 shows the effect of variety and sowing date on tuber weight per plant (kg) at Bgauda, Kadawa and combined during the 2017/2018 dry season. From the Bagauda location, tuber weight per plant was significantly affected by variety. Nicola YL and Nicola GL measured higher tuber weight per plant (kg). They were followed by Ditta, Marabel and Bertita, which were similar in tuber weight per plant (kg). Tuber weight per plant was significantly affected by sowing date. The effect of sowing at the middle of November outnumbered other sowing dates in tuber weight per plant (kg). This was followed by early November, middle of December and lowest from end of November. At Kadawa the effect of variety on tuber weight per plant (kg) was not significant. Effect of sowing date was highly significant at Kadawa with effect of middle of November at a higher level than other sowing dates in tuber weight per plant (kg). This was followed by early November, middle of December and end of November in a respective manner. Interaction between variety and sowing date at Kadawa location was insignificant.

Interaction between variety and sowing date on tuber weight per plant (kg) at 4WAS from Bagauda is shown in Table 3. Interaction between variety and sowing date was significant. Nicola YL sown at the middle of November produced higher tuber weight per plant (kg); while the lowest weight was from Marabel sown at by the middle of December.

Table 4 shows the effect of variety and sowing date on tuber yield in kg/ha at Bagauda, Kadawa and combined during the 2017/2018 dry season. Statistically from Bagauda location, the effect of variety was significant. Nicola YL produced the highest tuber yield at Kadawa and combined followed by Nicola GL and the lowest yield was produced by Bertita at Kadawa and combined.

Similarly effects of sowing date on tuber yield was only significant at Kadawa and combined with middle of November producing the highest tuber yield at both Kadawa and combined. While middle of December produced the lowest tuber yield. The interaction between variety and sowing date in tuber yield was significant at Bagauda, sowing Nicola YL producing the highest tuber yield at middle of November while the lowest tuber yield was produced by marabet at middle of December.

Table 1. Effect of variety and sowing date on number of tubers per plant of Irish potato (*Solanum tuberosum* L.) at Bagauda, Kadawa and combined during the 2017/2018 dry season.

Treatment	**Location**		
variety	**Bagauda**	**Kadawa**	**Combined**
Nicola YL	3.18ab	3.30a	3.24ab
Bertita	2.15c	1.84b	2.05d
Marabel	2.48bc	2.62ab	2.55cd
Ditta	3.29a	2.12b	2.70bc
Nicola GL	2.43a	3.39a	3.41a
SE	0.42	0.47	0.49

Sowing date

Early November	2.88a	2.84ab	2.86
Middle of November	2.83	3.38a	2.18
End of November	251	2.38bc	1.45
Middle of December	2.15	2.01c	1.68
SE	0.43	0.43	0.26
Interaction			
V×SD	NS	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparison Tests. NS= not significant, *= significant at P≤ 0.05, **= significant at P≤ 0.01, V= variety, SD= sowing date and SE=standard error.

Table 2. Effect of variety and sowing date on tuber weight per plant (kg) of Irish potato (*Solanum tuberosum* L.) at Bagauda, Kadawa and combined during the 2017/2018 dry season.

Treatment variety	Location		
	Bagauda	**Kadawa**	**Combined**
Nicola GL	0.08a	0.41	0.25
Bertita	0.06b	0.30	0.18
Marabel	0.05c	0.31	0.17
Ditta	0.07b	0.28	0.15
Nicola YL	0.09a	0.35	0.22
SE	0.07	0.65	0.27
Sowing date			
Early November	0.12ab	0.57ab	0.63
Middle of November	0.19a	1.08a	0.35
End of November	0.05b	0.19c	0.26
Middle of December	0.07b	0.45b	0.13
SE	0.05	0.29	0.21
Interaction			
V×SD	*	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparison Tests. NS= not significant, *= significant at P≤

Table 3. Interaction between variety and sowing date in tuber weight (kg) per plant of Irish potato (*Solanum tuberosum* L.) at Bagauda.

Sowing date	Variety				
	Nicola GL	**Bertita**	**Marabel**	**Ditta**	**Nicola YL**
Early November	0.07f	0.06c	0.08e	0.05h	0.36b
Middle of November	0.12c	0.04i	0.06g	0.08e	0.67a
End of November	0.06a	0.04i	0.04i	0.05h	0.08e
Middle of December	0.05h	0.05h	0.03j	0.09d	0.09c
SE			0.05h		

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. SE=standard error.

Table 4. Effect of variety and sowing date on tuber yield in kg/ha of Irish potato (*Solanum tuberosum* L.) at Bagauda, Kadawa and combined during the 2017/2018 dry season.

Treatment variety	**Location**		
	Bagauda	**Kadawa**	**Combined**
Nicola GL	0.57	0.39ab	0.47ab
Bertita	0.44	0.10d	0.27c
Marabel	0.36	0.33bc	0.34bc
Ditta	0.49	0.21cd	0.35bc
Nicola YL	0.58	0.53a	0.55a
SE	0.13	0.07	0.09
Sowing date			
Early November	0.49	0.34b	0.41ab
Middle of November	0.51	0.53a	0.52a
End of November	0.42	0.22bc	0.32c
Middle of December	0.53	0.15c	0.34b
SE	0.12	0.06	0.0
Interaction			
V×SD	NS	*	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparison Tests. NS= not significant, *= significant at P≤ 0.05, **= significant at P≤ 0.01, V=variety, SD=sowing date and SE: standard error.

Table 5. Interaction between variety and sowing date in tuber yield in kg/ha of Irish potato (*Solanum tuberosum* L.) at Kadawa

Sowing date	**Variety**				
	Nicola GL	**Bertita**	**Marabel**	**Ditta**	**Nicola YL**
Early November	0.40d	0.11h	0.40d	0.17f	0.60c
Middle of November	0.87a	0.21f	0.67b	0.33e	0.57c
End of November	0.17f	0.08i	0.10h	0.30e	0.43d
Middle of December	0.11h	0.00i	0.13g	0.03i	0.50c
SE			0.06		

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. SE: standard error.

DISCUSSION

Results from both locations and combined measured yield parameters show that variety and sowing date have an effect on yield attributes of Irish potato. Measured parameters show yields were higher from Nicola GL followed by Nicola YL at Bagauda, Kadawa and combined. These two varieties generally performed substantially better than other varieties. This could be due to their better adaptation, including tolerance to harsh weather conditions of the new environment (experimental sites). The differences could also be due to the varying levels of adaptation of the cultivars to local temperature and soil conditions. Moreover, other inherent traits like green leaf for photosynthetic efficiency from Nicola GL and more leaf area for better light interception from Nicola YL may also contribute to their better yield performance in the new environment over other remaining varieties. This is in line with an assertion that: maximum productivity depends primarily on rates of light interception and carbon assimilation by the crop surface (Watson, 1978). The significance effects of the variety could be attributed to genetics and ability of the crop (Irish potato) to utilize available environmental resources such as water, nutrients, temperature, light and agronomic practices. These factors, however, could vary in their effect across different locations as well as among different potato species (Watson, 1978).

Effects of sowing date on yield of Irish potato were observed in the dry season of 2017/2018 from two locations. Measured parameters on yield were higher when a sowing date of middle November was used. This could be attributed to effects of mean maximum and minimum temperatures during the month of November which favored the crop during earlier stages of crop development. This is in line with assertion made by Nash et al. (2008) that the highest yields are currently produced in areas where the daytime temperature is often over 38°C during the hottest part of growing season and nights are cool 18°C. Wurr et al. (1990) also reported that the final yields of crop are in many cases dependent on satisfactory growth during earlier stages of crop development, which is achieved through planting at the most suitable time. Sowing at middle of November that is, under irrigation, Irish potato production in Nigeria should coincide with the coldest month (November – January) so that the time of tuber bulking will coincide with the period of low temperature. Time of sowing also determines time of flowering and it has a major influence on dry matter accumulation, seed set and seed yield (Sofield, 1977). Gallagher and Biscoe (1978) also reported that crops sown at the optimum time make the best use of the available growth factors such as temperature and solar radiation at different stages of growth for high productivity. Wurr et al. (1990) also stated that for each type of crop, appropriate and proper time of sowing is one of the basic requirements for obtaining maximum yield and high profit returns. For example, Mortazavi-bak and Ramin-pour (2009) recommended that potato planting date should be calculated based on the length of the growing season, because the number of tubers produced per plant is affected by optimum sowing date.

CONCLUSION

The experimental results show that two varieties, Nicola GL and Nicola YL, have higher yields at Bagauda, Kadawa and combined. Similarly, an optimum sowing date that gives better yield is the middle of November.

RECOMMENDATION

It is suggested that for dry season production, varieties Nicola GL and Nicola YL are preferred, with corresponding sowing date of middle of November, and these varieties could be used to improve yields of Irish potato production in the Sudan savanna zone of Nigeria.

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STUDIES ON PRE-SOWING AND PRE-NURSERY PRACTICES FOR RAISING *SABA SENEGALENSIS* (L.) SEEDLINGS

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ABSTRACT

Saba senegalensis (L.) is an indigenous shrub like fruit tree still in the wild. The fruit is nutritionally endowed, containing high quantity of ascorbic acid and often used as food additive. Horticultural practices to enhance seed germination and produce certified seedlings were carried out in a high tunnel. Practices included the effect of the substrates (sawdust and rice husk), pre-planting seed preparation (seeds with or without mucilage), and seed storage duration (0, 3, 6, 9 days' delay in planting). Seeds were sterilized with 10% dilution of NaOCl, and seeds for the experiment on storage duration were stored at room temperature. Data were collected on days to seedling emergence, percent seedling emergence, seedling height and number of leaves produced. The data collected were subjected to analysis of variance in a completely randomized design (CRD). The results showed that sawdust was a better substrate for emergence of Saba seedlings; removal of seed mucilage before planting supported earlier and more seedling emergence; seeds sown without mucilage and stored for six days gave a better percent seedling emergence. Seedling height and number of leaves per plant eight weeks after sowing were similar for all seed storage duration except for nine-day delays. Information herein could provide basis for further research on the production of Saba senegalensis plants.

Keywords: Pre-Nursery; Delay seeding; Substrates; Seedling emergence

INTRODUCTION

Saba (*Saba senegalensis* L.) is a fruit plant yet to be domesticated, it however plays a vital role in the diets of the local residents where it grows. Restriction in consumption of the fruits is probably due to unawareness of its nutritional endowment and therapeutic effects (Kini *et al.*, 2008). The Saba fruits are consumed widely where they are found in the West Africa countries, mostly in the forest areas. It is an indigenous shrub-like fruit tree of the family Apocynaceae, native to the Sahel of Africa. Burkill (2000) reported that the tree does grow principally on riverbanks and in woodlands in Burkina Faso, Senegal, and Ivory Coast. It has been observed growing as vine up trees, and usually growing to the size of a large tree. Baiyeri (2003) reported that seedling emergence speed and growth could be enhanced by use of a suitable growth medium. Generally, of all nursery factors determining seedling quality, growth medium have been identified as most extremely important (Baiyeri, 2006).

In Nigeria, there is little or no horticultural documentation on all aspects of Saba plant, most critical being development of protocols for raising certified seedling for plantation establishment. This paper reports on the findings of study on seedling emergence as influenced by substrate, pre-planting seed preparation and duration of seed storage on seedling emergence.

MATERIALS AND METHODS

The experiment started was conducted in a high tunnel at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka. Nsukka is located in the derived Savanna zone (latitude 7.4, longitude 6.9 and altitude 475m). The location is characterized by lowland humid conditions with bimodal annual rainfall distribution that ranges from 1155 - 1955mm. A mean annual temperature of 29 - 31^{0}C and relatively humidity that ranges from 69 - 79% (Uguru *et al.*, 2011).

Saba fruits used for the experiment were sourced from Kogi state, Nigeria. The seeds were extracted and sterilized with 10% dilution of sodium hypochlorite. Seeds were shared into two portions and a portion had the mucilage removed before sowing in two substrates. The substrates were sawdust and rice hull. Substrates were soaked in water for 24 hours and washed twice to remove organic residue. The second experiment was a study on duration of seed storage (0, 3, 6, & 9 days) on seedling emergence. Fifty seeds were sown into five containers each storage day. Pre-nursery growth container was perforated plastic pots. Experimentation was in a high tunnel with an average temperature of ≈30.1^{0}C, and watering was daily.

RESULTS

Removal of seed mucilage before planting enhanced higher seedling emergence in sawdust substrate in contrast to the rice hull. There was 100% seedling emergence in sawdust substrate 7 weeks after sowing in contrast to 83.3% in rice hull. But when mucilage was not removed before seed-sowing emergence was higher (96%) in rice hull substrate and 84% in the sawdust (Table 1).

Delays in seed sowing significantly ($p < 0.05$) influenced percent seedling emergence all through the duration of study. Planting seeds till six days after extraction had statistically similar emergence pattern (Table 2). Planting nine days after extraction relatively had lower percent seedling emergence. Duration of delays in seed sowing significantly ($p < 0.05$) reduced number of leaves per seedling and height of seedlings eight weeks after planting (data not sown).

Table 1: Effect of substrate on emergence pattern (in percent) of Saba seedling (*Saba senegalensis* L.) planted with or without mucilage on the seeds.

Substrates	WK1	WK2	WK3	WK4	WK6	WK7
SD-m	31.1	67.8	82.2	85.6	97.8	100
RH-m	4.4	16.7	33.3	41.1	76.7	83.3
$LSD_{(0.05)}$	13.02	19.59	22.87	22.31	11.67	9.37
RH+m	0	4	24	40	84	96
SD+m	0	0	4	4	80	84
$LSD_{(0.05)}$	0.0	NS	NS	33.89	NS	NS

WK: Weeks after planting; SD: Sawdust; RH: Rice hull; -m: seeds planted without mucilage; m+: seeds planted with mucilage; NS: Non-significant

Table 2: Effect of delay in seed sowing (in days) on weekly seedling emergence of Saba (*Saba senegalensis* L.).

DELAYS	WK1	WK2	WK3	WK4	WK5	WK6	WK7
0	42.0	72.0	82.0	88.0	92.0	94.0	94.0
3	26.0	58.0	82.0	90.0	96.0	98.0	98.0
6	2.0	18.0	52.0	84.0	96.0	98.0	100.0
9	0.0	2.0	28.0	54.0	66.0	74.0	78.0
$LSD_{(0.05)}$	15.3	25.1	22.5	23.0	15.1	16.1	8.7

Delays = How long the seeds were kept to determine their effective storage period before the time of the last sowing; LSD = Fisher's least significant difference; WK = Week.

DISCUSSION

Non-removal of mucilage before planting delayed seedling emergence. About 68% seedling emergence was recorded two weeks after sowing when mucilage was removed before seed sowing in contrast to no emergence when mucilage was not removed. Seedling emergence became substantial six weeks after sowing with mucilage; seed mucilage probably degraded over time such that seedling emergence was no longer delayed. The delay was probably associated with the mucilage reducing moisture and air permeability; and so low water imbibition into the endosperm delayed initiation of metabolic activities that could eventually lead to germination and seedling emergence. It is imperative therefore, that an after-ripening procedure of mucilage removal is recommended for Saba seeds before planting. Sawdust was a better substrate probably due to less compaction and thus more aeration, relative to rice hull.

Pre-sowing treatments (of mucilage removal and sterilization with 10% dilution of sodium hypochlorite and storage under room temperature) indicated that Saba seeds could be stored up till six days before planting (with 100% emergence reachable). In fact, nine days after these pre-sowing treatments up to 78% seedling emergence was attainable. This probably suggests that these pre-sowing practices are panacea to seedling production in *Saba senagalensis* and so recommended for adoption.

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EFFECT OF VARIETY, PERIOD OF POD DELAY AND WITHIN-POD BEAN POSITION ON VIABILITY AND GERMINATION OF COCOA (*THEOBROMA CACAO*) UNDER DIFFERENT SHADE CONDITIONS

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ABSTRACT

Two trials were conducted under two different shade conditions in 2021 to evaluate the effect of variety, period of pod delay and within-pod bean position on viability and germination of cocoa (Theobroma cacao) at the central nursery of Cocoa Research Institute of Nigeria, Ibadan. The experiment was a 3×3×2 factorial experiment laid out in a Complete Randomized Design (CRD) with 18 treatment combinations replicated three times. In the main plot was the variety denoted V1 (F3 Amazon) and V2 (WACRI) while in the sub plot, the period of delay (D0-Cocoa pods planted on the day of harvest; D1- Planting 7 days after harvesting; and D2- planting 14 days after harvesting) and the sub-sub plot contained the bean position in the pod (P1-distal, P2-middle and P3- proximal). Varietal difference was only significant on days to end of germination with F3 Amazon variety (3.322) ended the process of germination earlier than WACRI under natural shade condition. Germination variables were significantly influenced by period of delay at both shade conditions as cocoa beans planted immediately at harvest (D0) were significantly ($P < 0.01$) highest (80.0 and 70.0 respectively) on percentage germination compared with beans delayed for 7 and 15 days before planting. The effect of within-pod bean position was significant ($P < 0.05$) in the order proximal > middle > distal on number of days to germination, days to end of germination, percentage germination and speed of germination under the two shade conditions. Period of delay beyond seven days should be discouraged by cocoa farmers because of the probable reduction in the quality of seed, while the F3 Amazon and seeds from proximal position are best for consideration when delay is inevitable.

Key words: bean position; period of delay; varietal difference; germination

INTRODUCTION

Cacao (*Theobroma cacao*) is one of 17 species of Theobroma and it is the most widely cultivated (Opoku-Ameyaw & Baah, 2010) amongst them. The economic product (i.e. the beans) whose number ranges between 20 and 60 per pod (Ortiz, 2016) are basic raw material for the production of chocolate (Motamayor *et al*., 2008; Amma *et al*., 2011). Cacao is well adapted to and thrives productively in the rainforest ecology of West and Central Africa-the region which accounts for the largest proportion of global production, especially from Cote d'Ivoire, Ghana, Cameroon and Nigeria. In Nigeria, cocoa is primarily propagated through seed by farmers. Mathew *et al*. (2012) identified the use of low quality seed for raising seedlings, low emergence and poor seedling vigor as some of the factors responsible for low productivity within the plantation. However, factors like variety and postharvest pod management for succeeding propagation are crucial to achieving improved productivity. Seed viability maintenance especially under storage, and their nursery and/or field performance is crucial to the sustenance of cocoa production most especially amongst smallholder farmers. Access and proximity to source of good planting materials usually compel farmers to delay planting as a result of distance to farmers' destination. Ahenkora and Halm (1977) recommended a limited storage period of one (1) week before planting. However, most farmers go beyond the one-week period as a result of crucial social engagement of smallholder farmers (unpublished Smallholder Cocoa Farmer Survey Report in Ghana, 2012). Similarly, cocoa seed planting is seasonal, and since cocoa pods are unavailable to all farmers at the appropriate time for raising seed nurseries, the storage of pods beyond one-week period has become inevitable for farmers (Opoku-Ameyaw *et al*., 2010). In spite of the above, farmers still indiscriminately use all seeds within the pod irrespective of bean size differences and the location (proximal, middle and distal) within the pod environment.

It is quite a natural phenomenon that cocoa seed loses its viability and vigor over a long period of delay before planting (both within the pod and scooped fresh beans/seed), as any other biological material does. This is attributed as storage environment conditions and the length of handling or storage during the period of delay which usually results into low germination of the seed from such pods. According to work done by Redshaw (1965), germination capacity of cocoa appears to be short lived, and that viability is lost within 10-15 days after the seeds are harvested, unless they are placed under special storage conditions which permit their germination. Therefore, cocoa beans meant for propagation to raise seedlings are expected to have completed their structural and functional development within the pod (the fruit) before they are plucked for use in raising seedlings (Opoku-Ameyaw *et al*., 2010).

The pod apart from been an apartment to house the beans, equally regulates seed growth and maturation. The location/apartment where different seeds appear within the fruit has a role to play in the resource distribution and sharing scheme within the pods (Lee, 1988). In cocoa, Ibikunle (1967) noted that seeds which developed in the expanded (i.e. middle) part of the cocoa pod produced bigger-sized beans and hence seedlings with better vigor. Researchers have been able to work on the bean position within the pod and post-harvest handling in relation to size of pods and physiological maturity. However, these previous related works have not examined the effect of pod delay and within-pod bean position as its affect cocoa seed viability and germination. The objective of this study is therefore to evaluate effect varietal differences, period of pod delay and within-pod bean position on seed viability and germination of cocoa under two different shade condition.

MATERIALS AND METHODS

Two trials were conducted during the wet season of 2021 under two different shade conditions-standard nursery shade net and natural shade (cacao tree canopy). The experiment was 3×3×2 factorial arrangement laid out in a Completely Randomized Design (CRD) with 18 treatment combinations and three replications. In the main plot is the variety denoted V1 (F3 Amazon) and V2 (WACRI)-both are common varieties in farmers' farms. In the sub-plot was the periods of delay (D0-Cocoa pods planted on the day of harvest; D1- Planting 7 days after harvesting; and D2- planting 14 days after harvesting) and the sub-sub plot was the beans position in the pod (P1- distal, P2-middle and P3-proximal). Similar physiologically mature pods of both varieties were used for the respective periods of delay. The pods were weighed using an electronic weighing scale to determine the weight of each pod, whilst a measuring tape was used to measure the length and girth (center, proximal and distal end) of the pods to ensure that uniform pods size were selected. The respective delayed pods after harvest were kept on an open platform in the laboratory. All the treatment combinations were planted the same day with one seed per standard polythene pot having been filled with top soil near full. Sawdust was used to mulch after planting. In an experimental unit was comprised four pots for observation. Observations were made on the germination-related parameters vis: 1) Days to germination: Number of days between planting and germination; 2) time (days) from start of germination to the final germination (at primary leaf emergence); 3) germination percentage: number of seedlings germinated per treatment divided by the total no of seedlings planted for each treatment and then multiplied by 100 percent and 4) speed of germination: Speed of germination= n1/d1+n2/d2+n3/d3+---------- n. Where, n = number of germinated seeds, d= number of days (Czabator, F. J. (1962)). Observation were made on the crops on a daily basis. All data collected were subjected to analysis of variance (ANOVA) procedures using GenStat Discovery latest Edition. Differences between the treatments means were compared using Least Significant Difference (LSD) test at 0.05 significance level

RESULTS

The number of days to germination of cocoa was significantly *(P < 0.05)* influenced by varietal difference, period of delay and within-pod bean position (Table 1). The beans from pods planted at harvest under standard shade net germinated significantly *(P < 0.01)* fastest (12.422 days) compared to beans from pods delayed for seven and fifteen days before planting, while pods delayed for seven days before planting germinated significantly *(P < 0.01)* fastest (13.222) when compared to 0 and 14 periods delay under natural shade condition. However, beans planted from proximal position at both shade conditions germinated significantly *(P < 0.05)* fastest (12.556 and 13.433) compared to distal and middle beans positions. Similarly, the interaction of variety, period of delay and within-pod bean position had significant *(P < 0.05)* influence on number of days to germination under standard shade net condition while under natural shade condition only the interaction of variety and period of delay significantly *(P < 0.05)* influenced number of days to germination (Figures 1 and 2).

Table 1 also shows that the effect varietal difference, period of pod delay and within-pod bean position were significant *($P < 0.05$)* on days to final germination of cocoa under different shade conditions. F3 Amazon variety planted under natural shade condition completed germination significantly *($P < 0.05$)* faster (3.322) than WACRI variety (3.530) while there was no significant *($P < 0.05$)* difference between the two varieties under standard shade net condition. However, at both shade conditions the effect of period of delay on final germination showed that beans planted from pods delayed for seven days significantly *($P < 0.01$)* ended germination the earliest (2.939) compared to 0 and 15 periods of delay under standard shade net while beans from pod with no delay were significantly *($P < 0.01$)* fastest (3.206) to complete germination under natural shade condition. However, beans planted from the proximal position completed germination significantly *($P < 0.05$)* fastest (3.278) compared to others only under natural shade condition.

Table 2 shows the significant *($P < 0.05$)* effect of variety, period of pod delay and within-pod bean position on percentage germination of cocoa under different shade conditions. At both shade conditions cocoa beans planted immediately at harvest were significantly *($P < 0.01$)* highest [80.0% (standard shade net) and 70.0% natural shade)] compared with beans delayed for 7 and 14 days before planting. Similarly, the beans from proximal position had significantly *($P < 0.05$)* highest germination percentage values of 72.2% and 66.7% at standard shade net and natural shade conditions respectively.

The effect of variety, period of pod delay and within-pod bean position were significant *($P < 0.05$)* on speed of germination of cocoa bean under different shade conditions (Table 2). The speed of germination was significantly *($P < 0.05$)* highest in beans planted from proximal position under the natural shade condition alone. However, interaction of variety and period of delay were significantly *($P < 0.05$)* highest on the speed of germination under shade net while interaction of variety, period of delay and within-pod bean position was significant *($P < 0.05$)* on the speed of germination under natural shade (Figures 3 and 4).

Table 1: Effect of Variety, period of pod delay and within-pod bean position on number of days to germination and days to end of germination of cocoa bean under different shade conditions

	Days to start of germination		Days to end of germination	
Treatment/location				
variety	**Standard shade net**	**Natural shade**	**Standard shade net**	**Natural shade**
F3 Amazon	12.673	13.656	3.089	3.322
WACRI	12.844	13.889	3.411	3.530
LSD	ns	Ns	Ns	0.105*
Period of Delay (Days)				
0	12.422	13.239	3.061	3.206
7	12.926	13.222	2.939	3.344
14	12.528	14.856	3.750	3.728
LSD	0.731**	0.2295**	0.3375**	0.189**
Within-pod beans position				
Distal	12.822	14.122	3.411	3.578
Middle	13.022	13.761	3.211	3.422
Proximal	12.556	13.433	3.128	3.278
LSD	0.289*	0.272**	Ns	0.139**
V × D	1.085*	0.309*	Ns	ns
V × P	1.015*	Ns	Ns	ns
D × P	0.798*	Ns	Ns	ns
V × D × P	1. 127**	Ns	Ns	ns

LSD-Least Significant Difference; V×D-Varieties and Period Of Delay; V× P- Within-Pod Beans Position; D × P - Period Of Delay And Within-Pod Beans Position.; V × D × P – Varieties, Period Of Delay And Within-Pod Beans Position; ** Significant At 1% Level Of Probability; *Significant At 5% Level Probability; Ns- Not Significant

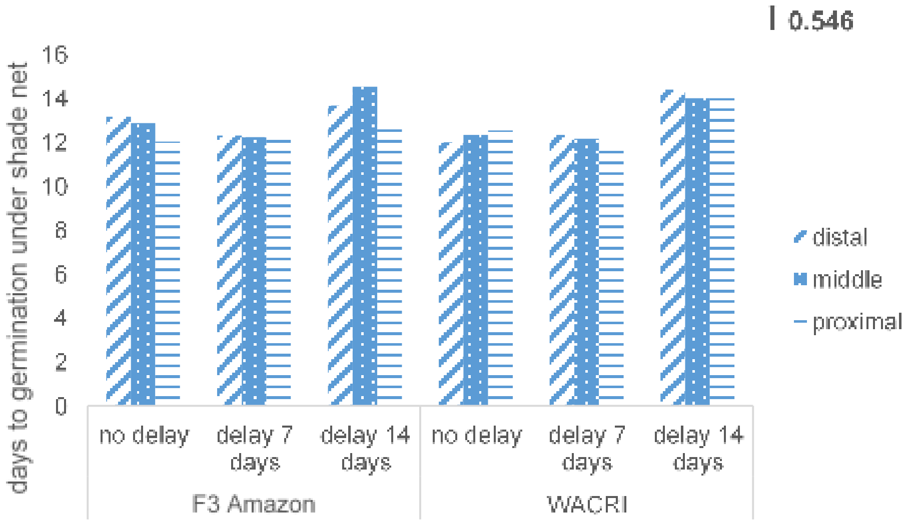

Figure 1: Interaction of variety × period of delay × within-pod bean position of cocoa on days to germination under shade net. Bars are separated using Standard error of means.

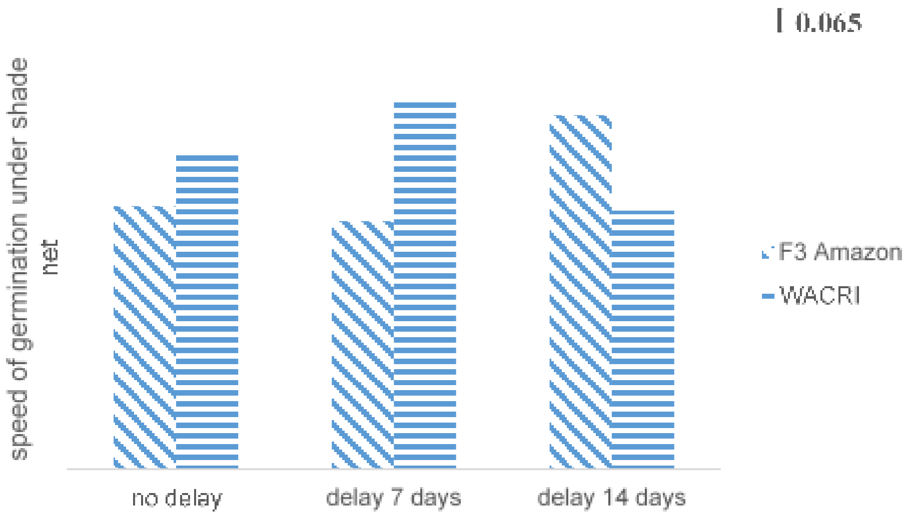

Figure 2: Interaction of variety × period of delay of cocoa on germination speed under shade net. Bars are separated using Standard error of means.

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Table 2: Effect of Variety, period of pod delay and within-pod bean position percentage germination and speed of germination of cocoa bean under different shade conditions

	Percentage germination (%)		Speed of germination	
Treatment/location				
variety	**Standard shade net**	**Natural shade**	**Standard shade net**	**Natural shade**
F3 Amazon	68.9	64.4	0.309	0.335
WACRI	65.2	57.8	0.337	0.366
LSD	Ns	ns	ns	ns
Period of Delay (Days)				
0	80.0	70.0	0.324	0.336
7	70.0	65.6	0.297	0.341
14	51.1	47.8	0.348	0.375
LSD	7.09**	9.24**	ns	ns
Within-pod beans position				
Distal	63.3	55.6	0.324	0.353
Middle	65.6	61.1	0.297	0.300
Proximal	72.2	66.7	0.348	0.398
LSD	5.62*	6.21*	ns	0.051*
V × D	Ns	ns	0.326*	ns
V × P	Ns	ns	ns	ns
P × D	Ns	ns	ns	ns
V × D × P	Ns	ns	ns	0.125*

LSD-Least Significant Difference; V×D-Varieties And Period Of Delay; V× P- Within-Pod Beans Position; D × P - Period Of Delay And Within-Pod Beans Position.; V × D × P – Varieties, Period Of Delay And Within-Pod Beans Position; ** Significant At 1% Level Of Probability; *Significant At 5% Level Probability; Ns- Not Significant

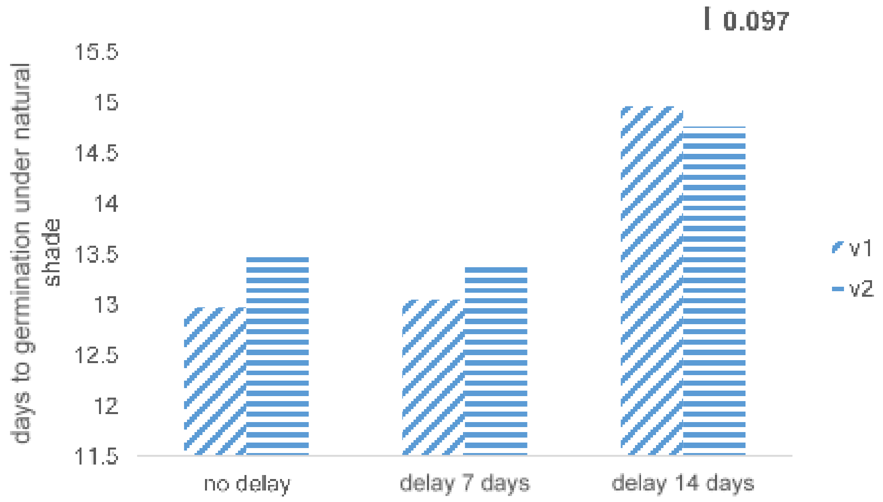

Figure 3: Interaction of variety × period of delay of cocoa on germination speed under natural shade. Bars are separated using Standard error of means

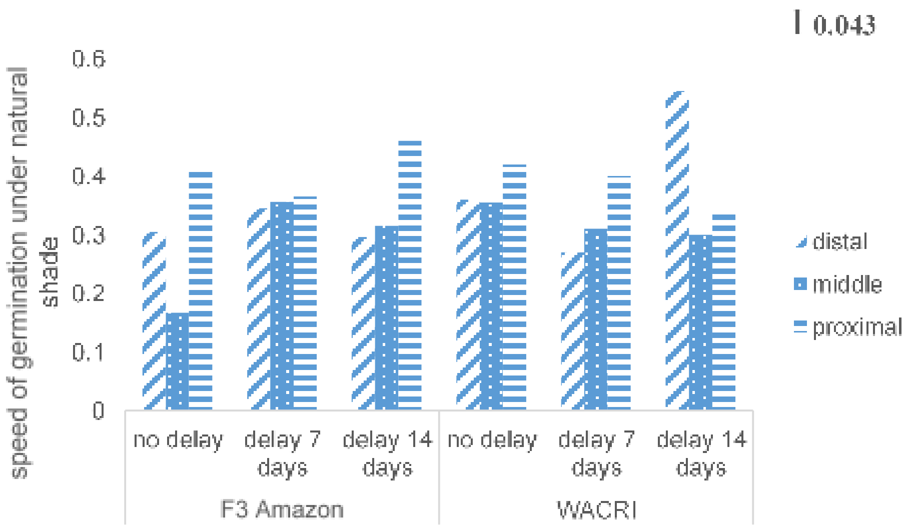

Figure 4: Interaction of variety × period of delay × within-pod bean position of cocoa on speed of germination. Bars are separated using Standard error of means.

DISCUSSION

Of the various methods of seed viability test, germination test is proven to be the most reliable. The germination of the seeds is a complex process where several reactions and individual factors are involved (Copeland and McDonald, 1995). These include physiological maturity and accumulated resource components of the seed, which are pivotal to seed germination. In the present study, the response of the varietal difference as a factor was not conspicuously expressed on germination indices tested except on days to end germination under natural shade condition where F3 Amazon variety ended germination significantly earlier (3.322) than WACRI (3.530); and similarly varietal difference effects were revealed in some few interactions with the other factors under both shade conditions. This may suggest that the most important factor that could determine germination when it comes to variety is the attainment of physiological maturity-the stage at which resources in seed within the pod are sufficient before planting. This was corroborated by Opoku-Ameyaw *et al*. (2010) that cocoa beans meant for propagation to raise seedlings are expected to have completed their structural and functional development within the pod (the fruit) before they are plucked for use in raising seedlings. However, F3 Amazon variety showed prospect over WACRI variety with higher values more than WACRI. This could also be attributed to the genetic makeup of F3 Amazon as an improved variety and the impact of the enviroment (Crossa *et al*., 1991; Mortazavian and Azizinia, 2014). The impact of period of delay was conspicuous on germination indices as period of delay beyond seven days had negative effect on germination parameters. Seeds planted at harvest, and seeds delayed for just seven days before planting were significant on germination indices which could be due to greater food reserve within the bean, at the early part of the storage, which was catalyzed and metabolized to provide the needed energy to quicken the germination process. However, with continued delay, the stored food reserves in the beans could have been used up through respiration during germination and therefore could not be readily available for the seedling to emerge when storage was delayed (Olympio and Kumah, 2009) at both shade conditions. Similary, the impact of delay in the present study agrees with Onakoya (2011) that Cocoa seeds lose viability on extraction from the pod within five to seven days, unless specially treated; and Redshaw (1965), that germination capacity of cocoa appears to be short lived, and that viability is lost within 10-15 days after the seeds are harvested, unless they are placed under special storage conditions which permit their germination.

Seed growth and development are dependent on the biomass investment from the mother plant, such that seeds with high resources have bigger size (Susko and Lovett-Doust, 2000; Khan *et al*., 2014). In the present study the effect of within-pod bean position was significant in the order

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proximal > middle > distal under the two shade conditions. The beans from proximal position recorded lowest days to germination and earliest day to end germination. The probable factor for the performance of seeds drawn from proximal position could be due to better resource accumulation being closer to the stylar compared to other positions, which could inform its size and potential viability as corroborated by Nakamura (1988) who identified proximity of the ovules to the stylar end as another an important factor in *Phaseolus vulgaris* L.; noting that seeds closer to the style (proximal) end were significantly better in size (endosperm content) than those nearer to the receptacle (the distal) end. Seeds with high resources have bigger size and the endosperm content determines seed sizes.

The interactions resulted in a reduction of the time taken for the sown seeds to start germination and also reduced the time taken from start of germination. This situation could be accounted for by the effect of internal respiration within the pod, which metabolic process may not have reached a level so high as to reduce the bean size within the first few days of delay and therefore did not affect the surface area of the bean. (Dwapanyin and Frimpong, 2003). This subsequently resulted in faster germination, reducing the time associated with the germination process.

CONCLUSION

In line with the objectives of this study, the study revealed that period of delay beyond seven days should be discouraged by cocoa farmers because of the probable reduction in the quality of seed to be sown. However, the seed from proximal position was the best for consideration when planting, most especially when pods are unavoidably delayed. The F3 Amazon variety can also be recommended to farmers when unavoidable delay in planting is envisaged.

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STEM GIRTH SIZE EFFECTS ON ROOTS NUMBER AND LENGTH OF MARCOTTED SWEET ORANGE (*CITRUS SINENSIS*) AT ISHIAGU EBONYI STATE

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ABSTRACT

An experiment was carried out to study the effects of stem girth size on roots number and length of roots of marcotted sweet orange (Citrus sinensis) at the Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria. Ishiagu is in a tropical environment which lay on Latitude 5^0 57^1N and longitude 7^0 34^1E with an annual rainfall of 1350 mm. It has an average humidity of 88 %, a mean annual temperature of 29 ^{0}C and is situated on a gentle slope. The design was a randomized complete block design, replicated four times. One-year-old stems of sweet orange made up of different girth sizes (1 cm, 2 cm, 3 cm and 4 cm) were measured, selected and marcotted at different periods of the year, in 2019. The numbers of developed roots were counted and their lengths measured with a meter rule. Numbers of adventitious roots and their lengths were significantly ($p \leq 0.05$) increased by the girth size of the stems. The 4 cm girth stems had the highest number of roots and also longer root lengths than others, while the least in performance was the 1cm girth. The time of marcotting significantly ($p \leq 0.05$) increased the roots number and length. The month of July had more root and longer root lengths than the months investigated.

Keywords: Marcotting, stem girth size, sweet orange and time

INTRODUCTION

Citrus is a hesperidium a many celled fleshly fruit which developed from a syncarpous pistil with axil placentation. It is a juicy fruit which is tasty, stomachic and rich in vitamin C. It is a shrub, growing less than ten meters tall with few shoots arising from the base. It begins to bear fruits between 2 - 5 years of planting especially when propagated vegetatively, while seeded stands bear fruits at 12 - 15 years after planting (Opeke, 2012.) *Citrus* species can be propagated by seed or budding / grafting. *Citrus* plants are polyembroyonic and apogamic. There is generally large proportion of the seedling that are identical with the mother plant thereby providing propagation plants as clones for pure lines. Cross pollination, however, do occur between the species resulting in variations seed lots of a pure line. Good varieties are propagated by bud grafting on a hard variety or by gootee (Phillips, 1971; Mathew *et. al.,* 1990). Uniformity in character is a desired feature obtained by budding.

Commercial propagation of citrus desire budded plants. Budding is the union of scion and root stock. Citrus is raised by budding and grafting to avoid gummosis, a fungi disease and tristeza a deadly virus disease (Opeke, 2012). Most root stocks have advantage of been disease resistant, vigorous in growth and adaptable to soil and climatic conditions (Hartmann *et. al.,* 2007). Though there is scion and root stock interaction which is hidden but taste and nutrient constituents of budded oranges are affected. Some root stocks were observed to affect the uptake of different nutrients like P, K, Ca, Cu, and Mg. Marcotting which is the manipulation of the plant stems to initiate roots has become a way of producing a clone of plants in which there is no genetic variation from the parent plant (Umeokechukwu *et. al.,* 2019). Unlike budding or grafting, where there is an interaction between scion and root stock which affects the plant, marcotting does not. While height and dwarfness of budded plant is influenced by the position of the scion on root stock, in marcotted plants, the new plant maintains a posture in growth like the mother plant.

Citrus sinensis probably originated in northeastern India in Burma and the adjoining areas (Opeke, 2012). Cross pollination between citrus species results in heterogeneity of seeds making it difficult to obtain seeds of pure line. As a result of these short comings coupled with the long delay in fruiting in seed propagated stands, air layering also called marcotting becomes the alternative in seedling multiplication. This is a system of vegetative propagation in which stems are manipulated to produce roots while still attached to the mother plant (Hartmann *et. al.,* 2007). The rooted stems / shoots are genetically identical with the parent stock. Marcotting is rarely employed in

Nigeria in seedling multiplication, due to constraints of technical know-how, slow in process and non availability of controlled environment. This experiment was designed to determine the effect of stem girths size on the rooting or root formation of marcotted citrus orange stems.

MATERIALS AND METHODS

This experiment was conducted at the citrus orchard of Federal College of Agriculture, Ishiagu Ebonyi State, Nigeria. Ishiagu is a derived savanna zone of South eastern Nigeria which lies between longitude 5^0 57' N and 7^0 31' E with mean annual rainfall of 1350 mm to 2500 mm, relative humidity of about 67 % during the dry season and 91 % during the rainy season (Nwite *et. al.,* 2008). The design was a randomized complete block replicated three times. During the 2019 rainy season in the months of April, May June and July 2019, a stand of sweet orange was selected. A year-old stems of different thickness were selected. Using a vernier caliper the stem thickness / sizes of 1 cm, 2 cm, 3 cm and 4 cm were identified through the appearance of the lenticels. Each stem was marcotted using fresh coconut shaft, ball of earth, with transparent polyethene and twine / rope. A notch (girdles of about 2 cm) was made on each stem of the orange. The ringed back was removed exposing the phloem vessels and the cambium. These were scraped with a sharp blade to avoid premature healing (Hartmann *et. al.,* 2007). The ball of earth was made using the coconut shaft and the soil which was placed on the scraped portion of the stem covered with transparent polyethene of 1 cm thick, tied together with a twine and allowed to incubate for 3 months. After the end of three months, the marcotted stems were severed washed with clean water to count the number of roots whose lengths were measured using a meter rule.

RESULTS AND DISCUSSION

Number of roots of marcotted sweet orange (*Citrus sinensis*).

The analysis of variance indicated a significant ($p \leq 0.05$) difference in the number of roots of the marcotted stems as shown in Table 1. Stems with girth of 4 cm had the highest number of roots followed by 3 cm, 2 cm and 1cm had the least. Stem thickness indicated proportionality with the cambium size (Microsoft® Encarta®, 2009). Thick stem sizes were able to produce more roots than the thin stems. Callus formation is necessary for the roots initiation (Hartmann *et. al.,* 2007). This is obtained from a thick cambium cells making thicker stem sizes better for marcotting of *Citrus sinesis* possible than thin stems.

Root length of marcotted sweet orange (*Citrus sinensis*)

The roots lengths were significantly ($p \leq 0.05$) affected by the time of marcotting. Stems marcotted in the months of July had longer stems than those of other months. This may be attributed to the reduced air temperature with increased relative humidity (Hartmann *et. al.,* 2007). July, 2019 has a low atmospheric temperature and high relative humidity in Ishiagu, Ebonyi State. Hartmann et. al., (2007) Observed that while germination require increased temperature, rooting requires a reduced temperature.

Table 1: Effect of Stem girth size on Number of roots of marcotted Sweet orange (*Citrus senesis*)

Stem size (cm)	April	May	June	July	Σx	ẍ
1	4.0	5.0	4.0	6.0	19.0	5.0 c
2	6.0	5.0	6.0	8.0	25.0	6.0 c
3	8.0	9.0	11.0	10.0	38.0	10.0 b
4	13.0	15.0	15.0	16.0	59.0	15.0 a
Σx	31.0	34.0	36.0	40.0	141	
ẍ	8.0bc	9.0b	9.0b	10.0a		

LSD (0.05) = 1.40 Means followed by same letter are not significantly different.

Table 2: Effect of Stem girth size on Root length (mm) of marcotted Sweet orange (*Citrus sinensis*)

Stem size (cm)	April	May	June	July	*Σx*	ẍ
1	4.0	4.0	4.0	5.0	17.0	2.3c
2	4.0	5.0	6.0	6.0	21.0	5.3b
3	5.0	5.0	7.0	7.0	24.0	6.0b
4	7.0	8.0	10.0	12.0	37.0	9.3a
Σx	20.0	22.0	27.0	30.0	99.0	
ẍ	5.0c	5.5bc	6.8ab	7.5a		

LSD (0.05) =1.44 Means followed by same letter are not significantly different

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STEM PRUNING INFLUENCED GROWTH AND LEAF YIELD OF THREE ACCESSIONS OF BITTER LEAF (*VERNONIA AMYGDALINA* DEL.)

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ABSTRACT

A preliminary investigation was conducted to study the effects of stem pruning on growth and leaf yield of three accessions of bitter leaf. The research was carried out at the Teaching and Research Farm of Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria. The three bitter leaf accessions were 'Nise', 'Umueze-Anam' and 'Nimo', which received four stem pruning levels namely no pruning, pruning to one stem, pruning to two stems and pruning to three stems. The experiment was laid out as a 3 x 4 factorial in randomized complete block design (RCBD) replicated six (6) times. Results showed that stem pruning had significant (P<0.05) effect on the growth and leaf yield of bitter leaf. The highest number of leaves, tallest plants, widest leaves, highest fresh (3.65 t/ha) and dry (1.97 t/ha) leaf yield were significantly (P<0.05) observed in plants that were pruned to three stems while the lowest mean values of these parameters were significantly recorded in unpruned plants. Growth and leaf yield varied among the accessions with 'Nise' accession producing most vigorous plants with the corresponding highest fresh (3.92 t/ha) and dry (2.07 t/ha) leaf yield. Combined effect of accession and stem pruning indicated that pruning 'Nise' accession to three stems significantly (p<0.05) produced highest fresh (5.99 t/ha) and dry (3.30 t/ha) leaf yield. Hence, 'Nise' accession was recommended as good planting material for farmers in Awka, Nigeria. Stem pruning of bitter leaf to three stems was also recommended to be adopted by the farmers since it accounted for most vigorous plants and highest fresh and dry leaf yield.

Key words: Bitter leaf, pruning, accession, growth, leaf, yield.

INTRODUCTION

Vernonia amygdalina, a member of the Asteraceae family, is a small shrub that grows in tropical Africa (Ijeh and Ejike, 2011). *Vernonia amygdalina* grows primarily in tropical Africa especially in Nigeria, Zimbabwe, and South Africa (Farombi, 2003). It is adapted and domesticated in parts of West Africa. The leaves are green and have a characteristic bitter taste. Every part of the plants is useful, notably the stems, leaves and roots (Adaramoye *et al*., 2008). The leaves of the plant may be consumed either as vegetable (macerated leaves in soups) or aqueous extract as tonics for the treatment of various illnesses (Atangwho *et al*., 2007). The leaves of *Vernonia amygdalina* are commonly used as soup condiments after washing and boiling to get rid of the bitter taste (Abosi and Raseroka, 2003). Specifically, it is used to prepare the popular Nigerian bitter leaf soup, 'onugbo' or Cameroon dish 'ndole' after the removing its bitter taste. Other popular use of *Vernonia amygdalina* in Africa includes traditional treatment of diseases, such as malaria, infertility, diabetes, gastrointestinal problems and sexually transmitted diseases (Farombi and Owoeye, 2011).

Plant accession is a distinct uniquely identifiable sample of seeds or planting material representing a breeding line or population which is maintained in storage and conservation for use (NPGS, 1991). Accession is described as a group of related plant material from a single specie which is collected at one time from a specific location. Each accession is an attempt to capture the diversity present in a given plant population. There are numerous accessions of bitter leaf but they are largely uncharacterized making it impossible to ascribe specific attributes to known accessions to facilitate industrial-scale production. There is scarcity of agronomic information on the accessions which are in existence in Nigeria and Anambra state in particular, where the plant exists virtually in every homestead both in the urban and rural areas because of its nutritional and medicinal importance.

Pruning is an agronomic practice which has been reported to increase branching in plants resulting to increased leaf production (Hossain *et al.,* 2007). Pruning is a horticultural practice involving the selective removal of certain parts of a plant, such as branches, buds, or roots (Nelson, 2017). It focuses more on the removal or reduction of parts of a plant, tree, or vine that are not requisite to growth or production, and are no longer visually pleasing, or are injurious to the health or development of the plant. Pruning is common practice in orchard and vineyard management for the improvement of flowering and fruiting. It is an important gardening skill, as it involves the trimming and cutting of plants to rid them of any injured, dead, or infected roots and wood. In some cases, pruning is also used as a preventive measure to make space for any new seedling or growth. It is important to prune trees and shrubs at the proper time (MaximumYield Inc, 2019).

In Anambra state, Nigeria, there is scarcely any household without deliberate efforts to maintain bitter leaf plant within the homestead because of the obvious nutritional and medicinal importance. However, there is scarcity of recommended agronomic information for optimum production of the crop (Ndukwe *et al*., 2020). There may be accessional variations and there are no recommendable accessions for higher leaf yield at present. In addition, stem pruning is a horticultural practice that increases plant productivity, it will be pertinent to determine its effect on the growth and leaf yield of bitter leaf. Hence, the objectives of this study were to evaluate the growth and leaf yield of three accessions of bitter leaf and to determine the effect of stem pruning on growth and leaf yield of bitter leaf.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the Department of Crop Science and Horticulture Nnamdi Azikiwe University, Awka, Anambra State Nigeria. Awka is a tropical rain forest with an average temperature of 27^0C - 30^0C. The area is located between latitude 06^0 151´N and longitude 07^0 081´E, with an average rainfall of 1810.3 mm per annum and a relative humidity of 75-80% (GEOMET-NAU, 2019). The experiment was carried out during the rainy season.

Stem cuttings of two bitter leaf accessions ('Nise and Umueze –Anam') were obtained from the research farm of Anambra State University Igbariam, Anambra while stem cuttings of 'Nimo' accession was obtained from Crop Science and Horticulture Teaching and Research Farm at Nnamdi Azikiwe University Awka. The stems were cut into an average length of 15 cm, bearing 3-5 nodes. The factors comprised of three bitter leaf accessions (Nise, Umueze-Anam, Nimo), which received four pruning levels which were no pruning, pruning to one stem, pruning to two stems and pruning to three stems. The experiment was laid out as a 3x4 factorial - in a randomized complete block design (RCBD) replicated six (6) times.

Ridges of 5 m long were manually made with a furrow space of 1 m between ridges. Planting was done by inserting the stem cuttings into the soil at 45° position to the soil level with at least two nodes underneath the soil while two nodes were above the soil. Six (6) stem cuttings were planted on the ridges with a spacing of 0.5 m by 1 m within and between rows respectively. At two weeks after planting, poultry manure was uniformly applied to the soil at 20 cm diameter away from each plant at the rate of 10 t/ha using ring method of application.

Data were collected on growth and leaf yield. Growth data were collected at two weeks' interval. They comprised height of tallest branch, stem girth of tallest branch, measured leaf area and total number of leaves. Height of tallest branch was obtained using a flexible measuring tape while stem girth was recorded with digital vernier caliper. Total number of leaves was obtained by counting the number of leaves on each branch of the plant while measured leaf area was obtained by measuring the length and width of the broadest leaves using a meter rule. Fresh and fully opened leaves were harvested by picking at 4 weeks' interval.

All the data collected were statistically analyzed following the procedure outlined for factorial experiment in randomized complete block deign using GENSTAT (2012) statistical software package. Treatments means were separated with least significant difference at 5% probability level.

RESULTS

Main effect of accessions and pruning on the number of branches of bitter leaf

The number of branches did not significantly (P>0.05) vary among the accessions at 9 and 11 weeks after planting (WAP) (Table 1). However, at 13, 15 and 17 WAP, there were variations in the number of branches of the accession. Nimo and Nise accessions significantly (P<0.05) produced higher number of branches at 13, 15 and 17 WAP than Umueze-Anam accession.

Pruning significantly (P<0.05) influenced number of branches of bitter leaf in all the sampling periods (Table 1). Expectedly, highest number of branches (4.50) was significantly recorded in the unpruned plants, followed by plants pruned to 3 branches, and then plants pruned to 2 branches. The least number of branches were recorded in plants pruned to 1 stem. This trend was observed at all periods of data collection.

There was significant (P<0.05) interaction effect of accession and pruning on the number of

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branches at 9, 11, 13, 15 and 17 WAP (Table 2). Highest number of branches (4 - 5) was consistently produced by unpruned Nimo accessions while lowest number of branches was significantly recorded in plants pruned to one branch in all the three accessions.

Table 1: Main effects of accession and pruning on number of branches of bitter leaf.

	Weeks after planting				
	9	11	13	15	17
Accession					
Nimo	2.49	2.41	2.71	2.75	2.75
Nise	2.41	2.37	2.46	2.76	2.75
Umueze-anam	2.26	2.27	2.26	2.33	2.29
$LSD_{0.05}$	ns	Ns	0.300	0.40	0.38
Pruning					
No Pruning	3.67	3.49	3.99	4.49	4.44
Pruning to 1 stem	1.00	1.03	1.01	1.03	1.03
Pruning to 2 stems	1.99	1.99	2.01	2.00	2.00
Pruning to 3 stems	2.88	2.89	2.89	2.93	2.92
$LSD_{0.05}$	0.356	0.26	0.347	0.456	0.44

Table 2: Interaction effects of accession and pruning on number of branches of bitter leaf

	Weeks after planting					
Accession	**Pruning**	**9**	**11**	**13**	**15**	**17**
Nimo	No pruning	3.98	3.67	4.83	5.00	5.00
	Pruning to 1 stem	0.98	1.00	1.00	1.00	1.00
	Pruning to 2 stems	2.00	2.00	2.00	2.00	2.00
	Pruning to 3 stems	3.00	3.00	2.99	3.00	3.00
Nise	No Pruning	3.70	3.47	3.79	4.82	4.82
	Pruning to 1 stem	0.98	1.00	0.985	1.08	1.06
	Pruning to 2 stems	1.96	2.01	2.03	2.02	2.02
	Pruning to 3 stems	2.98	3.01	3.02	3.12	3.10
Umueze_anam	No Pruning	3.33	3.33	3.33	3.67	3.50
	Pruning to 1 stem	1.05	1.10	1.03	1.02	1.02
	Pruning to 2 stems	2.00	1.97	2.00	1.98	1.98
	Pruning to 3 stems	2.67	2.67	2.67	2.67	2.67
$LSD_{0.05}$		0.62	0.46	0.60	0.79	0.77

Main effect of accession and pruning on number of leaves of bitter leaf

The number of leaves of bitter leaf significantly ($P<0.05$) varied among the accessions in all the sampling periods (Table 3). Nise accession significantly produced higher number of leaves than either the Nimo or Umueze-anam accessions. On the other hand, unpruned plants and plants pruned to three branches consistently produced highest number of leaves across the sampling periods (Table 3) while lowest number of leaves was recorded by plants pruned to one stem.

The combined effects of accession and pruning indicated significant influence on the number of leaves (Table 4). Pruning of Nise accession to three branches significantly enhanced the production of highest number of leaves at 9, 11, 13, 15 and 17 WAP whereas pruning of Nise to one

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branch on the other hand produced fewest leaves at all periods of data collection.

Main effects of accession and pruning on plant height of bitter leaf

There was significant difference (P<0.05) among the accessions as regards plant height (Table 5). Nise accession produced tallest plants (21.2, 35.6, 64.9, 70.6 and 79.60 cm at 9, 11, 13, 15 and 17 weeks after planting, respectively). Nimo accession, on the other hand, significantly produced shortest plants in all the sampling periods but the mean values were significantly at par with those observed in Umueze-anam accession.

Table 3: Main effects of accession and pruning on number of leaves of bitter leaf

	Weeks after planting				
	9	11	13	15	17
Accession					
Nimo	27.5	33.2	38.7	40.6	43.6
Nise	35.9	50.8	50.0	66.8	74.4
Umueze-anam	19.9	26.6	29.0	40.5	49.1
$LSD_{0.05}$	6.8	11.4	7.6	7.5	10.3
Pruning					
No Pruning	35.0	40.7	46.0	53.2	60.9
Pruning to 1 stem	16.0	25.6	32.9	40.7	44.4
Pruning to 2 stems	24.0	34.2	35.0	43.5	51.7
Pruning to 3 stems	36.1	47.0	43.0	59.7	65.7
$LSD_{0.05}$	7.9	13.2	8.8	8.7	11.9

Table 4: Interaction effects of accession and pruning on number of leaves on bitter leaf

		Weeks after planting				
Accession	**Pruning**	**9**	**11**	**13**	**15**	**17**
Nimo	No pruning	43.5	47.8	56.3	65.8	70.5
	Pruning to 1 stem	13.3	22.4	21.2	19.8	23.7
	Pruning to 2 stems	21.5	27.0	34.0	34.2	35.3
	Pruning to 3 stems	31.7	35.6	43.1	43.0	44.8
Nise	No Pruning	43.2	48.7	51.3	55.5	63.7
	Pruning to 1 stem	19.5	33.6	49.9	63.2	69.9
	Pruning to 2 stems	34.1	56.7	50.0	68.1	80.3
	Pruning to 3 stems	47.0	64.1	48.9	80.3	83.6
Umueze_anam	No Pruning	18.5	25.7	30.5	38.3	48.3
	Pruning to 1 stem	15.3	20.7	27.6	39.5	39.5
	Pruning to 2 stems	16.4	19.1	21.0	28.3	39.6
	Pruning to 3 stems	29.5	41.2	37.0	55.8	68.8
$LSD_{0.05}$		13.7	22.8	15.2	15.0	20.6

Plant height was significantly (p<0.05) influenced by pruning (Table 5). Expectedly, shortest plants were observed in plants that were not pruned while tallest plants were produced by plants that were pruned to three branches, although the mean values obtained did not significantly differ (P>0.05) with those recorded in plants pruned to either one or two branches. The interaction of

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accession and pruning had significant influence on plant height at 9, 11, 13, 15 and 17 WAP (Table 6). Pruning Nise accession either 2 or 3 branches significantly (P<0.05) gave rise to tallest plants while the shortest branch were obtained from unpruned Umueze-anam and Nimo accessions.

Table 5: Main effects of accession and pruning on plant height (cm) of bitter leaf.

	Weeks after planting				
	9	11	13	15	17
Accession					
Nimo	16.1	21.9	31.1	41.1	51.1
Nise	21.2	35.6	64.9	70.6	79.6
Umueze-anam	16.5	29.3	42.6	51.4	60.6
$LSD_{0.05}$	ns	8.8	13.5	14.0	15.3
Pruning					
No Pruning	12.9	20.4	36.8	35.8	45.3
Pruning to 1 stem	17.0	31.7	50.7	63.2	71.1
Pruning to 2 stems	19.4	30.3	44.9	55.2	64.9
Pruning to 3 stems	22.4	33.3	52.4	63.2	73.9
$LSD_{0.05}$	6.9	12.1	Ns	16.1	17.7

Table 6: Interaction effects of accession and pruning on plant height (cm) of bitter leaf

		Weeks after planting				
Accession	**Pruning**	**9**	**11**	**13**	**15**	**17**
Nimo	No pruning	17.5	21.2	30.4	32.7	46.7
	Pruning to 1 stem	15.2	21.9	27.5	47.0	51.0
	Pruning to 2 stems	13.7	17.7	25.4	37.8	48.3
	Pruning to 3 stems	18.0	26.7	41.2	46.9	58.6
Nise	No Pruning	11.7	22.6	42.0	37.9	44.9
	Pruning to 1 stem	15.4	32.5	73.9	73.7	82.9
	Pruning to 2 stems	28.9	44.2	72.4	86.1	95.7
	Pruning to 3 stems	28.8	43.1	71.2	84.6	95.0
Umueze_anam	No Pruning	9.4	17.5	37.9	36.7	44.4
	Pruning to 1 stem	20.5	40.8	50.7	69.0	79.5
	Pruning to 2 stems	15.8	29.1	37.0	81.8	50.6
	Pruning to 3stems	20.5	30.0	44.8	58.0	68.0
$LSD_{0.05}$		11.9	17.5	27.0	27.9	30.7

Main effects of accession and pruning on stem girth of bitter leaf

There was a significant difference (P<0.05) among the accessions in their stem girth at 9, 13, 15 and 17 WAP (Table 7). At 9 WAP, Umueze-anam and Nimo accessions produced similar but significantly wider stems compared to Nise accession. But at 13, 15, and 17 WAP, significantly (P<0.05) widest stems were obtained from Nise accession. During these growth periods, Umueze_anam and Nimo accessions produced narrower stems compared to Nise accession.

On the other hand, pruning significantly (P<0.05) influenced the stem girth of bitter leaf at all the growth periods (Table 7). Widest stems were obtained from the plants that were pruned to one stem in all growth periods although the mean values were significantly similar with mean values observed in plants pruned to 2 and 3 stems. Unpruned plants had significantly (P<) thinner stems than the pruned plants.

The interaction of accession and pruning significantly affected the stem girth of the bitter leaf especially at 17 WAP (Table 8). Widest stems at 17 WAP were notably observed in pruned plants from Nise accession but no pruning resulted in thinnest stems across all the accessions.

Table 7: Main effects of accession and pruning on stem girth (mm) of bitter leaf.

	Weeks after planting				
	9	**11**	**13**	**15**	**17**
Accession					
Nimo	4.23	6.42	8.92	9.84	11.38
Nise	2.95	5.93	11.59	12.38	13.99
Umueze– anam	5.64	5.76	8.92	9.81	11.05
$LSD_{0.05}$	2.20	ns	2.23	2.31	2.36
Pruning					
No Pruning	3.17	4.55	7.28	7.61	9.13
Pruning to 1 stem	6.16	7.42	11.45	12.98	14.10
Pruning to 2 stems	3.22	5.84	9.88	10.95	12.29
Pruning to 3 stems	4.53	6.34	10.65	11.16	13.03
$LSD_{0.05}$	2.54	1.48	2.58	2.66	2.72

Table 8: Interaction effects of accession and pruning on stem girth of bitter leaf.

		Weeks after planting				
Accession	**Pruning**	**9**	**11**	**13**	**15**	**17**
Nimo	No pruning	4.41	4.50	7.90	8.51	9.73
	Pruning to 1 stem	4.15	7.99	9.47	10.28	12.15
	Pruning to 2 stem	3.50	6.36	8.94	10.33	11.65
	Pruning to 3 stem	4.84	6.83	9.38	10.23	11.98
Nise	No Pruning	2.44	4.89	6.82	7.11	9.17
	Pruning to 1 stem	2.41	6.09	13.60	15.84	15.71
	Pruning to 2 stem	2.82	6.87	13.23	14.29	15.78
	Pruning to 3 stem	4.11	5.86	12.72	12.28	15.25
Umueze-anam	No Pruning	2.66	4.26	7.10	7.21	8.49
	Pruning to 1 stem	1.91	8.19	11.28	12.83	14.41
	Pruning to 2 stem	3.33	4.30	7.46	8.24	9.45
	Pruning to 3 stem	4.65	6.31	9.86	10.95	11.87
$LSD_{0.05}$		4.39	2.57	4.46	4.61	4.71

Main effects of accession and pruning on measured leaf area of bitter leaf

Measured leaf area of the accessions was significantly different only at 15 WAP (Table 9).

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Widest leaves were produced by Nise accession. Effect of pruning showed that plants pruned to 3 stems significantly produced widest leaves (Table 9). Interaction of accession and pruning did not have significant (P>0.05) effect on the measured leaf area.

Table 9: Main effects of accession and pruning on measured leaf area (m^2) of bitter leaf

	Weeks after planting				
	9	**11**	**13**	**15**	**17**
Accession					
Nimo	0.00788	0.00922	0.0242	0.0135	0.0137
Nise	0.00785	0.01355	0.0139	0.0176	0.0168
Umueze-anam	0.00831	0.01251	0.0137	0.0134	0.0158
$LSD_{0.05}$	ns	ns	Ns	0.0040	ns
Pruning					
No Pruning	0.00655	0.00988	0.0255	0.0145	0.0132
Pruning to 1 stem	0.00855	0.01229	0.0170	0.0157	0.0160
Pruning to 2 stems	0.00772	0.00976	0.0110	0.0129	0.0141
Pruning to 3 stems	0.00924	0.01511	0.0155	0.0162	0.0184
$LSD_{0.05}$	ns	0.00484	Ns	Ns	ns

Main effects of accession and pruning on total fresh and dry leaf yield of bitter leaf

The main effect of accession on leaf fresh and dry leaf yield indicated that Nise accession significantly (P<0.05) produced highest fresh leaf weights (196g), dry leaf weights (103.6g), fresh and dry leaf yields (Table 10). Lowest leaf fresh and dry yield were consistently observed in Nimo accession. Pruning significantly (P<0.05) influenced the fresh and dry leaf yield (Table 10). Pruning stems to 3 branches resulted in highest fresh and dry leaf yield, while unpruned plants significantly had lowest fresh and dry leaf yield. The interaction of accession and pruning had significant (P<0.05) influence on the fresh and dry leaf weights of bitter leaf (Table 11). Pruning the stems of Nise accession to 3 stems resulted in highest leaf fresh and dry yield while lowest leaf yield was obtained from unpruned plants of Umueze-anam accession.

Table 10: Main effects of accession and pruning on total fresh weight (g), total dry weight, fresh and dry leaf yield (t/ha) of bitter leaf

	Total fresh weight (g/plant)	Total dry leaf weight (g/plant)	Total fresh leaf yield (t/ha)	Total dry leaf yield (t/ha)
Accession				
Nimo	91.0	48.2	1.81	0.96
Nise	196.0	103.6	3.92	2.07
Umueze-anam	112.0	61.5	2.24	1.23
$LSD_{0.05}$	52.5	28.5	1.05	0.57
Pruning				
No Pruning	104.0	55.0	2.08	1.10
Pruning to 1 stem	122.0	67.0	2.45	1.34
Pruning to 2 stems	122.0	63.8	2.45	1.28
Pruning to 3 stems	183.0	98.5	3.65	1.97
$LSD_{0.05}$	60.6	32.9	11.21	0.66

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Table 11: Interaction effects of accession and pruning total fresh weight (g), dry weight (g) and leaf yield (t/ha) of bitter leaf

Accession	Pruning	Total fresh weight (g/plant)	Total dry leaf weight (g/plant)	Total fresh leaf yield (t/ha)	Total dry leaf yield (t/ha)
Nimo	No pruning	121.0	60.2	2.42	1.20
	Pruning 1_stem	98.0	51.5	1.96	1.03
	Pruning 2_stems	59.0	33.7	1.19	0.67
	Pruning 3_stems	84.0	47.4	1.68	0.95
Nise	No Pruning	118.0	58.8	2.36	1.18
	Pruning 1_stem	146.0	81.8	2.91	1.64
	Pruning 2_stems	221.0	108.7	4.43	2.17
	Pruning 3_stems	300.0	165.1	5.99	3.30
Umueze_anam	No Pruning	73.0	46.2	1.47	0.92
	Pruning 1_stem	123.0	67.8	2.47	1.36
	Pruning 2_stems	86.0	49.1	1.72	0.98
	Pruning 3_stems	164.0	82.9	3.29	1.66
$LSD_{0.05}$		105.0	56.93	2.10	1.14

DISCUSSION

The growth and yield differences among the accessions in our results is an indication that there could be inherent genetic variability among them. There could be further breeding investigations on these accessions for further improvement through breeding. Most vigorous plants and highest leaf yield were produced by Nise accession followed by Nimo while Umueze-anam accession performed poorest. This implied that Nise and Nimo accessions had easier adaptation to Awka environment than Umueze-anam accession. Nise and Nimo are suburbs and villages around Awka, Anambra State, Nigeria and these villages belong to the same agroecological zone (Awka agroecological zone) with Awka metropolis.

Our result showed that pruning had a significant effect on plant height, number of leaves and measured leaf area with pruning to three stems recording significantly highest mean values for these variables. Shortest plants in unpruned plants could be attributed to the effect caused by competition for solar radiation by many branches in the unpruned plants. This corroborates with reports of Ayala-Tafoya *et al*. (2019). Pruning modifies light distribution within canopy and increases their photosynthetic capacity and quantum yield of leaves (Hossain *et al.,* 2007). In addition, there must have been reduced competition for resources due to pruning to three stems. Similar finding had been reported by Sahu *et al*. (2018) who opined that pruning directly encourages the formation of enlarged leaves, increases mesophyll size and moisture content and also lengthens the period of stomata opening. It has also been reported that pruning helps to reduce transpiration per unit ground area (Alcorn *et al*., 2013; Chen *et al*., 2016) which would have also enhanced moisture utilization for higher assimilate production as evidenced in the pruned plants especially pruning to three stems which had more biomass and highest leaf yield.

CONCLUSION AND RECOMMENDATION

This study showed that pruning had significant effect on the growth and yield of bitter leaf. Pruning to three stem produced the highest leaf yield throughout the haevesting periods, especially in Nise accession. Therefore, stem pruning of bitter leaf especially pruning to three branches was recommended for adoption by the farmers. Nise accession was recommended to be a promising planting material for farmers within the study area.

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PRUNING EFFECTS ON CASHEW SEEDLING GROWTH AND DEVELOPMENT

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ABSTRACT

Cashew plant is an economic and tropical evergreen tree known most especially for its edible nuts and apple. It is mostly propagated by seeds which could be nursed before transplanting to the field. Pruning which is an important cultural management practice that helps in manipulating branching, light utilization, canopy formation, flowering and fruit production. Varying views from farmers on pruning call for a scientific investigation on its effects on the growth and development of young cashew plants. The experiment consists of 6 treatments which include Jumbo control (CtJ), Medium control (CtM), Pruned-out Jumbo (PoJ), Pruned-out Medium (PoM), Pruned-return Jumbo (PrJ) and Pruned-return Medium (PrM) all replicated three times in a randomized complete block design. Data on seedling emergence and morphology with particular reference to height and stem diameter were collected. After pruning treatments application at 12 weeks after sowing (WAS), the control had the highest plant height in both jumbo (45.63 cm) and medium (40.42 cm) biotypes at 24 WAS though the differences were not significant ($p \leq 0.05$) over the pruning treatments. Prior to application of pruning treatments, PrM and PrJ that ranked 6th and 4th position in plant height growth rate now ranked 2nd and 3rd respectively afterwards. This could be an indication that the mineralization of pruned branches over a longer period could enhance plant height of cashew seedling in both biotypes. Pruning seemed not to enhance the rate of stem diameter in medium biotype as PrM degenerated from 2nd position ranking to 4th and PoM from 1st to 3rd before and after pruning treatments application respectively.

Key words: Biotype, cashew, growth, pruning, seedling

INTRODUCTION

Anacardium occidentale L. (Cashew) is a tropical evergreen tree that produces true fruit called nut and a pseudo-fruit called apple. It is an essential commodity crop that provides food, employment and economic growth to many developing countries including Nigeria. Propagation in cashew is mainly by seed raised in the nursery for 2 to 3 months prior to field transplanting though *in-situ* sowing is equally recommended (Adeyemi and Nduka, 2019). A successful field establishment of cashew starts from the nursery. Pruning is the correct and cautious removal of plant parts such as shoots, spurs, leaves, roots or nipping away of terminal parts, to correct or maintain tree structure and increase its usefulness. It is one of the vital management practices in tree crops like cashew (Adeyemi, 2017) that entails modifying plant form and structure. Management of plant growth, canopy architecture, flower and fruit production are enhanced through pruning. Pruning increases stem potential, induces canopy transpiration and improves water status of plant. Branch, stem and trunk pruning of young trees induce the movement of photosynthates or plant nutrients towards the canopy of the plant for improved productivity. The small nodes on each plant structure contain growth hormones and if pruning is done directly above them, the hormones are activated to fix or regrow plant tissues (Bosque, 2021).

Some of the claims by cashew farmers on the effects of shoot pruning on young cashew plant needed to be investigated scientifically. Shoot pruning also results in the loss of plant nutrients contained in the prunes. It is equally imperative to determine the effect of prunes re-applied to the seedling. This study is therefore aimed at examining the effects of shoot pruning on the morphological parameters of young cashew seedlings when removed completely or resupplied as manure.

MATERIALS AND METHODS

The investigation was conducted under cashew trees, a semi-nursery environment, behind Agronomy block of the office complex at CRIN, Ibadan. The factorial experiment was laid out in a randomized complete block design consisting of two factors. Factor A was cashew nut biotype at two levels of jumbo (J) and medium (M). Factor B was pruning at three levels of: pruned branches removed (Po), pruned branches returned (Pr) to the seedling pot and un-pruned as control treatment (C). Consequently, there were 6 treatment combinations as follows: Control Jumbo (CtJ), Control Medium (CtM), Jumbo pruned returned (PrJ), Medium pruned returned (PrM), Jumbo pruned out (PoJ), Medium pruned out (PoM).

The treatments were replicated three times. Topsoil obtained under cashew plantation within the Institute was sieved using a 2 mm sieve to remove stones and debris. The prepared soil was put into 10.0 kg capacity plastic buckets perforated at the bottom for free drain off excess water. The soil was watered to water holding capacity two days prior to sowing of cashew nuts. Current season nuts obtained from CRIN were sown one nut per pot at the centre of the pot at 3.0 cm depth. Watering of the pots was done thrice a week at every other day interval. Data taken were on rate of seedling emergence, total emergence at 4 weeks after sowing (WAS) and morphological parameters of seedlings from 4 WAS at fortnightly till 12 WAS when pruning treatments were applied and data collection at a month interval afterward. Pruned branches were mashed using a mortar and pestle for ease of mineralization before being returned into the pots as manure. Data collected were analyzed with both descriptive (percentage) and analytical (analysis of variance) statistics. Means separation was done by the use of DMRT and LSD.

RESULTS AND DISCUSSION

Rate of seedling emergence in cashew biotypes

Cashew seedling emergence was earlier in medium biotype than in jumbo as indicated in Table 1. This is in concordance with the reports of Adeyemi *et. al*., (2017).

Table 1: Mean emergence (%) in cashew biotypes

Period (WAS)	Mean Germination % Medium cashew	Jumbo cashew
2	2.8a	0a
3	69.4a	38.9b
4	77.8a	66.7a

Emergence in medium cashew (2.8 %) commenced at 2 WAS while that of jumbo was at 3 WAS. However, the difference was not significant ($p \leq 0.05$) at 2 WAS as shown in Table 1. Mean emergence increased from 2 WAS to 4 WAS in both cashew biotypes. Highest rate of emergence (%) which was 96 and 100 for medium and jumbo respectively occurred at 3 WAS (Table 1). Emergence in medium was both superior and significant ($p \leq 0.05$) over jumbo at 3 WAS. The rate of emergence in the two cashew biotypes understudy was 2 WAS < 3 WAS > 4 WAS. At 4 WAS, the highest emergence (77.8 %) was obtained in medium biotype while its counterpart jumbo recorded 66.7 % but the difference was not significant ($p \leq 0.05$) as shown in Table 1. These observations agree with the reports of Adeyemi, et. al. (2017).

Morphological parameters of cashew as affected by pruning and biotypes

Pruning and biotypes effects on plant height of cashew seedling

At the completion of seedling emergence (4 WAS), jumbo cashew seedlings, had the highest plant heights than medium (Table 2). Order of plant height observed was at this stage: CtJ > PoJ > PrJ > PoM > CtM > PrM. In each of the treatments and throughout the period of observation, the height of jumbo seedling was higher than its corresponding medium but the differences were significant ($p \leq 0.05$) only from 8 – 20 WAS in the control treatments. These observations are in consonance with earlier reports by Adeyemi, et. al., (2017). In all the treatments, the height increased with the age of the seedling. This is expected of living and growing organisms like cashew seedling. However, the rate of increase was consistently at a decreasing rate till 12 WAS being the recommended maximum seedling age for field transplanting.

Table 2: Mean Plant Height (cm) of cashew seedling as affected by pruning and biotypes

Treatment	Seedling height 4 WAS	6	8	10	12	16	20	24
CtJ	18.27	25.83	32.87	36.27	38.80	40.70	42.80	45.63
CtM	16.17	20.50	24.03	25.50	27.00	29.83	31.10	40.42
PrJ	17.00	23.33	26.27	28.07	29.97	32.33	34.47	37.53
PrM	16.00	19.67	22.83	23.37	24.37	24.90	26.80	32.33
PoJ	18.10	24.67	29.47	31.88	33.03	36.03	37.73	39.48
PoM	16.67	22.93	27.70	29.77	30.47	33.27	36.63	38.57
LSD	**2.84**	**6.22**	**7.41**	**6.13**	**7.43**	**7.76**	**8.36**	**10.55**

As from 16 WAS till the end of the investigation, an irregular pattern was observed in the rate of growth of cashew seedlings as indicated by their heights. At recommended cashew seedling maximum age (12 WAS) and prior to pruning treatments application, jumbo seedlings maintained the higher plant heights over the medium with the order: CtJ > PoJ > PoM > PrJ > CtM > PrM.

After pruning treatments were effected at 12 WAS, the control seedlings maintained the highest plant height in both jumbo (45.63 cm) and medium (40.42 cm) biotypes at 24 WAS as shown in table 2. The order of seedling height 3 months after pruning treatments were applied was: CtJ > CtM > PoJ > PoM > PrJ > PrM. However, growth rate (%) from 16 – 24 WAS, which was 3 months, after the application of pruning treatments was in the order: CtM (26.20) > PrM (22.98) > PrJ (13.86) > PoM (13.74) > CtJ (10.80) > PoJ (8.74). Prior to the application of pruning treatments, 4 – 12 WAS, it was: CtJ (52.9) > PoM (45.29) > PoJ (45.20) > PrJ (43.28) > CtM (40.11) > PrM (34.35). This showed that PrM and PrJ that ranked 6th and 4th position before application of pruning treatments now ranked 2nd and 3rd respectively afterwards. This is an indication that the mineralization of pruned branches over a longer period could enhance plant height of young cashew plant.

Pruning and biotypes effects on cashew seedling stem diameter

The mean stem diameter (0.57 cm) of medium biotype cashew seedling was greater than that of jumbo (0.52 cm) prior to the application of pruning treatments (4 – 12 WAS) as shown in Table 3 contrary to what was observed in seedling height above. However, 3 months after the application of pruning treatments, jumbo was greater (1.05 cm) in seedling stem diameter than medium biotype (0.96 cm). Mean stem diameter from 4 to 12 WAS was in the order: CtJ > PoM > PrM > PoJ > CtM > PrJ. At 24 WAS, 3 months after the application of pruning treatments, the order was: CtJ > PoJ > PoM > CtM > PrJ > PrM.

Considering cashew seedling growth rate (%) from stem diameter perspective, that of medium biotype before (39.36) and after application of pruning treatments (22.79) were greater than jumbo (32.36) and (16.77) respectively. The order at 4 – 12 WAS was: PoM > PrM > CtM > PoJ > PrJ > CtJ. Three months after the application of pruning treatments, it was: CtM > PoJ > PoM > PrM > PrJ > CtJ as shown in Table 3. Pruning returned to seedling seemed not to enhance the rate of stem diameter in medium biotype as PrM degenerated from 2nd position ranking to 4th. Likewise, PoM that was in the 1st position ranking prior to the application of pruning treatments degenerated to the 3rd position afterwards. Furthermore, control medium that ranked 3rd 4 – 12 WAS advanced to the 1st at 24 WAS. Growth rate of control jumbo was least both before and after pruning treatments application. Stem diameter increased as seedling advanced in age as observed in seedling height reported earlier.

Table 3: Mean Stem diameter (cm) of cashew seedling as affected by pruning and biotypes

Treatment	Seedling diameter 4 WAS	6	8	10	12	16	20	24
CtJ	0.57	0.58	0.65	0.69	0.82	1.02	1.09	1.17
CtM	0.49	0.53	0.65	0.68	0.76	0.84	0.95	1.17
PrJ	0.52	0.55	0.62	0.67	0.77	0.9	0.96	1.08
PrM	0.43	0.48	0.6	0.68	0.73	0.8	0.86	0.99
PoJ	0.56	0.59	0.7	0.74	0.85	0.95	1.05	1.2
PoM	0.48	0.51	0.68	0.74	0.82	0.9	1.03	1.13
LSD	**0.07**	**0.06**	**0.16**	**0.12**	**0.08**	**0.17**	**0.22**	**0.25**

CONCLUSION

Three months after the application of pruning treatments, the control treatments had the highest plant height in both jumbo and medium though the differences were not statistically higher than the pruning treatments. Rate of seedling height growth indicated that the mineralization of pruned branches over a longer period could enhance plant height of

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cashew seedling in both biotypes. However, pruning returned to seedling seemed not to enhance the rate of stem diameter in medium biotype. These will be validated with further investigation which in on-going.

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CORRELATION ANALYSIS OF SEED YIELD WITH GROWTH AND YIELD COMPONENTS OF THREE VARIETIES OF KENAF (*HIBISCUS CANNABINUS* L.)

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ABSTRACT

Field trials were conducted during the 2017 wet season at the Research farms of the Institute for Agricultural Research, Samaru and Kadawa in the Northern Guinea and Sudan savanna Agro-ecological zones to study the "Correlation Analysis of Seed Yield with Growth and Yield Components of Kenaf (Hibiscus cannabinus L.)". Growth parameters studied include plant height, number of leaves, leaf area index, butt diameter, shoot dry weight, crop growth rate and relative growth rate while yield parameters include 100 seed weight, seed weight plant^{-1} and seed yield (kg ha^{-1}). Results obtained showed a significant and positive correlation between seed yield hectare^{-1} and plant height, number of leaves, leaf area index, butt diameter as well all yield characters studied in both locations. However, shoot dry weight; crop growth rate and relative growth rate were negatively correlated with seed yield of the crop. These characters should not be considered in breeding for increase/improve seed yielding ability of kenaf.

Key words: Correlation, Savanna, Kenaf, Rainfed, Yield

INTRODUCTION

Kenaf is a fast growing annual crop of the malvaceae family known for both its economic and nutritional importance. Kenaf is believed to have its origin in Africa (Western Sudan), occurring as early as 4000BC, where diversified forms of its species are widely grown (Mostofa *et al,* 2013, Dempsey, 1975, Kobayashi *et al*. 2003 and Cheng *et al*., 2004). It is an erect annual shrub, 1- 4 meters in height, with well-developed tap root, leaves straight and slender stems. It has large cream-colored, flowers characterized by a reddish-purple neck. The seeds are cylindrical or kidney-shaped, pubescent, grey in colour (Purseglove, 1974 and Dempsey, 1975). Kenaf is the most economically important fiber crop after cotton and jute. It is specifically grown for its fiber and seeds but some varieties have edible leaves consumed by humans and animals (USDA, 1986 and Webber *et al*., 2002). Kenaf fiber is used in the production of sacks, mats, carpets, ropes roofing and canvass; while the stalk is used in paper pulp production. The seeds contain about 20% oil which is extracted and used as lubricant and for illumination, soaps, paints and varnishes (Purseglove, 1968).

Kenaf is now commercially cultivated in more than 20 countries, particularly China, India and Thailand, which accounted for 90% of the sown area and more than 95% of the total production in the world (FAO, 2006). However, in 2015, India and China accounted for 44% and 29% of the world kenaf production (INFO, 2016). FAO statistics in (2016) revealed that kenaf production in Nigeria has been fluctuating since 2004 when the development of the crop started receiving attention in Nigeria's agricultural development programmes. Kenaf production peaked in 2005 and started declining between 2007 to 2010. In 2011, production started improving once more and peaked in 2012 after which it started declining gradually till 2015.

Therefore, the objective of this study is to determine the simple correlation coefficient between seed yield with growth and yield components of Kenaf (*Hibiscus cannabinus* L.)

MARTERIALS AND METHODS

The experiment was conducted at the Institute for Agricultural Research (I.A.R) Farm, Samaru, (Latitude 11^{0} 11N Longitude 07' 38 E, 686m) above sea level in Kaduna State and at Kadawa, (Latitude 11^{0} 39 N Longitude 08' 27 E, 500m) above sea level in Kano State, in the northern Guinea and Sudan savannah ecological zones of Nigeria, respectively during the 2017 wet season (Kowal and Knabe, 1972).

The treatments consisted of three varieties of kenaf (Ifeken 400, Ifeken D1 400, and Girin danani). The treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The gross plot size was 4m x 3 (12m^{2}) while the net plot was 2 x 3 (6m^{2}).

Required cultural practices were conducted as per treatment. The relationship between the parameters was determine by correlation coefficient using the procedure described by Little and Hills (1978). Data were observed and collected on plant height, number of leaves, leaf area index, butt diameter, crop growth rate, relative growth rate, 100 seed weight, seed weight plant^{-1} and seed yield hectare^{-1}.

RESULTS AND DISCUSSIONS

The correlation coefficient for the different variables assessed for seed yield of Kenaf per hectare showed that kenaf seed yield per hectare was observed to be significantly and positively correlated with all the parameters assessed except shoot dry weight, crop growth rate and relative growth rate at both locations in 2017 wet season (Tables 1 and 2). This may indicate the importance of these parameters as yield contributing factors in kenaf. The correlations between most factors in kenaf were significant and positive except that between plant height with leaf area index, butt diameter, shoot dry weight, crop growth rate and relative growth rate, number of leaves and other factors except with seed yield hectare^{-1} , butt diameter with shoot dry weight, crop growth rate, relative growth rate and 100 seed weight. No significant correlation was observed between shoot dry weight and other factors except with crop growth rate, while the correlation between crop growth rate with 100 seed weight, seed weight plant^{-1} and seed yield hectare^{-1}, relative growth rate with 100 seed weight, seed weight plant^{-1}, and seed yield hectare^{-1} was not significant at Samaru during the 2017 wet season (Table 1). The correlation between plant height, number of leaves, shoot dry weight, crop growth rate, relative growth rate and 100 seed weight number of leaves and crop growth rate , butt diameter with crop growth rate and 100 seed weight, shoot dry weight and other factors, crop growth rate with 100 seed weight, seed weight plant^{-1} and seed yield hectare^{-1}, relative growth rate with 100 seed weight, seed weight plant^{-1} and seed yield hectare^{-1} ,100 seed weight and seed weight plant^{-1} was not significant at Kadawa during the 2017 wet season (Table 2). These observations show the contributory role of these factors in enhancing seed yield in kenaf, as the coefficient between two variables is the sum of the paths connecting them as reported by Agbaje et al. (2011).

The positive and significant correlation observed between most of the growth and yield characters studied signifies their significant in improving seed yield seed yield of kenaf varieties (Akinrotimi and Okocha, 2018). The increase in plant heights, number of leaves and other positively correlated characters to the seed yield, indicate their role in facilitating assimilate production and subsequent translocations to the sink and hence increase in seed yield of the crop. Similar results have been reported by Babaji (1997). The negative and insignificant association between shoot dry weight, crop growth rate and relative growth rate on seed yield in both locations implies that any increase due to selection for shoot dry weight, crop growth rate and relative growth rate would be accompanied by a corresponding decrease in seed yield. These characters should therefore not be considered for improvement for high yielding kenaf crop. This conforms with earlier finding by Agbaje *et al.* (2011).

Table 1: Simple correlation coefficients among growth and yield parameters of kenaf at Samaru during the 2017 wet season

	1	2	3	4	5	6	7	8	9	10
1	1									
2	0.35*	1								
3	0.19NS	0.18NS	1							
4	0.24NS	0.19NS	0.42*	1						
5	0.18NS	-0.01NS	0.78**	0.25NS	1					
6	-0.29NS	-0.14NS	0.61**	0.04NS	0.30*	1				
7	0.32*	-0.16NS	0.59**	0.09NS	0.11NS	0.98**	1			
8	0.40*	0.19NS	0.66**	0.02NS	0.02NS	0.03NS	0.07NS	1		
9	0.68**	0.20NS	0.50**	0.38*	0.22NS	-0.07NS	-0.09NS	0.35*	1	
10	0.38*	0.38*	0.49*	0.39*	0.27NS	-0.09NS	-0.01NS	0.49**	0.99**	1

*Key: 1=Plant height, 2=number of leaves, 3=leaf area index, 4=butt diameter, 5=shoot dry weight, 6=crop growth rate (CGR), 7=relative growth rate (RGR), 8=100 seed weight, 9=seed weight plant^{-1}, 10=seed yield hectare^{-1}, **=significant at 1% level, *=significant at 5 % level, NS=Not significant*

Table 2: Simple correlation coefficients among growth and yield parameters of Kenaf at Kadawa during the 2017 wet season

	1	2	3	4	5	6	7	8	9	10
1	1									
2	0.25NS	1								
3	0.13NS	0.38*	1							
4	0.48*	0.30*	0.42*	1						
5	-0.07NS	-0.06NS	0.34*	0.33*	1					
6	-0.29NS	0.19NS	0.03NS	0.19NS	0.12NS	1				
7	-0.07NS	0.15NS	0.64**	0.38*	0.18NS	0.97**	1			
8	0.58**	0.09NS	0.50**	-0.25NS	0.20NS	0.16NS	0.20NS	1		
9	0.68**	0.40*	0.30*	0.32*	-0.14NS	-0.04NS	0.18NS	0.01NS	1	
10	0.70**	0.46*	0.36*	0.65**	-0.16NS	-0.10NS	0.19NS	0.55**	1.00**	1

*Key: 1=Plant height, 2=number of leaves, 3=leaf area index, 4=butt diameter, 5=shoot dry weight, 6=crop growth rate (CGR), 7=relative growth rate (RGR), 8=100 seed weight, 9=seed weight plant^{-1}, 10=seed yield hectare^{-1}, **=significant at 1% level, *=significant at 5% level, NS=Not significant*

CONCLUSION

The result has shown that a significant and positive correlation was observed between total seed yield ha^{-1} and other growth and yield characters except shoot dry weight, crop growth rate and relative growth rate in both locations. Hence, improvement programme for kenaf should not consider those characters with negative correlations as factors for improvement of the yield of kenaf

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ANALYSIS OFGROWTH AND YIELD RESPONSES OF VARIETIES OF COWPEA [*VIGNA UNGUICULATA* (L.) WALPERS] IN SAMARU-KATAF, KADUNA STATE FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

A field study was conducted in a research farm opposite the Feed-mill of School of Agricultural Technology Samaru-Kataf Campus of Nuhu Bamalli Polytechnic Zaria to assess the growth and yield responses of varieties of cowpea [Vigna unguiculata (L.) Walpers] to compound fertilizer and sprinkling irrigation systemwith the primary objective of comparing the growth and yield responses of varieties of cowpea grown.The treatments consisted of a 3 x 3 factorial experiment laid out in a Randomized Complete Block Design (R.C.B.D.) with three replicates and blocks each that gave a total of nine (9) plots. Thus, the sources of variations for the experiment treatments consisted of three varieties of cowpea, namely honey beans, black-eyed pea and grey mottled cowpea seeds commonly grown in the area of study. The varieties were coded as Hb, Bp and Gm. for honey beans, black-eyed pea as well as grey mottled beans, respectively – with cow dung manure and sprinkling irrigation system applied in Samaru-Kataf campus. In addition to the treatments, half a fertilizer bag of cow dung manure was well air-dried before incorporating it into each of the nine (9) plots during land preparation. The assessment of growth and yield responses of three varieties of cowpea [vigna unguiculata (L.) Walpers] to cow dung manure and surface irrigation was compared during the 2020 dry season (synonymous to the winter that spanned from December, January to February). All the findings were subjected to a statistical analysis "analysis of variance (ANOVA). It was found that only flowering percentage was significantly different while plant height, pod dry weight per plant, seeds per pod weight, 500 seeds weight and 500 seeds weight were not significantly different at p>0.01 and p>0.05 levels of significant error. The results indicated that all the three cowpea varieties had equal chances of performance in the study area in terms of growth and yield in irrigation system using cow-dug manure.

***Key words*:** Cowpea, Growth, Yield, Cow Dug Manure, Irrigation

INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walpers] is one of the most important versatile and nutritive grain legume crops native to Africa (Omoigui*et al.*, 2020; Yaw, 2015). The crop exhibitsdifferent morphological forms such as erect, semi-erect, climbing, prostrate or creeping and usually indeterminate under favourable environmental conditions (Bates*et al.*, 2015). The annual world cowpea production area was estimated at 11.8 to 14 million ha with an annual production of 4.5 to 5.4 million tons of dried grain and an average potential yield of 1.5 to 6 MT per ha (Boukar*et al.*, 2018). Africa alone accounts for about 91% of the global production; West Africa, with 10.7 million ha, represents 75%of Africa's production (FAOSTAT, 2013). The principal cowpea producing countries areNigeria, Niger, Brazil, Senegal, Mali, Burkina Faso and Ghana withNigeria, Niger and Mali leading the production in Africa (Ojiewo*et al.*, 2018; Belt*et al.*, 2015). In West and Central Africa, cowpea is usually cultivated by subsistence farmers on small scale as intercrop, in rotations or relay cropping with cereals such as sorghum, millet, and maize (FAOSTAT, 2010).

Cowpea is cultivated in all the Local Government Areas of Kaduna state based on local preferences for yield, maturity period and grain size or colour. Moreover, the bulk of the cowpea production in Nigeria is largely found in the Guinea Savanna and Forest zones (Abdou, 2018; Adusei *et al.*, 2015). The crop plays a very important role in achieving food security due to its high nutritional content of 23-30% protein, 50-67% carbohydrate, 1.9% fat, 6.35% fiber and small percentage of the B-vitamins such as folic acid, thiamine, riboflavin as well as somemicro-nutrients (Iron, Phosphorus, Zinc and Calcium) that improve human nutrition and health status (Kassambara, 2017; Adetonah *et al.*, 2016). Cowpea isbeing considered as a healthy alternative to soya bean as consumers look for more traditional food sources that are low in fat and high in fiber, and that have other health benefits (Singh, 2016). Protein from cowpea grain has good functional properties, including solubility, emulsifying and foaming activities and could be a substitute for soya bean for persons (especially infants) with soya bean protein allergies (Snapp*et al.*, 2018; Karikari and Arkorful, 2015). Processed food products of dry cowpea grain such as cowpea-fortified baked foods, extruded snack foods and weaning foods have been developed to reduce malnutrition among children in Nigeria (Boukar *et al.*, 2016). According to ICRISAT (2012) report, malnutrition and infant mortality are expected to drop significantly through increased consumption of cowpea from the current level of 9 kg per capita to 15 kg per capita by most house-holds in Nigeria.

The dry haulms of cowpea are used as fodder for livestock particularly during the dry season when animal feed is scarce making the crop an essential and integral part of sustainable crop-livestock farming systems in Nigeria (FAOSTAT, 2013). Cowpea is used in crop rotation, intercropping and as cover crop or green manure in relay cropping with cereals (Bates*et al.*, 2015). Moreover, cowpea is a shade-tolerant crop, hence compatible as an intercrop with a number of cereals and root/tuber crops, as well as cotton, sugarcane and most plantation crops (Burridge*et al.*, 2017).

Cowpea grows quickly, permits establishment of a good ground cover, and improves the cropping systems as well as soil fertility by suppressing weed andreducing soil erosion. Cowpea cultivation plays a very significant role in sustainable farming system in Nigeria due to its nitrogen fixing ability. It fixes nitrogen up to 240 kg/ha and leavesabout 60 –70 kg for succeeding crops and therefore contributes to increased yields of nitrogen demanding crops grown in rotation with it on the poor soils of Nigeria (Ojiewo*et al.*, 2018). It is obvious that, the importance of cowpea in the farming systems and as nutritious diet for millions of people and livestock makes it an ideal crop for achieving Sustainable Developmental Goals (SDGs) of reducing poverty and hunger, improving human health and nutrition as well asenhancing ecosystem resilience.

MATERIALS AND METHODS

The treatments consisted of a 3 x 3 factorial experiment laid out in a Randomized Complete Block Design (R.C.B.D.) with three replicates and blocks each that gave a total of nine (9) plots. Thus, the sources of variations for the experiment treatments consisted of three varieties of cowpea, namely honey beans, black-eyed pea and grey mottled cowpea seeds commonly grown in the area of study. The varieties were coded as Hb, Bp and Gm. for honey beans, black-eyed pea as well as grey mottled beans, respectively – withcow dung manure and sprinkling irrigation system applied in Samaru-Kataf campus. In addition to the treatments, half a fertilizer bag of cow dung manure waswell air-dried before incorporating it into each of the nine (9) plots during land preparation. The assessment of growth and yield responses of three varieties of cowpea [*vigna unguiculata* (L.) Walpers] to cow dung manure and surface irrigation was compared in Samaru-Kataf campus during the 2020 dry season (synonymous to the winter that spanned from December, January to February). The data were analysed using Analysis of Variance (ANOVA)at 5% and 1% levels of significance. Differencesbetween treatment means were determined using the Fisher Least SignificantDifference method. The computer package used for the analysis was SPSS 23.

RESULTS ANALYSIS AND DISCUSSION

Table 1 shows that black-eyed cowpea took the least number of days for its emergence, followed by honey beans and grey-mottled had the highest number of days. The table also shows that black-eyed recorded the highest number of leaves, plant heights and flower plants, followed by honey beans and grey-mottled recorded the least. Table 2 shows that black-eyed beans recorded the highest pod dry weight, followed by grey-mottled and honey beans recorded the least. The table also shows that black-eyed beans could produce the highest seeds per pod weight with honey bean and grey-mottled weighing the same. The table proves black-eyed beans recording the highest plant heights and flower plants, followed by honey beans, and grey-mottled had the least. Tables 3-9 show that the differences observed in Tables 1 and 2 are not statistically different in terms of average number of leaves, average Plant Height, Pod dry weight per plant, Seeds per pod weight, 100 Seeds weight and 500 Seeds weight at $p>0.01$ and $p>0.05$ levels of significant error. This implies that only flowering percentage was found to be statistically different at $p>0.01$ and $p>0.05$ levels of significant error.

Table 1. Effects of growth responses of varieties of cowpea grown in Samaru-Kataf Campus

Varieties	Days of emergence (No)	No. of leaves	Plant heights (cm)	Flower plants (%)
Honey beans (Hb)	47.0^{b}	79.0^{b}	50.1^{b}	53^{b}
Grey-mottled (Gm)	50.4^{a}	72.0^{c}	48.4^{c}	52^{c}
Black-eyed beans (Bb)	37.7^{c}	95.0^{a}	53.2^{a}	55^{a}
Standard Deviation (Std. Dev.)	0.8452	0.8944	0.8660	0.8944

Table 2. Effects of yield responses of varieties of cowpea grown in Samaru-Kataf Campus

Varieties	Pod dry weight per plant (g)	Seeds per pod weight (g)	100 seeds weight (g)	500 seeds weight (g)
Honey beans (Hb)	3.5^{c}	3.0^{b}	56.7^{b}	228.3^{b}
Grey-mottled (Gm)	4.3^{b}	3.0^{b}	46.2^{c}	186.0^{c}
Black-eyed beans (Bb)	4.5^{a}	4.0^{a}	59.4^{a}	239.1^{a}
Standard Deviation (Std. Dev.)	0.8660	0.8528	0.8528	0.8528

Table 3. ANOVA for average number of leaves

Source	Degree of freedom	Sum of squares	Mean square	F	Significance
Between Groups	2	89.200	44.600	0.30	.970
Within Groups	12	17600.400	1466.700		
Total	14	17689.600			

Table 4. ANOVA for average Plant Height

Source	Degree of freedom	Sum of squares	Mean square	F	Significance
Between Groups	789902	14.512	7.256	0.10	.990
Within Groups	12	8782.532	731.878		
Total	14	8797.044			

Table 5. ANOVA for Flowering Percentage

Source	Degree of freedom	Sum of squares	Mean square	F	Significance
Between Groups	2	6.533	3.267	0.004	.996
Within Groups	12	9038.400	753.200		
Total	14	9044.933			

Table 6. ANOVA for Pod dry weight per plant

Source	Degree of freedom	Sum of squares	Mean square	F	Significance
Between Groups	2	0.372	.186	0.41	.960
Within Groups	12	54.304	4.525		
Total	14	54.676			

Table 7. ANOVA for Seeds per pod weight

Source	Degree of freedom	Sum of squares	Mean square	F	Significance
Between Groups	2	0.133	.067	0.24	.976
Within Groups	12	32.800	2.733		
Total	14	32.933			

Table 8. ANOVA for 100 Seeds weight

Source	Degree of freedom	Sum of squares	Mean square	F	Significance
Between Groups	2	19.452	9.726	0.3016	.984
Within Groups	12	7102.152	591.846		
Total	14	7121.604			

Table 9. ANOVA for 500 Seeds weight

Source	Degree of freedom	Sum of squares	Mean square	F	Significance
Between Groups	2	315.036	157.518	0.16	.984
Within Groups	12	115108.56	9592.380		
Total	14	115423.596			

CONCLUSION

Based on the results of the study, it is concluded that all the three cowpea varieties had equal chances of performance in the study area in terms of number of leaves, Plant Height, Pod dry weight per plant, Seeds per pod weight, 100 Seeds weight and 500 Seeds weight, with Black-eyed beans being the best in terms of flowering Percentage in irrigation system using cow-dug manure.

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EVALUATION OF GROWTH AND YIELD PERFORMANCE OF SIXTEEN PEPPER LINES IN NIHORT MBATO, OKIGWE, IMO STATE

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ABSTRACT

*A field trial was conducted at National Horticultural Research Institute, (NIHORT) Mbato, Okigwe, Imo State. During the late rainy season/ dry season period of 2020 to determine effective performance of sixteen pepper lines in Mbato Okigwe Southeast Nigeria. Seeds of pepper lines were sourced from NIHORT headquarters, Ibadan, Oyo State. The pepper lines are Pe12, Bird eye/8, P3/6, Ibels1, P3/23, P3/1, 21-4-1-1/1, 53-1-2/3, 59-3-1-1/1, Egu15, 06-2/3, 34-1-2-1, 27-2-1-3/4, 21-4-1-5/red, 017-1-2 and 06-12/1. The pepper seeds were sown in nursery trays in the screen house at NIHORT- Mbato Okigwe and transplanted on prepared ridges at a distance of 0.5m*0.5m spacing. Basal application of poultry manure was applied to boost the soil nutrients. Manual weeding was done twice during the trial. Also insecticide (attacké) was applied at four, six, and eight weeks after transplanting to control insect pest attack. Data were collected on growth and yield parameters. The data collected were analyzed by computing and comparing the means. The result obtained shows that line pe12 gave the highest mean plant height 81.5cm while Bird eye/red recorded the highest mean of number of leaves and canopy spread 35.75 and 66.75(cm) respectively. Line 0612/1 had the highest leaf area of .675cm2 followed by p3/6 .625cm2. However, Bird eye/8 recorded the highest mean number of fruits of 189/plant with average weight of 360g. Followed by Pe12 which recorded average number of 175.5/plant with mean weight of 350g. In terms of early flowering and fruiting, pe12 and Ibel1 are preferred while bird eye/8, pe12, p3/6, 07-1-2 and Ibels are preferred and recommended in terms of adaptation to Mbato Okigwe environment.*

Key words: Pepper lines, evaluation, trial, growth, yield

INTRODUCTION

Pepper (*Capsicum frutescens*) is an important crop grown all over the world with 235,000 metric tons produced from 27,500 hectares of land (FAO, 2003). It is among the most commonly grown crops throughout Africa because of its utilization in soup, stews and salads (Adeyemi, and Ogunsola, 2017). Hot Pepper (*Capscum spp.*) is widely acceptable from the tropical to temperate environment (Adetula and Olakojo, 2006). It is a good source of vitamins and minerals, especially on iron and phosphorus (Salau,2015). It is also used as coloring condiments and flavors. In spite of high nutritional and economic value the average yield of pepper in Africa is still very low. Production of pepper is often reduced by both biotic and a biotic stress, the types of which can vary greatly among region (Barchenger, *et al.,* 2018). Again, high-yield and disease-resistant varieties are one of the most effective ways for farmers to increase productivity. Lines of pepper differ in the extent of their performance and predictable performance such as acceptability, fruit shape, size, heat, and flavors, which are critically important for adoption, benefits farmers and seed producer (Nwosu *et al*., 2019). Consequently, fresh lines are evaluated to assess adaption/ survivability, agronomic performance, yield and phenotypic correlations. In order to identify those lines which, have potential as new cultivars or as parents in localized breeding programs. Thus, the aim of this study was to evaluate sixteen pepper lines at NIHORT Mbato Experimental site, Okigwe, Imo State.

MATERIALS AND METHODS

Sixteen (16) pepper lines was brought from National Horticultural Research Institute (NIHORT), Ibadan for evaluation at the experimental site of National Horticultural Research Institute (NIHORT), Mbato Okigwe, Imo State during late rainy season/ dry season period. The pepper lines are Pe12, Bird eye/8, P3/6, Ibels1, P3/23, P3/1, 21-4-1-1/1, 53-1-2/3, 59-3-1-1/1, Egu15, 06-2/3, 34-1-2-1, 27-2-1-3/4, 21-4-1-5/red, 017-1-2 and 06-12/1. The pepper seeds were sown in nursery trays on 3rd July 2020 in the screen house at NIHORT- Mbato Okigwe. These pepper lines were transplanted on 3rd Sept.2020 (i.e. eight weeks in the nursery) on prepared ridges at a distance of .5m*.5m or 50cm apart. After three weeks of transplanting, basal application of poultry manure was applied to boost the soil nutrients. Manual weeding was done twice during the trial. Also insecticide (attacké) was applied at four, six, and eight weeks after transplanting to control insect pest attack. Mulching was done earlier to enable the plots retain moisture because of the dry season effect. Pre soil samples were collected, processed and analyzed. The site was well drained, non graveled soil but characteristically poor in nutrient concentration. The soil texture was sandy loamy (743g/kg sand, 155g/kg silt. 122g/kg clay) characterized by low organic matter, low CEC and are highly leached with soil pH of 4.76. The soil is low in total Nitrogen (0.90g/kg), Available Phosphorus (6.80 mg/kg), organic Carbon (1.56g/kg), Calcium (3.20 cmol/kg), Potassium (0.90 cmol/kg) and Magnesium (1.60 cmol/kg). Despite the cultural practices maintained in the field, die back of some lines like Ibels1, P3/1, Egu15, 34-1-2-1 and 27-2-1-3/4 were observed. Data were collected on percentage rate of germination, plant height (cm), average number of leaves(cm), leaf area (cm2), number of branches(cm), canopy spread(cm), date of both 50%&100% flowering, number of fruits/plant and weight (g)of the fruits/plant. The data collected were analyzed by computing and comparing the means.

RESULTS AND DISCUSSION

The results in table 1 shows that line Pe12 gave the highest mean plant height of 81.5cm while Bird eye/red recorded the highest mean number of leaves and canopy spread of 35.75 and 66.75cm, respectively. Line 0612/1 had the highest leaf area followed p3/6. This trend of results in the pepper lines shows that some of the pepper lines have some adaptable traits in our environment and these traits are crucial components of a plant species, ecological and carbon gain strategies (Nwosu *et al*., 2016). This is because height is a major determinant of a plant's ability to complete for light and also ensures that a species live, grows and reproduces (Faster and Westoby 2003). However, results obtained from table 2 shows that Bird eye/red recorded the highest average number of fruits (189/plant) with average weight of 360g. This was followed by Pe12 which recorded average number of 175.5/plant with mean weight of 350g. P3/6 had mean number of 98.5 with weight of 310g, 017-1-2 had 97/plant with mean weight of 310g, Ibels1; 67.75/plant with mean weight of 240g; while, line 34-1-2-1 and 59-1-1/1 had the lowest number of mean yield and weight of 32.5/plant, 160g, and 30.75/plant, 150g respectively. The differences in performance of the pepper lines on growth and yield parameters measured is an indication that lines of pepper differ in the extent of their performance which are critically important for adoption (Kahan *et al*., 2013). These differences in performance is important to help identify those lines which have potential as new cultivars or as parents in localized breeding programs (Barchenger *et al*., 2018).

Table 1: Mean Growth Parameters of the pepper lines

LINES	DO 50% E	DO100% E	PRG	D50%F	D100%F	PTH (cm)	NL (cm)	NB	LA (m)	CS (cm)
Pe12	14	16	98	60	67	81.5	256.5	25.5	.475	55.5
Bird eye/8	15	17	6	64	69	75.25	320.5	35.75	.325	66.75
P3/6	14	16	85	63	68	57.5	150.5	24	.625	57.5
Ibels1	13	16	50	63	67	46.5	79.5	21.5	.375	46
P3/23	13	16	10	63	67	55.5	68.5	12.5	.45	42.5
P3/1	14	17	70	62	68	45.75	140.25	18	.325	38
21-4-1-1/1	14	17	65	62	68	35.5	110.75	15	.425	43.5
53-1-2/3	13	16	15	60	67	35.75	95.5	12	.525	40.25
59-3-1-1/1	13	17	15	60	67	27.5	90.5	12.5	.55	28.5
Egu15	14	17	20	62	67	41.5	95.5	11.25	.45	36.5
06-2/3	14	17	30	62	67	39.5	91.5	8.25	.525	42.5
34-1-2-1/;.	14	17	40	63	68	29.5	80.0	8.75	.605	34.25
27-2-1-3/4	14	16	80	63	68	45.75	65.5	13.25	.45	43.25
21-4-1-5/red	13	16	60	62	67	31.5	48.5	7.25	.375	38.5
07-1-2	13		75	63	68	50.5	131.5	20	,525	34.25
06-12/1	13	16	50	62	67	35.75	79.25	14.5	.675	39.5

DO 50/100 E=Date of 50/100 emergence, PRG= percentage rate of germination, DF= Date of flowering, Pt H= plant height (cm), NL=number of leaves, leaf area, NB=number of branches, CS= canopy spread.

Table 2: Mean of yield of the pepper lines

Lines	N.F/P	W.tF/P
Pe12	175.5	250
Bird eye/8	189	360
P3/6	98.5	310
Ibels1	67.75	240
P3/23	39	200
P3/1	65.5	255
21-4-1-1/1	36.5	180
53-1-2/3	45.5	225
59-3-1-1/1	30.75	150
Egu15	43	220
06-2/3	40.75	200
34-1-2-1	32.5	160
27-2-1-3/4	56	215
21-4-1-5/red	62.5	250
07-1-2	97	310
06-12/1	60.5	245

NF/P= number of fruits/plant and Wt F/P=weight of the fruits/plant

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EVALUATION OF OKRA [*ABELMOSCHUS ESCULENTUS* (L.) MOENCH] HYBRIDS FOR GROWTH AND YIELD PARAMETERS UNDER HUMID CONDITION

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ABSTRACT

Evaluation of pre-commercial hybrids in a germplasm bank is essential for determining its commercial potential and utility as progenitor in okra breeding programme of the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. The aim of the study was to assess phenotypic divergence and the *per se* performance of selected okra hybrids from the okra breeding programme of NIHORT. Eight okra genotypes were crossed in diallel mating design without reciprocals. Six hybrids and their parental genotypes that gave enough seeds for field trial were however, selected for evaluation in the growing season of 2019 in a randomized complete block design with three replications at National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. Okra fruit yield, growth related parameters and other agronomic traits were measured. Results from Analysis of variance (ANOVA) showed highly significant differences ($P < 0.001$) among the parents and hybrids for all measured traits. The cross NHOK0182/NHOK0190 had the highest yield (152 kg ha^{-1}) above the trial mean. Plant height and number of fruits, ($r = 0.40$; 0.55 respectively) had positive correlations with okra fruit yield for the hybrids. This indicates that selection of these traits would be positive indices for improved okra fruit yield. The study concluded that NHOK0182/NHOK0190 attained the earliest days to first flowering, 50 % flowering and highest fruit weight. This hybrid could be a putative parent in breeding for earliness and increase yield. Further improvement and evaluation need to be carried out on the potential of hybrid NHOK0182/NHOK0190 other desirable traits before recommendation and release to farmers.

Key words: Diallel, hybrids, genetic divergence, *per se* performance, traits

INTRODUCTION

Okra, commonly known as lady finger [*Abelmoschus esculentus* (L.) Moench] is a warm-season annual herbaceous vegetable crop grown primarily for immature fruits. It is also an economically important vegetable crop grown in tropical and sub-tropical parts of the world. Okra belongs to the family Malvaceae, indigenous to tropical countries and grow all over West Africa (Schippers, 2000). It is apparently originated in Ethiopia, the mountainous area of Eritrea (Aladele *et al*., 2008). In Nigeria, it is being ranked third fruity vegetable in terms of consumption and production area following tomato and pepper (Ibeawuchi, 2007). Okra is primarily suitable for cultivation as a garden crop as well as on large commercial farms. West African okra is of economic importance because of its nutritive value. The tender pod of okra at edible stage contains 88 ml water, 2.1 g protein, 0.2 fat, 8 g carbohydrate, 36 calories, 1.7 fibre, 175.2 mg minerals and 232.72 mg vitamin in 100 g of edible portion (Berry *et al*., 1988). Most of the West African okra germplasms available in Nigeria are photoperiod sensitive (Ariyo, 1993). Flowering is prolonged as long as the day length remains short. They are grown during the dry season in the rainfed island ecosystem.

High degree of wide morphological variation exists among okra accessions. However, genetic variability is important in breeding programs for the development of high yielding varieties. The value of germplasm collection depends not only on the number of accessions it contains, but also upon the diversity present in those accessions. Characterization of genetic diversity in okra germplasm is essential in parental selection before hybridization. Diversity based on phenotypic and morphological characters usually varies with environments and evaluation of traits requires growing the plants to full maturity prior to identification. Precise and reliable identification of important plant varieties is essential in Agriculture and plant breeding purposes (Weising *et al*., 2005). Crosses between parents with maximum genetic divergence are likely to produce desirable segregation and recombination in their progeny (Reddy, 1988). Grain yield, being a quantitatively inherited trait, requires an approach of selecting plant characteristics that have significant correlations with yield. Correlation analysis is a handy technique in inter-relationship studies of agronomic traits for the identification of selection index for yield improvement in okra (Arshad *et al.*, 2006).

There is need to focus on the development of indigenously bred okra genotypes adaptable to Nigeria agro-ecologies. The objective of this study was to evaluate pre-commercial okra hybrids for the agronomic *per se* performance for further improvement, selection and commercialization.

MATERIALS AND METHODS

Eight varieties of okra were collected from the gene bank of the National Horticultural Research Institute (NIHORT), Ibadan (Table 1). The experiment was conducted at the screen house in December 2018 and on the field between June - August 2019 both at NIHORT Ibadan, Oyo State, rain forest zone (3^0 56' E, 7^0 33' N; 168m above sea level). The parental genotypes were crossed in all possible combination using diallel mating design with no reciprocal to give 28 direct F1 hybrids. Four full diallel were selected from the 8 x 8 and were evaluated because they had enough seeds needed for field trial. Therefore, 6 direct F_1 hybrids and the 4 parental genotypes giving 10 treatments were evaluated using the randomized complete block design with three replications. the treatments were evaluated on the field using a Randomized complete block design with three replications on a 2-row plot size of 2m x 0.75m. Cultural activities were carried out as when due. Data were collected on five plants withing the plot to eliminate border effect.

Table 1. Okra parental lines used in the study, status and their source

S/N	Accession_ ID	Status	Source
1	NHOK0151	Advanced breeding line	NIHORT Genebank
2	NHOK0188	Landrace	NIHORT Genebank
3	NHOK0184	Genebank material	NIHORT Genebank
4	NHOK0190	Genebank material	NIHORT Genebank
5	NHOK0189	Genebank material	NIHORT Genebank
6	NHOK0183	Genebank material	NIHORT Genebank
7	NHOK0182	Genebank material	NIHORT Genebank
8	NHOK0195	Landrace	NIHORT Genebank

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) for the hybrids revealed significant differences ($P < 0.001$) for some of the measured agronomic parameters except for fruit length and width, number of fruits, seed weight and yield (Table 2). Development of superior okra genotypes for desirable traits depend on the amount of variation for the trait existing in the parents (Mohammed *et al*., 2012). From this study, the hybrid of NHOK0182/NHOK0190 were the earliest to flower with average mean yield of 152 kgha^{-1} which was above the mean yield of 112kgha^{-1} for the trial.

Earliness is an important and desirable trait especially now that climate change is a strong limitation to agricultural productivity. Hybrid of NHOK0182/NHOK0190 and NHOK0188/NHOK0190 were the earliest to flower with the mean flowering day of 50 days after planting (Table 3).

Correlation is a measure of relatedness among characters and it plays an important role in crop improvement because of its effectiveness during selection (Afangideh *et al*., 2005; Falconer and Mackay, 1996). Significant positive and negative correlations were observed among the measured parameters (Table 4). The implication of this is that some parameters can be directly selected on while some more difficult to measure can be indirectly selected for when setting up selection criteria. From this study, a strong significant negative correlation was observed between days to first flower and yield (r=-0.36). This suggests that selection based on early maturity may result into lower fruit yield and light fruit weight. This result agrees with the reports of Adiger et al. (2011) and Cramer and Wehner (2000).

CONCLUSION

The study revealed the importance of evaluating the okra hybrids. Okra hybrids NHOK0182/NHOK0190, NHOK0188/NHOK0195 and NHOK0182/NHOK0195 were identified in this study as potential hybrids for further testing with famers. It will be concluded that the okra line NHOK0182 have good combining ability and could be further exploited in okra improvement.

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Table 2. Mean Squares from ANOVA for agronomic traits of okra hybrids

Parameters	Source of variation			CV (%)	Minimum	Maximum	Standard deviation
	Replication (df=2)	Hybrids (df =5)	Error (df= 82)				
Day to first flower	12.63	26.98**	6.45	4.92	48	62	2.78
Day to 50% flower	7.51	19.85***	2.38	2.98	49	56	1.86
Fruit Length (mm)	255.43	973.61	667.02	34.93	14.9	117.35	25.98
Fruit width (mm)	12.89	65.45	63.6	30.83	1.24	43.05	7.91
Plant height (cm)	414.54	657.98**	160.7	21.46	26	99	13.94
Number of fruits	1.91	1.03	0.54	9.28	6	10	0.77
Number of ridges	0.34	12.26***	0.54	11.21	5	9	1.09
Seed weight (g)	0.05	0.83**	0.17	17.04	1	3.38	0.45
1000-Seed weight (g)	27.05	361.80**	67.29	17.02	20	67.6	9.107
Fruit weight (g)	3376.57	1505.72	724.34	59.59	3.48	172.21	28.77
Yield (Kgha^{-1})	21103.55	9410.95	4527.13	59.59	8.7	430.525	71.93

*, **, *** Significant at 0.05, 0.01 and 0.001 probability levels, respectively

Table 3. Mean performance of agronomic traits of okra hybrids

Hybrid pedigree	Day to first flower	Day to 50% flower	Fruit Length (mm)	Fruit width (mm)	Plant height (cm)	Number of fruits	Number of ridges	Seed weight (g)	1000-Seed weight (g)	Fruit weight (g)	Yield (Kgha^{-1})
NHOK0182/NHOK0188	51.27±0.58	50.73±0.15	77.37±5.27	25.10±1.39	58.67±2.91	7.47±0.17	5.07±0.07	2.50±0.11	49.94±2.18	36.81±4.57	92.03±11.42
NHOK0182/NHOK0195	51.67±0.58	51.80±0.52	81.087±5.92	26.16±1.77	66.20±2.98	8.00±0.22	6.60±0.24	2.15±0.12	42.70±2.26	44.77±4.73	111.93±11.84
NHOK0182/NHOK0190	50.33±0.6	53.33±0.55	78.50±6.69	26.51±1.92	47.47±2.88	8.20±0.15	6.33±0.19	2.75±0.12	54.99±2.47	60.86±8.44	152.16±21.10
NHOK0188/NHOK0195	52.33±0.82	52.33±0.45	64.04±6.58	22.14±2.11	62.00±3.93	8.07±0.18	6.87±0.24	2.60±0.08	51.96±1.59	50.12±7.96	125.29±19.89
NHOK0188/NHOK0190	50.33±0.55	50.20±0.3	63.28±7.72	28.15±2.86	56.67±4.60	7.87±0.24	6.60±0.19	2.32±0.13	46.31±2.67	45.91±11.11	114.77±27.77
NHOK0195/NHOK0190	53.87±0.79	52.33±0.33	79.35±7.24	27.16±1.89	63.47±2.11	7.73±0.21	7.87±0.17	2.20±0.05	43.36±0.96	32.50±3.72	81.25±9.29
Mean	51.63	51.79	73.94	25.87	59.08	7.89	6.56	2.42	48.21	45.16	112.90
LSD (0.05)	1.85	1.12	18.76	5.79	9.21	0.53	0.53	0.29	5.96	19.55	48.88

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Table 4: Pearson's correlation coefficients (r) for the morphological traits of the okra hybrids

Parameters	Day to first flower	Day to 50% flower	Fruit Length (mm)	Fruit width (mm)	Plant height (cm)	Number of fruits	Number of ridges	Seed weight (g)	1000-Seed weight (g)	Fruit weight (g)	Yield (Kgha-1)
Day to first flower (days)		0.20*	-0.12	-0.15	-0.03	-0.14	0.15	-0.25**	-0.25*	-0.36***	-0.36**
Day to 50% flower			0.23*	0.05	-0.32**	-0.02	0.11	-0.05	-0.05	-0.11	-0.11
Fruit Length (mm)				0.79***	-0.02	0.02	0.06	0.01	0.00	0.15	0.15
Fruit width (mm)					0.03	-0.03	0.12	-0.01	-0.02	0.30**	0.30**
Plant height (cm)					0.22	0.3*	0.00	0.09	0.10	0.40	0.40
Number of fruits						0.22	-0.32*	0.25	0.25	0.55***	0.55***
Number of ridges							-0.29*	0.06	0.06	0.20	0.20
Seed weight (g)							-0.29*	0.06	0.06	0.20	0.20
1000-Seed weight (g)								-0.30*	-0.31	0.03	0.03
Fruit weight (g)										0.12	0.12

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PRELIMINARY INVESTIGATION OF YIELD RELATED TRAITS AND SEED SET AMONG INTERSPECIFIC HYBRIDS BETWEEN TWO OKRA SPECIES (*ABELMOSCHUS CAILLEI* (A. CHEV.) STEVELS AND *A. ESCULENTUS* (L.) MOENCH)

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ABSTRACT

Okra (Abelmoschus spp) is an important multi-purpose vegetable crop cultivated and consumed across most tropical and temperate regions of the world. A preliminary evaluation of intra and interspecific hybrids (without reciprocals) from Abelmoschus caillei (A. Chev.) Stevels and A. esculentus (L.) Moench was undertaken to determine their performance for seed set and yield contributing traits under open field conditions. The hybrids were laid out in a randomized complete design and data collected on ten quantitative traits. Significant variation was recorded for most traits except for pedicel length. Varying level of seed set was recorded for all the hybrid combinations with the lowest seed set per fruit recorded among the interspecific hybrid groups. The exhibition of seed viability among all the hybrid combinations even though with varying levels of seed set per fruit indicates the feasibility of improving the two okra species (A. esculentus and A. caillei) through interspecific hybridization. Furthermore, the presence of adequate variability among the hybrids for considered traits shows the possibility of identify promising segregants with best combination of desired traits from the A. esculentus and A. caillei species.

Key words: Okra, crossability, Hybridization, Inter-specific, Intra-specific

INTRODUCTION

Interspecific hybridization is considered a possible mechanism of plant diversification. Hybridization including wild and cultivated species has long been used for transfer of genetic material in crops (Mujeeb-Kazi and Rajaram, 2002). Wild relatives of crops have been recognized as an important source of useful traits for breeding programmes in okra (Udengwu, 2015). On the other hand, identification, harnessing and introgression of alleles associated with biotic and abiotic tolerance through interspecific hybridization between crop species has led to improved genetic gains in pest, disease, nutrient and yield levels of cultivated crops in recent times (Mogili et al., 2013). Interspecific hybridization among locally adapted cultivars and newly selected okra wild relatives harboring desired genes of interest may therefore play a very important role in producing broad-based segregating population from which recurrent selection could be carried out (Hamon and Hamon, 1991). New segregants combining high yield potential with pest and disease resistance of the *A. caillei* and earliness of *A. esculentus* that are of interest to all stakeholders along the okra value chain could be selected from segregating interspecific breeding populations. However, it is noteworthy that the F_1 seeds obtained from most interspecific crosses between *A. esculentus* and *A. caillei* produced hybrid seeds with strongly reduced fertility (Fatokun et al., 1979). The sterility is usually related to chromosomal/genomic differences leading to irregular gamete formation. Various studies have revealed that it is relatively easy to obtain F_1 plantlets irrespective of direction of crossing in some interspecific hybridization but in some cases F_1 plants were highly sterile limiting advancement to subsequent generations or even to obtain backcrosses. Fatokun et al. (1979) identified that when they carried out crosses between members of the two groups (*A. Caillei* and *A. esculentus*), the F_1 progenies were sterile with fruits bearing less than ten well developed seeds as against an average of 60 seeds in normal fruits. Furthermore, percentage germination of the seeds ranged from 4 to 18%. Other reports have highlighted that much input has for long been concentrated on the genetic improvement of *A. esculentus* in both developing and developed countries of the world, with minimal attention directed to the *A. caillei* (West African okra) despite the fact that it contains many desirable traits not found in *A. esculentus* (Singh and Bhatnager, 1976; Martin et al., 1981). This study seeks to investigate the agronomic performance and viability of F_1 hybrids from intra and interspecific hybridization among two okra species.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of National Horticultural Research Institute (NIHORT), Ibadan during the 2020 early (April to July) and late (September to December) planting seasons. Establishment of crossing blocks and crossing activities were carried out during the early planting seasons while evaluation of the F_1 hybrids and their parents under field conditions was carried out during the late season planting.

Genetic materials evaluated in this study comprised of newly developed F_1 hybrids (Interspecific without reciprocals and backcross) and their parents (Table 1). The genetic materials were grown in Randomized Complete Block Design with two replicates during the late planting seasons of 2020. Three seeds per hill were planted directly in 3cm holes and later thinned to two plant per hill after seedling establishment. Plants were spaced at 60 cm x 50 cm between and within rows respectively on a 2 x 1m bed constituting 10 stands per plot. Regular plant protection and other agronomic activities were carried out as when due to ensure full expression of desired traits and safeguard crop from pests. Manual weeding was done at three weeks after planting, while compound fertilizer NPK 15:15:15 was applied at three-week interval after sowing to enhance vegetative growth at the recommended rate of 60 kg/ha. Insect pest control was done by spraying Cyperfits (synthetic pyrethrum) at the rate of 80 g ai/ha.

Data on agronomic attributes were recorded on plot basis according to okra descriptors by Charrier (1984) for days to 50% flowering (DTF), plant height at maturity (cm) (PH), matured fruit width (FW) and length (cm) (FL), average number of fruits (NoF) obtained by the ratio between the total number of fruits and the number of plants in the plot, internode length (cm) (INL) and number of ridges per pod (NoR).

Table 1: Genetic materials evaluated in this study

Crosses	Genotype	Okra species/ cross combinations
P1	Ladyfinger	*A. Caillei*
P2	NHCaP3/22	*A. Caillei*
P3	MB1	*A. esculentus*
P4	NH47-4	*A. esculentus*
P6	Ik11	*A. esculentus*
P5	Iwo	*A. esculentus*
P1 x P2	Ladyfinger x NHCaP3/22	*Interspecific*
P1 x P3	Ladyfinger x MB1	*Interspecific*
P1 x P4	Ladyfinger x NH47-4	*Interspecific*
P1 x P5	Ladyfinger x Iwo	*Interspecific*
P1 x P6	Ladyfinger x Ik11	*Interspecific*
P2 x P3	NHCaP3/22 x MB1	*Interspecific*
P2 x P4	NHCaP3/22 x NH47-4	*Interspecific*
P2 x P5	NHCaP3/22 x Iwo	*Interspecific*
P2 x P6	NHCaP3/22 x IK11	*Interspecific*
P3 x P4	MB1 x NH47-4	*Intraspecific*
P3 x P5	MB1 x Iwo	*Intraspecific*
P3 x P6	MB1 x IK11	*Intraspecific*
P4 x P5	NH47-4 x Iwo	*Intraspecific*
P4 x P6	NH47-4 x IK11	*Intraspecific*
P5 x P6	Iwo x IK11	*Intraspecific*

RESULTS

High level of diversity was observed among the studied hybrids and their parents for most of the traits considered. The analysis of variance (Table 2) revealed varying levels of significance among genotypes for all traits except for pedicel length. The ranges of mean revealed sufficient variation for all the traits under study. Maximum range of variability was observed for average number of seeds per pod (7.5-100.5) while the minimum range was recorded for average number of branches per plant (0-3). Ik11 and MB1 x NH47-4 were the earliest to flower at 46 and 47 days respectively while highest number of fruits per plant was recorded for NHCaP3/22 and NHCaP3/22 x IwoNla (6 fruits). Highest stem cross section was observed for MB1 x IwoNla (30.88 cm) while the maximum plant height and fruit length was expressed by NHCaP3/22 x MB1 (77.75 cm) and NHCaP3/22 (12,93cm) respectively. Seed set was observed for all hybrid combinations even though it was minimal with the interspecific hybrids (Table 2). The highest number of seeds per fruit was recorded for NHCaP3/22 (40 seeds) and MB1 (100.50 seeds) for the *A. caillei* and *A. esculentus* parents respectively while Ladyfinger x IwoNla (48.67 seeds) and MB1 x IwoNla (70.5 seeds) had the highest seed set for the inter and intra specific hybrids respectively (Table 2). The least seed set was recorded for hybrids NHCaP3/22 x NH47-4 and NH47-4 x IK11 for the inter and intra specific hybrid combinations respectively.

DISCUSSIONS

The high significant differences observed for most traits indicates the abundant genotypic differences between hybrids and parents which manifested phenotypically. This is in line with the reports of Udengwu (2009) on the availability of high variability among interspecific okra hybrids and their parent in Nigeria. The presence of adequate variability among the genotypes for considered traits shows the feasibility of identify promising segregants with best combination of desired traits from the *A. esculentus* and *A. caillei* species. This could be exploited by okra breeders to FastTrack the incorporation of the heritable traits identified in this study towards development of new resilient okra varieties adaptable to the diverse okra growing regions in Nigeria. Advancing materials from NH47-4 x IwoNla, Ladyfinger x NHCaP3/22, NHCaP3/22 x MB1 and Ladyfinger x NH47-4 might produce promising early maturing progenies with longer fruit length while CaP3/22 x IwoNla, Ladyfinger x NHCaP3/22 and NH47-4 x IwoNla are likely to produce progenies with increased number of fruits per plant.

Different levels of seed set recorded for most hybrid combinations and their parents is a good indication that selection in favour of viable hybrids is feasible from this study. The minimal number of seeds per pod observed among the interspecific hybrids compared to intraspecific hybrids from the *A. esculentus* might be a reflection of some degree of incompatibility between the two species. This supports the reports of Fatokun et al., 1979 and David et al., 2016 who reported poor seed set among interspecific hybrids compared to intra specific hybrids from *A. esculentus* species in Nigeria and Ghana.

Top performing F_1 families for plant height (NHCaP3/22 x MB1, Ladyfinger x NH47-4, NHCaP3/22 x IwoNla) and F_1 hybrids (MB1 x IwoNla, NHCaP3/22 x MB1, Ladyfinger x MB1) with increased stem cross section are good candidates for developing segregating populations with tall plant architecture that are tolerant to lodging. Furthermore, hybrid combination Ladyfinger x IwoNla with highest seed set among the interspecific hybrid group are good candidates for advancement to F_2 generation for further selection to identify promising viable segregants with best combinations of desired traits from the two okra species.

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Table 2: Means and standard deviation of parents and interspecific hybrids

Genotype	PL	FL	FD	PH	NB	NF	CS	NoS	NR	DTF
NHCaP3/22	3.03	12.93	9.00	40.63	1	5.57	19.00	40.00	5.00	49.50
NHCaP3/22 x IK11	2.95	7.45	7.20	46.50	2	2.52	10.23	21.50	5.75	50.50
NHCaP3/22 x IwoNla	3.83	10.10	8.83	66.53	2	5.57	20.88	8.16	6.75	55.00
NHCaP3/22 x MB1	2.78	11.60	11.40	77.75	2	5.18	25.75	17.84	5.50	52.50
NHCaP3/22 x NH47-4	2.73	10.75	11.25	31.25	1	2.33	15.88	**7.50**	6.50	58.50
Ik11	2.00	5.25	11.50	35.75	1	4.04	13.00	73.00	7.50	46.00
IwoNla	2.25	8.00	7.25	28.50	2	4.42	14.50	58.50	5.00	48.50
IwoNla x IK11	1.75	8.33	9.50	37.00	0	2.90	21.60	59.67	6.00	47.50
Ladyfinger	2.75	10.00	7.00	21.50	0	4.80	11.00	38.50	5.00	56.50
Ladyfinger x NHCaP3/22	2.95	11.60	9.55	38.03	2	5.18	18.00	36.84	5.00	50.50
Ladyfinger x IwoNla	2.90	6.78	4.85	31.25	2	4.42	11.25	48.67	5.00	56.00
Ladyfinger x MB1	3.10	10.85	8.75	52.75	2	2.90	25.63	33.00	5.00	51.50
Ladyfinger x NH47-4	3.13	11.43	10.85	70.50	2	5.18	22.95	9.00	5.75	52.50
MB1	2.45	7.85	8.75	23.50	0	4.42	16.25	100.50	7.50	47.00
MB1 x IK11	4.48	11.13	18.95	53.95	2	4.80	22.13	56.50	6.75	53.50
MB1 x IwoNla	2.13	9.43	10.38	49.58	2	3.66	30.88	70.50	7.25	51.00
MB1 x NH47-4	2.40	10.78	10.45	51.88	2	4.42	25.23	63.00	8.00	46.50
NH47-4	2.25	5.50	8.50	40.50	1	3.28	18.00	63.00	8.00	54.00
NH47-4 x IK11	1.98	8.80	10.95	38.90	2	2.71	23.00	49.84	6.50	52.50
NH47-4 x IwoNla	2.30	11.98	11.83	30.00	3	5.18	14.25	55.67	6.00	50.50
Hybrid population mean	2.81	10.07	10.34	48.28	1.79	4.12	20.54	38.40	6.13	52.04
Parents population mean	2.45	8.25	8.67	31.73	0.71	4.42	15.29	62.25	6.33	50.25
Interspecific hybrid mean	3.04	10.06	9.08	51.82	1.81	4.16	18.82	22.81	5.66	53.37
Intraspecific hybrid mean	2.50	10.07	12.01	43.55	1.75	3.95	22.85	59.19	6.75	50.25
Trial population mean	2.71	9.53	9.84	43.31	1.46	4.18	18.97	45.56	6.19	51.50
Range	1.75-4.8	5.25-12.93	4.8-18.95	21.5-77.75	0-3	2.33-5-57	10.23-30.88	7.5-100.5	5.00-8.00	46-58
SED	0.92	1.15	3.25	9.99	0.75	0.97	4.14	11.40	0.82	2.08

DTF= Days to flowering; PH= Plant height at maturity; NoF= Average number of fruits per plant; FL= Fruit length; FW= Fruit width; PL= Pedicel length; Internode Inter.L= length; NoS= Number of seeds per fruit; NoR=Average number of ridges per fruit; cValues in columns followed by the *=significantly different, **=significantly different at P = 0.05.

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THE GROWTH AND FIELD SEEDLING ESTABLISHMENT OF TEA (*CAMELLIA SINENSIS* (L) O. Kuntze) AS INFLUENCED BY ITS INTERCROP WITH PLANTAIN IN IBADAN, NIGERIA

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ABSTRACT

The response of two tea cultivars (143 and 318) to their intercrop with plantain at three planting densities: 1111 plantain/ha (Tea/1111 Plantain), 2222 plantain/ha (Tea/2222 Plantain) and 0 plantain/ha (Tea sole) was evaluated on the field in Cocoa Research Institute of Nigeria, Ibadan. The experiment was laid out in Randomized complete block design arranged in Split-Plots with four replications. Data on Number of Leaves (NL), Number of Branches (NB), Leaf area (LA, cm^2) and Survival Count (SC, %) were obtained from the experiment. The data were analyzed with ANOVA at $\alpha_{0.05}$. Cultivar 143 was significantly superior to cultivar 318 in NL, NB, LA and SC. Tea/2222 Plantain increased NL, NB and LA by 26.6, 57.8 and 179.9%, respectively in comparison with Tea/1111 Plantain, and by 202.1, 228.0 and 2363.7% in comparison with Tea sole. The % survival of tea was significantly higher under Tea/2222 Plantain (79.43) in comparison with Tea/1111Plantain (32.24) and Tea sole (25.74). In interaction, the highest NL and NB was produced by cultivar 143 under 1111 plantain/ha, the highest LA and SC by cultivar 143 under 2222 plantain/ha; while the least NL, NB, LA and SC were produced by cultivar 318 under 0 plantain/ha. The growth and tea seedling establishment were enhanced in C143 grown in intercrop with plantain at 2222 stands/ha.

Key words: Tea cultivars, Intercrop, Growth, Plantain, Tea seedling establishment

INTRODUCTION

Tea is the most consumed beverage worldwide owing to its anti-oxidant property. Tea beverage is obtained from the tea plant (*Camellia sinensis* (L) O. Kuntze) after infusion of its leaves in hot water. Cultivation of tea on commercial scale in Nigeria is limited to the cool Mambilla highland with limiting land area. The need to expand tea production in Nigeria necessitated the exploration of the warm lowland for tea production despite its hot climate which constitutes a major constraint to the growing of tea in the area. The growth of tea was found to be hampered when grown as sole cropping without shade (Adeosun *et al*., 2019). Tea has been reported to be a shade loving plant; its entire photosynthetic apparatus is adapted to function with maximum capacity under shade (Jannedra *et al*., 2007). However, intercropping tea with shade crops has been found to be a veritable means of ameliorating the harsh weather of the lowland in Nigeria. Intercropping is the practice of planting two or more crops simultaneously on the same piece of land (Famaye *et al*., 2017). Benefits of intercropping include: insurance against crop failure through diversification, keeping the farmer busy all year round, improving land use efficiency, increasing income accruing to the farmer as well as increasing profit per unit area of land (Famaye *et al*., 2018). Besides, since tea cannot guaranty commercial scale harvest until 3 years after field establishment, farmers can sustain on plantain harvest before tea reaches maturity with tea/plantain intercrop. Growing horticultural crops under shade plants is practiced in many tea ecologies of the world. Intercropping pigeon pea (*Cajanus cajan*) and *Glyricidia sepium* have been reported to provide shade for growing tea in Sri Lanka and Hawaii (T. R. I., 2003; Valenzuella, 2011). Plantain has been intercropped with cacao (Famaye *et al.,* 2014) and tea (Obatolu and Ipinmoroti, 2000) to provide shade for optimum growth. However, there is dearth of information on the optimum plantain density that could enhance the growth and field seedling establishment of tea in the lowland ecologies of Nigeria. Therefore, this trial was aimed at assessing the effects of tea/plantain intercrop at different plantain planting densities on growth performance and field seedling establishment of two tea cultivars in Ibadan, Southwest Nigeria.

MATERIALS AND METHODS

This field trial was carried out in Cocoa Research Institute of Nigeria (CRIN) Station, Ibadan. Ibadan, a Tropical Rain Forest is located on Latitude 07 10'E and Longitude 03 52'E. Tea clonal materials were obtained from CRIN Station in Mambilla Plateau, Taraba State. Plantain suckers were obtained from CRIN Station, Ibadan. The land was cleared of all vegetation. The trial is a 2 x 3 factorial consisting of two tea cultivars (143 and 318) and tea intercrop with three plantain densities: 1,111 plantain stands ha^{-1} (3 x 3 m planting distance) (Tea/1111 Plantain), 2,222 plantain stands ha^{-1} (3 x 1.5 m planting distance) (Tea/1111 Plantain) and

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zero plantain stands ha^{-1} (Tea sole) as control. The experiment was laid out in Randomized Complete Block Design (RCBD) arranged in Split-Plots with four replications (Blocks). Each block comprised 2 main plots and 3 sub-plots: tea cultivars as main plots and plantain/tea intercrop at different planting densities as sub-plots. Each main plot consisted of 3 sub-plots of tea sole, tea intercrop with 1111 plantain ha^{-1} and tea intercrop with 2222 plantain ha^{-1}. In tea intercrop with plantain at 1111 plantain ha^{-1}, tea was planted between 2 rows of 3 plantain stands at 3 x 3 m spacing; while in tea intercrop with plantain at 2222 plantain ha^{-1}, tea was planted between 2 rows of 5 plantain stands at 3 x 1.5 m spacing. At 16 months of plantain establishment, 4 tea sprouted cuttings (clonal material) were transplanted at a spacing of 100 x 60 cm in each sub plot. The following growth parameters were measured on monthly basis: Number of leaves, Number of branches and Leaf area (cm^2); the survival counts (%) were measured at 9 Months After Transplanting (MAT). Data collected were analyzed with Analysis of Variance (ANOVA) and significant means separated with LSD (P=0.05).

RESULTS AND DISCUSSION

Tables 1, 2 and 3 show that C143 performed better than C318 in number of leaves, number of branches and leaf area. Cultivar 143 was significantly (P=0.05) superior to 318 in leaf area at 3-9 MAT, and in number of leaves and number of branches throughout the sampling periods. The better growth performance of C143 in comparison with C318 might be as a result of the fact that the former had been previously adjudged to be more vigorous in growth than the latter (CRIN, 1983). Tea/2222 plantain increased the number of leaves of tea by 13.9, 23.2, 17.7 and 25.6% at 3, 6, 9 and 12 MAT, respectively in comparison with Tea/1111 plantain, and by 24.9, 68.2, 233.6 and 202.1% at 3, 6, 9 and 12 MAT, respectively in comparison with Tea sole. The Tea/2222 Plantain enhanced the highest number of branches and leaf area and it was significantly (P=0.05) different from Tea/1111 Plantain and Tea sole, especially at 6-12 MAT. This indicates that plantain at 2222 plantain ha^{-1} provided adequate shade for tea which is necessary for its growth performance. This implies that imposition of shade on tea, a C3 plant, by plantain canopy favours tea leaf photosynthesis (Wijeratne *et al*., 2008). The tea sole had the least growth performance as it was exposed to the hot weather of the dry season which undermined its growth. When tea is grown as sole crop, it is fully exposed to the hot weather which in turn reduces its growth rate. The possible excessive rise in leaf temperature and build-up of vapour pressure gradients between the leaf and the surrounding area must have led to reduced vegetative growth of Tea sole. This corroborates the report of Famaye (2014 and 2017) which postulated better growth of cacao and coffee in intercrop with plantain and oil palm, respectively. The interactions between tea intercrop with plantain and the cultivars were significantly (P=0.05) different (Tables 1, 2 and 3). The highest number of leaves and number of branches were obtained in C143 under 1111 plantain at 3, 6 and 12 MAT; but at 9 MAT, C143 under 2222 plantain ha^{-1} had the highest number of leaves and number of branches. Moreover, C143 under Tea/1111 Plantain, C318 under Tea/2222 Plantain, C318 under Tea/1111 Plantain and C143 under Tea/2222 at 3, 6, 9 and 12 MAT, respectively had the highest leaf area. However, the least growth parameters were obtained in tea sole, especially in cultivar 318. Table 4 reveals that in field seedling establishment (Survival count), cultivar 143 was superior to 318. The highest survival counts of 82.81% was obtained in C143 under 2222 plantain ha^{-1}, followed by C318 (76.04%) under the same tea/plantain intercrop; while the least survival count was obtained in C318 under Tea sole. The C143 and C318 were not significantly (P>0.05) different in their survival counts. However, the survival of C318 was very low and significantly (P=0.05) lower than that of C143 under Tea/1111 and Tea sole. This implies that the survival of tea cultivars after the first dry season of its transplanting on the field was enhanced by their intercrop with plantain, a shade crop, and that Tea/1111 Plantain and Tea sole undermined the survival of C318. This corroborates the report that C143 tolerates harsh weather more than C318 (CRIN, 1985).

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Table 1: Effects of tea/plantain intercrop on number of leaves of tea plants on the field at Ibadan in 2018

Treatments		3 MAT	6 MAT	9 MAT	12 MAT
Tea cultivars					
C143		10.68a	9.92a	12.97a	16.05a
C318		6.32b	6.96b	9.43b	5.92b
Mean		8.50	8.14	9.97	10.98
Tea/Plantain densities (Stands ha^{-1})					
Tea/1111 Plantain		8.36ab	8.23b	11.81a	12.41a
Tea/2222 Plantain		9.52a	10.14a	13.91a	15.59a
Tea sole		7.62b	6.03c	4.17b	5.16b
Mean		8.50	8.14	9.97	10.98
Tea/Plantain densities x Tea cultivars (Stands ha^{-1})					
Tea/1111 Plantain	C143	12.09a	11.66a	14.89a	20.06a
	C318	4.63b	4.81b	12.94b	4.75b
		8.36	8.24	13.92	12.41
Tea/2222 Plantain	C143	10.69a	10.28a	16.63a	17.78a
	C318	8.34b	10.00a	7.00a	13.00a
Mean		9.52	10.14	11.82	15.39
Tea sole	C143	9.25a	7.81a	7.41a	10.31a
	C318	6.00b	4.25a	0.94b	0.00b
Mean		7.63	6.03	4.18	5.16

Means followed by the same letters in each column under each treatment are not significantly different by LSD (P=0.05)

Table 2: Effects of tea/plantain intercrop on number of branches of tea plants on the field at Ibadan in 2018

Treatments		3 MAT	6 MAT	9 MAT	12 MAT
Tea cultivars					
C143		2.06a	2.89a	3.09a	4.43a
C318		1.55b	0.79b	0.87b	2.52b
Mean		1.81	1.84	2.98	3.47
Tea/Plantain densities (Stands ha^{-1})					
Tea/1111 Plantain		2.67a	2.36a	2.05b	3.41b
Tea/2222 Plantain		1.66ab	2.47a	3.31a	5.38a
Tea sole		1.09b	0.69b	0.58c	1.64c
Mean		1.81	1.84	1.98	3.47
Tea/Plantain densities x Tea cultivars (Stands ha^{-1})					
Tea/1111 Plantain	C143	3.59a	4.21a	3.78a	5.81a
	C318	1.75a	0.50b	0.31b	1.00b
Mean		2.67	2.36	2.05	3.41
Tea/2222 Plantain	C143	1.41a	3.25a	4.45a	5.44a
	C318	1.91a	1.69b	2.17b	5.31a
Mean		3.16	2.47	3.31	5.38
Tea sole	C143	1.18a	1.19a	1.03a	2.03a
	C318	1.00a	0.19b	0.13a	1.25a
Mean		1.09	0.69	0.58	1.64

Means followed by the same letters in each column under each treatment are not significantly different by LSD (P=0.05)

Table 3: Effects of tea/plantain intercrop on leaf area (cm^2) of tea plants on the field at Ibadan in 2018

Treatments		3 MAT	6 MAT	9 MAT	12 MAT
Tea cultivars					
C143		189.56a	165.66a	216.76a	361.32a
C318		145.15b	140.94b	162.35b	242.73a
Mean		167.36	153.30	189.55	302.03
Tea/Plantain densities (Stands ha^{-1})					
Tea/1111 Plantain		163.10b	159.81b	209.31b	231.58b
Tea/2222 Plantain		193.70a	259.47a	333.20a	648.19a
Tea sole		145.27b	40.63c	26.16c	26.31c
Mean		167.36	153.30	189.55	302.03
Tea/Plantain densities x Tea cultivars (Stands ha^{-1})					
Tea/1111 Plantain	C143	217.32a	213.81a	328.17a	321.38a
	C318	108.89b	105.80b	338.21a	141.78b
Mean		167.36	159.81	333.19	231.58
Tea/2222 Plantain	C143	173.04a	227.10a	284.72a	709.97a
	C318	214.36a	291.84a	133.89b	586.41a
Mean		193.70	259.47	209.31	648.19
Tea sole	C143	178.33a	56.08a	37.37a	52.63a
	C318	112.21a	25.19a	14.95a	0.00a
Mean		145.27	153.30	26.16	26.32

Means followed by the same letters in each column under each treatment are not significantly different by LSD (P=0.05)

Table 4: Effects of tea/plantain intercrop on survival count of tea plants on the field in 2018

Treatments		Survival count (%)	
Tea cultivars			
C143			58.62a
C318		32.99a	
Mean			45.80
Tea/Plantain densities (Stands ha^{-1})			
Tea/1111 Plantain		32.24b	
Tea/2222 Plantain		79.43a	
Tea sole		25.74b	
Mean			45.80
Tea/Plantain densities x Tea cultivars (Stands ha^{-1})			
Tea/1111 Plantain	C143	51.98a	
	C318	12.50b	
Mean			32.74
Tea/2222 Plantain	C143	82.81a	
	C318	76.04a	
Mean			79.43
Tea sole	C143	41.07a	
	C318	10.42b	
Mean			25.75

Means followed by the same letters in each column under each treatment are not significantly different by LSD (P=0.05)

CONCLUSION: The growth and seedling establishment of tea was enhanced under its intercrop with plantain. However, while cultivar 143 could be grown in intercrop with 1111 and 2222 plantain/ha; C318 could only be grown successfully in intercrop with 2222 plantain/ ha

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GROWTH AND ESTABLISHMENT OF CACAO SEEDLINGS UNDER INTERCROP WITH PLANTAIN AT DIFFERENT TRANSPLANTING POSITIONS

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ABSTRACT

An investigation was carried out in Cocoa Research Institute of Nigeria (CRIN), Uhonmora Station, Edo State to evaluate the effect of transplanting positions of cacao (Theobroma cacao L) seedlings with plantains under field condition. Four treatments were evaluated: Plantain suckers on top of cacao seedlings at transplanting (PTCT), Cacao seedlings on top of plantain suckers at transplanting (CTPT), Cacao seedlings transplanted 30 cm apart from plantain suckers (CT30cmP) and Cacao seedlings transplanted 150 cm apart from plantain suckers (CT150cmP) as control. The experiment was arranged in Randomized Complete Block Design (RCBD) with three replications. Plantain suckers were planted at 3 x 3m spacing as shade crop while cacao seedlings (hybrid) were planted on treatment basis. The experiment was monitored for 22 months after transplanting. Data were collected on plant height, number of leaves, stem diameter, number of branches and leaf area at 3, 4, 5, 12, 13, 14 and 15 Months After Transplanting (MAT), and on Survival count (%)at 10 and 22 MAT. The data were analyzed with analysis of variance (ANOVA) as well as descriptive statistics, and significant means separated by Duncan multiple range test (P<0.05). The result showed that cacao seedlings on top of plantain (CTPT) at transplanting had the highest percentage of 91.67 and 75.00 survival count at 10 and22 MAT, respectively, closely followed by plantain on top of cacao seedlings at transplanting (89.00 % and 72.00%). When compared withCT150cmP, CTPT increased the plant height, number of leaves, stem diameter, number of branches and leaf area at 4 MAT, at 15 MAT, at 3, 13, 14, 15 MAT, at 3, 15 MAT and at 13, 14,15 MAT respectively by 1%, 10%, 61%, 2%, 3%, 8%,46%, 11%, 5%, 3% and 13%, respectively. Therefore, cacao seedlings transplanted on top of plantain was the most effective treatment for improving cacao seedling establishment and growth under field condition.

Keywords: Cacao seedlings, Plantain, Transplanting position, Seedling establishment, Growth

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is a tropical woody species which belongs to the family Malvaceace (Alverson *et al*., 1999). Under natural condition, the tree can attain a height of 20 -25 m (Lachenaud *et al*., 1997), whereas under cultivation, plant height varies from 3 to 5 m. The geographical origin of cacao is South America (Oluwalade, 2018). It is considered as one of the most important perennial crops with an estimated world output of 4.2 million tonnes in 2018 (ICCO, 2007), while FAO (2011) reported an estimated annual yield of 3.2 million tonnes in 2009. It is cultivated in the Humid tropics of the world (Yanelis *et al.,* 2012) with more than 70% production coming from Africa as source of income for producing countries (Simo *et al*., 2018). Cocoa production is dominated by small-scale farmers who live and work in the cocoa belt providing them employment and income (Minimol *et al*., 2015; Ngoh *et al.,* 2015) Cocoa is the most prominent export crop in Nigeria in terms of its production and export capacities.

Traditionally, cacao farmers in Nigeria established their farms with plantains or other food crops, either sown directly at stake or seedlings are transplanted from the nursery in to the field (La Anyane, 1963; Benneh, 1987; Opeke, 2005). Conventionally, cacao seedlings are planted or transplanted in between the plantain suckers (Owusu-Benpah, 1988). The temporary shade provided by plantain provides direct shade to the cacao seedlings for 2 to 3 years after transplanting. Moreover, despite the provision of shade by plantain for transplanted young cacao seedlings, it is a known fact that the highest percentage of these seedlings die between the first and second dry seasons as a result of soil moisture deficit during the peak of dry seasons (Babadele, 2018). It is also established that plantains that are planted to provide shade during the dry period do shed most of their leaves as a result of limited soil moisture in order to survive (Babadele, 2018). In Nigeria, cocoa production is limited to the rainforest and savanna transition zones. Presently, the level of cocoa production stands at 350,000 tonnes per annum

(ICCO, 2015), in spite of the fact that Nigeria is endowed with vast land areas suitable for its cultivation. Adoption of good management practices can bring about increased bean production of up to 100-300% (Famuagun, 2016). According to Famuagun and Agele (2010), the major reason attributed to low productivity despite the huge effort of the government were limited access to modern production technology, limited access to input and credit facilities, low percentage of survival (less than 35%) of transplanted seedlings at the end of the second dry season due to soil moisture stress and poor field management. There are also concerns that the projected global temperature rises and subsequent increase in potential evapo-transpiration and demand for plant water may lead to further drought stress during the dry season and deterioration of cocoa climate condition (Laderach *et al*, 2013; Schroch *et al.,* 2016). To solve the above mentioned problems, more robust farm management strategies are therefore needed.

Effective management of cacao seedlings on the field using agronomic practices like dry season irrigation and optimum shading regime to enhance root development could improve plantation establishment and cacao productivity. However, research efforts that would ensure cocoa sustainable production at the early stage of establishment are seen as steps in the right direction which remains sacrosanct for the survival of young cocoa in the field and the improvement of farmers' income (Agbongiarhuoyi *et al.,* 2016). Moreover, it is a known fact that cacao cultivation in Nigeria is predominantly in the hand of peasant farmers who cannot afford irrigation facilities. Due to climate change, rainfall and humidity have been on a decline progressively since mid-1970s (Omotosho *et al.*, 2000), while global warming has been on steady increase. Given the increasing global demand for cocoa and quest for obtaining sustainable production systems, it is imperative to understand the effects of some agronomic practices on the responses of cacao seedlings to dry season environmental conditions especially the hydrothermal stresses (Daymond and Hardley,2004). Improved insights would be valuable towards the attainment of optimum seedlings establishment and vigor on the field (Famuagun and Agele, 2019). Much of success of intercrops in cacao establishment depends on understanding the role each component plays in the system: cacao/plantain farming system has been recommended, but the transplanting arrangement in the face of global warming and climate change is a gap in research. Therefore, the objective of this work was to evaluate effect of different planting positions of cacao and plantain on survival and morphological growth of cacao on the field.

MATERIALS AND METHODS

Study area

Field experiment was carried out at the experimental farm of Cocoa Research Institute of Nigeria (CRIN), Uhonmora Station in Edo State between 2018 and 2020 covering two consecutive rainy seasons and two dry seasons. The location, a derived savanna zone of Nigeria, lies on latitude 6'5N and longitude 5'50'E. The rain fall is between 1000 – 1500 mm per annum. The maximum temperature ranges between 26 to 35 ^{0}C with an average of about 30 ^{0}C while minimum temperature ranges from 15 to 25^{0}C with an average of 20 ^{0}C. Relative humidity is high during the raining season, ranges from 50 to 85 % with an average of 75%. There are seasonal variations in the values of relative humidity, which varies from 65 to 89% during the rainy season and 46 – 70 % during the dry season. The rainy season which runs from April to October is characterized by heavy rains, low ambient temperature and high humidity; while the dry season runs from November to March and is characterized by little or no rain, high ambient temperature and very low humidity.

Acquisition and preparation of experimental materials

Seedlings of hybrid CRIN TC genotype were collected from CRIN, Uhonmora nursery, while plantain suckers were collected from experimental plots in the station. Experimental plot of 50 by 30 m was mapped out and the experiment was laid out in rows of 3 x 3 m.

Treatments and experimental design.

The field experiment comprised four treatments (four different transplanting positions of cacao seedlings and plantain suckers):Plantain suckers on top of cacao seedlings at transplanting (PTCT), Cacao seedlings on top of plantain suckers at transplanting (CTPT), and Cacao seedlings transplanted 30 cm (between 2 plantain stands) apart from plantain suckers at transplanting (CT30cmP) and Cacao seedlings transplanted 150 cm (between 2 plantain stands) apart from plantain suckers at transplanting (CT150cmP) as control. The experimentwas laid in Randomized Complete Block Design (RCBD) with three replications. Layout of the experimental site (Measurement,

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pegging, and holing) was carried out. One hundred and forty-four (144) plantain suckers were planted at 3 x 3m spacing as shade crop. The same number of five months old cacao seedlings (Hybrid) of average height of 50 cm (raised in the nursery) were transplanted on treatment basis. The experiment was monitored for 22 months after transplanting (MAT).

Data collection

Data collected included growth parameters of cacao seedlings (Plant height, Number of leaves, Stem diameter, Leaf area, Number of branches) and their Survival counts. The growth parameters were taken on monthly basis for 22 months commencing from 3 months after transplanting (3MAT). Plant height (cm)was measured using a meter rule from the ground surface to the tip of the main stem. Stem diameter (cm) was measured with Vernier Caliper 30 cm above the ground level. Number of leaves, Number of branches and Survival count were determined by visual count. Leaf area was also measured. The growth parameters were taken monthly for 22 months commencing from 3 MAT. Survival counts were carried out at 10 and 22 MAT. Data collected were subjected to statistical analysis using analysis of variance (ANOVA) as well as descriptive statistics, and significant means were separated by Duncan Multiple Range Test (DMRT) ($P<0.05$)

RESULTS AND DISCUSSION

Effects of transplanting positions of cacao seedlings on survival count are represented in Figure 1. Cacao seedlings on top of plantain suckers at transplanting (CTPT) and Plantain suckers on top of cacao seedlings at transplanting (PTCT) significantly ($P<0.05$) enhanced the survival count of cacao seedlings relative to other treatments at 10 and 22 MAT, while cacao seedlings on top of plantain at transplanting gave the highest survival count in both 10 and 22 MAT (Figure 1). The highest seedlings survival count recorded in 10 and 22 MAT under Cacao seedlings on top of plantain suckers at transplanting (CTPT) could be as a result of commensalism relationship between the transplanted cacao seedlings on top of the plantain suckers in which both shared the same environment and the cacao benefitted from the water and cooler weather around the biosphere especially during the dry season, yet the plantain was not adversely affected. The relationship is called table fellowship. This result also confirmed that the survival of transplanted cacao seedlings did not depend on the spacing adopted but the arrangement of cacao with the plantain. This result was corroborated by Ayegboyin *et al*. (2020), Famuagun and Agele (2019) who reported that the reduction in stand mortality under moderate and dense shaded plots was traced to improved microclimate conditions occasioned by shade plants that aided reduced air and soil temperature, reduced moisture loss through evaporation and increased activities of microbial organism under shaded microclimate. It was also observed that the same CTPT treatment had the lowest percentage mortality rate of 18% after the end of the first dry season; this was closely followed by PTCT (19%) (Figure 1).

Effect of transplanting position of cacao seedlings on growth parameters of cacao seedlings is presented in tables 1 -5. The CTPT also gave the highest plant height, number of leaves, stem diameter, number of branches and leaf area at 4 MAT, at 15 MAT, at 13, 14, 15 MAT, at 15 MAT and 15 MAT, respectively. When compared with the conventional transplanting of cacao seedlings in between the plantains (CT150cmP), CTPT increased the plant height, number of leaves, stem diameter, number of branches and leaf area at 4 MAT, at15 MAT, at 3, 13, 14, 15 MAT, at 3, 15 MAT and at 13, 14,15 MAT respectively by 1%, 10%, 61%, 2%, 3%, 8%,46%, 11%, 5%, 3% and 13% respectively; while CT150cmP treatment significantly enhanced cacao seedlings, number of leaves, number of branches and leaf area at 4 MAT, 4 and 13 MAT, 3, 4,5 MAT, respectively, when compared with the other treatments. This finding could be due to the fact that the cacao seedlings which could have been suppressed by plantain shade were not directly positioned under the plantain suckers but in between which is 150cm apart. This discovery is in agreement with the reports of Famaye *et al*. (2003) that, due to the competition that exists among them, closely spaced cacao seedlings produced smaller morphological parameters than well-spaced ones. Shipat (2001) as well as Famuagun and Agele (2016) also established that the leaves and circumference of plants are among the main factors that determine the vigour needed for the growth of cacao seedlings after transplanting.

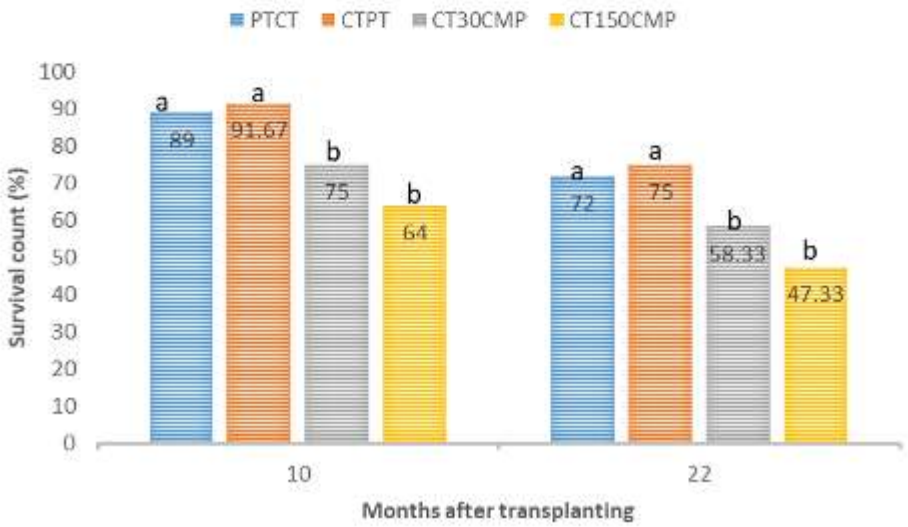

Figure 1: Effect of transplanting positions on survival count (%) of cocoa seedlings

Means followed by the same letters in each composite bars are not significantly different by DMRT (P<0.05)

PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30cmP: Cacao transplanted 30 cm apart from plantain; CT150cmP; Cacao transplanted 150 cm apart from plantain

Table 1: Effect of transplanting positions on plant height (cm) of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	74.33b	98.33c	124.00c	175.67a	179.67a	182.67a	187.00a
CTPT	94.33ab	147.00a	157.67ab	159.33a	173.00a	178.67a	195.33a
CT30cmP	92.00ab	134.00b	146.33b	162.33a	169.67a	182.00a	191.33a
CT150cmP	112.67a	145.67a	164.67a	177.00a	179.67a	186.67a	200.67a
Mean	93.33	131.25	148.17	168.58	175.50	182.50	193.58

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)

PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30cmP: Cacao transplanted 30 cm apart from plantain; CT150cmP; Cacao transplanted 150 cm apart from plantain

Table 2: Effect of transplanting positions on number of leavesof cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	23.00a	45.67b	64.33ab	92.33a	111.00a	114.33a	132.33a
CTPT	9.00c	48.00b	83.33a	91.33a	110.67a	112.67a	137.67a
CT30cmP	13.33b	31.00c	55.67b	90.00a	109.00a	109.00a	121.33a
CT150cmP	11.33bc	87.33a	87.33a	92.33a	127.00a	116.00a	123.67a
Mean	14.17	53.00	72.67	92.00	114.42	113.00	128.75

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)

PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30cmP: Cacao transplanted 30 cm apart from plantain; CT150cmP; Cacao transplanted 150 cm apart from plantain

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Table 3: Effect of transplanting positions on stem diameter(cm) of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	0.63a	1.57ab	1.83b	3.27a	3.33a	3.70a	3.67b
CTPT	0.43ab	1.60ab	2.23ab	3.03a	3.73a	3.83a	4.07a
CT30cmP	0.73a	1.20b	2.30ab	3.20a	3.47a	3.43a	3.77ab
CT150cmP	0.17b	1.83a	2.67a	3.37a	3.67a	3.73a	3.73b
Mean	0.49	1.55	2.26	3.22	3.55	3.81	3.68

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)

PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30cmP: Cacao transplanted 30 cm apart from plantain; CT150cmP; Cacao transplanted 150 cm apart from plantain

Table 4: Effect of transplanting positions on number of branches of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	0.47a	2.00b	5.67ab	3.50b	4.17b	5.67ab	5.33a
CTPT	0.37a	3.33b	5.00bc	3.60ab	4.20b	5.00bc	6.00a
CT30cmP	0.57a	1.33b	4.00c	4.37a	4.17b	4.00c	4.33b
CT150cmP	0.20b	6.67a	6.67a	4.00ab	6.67a	6.67a	5.33a
Mean	0.40	3.33	5.33	3.89	4.80	5.33	5.25

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)

PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30cmP: Cacao transplanted 30 cm apart from plantain; CT150cmP; Cacao transplanted 150 cm apart from plantain

Table 5: Effect of transplanting positions on leaf area (cm^2)of cocoa seedlings

Treatments	3 MAT	4 MAT	5 MAT	12 MAT	13 MAT	14 MAT	15 MAT
PTCT	70.33bc	84.00b	95.33b	308.33a	306.33a	308.67a	327.00b
CTPT	76.33c	74.33c	86.67b	164.67b	292.33a	302.67a	362.67a
CT30cmP	77.33b	82.00b	93.00b	153.33b	165.00b	206.33b	232.00a
CT150cmP	101.33a	110.33a	119.67a	241.33a	279.00a	292.67a	316.67b
Mean	79.08	87.67	98.67	215.12	260.27	277.58	309.58

Means followed by the same letters along each column are not significantly different by DMRT (P<0.05)

PTCT: Plantain on top of cacao seedlings at transplanting; CTPT: Cacao on top of plantain at transplanting; CT30cmP: Cacao transplanted 30 cm apart from plantain; CT150cmP; Cacao transplanted 150 cm apart from plantain

CONCLUSION AND RECOMMENDATION

Much of success of intercrops in cacao establishment depends on understanding the role each component plays in the system, cacao/plantain farming system has been recommended, but the transplanting arrangement in the face of global warming and climate change is a gap in research which this work has filled. Furthermore, the long dry season and the wind – storms early March to April in the study area usually devastate the plantains so that effective shade is not actually provided for the cacao in the later part of the dry season when the shade is needed most. According to this work, Cacao transplanting on top of plantain (CTPT) enhanced the best performance of cacao seedlings when compared to other treatments because cacao seedlings would have benefited from the soil moisture available at the base of plantain for survival and morphological growth.

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CASHEW ARCHITECTURAL GROWTH AND YIELD PATTERNS: A CASE OF CASHEW/ARABLE CROPS INTERCROPPING IN GUINEA SAVANNA AGRO ECOLOGY OF NIGERIA

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ABSTRACT

A field experiment on intercropping as alley cropping on cashew plantation was conducted at Cocoa Research Institute of Nigeria sub-station Ochaja, Kogi state to evaluate the impact of manure, yield and canopy development on cashew plant. Treatments consisted of intercrops of Bambara, Sesame and manuring using pelletizer fertilizer applied at the rate of 0, 4.84kg/plot and 9.68kg/plot to the soil of the intercrops under the cashew alley. The two-year field experiment was laid out at 6m x 6m in a split plot design with three replications. Data collected includes crown diameter, canopy spread, canopy North-South/East-West direction, canopy volume, canopy radius, canopy ground cover, while the cashew yield attributes are numbers of nut, nut weight, nut length, nut width, nut thickness and nut yield per plot. The results showed that cashew growth characters were influenced by alley crops of Sesame and Bambara nut, not only by improving the yield but also enhance vigorous growth and canopy development of the plants. The study also showed that intercropping with a combination of both Bambara + Sesame and the application of pelletized fertilizer of 9.68kg/plot proved to have the highest cashew yield among the treatments adopted. Cashew tree / crop intercropping in young cashew plantations in this study is an effective measure to increase growth, economic income and yield to the farmers at the early stage of its establishment.

Key words: *Bambara, Cashew, canopy, sesame, intercropping, fertilizer*

INTRODUCTION

Intercropping tree crops during the establishment phase with food crops is an age-long practice in the tropics. The benefits of such a practice includes food security for the household, income generation to partially offset the cost of establishment, weed control, and better use of growth resources (Rodrigo *et al*., 2001; Opoku-Ameyaw *et al*., 2003). Cashew is known to be commonly intercropped with arable crops in Nigeria. Results from intercropping studies indicate that increased crop diversity may increase the number of ecosystem services provided. Higher species richness may be associated with nutrient cycling characteristics that often can regulate soil fertility (Russell, 2002), and limit nutrient leaching losses (Hauggaard-Nielsen *et al*., 2003), by also maintaining their own soil fertility, regulating natural protection against pests, and sustaining productivity (Thrupp, 2002; Scherr and McNeely, 2008). Growing of crops simultaneously also enhances the abundance of predators and parasite which in turn prevent pests build up and minimized the usage of expensive and chemical weed control measures according to Lithourgidies *et al.,* (2011). One of the opportunities growing Cashew brings, especially during the early phase of its establishment is that it has the potential to accommodate intercrops due to the wide plant spacing associated in its cultivation (Carr *et al*., 2014). Planting density and tree canopy have a direct impact on the yield of tree crops (Nayak, 2019). The growth style of perennial trees determines the subsequent architecture of the tree and in cashew tree canopy volume is vital because it shows the bearing area, decides the tree spacing and population density per unit area (Ona *et al*., 2017). The cashew tree develops dome shaped canopy very fast having its foliage on the outside where flowers and fruits are found. Canopy growth pattern is a major factor that decides how fast a cashew tree can enter its economic production phase (Tolla 2004). The present study is proposed to improve understanding of compatibility of cashew with some selected arable, with respect to canopy development and yield enhancement.

MATERIALS AND METHODS

Experiments were conducted at the experimental farm of Cocoa Research Institute of Nigeria (CRIN) Sub-Station Ochaja (Latitude 7°46'N - 7°52' and longitudes 6°38'E – 6°48') Kogi State in the Southern Guinea Savanna Agro-ecological zone of Nigeria. The experiment was conducted within an already established three-year-old young cashew plantation. The cashew genotype in the plot was jumbo which was planted 6m x 6m and replicated three times. Thirty-six cashew trees with border plots were used for intercropping of bambara and sesame as alley crops and fertilized with pelletized fertilizer at the rate of 0, 4.84kg/plot and 9.68kg/plot per plot respectively fitted in a split plot and arranged in a complete randomized block design. All management practised were adopted uniformly. Data collected on cashew vegetative growth parameters includes plant height and trunk girth. Data relating to canopy measurement includes crown diameter, canopy spread, canopy North-South/East-West direction, canopy volume, canopy radius canopy ground cover, while the cashew yield attributes are numbers of nut, nut weight, nut length, nut width, nut thickness and nut yield per plot. Data collected was subjected to statistical analysis using SAS (version 9.4, 2011) Analysis of variance (ANOVA Procedure) was done using the PROC GLM procedure in SAS and mean were separated for significance with Tukey's Studentized RangeTest (HSD) at 5% ($P \leq 0.05$) probability level.

RESULTS AND DISCUSSION

Fruit trees like cashew are considered to have a positive influence on the soil nutrient content because of its tap root system. Bambara and Sesame are also characterized by a tap root system, which absorb waters and nutrients from deep soil layers. The results showed in table 1 was a variation between the use of Bambara nuts and sesame plants planted alone the cashew alley because the Bambara variety TVSu1166 with the application of pelletized organic fertilizer was highest in vegetative growth and canopy development compared to those of the sesame varieties. TVSu1166 Bambara variety planted in the cashew alley significantly influences, Girth and the canopy characters of canopy East - West, North - South, crown diameter, canopy spread, canopy radius, canopy ground cover, while the highest Height measured was recorded with the TVSu999 intercrop. According to Toschi *et. al*. (1993) cashew being a perennial and evergreen in nature with large canopies, can grow to about 10 to 12 meters in height. Similarly, in table 2 the effects of 9.68kg fertilizer was significantly different from 4.84kg in all the measured parameters. The pelletized fertilizer after decomposition resulted in different varietal responses to manuring. Similar observation was made by Ojeniyi *et al*. (2007), MoyinJesu (2007) in their report on manure and fertilizer application as a measure of plant vigor promotion and nutrient enhancement status. On the other hand, Xavier *et al.* (2013) reported that associating legumes with cashew plants reduces weed and herbicides usage, apart from increasing soil carbon, organic matter, and nutrient content. These increases in growth observed in this experiment could be due to the nitrogen fixing nature of Bambara which influenced cashew tree vegetative growth (Esteban, 2001) reposed.

The cashew yield per tree and features of nut characteristics as shown in table 3 *viz.*, number of nuts, weight, length, width, thickness, and nut yield shows that nut length, width and thickness of cashew nuts are highly variable characters depending on their size and age of the cashew plants. However, contrary to the growth pattern observed in this study, the application of manure to the intercrops had no significant influence on cashew yield and its attribute as showed in Table 3 but a higher value of the study parameters was obtained when fertilizers of higher dosages of 9.68kg was applied compared to the control plots. Similar observation was reported by Rathna and Swain (2006) and Pawar *et al.* (2009) works on mango intercropping.

CONCLUSION

Manuring exerted significant effects on cashew growth characters, canopy structure and yield in the presence of alley crops of Sesame and Bambara nut. The application of 4.84 and 9.68 kg/plot pelletized fertilizer enhanced cashew growth character, canopy structure and yield compared with un-manure plot. The interaction between Sesame and Bambara was positive to cashew growth, canopy development and yield. However, to encourage organic agriculture, Pelletized manure should be considered as a valuable fertilizer and can serve as a suitable alternative to chemical fertilizer (NPK). However, other organic fertilizer should be researched on other intercrops planted at cashew alley. While the residual effect of these fertilizers incorporated into the soil before planting and on contrasting environments is recommended for future validations.

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Table 1. Interaction effect on Cashew vegetative growth characters before planting of the intercrops.

Treatments	Height (m)	Girth (cm)	Canopy Volume (m^3)	Canopy East-West direction (m)	Canopy North-South direction (m)	Crown Diameter (m)	Canopy Spread(m)	Canopy Radius(m)	Canopy Ground Cover(m^2)
Fertilizer Treatments									
Un-manure (Control)	72.22b	19.70b	816.20b	17.15a	17.70b	17.43b	823.00a	11.62b	23.23b
Pelletizer fertilizer(4.84Kg/plot)	92.22a	29.22a	1444.60a	23.91a	24.99ab	24.45ab	752.60a	16.30ab	32.60ab
Pelletizer fertilizer (9.68Kg/plot)	97.66a	25.20ab	1285.10a	25.86a	27.35a	26.61a	365.30a	17.736a	35.47a
Crop Types									
E8	85.80ab	26.79a	1324.80ab	16.69b	19.11b	17.90b	365.60b	11.93b	23.86b
NCRIBen04E (Ex-Sudan)	84.28b	19.60a	928.70b	19.62b	22.01ab	20.81ab	611.20ab	13.88ab	27.75ab
TVSu1166	98.43a	28.40a	1454.90a	30.24a	31.31a	30.78a	1046.80a	20.52a	41.036a
TVSu999	80.94b	24.05a	1019.50ab	22.67ab	20.91ab	21.81ab	564.20ab	14.54ab	29.09ab

Means with the same letters along each column are not significantly different at 0.05 level of probability. *PF-Ferti-plus Pelletized fertilizer, TVSu1166 and TVSu999-Bambara varieties, E8 and NCRIBen04E- Sesame Varieties.*

Table 2: Interaction effect on cashew vegetative growth characters after planting of the intercrops.

Treatments	Height (m)	Girth (cm)	Canopy Volume (m^3)	Canopy East-West direction (m)	Canopy North-South direction (m)	Crown Diameter (m)	Canopy Spread(m)	Canopy Radius(m)	Canopy Ground Cover(m^2)
Fertilizer Types									
Un-manure (Control)	100.83b	23.84b	1379.80b	20.10b	20.94b	20.52b	497.4b	13.68b	27.36b
Pelletizer fertilizer(4.84Kg/plot)	123.75a	33.56a	2233.8a	27.76ab	29.54ab	28.65ab	986.5ab	19.10ab	38.20ab
Pelletizer fertilizer(9.84Kg/plot)	130.52a	30.15ab	2068.9a	31.41a	33.69a	32.55a	1207.3a	21.70a	43.40a
Crop Types									
E8	116.79a	31.92a	2135.3a	20.18b	24.43b	22.30b	568.7a	14.87b	29.74b
NCRIBen04E (Ex-Sudan)	113.23a	23.34a	1551.8a	23.83ab	24.54b	24.18ab	821.8a	16.12ab	32.24ab
TVSu1166	110.88a	32.39a	2223.0a	33.26a	37.52a	35.39a	1359.2a	23.59a	47.181a
TVSu999	132.57a	29.08a	1666.6a	28.43ab	25.75b	27.09ab	838.4a	18.06ab	36.12ab

Means with the same letters along each column are not significantly different at 0.05 level of probability. *PF-Ferti-plus Pelletized fertilizer, TVSu1166 and TVSu999-Bambara varieties, E8 and NCRIBen04E- Sesame Varieties.*

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Table 3. Interaction effect on Cashew yield and its components as influenced by intercropping and manuring.

Treatment	Number of nut	Nut Weight (g)	Nut Length (mm)	Nut Width (mm)	Nut Thickness (Cm)	Nut Yield (kg/tree)
			Interaction			
Un-manure (Control-Cn)						
Sole Cashew (Cn)	233.53	19.67	0.35	0.03	1.67	1455.35
						1965.50
Cashew + Bambara (Cn)	273.17	20.30	2.09	0.06	5.4	
Cashew + Sesame (Cn)	280.33	20.70	2.31	0.16	5.13	1600.20
Cashew + Sesame + Bambara (Cn)	164.00	20.13	1.02	0.20	4.63	1349.13
Cashew + Pf 4.84Kg/plot	300.30	20.66	0.46	0.31	3.77	1736.24
Cashew + Bambara + Pf 4.84Kg/plot	81.99	19.37	1.05	0.57	4.03	1880.61
Cashew + Sesame + Pf 4.84Kg/plot	250.27	21.03	2.20	1.31	8.57	1585.20
Cashew + Sesame + Bambara + Pf 4.84Kg/plot	199.38	20.77	0.36	0.34	2.47	1731.34
Cashew + Pf 9.68Kg/plot	210.33	20.10	2.18	1.24	3.07	1381.48
Cashew + Bambara + Pf 9.68Kg/plot	123.28	19.79	1.61	1.89	5.63	1134.18
Cashew + Sesame + Pf 9.68Kg/plot	323.65	19.8	0.35	1.22	4.03	1278.20
Cashew + Sesame + Bambara + Pf 9.68Kg/plot	396.73	21.47	1.26	1.99	6.6	2341.27

Means with the same letters along each column are not significantly different at 0.05 level of probability. *Cn- control*, *PF-Ferti-plus Pelletized fertilizer, TVSu1166 and TVSu999-Bambara varieties, E8 and NCRIBen04E- Sesame Varieties.*

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GROWTH AND YIELD OF OKRA IN LEGUME-OKRA SEQUENTIAL CROPPING SYSTEM

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ABSTRACT

Usually about two-thirds of the nitrogen fixed by a legume becomes available the next growing season after a legume in a rotation. The objective of this study was therefore to determine the growth and yield of okra planted after the legumes. The experiment was conducted at the Vegetable Research Farm, National Horticultural Research Institute (NIHORT), Ibadan, Oyo state. Legumes comprising cowpea, soybean, bambara nut and groundnut were planted at spacing of 60 cm x 30 cm (55,555 plats/ha), 45 cm x 30 cm (74,074 plants/ha), and 30 cm x 30 cm (111,111 plants/ha). The legumes were incorporated into the soil after harvest during land preparation for okra planting. Seeds of okra (NHAe 47-4) obtained from NIHORT was planted at a spacing of 50 cm x 50 cm. Five plants were randomly selected and tagged for data collection on growth and yield parameters. Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using the Duncan Multiple Range Test (DMRT) ($P \leq 0.05$). Results showed that total nitrogen of soil planted with soybean at 55,555 plants/ha was significantly higher (0.32 mg/kg). The residual effect of different legumes planted at varying population significantly affected growth, fruit yield and yield components of okra. Okra planted on plots previously cropped with cowpea at 74,074 plants/ha had significantly higher fruit yield (1.08 t/ha). It can then be concluded that planting cowpea at spacing of 45 cm × 30 cm (74,074 plants/ha) significantly increased yield of okra.

Key words: Okra, growth, year, sequential cropping system

INTRODUCTION

Sequential Cropping is a form of multiple cropping in which crops are grown in sequence on the same field with the succeeding crop planted after the preceding crop is harvested. Global population will hit 9.6 billion people by 2050 (United Nations, 2013) and will face global challenges among which achieving food security, lowering the risk of climate change by reducing the net release of greenhouse gases into the atmosphere and meeting the increasing demand for energy will be most critical. To meet these challenges, a policy framework needs to be developed in which the sustainability of production/ consumption patterns becomes central. In this context, food legumes and legume-inclusive production systems can play important roles by delivering multiple services in line with sustainability principles. Indeed, legumes play central roles: (1) at food-system level, both for human and animal consumption, as a source of plant proteins and with an increasingly importance in improving humans' health (Tharanathan and Mahadevamma, 2003); (2) at production-system level, due to the capacity to fix atmospheric nitrogen making them potentially highly suitable for inclusion in low-input cropping systems (Lemke *et. al.,* 2007); and (3) at cropping system levels, as diversification crops in agroecosystems based on few major species, breaking the cycles of pests and diseases and contributing to balance the deficit in plant protein production in many areas of the world, including Europe (Westhoek *et. al.,* 2011).

Okra (*Abelmoschus esculentus* (L.) Moench) is a widely cultivated vegetable crop and very important in the diet of Africans (Omotoso and Shittu, 2008). Fresh edible pods provide human supplementary vitamins such as Vitamins C, A, B-Complex, iron, and calcium (Chutichudet *et al.*, 2007). In Nigeria, the limiting factors in okra production and other vegetables among others include weed management, poor soil fertility, tillage practices, low yielding varieties and sub-optimal planting density (Iyagba *et al*., 2012). Bush fallow is the major natural method of replenishing the soil nutrient, this fallow system is gradually collapsing under the pressure of increasing population such that farmers increasingly practice a more or less sedentary agriculture on small land area (Kadeba, 1999). Moreover, the lack of the nutrient will lead to high cost of production whereby farmers would have to apply fertilizer to improve the soil nutrient if something good is to be expected. The use of inorganic fertilizers can improve crop yields but its use is limited due to scarcity, high cost, nutrient imbalance and soil acidity which can lead to environmental pollution. However, alternative cropping system which is environmentally friendly, cheap (reduce cost of production) and present for a longer period of time is to be adopted that could improve the soil nutrient and promote the growth and yield of okra which would increase the farmers' income.

The ability of legumes like cowpea, groundnut, soybean etc. to fix atmospheric nitrogen is perhaps the most notable aspect that sets them apart from other plants. Usually about two-thirds of the nitrogen fixed by a legume becomes available the next growing season after a legume in a rotation. For a long time, legumes have been known as the ―soil building crops because the biological, physical, and chemical properties of the soil are significantly improved when legumes are grown on it (Zhao-Hai Zeng, *et. al.,* 2016). It therefore makes good sense agriculturally to alternate them with cereals and other crops that require large amounts of N. The objective of this study was to determine the influence of leguminous crops at varying population on growth and yield of okra planted after the legumes.

MATERIALS AND METHODS

The experiment was conducted at the Vegetable Research Farm, National Horticultural Research Institute (NIHORT), Ibadan, Oyo state located in the rain-forest agro-ecological zone ($7^0 33^1$N and $3^0 56^1$E 168 m above sea level) between June and November 2019. Soil sampling was done randomly at the depth of 0-15 cm air dried, sieved through a 2mm mesh and taken to laboratory for analysis of physical and chemical properties of the soil. Soil sampling and analysis was also done according to the treatments after harvesting of the legumes.

The legumes comprising cowpea (Ife brown), soybean, bambara nut and groundnut (Kampala) were planted on a plot size of 3.6 m x 1.5 m (5.4 m^2) at 60 cm x 30 cm (55,555 plats/ha), 45 cm x 30 cm (74,074 plants/ha), and 30 cm x 30 cm (111,111 plants/ha). The four legumes, planted at three spacing with a check gave rise to thirteen treatment combinations laid out in randomized complete block design in three replications. Legumes were incorporated into the soil after harvest during land preparation for okra planting. Seeds of okra (NHAe 47-4) obtained from NIHORT was planted at a spacing of 50 cm x 50 cm. Weeding was carried out at 4 and 6 weeks after sowing using hoe. Five plants within net plot were randomly selected and tagged for data collection on Plant height (cm), number of leaves/plant, leaf length (cm), leaf area (cm^2), stem diameter (mm), fruit length (cm), fruit width (mm), average fruit weight (g), number of fruit/plant, fruit yield (t/ha). Data collected were subjected to analysis of variance (ANOVA) using SAS and significant means were separated using the Duncan Multiple Range Test (DMRT) at 5% probability level. Leaf area, Y = 115x – 1050, where Y is the leaf area and x is the length of the leaf (Olasantan, 1999).

RESULTS AND DISCUSSION

Result of analysis of variance (ANOVA) showed that significant differences existed in the amount of nutrients in the soil cultivated with different legumes at varying population. Plots cultivated with soybean at 55,555 plants/ha had significantly higher amount of organic carbon (3.89 mg/kg). Meanwhile, organic carbon of plot planted with bambara at population 74,074 plants/ha had the lowest (2.86 mg/kg) which was not significantly different from the one obtained from plot without legumes (2.99 mg/kg) (Table 1). Total nitrogen of soil planted with soybean at 55,555 plants/ha (0.32 mg/kg), 74,074 plants/ha (0.30 mg/kg) and 111,111 plants/ha (0.31 mg/kg), cowpea at 55,555 plants/ha (0.32mg/kg), bambara at 55,555 plants/ha (0.32mg/kg) and groundnut at 74,074 plants/ha (0.31 mg/kg) were significantly higher but not significantly different from one another. Meanwhile, total nitrogen of plot planted with cowpea at 111,111 plants/ha and 74,074 plants/ha and bambara at 111,111 plants/ha had the least total nitrogen of 0.2 mg/kg (Table 1). This result confirms the importance of legume residue in improving soil condition for the benefit of succeeding crops. The present study concurs with an earlier report, that legumes are excellent components within the various cropping systems (Yusuf and Yusuf, 2008). This revealed the significance of legume in nitrogen fixation and its inclusion to cropping system. It could also be due to the importance of legumes in improving the physico-chemical properties of the soil. This is due to increased availability of nitrogen in the soil and the increase in the amount of nitrogen as a result of nitrogen contributed by the legumes through nitrogen fixation (Ajeigbe *et. al.,* 2005).

Results of analysis of variance (ANOVA) showed that the residual effect of different legumes planted at varying population significantly affected growth of okra. Okra planted in plots previously cultivated with cowpea at 111,111 plants/ha was significantly taller (21.4 cm) while okra planted in plots without previous legumes produced the shortest plant with the least number of leaves

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(Table 2). Okra planted on plots previously cultivated with cowpea at 74,074 plants/ha had significantly higher stem diameter while okra planted on plots without previous legumes had the lowest stem diameter (Table 2). These results might be as a result of the fact that nitrogen produced by legumes enhanced growth of subsequent crop and couple with the report in an earlier study that nitrogen has a significant contribution to vegetative growth of plants (Sanginga *et. al.,* 2002). Result of analysis of variance (ANOVA) showed that okra fruit yield and yield components were significantly affected by varying population of legumes planted before Okra. Okra planted on plots previously cultivated with Groundnut at 74,074 plants/ha had significantly longer fruit (6.73 cm) while okra planted on plots without previous legumes had the shortest fruit (4.43 cm). Okra planted on plots previously cropped with cowpea at 74,074 plants/ha had significantly higher fruit yield (1.08 t/ha) while Okra planted on plots previously cultivated with soybean at 111,111 plants/ha had least fruit yield which was not significantly different from okra planted on plots not previously cultivated with legumes (Table 3). These results corroborate the reports of Yusuf *et al.,* 2009 that yield increases of cereals following legumes in rotation have been reported by many studies in the past years. These results could be as a result of nitrogen fixed by legumes into the soil as revealed by several studies that increase in the yield of cereals planted after legumes was mainly due to the N contribution associated with the symbiotic N fixation in the legume (Lo´pez-Bellido *et al.,* 2004).

Table 1: Soil chemical properties after harvest of legumes

Treatment	Organic carbon (mg/kg)	Total nitrogen (mg/kg)	Available phosphorus (mg/kg)	K
Soybean 111,111 plts/ha	3.57a	0.30a	3.5cde	0.08e
Soybean 74,074 plts/ha	3.75a	0.31a	4.00cd	0.14a
Soybean 55,555 plts/ha	3.89a	0.32a	4.5bc	0.10c
Cowpea 111,111 plts/ha	3.61a	0.20b	4.00cd	0.08e
Cowpea 74,074 plts/ha	3.64a	0.20b	7.50a	0.13b
Cowpea 55,555 plts/ha	3.86a	0.32a	5.50b	0.09d
Bambara111,111 plts/ha	3.57a	0.20b	3.00de	0.09d
Bambara 74,074 plts/ha	2.86c	0.24ab	2.50e	0.09d
Bambara 55,555 plts/ha	3.89a	0.32a	3.00de	0.09d
Groundnut111,111plts/ha	3.04bc	0.25ab	4.00cd	0.07f
Groundnut 74,074 plts/ha	3.71a	0.31a	4.50bc	0.09d
Groundnut 55,555 plts/ha	3.46ab	0.29ab	5.50b	0.10c
Control	2.99c	0.25ab	3.00de	0.08e
F sig. $_{0.05}$	**	*	**	**

Means with the same letter were not significantly different along each column.

Table 2: Growth of okra in sequential cropping after different legumes at varying population

Treatment	Plant height (cm)	Number of leaves	Leaf length	Stem diameter
OS111,111	14.4c-e	5.67a	7.73b-d	3.23d-f
OS74,074	16.8b-e	5.13a	8.51a-c	3.78b-f
OS55,555	13.07ef	5.33a	7.07cd	3.24d-f
OC111,111	21.4a	6.33a	11.33a	5.31ab
OC74,074	18.4ab	6.33a	11.2a	5.36a
0C55,555	16.6b-e	6.40a	9.47a-c	4.50a-e
OB111,111	15.47b-e	5.27a	7.90bc	3.68c-f

OB74,074	14.13d-f	5.47a	7.33cd	3.04ef
OB55,555	18.27a-c	5.60a	9.33a-c	4.69a-d
OG111,111	17.73a-d	6.53a	10.51ab	5.13a-c
OG74,074	16.7b-e	5.60a	8.12bc	3.75c-f
OG55,555	17.27b-d	6.20a	9.77a-c	3.98a-e
Control	10.27f	3.47b	5.00d	2.28f
F sig. $_{0.05}$	**	*	**	**

Means with the same letter were not significantly different was along each column.

Table 3: Fruit yield and yield components of okra sown after different population of legume

TREATMENT	Fruit yield (t/ha)	Fruit diameter (mm)	Fruit length (mm)
OS111,111	0.17f	5.00cde	20.17ab
OS74,074	0.46cde	5.47bcde	19.33abc
OS55,555	0.40def	5.60bcd	19.07abc
OC111,111	0.81ab	6.21ab	19.52abc
OC74,074	1.08a	5.51bcde	18.53abc
0C55,555	0.72bc	4.85de	17.33abc
OB111,111	0.43def	5.83abcd	18.70abc
OzB74,074	0.22ef	5.73abcd	17.00abc
OB55,555	0.58bcd	5.99abc	17.69abc
OG111,111	0.78b	6.49ab	21.15a
OG74,074	0.66bcd	6.73a	15.32cd
OG55,555	0.55bcd	5.77abcd	15.92bcd
Control	0.20ef	4.43e	11.64d
F sig. $_{0.05}$	**	*	**

Means with the same letter were not significantly different along each column.

CONCLUSION

The study showed the potentials of leguminous plants as a renewable nutrient source for soil under continuous usage. Planting cowpea at spacing of 45 cm × 30 cm giving rise to a population of 74,074 plants/ha significantly increased yield of okra and is therefore recommended.

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EVALUATION OF AGRONOMIC CHARACTERS OF SESAMUM RADIATUM (SCHUM AND THONN) AS INFLUENCED BY INTRA-ROW SPACING IN KASHERE, NIGERIA

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ABSTRACT

Field experiment was conducted in 2020 under Irrigation at the Teaching and Research Farm of the Faculty of Agriculture, Federal University of Kashere (Latitude 9^0, 54 46^{11} N and Longitude 11^0, 0 27^{11} E) to evaluate the agronomic characters of *Sesamum radiatum* (Schum and Thonn). The treatment consisted of three Intra-row spacing (10, 15 and 20cm) laid out in a randomized complete block design (RCBD) with four replications. The variable measured were plant height, number of branches, stem girth, leaf length/width and Fresh leaf yield. Data collected were subjected to analysis of variance (ANOVA) and means separation were done using least significant difference (LSD). The result obtained showed that the Intra-row spacing of 2ocm significantly ($P \leq 0.05$) produced tallest plant (81.8cm), highest number of branches (13.8) and highest fresh leaf yield (5.8t/ha). It was concluded that the Intra-row spacing of 20cm produced optimum growth and fresh leaf yield. Farmers in Kashere and its environs could adopt this spacing to ensure optimum growth, performance and leaf yield of *Sesamum radiatum* (Schum and Thonn).

Keywords: Agronomic characterization, Intra-row spacing, *Sesamum radiatum*, Kashere Nigera.

INTRODUCTION

Sesamum radiatum (Schun and Thonn) also called Black benniseed (English) and Karkaci (Hausa) is a traditional leafy vegetable of national important found in a wide range of habital and in moist places in open savannah and belong to the family *Pedaliaceae* (Grubben and Denton, 2004; Garjila, 2016). *Sesamum* comprises about 20 species, most of which are indigenous to tropical Africa. Sometimes small horns can be present on fruit of *Sesamum radiatum* and in that case confusion is possible with *Ceratotheca desmoids. Sesamum radiatum* and other *Pedaliaceae* are covered with mucilage glands. The gland may enable the plant to withstand severe desiccation without tissue death, after contact with water, the outer cells wall of the head cells dissolve, producing an enormous amount of mucilage (Adeoti *et al*.,2012; Garjila *et al*.,2020).

Sesamum radiatum are only grown on a small scale, mainly for home consumption. In Nigeria a leaf yield of 5-6 tonnes/ha can be expected. For leaf production, the plant is topped to promote the growth of new basal shoots from which large leaves can be harvested. The plant is a popular vegetable in Africa in which the edible leaves are used and shots cooked and eaten as vegetable. The plant also yields an oil and has local medicinal uses. It is cultivated in Africa, India, Srin lanka and South America (Guyana), mainly for its edible leaves, also for its high quality seed oil which is traded in mixture with the vegetable oil of *Sesamum indicum* (Garjila et al, 2020; TPD, 2020). The leaves are also used for treating various sickness including stomach oilments, catarrh, eye pains, bruises and erupted skin (Ogunlesi et al, 2010). A paste made from the pounded seeds combined with shea butter (*Vitellaria paradoxa*) and other ingredients, is applied as a treatment for rectal prolapsed. A leaf infusion is used as a shampoo and to kill head lice (Dansi *et al*., 2012; Garjila, 2016; TPD, 2020).

There are a number of constraints that limits the production of *Sesame*. One of them is lack of optimum plant population and row spacing recommendations. Farmers in the arid and semi-arid areas usually use high population and broadcast method for all crops grown for various

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reason. This practice mostly resulted in poor seedlings growth and development, because of severe competition at the seedlings stage that leads to lower yield (Lakew *et al*.,2018). Yield responses to plant population and row spacing need to be known for practical purpose, as plant density is a major management variable used in matching crops requirement to the environmental offer of resources (Smith and Hamal, 2012). Despite the nutrition, medicinal and economic value of the plant, it is still unfortunately neglected by scientific research (Adeoti *et al*.,2012), and poorly investigated and is currently classified among the natural underutilized species of crops (Dansi *et al*.,2012). In view of that there is need to determine the spacing for the optimum production of *Sesamum radiatum* (Schum and Thonn) in the study area.

MATERIALS AND METHODS

The field experiment was carried out under irrigation in 2020 at the Teaching and Research Farm of the Faculty of Agriculture, Federal University of Kashere (Latitude 9^0, 54' 46" N and longitude 11^0, O' 27" E), at an altitude of 349m above sea level.

The treatment consisted of three intra-row spacings (10, 15 and 20cm) laid out in a randomized complete block design (RCBD) with four replications. Clearing and sloughing of the trial field was carried out manually using cutlass and hoes. Sunken seed beds were constructed and each measured 2m x 3m ($6m^2$). Prior to seedbed preparation, representative soil samples were collected at 0-15cm depth using a soil auger and bukked to form a composite sample. The soil was air dried in the laboratory and grounded to fineness and sieved through 2-mm mesh before using for routine analysis following the prescribed standard analytical procedure (IITA, 1982).

The *Sesamum radiatum* seeds sourced from local seed banks in the area were mixed with sand and then drilled in an inter-row of 50cm apart after thorough watering of the seedbeds. At 2 weeks after emergence, the seedlings were thinned to one plant per stand at 10, 15 and 20cm intra-row spacings. All normal agronomic management practices such as land preparation, weeding, manure application, pest and disease control, erosion control, etc. were followed to ensure good crop growth.

Harvesting of the fresh shoots was carried out at 2 weeks' intervals commencing from 8 weeks after sowing (WAS) and terminated at 16 WAS. Parameters measured were plant height (cm), number of branches, stem girth (cm), leaf length/width (cm) and fresh leaf yield (t/ha) was determined from the summation of leaf yield at the end of harvest. Data collected were subjected to analysis of variance (ANOVA) using SAS 9.4 version and means separation was done using the least significant difference (LSD) at $P \leq 0.05$.

RESULTS AND DISCUSSION

Analysis of the physic-chemical characteristics of the surface soil samples at the site during the period of the experiment showed higher proportion of sand, low silt and clay contents respectively indicating a sandy loam texture (Table 1). The sandy nature of the soil indicated its limited ability to retain water and nutrients unlike soils with large amount of clay or organic matter which tend to have higher tenacity to retain nutrients against leaching. The low silt content of the soil suggests that its agricultural potential could be improved by adoption of appropriate soil management and cropping practice (Uchida, 2000).

The effect of different intra-row spacings on plant height, numbers of branches and stem girth were significant at $P \leq 0.05$ as shown on Table 2. Plant height increased as intra-row spacing were increased with the tallest plants (39.3/81.8cm) at 4 and 6WAS with the highest intra-row spacing (20cm), while plants in 10 cm intra-row spacing were shortest (28.2/42.8cm) at 4 and 6WAS respectively. The tallest plants produced the highest number of branches (13.8) with largest stem girth (1.2cm) and plant in the 10cm intra-row spacing had fewest branches (5.6) which also had smallest stem girth (1.0cm) during the same period. The results is in agreement with the findings of Garjila *et al*., (2020) and Thompson (2021) who reported that the ideal spacing between the rows in your garden provides ample room for your plants to grow for you to work in and encourage large and healthier plants.

Plant leaf growth and expansion increased significantly ($P \leq 0.05$) from plants in 10cm intra-row spacing plots and maximized in plants in plots with the highest intra-row spacing (20cm). Plants in 20cm intra-row spacing produced the longest leaves (4.3cm) and widest leaves (1.3cm) than plants in 10cm intra-row spacing with shortest leaves (1.4cm) and smallest leaves (0.8cm) respectively. This results are also similar to the findings of Idoko *et al*., (2018), Lakew *et al*., (2018) and Garjila *et al*., (2020) who reported increased in intra-row spacing.

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Fresh leaf yield was also influenced by intra-row spacing and like other parameters. It also increased significantly (P≤0.05) with each incremental spacing and maximize at the maximum intra-row spacing. While plants in shorter spacing had the least values for parameter spacing had the least values for the parameter (Table 2). The highest fresh leaf was produced in plots with an intra-row spacing of 20cm (5.8t/ha) followed by 15cm (4.8t/ha) and 10cm with the lowest fresh leaf yield of 3.8 e/ha. This result is in agreement with the findings of Haruna and Abimiku (2012), Eifediyi *et al*. (2018), Lakew *et al*. (2018), Raymond *et al*. (2020) and Garjila *et al*. (2020) who reported highest yield with increased in plant spacing and organic manure.

Table 1: Pre-planting Physico-chemical properties of soil at the experimental site.

Parameter	Soil depth 0 – 15cm
Sand (%)	83.44
Silt (%)	7.35
Clay (%)	11.42
Texture	
pH 1:2.5 (Hz0)	6.32
pH 1:2.5(CaC12)	5.2
Organic carbon (gkg^{-1})	5.41
Total N (gkg^{-1})	3.62
C/N ratio	4.31
Available P (mgkg^{-1})	2.24
Exchangeable Calcium (cmol kg^{-1})	0.53
Exchangeable magnesium (cmol kg^{-1})	1.36
Exchangeable potassium (cmol kg^{-1})	1.53
Exchangeable Sodium (cmol kg^{-1})	0.55
Effective cation exchange capacity (cmol kg^{-1})	5.26

CONCLUSION

Sesamum radiatum (Schum and Thonn) responded differently to intra-row spacing with the highest fresh leaf yield obtained in plots with widest intra-row spacing (20cm) which could be an indication that higher yields may still be possible at wider intra-row spacing than 20cm.

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Table 2: Growth and leaf yield Parameters of Sesamum radiatum Schum as influenced by Poultry Manure and Intra-row Spacing in Kashere, Nigeria.

Treatment	Plant height (cm)		Number of branches	Stem girth (cm)	Leaf length (cm) Leaf width (cm)	Fresh Leaf yield (t/ha)	
	4WAS	6WAS	6WAS	6WAS	Per Plant	Per Plant	t/ha
Intra-row spacing (cm)							
10	28.2	42.8	5.6	1.0	1.4	0.8	3.8
15	33.4	62.1	9.5	1.2	3.2	1.1	4.8
20	39.3	81.8	13.8	1.3	4.3	1.3	5.8
LSD (0.05)	2.41	2.52	2.43	0.05	0.33	0.32	0.46

WAS= Weeks after sowing.

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PLANTING POSITION AND PINCHING INFLUENCE ON GROWTH AND LEAF YIELD OF BITTER LEAF (*VERNONIA AMYGDALINA* DEL.)

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ABSTRACT

Growth and yield responses of bitter leaf to pinching and planting positions were studied at the Teaching and Research Farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Nigeria. The planting positions were horizontal (180˚ to the soil surface), slanting (45˚ to the soil surface) and vertical (90˚ to the soil surface) while pinching levels were pinching and no pinching. The pot experiment was laid out as a 2 x 3 factorial experiment in completely randomized design, replicated eight times. Data on number of leaves, plant height, number of primary branches, fresh and dry leaf yield were collected. Results showed that planting positions and pinching significantly (P<0.05) influenced the growth and yield of bitter leaf. Horizontal planting position enhanced production of tallest plants, widest stems, highest number of leaves and highest fresh leaf yield (2.35 t/ha) whereas the slanting method resulted in lowest fresh leaf yield (1.55 t/ha). Expectedly, shorter plants were observed in pinched plants but the pinching significantly (P<0.05) promoted production of higher number of leaves and fresh leaf yield (2.43 t/ha) than the unpinched plants (2.20 t/ha) particularly when horizontal planting position was used. Horizontal planting position and pinching of bitter leaf was therefore recommended to be adopted by bitter leaf farmers in the study area for higher fresh leaf yield.

Key words: *Vernonia amygdalina*, planting orientation, pinching, tipping, leaves, yield.

INTRODUCTION

Vernonia amygdalina, commonly known as bitter leaf, because of the bitter taste of the leaves, have valuable nutritional and medicinal qualities owing to many phytochemicals found in the plant. It contains significant quantities of lipids (Ejoh *et al*., 2007), proteins with essential amino acids (Igile *et al*., 1994). It also contains carbohydrates (Eleyinmi *et al*., 2008) and carotenoids, though not in large quantities (Udensi *et al*., 2002). The leaves also contain essential elements such as calcium, iron, protein, potassium, phosphorus, manganese, copper and cobalt (Bonsi *et al*., 1995). The plant leaves can be used for flavouring, seasoning and garnishing of foods (Fayemi, 1999). The plant has been shown to be anti-helminths, blood purifier, anti-laxative and anti-malarial. It is also used by scientists in curing joint pains associated with diabetes, persistent headache, fever reduction and a host of others (Momoh *et al.,* 2010). The roots are used for treatment of gastro-intestinal problems, malaria, toothache, and fertility problems. The aqueous leaf extract in combination with *Azadirachta indica* leaf extract was reported to be the best cure for type 2 diabetes in Nigeria (Eyong *et al*., 2011).

In Nigeria, the leaves of bitter leaf are squeezed severally to remove the bitter taste and thereafter utilized to prepare bitter leaf soup. Bitter leaf soup is a common soup in Nigeria and a special delicacy in Anambra state, Nigeria hence, the plant is found virtually in all households in the state. The major commercial bitter leaf farmers exist within Nimo and Oraukwu communities in Njikoka Local Government Area of Anambra state. The commonest planting material for bitter leaf is the stem cuttings which are planted at different orientations namely slanting (at an angle to the soil surface) and vertical (upright in vertical position). Despite the economic importance of bitter leaf, there is lack of documented information on the appropriate planting position for optimum productivity of bitter leaf. According to Legese *et al*. (2011), the root yield of cassava was significantly influenced by planting position of the stem cuttings. In another study, Amponsah *et al*. (2017) reported significant variation in yield and root tuber breakage of cassava as well as field capacity of improved manual cassava harvesting tool. Research on planting position of bitter leaf stem cutting could give relevant information to the farmers as regards the best planting position for optimum growth and productivity of bitter leaf.

On the other hand, Ndukwe and Baiyeri (2018) had opined that pinching is one of the methods for re-direction of photo-assimilate to the needed part of the plant since manipulation of source-sink relationship serves as one of the sustainable strategies to increase crop yield. Pinching, a horticultural operation, is the removal of the terminal growing end of a plant resulting in the promotion of branching and more leaf production by counteracting the effect of apical dominance. Since bitter leaf is a leafy vegetable, more leaf production and yield may be improved with pinching. Hence, the aim of this study was to determine influence of planting position and pinching on growth and leaf yield of bitter leaf.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the Teaching and Research Farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka, Nigeria. Awka is a tropical rain forest with an average temperature of 27^0C - 30^0C. The area is located between latitude 06^0 15'N and longitude 07^0 08'E, with an average rainfall of 1810.3 mm per annum and a relative humidity of 75-80%.

Composition, Composting and Potting of Growing Media

The media comprised top soil and poultry manure (3:1 volume/ volume) which was mixed and composted for 6 weeks. Thereafter, the media was potted in perforated 7 liter growing pots. The average weight of the media in the pots was 10kg. The pots were placed 1m x 1m apart.

Source of Planting Material and Treatments

The planting material was stem cuttings of bitter leaf which were collected from bitter leaf plants growing at the teaching and research farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka. The stem cuttings were cut at 15 cm long consisting of about 7-10 nodes.

Treatments and Experimental Design

During planting, three planting positions were used namely horizontal, vertical and slanting. In horizontal planting, the stem cuttings were totally buried at the depth of 5 cm while in vertical planting, stem cuttings were inserted into the media vertically (90°) with 2-3 nodes of the cuttings underground while the remaining nodes were above ground. But in slant planting, the cuttings were inserted into the media in a slanting position (45° to the top of the media) with 3-4 nodes remaining underground while the rest of the nodes were above the media surface. On the other hand, some plants were pinched at one month after planting while none pinched plant represented the control. These factors were combined and laid as 3 x 2 factorial experiment in a complete randomized design (CRD) with eight replications.

Cultural practices

Weeding was done manually with hand and hoe. Irrigation water (1.5 litres) was daily applied during the dry season. At the establishment of rain, the pots were left for rain fed.

Data collection

Data collected during the experiment were growth and leaf yield of *Vernonia amygdalina*. Data on growth included, number of branches and height of tallest branch (measured from the soil level to the point of attachment of the last leaf on the shoot obtained with the aid of flexible meter tape in centimeter), stem girth of tallest branch (measured with the aid of a digital center caliper at 10cm above soil level) and number of leaves obtained from counting. Fresh leaves were harvested at monthly interval and weighed. The fresh leaves harvested were oven-dried in a laboratory oven at 70°C until a constant weight was obtain as the leaf dry weight.

Data analysis

The data collected were subjected to statistically analysis using analysis of variance for factorial experiment in completely randomized design with the aid of GENSTAT software package (GENSTAT, 2012). Least significant difference at 5% level of significance was used to detect significant treatment means.

RESULTS

Effect of planting position on plant height and number of leaves of bitter leaf before pinching

Planting position significantly ($P<0.05$) influenced growth attributes of bitter leaf at 7 and 9 weeks after planting (WAP), before pruning the plants (Table 1). Tallest plants and highest number of leaves were recorded in shoots emerged from horizontal stem planting. At 7 WAP, planting the stem cuttings in vertical position resulted in producing shortest plants and least number of leaves. But at 9 WAP, shortest plants and least number of leaves were recorded in shoots that emerged from stems planted in slanting position.

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Table 1: Growth response of bitter leaf as influenced by planting position before pruning

	7 WAP			9 WAP		
Planting position	Plant height (cm)	Stem girth (mm)	Total no. of leaves	Plant height (cm)	Stem girth (mm)	Total no. of leaves
Horizontal	10.48	9.07	33.0	16.42	12.47	19.25
Slanting	8.63	7.31	31.5	9.01	12.00	14.28
Vertical	6.50	8.91	22.3	12.21	12.75	16.41
LSD0.05	2.57	1.34	8.40	3.27	Ns	2.53

Effect of planting position and pinching on plant height of bitter leaf

Plant height after pruning indicated significant ($P<0.05$) variation as a result of planting positions and pinching as well as their interactions (Table 2). Main effects revealed that horizontal planting could produce tallest plants. Expectedly, plants that were not pinched also produced taller plants than pinched plants. The interaction of planting position and pinching showed that planting the stems horizontally without pinching produced tallest plants although the mean values were significantly at par with the values recorded with vertical planting without pinching, in all the sampling periods.

Table 2: Main effect and interaction effect of planting position and pinching on plant height of bitter leaf

	Weeks after planting							
	11	13	15	17	19	21	23	25
Planting position (PM)								
Horizontal	25.63	34.48	46.64	52.00	55.44	56.51	59.77	62.65
Slanting	15.47	19.53	27.27	34.70	38.05	38.02	42.06	45.55
Vertical	20.89	25.35	38.59	43.90	50.77	50.77	54.41	57.91
$LSD_{0.05}$	3.52	3.46	4.59	5.15	4.86	4.82	4.75	4.82
Pinching (P)								
No Pinching	22.04	29.26	40.35	47.00	52.61	52.61	56.29	59.64
Pinching	19.28	23.66	34.65	40.00	43.56	44.25	47.87	51.11
$LSD_{0.05}$	2.87	2.82	3.75	4.20	3.97	3.93	3.88	3.93
PM + P Interaction								
Horizontal + No Pinching	26.42	37.97	48.67	55.00	59.10	59.10	62.42	65.47
Horizontal + Pinching	24.85	31.00	44.62	49.00	51.78	53.91	57.12	59.83
Slanting + No Pinching	15.31	19.29	30.79	39.20	42.53	42.53	46.80	50.34
Slanting + Pinching	15.62	19.78	23.75	30.10	33.57	33.51	37.33	40.76
Vertical + No Pinching	24.40	30.15	41.59	46.80	56.21	56.21	59.65	63.10
Vertical + Pinching	17.37	20.19	35.59	40.90	45.32	45.32	49.16	52.73
$LSD_{0.05}$	4.97	4.89	6.49	7.28	6.88	6.81	6.72	ns 6.81

Effect of planting position and pinching on number of leaves of bitter leaf

Number of leaves was significantly ($P<0.05$) influenced by planting positions, pinching and the interaction (Table 3). Highest number of leaves was recorded in shoots that emerged from either horizontal or vertical planting positions. Pinching the plants resulted in higher number of leaves than the no pinched plants especially at 19, 21, 23 and 25 WAP. Similarly, the combined effect of planting position and pinching significantly ($P<0.05$)

recorded highest number of leaves for pinched plants which emerged from horizontal planting.

Table 3: Main and interaction effects of planting position and pinching on number of leaves of bitter leaf

	Weeks after planting							
	11	13	15	17	19	21	23	25
Planting position								
Horizontal	11.0	18.6	33.8	-	32.9	33.1	35.7	52.4
Slanting	11.7	15.2	18.4	-	17.7	17.7	21.7	34.1
Vertical	13.0	18.2	23.4	-	23.2	23.2	31.7	42.5
LSD 0.05	ns	ns	5.89	-	8.63	8.63	6.88	7.45
Pinching								
No Pinching	15.7	18.9	23.7	-	22.7	22.7	23.8	37.2
Pinching	8.1	15.8	26.7	-	26.4	26.6	35.5	48.9
LSD 0.05	5.19	ns	Ns	-	7.05	ns	5.62	6.08
PM + P Interaction								
Horizontal + No Pinching	15.2	16.3	31.8	-	32.5	32.5	29.3	46.3
Horizontal + Pinching	6.9	20.8	35.7	-	33.3	33.8	42.0	58.4
Slanting + No Pinching	14.6	17.6	18.9	-	13.6	13.6	19.0	30.3
Slanting + Pinching	8.8	12.9	18.0	-	21.8	21.8	24.3	38.0
Vertical + No Pinching	17.5	22.7	20.3	-	22.2	22.2	23.2	34.8
Vertical + Pinching	8.5	13.8	26.4	-	24.3	24.2	40.3	50.2
$LSD_{0.05}$	ns	ns	8.3	-	Ns	ns	9.7	10.5

Effect of planting position and pinching on leaf yield of bitter leaf

Table 4 shows the combined effect of planting position and pinching on fresh and dry leaf weight of bitter leaf. There was significant interaction effect on both fresh and dry leaf yield. Horizontal planting of stem cuttings and pinching of shoots resulted in the production of significantly ($p<0.05$) heaviest fresh and dry leaves at every harvest. However, the mean values obtained were statistically at par with mean values recorded for yields from plants that developed from horizontal stem cuttings without pinching. The lowest leaf yield was produced by plants developed from planting position with or without pinching. Although harvest index was not influenced by planting position or pinching but the value ranged from 55.5 to 72.3%.

Table 4: Main and interaction effects of planting positions and pinching on fresh and dry weights of bitter leaf

	Leaf fresh weight (g/plant)		Leaf dry weight (g/plant)				
	11WAP	18WAP	11WAP	18WAP	Leaf Area at 19WAP	Total leaf yield (t/ha)	Harvest index (%)
Planting position (PM)							
Horizontal	19.11	48.3	4.77	23.3	90.2	2.31	63.0
Slanting	7.88	25.9	2.51	12.8	59.8	1.66	62.7
Vertical	12.70	39.5	3.26	18.5	79.6	1.58	59.2
LSD0.05	3.80	14.03	1.06	7.80	15.8	0.43	ns

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Pinching (P)							
No pinching	13.27	35.2	3.37	16.1	78.0	1.91	58.5
Pinching	13.19	40.6	3.67	20.3	75.0	1.80	64.8
LSD0.05	ns	ns	Ns	ns	Ns	ns	ns
PM + P Interaction							
Horizontal + No Pinching	17.54	43.2	4.30	19.9	83.9	2.20	59.6
Horizontal + Pinching	20.68	53.3	5.25	26.8	96.4	2.43	66.5
Slanting + No Pinching	8.36	27.3	2.80	13.1	68.9	1.99	53.2
Slanting + Pinching	7.40	24.5	2.23	12.5	50.6	1.33	72.3
Vertical + No Pinching	13.90	35.0	3.00	15.3	81.2	1.53	62.8
Vertical + Pinching	11.50	43.9	3.53	21.7	77.9	1.63	55.5
$LSD_{0.05}$	5.38	11.46	ns 1.50	11.0	22.4	0.60	ns

Effect of planting position and pinching on shoot and root yield of bitter leaf

Fresh root weight and number of roots were significantly (P<0.05) highest for horizontal planting followed by vertical planting although the mean value was statistical similar with slant planting (Table 5). Pinching resulted in producing heavier secondary branches than no pinching. Interaction of planting position and pinching indicated that fresh weight of secondary branches and number of roots were significantly highest in pinched and unpinched plants developed from horizontal planting of stems, respectively.

Table 5: Effect of planting position and pinching on growth parameters at destructive sampling

	Fresh shoot weight (g)	Fresh weight of secondary branch (g)	Fresh root weight (g)	No. of roots	Length of tallest root	Diameter of tallest root (mm)
Planting position (PM)						
Horizontal	67.2	27.8	110.4	111.6	47.6	12.6
Slanting	50.2	8.6	81.3	63.4	66.5	11.2
Vertical	54.5	17.3	81.7	64.8	60.3	12.7
LSD0.05	Ns	Ns	26.8	24.6	Ns	ns
Pinching (P)						
No pinching	65.7	1.6	86.5	82.0	56.3	12.8
Pinching	48.9	34.2	95.7	77.9	60.0	11.6
LSD0.05	Ns	17.3	ns	Ns	Ns	ns
PM + P Interaction						
Horizontal + No Pinching	75.1	0	97.3	118.0	42.5	12.8
Horizontal + Pinching	59.4	55.7	123.5	105.2	52.8	12.4
Slanting + No Pinching	66.5	0	80.4	58.7	74.0	11.5
Slanting + Pinching	33.8	17.2	82.1	68.1	59.1	10.8

Vertical + No Pinching	55.5	4.7	81.8	69.2	52.3	14.0
Vertical + Pinching	53.5	29.9	81.5	60.4	68.2	11.5
$LSD_{0.05}$	Ns	29.9	ns	34.8	Ns	ns

DISCUSSION

The result of this study showed that planting position and pinching can influence the growth and yield of bitter leaf. Horizontal planting of the stem cuttings produced tallest plants, highest number of leaves, branches and highest fresh leaf yield compared to other planting positions. More roots must have developed from stem cuttings planted horizontally since they were totally buried in the soil (Abdullahi *et al*., 2014). Covering the entire stem cutting with soil (earth), must have exposed the stem cuttings to having more energy storage for a higher growth and development. However, pinching of the apical part of the stem cuttings also can affect the performance of bitter leaf in terms of branching and subsequently, number of leaves. In this study, it was recorded that no pinching of the apical part of the bitter leaf performed less when compared to pinching. Removing the apical part actually induced or facilitated stem branching which led to subsequent increase in the number of leaves, the primary target of most farmers. Where the farmer intends to plant for the purpose of producing stem cuttings, it showed that pinching can significantly increase the stem yield by producing more branching. According to Singh *et al*. (2017), pinching is commonly undertaken to promote branching and bushy growth of the canopy by counteracting the effects of apical dominance. It was also observed that pinching enhanced spread of the canopy due to branching in contrast to no pinching. Pinching significantly increased branching, number of leaves which automatically created a shade hence can also suppress growth of weed and their comparative competition for nutrient, water, air and light.

CONCLUSION

The study showed the importance of manipulating plants with horticultural strategy for better performance in terms of growth, development and more especially yield. Therefore, horizontal planting position and pinching of plants was recommended to be adopted by bitter leaf farmers in Awka.

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EFFECT OF SPACING AND PLANTING METHOD ON GROWTH AND YIELD OF RADISH (*RAPHANUS SATIVUS*) AT KADAWA, KANO STATE

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ABSTRACT

A field experiment was conducted at National Horticultural Research Institute Research Farm at Kadawa during 2020 dry season, to study effect of spacing and planting pattern on growth and yield of radish (*Raphanus sativus*). Three spacings (10cm, 15cm, and 20cm) and two planting patterns (Direct sowing and transplanting) were investigated. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replicates. The results showed that there was no significant difference for all studied traits among the treatments interactions. However, seeds directly planted in the field at the spacing of 10cm revealed high number of leaves per plant, tall plants, leaf length per plant, thicker tuber and long tuber while heavy tuber weight per plant was recorded for transplanting at spacing 20cm. Based on the results of this study, it suggested that transplanting at the spacing of 20cm provides high tuber yield of radish.

Key words: Radish, Spacing, Growth, Planting Method, Tuber Yield

INTRODUCTION

Radish (*Raphanus sativus*) belongs to the family brassicaceae that was domesticated in Asia in pre-roman times. Radish being mostly eaten raw as crunchy salad and edible root vegetable (Annon, 2007). Radish is very rich in nutrients such as minerals, vitamins, folic acid, antioxidants, antimicrobial, antibacterial and anthocyanin. It also has the capacity to treat skin ailments like dry skin. Drinking radish juice helps to clean the kidneys and also treats urinary health issues, taking radish help to treat cancer; it is good options for those who wish to lose weight to be eaten radish. Some of the factors responsible for reduced growth and lower yield of most vegetable crops including radish are cultural practices such as proper timing of dates of sowing, and appropriate plant population to be used for raising vegetable crops in order to get higher production of good quality vegetables. However, growth and tuber yield of radish depends on good agronomic practices, including spacing and planting method. Lavanya et al. (2014) reported high root yield for 45x10cm, while El-Desuki et al. recorded maximum plant height and root yield of radish at 10x20cm. There is little information regarding spacing and plant methods of radish in Sudan Savannah. Therefore, the experiment was conducted to determine effect of spacing and planting method on growth and yield of radish.

MATERIALS AND METHODS

The research was conducted at National Horticulture Research farm Kadawa. The Experiment was undertaken in a randomized complete block design (RCBD) and replicated three times with an alley of 0.5m between plots. Plot sizes consist of 6 ridges 0. 75m apart of 3m. The treatments consist of planting method (direct sowing and transplanting) and spacing (10cm, 15cm and 20cm) which were randomly allocated to the plots. Weeding was conducted manually using local hoe at 3 and 6 weeks after sowing and later supplemented with earthen up to support the crops rooting. Data were taken on number of leaves, plant height, leaves length, leave width, canopy spread, tuber length, tuber diameter and tuber weight. Harvesting was done manually after the tubers were matured. The data were analyzed using STAR software 2.0.1 (2014).

RESULTS AND DISCUSSION

The results indicate the effect of spacing and planting method on plant height, number of leaves per plant, leaf length per plant, leaf width per plant and canopy spread per plant at Kadawa farm (Table 1). The results revealed non-significant difference for spacing and planting method interaction of the studied traits. Spacing of 10cm sowed directly on the field recorded high number of leaves (24.82) followed by spacing of 15cm (18.71). Minimum number of leaves per plant were observed at 20cm transplanted. Lavanya *et al.* (2014) reported high number of number of leaves per plant at 10cm spacing. This result agreed with the finding of Pervez et al., 2004. The results also revealed that, spacing at 10cm under direct sowing and transplanting recorded taller plants of 26.10 and 25.82cm, respectively, which were significantly higher than 15cm and 20cm spacing. Transplanting at the spacing of 10cm recorded long leaf length (28.47cm) followed by direct planting (19.86cm) at the same spacing, while shorter leaf length (11.92cm) was noticed under transplanting at 20cm spacing. Both 20cm and 10cm spacings at direct sowing showed wide leaf width per plant compared to transplanting with values of 14.85cm and 10.62cm. It observed that at 10cm and 15cm spacings direct sowing and transplanting, recorded wider spread of leaves of 32.76cm and 30.82, respectively; than the other spacings. Spacing of 20cm and 15cm at direct sowing showed thicker tubers with values of 57.22mm and 46.79mm, respectively; which were significantly better compared to the values recorded under transplanting method. Thicker tuber (40.09mm) was also recorded at spacing of 10cm under transplanting method. Direct sowing and transplanting at both 15cm and 20cm revealed longer tuber per plant. These results for thicker and long tubers were due to wide space for the tuber development and minimum competition for nutrients, sunlight and water. The results for tuber weight per plant, showed no significant differences treatments interaction, however, transplanting recorded high yield for tuber per plant for 20cm and 10cm spacings than direct sowing. The results corroborated with findings of Pervez *et al*., 2004, Brintha and Seran, 2009, and Lavanya *et al.* (2014).

CONCLUSIONS

Based on the results of this study, it suggested that transplanting at the spacing of 20cm provides high tuber yield of radish.

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Table 1: Effect of spacing and planting method on growth of Radish at Bagauda during 2020.

	NLPP		PHT (cm)		LLPP (cm)		LWPP (cm)		CNSPP (cm)		TD (mm)	
	Planting Method		Planting Method		Planting Method		Planting Method		Planting Method		Planting Method	
Spacing	Direct	Transplant	Direct	Transplant	Direct	Transplant	Direct	Transplant	Direct	Transplant	Direct	Transplant
10cm	24.82	17.30	26.10	25.82	19.86	28.47	10.62	8.95	32.76	30.82	33.05	40.09
15cm	18.71	9.69	20.32	20.48	16.44	16.41	14.85	7.39	29.18	25.18	46.79	28.21
20cm	15.94	11.85	21.12	23.46	12.78	11.92	6.55	7.09	27.47	25.78	57.22	34.31
Mean	16.39		22.88		17.65		9.24		28.53		39.95	
CV (%)	46.99		37.15		53.71		57.46		31.46		25.35	
SE±	6.29		6.94		7.74		4.34		7.33		8.27	
Interaction	NS		NS		NS		NS		NS		NS	

NLPP = Number of leaves per plant, PHT = Plant height, LLPP = Leaf length per plant, LWPP = Leaf width per plant and CNSPP = Canopy spread per plant, and TD = Tuber diameter

Table 1 continued

	TL (cm)		TWPP (Kg)	
	Planting Method		Planting Method	
Spacing	Direct	Transplant	Direct	Transplant
10cm	20.41	18.99	0.16	0.31
15cm	24.18	21.92	0.28	0.24
20cm	22.80	20.333	0.32	0.41
Mean	21.44		0.29	
CV (%)	22.45		81.54	
SE±	3.93		0.19	
Interaction				

TD = Tuber diameter per plant, TL= Tuber length per plant and TWPP = Tuber per plant

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GROWTH AND YIELD OF SOME PEPPER LINES DURING EARLY CROPPING SEASON IN RAINFOREST AGRO-ECOLOGICAL ZONE OF NIGERIA

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ABSTRACT

Pepper production in rainforest agro-ecology of Nigeria is still short of what is demanded due to growing of unknown sources of seeds and for our local pepper farmer in the study area to have a distinct pepper line, there was need to have new varieties or lines with higher yields, superior quality and pest's resistance evaluated. Therefore, this study was designed to evaluate the growth and yield of some selected pepper line during early cropping season. The field trial was conducted during early cropping season of 2020 in rainforest agro-ecology of Nigeria. The trial was laid out as randomized complete block design and replicated thrice. Treatments consisted of 30 pepper lines. Data collected on growth and yield attributes of pepper lines were subjected to analysis of variance and significant means were separated using Least Significant Difference at P≤0.05. General growth and yield characters in the pepper lines varied significantly during the early cropping season. Pepper line SP103 (T2) recorded the highest yield follow by NCHF IRB (T4); SP 103 (T10) and NHCC RD5 (T6). These lines should also be used for further breeding and physiological studies.

Key words: Pepper lines, Yield, Rainforest agro-ecological zone.

INTRODUCTION

Pepper is one of the most important vegetable crops in the world. In 2018 the total cultivated area under pepper in Ethiopia was 8001 hectares with a production quantity of 4889 tons (FAOSTAT, 2018). There are twenty-five wild and five domesticated species of pepper belonging to the genus *Capsicum* (Bosland and Votava, 2000). There is the general believe that Central and South Americas are the original centers of pepper (*Capsicum* spp.). Exclusively, chili and sweet pepper (*Capsicum annum*) are from Mexico while aromatic hot pepper (*Capsicum chinense*) is from the Amazonian region and Bird pepper (*Capsicum frutescens*), the coastal regions of the southern part of tropical South America. *Capsicum annuum*, *Capsicum frutescence* and *Capsicum chinense* in tropical Africa are treated as a single species, *Capsicum annuum* (Purseglove *et al*., 1981; Grubben *et al*., 2004). Grubben *et al*. (2004) classified *Capsicum annum* into four cultivar-groups namely: Sweet pepper, chili, bird pepper and aromatic pepper. Pepper fruits may be used as a vegetable, spice and coloring as well as for medicinal purposes (Sana, 2003). The fruit which is eaten either in the fresh or processed form has high vitamin and mineral contents (Burton and Foster, 1988; Yayock *et al*., 1988).

However, in the study areas farmers used to grow unknown sources of seeds and for our local pepper farmer to have a distinct pepper line, there was the need to have new varieties or lines with higher yields, superior quality and pest's resistance evaluated. Thus, the objective of this study was to evaluate the growth and yield of some selected pepper line during early cropping season.

MATERIAL AND METHODS

The field trial was carried during early cropping season (March - August 2020) at block 3 Vegetable Research Field of the National Horticultural Research Institute (NIHORT), Ibadan (Latitude 7° 22' N and Longitude 3° 50' E at 234m above sea level), located in the forest agro-ecological zone of Nigeria. The experimental site had been under continuous cultivation for many years.

Nursery Preparation: Top soil was collected and sterilized by heating to 100^0C in a metal drum and was allowed to cool. The sterilized soil was filled into nursery trays after which seeds of pepper lines were sown. Regular watering and monitoring was carried out in the nursery for five weeks. Experimental Design and Treatments Application: The trial was laid out as randomized complete block design (RCBD). The treatments consisted of 30 pepper lines namely; T1= HP75, T2= SP103, T3=P_1/9, T4=NCHF IRB, T5= P4/5, T6= NHCC RD5, T7= NHCC RD4, T10= SP 103, T11= P_1/4, T12= NHCC RD6, T13= NHCC RD2, T16= SP 167, T17= SP 103 POLL A13, T20= P3/1, T25=NHCC RD_3.

Field Establishment: The land was ploughed and left for two weeks to allow buried weeds to decay and reploughed followed by harrowing. Pepper seedlings were transplanted at 5 weeks after sowing (WAS) at the spacing of 50 cm x 50 cm. The plot size was 2 m x 2 m, alley of 1.0 m within plots and 1.0 m between replicates.

Cultural Management Practices: At 3 weeks after transplanting, NPK 20-10-10 fertilizer was applied at rate of 5g /plant. Weeds were controlled using hand hoeing at 3weeks interval during the rainy while weeding was carried at 4 weeks' interval during the dry season. Neem biopesticide was applied to control the fungi infection.

Data Collection: The following data were collected from five (5) randomly selected tagged plants within the plot for growth and yield attributes; Plant height, Stem Girth, Number of leaves, Number of branches, number of fruit per plant and average fruit weight ton/ha.

RESULTS AND DISCUSSION

Raining season

Effects of growth parameters on pepper lines are presented in Table 1. The result had no significant effect on the plant growth. The highest plant height of 12.58cm was observed from P4/5 line (T5) while the least plant height of 1.50cm was recorded from SP 167(T16). Pepper line of P4/5(T5) had the highest number of leaves (20 leaves) while the least number of leave (1.67) was gotten from NHCC RD_3 (T25) (Table 1). There were no significant differences among the stem girth of the tagged plants but NHCC RD4 (T7) gave the highest value of 0.73cm at 2WAT while SP 103 POLL A13 (T17) recorded the lowest at 0.00, similar result was obtained at 4WAT where P4/5(T5) had the highest at 2.31cm and SP 167 (T16) gave the lowest at 0.47cm. With regards to relationship between plant height and stem girth, our study agrees with work done by Rudall (1994) which stated that increase in height is often accompanied by a corresponding increase in stem thickness. Furthermore, there were also no significant differences among branches but SP103 (T2) had the highest at 5.33 while there were four pepper lines which gave lowest value at 0.00 and they are NCHF (T4), NHCC RD4 (T7), SP 167(T16) and SP 103 POLL A13 (T17) respectively. The variation in the growth parameters among the pepper lines may be attributed to their genetic potential as well as environmental factors. In table 2, there were significant variation in the yield attributes among the pepper lines. P_1/9(T3) had the highest value for number of fruit/plant at the average of 20.67 while SP 103 POLL A13 (T17) had the lowest average value of 1.33. The highest fruit yield of 5.15 ton/ha, was recorded from SP103 (T2) which was significantly varied among the pepper lines while P3/1 (T20) had the lowest yield of 0.15 ton/ha. The significant differences in fruit yield in the pepper lines as found in this study agrees with the findings of other studies (Izge *et al*., 2007; Hassan Wasiullah *et al*., 2003; Hassan *et al*., 2001; Sana *et al*., 2003; Khoshnazar *et al*., 2000) who reported similar differences in other crops as a result of genetic and environmental factors. In conclusion, growth and yield characters in the pepper lines varied significantly during the early cropping season. Pepper line SP103 (T2) recorded the highest yield follow by NCHF IRB (T4); SP 103 (T10) and NHCC RD5 (T6). These lines should also be used for further breeding and physiological studies.

Table 1: Effect of growth parameter on pepper lines during early cropping season

Treatment	Plant height	Plant height	Number of Leaf	Number of Leaf	Stem girth	Stem girth	Number of branches
	2WAT	4WAT	2WAT	4WAT	2WAT	4WAT	4WAT
T1	6.17	9.75	1.67	8.17	0.40	1.92	3.33
T2	4.67	6.83	6.67	14.50	0.38	1.45	5.33
T3	8.33	9.33	2.33	11.33	0.33	1.63	1.33
T4	5.83	12.42	2.00	8.83	0.30	1.34	0.00
T5	8.08	12.58	9.33	20.00	0.70	2.31	2.33
T6	6.00	6.83	4.17	8.50	0.68	2.29	2.33
T7	7.25	9.25	3.17	9.50	0.73	2.06	0.00
T10	5.17	10.75	3.33	19.00	0.50	2.12	1.33
T11	7.50	9.58	6.00	15.33	0.60	1.99	1.50
T12	2.67	8.08	2.17	8.50	0.37	1.59	4.67
T13	3.75	5.75	4.00	4.00	0.72	1.68	3.00
T16	1.17	1.50	1.17	2.00	0.23	0.47	0.00

T17	0.00	11.25	0.00	10.50	0.00	1.68	0.00
T20	6.83	9.88	1.83	8.50	0.57	2.09	1.17
T25	2.00	6.33	1.06	1.67	0.33	1.06	1.17
L.S.D	7.13	7.13	6.25	13.39	0.81	2.32	3.85
SIG	Ns	Ns	NS	Ns	Ns	Ns	Ns

T1= HP75, T2= SP103, T3=P_1/9, T4=NCHF IRB, T5= P4/5, T6= NHCC RD5, T7= NHCC RD4, T10= SP 103, T11= P_1/4, T12= NHCC RD6, T13= NHCC RD2, T16= SP 167, T17= SP 103 POLL A13, T20= P3/1, T25=NHCC RD_3.

Table 2: Effect of yield attributes on pepper varieties during the early cropping season

Treatment	Number of fruit/Plant	Average fruit weight ton/ha
T1	13	2.33
T2	20.67	5.15
T3	10.67	2.73
T4	15.33	5.04
T5	7	1.55
T6	10.67	3.37
T7	11	1.66
T10	18	3.5
T11	5.33	1.61
T12	11.67	2.83
T13	5.33	2.45
T16	3	0.48
T17	1.33	0.27
T20	2	0.15
T25	3	0.83
L.S.D.	9.56	2.97
Sig.	**	*

T1= HP75, T2= SP103, T3=P_1/9, T4=NCHF IRB, T5= P4/5, T6= NHCC RD5, T7= NHCC RD4, T10= SP 103, T11= P_1/4, T12= NHCC RD6, T13= NHCC RD2, T16= SP 167, T17= SP 103 POLL A13, T20= P3/1, T25=NHCC RD_3.

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GROWTH AND YIELD EVALUATION OF EIGHT ACCESSIONS OF BITTER LEAF (*VERNONIA AMYGDALINA* DEL.) IN A HUMID TROPICAL ZONE

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ABSTRACT

A field experiment was conducted to evaluate the growth and yield of eight accessions of bitter leaf (Abatete, Akpu, Ifite-Awka, Mbaukwu, Nimo, Nkpologu, Oraifite and Ukpo) in Anambra State, Nigeria. The experimental design was Randomized Complete Block Design replicated ten times. Growth data collected were number of branches, number of leaves, plant height, and stem girth and leaf area at two weeks' interval. The yield data were fresh weight of leaves and total leaf yield. Ukpo, Akpu and Oraifite significantly (P<0.05) produced tallest plants (113.7, 113.1 and 107.8cm, respectively), Highest number of leaves (168, 123.2 and 109.7, respectively), widest stems (15.97, 15.90 and 15.05mm respectively), highest number of branches (3.85, 3.73 and 3.71 respectively) and total fresh leaf yield (4.07, 3.36 and 2.08t/ha respectively). Results obtained from the study indicated that Ukpo, Akpu and Oraifite accessions should be given the highest consideration when setting up a bitter leaf farm in Awka. More studies need to be embarked on to determine the genetic variability of these accessions, so as to give more insight on the various nutritional, pharmaceuticals and other potentials of these bitter leaf accessions.

Key words: *Vernonia amygdalina,* accessions, yield, biomass, leaf

INTRODUCTION

Vernonia amygdalina, also known as bitter-leaf, is a tropical African shrub or small tree that is also widely dispersed in Asia (Oseni and Babatunde, 2016). It belongs to the Asteraceae or Compositae family. Bitter leaf is a drought-resistant plant that thrives in humid conditions. It is widely grown in Benin, Nigeria, Cameroon, Gabon, and the Democratic Republic of Congo, as well as to a smaller extent in adjacent countries (Ijeh and Ejike, 2011). Bitter leaf is used for more than just cooking. Malaria, infertility, diabetes, gastrointestinal issues, and sexually transmitted diseases are all traditionally treated with bitter leaf in Africa (Farombi and Owoeye, 2011). According to Eyong *et al*. (2011), the best therapy for type-2 diabetes in Nigeria is aqueous leaf extracts of bitter leaf and *Azadirachhta indica*. In Northern Nigeria, bitter leaf is given to horse feed to make a strengthening or fattening tonic known as "Chusan Dokin" (Hamzah *et al*., 2013). In addition, the roots can be used to treat gastrointestinal issues, malaria, toothaches, and infertility issues (Momoh *et al*., 2010). Although *V. amygdalina* is usually propagated by cutting, the hairy root of *V. amygdalina* can also be grown in vitro using explant cultures and auxin. For its adventitious root induction, IBA (concentrations ranging from 0.25 to 2 mg/l) was determined to be the optimum growth regulator (Khalafalla *et al*., 2009). Accessions can be found in almost every domesticated crop. They are studied in order to pick the highest performing accession to assist a crop thrive. Accessions differ in terms of growth, nutrition, and physiological aspects, indicating variability (Ahiakpa *et al*., 2013). Many morphological variations have been found in bitter leaf identified in Nigeria but there is scarcity of information on morphological differences in bitter leaf even when there are identifiable variations (Field Survey, 2017). Hence, the objective of this study was to evaluate the growth and leaf yield of eight accessions of bitter leaf.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Research Farm of Crop Science and Horticulture, Nnamdi Azikiwe University Awka, Anambra State, Nigeria. The Research Farm is at an altitude of 91m from sea level with latitude and longitude $6^{0}15'$ N and $7^{0}07'$ E respectively. The farm has an average annual rainfall of 1650-2000 mm per annum with a temperature of 27°C-30°C respectively and a relative humidity of 75-80% (GEOMET-NAU, 2019).

Establishment and Planting

The bitter leaf accessions that were evaluated includes Abatete, Ukpo, Akpu, Oraifite, Nkpologu, Ifite, Nimo and Mbaukwu. Stem cuttings of these accessions were collected from plots of farmers in the different communities. Stem cuttings of length 1 meter each were collected from 3 farmers' plots per community. These cuttings were later cut into smaller-sized stem cuttings of 15cm bearing 3-5 nodes. The 15 cm stem cuttings were planted in a 45^0 slanting position with plant spacing of 50 cm x 50 cm.

Cultural Practices

The plot was cleared from the existing vegetation. Ridges of 7 m long and 1 m width were made. Each of the accessions was planted as a single row plot of 10 plants per ridge. The ten plants represented the replications. Weeding was done at intervals, at least once in a month. Application of 10 t/ha poultry manure at a uniform rate was done at 4 weeks after planting to facilitate growth of leaves and improve vigour. The experimental design was randomized complete block design replicated ten times.

Data Collection

Data were collected from the 5 middle-most plants per ridge or accession. Data collection commenced at 4 weeks after planting which continued at 2 weeks' interval. The growth parameters were plant height of tallest branch (taken by measuring with flexible meter rule vertically from the ground level to the point of attachment of the last two opened leaves at the apex, to the nearest 1 cm), number of branches (obtained by counting the total number of primary branches per plant), stem girth of tallest branch (measured with the aid of a digital vernier caliper at 10 cm above the soil level), and number of leaves (obtained by counting the total number of fully opened green leaves per plant). The leaf yield was obtained by harvesting the fresh leaves at 12 weeks after planting. The fresh leaves were weighed with a digital weighing balance. Thereafter, the fresh leaves were dried to a constant weight with the corresponding determination of the dry leaf weights.

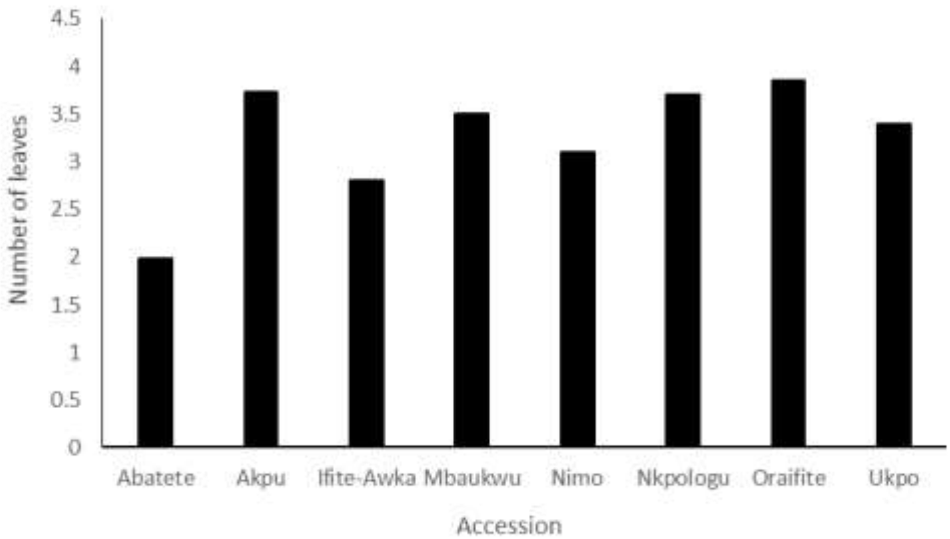
Data Analysis

All the data collected were subjected to analysis of variance following the procedure for randomized complete block design using GENSTAT (2012). Mean separation was done using least significant difference (LSD) at 5% level of probability.

RESULTS

Effect of accession on number of branches of bitter leaf at 4 weeks after planting

Table 1 shows the effect of accession on number of branches of bitter leaf at 4 weeks after planting (WAP). Oraifite accession produced the highest number of branches although the number of branches (3.85) was not significantly ($p > 0.05$) different with the mean number of branches produced by Akpu, Nkpologu, Mbaukwu, Ukpo and Nimo. However, the lowest mean number of branches (1.98) were significantly ($P<0.05$) recorded in Abatete accession.



Effect of accession on plant height (cm) of bitter leaf at 4, 6, 8, 10, 12 weeks after planting

Table 2 shows the effect of accession on the plant height of bitter leaf at 4, 6, 8, 10 and 12 WAP. Tallest plants were significantly ($p>0.05$) recorded in Oraifite, Ukpo and Akpu accessions at 4, 6, 8, 10 and 12 WAP. The shortest plants were significantly produced by Ifite-Awka and Nimo accessions.

There was a remarkable increase in plant height across the accessions at every 2 weeks' interval, although the accessions Ifite-Awka and Nimo showed a slow increase in plant height compared to the other accessions. It was observed that Abatete accession showed a sharp increase in plant height between 8 and 10 weeks after planting.

Table 2: Effect of accession on plant height (cm) of bitter leaf at 4, 6, 8, 10, 12 weeks after planting (WAP)

Accessions	4WAP	6WAP	8WAP	10WAP	12WAP
Abatete	17.3	35.5	42.0	90.8	97.8
Akpu	32.7	69.2	80.4	100.9	107.8
Ifite-Awka	6.7	9.0	10.9	23.7	31.3
Mbaukwu	16.2	36.8	38.9	66.6	74.1
Nimo	9.7	14.5	17.1	36.5	44.6
Nkpologu	16.7	50.5	52.0	84.2	92.4
Oraifite	34.0	72.7	75.0	112.0	113.1
Ukpo	29.3	68.8	72.5	107.9	113.7
$LSD_{0.05}$	7.7	14.8	14.3	18.0	18.0

Effect of accession on stem girth (mm) of bitter leaf at 4. 6, 8, 10 and 12 weeks after planting

Table 3 revealed that the Ukpo accession had widest stems (4.95) at the 4WAP but there was no significance ($p>0.05$) difference from Akpu, Oraifite and Mbaukwu at 4 WAP. Data collected at 6 WAP also showed that Oraifite accession produced the widest stems (10.89). However, the mean values did not significantly ($p>0.05$) vary between Ukpo and Akpu. At 10 and 12 WAP, widest stems were significantly produced by Oraifite, Ukpo, Abatete, Akpu and Nkpologu accessions. At 8 WAP, Akpu accession produced widest stems although the mean value (11.17) did not significantly differ with the mean values (10.99 and 10.41) recorded for Oraifite and Ukpo accessions.

Table 3: Effect of accession on stem girth (mm) of bitter leaf at 4, 6, 8, 10, 12 weeks after planting (WAP)

Accessions	4WAP	6WAP	8WAP	10WAP	12WAP
Abatete	3.20	8.04	8.70	14.07	15.10
Akpu	4.91	10.05	11.17	14.21	15.05
Ifite-Awka	2.50	3.15	3.31	6.37	7.27
Mbaukwu	3.84	8.06	8.12	11.07	12.02
Nimo	2.35	3.95	4.04	7.39	8.27
Nkpologu	2.85	8.88	8.81	13.37	14.22
Oraifite	4.77	10.89	10.99	15.10	15.97
Ukpo	4.95	10.16	10.41	14.96	15.90
$LSD_{0.05}$	1.11	1.94	1.90	2.32	2.30

Effect of accession on number of leaves on the tallest branch of bitter leaf at 4, 6, 8, 10 and 12 weeks after planting

Table 4 shows that the Oraifite accession produced the highest number of (16.38) at 4 WAP which was not significantly different from Akpu and Ukpo accessions. At 6 WAP, the Nkpologu accession produced the highest number of leaves (35.4) but the mean values was not significantly different ($p>0.05$) from Oraifite, Ukpo and Akpu accessions. At 8 WAP Akpu accession recorded highest number of leaves (42.3), although the mean number of leaves was not significantly (p>0.05) different with Ukpo, Nkpologu and Oraifite accessions. At 10 and 12 WAP, Ukpo and Abatete significantly (p<0.05) produced the highest number of leaves (95.7 and 101.0 respectively) while Nimo and Ifite-Awka accessions consistently produced fewer numbers of leaves at 4, 6, 8, 10 and 12 WAP.

Table 4: Effect of accession on number of leaves on the tallest branch of bitter leaf at 4, 6, 8, 10 and 12 weeks after planting(WAP)

Accessions	4WAP	6WAP	8WAP	10WAP	12WAP
Abatete	12.31	21.4	26.5	86.3	90.1
Akpu	15.75	33.9	42.3	64.9	71.9
Ifite-Awka	7.40	8.7	10.9	17.0	24.0
Mbaukwu	13.38	18.9	21.5	40.3	51.5
Nimo	7.60	10.3	13.0	22.1	28.9
Nkpologu	10.60	35.4	38.6	46.3	52.2
Oraifite	16.38	34.3	38.1	71.2	77.9
Ukpo	14.38	35.2	40.3	95.7	101.0
$LSD_{0.05}$	3.265	11.92	13.89	16.57	15.57

Effect of accession on total number of leaves of bitter leaf at 4, 6, 8, 10 and 12 weeks after planting

The total number of leaves significantly (p>0.05) varied among the accessions at 4, 6, 8, 10 and 12 WAP (Table 4.5). At 4 WAP Oraifite and Akpu accessions produced the highest number of leaves (46.3 and 45.6, respectively). At 6 and 8 WAP, Ukpo and Akpu accession recorded highest number of total leaves (62.8 and 71.5, respectively at 6 and 8 WAP). However, these mean total numbers of leaves did not significantly (p>0.05) vary with the mean total number of leaves obtained from Akpu, Oraifite and Nkpologu accessions. Similary, at 10 and 12 WAP, Ukpo accession produced the highest number of total leaves. This was followed by Abatete, Akpu and Oraifite accessions. Nimo and Ifite-Awka accessions consistently recorded least number of total leaves across the period of data collection.

Effects of accession on measured leaf area, total leaf fresh weight and yield of bitter leaf

Measured leaf area was broadest in Ukpo accession (Table 6). However, the mean leaf area (100.7cm^2) for Ukpo accession was not significantly different with the mean measured leaf area recorded for Abatete (95.3cm^2), Mbaukwu (94.7cm^2), Oraifite (96.4cm^2), and Akpu (93.3cm^2). Ifite-Awka and Nimo accessions had narrower leaves than other accessions.

Table 5: Effect of accession on total number of leaves of bitter leaf at 4, 6, 8, 10 and 12 weeks after planting(WAP)

Accessions	4WAP	6WAP	8WAP	10WAP	12WAP
Abatete	20.2	31.6	38.2	115.4	120.5
Akpu	45.6	62.2	77.8	112.5	123.2
Ifite-Awka	15.9	14.3	18.0	28.5	40.8
Mbaukwu	34.3	33.4	38.2	64.7	82.2
Nimo	18.7	17.5	21.7	33.0	45.1
Nkpologu	28.8	52.0	57.2	27.0	31.7
Oraifite	46.3	60.4	66.8	100.1	109.7
Ukpo	33.1	62.8	71.5	157.5	168.0
$LSD_{0.05}$	11.54	18.95	21.28	38.52	39.67

It was observed that the accession Ukpo produced the highest total weight of leaves followed by Oraifite and Akpu (203.4, 173.9 and 167.8 respectively). But total leaf fresh weight was significantly lowest in Ifite-Awka and Nimo accessions. On the other hand, Ukpo and Akpu accessions significantly ($P<0.05$) produced highest fresh leaf yield compared to other accessions while the lowest fresh leaf yield was recorded in Ifite-Awka and Nimo accessions.

Table 7: Effects of accession on measured leaf area, total leaf fresh weight and yield of bitter leaf

Accessions	Measured leaf area (cm^2)	Total leaf fresh weight (g)	Total leaf fresh yield (t/ha)
Abatete	95.3	101.9	2.04
Akpu	95.3	167.8	3.36
Ifite-Awka	46.9	52.8	1.06
Mbaukwu	94.7	136.0	2.72
Nimo	40.0	69.4	1.39
Nkpologu	84.8	99.9	2.00
Oraifite	96.4	173.9	2.08
Ukpo	100.7	203.4	4.07
$LSD_{0.05}$	9.95	48.3	0.97

DISCUSSION

The results of this evaluation demonstrated that the growth and biomass variations in the accessions could be as a result of intrinsic genetic variability. The report of Amoatey *et al*. (2015) indicated genetic variability in 29 okra accessions. Oraifite, Akpu, and Ukpo accessions exhibited high vigour and can quickly adapt to a new habitat. Although agronomic characterization and evaluation are the primary steps in determining genetic diversity, but to assess the real extent diversity of the bitter leaf accessions in Anambra state, agronomic, physiological, biochemical and molecular evaluation and characterization must be done as information on them are not available.

CONCLUSION

From the study, Ukpo, Akpu and Oraifite accessions should be given the highest consideration when setting up a bitter leaf farm within the study area. More studies need to be embarked on to determine the genetic variability of these accessions, so as to give more insight on the various nutritional, pharmaceuticals and other potentials of these bitter leaf accessions.

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ASSESSMENT OF ARABLE PLOT UNDER LONG TIME CASSAVA CULTIVATION FOR COFFEE PRODUCTION IN IWARAJA, OSUN STATE, NIGERIA

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ABSTRACT

An arable land under long term cassava cultivation was assessed for its suitability for Coffee cultivation at Iwaraja in Osun State, Nigeria. The soil samples at both the top and sub-soil levels were analysed for the physical and chemical attributes and it indicated that the site soils had mean gravel content of 38.96% at the top soil and 44.53% at the sub-soil which indicates that the gravel content increased with soil depth. Thus, the site soil is characterized with stones, boulders, pebbles and gravels. The soils were sandy loam with the soil silt + clay contents lower than 32% which indicates need for irrigation during dry spells to support planted coffee seedlings. The soil pH 5.00-7.50 was suitable for coffee cultivation while the organic C of 0.65-2.09 g/kg soil was very low Total Soil N content of 0.06% is low compared with the critical level of 0.1% for coffee. The soil available P of 22.29 mg/kg soil was higher than critical value of 9mg/kg soil. The soils are lower in K and Ca contents but sufficient in Mg content, however, K/Mg ratio of 0.27-0.49 is lower than 2.0 expected. Generally, the soil Mn, Fe, Cu and Zn contents were optimal. The site soil was generally very low in macro-nutrients and most importantly N, which must be outsourced through fertilizer application and majorly, by way of organic manure application in order to build up the soil organic matter content and to achieve optimum growth and establishment of coffee plants.

Key words: Coffee production, fertilizer scarcity, optimal yield, soil management, water supply

INTRODUCTION

Coffee spp. is a crop of economic importance that contributes substantially to the foreign exchange earnings of the producing nations (Tijani *et al.*, 2001; Famaye, *et al.,* 2012). In Nigeria, Coffee is among the vital tree crops of high economic importance with more than 350,000Mt year^{-1} in the 1990's but dropped to less than 200,000Mt year^{-1} in 2006 (Ipinmorot and Ogeh, 2014). Though, coffee remains a big revenue spinner in the world market but Nigeria's production has fallen to less than 60,000 metric tonnes in 2020 (The Nation, 2021) and stakeholders are calling for repositioning of the coffee industry to enable the Nigeria earn more foreign exchange from coffee production. Presently, the Nigerian government is on diversifying the economy from sole dependence on petroleum into agriculture as a business. To this effect, more people are attracted to plantation agriculture, with more new plantations of tree crops and most importantly, coffee, being established. Virgin forests are the most ideal for opening up of tree crop plantations such as coffee. However, due to scarcity of virgin lands or forests and the huge cost of land acquisition, most people are left with the option of establishing their plantation crops on fallowed lands, arable cropped lands and lands supporting old unproductive or moribund plantations (Ipinmoroti, *et al.*, 2005). It is pertinent to note that such lands require being evaluated to know their suitability for sustainable coffee plantation management. This study was carried out to evaluate soils on land under long time cassava production for suitability for coffee cultivation at Iwaraja area, Osun State, Nigeria.

MATERIALS AND METHODS

The site is approximately 4ha and is on a hilly land that is sloppy down to the northeast direction with some shrub tress, scattered oil palms and rock outcrops as common features. Some portion of the site is currently cultivated to cassava on heaps while others were under fallow condition after several years of being used for cassava cultivation, which is an indication of human activities on the land. Soil samples were collected at approximately 25 meters apart along two traverse lines with first traverse at the upper slope and the second traverse at the lower slope. On each traverse line, 4 sampling points were made and at each point, 2 sampling depths, 0-30 and 30-60 cm depths were made, for a total of 16 samples. The collected soil samples were labelled and taken for laboratory processing and analysis. Soil samples were analysed for some physical, chemical and nutrient contents that are relevant to coffee production.

The soil samples were each air dried, sieved through 2 mm sieve and routine physical and chemical analysis carried out. Soil particle size distribution was by hydrometer method, while the soil pH was in soil/water ratio of 1:2.5 and read with pH- electrode Soil Total N was determined by micro-kjeldah method (Bremmer, 1996) and available P was measured by Bray 1 method (Bray and Kurtz, 1949). The organic carbon (OC) was determined by wet dichromate oxidation method (Nelson and Sommers, 1982). The exchangeable bases were extracted by 1N NH_4OAC at pH=7 and the K, Ca and Mg contents were read using atomic absorption spectrophotometer (Tel and Rao, 1982). The soil Zn, Fe, Mn and Cu were determined after extracting the soils with 0.1N HCl and the filtrate read on a Perkin-Elmer AAS (A.O.A.C., 1990).

RESULTS AND DISCUSSION

Soil physical attribute

The site soil samples showed that at 0-30 cm soil depth, gravel content ranged from 27.9-68.9% with mean value of 38.96%, while at depth of 30-60 cm, gravel content ranged from 26.97 – 83.8% with mean value of 44.53% (Table 1). The gravel content therefore increased with soil depth. Thus, the site soil is characterized with stones, pebbles and gravels. The soil textural analysis (Table 2) indicated that the soils of the site were generally sandy loam with more sand compared to the silt and clay contents. Though the clay content increased with soil depth, the soil Silt + clay contents were lower than 32% at the top soil (Table 2). This indicated that the soils will not be able to hold sufficient water for sustainable coffee cropping, especially, during the dry season (Ipinmoroti and Ogeh, 2014). There would be need for irrigation during the dry season. Due to the sloppy nature of the land, there is need for introduction of cover crops to fill the gaps between stands of coffee seedlings to protect the land against agents of erosion. Arable crops like melon, maze, rice, cocoyam and the use of plantain are common on plantation crops under a mixed-cropping system when the main crops are still in the juvenile stage of establishment (Famaye *et. al.*, 2012; Ipinmoroti *et al.*, 2007)

Table 1: Core soil samples stone and gravel contents (gm)

Soil depth	Core sample	Soil	Stone/ gravel	% Stone/ gravel
Upper slope				
T_1 = 0-30	6.95	4.15	2.80	40.30
T_1 = 30-60	5.24	3.15	2.09	39.90
T_2 = 0-30	4.09	2.95	1.14	27.90
T_2 = 30-60	10.86	1.76	9.10	83.80
T_3 = 0-30	10.45	3.25	7,20	68.90
T_3 = 30-60	3.93	2.87	1.06	26.97
T_4 = 0-30	4.03	2.70	1.33	33.00
T_4 = 30-60	5.19	2.93	2.28	43.50
Lower slope				
T_5 = 0-30	3.60	2.54	1.06	29.40
T_5 = 30-60	4.52	2.61	1.91	42.30
T_6 = 0-30	4.19	2.66	1.53	36.50
T_6 = 30-60	4.18	2.43	1.75	41.90
T_7 = 0-30	3.85	2.47	1.38	35.80
T_7 = 30-60	4.57	2.35	2.22	46.60
T_8 = 0-30	3.86	2.32	1.54	39.90
T_8 = 30-60	4.47	3.07	1.40	31.30

T_1 – T_8 = Representative core sampling points

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Table 2: Mechanical analysis and textural class of the site soils

	Soil depth (cm)	Sand(%)	Silt	Clay	Texture
		←	%	→	
Upper slope					
	A_1 = 0-30	75.80	17.40	6.80	Sandy loam
	A_1 = 30-60	57.80	27.40	14.80	Sandy clay loam
	B_2 = 0-30	67.80	27.40	4.80	Sandy loam
	B_2 = 30-60	65.80	25.40	8.80	Sandy loam
Lower slope					
	C_3 = 0-30	77.80	17.40	4.80	Sandy loam
	C_3 = 30-60	63.80	19.40	16.80	Sandy clay loam
	D_4 = 0-30	79.80	15.40	4.80	Sandy loam
	D_4 = 30-60	69.80	21.40	8.80	Sandy loam

A – D = Representative composite soil samples on the plot

Soil chemical properties and macronutrient contents

The level of the site soil pH, organic C and major nutrient contents are indicated in Table 3. The values varied from point to point along the land transverse and across the slopes of the land as well as down the soil profile. The trend for each attribute showed that the soil pH ranged from 6.17-7.20 at the 0-30cm depth while it was 6.40-7.40 at 30-60cm depth (Table 3). These values were within the range of pH 5.00-7.50 that is considered suitable for coffee cultivation. However, there is need for caution to checkmate farming activities that may lead to any further increase in the soil pH in the long run. The soil organic C was 0.59-2.09 g/kg soil at the 0-30cm depth and 0.30-0.9 g/kg soil. The value was higher at the top soil level compared with the subsoil, which indicates that the soil organic C decreases down the soil profile. The very low amount of the soil organic C shows that the soil is very low in organic matter content. A good soil that will adequately support the establishment and sustainable production of coffee must have at least 3.3% soil organic C. this thus indicates the need to involve use of cultural practices that will contribute to the build-up of the soil organic C. This may be by the use of cover crops, organic fertilizers, mulching and pruning of alley crops on the field (Ipinmoroti and Ogeh, 2014; Famaye *et al.*, 2012).

Table 3: Soil chemical properties and macronutrient contents of the site soils

S/N	Soil depth	pH	OC	N	P	K	Ca	Mg	Na	$Al^{+3}+H^+$	ECEC	BS
			← %	→	mg.kg	←			cmol/kg		→	%
Upper slope												
	A_1 = 0-30	7.20	0.59	0.08	18.24	0.21	4.40	0.97	0.30	0.05	5.93	99.16
	A_1 = 30-60	6.90	0.33	0.05	21.50	0.19	4.01	0.66	0.26	0.06	5.18	98.84
	B_2 = 0-30	6.80	0.66	0.04	24.24	0.29	4.28	0.82	0.30	0.05	5.74	99.13
	B_2 = 30-60	6.43	0.30	0.05	30.19	0.23	3.58	0.61	0.33	0.07	4.82	98.55
Lower slope												
	C_3 = 0-30	6.17	1.28	0.10	23.52	0.44	3.73	0.79	0.36	0.08	5.40	98.52
	C_3 = 30-60	5.87	0.90	0.11	23.99	0.27	3.29	0.65	0.30	0.09	4.60	98.04
	D_4 = 0-30	6.60	2.09	0.14	23.14	0.48	4.19	0.76	0.43	0.10	5.96	98.32
	D_4 = 30-60	7.40	0.76	0.09	25.07	0.32	3.50	0.63	0.30	0.05	4.80	98.96

A – D = Representative composite soil samples on the plot

The total soil N ranged from 0.01-0.14 % with mean value 0f 0.06 % at the 0-30cm depth while it is 0.05-0.11 with mean value of 0.05% at the 30-60cm depth. The amount of soil N was higher at the lower slope with mean of 0.12 % compared to the upper slope with mean of 0.06%. This indicates that certain amount of the soil N at the upper slope had been washed down the lower slope. The mean total soil N content of 0.06% is very low when compared with the critical level of 0.1% for sustainable coffee cultivation on the soil, there would be need to apply N supplying fertilizers in order to meet the N needs of the coffee plants for vigorous and healthy growth (Adeoye, *et al*., 2001; Ipinmoroti, *et al*., 2007). The soil available P was 18-24.24 mg/kg soil with mean value of 22.29 mg/kg soil at 0-30cm depth and it was 21.50-30.19 mg/kg soil with mean value of 25.18 mg/kg soil at 30-60cm depth. However, the soil available P was higher at the upper slope compared to the lower slope. In overall, the amount of the soil available P is higher than the critical value of 9mg/kg soil, which implies that, there would be no need for application of P supplying fertilizer, especially at the juvenile stage. However, for good soil health and sustainable soil P level, soil fertility management on the farm after 3 years of establishment should involve P fertilizer application based on crop removal on annual basis that should be in two split applications in June and September of the year.

The soil K content had a mean value of 0.31cmol/kg soil at the 0-30cm depth and 0.25cmolkg soil at the 30-60 cm depth. The soil K was higher at the lower slope compared to the upper slope. The mean values were lower than the soil critical level of 0.35cmol.kg soil for soils suitable for coffee cultivation. This suggests the need for application of K supplying fertilizer(s) for optimum coffee cultivation. The soil Ca content was 3.73-4.40cmol.kg soil at 0-30 cm level and 3.29-4.10cmol.kg soil at 30-60cm level, which shows that it decreased with soil depth. Irrespective of the soil depth, the soil Ca content was lower than the critical value of 8.0cmol.kg soil. Hence, there is need for Ca supplying fertilizer in order to meet the needs of coffee plants on the plot.

The soil contains 0.76-0.97cmol/kg soil of Mg at the 0-30cm depth and 0.26-0.33cmol.kg soil at the 30-60cm depth. This showed that there was a higher Mg content at the lower slope compared to the upper slope, which was in trend with the soil Ca content. It is higher in the top soil compared to the subsoil. The soil is however sufficient in Mg content and hence, the soil will not need Mg supplying fertilizer as part of the soil fertility management. However, the soil K/Mg ratio ranged from 0.27-0.49 which is lower than 2.0 expected for K and Mg nutrient balance. Hence, there is need for great amount of K fertilizer to bring the soil K/Mg to 2.0 level so that the soil will have a balance nutrient for the coffee plants. The soil Na content was 0.30-0.43 cmol/kg soil at 0-30cm level and 0.26-0.33 cmol/kg at 30-60cm depth. It was higher at the lower slope compared with the upper slope, however, the range was not high to the extent of causing any deleterious effect on coffee plants.

The soil exchangeable acidity (H^{-+} Al^{+3}) was 0.05-0.10cmol/kg soil at 0-30cm and 0.06-0.09cmol/kg soil at 30-60cm depth. The values were highly negligible and could not lead to any serious acidity threat on the field crops. Hence there is no need for any acidity control measure on the field. However, activities that can escalate acidity threat must be avoided since the soil organic C content was generally very low. The soil ECEC values decreased with soil depth but higher at the lower slope compared to the upper slope (Table 3). The values were too low when compared to 30cmol/kg soil common in tropical soils (Ayoola and Agbola, 2002). This shows that the soil organic matter must be built upon in order to increase the cation exchange sites of the soil. This will make the soil to be able to hold nutrients against leaching losses and also able to make same available to crops for optimum production on a sustainable manner.

Soil micro-nutrient contents

The soil micro-nutrient content (Table 4) showed that the lower slope had higher Mn content compared to the upper slope. On the other hand, the Fe content increased with soil depth and it was higher at the upper slope than at the lower slope. This trend was observed for the soil Cu content. The soil Zn content was 44.07-52.90 mg/kg soil at the 0-30cm level compared to 26.60-53.47 at the 30-60cm level. In all, the amount of the soil Mn, Fe, Cu and Zn contents were optimal for coffee production without any detrimental effect.

Table 4: Site soil micronutrient contents

S/N	Soil depth	Mn	Fe	Cu	Zn
		←	mg.kg		→
Upper slope					
	A_1 = 0-30	55.05	5.40	0.50	44.07
	A_1 = 30-60	117.65	11.70	0.70	53.07

B_2 = 0-30	65.10	4.30	0.49	49.02
B_2 = 30-60	42.75	18.00	0.47	30.15
Lower slope				
C_3 = 0-30	97.15	2.40	0.40	46.55
C_3 = 30-60	83.80	11.10	0.63	43.05
D_4 = 0-30	112.20	8.20	0.66	52.90
D_4 = 30-60	74.15	9.30	0.58	26.60

A – D = Representative composite soil samples on the plot

CONCLUSION

The site soil is very low in macro-nutrients that are vital for sustainable coffee production. The nutrients must be outsourced through the use of fertilizers application in order to achieve optimum growth and establishment of the coffee plants. This must majorly be by way of organic manure application and most importantly with the use of poultry manure, which is the most common and cheapest and richest source of those nutrients and organic matter to the field. It is recommended that the application of this manure could be done at 1.5 t/ha. However, the manure must be maturely cured before usage in order not to cause any injury to the coffee or any other companion crop(s).

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SUITABILITY ASSESSMENT OF SOILS FORMED IN GRANITE AND GNEISS IN HUMID AREA OF SOUTHWESTERN NIGERIA FOR CASHEW PRODUCTION

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ABSTRACT

Cashew is an important nut crop which has been generating substantial foreign exchange earnings for the country. However, its production has diminished in recent years due to lack of assessment of the soils. The objective of this study is to assess the soils formed in granite and gneiss in humid area of southwestern Nigeria for cashew production. Five profile pits were established at different physiographic positions along the toposequence in Ife Area, Osun state, Nigeria and described following the FAO/UNESCO guidelines for soil profile description. In order to examine the attribute of the soils, samples were collected, subjected to routine analysis and evaluated its potential for cashew production. The morphological, physical and chemical characteristics of the soils were determined. Suitability of the soils for cashew production was carried out using parametric approach. The result showed that the soils were very deep (127-200cm) and well drained. Soil surface textures were sandy loam underlain by sandy clay loam. The clay contents were low and increased with soil depth while sand content were high at the surface level and decrease with soil depth. The soils were acidic in nature and soil organic carbon content varied from low to high value ranging from 0.04 to 1.64%. Available phosphorus and Exchangeable bases were above the critical values needed for ideal cashew production. Suitability evaluation result showed that pedons 1, 2, 4 and 5 are presently highly suitable for cashew production while pedon 3 is moderately suitable. Potentially, all the pedons are highly suitable for cashew production.

Key words: Suitability assessment, granite, gneiss, cashew

INTRODUCTION

Cashew (*Anarcadium occidentale L.*) is one of the essential cash crops next to cocoa as export crop. It requires less intensive maintenance compare to other crops. Its various parts are of economic value such as source of food, income and medicine. Also, a source of raw materials to beverage, food and confectioneries industries (Oni, 2015). Cashew industry plays an important socio-economic role as it provides employment to people such as harvesters, transporters, processors among others. Cashew has been stated to be grown and marketed for its raw nuts, apple, processed kernel and wood. Cashew is one of the most popular nuts that have low levels of soluble and saturated fats, also contains high percentage of proteins and polyunsaturated fatty acids to reduce cholesterol levels in the blood; and high level of mineral salt (Chemonics International, 2002). Nambiar et al., (1990) reported that cashew nuts proteins are whole, each kilogram of the nut yields about 6000 calories compared to 3600 calories from cereals, 1800 calories from meat and 650 calories from fresh citrus fruits. It also has all the necessary amino acid. Low soluble sugar content (<1%) in the kernel make cashew consumers not to be vulnerable to excess calories (SasiVarma, 2002).

Researchers have developed several products from cashew nuts and these include kernel oil, roasted kernel sacks, cashew nut shell liquid; from the apple: syrup/juice, jams, wine, alcohol; from wood: firewood, charcoal, furniture and it is also use for boats building. Chemonics International, (2002) reported that the stability of cashew kernel oil is higher than that of commercial like cocoa butter, palm oil, groundnut oil. Cashew apple is highly rich in vitamin C, its content is several times higher than citrus orange. Presently, Nigeria is ranked third and fifth highest cashew-producing country in Africa and world respectively with 155,000 metric tons' production in the year 2015 (ACMR, 2015).

Cashew production currently in Nigeria is constrained by lack of adequate land evaluation system, lack of access to good quality planting material which leads to low quality, small nuts and kernel size; and high susceptibility to pest and diseases. Land suitability assessment (LSA) is the examination of a piece of land for its capability to sustain a specific agricultural use (Littleboy *et al.*, 1996). Generally, LSA for agricultural purposes includes characterization of the biophysical and ecological characteristics of a location according to the agricultural potentials of the land. It encompasses evaluating the relative edaphic-ecological requirements of the crops with the spatial edaphic-ecological conditions of a particular location. The locations where the edaphic-ecological conditions amalgamate with the crop requirements will be acknowledged as suitable. Thus, LSA consists of analysis of soil, topography, climatic and vegetation data with the intention of matching land physiognomies with crop requirements (Wang *et al*., 2006).

Inadequate information is obtainable on suitability evaluation of cashew production in spite of its high economic value, significance to populace and the economy. When adequate information is available on its land evaluation, this will ascertain optimal and sustainable production. So, the country would become the World's number one cashew nuts producer. The numerous significance of cashew tree and its long-lived perennial nature thus necessitate land suitability evaluation of its production, hence this research is imperative. The objective of this research is to evaluate the soils of Ife area and assess their suitability for cashew production.

MATERIALS AND METHODS

The study area

The study was conducted in Ife Central Local Government area of Osun State, at the Teaching and Research Farm (T&RF), ObafemiAwolowo University (OAU). The T&RF is located between latitudes 7° 32' and 7° 33'N and longitudes 4° 32' and 4° 40'E, at about 200 m above sea level. The total annual rainfall is about 1502.23 mm, predominant annual wind direction is 221.87° while the mean annual temperature is 29.42°C (NASA, 2019). The soil temperature regime in the study area is considered isohyperthermic (Amusan and Ashaye, 1991). The climate of the area is tropical with wet and dry seasons.

Field study

Five profile pits were established and geographical location of each pedon was recorded using GPS as follow: pedon 1 (latitude 7° 32' 50.8''N and longitude 7° 32' 57.3''E), pedon 2 (latitude 7° 32' 50.6''N and longitude 7° 32' 56.0''), pedon 3 (latitude 7° 32' 49.0''N and longitude 7° 32' 56.5''E) pedon 4 (latitude 7° 32' 47.2''N and longitude 7° 32' 57.5''E) pedon 5 (latitude 7° 32' 45.4''N and longitude 7° 32' 58.1''E). The five profile pits established were described according to the FAO/UNESCO (2006) procedures for soil profile description. The profile pits were described horizon by horizon for horizon depth/thickness, with the aid of a measuring tape, colour (moist) using Munsel colour Chart, texture using hand feel method while the nature of the soil structure, consistence, mottles, presence or absence of inclusions (nodules and concretions) roots and horizon boundaries were carefully documented on the field. Soil samples for bulk density determination were collected from each horizon. Multiple sub-sampling method was employed to guarantee representativeness of the samples collected from a given horizon. The soil samples collected were bagged, labeled and taken to the laboratory for physical and chemical analyses.

Laboratory analyses

Soil samples collected were air-dried, pulverized and sieved through a 2mm sieve. The less than 2 mm fraction was retained for analyses in the laboratory except bulk density determination. The following physical and chemical analyses were carried out: Particle size distribution using the Bouyoucos hydrometer method (1965) as reported by (Gee and Or, 2002).The soil pH both in distilled water and 1.0 N KCl (Thomas, 1996).Soil organic carbon by the Walkley-Black (1934) method using the chromic acid digestion as reported by (Darrell *et al*., 1994).Available phosphorus (Bray and Kurtz, 1945 as reported by Kuo,1996).Total nitrogen using the micro-Kjeldahl digestion method (Bremner, 1996).Exchangeable cations were extracted with 1.0 N NH_4OAc solution at pH 7, Mg and Ca were determined by AAS and K and Na by flame photometer (Thomas, 1982) modified by Jones (1998).Cation exchange capacity by 1.0 N ammonium acetate (NH_4OAc) at pH 7 (Sumner and Miller, 1996).Exchangeable acidity was determined by 1.0 N KCl and titrated with 0.05 N NaOH and HCL solutions to measure total acidity ($Al^{3+}$and H^+) concentrations respectively (Mclean, 1965) while effective cation exchange capacity (ECEC) was computed by the summation of exchangeable cations and exchangeable aluminium.

Land evaluation

Following the method of Sys *et al*., 1993 suitability of the soils for cashew production were assessed using parametric approach. Each pedon was assigned to suitability classes by matching their characteristics with the requirements for cashew production (Table 1). Each feature was ranked using Square root method equation:

IP = A x √ ((B/100) x (C/100) x … x (F/100)). where; IP is the index of productivity, A is the overall lowest

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characteristic rating and B, C…F are the lowest characteristic ratings for each land quality group (Udoh *et al*., 2006). Current and potential index of production for each pedon was calculated. In each pedon, only one member of each of the five land quality groups (climate(c), topography (t), wetness (w), soil physical characteristics(s) and fertility (f)) were used in the calculation because there were strong correlations among members of the same group (Ogunkunle 1993).

RESULTS AND DISCUSSION

Morphological and physical properties:

Pedon 1: It occupies the upper slope position of the landscape. The soils were deep and well drained. The colour varies from brown (10YR 5/3) with silt loam texture, coming down to strong brown (7.5 YR 4/6) gravelly sandy clay loam (SCL) texture; to red (2.5 YR 5/8) with SCL texture and reddish yellow (5 YR 6/8) with silty clay loam texture in the subsoil. Duncan, (2001) reported that soil texture is critical for cashew production, its production relates to well-drained soil with a sandy loam texture. Widiatmaka *et al*. (2014) also stated that cashew seems to flourish in a free-draining and light-textured soil. The soils have moderate medium crumb on the surface coming down to moderate medium sub-angular blocky structure in the subsoil with diffuse and wavy horizon boundary. Bulk density values ranged from 1.33 on top to 1.71 g/cm^3 in the subsoil. These bulk values are ranked low and will not harm crop production. Bulk density is a reflection of texture and structure. Aubertin and Kardos (1965) reported that a normal range for sand is 1.2 to 1.8 mg/m^3; clay is 1.0 to 1.6 mg/m^3 with potential root restriction occurring at ≥ 1.4 mg/m^3 for clay and ≥1.6 mg/m^3 for sand. Generally, the studied soils are not expected to cause any obstacle to seedling emergence and root activity (water and nutrient uptake).

Table 1: Land use requirements for cashew cultivation

Land, soil and climatic characteristics	S11 (100%)	S12 (95%)	S2 (85%)	S3 (60%)	N1 (40%)	N2 (25%)
Climatic(c)						
Annual rainfall (mm)	1600-2000	1200-2000	800-1200	500-800	-	<500
Length of dry season (months)	2-3	<2	4-5	5-6	-	>6
Mean annual temperature (°C)	>18	-	10-18	4-10	-	<4
Topography (t)						
Slope (%)	0-4	4-8	8-16	16-30	30-50	>50
Wetness (w)						
Flooding	Fo	-	-	-	-	F1
Drainage	Good	Moderate	Imperfect fluctuating groundwater	Imperfect permanent high groundwater	Poor drainage	Very poor drainage
Physical soil characteristic(s)						
Texture/structure	C-60s, SiC, Co, SiCL, CL, SiL, Sc	C+60s, C-60v, L SCL,SL, Lfs, LS	C+60v, LCS, fs	S, CS	-	Cm
Coarse fragments (Vol.%)	<3	<15	<35	<55	-	>55
Soil depth (cm)	>100	100-75	75-50	50-25	-	<25
Fertility characteristics (f)						
Apparent CEC (Meq/ 100 g soil)	Any					
Base saturation (%)	>35	20-35	<20			
Organic matter (% C, 0-15cm)	>1.5	0.8-1.5	<0.8			

F1 = Slight, C+60s = Very fine clay blocky structure, SCL = sandy clay loam, C-60V = Clay F1 = Slight, C+60s = Very fine clay blocky structure, SCL = sandy clay loam, C-60V = Clay vertisol structure, fs = fine sand, C+60v = Very fine clay vertisol, C-60s =Clay blocky structure, SiC = Silt clay, SiCL = silt clay loam, SiL =silt loam, Sc = sandy clay, LS =loamy sand, L= loam, LCS =loamy clay sand, CS = clay sand, S= sand Cm = massive clay, Lfs= loamy fine sand.

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S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N1 = presently not suitable, N2 = permanently not suitable

Source: Modified from Sys (1985).

Pedon 2: It occupies upper slope to middle position on the landscape. It is the deepest and well drained. On the soil surface, the texture is sandy loam, structural aggregate is moderate; moist consistence is loose while wet consistence of the soils is not sticky, not plastic with common fine, very fine root distribution. Soil colour range from dark brown (7.5 YR 3/2) at the surface to reddish yellow (7.5 YR 6/8) at sub soil. Bulk density values ranged from 1.13 g/cm^3 at the surface to 1.62 g/cm^3 at subsoil. These values are rated low as reported by Soil Survey Staff (2006) that a value of 1.85 g/cm3 could hinder penetration of plant roots.

Pedon 3: It occupies the middle slope on the landscape, mostly deep and well drained. The soils have a very dark grey colour (7.5 YR 3/1) with gravelly sandy loam texture on top coming down to yellowish red (5 YR 5/6) with gravelly sandy clay loam to red (2.5 YR 4/6) with slightly gravelly, sandy clay loam to red (2.5 YR 5/6) with slightly gravelly clay. The soil has a weak fine crumb on the surface coming down to moderate medium sub-angular blocky structure in the subsoil. Very few very fine and coarse roots occurred frequently in the pedon. Bulk density values ranged from 1.46 g/cm^3 at the surface to 1.75 g/cm^3 at subsoil.

Pedon 4: The soils were moderately deep and well drained. The soils have sandy loam texture with dark brown (7.5 YR 3/2) at the surface coming down to reddish brown (5 YR 4/4) gravelly sandy clay to strong brown (7.5 YR 5/8) gravelly sandy clay and red (2.5 YR 5/8) slightly gravelly clay at subsoil. The soils have a fine weak crumb on the surface coming down to moderate medium crumb at subsurface, very fine, few medium roots are common. Bulk density values ranged from 1.39 g/cm^3 at the surface to 1.61 g/cm^3 at subsoil.

Pedon 5: It occupies the lower slope portion on the landscape. The soil is poorly drained but very deep. The colour varies from dark brown (7.5 YR 3/2) with gravelly sandy clay loam to brown (7.5 YR 5/4) gravelly sandy loam; to strong brown (7.5 YR 5/8) slightly gravelly clay loam; to reddish yellow (5 YR 6/8) gravelly sandy clay and reddish yellow (7.5 YR 6/6) slightly gravelly sandy clay at subsoil. Structural aggregate is moderate, very few fine roots are common. On the soil surface moist consistence is very friable while wet consistence is non sticky, non-plastic. At subsoil, they are friable, sticky and plastic respectively. Bulk density values ranged from 1.55 g/cm^3 at the surface to 1.86 g/cm^3 at subsoil.

The soil's chemical properties

The soil pH ranged from extremely acid to moderately acid in water (4.4 to 5.6) and from extremely acid to strongly acid (3.6 to 5.1) in 1N KCl solution. The values fluctuate irregularly with depth. Aliyu, (2007) stated that cashew can grow best in well drained sandy soils with pH ranging from 4.5 to 6.5. Factors suggested to be responsible for the acidic nature of the soil could be nature of the parent rock, high rainfall which made the soil to be fragile and vulnerable to leaching of exchangeable bases from the soils.

The percent organic carbon was low to high ranging from 0.04 to 1.64%. The low values might be connected with the decomposition of organic matter due to high temperature, continuous removal of crop residues and bush burning in the study area. Lal (1991) reported that the high OM content at the surface horizon of most of the pedons could be ascribed to more decomposable organic materials in the surface soils. This high content of OM at the surface soil was not unexpected since it is at the soil surface that litters accumulate which subsequently decayed and mineralized to yield OM (Olayinka, 2009).

Phosphorus is a fundamental part of the genetic material of the cell nucleus in cashew. Its deficiency causes stunting, delayed maturity and shriveled seeds (Aikpopodion *et al.,* 2009). Available phosphorus content of the soils was above the critical value of 10 ppm recommended for most cultivated crops in the area as stated by Obigbesan, (2009). The values ranged from 12.34 to 34.50 ppm.

The calcium content of the soils ranged from 0.91 to 3.17 cmol/kg. All the pedons examined had their exchangeable Ca^{2+} content greater than 0.8 cmol/kg which is the critical value for Ca^{2+} in cashew production (Egbe *et al.,* 1989). Magnesium content of the soils varied from 0.34 to 1.04 cmol/kg soil. The soil Mg^{2+} values for each pedon were above the critical value of 0.08 cmol/kg for ideal soils of cashew. Exchangeable potassium (K) contents ranged between 0.06 and 0.22 cmol/kg. Potassium contents of the studied soils were adequate for cashew since most of the values were higher than the critical level (0.12 cmol/kg) of potassium for cashew production as reported by Egbe *et al.* (1989). Exchangeable Na remained almost constant in all the pedons. The values were less than 1 cmol/kg, this indicates that the studied soils were not sodic (EUROCONSULT, 1989). In general, the result of the chemical analysis of the studied soils revealed that the soils were not deficient in essential macronutrients elements needed by cashew for ideal production.

Land suitability evaluation

Land evaluation was carried out using parametric method (Sys *et al.,*1993). Table 1 shows the factor rating of land use requirements for cashew indicating S1 (highly suitable) rated 100%, S2 (moderately suitable rated 85%, S3 (marginally suitable) rated 60%, N1 (presently not suitable) rated 40% and N2 rated 25% (permanently not suitable). The suitability class of a soil is that indicated by its most limiting characteristics. Table 2 shows the summary of land suitability classes for actual/current suitability class and potential suitability class (i.e after soil fertility improvement). The assessment of the soils for crop production encompassed the use of properties that are permanent in nature and that cannot be altered or modified without excessive cost. Such properties include soil depth, slope, drainage, texture and amount of coarse fragments. These properties are known to generate some kind of hindrance to crop production. Chemical properties that are usually considered (e.g. fertility) can be changed by minor improvement (Sys, 1985).

The annual rainfall of the study area approximately 1502 mm for all the pedons made the soil fall into suitability class S1 and rated 100% due to sufficient rainfall requirement for cashew production (1600-2000 mm) as detailed in Table 1. The mean annual temperature (29.42^{o}C) was within the class S1, rated 100% and therefore highly suitable for cashew production. All the pedons are well drained. Therefore, with reference to flooding and drainage, the soils fall within S1 suitability class, rated 100 and highly suitable for optimal yield of cashew. Similarly, in term of coarse fragment, all the pedons were considered as S1 because there were no stones and gravels which can pose an impediment to root development and movement. Average soil rooting depth and textural class in all the pedons fall within high suitability class S1 and was scored 100. When organic matter was used as an evaluation criterion, all the soils are highly suitable (S1). With reference to base saturation, all the pedons fall into S1 class.

In summary, the result for the actual suitability showed that pedons 1, 2, 4 and 5 were highly suitable while pedon 3 was moderately suitable for cashew production. The potential suitability which is a reflection of what is expected after effective soil fertility management is highly suitable (S1) for all the pedons. This implies that little fertility management practices are required to achieve optimum cashew production on the studied soil. Therefore, the soil is recommended for cashew production.

CONCLUSION

Considering the result of the studied soils, the study revealed that there is need for little fertilizer supplement for optimal productivity of cashew. The soils were highly suitable. Fertility was not a major limitation likewise climate, topography, physical soil characteristics and wetness.

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Table 2: Land suitability ratings of the study area for cashew production

Land qualities	P1(A)	P1(B)	P2(A)	P2(B)	P3(A)	P3(B)	P4(A)	P4(B)	P5(A)	P5(B)
Climate (C)										
Annual rainfall (mm)	95	95	95	95	95	95	95	95	95	95
Mean annual temperatures (°C)	100	100	100	100	100	100	100	100	100	100
Topography (T)										
Slope (%)	100	100	100	100	100	100	100	100	100	100
Wetness (W)										
Soil drainage	100	100	100	100	100	100	100	100	100	100
Soil Physical Properties (S)										
Texture	95	95	95	95	95	95	95	95	95	95
Soil depth (cm)	100	100	100	100	100	100	100	100	100	100
Coarse fragment (%)	95	95	95	95	95	95	95	95	95	95
Fertility Characteristics (F)										
Soil organic carbon	95	100	95	100	60	100	100	100	95	100
Base saturation	95	100	95	100	95	100	95	100	95	100
CEC	95	100	95	100	95	100	95	100	95	100
Aggregate suitability	**90**	**90**	**90**	**93**	**57**	**93**	**93**	**93**	**90**	**93**
Suitability symbol	**S1**	**S1**	**S1**	**S1**	**S2**	**S1**	**S1**	**S1**	**S1**	**S1**

P1 = Pedon 1, P2 = Pedon 2, P3 = Pedon 3, P4 = Pedon 4.
A = actual/current suitability class, B = potential suitability class (after soil fertility improvement)
Aggregate suitability scores: S1(75-100); S2(50-74); S3(25-49); N1(12-24); N2(0-12).

SOIL QUALITY INDEX ANALYSIS OF SOILS UNDER MANGO ORCHARD AT INSTITUTE FOR AGRICULTURAL RESEARCH FARM SAMARU, NIGERIA

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ABSTRACT

The soil quality index (SQI) for Mango orchard was developed to meet the nutritional criteria of the crop, the increasing demand for the production and quality of mango using a range of soil indicators. The objective of this study was to develop SQI for assessing the effects of current arable management practices on soil quality for tropical soils. Soil samples were randomly collected and analysed for physical, chemical and microbial properties. Principal component analysis was used to determine a minimum data set (MDS). Soil pH, microbial biomass carbon, bulk density, available phosphorus, extractable copper, and cation exchange capacity were identified as the MDS. The SQI was rated low, this implies that mango orchard has a negative influence on soil quality. The method developed in this study can be used to provide a practical, quantitative tool for assessing soil quality under any agricultural management systems.

Key words: Principal component, Data set, Indicator, Samaru

INTRODUCTION

Soil quality is an account of the ability of soil to provide ecosystem and social service through its capacities to perform its function and respond to external influences. Karlen et al. (2001) define soil quality as the capacity of soil to function within the ecosystem and land-use boundaries, to sustain productivity, maintain environmental quality, and promote plant growth as well as animal health. Soil quality is a complex functional concept and cannot be measured directly in the field or laboratory but can be inferred from soil characteristics (Demessie *et al*., 2012). A range of soil parameters or indicators has been identified to estimate soil quality. However, soil quality is often related to management goals and practices. Soil quality may be affected by land-use type and agricultural management practices because these may cause alterations in soil's physical, chemical and biological properties, which in turn results in a change in land productivity (Gelaw *et al*., 2015). Soil quality assessment uses tools to quantify and evaluate the effects of soil management practices (Armenise *et al*., 2013), land use type (Rahmanipour *et al*., 2014) and cover crop (Navas *et al*., 2011) on soil function.

MATERIALS AND METHODS

Location of Study of Area

The IAR experimental farm is located between latitude 11°10'30''N and 11°11'40''N and longitudes 007°36'30''E and 007°38'6'' E, within Sabon gari Local Government Area of Kaduna State The study area has an altitude of 686 meters above sea level. The geological Survey indicated that the study area is located within the undifferentiated Basement complex parent material. (Wright and McCurry, 1970).

Fieldwork

To achieve the objectives of the study, surface soil from 0-20cm were collected from the mango orchard and a natural grass land considered as control in this experiment.

Laboratory Analysis

Soil samples collected were air-dried in the laboratory, crushed with porcelain pestle and mortar and sieved to remove material greater than 2mm (gravel). Percent gravel to total soil was calculated. The less than 2mm fractions were subjected to physical and chemical using procedure described in IITA Manual (1979). Microbial Biomass Carbon and Nitrogen were determined by the chloroform-fumigation method (Okalebo *et al*., 2001).

Soil quality determination

Soil quality was determined following three steps listed below: (1) most critical soil quality indicators, i.e., minimum data set (MDS) of indicators that best-represented soil functions were selected; (2) the indicators were scored; and (3) the scores were integrated into final Soil Quality Index (SQI) (Andrews *et al*., 2002).

Statistical Analysis

Data analysis was carried out using SAS software (SAS Institute, 1990). Principal component analysis (PCA) was carried out from a subset of variables using the PRINCOMP procedure. Lastly, the indicators retained within the principal component (PC) were then subjected to correlation analysis using CORR procedure.

RESULTS AND DISCUSSIONS

The result obtained from Principal components analysis (PCA) (Table 1) indicated that five (5) components of principal component (PC) had an eigenvalue >1, thus, explained 100% of the variability of the data. Soil pH and extractable Cu, had the greatest loading variables under PC 1 and exchangeable Mg, K, exchangeable acidity, cation exchange capacity (CEC), total porosity, moisture at field capacity and sand had a loading value within 10% of the greatest value, but pH and Cu were selected because their correlation coefficient < 7 (Table 2). In PC 2, CEC had the highest loading value and only aggregate stability (MWD) had a loading value within 10% of the greatest value. All the variables selected when correlated had a coefficient of correlation greater than 7 thus, were considered redundant hence, CEC was selected. In PC 3 Ca had the highest loading value and only available phosphorus (AvP) had a loading value within 10% of the greatest. exchangeable Ca and AvP had a correlation coefficient >0.7 (Table 2) thus, exchangeable Ca was retained as valuable indicators for PC 3. Microbial biomass carbon (MBC) was identified from PC 4 on the same bases. In PC 5, Bulk density has the highest loading value and soil pH and Extractable manganese had a loading value within 10% of the greatest value. Bulk density, soil pH and Extractable manganese had a correlation coefficient >0.7 (Table 2) thus, bulk density was retained as valuable indicators. Therefore, pH, Cu, CEC, Ca, MBC and bulk density were selected as the MDS. The contribution of the indicators selected in Table 1 in forming the soil quality indicator (SQI) was NG 42.37

The result obtained from principal component analysis (Table 1) shows pH, MBC, bulk density, AvP, extractable Cu, and cation exchange capacity were most important parameters for the evaluation of soil quality in the area. The concentration of the above mention parameters was controlled by the presence of soil organic carbon (SOC). SOC had been reported by many authors (Oluwatosin *et al*., 2003, Singh *et al*., 2014) to improve the levels of some of the soil quality indicators such as aggregate stability, pH, microbial biomass carbon, compaction and reduce erosion. soil organic matter also influences soil function, determining soil nutrient status, water holding capacity and susceptibility of soil to degradation (Oluwatosin *et al*., 2003). The soil quality index the orchard was rated "low" category (SQI < 50%). Low soil quality in mango orchard (47.69), could be attributed to land management practices.

CONCLUSION

Quantifying the effect of mango cultivation on soil quality is essential to better understand the role of mango cultivation in land degradation. Soil quality of a mango orchard in IAR farm at Samaru was evaluated using soil quality index (SQI) methods. The SQI was calculated using a MDS selected using PCA and norm values of six indicators which gave 100% of the variance of the total data set. The value of the SQI indicated that the soils were of low quality

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Table 1: Results of principal component analysis indicating properties selected as the minimum dataset in Mango orchard at Institute for Agricultural Research farm, Samaru

Eigen value	16.18	9.30	2.34	1.91	1.27
Diff	6.88	6.96	0.42	0.64	1.27
Proportion (%)	52.00	30.00	8.00	6.00	4.00
Cumulative proportion	0.52	0.82	0.90	0.96	1.00
Eigenvectors	PC1	PC2	PC3	PC4	PC5
Exchangeable Calcium	**0.23**	0.07	-0.03	-0.07	-0.25
Exchangeable Magnesium	0.12	0.26	-0.21	0.09	0.03
Exchangeable potassium	0.14	0.18	-0.27	0.34	0.01
Exchangeable sodium	**0.24**	0.07	0.11	-0.06	-0.11
Exchangeable acidity	0.15	0.10	0.37	0.33	0.07
Cation Exchangeable Capacity	0.20	0.17	0.17	-0.31	0.29
Soil aggregate stability	0.03	0.14	**0.55**	-0.20	-0.17
Base Saturation	0.19	0.20	-0.04	0.10	-0.02
Exchangeable sodium percentage	**0.24**	0.02	0.10	-0.07	-0.17
Available phosphorus	-0.03	**0.30**	-0.08	-0.18	-0.27
Total Nitrogen	**0.22**	0.13	0.01	0.03	-0.17
Organic carbon	**0.25**	0.04	-0.03	0.04	0.07
pH	0.02	0.25	0.34	-0.07	**0.33**
Bulk density	0.04	**0.28**	-0.16	0.04	**-0.36**
Particle density	0.01	**0.32**	-0.06	-0.11	0.17
Total porosity	-0.11	**0.28**	0.00	-0.14	0.17
Hydraulic conductivity	-0.19	0.21	0.02	-0.09	-0.12
Field capacity	**0.22**	0.10	0.19	-0.08	0.00
Permanent wilting point	**0.23**	-0.07	0.05	0.18	-0.17
Available water capacity	**0.24**	-0.05	-0.03	-0.02	0.07
Microbial biomass Nitrogen	-0.18	0.17	-0.16	-0.23	0.05
Microbial Biomass Carbon	-0.05	0.21	-0.02	**0.49**	0.29
Extractable copper	0.05	**0.31**	-0.11	-0.12	-0.15
Extractable iron	**-0.22**	0.16	0.03	0.00	0.06
Extractable zinc	-0.19	0.20	0.04	0.10	-0.05
Extractable manganese	**0.22**	-0.05	-0.14	-0.12	**0.33**
Gravels	-0.10	**0.29**	0.05	0.00	0.21
Clay	**0.24**	0.06	-0.06	0.09	0.10
Silt	**0.24**	0.04	-0.14	0.01	0.13
Sand	**0.24**	0.04	-0.14	0.01	0.13

PC=Principal component

Table 2: Correlation matrix for the total dataset

	Ca	Mg	K	Na	EA	CEC	MD	BS	EP	AP	TN	OC	pH	BD	PD	TP	Ks	FC	PW	AW	MN	MC	Cu	Fe	Zn	Mn	GR	Cy	St	Sd
Ca	1.0	0.5	0.6	0.6	0.7	**0.7**	0.0	0.6	**0.7**	**0.7**	**0.7**	**0.7**	0.4	0.0	0.5	0.6	0.7	0.5	0.1	0.3	**0.7**	0.3	0.3	0.7	0.7	0.7	0.3	0.7	0.0	0.5
Mg		1.0	0.6	0.3	0.6	0.5	0.3	**0.9**	0.6	0.6	**0.8**	**0.7**	0.2	0.6	0.2	**0.7**	0.4	0.0	0.6	0.5	0.2	0.6	0.6	0.5	0.4	0.4	0.1	**0.7**	0.5	0.6
K			1.0	**0.9**	**1.0**	**0.9**	0.6	**0.9**	**1.0**	**1.0**	**0.8**	**0.9**	0.4	0.3	0.1	0.6	**0.9**	**0.7**	0.2	0.3	**0.8**	**0.9**	0.4	**0.9**	**0.9**	**1.0**	0.1	**1.0**	0.2	0.6
Na				1.0	**0.9**	**0.9**	0.3	0.5	**0.9**	**0.9**	**0.7**	**0.8**	0.6	0.1	0.2	0.6	**1.0**	**0.8**	0.6	**0.7**	**1.0**	**0.7**	0.1	**0.9**	**1.0**	**1.0**	0.3	**0.9**	0.2	0.6
EA					1.0	**1.0**	0.4	**0.8**	**1,0**	**1.0**	**0.9**	**1.0**	0.5	0.4	0.0	**0.7**	**0.9**	0.7	0.2	0.4	**0.9**	**0.9**	0.2	**1.0**	**1.0**	**1.0**	0.2	**1.0**	0.1	**0.7**
CEC						1.0	0.2	**0.7**	**1.0**	**1.0**	**0.9**	**1.0**	0.7	0.5	0.1	**0.8**	**1.0**	0.5	0.2	0.5	**0.9**	**0.8**	0.1	**1.0**	**1.0**	**0.9**	0.5	**1.0**	0.2	**0.8**
MD							1.0	0.6	0.4	0.3	0.1	0.3	0.5	0.2	0.5	0.2	0.2	**0.7**	0.2	0.1	0.2	0.5	0.7	0.2	0.2	0.5	0.7	0.4	**0.8**	0.3
BS								1.0	**0.8**	**0.8**	**0.8**	**0.8**	0.1	0.4	0.2	0.6	0.6	0.4	0.3	0.2	0.5	**0.8**	0.6	**0.7**	0.6	0.7	0.1	**0.9**	0.6	0.5
EP									1.0	**1.0**	**0.8**	**1.0**	0.5	0.3	0.1	0.7	**1.0**	**0.7**	0.3	0.5	**0.9**	**0.9**	0.2	**1.0**	**1.0**	**1.0**	0.2	**1.0**	0.0	**0.7**
AP										1.0	**0.9**	**1.0**	0.6	0.4	0.1	**0.8**	**1.0**	0.6	0.2	0.4	**0.9**	**0.9**	0.2	**1.0**	**1.0**	**1.0**	0.3	**1.0**	0.0	**0.8**
TN											1.0	**1.0**	**0.7**	0.7	0.1	**0.9**	**0.8**	0.2	0.2	0.1	0.6	**0.8**	0.3	**0.9**	**0.8**	**0.7**	0.5	**0.9**	0.0	**0.9**
OC												1.0	0.6	0.5	0.1	**0.8**	**0.9**	0.5	0.1	0.3	**0.8**	**0.9**	0.3	**1.0**	**0.9**	**0.9**	0.4	**1.0**	0.0	**0.8**
pH													1.0	0.6	0.4	**0.9**	**0.7**	0.0	0.0	0.5	0.6	0.5	0.3	0.7	0.7	0.4	**0.8**	0.5	**0.7**	**0.9**
BD														1.0	0.3	**0.7**	0.3	0.4	0.6	0.2	0.1	0.6	0.4	0.4	0.3	0.1	0.6	0.4	0.1	**0.8**
PD															1.0	0.3	0.2	0.2	0.4	0.3	0.3	0.2	**0.7**	0.2	0.2	0.1	0.0	0.0	0.4	0.2
TP																1.0	**0.7**	0.0	0.3	0.1	0.6	0.7	0.1	**0.8**	**0.7**	0.6	0.6	**0.7**	0.2	**1.0**
Ks																		0.7	0.4	**0.7**	**1.0**	**0.8**	0.0	**1.0**	**1.0**	**1.0**	0.4	**0.9**	0.3	**0.8**
FC																		1.0	**0.8**	0.6	**0.8**	0.5	0.1	0.6	0.6	**0.8**	0.3	0.6	0.1	0.0
PW																			1.0	**0.9**	0.6	0.0	0.5	0.3	0.4	0.5	0.2	0.1	0.4	0.2
AW																				1.0	**0.8**	0.2	0.6	0.5	0.6	0.6	0.3	0.3	**0.7**	0.2
MN																					1.0	0.7	0.2	**0.9**	**1.0**	**1.0**	0.3	**0.8**	0.3	0.6
MB																						1.0	0.5	**0.9**	**0.8**	**0.8**	0.2	**0.9**	0.1	**0.7**
Cu																							1.0	0.1	0.0	0.1	0.3	0.3	**0.7**	0.0
Fe																								1.0	**1.0**	**1.0**	0.4	**1.0**	0.1	**0.8**
Zn																									1.0	**1.0**	0.4	**0.9**	0.2	**0.8**
Mn																										1.0	0.2	**0.9**	0.0	0.6
GR																											1.0	0.2	**0.7**	**0.8**
Cy																												1.0	0.1	**0.7**
St																													1.0	0.4
Sd																														1.0

EA=Exchangeable acidity, CEC=Cation exchange capacity, MD=Aggregate stability, BS=Base saturation, AP=Available phosphorus, TN=Total Nitrogen, OC=Organic carbon, BD=Bulk density, PD=Particle density, TP=Total porosity, Kc=Hydraulic capacity, FC=moisture at field capacity, PW=permanent wilt point, AW=Available water content, MN=microbial biomass nitrogen, MB=microbial biomass carbon, GR=gravels, Cy=clay, St=silt, Sd=sand

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DYNAMICS OF PHOSPHORUS FIXATION IN SELECTED TEA CROPPED SOILS ON THE MAMBILLA PLATEAU IN TARABA STATE, NIGERIA

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ABSTRACT

Phosphorus has been found to be the most limiting macronutrient in tea cropped soils of the Mambilla Plateau. For appropriate fertilizer recommendation and adequate application to be achieved, the fate and chemistry of phosphorus in the acidic tea soils of the plateau must be understood. Top soil at 0-20cm depth was collected in selected tea farms in Kusuku and Nguroje. The samples were processed and incubated with phosphorus solution of 35, 70, 140, 280 and 560mg P kg^{-1} soil for a period of 3, 15, 30, 45 and 60 days. Result showed a progressive P fixation in both soils from the beginning of the experiment to the end. However, desorption of the adsorbed phosphorus was noticed in both soils within the period of incubation suggesting physisorption controlled mechanism. At the expiration of the experiment, more than 90% of the applied phosphorus was fixed in both soils. P fixation was negatively correlated with soil pH and positively correlated with Fe, Mn, Zn, Cu, Silt and clay at significant level. Kusuku soil with higher values of Clay, Mn, Fe and Zn exhibited higher P fixation capacity than Nguroje soil. The high P fixation capacity of Kusuku and Nguroje soils will reduce the amount of phosphorus readily available for tea uptake after fertilizer application. Though the adsorbed P will eventually become bioavailable, provision for the fixed P should be made at the time of fertilizer recommendation.

Key words: Tea, Phosphorus, fixation, fractional recovery

INTRODUCTION

Tea (*Camellia sinensis*) is the most widely consumed beverage in the world and ranked second to water as the most consumed drink worldwide (Ho *et al,* 2009). Production of tea is steadily on the increase globally. Tea has a significant role as a health drink. It is cultivated in fifty countries with major producers being India, China, Kenya, Sri Lankar, Vietnam, Turkey, Indonesia and Iran (FAO, 2014). Nigeria is one of the countries in Africa that produce tea. Tea cultivation in Nigeria is mainly done on the Mambilla Plateau in Sardauna Local government area of Taraba State in the Northern part of the country. Report of Food and Agriculture organization (FAO) showed that the world production of tea stands at 5.56 million tons with plantation hectarage of 3.80 million (FAO, 2014). In spite of the fact that tea's nativity is traceable to the humid tropics and subtropics, it has been found to have a very wide adaptability and thus can be cultivated in a wide range of climatic conditions and soils. It is also grown across a range of altitude from sea levels up to about 2,200 meters above sea level. Tea cultivation requires a minimum rainfall of 1,200mm per year but thrives optimally with annual rainfall of 2,500 – 3,000Mm.

Currently in Nigeria, tea cultivation for commercial purpose is only on the Mambilla Plateau in Sardauna local government area of Taraba State. This is due to the favorable climatic and soil conditions for tea cultivation on the plateau. The climate of the plateau is semi temperate in nature. Outdoor temperature taken by 7.00 am hardly exceeds 19°C. It can be as low as 13°C during winter. At noon, temperature ranges between 14 and 30°C depending on the period of the year (Aikpokpodion, 2020). Mambilla Plateau has elevation of 1500-2000 meters above sea level with an annual rainfall of 2000-3000mm.

In recent time, the yield of tea crop on the Mambilla Plateau has been on a decline. This might in part be a consequence of the low level of some macro nutrients in the soil. The report of Obatolu (1984) showed that phosphorus was the most limiting macronutrient in kusuku tea grown soil. A recent nutrient auditing carried out by the author on the various tea plantations on the Mambilla plateau showed that all the sampled tea farms had available P lower than 15mg/kg which is the critical level of P required for tea cultivation. The low available P content of the soils could be due to inherent acidic nature of the soils which promotes P fixation in soil and makes it unavailable for tea plant uptake. Information obtained from the farmers indicates that, none of the small scale tea farmers applies fertilizer in replenishing the soil. Rather, they solely depend on the inherent nutrients in the soils for tea sustainability. On the other hand, the Mambila Beverage Company Kakara, the producer of

Highland tea applies N:P:K 15:15:15 fertilizer occasionally on its tea plantations. The fertilizer application however, shows little or no difference on tea yield probably as a result of nutrients fixation in soil.

For adequate phosphorus fertilizer application to be obtained in acidic soils with high potential for P fixation, it becomes necessary to understand the chemistry and fate of applied phosphorus in such soils in order to avoid inappropriate fertilizer recommendation and application.

In order to achieve this, the study was carried out to examine the dynamics of applied Phosphorus fertilizer with respect to its fixation and bioavailability in tea cropped soils.

MATERIALS AND METHODS

Soil Sample Collection

Top soil samples were collected with soil auger at the depth of 0-20cm from selected tea farms at Kusuku and Nguroje in May, 2019. The soil samples were air-dried and sieved with 2mm sieve in the Analytical laboratory of the Mambilla Substation, Cocoa Research Institute of Nigeria, Kusuku, Taraba State.

Fractional recovery

Liquid phosphorus fertilizer was prepared in the analytical laboratory of Mambilla Substation in accordance with a modification of Hunter, (1975) method. To obtain 700ml mg PL^{-1}, 1.54g of KH_3PO_4 was prepared in 500ml of distilled water as stock solution. Five (5) sorption treatment solutions were prepared by diluting 10, 20, 40, 80 and 100ml of the stock solution to 100ml. A 6.0g of each soil sample was weighed into 80ml plastic cups in tray racks and 3ml of each of the five sorption solutions was added to the soil samples to arrive at 35, 70, 140, 280 and 560mg P kg^{-1}soil accordingly. Distilled water was thereafter added to the soil samples to keep the soil moisture at field capacity. The experimental set up was made in triplicate.

The treated soil and the control samples were incubated for a period of 3, 15, 30, 45 and 60 days under moist condition by adding distilled water when necessary. At the end of each incubation period, the treated samples and the counterpart control samples were air-dried and 3g of each subsample extracted with 18ml of Mehlich 3 solution for phosphorus determination. Colorimeter was thereafter used to quantify the recovered phosphorus after soil incubation. Fractional recovery and P fixation were calculated from the data obtained from P extraction. Obtained data were subjected to statistical analysis to evaluate the parameters that control P fixation in the studied soils.

RESULTS AND DISCUSSION

Fractional recovery and P fixation

Fractional recovery of P in Nguroje soil treated with 35mg Pkg^{-1} soil decreased from 0.038 at 3 days after incubation to 0.0013 at 60 days after incubation (Table 1). Result showed a progressive reduction in phosphorus recovery as incubation period increased. It implies that, as the incubation period increased, phosphorus fixation also increased. Similarly, the fractional recovery of P in Kusuku soil treated with 35mgPkg^{-1} soil also decreased from 0.0191 at 3 days after incubation to 0.0006 after 30 days of incubation. Result showed an increase in P recovery in Kusuku soil at 45 days after incubation. It suggests a desorption of certain fraction of initially fixed P in the soil matrix.

Table 1: Fractional recovery of P in investigated soil samples

Mg P/kg soil	Fractional recovery Nguroje 3 days	Kusuku	Nguroje 15days	Kusuku	Nguroje 30days	Kusuku	Nguroje 45days	Kusuku	Nguroje 60days	Kusuku
35	0.0380	0.0191	0.0014	0.0037	0.0251	0.0006	0.0017	0.0015	0.0013	0.0004
70	0.0286	0.0140	0.0014	0.0030	0.0063	0.0034	0.0019	0.0014	0.0016	0.0007
140	0.0238	0.0047	0.0026	0.0019	0.0035	0.0073	0.0034	0.0021	0.0024	0.0010
280	0.0202	0.0060	0.0052	0.0013	0.0046	0.0096	0.0040	0.0036	0.0038	0.0028
560	0.0048	0.0024	0.0026	0.0060	0.0032	0.0054	0.0023	0.0020	0.0031	0.0018

The observed progressive reduction in P fractional recovery with incubation time is in consonance with the report of Ogunlade *et al*. (2011) and Mallikarjuna *et al.* (2003). The decline in phosphorus recovery was indicative of fixation of a proportion of applied phosphorus in soil solution. A progressive decrease in P fractional recovery from 0.0286 to 0.0016 during 3 and 60 days after incubation respectively was also observed in Nguroje soil treated with 70 mg P kg^{-1} soil. The scenario was however different in Kusuku soil in which progressive decline in P recovery was only sustained in the first 15 days after incubation. Phosphorus fractional recovery declined from 0.014 at 3 days after incubation to 0.0030 at 15 days after incubation. The rate at which P fixation proceeds in soils is an important factor to be considered when assessing P availability to the growing plants. The observed increase in P fixation with reaction time is in agreement with the report of Ghani and Islam (1946) in which P fixation increased from 45% and 85% at 6 hours after incubation to 70 and 95% respectively 6 weeks after incubation in soils of Dacca (pH 5.2) and Berhampur (pH 4.6). Evaluation of phosphorus fixation with reaction time shows a rapid adsorption 96.20 and 98.09% in Nguroje and Kusuku soils respectively at three days after incubation. According to the report of Gupta, (1965) most of the applied soluble P was fixed up in 24 hours but gradually increased up to 30 to 45 days in soils depending upon the type of soil and thereafter remains constant. Desorption of adsorbed P was observed at 30 days after incubation which resulted to increase in P fractional recovery (Table 1). The redistribution of P in terms of desorption that took place at 30 days of P treatment indicates that, a proportion of phosphorus that was adsorbed between 3 and 15 days of treatment was released back into soil solution for tea uptake. This suggests that, phosphorus chemistry in soil is dynamic and not static. As the concentration of P in solution increased beyond70 $mgkg^{-1}$, a progressive decline in P recovery with time reached a climax at 15 days after incubation in both Nguroje and Kusuku soils. The decline in P adsorption in both soils at solution P concentration of 70 $mgPkg^{-1}$ soil suggests saturation of sorption sites on the soil surfaces. Phosphorus fractional recovery was lower in Kusuku soil compared with Nguroje soil. This implies higher phosphorus fixation in Kusuku soil.

In acidic soils of Baruijpur in West Bengal, Basu and Mukerjee (1972) reported a gradual adsorption of phosphorus up to 5 days before reaching a steady state at 18 days after incubation. In alluvial soils of Madhaya Pradesh, P fixation increased with time up to 60 days before reaching a steady state (Dravid and Apte, 1975). The first stage where P fixation is rapid is attributed mainly to exchangeable Al and Ca ions while the second stage of slow P fixation is attributed to the non exchangeable Al presumably dissociated from the non exchangeable sites (Kanwar and Grewal, 1990).

Clay and clay minerals factor in P fixation

Clay fraction of soil is the main site of phosphorus fixation. The nature of clay minerals is also a factor that determines the capacity and intensity of phosphorus fixation in any soil. Phosphorus fixing capacity of the clay minerals is mainly due to the replacement of OH ions from the clay minerals surface and reaction with soluble Al originating from the exchange sites and from the lattice dissociation of clay minerals to form insoluble P compounds. Phosphorus is retained in soil to a greater extent by clays of the 1:1 type (Kaolinite) than the 2:1 type clays (montmorillonite, illite, vermiculite) (Idris and Ahmed, 2012). According to Dean (1949), Fe and Al appear to be the most likely soil constituents that fix P by chemical precipitation in acid soils. Hydrous oxides of Fe and Al have the ability to fix phosphate through adsorption on their surfaces. They occur in soils as discrete particles or films on other soil particles. They occur in the form of amorphous and crystalline hydroxyl compounds in soil. However, when aluminum and iron oxides in soil are less crystalline, the phosphate fixing capacity of the soil increases due to greater surface area available for adsorption. On the other hand, crystalline hydrous oxides fix more phosphate in soil than layer silicates.

Fixation of nutrients in soil is hardly ascribed to a single mechanism or a single soil constituent due to the complex and multi-components nature of soil matrix. However, the higher P fixation in Kusuku soil compared with Nguroje soil may not be unconnected with the higher clay content of Kusuku soil compared with Nguroje soil. Result (Table not shown) showed that Kusuku soil had 340g of clay per kg soil while Nguroje soil had 160mg clay per kg soil. In addition to higher clay content of Kusuku, the soil was also higher in Fe (17$mgkg^{-1}$) than Nguroje soil (14.65$mgkg^{-1}$). Phosphate ions are chemically unstable in soil solution and readily react with oxides and hydroxides of Al and Fe found on clay surfaces of acidic soils (Bolland *et al.,* 2003).

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Correlation of soil physicochemical properties of the investigated soils with fractional recovery showed that P fixation increased significantly with clay, Fe, Zn and Mn. In a similar study conducted by Ogunlade *et al*., (2011), it was reported that P fixation increased with clay, organic carbon, Fe and Mn in selected cocoa soils in Nigeria. Thomazi *et al*., (1990) reported that Fe oxides and clay were the main factors contributing to P fixation in soils. Owusu-Bennoah and Acquaye (1989) report showed that phosphate sorption was highly correlated with clay and free Fe_2O_3.

The sesquioxides present in the free and hydrated state also determine P fixation in acid soils. Certain reports have validated the influence of sesquioxides on P fixation. Raychaudhuri and Mukerjee, (1941) reported an increase in P fixation with increase in HCL extracted sesquioxides in red soils. Ghani (1943) reported a considerable reduction in P fixing power of an acidic soil through de-activation of Fe and Al by means of 8-hydroxyquinoline. In addition, an account of Ghani and Islam, (1946) showed that 90% of fixed phosphate in soil was recovered as Fe and Al phosphate.

Other chemical constituents of the soil that might have enhanced higher P fixation in Kusuku soil compared with Nguroje soil is the Ca and Mg contents of the soil. Pearson correlation showed that phosphorus fixation increased with Ca and Mg in Kusuku and Nguroje soils significantly (P = 0.01). Calcium content of Kusuku soil was thrice the value of Ca in Nguroje soil while the value of Mg in Kusuku soil was twice that of Nguroje soil. The nature of the exchangeable Cations present on the colloidal complex of the soils plays an important role in P fixation. Patel and Viswanath, (1946) reported an increase in P fixation capacity with the increase in exchangeable Ca, exchangeable bases and total Cation Exchange Capacity. The exchangeable Ca ions act as bridge between phosphate ions and clay surfaces. According to Kanwar and Grewal, (1990), about 30% of P fixation in acidic soils of Himachal Pradesh was due to exchangeable Ca and Mg.

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IDENTIFYING SOIL PROPERTIES UNDER COCOA (*THEOBROMA CACAO L.*) PLANTATION USING SOIL SAMPLING DIRECTED BY APPARENT SOIL ELECTRICAL RESISTIVITY AT IBADAN SOUTHWEST NIGERIA

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ABSTRACT

Conventional soil sampling methods currently treat cocoa plantation homogeneously ignoring the natural inherent variability of soils and crop conditions. Site-specific crop management or precision agriculture has been proposed as a means of coping with spatially variable soil properties that affect crop yield. Soil electrical resistivity (ER) method to determine soil properties under cacao plantation was evaluated at Cocoa Research Institute of Nigeria. Omega resistivity meter was used to generate soil apparent resistivity of 120 cocoa trees in-situ using the Wenner configuration and PMS714 moisture meter was used to determine moisture in-situ. Soil samples were collected for baseline laboratory analysis. Data collected was subjected to correlation, non – linear and linear multiple regression analysis using Origin PRO V.8.1 statistical software. It was observed that soil electrical resistivity (ER) significantly correlated with some soil properties such as; bulk density, moisture content, soil organic matter, P, K, Ca with a correlation coefficient (r) of 0.65(P<0.01), -0.61(P<0.05), -0.69(P<0.01), -0,72(P<0.01), -0.61(P<0.05), and -0.67(P<0.01) respectively. Therefore, monitoring soil productivity and management of large agricultural field with soil resistivity methods rather than the conventional methods which is expensive, time consuming, hazardous and tedious.

INTRODUCTION

Cocoa production thrives in tropical environment and a source food and income millions of farmers across Africa, Latin America, the Caribbean and Asia. Cocoa grows well in loamy soils, well deep, well drained and good moisture holding capacity soils with pH range of 5.0-7.5. Cocoa production is mainly impeded by drought, diseases and nutrient status of the soils. Methods of determining soil properties affecting cocoa yield is time-consuming, cumbersome and costly (Asowata *et al*., 2017). Recently, soil electrical resistivity method of predicting soil properties influencing growth and yield of crops has been introduced into precision agriculture. The apparent electrical resistivity (ERa) measurements of soil can be considered as a proxy for the variability of soil physical properties (Banton *et al.,* 1997). The measurement of apparent soil electrical resistivity (ERa) is a technology that has become an invaluable tool for identifying soil physical and chemical properties influencing crop yield (Corwin *et al*., 2003).

The use of precision agriculture that is based on chemical and physical properties of the soils requires dense sampling to determine spatial variability in the field (SILVA et al., 2010). A decreased density of sampling can lead to errors in estimating the spatial variability of soil nutrients and, consequently, errors in recommendations. With the aforementioned modern methods, spatial variability within a field could be documented under various crops (Corwin et al., 2003). Dabas *et al*., 1994 used soil electrical resistance to identify areas of poor crop growth in a field by precise electrical soil mapping. Soil resistivity is the property of the soil that impedes or resists the flow of electric current through the soil. There is little or no information as regard cocoa plantations and soil electrical resistivity technique of identifying soil properties influencing cocoa yield. Thus, the objectives of this research were to determine the correlation between apparent soil electrical resistivity and soil properties under cocoa production system.

MATERIALS AND METHODS

Site description

The study site is about one-acre plot located in the cocoa seed garden field at Cocoa Research Institute of Nigeria, (latitude 7° 13' 0287"N, longitude 3° 51' .685"E) with about 1320 mm annual rainfall and average daily temperature of 30°C. The experimental area is geologically underlain by undifferentiated basement complex rocks in undulating surfaces with sparse rock outcrop. The soils are deep, well drain sandy loam surface soils over gravelly sandy clay loam subsoil. The cocoa plantation experimental set up is a randomized complete block design with eight (8) hybrids cocoa variety's' trees selected as treatments and replicated three times. Soil samples

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were collected at a depth of 0 to 30cm for laboratory analysis. Soil Electrical Resistivity survey at electrode spacing of 30cm and a depth of 30cm of investigation based on wenner configuration (Fig.1) was conducted using Omega resistance meter and PMS714 soil moisture meter was used to determine the soil moisture content per tree in-situ as seen in plate 1, and the cocoa trees were also geo-referenced.

In theory, apparent electrical resistivity (ρa) of a material is defined as follows:

$$\rho a = \frac{A\Delta U}{LI} \text{ (ohm m)} \quad 1$$

$$\rho a = \frac{K(\Delta U)}{I} \quad 2$$

$$K = 2\pi a \quad 3$$

Where A is the cross sectional area, I is current, L is the length of wire, K is the geometric factor and ΔU is the potential difference generated within the soil. The potential difference provides information of about the surface and subsurface soil heterogeneity and their electrical properties

Plate 1: A set up of soil electrical resistivity and soil moisture survey under cocoa plantation in-situ

RESULTS AND DISCUSSION

Electrical resistivity (ER) of the soil under cocoa plantation at CRIN

The electrical resistivity (ER) values for soils under various hybrid cocoa varieties are presented in Table 1. The ER values varied across cocoa varieties. Tc-5 gave the lowest ER. Also, soil under Tc-5 plots had the highest soil moisture content as ER strongly depends on soil moisture due to the fact that good moisture content keeps the nutrient in ionic form (soil electrical charge density) responsible for soil electrical resistivity. Soil moisture negatively correlated with soil electrical resistivity, the negative correlation implies that an increase in the value of the soil property leads to a decrease in the measured ER and vice versa. Table 2, also shows a significant negative correlation between soil moisture and soil electrical resistivity.

Table 1: In-situ soil electrical resistivity (ER) under cocoa plantation at CRIN

Cocoa varieties	No of samples	Soil ER (Ωm)			
		Min.	Max.	Mean	S.D
TC1	15	78.41	398.53	172.46	87.89
TC2	15	84.27	350.84	198.75	87.07
TC3	15	21.12	438.50	226.18	131.43
TC4	15	174.51	396.65	269.80	62.91
TC5	15	47.71	285.98	139.08	70.31
TC6	15	71.68	276.37	165.72	59.97
TC7	15	68.55	436.61	181.31	92.89
TC8	15	105.46	470.92	239.52	94.55

CRIN: Cocoa Research Institute of Nigeria.

Table 2: Physical properties of soil under cocoa plantation at Cocoa Research Institute of Nigeria

Cocoa cultivars		Physical properties				
		ϴ (%)	BD($Mg\ m^{-3}$)	Sand($g\ kg^{-1}$)	Clay($g\ kg^{-1}$)	Silt($g\ kg^{-1}$)
TC5	N	15	15	15	15	15
	Min.	8.20	1.14	555.20	140.00	132.80
	Max.	19.80	1.67	675.20	312.00	204.80
	Mean	11.42	1.39	637.20	192.80	170.00
	S.D	3.13	0.17	31.67	43.76	21.33
TC6	n	15	15	15	15	15
	Min.	6.70	1.19	555.20	104.80	152.80
	Max.	15.30	1.51	715.20	232.00	232.80
	Mean	10.71	1.35	633.87	177.00	189.13
	S.D	2.66	0.10	54.75	40.57	21.68
TC7	n	15	15	15	15	15
	Min.	7.40	1.13	575.20	144.80	152.80
	Max.	15.50	1.62	675.20	252.00	220.00
	Mean	10.68	1.46	631.20	183.20	185.60
	S.D	2.36	0.13	30.43	31.62	21.98
TC8	n	15	15	15	15	15
	Min.	4.70	1.25	5995.20	104.80	132.80
	Max.	10.40	1.65	695.20	212.00	232.80
	Mean	7.97	1.40	648.60	157.60	193.87
	S.D	1.50	0.11	34.26	29.45	23.67

Correlation between soil properties and electrical resistivity (ER) under cocoa plantation

Multiple linear regressions were carried out to establish models showing relationship between ER and soil properties**.** The soil electrical resistivity values varied across cocoa varieties with some positive and negative correlation with soil properties. Soil properties that significantly correlated with ER under a variety may not be significant with ER under another variety except for soil moisture content which was observed to have a significant negative correlation with the ER under all the varieties. (Corwin *et.al.,* 2003) obtain a significant positive correlation between soil moisture content and soil electrical conductivity ECa, (ECa=1/ER). This current study revealed significant correlation of electrical resistivity measured in-situ with many soil properties-mainly soil moisture content, pH, texture, bulk density, SOM, P, and Ca as seen in Table 3.

Electrical resistivity relates well to texture, salinity and water content (major drivers), organic matter, CEC, Avail. P etc (proxy) and water, temperature and bulk density (temporal effects). Soil electrical resistivity response is dominated by transient soil properties (moisture and temperature) (Sunshine *et al.,* 2014). Soil temperature influences the rate of decomposition of organic matter and consequently affects nutrient availability in soil (Oshunsanya, 2011). The prediction model of soil properties from ER fitted into different equations for all the eight cocoa varieties. Table 4 shows that Quadratic, Cubic and power equations was best for Tc-5, Tc-6 while other varieties fits into one or more equations respectively.

Table 3: Correlation between soil properties and electrical resistivity (ER) under cocoa plantation at CRIN

Soil property	Soil electrical resistivity of Hybrid cocoa plots							
	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8
Sand	-0.22	0.76**	0.12	-0.39	0.22	0.37	0.19	0.37
Silt	0.06	-0.13	-0.39	0.36	-0.08	0.04	-0.13	-0.33
Clay	0.12	-0.78**	0.09	0.25	-0.12	-0.52*	-0.09	-0.17
BD	0.65**	0.55*	0.73**	0.55*	0.62*	0.21	0.57*	0.56*
Soil moisture	-0.61*	-0.65**	-0.84**	-0.80**	-0.67**	-0.74**	-0.66**	-0.65**
pH	0.04	-0.31	-0.26	-0.10	0.02	0.60*	-0.67**	-0.76**
SOM	-0.69**	-0.51	-0.62*	-0.27	-0.44	0.26	-0.55*	-0.614*
N	-0.46	0.13	-0.41	0.02	0.14	-0.23	0.07	-0.53*
P	-0.72**	-0.61*	-0.69**	-0.54*	-0.62*	-0.49	-0.60*	-0.62*
K	-0.41	-0.14	-0.13	0.06	-0.55*	-0.03	-0.16	-0.02
Ca	-0.61*	-0.74**	-0.48	-0.52*	-0.63*	-0.71**	-0.53*	-0.53*

** = Significant (test for |r| = 0) at the P ≤ 0.01 level. * = Significant (test for |r| = 0) at the P ≤ 0.05 level

CONCLUSION

Soil electrical resistivity is a measure of several soil properties. Nevertheless, at this particular study site, ER was useful indicators of soil properties. Some properties have positive correlation with soil electrical resistivity while some were negatively correlated. The negative correlation implies that an increase in the value of the soil properties leads to a decrease in the measured ER and vice versa. While the positive correlation means an increase in the soil properties leads to an increase in the ER. Soil properties that significantly correlated with ER under a variety may not be significant with ER under another variety except for soil moisture content which was observed to have a significant negative correlation with the ER under all the varieties and this conformed with significant positive correlation between soil moisture content and soil electrical conductivity (ECa) (Corwin *et.al*., 2003) where ECa has an inverse relationship with ER [i.e. ECa=1/ER). This current study revealed significant correlation of electrical resistivity measured in-situ with many soil properties-mainly soil moisture content, pH, texture etc. The variation of the soil resistivity may be explained by the wide textural variation in the topsoil (Olorunfemi and Fasuyi, 1993; Mohammed, *et al*., 2012). Resistivity value less than 100 Ωm typifies clay while those in the range of > 100 and < 1000 ohm-m may indicate clayey sand, saturated sand while resistivity in the range of > 1000 ohm-m may represent lateritic sand (hard pan), sand and bedrock. The soils of the plantation varied in their physical properties. The variation in the physical properties of the soil could be as a result of leaf litter falls, in which the quantity of leaf litter fall varies from variety to variety. Hybrid cocoa variety with highest number of leaves which determines the leaf falls is expected to have higher soil moisture as leaf litter falls prevent loss of soil water through evaporation (Ogunlade and Iloyanomon, 2009). This current study revealed significant correlation of electrical resistivity measured in-situ with many soil properties-mainly soil moisture content, pH, texture, bulk density, SOM, P, and Ca. Further work should be done using soil electrical resistivity methods to predict soil properties and yield of cocoa in other locations and at different period using modern equipment like land mapper ERM 02.

Table 4: Curve fit Model generated from the relationship between Soil electrical resistivity (ER) and soil properties under cocoa plantation

Soil Properties	TC5`			TC6		
	Model	R^2	Model equation	Model	R^2	Model equation
Sand (g kg^{-1})	Quadratic	0.08	ER = -3847.0 + 12.4(Sand) – 0.0(Sand)^2	Quadratic	0.27	ER = 3272.7-10.3(sand)+ 0.01(sand)^2
Silt (g kg^{-1})	Power	0.03	ER = 4384.5 (Silt)$^{-0.7}$	Quadratic	0.04	ER = -663.9 +8.6(silt) -0.02(silt)^2
Clay (g kg^{-1})	Quadratic	0.03	ER = 41.4 + 1.1(Clay) -0.0(Clay)^2	Quadratic	0.41	ER = 782.8 -6.8(clay) +0.02(clay)^2
BD (Mg m^{-3})	Quadratic	0.41	ER = -1287.8 + 1779.8(BD) – 534.6(BD)^2	Quadratic	0.21	ER = -4940.0 +7494.8(BD) -2735.2(BD)^2
Ɵ (%)	Quadratic	0.61	ER = 841.3 -99.3(Ɵ) +3.1(Ɵ)^2	Quadratic	0.68	ER = 763.3 -94.9(Ɵ) +3.5(Ɵ)^2
pH	Power	0.01	ER = 194.5 (K)$^{-0.3}$	Exponential	0.41	ER = 12.2 * exp(0.5(pH))
OM (%)	Cubic	0.39	ER = 110.2 +255.1(OM) -160.9(OM)^2 +25.1(OM)^3	Cubic	0.22	ER = 144.9 + 56.9(OM) -48.6(OM)^2 +10.6(OM)^3
N (g kg^{-1})	Quadratic	0.07	ER = -186.2 + 371.4(N) -98.5(N)^2	Quadratic	0.08	ER = 4.9 +228.8(N) -74.3(N)^2
P (mg kg^{-1})	Power	0.53	ER = 17593700.3 (P)$^{-6.6}$	Quadratic	0.48	ER = -622.1 +228.1(P) -15.7(P)^2
K (cmol kg^{-1})	Exponential	0.32	ER = 819.1* exp(-1.8 (K))	Quadratic	0.06	ER = 372.7 -415.0(K) +199.1(K)^2
Ca (cmol kg^{-1})	Quadratic	0.54	ER = -2519.8 + 1123.6(Ca)-115.1(Ca)^2	Inverse	0.52	ER = -191.6 +1939.6/Ca
Mg (cmol kg^{-1})	Cubic	0.69	ER = -114.8 + 144.8(Mg) – 1695.7(Mg)^2 +570.5(Mg)^3	Quadratic	0.56	ER = 155.3 +254.0(Mg) -165.2(Mg)^2
Na (cmol kg^{-1})	Quadratic	0.13	ER = -333.5 + 1532.2(Na) -1173.6(Na)^2	Quadratic	0.16	ER = 771.9 -1844.1(Na) +1342.5(Na)^2
Zn (mg kg^{-1})	Cubic	0.17	ER = 253.3 -166.5(Zn) + 55.7(Zn)^2 -4.9(Zn)^3	Cubic	0.22	ER = 152.4 -56.8(Zn) + 106.8(Zn)^2 -34.3(Zn)^3
Cu (mg kg^{-1})	Quadratic	0.46	ER = 332.0 -13.4(Cu) -3.4(Cu)^2	Cubic	0.70	ER = 250.8 -33.0(Cu) -9.6(Cu)^2 +2.4(Cu)^3

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VARIABILITY OF SOME SOIL PHYSICAL PROPERTIES IN CITRUS AND MANGO ORCHARDS

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ABSTRACT

Knowledge of some physical properties in soil as well as physical properties architecture in tree is important for successfully running the precision farming. Hydraulic conductivity, bulk density, water holding capacity, compaction, aggregate stability etc. are known to vary under different water regimes, tillage implementation, soil management, etc. Land use management is also known to have profound impact on some physical properties. Both the soil and tree components are dependent on the abiotic stresses existed in the field or green house condition. This research was carried out to examine the variability of some physical properties of soil under citrus and mango orchards at National Horticultural Research institute (NIHORT). Soil samples were collected from the depths of 0-15cm randomly from both orchards. A total of 16 samples were used for the study. The samples collected were air dried, crushed and sieved in a 2mm sieve and was prepared for laboratory analysis. Means and coefficient of variation were used as statistical tools. The result showed that the textural classes of the site are sandy loam and loamy sandy, which shows that the soil at the studied site is suitable for planting. Saturated hydraulic conductivity of citrus orchard vary from 10.8cm/hr to 48.6cm/hr while, under mango orchard ranges from 18.6cm/hr to 42.0cm/hr that is, ranges from low to high due to slow movement of water, bulk density of citrus orchard vary form 1.22g/cm^3 to 1.4g/cm^3 while, under mango orchard ranges from 1.2g/cm^3 to 1.40g/cm^3 which is moderate. Total porosity under citrus orchard vary from 47.2% to 54% and under mango orchard ranges from 47.2% to 55%. Soil permeability under citrus orchard ranges from 0.01m^2 to 0.05m^2 while, under mango orchard ranges from 0.02m^2 to 0.05m^2. This study provides new insight for soil site specific management in addressing issues such as where to place the proper interventions (tillage, irrigation and crop type to be grown).

INTRODUCTION

Soil, as a natural body, is inherently heterogeneous because of the many factors that contributes to soil formation and the complex interactions of those factors. Variability in soil properties has been found to significantly influence soil management and crop production (Fasina 2003). Apart from inherent soil differences, variation in soil properties are due to soil forming factors (climate, parent materials, organisms, relief and time and differences in weathering rates (Mzuku *et al*., 2005, Udoh *et al*., 2007). Man has contributed to soil variability through factors such as land use, fertilizer application and different management practices (Ogunkunle and Erinle 1994; Ryan *et al*., 1997; Fasina, 2003). Soils vary in time and space (Onweremadu and Akamigbo, 2007). Variations could be as a result of changes in the lithological origin (Onweremadu, 2008), land use and landscape position (Onweremadu, 2007). Variability in physicochemical properties of soils of similar lithological and climatic origin can be ascribed to differences in soil management, and this affects soil quality (Brady and Weil, 2002). Soil spatial variability is an important determinant of efficiency of farm inputs and yield, (Salgam, 2011) as well as crop management and design and effectiveness of field research trials, (Khan *et al*., 2019). These variations differed among soil properties, and may reflect the impacts of plant, soil fauna, precipitation and management practices adopted in the area, Jafari *et al*., 2011). Soil variability is the reason sampling procedures are so important. Soil varies continuously within fields and between farms. Surface variation may be easily seen, but nutrient variability is usually not obvious. The most noticeable differences ate those which are physical because they are visible. Texture, colour, slope, erosion and drainage are some obvious visible differences. Citrus is a genus of flowering trees and shrubs in the rue family, *Rutaceae*. Plants in the genus produce citrus fruits, including important crops like oranges, lemons, grape fruits and limes. Citrus generally require 12 elements apart from C, H and O. Which include N, P, K, Mg, Ca, S (macronutrients), Mn, Cu, Zn, B, Fe and Mo (micronutrients) (Davies and Albrigo 1994). Since nutrient uptake efficiency ranges from 20-50% in citrus groves, nutrient application must exceed the minimum requirement of the tree. However, split application of 2-3times per year has been advocated for, to avoid placing a large amount of fertilizer in the soil and thereby encouraging leaching loses (Avav *et al*., 2002). Mango is a juicy stone fruit (drupe) belonging to the genus *Mangifera*, consisting of numerous tropical fruiting trees cultivated mostly for edible fruit. The majority of these species are found in nature as wild mangoes. They all belong to the flowering plant family *Anarcardiaceae*. Therefore, the objective of this study is to evaluate the variability of selected soil physical properties and to determine the relationship between some soil properties in citrus and mango orchard.

MATERIALS AND METHODS

The experiment was carried out at the National Horticultural Research Institute Ibadan, Oyo State. The area lies between Latitude 7^{o}40'N, Longitude 3^{o}84'E and 213m above sea level in the Greenwich Meridian, its average rainfall is about 1250mm while average annual mean temperature is 26^{o}. The average relative humidity is 74.53% (NIHORT, 2013). The soil samples were taken from NIHORT citrus and mango orchard. The citrus orchard was established in the year 1996, at a spacing of 7m by7m per stand and the mango orchard was established between the years 1987-1989 at a spacing of 10m by10m per stand. Soil samples were collected within the field and 16 soil samples were randomly collected at 0-15cm depth. Soil physical properties was analysed in the laboratory which include: Particle size distribution, saturated hydraulic conductivity, soil bulk density, permeability. Data collected was statistically analysed using mean, standard deviation and coefficient of variation. Data collected was statistically analysed using mean, standard deviation and coefficient of variation

RESULTS AND DISCUSSIONS

Mean values of physical properties of soils under citrus and mango orchards is as presented in Table 1. Saturated hydraulic conductivity Ksat of citrus orchard has the least value of 10.8cm/hr and for mango orchard is 18.6cm/hr (Table 2). This is in agreement with the report by Ezeaku *et al*., 2005 that the implication of low values of Ksat can be as a result of limited crop production due to unavailability of little or too high water transmission at the root zone. The Citrus and Mango orchard observed in the study area was highly variable with 48.6cm/hr and 42.ocm/hr value respectively. This is in line with the findings of Ezeake *et al*., 2005 who reported that high value of Ksat can be as a result of high water transmission and this result of higher bio- turbation (e.g. burrowing activities by animals and root movement in soils) which may results to higher bio-pores and cross sectional area that contribute to flow and such soils could be regarded as a hydraulic conductivity. Bulk density in citrus orchard ranged from 1.22g/cm3- 1.40g/cm3 (Table 3), which ranges from fine texture soil (FTS) to medium texture soil (MTS) while under mango orchard it ranges from 1.20g/cm3-1.40g/cm3 which is also regarded as fine texture soil (FTS), and medium texture soil (MTS). Ezeaku (2005) reported and suggested that lower mean obtained from the result could be as a results of constant cultivation, high organic matter due to mulching, addition of other organic material and biodegraded. In order to compare the variability of soil properties in citrus and mango orchard of studied site, the co-efficient variation(CV) was used and the result was categorized according to (Wild and Dress 1983) 0-15 is regarded as low variability, between 15 and 35 is regarded as moderately variable while greater than 35 is regarded as highly variable (Tables 4 & 5).

TABLE 1: Particle size distribution analysis

	Samples	Sand g/kg	Clay g/kg	Silt g/kg	Textural class
Citrus	687	92		221	SL
	783	78		139	LS
	727	150		123	SL
	853	60		87	LS
	869	104		27	LS
	884	108		8	LS
	763	110		127	SL
	837	154		9	LS
Mango	765	77		158	LS
	674	79		247	SL
	775	140		85	LS
	805	17		216	LS
	650	134		53	SL
	832	115		43	LS
	852	105		43	LS

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742	126	136	SL

Keys SL- Sandy Loam, LS- Loamy

Table 2: Saturated hydraulic conductivity of the study Area

Parameters	Citrus (cm/hr)	Mango (cm/hr)
	48.6	18.6
	25.8	24.6
	22.2	33
	39.6	39.6
	10.8	22.8
	32.4	24.6
	19.2	42
	26.4	24.6
Mean	28.13	28.73
Standard deviation (SD)	11.9	8.46
Coefficient of variation (CV)	42.3	29.44

Table 3: Bulk density of the study area

Parameters	Citrus (g/cm^3)	Mango (g/cm^3)
	1.40	1.30
	1.32	1.20
	1.35	1.30
	1.40	1.20
	1.30	1.22
	1.22	1.31
	1.31	1.35
Mean	1.32	1.28
Standard deviation (SD)	0.06	0.07
Coefficient of Variation (CV)	4.46	5.63

Bulk density ratings: Fine texture soil 1.0 - 1.2, Medium texture soil 1.3 - 1.5, Coarse texture soil 1.6 - 1.9, Gravel: Greater than 2.0

Table 4: Soil permeability of the study area

Parameters	Citrus (m^2)	Mango (m^2)
	0.05	0.02
	0.03	0.03
	0.02	0.03
	0.04	0.04
	0.01	0.02
	0.03	0.03
	0.02	0.04
	0.02	0.04
Mean	0.03	0.03
Standard deviation (SD)	0.01	0.01
Coefficent of variation (CV)	46.55	26.56

Table 5: Soil porosity of the study area

Parameters	Citrus (%)	Mango (%)
	47.2	51
	51	55
	51	51
	50	47.2
	47.2	55
	51	54
	54	51
	51	50

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Mean	50.3	51.7
Standard deviation (SD)	2.23	2.71
Coefficient of variation	4.54	5.24

CONCLUSION

The result shows the variability of some soil physical properties in citrus and mango orchard. The result of the studied site shows the bulk density in citrus orchard ranged from 1.22g/cm^3 -1.40g/cm^3 which is regarded as fine texture soil (FTS) and medium texture soil (MTS). Mango orchard ranges from 1.20g/cm^3 -1.40g/cm^3 which is also regarded as fine texture soil (FTS), and medium textured soil (MTS). Saturated hydraulic conductivity of the two orchards vary from 10.8cm/hr to 48.6cm/hr which ranges from low to high variable, due to slow movement of water, bulk density was moderate which ranges from 1.20 – 1.40g/cm3, total porosity varies from 42.7% -54%, the permeability values are very low which shows that variability occur at different sampling point. The study revealed that there was increase in the soil properties in (saturated hydraulic conductivity, bulk density, particle size distribution and permeability) of the study area. Hence, the characteristics of these parameters showed that variability occurs at different sampling points. This study provides new insight for soil site specific management in addressing issues such as where to place the proper interventions (tillage, irrigation and crop type to be grown.

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DISTRIBUTION OF SOIL HEAVY METALS AND PHYSICOCHEMICAL PARAMETERS IN THE SOILS OF COCOA FARMS AND THEIR ADJACENT FORESTS IN SOUTHERN NIGERIA

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ABSTRACT

Soil samples were collected from randomly selected cocoa farms and their respective adjacent forests from nine cocoa producing local government areas across Abia, Cross River and Edo States. The soil samples were thereafter subjected to heavy metals/physicochemical analyses. Out of all the heavy metals tested, chromium was highest, with a range of 3.05-5.448mg/kg, 1.558-6.553mg/kg and 0.918-6.373mg/kg for samples obtained from Cross River, Abia and Edo States respectively. Also, the heavy metal contents in Cross River State are the highest, while those of Abia and Edo much lower ranges. The heavy metal contents of the cocoa farm soils were higher than their respective adjacent forests across all the locations sampled. While the value of chromium across all the locations were within the permissible limits. Other heavy metals were however below permissible limits. Thus, the metals do not yet constitute a source of contamination to the soils. The higher heavy metal values recorded for soil samples obtained from cocoa farms compared with those of the adjacent forests across the sample locations is however, an indication of pesticide usage on the farms.

Key words: cocoa, heavy metals, contamination, permissible limits

INTRODUCTION

Cocoa production is distinctive to tropical environments and provides livelihood for millions of small-holder farmers in Africa, Latin-America, The Caribbean and Asia. The crop does well in deep, well drained and good moisture holding capacity soils with pH range of 5.0 to 7.5. Worldwide, cocoa comes from small scale farmers out of which West Africa produces over 70% (FAO, 2007). Nigeria produces about 367,000 tonnes of the world production in 2013. Studies on cocoa chemical composition and properties shows that a moderate consumption of cocoa may be beneficial for human health, mainly due to high content of polyphenolic compounds such as flavonoids, as antioxidants. In spite of the many health benefits of cocoa and cocoa products, there are still safety worries in respect to occurrence and levels of heavy metals in cocoa and cocoa products, such as cadmium (Cd), chromium (Cr), nickel (Ni) and lead (Pb). It was reported by Rankin *et al*., 2005 that cocoa and cocoa products from Nigeria contains high amount of Lead (Pb).

The use of pesticides and herbicides is common among cocoa farmers to control disease causing pest, and weed control. Most of these agrochemicals are not biodegradable and their continuous usage can lead to soil contamination with heavy metals (Aikpokpodion., 2012). Heavy metals pollution of soil is of grave concern because of its effect on the food chain (Singh *et al*., 2011). It is essentially caused but not limited to Cu, Ni, Cd, Zn, Cr and Pb, while some few heavy metals (Zn, Fe, Ca, Mg) have been reported to have bio importance to human and plants at very low concentration (Singh, 2011 and Duruibe et al, 2007). The aim of this study is evaluate the contamination of some heavy metals in soils of selected cocoa farms and adjacent forest in the study areas.

MATERIALS AND METHODS

Physicochemical/heavy metal analyses

Soil samples were collected from randomly selected cocoa farms and adjacent forests from nine cocoa producing local government areas across Abia, Cross River and Edo States. The samples were separately taken at 0-20cm (top soil) and 20-40cm (sub-soil) depths with the aid of a soil auger. Six (6) core soil samples were randomly collected at about 6m intervals within each plantation to obtain a representative sample of each farm. The composite soil samples were properly labeled and their respective locations geo-referenced. The samples were properly processed and sieved. Each of the composite samples was then sub-sampled for laboratory (heavy metals, pH, texture, total nitrogen and cations) analyses using standard methods.

RESULTS AND DISCUSSIONS

The heavy metals concentration: cadmium (Cd), lead (Pb), chromium (Cr) and nickel (Ni) in soils across the study areas is presented in Table 1. The distribution of heavy metals shows an increasing order of Cr > Pb > Cd > Ni across the states. Cd, Pb, Cr and Ni contents of the soils varies across locations. The range of Cd contents in selected farms and adjacent plots in Abia, Edo and Cross River as seen in Table 2 shows that Abia had a mean value of 0.675mg/kg for cocoa farms and 0.691mg/kg for its adjacent plots. Values obtained from some of the locations were slightly higher than the permissible values with all the states having a mean value less than the permissible range. There appeared not to be a significant difference in the soil cadmium contents between cocoa farms and adjacent forests in the three states. This suggests an edaphic nature of Cadmium in the area due to weathering of parent rocks (Alloway,1995) which collaborates earlier findings by Ogunlade *et al*. (2011) that most farmers don't use fertilizers in their cocoa farms but the use of agrochemicals is already gaining momentum amongst cocoa farmers (Issa, 2016). The cadmium values in both cocoa farms and adjacent plots across the states are within the permissible levels of cadmium by various authorities (0.8mg/kg WHO, 1996, 0.76mg/kg, Commentuijn *et al.* (1997), 0.5mg/kg (Saadia *et al*., 2016). It is important to stress that excessive levels of cadmium in soil (>1 mg/kg) presently found in samples maybe due to closeness of such farms to some industrialized areas and may largely be as a result of emissions (Oversteyns.,1992).

The amounts of lead in the cocoa farm and adjacent forest soils across the three states were generally lower than permissible standards. The values were lower when compared with the National Environmental Quality Standard (NEQS) of 25mg/kg as reported by Saadia *et al*. (2016) and 85mg/kg (WHO,1996) (Table 3). This shows that lead content was natural in the samples and so, did not pose any contamination threat to cocoa or other crops in the area under evaluation.

The highest Cr values detected from the samples taken from Abia, Edo and Cross-River States were 6.553, 6.373 and 5.448mg/kg in both cocoa farms and adjacent plots. These were however far below the permissible levels of 20mg/kg(NEQS), 150mg/kg(EU,2002) and 100mg/kg (WHO., 1996) indicating there was no contamination threat as regards the heavy metal. The Ni contents both in the soil of cocoa farms and adjacent plots sampled in the three States were very low (Zarcinas *et al.,* 2004) and does not pose any contamination threats to consumption of cocoa and cocoa products from the area.

Mn, Fe, Cu and Zn

The concentration of Mn, Fe, Cu and Zn (required for cocoa production in very small quantities) in the soil samples were below the permissible levels (Cu: 140mg/kg EU 2002, 100mg/kg, WHO/FAO 2001, Zn: 50mg/kg WHO,1996) (Table 3).

Table 1. Heavy metals parameters in some selected cocoa farms and adjacent forests in the study area

States	LGA/community	Cd mg/kg		Pb mg/kg		Cr mg/kg		Ni mg/kg	
		Cocoa plot	Adj plot	Cocoa plot	Adj plot	Cocoa plot	Adj plot	Cocoa plot	Adj plot
Abia	Udeoro-3 Bende	0.875	NA	1.975	NA	1.558	NA	0.255	NA
	Uguanta-2	0.732	0.875	0.925	1.550	6.553	3.085	0.208	0.213
	Uguanta Bende	0.725	NA	1.117	NA	2.693	NA	0.220	NA
	Ukaluuta	1.115	1.012	2.725	0.725	6.135	5.485	0.281	NA
	Isieruote iyienyi	0.987	0.375	1.875	2.875	3.790	4.725	0.302	0.133
	Umu north LGA	0.725	0.500	1.975	1.650	4.663	5.338	0.236	0.096
	Owan west LGA	0.725	0.550	2.711	1.475	3.443	4.715	0.098	0.101
Edo									
	Uhunode LGA	0.775	0.875	2.329	0.708	6.373	3.133	0.211	0.180
	Esan west	0.904	0.713	0.275	0.425	0.918	0.375	0.085	0.076
Cross River	Ikom LGA	0.825	NA	0.341	NA	3.675	NA	0.090	NA
	Etung LGA	1.075	NA	0.725	NA	4.188	NA	0.123	NA
	Boki	1.075	NA	2.425	NA	5.448	NA	0.137	NA

Table 2: Ranges of values per states of Heavy metals across the states

Soil properties	Abia Cocoa	Adjacent	Edo Cocoa	Adjacent Forest	Cross River Cocoa	Adjacent
Mn	4.265-10.900	3.580 -7.350	2.605-12.355	2.755-14.755	2.895-6.745	-
Fe	0.995-4.155	1.230-2.290	2.590-6.395	1.840-6.785	1.205-8.015	-
Cu	0.315-2.090	0.330-2.170	0.265-1.215	0.285-0.755	0.525-1.190	-
Zn	0.439-2.723	0.633-1.777	2.021-5.867	1.945-2.224	0.691-1.704	-
Cd	0.323-1.115	0.375-1.012	0.725-0.904	0.550-0.875	0.825-1.075	-
Pb	0.450-2.725	0.725-2.875	0.275-2.711	0.425-1.475	0.341-2.425	-
Cr	1.558-6.553	3.085-5.485	0.918-6.373	0.375-4.515	3.675-5.448	-
Ni	0.115-0.302	0.096-0.213	0.085-0.211	0.076-0.180	0.090- 0.137	-

Table 3. Heavy metal permissible levels in soils and plants

Heavy metals	Soil (mg/kg)	Plants (mg/kg)
Cadmium	0.8	0.02
Zinc	50	0.6
Copper	36	10
Chromium	100	1.3
Lead	85	2
Nickel	35	10

Source: WHO, 1996

Physiochemical Properties

Results of the baseline analysis of the physical and chemical properties of the soil samples across the states are as presented in Table 4. The textural classes of the samples were sandy-loam. The pH, a useful factor that influences heavy metals availability in agricultural soils tended towards acidity, ranging from between 4.22 and 6.38. At high pH (alkalinity), some metals are not available for uptake. Mg, Ca, and K are available at pH>8 but Fe, Zn and Cu are less available. The nitrogen content of all the samples was adequately above the critical value of 0.09 %N for cocoa soil (Egbe *et al.*, 1989). Majority of the samples did not meet the phosphorus and potassium critical values of 10mg/kg and 0.3cmol/kg required for cocoa cultivation. The exchangeable calcium and magnesium was moderately adequate across the states for cocoa soils (Egbe *et al.*, 1989). The physiochemical properties of soils influence the mobility and pathways of nutrients and pollutants in soils. Similarly, the accumulation of heavy metals in soils is also governed by a number of soil properties such as pH, organic matter, conductance, inorganic ions (Vern and Don, 2011).

CONCLUSION

The number/type of pesticides used on cocoa farms in the study areas varied with location and farmers' perceived effectiveness/availability of those chemicals. Farmers in Cross River States impressively made use of government approved chemicals to control pests and diseases on their cocoa farms. This was a clear contrast to what obtained in Edo State. An average compliance was, however, noticed among farmers in Abia State.

Table 4. Distribution of soil properties of cocoa plantations and adjacent forests in some states

Soil properties	Ranges of values per states					
	Abia		Edo		Cross River	
	Cocoa	Adjascent	Cocoa	Adjascent	Cocoa	Adjascent
pH	4.43-6.22	4.46-6.14	6.06-6.38	5.86-6.29	4.22-5.56	-
% Sand	71.52-79.52	73.52-83.52	87.52	85.52-87.52	73.52-77.52	-
% Silt	12.56-20.56	8.56-16.56	4.56	4.56-6.56	12.56-18.56	-
% Clay	7.92-13.92	5.92-9.92	7.92	7.92	7.92-13.92	-
Ca(cmol/kg)	7.95-28.44	5.09-30.61	3.42-11.14	5.05-7.89	4.42-16.68	-
Mg(cmol/kg)	1.39-2.18	1.30-1.96	0.96-1.82	1.29-1.48	1.03-1.43	-
Na(cmol/kg)	0.27-1.04	0.27-0.77	0.10-0.47	0.13-0.33	0.47-0.57	-
K(cmol/kg)	0.18-0.40	0.20-0.48	0.18-0.26	0.16-0.18	0.18-0.22	-
Total N %	0.13-0.36	0.17-0.34	0.16-0.26	0.15-0.27	0.13-0.24	-
Org- C (g/kg)	1.60-3.80	2.23-3.69	2.12-2.96	1.54-2.77	1.66-3.08	-
Avail-P (mg/kg)	1.33-14.72	0.67-9.37	1.67-7.03	0.84-13.34	0.33-2.21	-

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PERFORMANCE OF SWEET POTATO (*IPOMOEA BATATAS*) AND SOIL PROPERTIES UNDER TILLAGE-MULCH IN OMUO EKITI, RAINFOREST ZONE OF NIGERIA

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ABSTRACT

Field experiment was conducted during 2018 planting season at Omuo Ekiti in the rainforest zone of Southwest Nigeria on sandy loam to develop soil management practice to enhanced soil productivity of sweet potato (Ipomoea batatas). Ten mulch-tillage practices involving five mulch rates (0, 5, 10, 15, and 20 t/ha) and two tillage methods (no-tillage and manual ridge) were investigated. Soil physical and chemical properties and growth and yield parameters of sweet potato were evaluated. It was found that soil moisture content and porosity increased with increase in rate of mulch whereas soil temperature and bulk density reduced irrespective of tillage method. No-tillage had lower soil temperature, high moisture content and lower porosity compared with manual ridge. Soil organic matter (OM), N, available P, K, Ca Mg and pH increased with mulch rate and No-tillage had higher values of OM, N, P, K, Mg, and pH relative to manual ridge. Number and weight of tubers increased with mulch rate. Relative to the control, the 5, 10, 15 and 20 t/ha mulch increased yield by 25, 38, 66, and 67% respectively. Considering the need to maintain high soil fertility and more suitable soil physical conditions for enhanced potato yield, it is recommended that no-tillage be combined with 20 t/ha mulch.

Keywords: Tillage, Weed Mulch, Soil Productivity, Sweet potato, Omuo Ekiti

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) is cultivated largely in tropical and subtropical agro-ecologies. The tuber is eaten boiled, roasted, fried and baked or made into syrup and also serves as raw materials for the manufacture of starch, glucose and alcohol (Yasmin *et al.,* 2007). The leaves are also used as vegetables in some communities in Nigeria and widely used as fodder for livestock. The tuber is an excellent source of anti-oxidants and carotenes chiefly in the orange flesh colour varieties thus providing cheap and rich source of vitamin A for poor people (Woolfe, 1992). Sweet potato production is constrained by depletion of soil fertility and degradation of soil physical properties and inadequate fertilizers. It is established that chemical fertilizers have failed to make necessary impact in tropical agriculture and Nigeria in particular, sustainable crop production is not possible with dependence on chemical fertilizers alone (Ojeniyi, 1995). Sweet potato is often grown on raised beds and mounds, but it is established by research that no-tillage is important in soil and water conservation and has been favourable to crops performance in the humid zones (Adekiya and Ojeniyi, 2011; Agbede, 2008). Tillage affects soil properties such as temperature, moisture content, bulk density, porosity and infiltration which affect crops performance. If intensively performed or mechanized it causes rapid degradation of soil physical, chemical and biological qualities especially in humid zones of southern Nigeria.

Mulch on the other hand is a layer of plant residue applied to the surface soil to conserve moisture and improve its fertility and it is a common practice recommended for tropical small holder farming (Akanbi and Ojeniyi, 2007). The technique improves biotic activity and adds nutrients thereby improving soil fertility and crops yield. Akanbi *et al.* (2013) recognized the need to intensify studies into locally sourced, cheap, adoptable organic sources of plant nutrients. In order to alleviate the problems of low soil fertility and quality affecting yield of sweet potato, there is the need to develop an organic base soil management for sustainable production of crop. The problems of low soil fertility and soil quality affecting yield of sweet potato can be alleviated with repetitive cultivation, therefore there is need to develop an organic no-till bared soil management for sustainable production of the crop. It is already established that total dependence on chemical fertilizer has failed to sustain crop production in the tropics (Ojeniyi, 2000; Ano and Agwu, 2005). The importance of no-tillage and mulching in soil and water conservation, growth and yield of crops in Nigeria has been reported (Agele *et al.,* 1999). However, research information is scarce on response of sweet potato to tillage and mulching in different agro ecological zones of Nigeria. Ossom et al. (2001) in Papua New Guinea reported the benefits of applying mulches to sweet potato to stabilize yield. The main objective of this work was to develop tillage- mulch practices for sustaining soil quality and yield of sweet potato in Omuo Ekiti rain forest Zone of Nigeria.

MATERIALS AND METHODS

The study was conducted during 2018 cropping season at Omuo-Ekiti, Ekiti State Nigeria. Omuo-Ekiti is located on latitude 7 ° 76` N and longitude 5 ° 72` E and Altitude of 460 m. The location has a bimodal rainfall of 1250 to 1460 mm with mean annual rainfall of 1367 mm and average number of rainy days of about 112 per annum. Temperature is almost uniform throughout the year 23 – 32°C with little deviation from mean annual of 27 °C. The area falls within the high forest zone where the rich tropical forests once thrived. The location has a tropical humid climate with distinct wet and dry seasons. The wet season is from late March to October with little dry spell in August.

Experimental design and treatments

The experiment was laid out using split plots design arranged in a randomized complete block with each treatment replicated four times. The area used was 697 m^2 in size having a total of 8 main plots and each main plot has 5 sub-plots. Each main plot measured 19 x 2.5 m with discard of 3 m within the main plots and 2 m in between sub-plot and 2 m round the whole plot. The trial consisted of 2 x 5 factorial combinations of two tillage methods {(1) No-tillage, NT i.e. manual clearing with cutlass and weeds removed from plots before planting on flat without primary or secondary tillage operation and (2) Manual tillage, MT i.e. preparation of ridges by heaping the soil surface layer using the traditional hoe after cleared weeds were removed from the plots} and five levels of mulch, Siam weed (*Chromolaena odorata)*, (0, 5, 10, 15 and 20 t/ha). These were combined to make 10 treatments. Tillage operation was carried out in May.

After tillage operations, planting of 30 cm sweet potato vines variety TIS87/0087 obtained from National Root Crop Research Institute, Umudike, Nigeria was done in May 2015 at the spacing of 0.5 x 1m while mulch application followed a day after the planting. Fresh Siam weed collected from a nearby farm and hedge containing green tender stems and the leaves equivalent to 0, 5, 10, 15 and 20 t/ha was applied to cover the soil. Weeding operation was done manually at 3 and 8 weeks after planting at each site.

Analytical Procedures

One month after planting sweet potato / mulch application, determination of certain soil physical properties in all plots at the site commenced and this was done at one- month interval on four occasions. Six samples were collected at 0-10 cm depth from each plot using a steel cone sampler and were used for evaluation of bulk density, total porosity and gravimetric water content after oven-dried at 100°C for 24 h. Total porosity was calculated from the values of bulk density and particle density. Soil temperature was determined at 15.00 h with a soil thermometer inserted to 10 cm depth. Six readings were made per plot at each sampling time at 1-month interval and mean data were computed.

Prior to commencement of experiment, soil samples randomly collected from 0 – 20 cm depth were thoroughly mixed inside a plastic bucket to form a composite which was later analyzed for physical and chemical properties. At the harvest, another set of composite samples were collected per plot basis and similarly analyzed for routine chemical analysis as described by Carter (1993). The soil samples were air-dried and sieved using a 2 mm sieve before making the determinations. Soil organic matter was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson and Sommers, 1996), total N was determined by micro-Kjeldahl digestion method (Bremner, 1996), available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry (Frank et al., 1998). Exchangeable K, Ca and Mg were extracted using 1.0 N ammonium acetate. Thereafter, K was determined using a flame photometer and Ca and Mg were determined by EDTA titration method (Hendershot and Lalande, 1993). Soil pH was determined in soil water (1:2) medium using the digital electronic pH meter. Particle size analysis was done using Bouyoucos hydrometer method (Sheldrick and Hand Wang, 1993). Soil bulk density was determined using the core method (Campbell and Henshall, 1991).

Yield components

Ten plants from the sub-plots were randomly selected for the yield determination. Yield parameters assessed included tuber length, tuber diameter, number of tubers, tuber girth and tuber weight. These were determined at harvest (5 months after planting).

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) using the SAS package (SAS, 2001) and Microsoft Office Excel 2007 packages and treatment means were compared using the Duncan's multiple range test (DMRT).

RESULTS

Pre-Planting Soil properties

Table 1 shows pre-planting soil properties of the experimental site at Omuo Ekiti. The values of soil Bulk density was 1.31 g/cm^3, Porosity 50.6%, Soil temperature 36.1 and Soil moisture 6.31%; other parameters were soil pH 5.6, total N 0.15 %, available P of 12.1 mg/kg, exchangeable K 0.18 cmol/kg, Ca 3.2 cmol/kg, Mg 1.2 cmol/kg and Organic matter (OM) 2.38 %. The soil at the location was acidic, low in N, available P, exchangeable K and OM based on rating of Akinrinde and Obigbesan (2000).

TABLE 1: Pre-Planting Soil properties

Property	Value
Sand (%)	66
Silt (%)	18
Clay (%)	16
Textural Class	Sandy Loam
Bulk density g/cm^3	1.31
Total porosity (%)	50.6
pH (H_20)	5.6
Organic Matter (%)	2.38
Total N (g/kg)	1.5
Available P (mg/kg)	12.1
Exchangeable K cmol/kg	0.18
Exchangeable Ca cmol/kg	3.2
Exchangeable Mg cmol/kg	1.2

Table 2 presented data on effect of tillage and mulch on soil physical properties in Omuo Ekiti, the result revealed that Soil moisture and porosity increased with mulch rate irrespective of tillage methods, NT had more moisture than ridge irrespective of mulch rate. Irrespective of mulch rate, soil moisture content under NT and MR were 8.1 and 7.8% respectively, the mean moisture content for 0, 5, 10, 15 and 20 t/ha Mulches were 6.4, 7.3, 7.9, 8.9 and 9.1% respectively. Effect of mulch was significant, whereas tillage had no significant effect. Overall mean values of porosity for 0, 5, 10, 15 and 20 t/ha mulch were 38.0, 42.6, 44.5, 50.3 and 51.7% respectively. The values of porosity were similar for no-tillage (NT) and manual ridging (MR), although were often slightly higher in case of MR at every mulching rate. The mean total porosity for NT and MR in Omuo Ekiti were 45.5 and 46.4% respectively.

Temperature and soil bulk density reduced with increase in mulch rate irrespective of tillage method. Bulk density mean values for 0, 5, 10, 15 and 20 t/ha mulch rate were 1.31, 1.20, 1.17, 1.13 and 1.18 g/cm^3, mulch effect was significant, NT had less soil temperature than MR irrespective of mulch rate. The mean soil temperature and soil bulk density under NT and MR in Omuo Ekiti were 30.5^{0}C and 33.0^{0}C and 1.19 and 1.17 g/cm^3 respectively. Hence, NT reduced soil temperature and bulk density relative to manual tillage.

Table 2: Effect of Tillage-mulch combination on Soil physical properties in Omuo Ekiti

Treatment	Moisture (%)		Temperature (^{0}C)		Porosity (%)		Bulk density (g/cm^3)	
(t ha^{-1})	NT	MR	NT	MR	NT	MR	NT	MR
0	6.89e	6.67e	33.6a	34.1a	36.9e	38.1e	1.32a	1.31a
5	7.71d	7.04d	31.9b	32.3b	42.3d	44.2d	1.21b	1.19b
10	7.93c	7.76c	30.3c	31.8c	44.6c	44.9c	1.18c	1.16c
15	9.01b	8.45b	28.4d	29.7d	51.1b	52.0b	1.13d	1.13d
20	9.16a	9.03a	28.3d	29.6d	52.7a	52.7a	1.09e	1.07e
Mean	8.14	7.79	30.5	33.4	45.5	46.4	1.19	1.17
LSD (0.05)		0.41		3.01		1.04		0.30

Data followed by the same alphabet along the columns are not significantly different at P < 0.05 using Duncan's Multiple Range Test (DMRT). NT = No Tillage, MR = Manual Ridge

Table 3: Effect of Tillage-mulch combination on soil chemical properties in Omuo Ekiti

Treatment	pH (H_2O)		OM (%)		N (%)		P (mg/kg)		K (mg/kg)		Ca (mg/kg)		Mg (mg/kg)	
(t ha^{-1})	NT	MR	NT	MR	NT	MR	NT	MR	NT	MR	NT	MR	NT	MR
0	5.13e	5.06e	1.49e	1.17e	0.15d	0.13e	8.7e	7.9e	0.160e	0.150e	2.03e	2.04e	0.48e	0.36e
5	6.01d	5.92d	2.28d	1.96d	0.16c	0.15d	12.6d	11.9d	0.240d	0.210d	2.76d	2.78d	1.51d	1.42d
10	6.14c	6.06c	2.61c	2.32c	0.17b	0.16c	14.9c	12.9c	0.270c	0.250c	2.89c	3.46c	1.55c	1.49c
15	6.36b	6.18b	3.37b	2.86b	0.18a	0.17b	17.1b	15.7b	0.360b	0.300b	5.28b	4.82b	1.62b	1.53b
20	6.41a	6.34a	3.82a	3.04a	0.18a	0.18a	17.3a	16.1a	0.390a	0.320a	6.14a	5.79a	1.69a	1.60a
Mean	6.01	5.91	2.71	2.27	0.167	0.158	14.3	12.9	0.283	0.245	3.82	3.78	1.37	1.28
LSD (0.05)		0.30		0.47		0.30		1.62		0.3		0.3		0.30

Data followed by the same alphabet along the columns are not significantly different at P = 0.05 using Duncan's Multiple Range Test (DMRT). NT = No Tillage, MR = Manual Ridge

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Soil pH, OM, N, P, K, Ca and Mg increased with increase in mulch rate between 0 to 20t/ha irrespective of tillage treatments. Soil pH, OM, N, P, K, and Mg recorded higher value for NT than MR irrespective of mulch rate. Exchangeable Ca values were similar between the two tillage treatments. The mean values recorded for NT and MR were 3.82 and 3.78 as presented in Table 3.

Table 4: Effect of Tillage-mulch combination on yield and yield components of sweet potato in Omuo Ekiti

Treatment	Tuber length (cm)		Tuber girth (cm)		Number of tuber/Plant		Tuber weight (t/ha)	
(t ha^{-1})	NT	MR	NT	MR	NT	MR	NT	MR
0	11.01c	11.55c	12.89d	13.18d	7.8e	8.2e	14.3d	13.7c
5	14.00b	14.50b	16.11c	15.86c	10.6d	10.7d	18.3bc	17.0b
10	14.62b	15.14b	17.60b	16.40c	12.6c	12.5c	20.0b	19.0b
15	16.99a	17.38a	19.56a	19.08b	14.4b	14.2b	22.3a	23.3a
20	18.57a	18.79a	20.54a	20.45a	15.3a	15.0a	23.3a	25.0a
Mean	15.04	15.47	17.34	17.00	12.1	12.1	19.7	19.6
LSD (0.05)		1.24		0.80		0.44		0.20

Data followed by the same alphabet along the columns are not significantly different at P < 0.05 using Duncan's Multiple Range Test (DMRT). NT = No Tillage, MR = Manual Ridge

Table 4 presented data on yield and yield components of sweet potato in Omuo Ekiti, the result revealed that tuber length, Tuber girth, number of tuber and tuber yield of sweet potato increased with increase rate of mulch from 0 to 5 t/ha mulch at $P < 0.05$. With respect to tillage method, mean values for NT and MR were not significantly different from each other.

DISCUSSION

This work shows that mulch improved soil physical properties by reducing soil temperature and bulk density which reduced with increase in mulch rate irrespective of tillage method. Soil moisture content and porosity increased with increase in mulch rate irrespective of tillage method. Returning crop residues to the soil is known to improve soil quality and productivity through favourable effects on soil properties (Lai and Stewart, 1995). Favourable effects of residue mulching on soil organic carbon, water retention and aggregate stability have been reported on soil surface layer (Duicker and Lai, 1999). Conservation of soil moisture is one of the major advantages of mulch farming. Plant residues shade the soil, serve as major barrier against moisture losses from soil, slow surface runoff and increase infiltration. Hence this work found that soil moisture content increased with mulch rate. The increase in moisture content expectedly reduced soil temperature (Agele *et al.,* 1999). The finding that mulch increased porosity and reduced soil bulk density is consistent with the findings of Noltidge *et al.,* (2005) and Akanbi and Ojeniyi (2007)

Soil fertility as indicated by concentrations of organic matter, N, P, K, Ca and Mg was increased by mulching. The values for these nutrients increased with increase in mulch rate. The NT had higher concentrations of soil OM, N, P, K, Mg and higher pH than tilled MR. this is attributable to presence of plant residues and roots in surface soil. The residues decomposed to improve soil OM and hence nutrients concentration. The weight and number of tubers increased with increase in rate of mulch but values were similar for NT and MR irrespective of mulch rate. This indicated that sweet potato can be cultivated using no-till without significant loss of yield. The maximum and higher yield were given by combination of MC and 15t/ha mulch. Relative to the control, the 5, 10, 15 and 20 t/ha mulch increased potato yield by 25, 38, 66, and 67% respectively. Combination NT + 20 t/ha mulch gave highest values, for tuber weight, number of tubers, exchangeable soil K, Ca, Mg, total N, OM, available P and moisture content. This indicated that these soil properties are influential and determining performance of sweet potato. It also implies that nutrients availability overrides effect of tillage in determining performance of sweet potato (Ojeniyi and Adejobi, 2005).

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CONCLUSION

Field experiment was conducted in Omuo Ekiti (Rainforest zone) to develop affordable low external input soil management system for enhanced soil productivity and production of sweet potato. Relative to control, mulching at 5, 10, 15 and 20 t/ha increased soil moisture, porosity and reduced bulk density irrespective of tillage method. Soil organic matter (OM), N, P, K, Ca, Mg and pH increased with increase in rate of mulch. No-tillage also increased soil OM, N, P, K, Mg and pH. Relative to ridging, 5, 10, 15 and 20 t/ha mulch increased sweet potato yield by 25, 38, 66, and 67% respectively. Whereas tillage method did not influence potato yield parameters significantly. It is concluded that no-tillage is suitable for production of sweet potato in the agro ecological Zone studied; it also conserves soil fertility relative to ridging. Mulching is highly advantageous to ensuring improved soil nutrients content, improving soil physical properties and performance of sweet potato. A combination of no-tillage with 20 t/ha mulch is recommended for production of sweet potato.

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EFFECT OF TILLAGE PRACTICES ON SOIL PROPERTIES AND GROWTH AND YIELD OF *ZEA MAYS* (MAIZE) IN SOUTHWEST NIGERIA

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ABSTRACT

Increasing global climate change continues to impact agricultural productivity especially soil properties in sub-Saharan Africa. Therefore, the need for sustainable food production and climate change adaptation measures, like tillage practices, becomes imperative. A field experiment was established to examine the effect of tillage practices on the growth and yield of Zea mays (maize) and selected soil properties. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times. The treatments were manual, no tillage and zai pits. Each experimental (3m by 3m) had fifteen seedlings at a spacing of 75cm by 50cm given a total of 100m² plot. A composite soil sample was obtained from the experimental plot before tillage (0-15cm) and at the end of the experiment and was analyzed for soil properties in the laboratory. Data were collected on plants height (cm), numbers of leaves per, stem diameter(cm), and grain yield and were subjected to analysis of variance (ANOVA) after which means were separated using Duncan Multiple Range Test (DMRT) at p≤0.05. Plant height ranged from 58.7cm in the zai pit plot to 159.9cm in the manual ridge plot. Stem diameter, number of leaves also increase appreciably across the treatments. Manual ridge gave the highest yield of 5.1 tonnes per hectare while no ridge gave the yield of 2.40 tonnes per hectare. It can be concluded that all the tillage methods may be adopted and also the manual ridge tillage should be utilized the most since it gave the highest grain yield of maize.

Keywords: tillage, Zai pits, maize, soil properties, growth, and yield parameters**.**

INTRODUCTION

Maize is a major staple food for humans and a primary constituent of animal feed. It also plays important role in food security, employment, and income generation for families especially in underdeveloped countries where hunger and starvation are prevalent (Ayoola and Makinde, 2007). This has led to huge demand and the need to expand production through modern tillage practices. Tillage practices have been reported to have a significant and positive impact on crop production especially soil properties which enhance germination through enhanced root growth by improving vertical and horizontal proliferation of roots through the reduction in soil strength in the subsoil (Okeleye and Oyekanmi 2003, Barry, 2007). This practice involves the mechanical manipulation of soil to keep it loose for plant growth which includes: preparation of a suitable seedbed for germination. Soil tillage management can also affect factors controlling soil respiration including substrate availability and microbial abundance, soil temperature, water content, pH, redox potential (Kladivko, 2001), and soil aggregate stability. However, improper use of tillage operations can be harmful to the soil's properties (physical, chemical, and biological). Therefore, currently, there is a significant interest in the shift to conservational and no-tillage methods to control the erosion process (Iqbal *et al.,* 2005). The choice of a tillage method amongst others however is site-specific according to the soil properties and water regime of the farmland. The specific objectives of the study are to determine the effect of tillage practices on selected physical and chemical properties of soil and the growth and yield of maize.

MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farm of Federal College of Forestry, Ibadan which falls within the Northwest Local Government area of Oyo state. The area is situated in the rain forest agro-ecological zone of Nigeria and lies between latitude7^0 54^1 N and longitude 3^0 34^1 E. The annual rainfall range from 1400 mm-1500 mm. The average temperature is about 32^{0}C with a relative humidity of 80-85% with two distinct seasons of wet (April – October) and dry (November- March) (FRIN, 2018). The experimental field (100m²) was cleared and tilled manually with cutlass and hoe which was partitioned into nine experimental plots each measuring 3m by 3m and fifteen stands respectively. The experiment was laid out in a Randomized Completely Block Design [RCBD] with three replicates. Three tillage methods: (1) Manual ridge (the ridge was prepared by heaping the soil surface using the traditional method), (2) No ridge (the soil was not manipulated, seeds were planted on the recommended spacing), (3) Zai pit (the digging of planting pits of 30cm diameter and 15cm depth before planting at a recommended spacing). Planting was done at a spacing of 75 by 50cm at 2cm depth and two seeds per hole. Before planting, soil samples were collected randomly (0-15cm topsoil) from the experimental plots which were composited and analyzed for physical and chemical properties. Data was collected on the following parameters: plant height (cm), number of leaves, stem diameter (mm), and grain yield were recorded.

RESULTS AND DISCUSSIONS

Table 1 shows the results of the physical and chemical properties of soil at the experimental site before planting. It was observed that the soil of the study area is characterized by a low level of nitrogen (0.08) while the pH was slightly acidic (6.7) which is conducive for maize production. Exchangeable Ca and Mg concentrations were 0.14 and 0.16 cmol/kg respectively. The exchangeable cations indicated low concentration of K+ with 0.66 cmol/kg and Na+ 0.26 cmol/kg. The particle size distribution indicated sandy loam using the textural classes. According to Metson (1961), textural class of the soil has high influence on the physical and chemical properties of the soil.

TABLE 1: The physical and chemical properties of soil of the experimental site before planting

PARAMETERS DETERMINED	VALUE
PH (H_2O)	6.7
Total Organic Carbon (%)	9.5
Available PHospHorus	0.08
Total Organic Matter (%)	16.38
Total nitrogen (%)	0.08
Exchangeable Bases (Cmo/kg)	
Na	0.26
K	0.66
Ca	0.14
Mg	0.16
Extractable Micro Nutrients (mg/kg)	
Mn	0.03
Fe	0.18
Cu	0.01
Zn	0.15
% Silt	23.5
% Sand	70
% Clay	6.5
Textural Class	Sandy Loam
Bulk density	1.2
Saturated hydraulic conductivity	12.8

The effect of tillage practices on the height of *Zea mays* is represented in Table 2. Plant height increases appreciably with the number of leaves. Plant height differs significantly (p=0.05) across the treatments. The mean height values range from 6.5 – 159.9 cm at 2 and 8 WAP. The manual ridging treatment had the highest mean height value from 2 - 8 WAP. However, the Zai pit treatment had the highest mean values at 2, 6, and 8 WAP with 7.7, 39.3, and 58.7 cm respectively. the least mean value for Zea mays was observed with the No-ridging treatment at 2WAP while the highest was observed with Zai pit at 8 WAP. These results are in tandem with Kayode and Ademiluyi (2004), who observed the shortest height of maize in the No-tillage practice compared with the tilled plots on sandy loam soil in the southwest part of Nigeria. Alkins and Afuaka (2010) also reported taller cowpea plants in the tilled plots compared to that of the No-tilled plots.

The effect of the three different tillage practices on the number of leaves of maize is as represented in

Table 3. The number of leaves differs significantly (p=0.05) across treatments between 2 and 8 WAP. The mean value of the number of leaves ranges from 4.9 to 159.9 in the Zai pit and manual ridging plot at 2 to 8 WAP respectively. The highest value was observed with the manual ridging plot at 8 WAP. Similar results were obtained by Aikins and Afuaka (2010) for cowpea.

TABLE 2: Effect of tillage practices on the height of Z*ea Mays* (cm)

Treatment	Weeks After planting (WAP)			
	2	4	6	8
Manual ridge	8.6ab	15.2a	68.2ab	159.9a
No ridge	6.5a	12.8a	24.7a	81.9a
Zai pit	7.7ab	11.8a	39.3a	58.7a

*Means in the same column having the same alphabet are not significantly different from each other at a 5% level of significant difference.

TABLE 3: Effect of tillage practices on the number of leaves of maize

Treatment	Weeks After planting (WAP)			
	2	4	6	8
Manual ridge	6.22b	8.44ab	10.56ab	15.9a
No ridge	5.0a	5.78a	8.00a	11.67a
Zai pit	4.89ab	6.56a	8.11a	11.67a

*Means in the same column having the same alphabet are not significantly different from each other at a 5% level of significant difference.

The effect of tillage practices on the stem diameter of maize is shown in Table 4. Stem diameter differs significantly (p=0.05) across the treatments between 2 and 8 WAP with a mean value ranging from 1.52mm in the No-ridging plot and 5mm in the Manual ridging plot. A similar result was obtained by Aikins and Afuaka (2010) for cowpea.

TABLE 4: Effect of tillage practices on stem diameter of maize (mm).

Treatment	Weeks After planting (WAP)			
	2	4	6	8
Manual ridging	2.3ab	3.6a	4.9ab	5.0ab
No ridging	1.5a	2.8a	3.8a	4.1a
Zai pit	1.7a	3.3a	3.8a	3.8a

*Means in the same column having the same alpHabet are not significantly different from each other at 5% level of significant difference

Table 5 shows the effect of tillage practices on maize yield. Among the tillage treatments ridge-tillage plot Presented weight of 1000 grains and grain yield (t/ha) this might be due to proper soil loosening which led to deep rooting ability, water utilization and nutrient uptake for crop growth and yield. The lowest yield (t/ha) were obtained in no-tillage systems. These results are in agreements with that of Videnovil *et al.,* (2011) who observed higher maize yield in conventional tillage plots in comparison with that of the no-tillage plots. Clear indication of better moisture availability to the root zone in the zai pits plot account for the maize growth and better yield. The main cause for the low yield from no tillage system could be due to a very shallow impeded root development moisture infiltration near the plant root. Moreover, this treatment had also number of leaves, plant height and stem diameter which all lead to low yield.

TABLE 5: Effects of Tillage practices on Maize Crop Yield (t/ha)

Treatment	Yield
Manual Ridge	5.066b
No ridge	2.40a
Zai pit	4.67ab

*Means in the same column having the same alpHabet are not significantly different from each other at 5% level of significant difference

Table 6 shows the effect of the different tillage practices on soil physical and chemical properties after planting. It was observed that the Nitrogen level is low, the pH was slightly acidic though conducive for maize production. A general reduction in the pH levels was observed for all the treatments after harvesting. The decline in the total nitrogen concentration of the soil after harvesting indicates high N uptake by the maize. Hanway (1971) observed that nitrogen tends to be depleted rapidly from the soil with grain farming such as maize. The exchangeable cations indicated moderate K+ concentrations with 0.6 cmol/kg and Na+ 0.24 cmol/kg. Total organic carbon ranged from 9.5 % before the experiment to 8.91% in the manual ridge plot and 8.71% in the Zai pit plot. The particle size distribution indicated sandy loam using the textural class. Although the no-ridge plot had higher values of both chemical and physical properties, the growth and yield values were lesser compared to the manual ridge and Zai pit. This could be attributed to soil compactness, bulk density, porosity which may hinder root proliferation, and water and nutrient movement with the soil which is essential for plant growth.

TABLE 6: The effect of tillage practices on the post-planting analysis of the soil

PARAMETERS DETERMINED	No Ridge	Zai pit	Manual Ridge
pH (H_2O)	6.7	6.60	6.50
Total Organic Carbon (%)	9.5	8.71	8.91
Available PHospHorus	0.08	0.06	0.05
Total Organic Matter (%)	16.38	15.36	15.36
Total nitrogen (%)	0.08	0.06	0.05
Exchangeable Bases (Cmol/kg)			
Na	0.26	0.24	0.24
K	0.66	0.08	0.6
Ca	0.14	0.11	0.11
Mg	0.16	0.12	0.12
Extractable Micro Nutrients (mg/kg)			
Mn	0.03	0.01	0.01
Fe	0.18	0.13	0.15
Cu	0.01	0.01	0.01
Zn	0.15	0.13	0.12
% Silt	23.5	23.5	23.62
% Sand	70	68.70	68.70
% Clay	6.5	7.85	7.78
Textural Class	Sandy Loam	Sandy loam	Sandy loam
Bulk density	1.2	1.13	1.13
Saturated hydraulic conductivity	12.8	12.8	12.8

CONCLUSION AND RECOMMENDATION

The physical properties of the soil are important in food production. It enhances all other components including the chemical and biological properties. A good soil structure is essential for the distribution of air, water, and nutrients. This study has clearly shown that manual tillage pulverizes the soil and improves the growth and yield of maize than the no tillage type.

However, the result of this study showed that the various tillage methods had no significant effect on the soil properties. It can be concluded that the manual ridge and Zai pit methods can be adopted or utilized for maize production although manual ridge gave the highest maize grain yield

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EFFECTS OF DIFFERENT LAND USE SYSTEMS ON SOME PHYSICO-CHEMICAL SOIL PROPERTIES IN THE RAINFOREST ZONE OF NIGERIA

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ABSTRACT

Changes in some soil physical and chemical properties, associated with Forest derived land uses were compared with natural or primary forest (NF) in the rainforest Zone of Nigeria. The land use systems were mature oil palm plantation (OP), bush fallow or Secondary forest (BF), alley cropping (AC), with multi-purpose trees [MPTS] and continuous Cassava (Manihot esculenta Crantz) cropping, with and without fertilizer (FC and UC, respectively). The study was conducted on adjacent large unreplicated plots with different histories and length of cultivation but uniform characteristics (slope, elevation and soil type and texture). Soil pH was generally acidic, decreased with depth (0 to 10, 10-20 and 20 - 40-cm) and was significantly different (p = 0.05) among the land use systems, with OP having the highest pH values. Exchangeable K, Mg, Na and Al, cation exchange capacity(CEC) and exchangeable acidity were highest for NF, while Ca, base saturation were highest for OP, when compared to the other land use systems. Five, ten and thirty years of BF, AC and OP respectively were not sufficient to re-establish fertility levels similar to the primary forest. The effect of fertilizer was not significant for most of the soil properties. Soil bulk density was significant, in all three depths, while C: N ratio was not.

Key words: Land use systems, Soil properties, Rain forest zone

INTRODUCTION

Primary forests and forest derived land uses play vital roles in global carbon cycles and Nutrients dynamics in terrestrial ecosystems (Sharma and Rai, 2007; Don *et al*., 2009; Nair *et al*., 2009), especially in the tropics, where the conversion of forest to agricultural and other land uses have been on the increase over the past few decades (Fernandes *et al*., 1997; Lal, 2005). Clearing primary forest for agriculture leads to unsustainable land use characterized by declining soil fertility, and quality, low Productivity and the overall alteration in the global biogeochemical cycles (Schrot *et al*., 2002, McGrath *et al*., 2001; Celik, 2005; Sharma and Rai, 2007). Forest conversion affects the soil through its effect on soil organic matter (SOM) content, which influences ecosystem cycles of carbon, nitrogen and other nutrients as well as on soil physical properties (Brown and Lugo 1990; Lal, 2005; Celik, 2005; Puget and Lal, 2005; Kong *et al.,* 2006; Jelinski and Kucharik,2009; Nair *et al*., 2009). Loss of SOC stock upon conversion from forest to crop has been documented in several studies. For example, Carter *et al*., (1998) reported that based on an equivalent soil mass, to accommodate differences in soil bulk, paired forest and cultivated site showed that cultivation decreased the mass of organic carbon (35%) and total nitrogen (10%) in the soil profile of Podzolic soils. Kern and Johnson (1993) and Murty *et al*., (2002) reported the decrease of SOC stock in the major US cropland soils at approximately 16% and 12-25% respectively. In their own study, Guo and Gifford (2002) reported that soils lost 42 and 59% of their SOC stock upon conversion from forest to crop and from grassland to crop respectively. For a Mollisol in central Ohio, Puget and Lal (2005) reported that cropped systems had 51+ 4 (equivalent mass) Mg ha^{-1} lower SOC and lower 3.5 + 0.3 (equivalent mass) Mg ha^{-1} N in the top 30 cm soil layer than under forest. Research information on the effect of conversion of forest into agricultural land on Other soil properties like bulk density, total porosity and C.N etc. have been contradictory. However, a majority of the studies showed that soils under forest had lower bulk density than adjacent soils under cultivation. The study of the effect of conversion of natural ecosystems e.g. forest to agriculture on Soil properties and SOC sequestration has continued to remain a major global issue, especially in recent times because of our collective concern of environmental degradation and climate change. With the renewed emphasis on deforestation and its effect on CO_2 and other greenhouse gases (GHGs) emissions into the atmosphere, there is a need to intensify scientific research in this area, especially in the different ecological zones of the tropics, where such information is limited. It is also reported that agroforestry systems have a higher potential to sequester C than field crops and pastures (Sanchez, 2000; Sharrow and Ismail, 2004; Kirby and Potvin, 2007; Nair *et al*., 2009). Such information is lacking in the rainforest zone of Nigeria and need to be generated from research. This Study, therefore, was undertaken to evaluate the effect of natural forest and forest derived Land uses on changes in soil physico-chemical properties in an ultisol in the rainforest zone of Nigeria. The specific objective is to determine changes in soil bulk density, porosity, PH. exchangeable cations and acidity, CEC and base and Al saturations in the topsoil.

MATERIALS AND METHODS

Soil samples for this study were collected from the research stations of Michael Okpara University of Agriculture, and National Roots Crops Research Institute, both located at Umudike (5^0 25' N and 7^0 35' and 125 m elevation) in south-eastern Nigeria. Eleven closely sited (within 1.5 km radius) land use systems were used for the study. The NF and BF plots are adjacently located at the Michael Okpara University of Agriculture. While the AC, OP, TA, IS, MI, DB, PM, UC and FC plots are adjacently sited at National Root Crops Research Institute. Details of site and vegetation characteristics of these land use Systems have been reported elsewhere (Uche, 2006) and are only summarized here.

Soil Sampling and Chemical Analysis

For all land use systems, soil texture of the topsoil and slope position (middle slope) in a Chrono sequential transect were used as criteria to locate sampling areas. This was necessary in order to minimize error in data interpretation arising from spatial variability. Soil sampling was done in unreplicated 100 m by 100 m quadrants in each land use type. Each quadrant was subsequently divided into 10 sub quadrants, each measuring 10 m by 10 m from which three were randomly selected and from which samples were collected. Disturbed (composite) samples by auguring and undisturbed (core) samples using cylindrical metal cores of 5.0 cm internal diameter and 5.0 cm height were taken in three replicate from each of 0- to 10-, 10- to 20- and 20- to 40- cm depths. The core samples were taken with a hammer-driven sampler. Core samples were used to determine physical properties (bulk density and total porosity) as described by Grossman and Reinsch (2002), while the auger samples were used to determine chemical properties (PH), organic C, total N, exchangeable acidity and cations {K, Ca, Mg, Na, Mn and Al).

Statistical Analysis

The eleven land use systems were not replicated in the field. Each land use type was represented by 100 m by 100 m quadrant, sub-divided into ten (10 m by 10 m) sub-quadrants from which three were randomly selected and then used as pseudo-replicates for the statistical analysis. The land use plots were all located in the same area (within a $1^{1/2}$ m radius) and soil sampling sites were selected on the basis of uniformity in characteristics which included slope, elevation, soil type and texture as well as present land use. The actual ages of the site and their land use histories are well documented. Research studies which use pseudo replication as a technique to overcome the lack of replication in on-farm and land use experiments have been documented in the past (Brown and Lugo, 1990; Blanco-Canqui and Lal, 2008; Jelinski and Kucharik, 2009). Significance of differences for the Different soil parameters among the different land use systems and soil depths was analysis of variance (ANOVA) using Statistical Analysis Systems (SAS, 1999). Significance was assigned to probability level of p = 0.05.

RESULTS

Soil Bulk Density and Total Porosity

Forest and forest derived land use systems had significant effect on soil bulk density (Table 1) and total porosity (Table 2) in the 0- to 10-, 10- to 20, 20- to 40- cm depths. In all these depths, lowest bulk density and highest total porosity were obtained for cassava based Systems (UC and FC). In the 0- to 10- cm depths, the NF, TA, PM, UC and Fc systems had bulk density values lower than 1.40 g cm^{-3}, while the BF, AC, OP, IS, MI, and DB systems had21 values higher than 1.40 g cm^{-3}. Similarly, for the 0- 10- cm depth, the UC and FC systems had total porosity values higher than 50%, while the other land use systems have porosity values lower than 50%. In the 10-to 20- and 20- to 40- cm depths, bulk density and total porosity did not differ significantly between the NF, BF, AC, OP, IS, MI, DP, and PM systems. Generally, bulk density increased with soil depths, while total porosity decreased for all land use systems.

Table 1. Soil bulk density of 10 – 10, 10 – 20 and 20 – 40 cm depths under different land use

Systems Land use system	Soil bulk density (Mg m^{-3}) Soil depth (cm)		
	0 – 10	10 – 20	20-40
Natural forest (NF)	1.37 ± 0.06	1.52 ± 0.11	1.56 ± 0.18
Bush fallow (BF)	1.53 ± 0.10	1.59 ± 0.13	1.71 ± 0.12
Alley cropping with MPTs (AC)	1.48 ± 0.08	1.62 ± 0.09	1.67 ± 0.15
Oil palm plantation (OP)	1.42 ± 0.11	1.64 ± 0.09	1.69 ± 0.09
Alley cropping (TA)	1.36 ± 0.07	1.43 ± 0.10	1.49 ± 0.06
Alley cropping (IS)	1.43 ± 0.09	1.53 ± 0.12	1.62 ± 0.11
Alley cropping (MI)	1.53 ± 0.15	1.66 ± 0.18	1.69 ± 0.12
Alley cropping (DB)	1.55 ± 0.13	1.62 ± 0.14	1.64 ± 0.12
Alley cropping (PM)	1.35 ± 0.08	1.57 ± 0.10	1.58 ± 0.09
Unfertilized cassava (UC)	1.25 ± 0.06	1.29 ± 0.08	1.44 ± 0.06
Fertilized cassava (FC)	1.34 ± 0.10	1.35 ± 0.07	1.47 ± 0.10

Mean (n = 3) and standard deviation.

Table 2. Total porosity of 0 – 10, 10 – 20 and 20 – 40 cm depths under different land use

Systems Land use system	Total porosity (%)		
Soil depth (cm)	0 – 10	10 – 20	20-40
Natural forest (NF)	47.± 2.1	42.8 ± 10	41.1 ± 1.1
Bush fallow (BF)	41.1 ± 1.5	40.0 ± 1.5	35.4 ± 1.0
Alley cropping with MPTs (AC)	44.1 ± 1.2	39.0 ± 1.7	37.1 ± 1.6
Oil palm plantation (OP)	46.4 ± 3.1	42.9 ± 1.9	36.9 ± 1.4
Alley cropping (TA)	49.2 ± 2.8	45.7 ± 2.2	43.8 ± 1.7
Alley cropping (IS)	46.2 ± 1.6	42.3 ± 2.5	39.0 ± 1.0
Alley cropping (MI)	42.3 ± 1.7	37.2 ± 1.5	36.1 ± 1.2
Alley cropping (DB)	41.4 ± 1.2	39.3 ± 1.9	39.0 ± 2.0
Alley cropping (PM)	48.9 ± 1.9	41.9 ± 2.2	39.4 ± 2.2
Unfertilized cassava (UC)	52.9 ± 2.6	51.4 ± 2.5	45.8 ± 2.1
Fertilized cassava (FC)	50.6 ±2.2	48.3 ± 3.1	44 .2 ± 1.8

Mean (n = 3) and standard deviation.

Soil pH

Soil pH values over the entire sampled depths were acidic and significantly different among the different land use systems (Tables 3 – 5). In all three depths, soil pH was highest for OP system and lowest for NF system. Generally, for each land use system, soil pH for the 0- to 10-, 10- to 20- and 20- to 40- cm depths did not show any definite trend and did not differ appreciably.

Exchangeable Potassium, Calcium, Magnesium, Sodium, Manganese and Aluminium.

Significant differences among the different land use systems were found in the measured soil characteristics in the 0- to 10- cm depth (Table 3), 10- to 20- cm depth (Table 4), and 20- to 40- cm depth (Table 5). In addition, differences between the highest and lowest values of each of these characteristics ranged widely. For example, in the

0- to 10- cm layer, the highest value of K was 0.41 cmol kg^{-1} (NF) and the lowest was 0.076 cmol kg $^{-1}$ (IS), showing a difference of 439% for the variability in K content that existed among the land use systems. Similarly, the highest value of Ca was 2.20 cmol kg^{-1} for OP and the lowest was 0.16 for TA system, showing in difference of 128% and also illustrating a high variability in Ca content among the different land use systems. Exchangeable K, Na and Al in all three depths were highest for NF, while Ca was highest for OP, when compared with the other land use systems. Exchangeable Ca and Mg in all three depths were lowest for TA, while exchangeable Al was lowest for OP system in comparison to the other systems. The study found that the content of exchangeable K, Ca Mg, Na and Mn decreased with soil depth in all the land use systems, while the content of exchangeable Al increased with depth in all the land use systems. For example, under the NF system, exchangeable K, Ca, Mg, Na and Mn showed a decrease of 39.90, 88, 42 and 90 percent respectively from the 0- to 10- cm to the 20- to 40- cm depth. On the other hand, exchangeable Al showed an increase of 22 percent between these two depths. Similarly, for the OP systems, the decrease in the concentrations of exchangeable K, Ca, Mg, Na and Mn was 30, 42, 31, 44 and 59 percent respectively, while the increase in Al concentration was 91 percent from the 0- to 10- cm to the 20- to 40- cm depth. These results showed that nutrient dynamics under the land use systems varied considerably.

Table 3. Soil characteristics of the 0 – 10 cm depth under different land use systems at Umudike, Southeastern Nigeria

	Land use system										s
Soil characteristics	NF	BF	AC	OP	TA	IG	MI	DB	PM	UC	FC	LSD (0.05)
PH (H_2O)	4.10	4.48	4.50	5.45	4.28	4.80	4.55	4.58	4.50	4.63	4.37	0.30
Exchangeable Cations (cmol kg^{-1})												
Potassium	0.41	0.13	0.13	0.23	0.087	0.095	0.087	0.11	0.13	0.13	0.17	0.10
Calcium	1.55	0.40	1.09	2.20	0.16	1.42	0.75	1.96	1.15	0.49	0.81	0.85
Magnesium	0.66	0.082	0.27	0.62	0.070	0.034	0.17	0.44	0.23	0.10	0.078	0.27
Sodium	0.17	0.067	0.090	0.059	0.043	0.027	0.028	0.047	0.055	0.041	0.061	0.022
Manganese	0.084	0.017	0.046	0.039	0.025	0.096	0.060	0.054	0.017	0.020	0.015	0.056
Aluminium	3.77	1.99	1.81	0.030	2.58	0.88	1.58	1.26	1.50	2.28	2.34	1.26
Exchangeable acicity (cmol kg $^{-1}$)	4.10	2.05	1.99	0.030	2.69	0.92	1.65	1.50	2.20	2.36	2.42	1.56
CEC (cmol kg^{-1})	7.05	2.76	3.57	3.16	3.10	2.59	2.78	4.14	3.09	3.15	3.55	1.76
Base saturation (%)	39.57	24.00	43.83	97.75	11.61	64.67	36.51	61.76	28.33	24.16	31.24	12.21
Al saturation (%)	53.58	72.10	50.70	0.95	83.23	30.13	56.83	30.43	61.83	72.38	65.92	21.02

Land use system abbreviation as in Table 1.

Table 4. Soil characteristics of the 10 – 20 cm depth under different land use systems at Umudike, South-eastern Nigeria

					Land use system						
Soil characteristics	**NF**	**BF**	**AC**	**OP**	**TA**	**IS**	**MI**	**DB**	**PM**	**UC**	**FC**	**LSD (0.05)**
pH (H_2O)	4.13	4.52	4.44	5.53	4.21	4.71	4.53	4.66	4.37	4.54	4.51	0.36
Exchangeable Cations (cmol kg^{-1})												
Potassium	0.27	0.092	0.11	0.18	0.082	0.090	0.063	0.10	0.069	0.15	0.19	0.12
Calcium	0.25	0.29	0.65	2.18	0.067	0.160	0.24	0.47	0.10	0,13	0.44	0.55
Magnesium	0.13	0.038	0.095	0.58	0.030	0.041	0.045	0.097	0.042	0.063	0.042	0.17
Sodium	0.092	0.091	0.048	0.060	0.019	0.049	0.026	0.050	0.028	0.068	0.079	0.024
Manganese	0.013	0.016	0.010	0.029	0.010	0.013	0.018	0.014	0.004	0.012	0.018	0.023
Aluminium	4.72	2.08	3.76	0.12	3.10	2.60	2.73	2.30	2.27	2.70	3.05	1.47

Exchangeable Acidity (cmol kg^{-1})	4.88	2.13	0.91	0.12	3.20	2.20	2.78	2.36	2.37	2.78	3.12	1.22
CEC (cmol kg^{-1})	5.68	2.62	3.84	3.14	3.14	2.70	3.17	3.06	2.60	3.38	3.89	1.01
Base saturation (%)	13.01	17.76	23.62	94.26	5.56	18.00	11.93	23.20	9.33	20.06	19.05	9.42
Al saturation (%)	83.10	79.39	71.88	3.82	90.91	78.80	86.12	74.68	82.27	79.88	78.41	19.46

Land use system abbreviation as in Table 1.

Table 5. Soil characteristics of the 20 – 40 cm depth under different land use systems at Umudike, South-eastern Nigeria

	Land use system										s	
Soil characteristics	**NF**	**BF**	**AC**	**OP**	**TA**	**IS**	**MI**	**DB**	**PM**	**UC**	**FC**	**LSD (0.05)**
pH (H_2O)	4.14	4.42	4.55	5.46	4.32	4.51	4.69	4.59	4.40	4.60	4.45	0.39
Exchangeable Cations (cmol kg^{-1})												
Potassium	0.25	0.12	0.058	0.16	0.060	0.090	0.053	0.061	0.051	0.11	0.13	0.09
Calcium	0.16	0.47	0.63	1.40	0.020	0.16	0.34	0.32	0.040	0,33	0.34	0.76
Magnesium	0.080	0.062	0.055	0.43	0.021	0.041	0.030	0.053	0.028	0.074	0.038	0.16
Sodium	0.099	0.068	0.038	0.050	0.012	0.050	0.033	0.042	0.016	0.039	0.093	0.026
Manganese	0.008	0.022	0.004	0.016	0.009	0.013	0.012	0.010	0.005	0.007	0.011	0.091
Aluminium	4.86	3.29	3.20	0.33	2.63	2.60	2.58	2.49	2.52	2.79	3.41	1.44
Exchangeable Acidity (cmol kg^{-1})	4.97	3.37	3.31	0.33	2.70	2.64	2.64	2.69	2.59	2.87	3.49	1.36
CEC (cmol kg^{-1})	5.59	4.13	4.10	2.38	2.18	2.98	3.11	3.10	2.73	3.42	4.05	1.71
Base saturation (%)	10.63	17.49	18.99	85.26	3.99	11.28	14.78	15.49	4.97	15.80	13.72	8.16
Al saturation (%)	86.94	79.66	78.05	13.87	93.59	86.62	82.96	80.32	92.31	81.58	84.20	24.06

Land use system abbreviation as in Table 1.

Exchangeable Acidity, CEC

Exchangeable acidity and CEC were significantly highest in the NF system in the 0- to 10-, 10- to 20- and 20- to 40- cm depths when compared with the other land use systems (p=0.05) (Table 3 – 5). Similarly, base saturation and Al saturation were higher in the OP and TA systems respectively in all three depths than in any of the other land use systems (Table 3 – 5). On the other hand, in all three depths, exchangeable acidity, CEC and Al saturation were lowest in the OP system, while base saturation was lowest in the TA system, when compared with the other systems. Averaged over the three depths, exchangeable acidity was 4.65, 3.01,

2.86, 2.67, 2.52, 2.36, 2.21, 2.18, 1.92 and 0.16 cmol kg^{-1} for NF, FC, TA, AC, UC, BF, MI, PM, DB, IS and OP systems respectively. Similarly, averaged over the three depths, CEC was of the order NF > AC > FC > DB > UC > BF > TA > MI > PM > IS > OP systems. As with exchangeable acidity and CEC, base saturation and Al saturation averaged over the three depths did not follow any definite trend among the different land systems. Base saturation and Al saturation values varied between 7.05% (TA) to 92.50% (OP) and 6.22% (OP) to 89.24% (TA) respectively.

DISCUSSION

The lower bulk density and higher porosity in the 0- to 10-, 10- to 20- and 20- to 40- cm depths of soils under continuous cassava cultivation than soils under forest plantation and alley cropping might be ascribed to the loosening of the topsoil by the tuberous roots of cassava over time. This effect might have overshadowed the effect of continuous cultivation on loss of soil organic matter (SOC) and decline in soil aggregation both of which would otherwise result in increased bulk density. Opara-Nadi and Lal (1987) observed that the development of tuberous roots under cassava in the topsoil (0—20 m) led to a decrease in bulk density which is intimately connected with increased porosity and alteration of pore size distribution.

The acidic nature of the soils under all the land use systems was more a reflection of the nature of the parent material (quartz rich, coarse textured and strongly leached) as reported by Ojanuga (1991) than the effect of land use systems. The higher soil PH in the 0- to 10-, 10- to 20- and 20- to 40- cm depths under oil palm plantation than any of the other systems may be attributed to high calcium content, high base saturation and low aluminium content. The long-term inorganic fertilizer input in the FC system did not affect the soil PH as there was no significant difference in pH between the fertilized and unfertilized and cassava plots.

The higher values of exchangeable K, Na and Al, CEC and acidity under forest soil than soils under any of the other land use systems as well as the relatively high concentrations of Ca and Mg under forest soil demonstrate the high capacity of forest soils to conserve and enhance SOM, which in turn, has positive implications on the conversation of nutrients. The result of this study confirms those of other studies on tropical ecosystems and other ecosystems (Fernandez et al., 1997; Sanchez, 2000; McGrath *et al*., 2001; Lal, 2005; Jelinski and Kucharik, 2009; Nair *et al*., 2009). The relatively lower levels of exchangeable nutrients and acidity as well as CEC under bush fallow, agroforestry and oil palm plantation than primary forest demonstrate the fact that the recovery of these systems in terms of nutrient addition is a rather slow process. Similar studies showing that the rate of recovery of bush fallows following forest clearing in terms of nutrient build-up and fertility status is rather a slow process have been reported (Brown and Lugo, 1990; Szott and Palm, 1996). These studies also show that rate of recovery of bush fallows and fertility status depends on a number of factors such as climate, type of secondary vegetation, rate of turn-over of SOM as well as nutrient and fertility levels at the onset of fallow regeneration. These factors were not examined in study but it may suffice to mention here that the tree species in the alley cropping systems were not leguminous tress capable of fixing atmospheric nitrogen and also having high rate of SOM turn-over in the soil. The very high base saturation in the 0 – 40 cm depth of soil under OP system demonstrates the high levels of exchangeable acidity and Al saturation under this system. Exchangeable Ca, Mg and K in that order contributed to the high base saturation of soil under OP system. Both Ca and Mg distributions in the OP system as well as K distribution in the NF system were strongly stratified with depth in these two systems, which had the highest concentrations of these elements in the top 40 cm depth in comparison to the other land use systems. These three elements were dominant in the CEC level in the soil. The effect of CEC was perhaps a more important action than exchangeable cations and acidity in determining the nutrient status and overall fertility of soils under most of the land use systems.

CONCLUSION

This study, showing the concentrations of exchangeable K, Ca, Mg, Na, Mn and Al, exchangeable acidity and CEC on conversion of natural forest to agriculture in southeastern Nigeria, is in agreement with other studies in other ecological zones. The higher concentrations of exchangeable K, Na and Al, CEC and acidity under the forest site than under any of the other land systems as well as relatively high concentrations on Ca and Mg under forest demonstrate the high capacity of forest ecosystems to conserve and enhance SOM, which in turn leads, to soil nutrient conservation. In addition, 5, 10 and 30 years of bush fallow (forest regrowth), alley cropping with MPTs and oil palm plantation respectively were not sufficient to establish the fertility levels similar to the natural forest. Overall, land use change from forest to agriculture in the study area affected the primary soil chemical properties that characterize soil fertility such as organic carbon, total nitrogen and CEC.

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SUBSOIL CONSTRAINTS, THEIR MANAGEMENT FOR HORTICULTURAL CROPS PRODUCTION IN NIGERIA AND IMPACT ON CITRUS

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ABSTRACT

Subsoils play vital roles in the performance of crops. Constraints in the subsoil are major limitation to soil fertility and productivity. Therefore, there is need for information on subsoil properties how they affect agricultural production. Soil profile pits were dug and characterized for sub soil constraints to horticultural crops production. Constraints to horticultural crops production include high gravel content (>40%), high bulk density (>1.8mg/m3), stoniness (very stony to extremely stony), soil acidity, low ECEC (<5cmol/kg), shallow effective soil depth (<50cm), high water table and poor to imperfect drainage. Biological sub soil constraints include presence of nematodes such as Melodogyne incognita, Tylenchulus semipenetrans and Pratylenchus. Due to the presence of sub soil constraints, plants roots were few to common at the lower depth and in some case showed lateral extension. Management options recommended include drip irrigation, soil modification and soil fertility management. Subsoil constraints affect crop performance and yield. Therefore, it is important to amend and manage the soils to attain optimum plant growth and enhance food security.

Key words: subsoil constraints, stoniness.

INTRODUCTION

Soil are important natural resource but constraints to its productivity exist in different forms. This may be physical (Suganthi *et al.,* 2017), chemical (Wokocha *et al.,* 2016), biological (Ackermann *et al.,* 2007), or morphological (Osujieke, 2017). These constraints may be spatial temporal, within and between soil types. Subsoils are very important in crop production as they serve as reservoir for soil water and nutrient retention (Brady and Weils). Subsoil properties are valuable to final yield of crop. Horticulture is vital to healthy living (Olufolaji, 2021) and economic empowerment. However, different subsoil constraints to crop production can occur simultaneously and negatively impact growth and performance of horticultural crops. Therefore, integrated management options are required especially for tropical soils. Attainment of full crop genetic potentials is not very feasible without suitable soil conditions (Bandyopadhyay *et al.,* 2009). Options to be adopted should be based on environmental, ecological, health, economic, climatic, agronomic and technical, geographic considerations; so as to enhance adequate management of roots and soil environment for crop production. Strategies that can be adopted in managing subsoil constraints include

1) Modifying the rhizosphere (root zone) to make it suitable for crop growth
2) Altering agronomic management practices to minimize reliance on the sub soils. E.g. the use of mounds or beds.
3) Use of compost/farmyard manure.
4) Use of tillage to break hard soils
5) Selection of adaptable or tolerant varieties
6) Land use based on soil suitability
7) Site specific management and precision agri- horticulture

Types of soil constraints

Soil constraints to crop production can be grouped into 4 as shown in Table 1.

Table 1: Classification of soil constraints to crop production

Constraints	Examples
Chemical	Low ECEC, nutrient deficiency, nutrient toxicity, acidity, sodicity, salinity, alkalinity, nutrient imbalance, aluminum saturation.
Physical	High bulk density, high clay or sand content, high porosity, shallow soil depth,, high permeability, water repellency, crusting, water logging, low or high infiltration rates, surface crusting, sub soil impedance, low water holding capacity
Morphological	Presence of Impervious layer (pans),high stoniness and gravel content, excessive wetness, excessive drainage, imperfect drainage
Biological	Presence of nematodes, bacteria and other pathogens, termite mounds

Causes of soil constraints

Subsoil constraints to crop production are product of several factors. These include

a) Natural factors: These include pedogenic processes such as formation of stone lines, presence of intrusive igneous rocks, formation of clay pan, sand stone etc.
b) Anthropogenic activities: Various anthropogenic activities such as indiscriminate fertilizer use, tillage operation, use of recycled water which can cause soil water repellency over time, etc. Al and Ca are binding agents. There can be formation of aggregates due to increase in their release into the soils as a result of indiscriminate use of phosphate and phosphoric fertilisers, Furthermore, ammonium based fertilisers can cause increase in clay dispersion.

MATERIALS AND METHODS

The study was carried out on four pedons in Ido Local Government Oyo state, South western Nigeria. The study site is found in Zone Q of the agro ecological zones of Nigeria. It is located on Basement complex rock geology in the rainforest savannah transition ecology of Nigeria. The area has an undulating topography with characteristic sub soil stoniness and presence of localized hard pans and impenetrable layers in some points of the farm. A detailed soil survey of each of the site was carried out. The areas were divided into grids of 50m X 50 m. Soil examination was done with the aid of a soil auger at the depths of 0 -30 cm, 30 – 60 cm and 60 – 90 cm. to determine the different soils types within each site and to locate their boundaries. Soil morphological and physical characteristics such as texture, consistency (determined by hand feel), effective soil depth, drainage, concentration of gravels and stone, size and abundance of concretions and mottles were determined. Soils with similar characteristics were grouped together into mapping units. Modal profile pits of 1 m x 1.5 m x 2 m were dug at points representative of each mapping unit. The soil profiles were characterised and described using FAO (1990) guidelines for soil profile description. Soil samples were taken from the lowest genetic horizon to the topmost to avoid contamination. The samples were labelled and taken to the laboratory, air dried and processed for analysis. Results of the morphological, physical and chemical analysis were used for soil classification and land evaluation crop production.

RESULTS

Roots distribution, abundance, drainage and level of stoniness are presented in Table 2. There was high root abundance in the A horizon compared to the common and medium to coarse root in the lower B horizon of the soils. Soil fertility status affects the performance of crops. The high abundance of roots in upper layer of the soil may be due to the higher fertility status usually observed in A horizon due to accumulation of nutrients in the surface soils. No stones were recorded in the horizons of Pedon A which led to higher root abundance. There was extreme stoniness in the lower horizons of Pedons B and C with few mottles. Decomposing rock (saprolite) was observed in Pedons B, C and D with no presence of roots recorded in lower depths. Saprolites were observed in Pedon B (>150cm), Pedon C (96cm-154cm) and Pedon D (90-128cm). Pedon D occurs in the lower slope/valley bottom and showed evidence of mottling due to imperfect drainage. Excessive drainage or wetness due to high infiltration and poor drainage resulted in lower root volume in pedons B, C and D.

Table 3 shows the impact of high gravel and stoniness on the performance of citrus in two orchards. Higher tree loss was recorded in orchard with high stone/gravel content (24 trees) compared to the soil with low to medium stoniness (4 trees).

Table 2: Distribution of roots, stoniness and drainage pattern in four pedons

Pedon	Depth (cm)	Roots abundance	Roots size	Stoniness	Drainage
A	0-10	Many	Very Fine	No stones	Well drained
	10-25	Many	Fine	No stones	Well drained
	25-34	Common	Fine	No stones	Well drained
	34-95	Very few	Medium	No stones	Well drained
	95-144	Very few	Medium	No stones	Poorly drained
	144-173	Very few	Medium	No stones	Poorly drained
B	0-22	Many	Very fine		Well drained
	22.44	Many	Fine		Well drained
	44-72	Few	Coarse/medium		Well drained
	72-100	No roots	-	Extremely stony	Excessively drained
	100-150	No roots	-	Very stony	Excessively drained
	>150	No roots	-	(Decomposing saprolite)	Excessively drained
C	0-25	Medium	Many		Well drained
	25-47	Coarse	Many		Well drained
	47-56	Fine/medium/ coarse	Few		Well drained
	56-96	Fine/medium/coarse	Very few-few		Excessively drained
	96-111	No roots	-	Decomposing rock (saprolite)	Excessively drained
	111-154	No roots	-	Decomposing rock (saprolite)	Excessively drained
D					
	0-26	Fine	Many		Well drained
	26-40	Fine/medium	Many		Well drained
	40-74	Fine	common	Stony	Imperfectly drained
	74-90	No roots	-	Very stony	Imperfectly drained
	90-128	No roots	-	Decomposing rock (Saprolite)	

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Table 3: Citrus tree loss in two soil types with different degrees of stoniness after 18 years of establishment

Abundance of stones	Tree loss
Very stony	24
Fairly stony	8

DISCUSSION

Morphological properties of the soils affect crop root development and its eventual productivity. The roots of crops serve as medium for nutrient and moisture uptake. Subsoils are reservoirs for nutrients leached from the top soil. Higher root abundance is usually recorded in the top soil layer of the soils due to higher soil fertility, friability of the soil and of fair to low abundance of gravel and stones. This enhances deeper root penetration and improves crop yield. Low root restriction due to absence of hardpans and impervious layers enhanced more volume and distribution of roots to lower depth. In cases where root restrictions such as stoniness occur in high abundance, root penetration cannot go beyond certain depth. There were fewer roots beyond certain lower depth as seen in the pedons. With high stone/gravel content, soil moisture retention is reduced. To ensure productivity of such soils, supplemental irrigation and integrated soil fertility management (ISFM) should be used. This includes planting of cover crops and use of compost. Poor root depth and anchorage affect the extent of soil nutrient uptake. Modifications are needed to improve root zone conditions for better crop growth (Ityel *et al.,* 2011). According to (Helman, 2004), deep soils tolerate larger root system and this can support vigorous tree growth and ability to withstand moisture trees and production of bigger trees. Furthermore, Ndo *et al.,* (2019), identified soil properties as having effect on incidence and severity of pest and diseases. Poor utilization of information on subsoil properties affects soil management for increased productivity (Ahukamere *et al.,* 2012). Shallow rooting depth can lead to loss of farms; especially orchards due to tree loss. High gravel content and rock outcrops are serious restrictions to crop production (Orimoloye, 2016). It is recommended that soil depth of over 100cm is suitable for crop production especially tree crops. Therefore, shallow rooted crops such as vegetables should be cultivated on shallow soils. Land form is a factor to consider in assessment of suitability or classification of soils for tree crops production. Depth of occurrence of subsoil constraints can be as a result of the location of soils on the catena. In situations where there is poor drainage within the rooting zone, roots diseases such as root can occur in the subsoil and reduce crop yield. Some constraints to tree crop production include sodicity, salinity, acidity and low nutrient reserves. Others are biological constraints such as presence of pest and disease. Srivastava and Singh (2009), stated that beyond soil fertility constraints, decline in citrus productivity is caused by factors such as presence of acidic or alkaline argillic (clay enriched) or spodic (organic hardpan) horizon. With occurrence of hard pans and other restrictive layers, there could be soil mechanical impedance leading to limitation in aeration and permeability. With such, infiltration is reduced under irrigation or rainfed conditions leading to poor utilization of available soil water. In addition, fertilizer materials supplied are also lost due to seepage and low infiltration of water into the soils. These culminate in yield decline, loss of farm inputs and low economic returns to the farmers. High stone/gravel content can lead to low water retention while excessive clay in the subsoil can cause poor aeration (oxygen stress) and make the plant vulnerable to drought and lodging during prolonged dry season, especially in crops like plantain and Banana. In order to make such crops less vulnerable to the effect of prolonged dry season, regular and adequate supplemental irrigation should be provided. Soil properties affect farm operations such as tillage which on the other hand affects yield and crop performance (Alam *et al.,* 2014). High clay and gravel contents in surface soils also affect germination of seeds especially if used for seedling production in the nursery. With modification of such soils through increase in soil volume, germination can be enhanced.

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SOIL MODIFICATION, USING TERMITE MOUNDS AND ITS EFFECTS ON THE GROWTH AND YIELD OF *CELOSIA ARGENTEA*

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ABSTRACT

Termite mound soil amends soil fertility and utilized as an alternative to npk fertilizers by smallholder farmers in Africa. A research was carried out to investigate the effect of soil modification using termite mounds and its effects on the growth and yield of Celosia argentea. The experiment was conducted at the Federal College of Forestry, Ibadan. It lies between latitude 7⁰ 23ᴵN, and longitude 3⁰ 15ᴵE. The climatic condition of the area is tropically dominated by rainfall pattern from 1400mm to 1500mm (FRIN, 2015). The experiment was laid out in a Completely Randomized Design with five treatments replicated six times. The Treatments were; Termite mound, degraded soil, soil + termite mounds (3:1), Soil + Termite mound (2:2), Soil + Termite mound (1:3). The parameters assessed were plant height, stem girth, number of leaves and yield. The data collected were subjected to Duncan Multiple Range Test at 5% level of probability. The results showed that there were significant ($P < 0.05$) differences among the treatments used with respect to plant height, stem girth, numbers of leaves and yield respectively. At 8 weeks after transplanting, number of leaves ranged from 24 in the degraded soil + termite mound (1:3) plot to 14 in the plot where degraded soil was used. Stem girth also increases appreciably across treatments. Plant height ranged from 31.77cm in the degraded soil + termite mound (1:3) plot to 17.73 cm in the plot where degraded soil was used. Degraded soil + termite mound (1:3) gave the highest yield of 44.85kg/ ha while the degraded soil gave the lowest yield of 10.12 kg/ha. This result suggests that the incorporation of termite mound into cropping systems will increase productivity and yield (kg/ha) of Celosia argentea. Hence, degraded soil + termite mound (1:3) may be recommended for the production of Celosia argentea especially in the study area. Therefore, it can be recommended that degraded soil + termite mound can be used by farmers to increase Celosia argentea production especially in the study area.

Key words: Soil modification, Termite mound*, Celosia argentea,* Growth and yield.

INTRODUCTION

Termite mounds is a mixture of soil, organic debris or living plants tissues collected often over extensive foraging areas, transported to their domain and subjected to increase degradation when it is digested by termites (Ekundayo and Orhue, 2011). Orhue *et al.,* (2007) noted that plant nutrients and organic material are withheld from circulation in plant – soil system until they finally decay. Detailed studies of termites' mound have been reported in the Niger Delta region of Nigeria (Ekundayo and Orhue, 2011). Study on termites' mounds on soil and crop productivity in tropical and subtropical areas lacking. Reports have shown the benefits of using termite's mounds as soil plant-soil system amendments. These includes; contribution of nutrients to improve soil fertility and crop productivity (Shepard *et al.,* (1995). Studies have shown significant higher amount of exchangeable cations, macronutrients, organic matter and pH in termites' mound soil Semnhi *et al., (*2008) identified termites as common biological agents that produce symptoms physical and subsoil soils. It is also reported that activities increase the content of organic matter in the soils they use for construction of their nests and also modifies clay minerals composition of these minerals (Jouquet *et al.,* (2002). Despite the benefits derivable from the use of plant-soil systems in tropical and subtropical areas, they have their limitations to use by farmers. It is reported that the problem associated with the use of termite mounds is how to get the huge quantities reported to satisfy the nutritional needs of crops.

Celosia argentea is one of the most important leafy vegetable in South Western Nigeria (Adeyeye *et al.,* 2013). It is a vegetable of high economic value particularly in the dry season as it provides a source of living for most rural vegetable farmers. (Akinfasoye *et al.,* 2008). The leaves and succulent stems are consumed as vegetable because it constitutes a cheap and rich nutrient source of the income earners, and the seed could also be processed into food items supplements and additives (Adeyeye *et al.,* 2013). It also has some medicinal properties for example, in Kenya, the Ma sai use the liquid extract from the leaves and flowers to bathe a patient recovering from illness and as an antidote for snake bites (Akinyeye *et al.,* 2013). The root is also used to treat chronic eczema and gonorrhea while the seeds are used to treat diarrhea (Denton *et al.,* 2001). One of the reasons for the *interest* of celosia is because of its nutrients qualities. It has been reported to contain protein 4.7g, Fat 0.7g, Carbohydrate 7.3g, Fiber 1.8g, Water 83.8g, Calcium 260mg, Phosphorous 43mg, Iron 7.8mg, per 100g edible portion (Grubben and Denton, 2004). Celosia thus has high potentials for reducing malnutrition which is rampant in Nigeria. In spite of the limitations, the long-term benefits in terms of improving soil fertility and enhancing food production cannot be over emphasized (Fragoso and Lavelle, 1992). Studies ascertaining the yield of vegetable affected by the use of termite mound are scanty in Ibadan, South West region of Nigeria. The objective of this study is to determine the best rate to modify termite mounds on the growth and yield of *Celosia argentea.*

MATERIALS AND METHODS

The experiment was carried out at Federal College of Forestry (FCF), Jericho (latitude 7^0 23^IN, and longitude 3^0 15^IE) Ibadan, Oyo state. The climatic condition of the area is tropically dominated by rainfall pattern from 1400mm to 1500mm (FRIN, 2015). *Celosia argentea* seeds were sown into germination box filled with top soil and watered daily to keep the soil moist but not drenched. Sprouting started at five days after sowing. The seeds were later transplanted into the pots already filled with termite mounds and degraded soil.

Screen house studies

The air dried termite mound was bulked to form a composites sample. The dried termite mound soils were crushed to disintegrate the lump structures into smaller aggregates particles and thereafter variously combined to serve as treatments. Composite termite mounds samples from the surrounding field and degraded soils serve as control for standardization. The experiment was completely randomized design (CRD) replicated six times. Treatments used for the experiment were: T1 = Termite mound, T2 = degraded soil, T3=termite mound (3:1), T4 = soil + termite mound (2:2) and T5= soil + termite mound (1:3). Four (4) kilogram soils was weighed into polythene pots, thereafter soil in each pots were turned, properly mixed and watered (200ml) prior to planting. Seedlings were sown into each pot at a depth of 3cm

Data collection

Two plants from the experimental unit were randomly selected and used for data collection on Plant height, Stem girth, Number of leaves, at 2, 4, 6, and 8 weeks after planting. data was also collected on the yield of *Celosia*

Data analysis

Data collected were analyzed statistically using statistical software package for social sciences. Means were separated using Duncan Multiple Range Test at 5% level of significance.

RESULTS AND DISCUSSION

The soils at the experimental site have been classified as an Alfisol (Smyth and Montgomery, 1962) with its distinctive characteristics. The data in Table 1 further confirms this assertion and also reveals that the soils are moderate in zinc, high in potassium and phosphorous. Organic carbon and total nitrogen content of the degraded soil were 4.52 and 0.54 g kg^{-1} respectively which is below the critical level of 10 – 14 g/kg and 1.6 – 2.0 g/kg respectively, while that of termite mound were 10.16 g kg^{-1} and 1.12 g kg^{-1} which is moderate (Adeoye and Agboola, 1985) and nearly neutral pH. This implies that the soil is suitable for vegetable production. The extractable Mn and Fe contents of the termite mound are high with 275 and 288 mg kg^{-1}, respectively, and that of degraded soil were 410 and 405 mg/kg. The texture of termite mound was loamy sand and that of degraded soil was loamy sand texture indicating a well-drained soil suitable for growing vegetable. Soil modification using termite mounds and its effects on plant height of *Celosia argentia* at 2, 4, 6, and 8 WAP were represented in table 2. There were significant differences among the treatments on plant height of Celosia. Among the five treatments used, T5 (Degraded soil +Termite mounds 1:3) had the highest plant height (31.88cm) followed by T1 (termite mounds) (31.06cm), followed by T4 (Degraded soil + Termite mounds 2:2) (29.09cm), followed by T3 (Soil incorporated with Termite mound mounds 3:1) (27,22cm) and least by T2 (Degraded soil) (17.73cm). This is in line with Garba *et al.,* (2011) who reported the same trend in their work on effects of termite mound material on the physical properties of sandy soil and the growth characteristics of tomatoes (*Solanum lycopersium*. L.) In Semi-Arid of Niger. Soil modification using termite mounds and m effects on numbers of leaves of *Celosia argentia* at 2, 4, 6, and 8 WAP were represented in table 3. There were significant differences among the treatments on number of leaves of Celosia. Among the five treatments used, T5 (Termite mounds + Degraded soil in (1:3)) had the highest numbers of leaves (23) followed by T1 (termite mounds) (22), followed by T4 (Degraded soil + termite mounds in ratio of 2:2) (21), followed by T3 (Soil incorporated with Termite mound mounds with ratio of 3:1) (20) and least by T2 (Degraded soil) (14). This is in accordance with Elker Deweer *et al.,* (2014) who reported the same trend in their work on growth response of *Amaranth* to admixture of termite mound material. Soil modification using termite mounds and its effects on stem girth of *Celosia argentia* at 2, 4, 6, and 8 WAP were represented in table 3. There were significant differences among the treatments on Stem girth of leaves of *Celosia*. Among the five treatments used, T5 (Degraded soil = Termite mounds in ratio of 1:3) had the highest stem girth (1.88) followed by T1 (termite mounds) (1.0), followed by T4 (Degraded soil + termite mounds in ratio of 2:2) (1.5), followed by T3 (Soil + with Termite mound mounds with ratio of 3:1) (1.3) and least by T2 (Degraded soil) (0.44). This is in line with Garba *et al*., (2011) who reported that significant differences were observed in different treatments on effects of termite mound materials on the physical properties of sandy and on the growth characteristics of Tomato (*Solanum lycopersicum* L) in semi-arid Niger. Soil modification using termite mounds and its effects on yield of *Celosia argentia* is presented in table 4. There was a significant difference among the treatments. Among the five treatments used, T5 (Termite mounds+ Degraded soil (1:3) had the highest yield (44.85 kg/ha) followed by T1 (termite mounds) (39.06 kg/ha), followed by T4 (Degraded soil + termite mounds in ratio of 2:2) (39.06 kg/ha), followed by T3 (Degraded soil + Termite mounds 3:1) (37.20 kg/ha) and least by T2 (Degraded soil) (10.12kg/ha). This is in line with Garba *et al*., (2011) who reported that significant differences were observed in different treatments on effects of termite mound materials on the physical properties of sandy and on the growth characteristics of Tomato (*Solanum lycopersicum* L) in semi-arid Niger.

Table 1: Pre-planting soil physical and chemical properties of the experimental site

Soil parameters	Content in Degraded Soil	Content in Termite Mound
pH (H_2O)	5.8	5.3
Organic carbon (g kg^{-1})	4.52	10.16
Total nitrogen (g kg^{-1})	0.54	1.12
Available phosphorus(mg kg^{-1})	2.18	1.15
Exchangeable cations (cmol kg^{-1})		
Ca	1.58	1.98
Mg	1.10	2.64
K	0.95	1.36
Na	0.60	0.70
Extractable micronutrient (mg kg^{-1})		
Mn	410	275
Fe	405	288
Cu	1.52	1.66
Zn	1.17	1.14
Exchangeable Acidity (cmol kg^{-1})	0.3	0.5
Particle size distribution (g kg^{-1})		
Sand	646	440
Silt	112	270
Clay	242	90
Textural class	Loam sand	Clay loam

Table 2 Effect of soil modification using termite mounds on plant height of *Celosia argentia*

Treatments	2	4	6	8
Termite Mound (TM)	21.06[a]	24.08a	27.06[a]	31.06[a]
Degraded Soil (DS)	7.73[b]	10.73[b]	13.73[b]	17.73[b]
TM + DS (3:1)	17.22[a]	20.22[a]	23.22[a]	27.22[a]
TM + DS (2:2)	19.04[a]	22.04[a]	25.04[a]	29.09[a]
TM + DS (1:3)	21.88[a]	24.88[a]	27.88[a]	31.88[a]

Means followed by the same letter in each column for each treatment are not significant from each other by DMRT at 5% level of probability.

Table 3: Effect of soil modification using termite mounds on number of leaves of *Celosia argentia*

Treatments	2	4	6	8
Termite Mound (TM)	12[a]	15[a]	18[a]	22[a]
Degraded Soil (DS)	4[b]	7[b]	10[b]	14[b]
TM + DS (3:1)	9[a]	13[a]	16[a]	20[a]
TM + DS (2:2)	10[a]	13[a]	17[a]	21[a]
TM + DS (1:3)	12[a]	16[a]	19[a]	23[a]

Means followed by the same letter in each column for each treatment are not significant from each other by DMRT at 5% level of probability.

Table 4: Effect of soil modification using termite mounds on stem girth of *Celosia argentia*

Treatments	2	4	6	8
Termite Mound (TM)	0.18[a]	0.26[a]	0.47[a]	1.0[a]
Degraded Soil (DS)	0.09[a]	0.17[a]	0.35[a]	0.44[b]
TM + DS (3:1)	0.21[a]	0.38[a]	0.49[a]	1.3[a]
TM + DS (2:2)	0.31[a]	0.47[a]	0.76[a]	1.5[a]
TM + DS (1:3)	0.38[a]	0.49[a]	0.76[a]	1.88[a]

Means followed by the same letter in each column for each treatment are not significant from each other by DMRT at 5% level of probability.

Table 5: Effect of soil modification using termite mounds on yield of *Celosia argentia*

Table Treatments	Weight (kg/ha)
Termite Mound (TM)	39.06[a]
Degraded Soil (DS)	10.12[b]
TM + DS (3:1)	37.20[a]
TM + DS (2:2)	35.50[a]
TM + DS (1:3)	44.85[a]

Means followed by the same letter in each column for each treatment are not significant from each other by DMRT at 5% level of probability.

CONCLUSION AND RECOMMENDATION

The result of this study showed that clay content in termite mound soils was higher than the degraded soil. Silt content however, was found higher in termite mound. It was also shown that a mixture of termite mound and degraded soil (T5) (Termite mound +Degraded soil 1:3) gave the highest value in the crop parameters measured than the value obtained in degraded soil and there was significant difference. *Celosia argentea* growth performance parameters (plant height, number of leaves, and stem girth) were significantly increased (P<0.05) with a mixture of T5 (Termite mound + Degraded soil) than degraded soil T2. (Degraded soil). Thus, the combined use of termite mound and degraded soil is recommended for great potentials to increase soil and crop productivity. Therefore, it can be concluded and recommended that Termite mound can be used by farmers to increase *Celosia argentea* yield production especially in the study area.

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SOIL FERTILITY EVALUATION OF PROPOSED CASHEW PLANTATION SITE IN OMU-ARAN, KWARA STATE

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ABSTRACT

Study was carried out at Akera village in Irepodun Local Government Area of Omu-Aran, Kwara State, Nigeria in 2020 to evaluate the soil fertility status of a site proposed for cultivation of cashew. The site was demarcated into three blocks based on existing vegetation cover and topography. Soil samples were collected in a stratified manner in line with these identifiable features. Using soil auger, two soil samples were collected per augering point at 0 – 20 and 20 – 40 cm depths respectively. Samples were labelled, air dried, sieved through a 2 mm sieve for soil physical and chemical properties determination following standard laboratory procedures. Results of the mechanical analysis revealed that the sand (%) contents were 62.20 - 64.25 with a mean of 63.55 and 62.20 - 64.70 with an average value of 63.70 at 0 – 20 and 20 – 40 cm depths respectively. The clay + silt contents indicated that the soil was moderate in clay. The upper slope was more gravely than other parts. The OC, total N, available phosphorus (P), exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}) contents across the site were low and below the critical levels. Consequently, for the site to support sustainable cashew production, soil nutrients supplementation in form of organic fertilizer application coupled with good agricultural practices that include appropriate choice of intercrops at the juvenile stage of the plantation and effective weed control techniques were recommended.

Key words*:* Augering, cashew, cultivation, soil fertility, suitable site.

INTRODUCTION

Cashew is a perennial crop adaptable to several ecologies considered marginal to many other tree crops and as such classified as a hardy crop. Its ability to adapt to dryer environment makes it useful in curtailing desert encroachment particularly in the northern part of Nigeria (Adeyemi and Nduka, 2019). Research findings have revealed nutrients requirements of cashew plant for optimal growth and yield (Egbe *et al*., 1989; Ipinmoroti, 2016). Cashew cultivation is a long time investment that requires careful site selection for optimal productivity. It is therefore imperative to ensure that the site so selected is suitable and sustainable in terms of soil structure, texture and adequate nutrients. This is necessary as a guide in soil fertility management for sustainable cashew production and to forestall blanket fertilizer application with its deleterious effects such as nutrient fixation and imbalance. The objective of this study therefore, was to evaluate the suitability of the proposed farm site at Akera village in Irepodun Local Government Area of Omu-Aran, Kwara State for sustainable cashew cultivation.

MATERIALS AND METHODS

The site was demarcated into three blocks based on the types of vegetation cover and topography. Soil samples were collected in a stratified manner based on these identifiable features. Two soil samples were collected per augering point at 0 – 20 and 20 – 40 cm soil depths respectively with the use of soil auger. A total of eighteen core soil samples were collected from two depths across the 2.0 ha farm site. These were composited to six samples. The samples were labelled, air dried and sieved with a 2 mm sieve. Samples were partitioned for various properties such as particle size analysis, pH macro and micro nutrients determination among others. The particle size distributions of the soil were determined using the hydrometer method as described by (Gee and Bauder, 1996). The organic carbon (OC) content was by wet digestion method (Nelson and Sommers, 1996), while the pH of the soil in soil to water ratio of 1:2 was by the use of electrical pH meter. The soil total N content was by the use of Micro Kjeldahl method (Bremner, 1996). Available Phosphorus (P) was determined by Bray 1 method (Kuo, 1996). The exchangeable cations of K, Ca and Mg were extracted by leaching the soil with 1NNH4 OAC at pH 7 and the contents determined by the use of flame photometer. Ca and Mg contents were by the use of atomic spectrophotometer (AAS), likewise the soil micro nutrients (Fe, Mn and Cu).

RESULTS AND DISCUSSION

The Particle Size

The mechanical analysis revealed that the site contained 62.20 – 64.25 % sand at 0 – 20 cm depth with a means of 63.55 %, while at 20 – 40 cm depth, it ranged from 62.20 to 64.70 % with an average value of 63.70%. The clay contents (%) ranged from 9.60 to 11.00 with an average of 10.43 and from 5.00 to 11.60 with a mean value of 9.13 at 0 – 20 cm and 20 – 40 cm depths respectively (Table 1). The silt (%) found in the top soil varied from 26.20 to 26.70 while at 20 – 40 cm depth, it was 24.70 to 30.40. This showed that the middle slope of the site was slightly gravely than the other parts at both depths. The soil was predominantly sandy clay loam with some noticeable pebbles on the surface. Percentage sand and silt contents of the study area were within the recommended range, though the clay content was above the critical level (Obatolu, 1996). The average clay + silt contents of each of the three slopes considered were above the critical value of 32 % recommended by Egbe *et al.,* (1989) for cashew cultivation in Nigeria. This implied that the soil should be able to retain soil moisture (water), for plant use during the dry periods, for sustainable cashew production. Nonetheless, provision should be made for alternative source of water, other than rainfall, in lieu of the fact that rain-fed agriculture is no longer fashionable due to the current irregular rainfall pattern stemming from climate change. Consequently, digging of well or sinking of borehole for irrigation purpose in the dry season would be advised.

Table 1: Soil physical characteristics and pH of samples collected at different depths and slopes.

Location	0 – 20 cm depth pH (H_2O)	sand ←	silt %	clay →	TC	20 - 40 cm depth pH (H_2O)	sand ←	silt %	clay →	TC
Upper slope	6.20	64.20	26.20	9.60	**SCL**	6.20	62.20	27.00	10.80	**SCL**
Middle slope	5.65	64.25	24.70	10.60	**SCL**	5.65	64.70	24.70	11.60	**SCL**
Lower slope	6.60	62.20	26.70	11.00	**SCL**	6.60	64.20	30.40	5,00	**SCL**
Mean	**6.15**	**63.55**	**25.87**	**10.43**		**6.15**	**63.7**	**27.35**	**9.13**	

TC Textural classification **SCL** Sandy clay loam

The pH values of the study area within 0 – 20 cm depth ranged from 5.65 to 6.60 with an average mean value of 6.15 and 5.65 – 6.60 with a mean value of 6.15 at 20 – 40 cm depth (Table 1). The pH values across the site were slightly acidic. Cashew has been reported to grow on soils of pH 6.5 – 3.0*;* best growth was obtained between pH 5.0 and 4.5 with 4.5 as the absolute best (Owaiye, 1989). The pH of the site should not pose a threat to good growth and productivity of cashew. However, any activities that will alkaline the soil should be avoided.

The exchangeable cations (Ca^{2+}, Mg^{2+}, K^{+}) content of the site

Calcium (Ca^{2+})

The soil Ca content (cmol/kg) at 0 – 20 cm depth ranged from 0.30 – 0.50 with a mean value of 0.38 as shown in Table 2a and from 0.31 to 0.34 with a mean value of 0.32 at 20 – 40 cm depth (Tables 2b). This showed that the site to be critically low in calcium at both the upper and lower levels when compared with 8.0 cmol/kg soil calcium recommended by Egbe *et al.* (1989) for optimum cashew production in Nigeria.

Table 2a: Exchangeable bases at 0 – 20 cm depth

Locations	Exchangeable bases Ca^{2+} cmol/kg	Mg^{2+}	K^{+}	Na^{+}
Upper slope	0.34	0.16	0.58	0.46
Middle slope	0.50	0.18	0.61	0.42
Lower slope	0.30	0.16	0.56	0.44
Mean	**0.38**	**0.17**	**0.56**	**0.44**

Table 2b: Exchangeable bases at 20 – 40 cm depth

Locations	Exchangeable bases Ca^{2+} cmol/kg	Mg^{2+}	K^{+}	Na^{+}
Upper slope	0.32	0.21	0.53	0.41
Middle slope	0.31	0.21	0.46	0.37
Lower slope	0.34	0.23	0.61	0.42
Mean	**0.32**	**0.21**	**0.53**	**0.40**

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Magnesium (Mg^{2+})

The magnesium content of the site was very low as observed and reported above for calcium. The values within the upper depth (0 – 20) cm ranged between 0.16 and 0.18 with an average value of 0.17 cmol/kg soil (Table 2a). At the deeper depth (20 – 40) cm however, the Mg content was higher than at the upper depth (Table 2b), though still low compared to the critical value of 0.8 cmol/kg soil considered optimal for cashew production in Nigeria (Egbe *et al*., 1989).

Potassium (K^{+})

The exchangeable potassium in cmol/kg soil at 0 – 20 cm soil depth varied from 0.56 - 0.61 across the slopes with a mean of 0.56 in Table 2a. At 20 – 40 cm depth, the exchangeable K^{+} ranged from 0.46 to 0.61 with a mean value of 0.53 (Table 2b). The site under consideration had higher K^{+} at the upper depth than at the lower contrary to what was obtained for Mg^{2+} above. The K^{+} contents of the site were equally low (Egbe *et al*., 1989) as reported earlier for Ca^{2+} and Mg^{2+}. The low exchangeable cations (Calcium, Magnesium and Potassium) contents observed in this study are in consonance with the earlier findings of Ipinmoroti and Ogeh, (2012).

Essential macro nutrients of the site

Soil Organic Carbon (SOC)

The soil organic carbon in percentage at 0 – 20 cm and 20 – 40 cm soil depths ranged from 9.85 – 10.70 and 8.62 – 9.69 with the mean values of 10.33 and 9.33 respectively (Table 3). The OC contents across the site were below the critical mean value of 30 % (Egbe *et. al*., 1989). This may be due to previous use of the site for farming activities.

Organic Matter (OM)

The mean soil organic matter content of the site at the upper depth was 17.91 % and lower at the lower depth as shown in Table 3. Although the OM was equally low as reported for OC above, but both could be improved on through fertilizer application (preferably organic) regimes that will put into consideration both macro and micro nutrients need for good cashew seedlings field establishment, growth, development and productivity.

Table 3: Results of the essential macro nutrients of the site

Location	0 – 20 cm OC %	OM	N	AV.P Mgkg	20 – 40 cm OC %	OM	N	AV. P mg/kg
Upper slope	10.63	18.32	0.05	7.95	9.69	16.72	0.04	7.85
Middle slope	9.85	16.98	0.06	8.11	8.62	14.87	0.06	6.92
Lower slope	10.70	18.44	0.07	7.45	9.69	18.05	0.07	7.82
Mean	**10.33**	**17.91**	**0.06**	**7.84**	**9.33**	**16.54**	**0.06**	**7.54**

The Total Nitrogen (N)

The native mean total N (%) of the site was low 0.06 at both the upper and lower levels of soil sampling (Table 3), which is far below the critical level of 1.0 (Egbe *et. al*., 1989). The N content was inversely proportional to the gradient of the site as N was highest at the lowest slope probably due to washing down of the soil nutrients from the upper and middle slopes of the site to the lower as a result of water erosion.

Available Phosphorus (Av. P)

The available P (mg/kg) content varied from 7.45 – 8.11 with mean of 7.84 at the upper depth and 6.92 to 7.85 at the lower depth with a mean value of 7.54 (Table 3). The available P contents were below the critical value of 10.00 mg/kg recommended by (Egbe *et. al*., 1989). Consequently, there would be need to enhance the P of the site through soil amendments for better crop performance.

The proposed farm site was found to be appropriate for cashew cultivation in terms of its physical characteristics and pH. It was however discovered to be inherently low in its fertility status as reflected in the low exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}), essential macro nutrients (SOC, OM, N, Av. P) probably due to the land use system (excessive cultivation of the land by the native farmers to crops such as cassava and maize which are heavy nutrient feeders. This necessitates the need for nutrient supplementation through fertilizer application, preferably organic based, so as to build-up the soil organic matter content, rectify the low organic carbon as well as the, Ca^{2+} Mg^{2}, K, N and P contents of the soils to ensure optimal productivity of the site. In addition, adoption of efficient management practices such as appropriate cropping systems is inevitable for sustainable cashew cultivation at the proposed site.

CONCLUSION

The proposed site under consideration would support sustainable cashew cultivation if the under-listed good agricultural practices could be adopted:

- Application of appropriate soil amendment (preferably from organic sources) techniques, based on the results of soil analysis, for the supply of needed nutrients in right quantities
- Provision of irrigation facilities to supply water to cashew especially in the dry season
- Adoption of appropriate intercropping systems with cashew at the juvenile stage
- Procurement of planting materials from reputable sources like CRIN

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SOIL FERTILITY EVALUATION OF SOME KOLA PLANTATIONS IN OSUN AND EKITI STATES

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ABSTRACT

The knowledge of soil fertility status is very much essential for the judicious application of fertilizer and its amendment for sustainable production of kola in Nigeria. Hence, studies were carried out to evaluate the physico-chemical properties of the soil and to determine the leaf nutrient status of kola plantations Osun and Ekiti States. Ten core samples at 0-20cm and 20-40cm were randomly collected using soil auger and bulked into composite samples to obtain representative soil samples which were taken to the laboratory for processing and analysis. Total nitrogen was low in kola plantations evaluated in Osun state. Hence, Nitrogen fertilizer should be applied to kola farms in Osun State. While soil available phosphorus, exchangeable calcium and magnesium contents were adequate in kola plantations evaluated in both states, exchangeable potassium content was grossly inadequate. The potassium level in the kola leaf was also inadequate in Osun and Ekiti states, hence both locations would require potassium fertilizer application.

Keywords: Kola plantations**,** soil fertility, fertilizer application

INTRODUCTION

Kolanut is one of the several tropical tree crops used in local and international trade and was a major export earner for Nigeria before independence when the attention of the Nigerian government shifted to oil and its derivatives (Akinbode, 1982). Production of kolanut in Nigeria ranges from 85,000 to 127,000 metric tonnes annually (Ologunagba, 2009) representing around 70% of World production (Famuyiwa, 1987). The cultivation of kolanut in Nigeria is ecologically limited to the rainforest zones of southern and riverine areas of the savannah region. Kola production levels over the years have been reported to decline due to old age, incompatibility and soil nutrient imbalance. Rehabilitation of old kola plantation by coppicing and total replanting has met with low percentage of success. The increasing land use without adequate and balanced use of chemical fertilizers and with little or no use of organic manure have caused severe fertility deterioration of the soil resulting in stagnation or even decline of kola productivity in Nigeria. The need of the time is to achieve substantially higher kolanut crop yield than the present yield levels from our limited land resources on sustainable basis. The knowledge of nutrient status of soil is very much essential for the judicious application of fertilizer and its amendment for higher crop production. Hence, the objectives of the study were to evaluate the physico-chemical properties of the soil and to determine the leaf nutrient status of kola plantations.

MATERIALS AND METHODS

Soil samples were taken from kola plantations across important kola producing communities covering two states; Osun and Ekiti States. In each of the plantations visited, ten core samples at 0-20cm and 20-40cm were randomly collected using soil auger and bulked into composite samples to obtain representative soil samples which were taken to the laboratory for processing and analysis. The soil samples collected were air-dried, thoroughly mixed, crushed and sieved to pass through 2mm sieve. Samples collected were analyzed for the pH, organic carbon, Nitrogen, Phosphorus, potassium, Calcium and Magnessium contents. The soil pH was measured electronically with glass rod electrode pH meter in soil/water ratio of 1: 2.5 (Mclean, 1982). The soil organic matter was determined by acetate dichromate oxidation method (Nelson and Sommers, 1982). The total Nitrogen was determined by the micro Kjedahl method (Bremmer, 1996). The available P was determined using Bray 1 method (Bray and Kurtz,1945), while the exchangeable cations were activated by leaching 5g of soil with 50ml of 1N NH4OAC at pH 7 and the K, Ca and Mg were measured by atomic absorption spectrophotometer (AOAC, 1990). The soil particle size distribution was determined using the hydrometer method (Bouyoucos, 1951) and soil texture determined using textural triangle. The soil textural class was determined by the hydrometer method using hexametaphosphate as the dispersing agent.

RESULTS AND DISCUSSIONS

The mean soil pH of soil at Osun and Ekiti states were 5.85 and 6.10 respectively at 0- 20cm depth

(Table 1). This is slightly acidic and appropriate for kola production (Egbe *et al.*, 1989), however, any activity that would further decrease the pH of the soil, such as use of ammonium nitrogen based fertilizer should be avoided. Organic carbon content of the soil was low in kola plantations evaluated in Osun State with mean value of 16.45g/kg but moderate in Ekiti State with a mean value of 20.85g/kg. The low organic carbon in Osun State could be attributed to low natural organic matter return to the soil and other human activities such as burning (Ahmed 1995). Total nitrogen content was low in kola plantation soils of Osun state. The mean value (0.88g/kg) was below the critical nitrogen soil content of 1.0g/kgN required by Kola as reported by Egbe et.al 1989. This is a reflection of low organic carbon content in the soil (Onyekwere et al 2009) Therefore; there will be need for nitrogen application in all the kola plantations evaluated in Osun state. The soil nitrogen content in kola plantations assessed in Ekiti State were adequate and would not require nitrogen fertilizer application.

Soil available phosphorus contents were adequate for kola in all the farms evaluated in both states hence there would be no need for application of phosphorus fertilizer. This was well above the soil critical level of 6mg/kg P required for kola production (Egbe *et al.*, 1989) and this is similar to Iloyanomon *et al,* 2011 which reported that high Phosphorus content in leaf litter resulted into high P in the soil as a result of the fast decomposition of the Kola leaves. Soil exchangeable potassium was adequate across the kola plantations examined in the two States. Potassium is important in fruiting of Kola; adequate potassium is required for a good quality of Kola fruit (Adebowale and Odesanya, 2015). Soil exchangeable calcium and magnesium were adequate at both locations examined.

Table 1: Ranges and Mean values of Physical and chemical properties of soils of kola plantations in Osun and Ekiti State at 0-20cm

Parameters	Osun State			Ekiti State		
	Min	Max	Mean	Min	Max	Mean
pH	5.6	6.10	5.85	5.90	6.40	6.10
O.C(g/kg)	12.80	19.80	16.45	15.60	30.70	20.85
Total N (g/kg)	0.6	1.10	0.88	0.90	1.60	1.20
Avail P (mg/kg)	5.56	10.00	7.67	4.33	10.67	8.34
Exch K (cmol/kg)	0.14	0.24	0.20	0.17	0.38	0.24
ExchCa(cmol/kg)	7.51	12.95	10.24	7.36	16.08	11.06
ExchMg(cmol/kg)	1.40	2.04	1.76	1.33	2.50	1.71
ExchNa(cmol/kg)	0.39	0.60	0.43	0.39	0.48	0.44
Sand (g/kg)	668	728	703	648	748	693
Silt (g/kg))	160	180	165	140	290	202.50
Clay (g/kg)	112	172	132	62	132	104.50

Table 2: Ranges and Mean values of Physical and chemical properties of soils of kola plantations across Osun and Ekiti state at 20-40cm

Parameters	Osun State			Ekiti State		
	Min	Max	Mean	Min	Max	Mean
pH	5.60	6.10	5.90	5.70	6.30	6.08
O.C(g/kg)	07.20	22.70	13.28	6.80	13.60	9.30
Total N (g/kg)	0.4	1.00	0.68	0.40	1.90	1.03
Avail P (mg/kg)	6.78	8.44	8.11	5.78	11.67	7.98
Exch K (cmol/kg)	0.12	0.20	0.16	0.14	0.28	0.19
ExchCa (cmol/kg)	7.36	12.12	10.04	9.15	13.81	9.40
ExchMg cmol/kg)	1.34	3.17	2.09	0.92	1.87	1.40
ExchNa (cmol/kg)	0.39	0.51	0.43	0.36	0.46	0.41
Sand (g/kg)	648	748	683	648	708	683
Silt (g/kg))	100	180	150	180	220	195
Clay (g/kg)	132	167	167	112	132	122

Table 3: Ranges and Mean values of Leaf nutrient content (g/kg) of kola plantations across Osun and Ekiti States

Parameters	Ekiti State			Osun State		
	Min	Max	Mean	Min	Max	Mean
N (g/kg)	12.7	24.6	18.7	12.1	29.2	18.9
P (mg/kg)	0.82	1.4	0.80	0.81	1.00	8.85
K(g/kg)	08.26	12.64	8.90	3.89	7.78	6.15
Ca (g/kg)	2.90	5.94	4.36	3.87	5.84	4.66
Mg (g/kg)	2.17	2.67	2.40	0.22	3.06	2.52
Na (g/kg)	1.94	2.18	2.00	1.71	2.04	1.89

The mean Nitrogen content of the kola leaf was 18.90g/kg in Osun State and 18.70g/kg in Ekiti State (Table 3) which is above the foliar critical level of 10g/kg N required for kola production (Egbe *et al* 1989). The phosphorus content of kola leaf in Osun and Ekiti States were above the foliar critical level of P required for kola production. This is similar to the findings of Iloyanomon and Ogunlade 2011 who reported high phosphorus content in kola plantations in Ibadan but contrary to the findings of Ogunlade and Aikpokpodion (2006) who reported low P in cocoa soils in Southwestern Nigeria. The potassium and magnesium content of the kola leaf was below the foliar critical level of 12g/kg and 3.4 g/kg respectively in Osun and Ekiti States. Calcium content of the kola leaves in both Osun and Ekiti states were slightly lower than the foliar critical level.

CONCLUSION

The study was carried out in Osun and Ekiti states, Nigeria to evaluate the soil nutrient status of some selected kola plantations. Soil pH in both states were slightly acidic with those of Osun State being more acidic. Therefore, any activity that will further acidify the soil should be avoided in both states. Total nitrogen was low in kola plantation soils evaluated in Osun state but adequate in kola plantations assessed in Ekiti State. Hence, Nitrogen fertilizer is needed in Osun State. While soil available phosphorus, exchangeable calcium and magnesium contents were adequate in kola plantations evaluated in both states, exchangeable potassium content was grossly inadequate. The potassium level in the kola leaf was also inadequate in Osun and Ekiti states, hence both locations would require potassium fertilizer application. The study is highly essential to recommending appropriate soil fertility management strategies that will enhance kola yield on sustainable basis in the study areas.

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ASSESSMENT OF SOIL FERTILITY IN SOME SELECTED CASHEW FARMS IN ENUGU, KOGI AND OYO STATES FOR PROPER MANAGEMENT AND ENHANCED PRODUCTIVITY

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ABSTRACT

Soil fertility of cashew plantations in Kogi, Oyo and Enugu was evaluated to evolve strategies for effective management. Soil samples were collected from two pre-selected farms in each Local Government Areas using a soil auger at two soil depths of 0-20cm and 20-40cm. Soil samples were collected at a distance of 1m from the base of selected cashew mother tree. The soil samples were bulked to make composite samples and were analysed using standard laboratory procedures. The sand fraction of the soils of the farms evaluated ranged from 829 to 889g/kg while the clay content of the soil in the six farm locations across the three states ranged from 84 to 154g/kg soil at 0-20cm.The silt fraction ranged from 26 to 146g/kg soil. The soils of all the farm locations fall within the sandy loam textural classification. The pH of the soils in the farms in Enugu State was 5.21 while that of Kogi State was 5.9. The pH of the farms in Oyo State was 6.25. The pH of soils in the three States ranged from strongly acidic to slightly acidic. The N in the soils of the farms across the three States was generally low and hence there is need for N supplementation. The N in cashew farms in Enugu State ranged from 0.26 to 0.65g/kg soil while that of Kogi State ranged from 0.35 to 0.77g/kg soil. The N in Oyo State had a mean of 0.44g/kg soil in Orire LGA and 0.66g/kg soil in Surulere LGA. The available P in Enugu and Kogi States was adequate for cashew cultivation with an average value of 4.3 and 4.5mg/kg soil respectively. However, the available P in the cashew farms in Oyo State was below the level required for cultivation of cashew with an average value of 3.0mg/kg soil. The exchangeable K in Enugu and Kogi States was low with an average value of 0.08 cmol/kg soil. There will be need for external addition of phosphorus and potassium fertilizers. The fertilizers required for optimum cultivation of cashew in the three States ranged from 68 to 134 kg N/ha, 2.8 to 3.2 kgP_2O_5/ha and 9 to 66kg K_2O/ha.

Keywords: cashew, soil fertility, productivity, leaf nutrient, fertilizers

INTRODUCTION

Cashew, *Anacardium occidentale L.*, is grown largely by smallholder farmers in all agro-ecological zones of Nigeria (27 out of 36 States). However, economic production is concentrated around the middle belt and northern parts of the Southwest. Cashew is a major source of income to Nigerian government, farmers, processors, marketers and other stakeholders along the value chain and has average yield per hectare of 450-500kg/ha (The Guardian online, 2019). Currently, the land area cultivated to cashew in the country has increased to almost 400,000 hectares (FAO, 2018; Olubode et al., 2017) and this cultivation progression may be attributed largely to increase in world market demand of its nuts. Cashew is grown from the rainforest zone to savanna area of Nigeria and is grown on wide range of soils. It is known that cashew farmers in Nigeria use little or no fertilizer as they rely on natural means of supplying nutrients through leaf litter fall (Ibiremo and Iloyanomon, 2015, Agbongiarhuoyi, *et. al* 2014). The application of fertilizer is however inevitable for the replacement of soil nutrients that are mined through cashew apple and nut harvest annually. The objectives of this study were to assess the fertility status of soils of some cashew plantations across the three States of Enugu, Kogi and Oyo and evolve strategies for effective management to enhance cashew productivity.

MATERIALS AND METHODS

Two farms were selected from each Local Government Area (LGA) and two LGAs were selected in each of the three States of Enugu, Kogi and Oyo which form the bulk of cashew producing States in Nigeria. Soil samples were collected from each farm using a soil auger at soil depths of 0-20cm and 20-40cm, and at a distance of 10m apart. Soil samples were collected at a distance of 1m from the base of selected cashew mother tree. The soil samples were bulked to make composite samples and analysed for some physical and chemical properties using standard laboratory procedures according to IITA (1982). The information obtained were used as basis for fertilizer computation and recommendations.

RESULTS AND DISCUSSION

Soil textural characteristics of cashew plantations in Enugu, Kogi and Oyo States

The sand fraction of soils in the two farms selected in Udi Local Government Area, Enugu State had an average value of 890g/kg soil at 0-20cm soil depth while the sand fraction in soils of the two farms evaluated in Nsukka LGA was 849g/kg soil which was slightly lower than that of Udi LGA (Table 1). In Kogi state, the mean value of the sand content across the two farms at 0-20cm soil depth in Ofu LGA was 869g/kg soil while that of Dekina LGA was 809g/kg soil which is about 7% lower. However, the sand content of the farms in the two locations of Orire and Surulere LGAs had an average value of 809g/kg soil. The clay content in the two farms of Udi LGA had an average value of 84g/kg soil while that of Enugu was 104g/kg at 0-20cm. In Kogi state, the two farms evaluated in Ofu LGA had a mean value of 94g/kg at 0-20cm while that of Dekina LGA was 154g/kg at the same depth which indicated that the clay in Ofu LGA was much lower than that of Dekina LGA. The mean clay content of the soils of farms locations in Orire and Surelere LGAs was 109g/kg soil. The mean silt content of the soil in the farms evaluated in Udi and Nsukka LGAs of Enugu State was 31g/kg soil at 0-20cm which was relatively lower than the silt content in the soils of farms in Kogi State with an average value of 36g/kg soil at 0-20cm (Table 1). In the farm locations of Oyo State, the mean silt content in the soils of Orire LGA was 86g/kg while that of Surulere LGA was 76g/kg at 0-20. The soils in the three States under consideration indicated that sand fraction was very high and could be classified texturally as sandy loam and suitable for cashew (Egbe *et.al* 1989, Ohler, 1989).

Soil chemical characteristics of cashew plantations in Enugu, Kogi and Oyo States

The pH of the soils in the two farms in Udi LGA was 5.55 at 0-20cm while that of the Nsukka LGA was 4.85 (Table 1). The pH of the soils in Ofu and Dekina LGAs ranged from 5.40 to 6.50. The mean pH of the soils in the two farms in Orire LGA was 6.00 while that of Surulere LGA was 6.30. Cashew thrives well in a wide range of pH and the range obtained in this study is suitable for cashew (Ohler 1989. The organic carbon in the soils of the farm locations in Udi and Nsukka LGAs was 14g/kg which is much lower than the organic carbon obtained in the farm locations of Kogi state with a value of 17g/kg. The organic carbon in the soils of Oyo state was higher with an average value of 17.9g/kg soil compared with soils of Enugu and Kogi States with mean values of 14.12 and 17.09 g/kg soil respectively. The organic carbon content in the soils of the farms in Orire LGA was 19g/kg soil. The higher organic carbon in the soils of Oyo State may impact positively on the fertility status than the soils in Enugu and Kogi States. The N in the soils in the farms evaluated across the three States was generally low and there is need for N supplementation. The N in cashew farms in Enugu State ranged from 0.26 to 0.65g/kg soil while that of Kogi State ranged from 0.35 to 0.77g/kg soil. The N in Oyo State had a mean of 0.44g/kg soil in Orire LGA and 0.66g/kg soil in Surulere LGA. The total nitrogen in the soils of the farms in Udi LGA ranged from 0.26 to 0.65 g/kg. The average total N in the farms evaluated in Udi LGA and Nsukka LGA was 0.45g/kg. In Kogi state, the N in the soils of the farms in Ofu LGA was 0.5g/kg soil while that of Dekina LGA was o.63g/kg soil at 0-20cm. The total N for the soils in the two farm locations in Orire LGA was 0.44g/kg while that of Surulere LGA was 0.66g/kg soil at 0-20cm (Table 1). The average total N across the farm locations in the three States was 0.54g/kg which was less than the critical value (1g/kg soil) for cashew cultivation (Ohler, 1989; Egbe, 1989). The available P in the farm locations in the three states ranged from 2.98 to 5.35 mg/kg soil. The available P in the two farms in Udi LGA was 4mg/kg soil while that of the two farms in Nsukka LGA was 4.6mg/kg at 0-20cm depth. In Kogi state, the farms in Ofu LGA had 3.75mg/kg soil as average value for available P at 0-20cm while that of Dekina LGA was slightly higher with 5.35mg/kg. However, the available P in the two farms of Orire LGA was 3.06 mg/kg and that of Surulere LGA was 2.98mg/kg. The available P in Enugu and Kogi States was adequate for cashew cultivation with an average value of 4.3 and 4.5mg/kg soil respectively. However, the available P in the cashew farms in Oyo State was below the level required for good cultivation of cashew with an average value of 3.0mg/kg soil. It is evident that the level of available P in the soils of cashew farms evaluated in Enugu and Kogi States does not require amendment as at now but this may likely shift toward deficiency in the future. The exchangeable K in Enugu and Kogi States was low with an average value of 0.08 cmol/kg soil. There will be need for addition of potassium fertilizer. Conversely, the exchangeable K in farms in Oyo State was adequate with an average value of 0.14cmol/kg soil. The exchangeable K in soils of farms evaluated in Enugu state was 0.06cmol/kg which is much lower than the critical value required for cashew cultivation which is 0.12cmol/kg soil. The average values of exchangeable K in the four locations evaluated in Kogi and Oyo states were

0.09 and 0.16 cmol/kg soil respectively. These values are also below the critical value of 012cmol/kg. Hence, the need for management of potassium based fertilizers. The exchangeable sodium, magnesium and calcium in the twelve cashew farms evaluated were 0.15, 1.16 and 1.34 cmol/kg soil respectively (Table 1). These values are adequate for good cashew production according to Ohler (1989) and Opeke (2005). The soil available copper across the farms locations in the three states ranged from 0.17 to 2.43mg/kg soil while available Iron ranged from 2.45 to 19.25mg/kg soil. The average values of Zinc and Manganese in the soils of the farms evaluated in the three states were 1.25 15.68mg/kg soil respectively.

Fertilizer computation based on the results of soils at 0-20cm depth

The interpretation of the samples on the various farms is based on the interpretation rules generally adopted for tropical soils. Considering the soil test values from the various farm sites across the three States and the already established critical values for these elements; the fertilizer recommendation indicated that in Enugu, the two farms in Udi LGA required 134 Nkg/ha and 58kgK_2O/ha while in Nsukka LGA the farms will need 78kg N/ha and 65 kg K_2O /ha. In Kogi the two farms in Ofu LGA will require 100khN/ha 38 kg K_2O /ha while the two farms in Dekina will need 74 kgN/ha and 9 kg K_2O/ha. However, in Oyo, the two farms in Orire LGA will require 112kgN/ha and 3kgP_2O_5/ha while that of Surulere LGA need 68kgN/ha and 3kgP_2O_5/ha.

CONCLUSION

Site specific fertilizer is required for optimum returns on its usage and the fertilizers required for optimum cultivation of cashew in the three States ranged from 68 to 134 kg N/ha, 2.8 to 3.2 kgP_2O_5/ha and 9 to 66kg K_2O/ha.

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Table 1: Physical and chemical characteristics of soils of some selected cashew farms in Enugu, Kogi and Oyo States, Nigeria

Location code	Textural Class (g/kg)			pH	O.C g/kg	Total N g/kg	Avail. P mg/kg	Exch. Bases cmol/kg				Micronutrients (mg/kg)			
	Sand	Clay	Silt					Exch. K	Exch. Na	Exch. Mg	Exch. Ca	Cu	Fe	Zn	Mn
EU Farm 1	889.6	84.0	26.4	5.55	9.90	0.26	4.89	0.06	0.17	0.22	0.39	0.30	14.7	0.52	0.90
EU Farm 2	889.6	84.0	26.4	5.60	12.40	0.40	3.06	0.06	0.14	0.36	0.62	0.05	6.15	0.92	5.35
EN Farm1	859.6	104	26.4	4.80	19.40	0.65	6.12	0.08	0.17	0.17	0.44	0.15	22.70	1.22	2.60
EN Farm 2	869.6	104	46.4	4.90	14.80	0.58	3.06	0.06	0.17	0.35	0.48	0.35	15.80	1.15	1.75
KO Farm1	869.6	104	26.4	5.70	18.00	0.65	2.91	0.04	0.17	0.24	0.93	0.40	8.65	0.84	5.15
KO Farm2	869.6	84	46.4	6.30	15.80	0.35	4.59	0.12	0.17	0.41	1.83	0.45	2.70	1.09	24.65
KD Farm1	829.6	124	46.4	6.50	15.80	0.49	6.88	0.12	0.24	0.74	2.77	0.55	3.25	1.71	12.60
KD Farm2	789.6	184	26.4	5.40	18.20	0.77	3.83	0.10	0.20	0.49	1.54	0.40	7.15	0.93	7.35
KCR	829.6	124	46.4	5.60	17.60	0.49	4.59	0.05	0.14	1.35	1.32	0.65	6.05	0.82	26.15
YO Farm 1	809.6	104	86.4	6.05	17.30	0.46	3.06	0.12	0.10	0.55	2.01	0.70	3.48	1.18	44.45
YO Farm2	809.6	104	86.4	6.10	15.10	0.42	3.06	0.20	0.10	1.13	2.46	0.80	4.00	1.45	12.55
YS Farm1	809.6	104	86.4	6.30	19.80	0.90	3.06	0.12	0.10	1.27	2.06	0.25	7.50	1.73	20.35
YS Farm2	809.6	124	66.4	6.30	17.50	0.42	2.91	0.14	0.10	0.84	1.83	0.15	8.00	1.33	36.60
YCR	849.6	124	26.4	6.50	19.80	0.69	3.41	0.18	0.14	4.60	0.75	2.45	2.45	2.22	12.20

Legend: E- Enugu State
EU-Enugu Udi LGA
EN- Enugu Nsukka LGA

K- Kogi State
KO- Kogi Ofu LGA
KD- Kogi Dekina, KCR- Kogi CRIN Ochaja

Y- Oyo State
YO - Oyo Orire LGA
YS - Oyo Surulere LGA, YCR- Oyo CRIN Ibadan

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NUTRITION AND SOIL FERTILITY MANAGEMENT OF COFFEE ROBUSTA IN NIGERIA: A REVIEW

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ABSTRACT

Majority of the soils in Nigeria are exposed to leaching effects due to incessant rainfall that leads to low organic matter and nutrient contents. Consequently, the importance of coffee nutrition cannot be exaggerated because nutrition affects the size and coffee bean quality. This study was carried out to review nutritional conditions and fertility status of soils for coffee robusta production in Nigeria. It was revealed that most soils under coffee production in Nigeria are moderate to marginally suitable in fertility status. However, some of the soil contents for the nutrients needed for high yield coffee sustainability were above the critical values. Therefore, good management practices that would replenish lost nutrient elements in the soil and leaf were considered necessary.

Key words: *Coffee robusta*, soil fertility, nutrition and soil management

INTRODUCTION

Coffee is an important worldwide cash crop that is cultivated on more than three million farm units most of which are small agricultural enterprises (CRIN Annual report, 2004). Coffee is of different species but only two (Arabica and Robusta) are widely cultivated. The two most important commercial species cultivated in Nigeria are the Arabica coffee which is cultivated in upland area, which accounts for only 4% and robusta that is common in lowland area accounts for over 94% of Nigeria coffee export (CRIN Annual report, 2009). Coffee robusta (C. robusta) is cultivated in the following states across the nation: Oyo, Osun, Ogun, Ekiti, Kwara, Ondo, Kogi, Edo, Delta, Abia, Cross River, (Williams 2008; Ibiremo et al., 2013). C. robusta was said to originate from central and western Sub-Sahara Africa (Dagoon, 2005). Its production on large scale started in Nigeria as far back as 1940s on a large scale, but gained momentum in the early to mid-1950s. C. robusta known scientifically as Coffea canephora (Pierre ex A. Froehner) is a flowering plant which belongs to order Gentianales and botanical family Rubiaceae. It is less susceptible to diseases (Penarredonda, 2017), more vigorous growth and productive cultivars than the Arabica coffee (Coste, 1992). Ibiremo et al., 2013 reported that coffee was a means of livelihood for more than 2, 800,000 farmers between 1960s and 1980s in Nigeria. It is a source of food, employment and foreign exchange for many developed and developing countries. Currently, over 20 million people are engaged directly in the production of coffee globally while the international coffee trade has about 500 million people in its management, from cultivation to the final product for consumption (Ayegboyin et al., 2015). ICO (2015), but they also reported that coffee world production is on decline from 27.2% in the 1970s to an average of 16% in the 1990s and 13.1% in the 2000s. to corroborate this, FAOSTAT (2018) as cited by Iloyanomon et al., (2020) stated that production of coffee in Nigeria has decreased from 1,849 tonnes of green beans in 2018 as against 5,340 metric tonnes in 2006. Declination in production was attributed to factors such as lack of land suitability assessment, poor farm management, poor market for coffee bean produced, old age of plantation, pests and diseases, weed competition among others. Presently, Nigeria is ranked 13th among coffee producers in Africa and 41st position in the world, producing just about 40,000 of 60kg bags, 2, 400 metric tons, 5,291,000 pounds (Szenthe Adriana, 2019).

Soil and Land Requirements

Soils are indispensable factor in the world growth issues in respect to food security, land degradation, poverty alleviation and general well-being of the citizens. It is a determinant factor for the wealth of any nation. Tropical soils consist mostly of Ultisols, Alfisols, Oxisols, Entisols, Aridisols and Inceptisols. These soils are prone to leaching and fast degradation (Amakiri 2004), they must therefore be carefully managed. Proper management of soil and other resources plays important role in their productivity. To improve soil health, the continuous soil management that is combined with other good management practices is very important. Coffee cultivation requires appropriate soil conditions, good agricultural practices, appropriate coffee cultivars, pest and diseases control (Ipinmoroti and Ogeh, 2012). On the overall, coffee can be cultivated on various types of soils but the ideal is a deep and sandy loam. A fertile, free draining, slightly acidic, well aerated, and deep soil with a minimum depth of 1-1.5 m is required for effective productivity. Hence, waterlogging, heavy clay or poor-draining soils should be avoided. MARDNAEC (2009) reported that a well aerated soil to allow root penetration, well structure and porous soil to assure quick penetration, stable soils to minimize erosion on steep slopes is suitable for coffee production.

Most soils under coffee production in Nigeria are moderate to marginally suitable in fertility status (Egbe *et al*., 1989), this is in agreement with the work of Ipinmoroti et al., (2019) with the report that farm sites evaluated for coffee production in two sub-urban communities in Ibadan, Nigeria were moderately suitable for coffee production. Ayegboyin et al., (2015) on a research that assess the performance of C. canephora seedlings raised on soil collected from different soil types, depth and amendments reported that top soils, whether from virgin forest or cultivated land without additional fertilizer have the same potential for raising C. robusta seedlings. It was however, suggested that cultivated land should be left fallow for some time before being used to raise coffee seedlings. Either organic fertilizer (Pacesetter grade B) of 60kgN ha^{-1}, 30kg$P_2 0_5$ ha^{-1} and 30kgK_2O or NPK 20:10:10 is recommended as early as 4 weeks after sowing to enhance seedling growth when top soil from heavily cultivated land is used. The performance of coffee seedlings on three nursery beds made of top soil, sawdust, top/sawdust mixture in equal proportion was studied at the central nursery of Cocoa Research Institute of Nigeria (CRIN), Ibadan with the objective of finding alternative growing medium for top soils in order to reduce sole dependency on top soil for seedlings production and at the same time to reduce cost. The result showed that top soil/sawdust medium will be suitable for raising of coffee seedlings in the nursery (CRIN Annual report, 2000). *C. robusta* requires temperature ranging from 22 - 28^{O}C. Phyiological problems such as poor fruit setting, flower abortion, development and premature ripening occur when temperature is greater than 30^{O}C. In addition, an altitude ranges of 900-1500 m above sea level and rainfall range of 1,200 mm to 1800 mm is required (UCDA, 2019).

Coffee Nutrition

Coffee plant requires adequate nutrients for optimum production. Both macro and micro nutrients are needed. Nitrogen (N), Phosphorus (P) and Potassium (K), Magnesium (Mg), Calcium (Ca), are required in large quantities while Zinc (Zn), Copper (Cu,) Boron (B), Iron (Fe), Manganese (Mn), Molybdenum (Mo), Sulphur (S) and chlorine (Cl) are required in small quantities. Quantities of these elements in the soil and plants are determined through soil and leaf sample analysis. Nutrients application is done to replenish those that are lost. Thus, fertilizers are needed to be applied in the necessary amount. UCDA, (2019) suggested that for proper and effective use of fertilizer, both soil and coffee leaves should be sampled and analyzed once in a year to determine the present status of nutrients and pH of such coffee plantation. This would make for proper understanding of the nutrient recycling and management of fertilizer for optimum production of coffee. Iloyanomon *et al*., 2011 reported on a research carried out in Ibadan, Nigeria on soil fertility evaluation of coffee (C. robusta) plantations of different ages and stated that N, P, Ca, Mg contents were adequate irrespective of age of the plantations but the soil K content was insufficient to meet the coffee plants nutrient requirements.

NITROGEN (N)

Nitrogen is an essential structural component of various compounds that are important for plant growth and development (Agbede, 2009). It is also important for carbohydrate utilization, growth and development. High N content in the soil and leaves of coffee plantation of different ages in Ibadan, Nigeria was reported by Iloyanomon et al., (2011). The values were above soil and foliar critical levels for coffee productivity (Tables 1 and 2). The N sufficiency could be ascribed to leaf litter produced under the plantations. Iloyanomon et al., (2020) reported 27.60 – 60.07 kgNha^{-1} yr^{-1} in coffee leaf litter. Medina et al., (2000) reported that leaves and branches from the coffee plant returned about 41 kgNha^{-1} yr^{-1}. Coffee leaves comprised of 53kgN/ha which was 47% of N uptake by coffee plant (Coffeeasean, 2008). On the other hand, N deficiency was reported by Iloyanomon et al., (2020) in some coffee plantations. Low N content of the soil was probably due to fast growing high yielding coffee cultivar which takes up to 135 kgNha^{-1} as reported by Mitchell 1988; and that the low quantity of leaf litter fall was insufficient to ensure buildup of the N removed by the harvested coffee berries. Therefore, good management practices that could replenish N in the soil is necessary.

PHOSPORUS (P)

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P is a vital element in the establishment of new plantations due to its importance in cell division and root development (Akande et al., 2008). Ibiremo and Akanbi (2015) reported that soils under cultivation contain abundant P but most of which are fixed and unavailable to the plants. P sufficiency was recorded in the coffee plantations by Iloyanomon et al., (2011) since the soil P values were above the soil and foliar critical levels for coffee (Tables 1 and 2). The high value could be as a result of low P removal as reported by Nelliat, 1978 who reported 7kgP2O5 being removed by coffee berries from the field on harvesting. Likewise, one tonne of coffee has been stated to remove 7kg P_2O_5 (Jessy, 2011). Coffee leaves contain 11kg P/ha (Coffeeasean, 2008). P content of the soil and leaf from some coffee plantations of different ages has been reported to be low (Iloyanomon, 2020).

Table 1: Soil critical levels of nutrient elements of C. robusta

Nutrient Elements	Soil critical level
Soil pH	5.1-6.5
Soil texture (g/kg)	300-320
Organic carbon (g/kg)	9.00
N (g/kg)	0.9
P (mg/kg)	6.0
K (cmol/kg soil)	0.40
Ca (cmol/kg soil)	0.89
Mg (cmol/kg soil)	0.80
Ca : Mg	3-5
Zn (mg/kg)	2-10
Cu (mg/kg)	0.3-10
Mn (mg/kg)	<50
Fe (mg/kg)	2-20

Source: Iloyanomon et al. (2011).

Table 2: Foliar critical levels of nutrient elements of *C. robusta*

Nutrient Elements	Critical level (%)
N (g/kg)	1.10
P (mg/kg)	0.7 – 0.9
K (cmol/kg soil)	1.4
Ca (cmol/kg soil)	0.37
Mg (cmol/kg soil)	0.13
Ca : Mg	1.19
Zn (mg/kg)	0.002-0.003
Cu (mg/kg)	0.016-0.002
Mn (mg/kg)	0.005-0.01
Fe (mg/kg)	0.07-0.02

Source: Iloyanomon *et al.*, 2011.

POTASIUM (K)

K is necessary for formation and translocation of carbohydrates, cell division, regulation of osmosis or control of water in the plants and increases the resistance of some plants to certain diseases and insects attack as well as activator of various enzymatic systems (Ibiremo and Akanbi 2015). Moyin-Jesu (2008), noted deficiency symptom of N, P, K as shown by yellow coloration, purple without application of fertilizer. Jessy (2011) stated that at the berry development stage, K requirement and absorption is highest with its peak at the ripening stage. Its uptake rises just after the main flowering at the last stage of fruit development and later as the plant recovers from fruit bearing where water is not limiting. Iloyanomon et al., (2011, 2020) reported very low K content in the soil and leaves of coffee plantation of different ages in Ibadan, Nigeria. This is similar to the findings of Carvajal (1985) who reported K insufficiency on a soil farmed with coffee for over 22 years. The low value of K was ascribed to loss of K during harvesting of coffee berries. A tonne of coffee beans has been reported to remove 35kg N, 7kg P_2O_5 and 50kg K_2O (Jessy, 2011). Therefore, harvesting of coffee berries with high concentration of K without replenishment of the lost through K fertilization could lead to deficiency of K from the coffee plantation. Functions of both macro and micro elements are summarized in Table 3.

Table 3: Macro and Micro Elements needed for coffee production and their functions

Elements	Functions
N	Essential for vegetative growth Enhances coffee bean size Helps in formation of chlorophyll (green colour) Helps in formation of hormones and enzymes It increases tree bearing capacity
P	Necessary for root development Promotion of early berry maturity It increases bean density Essential for flowering and ripening of berry Helps in formation of energy compounds
K	Essential for berry development and ripening Enhanced mucilage formation Helps in promotion of healing injured tissue especially after picking and pruning Necessary for photosynthesis and disease resistance Regulation of water uptake from the soil
Mg	It is a major constituent of chlorophyll Helps in seed germination Essential for photosynthesis It produces energy for the plants
B	Promotes shoot and root growth Essential for germination of pollen Facilitates flowering, fruit set and development Transport of sugar
Ca	Necessary for growth of terminal buds and flower formation Helps in bark formation (formation of cell wall) Facilitates root and apical growth
Zn	Enhances fruit set and leaf size Boost flower initiation and formation Sets the inter-nodal spacing on the branch and the stem
Fe	Helps in the production of chlorophyll Promotes bean colour Together with copper, it facilitates energy transfer during food manufacture
Cl	Helps in photosynthesis Gas exchange and water balance
Mn	Component for manufacture of enzymes Helps in photosynthesis
Mo	Helps in Nitrogen metabolism
Cu	Essential for chlorophyll and protein formation

S	Necessary for plant growth Helps in disease resistance, seed production and protein synthesis

Source: UCDA, (2019)

Fertilizer Management

Nigerian soils are generally low in quite a number of essential nutrients due to various factors such as erosion, leaching, bush burning, low activity clay, and among others, hence, these must be provided to foster good and optimum coffee yield. Ibiremo *et al.,* (2011b) stated that most soils upon which coffee is cultivated are usually poor in nutrient contents such as nitrogen, phosphorus and potassium. Likewise, Iloyanomon *et al*., (2011) reported that coffee cultivation in Nigeria lacks good soil management systems as production gets little or no fertilizer applications in the hands of major producers who are small scale farmers. This has resulted into removal of nutrients through harvesting of coffee berries without replacement of lost nutrients. Application of appropriate fertilizer could increase C. robusta yield from average current of 1 metric tonne up to 3 metric tonnes of FAQ per hectare per year (UCDA, 2019).

Fertilizers are added to the soils to increase yields or improve crop productivity. The integrated use of organic and inorganic fertilizers is desirable to sustain coffee yield and maintain soil fertility. C. robusta responds well to application of both organic and inorganic fertilizers. Ojeniyi (1981) reported that application of NPK fertilizer in C. robusta enhanced uptake of some essential nutrients such as Mg, Ca, Mn, S and Cu in the soil therefore organic fertilizer is recommended in the production of coffee because of the vital roles they perform in the soil and plants. Application of organic and inorganic fertilizers depends on factors such as the history of the soil, soil condition, inherent soil fertility status (Ngaruiya, 1995). Various NPK formulations (liquid and solid) in Nigeria are used by farmers for some tree crops and arable crops production. Foliar spray is a well-established tool to enhance and improve plant nutrition. Liquid fertilizers are mostly foliar fertilizers that contain high purity NPK and trace elements. They are effective and quick by spraying on leaves and dissolve in water (Ibiremo et al., 2013). Ibiremo and Akanbi (2015) stated that the use of NPK fertilizer formulation especially liquid NPK provides another fertilizer options to farmers as ways of fostering coffee productivity. Likewise, liquid NPK fertilizer could simply be used in addition with other agro-chemicals like insecticides and fungicides for effective growth. In addition, Ibiremo et al., (2013) reported that the positive influence of NPK fertilizer formulations on the coffee seedlings growth mainly NUTRICO-1(NPK-liquid fertilizer) is a pointer and that there is need to explore other fertilizer formulations that will combine efficiency with cost effectiveness and ease of application in the production of coffee and other fruit trees.

Organic materials are natural source of major and micro nutrients. Coffee gains from organic manure in form of farmyard manure, compost, human faeces, human urine or composted household refuse (Adejobi et al., 2011). The use of cocoa pod husk has been reported by Obatolu (1995) as fertilizer for coffee. Cocoa pod husk ash (CPHA), organo-mineral fertilizer (OMF), their combinations and urea increased uptake of nutrient by coffee seedlings. Combination 15 t ha^{-1} + 5 t ha^{-1} CPHA gave highest soil OM, N, leaf K, Mg and K gave highest value for most growth and yield parameters signifying that availability of OM and N, K and Mg dictate strongly the performance of coffee. Aside from organic material (CPHA, OMF) urea alone increased P, K, Mg, Ca and Na concentration (Adejobi et al., 2011). Ojeniyi (1980; 1981), had observed that application of NPK fertilizer caused deficiency of Ca and Mg in leaves of C. robusta; although NPK at suitable combination enhanced the yield of coffee considerably. Yet in unfertilized plots, deficiency symptoms of N, P, K, and Mg were noted (Ojeniyi, 1980). Therefore, organic fertilizers such as CPHA and OMF would be effective in increasing coffee seedlings performance and nutrient uptake (Adejobi et al., 2011).

CONCLUSION

The study reviewed nutritional conditions and fertility status of soils for coffee robusta production in Nigeria. It was revealed that Nigerian soils are moderate to marginally suitable for coffee production and will require good management practices to obtain optimum productivity. Therefore, deficient nutrients should be supplied through the use of appropriate fertilizers which has been reported to increase coffee productivity.

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SOIL AND FERTILIZER MANAGEMENT IN CASHEW (*ANACARDIUM OCCIDENTALE* L) PRODUCTION IN NIGERIA: A REVIEW

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ABSTRACT

Research achievements in soil and fertilizer management in cashew production in Nigeria were reviewed, emphasizing historical antecedents, soil and fertilizer management among other things. Cashew thrives well in moderately deep soil of 1-1.5 m that is sandy loam with at least 60% sand and well drained that has capacity to supply continuous nutrients. Information on nutritional requirements showed that combination of urea at 120 kg/ha with MOP at 48 kg/ha gave the highest yield of 3.53 kg/tree for the first year, single application of SSP at 144 kg/ha significantly slightly increased yield during the second year, while NPK fertilizer when applied as urea at 60 kg/ha, SSP at 144 Kg/ha and MOP at 24 kg/ha gave the highest yield for the second year and significantly reduced the disease infection. Fertilizer application rates and other technical requirements of cashew cultivation are highlighted in this paper. Gaps for further research were identified which include the use of integrated nutrient management and site-specific fertilizer application for cashew cultivation were also proposed.

Keywords: *Nutrient, cashew, fertilizer, yield, Urea, Muriate of potash (MOP), Single super phosphate (SSP).*

INTRODUCTION

The history of cashew in Nigeria dates back to 15th century. As at that time, cashew was mainly used in afforestation schemes for the control of soil erosion in the former Eastern Nigeria. In Nigeria, commercial cashew plantations started in the early 1950s with the establishment of commercial plantation in different regions of Nigeria. Cocoa Research institute of Nigeria (CRIN) in 1975 commenced research on the cultivation, uses of cashew in Nigeria. Falade (1978) reported that its cultivation has spread to other agro-ecological zones of Nigeria. Cashew grows almost everywhere in Nigeria but is concentrated primarily in the southern and middle belt regions by small land holdings farmers. The majority of export of quality nuts comes from the Western and Eastern parts of the country. Industrial cashew processing in Nigeria began in the early 80's when the old Eastern Regional Government established the Premier Cashew Processing Factory, located in Oghe in Enugu State, primarily to process the harvest from the government owned 650ha cashew plantation as well as to serve other small land holding farmers in and around the States of Kogi and Benue.

Soil and climatic requirements

Cashew can be cultivated in a variety of soil types and in selecting suitable soil for cashew visual observation could be employed minimally to know the types of trees, weeds and presence of worm cast among other ecological indicators. The crop is predominantly found in all parts of the country. Falade, (1978) revealed that the wide spread coverage of the crop indicates that cashew grows on a variety of soil types. Suitable soils for cashew ranges from entisols in the South, ultisols in the West, ultisol or oxisol in the East to alfisols in the North (Obatolu, 1996). Most of the soils producing cashew are light in texture ranging from sandy to loamy sand. Cashew thrives well in moderately deep soil of 1-1.5 m that is sandy loam with at least 60% sand and well drained that has capacity to supply continuous nutrients. Excess of gravel and clay along profile retard cashew root growth and must be avoided. A well-drained friable deep and medium- textured soil that can retained enough moisture during climatic stress of a long dry season and an annual rainfall of 400-1,500mm is recommended for cashew production.

Soil fertility management

The soil type and the quality of the soil influence the growth and development of cashew plant. In Nigeria, soils on which cashew is grown is sandy loam in nature (Ayodele, 1993), which cannot hold nutrients for prolonged periods. It has been observed that most Nigerian cashew farmers do not use fertilizer and thus the nutrients being mined by the plants are not replenished. According to Ohler, (1979) reported that cashew flourishes in soils where most other crops do not perform better with nutritional assistance. Cashew respond well to fertilizer application, mostly during the vegetative growth stage (Hammed *et al*., 2011). The limited production may be as a result of nutrient deficiency in the soil. The use of organic fertilizer amended with phosphate fertilizer and Arbuscular mycorrhizal fungi (AMF) innoculation were found to have positive influence on the growth and chemical properties of the soil of cashew. Nigerian Sokoto rock phosphate (SRP) for cashew production also according to (Ibiremo,2010; Ibiremo *et al*..2012). Recent work by Adewale *et al.* (2013) also revealed that the trend of growth and development of cashew genotypes differed in response to varied combination of the soil nutrient. Cashew farmers in Nigeria use little or no fertilizer. Continuous harvest without appropriate nutrient replenishment, leads to nutrient mining. Cashew is responsive to nutrient supplementation as nutrients are lost through harvesting of nuts/apple. Most existing cashew plantation in Nigeria produce one-third of what obtained in other Countries. Research established soil and foliar critical levels for cashew below which fertilizer should be applied soil critical levels: Total N 1g/kg, Available P 3.7mg/kg soil, Exch. K 0.12 cmol/kg soil, Mg 0.08 cmol/kg soil, Ca 0.08 cmol/kg soil. The foliar critical level is N 1.24%, P 0.12%, K 0.34%, Ca 0.18%, Mg 0.88%. (Egbe *et al*., 1989). Below these soil and foliar critical levels, nutrient supplementation as fertilizer is necessary. Research established soil and foliar critical levels for cashew below which fertilizer should be applied: Soil critical levels: Total N 1g/kg, Available P 3.7mg/kg soil, Exch. K 0.12 cmol/kg soil, Mg 0.08 cmol/kg soil, Ca 0.08 cmol/kg soil. One kilogramme of cashew apple and nuts removed 64g N, 2g P, 25g K, 4g Ca, 2g S, 525mg Fe, 64mg Mn, 88 mg Zn and 27 mg. The deficiency symptoms of nutrients include yellowing of leaves and stunted growth due to N deficiency while P deficiency leads to leaves changes from leaf green to dark green, to bronze and yellowish shade. Leaves are small and K deficiency results in leaf chlorosis and firing of edges of the leaves.

Soil requirements for cashew

Falade (1978), reported that soils of the cashew in Ochaja, Kogi state, Nigeria have low levels of exchangeable bases, nitrogen and phosphorus indicating that possible response to fertilizer by cashew crop was possible. Adejumo (2010) reported that urea at 120 kg/ha when combined with MOP at 48 Kg/ha gave the highest yield of 3.53 kg/tree and lowest disease infection (90 inflorescence panicles infected) for the first year agree with the report of Katan (2009) that NO_3 nutrition stimulates K uptake and vice versa promoting the synthesis of organic N compounds. In the second year, NPK fertilizer when applied as urea at 60 kg/ha, SSP at 144 Kg/ha and MOP at 24 kg/ha gave the highest yield for the second year and reduced disease infection (125 inflorescence panicles infected) significantly. According to Adejumo, 2010, this might be attributed to a balanced NPK nutrition, especially SSP at high concentrations. The observation of increased yield and reduced disease infection of single application of urea at 60 and 120 kg/ha and SSP at 72 and 144 kg/ha observed for the second year was not surprising. Nitrogen is the most commonly used fertilizer and is essential for the production of many cellular components (Huber and Thompson, 2007). Yields of trees grown in this way are very much lower than the potential that could be gained if fertilizer was applied (FAO, 2004). Azam-Ali and Judge (2001) reported that potential yield of 10 to 15 kg per tree could be obtained under optimum conditions. The result is presented in Tables 1 and 2 below:

Table 1: Effect of fertilizer application on yield disease infection of cashew

Year	Type of fertilizer	Rate (kg/ha)	Result
First	SSP	144	Slight increase in yield and reduction in infection
Second	Urea+ MOP	120+48	Highest yield of 3.53kg/tree and lowest disease
Second	NPK+SSP+MOP	60+144+24	Highest yield and significantly reduced disease

Source; T. O. Adejumo, Department of Microbiology, Adekunle Ajasin University.

Table 2: Nutritional requirements and recommended fertilizer rates for cashew

Age	Urea (g)	SSP (g)	MOP
1^{st} year	375	275	75
2^{nd} year	750	525	150
3^{rd} year	1100	750	200

Source: Cocoa Research Institute of Nigeria

Strategies to be adopted to increase cashew area in the states

a) Cultivable waste lands can be utilized for cashew plantations by different government agencies.

b) Awareness must be created among all the players (farmers, processors and entrepreneur) in cashew sectors through circulation of leaflets and booklets on improved cultivation practices.

c) Technology dissemination to the rural youth through training, demonstration and electronic media together with formation of farmer groups of common interest for holistic development.

Gaps in knowledge

Research effort should be made on the use of crop wastes as soil amendment alternative for cashew cultivation. These could also be integrated with inorganic fertilizers to improve their efficiency. Hence, the waste –to- wealth approach will reduce wastage within farming system.

Recommended research

Gaps for further research were identified which include the use of integrated nutrient management and site-specific fertilizer application for cashew cultivation are hereby also proposed.

CONCLUSION

Suitable soils for cashew cultivation are well drained soil, deep and medium texture soil that can retain enough moisture and nutrients for improve productivity. Use of unsuitable lands for cashew will not only lead to wastage of resources but also will reduce productivity. Hence, suitable soils with appropriate management practices will lead to high yield of cashew.

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REVIEW OF KOLA RESEARCH ON SOIL AND PLANT NUTRITION

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ABSTRACT

The nuts of kola (Cola species) are used in local and international trade as well as pharmaceutical, drug and wine production, religious, social and traditional functions. The results of fertilizer trails on common species of kola were discussed. Result on plant nutritional research, soil nutrient depletion due to nutrient mining as a result of yearly harvest and effect of fertilization on yield were reviewed. It was shown that poor soil fertility and nutrient element reduction lead to poor growth and establishment, decline in yield and quality. Boron deficiency was shown to reduce plant growth and number of nuts but significantly increased nuts weight. Major nutrient such as N, P, Ca, Mg and K were also reported to show deficiency symptoms which also affected growth and yield. The order of importance of essential nutrients was stated as boron>copper>zinc>phosphorus>calcium>potassium>magnesium. Nitrogen or any other element affect growth and yield only when it is significantly deficient. Loamy sand to clay soil with sand 65-70%, silt 14-19%, clay 15-20%, pH 5-6, N 0.14-0.18%, available P 6-8mg/kg, exchangeable cation 0.35-0.40, 0.32-0.35, 2.9-3.5 and 0.9-1.0 cmol/kg for K, Na, Ca, and Mg respectively are requirement for Kola production. Minimum NPK fertilizer recommended was 131kg N, 21kg P and 139kg K base on amount removed by yield per hectare per year. Critical soil and leaf nutrient level for N, P, K, Mg, Ca were reported as 0.1%, 3.87mg/kg, 0.12cmol/kg, 0.8cmol/kg, 0.8cmol/kg and 1.5%, 0.22%, 1.19%, 0.25%, 0.8% respectively and inclusion of micronutrient supplying fertilizer for kola production recommended. Significant increase in growth and yield was reported for sole application of organic fertilizer and also when combined with inorganic fertilizer. Inorganic fertilizer was said to be scarce, costly with adverse effect on soil acidity.

Keywords: Kola, Yield, Soil fertility, Nuts.

INTRODUCTION

There are more than forty species of Kola and the two most common and productive species of this crop used in Nigeria are *Cola nitida* and *Cola acumunata* (Adebowale 2015, Ndagi *et al.,* 2012). In Africa, especially West Africa where Kola originated, it is used to produce several pharmaceutical drugs, wine, liquors and confectionary in addition to its use as masticator and stimulant. Kola trade has increased over time since its inception as early as the nineteenth century raising the standard of living of the trader (Kanmegne, 2015). Presently, the demand of kola nut is far in excess of its production. Thus, there is a need to increase both its acreage as well as productivity (Ndagi 2012). The sustained increase in demand of kola nut has led to greater interest in it as tree crop. But it has been realized that fewer information existed on kola, particularly on soil fertility and plant nutrition. Also, the very few report that are available needed to be assembled for easier review as well as guide for further nutritional research on the crop. Therefore, the aim of this review is to focus attention on past work with view to know knowledge gap in order to recommend areas of further studies.

CHALLENGES OF SOIL NUTRIENT DEFICIENCY ON PRODUCTION

Soil fertility degradation is one of the most serious threats to kola production and effect of poor soil fertility lead to reduced growth, poor establishment, and decline in yield, poor kola nut quality and increase in disease and pest infestation. The production of kola nut is influenced by soil fertility. Nutrients are "mined" from the soil through kola pod yearly harvests but farmers hardly employ practices to ensure nutrient replacement through processes like fertilizer applications. This leads to non sustainable production of kola as the resulted low fertility status would at a point be no longer able to sustain production. Ipinmoroti *et al.* (2000) and Asogwa et al. (2012) reported falling kola yields due to old age and soil nutrient depletion and stated that ability of any soil to replace nutrients absorbed by crops depend mainly on the clay type, mineral composition of the fine fraction and soil fraction in toposequence. Also, Ajiboye *et al.* (2019) have shown that the decline in yield and soil physical and chemical degradation occur as result of mismanagement of agricultural land in the sub-Saharan Africa

According to Asogwa *et al,* (2012) there is an abundance of soils of high, medium, and low fertility that can be strategically exploited for kola nut cultivation in an effective land utilization policy and such suitable soils have long been identified in sub-Sahara Africa. These suitable soils should be utilized for new plantings of improved kola seedlings to ensure high production. Despite endowment in soil resources suitable for kola nut production, as well as long history of kola nut production particularly in Nigeria, the main challenge facing production is drop in yield of kola trees which result to low return from the stands (Ndagi, 2012). This has made farmers resolved at abandoning their farms for the production of annual crops like maize, cassava, guinea corn, and vegetables (pepper, tomatoes, etc.), among others (Ndagi, 2012). The need of the hour is to find a way for adequate nutrient replenishment to enhance the nutrient status of the soil above the critical nutrient level established for kola.

BORON- AN ESSENTIAL MICRONUTRIENT FOR KOLA

Effect of different rates and sources of boron on yield of kola between1968 and 1976 were reported by Egbe (1980). It was shown that non boron deficient tree consistently gave higher yield (nearly thrice) than the tree with boron deficient symptoms with a marked decline in yield. This confirmed Jacob *et al.,* (1972) and Egbe (1973) observation of wide spread of boron and copper deficiency in Kola plantations. The study on Kola clonal materials (AA 86 and some *C. nitida* tree) being screened for yield performance in Osogbo under old Oyo state and CRIN Gambari experimental station (1970) showed signs and symptoms of boron deficiency which include thickened shoots and broad leaves surface becoming uneven, less glossy as well as die back of the growing point with subsequent profuse bud break of many lateral shoots followed by necrotic spot on young leaves.

Abnormally short stem internodes of the branches were also observed with leaves showing various deficiency symptoms as well as production of parthecarpic fruits. The crop yield of *C. nitida* and its components such as branches (hands) per tree, pod per bunch, nut number per pod and mean nut weight were recorded for plant that were boron deficient and non boron deficient for six consecutive harvest seasons from 1971-76. It was observed that non boron deficient tree consistently gave higher yield than the tree with symptom. In 1973-1975 it was reported that boron deficient tree of clone AA86 in Gambari Experimental Station (GES) showed a marked decline in yield. The trees with visual boron deficiency symptoms produced less fruits per tree and pods per hand than the symptomless one. The boron deficient tree had a mean nut weight which was significantly higher than that of the normal tree. The higher mean nut weight of boron deficient tree (AA86) was believed to be as a result of the marked lower number of hands per tree as well as pods per hands. Eijnatten (1967) and Jacob (1973) had observed that higher number of pods per fruiting point had a decreasing effect on nut weight. From the yield data shown, it was concluded that *C. nitida* production, particularly in area where the soil was derived from basement complex rock in Nigeria suffered from inadequate boron supply. Through these reports it has been shown that boron deficiency in kola tree seems to contribute adversely to irregularity of bearing and has been discovered to depresses the yield of kola and that trees with visual B-deficiency symptoms produced less fruiting branches (hands) per tree as well as less pods per hands than symptomless one.

Joseph and Ipinmoroti (2013) examined soil and leaf micronutrient content of kola plantation in Uhomora, Edo State and found that Cu, Mn, Zn, and Fe level were 0.39, 0.03, 30.1, and 198 mg/kg soil compare to the critical level of 2.5, 0.1, 0.1 and 4.5mg/kg soil recommended for tree crop (McKenzie, 2001), while leaf micronutrient was found to be 2.11, 0.15, 20.92 and 27.85mg/kg dry weight for Cu, Mn, Zn, and Fe respectively. The leaf Cu, Mn and Zn content were far below critical level of 8.0, 20.0 and 25.0 mg/kg dry matter weight recommended for tree crops (McKenzie, 2001). They concluded that kola plantations nutrient management need inclusion of micronutrient supplying fertilizer for balanced nutrient supply.

MAJOR MACRONUTRIENT FOR KOLA

Egbe (1968) reported chlorosis as well as reduced growth in kola due to nitrogen deficiency and that phosphorus requirement was low at the beginning of growth but increase considerably with maturity. It was observed that calcium deficiency resulted in chlorosis from the tip and towards the base of the leaf. The rate of leaf production was notably reduced; new leaves were smaller than normal and attack by fungus accompanied deficiency. Magnesium and Potassium deficiency showed interveinal chlorotic spots in both sides of the midrib of the leaves extending to the base from the tip and development of puffy leaves with tissue between main lateral veins; papery texture as well as rounded leaves with drip trips pinched respectively.

Egbe and Ayodele (1981) stated that the order of importance of the essential nutrient for kola was boron>copper>zinc>phosphorus>calcium>potassium>magnesium and reported positive response of kola to PK (mineral fertilizer) application with more pod than P, K, or N alone or NP or NK and that N was observed to have depressive effect on production. It was concluded that the fertilizer N forced vegetative growth at the expense of fruiting and that all the fertilizers seem to have depressive effect on nut production when compared with the control tree and that this indicate that nutrient other than NPK are limiting yield of kola. Likewise, response of kola seedling tree to NPK was observed to be quite different from those of the ramet on the same soil type and climate. Ayodele (1983) reported that application of P, K, NK and PK resulted to higher average kola yield than the control while N, NP and NPK depressed yield. It has been confirmed that kola seedling would respond to fertilizer treatment because some moribund kola plot that were supplied with kola seedling showed some nutrient deficiency symptoms. NPK fertilizer was applied right to the plot from year of planting through maturity at mean application rate of 98, 98 and 58 kg/ha/annum of urea, superphosphate and potash respectively. The result indicated that at the rate of applied fertilizer on ramet, N and NP depressed yield at 5% level, indicating that the applied rate is probably too high. P, PK and NPK had no significant effect on yield, K and NK increase nut yield at 1% and 5% level of significance respectively. It was also found that treatments had no significant effect on nut yield of kola from seedlings.

Egbe and Ayodele (1984) reported that soil suitable for the growth of kola is formed from various parent materials and varied, ranging from loamy sand to clay. It was also reported that low nutrient was derived in soil from sandstone which is particularly low in exchangeable bases, nitrogen and phosphorus. Based on the result of physical and chemical analysis carried out, some of the textural and chemical properties considered favourable for the good growth of Kola were; sand 65-70%, silt 14-19%, clay 15-20%, pH 5-6, N 0.14-0.18%, available P (Bray 1) 6-8mg/kg, exchangeable cation 0.35-0.40, 0.32-0.35, 2.9-3.5 and 0.9-1.0 cmol/kg for K, Na, Ca and Mg respectively, organic carbon 1.6-2.0% as well as Carbon/Nitrogen ratio of 11:13.

In 1987 and 1988, Ayodele estimated the amount of nutrient (NPK) removed from the soil in harvested kola and found that the husk and the seed coat have higher content of N, P and K than the nut and suggested that the coat could be a good source of fertilizer. The calculated amount of N, P and K removed from the soil was estimated using 500-5000 nuts/hectare/year as 130.91kg, 10.34kg and 138.74 kg respectively. On the basis of this, minimum NPK fertilizer was recommended for kola production as 131kgN, 21kg P and 139kg K. Egbe *et al.* (1988) observed that kola plantation in Nigeria had low exchangeable K, total N and available P as well as widespread deficiency of boron and copper. In addition, critical soil and leaf nutrient level was established for kola productivity as 0.1% N, 3.7mg/kg P, 0.12cmol/kg K, 0.8cmol/kg Mg , 0.8 cmol/kg Ca and 1.09% N, 0.08% P, 1.2% K, 0.34% Mg , 0.47% Ca respectively (Egbe *et al.,* 1989).

Ayodele (1999) through studies on effect of NPK on the seedling of kola showed that it responded to additional element (e.g. NPK) only if the soil is deficient in such nutrient element. Likewise, Ipinmoriti *et al*., (2000) observed that some moribund kola plantation after decade without fertilizer application showed decline yield and too low soil N and K content while Ca was reported to be too high. Ayodele (1995) examined plantations of kola in Nigeria and found it to be generally acidic with pH value between 4.0 and 6.7, the N content was found to be below critical level of 0.1% though with no symptom of deficiency. The available P ranged between 1.0-8.5mg/kg and exchangeable base mean value for K, Ca and Mg in the study was 0.37cmol/kg, 3.13cmol/kg and 0.96cmol/kg higher than the 0.12cmol/kg, 0.8cmol/kg and 0.8cmol/kg reported critical values for soil. It was indicated from the study that moderate nutrient status of the soil with value of about 67% sand, 16% silt 17% clay, pH (H_2O) 6.0, 0.16% total N, 6.0 mg/kg available P, 0.37cmol/kg K, 0.3cmol/kg Na, 3.13cmol/kg Ca, 0.96cmol/kg Mg, 1.8% C and C/N of 13 support good growth of kola (*Cola nitida*) Adebowale *et al.,* (2015) discovered from five selected kola plantation in Ogun State pH range of between 5.29-7.57, sand, clay and silt content range between 49.95-73.57%, 17.57-35.81% and 2.64-14.72% respectively. The soil organic content was found adequate in almost all the soil while nitrogen was found to be below critical value of 0.1% and

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available P was between 3.98-8.03mg/kg which was above the critical value of 3.7mg/kg soil. The exchangeable K was between 0.08-0.44cmol/kg, Ca content was found to be above critical value of 0.8cmol/kg while Mg was found to be below the critical level of 0.8cmol/kg.

ORGANIC AMENDMENT IN KOLA PRODUCTION

Egbe *et al.* (1988) found the use of animal as well as crop wastes in the form of farmyard manure or compost helpful in improving production. They observed that the use of chemical fertilizer on kola production had been hindered by its scarcity, high cost, incomplete nutrient supply as well as possible enhancement of soil acidity, low total N, available P and exchangeable K. Also, It is expected that young plant should be raised using top soil rich in organic matter. However, it is often difficult to obtain adequate suitable top soil due to deforestation.

Ajayi *et al.,* (2007) reported better growth performance and nutrient (N, P, Mg and Ca) uptake in kola seedlings (*Cola acuminata*) through application of cocoa pod husk in screen house. Ogunlade *et al.* (2008) also reported amendment of subsoil with 5ton /ha of either KPH or poultry droppings which consistently gave higher seedling height than 2.5 ton/ha and unamended top soil. Moyin-Jesu 2009 used amended organic fertilizer to raise kola seedling (*Cola acuminata*) and observed that the organic residues significantly increase growth and nutrient uptake of kola seedling, soil pH and organic matter content. Adejobi and Ayegboyin (2011) stated that urine has high nitrogenous fertilizer value than facea, contained up to 0.9%N, 0.12%P and 0.26% K and that human urine combined with cocoa pod husk releases more nutrient for kola production than faeces and cocoa pod husk separate application.

Kola testa has been suggested as a possible fertilizer ingredient (Olubamiwa, 2002). Adeosun *et al.,* (2013), used kola testa and NPK fertilizer as amendments and reported significant increase in growth performance, soil and leaf nutrient composition of kola seedling from sole and combined application compared to the control Adejobi (2015) stated that combined application of organic (human urine, Kola pod husk ash, goat dung) and inorganic fertilizer (urea) increased significantly the plant height, number of leaves, number of branches, shoot length, stem girth, leaf area, dry root weight and fresh shoot weight of kola seedling relative to urea treatment and the control. The leaf analysis of the kola seedling also showed that there was significant increase ($P<0.05$) in the leaf N, P, K, Ca, and Mg content for different organic fertilizer sources compared to control.

CONCLUSION

Kola is an important economic cash crop to a significant proportion of Nigeria population who are involved in kola farming, trading and industrial utilization. While the demand is rising, the production remains low because many of the trees in Nigeria are unfruitful or have very low yield due to inefficient pollination, old age, soil nutrient deficiency incompatibility, pests and diseases among others.

Work has not been done extensively on the effect of macro nutrient and micro nutrients. The positive and adverse effects of combination of these various elements (such as Ca and Mg, P and Zn, etc) on both seedlings and ramets growth and fruiting have not been evaluated.

RECOMMENDATION/ AREA OF RESEARCH IMPROVEMENT

The following are recommended to improve kola nut production:

(1) That attention should be given to soil fertility management of existing kola plantations and appropriate fertilization policy established to enhance productivity.

(2) Cocoa Research Institute of Nigeria (CRIN), particularly soil and plant nutrition section should be given necessary support in this regard.

(3) Farmers should be trained on the use of affordable, soil friendly and low cost organic amendment.

(4) Researchers should be as practical as possible in working with the farmers by setting up demonstration plots.

(5) Efforts should be geared toward organizing kola farmers into association and/or cooperative because this has the potentials of facilitating coordination and implementation of research findings.

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EVALUATION OF NUT YIELD AND FOLIAR NUTRIENT CONTENTS OF THREE CASHEW BIOTYPES AT DIFFERENT REPRODUCTIVE STAGES

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ABSTRACT

Poor soil fertility status is one of the major factors responsible for decline growth and productivities of cashew in Nigeria. The study was conducted to evaluate some leaf nutrients contents of three cashew biotypes at different reproductive stages. The nut yield was also evaluated. The experiment was conducted at the cashew plot in Zone 3 and 4 (07° 10' N and 03° 52' E) of Cocoa Research Institute of Nigeria (CRIN) Ibadan. The cashew biotypes were established in blocks based on cashew biotypes of madras, small, medium, large and jumbo nuts size. The cashew trees sampled were randomly selected from three blocks (i.e. trees producing small nuts, medium nuts, and large biotypes and replicated three times). Leaf samples were collected on each selected tree at four different reproductive stages, processed and analysed chemically following standard procedures during the 2018/2019 production season. Soil samples were also collected, processed and analysed following standard procedures. Nuts from each sampled cashew tree were also collected every week as the fruit matured and dropped until the end of fruiting season. Nut yield data were subjected to Analysis of variance and treatments means were separated using Duncan Multiple Range Test (DMRT). Results indicated that nitrogen and phosphorous contents of the leaves were higher before flowering. The values of these two essential nutrients drastically reduced during flowering. Adequate supply of nitrogen and phosphorous is essential for efficient flowering and fruiting in cashew production. It is therefore recommended that farmers should apply fertilizers that are rich in nitrogen and phosphorus before the flowering stages to enhance cashew productivity. Cultivation of cashew biotypes with large and medium nut sizes is also recommended for farmers for higher nut yield.

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is grown for it nuts and the pseudo- apple from which products, such as cashew juice wine, vinegar, jams, chocolate, cashew nut shell liquid (CNSL) and cooking oil are obtained. Cashew has a great potential as a foreign exchange earner and source of industrial raw material with the prospect of becoming a major commercial tree crop in Nigeria. The main focus of cashew farming/cultivation is the nut yield which is majorly determined by genetic potential of the variety planted and soil fertility, among other factors. Crop growers often attempt application of organic and inorganic fertilizers to boost soil nutrient and enhance their crop productivity. However, the foliar nutrient dynamics of cashew at different reproductive stages within the season vis-à-vis the nut yield has not been fully understood. Therefore, understanding nutrient concentration of cashew leaves at different reproductive stages within a season will guide on the appropriate soil fertility management options for enhancing cashew nut production. Therefore, the objective of this study was to evaluate some leaf nutrient contents of three cashew biotypes at different reproductive stages within the season. The nut yield was also evaluated.

MATERIALS AND METHODS

The experiment was conducted at the cashew germplasm plot in zone 3 and 4 (Latitude 07°10'N and Longitude 03°52'E) of Cocoa Research Institute of Nigeria (CRIN) Ibadan between November, 2018 and May 2019. The cashew plot was established in blocks based on cashew biotypes of madras, small, medium, large and jumbo nut sizes. The cashew trees tagged and labelled for this trial were randomly selected from 3 of the blocks - cashew trees producing small, medium and large nuts and replicated three times. Leaf samples were collected from cashew trees in each block representing each biotype- small, medium and large at four different reproductive stages (Before Flowering (Bf), During Flowering (DF), During Fruiting (DFT) and After Fruiting (AFT) in three replicates. The leaf samples were oven dried at 70^{oc} and grinded to powder for laboratory analysis following standard laboratory procedures. Nine core soil samples bulked together as a composite sample per biotype in each block were collected using soil auger at 0-20cm depth. The soil samples were air dried, sieved and analysed chemically following standard laboratory procedures. The nuts from each sampled cashew trees were also collected every week during fruiting season as the fruit matured and dropped. This continued till the end of fruiting season.

RESULTS AND DISCUSSION

The soil pH values ranged between 7.2 and 7.6 (Table 1), a little above the critical range of 4.5 to 6.5 (Egbe *et al*., 1989). The soil across the three blocks was sandy loam with sand and silt contents ranging from 838 to 898g/kg and 54 to 114g/kg respectively. The soil particle size composition affects its characteristic properties such as water holding capacity, permeability, porosity, infiltration and susceptibility to erosion and leaching (Aikpokpodion *et al.,* 2010). Soil and leaf nutrient status can give better indication of nutrients requirements (Rupa T.R et al., 2014). The soil test results indicated that the major nutrients were adequate for cashew production. The values of total nitrogen, available phosphorus and exchangeable cations were above the critical values recommended for cashew as reported by Egbe et al (1989). However, the organic carbon content was low in the three blocks of small, medium and large cashew nut sizes.

Table 1: Some properties of soils under cashew plantations with different biotypes

Soil properties	Cashew plantations with different biotypes		
	Small	Medium	Large
pH	7.6	7.4	7.2
Sand(g/kg)	878	838	898
Silt(g/kg)	74	114	54
Clay(g/kg)	48	48	48
Textural class	Sandy loam	Sandy loam	Sandy loam
Organic Carbon (%)	1.19	1.56	1.21
Total Nitrogen (%)	0.10	0.12	0.11
Available Phosphorus(mg/kg)	24.7	22.5	24.4
Exchangeable Potassium(cmol/kg)	0.46	0.42	0.28
Exchangeable Calcium(cmol/kg)	15.06	14.90	15.11
Exchangeable Magnesium(cmol/kg)	2.81	2.61	2.31
Exchangeable Sodium(cmol/kg)	0.72	0.65	0.64

The N contents of the cashew leaves for small, medium and large biotypes before flowering were adequate and above the foliar critical range for cashew (Egbe *et al*., 1989) which was similar to adequacy of soil N, P and K contents obtained before flowering. Ghosh and Bose (1986) reported that leaf N of 1.51% was optimum for high nuts yield and N content range of 2.4-2.58% indicated sufficient N and 0.98-1.38 % showed N defficiency (Haag et al., 1975). Similarly, Aikpokpodion et al., 2009 reported P range of 0.1-0.7%, this is also similar to results obtained by (Kumar et al., 1982) 0.06-0.18% and 0.08-1.35% obtained in this work. However, the N leaf contents declined during flowering and fruiting below the critical value (Table 2). Similarly, the P contents of the leaves were adequate before flowering but the values decreased for all biotypes during flowering and fruiting. Of all the macronutrients examined in the cashew leaves, the reduction of N and P during flowering and fruiting were more pronounced and this might be due to the need for more of N and P in flowers and fruits production in cashew. This implied that N and P are needed more during flowering and fruit formation for increase in yield. Gawankar et.al (2010) reported significantly higher number of flowers and nut yield of cashew over the control when urea (2%) foliar spray was applied on 10-year-old cashew plants. Cashew flowering is always preceded by new leaf and shoot (ie cashew flowers on the current season's growth) and nitrogen in particular as well as phosphorus will be required for new shoot growth (Mclaughlin et.al 2020). Therefore, adequate supply of nitrogen and phosphorus through organic or inorganic fertilizer source is essential before flowering for optimum flower and fruit formation which will ultimately enhance cashew nut yield.

Table 2: Macro Nutrient Contents of Cashew leaves of various biotypes at different reproductive stages

Reproductive stages	Cashew Biotype	Macro Nutrient Contents (%)				
		N	P	K	Ca	Mg
Before Flowering(BF)	Small	0.81	0.105	1.148	0.131	0.144
	Medium	1.06	0.128	1.175	0.216	0.168
	Large	1.03	0.135	1.227	0.221	0.173
During Flowering(DF)	Small	0.01	0.085	1.070	0.221	0.119
	Medium	0.02	0.089	1.175	0.250	0.182
	Large	0.64	0.092	1.070	0.263	0.163
During Fruiting(DFT)	Small	0.14	0.018	1.305	0.287	0.203
	Medium	0.60	0.099	1.096	0.281	0.166
	Large	0.31	0.094	1.357	0.230	0.119
After Fruiting(AFT)	Small	0.04	0.098	1.279	0.262	0.157
	Medium	1.69	0.116	1.148	0.320	0.247
	Large	1.25	0.078	1.044	0.210	0.087

The average number and weight of cashew nuts obtained for the different biotypes is shown in Table 3. The number of medium nuts was significantly higher than small and large nuts. However, small and large cashew biotypes were not significantly different in terms of nut count. Considering the weight of cashew nuts, medium and large nuts were not significantly different. Weight is normally considered by cashew buyers hence cultivation of cashew biotypes with large and medium nut sizes is recommended for higher nut yield.

Table 3: Average Nuts Yield from Three Cashew Biotypes

Biotype	Nut Counts		Nut Weight	
	Number/tree	Number/ha	(kg/tree)	(kg/ha)
Small	205b	56,990b	0.83b	147.74b
Medium	649a	180,422a	3.40a	945.2a
Large	252b	70,056b	3.05a	847.9a

Means with same alphabets on the same column are not significantly different

CONCLUSION

Adequate supply of nitrogen and phosphorous is essential for efficient flowering and fruiting in cashew production. It is therefore recommended that farmers should apply fertilizers that are rich in nitrogen and phosphorus before the flowering stages to enhance cashew productivity. Cultivation of cashew nut types with large and medium nut sizes is also recommended for farmers for higher nut yield.

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RESPONSE OF WATERMELON (*CITRULLUS LANATUS*) TO PLANTING DENSITY AND FERTILIZER TYPE IN SUDAN SAVANNA ECOLOGICAL ZONE OF KEBBI STATE

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ABSTRACT

Field experiments were conducted at Teaching and Research Farm of the Kebbi State University of Science and Technology (KSUSTA) Aliero located in Jega (lat. 12°12.99' N; long. 4° 21.90'E; Alt 197m) during 2019 and 2020 dry seasons. The aim of the experiment was to study the response of Watermelon (Citrullus lanatus) to planting density and fertilizer type. Treatments consisted of five (5) plant population densities 40,000, 26,667, 20,000, 17,778 and 13,333 plants/ha and two (2) fertilizer application (cow dung and NPK) plus the untreated control; each fertilizer type is designed to supply the recommended nitrogen dose of 120kg N ha^{-1}. Treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Results revealed that vine length, number of leaves, crop growth rate, number of fruits per plant, fruits weight per plant and fresh fruit yield were higher with planting density of 40,000 pha^{-1} when combined with the application of NPK fertilizer. Based on the results, it could be concluded that, planting density of 40,000 pha^{-1} recorded the higher yield and NPK mineral fertilizer have relatively the superior performance on growth and yield of Watermelon.

Key words: Watermelon, Cow dung, NPK, Panting density, Fertilizer type, Growth, Yield

INTRODUCTION

Watermelon (*Citrullus lanatus*), a member of the Cucurbitaceae family, is widely cultivated for its fruit and vegetative parts (Schippers, 2002). The fruit is an important source of carotenoids and a precursor of vitamin A (Setiawan *et al*., 2001). According to National Watermelon Promotion Board (2008), It ranks among the top five most frequently purchased and cultivated fruits globally with a per capita annual consumption of 7 kg (NWPB, 2008). The fruit can be served fresh in fruit salads, cooked and used as confectionary, and is becoming an everyday fruit like bananas, apples, and oranges. Its seed is also considered an important dietary item and contains a high amount of minerals and other nutrients (Oyenuga and Fetuga, 1975). Its centre of origin has been traced to both the Kalahari and Sahara deserts in African (Janet *et al*., 1996) and these areas have been regarded as point of diversification to other part of the world (Schipper, 2002). In Nigeria, though there are no official figures recorded for the production, the crop has a wide distribution as a garden crop, while as a commercial vegetable production. It cultivation is confined to drier savanna region of Nigeria (Anon, 2006).

Plant spacing is an important agronomic attribute, since it is believed to have effects on light interception which affects the photosynthetic process. In watermelon, increasing planting density decreases the number of fruits per plant, but individual fruit size is mostly unaffected (Duthie *et al*., 1999). Also, it affects the photosphere and rhizosphere exploitation by the plants especially when spacing is inadequate and the plants suffer from clustering together (Talukder *et al*., 2003). The use of spacing in crop production is very important and good because it reduces competition between plants and weeds. When adequate spacing is done in plant production, it increases crop growth and yield. Generally, in Watermelon, the yield and number of fruits per unit area increased with increased crop density, whereas the yield and number of fruits per plant decreased. High planting density increased the number of fruits per area (NeSmith, 1993). However, some studies showed that average weight of fruits decreases with increase in plant density (Motsenbocker and Arancibia, 2002).

On the other hand, Fruits and vegetables production cuts across Nigeria's geo-political zones and generates income to the farmers. Low soil fertility has been recognized as a major and general problem of crop production in the Savannah areas of Nigeria (Saidu *et al*., 2011). This type of problem is solved through the use of either organic or inorganic fertilizer. Generally, excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield and maximum value of growth (Dauda *et al*., 2008). However, the use of inorganic fertilizers alone may cause problems for human health and the environment (Aisha *et al*., 2007). So also, the use of inorganic fertilizer by resource-poor farmers is limited by its scarcity, cost and untimely availability. Cultivation with persistent application of inorganic fertilizers increases soil acidity and soil physical degradation which may reduce crop yield (Saidu *et al*., 2011). On the other hand, organic manure can serve as alternative practice to inorganic fertilizers for improving soil productivity (Sarkar *et al*., 2003). The use of organic manure also has their limitations including high risk of infection, high cost of transportation and labour on account of its bulkiness as well as a slow release of nutrients for plant uptake (Adekiya *et al*., 2012). The aim of this study was to evaluate selected planting densities and their responses to different soil fertility sources in the study area.

MATERIALS AND METHODS

The experiment was conducted in Teaching and Research Farm of the Kebbi State University of Science and Technology (KSUSTA) Aliero located in Jega (lat. 12°12.99' N; long. 4° 21.90'E; Alt 197m) during 2019/20 and 2020/21 dry seasons. The area has a long dry season that is characterized by cool dry air (Harmattan) that prevails from November to February; and hot dry air extending from March to May. The locations were used for cultivation of vegetable and cereal crops. The treatments consisted of five (5) plant population densities 40,000, 26,667, 20,000, 17,778 and 13,333 plants/ha and two fertilizer application (cow dung and NPK) plus the untreated control. The land was ploughed and harrowed to a good tilt. Water channels were constructed to facilitate free and efficient irrigation. Plot size was 5m x 3m (15m^2). A space of 1.0m between the plots, and 1.5m between replicates will also be use as borders. Tube well was used as the source of water where water pump machine was used to draw water, with aid of delivery hoses, to the experimental plots. Irrigation was done at 3-5days' interval depending on the crop's need. Weeds were controlled manually using hand hoe at 3 and 6 weeks after sowing (WAS). Watermelon fruits were harvested before they were fully mature and was staggered at 3-4 days over 3weeks. Data were collected on Vine Length (cm), Number of Leaves, Shoot Dry Weight, Number of fruits per plant, Fruits weight per plant and Yield (t ha^{-1}). Data generated were analyzed following analysis of variance procedure, and treatment means were separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Soil Physical and Chemical Properties of Experimental Site: Physical and chemical properties of soils of study location prior to the experiments are presented in Table 1.

Table 1: Physical and chemical properties of experimental sites soil during 2019/2020 dry session

	2019	2020
0–30cm depth		
Particles size Analysis		
pH	6.60	6.11
Organic Carbon %	1.04	0.87
Organic Matter %	1.79	2.01
Total N %	0.084	0.093
P mg/kg	0.93	1.05
Ca (Cmol/kg)	0.50	0.78
Na Cmol/kg	0.52	0.62
Mg Cmol/kg	0.80	0.74
K Cmol/kg	1.95	2.56
CEC Cmol/kg	8.40	8.94
Sand %	63.3	61.7
Silt %	24.9	28.2
Clay %	11.8	10.1

Chemical composition of cow dung and poultry manure

Chemical compositions of manures prior to the experiments are presented in Table 2.

Table 2: Chemical Composition of cow dung (CD) and poultry manure (PM)

Parameters	Cow dung	
	2019	2020
O. C (g kg^{-1})	4.13	4.09
P^H	7.60	7.20
T. N(mg kg^{-1})	1.02	1.08
Na (mg kg^{-1})	155	175

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K (mg kg^{-1})	3800	3650
Ca (mg kg^{-1})	0.85	0.96
P (mg kg^{-1})	4.51	4.34

Response of Plant Density on the Growth and Yield of Watermelon

Vine length, Number of leaves and Shoot dry weight of Watermelon as affected by Planting Density during 2019/2020 dry season are presented in Table 3. Greater vine length and shoot dry weight was recorded by Planting density of 13,333 pha^{-1}. The influence of planting density in this study showed that vine length and shoot dry weight increased significantly as planting decreases. Decrease in plant density, increased the vine length and shoot dry weight which is a known vegetative components of watermelon which could be attributed to wide variability in crop performance caused by planting density as reported by Dantata (2008). Number of leaves was similar irrespective of planting density during 2019 dry trial but planting density of 13,333 pha^{-1} recorded the higher number leaves. This behavioural pattern of response in leaves number exhibited by watermelon in this study, agrees with the findings of Davis *et al.* (2008) who reported various differential growth behaviour among watermelons. The authors' report on the fact that growth of watermelon varied according to year has also found expression in the current study. Number of fruits per plant, Fruits weight per plant and Fruit yield of Watermelon as affected by Planting Density during 2019/2020 dry season are presented in Table 4 Higher number of fruits and fruit yield was recorded by planting density of 40,000 pha^{-1}. This result was in agreement with those reported by Maynard and Scott (1998) who stated that in the wider spaced plants, the area allotted for development of the single plant is larger and hence provide a possibility for more lush growth and development of fruit bearing branches. For high densities, plants compete with each other for nutrients, water and light and, therefore, develop less fruiting branches.

Response of Fertilizer on the Growth and Yield of Watermelon

Vine length, Number of leaves and Shoot dry weight of Watermelon as affected by Fertilizer type during 2019/2020 dry season are presented in Table 3. Greater Vine length, Number of leaves and Shoot dry weight were recorded by the application of NPK fertilizer followed by the application Cow dung while the lowest data were recorded by the untreated control. This could be attributed to the role of applied NPK in enhancing production of assimilates during growth and consequent partitioning of these assimilates to fruits which enhanced vegetative growth. Similar result was reported by Bairwa *et al.* (2009).

Number of fruits per plant, Fruits weight per plant and Fruit yield of Watermelon as affected by Fertilizer type during 2019/2020 dry season are presented in Table 4. Greater Number of fruits per plant, Fruits weight per plant and Fruit yield was obtained from the application of NPK fertilizer This could be attributed to the significant role played by NPK in the improvement of soil fertility, nutrient uptake and enhancement of crop yields. NPK fertilizers have been reported to cause significant effects on fruit weight, fruit number and fruit yield (Sarkar *et al*., 2003).

Interaction

The significant interaction between planting density and fertilizer type on Fruit yield (Table 5). Have clearly indicated the interdependence and complimentary role of planting density and fertilizer type in influencing the manifestation of the potentials of watermelon in terms of growth, development and yield as reported by Motsenbocker and Arancibia (2002).

Table 3. Vine Length, Number of leaves and Shoot dry weight of Watermelon as influenced by Planting Density and Fertilizer Type at Aliero and Jega during 2019/2020 dry season

Treatment	Vine Length (cm)		Number of Leaves		Shoot Dry Weight	
	2019 Dry season 8WAP	2020 Dry season 8WAP	2019 Dry season 8WAP	2020 Dry season 8WAP	2019 Dry season 10WAP	2020 Dry season 10WAP
Planting Density (P)						
P1(40,000 pha^{-1})	89.93ab	74.77	9.42a	13.11a	16.28ab	25.65b
P2(26,667 pha^{-1})	77.33b	72.33b	9.35a	13.61a	14.37b	25.90b
P3(20,000 pha^{-1})	96.46ab	78.13b	9.37a	13.08a	14.60b	36.40ab

P4(17,778 ha^{-1})	95.11ab	71.71b	8.88a	13.73a	13.37b	26.03b
P5(13,333 ha^{-1})	102.22a	98.64a	10.35a	14.02a	18.55a	40.17a
SE±	**6.949**	**6.482**	**0.876**	**1.219**	**1.791**	**5.683**
Manure (M)						
CD	90.06b	81.32b	8.78b	10.45b	17.64a	29.90b
NPK	112.53a	92.44a	11.16a	14.02a	20.38a	35.99a
Control	57.44c	68.00b	5.49c	5.06c	11.40b	23.60c
SE±	**5.383**	**5.021**	**0.678**	**0.944**	**1.387**	**4.402**
Interaction						
P x M	NS	NS	NS	NS	NS	NS

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level of significance using DMRT, NS: not significant at 5% level of significance, *: significant at 5% level of significance.

Table 4. Number of fruits per plant, Fruits weight per plant and Yield of Watermelon as influenced by Planting Density and Fertilizer Type at Aliero and Jega during 2019/2020 dry season

Treatment	**Number of fruits per plant**		**Fruits weight per plant**		**Yield (t ha^{-1})**	
	2019 Dry season	**2020 Dry season**	**2019 Dry season**	**2020 Dry season**	**2019 Dry season**	**2020 Dry season**
Planting Density (P)						
P1(40,000 ha^{-1})	4.33a	3.02a	3.01ab	2.01b	19.48a	17.19a
P2(26,667 ha^{-1})	3.02ab	2.00ab	2.64c	1.64bc	9.75b	8.67bc
P3(20,000 ha^{-1})	3.20ab	2.21ab	3.18ab	2.08b	9.45b	9.12b
P4(17,778 ha^{-1})	3.06ab	1.93b	2.98b	1.98bc	6.44c	6.79bc
P5(13,333 ha^{-1})	3.40ab	2.08ab	3.94a	3.44a	5.52c	4.84c
SE±	**0.2038**	**0.133**	**0.108**	**0.129**	**0.935**	**1.311**
Manure (M)						
CD	3.97b	1.78b	2.68b	1.68b	8.84b	9.85b
NPK	5.16a	2.59a	3.79a	2.51a	13.84a	11.88a
Control	1.48c	0.77c	0.93c	0.88c	3.70c	2.24c
SE±	**0.157**	**0.103**	**0.083**	**0.100**	**0.724**	**1.016**
Interaction						
P x M	NS	NS	NS	NS	*	*

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level of significance using DMRT, NS: not significant at 5% level of significance, *: significant at 5% level of significance.

Table 5. Interaction of Plant density and Fertilizer type on yield (t ha^{-1}) in Aliero and Jega location during 2019/2020 dry season

Planting density	**Manure**		
	CD	**NPK**	**control**
		2019	
P1(40,000 ha^{-1})	9.26d	17.40a	7.31e
P2(26,667 ha^{-1})	14.45b	9.88d	8.01de
P3(20,000 ha^{-1})	14.18b	8.51de	10.67c
P4(17,778 ha^{-1})	11.31c	10.60c	6.41ef
P5(13,333 ha^{-1})	9.64d	6.10ef	4.10f
SE±		1.621	
		2020	
P1(40,000 ha^{-1})	11.66b	15.91a	6.82e
P2(26,667 ha^{-1})	9.12c	12.01b	6.99e
P3(20,000 ha^{-1})	9.33c	11.56b	6.46e
P4(17,778 ha^{-1})	8.65cd	4.89f	4.82f
P5(13,333 ha^{-1})	7.47d	8.93cd	6.11e
SE±		2.272	

Means followed by the same later (s) are not significantly different at 5% level using DMRT

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CONCLUSION

Based on the results, it could be concluded that, planting density of 40,000 pha^{-1} recorded the higher yield and NPK mineral fertilizer have relatively the superior performance on growth and yield of Watermelon.

RECOMMENDATION

From the findings of this study, the following recommendations could be made:

1. Planting density of 40,000 pha^{-1} could be adopted for higher Cucumber fruit yield in the study area.

2. Application of NPK fertilizer could also be considered since it recorded superior performance among the fertilizer types tested in the study area.

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FRUIT QUALITY OF MUSK MELON AS INFLUENCED BY POULTRY MANURE AND INTRA ROW SPACING

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ABSTRACT

Musk melons (Cucumis melo) are fruits which are rich in nutrients especially vitamins and minerals. They can be used for weight loss, healthy skin and heart, improved immunity and eye vision. They are particularly rich in vitamins A and C. In order to determine the effect of poultry manure and intra row spacing on the percentage brix, Vitamin A and Vitamin C contents of musk melon field trial was carried out at Samaru, in the Northern Guinea Savanna of Nigeria during the 2019 rainy season. The treatments consisted of four poultry manure rates (0, 3.5, 7 and 10 t ha^{-1}) and three intra row spacing of 30, 50 and 70 cm with an inter row spacing of 75 cm. The treatments were factorially combined, laid out in a randomized complete block design and replicated three times. The variety used was a local one named X- Jaja. Three fruits were collected as per treatment from the net plots for yield and nutrient analysis. The sugar content (% brix) was determined using a Refractometer while the vitamin A and C contents of the musk melon were determined in the analytical laboratory using a UV Spectrophotometer 2550 model. The data were recorded for each treatment with the average computed and then subjected to analysis of variance and treatment means were separated using the New Duncan multiple range test. The results show that application 3.5 t ha^{-1} of poultry manure significantly produced the highest percentage brix, Vitamin A and C. The vitamin A and C values obtained were observed to be significantly higher with 70 and 50 cm intra row spacing respectively. However, spacing at the different levels used in the trial did not significantly influence the percentage brix. Based on the result of this trial, it can be concluded that application of 3.5 t ha^{-1} of poultry manure with 50 cm spacing gave the optimum amounts of sugars, vitamin A and C in musk melons production at Samaru.

Key words: Muskmelon, Poultry Manure, Brix, Vitamins

INTRODUCTION

Musk melon (*Cucumis melon* L.) belongs to the family Cucurbitaceae. It is a specie of melon that has been developed into many cultivated varieties. These include smoothly skinned varieties such as honey dew, Crenshaw and Casaba and different netted cultivars (Cantaloupe, Persian melon and Santa class melon). Musk melon is grown commercially to a limited extent in several countries of Europe, Asia, Africa, South and Central America. The United States leads in commercial production (Kroll, 2013). However, the crop is gaining recognition in drier savannah part of Nigeria such as kano, katsina, Jigawa, Gombe and Borno states.

When ripe, musk melon can be eaten raw as snacks, a fruit side dish or tossed with other fruits in a salad. Musk melon is featured in several beverages especially in India, where pureed musk melon and water are combined in a simple drink and touted for its numerous health benefits. Pureed musk melon is also used to flavour sorbets and ice cream. In China, Japan and Korea, Kwaci and Kwatji, (dried salted melon seeds) are sold as snacks. The seeds also are sometimes pressed to produce melon oil and or ground into powder and taken as a natural remedy for certain ailments. Strips of musk melon flesh are dried for fruit leather. Fewer dishes call for cooked musk melon, but winter melon varieties with Crips cucumber or squash like flavours, are used in stews and curries or stir fried with vegetables or other fruits. Sweeter musk melon types can be blended in to jam (Kroll, 2013). Muskmelon is rich in nutrients and can be used for weight loss, healthy skin, healthy heart, improved immunity and eye vision. It helps to cure kidney stone and prevents complications or problems during pregnancy. It also eases menstrual cramps. Per 100 gram serving, cantaloupe melons provide 34 calories and are a rich source (20% or more the Daily Value, DV) of vitamin A (68% DV) and vitamin C (61% DV), with other nutrients at a negligible level.

In spite of the increasing relevance of muskmelon in Nigeria, low yields are obtained in farmers' fields because of declining soil fertility due to continuous cropping and disregard for soil amendment materials Adekiya and Ojeniyi, (2002). Application of poultry manure is one of the ways of improving soil fertility which is cheap than inorganic fertilizer and effective in supplying nutrient for crop growth and also essential for establishing and maintaining the optimum soil physical conditions by reducing soil temperature, bulk density and increasing the total porosity for plant growth and yield (Enujeke *et al.*, 2013).

Plant spacing helps to ensure that each crop has an equal chance to grow and also to simplify execution of field operations. The rate at which field operations are carried out, weed-crop competition and yield are influenced by the spatial arrangement on the field (Celac, 2011). Despite the importance of musk melon its production and productivity is low in Nigeria and this can be improved by determining the appropriate spacing and optimum use of organic manure as part of good cultural practices. To satisfy the ever increasing need for the production of Musk melon for the Nigerian populace, there is need for extensive research to be carried out so as to maximize farmers' yields by varying the application rate of poultry manure and plant spacing for the production of Musk melon in Samaru Zaria and its environment.

MATERIALS AND METHODS

The experiment was conducted at the Horticultural garden of the Institute for Agricultural Research (I A R), Samaru (Lat. 11º17'N Long. 09º38'E and 686m above sea level), in Northern Guinea Savannah ecological Zone of Nigeria, during the 2019 wet season. The treatments consisted of four poultry manure rates (0, 3.5, 7 and 10 t ha^{-1}) and three spacing rates (75$cm \ x \ 30cm$, 75$cm \ x \ 50,$ 75cm x 70cm). The treatments were laid out in a randomized complete block design (RCBD) and replicated three times. The variety used was collected from local farmers in Jaja village, Kudan local government of Kaduna states. It has a maturity period of 80 days with potential yield of 10 t ha^{-1} and becomes yellow in colour when mature. The poultry manure was collected from Animal Science farm IAR/ABU and was analysed to test for the macro nutrients which was 16.95g/kg N, 5.89g/kg $P_2 0_5$, 4.15g/kg K_20. Soil sample of the experimental site was taken randomly at various locations at the depth of 30 cm using soil auger. The sample was bulked to form a composite sample mixture, air dried and thoroughly mixed, then ground and sieved with 2mm mesh before laboratory analysis for its physical and chemical properties. The field which is 0.15 hectare was harrowed and ridged at 75cm apart and then divided in to plot according to the treatments. The gross plots consisted of 3 m length and 3 m width while the net plot consisted of two inner ridges of 3 $x \ 1.5m$. Seeds were sown on the 10th June, 2019 at different spacing rate of 75 x 30cm, 75 $x \ 50cm,$ 75 x 70cm inter and intra row three seeds were sown which was later thinned to two plants per stand at 2WAS. Poultry manure was applied and incorporated in to the ridges by opening the crest and burying the manure as per treatment (0, 3.5, 7, 10 t ha^{-1}) two weeks before sowing. Weeds were controlled manually by hoe weeding at 3 and 6 WAS. Cypermethrin was applied against the incidence of insect pests at the rate of 4 L ha^{-1}, at one-week interval when the crop started flowering. There was no disease incidence noticed during the course of the experiment.

Harvesting was done by hand picking when the fruits attained physiological maturity (when the fruits turn from green to yellow colour). Data was collected from the 3 tagged plants in the net plot. The sugar content of the crop was determined using refracto meter and the average was recorded. The vitamin A and C content of the muskmelon were determined using UV-spectrophotometer 2550 model to test the vitamin A and C content of the fruit. The data collected were subjected to statistical analysis of variance (ANOVA) as described by Little and Hills (1978). The treatment means were separated using New Duncan Multiple Range Test (DMRT), (Duncan, 1995).

RESULTS AND DISCUSSION

The effect of poultry manure and intra row spacing on brix percentage of musk melon is presented in Table 1. The result showed that, application 3.5 t ha^{-1} of poultry manure significantly gave the highest percentage brix while the control rate gave the least. However, application of 10 t ha^{-1} gave comparable sugar content with the application of 3.5 and 7 t ha^{-1}. There were no significant differences in the percentage brix of musk melon with the different intra row spacing. However significant interaction of poultry manure and plant spacing on percentage Brix of musk melon was observed as shown in Table 2. The results show that combination of poultry manure and 50 percentage intra row spacing gave the least percentage brix while the combination of 3.5 t ha^{-1} of poultry manure with 50cm or 70cm significantly produced the highest percentage brix. Similarly, Table1 shows the effect of poultry manure and intra row spacing on the vitamin A content of musk melon. Application of poultry manure significantly influence the vitamin A content of musk melon.

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Where there was corresponding decrease in vitamin A content when poultry manure was increase from 3.5 to 10 t ha^{-1} while the control gave the least amount of vitamin A. significant respond was obtained with intra row spacing on the vitamin A content of musk melon where increasing the intra row spacing from 30 to 70cm increase the vitamin A content of musk melon. There was no significant interaction observed between the factors on the vitamin A content.

Table 1: The effect of poultry manure and intra row spacing on the percentage brix, vitamin A and C of musk melon at Samaru

Treatment	Brix (%)	Vitamin A (mg l^{-1})	Vitamin C (mg l^{-1})	Yield (kg ha^{-1})
Poultry manure (P) t ha^{-1}				
0	4.29c	1.15d	0.24b	1252
3.5	7.71a	1.73a	0.26a	6914
7.0	6.49b	1.55b	0.19c	6025
10.0	6.80ab	1.32c	0.17d	5037
SE ±	0.340	9.724	0.585	
Spacing (S) cm				
30	6.05	1.37c	0.19c	5500b
50	6.44	1.45b	0.25a	9944a
70	6.46	1.48a	0.21b	5574b
SE±	0.290	8.421	0.506	2370.3
Interaction				
P X S	*	NS	NS	NS

Means followed by the same letter(s) in a column are not significantly different from each other using Duncan Multiple Range Test (DMRT). * : Significant at 0.05; ** : Highly Significant at 0.01; NS : Not Significant

The effect of poultry manure and intra row spacing on vitamin C content of musk melon is presented in Table2. Significant differences where observed on the vitamin C content when poultry manure was applied. Increasing poultry manure from 0 to 3.5 t ha^{-1} significantly increase the vitamin C content however further increase from 3.5 to 10 t ha^{-1} significantly reduce the vitamin C content. Significant response was recorded with intra row spacing. Increasing the intra row spacing from 30 to 50cm significantly increase the vitamin C content however further increase to 70cm significantly decrease the vitamin C content. There was no significant interaction between the factors on the vitamin C content. The fruit yield and quality of musk melon increased significantly with the application of poultry manure when compared to the control. This could be due to the fact that more nutrients were made available to the plants when the organic manure was applied. Similar results were reported by (Dunsin *et al*., 2019, Antonios *et al*., 2019 and Hassan *et al*., 2012). The Vitamins A, C and fruit yield which was significantly increased with increased spacing could be due to reduced competition among plants as a result of wider spacing and available nutrients.

Table 2: Interaction of poultry manure and intra row spacing on percentage brix of musk melon at Samaru.

	Poultry manure (t ha^{-1})			
Spacing (cm)	**0**	**3.5**	**7.0**	**10.0**
30	4.36i	7.90a	6.36g	7.13e
50	4.10j	7.96a	7.30b	6.50f
70	4.40i	7.26c	5.80h	6.76e
SE ±	0.085			

Means followed by the same letter(s) within a treatment group are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT).

CONCLUSION

Based on the result of this trial, it can be concluded sthat application of 3.5 t ha^{-1} of poultry manure with 50 cm spacing gave the optimum amounts of sugars, vitamin A and C in musk melons production at Samaru.

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PRODUCTIVITY OF ONION (*ALLIUM CEPA* L.) AS INFLUENCED BY POULTRY MANURE APPLICATION AND INTRA ROW SPACING AT SAMARU NORTHERN GUINEA SAVANNA

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ABSTRACT

The productivity of onion in Nigeria despite being a crop of commercial crop is adversely affected partly by poor agronomic practices of farmers some of which include suboptimal nutrient application and plant population per unit area. In order to overcome the challenge and meet demand, a trial was carried out in 2018 at the Institute for Agricultural Research Orchard to determine the effect of Poultry manure and intra row spacing on the productivity of onion in Samaru located at the Northern Guinea Savanna of Nigeria. Treatments consisted of four poultry manure rates (0, 1.5, 3 and 4.5 tha^{-1}) and intra row spacing (15, 20 and 25cm) laid out in a randomized complete block design with three replications. Data were collected on plant height, crop growth rate, bulb diameter and bulb yield. Results showed significant increases with poultry manure application except on bulb diameter while varying the intra row spacing had no significant effect on the parameters taken. Highest yield (6tha^{-1}) was recorded at 4.5tha^{-1} of poultry manure and could therefore be adopted for onion production using 20 cm intra row spacing in the Northern Guinea Savanna of Nigeria.

INTRODUCTION

Onion is a vegetable crop of the family Allium which are known for their characteristic pungent flavours and medicinal properties. It can be consumed raw or used as spices in various local delicacies and soups. The crop is rich in nutrients (Vitamin C 9%, Vitamin B6 9%, Mg 3%, Ca 2%, Fe2% etc.), helps reduce risk from cancers and lower blood pressure (Anon, 2021a). Nigeria is one of the largest producers of onions in the world with over 2million tonnes annually bulk of which are cultivated in the northern part with the red type being the most commonly cultivated for commercial purposes (Anon, 2021b). There is a high demand for onion in Nigeria which farmers are often not able to meet often due to poor agronomic such as suboptimal nutrient application and plant population among others. Nitrogen, Phosphorus and Potassium are some of the critical nutrients required by onion as nitrogen and potassium enhance strong and early growth while phosphorus enhances root development (Anon, 2021a). Supply of these nutrients is therefore needful for good growth, development and high yields. These nutrients can be supplied through the application of which in addition to nutrient supply serve as soil amendment. Additionally, manures pose very little to man and his environment compared to synthetic or chemical fertilizers. Failure of farmers to plant at optimum intra row spacing further reduces plant population and consequently total yield and supply as such demands not met. A trial was therefore conducted to determine the effect of poultry manure and intra row spacing on onion in Samaru Northern Guinea Savanna.

MATERIALS AND METHODS

The trial was carried out at the orchard of the institute for Agricultural Research, Ahmadu Bello University Zaria in the Northern Guinea Savanna. Treatments consisted of four poultry manure rates (0, 1.5, 3 and 4.5tha-1) and three intra row spacing (15, 20 and 25cm) laid out in a randomized complete block design with three replications. Seeds (red creole) were broadcasted in the nursery on the 18th January, 2018 and mulched with dry straw for 10 days after which it was removed to enhance sunlight uptake and hardening of seedlings. Transplanting of the seedlings was done on the 18th March when the seedlings were 8weeks old. Poultry manure was incorporated two (2) weeks prior to transplanting. Transplanting and manure incorporation was done according to the treatments. Data was collected on plant height and crop growth rate at 6 and 9 weeks after transplanting (WAT), bulb diameter and bulb yield at harvest. Data collected was subjected to analysis of variance as described by Snedecor and Cochran (1967), using the general linear model (GLM) procedure of the statistical analysis system (SAS) package (SAS, 1990) version 9.1. Treatment means were separated using Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

The result of soil analysis of the experimental site (Table 1) showed that the soil was loam, moderately acidic, had low nitrogen, phosphorus and potassium. The organic matter content was also moderate. Poor nutrient status of the soil could be due to continuous cultivation and the addition of fertilizers rather results in further soil degradation which might have been the reason for the moderate acidity recorded. This is in agreement with Belay, 2015 who stated that loss in soil fertility is aggravated by continuous cultivation which leads to nutrient mining of the soils.

Results of poultry manure analysis (Table 2) also showed that the total nitrogen (1.57%), phosphorus (0.27) and potassium (0.11) content of the manure were low.

Table 3 showed significant increases in plant height and crop growth rate (CGR) with poultry manure application. Results on plant height showed that at 6WAT, poultry manure application up to 3tha^{-1} increased height of onion beyond which similar increases were recorded. At 9WAT however, poultry manure application increased height of onion up to 4.5tha^{-1} manure applied. Similarly, the CGR at 6WAT showed that at 4.5tha^{-1} poultry manure, CGR was higher than the control but comparable to 1.5 and 3tha^{-1}. At 9WAT however, application of 3.0tha^{-1} and 4.5tha^{-1} poultry manure significantly increased CGR than the control but comparable to 1.5tha^{-1}. The bulb diameter and yield of onion is shown on table 4. Results showed that bulb diameter was not significantly affected by both poultry manure application and varying of intra row spacing. However, yield was significantly affected by poultry manure only where increase in poultry manure rates applied resulted in significant increase in yield up to the highest manure rate (4.5tha^{-1}). The increases due to poultry manure application could be attributed to nutrients supplied by the manure especially as the fertility status of the soil of the experimental site was poor. Ehizogie 2018 recorded similar results where onion yield among other parameters increased with poultry manure application when compared with the control. Additionally, poultry manure improves soil organic matter content which consequently affect aggregate stability thereby improving aeration, buffering of soil reaction, water holding capacity, cation exchange capacity and microbial activity thus resulting in the positive responses observed with poultry manure application Adeyemo *et al.,* 2019.

Table 1: Physical and chemical properties of the soil of the experimental site

Particle size distribution (gkg^{-1})	**0-15cm**
Sand	430
Silt	459
Clay	111
Textural class	Loam
Chemical properties	
pH in H_2O	6.31
pH in0.01m $CaCl_2$ (1:2:5)	5.78
Organic carbon (gkg^{-1})	12.65
Nitrogen(gkg^{-1})	0.62
Available P (mgkg^{-1})	9.25
Exchangeable cations cmolkg^{-1}	
Ca	3.21
Mg	0.42
K	0.11
Na	0.14
Al^{+++}+H^+	0.22
CEC	4.10

Analysed at the analytical laboratory of the Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria.

Table 2: Nutrient content of poultry manure applied

Nutrients (%)	
Nitrogen	1.57
Phosphorus	0.27
Potassium	1.12

Analysed at the analytical laboratory of the Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria.

Table 3: Effect of poultry manure and intra row spacing on the height and crop growth rate of onion at Samaru in 2018

Treatments	**Height (cm)**		**Crop Growth Rate (gwk^{-1})**	
Poultry manure (P) (tha^{-1})	**6WAT**	**9WAT**	**6WAT**	**9WAT**
0	10.9c	12.1c	0.35b	0.49b
1.5	13.7b	16.5b	0.39ab	0.72ab
3	14.81b	18.8	0.66ab	1.21a

4.5	16.7a	21.9a	0.79a	1.28a
SE±	0.84	1.02	0.14	0.23
Intra row spacing (I) (cm)				
15	13.7	16.8	0.62	0.72
20	14.9	16.6	0.57	1.05
25	13.6	18.5	0.46	1.01
SE±	0.73	0.89	0.12	0.20
Interaction				
P*I	NS	NS	NS	NS

Means followed by the same letter(s) within the each column are not significantly different at 5% level of probability using DMRT.

Table 3: Effect of poultry manure and intra row spacing on the bulb diameter and yield of onion at Samaru in 2018

Treatments		
Poultry manure (P) (tha^{-1})	**Bulb Diameter/ plant (cm)**	**Bulb Yield (tha^{-1})**
0	2.5	1.9c
1.5	2.7	2.4bc
3	4.9	3.3b
4.5	3.9	6.0as
SE±	0.87	4.00
Intra row spacing (I) (cm)		
15	3.0	3.5
20	4.2	3.5
25	3.3	3.3
SE±	0.76	3.50
Interaction		
P*I	NS	NS

Means followed by the same letter(s) within the each column are not significantly different at 5% level of probability using DMRT.

CONCLUSION

Based on the result of the trial it can be concluded that 4.5tha^{-1} of poultry manure and 20cm intra row spacing could therefore be adopted for onion production in the Northern Guinea Savanna of the Nigeria.

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GROWTH AND YIELD OF BIRD'S EYE CHILLI PEPPER (*CAPSICUM FRUTESCENS* L) AS AFFECTED BY INTRA ROW SPACING AND NPK FERTILIZER IN THE NORTHERN GUINEA AND SUDAN SAVANNAH OF NIGERIA

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ABSTRACT

Field trials were conducted to determine the effect of intra row spacing and NPK fertilizer on the growth and yield of Bird's eye chilli pepper (Capsicum frutescens L.). The trials were carried out during the 2017 wet season at the Institute for Agricultural Research farm Samaru, ($11^{0}11^{1}$N;$07^{0}38^{1}$E and 686m attitude), Kaduna State and at IRS/ IAR Kadawa Station ($11^{0}39^{1}$N;$08^{0}02^{1}$E and 500m attitude), Kano State. The treatments evaluated were three intra row spacings (20 cm, 30 cm and 40 cm) and four levels of NPK 20:10:10 (0, 300, 600 and 900kgNPKha^{-1}) which were factorially combined and laid out in a randomized complete block design (RCBD) and replicated three times. Data were collected on growth, yield and yield components. Plant height, CGR and RGR were not significantly affected by intra row spacing but were significant on NAR, fresh fruit weight per plant and fresh fruit yield per hectare. Application of NPK fertilizer significantly increases only the fruit yield per plant and fruit yield per hectare. Significant interaction between intra row spacing and NPK fertilizer was observed from fresh fruit yield per plant and fruit yield per hectare. Highest fruit yield/ha was obtained at a spacing of 20cm and NPK of 300kg/ha.

Key words: Intra row spacing, NPK fertilizer, chilli pepper, Growth and Yield.

INTRODUCTION

The bird's eye chilli pepper is one of the most widely used spicy that generate high income to farmers compared to the other varieties because of it purgency, nutritional and industrial use, it is a major vegetable after tomato and onion. In recent years the production of chilli pepper in Nigeria has once been reported as an exporting commodity (Adigun2001). Production constraints such as cost, poor method of fertilizer applications, method of drying, poor planting arrangement (spacing) and search for crude oil (fuel) has drastically reduced the value, quality and yield of chilli pepper production in Nigeria.*Capsicum annuum* and *Capsicum frutescens* are the most common dry species used in Nigeria, the crop is widely cultivated because of its spicy property and nutritional value which accounts for a large portion of vitamins A and C in many Nigerian diets. Most vegetable crops have been reported to do well under appropriate plant spacing and fertilizer application which leads to Maximum plant growth and fruit yield whereas too high or low fertilizer and poor plant arrangement could result to poor fruit quality and yield (Paththinige *et al*. 2008). However, there is still Paucity information on the Effect of intra row spacing and NPK fertilizer on growth and yield of bird's eye chilli pepper. In some other place, using intra row spacing have been proved to significantly increase the yield of bird eye's chilli pepper (Aliyu 2002, Shiral and Hagimon, 2004) who reported that narrower spacing which is synonymous to high plant densities have been found to bring about higher fruit yield per unit planting area in Hot pepper, while the application of NPK fertilizer significantly increase the Growth and Yield component of chilli pepper (Yasuor, 2013). Because of reduction in value, quality and poor management practice resulting into low yield of these crop, the scope of this study was to find out the appropriate intra row spacing and NPK fertilizer that will give maximum growth and yield of bird eye's chilli pepper.

MATERIALS AND METHODS

Field experiments were conducted on a loamy soil during 2017 rainy season at the Research farm of Institute for Agricultural Research, Ahmadu Bello University, Samaru ($11^0$11'N; 7^0 38'E and 686 m above sea level) Zaria in the Northern Guinea Savannah Ecological Zone, Kaduna State and at Irrigation Research Station (IRS/IAR) research farm Kadawa ($11^0$39'N; 08^0 02'E and 500 m above sea level) in the Sudan Savannah Kano State of Nigeria. The treatments consisted of four levels (0, 300, 600 and 900kgha^1) of NPK fertilizer 20:10:10 equivalent to 0:0:0, 60:30:30, 120:60:60, 180:90:90 and three intra row spacings (20 cm, 30 cm and 40 cm). Treatment were factorially combined and arranged in a Randomized Complete Block Design (RCBD) and replicated three times. The gross plot was 2.4 x 4.5 m (10.8 m^2) while the net plot size was 1.5 x 2.4m (3.6 m^2) and inter row spacing of 75 cm respectively was adopted. Data were collected on growth (plant height, CGR, RGR and NAR) and yield component (fresh fruit yield per plant and fresh fruit yield per hectare).

RESULTS

The result shows no significant effect on plant height, CGR and RGR using intra row spacing all through the sampling period, but shows significant effect on NAR at 10 WAT at Samaru and Kadawa. Using 40 cm intra row spacing produced significantly higher NAR than the closer spacings 20 and 30cm which were statistically at par Table1. Application of NPK fertilizer had no significant effect on plant height, CGR, RGR and NAR at 10 WAT at both locations. Table 2. Effect of intra row spacing and NPK fertilizer on fresh yield of chilli pepper. Fresh fruit yield g/plant and fruit yield kg/ha were significantly affected by the intra spacing at Samaru and Kadawa Combined each decrease in the intra row spacing from 40cm to 20cm resulted in significant decrease in fresh fruit yield per plant, while for the fruit yield kg/ha the reverse is the case, Spacing of 20cm gave more fruit yield per hectare than 30 and 40 cm intra row spacing which were statistically at par at Kadawa while at Samaru and the combined each increase in spacing from 20 to 40cm significantly decrease the yield. The fruit yield of pepper increased significantly when NPK fertilizer was applied at both locations. At Samaru, application of 300 and 600kg NPK fertilizer produced higher fruit yield per plant than 900kg NPK and the control while at Kadawa and combined applying 300kg NPK out yielded the other levels while for fruit yield kg/ha, the Application of 300kg NPK fertilizer was significantly better than 600 and 900kg and higher than the control at Samaru while at Kadawa all the applied NPK fertilizer were statistically at par and higher than the control in fruit yield. Table 3. Shows the interactions between fresh fruit yield per plant and fresh fruit yield kg/ha at Samaru and Kadawa Combined. It was observed that application of 300kgNPK/ha in combination with 30cm intra row spacing resulted in the highest fresh fruit yield per plant (g) while for the combined analysis of the fruit yield kg/ha indicates that all the three intra row spacings were statistically similar in fresh fruit yield when 0 and 300kgNPKha^{-1} were considered, however 20 cm significantly out yielded 30 and 40 cm intra row spacing when 600 and 900kgNPKha^{-1} were applied.

Table 1. Effect of intra row spacing and NPK fertilizer on growth parameters of chili pepper at Samaru and Kadawa during 2017 wet season at 10 WAT

	Plant Height (cm)		CGR(gwk^{-1})		RGR(gg^{-1}wk^1)		NAR(g^{-1}cmwk^{-1})	
Treatment	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa	Samaru	Kadawa
Intra row spacing cm								
20	41.60	42.67	1.037	1.042	0.211	0.272	0.00090b	0.00162b
30	42.53	34.88	1.242	0.841	0.226	0.260	0.00094b	0.00180b
40	42.66	38.44	0.901	1.023	0.181	0.249	0.00183a	0.00232a
SE±	1.636	1.438	0.203	0.124	0.0315	0.035	0.0002	0.0003
NPK (20:10:10)								

Fertilizer g/ha								
0	40.28	32.40	1.327	0.820	0.147	0.224	0.00101	0.00124
300	41.42	37.54	1.154	9.961	0.187	0.261	0.00118	0.00173
600	34.18	40.58	0.953	0.947	0.239	0.272	0.00131	0.00217
900	42.73	44.13	0.806	1.148	0.252	0.284	0.00137	0.00251
SE±	1.889	5.125	0.234	0.143	0.039	0.040	0.0003	0.0004

Means in a column of any set of treatment followed by different letter(s) are significantly different at 5% significant levels using DMRT.

Table 2: Effect of intra row spacing and NPK fertilizer on fruit yield of Chilli pepper (Samaru, and Kadawa Combine) during 2017 wet season.

	Fresh fruit yield (g/plant)			Fresh fruit yield (kg/ha)		
Treatment	Samaru	Kadawa	Combine	Samaru	Kadawa	Combine
Intra row spacingcm						
20	81.88c	87.45b	84.67c	6844.50a	6981.7a	6913.10a
30	97.36b	106.68a	102.02b	4956.00b	5640.60b	5298.30b
40	114.79a	115.39a	115.09a	4114.50c	4764.00b	4439.30c
SE±	4.512	6.151	3.968	240.781	377.649	225.922
NPK (20:10:10)						
Fertilizer g/ha						
0	74.10c	78.74c	76.42c	2804.40d	3631.70b	3218.10d
300	120.38a	136.35a	128.37a	7430.00a	7078.70a	7254.30a
600	107.04a	102.99b	105.025b	5955.80b	6672.80a	6314.40b
900	90.51b	94.60bc	92.56b	5029.90c	5798.50a	5414.20c
SE±	5.210	7.103	4.581	278.029	436.070	260.873

Means in a column of any set of treatment followed by different letter(s) are significantly different at 5% significant levels using DMRT

Table 3: Interactions between inter row spacing and NPK fertilizer of chilli pepper at Samaru and Kadawa combine during 2017 wet season.

	Fresh fruit yield per plant (g)		
Treatment	**Intra row spacing (cm)**		
	20	**30**	**40**
NPK (20:10:10)			
fertilizer g/ha			
0	59.68f	76.56cf	93.01de
300	119.18bc	144.23a	121.69abe
600	85.49ef	99.45cde	130.11ab
900	74.31ef	87.83e	115.53bcd
SE±	7.935		
	Fresh fruit yield (kg/ha)		
0	3578.69fg	3222.23fg	2853.13g
300	8385.33a	7114.79abc	6262.89bcd
600	8821.63a	5443.93cdc	4677.55defg
900	7223.14ab	5055.80def	3963.57efg
SE±	451.84		

Means in a column of any set of treatment followed by different letter(s) are significantly different at 5% significant levels using DMR

DISCUSSION

Response to intra row spacing

Plant height, CGR and RGR were not significantly influenced by the intra row spacing ranging from 20 cm to 40 cm at both locations. This might be due to the fact that the plants have the same genotypes which gave each plant equal advantages to perform at the same past irrespective of their individual spacing. This agrees with the findings of Salau *et al*. (2008) who reported non significant response with intra row spacing of hot pepper in some growth and yield components during his trials in 2009 and 2010. The significant increase in the Net assimilation rate as observed by the intra row spacing could attribute to the fact that wider spaced plants (40 cm) tend to have higher photosynthetic potential (NAR) as intra row spacing increased because of less plant and its broad leaves which allows it to access light and water source for photosynthesis within the canopy. This only improved the individual performance but could not compensate for the low leaf area per unit area of land as a result of sparse plant population (Russo 2003). The increase in fruit yield per plant observed from the wider spacing when comparing with other individual plants could be that plant accommodating the wider spacing has more space to develop properly with less inter and intra plant competition for utilizing the available resources resulting in higher fruit yield per plant. This result is in conformity with the findings of Aminifard *et al*. (2010) who reported that the performance of hot pepper was enhanced by wider spacing as the number of fruits per plant and fruit size were reduced at closer spacing. The highest and lowest fruit yield per hectare was observed in 20 cm and 40 cm. This could contribute to the fact that the increase in the plant number as a result of using the closer spacing per unit area might have contributed to the extra yield per unit area leading to high yield. This result is in conformity with the findings of Law-Ogbmo and Eghareuba (2009), Aminifard (2010) and Islam *et al*. (2011) who reported that highest fruit yield per hectare of sweet pepper and other plants were obtained from plants grown at closer spacing with in Row spacing of 20 cm and 30 cm respectively and also the yield advantage due to narrow spacing could be attributed to the development of a full canopy in early development stages (Fukai *et al.* 2004).

Response to NPK fertilizer

The application of NPK fertilizer differed significantly among the yield parameters. The non significant response exhibited by the growth component to the application of NPK fertilizer could be due to the inherent character that are genetically controlled rather than being influenced by management practice (Nielson 1979). Application of NPK fertilizer significantly increases the fruit yield per plant and fruit yield per hectare due to plant nutrient absorption. This report is in conformity with Suge *et al*. (2011) who reported that increasing NPK rates from 50% to 100% of the recommended rates encouraged the fruit quality. The significant interaction between intra row spacing and NPK fertilizer application observed on fruit yield of chilli pepper shows that intra row spacing and NPK fertilizer plays a major role in the growth and yield of bird eye's chilli pepper in other to attain a higher yield per hectare. The Plant spacing ensures the proper use of land for growth and development of the plant for good yield while fertilizer application is very much essential for good plant establishment and expected growth. This agrees with the finding of Abdel Mawgoud *et al*. (2007) who reported that two management practice which greatly influence growth and fruit yield are spacing and fertilizer application.

CONCLUSIONS

The growth (NAR) and yield component of bird eye's chilli pepper were significantly affected by intra row spacing and NPK fertilizer. Plant height, CGR and RGR were not significantly affected by intra row spacing and NPK fertilizer. Intra row spacing and NPK fertilizer significantly increases the fresh fruit yield per plant and fruit yield per hectare. Therefore, from the above study it can be deduce that the use of intra row spacing and NPK fertilizer in pepper production cannot be underestimated for its growth and development. Application of 300kgNPK/ha gave 7254.30kg/ha fresh fruit yield per hectare and a spacing of 20 cm gave higher fruit yield of 6913.10kg/ha which could be recommended by farmers for bird eye's chilli pepper production in the Northern Guinea and Sudan Savannah of Nigeria.

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CABBAGE (*BRASSICA OLERACEA L. VAR. SAVOY*) RESPONSE TO ORGANIC MANURE RATES

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ABSTRACT

The present investigation was conducted during the 2020 dry seasons under irrigation at Gwallaga- mayaka Fadama Farm site, Bauchi (Latitude 10^0-17" N. Longitude 9^0-49" E, 609.3m above sea level) in the Northern Guinea Savannah zone of Nigeria. Cabbage (Brassica oleraceae L. var. savoy) was planted on soils treated with control, Poultry manure-based compost (6.0 t/ha), Cow dung manure (6.0 t/ha), Sheep manure (6.0 t/ha) and Vermicompost (6.0 t/ha) arranged in factorial combination and laid out in Randomized Complete Block Design replicated thrice. All organic manure applied significantly affect plant height, number of leaves per plant, root length at harvest, head diameter at harvest, weight per head, yield per hectare, pH, organic matter, P and K levels. Poultry manure-based compost gave the tallest height, highest number of leaves, longest root, heaviest weight per head, largest head diameter, highest yield, increased in pH, highest organic matter, N, P and K levels than other treatments and control. However, there was a consistent compatibility of cabbage with poultry manure-based compost as a suitable soil improvement input for sustainable cabbage production. Further studies using poultry manure-based compost rate of 6.0t/ha in combination with cabbage variety savoy be conducted to ascertain its superiority over other organic manure sources for soils improvement and sustainable cabbage production in the study area.

Key words: Fertility, Input, Management, Restoration, Sustainability, Yield

INTRODUCTION

Cabbage (*Brassica oleraceae* L. var. savoy) is considered a high value vegetable due to its relative importance to human health and the economy of farmers involved in its production (Jahangir *et al*., 2009). The crop is a leafy green vegetable closely related to other high value Cole crops such as broccoli, cauliflower and Brussels sprout which are good sources of vitamins A, C and E, minerals and contain antioxidants which are important for good health, being rich in calcium, folic acid, selenium, potassium, sulphur, magnesium and help in restoring vitality, fitness, calming nerves and promote relaxation and sleep (Jahangir *et al*., 2009). It also contains an anticarcinogenic properties, aid in bowel cleansing due to the presence of glucosinolates and photochemical products that offer an extra protection against heart disease (Rosa and Rodrigues, 2001). There is an increasing scenario in production failing to keep up with daily demand and this has stimulated interest in the greater utilization of organic manure for restoring, rejuvenating soil fertility and fertilizing vegetable crops in order to achieve an increased in yield. Organically grown high value vegetables occupy a major part of the fresh produce industry that has experienced strong growth in the 1990s (Olusola, 2002).

There is a considerable potential to maintained, increased and improved the quality and yield of high value vegetable crops such as cabbage through improved cultural practices like the use of organic manure (Batt *et al.,* 2008). Organic manures are any organic material added and mixed with the soil in order to increase and maintain the soil fertility by improving the chemical and physical properties of the soil (Arancon *et al.,* 2006). Organic farming preserves and enhances fertility of the soil (Abdel *et al*., 2004). Building up or nourishing the soil with the use of organic compost is the major concept of organic farming which is highly sustainable strategy (Stephens and Kostewicz, 2009). The production of high value vegetable crops such as cabbage through the use of organic manure is one among the many cultural practices that would improve quality of produce and at the same time improve the soil fertility. However, adopting organic vegetable crop production systems with low inputs will provide greater food security for rural and urban dwellers

(Altieri, 2002). The present study intend to determine the response of cabbage variety savoy to different rates of organic manure and to identify the best rate amongst the applied organic manure on growth and yield of cabbage, and, on soil pH, soil organic matter content, phosphorus (p) and potassium (k).

MATERIALS AND METHODS

The Study Area: Field experiment was conducted under irrigation at Gwallaga-Mayaka Fadama farm, Bauchi (10^0 17" N, 9^0 49" E and 609.3m above sea level) located in the Northern Guinea Savannah ecological zone of Nigeria (Kowal and Knabe, 1972) during the 2020 dry season.

Sampling Design: Total field size was 100 square meters, total bed size was 1 x 6 meters spaced 30 x 40 cm under the double row planting method replicated thrice in a randomized complete block design (RCBD). Organic manure applied were incorporated in a single dose into the prepared beds according to the design two weeks before transplanting. Cabbage *(Brassica oleraceae* var. savoy) was sown into nursery beds and transplanted when at three-to-four leaves stages to already prepared permanent growing beds. Soil samples of each replicate were collected and bulked before applying the organic manure and after termination of the study from a depth of 0-30 cm. Samples were analysed for pH, organic matter, percent nitrogen, phosphorus and potassium, all important cultural and management practices such as weeding, watering and hilling-up were carried out when necessary. Azadirachta indica seed extract was used to control the mild pest attack noticed.

Analytical Techniques: Measurements were conducted for cabbage plant height (cm**),** number of leaves per plant, root length at harvest (cm), head diameter at harvest (cm), weight per head (kg), yields (kg/ha), pH, organic matter, P and K levels. All data collected were analyzed using the equation of Chapman and Ayrey (1981) in variance of randomized complete block design in three replicates. Mean difference were determined using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSIONS

The initial physico-chemical properties of the top indicated that the soils are mostly clay-loam with low organic matter (Kowal and Knabe, 1972). However, Tab le 1 showed the chemical composition of the various organic manure applied, where poultry manure-based compost and sheep manure gave the highest and lowest value in all the chemical properties analyzed, respectively.

Table 1. Nutrient status of the various organic manure used.

Chemical properties	PMBC	CDM	SM	VMC
OC %	18.15	15.45	12.15	16.49
Total N %	1.93	1.21	1.19	1.32
C:N ratio	12.75	11.45	10.99	11.68
P %	0.91	0.67	0.56	0.79
K %	0.61	0.45	0.41	0.50
pH	6.63	6.41	6.29	6.52
S %	0.55	0.25	0.20	0.29
Mg ppm	5310	5130	5011	5213
Cu ppm	9.91	8.66	7.99	9.10
Fe ppm	976	954	912	964
Ca ppm	279	254	248	261
Zn ppm	297	279	267	281

PMBC = Poultry manure-based compost, CDM = Cowdung manure, SM = Sheep manure, VMC= Vermicompost.

Plant height, Head Diameter and Weight per head

Table 2 showed that there were significant differences among the different organic manure applied and the control. However, poultry manure-based compost had a higher plant height than the other organic manure and control. Similar trend was obtained in head diameter and head weight per head where significant differences occur between the various organic manure rates and control, poultry manure-based compost significant, gave the largest and heaviest head than the other organic manure, Control generally had the lowest and lighter weight per head**.**

The use of organic manure in vegetable crop production such as cabbage is on the increase in view of the high price of inorganic fertilizers and the difficulty in procuring it at the required time Snyder, (2009). Furthermore, organic manure is the most valuable of all soil enriching elements that historically had been used as a source of plant nutrients for soil fertility restoration and for vegetable crop production (Ingrid (2004) and that, nutrient contents of decompose chicken manure is among the highest of all animal manures, its use as organic soil amendment will provide appreciable quantities of all important plant nutrients.

Table 2: Cabbage Plant height, Head Diameter and Weight per head as influenced by various organic manure rates

Treatment	Plant height (cm) 2020	Mean	Head Diameter (cm) 2020	Mean	Weight per head (g) 2020	Mean
Control	12.45d	16.06d	18.68d	15.13e	99.10e	109.58e
PMBC	22.60a	22.19a	21.19a	20.97a	305.23a	312.61a
CWD	17.53b	19.53c	19.55c	18.06c	162.35c	196.61c
SM	14.16c	20.57b	19.46c	17.65d	120.6d	190.68d
VMC	17.76b	19.70c	20.95b	19.06b	190.9b	216.42b
LS	**	**	**	**	**	**
CV (%)	13.66	16.95	13.23	11.95	15.01	14.16

PMBC = Poultry manure-based compost, CDM = Cowdung manure, SM = Sheep manure, VMC= Vermicompost, LS = Level of significance, LS = Level of significance. Means with the same letter (s) in a column are not significantly different at 5% level by DMRT.

The significant effect of the different organic manure applied on cabbage plant height, head diameter and weight per head could be attributed to adequate amount of nutrients elements present in the various organic manure applied particularly the macro element of nitrogen, phosphorus and potassium whose released add more of these nutrients elements to the soil as reported by Bulluck *et al*. (2002).

Number of leaves, root length and yield t/ha

Table 3 showed a significant difference among the various organic manure rates and control on cabbage number of leaves, root length and yield per hectare. Poultry manure-based compost produced the highest means followed by vermicompost and control. The significant differences obtained indicated a more efficient use of nutrients released by the various organic manure applied by cabbage root owing to their availability within the root zone for timely absorption and utilization. Organic manure is a supplier of N, P and K to the soil which also increases the phosphate solubilizing bacteria in the rhizosphere (Khan *et al*., 2008). Wang *et al.* (2001) reported that organic manure improves the structure of the soil directly through their action as bulky diluents in compacted soils or indirectly when the waste products of animals or micro-organisms cement soil particles together thereby improving the soil structure and increases the amount of water available to the crops root. When decompose chicken manure was applied under field conditions at 8.2 t/ha organic carbon mineralization of 50% was obtained (Abdel *et al.,* 2004, Zahid, 2001) and that further increase beyond 8.25t/ha is not advisable and may lead to unnecessary monetary losses.

Table 3. Cabbage Number of leaves, Root length and Yield as influenced by various organic manure rates

Treatment	Number of leaves 2020	Mean	Root length (cm) 2020	Mean	Yield (t/ha) 2020	Mean
Control	17.42e	8.63e	14.59e	10.11e	8.75d	7.64e
PMBC	26.51a	20.11a	22.90a	13.97a	19.96a	18.54a
CDM	20.43c	17.52d	20.45c	12.06c	9.40c	10.90c
SM	19.96d	18.00c	19.96d	11.65d	9.66c	9.07d
VMC	21.73b	19.17b	21.35b	12.56b	11.48b	11.32b
LS	**	**	**	**	**	**
CV (%)	4.80	5.28	2.88	4.95	3.55	2.57

PMBC = Poultry manure-based compost, CDM = Cowdung manure, SM = Sheep manure, VMC= Vermicompost, LS = Level of significance. Means with the same letter (s) in a column are not significantly different at 5% level by DMRT.

Organic matter, P and K levels

Table 4 present the results of analysis of initial soil properties of the experimental site before and after the experimentation. The soil is clay loam and slightly acidic, low in organic matter, phosphorus and potassium. However, after application of all the organic manure, soil values obtained indicated that pH level was changed to neutral (increase), there was a significant increase in phosphorus and potassium content of the soil and poultry manure-based compost significantly produced the highest means. This might be ascribed to the flocculating, aggregating and conditioning role of the applied organic manure, because Ammonium-N (NH_4-N) is a significant part of total N in decompose organic manure, which additionally contains uric acid which metabolizes rapidly to NH_4-N in most soils (Dixon, 2006). Meanwhile, availability of these organic elements to cabbage will enable the crop absorbed much of phosphorus and potassium for root, leave and head development considering the initial pH, organic matter, phosphorus and potassium content of the soil. Furthermore, decompose poultry manure is especially suitable for acid soils as it has strong liming effect as it reduces the acidity of the soils thereby protects crops from aluminum toxicity (Manivannam *et al.,* 2009). Organic manure has the potential to supply most of the nitrogen and sulphur and half of the phosphorous taken up by crops root from the soil and also supply most of the cation exchange capacity (CEC) of acidic and highly weathered soils (Manivannam *et al.,*2009).

Table 4: pH Level, Organic matter, Phosphorus and Potassium contents of the soil of experimental site as influenced by various organic manure rates

Treatment	pH 2020	OM (g/kg) 2020	P (g/kg) 2020	K (Cmol/kg) 2020
Control	4.09	0.20	5.60	0.30
PMBC	6.08	2.25	6.05	0.34
CDM	5.44	1.50	5.55	0.30
SM	5.06	1.00	5.90	0.31
VCM	5.90	1.98	6.00	0.32
Initial analysis	5.20	0.17	5.40	0.24

PMBC = Poultry manure-based compost, CDM = Cowdung manure, SM = Sheep manure, VMC= Vermicompost, LS = Level of significance.

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Benefits derivable from organic manure application to soil are improved soil physical properties when applied to heavy or sandy soils and the fibrous portion of the organic manure having high carbon content promotes soil aggregation which in turn improved the permeability and aeration of clay soils and the ability to absorb moisture which also helps in the granulation of sandy soils and consequently improves the soil water holding capacity (Wang *et al.,* 2001). Treating sandy soil with organic manure decreased macro pores which increased micro ones and as a result hydraulic conductivity decreased and more reduction was obtained by increasing the application rates (Sunassee, 2001). Vermicompost contains more organic matter, nitrogen, phosphorous, sulphur, calcium and magnesium (Zahid, 2001).

CONCLUSION AND RECOMMENDATIONS

It was established that the organic manure treatments had a statistically significantly and positive impact on all agronomic variables of cabbage crop study. All the organic manure has a high impact on the growth, yield of cabbage and soil organic matter, soil pH, P and K levels. Poultry manure-based compost gave the highest growth and yield value, soil organic matter, soil pH, P and K levels. Furthermore, the response of cabbage under organic manure at 6 t/ha was better and higher under poultry manure-based compost compared to other organic manure treatments and control. The use of poultry manure-based compost at 6 t/ha in combination with cabbage variety should be examined again in the study site in order to further ascertain its superiority in terms of cabbage yield, soil fertility restoration and soil reclamation over other organic manure rates used.

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DEVELOPMENT OF IRRIGATION SCHEDULES FOR IBADAN NORTH LOCAL GOVERNMENT, OYO STATE, NIGERIA USING AQUA-CROP

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ABSTRACT

In an attempt to encourage farmers in Ibadan North local government areas of Oyo State, Aquacrop model was used in simulating the appropriate irrigation water requirements that will produce optimal yield of tomato for drip, sprinkler and furrow irrigation in the investigated environment. Dry biomass yield of 8.1, 7.9 and 7.5 ton/ha were simulated for drip, sprinkler, and furrow irrigation respectively. These will provide a guide to farmers in the area on the likely yield to expect, provided they follow the guideline provided regarding other farm operations (weed and nutrient management etc.). Other factors that will guide the choice of appropriate irrigation system for individual farmers are provided in the write up.

INTRODUCTION

Ibadan North is a Local Government Area in Oyo State, Nigeria. Its headquarters is located at Agodi in Ibadan. Several households in Ibadan North Local Government area depend on agriculture (Wahab and Abiodun 2018). They are mostly smallholder farmers (< 2 ha land) due to the traditional land tenure system that denied them access to large acreage of land (Nyambo et al, 2019). Major crops produced in the area are horticultural crops which helps to augment family needs like feeding, rent and payment of school fees. Unfortunately, they largely depend on rainfed cultivation partly due to their low level of income. Most never bother to find out the cost of irrigation but they depend on the assumption that "it is very expensive" and beyond their reach (Takeshima 2016).

Because most farmers produce in the raining season, they hardly break even. The price of their commodities is usually low due to high supply, relative to demand which leads to discouragement amongst them. Consequently, it is increasing difficult to the youths to show interest in agriculture (Adesina and Favour 2016). They youths would rather migrate to the city in search of "white collar jobs" or engage in petty trading, and lately, in commercial motorcycling. If they could be encouraged to produce their crops also in dry seasons, they will likely make enough profit to compensate for losses they might have incurred in raining season. Hence, their livelihood will be enhanced. We therefore used Aquacrop model in simulating the appropriate irrigation schedule that will produce optimum yield of tomato (our test crop) in the investigated area.

Fortunately, Ibadan north local government is blessed with some perennial streams and rivers (Ajibade et al 2010, Agboola et al., 2012). It also enjoys bi-modal annual rainfall of approximately 1420 mm. It usually starts March – early November, with a short dry spell in August, referred to as August break. The months of November to March are normally dry with cold harmattan weather. We simulated for three types of irrigation *viz* drip, sprinkler, and furrow irrigation. It is expected that that farmers in the area will take advantage of the simulation result and pick the most appropriate irrigation method for their locations.

MATERIALS AND METHODS

Brief information and assumptions:

Investigated area: Ibadan North Local Government area of Oyo State, Nigeria (Latitude 7.3621 Longitude 3.9372, Altitude 139.85 meters above sea level).

Crop investigated: Tomato (high density)

Weed management: Assumed to be Perfect

Other assumptions, based on some known facts in the area: No mulch, Moderate soil fertility

Irrigation Water Quality: Excellent.

Simulation period: 1st December, 2016 to 20th March, 2017 (110 days)

Weather data used: 1st January, 2015 to 31st December, 2018, downloaded from https://power.larc.nasa.gov/data-access-viewer/

Details of the steps taken, including weather and soil information of the study area are provided in Figure 1. For drip irrigation, ten (10) mm of irrigation water was applied at transplanting. This was repeated at 3 days' interval up until 75 days after transplanting (DAT), slightly beyond the flowering period. It was thereafter reduced to 5 mm untill 95 DAT after which irrigation ceased. By this stage, the fruits were already matured. Excess moisture will only lead to increase in water content of the fruit, thereby encouraging pest build up and spoilage.

Thirty (30) mm of irrigation water was applied *via* sprinkler method at transplanting at 7 days' interval. This was increased to 40 mm at 40 DAT when the plant was matured and the roots are well developed. It was later reduced to 25 mm at 70 DAT up until 90th DAT when irrigation ceased after full maturation of fruits.

Forty (40) mm of irrigation water was supplied by furrow irrigation method at transplanting. This continue at 10 days' interval until 40th DAT when the depth of irrigation water was increased to 60 mm. This we maintained until 80th DAT when it was further reduced to 50 mm and we stopped irrigating at 90th DAT when the fruits were already matured.

Several options were tried but the best options are reported. In choosing the best option, consideration was not given to yield alone, but also we tried to minimize runoff and drainage to the bearest minimum (so as to minimize waste of resources). Consideration was also given to water use efficienty and evappotranspiration (ET) water productivity. During the simulation process, we tried as much as possible to avoid stomata closure or any other forms of water stress, most especially at the critical period of its morphological development like flowering and fruitng. In spite of our efforts, we ended up with some level of stress but they were limited to towards the end of the growing cycle, when the stress will have minimal effects on the crop. At best, the stomata closure at this stage will only improve the shelf life of tomato thereby preventing losses.

RESULTS AND DISCUSSION

Drip Irrigation

Dry yield and biomass yield of 8.1 and 12.8 ton/ha respectively were simulated (Figure 2). ET water productivity was 2.51 kg yield per m^3 water evapotranspired. Rainfall and drip irrigation supplied 69.8 and 275.0 mm of water respectively. None of the supplied irrigation water was drained but 74.9 mm, largely from the rain component, was evaporated. Water use efficiency (considering the rainfall and supplementary irrigation) was about 71.5%. It turned out to be 89.7% when irrigation water alone was considered.

Sprinkler Irrigation

The plant experienced a little stress close to the onset of flowering but the increased moisture around this period provided the needed stability effects such that we were able to save cost *via* water management and at the same time, the yield and quality were not compromised. Rainfall supplied 69.8 mm while 385 mm was supplied by sprinkler irrigation (Figure 3). None of these components were drained and 119.7 mm was lost to evaporation thus bringing water use efficiency to 53.7% (supplementary implication) and 63.4% when irrigation water alone was considered. Biomass and dry yield were 12.6 and 7.9 ton/ha respectively; ET water productivity was 2.18 kg yield per m^3 water evaporated.

Furrow Irrigation

Biomass and dry yields were 12 and 7.5 ton/ha respectively (Figure 4). Rain and irrigation water by furrow irrigation method contributed 69.8 and 410 mm respectively. Out of these, 79.5 and 78.9 mm were lost to drainage and evaporation respectively. Hence, water use efficiencies were 48.3 and 56.5% respectively for supplementary and full irrigation.

CONCLUSIONS

We have provided three (3) alternatives for farmers in Ibadan North local government area, Oyo State, Nigeria. Each farmer is at liberty to pick the options that is best suited for him based on certain considerations: Although, dry biomass yield of 8.1, 7.9 and 7.5 ton/ha were simulated for drip, sprinkler, and furrow irrigation respectively, we will require the services of agricultural economists so we may be able to decide the cost of inputs, relative to income (benefit cost ratio *etc*). For example, the depth of irrigation water, hence the cubic meters of water used are not the same. Also, while weeding will be required for up to three times for both sprinkler and furrow irrigation, drip irrigation will likely not require weeding as water will only be delivered to the root zone of the crop whereas weeds will not be able to survive. Other considerations by farmers in the area will include:

1. The source of water to be used for irrigation. A perennial stream / river, or groundwater?

2. Location of their farm relative to water source. For example, if the farm is downstream of the water source, water can be delivered by gravity. Hence, cost of pumping the water from water source to the field will be eliminated.

3. Financial status of the farmer. Is he able to raise the startup capital for such systems as drip or sprinkler irrigation etc.

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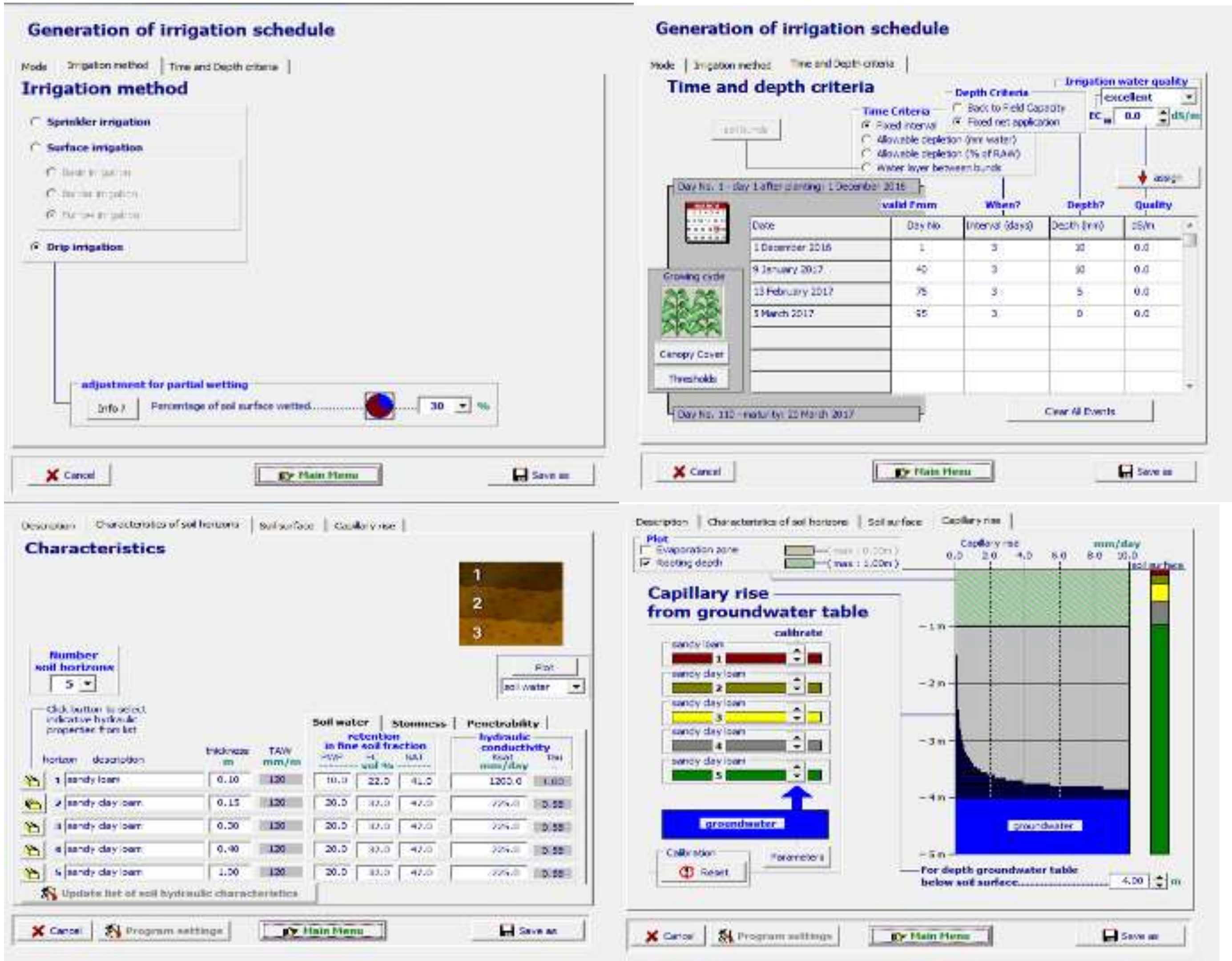

Figure 1. Time and depth criteria for drip irrigation schedule and soil characteristics of the investigated area.

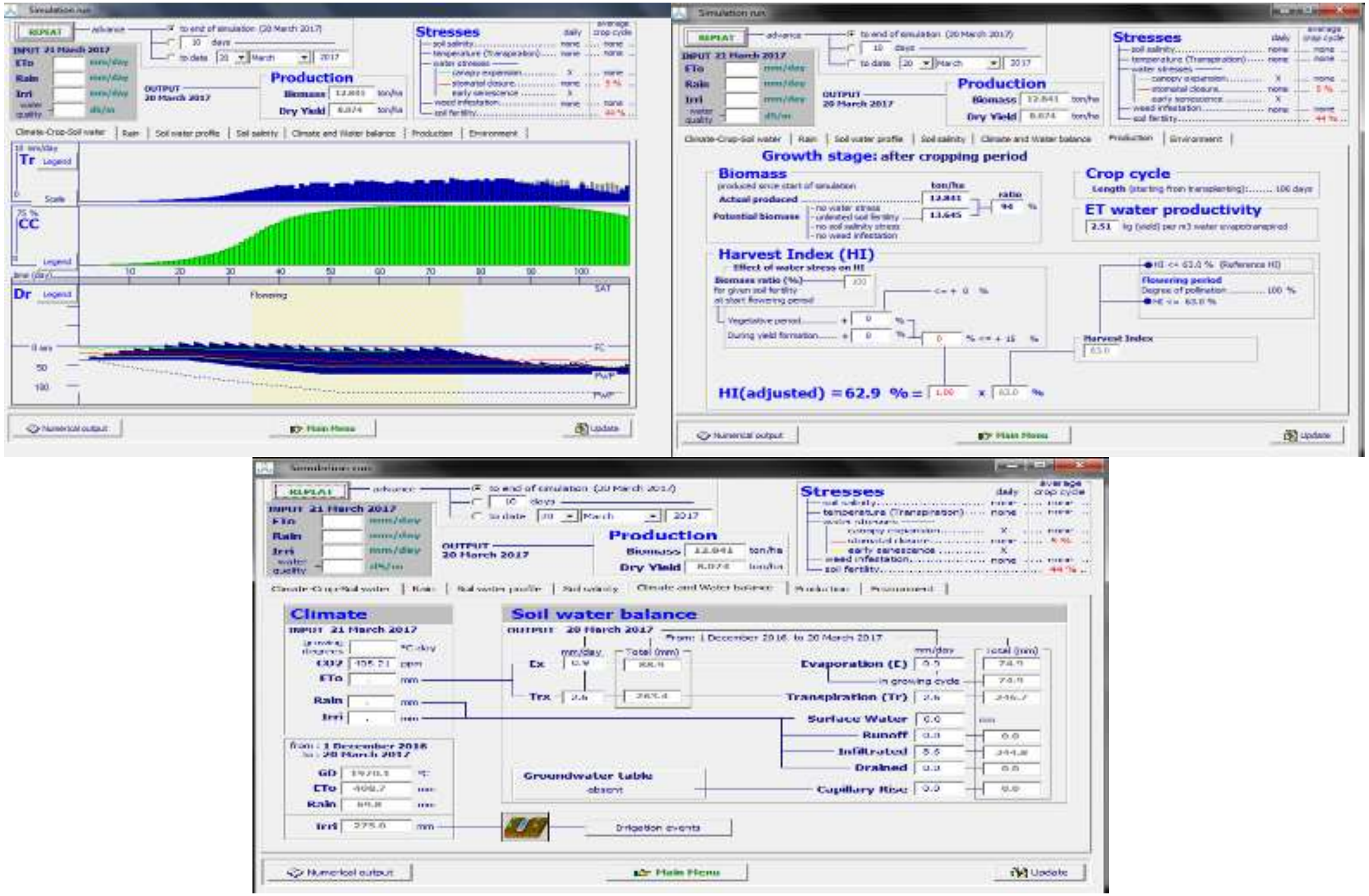

Figure 2. Simulated yield and other yield parameters for the investigated area under drip irrigation method.

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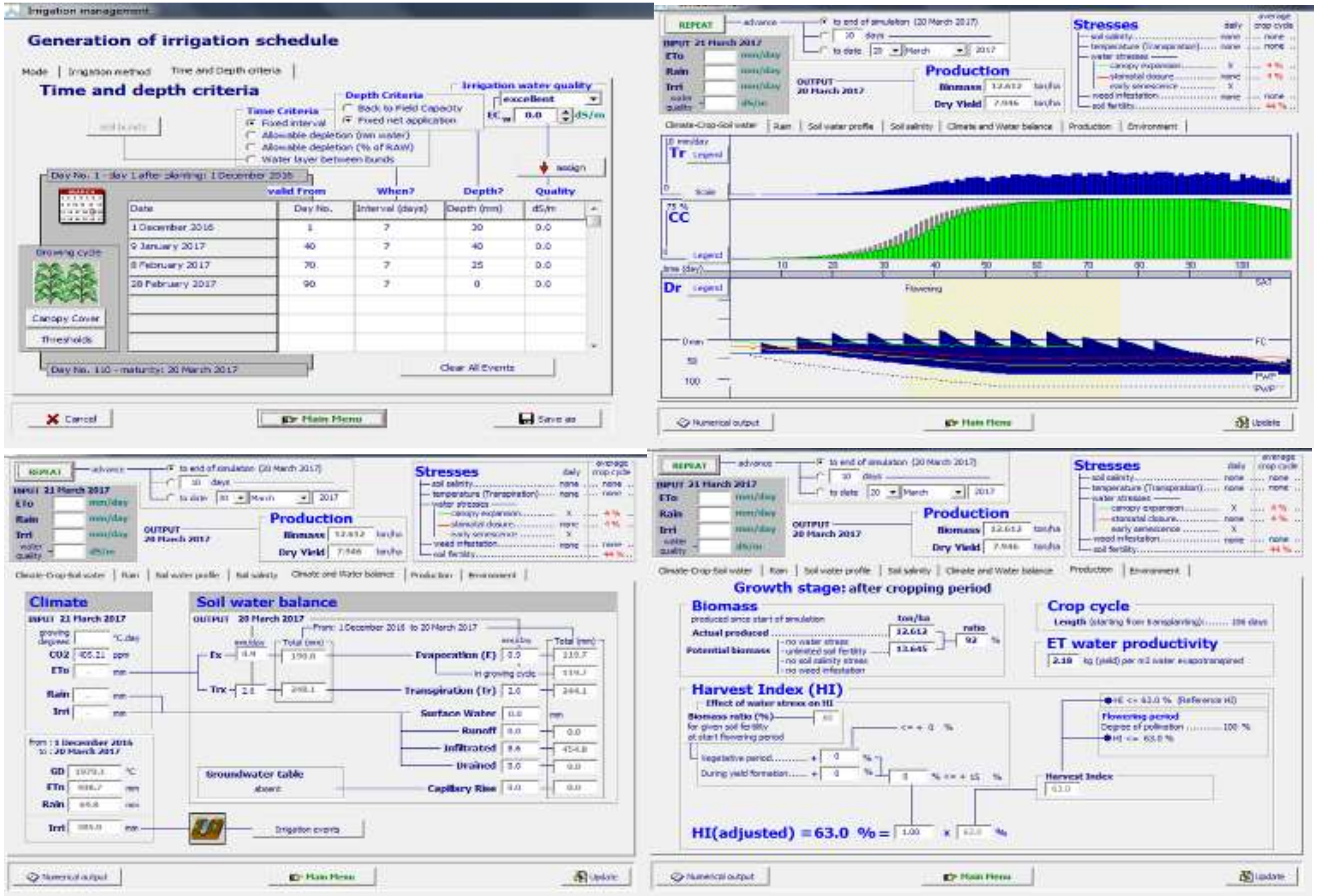

Figure 3. Simulated yield and other yield parameters for sprinkler irrigation in the investigated environment

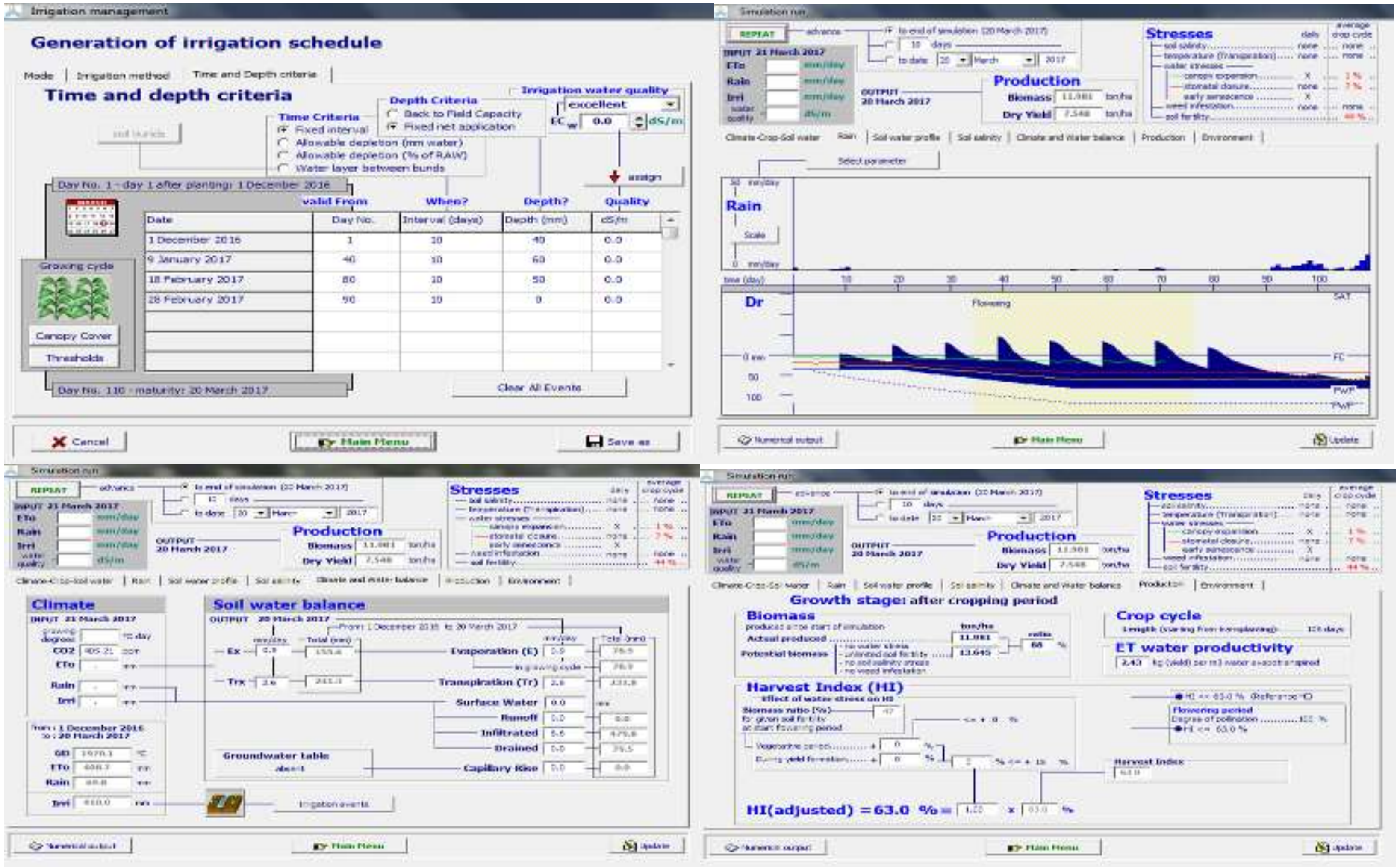

Figure 4. Simulated yield and yield parameters for flood irrigation for the investigated environment

GROWTH AND YIELD OF LETTUCE (*LACTUCA SATIVA* L.) AS INFLUENCE BY IRRIGATION FREQUENCY AND POULTRY MANURE IN BIRNIN KEBBI, NORTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

As available water resources and plant nutrients are becoming less by the day, there is a pressing need to give more emphasis to efficient use of irrigation water as well as plant nutrients for maximum economic return and resources sustainability. As such, field experiments were conducted to determine Growth and Yield of Lettuce as Influence by Irrigation frequency and Poultry Manure at Irrigation and Demonstration Farm (lat. 12°27'13"N; long. 4°12'01"E; 197m above sea level), Waziri Umaru Federal Polytechnic Birnin kebbi during 2020/2021 dry season. The aim of the experiment was to study the response of Lettuce to irrigation frequency and poultry manure. Treatments consisted of three (3) Irrigation intervals which are; Daily application of water, 1day interval application of water and 2days interval application of water which denoted as A, B and C; and three (3) levels of nutrients which are; 2tonnes/ha, 4tonnes/ha and 6tonnes/ha denoted as N1, N2, N3 and the untreated control respectively. Treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. Result revealed that; Daily application of water or One-day interval applications of water are most suitable for Lettuce production in Birnin Kebbi. Similarly, Application of 4t/ha of poultry manure gives greater yield advantage. The result of the research concluded by recommending Daily application of water or One-day interval application of water as well as application of 4t/ha of poultry manure could be adopted for higher yield of Lettuce.

Key words: Lettuce, Irrigation, Poultry manure, Growth, and Yield

INTRODUCTION

Lettuce (*Lactuca sativa* L.) is one of the important leafy vegetable used as salad and also marketed as fresh vegetable. Genus Lactuca has more than 100 species and six types. Different types of lettuce are Romaine (Cos), Crisp head (Ice berg), Butter head, Stem (Asparagus), Leaf (Cutting) and Oil-seed lettuce (Moreira *et al*., 2014). It is commercially grown in Asia, North and Central America, Europe as well as Africa. The major lettuce growing countries in the world are China, US, Spain, Italy, India and Japan. Most lettuce varieties are eaten fresh and are commonly served as the base of green salads. It ranges in colour from yellow to dark green depending on the variety. Lettuce plant can vary greatly in size, shape and leaf type but generally, the leaves of the plant form a dense head or loose rosette. The stem of the plant is short, with a larger leaves arranged at the bottom and becoming progressively smaller further up the stem. Leave can be smooth or curly. The lettuce plant can grow to a height of 20-100cm in height depending of variety and it typically grown as annual, harvested after only one growing season (Villas Boas *et al*., 2004). Lettuce probably originated from Asia, where it was grown for centuries and its early forms were used in Egypt around 4500 BC. The Romans grew types of lettuce resembling the present romaine cultivars as early as the beginning of the Christian era. The crop was also used in China by the 7th century A.D. lettuce now one of the world's most important salad crops and is grown worldwide (Maboko and Plooy, 2008).

According to FAOSTAT (2018), annual global production for lettuce approximately stands at 27.86 million tonnes. The major producing countries include China (12,855,211 tonnes), United state (3,827,390 tonnes), India (927,349 tonnes), Spain (875,000 tonnes) and Italy (844,976 tonnes) as at 2018 (FAOSTAT, 2018). Nigeria's annual lettuce output is less than 200,000 tonnes and can be grown across most state, Plateau state has the highest. Lettuce is one of healthiest food put on this planet. The green leafy vegetable contains many health benefits, such as maintaining normal blood sugar levels, fighting off inflammation, reducing the risk of heart disease and helping people lose weight. It is rich in vitamin A and C and minerals like calcium, iron, magnesium, potassium and sodium. However, Vitamin-C is lost if it is over cooked. It is grown for its tender leaves and head, which are chopped and used as salad with salt and vinegar and it is gaining popularity with the change in food habit and health consciousness among the people (Brito *et al.*, 2012).

Lettuce is a cool season crop that grows best within a temperature range of 12°C to 20°C. It does not suffer from light frosts and winter cold except near maturity. Severe frost before harvest can scorch leaves and heads. Temperatures above 27°C affect head development and plant edible quality and also promote premature seed stalk development. High temperatures also inhibit germination and can cause a high incidence of tip burn. The crop has high moisture requirements and not more than 50 % of the available water in the root zone should be depleted before irrigation. The plant grows well on a wide variety of soils ranging from light sand to heavy clay, whoever, best results are obtained on fertile loams that are rich in organic matter. A pH between 5.5 and 7 is optimum. Lettuce should be grown on soils with a high water-holding capacity and proper drainage for good root growth and plant performance (Brito *et al.*, 2012).

Insufficient water supply (rainfall or irrigation) and Low soil fertility are among the most important factors that limit vegetables production in any region in Nigeria are. The period of harmattan (Shining sunlight, dry and dusty wind blowing over West Africa between the November and middle of March) in the lowland northern states such as Kebbi and Sokoto, majority of farmers lacks basic knowledge of irrigation scheduling and this affect the productivity of the system, as the crops are either over or under irrigated, leading to wastage of the little available water. On the other hand Low soil fertility has also been recognized as a major and general problem of crop production in the Savanna areas of Nigeria (Adekiya *et al.,* 2012). Lettuce is more susceptible to nutrient deficiencies than most crop plants because of their shallow root system it becomes necessary to provide adequate level of soil fertility through the use of organic manure (Akanbi *et al.,* 2010).

Irrigation scheduling is a critical management input to ensure optimum soil moisture status for proper plant growth and development as well as for optimum yield. Therefore, it is essential to develop irrigation scheduling strategies under local climatic conditions to utilize scarce water resources efficiently and effectively. Fertility of most soils has already declined due to continuous cropping and reduced the use of organic manure (Nweke *et al.*, 2013). Farmers in these areas have low knowledge of timely and optimum application of irrigation. In addition, the cultivation of lettuce requires proper supply of plant nutrient, hence it is necessary to evaluate the effect organic manure on growth and yield performance of lettuce. The main aim of this research is to determine the effects of irrigation frequency and Poultry manure on the growth and yield lettuce (*Lactuca sativa* L).

MATERIALS AND METHODS

Experimental Site

The research was carried out in a dry season of 2020/2021 at Irrigation and Demonstration Farm (lat. 12°27'13"N; long. 4°12'01"E; 197m above sea level), Waziri Umaru Federal Polytechnic Birnin kebbi. The area has a long dry season that is characterized by cool dry air (harmattan) that prevails from November to February/March; and hot dry air extending from March to May. The location was used for cultivation of vegetable and cereal crops.

Treatments and Experimental Design

The treatments consist of three (3) Irrigation intervals (A, B and C) and three (3) levels of nutrients (N1, N2 and N3). The treatments are; Daily water, 1day interval and 2days interval denoted as A, B and C; the levels of nutrients are; 2tonnes/ha, 4tonnes/ha and 6tonnes/ha denoted as N1, N2 and N3 respectively. The experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications.

Cultural Practices.

The land was leveled and constructed into seed beds. The plot size was 2 x 2m (4m^2). Space measuring 1m was left between blocks and 0.5m between plots. Seeds were broadcasted across seed bed. Watering can was used to apply water. Irrigation was scheduled according to the treatments. Manure was applied before planting and the amounts were applied according to treatments. Weeds were controlled manually using hand hoe at 2 and 4WAP and occasional hand pulling when necessary to ensure weed free plots.

Data Collection

Data were collected on the following growth and yield parameters.

Growth parameters

- Plant height (cm), Plant heights of 5 tagged plants were recorded at 4 and 6WAP. This will be achieved by measuring the plant from ground level

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to the tip of plant using a measuring tape/ruler. The mean will be calculated and recorded

- Number of leaves per plant: Number of leaves of 5 tagged plants was counted and the mean number per stand will be recorded for each plot at 4 and 6WAP

Yield parameters

- Fresh Yield Plot^{-1} (kg/plot): Fresh yield per plot was obtained from all the harvested plant within the plot using a weighing balance.

- Fresh Plant yield (t ha^{-1}): Fresh yield per plot were extrapolated to per hectare in tonnes.

Data Analysis

The data collected were subjected to analysis of variance (ANOVA) and means were separated using Least Significant Difference (LSD) and Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Soil Physical and Chemical Properties of Experimental Site

Physical and chemical properties of soil of study location prior to the experiments are presented in Table 1. The result indicated that particle size distribution at both 2020 and 2021 was dominated by sand, with values of 63.3 and 61.7%, respectively. For silt particles, it was 24.9 and 28.2%, respectively. Least particle size distribution was observed with clay having recorded 11.8% for 2020 and 10.1% for 2021. The soil was found to be sandy loam. This suggests that the soil in both locations has high macro porosity and low ability to retain water. Soil pH at 2020 (7.46) and 2021 (6.11) indicated that the soil at 2020 was slightly alkaline while that at 2021 was slightly acidic. Organic carbon, total N, available P and Ca were observed to be low in both locations. Exchangeable Mg was moderate, while exchangeable K and Na were higher in both 2020 and 2021 locations.

Table 1. Physical and chemical properties of soil of the experimental site during 2020/2021 dry session

Particles size analysis	2020	2021
	0–30cm depth	
P^{H}	6.60	6.11
Organic Carbon %	1.04	0.87
Organic Matter %	1.79	2.01
Total N %	0.084	0.093
P mg/kg	0.93	1.05
Ca Cmol/kg	0.50	0.78
Na Cmol/kg	0.52	0.62
Mg Cmol/kg	0.80	0.74
K Cmol/kg	1.95	2.56
CEC Cmol/kg	8.40	8.94
Sand %	63.3	61.7
Silt %	24.9	28.2
Clay %	11.8	10.1

Chemical Composition of Poultry Manure (PM)

Chemical compositions of manure prior to the experiments are presented in Table 2. The result indicated that, poultry manure contained organic manure carbon (g kg^{-1}) with values of 3.31 at 2020 and 3.25 at 2021. Poultry manure pH values of 6.10 and 6.20 indicated that, the manure was slightly acidic. However, the result indicated that poultry manure contained high amount of total N in 2021 (1.94 mg kg^{-1}) than in 2020 (1.71 mg kg^{-1}). The result shows an indication of the poultry manure capability of improving the soil nutrient status.

Table 2. Chemical composition of Poultry Manure (PM) during 2020/2021 dry Season

Character	Poultry manure	
	2020	2021
Organic carbon (gkg^{-1})	3.31	3.25
P^{H}	6.10	6.20

Total N (mg kg^{-1})	1.71	1.94
Na (mg kg^{-1})	135	142
K (mg kg^{-1})	2500	2500
Ca (mg kg^{-1})	0.45	0.60
P (mg kg^{-1})	7.63	8.24

Plant Height (cm)

Plant Height of Lettuce as Influenced by Irrigation frequency and Poultry manure rate in Birnin Kebbi during 2020/2021 dry season is presented in Table 3. Plant height of lettuce was significantly ($p<0.05$) affected by irrigation frequency in both seasons. Daily application of water produced significant taller plants followed by One-day interval application of water. Shortest plants were recorded by two days interval application of water. This trend could be linked to adequate supply of the photosynthetic raw material (water), which controls most of the plant physiological processes including height development. According to Brown (1984), high temperatures reduce the rate of photosynthesis in most plants. With the characteristic high temperatures of the experimental site, the rate of evapotranspiration was very high. Therefore, keeping irrigation interval above one day has greatly deprived the plant the available water for optimum photosynthesis, hence less dry matter was partitioned, which might have resulted in reduced size of plant (Samson and Ketema, 2007). Soil moisture and nutrient conditions were directly affected by the irrigation regime, when irrigation water can be used in a timely manner to offset the water consumption of crops, the crops can grow and develop rapidly. However, too much water can lead to extended oversaturation of soil moisture in the root zone, resulting in the inability of the root system to respire normally, thus inhibiting the growth of the plants, whereas insufficient water cannot meet the normal water requirements of the crops, resulting in slow growth (Yu *et al.,* 2016).

Poultry manure had significantly ($p<0.05$) affected plant height in both trials (Table 3). Application of 4t/ha of poultry manure gave significant taller plants followed by the application of 3t/ha of poultry manure while the untreated control gave significant shortest plants. This finding was buttressed the report of Bairwa *et al.* (2009) that, mineralization of manures aids in soil nutrient buildup that in turn leads to improved nutrient availability to the growing crop. Moreover, the organic manures are also significant sources of major and micronutrients much needed by plants (Tyagi *et al*., 2016). Similar results have been reported by Sharma *et al*. (2015). The better performance of crops with poultry manure in all the growth characters observed infers that the plant response to poultry manure which agrees with earlier finding of Olatunji and Oboh (2012). Significant interaction was not recorded between the irrigation frequency and poultry manure (Table 3).

Table 3: Plant Height of Lettuce as Influenced by Irrigation frequency and Poultry manure rate in Birnin Kebbi during 2020/2021 dry season.

Treatment	Plant Height (cm) 2020 Dry Season	2020 Dry Season	2021 Dry Season	2021 Dry Season
	6WAP	8WAP	6WAP	8WAP
Irrigation Frequency (days)				
Daily Application	23.67^{a}	24.51^{a}	30.01^{a}	27.33^{a}
One (1) day interval	22.98^{a}	25.01^{a}	27.87^{b}	24.47^{b}
Two (2) days interval	19.82^{b}	20.27^{b}	19.94^{c}	21.09^{c}
SE ±	0.793	0.861	0.937	0.739
Poultry manure (tha^{-1})				
Control	14.27^{c}	13.46^{c}	15.09^{d}	16.37^{d}
2	21.79^{b}	22.23^{b}	21.23^{c}	23.90^{c}
3	23.69^{ab}	23.19^{b}	25.78^{b}	26.59^{ab}
4	25.74^{a}	27.66^{a}	30.11^{a}	29.63^{a}
SE ±	0.687	1.003	0.837	0.691
Interaction				
I x PM	NS	NS	NS	NS

Within treatments, means in a column followed by same letter (s) are not significantly different at 5% level using LSD. NS = not significant; * = significant

Number of Leaves

Number of Leaves of Lettuce as Influenced by Irrigation frequency and Poultry manure rate in Birnin Kebbi during 2020/2021 dry season is presented in Table 4. Number of leaves of lettuce was significantly ($p<0.05$) affected by irrigation frequency in both seasons. Daily application of water gave significant higher number of leaves followed by One-day interval application of water while the lowest number of leaves was recorded with two days' interval application of water. As explained earlier, high irrigation frequency ensures production of more photosynthate, by supplying enough water to compensate for the high evapotranspiration that resulted due to high temperatures of the experimental area. This ensures concentration of more solutes in high irrigation frequency leaves than low irrigation frequency leaves (Yu *et al.,* 2016).

On the other hand, poultry manure showed significant ($p<0.05$) effect with respect to number of leaves. Application of 4t/ha of poultry manure gave significant higher number of leaves followed by the application of 3t/ha of poultry manure while the untreated control gave significant fewest number of leaves. Organic manure differs from chemical fertilizers due to the fact that they provide plants with the needed nutrients and at the same time build the soil structure (Akanbi *et al*., 2004 and Charoenpakdee, 2014). Soils with lots of poultry manure remain loose and airy, hold moisture and nutrients better, stimulate growth of soil organisms, and promote healthier root development. Organic fertilizers are made from plant and animal sources or from rock powders (Ogunlade *et. al*., 2009). Poultry manure has been reported to have a great ability to conserve nitrogen and improve plant nutrient uptake by acting as a buffering agent against undesirable pH fluctuations and by improving soil water availability through retention and aeration which ultimately contributes to better nutrients utilization by the crop (Adediran, 2015). There was no significant interaction between the irrigation frequency and poultry manure.

Table 4: Number of Leaves of Lettuce as Influenced by Irrigation frequency and Poultry manure rate in Birnin Kebbi during 2020/2021 dry season

Treatment	Number of Leaves 2020 Dry Season	2020 Dry Season	2021 Dry Season	2021 Dry Season
	6WAP	**8WAP**	**6WAP**	**8WAP**
Irrigation Frequency (days)				
Daily Application	9.33^{a}	13.38^{a}	10.01^{a}	14.33^{a}
One (1) day interval	9.27^{a}	11.90^{b}	9.33^{b}	12.47^{b}
Two (2) days interval	8.21^{b}	9.98^{c}	7.33^{c}	9.09^{c}
SE ±	0.234	0.367	0.937	0.739
Poultry manure (tha^{-1})				
Control	6.03^{c}	9.57^{c}	5.09^{d}	8.37^{d}
2	9.70^{b}	11.16^{b}	10.23^{c}	12.90^{c}
3	9.89^{b}	11.99^{b}	11.78^{b}	13.59^{ab}
4	10.67^{a}	15.39^{a}	12.11^{a}	14.63^{a}
SE ±	**0.478**	**0.337**	**0.873**	**0.691**
Interaction				
I x PM	NS	NS	NS	NS

Within treatments, means in a column followed by same letter (s) are not significantly different at 5% level using LSD. NS = not significant; * = significant

Fresh Yield

Total Yield (kg/plot) and Total Yield (t/ha)

Total Yield (kg/plot) of Lettuce as Influenced by Irrigation frequency and Poultry manure rates in Birnin Kebbi during 2020/2021 dry season is presented in Table 5. Total yield of lettuce per plot was significantly ($p<0.05$) affected by irrigation frequency in both seasons. Daily application of water and One-day interval application of water produced significantly higher yield per plot while the lowest yield per plot was recorded with two days' application of water. The frequent irrigation at Daily application of water or One-day interval application of water made water available at the root zone and this enhanced uptake of nutrients from the soil, transport these nutrients as well, and translocation of assimilates to shoots. Similar findings were reported by Wang *et al*. (2004) and Islam *et al*. (2009) who independently noted significant increase in dry matter production, plant height, number of leaves per plant and yield with frequent irrigation interval than with wider intervals. As a result, the moisture enhanced efficient uptake and utilization of nutrients for photosynthesis and leaf formation leads to higher plant weight, size and yield (Kang *et al*., 2004 and Slamet, 2017). The result showed that different levels of irrigation responded differently to yield of lettuce. Data from the experiment indicate that both Daily application of water and One-day interval application of water had highest total yield. The effect of irrigation frequency on yield has been investigated and similar results reported by Jordan *et al*. (2003).

However, poultry manure showed significant ($p<0.05$) effect with respect to fresh yield of lettuce (Table 5). Application of 4t/ha of poultry manure gave significant higher yield followed by the application of 3t/ha of poultry manure which in turn was higher than the application of 2t/ha of poultry manure. The untreated control produced significantly lowest yield. Maximum fresh yield was found with 4t/ha of poultry manure. This might be due to the availability of nutrients at the critical stages of the crop growth resulted early establishment, vigorous growth and development of plants leading to longer and wider leaves (Mal *et al*., 2013 and Slamet, 2017) and resulted into adequate slow but steady supply of nutrients which favored increased production of photosynthesis during the growth stages and consequently partitioning and allocation of the dry matter at the developmental stages of okra (Slamet, 2017). There was significant interaction between the irrigation frequency and poultry manure with respect to yield of lettuce in 2020 dry season. The interaction between irrigation frequency and poultry manure with respect to yield of lettuce (Table 6), the highest yield was recorded at Daily application of water, coupled with the application of 4t ha^{-1} of poultry manure. The lowest yield was recorded when irrigation frequency was kept at 2 days' interval coupled with the application of 2t ha^{-1} of poultry manure.

Table 5: Number of Leaves of Lettuce as Influenced by Irrigation frequency and Poultry manure rate in Birnin Kebbi during 2020/2021 dry season

Treatment	Fresh Yield 2020 Dry Season	2020 Dry Season	2021 Dry Season	2021 Dry Season
	Total Yield (kg/plot)	**Total Yield (tha^{-1})**	**Total Yield (kg/plot)**	**Total Yield (tha^{-1})**
Irrigation Frequency (days)				
Daily Application	2.50^{a}	25.00^{a}	2.35^{a}	23.50^{a}
One (1) day interval	2.40a	24.00^{a}	2.20a	22.00^{a}
Two (2) days interval	1.90^{b}	19.00^{b}	1.50^{b}	15.00^{b}
SE ±	0.311	0.871	0.471	0.398
Poultry rate (t ha^{-1})				
Control	0.30^{d}	3.00^{d}	0.55^{d}	5.50^{d}
2	1.70^{c}	17.00^{c}	1.65^{c}	16.50^{c}
3	2.00^{b}	20.00^{b}	2.10^{b}	21.00^{b}
4	2.60^{a}	26.00^{a}	2.75^{a}	27.50^{a}
SE ±	0.231	0.452	0.351	0.617
Interaction				
I x PM	NS	*	NS	NS

Within treatments, means in a column followed by same letter (s) are not significantly different at 5% level using LSD. NS = not significant; * = significant

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Table 6: Lettuce Fresh Yield (t/ha) as Affected by Irrigation Frequency x Poultry manure Interaction in 2020 Dry season.

Treatment	Poultry Manure		
Irrigation Frequency (days)	2t ha^{-1}	3t ha^{-1}	4t ha^{-1}
Daily Application	23.40^{d}	24.30^{c}	27.00^{a}
One (1) day interval	22.50^{e}	23.60^{d}	26.00^{b}
Two (2) days interval	20.20^{f}	22.30^{e}	23.40^{d}
SE ±	**1.983**		

Across columns and rows, means followed by the same letter (s) are not significantly different at 5% level using DMRT.

INTERACTION

The significant interaction between irrigation frequency and poultry manure on Fresh yield (Table 6). Have clearly indicated the interdependence and complimentary role of irrigation frequency and poultry manure in influencing the manifestation of the potentials of lettuce in terms of growth, development and yield as reported by Slamet (2017). Application of 4tha^{-1} attained higher yield when combined with Daily application of water or One-day interval application of water (Table 6). This might be due to adequate water available for efficient dissolving of the added manure as well as quickly mineralized and higher nitrogen content of Poultry manure (Table 2) that enhanced the growth and development of lettuce by increasing the rate of plant metabolic processes like photosynthesis and respiration which in turn helped to build the plant tissue (Slamet, 2017).

CONCLUSION

From the findings of this research, it may be concluded that Daily application of water or One-day interval application of water are most suitable for Lettuce production in Birnin Kebbi. Similarly, Application of 4t/ha of poultry manure gives greater yield advantage.

RECOMMENDATION

From the findings of this study, the following recommendations could be made:

1. Daily application of water or One-day interval application of water could be adopted for higher lettuce yield in the study area.

2. Application of 4tha^{-1} of poultry manure could also be considered since it recorded superior performance among the levels of manure tested in the study area.

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INFLUENCE OF UREA RATE AND GIBBERALLIC ACID CONCENTRATIONS ON BIOCHEMICAL CONTENT OF FLUTED PUMPKIN (*TELFAIRIA OCCIDENATLIS* HOOK F.) UNDER DIFFERENT IRRIGATION REGIMES

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ABSTRACT

Nitrogen rate, Irrigation regimes and growth hormones were among the major constraints concerning the production of Fluted Pumpkin in the north. Fluted Pumpkin is a leafy vegetable used as food, blood tonic and in managing diseases such as hypercholesterolemia, hyperglycaemia, anaemia, chronic fatigue, diabetes among others. Experiment was therefore conducted to investigate the inspiration of Nitrogen rate and Gibberallic concentration on biochemical content of Telfairia occidentalis in the Teaching and Research Farm of Faculty of Agriculture, Bayero University, Kano. The treatments consisted of 3 nitrogen levels (0,45 and 60kgN/ha), 3 irrigation regimes (3, 5 and 7days intervals) and 3 Gibberallic acid at (0ppm, 500ppm and 1000ppm). The experimental design was split-plot with nitrogen rate and irrigation regime in the main plot while GA_3 concentrations in the sub-plot treatment. Samples from each treatment combinations were determined for proximate content and mean values were presented as the means of triplicate samples in mg/100g. Proximate content (Tables 1-2) were inclined by irrigation regimes, nitrogen rate and gibberellic acid concentrations. The nutrient content gives the result as carbohydrate, crude protein and total ash to be higher; 31.25±3.1, 17.66±2.7 and 22.31±1.8 mg/100g respectively at 5 days' irrigation regime. Urea at the rate of 60kgN/ha recorded to have high content of carbohydrate (28.46±3.7 mg/100g). Gibberellic acid at 500ppm recorded higher mineral content of Na (29.34±1.7), Ca (57.42±2.9) and Fe (35.89±4.8) mg/100g.It is therefore recommended that Telfairia occidentalis soil should be supplemented with 60kgN/ha and 3days irrigation regime in combination of 500ppm GA_3 concentration. Similar research can be conducted on other crops by either increasing or decreasing the rate or concentrations of growth promoting compounds to determine the influence on proximate content.

Key words: Fluted pumpkin, Nitrogen rate, GA_3, Irrigation regime, Biochemical content, split-plot.

INTRODUCTION

Vegetables are good source of fibre, which lowers the body cholesterol level, consequently decreases the risk of cardiovascular diseases. Fluted pumpkin (*Telfairia occidentalis* Hook F) is a tropical vine grown in West Africa as a leaf vegetable and its edible seeds. The term fluted refers to the shape of the female flowers which resemble a flute. The crop is a member of cucurbitaceous (Akoroda, 1990a).

MATERIALS AND METHODS

The experiment was conducted in 2017 and 2018 dry season, at the teaching and research farm of the faculty of Agriculture Bayero University Kano. The seeds were planted one seed per hole at the depth of 5cm with the hilum facing downward (Musa, 2010). The treatments consisted of a factorial combination of Nitrogen rates (0 kg N/ ha, 45kg N/ha and 60kg N/ha), irrigation regimes (3days, 5days, and 7days) and Gibberallic acid concentrations (0ppm, 500ppm and 1000ppm). The treatments were laid out in Randomised split arrangement with irrigation intervals and nitrogen rate assigned to the main plots while Gibberallic acid concentrations was assigned to the sub-plot. The treatments were replicated three times. Nitrogen in the form of urea was applied in split, at planting and at 12 weeks after planting. 0kgN/ha (control), 45kgN/h and 60kgN/ha according to the treatment combination. Gibberallic acid at a concentration of 0ppm, 500ppm and 1000ppm was prepared using standard procedure described by John (1987). The whole experimental plots received uniform irrigation at 3 days' interval for 3weeks for the plant to establish, after which the irrigation treatment was introduced at 3, 5 and 7days interval. Pest and weed were controlled as described by (Olaniyi and Akanbi, 2007).

Determination of proximate Content of *T. occidentalis* Leaves

Telfairia occidentalis leaves were detached from six tagged plant from each treatment combination. Twenty gram (20g) was measured at 18 $WAGA_3A$. The samples were packed in envelopes with their label and gathered in oven and dried at 75°C until properly dried (Akanbi *et al*., 2007). The powdered samples were used for Biochemical analysis. All parameters for proximate content were obtained in triplicate and the mean values were recorded as 100ml/g (AOAC, 1990).

RESULTS AND DISCUSSION

Leaf Biochemical Content at Harvest at 18 WAGA$_3$A

Table 1 shows the effect of irrigation regime, nitrogen rate and Gibberellic acid concentration on leaf proximate content of *Telfairia occidentalis* at 18WAGA$_3$A final harvest in 2017 season. Irrigation regime influenced leaf carbohydrate content, Crude fibre content and total ash content. Irrigation at 5days interval had the highest carbohydrate content, crude fibre, crude protein and total ash, 31.25±3.2, 15.42±1.4, 15.42±1.4, 17.66±2.7 respectively while 3days irrigation had the lowest. Irrigation at 3 days' regime had the highest crude fat content 1.8±0.9.

Nitrogen at the rate of 60kg/ha had the highest carbohydrate content while the control had the least value. The untreated control recorded the lowest crude fibre content while nitrogen at 60kg/ha had the highest. However, nitrogen at 45kg/ha had the highest crude protein while the lowest protein content was observed from plots without nitrogen application. Nitrogen at the rate of 60kg/ha had the highest total ash content and crude fat content while the control had the least.

Applying GA$_3$ at the rate of 500ppm supported the highest carbohydrate content and the control had the least. Similar trends were observed on crude fibre and crude protein content. Highest total ash content was observed from plot treated with 1000ppm of GA$_3$ while the control had the lowest. The highest fat content was recorded from plots with 500ppm GA$_3$, while no GA$_3$ concentration recorded the lowest fat content.

Table 1. Effect of Irrigation Regime, Urea Rate (N) and GA$_3$ Concentrations on Biochemical content (mg/100g) of *Telfairi aoccidentalis* Dry Leaf Matter at 18WAGA$_3$A

	Proximate content				
Treatment	Carbohydrate	Crude fibre	Crude protein	Total ash	Crude fat
Irrigation Regime					
3days	27.46±3.4	16.26±1.6	13.52±4.6	19.61±1.3	1.83±0.9
5days	31.25±3.1	15.42±1.4.	17.66±2.7	22.31±1.8	1.75±0.7
7days	17.44±0.1	13.11±0.3	11.72±1.4	18.33±0.1	1.41±0.3
N(kg/ha)					
0	17.41±0.1	24.62±0.2	9.31±1.3	9.26±0.2	1.04±0.1
45	26.59±1.6	13.49±1.4	13.19±1.6	12.27±1.7	1.13±0.2
60	28.46±3.7	15.44±2.6	12.57±0.4	10.68±1.2	1.55±0.9
GA$_3$ (ppm)					
0	25.29±0.8	11.40±0.2	14.50±0.3	8.42±0.2	1.02±0.2
500	34.22±1.9	21.38±1.7	20.53±1.7	11.46±1.3	1.32±0.6
1000	28.52±1.8	18.40±1.4	16.51±1.5	15.31±1.5	1.02±0.3

Values are given as means of three replicates ± SD, WAGA$_3$A= Weeks after Gibberellic Acid Application.

Leaf Mineral Content at Harvest 18 WAGA$_3$ A

Table 2 shows the effect of irrigation regime, nitrogen rate and Gibberellic acid concentrations on leaf mineral content of *Telfairia occidentalis* at 18 WAGA$_3$A final harvests in 2017 season. Irrigation at 5 days' interval recorded the highest Sodium content while 3 days recorded the least. Similar observation was with Potassium (P), calcium (Ca), iron (Fe) and magnesium (Mg).

Applying nitrogen at the rate of 60kgN/ha recorded the highest value of sodium content (34.22±2.7) while the control had the lowest value. Similar trends were observed in Potassium, iron and calcium contents. However, applying 45kgN/ha of N had the highest value of Magnesium content (77.13±2.0) while the lowest magnesium content was observed where no nitrogen was applied 39.48±1.5).

Gibberellic acid concentration influence leaf mineral content. Spraying the crop with 500ppm GA$_3$ had the highest sodium (29.34±1.7) than the control, while the control recorded the lowest potassium content (12.21±1.8). Similar trends were observed for potassium (K) and Iron (Fe). Applying 1000ppm of GA_3 supported the highest Magnesium (Mg) content (64.29±3.1) while the control had the least value (49.3.7±2.9).

Table 2. Effect of Irrigation Regime, Urea Rate (N) and GA_3 Concentrations on Mineral Content (mg/100g) of *Telfairia occidentalis* Dry Leaf Matter at 18 $WAGA_3A$

		Mineral content			
Treatment	Sodium (Na)	Potassium (K)	Calcium (Ca)	Iron (Fe)	Magnesium (Mg)
Irrigation Regime					
3days	27.85±2.4	10.21±3.7	23.77±2.6	28.70±4.6	48.99±2.7
5days	33.19±2.6	13.38±2.8	28.34±2.7	38.31±3.9	66.79±3.6
7days	31.38±1.8	13.41±1.4	24.71±3.5	31.39±4.2	64.32±2.1
N(kg/ha)					
0	28.16±0.5	11.21±1.8	18.12±1.6	26.29±2.5	39.48±1.5
45	31.38±2.4	12.33±2.4	26.18±2.1	33.88±4.1	77.13±2.0
60	34.22±2.7	13.38±2.8	28.27±2.6	35.61±3.8	68.32±2.7
GA3(ppm)					
0	26.48±1.4	12.77±1.0	42.02±1.5	28.54±3.6	49.37±2.9
500	29.34±1.7	13.37±3.1	57.42±2.9	35.89±4.8	58.49±3.0
1000	27.37±2.4	14.69±2.8	46.82±2.5	27.48±4.5	64.29±3.1

Values are given as means of three replicates ± SD, $WAGA_3A$= Weeks after Gibberellic Acid Application.

Effect of Irrigation Regime on Biochemical Content of Fluted Pumpkin (*T. occidenatlis* Hook F)

Nutritional content of *T. occidentalis* leaves were significantly affected by watering regime. High carbohydrate content in *T. occidentalis* (31.25mg/g) gave rise to high energy value of about 293.13kcal/1000g. In line to this study is the report of Idris, (2011) that *T. occidentalis* leaves recorded high carbohydrate content.

Results of proximate analysis revealed that Irrigation interval of 5days yield higher contents of Mg, Ca, P, K and Fe. Prolonged watering regimes had a profound negative effect on concentrations of these mineral elements. This corroborated with the findings of Moftah and Al-Humaid, (2006) that concentration of N, P, K and Ca in tuberose plant leaves were substantially decreased by severe water deficit condition.

Effect of Urea (N) Rate on Biochemical Content of Fluted Pumpkin (*T. occidenatlis* Hook F)

Fertilizer rate affect the shoot nutritional content of *T. occidentalis*. In all the nitrogen level 0kgN/ha recorded the lowest values of nutritional and mineral content of the crop. The proximate content of *T. occidentalis* was high as the N rate increased, even though there was no significant difference observed between 45 and 60kgN/ha, which were higher than control. Crude protein content was observed to be higher as the N rate increased from 0kg to 60kg.

This result agreed with the findings of Olaniyi and Akanbi (2007), that the integration of N-fertilizer and organic fertilizer; and their sole application relatively improved moisture, fibre, crude protein, dry matter, fat and Ca contents of fluted pumpkin. This could be attributed to the successive increase in nitrogen level in response to urea fertilizer. The finding was contrary to that of Zakaria *et al*., (2006) that N fertilizer at the rate above 60kgN/ha was found to play no significant effect on protein content of leafy vegetables. Olsen *et al*., (1993) observed similar effect on pepper.

Split applications of nitrogen fertilizer at appropriate time corresponding to plant need, may increase Fe content of vegetables and crops nutritional value this agrees with the finding of Fei *et al*., (2008). Similarly, Fe content in different parts of the plant may be affected by nitrogen fertilizer.

Effect of Gibberellic Acid Concentrations on Biochemical Content of Fluted pumpkin (*T. occidentalis* Hook F)

Proximate content of *T. occidentalis* leaves was found to be affected by GA_3 concentrations. The edible portion of *T. occidentalis* had higher percentage Carbohydrate, crude protein, and crude fat at a 500ppm of GA (mg/100g). Total ash and crude fat were found to be higher at 1000ppm concentration. This agrees with the findings of Dybing and Lay, (1982) who observed the quality of plants with respect to oil latex, sucrose and protein content of *Datura innoxia* plants at high concentrations of growth hormones. Kadiri *et al.,* (1997) reported similar increase in vitamin A, B6 and C content of *Abelmoschus esculentus* and *Solanum gilo* following foliar spraying with IAA, GA_3 and coconut milk at various concentrations. The low percentage of crude fat in *T. occidentalis* leaves showed that vegetables are low in fat content; as such they are good source of dietary fibre. The high percentage of crude fat in the control treatment (1.32mg/100g) could be attributed to the inherent fertility of the soil.

The composition of Phosphorus, Potassium, Calcium, Iron and Magnesium were higher at 500ppm concentration. This finding could be attributed to the fact that GA_3 stimulates growth and nutritional content of vegetable crops when applied at right time and correct proportion. This agrees with the report of Ouzounidou *et al*., (2008); and Ashraf, (2010) that moderate concentration of GA_3 or Etherel had superior effect on various total yield and nutrient content of onion plant. Similarly, Mukhtar, (2008) reported higher increase in biochemical and some mineral content of *H. sabdariffa* at various concentrations of growth regulators.

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DOMESTICATION AND PERFORMANCE OF AMARA (*TACCA LEONTOPETALOIDES* (L) KUNTZE) UNDER DIFFERENT SPACINGS IN LAFIA NASARAWA STATE,NIGERIA.

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ABSTRACT

A field trial was carried out for two years (2018 and 2019 rainy seasons) to study the performance of Amara (Tacca leontopetaloides(L) Kuntze under different row spacings in Lafia Nasarawa State Nigeria. Three different intra row spacings (30; 45 and 60cm) with a uniform inter row of 30cm were used. The three row spacings were replicated three times and all the nine plots were laid in a randomised complete block design (RCBD). In both years of the study; the investigation revealed that the use of 30cm x 30cm row spacing produced larger tubers and higher yield per hectare than the rest of the spacings used.

Keywords; Amara, Spacing, Fertilizer Rate, Domestication, Performance.

INTRODUCTION

Amara (Tacca leontopetaloides (L) Kuntze) is a wild plant commonly called Amara in Plateau and Nasarawa States of Central Nigeria. At present, the crop plant is harvested from the wild and eaten as food derived from tubers that are similar to those of Irish potatoes. Amara tubers can be processed into flour which is made into a Gel meal prepared first by boiling water and making a soup sauce. The flour is added to make a fine gel and allowed to settle into a semi-solid tasty delicacy. Such a dish is highly cherished by the Taroh and Goemai people of Plateau state and the Alago people of Nasarawa state. Tacca leontopetaloides (L)Kuntze has up to 47 synonyms. The Basionym, Leontice leontopetaloides (L) appeared in species Plantarum. The common synonyms today are Tacca pinnatifida and Tacca involacurata. The local names are also many and varied with some related to the local communities in which they are found. They include; Bat flower, Polynesian arrowroot, Yabio, Fiji arrowroot, Kabusa, Masao and many more (NDB, 2004). Amara is a plant mostly found along the fringes of the Middle Belt of Nigeria, notably Plateau and Nasarawa states. Although the plant possesses such tremendous qualities in terms of food and medicine, it is yet to be domesticated in Nigeria and no literature has so far reported its production under conventional agronomic practices (e.g. spacing) as applied to crops such Irish potato, cassava and yam.

Considering its food values, gelling qualities and its medicinal qualities, Amara is worth a plant to be recognised as more than a wild collection. Thus, it should be cultivated under field conditions in addition to other similar tuber crops such as Irish potato, cocoyam, cassava and yam in order to provide additional food source to feed the ever-growing population of Nigeria.

MATERIALS AND METHODS:

A field trial was carried out at the Teaching and Research Farm of College of Agriculture, Lafia, Nasarawa State during the wet seasons of 2018 and 2019. Lafia is located at latitude 08.33 N and longitude 08 .32E in the southern guinea savannah of Nigeria. Data on rainfall distribution, maximum and minimum temperatures and relative humidity of the study area for the two years were obtained from the Nigeria Meteorological Agency (NIMET) of the Federal Ministry of Aviation, Lafia office. The site for the research was under maize production for three consecutive years. The soil of the area is sandy loam which is characterised by low N, P, and K as shown in the soil textural and chemical analyses table 1.

Table 1: Physical and chemical analyses of soil before planting

Soil properties at 0 – 3cm depth	
Physical composition	
Clay (g/kg)	8.64
Silt	11.14
Sand	80.22
Textural classification (USDA)	Sandy loam
Chemical composition	
pH (H_2O)	5.18
pH (0.01M$CaCl_2$)	5.04
TN%	0.13
Avail. P (ppm)	18.08
K (mg/kg)	0.16
OC (mg/kg)	0.42
C/N_c	3.23

Mg (Mol/kg)	1.45
Ca (Mol/kg)	2.21
Na (Mol/kg)	0.85
CEC (Mol/kg)	4.67

The treatments consisted of only one factor (spacing) with three intra row levels: 30cm, 45 cm and 60cm and a uniform inter row spacing of 30cm.

The three inter row spacings were replicated three times and all the plots were laid out in a randomised complete block design (RCBD). The experimental site in each of the two years under investigation was first harrowed twice at the onset of the rainy season. The area was then mapped out into plots of $9m^2$ each. The plots were then arranged side by side in rows of three blocks with each row having 3 plots. The space between blocks was 1m apart while the space between plots within a block was 50cm. Amara seedlings for transplanting were collected from the wild around college of Agriculture Lafia. The seedlings were then planted at a depth of 3-5cm. Weed control and other agronomic practices were applied at 2 weeks after transplanting.

Data collection:

Ten sampled plants were randomly chosen from each plot and tagged for data collection. From the ten tagged plants, growth parameters such as plant height and stem diameter were taken forthnightly while yield parameters such as tuber size, and tuber yield (weight) were obtained by harvesting, measuring and weighing tubers in $1m^2$ area of each plot.

Data analysis:

Analysis of variance (ANOVA) was carried out to test for the level of significance among treatments using F-test as described by Snedecor and Cochran (1967). Where the F test was significant, Duncan's Multiple Range Test(DMRT) was used to separate the means of the treatments.

RESULTS AND DISCUSSION

Plant height: Effect of row spacing on plant height of amara during the wet seasons of 2018 and 2019 is presented in table 2. Intra row spacing showed a significant effect on the growth height of amara in both years. In 2018, amara plants sown at 30cm x 30cm exhibited the highest growth rate throughout the sampling dates followed by plants sown at 30cm x 45cm. Amara plants sown at 30cm x 60cm were the least in growth rate throughout the study period. In 2019 wet season however, except at 12 weeks after planting, 30cm x 30cm and 30cm x 45cm were at par with each other on growth height while 30cm x 45cm produced taller plants (32.80cm) followed by 30cm x 30cm (29.00cm) with 30cm x 60cm having shorter plants throughout the study period (25.60cm). It should however be noted that during the study period, growth heights of plants sown at 30cm x 30cm and 30cm x 45cm were not significantly different from each other but both were significantly different from the heights of plants sown at 30cm x 60cm.

Stem diameter: The effects of row spacing on amara stem diameter grown during the 2018 and 2019 wet seasons are presented in table 3. In both years, Amara plants sown at a spacing of 30cm x 60cm produced higher stem diameter than those sown at 30cm x 45cm. Plants sown at 30cm x 30cm on the other hand, had the least stem diameter. In both years, plants sown at 30cm x 45cm and 30cm x 60cm had significantly greater stem diameter than those sown at 30cm x 30cm. This, by implication shows that with wider spacing, the plants on the field are less populated and hence there is little or no etiolation experienced by the plants on such plots. This result does not agree with that got by O-Sage Katanka *et al.* (1984) who reported that Xanthomonas and Colocasia spp sown at three different spacings: 1m x 1m, 1m x 0.75m and 1m x 0.5m and evaluated for leaf area index, number of leaves and dry weight of different parts determined were not statistically different.

Table 2: Effect of spacing on plant height (cm) of Amara plant at Lafia, Nasarawa State during 2018 and 2019 wet seasons

Treatments	Weeks after Transplanting (WAT)											
	2		4		6		8		10		12	
Row spacing (cm x cm)	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
30cm x 30 cm	27.70a	24.00ab	29.60a	25.40ab	30.90a	27.00ab	32.70b	28.10ab	33.60a	29.00ab	33.60a	28.88a
30cm x 45cm	22.70ab	27.00a	23.80ab	29.30a	25.20ab	31.00a	26.80ab	32.10a	27.20ab	32.80a	27.20ab	32.49a
30cm x 60cm	20.90b	19.70b	22.20b	20.20b	23.20b	21.30b	24.60b	22.20b	25.10b	22.90b	25.10b	25.63b
±SE	1.249	1.256	1.292	1.332	1.374	1.403	1.439	1.455	1.501	1.507	1.105	1.565

Means within a column of a set of treatments followed by unlike letter (s) are significantly different using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Table 3: Effect of spacing on plant stem diameter (cm) of Amara plant at Lafia, Nasarawa State during 2018 and 2019 wet seasons

Treatments	Weeks after Transplanting (WAT)											
	2		4		6		8		10		12	
Row spacing (cm x cm)	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
30cm x 30 cm	0.2727a	0.2680a	0.3327b	0.3253a	0.4367b	0.3680a	0.5567c	0.4347b	0.6693b	0.5387b	0.7773b	0.6507b
30cm x 45cm	0.2807a	0.2873a	0.3547a	0.3173a	0.4807a	0.3673a	0.5893b	0.4720a	0.7167a	0.5893b	0.8387a	0.7113a
30cm x 60cm	0.2773a	0.2713a	0.3733a	0.3013a	0.4880a	0.3560a	0.6173a	0.4720a	0.7320a	0.6140a	0.8440a	0.7187a
±SE	0.004	0.006	0.004	0.007	0.004	0.006	0.005	0.005	0.005	0.006	0.004	0.005

Means within a column of a set of treatments followed by unlike letter(s) are significantly different using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

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Tuber size (cm). The effects of row spacing on tuber size at harvest observed during the wet seasons of 2018 and 2019 are shown in table 4. In both years, the use of 30cm x 30cm row spacing produced tubers with larger sizes (22.71) cm while the use of 30cm x 60cm row spacing produced the least tuber size (17.03cm).

Table 4: Effect of row spacing on Amara tuber size (cm) in Lafia, Nasarawa State during 2018 and 2019 wet seasons.

Treatment	Mean tuber size(cm)	
	2018	2019
Row spacing (cm x cm)		
30cm x 30cm	22.71	22.03a
30cm x 45cm	21.53	18.65ab
30cm x 60cm	21.19	17.093b
±SE	0.440	0.713

Means within a column of a set of treatments followed by unlike letter (s) are significantly different using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Tuber yield (t/ha): The effect of row spacing on tuber yield observed during the 2018 and 2019 wet seasons is presented in table 5. It could be observed that in both years of the study, row spacing 30cm x 30cm produced higher mean yields of 6.93t/ha and 6.47t/ha that are significantly ($p < 0.05$) higher than that of 30cm x 60cm spacing which had the least tuber yield of 3.16 and 2.65t/ha. This result shows that amara plants would likely give higher yield when sown at close spacing of 30cm x 30cm or even less. This result tends to tally with that got by Arene et al (1984), when they evaluated the effects of spacing (10, 20, and 30cm), land preparation (ridges and flats) and mulch on two varieties of ginger in 1982 and 1983, the highest yields were obtained under mulch for both ridges and flats at 10cm spacing. Sulikeri et al (1977), also reported that the highest yield of egg plant cultivar 'malapur' were obtained at closer spacing with FYM at 10t/ha and NPK fertilizer.

Table 5: Effect of row spacing on Amara tuber yield (t/ha) grown in Lafia, Nasarawa State during 2018 and 2019 wet seasons.

Treatment	Mean tuber yield (t/ha)	
	2018	2019
Row spacing (cm x cm)		
30cm x 30cm	6.98a	6.47a
30cm x 45cm	4.51b	3.81b
30cm x 60cm	3.16c	2.65b
±SE	0.186	0.245

Means within a column of a set of treatments followed by unlike letter (s) are significantly different using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

SUMMARY

During the study period, it was observed that spacing of 30cm x 30cm led to the production of taller plants than 30cm x 45cm and 30cm x 60cm used. However, stems of the plants were thicker with spacing of 30cm x 60cm than the other spacings used. On the other hand, production of larger tubers was observed with spacing of 30cm x 30cm. Similarly, spacing of 30cm x 30cm led to higher tuber yield than the wider spacing used.

CONCLUSION

From the foregoing results, it has become evident that amara plant requires close spacing, may be closer than 30cm x 30cm to give higher yield.

RECOMMENDATION

From the results obtained, it can now be recommended that amara seedlings should be transplanted onto the field at a spacing of 30cm x 30cm or even less in order to obtain higher yield.

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EFFECT OF SETT SIZES AND PLANT POPULATION ON THE GROWTH AND YIELD OF GINGER IN ULTISOL ENVIRONMENT

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ABSTRACT

The use of inappropriate sett size and plant population has deprived farmers of ginger suitable yield. A field trial on the effect of sett size and population density on the growth and yield of ginger (Zingiber officinale Koswe) was conducted between April to October, 2018 and 2019 at Experimental farm of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria. The field trial involved three sett sizes of 10, 15 and 20 g and four plant populations of 1,000,000, 333,333, 500,000 and 250,000 plants per hectare. The trial was laid out in a 3 × 4 factorial arrangement fitted into randomized completely block design with three replicates. Data were collected on growth variables (plant height and number of leaves) and yield variables (rhizome length, rhizome weight and rhizome yield) at harvest. Plant height and number of leaves (m^{-2}) were significantly influenced by sett size and plant population. Plant height and number of leaves per unit area increased with increase in sett size and plant population. Sett size and plant bpopulation had no effect on rhizome length. Rhizome weight increased with increase in sett size and decreased with increase in plant population. Plants which grown from 20 g sett had the highest rhizome yield while a population of 1,000,000 plants per hectare had the highest yield which was comparable with the rhizome yield obtained from 500,000 plants per hectare. Therefore, it is suggested that ginger farmers in the humid agro ecological zone of Nigeria should adopt sett size of 20 g and 500,000 plant per hectare.

Key words: Growth, plant height, plant population, sett size, yield components.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an herbaceous perennial plant belonging to the order Zingiberales and the family Zingiberaceae. Ginger is used throughout the world as a spice or fresh herb for cooking and varieties of other value added products (Bartley and Jacobs, 2000). It is available in the form of oil, oleoresins, grind and fresh ginger.

Nigeria's annual total production is 117,000 tonnes (FAOSTAT, 2012), 10 % of which is locally consumed as fresh ginger and 90 % dried primarily for the export markets (Ajav and Ogunlade, 2014). The average crop yield per hectare is 3.52 t ha^{-1} (National Root Crop Research Institute, 2009). This present productivity level is quite low indicating the need to increases the yield level of this crop. The major problems responsible its low productivity among others were low soil native fertility, scarcity of planting material, suboptimal plant population, non-use of fertilizer inputs among other factors.

Plant population plays an important role in contributing to good growth and high yield, because very high plant population will create opportunity for plants to have a proper light interception for photosynthesis and may lead to high level of disease incidences. On the other hand, very low population will also reduce the expected yield per unit area. Inter and intra-row spacing is one of the major factor that influence the growth and development of ginger.

Limited availability and cost of planting materials is a major constrain to ginger production in Africa. Panting materials can account for about 50 % of the cost of the production. Large quantity of materials of seed ginger is needed to plant one hectare. If farmers do not purchase seed ginger, they may set aside 30 % of their harvest for planting the next year. Appropriate sett size should be determined to boost its production. Hence, this study was conducted to evaluate the effect of sett seizes and plant population on the growth and yield of ginger.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted between April and October, 2018 and 2019 at The Experimental Farm of Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria. The study area lied approximately on longitude 5^0 and $6^{\,0}$ 30 E; and latitude 5^0 and $6^{\,0}$ 30 N with elevation of 162m above the sea level. The climate is tropical rain forest with rainfall occurring between March and October with average temperature of 27 ^{0}C. The existing vegetation on the site were Guinea grass (*Panicum* maximum) and sensitive plant (*Mimosa* *pudica)*. The soil was characterized by well drained sandy loam soil and a moderately flat topography. The soil type was a typical ultisols which developed from a coastal plain sand.

Composite soil samples were taken from the site in both years of cropping and analyzed for their physical and chemical properties using standard laboratory procedures as outlined by Mylavarapus and Kennelley (2002).

Experimental design and treatment

The treatments were three sett sizes (2, 4 and 6 cm) and four plant population (250000, 333333, 500000 and 1000000 plants per hectare) laid out in a 3 × 4 factorial agreement fitted into a randomized complete block design with three replications. Each plot had a dimension of 1.0 × 1.0 m with 0.5 m between plot and 1.0 between blocks. Each replicate had 12 plots and total of 36 plots made up the experimental site. Experimental site occupied area of 1800m^2.

Cultural practices

The land was normally cleared, marked out into blocks and plots and beds constructed manually using hoe and spade. After which cured poultry manure was applied on marked out plots as basal at 15 t ha^{-1} four weeks prior to planting for equilibrium. Three seed setts (10, 15 and 20 g) of rhizome were sown on April 28, 2018 and 2019 according to the design of the experiment. The setts were planted in-situ at a spacing of 5× 20 cm, 10 × 20 cm, 15 × 20 cm and 20 × 20 cm corresponding to 1000000, 500000, 333333 and 250000 plants per hectare (pph) as per treatment. The planting depth was 3 cm and placement orientation was horizontal. Watering was done the following day by supplying equal quantity to every plot with watering can. The plots were weed-free, rain-fed, rouging of disease plants and land picking of pests were done when required. Rhizomes were harvested at 150 days (24 September 2017) from planting when the leaves and shoots have dried off.

Data Collection and analysis

Plant growth were monitored in-situ from four randomly selected inner row plants per plot using conventional growth indices which include plant height and number of leaves at 19 weeks after planting (WAP). Plant height were measured from the base of the plant to the apical meristem of the randomly selected plants with a calibrated metre rule and the mean computed. The fully extended leaves in all the sampled plants were counted, recorded and average computed.

For the yield variables, the tagged plants in each plot were harvested and data were collected on rhizome length, weight and yield. All harvested rhizomes from all sampled plants were measured using a metre rule and total sum divided by the number of rhizome to obtain the average rhizome length. Rhizome weight was measured by weighing all harvested rhizomes from sampled plants using digital weighing balance. Rhizome yield was estimated from rhizome weight as;

$$\text{Rhizomes yield} = \frac{\textit{Rhizomes weight}}{\textit{Plant spacing}} \times \frac{10000}{1000 \times 1000}\ \text{t ha}^{-1}$$

Year-wise data were analyzed using analysis of variance, followed by combined analysis over two yearss with Genestat Statistical Programme, Version 8.1 and significantly differences among treatment means were compared using Least Significant Difference (LSD) at 0.05 level of probability.

RESULTS

Properties of soils of the experimental site

The physical and chemical properties of the soil prior to cropping with ginger is presented in Table 1. Soils of both years were sandy loam textually, moderately acidic and organic carbon. Total nitrogen, available phosphorus and exchangeable cations were low.

Growth of ginger

The height and number of leaves of ginger as influenced by sett size and plant population is presented in Table 2. Sett size had significant ($P<0.05$) effect on plant height and number of leaves. Plant height and number of leaves increased with increase in sett size. Sett size of 20 g had the tallest and the leafiest plants.

Plant height number of leaves per m^2 varied among plant populations. Plants produced grown at 500,000 pph had the tallest but only significantly taller than plants grown at 250,000 pph. Plant grown at a plant population of 1,000,000 pph had the highest number of leaves.

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Table 1: Physical and chemical properties of the soil of the experimental site

Parameter	Value	
	2018	2019
Particle size (g kg^{-1})		
Sand	892.00	886.00
Silt	58.00	64.00
Clay	50.00	50.00
pH(H_2O 1:2)	5.60	5.80
Organic carbon (g kg^{-1})	13.40	16.80
Total nitrogen (g kg^{-1})	0.80	0.88
Available phosphorus (mg kg^{-1})	5.32	6.24
Exchangeable cation (cmol kg^{-1})		
Calcium	0.87	0.86
Magnesium	0.32	0.40
Potassium	0.21	0.24
Sodium	0.12	0.18
Exchangeable acidity (cmol kg^{-1})		
Hydrogen	0.12	0.12
Aluminum	0.04	0.04

Table 2: Growth of ginger plant as influenced by sett size and plant population

Treatment	Plant height (cm)			Number of leaves		
	2018	2019	Combined	2018	2019	Combined
Sett size (g)						
10	19.50	12.63	16.07	11.50	23.50	17.50
15	31.75	19.01	25.38	25.50	28.50	27.00
20	39.83	25.71	32.27	18.00	49.30	33.65
$LSD_{(0.05)}$	0.282	1.754	3.820	3.325	19.630	12.683
Plant population (plants per hectare)						
250000	26.00	17.80	21.90	13.67	28.70	21.19
333333	31.00	18.40	24.70	18.33	22.80	20.57
500000	32.67	19.24	25.96	20.67	20.80	20.74
1000000	30.44	21.04	25.74	16.33	62.80	39.57
$LSD_{(0.05)}$	0.326	ns	2.205	2.525	22.670	12.598
Interaction	ns	ns	Ns	ns	Ns	ns
Mean	30.03	19.12		17.25	33.77	
$LSD_{(0.05)}$ year	3.119			8.623		

ns - Not significantly at 0.05 level of probability

Yield components of ginger

Yield components as influenced by sett size and plant population are presented in Table 3. Yield components varied significantly (P<0.05) among sett size and plant population except rhizome length. Plants grown with 20 g sett had the highest rhizome weight and yield. Rhizome weight decreased with increase in plant population. The lightest and heaviest rhizomes were produced from plants grown with 1,000,000 and 500,000 pph, respectively. However, rhizome yield increased with increased in plant population. The highest yield was observed with plant grown in 1,000,000 pph plot but at par with plant grown in 500,000 pph plot.

Table 3: Rhizome yield components of ginger plant as influenced by sett size and plant population

Treatment	Rhizome length (cm)			Rhizome weight (g)			Rhizome yield (t ha^{-1})		
	2018	2019	Combined	2018	2019	Combined	2018	2019	Combined
Sett size (g)									
10	4.50	14.10	9.30	28.10	13.50	20.80	9.92	4.03	6.97
15	5.09	9.90	7.50	31.80	32.90	32.35	14.67	9.92	12.29
20	5.92	11.20	8.60	55.30	44.80	50.05	21.58	16.50	19.04
$LSD_{(0.05)}$	1.081	Ns	Ns	9.000	11.910	5.800	0.852	2.968	1.634
Plant population (plants per hectare)									
250000	7.33	9.50	8.40	57.60	33.30	45.45	13.44	7.33	10.39
333333	5.89	9.20	7.50	43.90	31.60	37.75	16.11	8.27	12.19
500000	3.33	18.70	11.00	36.20	31.70	33.95	18.11	9.67	13.89
1000000	4.11	9.60	6.90	13.90	25.10	19.50	13.39	15.33	14.61
$LSD_{(0.05)}$	1.248	Ns	Ns	10.310	ns	6.700	0.852	2.427	1.887
Interaction	ns	Ns	Ns	ns	ns	ns	ns	ns	ns
Mean	5.20	11.70		38.40	30.40	ns	ns	10.15	
$LSD_{(0.05)}$ year	4.690			4.740					

ns - Not significantly at 0.05 level of probability

DISCUSSION

The soil of the experimental site was an acidic sand, a typical ultisols developed from coastal plain sand. The soil had low fertility status. This necessitated the need for poultry manure application to improve the supplement nutrients that are deficient in the soil.

This field trial demonstrated that sett size and plant population had ample effects on the productivity of ginger. With sound agronomic practices coupled with appropriate sett size and plant population, ginger production can be successfully enhanced in the humid ultisols environment. The productivity of ginger in Nigeria is relatively low, about 10 t ha^{-1} (FAO, 2008). This low productivity was due to inadequate sett size as well as inappropriate plant population among other factors. Trial showed that plant growth arisen from the larger sett size grown more vigorous than the smaller sett size. This was in agreement with Sambo (1992) who reported higher growth rate was observed with largest sett compared with smaller setts. This finding was also in agreement with the observation of Misra and Neduchezhezhiyam (2004) in yam who found out that the sizes of tuber significantly affected the vine length. The higher growth accrued to plants grown with larger sett could be attributed to the availability of sufficient food reserves which probably encourage vigorous growth.

Plant height decreased with lower plant population (250,000 pph) and highest at 500,000 pph and comparable with 1,000,000 pph. This observation was in agreement with the findings of Desta (2008) in onion, who reported the decrease of plant height at very high population which could probably be due to intense competition for growth resources (physical space, water, nutrient and light) as a result of overcrowding resulting in decreased plant height. At 500,000 pph, plant attained highest height which might have adjusted its canopy in the vertical spacing by increasing inter-nodal length as a result of proper horizontal space (Yadav *et al*., 2013). Increasing plant population resulted in higher number of leaves up to 500,000 pph indication proper plant population with less competition for limited available growth resources. 1,000,000 pph exhibited similar number of leaves with 500,000 pph due to intense completion resulting in overshading and premature drying up of lower leaves.

Rhizome weight and yield increased with increase in sett size. This result is in conformity with Ravindran and Bacu (2005) on ginger in which larger setts produced higher yield than smaller sett. The yield variation between smaller and larger setts could be due to the fact that plants arising from the larger sett have more available nutrients to initiate vigorous and rapid growth and producing maximum yield and yield attributes than smaller sett size (Sengupta and Dasguta, 2011).

The rhizome weight decreased with higher plant population observed in this trial was in agreement with the finding of Sen *et al* (1990) who reported that yield per unit area was higher where cuttings are densely planted. The higher rhizome weight produced from lower plant population might be due to better availability of nutrients, water, physical space and light for the enlargement of rhizomes (Yadav *et al*., 2013). Competition for growth resources is less as the population maximum has not be attain and growth resources are high for plants, which results in a greater weight per plant. The highest rhizome yield accrued to 500,000 pph might be due to higher number of plants per unit area together with efficient utilization of nutrients by the growing plants (Yadav *et al*., 2013).

CONCLUSION AND RECOMMENDATIONS

Sett size and plant population have profound effect on the overall performance of ginger production in the humid forest environment. This study showed that rhizome yield was increased to ensure sustainability through the use of larger sett and appropriate plant population. Sett size of 20 g produced plant which had the tallest and leafiest in addition to having the heaviest and highest rhizome yield. 500,000 pph witnessed highest plant height and rhizome yield. Sett sizes of 20 g cropped at 500,000 pph had the most vigorous plants and rhizome yield. Based on these facts, the farmers should adopt sett size of 6 cm and 500,000 pph for optimum production of ginger in the ultisols environment

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PHYSIOLOGICAL PLANT GROWTH ANALYSIS AND GRAIN YIELD OF TWO VARIETIES OF GRAIN AMARANTH (*AMARANTHUS CRUENTUS* L.) IN RESPONSES TO PLANT POPULATION AND SOIL AMENDMENTS IN SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

Experiments were conducted at the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria in 2018 and 2019 cropping seasons to determine the effects of plant population and soil amendments on the physiological plant growth and yield of two varieties of grain amaranth. The treatments consisted of two varieties of grain amaranth (TE81/28 and CEN18/97), three plant populations (100,000; 60,000 and 40,000 plants ha^{-1}) and five levels of organic fertilizer (0, 25, 50, 75 and 100 kg N ha^{-1}) and 100 kg N ha^{-1} of inorganic fertilizer (NPK) to make up six levels of soil amendments. The treatments were laid out as split split plot in a randomized complete block design replicated three times. The main plot consisted of Amaranth varieties, while plant population and soil amendments were in the sub-plot and sub-sub plot respectively. Data on physiological plant growth parameters collected includes - crop growth rate, relative leaf growth rate, net assimilation rate, leaf area ratio and grain yield and were analyzed using the analysis of variance and treatment means differences were separated by the use of least significant difference at 5% probability level. The results showed that the organic fertilizer gave a progressive increase in the parameters measured with an increase in application rates, however, the in-organic fertilizer (100 kg N ha^{-1} NPK) significantly increased both the physiological plant growth indices compared to the organic fertilizer rates, while plant population was optimum in yield parameters at 60,000 plants ha^{-1} with CEN18/97 amaranth variety.

Key words: Amaranth, Variety, Soil amendment, physiological, analysis and Yield.

INTRODUCTION

Vegetables are valuable in maintaining the alkaline reserve of the body because of their high carbohydrate, fiber, vitamins and minerals contents and this makes each vegetable group contributes to diet in their own way (Robinson, 1990). Nutritionally, vegetables play key roles in alleviating food insecurity and ill health in developing counties. Studies have shown the potential synergetic effects of vegetables as neutraceuticals (Micro-nutrient dense and medicinal) (Kimiywe, *et al.,* 2007).

Like many other vegetables, grain amaranth is a widely cultivated plant which produces grain as well as leaves for human and animal utilization. Nutritionally, grain amaranth is valuable, and it is an economically important crop that all efforts should be put towards its increased production as food for man, animal and for commerce. Vegetables play valuable roles in alleviating food insecurity and ill health in man. Like many other vegetables, grain amaranth cultivated for the grain as well as leaves for man and animal utilization. It is a high protein pseudo-cereal plant with an upright growth habit with both the grain and leaves often being utilized for both man and animals as food (Saunders and Becker, 1984). Grain amaranth has the potential to substitute for expensive animal protein because of its comparable protein quality.

Soil fertility needs for grain amaranth production varies significantly depending on rainfall amounts and distribution (Mposi, 1999). Akiri, (2019) described soil fertility degradation as the second most serious constraint to food security in Africa. Sanchez (2002), and Akinrinde (2006) attributed the low soil fertility to nutrient leaching, fast mineralization of organic matter, erosion of the top soil by intensive rainfall, bush burning, over grazing, clearing and continuous farming activity thus, severely reducing the soil productivity and results in low economic returns from farming activities. Mafongoya *et al.* (2006) attributed the low productivity of tropical African soils to their low nutrient holding capacities, high acidity, low organic matter, poor soil structure and low water-holding capacity. The heavy use of inorganic nitrogenous fertilizers is known to be inimical to the activities of symbiotic nitrogen fixing organisms, such as *Rhizobium spp* (Akinrinde, 2006). Indeed, fear is being expressed about the contribution of N fertilizers to the environmental problems arising from N pollution of the earth's atmosphere with its oxides resulting in the greenhouse effect (FAO, 1994). Health issues and environmental concerns had drawn attention to organic agriculture aims at maintaining balance of nature and to produce crops without damaging the environment, besides its nutritional qualities.

Plant population studies conducted with grain amaranth often resulted in conflicting reports (Weber, 1987); with environmental factors being pinned as the most likely factors responsible for a greater part of the differences observed. Henderson *et al.* (2000) reported significant environment and plant population effects on grain yield and suggested that different plant population should be adopted in different environment.

Despite the nutritional and industrial value of grain amaranth, little attention has been given to it in Nigeria. The crop has not been extensively studied in the area of fertilization, plant population, varietal effects and responses to classical growth indices, hence the need for this study. The study was to produce appropriate production package for optimum grain yield with a view to encouraging the production of the novel species in Nigeria and to determine the appropriate soil amendment level, with the optimum plant population, varietal effects on grain amaranth growth and yield.

MATERIALS AND METHODS

Site description

The study was conducted in 2018 and 2019 cropping seasons on an Inceptisoil at the experimental farm of the National Horticultural Research Institute (NIHORT) Jericho, Idi-Ishin, Ibadan (7^0 30'N, 3^0 50'E); with altitude of 168 m above sea level and average annual rainfall of 1200.25 mm and 1320.00 mm (2018 and 2019) in the Rain forest zone of Nigeria.

Treatments and experimental design

Two varieties (TE81/28 and CEN18/97), three plant populations (100,000, 60,000 and 40,000 plants ha^{-1}) and six fertilizer levels (0, 25, 50, 75, 100 kg N ha^{-1} organic fertilizer and 100 kg N ha^{-1} in-organic fertilizer (NPK 15 15 15) were evaluated. Varieties were in the main plot while plant population and fertilizer rates were in the sub and sub-sub plots respectively. The experimental design was a 2 x 3 x 6 factorial arrangement fitted into split split plot and replicated three times. The area of each plot was 4m^2, well labeled and in correspondent to each treatement and separated by alley ways of 1m between plots. Ridges were constructed around each plot to prevent erosion. Mechanical land preparation was adopted using tractor drawn disc plough and harrow. The land was ploughed once and harrowed twice to give a well pulverized soil. Thereafter the field layout was carried out to mark out the appropriate number of treatment plots.

Seeds of the Amaranth species were planted directly on the prepared and labeled in the plots on the 5th and 7th of July in 2018 and 2019 respectively. Seeds were planted to obtain the population density of 100,000, 60,000 and 40,000 plants ha^{-1}. Properly cured organic fertilizer to supply 0, 25, 50,75 and 100 kg N/ha and in-organic fertilizer (NPK 15:15:15) to supply 100 kg N/ha were applied two weeks after planting by deep side placement at about 8-10 cm away from the base of the plants. Manual hand weeding was done two weeks after planting followed by weekly hand picking of weeds. After 40 days of planting, two plants were randomly selected, harvested per plot, the leaves carefully removed and the leaf area determined in the laboratory using leaf area meter model ATMK 2; Detal-T Device LTD. The whole plant's parts (leaves and stems) were then put inside separate envelopes and oven dried for 84 hours at 80^{0}C. The samples were allowed to cool, weighed to determine the dry matter per plot. At 54days after planting the same procedures above were repeated. The leaf area (size of assimilatory system) and dry matter (plant weight) obtained at 40 and 54 days after planting were then used to calculate the following components of classical growth analysis according to Beadle (1987).

Crop growth rate (CGR)

This is expressed in terms of the weight per unit area and time (kg m^{-1} S^1).

$$CGR = \frac{(W_2 - W_1)}{\quad} ;$$

W_2 = Final dry matter weight

W_1 = Initial dry matter weight

t_2 = final time

t_1 = Initial time

Relative leaf growth rate (RLGR)

This is expressed in terms of the growth of the leaf and the expansion in area.

RLGR = $\dfrac{}{t_2 - t_1}$;

A_2 = Final leaf area

A_1 = Initial leaf area

t_2 = final time

Net assimilation rate (NAR)

Net assimilation rate is defined as the increase of plant material per unit of assimilatory material per unit time.

NAR = $\dfrac{(W_2 - W_1)(\ln A_2 - \ln A_1)}{(A_2 - A_1)\cancel{(t_2 - t_1)}}$;

W_2 = Final dry matter weight

W_1 = Initial dry matter weight

A_2 = Final leaf area

A_1 = Initial leaf area

Leaf area ratio (LAR)

Leaf area ratio (LAR) is the ratio of the assimilatory material p

LAR = $\dfrac{(A_2 - A_1)(\ln W_2 - \text{Ln } W_1)}{(W_2 - W_1)\cancel{(\ln A_2 - \text{Ln } A_1)}}$;

W_2 = Final dry matter weight

W_1 = Initial dry matter weight

A_2 = final leaf area

Determination of yield:

The seed head of 10 randomly selected plants used for biological yield were harvested, sundried for five days and weighed to obtain the unthreshed seed weight per plot. The dried seed head obtained from the unthreshed seed weight was threshed manually by the use of club to get the seeds which were sundried for three days, and weighed to get the seed yield**.** The obtained data were subjected to analysis of variance **(ANOVA**) using Genstat Discovery 4 statistical package (2019) and mean differences were separated using LSD $_{0.05}$.

RESULTS

Effects on Physiological growth parameters

The results obtained shows that grain Amaranth growth rate increased significantly with increased rates of the organic fertilizer, however the use of the inorganic fertilizer resulted in significantly higher CGR values than the organic fertilizer for the two years of assessment (Table 1). The results also showed that planting grain Amaranth at low population rate of 60,000 plants per ha resulted in optimum crop growth rate than other rates for both years of assessment, while. variety CE18/97 was significantly superior to variety TE81/28 in both 2018 and 2019 cropping seasons. In similar trend, the relative leaf growth rate increased significantly with increased rate of the organic fertilizer while, the inorganic fertilizer resulted in significantly higher RLGR than organic fertilizer (Table 2) with variety TE81/28 producing significantly higher relative leaf growth rate than variety CEN18/97.

Table 1: Effects of soil amendment application, plant population and variety on crop growth rate of grain amaranth in 2018 and 2019

	Crop growth rate (g d^{-1})	
Treatments	2018	2019
Variety		
TE81/28	2.89	14.06
CE18/97	3.20	14.17
SED	0.002	0.011
$LSD_{0.05}$	0.008	0.0162
Plant population ha^{-1}		
100,000	2.98	13.05
60,000	3.02	14.63
40,000	3.14	14.66
SED	0.002	0.0008
$LSD_{0.05}$	0.005	0.016
Soil amendment (Sa) (kg N/ha)		
0	1.37	8.11
25 organic	2.13	10.54
50 organic	2.71	13.02
75 organic	3.33	15.09
100 organic	3.84	17.73
100 inorganic	4.90	19.78
SED	0.003	0.0033
$LSD_{0.05}$	0.006	0.0072

LSD = Least Significant Difference

Table 2: Effects of soil amendment application, plant spacing and variety on relative leaf growth rate of grain amaranth in 2018 and 2019

	Relative leaf growth rate	
Treatments	**2018**	**2019**
Variety		
TE81/28	0.25	1.62
CE18/97	0.24	1.60
SED	0.0002	0.0002
$LSD_{0.05}$	0.0007	Ns
Plant population ha^{-1}		
100,000	0.24	1.57
60,000	0.25	1.58
40,000	0.25	1.67
SED	0.0001	0.0112
$LSD_{0.05}$	0.0003	0.0232
Soil amendment (Sa) (kg N/ha)		
0	0.14	0.98
25 organic	0.20	1.27
50 organic	0.21	1.44
75 organic	0.23	1.64
100 organic	0.31	1.83

100 inorganic	0.39	2.51
SED	0.0002	0.0186
$LSD_{0.05}$	0.0003	0.0414

Ns: = not significant; LSD = Least Significant Difference

Results on Table 3 showed that application of different forms and rates of soil amendment, increased net assimilation rate (NAR)with increased rates of the soil amendments. The population of 60,000 plants per hectares resulted in significantly higher NAR than for other population density. The results further showed that variety TE81/28 had significantly better NAR than CEN18/97. The results on effects on leaf area ratio (LAR) showed same trend as obtained above for NAR (Table 4). However, none of the organic fertilizer rates performed better than the inorganic fertilizer. The lower population resulted in significantly higher leaf area ratio than the higher populations, with variety CEN18/97 producing significantly higher leaf area ratio than TE81/28. Seed yield trend indicated that the soil amendments resulted to higher seed production while, it was lower for the control treatment (Table 5). There were no significant mean differences resulting from plant variety but the seed yield was higher at the lower plant population.

Table 3: Effects of soil amendments, plant spacing and variety on the net assimilation rate of grin amaranth in 2018 and 2019.

Treatment	Net assimilation rate 2018	2019
Variety (Var)		
TE81/28	2.38	12.32
CEN18/97	2.02	11.96
SED	0.00009	0.0513
$LSD_{0.05}$	0.0004	0.1041
Plant population per ha^{-1}		
100,000	2.18	12.09
60,000	2.28	12.74
40,000	2.14	11.59
SED	0.0002	0.0408
LSD	0.0005	0.0837
Soil Amendments (Sa)		
0 kg N/ha (Organic)	0.89	5.02
25 kg N/ha (Organic)	1.12	6.92
50 kg N/ha (Organic)	1.71	9.64
75 kg N/ha (Organic)	2.45	13.73
100 kg N/ha (Organic)	3.05	16.89
100 kg N/ha Inorganic	3.99	20.62
SED	0.0002	0.0608
LSD	0.0005	0.1350

LSD = Least Significant Difference

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Table 4: Effects of soil amendments, plant spacing and variety on the leaf area ratio of grain amaranth in 2018 and 2019

Treatments	Leaf area ratio	
	2018	**2019**
Variety (Var)		
TE81/28	187.28	328.7
CEN18/97	203.69	374.7
SED	4.25	3.700
$LSD_{0.05}$	9.3	7.510
Plant population per ha^{-1}		
100,000	178.36	302.8
60,000	201.34	326.9
40,000	206.76	425.4
SED	2.00	4.540
LSD	4.62	9.360
Soil Amendments (Sa)		
0 kg N/ha (Organic)	62.98	164.31
25 kg N/ha (Organic)	140.42	192.92
50 kg N/ha (Organic)	171.82	277.82
75 kg N/ha (Organic)	211.63	346.31
100 kg N/ha (Organic)	261.53	449.23
100 kg N/ha Inorganic Fert.	324.51	679.72
SED	3.26	6.420
LSD	6.52	14.29

LSD = Least Significant Difference

Table 5: Effects of soil amendments, plant spacing and variety on the Seed Yield of grain amaranth in 2018 and 2019.

	Seed yield (kg /ha)	
Treatments	**2018**	**2019**
Variety		
TE81/28	3030	3712
CEN18/97	3196	3801
SED	64.0	63.0
$LSD_{0.05}$	Ns	Ns
Plant population per ha^{-1}		
100,000	2799	3536
60,000	3330	3963
40,000	3211	3770
SED	77.6	92.8
$LSD_{0.05}$	160.6	187.5
Soil Amendments (Sa)		
0 kg N/ha (Organic)	1818	2194
25 kg N/ha (Organic)	2216	2830
50 kg N/ha (Organic)	2765	3295
75 kg N/ha (Organic)	3080	3841
100 kg N/ha (Organic)	3855	4695
100 kg N/ha Inorganic Fert.	4946	5681
SED	110.0	107.8
$LSD_{0.05}$	221.1	215.8

Ns: = not significant; LSD = Least Significant Difference

DISCUSSION

Results of the present study showed that physiological growth indices including crop growth rate (CGR), relative leaf growth rate (RLGR), net assimilation rate (NAR) and leaf area ratio (LAR) of grain amaranth increased significantly with increased application of organic soil amendments. Nevertheless, the values were significantly inferior to inorganic fertilizer applied at 100 kg N ha^{-1}. The results were in line with the findings of Ogboma et al., (2009) who reported that crop growth rate increased significantly as the soil amendment increases and at low plant population. Abidin and Yassdar (1986) had earlier reported that N application encourages crop growth rate, while nitrogen fertilizer 50kg N/ha significantly increased crop growth rate compared with the control (Anika *et al.*, 2009). Similarly, Makinde *et al* (2009) reported that crop growth rate was significantly enhanced by N application to grain amaranth.

This study showed that net assimilation rate increased significantly with increase in soil amendments. The result was in line with the findings of Abidin and Yassdar (1986) who reported that N application increased net assimilation rate significantly over the control (no fertilizer). Similarly, NAR increased with decrease in plant population. Low plant population lead to less competition for light and moisture with resultant improved plant growth. Watson (1952) attributed variation in CGR to variation in leaf area index (LAI) and or NAR. The increase in CGR and NAR with increased N application observed in this study was in conformity with observations by Akintoye (1995) and Abayomi and Fagbenja (2005). The trends of the RLGR were similar to those of CGR. This was also similar to the observation of Abayomi and Fagbenja (2005) on maize. Pawar and Chetti (1996) had earlier reported positive relationship between grain yield and leaf area ratio in sorghum. In similar vein, agronomic practice that would minimize high leaf area ratio such as the use of optimum population density need to be given high priority for profitable commercial crop production. In this study, leaf area ratio was significantly increased by increase in soil amendment application, while plant population of 60,000 stands per hectares gave the highest leaf area ratio.

Results of this study showed that seed yield of grain amaranth increased with increased application of organic soil amendments, but the optimal values were obtained with inorganic fertilizer at 100 kg N/ha. Total seed yield showed that increased soil amendments resulted in significant increase in seed yields. The application of 100kg N/ha of inorganic fertilizer resulted to the highest seed yield. The results were in consonance with the findings of Elbehri et al, (1993), Myers (1998) and Bruce and Philip (2008) who reported a linear response of grain amaranth yield to N fertilization. The increase in grain yield as fertilizer application rates increased could have been due to increase in plant growth. This responsiveness of grain amaranth yield to nitrogen fertilization was also consonant with reports (Mahyers, 1996; Jefferson Institute, 1999; Bruce and Philipe, 2008). Kauffman and Weber (1990) also found grain yield to increase when nitrogen was applied at rates up to 90kg N/ha, to double at 100kg N and reduce at higher rates. Apaza-Gutierrez et al (2002) reported that grain amaranth yield showed a linear response to chemical and organic fertilizers. Manga et al. (2001) reported that the application of nitrogen fertilizer at the rate of 50kg N/ha was optimum for yield of grain amaranth in the Savanna ecological zones of Nigeria. Richard et al (2018) reported that the rate of increase in grain amaranth yield rose steadily as the rates of organic and inorganic N was raised from 0 to 100kg N/ha. Law Ogboma et al. (2009) reported that increase in organic soil amendment decreased the seed yield of grain amaranth agreed with the findings of Adediran and Banjoko (2002), who reported that the application of manure resulted in the enhancement of yield in the crop.

The results of this study on seed yield were in trend with reports on other crops. The 60,000 plants per hectares resulted to highest seed yield which was significantly higher than at 100,000 and 40,000 plants per hectare respectively. The results of the present study were at variance with the findings of Anon (1990) in a multi locational AICR trials conducted at Gujarat and Delhi who revealed that narrow spacing of 30cm resulted in higher yield over the wider row spacing of 75cm in grain amaranth. Seed yield responded similarly to the soil amendment and plant spacing in the two evaluated amaranth varieties. This was in line with Gutierrez et al (2002) who reported that grain yield in grain amaranth varieties responded similarly to variations in plant density.

CONCLUSION

Grain amaranth is a vegetable crop with high protein content that has great potential for sustainable food security if properly managed. The results revealed that plant height, number of leaves, stem girth as well as the grain yield of grain amaranth varied significantly with variety, plant population and soil amendments. Application of organic soil amendment at the rate of 100 kg N/ha gave the highest grain yield. Planting at 60,000 plants/ha produced optimum grain yield of the grain amaranth, compared to 100,000 and 40,000 plants/ha while CEN18/97 variety gave the highest grain yield which was not significantly higher than TE81/28 variety. In conclusion, application of 100kg N/ha of organic fertilizer was the best soil amendment for the grain amaranth production, while 60,000 plants per hectare was the most appropriate using CEN18/97 variety.

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GROWTH RESPONSE OF OIL PALM (*ELAEIS GUINNENSIS*) SEEDLINGS TO SELECTED PLANT RESIDUES IN ILE-OLUJI RAIN FOREST ZONE OF NIGERIA

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ABSTRACT

A nursery experiment was carried out to determine the response of oil palm (Elaeis guineensis) seedlings to selected plant residues in the nursery in the dry season. A Completely Randomnized Design (CRD) involved four treatments viz: pigeon pea shell, cowpea shell, NPK fertilizer with control experiment. The four treatments were replicated three times. Plant residues were applied at the rate of 0.03 kg/pot while N.P.K. 15-15-15 at 0.0005kg/pot four weeks after emergence (WAE) to single seedlings grown in polythene bags. The following parameters were recorded at bi-weekly intervals after seedling emergence: plant height, leaf area, stem girth, and number of leaves. Soil and plant analysis were carried out to determine nutrient contents. The lowest response was recorded for the control treatment, followed by N.P.K 15-15-15 while the highest was recorded for the pigeon pea husk followed by cowpea husk.

INTRODUCTION

Most of the nutrients in the soils of the Western part of Nigeria has depleted in nutrients status due to continuous agricultural uses and pressure from population explosion. Also, oil palm seedlings required much nutrients in their nursery stage due to this the soil must be amended with nutrients in order to support oil palm seedlings in the nursery. (Imogie *et al.,* 2016). Crop residues such as parts of leguminous plants (leaves and husk) can be used as mulching material which when degraded will increase the nutrient status of soil. Mulching with plant residues has been shown to be beneficial to crops (Agbona et al, 2020) and mulched seedlings subsequently grow better in the nursery (Gunn et al, 1961). Mulching shows significant improvements on other crops in the nursery. (Agbona *et al*, 2020, Agele et al, 2013, Agele *et al*, 2008). Agele *et al*., 2013 opined that plant residues improve crop growth and also stated that soil containing plenty of organic matter makes for better performance of crops and provides the best condition for seed to germinate. Similarly, Agele *et al*, 2013 and Agbona *et al* 2020 confirmed that organic matter helps in binding the soil aggregates and increases microbial activities. Iwueke, (1987) pointed out that the use of organic matter such as plant residues is not injurious to plants but rather improve their yields. This was also supported by Adebisi *et al*., 2020, Agbona *et al*, 2020 and Agele et al, 2013. Ayeni et al, 2020 pointed out that the major elements present in plant residues are nitrogen, phosphorus, magnesium and potassium. Similarly, Agbona *et al*., 2020 stated that nutrients supplied by plant residues are very important in the development and growth of seedlings in the nursery. The applications of plant residues inform of manure will no doubt produce healthy seedlings and reduce cost of production.

MATERIALS AND METHODS

The experiment was carried out at the nursery site of Teaching and Research Farm, Federal Polytechnic, Ile-Oluji during the dry season of 2020. The climate of the site can be described as sub-humid tropics with distinct dry and wet season. The annual rainfall ranges from 1100-1300 mm with moderately high temperature (24.4-28^{0}C). the relative humidity is moderately high all the year round. The organic materials used were collected from Farm Settlement Village, Ile-Oluji.

Experimental Design and Treatment

The experimental design used was randomized completely block design (CRD). In each plot there were 15 seedlings and the design was made up of 3 blocks with each block containing 60 seedlings. Making a total number of 180 oil palm seedlings for the experiments.

The polybags used for the experiment were filled with topsoil adequately watered and allowed to settle for 5 days to promote microbial activities. The polybags were arranged on a raised platform to prevent insect (termites) attack. Karate and Basudin were used to control termites and other insects at recommended rates. The germinated oil palm nuts were purchased from National Institute for Oil Palm Research (NIFOR) Benin and they were planted on 20th of March, 1999. Over 99% of the planted nuts emerged. There were four treatments replicated three times. The treatments were: Cowpea husks, Pigeon pea husks, N.P.K 15-15-15 and Control

0.003kg of the plant residues and 0.0005kg of NPK were applied. The plant residues were applied around the base of the plant while the ring method was adopted for NPK when the seedlings were 4-5 weeks old.

The following parameters were taken from random sample of five seedlings per treatment per plot fortnightly: plant height, stem girth, number of leaves and leaf area. Plant height was taken from the surface of the soil in the polybags to the tip of each seedlings, number of leaves per plant was counted while stem girth was determined by using a string tied round the stem and later spread on a metre rule. The leaf area was calculated by spreading the leaf on a big graph sheet and measurement taken in cm.

The soil samples connected from the area where the topsoil was collected for nursery planting were analysed for pH in water and 0.1M of $CaCl_2$. Soil organic matter was determined by using wet dichromate oxidation method. The sand, silt and clay contents were determined from the "particle size analysis" (Crockford and Nowell, 1956).

The exchangeable bases (cations K^+, Ca^{++} and Mg^{++}) were determined by extraction with 1M of NH4OAC and the extracts were determined on flame photometer. The available phosphorus was extractants by Bray P extrants and the filtrates were developed into blue colouration using Murphy reagent.

Plant residues analysis was done to determine % ash, % phosphorus % nitrogen and % magnesium. Nutrients analysis of the leaves of the seedlings was also carried out to determine % ash, % calcium and % magnesium to evaluate the uptake of nutrients by the plants.

Data Collection and Statistical Analysis

All the data collected were subjected to the analysis of variance (ANOVA). The least significance difference (L.S.D) was used to separate the means.

RESULTS

Soil Analysis

Table 1 shows the physio chemical properties of the soil used. The pH value was 6.90 in (H_2O) and 6.60 in ($CaCl_2$) indicating that the soil is slightly acidic. The percentage organic matter was 4.32, which is greater than the 3% recommended for oil palm. Nitrogen value is also 0.28% which is greater than 0.15% recommended for the production of oil palm. The value of other elements and cation exchange capacity of K, Ca and Mg are also shown in the table below.

Table 1. Soil Analysis before the Experiment

PH		%Organic Carbon	%Organic Matter	%Organic Nitrogen	Available Phosphorous (PPM)	Exchange Cations (mg/kg)		
1.1 H20 Suspension	2.1CaCl2 Suspension							
		2.51	4.32	0.28	18.69	K	Ca	Mg
6.90	6.60					17.89	125.40	80.95

Table 2 shows the soil analysis after the experiment. The result shows that the pH of the soil was reduced making a little more acidic except in the control experiment where the value increased by 0.5. the corresponding percentage of organic carbon, organic matter, nitrogen, available phosphorus and exchangeable of K, Ca, Mg of cowpea husks, pigeon husks and NPK (15-15-15) show slight increase, in their content. However, the soil analysis shows reduction in the corresponding values of the control experiment in relation to the soil test before the experiment.

Table 2: Soil Analysis after the Experiment

Treatments	pH (suspension)		% organic carbon	% organic matter	% Nitrogen	Available phosphorous In (ppm)	Exchangeable cation (mg/kg)		
	1.1 H_20	2.1 $CaCl_2$					K	Ca	Mg
Cowpea husk	6.80	6.40	2.57	4.43	0.35	28.70	10.89	127.40	85.40
Pigeon husk	6.70	6.00	2.66	4.58	0.37	26.69	32.89	126.42	82.29
N.P.K (15-15-15)	6.0	5.50	2.54	4.38	4.58	29.01	27.90	125.09	81.98
Control	6.85	6.50	2.30	3.97	0.10	15.70	15.75	120.20	80.06

Plant Analysis

Table 3 shows the result of plant analysis of pigeon pea and cowpea husk. The analysis clearly indicates that cowpea had more nutrients considering its ash, nitrogen, phosphorous, potassium, calcium and magnesium before the experiment.

Table 3: Plant Nutrient Analysis (%) of Cowpea and Pigeon Pea Husks

Sample	Ash	Nitrogen	Phosphorous	Potassium	Calcium	Magnesium
Cowpea husks	8.49	4.03	1.19	1.74	1.59	0.62
Pigeon pea husks	4.78	3.38	0.30	0.96	0.54	0.20

Leaf Analysis

Table 4 shows the result of leaf analysis after the experiment. The result indicates that NPK fertilized plants had the highest nutrient in its leaves.

Plant Height

At 2 WAE, plant height (Table 5) differed significantly as a result of the application of different plant residues and inorganic fertilizer. The effect of pigeon pea husks was significantly different from other treatments. NPK and the control were not significantly different in their effects. The pattern was similar for all other weeks.

Table 4: Leaf Analysis of Plants Fertilized with NPK and Crop Residues

Sample	Ash	Nitrogen	Phosphorous	Potassium	Calcium	Magnesium
Cowpea husks	11.75	4.24	2.20	1.18	0.10	0.02
Pigeon pea husks	11.01	4.15	1.88	0.66	0.09	0.02
NPK 15-15-15	11.97	4.77	2.06	1.14	0.11	0.03
Control	11.62	3.69	0.92	1.85	0.11	0.02

Table 5. Plant Height at Different Times After Treating Emerged Seedlings

TREATMENTS	WAE			
	2	4	6	8
Cowpea husks	24.5a	26.87a	32.56a	36.46a
Pigeon pea husks	28.7b	33.17b	33.41a	37.42a
NPK 15-15-15	18.91c	21.95c	21.95c	29.80b
Control	18.96c	22.95c	28.56b	31.80c
LSD (0.05)	2.5	3.23	2.73	1.96

WAE= Weeks after emergence

Leaf Area

The differences in the leaf area (Table 6) were significant at 2 and 8 WAE. At 8 WAE, the leaf area recorded for seedling treated with pigeon pea husks was significantly different from that recorded for cowpea. However, the two treatments were not significantly different from the control.

Number of Leaves

The analysis of variance (Appendix) shows that the number of leaves (Table 7) at 4,6 and 8 WAE was not significantly influenced by the number of leaves as a result of the treatment applied. At 8 WAE, number of leaves for cowpea and pigeon pea were the same statistically. The number of leaves for NPK (15-15-15) and the control were also the same. The two pairs were significantly different from each other.

Stem Girth

The analysis of variance showed that there were significant differences in the stem girth (Table 8) at 2 and 8 WAE due to the treatments applied. At 8 WAE, the stem girth for cowpea and pigeon pea were the same statistically. The stem girth for NPK and the control were also the same. The two pairs were significantly different from each other.

Table 6: Leaf Area

TREATMENTS	WAE			
	2	4	6	8
Cowpea husks	5.14a	4.65	4.37	5.43a
Pigeon pea husks	5.14a	4.96	4.02	5.862
NPK 15-15-15	3.85b	4.43	3.83	5.09c
Control	3.25a	4.78	3.90	5.59ab
LSD (0.05)	0.52	NS	NS	0.31

*NS = Not Significant, WAE = Weeks After Emergence

Table 7: Number of Leaves

TREATMENTS	WAE			
	2	4	6	8
Cowpea husks	3.73	3.47[a]	5.33[ab]	6.28[a]
Pigeon pea husks	3.67	4.07[b]	5.47[a]	5.86[b]
NPK 15-15-15	3.33	3.80[ab]	5.00[b]	5.62[b]
Control	3.49	3.53[a]	4.93[b]	5.52[b]
LSD (0.05)	NS	0.37	0.45	0.36

*NS = Not Significant, WAE = Weeks After Emergence

Table 8: Stem Girth

TREATMENTS	WAE			
	2	4	6	8
Cowpea husks	2.26a	2.70	3.9	3.89[a]
Pigeon pea husks	2.43	2.75	3.48	3.95[a]
NPK 15-15-15	2.13b	2.50	3.21	3.42[b]
Control	2.11b	2.48	3.17	3.43[b]
LSD (0.05)	0.2	NS	NS	0.18

*NS = Not Significant, WAE = Weeks After Emergence

DISCUSSION

From the results of the project, the effect of pigeon pea husks on oil palm seedlings was found to be better than other treatments in most of the parameters examined. It was closely followed by cowpea husks. Plants treated with cowpea husks compared favorably well with those treated with pigeon pea husks. This has evident in parameters such as number of leaves, stem girth and plant height. Although results from plant analysis confirmed that cowpea husks contain more nutrients than pigeon pea husks. Its better performance might be due to the rate of decomposition of the two plant residues. This confirmed the work of James (1999) who concluded that organic fertilizer takes time to decompose in their nature. According to him, the finer the particle sizes and the fresher the plant residues the faster will be the rate of decomposition.

Soil analysis before and after the experiment revealed that soil was rich in nutrients. Thus, small addition of nutrients from pigeon pea husks may have increase soil nutrient contents to meet the requirement of the seedlings.

The effect of NPK 15-15-15 was more pronounced than that of the control, experiment and this confirms previous report on the plant response to mineral fertilizer (Yaro *et al.,* 1989). They noted that fertilizer produces plant foods which readily dissolve into the soil for plant uptake.

The control plants competed very closely with the NPK fertilized plants due to initial high nutrient content of the soil. The soil analysis before the experiment confirms that the soil had 0.28% nitrogen and 4.32% organic matter while the final leaf analysis for the control plants gave 3.69% of nitrogen. The latter probably arose from the high organic matter content of the soil before experiment.

Pigeon pea husks increased the carbon content nitrogen, organic matter content, available phosphorous and exchangeable K, Ca and Mg of the soil. This was closely followed by cowpea husks. The NPK showed little increase in the soil nutrient value but it cannot be compared with the organic materials. This was in accordance with the work of Nyle, (1984) who reported that most dry matter of plant residues are mostly carbon and hydrogen and essential elements in such residues are mostly carbon and hydrogen and essential elements in such residues which helps in soil aggregation and also improve microbial activities. Similarly, Agbona *et al*. (2020) reported that plant materials decomposed easily if irrigation is maintained, thus nutrients are released subsequently to the plant rooting zones. Also, Adebisi *et al*. (2020) and Ayeni *et al*. (2020) reported same results in using plant waste and residues as organic materials in raising crops.

Generally, economic analysis would most likely indicate the superiority of pigeon pea husks to the remaining treatments. Although one would expect that NPK (15-15-15) might perform better as a result of its high percentage of Nitrogen uptake in the plant leaves (leaf analysis). Its effect is not significant due to its initial toxicity on the seedlings earlier at the beginning of the experiment. Before the seedlings picked up, other treatment had outgrown it. This clearly supports the previous work of Rajaratnam (1973) who stated that inorganic fertilizers can be toxic to oil palm seedlings in nursery.

CONCLUSION AND RECOMMENDATION

Oil Palm (*Elaeis guineensis*) responded positively to the organic materials (plant residues) used as a result of easy release of its nutrients for plant uptake and it improvement of microbial activities. Plant residues increased the organic matter content and exchangeable cations of the soils. Based on the result obtained from this experiment, I hereby recommend leguminous plant residues most especially pigeon pea husks for raising oil palm seedlings in the nursery.

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RESPONSE OF BELL PEPPER (*CAPSICUM ANNUUM* L.) TO DIFFERENT CONCENTRATIONS OF GIBBERELLIC ACID (GA_3) AND COCONUT MILK IN SUDAN SAVANNAH OF NIGERIA

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ABSTRACT

To investigate the efficacy of different concentrations of Gibberellic Acid (Ga_3) and Coconut Milk on the performance of Bell pepper (Capsicum annuum l), a field trial was conducted at the nursery site of Shelterbelt Research Station Kano Latitude 12^0 1' 42.20" to 12^0 1' 43.65" N and Longitude 8^0 30', 9.06" to 8^0 30' 29.07" E), during the rainy season of 2020. The aim of the research was to determine the effect of gibberellic acid (GA_3) and coconut milk on growth and yield of Red bell pepper (Capsicum annuum). The experiment was laid on complete Randomized Block Design (CRBD). The treatments consist of Gibberallic acid (GA_3) at three concentrations (100ppm, 200ppm and 300ppm) and Coconut milk at three levels (4%, 5% and 6%). The experiment was replicated three times and the parameters measured were the growth and yield characters. The data collected were subjected to analysis of variance (ANOVA) using and means were separated using Duncan Multiple Range Test (DMRT) at 5%. From the result obtained 300ppm Gibberallic acid shows a significant effect on plant height at 4WAT, all the GA_3 concentrations had a significant effect ($p<0.05$) on Number of Fruits plant^{-1} and fruits weight plant^{-1} whereby more number of fruits plant^{-1} (12.66) and highest fruit weight plant^{-1} (68.00g) were recorded with 200 ppm gibberellic acid. However, number of leaves plant^{-1}, number of branches plant^{-1}, and number of flowers plant^{-1} were not affected by the application of GA_3 on Capsicum annuum. Coconut Milk also shows significant effect on vegetative growth and yield components of Capsicum annuum where by significantly more Number of flowers (15.02 and 14.35), fruits plant^{-1} (13.68 and 12.35) and fruit weight plant^{-1} (70.11.00g and 70.01g) were recorded with 6% and 5% Coconut milk respectively. The findings of the research revealed that application of GA_3 have more effect on yield than the vegetative growth whereby Coconut milk have significant effect on both vegetative growth and yield of Capsicum annuum.

Key words: *Capsicum annuum;* Gibberellic Acid; Coconut Milk

INTRODUCTION

Red bell pepper (*Capsicum annuum L*), also known as sweet pepper, green pepper, or pimento, belong to the family Solanaceae. The crop is native of tropical South America especially Brazil which is thought to be the original home of pepper (Islam *et al*., 2010). It is a warm season annual crop when grown in temperate regions and a herbaceous perennial when cultivated in tropical areas. It is an important vegetable crop all over the world which ranks second in the vegetable cycle after tomato (Anonymous, 1989). Red bell pepper is a delicious vegetable that can be enjoyed either raw or cooked and it is an excellent source of antioxidants, vitamin A and C as well as nerve-supportive vitamin B6, it is also a very good source of heart-healthy fiber, vitamin E, folate, potassium, vitamin K as well as the enzyme-supportive molybdenum.

Nigeria still imports pepper, thus indicating that there is high demand for pepper locally despite the good weather, soil and numerous potential of pepper in Nigeria not to talk of the export, pepper yield in Nigeria have been very low compare to Western Europe, the low yield of pepper could be attributed to some production challenges which include diseases, pests and poor management practices (Jaliya, 2006).

Currently, growth enhancing substances are commonly used in agriculture to enhance productivity (King and Evans, 2003). Plants growth enhancing substance can be regarded as any material or substance which when apply to growing plant either by foliar spray, injection or by drilling into soil in low concentration would influence the plant growth rate above or below normal process and result to more productivity of the crop (Anonymous, 2016). Gibberellic acid is one of the most important growth stimulating substances used for promoting cell elongation, cell division and thus promotes growth and development of many plant species (Anonymous, 2003). Gibberellic acids are used in Agriculture as plant regulators to stimulate both cell division and cell elongation that affect leaves as well as stems (eventually affecting fruit development and fruit set) (Bhaskar and Rao 1998).

Many research has been done over the years to determine the chemical composition of coconut milk and in particular the active growth promoting factors , Among the known components reported by Raghavan (1977), are inorganic ions such as phosphorus (P), magnesium, potassium, and sodium, amino acids including glutamic acid, asparagine, proline, and glycine, organic acids particularly malic acid, vitamins, sugars, auxins, cytokinins, and giberrellins and other miscellaneous substances that help to promote plant growth and yield (Raghavan, 1977).

As earlier reported that Nigeria do still imports peppers because of their high demand, as such there is need to find a way of increasing peppers production and yield locally. Many studies have shown that foliar application of Gibberellic acid with optimum concentration increased yield of many crops compared to traditional farming (Paroussi *et al*., 2002), also Coconut milk is an organic plant growth enhancer which contains many components that help plant growth and yield. Therefore, the aim of this research is evaluate the effect Gibberellic acid and Coconut milk on the growth and yield of Red bell pepper (*Capsicum annuum L).*

MATERIALS AND METHODS

Experimental Site

The Research was Conducted during the rainy season of 2020 at the Nursery site of Shelterbelt Research Station Kano Latitude 12^0 1' 42.20" to 12^0 1' 43.65" N and Longitude 8^0 30', 9.06" to 8^0 30' 29.07" E), which is in Sudan savannah ecological zone of Nigeria.

Planting Media

The planting media consisted of four different components (Cow dung, River sand, Top soil and Saw dust) mixed in the ratio of 1:1:1:1. 42 rubber pots of 25cm width and 15cm depth were filled to serve as growing media. The seedlings of *Capsicum annuum* were sourced from sub-station of National Horticultural Research Institute (NIHORT) research farm, Kadawa irrigation site Kura local government area, Kano.

Treatments and Experimental Design

The treatments consisted of gibberellic acid at three levels, 100ppm, 200ppm and 300ppm and coconut milk at three levels, 4%, 5% and 6% and distilled water as control. The experiment was laid out on a Complete Randomized Block Design (CRBD) which was replicated three times, each replication consisted of seven plots, with two pots per plot and each pot consisted of two plants. Data was collected from the two plants per plot.

Preparation of the Treatment Concentrates

Gibberellic acid was prepared in the laboratory as described by John (1987), the stock solution of the GA_3 was prepared by dissolving 0.125g of GA_3 powder in a 60ml of distilled water. This stock solution was then used to prepare the different concentration of the GA_3 as follows; 100ppm was prepared by diluting 25ml of stock solution with 475ml of distilled water, 200ppm was prepared by diluting 50ml of stock solution with 450ml of distilled water and 300ppm was prepared by diluting 75ml of stock solution with 425ml of distilled water (John, 1987). While the coconut milk was prepared using Junita *et al*., (1988) method whereby 1kg of the fresh coconut flesh was crushed and blends using an electric blender in about 1000ml of water to obtain the aqueous extract of the coconut milk. 4% was obtained by diluting 4ml of the aqueous extract of coconut milk in 96ml of distilled water, 5% by diluting 5ml of the aqueous extract of coconut milk in 95ml of distilled water and 6% by diluting 6ml of the aqueous extract of coconut milk in 94ml of distilled water.

Application of the Treatments and Data Collection

Foliar application of the treatment was carried out using hand sprayer at vegetative, flowering and fruiting stages of the *Capsicum annuum* transplanted on the filled rubber pots at the age of four weeks after sowing. The data collected were subjected to analysis of variance (ANOVA) using Genstat and significant different means were separated using Duncan Multiple Range Test (DMRT).

RESULT AND DISCUSSION

Plant Height (cm)

Table 1 shows the Effect of Gibberellic acid and Coconut milk on plant height of Red bell pepper in the Nursery. The result shows significant difference ($P<0.05$) between the treatments at 4 weeks after transplanting. At 4 weeks after transplanting the highest plant height was recorded with treatment CM_6 Followed by treatment CM_4 and G_{300} statistically similar, followed by the rest of the treatments with exception of treatment G_{200} that

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recorded the least plant height. However, the Result shows no any significant different among the treatments at the remaining sampling period of the trial.

Table 1: Plant Height of Red bell pepper (*Capsicum annuum* L.) as affected by the application Gibberellic acid and Coconut milk in the Nursery

Treatments		Plant Height		
GA_3/CM Conc'.	4 WAT	6 WAT	8 WAT	10 WAT
G_{100}	14.98^{bc}	22.19	27.29	33.29
G_{200}	13.01^{c}	21.16	25.48	30.76
G_{300}	16.19^{ab}	23.84	27.38	34.39
CM_4	16.66^{ab}	23.63	27.37	31.51
CM_5	15.36^{bc}	22.94	27.50	36.19
CM_6	18.45^{a}	25.26	28.02	32.21
CONTROL	15.32^{bc}	24.86	28.82	35.36
LSD (5%)	2.254	4.320	4.852	5.583
Significance	*	NS	NS	NS

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT).

Number of Branches Plant^{-1}

Table 2 present the Effect of gibberellic acid and coconut milk on number of branches per plant of red bell pepper (*Capsicum annuum l*) in the Nursery. The result shows significant difference (P<0.05) between the treatments at 8 weeks after transplanting, more number of branches were recorded with plant treated with treatment CM_5, followed by the rest of the treatments statistically the same with exception of treatment G_{200} which recorded the lowest number of branches per plant.

Table 2: Effect of Gibberellic acid and Coconut milk on Number of Branches Plant^{-1} of Red bell pepper (*Capsicum annuum* L.) in the Nursery.

Treatments		Number of Branches		
GA_3/CM Conc'.	4 WAT	6 WAT	8 WAT	10 WAT
G_{100}	0.34	6.83	10.84^{ab}	12.68
G_{200}	0.34	4.50	8.34^{b}	9.51
G_{300}	1.01	8.60	11.34^{ab}	13.01
CM_4	0.15	6.00	12.18^{ab}	14.01
CM_5	0.00	7.16	13.34^{a}	14.61
CM_6	0.84	6.33	11.18^{ab}	13.51
CONTROL	0.67	6.66	12.51^{ab}	14.68
LSD (5%)	1.375	5.191	4.320	4.833
Significance	NS	NS	*	NS

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Number of Leaves Plant^{-1}

Table 3 Present the Effect of gibberellic acid and coconut milk on number of leaves plant^{-1} of red bell pepper (*Capsicum annuum* L.) in the Nursery. The result shows significant difference (P<0.05) between the treatments at 4 weeks after transplanting. At 4 Weeks after transplanting more number of Leaves were recorded with to reatment CM_6 followed by the rest of the treatments statistically similar with exception of treatment CM_5 and G_{100} that recorded the lowest number of leaves per plant. However, there were no significant difference (P<0.05) between the treatments during the rest of the sampling period of the trial.

Table 3: Number of Leaves of Red bell Pepper (*Capsicum annuum* L.) as affected by the Application of Gibberellic acid and Coconut milk in the Nursery

Treatments		Number of Leaves		
GA_3/CM Conc'.	4 WAT	6 WAT	8 WAT	10 WAT
G_{100}	8.04^{b}	32.50	60.50	65.01
G_{200}	8.45^{ab}	34.00	55.67	60.68
G_{300}	11.42^{ab}	44.33	61.83	66.41
CM_4	9.42^{ab}	29.83	47.67	53.34
CM_5	8.09^{b}	30.83	43.00	53.01
CM_6	12.31^{a}	35.17	59.67	64.31
CONTROL	9.84^{ab}	38.33	64.50	69.34
LSD (5%)	3.632	24.800	33.760	34.710
Significance	*	NS	NS	NS

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT).

Number of Flowers and Total Yield Plant^{-1}

Table 4 shows the Effect of Gibberellic acid and Coconut milk on Number of Flowers and total fruits yield plant^{-1} of Red bell pepper (*Capsicum annuum* L.) in the Nursery. The result shows significant difference (P<0.05) between the treatments at 8 weeks after transplanting, more number of flowers were recorded with Treatment CM_5 and CM_6 statistically the same, followed by the rest of the treatments G_{100}, G_{200} and control statistically at par, while the least number of flowers per plant were obtained with treatment G_{300} and CM_4. However, there were no significant differences between the treatments at 6WAT. While the effects of Gibberellic acid and Coconut milk on total yield of Red bell pepper plant^{-1} result obtained shows that there was no significant difference (P<0.05) between the treatments in regards to total Number of harvested fruits plant. However, the result shows significant difference (P<0.05) between the treatments based on weight of the total fruits harvested plant, treatment G_{200} and CM_5 statistically similar, recorded the highest fruit weight, followed by rest of the treatments statistically the same, however, the least fruit weight was recorded with treatment CM_4 and the control.

Table 4: Effect of Gibberellic acid and Coconut milk on Total Yield Plant^{-1} of Red bell pepper (*Capsicum annuum* L.) in the Nursery

Treatments	Number of Flowers plant^{-1}	Number of Fruits Plant^{-1}	Total Fruits weight Plant^{-1} (g)
GA_3/CM Conc'.	8WAT	At Harvest	At Harvest
G_{100}	9.02^{ab}	10.67	47.65^{ab}
G_{200}	7.02^{ab}	13.68	70.01^{a}
G_{300}	5.02^{b}	12.35	52.65^{ab}
CM_4	4.68^{b}	5.35	28.68^{b}
CM_5	14.35^{a}	11.68	70.11^{a}
CM_6	15.02^{a}	11.35	55.00^{ab}
CONTROL	9.67^{ab}	6.68	30.65^{b}

LSD (5%)	8.190	8.056	31.780
Significance	**	NS	**

Means followed by the same letter(s)in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT).

DISCUSSION

Effect of Gibberellic Acid (GA_3) on Growth and Yield of *Capsicum annuum* in the Nursery

Application of GA_3 at 300ppm have a significant effect on height of *Capsicum annuum* in the Nursery at 4WAT this finding is inconformity with the finding of Gut *et al.,* (2006) that conducted a research to study the impact of GA and Nitrogen on plant height and other growth parameters of *Araucaria heterophylla*, maximum height of 42.4cm and 36.1cm were obtained using 300ppm and 2.0g N respectively. It was also reported by Qureshi *et al.,* (2013) that GA alone or in combination with other materials such as $CaCl_2$ significantly increases plant height.

However, in this research finding 100ppm and 200ppm were found to be insignificant on plant height of *Capsicum annuum* in the Nursery this may be due to the inability of GA_3 to make the cell expand after cell division as reported by Haber and hippold (1960) that cell division alone cannot result in increased growth of tissues because the division of cell into two each one half the size of parent cell will not result in enlargement, cell expansion after cell division is necessary for normal growth.

Number of leaves and Branches of *Capsicum annuum* in the Nursery were not affected by the Application of GA_3 at all the level of concentrations in this research finding, The result is similar with what was obtained by Asadi *et al.,*(2013), who studied the influence of various GA_3 concentration on fruit yield and vegetative properties of strawberry plants, they concluded that GA_3 Application had no significant effect on number of leaves and branches crowns whereas runners and number of flowers increased significantly.

Application of GA_3 have no significant difference between the treatments on number of flowers per plant of *Capsicum annuum* in the nursery, this may be due to increase of vegetative growth which consequently decrease reproductive growth as reported by Baghel *et al.,* (2004), that in many woody plants and fruits, GA inhibits flower formation, in such case Growth retardants.

Yield of *Capsicum annuum* in the nursery was significantly affected by the application of GA_3 at all the concentrations, plant treated with GA_3 gives more fruits weight than the control this may be due to beneficial effect of GA_3 in delaying the formation of abscission layer as reported by Rani and Brahmachari (2004). The result of this finding is inconformity with the finding of Gut *et al.* (2012) that GA_3 application help in improvement in number of fruits per cluster, fruit set and marketable fruit number per plant and extended maturity time and harvest.

Effect of Coconut milk on Growth and Yield of *Capsicum annuum* in the Nursery

The research findings of this trial shows significant effect of coconut milk on plant height of *Capsicum annuum* in the Nursery, 6% and 4% coconut milk significantly increase plant height at 4WAT, this may be due to the presence of cytokinin in the coconut milk, this finding is in agreement with the finding of Carey *et al.,* (2007) who used cytokinin to increase plant height in petunia. Coconut milk at 6% was found to increased the number of leaves per plant of *Capsicum annuum* in the Nursery and 5% coconut milk significantly increase number of branches, this result is in conformity with the finding of Brintha and Kumuthini (2016) that found increase in number of leaves of Ixora at 38%, 50% and 70% respectively due to the treatment with Coconut milk. This is also in agreement with the finding of Amrut and Rajput (2013), who reported that application of coconut milk, increased the number of branches in fenugreek. Yield of *Capsicum annuum* was significantly affected by the application of coconut milk at 6 and 5% concentration in the nursery, more number of fruits were obtained with plants treated with coconut milk than the control, fruit weight was also significantly affected by the application of coconut milk, this may be due to presence of important components in coconut milk like the cytokinin, gibberellins, Auxin, inorganic ions e.g. phosphorus, sulphur etc as reported by Raghavan (1977).

CONCLUSION

From the results of this research, it can be concluded that GA_3 at all the levels of concentration have a significant effect on yield of *Capsicum annuum* in the nursery, the optimum concentration of GA_3 on yield was 200ppm followed by the rest of the concentrations. While coconut milk had a significant effect on both growth and yield of *Capscicum annuum* in the nursery, the optimum concentration of coconut milk on growth and yield of *Capsicum annuum* in the nursery was 6%, then 5%. Therefore, it is recommended that 6% Coconut milk should be used to increase Growth and yield of *Capsicum annuum* in the area of study.

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RESPONSE OF SWEET PEPPER (*CAPSICUM ANNUM*) TO COW DUNG AND POULTRY MANURE AMENDED WITH UREA IN KABBA, KOGI STATE, NIGERIA

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ABSTRACT

Field experiments were conducted at the experimental field plot of Kabba College of Agriculture in 2019 and 2020 seasons to evaluate the effect of integrated use of organic and inorganic fertilizer on growth and yield of pepper in Southern Guinea Savanna agro-ecology of Nigeria. The treatments consisted of different sources of nutrients through organic sources compared to that of untreated control and chemical fertilizer. The different sources of organic manure used were Poultry manure and Cow dung manure and commercially available inorganic fertilizer (urea). The experiment was arranged in randomized complete block design and replicated three times. Data were taken on growth and yield characters of pepper. All plots with amendment whether organic residue alone or in combination with urea was better than the control plots. Plot with poultry manure alone or at reduced rate with urea were better than plots with cow dung manure in plant height and number of leaves. Mean highest number of fruits and heaviest fruits occurred in plots with poultry manure + cow dung manure + urea combined at reduced rate of 2.5t/ha:2.5 t/ha:30 kg/ha.

Key words: Pepper; Poultry manure; Cow dung manure; Urea fertilizer; Inorganic fertilizer

INTRODUCTION

Capsicum (*Capsicum annum*) Sweet pepper belongs to family Solanaceae and is native to Mexico with secondary center of origin at Guatemala and Bulgaria (Safford, 1926; Adhikari *et al*, 2016). The fruits are non-pungent and have been widely used in immature or green stage as vegetable for salads. Considered as high cash crop, it has occupied an important rank in world agriculture due to its high profit and nutritional values for human health. Sweet pepper fruits are a rich source of vitamin C, polyphenols, chlorophylls, carotenoids, sugars (Flores, 2009) magnesium, calcium, potassium, phosphorus and iron (Jadczak *et al.,* 2010).

Pepper production cuts across Nigeria's geo-political zones and generates income to the farmers, but the production system is on a low scale in southern Guinea Savannah, due to improper fertilizer usage which lead increases soil acidity (Cheezy and Yayock, 1989). To meet the increasing demand for pepper, the use of excessive inorganic fertilizers is becoming a common practice as a means of raising the productivity. This has created negative effects on human health and environment. Application of chemical fertilizers alone can supply only one or two nutrient elements to the crop. The use of chemical fertilizers has been many-a-times reported for degrading soil and water resources. The use of organic manure alone is also faced with problems of bulkiness and dirt. Supplying only organic inputs can improve soil physical and biological environment but suffers from drawback of low content of plant nutrients (Adhikari *et al*, 2016). Stockdale *et al*. (2001) organic farming is both a philosophy and a system of agriculture which avoids or largely excludes the use of synthetically produced fertilizers, pesticides and to the maximum extent possible relies upon crop rotations, crop residues, animal manures, legumes, green manures, off farm organic wastes, mineral bearing rocks and bio-fertilizers to maintain soil productivity and to supply plant nutrients and biological means to control insects, weeds and other pests. A balanced use of organic and inorganic fertilizers could enhance soil chemical, physical, and biological properties as well as rate of nutrient turn over within the soil-plant system (Paul and Mannan, 2006). Combined use of organic and Inorganic fertilizer reduced cost and amount of fertilizer required by crops (Krupnik *et al*., 2004). It also produced highest plant growth (Alam, 2006).

The high cost of pepper in the Nigerian market justifies that the production is far lower than the demand. If proper nutrient management is adapted by the pepper producer, the production will certainly goes up to meet the demand. This study was therefore designed to evaluate the effect of integrated use of organic and inorganic fertilizer on growth and yield of pepper in Southern Guinea Savanna agro-ecology of Nigeria.

MATERIALS AND METHODS

Field experiments were conducted at the experimental field plot of Kabba College of Agriculture in 2019 and 2020 seasons. Kabba is located in the Southern Guinea Savanna Ecological Zone of Nigeria of latitude 07° 53' N and longitude 6° 8' E. The rainy season spans from April to November with the maximum rainfall in August while dry season extends from December to March. The mean annual rainfall is 1570mm, while annual temperature ranges from 18 to 32 °C and mean relative humidity is 59%.

The experiment was carried out in Complete Randomized Block Design (RCBD) with six treatments replicated thrice. The treatments consisted of different sources of nutrients through organic sources compared to that of untreated control and chemical fertilizer. The different sources of organic manure used were Poultry manure and Cow dung manure and commercially available inorganic fertilizer (urea). Weeding, crop management and harvesting was done manually. Various growth and yield attributes were examined at various times of crop cycle.

All data collected were analyze using the analysis of variance (ANOVA) using general linear model procedure of the statistical analysis system (SAS Institute, 2003) and means were compared using least significant difference Test at p = 0.05 probability level (Steel and Torres, 1987).

RESULTS AND DISCUSSION

The physicochemical properties of the soil in the study area were given in the Table 1. The results showed that the texture of the soil was sand, clay loam and was slightly acidic in nature with PH of 6.1. The organic matter content was low (1.51 g/100g). Total N was low (0.13 g/100g). The available P and potassium were equally low with values of 2.26 mg/kg-1 and 0.41Cmol/kg-1 respectively. The cation-exchange-capacity was low. Generally, the soil fertility was low based on the above fertility indices. The chemical composition of agricultural waste materials used is also shown in Table 1. The chemical characteristics of poultry manure and cow dung differed significantly (p=0.05). The materials were relatively high in the essential nutrients required for the growth and development of crop.

Table 1. pre planting soil analysis and composition of poultry manure and cow dung manure used

Properties	Soil	Poultry manure	Cow dung manure
Particle size (g/kg)			
Sand	514	-	-
Clay	289	-	-
Silt	197	-	-
pH(water)	6.1		
Organic carbon (%)	1.51	35.6	46.4
Total nitrogen (%)	0.62	4.14	2.73
C/N ratio	-	11.34	17.00
Available phosphorus	2.26	34.16	36.8
Exchangeable cation (Cmol/kg)			
Potassium	0.41	58.46	13.32
Calcium	2.26	3.76	3.87
Magnesium	2.12	3.16	2.23

The effect of different organic materials and their combinations with urea fertilizer on plant height and number of leaves produced in a pepper are presented in Table 2. Significant differences were observed in pepper height and number of leaves produced in 2019 and 2020.

All plots with amendment whether organic residue alone or in combination with urea was better than the control plots. Plot with poultry manure alone or at reduced rate with urea were better than plots with cow dung manure in plant height and number of leaves in both years.

These could be attributed to the nutrient released to the plant by the amendment applied to soil and crops. The better performance of plots with either cow dung or poultry manure either simply or in combination with urea corroborated the result of Kang and Balasubramanian (1990), Ogundare (2011) and Asaidu and Unagwu (2021). This was attributed to the nutrient released by the materials applied to the soil.

Table 2: Effect of integrated use of organic and inorganic fertilizer on growth characters of pepper

Treatments	Plant height cm			Number of leaves		
	2019	2020	MEAN	2019	2020	MEAN
PM5 t/ha	15.61	14.27	14.94	38	30	34
CDM t/ha	14.22	13.40	13.81	27	31	29
PM 2.5t/ha+Urea 30kg/ha	17.41	15.59	16.50	28	42	35
CDM 2.5 kg/ha + Urea 30kg/ha	12.63	15.01	13.82	26	30	28
PM2.5 t/ha 2.5+CM2.5t/ha +Urea 30 kg/ha	14.44	16.14	15.29	31	37	34
CTRL	12.48	6.92	9.70	22	24	23
LSD	3.46	2.89	2.11	4.14	4.83	3.96

Plots with poultry manure produced taller plants and more number of leaves compared to plots with cow dung manure either alone or in combination with urea. Analysis of the material shows that cow dung was high in C\N ratio compared to poultry manure. This indicated that mineralization is easier with poultry manure compared to cow dung manure. This could be responsible for the better performance of poultry manure plots compare to cow dung plots.

Table 3 presents the effect of poultry manure, cow dung manure and their combinations with urea on number of fruits per plant and individual fruits weight. The mean highest number of fruits and heaviest fruits occurred in plots with poultry manure, cow dung manure and urea combined at reduce rate. Followed by plots with poultry manure combined with urea at reduce rate. While plots with poultry manure alone was better in number of fruits and fruit weight than plots with cow dung alone or in combination with urea. The least number of fruits and lightest fruits occurred in the control plots. The better performance of plots with poultry manure+ cow dung manure + urea could be as a result of prompt released of nutrient to the plant. Urea released it nutrient, then poultry manure white at later stage cow dung mineralized and releases it nutrients. Plots with poultry manure alone or in combination with urea gave more number of fruits and heavier fruits compare to plots with cow dung manure. This is expected because poultry manure releases it nutrient quicker than cow dung manure due to the differences in their C\N ratio.

The least number of fruits and fruits weight occurred in control plots. Control plots only dependent on the soil inherent nutrient and from the analysis of the soil use for the experiment, the soil was low in soil fertility and consequently low fruit yield of the control plots.

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Table 3: Effect of integrated use of organic and inorganic fertilizer on growth Yield characters of pepper

Treatments	Number of fruits per plant			Fruit weight (g)		
	2019	2020	MEAN	2019	2020	MEAN
PM5 t/ha	24	18	21	218	214	216
CDM t/ha	11	15	13	211	167	189
PM 2.5t/ha+Urea 30kg/ha	26	18	22	198	246	222
CDM 2.5 kg/ha + Urea 30kg/ha	19	15	17	149	163	106
PM2.5 t/ha 2.5+CM2.5t/ha +Urea 30 kg/ha	18	34	26	258	240	249
CTRL	04	10	07	46	60	53
LSD	3.41	5.93	6.07	38.4	46.8	39.8

CONCLUSION

For optimum production of pepper in the study area, Pepper farmer should make use of poultry manure, cow dung and urea combined at ratio of 2.5t/ha:2.5 t/ha:30 kg/ha. This will improve the production of pepper in the area

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EFFECTS OF PLANT RESIDUES AND NPK FERTILIZER ON SOIL PROPERTIES AND PERFORMANCE OF WHITE SEED MELON (*CUCUMEROPSIS MANNII* NAUDIN)

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ABSTRACT

Field experiment to study effect of crop residues combined with NPK fertilizer (NPKF) on soil chemical and physical properties, growth and yield of white seed melon was carried out at Kabba, Kogi State Nigeria. Soil amendments tested involved application of cocoa bean husk (CBH), cocoa pod husk (CPH), cocoa pod waste (CPW), weed much (WM) in combination with NPK 15:15:15 Fertilizer to produce eleven treatments 4 t/ha CBH + 200 kg/ha NPKF, 4 t/ha. CBH + 100 kg/ha NPKF, 4 t/ha CPH + 200 kg/ha NPKF, 4 t/ha CPH + 100 kg/ha NPKF, 4 t/ha CPW + 200 kg/ha NPKF, 4 t/ha CPW + 100 kg/ha NPKF, 4 t/ha KPH + 200 kg/ha NPKF, 4 t/ha KPH + 100 kg/ha NPKF, 2 t/ha WM + 200 kg/ha NPKF, 2 t/ha WM + 100 kg/ha NPKF and control (no treatment), all the amendments tested significantly improved soil physical and chemical properties and growth performance of white seed melon relative to control. Three cocoa plants residues in combination with NPKF at reduced rates 4 t/ha CBH + 200 kg/ha NPKF, 4 t/ha CPW + 200 kg/ha NPKF and 4 t/ha CPH + 200 kg/ha NPKF respectively significantly ($p < 0.05$) improved soil pH, organic matter (OM), available P, exchangeable k, Ca and Mg, Na, Fe, Al and ECEC among the amendments tested. 4 t/ha CBH + 200 kg/ha NPKF, 4 t/ha CPW + 200 kg/ha NPKF and 4 t/ha CPH + 200 kg/ha NPKF reduced soil bulk density and increased total porosity. All treatments increased number of leaf and branches, vine length, leaf length and width of white seed melon compared to the control. 4 t/ha CBH + 200 kg/ha NPKF, 4 t/ha CPW + 200 kg/ha NPKF, 4 t/ha CPH + 200 kg/ha NPKF, had highest value of branches.

Keywords: White seed melon, plant residues, soil physical properties, soil chemical properties, yield.

INTRODUCTION

Food production in Sub-Sahara Africa is constrained by inadequate soil fertility, Nigeria inclusive. Soil fertility is the status of the soil with respect to its ability to supply essential elements for plant growth without a toxic concentration (Boyd, 1996). When soil is not fertile, methods of replenishing lost nutrients such as bush fallowing, application of organic and inorganic fertilizer, crop rotation could be adopted to return the lost nutrients. Increase in population pressure has led to inadequacy of traditional bush fallowing in meeting requirement of fertile land due to drastic reduction in length of fallow period, which may be up to ten (10) years or at least three (3) years. Recent experience in Nigeria agriculture shows that the use of inorganic fertilizers to achieve high crop yield is unsustainable due to its scarcity and high cost (Ojeniyi, 2000). Inorganic fertilizers ensure quick availability of nutrients to crops but they have limited residual effect of the applied nutrients (Okigbo, 2000). In addition, inorganic fertilizer has not been helpful in intensive agriculture because it is often associated with reduction in crop yield, soil acidity, nutrient imbalance and degradation of soil physical attributes. Other limitations include nutrients leaching, erosion and volatilization (Ojeniyi, 2000). Chemical fertilizers are said to have the following characteristics (Jim Ellison, 2011); Water solubility of chemical fertilizers result in fast release. Many chemical fertilizers own high acid content like sulphuric and hydrochloric acids which going through soil acidity successfully results in the death of Nitrogen fixing bacterium, the organism that plays a central role in refurbishing plants nitrogen demands. Organic fertilizers are known to be slow released nutrient sources. This implies that crops can suffer initial starvation from nutrient immobilization prior to mineralization. They are also required in large quantities which may not be readily available to farmers (Agbede, and Kalu, 1995; Okigbo, 2000; Adekiya et al, 2012). Organic fertilizer can be used to improved soil characteristics and obtain high crop yields in addition with inorganic fertilizer (Cezar, 2004). Akanbi et al., (2013) and Ojeniyi (2016) recognized the need to intensify studies into locally sourced, cheap, adoptable organic sources of plant nutrients. Babadele and Ojeniyi (2013) found that plant variety such as those of siam weed and sawdust used alone or combined further with NPK fertilizer at reduced rate supplied nutrients and improved yield. Manures were found to suppress diseases by generating ammonia and other nitrous acid in the soil (Larzarovite, 2000). Organic amendments discharge their nourishing contents only when they break down through the intricate ecology of living creatures in the soil at that time they steadily discharge contents. All the components in the organic amendments are completely essential soil nutrients. The fact that the material is organic signifies that it is derived from a once living plant, animal or a mix of both, which assures us that all components there are crucial to life. Organic amendment is relatively cheaper and it has all the carbon and vitality to conform to the demands of soil microbs. The above characteristic of organic and inorganic fertilizers which complements each other makes its combination a necessary component for crop production. While the importance of the mixture has been demonstrated (Onunka, et. al, 2002). Mann's cucumeropsis (*Cucumeropsis mannii)* a member of the Cucurbitaceae family, a species of melon native to tropical Africa. It is an important quality and a very high nutrient – demanding crop. It requires adequate nutrition for maximum performance. The fruit is egg-shaped with about 19cm long and 8cm wide. This crop is primarily harvested for its large white seeds called egusi-itoo. The seeds are commonly processed into soups and oil products, and are also eaten individually as a snack (National Research Council, 2006). Benefits of *Cucumeropsis mannii* are many but soil fertility is one of the most important factors limiting its production. (National Research Council, 2006) reported that a complete fertilizer should be applied before the propagation of *Cucumeropsis mannii* with periodical application of nitrogenous fertilizer Growing of *Cucumeropsis mannii* in savannahs with low fertility and organic matter was reported to be more challenging (National Research Council, 2006). The objective of this experiment was to determine the effect of combined amendments on soil properties and growth performance of white seed melon

MATERIALS AND METHODS

The study was conducted during 2019 cropping season at the Teaching and Research Farm of ABU College of Agriculture, Kabba, Kogi State. Kabba is located in the Southern Guinea savanna Agro - Ecological Zone of Nigeria on latitude 7^0 50' N and longitude of 6^0 03'E and altitude of 427 m with average rainfall of 130 mm and mean annual temperature between 28.8 ^{0}C to 35 ^{0}C. The annual relative humidity is 81.2 percent.

Experimental design and treatments

The experiment was arranged in a randomized complete block with each treatment replicated four times. The area used was 24 m x 51 m (1224 m^2) in total. Each plot measured 4 m x 3 m with discard of 1 m within the plots and 2 m between the block. The trial involved six treatments of cocoa bean husk (CBH); cocoa pod husk (CPH); cocoa pod waste (CPW); Kola pod husk (KPH) at 6 t/ha each, 4 t/ha (*Tithonia diversifolia*) weed mulch (WM), 300 kg/ha. NPK 15:15:15 fertilizer (NPKF) and control (no amendment). Two seeds of white seeds melon were planted per hole and later thinned to one at a spacing of 1 m x 1 m with a total of twenty (20) plants per plot

Prior to commencement of experiment, soil samples randomly collected from 0 – 20 cm depth were thoroughly mixed to form a composite which was later analyzed for physical and chemical properties. At the harvest, another set of composite samples were collected per plot basis and similarly analyzed for routine chemical analysis as described by Carter (1993). The soil samples were air-dried and sieved using a 2 mm sieve before making the determinations. Soil organic matter was determined by the procedure of Walkley and Black using the dichromate wet oxidation method (Nelson and Sommers, 1996), total N was determined by micro-Kjeldahl digestion method (Bremner, 1996), available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry (Frank et al., 1998). Exchangeable K, Ca and Mg were extracted using 1.0 N ammonium acetate. Thereafter, K was determined using a flame photometer and Ca and Mg were determined by EDTA titration method (Hendershot and Lalande, 1993). Soil pH was determined in soil water (1:2) medium using the digital electronic pH meter. Particle size analysis was done using Bouyoucos hydrometer method (Sheldrick and Hand Wang, 1993). Soil bulk density was determined using the core method (Campbell and Henshall, 1991).

Data collection and statistical analysis

Five plants of white seed melon were randomly selected from each plot across the three blocks for growth determination. The parameters assessed included number of leaves, number of branches, vine length, leaf length and width.

The data collected were subjected to analysis of variance (ANOVA) using the SPSS package (version 16) and treatment means were compared using the Duncan's multiple range test (DMRT).

RESULTS

Pre-Planting Soil properties

Table 1 shows soil properties of the experimental site prior to planting. The values of soil Bulk density were (1.45 and 1.38 g/cm^3), Porosity (43.2 and 42.4 %), Soil temperature 36.1 and Soil moisture 6.31 % The result revealed that the soil of the experimental site was sandy loam, acidic, low in N, available P, exchangeable K and OM in accordance with the rating of Akinrinde and Obigbesan (2000). Therefore, the results revealed that effective production of crop would therefore require additional soil conditioner.

TABLE 1: Pre-Planting Soil properties

Property	Values
Sand (%)	77.6
Silt (%)	11.9
Clay (%)	10.5
Textural Class	Sandy loam
Bulk density g/cm^3	1.45
Total porosity (%)	43.2
pH (H_20)	5.61
Organic Matter (%)	2.28
Total N (gkg^{-1})	0.17
Available P (mgkg^{-1})	13.41
Exchangeable K (cmolkg^{-1})	0.14
Exchangeable Ca (cmolkg^{-1})	2.13
Exchangeable Mg (cmolkg^{-1})	1.14
Na (cmolkg^{-1})	0.52
H (cmolkg^{-1})	1.37
Al (cmolkg^{-1})	0.75
ECEC	6.05
BS (%)	65.0

BS = Base saturation

Table 2 presents data on effects of combined application of amendments on growth performance of white seed melon. All the amendments tested significantly improved growth performance of white seed melon relative to the control. Highest number of leaf was obtained for plant treated with 4 t/ha CBH + 200 kg/ha NPKF although showed no significant difference with the value recorded for 4 t/ha CBH + 200 kg/ha NPKF but significantly ($p < 0.05$) higher than the values recorded for other amendments. Number of branches experienced significant improvement by combined amendments compared with the control. Highest and least number of branches (11.30 and 10.13) were recorded for 4 t/ha CBH + 200 kg/ha NPKF and 2 t/ha WM + 100 kg/ha NPKF respectively. The plant residues combined with NPKF also increased vine length significantly relative to control. Highest value of vine length was recorded for 4 t/ha CPW + 200 kg/ha NPKF and was not significantly different from other amendments. Highest and least values of leaf length and width (16.97, 13.70) and (22.57, 18.57) were recorded for 4 t/ha CPW + 200 kg/ha NPKF and Control respectively.

Table 2: Effects of combined amendments on growth components of white seed melon (*Cucumeropsis mannii*) at Kabba

Treatments	No of leaf	No of branches	Vine length (cm)	Leaf Length (cm)	Leaf width (cm)
Control	198.78g	7.70e	286.37d	13.70k	18.57f
4 t/ha CBH + 200 kg/ha NPKF	270.2abcd	11.30a	813.13abc	16.83abc	22.57a
4 t/ha CBH +100 kg/ha NPKF	263.27de	11.20a	792.13abc	16.50bcde	21.40ed
4 t/ha CPH + 200 kg/ha NPKF	264.87cde	11.30a	810.97abc	16.37defgh	22.47ab
4 t/ha CPH + 100 kg/ha NPKF	263.1ef	11.23a	790.27abc	16.00ghi	21.90abc
4 t/ha CPW + 200 kg/ha NPKF	272.23a	11.27a	839.87a	16.97a	22.57a
4 t/ha CPW + 100 kg/ha NPKF	264.27de	11.30a	818.00abc	16.53bcde	22.03abc
4 t/ha KPH + 200 kg/ha NPKF	265.53bcde	10.70b	805.30abc	16.13efghi	22.47ab
4 t/ha KPH + 100 kg/ha NPKF	261.9ef	10.53bc	795.23abc	15.97ij	22.23abc
2 t/ha WM + 200 kg/ha NPKF	264.27de	10.40d	778.63bc	15.77ij	21.73cd
2 t/ha WM + 100 kg/ha NPKF	257.97f	10.13d	766.47c	15.57ij	20.93e

NPKF = NPK 15:15:15 fertilizer, CBH = cocoa bean husk, CPH = cocoa pod husk, CPW = cocoa pod waste, KPH = kola pod husk and WM = weed mulch: means with the same letters are not significantly different ($P < 0.05$) from other.

The results of the effects of combined amendments on soil physical properties are presented in table 3. All the amendments tested significantly ($p < 0.05$) improved soil moisture content, porosity, bulk density and temperature relative to control. Among the amendments tested, highest values of soil moisture content and porosity (9.32 and 46.40) were obtained for soil treated with 4 t/ha CBH + 200 kg/ha NPKF and were significantly different from other amendments including control except value of porosity (46.10) recorded for 4 t/ha CPH + 200 kg/ha NPKF. Values of soil bulk density and temperature were significantly improved by the amendments relative to control. Least and highest bulk density and temperature (1.12, 1.30) and (25.7, 33.6) were recorded for 4 t/ha CBH + 200 kg/ha NPKF and Control respectively.

Table 3: Effects of combined amendments on soil physical properties at Kabba

Treatments	MC **(%)**	Porosity **(%)**	BD g/cm^3	Temperature **(^oC)**
Control	6.07i	32.40h	1.30a	33.6a
4 t/ha CBH + 200 kg/ha NPKF	9.32a	46.40a	1.12h	25.7e
4 t/ha CBH +100 kg/ha NPKF	9.16c	44.20b	1.14f	26.9d
4 t/ha CPH + 200 kg/ha NPKF	9.28b	46.10a	1.13g	26.0e
4 t/ha CPH + 100 kg/ha NPKF	8.71d	43.80b	1.15e	26.2e
4 t/ha CPW + 200 kg/ha NPKF	9.31b	41.10i	1.14f	25.8e
4 t/ha CPW + 100 kg/ha NPKF	8.63e	40.90c	1.13g	26.4e
4 t/ha KPH + 200 kg/ha NPKF	8.01f	39.70d	1.16d	27.4d
4 t/ha KPH + 100 kg/ha NPKF	6.58h	38.20e	1.16d	29.1c
2 t/ha WM + 200 kg/ha NPKF	7.69g	34.80f	1.15e	28.1d
2 t/ha WM + 100 kg/ha NPKF	6.51h	33.40g	1.17c	30.3b

NPKF = NPK 15:15:15 fertilizer, CBH = cocoa bean husk, CPH = cocoa pod husk, CPW = cocoa pod waste, KPH = kola pod husk and WM = weed mulch: means with the same letters are not significantly different ($P < 0.05$) from other.

Soil pH, OM, N and P as affected by amendments are presented in table 4. All the amendments tested significantly ($p < 0.05$) increased soil pH, OM, N and P concentration relative to control after harvest. Concentration of soil pH, OM, N and P were significantly increased by 4 t/ha CBH + 200 kg/ha NPKF relative to other amendments while the least values of soil pH, OM, N and P (6.09, 3.45, 0.68 and 18.29) were respectively recorded for 2 t/ha WM + 100 kg/ha NPKF.

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Table 4: Effects of combined amendments on soil chemical properties at Kabba

Treatments	pH	OM (%)	N (%)	P (%)
Control	5.20i	1.97h	0.27i	8.41h
4 t/ha CBH + 200 kg/ha NPKF	6.78a	5.04a	0.97a	26.01a
4 t/ha CBH +100 kg/ha NPKF	6.64d	4.93b	0.91b	24.46c
4 t/ha CPH + 200 kg/ha NPKF	6.68c	4.82c	0.89c	25.07b
4 t/ha CPH + 100 kg/ha NPKF	6.47e	4.81d	0.81e	23.10d
4 t/ha CPW + 200 kg/ha NPKF	6.71b	5.01a	0.97a	24.70c
4 t/ha CPW + 100 kg/ha NPKF	6.48e	4.66e	0.87d	22.07e
4 t/ha KPH + 200 kg/ha NPKF	6.42f	4.65e	0.74f	23.11d
4 t/ha KPH + 100 kg/ha NPKF	6.40g	3.98f	0.73g	22.87d
2 t/ha WM + 200 kg/ha NPKF	6.10h	3.47g	0.73g	19.80f
2 t/ha WM + 100 kg/ha NPKF	6.09h	3.45g	0.68h	18.29g

NPKF = NPK 15:15:15 fertilizer, CBH = cocoa bean husk, CPH = cocoa pod husk, CPW = cocoa pod waste, KPH = kola pod husk and WM = weed mulch: means with the same letters are not significantly different (*P* < 0.05) from other.

Effects of amendments on soil exchangeable properties are presented in table 5. All the amendments tested significantly improved soil K, Ca, Mg, Na, ECEC and BS relative to control after harvest. Among the fertilizer treatments, highest K, Ca, Mg, Na, ECEC and BS (0.97, 1.76, 0.88, 0.80, 6.70 and 65.82) were respectively obtained for soil treated with 4 t/ha CBH + 200 kg/ha NPKF and were significantly ($p < 0.05$) higher than the values recorded for other amendments.

Table 5: Effects of combined amendments on soil exchangeable properties at Kabba

Treatments	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	Na (cmol/kg)	H+ (cmol/kg)	Al (cmol/kg)	ECEC (cmol/kg)	BS (%)
Control	0.47j	1.61i	0.40i	0.61i	1.62h	0.27h	4.98i	62.05e
4 t/ha CBH + 200 kg/ha NPKF	0.97a	1.76a	0.88a	0.80a	1.81b	0.48e	6.70a	65.82a
4 t/ha CBH +100 kg/ha NPKF	0.91c	1.68e	0.83d	0.76c	1.79c	0.51b	6.48d	64.51b
4 t/ha CPH + 200 kg/ha NPKF	0.94b	1.73c	0.84c	0.79b	1.81b	0.49d	6.60b	65.15a
4 t/ha CPH + 100 kg/ha NPKF	0.88d	1.67f	0.81e	0.73e	1.76d	0.52a	6.37e	64.21c
4 t/ha CPW + 200 kg/ha NPKF	0.84e	1.75b	0.87b	0.75d	1.82a	0.49d	6.52c	64.57b
4 t/ha CPW + 100 kg/ha NPKF	0.79g	1.67f	0.79f	0.76c	1.75e	0.45g	6.21i	64.57b
4 t/ha KPH + 200 kg/ha NPKF	0.82f	1.69d	0.83d	0.73e	1.79c	0.50c	6.36e	63.99c
4 t/ha KPH + 100 kg/ha NPKF	0.79g	1.65g	0.76g	0.70g	1.70f	0.48e	6.08g	64.14c
2 t/ha WM + 200 kg/ha NPKF	0.77h	1.68e	0.81e	0.71f	1.81b	0.49d	6.27f	63.32d
2 t/ha WM + 100 kg/ha NPKF	0.61i	1.64h	0.75h	0.68h	1.69g	0.46f	5.83h	63.12d

NPKF = NPK 15:15:15 fertilizer, CBH = cocoa bean husk, CPH = cocoa pod husk, CPW = cocoa pod waste, KPH = kola pod husk and WM = weed mulch: means with the same letters are not significantly different (*P* < 0.05) from other.

DISCUSSION

Optimum yield could not be obtained from sole application of organic manures due to slow release of nutrients.

Use of organic and inorganic fertilizers has been advocated for sustainable soil productivity under intensive continuous cultivation in southwest Nigeria (Adepetu, 1997), sustainable nutrient management on small holder farms can be achieved by a combination of mineral fertilizers and organic soil amendments (Vanauwe, 2004). From this study, contribution of amendments to soil fertility has clearly shown through increased availability of plant nutrients for its growth and development (Brandy and Weil, 2007; Adeoluwa et al., 2010). Combination of organic and inorganic sources of nutrients led to optimal pH of about 6.0 – 7.0 which is recommended for nutrient availability and suitable for most tropical field and arable crops. It could be seen that combination of 4 t/ha CBH + 200 kg/ha NPKF, 4 t/ha CBH + 100 kg/ha NPKF and 4 t/ha CBH + 200 kg/ha NPKF gave highest value of soil N, P and K which are the nutrients most often limiting to tropical crops and deficient tropical soils (especially N and P). The improved soil chemical and physical properties should have enhanced nutrients and moisture uptake by melon. The better attributes of combination of nutrient

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sources is further confirmed by the relatively high soil organic matter contents at the experimental site and in the cases of 4 t/ha CBH plus any of 200 or 100 kg/ha NPKF. The integrated soil fertility Management (ISFM) approach supports that there are positive interrelations and complementarities of organic and mineral nutrient sources to support sustained soil fertility and crop productivity. The trend in the values of soil physical and chemical properties indicated that higher values of soil organic matter were more favourable to soil quality hence melon performance. The result of the experiment also showed that soil amendments improved soil fertility and increased growth components of white seed melon relative to control. This is consistent with the findings of Liu and Stutzel (2004) and Adeoluwa *et al.* (2010). The result is also in agreement with that of Prasad and Singh (2000) who reported that soils treated with soil amendments increased number of leaves and other growth components compared with untreated soil.

CONCLUSION

Combination of selected plant residues with synthetic fertilizer (NPK 15:15:15) showed improving effects on soil physical and chemical properties and growth components of white seed melon compared with control. Combination of 4 t/ha CBH + 200 kg/ha NPKF, 4 t/ha CPW + 200 kg/ha NPKF and 4 t/ha CPH + 200 kg/ha NPKF gave highest value of soil N, P, K, Ca, Mg, ECEC and BS respectively compared to others. The overall results revealed that combination of plant residues with NPKF particularly 4 t/ha CBH + 200 kg/ha NPKF can be used for improving soil with profitable production of white seed melon in the study area.

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DRY MATTER PARTITION AND NUTRIENT CONTENT OF CUCUMBER GROWN WITH NPK AND COMPOST FERTILIZERS ON AN ALFISOL

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ABSTRACT

Experiment were conducted at the Vegetable field of National Horticultural Research Institute, Ibadan to investigate the dry matter partition and nutrient content of cucumber when grown with NPK (15:15:15) and compost on an alfisol. The study was a 2 x 3 x 4 factorial experiment, with two varieties of cucumber (Marketmore and Poinsett), three Nitrogen levels (0, 30, 60 kg ha-^{1}) and four levels of compost (0,5,10 and 20 tons ha-^{1}) fitted into split- split plots with variety as main plot, NPK (15:15:15) and compost as sub and sub-sub plots respectively and the treatments were replicated thrice. Results indicated that Poinsett variety had higher content of P and K, and also it is 37%, 0.24% and 0.44% higher in Mg, Fe and Zn content respectively than Marketmore variety when planted on an alfisol. Cucumber planted with 10 tons ha^{-1} of compost had higher content of P, K, Mg and Fe. Poinsett variety accumulated more dry matter into roots and shoot than Marketmore variety.

Key words: Alfisol, nutrient, Poinsett, Marketmore and dry matter.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the oldest vegetables cultivated by man with historical records dating back 5000 years (Wehner, 2007). It is one of the most popular members of the *Cucurbitaceae* family. It is cultivated for fresh fruit which is locally consumed or exported for generation of national income. Cucumber is an important component in vegetable salad for human nutrition, and serves as remedy in the treatment of constipation, jaundice and indigestion. The fruit varies in shape, size and color. A matured cucumber fruit when analyzed for fruit nutrient composition is 3.8 g dry matter, 0.6 g protein, 2.0 mg calcium, 0.4 mg riboflavin, 0.2 mg niacin and 11 mg vitamin. Cucumber production requires soil that is rich in organic matter content such that can provide the essential nutrients required for its growth and development, because nutrient deficient soil results to bitter and misshapen produce that will not be accepted by consumers thereby causing economic loss to farmers (Eifedeyi, 2010).The scarce and costly mineral fertilizer with its other limitations cannot be the only solution to improve soil productivity in tropical Africa, there is a need to explore the potential of combining organic fertilizers with synthetic fertilizers to provide solution to cucumber production challenges. There is paucity of information on the use of composted organic materials combined with NPK (15:15:15) fertilizers for the production of cucumber crop. This study was conducted to investigate the dry matter yield and mineral content of cucumber fruit when grown with NPK (15:15:15) and compost fertilizers.

MATERIALS AND METHODS

Experiments were carried out in Vegetable field of National Horticultural Research Institute, Ibadan, Nigeria (7^{0} 25'' and 3^{0} 52E) to determine the effects of variety, NPK (15:15:15) and Compost on dry matter partitioning and fruit nutrient content of cucumber planted on an alfisol in Ibadan, Southwest, Nigeria. The experiment was a 2 x 3 x 4 factorial experiment, with two varieties of cucumber (Marketmore and Poinsett), three Nitrogen levels (0, 30, 60 kg ha-^{1}) and four levels of compost (0,5,10 and 20 tons ha-^{1}) fitted into split- split plots with variety as main plot, NPK (15:15:15) and compost as sub and sub-sub plots respectively and the treatments were replicated thrice. Compost was prepared by combining dried and sorted cassava peel with dried and sorted poultry manure obtained from battery cage system, and mixed together on 3:1 ratio dry basis. Cucumber seeds (4) were sown at a spacing of 50 cm x 50 cm and later thinned to one seedling per stand at two weeks after planting. Compost fertilizer was incorporated into the soil two weeks before planting to allow for mineralization into the soil while NPK (15:15:15) was split applied at 2, 4 WAP and anthesis. Weed control was achieved by hand weeding at specific period as required to maintain a weed free plot throughout the period of the crop growth. Four plants were randomly selected and tagged per plot for plant growth characteristics and from which fruit harvested were analyzed for fruit nutrient content. Four plants were also destructively sampled per plot at flowering for dry matter determination. They were carefully uprooted and separated into roots, vines and leaves after which they were bagged separately in brown envelopes and oven dried to a constant weight at 75^{0}C for 48hours. From these, the mean dry weights of each plant part were taken. Data collected were subjected to analysis of variance (ANOVA) using Genstat 2013 Version. The means of the main effects and their interactions were compared with Least Significant Different (LSD) at P = 0.05.

RESULTS AND DISCUSSION

Table 1 represents the chemical composition of initial materials and the matured compost after composting process, it indicated that the matured compost contained the major and trace elements that can support cucumber production on an alfisol.

Table 1. Chemical properties of compost materials and matured compost

Properties	Poultry manure	Cassava peel	Matured compost
pH [H2O] *	8.4	6.0	8.2
Org. C (%)	18.30	20.57	64.86
Total N (%)	0.46	0.46	0.50
P (%)	3.90	0.05	1.59
K (%)	0.88	0.97	0.76
Na (%)	0.25	0.03	0.17
Fe (%)	0.70	0.07	1.20
Zn (mg kg^{-1})	385	14	154
Cu (mg kg^{-1})	59	10	31
Mn (mg kg^{-1})	526	80	372

* = Aqueous suspension of matured compost.

Effects of variety, NPK (15:15:15) and Compost on dry matter partitioning of cucumber on an alfisol.

The main effects of variety, NPK (15:15:15) and compost rates on dry matter partitioning of cucumber in alfisol for the two cropping seasons are shown in Tables 2. The varietal effect was significant (P = 0.05) only on dry matter accumulated to shoot in both years at the time of harvest. Poinsett variety generally had higher dry matter partitioned to root and shoot. Even though dry matter to root was not significantly influenced by variety, its partitioning to stem was significant, as Poinsett variety significantly accumulated 2.15 g in first planting and 2.39 g per plant in second trial dry matter than Marketmore variety. Dry matter partitioning in both years of study in alfisol was not significantly influenced by NPK (15:15:15) and compost application. The various two way and three-way interactions of variety, NPK (15:15:15) and compost had no significant effect on dry matter partitioning to root and shoot in both years of study

Effects of variety, NPK (15:15:15) and compost on nutrient content of cucumber on an alfisol

Table 3 illustrates the main effects of variety, NPK (15:15:15) and compost on mineral contents of cucumber fruits. Nitrogen (N) content of cucumber were not significantly influenced by varietal differences, NPK (15:15:15) levels or compost applied, but the three factors significantly influenced the Phosphorus (P) and Potassium (K) content. Poinsett fruits significantly had higher content of P and K minerals. This further proved the superiority of Poinsett performance in absorption and utilization of mineral elements in same environment. The same trend was also observed for Calcium (Ca), Magnesium (Mg) and content Iron (Fe) content of Poinsett. Poinsett variety was more superior in Fe and Zinc (Zn) content of fruit than Marketmore variety. It was 0.24% and 0.44% higher in Fe and Mg content than Marketmore when grown on an alfisol.

NPK (15:15:15) application had significant effects on P and K content of cucumber fruits, the higher the NPK applied, the higher the P and K contents of the fruits up to 60 kg N ha^{-1}NPK application (Table 3). NPK (15:15:15) and compost rates, had no significant effect on Fe content of cucumber fruits on an alfisol, but both had significant effects on Fe content. Cucumber treated with 60 kg N ha^{-1}NPK

(15:15:15) significantly had higher Fe content in the study, while cucumber grown with 10tons ha^{-1} also significantly had higher Fe content in their fruit than other treatments (Table 3).

NPK (15:15:15) and compost had no significant effect on Zn content of fruit of cucumber grown in the alfisol (Table 3). All the interaction produced significant effect on Fe content of cucumber fruit. For both varieties the higher the quantity of NPK applied up to 60 kg N ha^{-1}NPK (15:15:15) the higher is the quantity of Fe mineral in their fruits. Application of NPK (15:15:15) also influenced Mg content of cucumber fruit, the higher the NPK fertilizer applied, the higher the Mg content fruit up to 60 kg N ha^{-1}NPK, the higher the NPK fertilizer, the higher also is the Ca content of fruit, but this was not significant (Table 3).

Table 2: Effects of variety, NPK (15:15:15) and compost on dry matter partitioning of cucumber on an alfisol

Treatment	Root dry weight (g)		Shoot dry weight (g)	
	1st planting	**2nd planting**	**1 planting**	**2nd planting**
Variety				
Marketmore	0.13	0.15	2.94	3.27
Poinsett	0.14	0.16	5.09	5.66
Prob. of F:	ns	ns	x	x
LSD (P = 0.05)	0.04	0.05	1.32	1.44
NPK (kg N ha^{-1})				
0	0.12	0.14	3.29	3.66
30	0.14	0.16	4.32	4.80
60	0.15	0.17	4.44	4.94
Prob. of F:	ns	ns	ns	ns
LSD (P = 0.05)	0.05	0.06	1.61	1.76
Compost (ton ha^{-1})				
0	0.14	0.16	3.95	4.38
5	0.11	0.11	3.67	4.08
10	0.16	0.17	3.72	4.13
20	0.15	0.16	4.73	5.26
Prob. of F:	ns	ns	ns	ns
LSD (P = 0.05)	0.06	0.07	1.86	2.03

x = Significant at 0.05 probability level; ns = not significantly different at p = 0.05

Table 3: Main effects of variety, NPK (15:15:15) and compost on nutrient content of cucumber fruits on an alfisol.

Treatment	N	P	K	Ca %	Mg	Fe	Zn
Variety							
Marketmore	0.10	0.22	1.32	0.18	0.12	0.25	0.19
Poinsett	0.12	0.42	1.54	0.21	0.19	0.49	0.63
Prob. of F:	ns	x	x	ns	x	x	x
LSD (P = 0.05):	0.03	0.001	0.01	0.11	0.003	0.001	0.20
NPK (kg N ha^{-1})							
0	0.11	0.30	1.39	0.18	0.14	0.34	0.25
30	0.11	0.27	1.39	0.16	0.15	0.33	0.65
60	0.12	0.39	1.51	0.25	0.18	0.44	0.32
Prob. of F:	ns	x	x	ns	x	x	ns
LSD (P = 0.05):	0.02	0.0007	0.007	0.08	0.004	0.0007	0.79
Compost (tons ha^{-1})							
0	0.11	0.32	1.44	0.18	0.15	0.36	0.26
5	0.11	0.30	1.41	0.18	0.16	0.36	0.26
10	0.11	0.34	1.44	0.24	0.17	0.38	0.83
20	0.11	0.32	1.44	0.18	0.15	0.37	0.27
Prob. of F:	ns	x	x	ns	x	x	ns
LSD (P = 0.05)	0.02	0.0007	0.0008	0.08	0.001	0.0007	0.80

x = Significant at 0.05 probability level; ns = not significantly different at p = 0.05

Compost application significantly influenced P and K content of fruits. 10 tons ha^{-1} compost application significantly had higher P and K contents in their fruits (Table 3). Calcium content of cucumber was not influenced by variety, NPK (15:15:15) and compost, but the three factors had effects on Mg content. Poinsett fruits under same environment contained 37% more Mg than Marketmore variety (Table 3). Compost application had significant effects on Mg in cucumber, the higher the quantity applied, the higher is the content of Mg in the fruit up to 10 tons ha^{-1} application, beyond this rate, the fruits Mg quantity declines (Table 3). Storey (1995) and Epstein (1997) confirmed that compost is of more importance than inorganic fertilizer because it consists of relatively stable decomposed materials resulting from accelerated biological degradation of organic matter under controlled aerobic conditions. The report of other studies (Rizk 2012; *AL*-Kahtani *et al* 2012), supported the role of compost in increasing the nutrient of fruits and that compost fertilizers contain more nutrients than mineral fertilizers.

The effects of Variety, NPK and compost interaction is represented in Table 4, it indicated that the interaction had no significant effects N, Ca, Mg and Zn content of the fruit, but the interaction was significant on K, P and Fe content of cucumber on the alfisol. Poinsett grown with 60 kg N ha^{-1} combined with 10 tons ha^{-1} of compost had higher P content, followed in ranking by same variety planted with 60 kg N kg ha^{-1} and same variety grown with 60 kg N ha^{-1} with 5 tons ha^{-1} of compost. Also, for K and Fe, Poinsett grown with 60 kg N ha^{-1} combined with 10 tons of compost had higher fruit content of K and Fe (Table 4).

Table 4: Effects of variety, NPK and compost interaction on fruit content of cucumber an alfisol

Variety	NPK Kg ha^{-1}	Compost N tons ha^{-1}	P	K	Ca	Mg %	Fe	Zn	
Marketmore	0	0	0.09	0.17	1.26	0.15	0.10	0.18	0.13
		5	0.09	0.16	1.24	0.14	0.10	0.18	0.11
		10	0.09	0.18	1.27	0.14	0.10	0.20	0.16
		20	0.10	0.20	1.28	0.14	0.12	0.22	0.16
	30	0	0.10	0.21	1.38	0.15	0.13	0.23	0.17
		5	0.10	0.24	1.28	0.15	0.14	0.26	0.20
		10	0.10	0.23	1.30	0.16	0.14	0.26	0.18
		20	0.10	0.20	1.32	0.17	0.13	0.25	0.18
	60	0	0.11	0.26	1.38	0.16	0.11	0.30	0.23
		5	0.11	0.25	1.42	0.18	0.16	0.36	0.25
		10	0.11	0.25	1.34	0.49	0.12	0.28	0.21
		20	0.11	0.26	1.41	0.17	0.14	0.33	0.24
Poinsett	0	0	0.12	0.41	1.50	0.21	0.17	0.48	0.35
		5	0.12	0.38	1.48	0.20	0.16	0.46	0.33
		10	0.12	0.46	1.57	0.23	0.20	0.52	0.37
		20	0.12	0.44	1.55	0.23	0.18	0.50	0.36
	30	0	0.11	0.30	1.46	0.16	0.15	0.40	0.28
		5	0.11	0.27	1.44	0.16	0.16	0.37	0.26
		10	0.12	0.35	1.50	0.18	0.21	0.44	3.64
	60	0	0.13	0.55	1.63	0.26	0.22	0.58	0.42
		5	0.13	0.50	1.62	0.26	0.23	0.54	0.40
		10	0.13	0.58	1.64	0.24	0.24	0.60	0.43
		20	0.13	0.48	1.60	0.24	0.22	0.53	0.38
Prob. of F:			ns	x	x	ns	ns	x	ns
LSD (P = 0.05):			0.12	0.002	0.02	0.19	0.03	0.002	1.94

x = Significant at 0.05 probability level, ns: non-significant at P < 0.05

CONCLUSION AND RECOMMENDATION

The chemical analysis of compost and the material used (cassava peel and poultry manure) indicated high nutrient content, absence of heavy and toxic metals like cadmium, (Cd), chromium (Cr), lead (Pb) and Selenium (SE). This shows their suitability as potential organic fertilizer for cucumber production. Poinsett variety of cucumber gave higher dry matter yield and nutrient content of minerals in their fruit than Marketmore variety.

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Highest mean values of dry weight and mineral content of fruit for the two cucumbers were obtained at 60 kg N ha^{-1}NPK when grown on an alfisol.

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EFFECTS OF COMBINED N: P: K AND SILICON FERTILIZER RATES ON GROWTH AND YIELD OF TOMATO CULTIVARS

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ABSTRACT

Thin basal stem and robust aerial stem diameters (BSD and ASD) along the stem of tomato plants majorly accounts for prostrate growth observed under field conditions. A pot experiment was conducted to study the effects of combined N:P:K and silicon fertilizer rates (0ml+0kgN, 0ml+50kgN, 0ml+100kgN, 500ml+50kgN, 500ml+100kgN, 1000ml+50kgN, 1000ml+100kgN) on growth and yield of improved tomato cultivars; Tropimech, UC-82, Roma-VF and a local cultivar- Kerewa. The aim was to identify the best combinations that could minimize the variation in BSD and ASD in favour of BSD for improved growth and yield of tomato under controlled condition. Data on growth parameters such as BSD and ASD, leaf thickness, total number of fruits, and total weight of fruits were collected at maturity. Combined N:P:K and silicon fertilizer generally reduced the stem diameter variation. Application of 50 kg ha^{-1} of N:P:K fertilizer in combination with 500 or 1000 ml ha^{-1} of orthosilicic acid (OSA) improved the yield components of tomato while application of 100 kg ha^{-1} of N:P:K with 500 or 1000 ml ha^{-1} of OSA improved the vegetative parameters of tomato cultivars. Kerewa had the highest yield (54.84 g) with the widest BSD (6.22 mm) and ASD (5.66 mm) while UC-82 maintained average vegetative growth and fruit yield. Across treatment combinations, the BSD was wider than the ASD revealing the possibility of growth conditions having different effect on BSD and ASD of tomato.

Key words: aerial stem; basal stem; combined fertilizers; N:P:K fertilizer; orthosilicic acid fertilizer; tomato

INTRODUCTION

Tomato cultivars are known for their high vegetative growth and fruit yield which make them susceptible to prostrate growth at maturity. Prostrate growth develops when plant stem cannot withstand the heavy weight of fruits. Variations in basal and aerial stem diameters caused by thin basal stem and robust aerial stem diameter along stem height combined with increase fruit yield have been observed to be the major causes of prostrate growth in tomato under field condition(Olagunju et al., 2019). This necessitated staking which can increase cost of production(Kemble et al., 1994). However, it remains unclear if the observed variation in field is the same under controlled condition and whether the combination of silicon with NPK fertilizer can effectively minimize this variation. In addition, cultivars that can combine reduced variation in basal and aerial stem diameters along the stem of tomato with higher yield can minimize the cost associated with staking in tomato production under combined silicon and NPK fertilizer rates. Nitrogen and silicon are nutrient elements that can increase the vegetative growth and fruit yield of plants. Though higher application rates of nitrogen fertilizer can increase yield, it can also increase the susceptibility of tomato cultivars to prostrate growth. Silicon, on the other hand, is an essential element because it is known to be beneficial to plant but its absence would not prevent plant from completing its life cycle. Furthermore, while nitrogen is an essential element that improves both the vegetative growth and yield of crops, silicon increases the mechanical strength of the stem through increase in structural stability of the stem in addition to alleviating both biotic and abiotic stresses in plant(He et al., 2015). Orthosilicic acid fertilizer is a silicon fertilizer formulated in the form that can easily be absorbed by plant. However, its role in improving the growth and yield of tomato has not been investigated. Tomato is one of the low silicon accumulating plants and has been observed to display passive absorption of silicon (Shi et al., 2014). Despite its limited response to silicon, tomato has been reported to benefit from both silicon and nitrogen fertilizers. Therefore, this study was conducted to establish the effectiveness of combined silicon and nitrogen fertilizer rates in improving growth and yield of tomato cultivars under controlled condition.

MATERIALS AND METHODS

The experiment was conducted in the screen house of College of Agricultural Sciences Olabisi Onabanjo University, Ayetoro Campus. Four tomato cultivars comprising three improved cultivars namely, Tropimech, UC-82, Roma-VF and a local cultivar- Kerewa, were planted in soils contained in 7-liter sized pot. Combination of nitrogen and orthosilicic acid fertilizer rates comprising; 0ml+0kgN, 0ml+50kgN, 0ml+100kgN, 500ml+50kgN, 500ml+100kgN, 100ml+50kgN, 1000ml+100kgN were applied on the tomato cultivars before flowering. The soils, scooped to a depth of 0-15 cm from Teaching and Research Farm of the College. The seeds of the tomato cultivars were nursed in separate pot for three weeks after which they were transplanted into the pots based on treatment arrangement fitted into Completely Randomized Design and replicated three times. Application of orthosilicic acid fertilizer commenced at one week after transplanting and was sprayed at two weeks' interval over six weeks according to recommended spray schedule of the manufacturer (Privi Life Science, India). Meanwhile N:P:K 20:10:10 fertilizer rates at 50 kg N ha^{-1} and 100 kg N ha^{-1} equivalent of0.78 g and 1.56 g per 7 kg soils, respectively were applied at two weeks after transplanting At maturity, when all fruits had reached physiological maturity and when fruits were firmed, growth parameters such as plant height, aerial and basal stem diameter, leaf thickness, leaf area were taken from the plants. Stem diameter variation (SDV) was computed using the method of (Olagunju et al., 2019) with little modification as

$$Stem\ diameter\ variation = \frac{\left[\left\{\frac{BSD - ASD}{BSD}\right\} \times 100\right]}{Plant\ height}$$

Yield parameters such as average number of fruits, average weight of fruits and total weight of fruits were also taken.

Data analyses

Data collected on growth and yield parameters were subjected to Analyses of Variance (ANOVA). Significant treatment means were separated using Fischer's Protected Least Significance Difference. Polygon view of Genotype x traits and fertilizer combinations x traits biplots were also plotted against the growth and yield parameters. The statistical package used was Genstat 12th Edition.

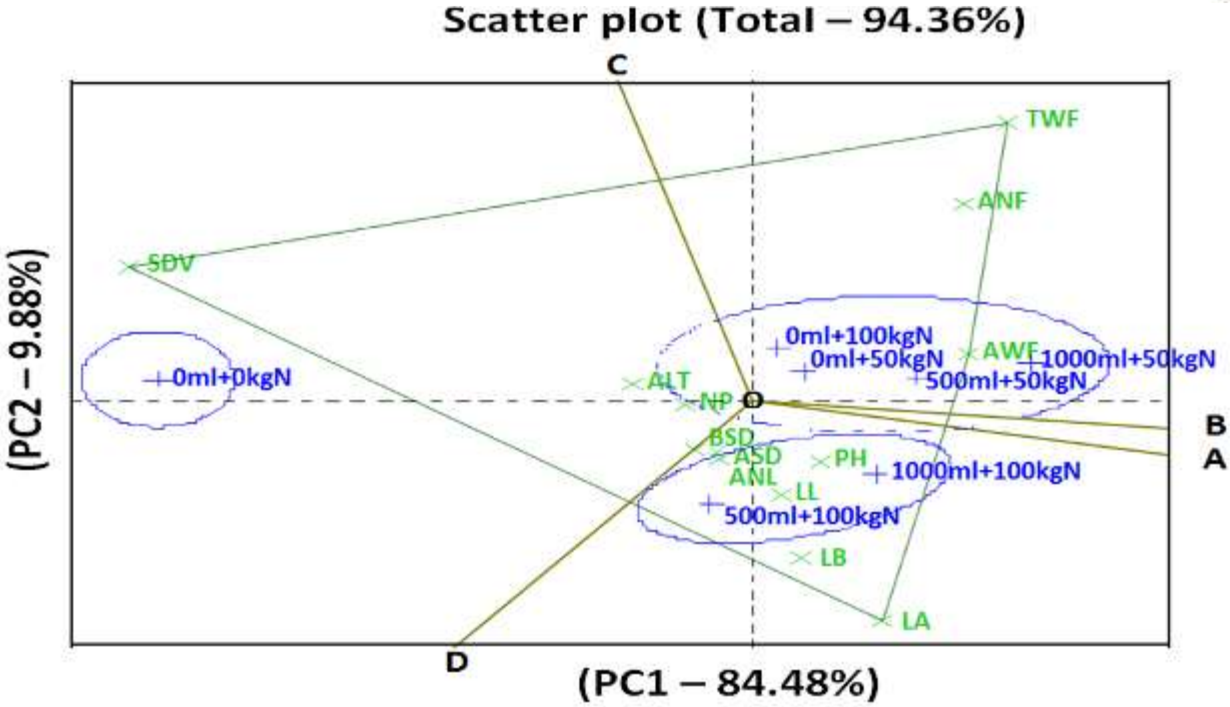
RESULTS AND DISCUSSION

The effects of combined N:P:K and silicon fertilizer rates was significant on the vegetative growth and fruit yield of the tomato cultivars (Table 1).Application of 50 kg ha^{-1} of N:P:K fertilizer in combination with 500 or 1000 ml ha^{-1} of OSA effectively improved the fruit yield and its component parameters (Sector BOC in Fig 1a) while application of 100 kg ha^{-1} of N:P:K in combination with 500 or 1000 ml ha^{-1} of OSA contributed to improved vegetative growth including basal and aerial stem diameters of the tomato cultivars (Sector AOD, Fig 1a). Application of 50 kg ha^{-1} had earlier been recommended for improving both the growth and yield of improved tomato cultivars towards reducing prostrate growth while maintaining appreciable yield increase(Olagunju et al., 2019). The result further suggested that doubling N:P:K fertilizer to 100 kg ha^{-1} may not be beneficial to tomato yield. The reduced growth and fruit yield of the tomato cultivars under no application of the fertilizers revealed the importance of the two fertilizers in improving the growth and yield of the tomato cultivars. However, the increased effectiveness of N:P:K fertilizer on growth and fruit yield of the tomato cultivars when applied in combination with orthosilicic acid fertilizer revealed the beneficial roles of silicon in increasing nutrient absorption in plants. Among the cultivars, Kerewawas exceptional in having the highest number of fruits which resulted in increased total weight of fruits (Table 1). The cultivar was also observed to have better growth in terms of wider basal and aerial stem diameter and reduced stem diameter variation. The adaptability of the cultivar to the local condition of growth could have contributed to the better performance observed. The cultivar, UC-82 was however exceptional in having the most average growth and yield among the cultivars (Fig 1b) but performed better than Roma-VF, a cultivar that has been reported to be less productive to UC-82 under field condition(Isah et al., 2014). The robust basal and stem diameters of Kerewa combined with its reduced stem diameter variation and the average performance of UC-82 for these traits suggest the two cultivars are suitable for erect growth and high yield. Combined N:P:K and orthosilicic acid fertilizer can effectively improve the growth and yield of improved tomato cultivars especially when applied at the rate of 50 kg ha^{-1} N + 1000 ml ha^{-1} OSA while no application of the two fertilizers can significantly reduce the growth and yield of tomato cultivars. The wider BSD than the ASD observed in this study which is at variance to the observed variation under field condition, where the reverse was observed, is an indication that the growth condition may influence the pattern of variation in BSD and ASD and can affect growth habit of tomato.

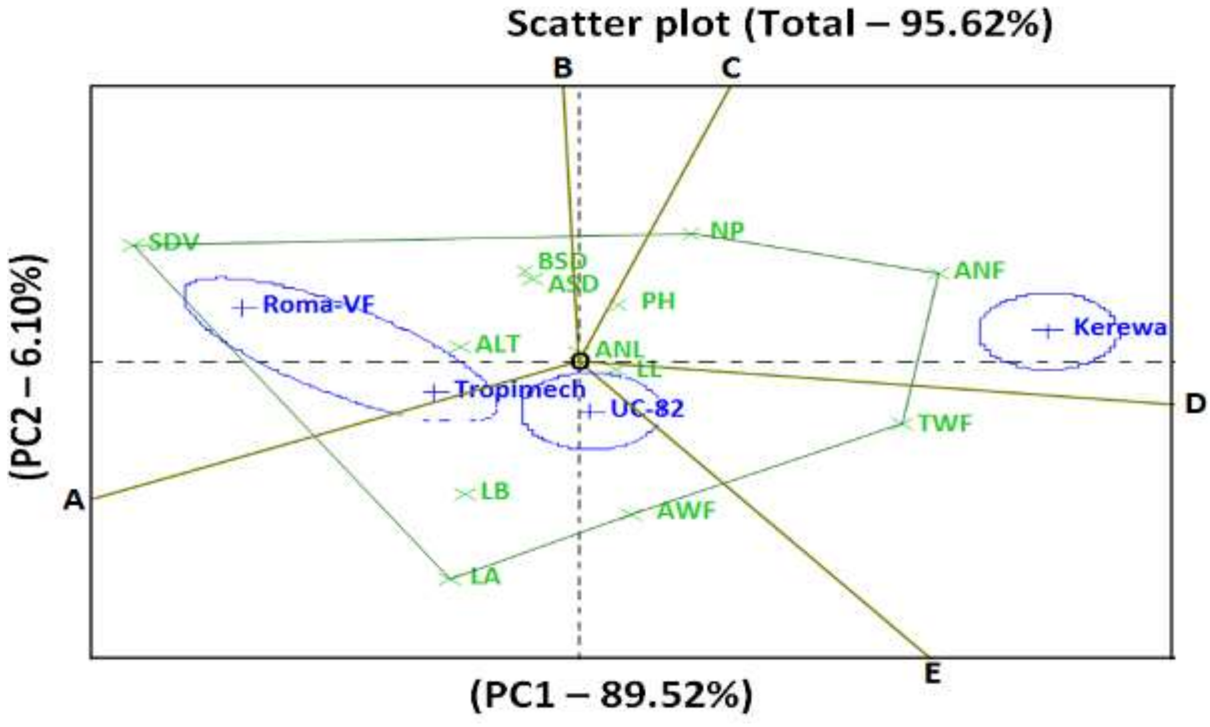
Table 1: Effect of combinations of ortho-silicic acid and NPK fertilizer rates on morphological traits and yield components of improved tomato cultivars

Source of variation	PH (cm)	BSD (mm)	ASD (mm)	SDV(cm^{-1})	ANL	NP	LB (cm)	LL (cm)	LA (cm^2)	ALT (mm)	ANF	AWF (g)	TWF (g)
Orthosilicic acid (OSA)+NPK fertilizer rates (FCs)													
0 ml Si+0kg N ha^{-1}	28.46^{e}	4.97^{c}	3.82^{d}	0.93^{a}	6.21^{d}	5.46^{c}	9.60^{c}	12.50^{c}	9.86^{c}	0.26^{b}	0.42^{d}	3.02^{c}	7.47^{d}
0 ml Si+50 kg N ha^{-1}	41.50^{d}	5.24^{c}	4.62^{c}	0.34^{b}	7.04^{cd}	6.92^{ab}	16.27^{b}	18.69^{b}	22.56^{b}	0.26^{b}	1.71^{bc}	13.93^{b}	36.52^{bc}
0 ml Si+100 kg N ha^{-1}	42.67^{cd}	6.50^{ab}	5.49^{ab}	0.45^{b}	7.00^{cd}	6.58^{ab}	17.29^{ab}	19.39^{b}	24.87^{ab}	0.28^{a}	1.83^{a-c}	18.65^{ab}	41.36^{ab}
500 ml Si+50 kg N ha^{-1}	56.58^{ab}	5.98^{b}	5.07^{bc}	0.35^{b}	8.67^{ab}	6.42^{b}	19.25^{ab}	21.38^{b}	30.67^{ab}	0.28^{a}	1.92^{ab}	22.97^{a}	46.40^{ab}
500 ml Si+100 kg N ha^{-1}	46.75^{b-d}	5.95^{b}	4.96^{bc}	0.39^{b}	8.00^{bc}	6.17^{bc}	18.79^{ab}	21.33^{b}	28.71^{ab}	0.25^{b}	1.04^{c}	15.96^{ab}	20.38^{cd}
1000 ml Si+50 kg N ha^{-1}	66.58^{a}	7.09^{a}	5.79^{a}	0.27^{b}	9.75^{a}	7.42^{a}	20.83^{a}	25.67^{a}	33.60^{a}	0.28^{a}	2.38^{a}	22.76^{a}	57.79^{a}
1000 ml Si+100 kg N ha^{-1}	53.33^{bc}	6.59^{ab}	5.57^{ab}	0.28^{b}	7.92^{bc}	6.67^{ab}	21.17^{a}	21.67^{ab}	34.96^{a}	0.26^{b}	1.67^{bc}	15.16^{b}	35.60^{bc}
LSD	*11.12*	*0.70*	*0.70*	*0.36*	*0.23^{t}*	*0.18^{t}*	*4.44*	*4.23*	*10.31*	*0.02*	*0.25^{t}*	*7.15*	*16.96*
Significance	***	***	***	***	***	**	***	***	***	***	***	***	***
Cultivars (C)													
Kerewa	58.88^{a}	6.72^{a}	5.66^{a}	0.27^{b}	9.07^{a}	8.76^{a}	17.02^{a}	24.07^{a}	24.5^{a}	0.27^{a}	2.60^{a}	19.41^{a}	54.84^{a}
UC-82	46.36^{b}	5.86^{b}	4.92^{b}	0.37^{b}	7.57^{b}	6.05^{b}	19.17^{a}	20.76^{b}	30.0^{a}	0.27^{a}	1.48^{b}	15.05^{ab}	36.50^{b}
Roma-VF	41.71^{b}	5.94^{b}	4.89^{b}	0.58^{a}	6.86^{b}	5.43^{b}	16.44^{a}	17.16^{c}	24.0^{a}	0.27^{a}	0.91^{c}	11.37^{b}	19.25^{c}
Tropimech	44.98^{b}	5.68^{b}	4.73^{b}	0.51^{b}	7.69^{b}	5.83^{b}	17.77^{a}	18.36^{bc}	27.4^{a}	0.26^{a}	1.29^{bc}	18.43^{a}	29.71^{bc}
LSD	*8.41*	*0.53*	*0.53*	*0.27*	*0.18^{t}*	*0.14^{t}*	*3.35*	*3.20*	*7.79*	*0.01*	*019^{t}*	*5.40*	*12.82*
Significance	***	***	***	*	***	***	ns	***	ns	ns	***	*	***
FCs x C	Ns	Ns	ns	Ns	Ns	***	ns	ns	ns	ns	***	ns	***

*$p< 0.05$, **$p<0.01$ and ***$p< 0.001$; ns = non-significant; means with the same letter(s) are not significantly different from one another using Fishers Protected Least Significance Difference test; ns = non-significant. LSD= Least significant difference. LSD with superscript 't' are from transformed mean. PH = Plant height; BSD = Basal stem diameter; ASD = Aerial stem diameter; SDV = Stem diameter variation; ANL = Average number of leaves; NP = Number of petioles; LB = Leaf breadth; LL = Leaf length; LA = Leaf area; ALT = Average leaf thickness; ANF = Average number of fruits; AWF = Average weight of fruits; TWF = Total weight of fruits



(a)



(b)

Figure 1: Treatments x traits biplot of (a) Fertilizer combination rates x traits and (b) cultivars x traitsbiplotsof improved tomato cultivars

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PERFORMANCE AND NUTRIENT COMPOSITIONS OF TOMATO (*LYCOPERSICON LYCOPERSICUM*) GROWN WITH COMPOSTED COCOA POD AND NPK FERTILIZER

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ABSTRACT

Field experiments were conducted to study the influence of different levels of organic fertilizer on the performance and mineral composition of tomato. The experiment was carried out at the Landmark University Teaching and Research farm located at kilometer 4, Ipetu Road, Omu-aran, Kwara State (7°45 N and 9°30 N and longitudes 230 E and 6°25 E). Treatment consisted four levels of composted cocoa pod (0, 3.25, 6.50, and 9.75 g bag^{-1}) and NPK fertilizer. Treatments were replicated three times in a completely randomized design. The following parameters were taken – plant height, number of leaves, yield and mineral (Ca, Mg, K, and Zn) composition of the fruit. Data collected were subjected to statistical analyses of variance (ANOVA) using statistical Analysis Software (SAS, 2002). The significant treatment means were compared using Duncan Multiple Range Test (DMRT) at 0.05 level of probability. The results of the study showed that, vegetative growth, yield and mineral composition of tomato were highest under the application of 6.5 g of CP+PM, and 9.75 g of CP+PM. Values obtained under the control treatments were significantly lower than other treatments. Therefore, economically, application of 6.5 g of CP+PM can be considered as a sustainable strategy for the production and superior quality of tomato.

Key words: Tomato, performance, nutrient composition, organic and inorganic fertilizer

INTRODUCTION

Tomato (*Solanum lycopersycum* L), is one of the most important vegetables nationwide. It is relatively a short duration crop which gives a high yield, and it is also economically attractive. Tomatoes are warm season crop and are sensitive to high humidity / rain. Thus, high yield of tomato is as a result of well-drained, sandy loam, and rich in humus soils. Tomatoes are rich in phosphorus, essential amino acids, vitamin B and C, iron, minerals, sugars, and dietary fibres and are considered as one of cheapest sources of important vitamins A and C, as well as, minerals such as iron and phosphorus. Extensive use of synthetic fertilizer to maximize the productivity often leads to depletion of essential soil nutrients, environmental degradation and adversely affects soil rhizosphere microbiota. Inorganic fertilizers have played a significant role in increasing crop production since the "green revolution (Liu *et al*., 2010); however, they are not a sustainable solution for maintenance of crop yields (Vanlauwe *et al*., 2010). Long-term overuse of mineral fertilizers may accelerate soil acidification, affecting both the soil biota and biogeochemical processes, thus posing an environmental risk and decreasing crop production (Aciego Pietri *et al*., 2008). Recently, organically cultivated vegetables have attracted considerable scientific interest and consumer demand as healthier products with safer characteristics. In a similar vein, organic agriculture, a sustainable means of vegetable cultivation has often been identified as an eco-friendly production system that can produce food with minimal risk to the environment (Dorais, 2007). Organic farming restricts the use of agrochemicals and offers a way to reduce the adverse effects of chemical fertilization (Aguilera *et al*., 2013; Aires *et al*., 2013). Organic amendments, such as compost and agricultural wastes, could therefore be a useful tool to sustainably maintain or increase soil organic matter, preserving and improving soil fertility and crop yield. This study therefore focuses on the use of organic amendment (composted cocoa pod with poultry manure) on the performance and mineral composition of tomato

MATERIALS AND METHODS

Description of the study Area

The research was conducted during the 2020/2021 cropping season at the Teaching and Research Farm of Landmark University, Omu-Aran, Nigeria. The site lies between latitude 8.9°N and longitude 50°61 E of the equator. It has annual rainfall pattern which extends between the month of April and

October with minimum 600 mm-1200 mm, the dry season is between October and March.

Soil sterilization, bagging and analysis

A well tilled soil characterized with good pore spaces was obtained from Teaching and Research Farms, Landmark University and was thoroughly mixed and sterilized to ensure the complete absence of disease-causing pathogen. Ten kilograms of the sterilized soil was filled into a perforated polythene bags of size 30 cm x 17 cm. Soil samples were randomly taken from the transplanting bags, bulked, air-dried and allowed to pass through a 2-mm sieve for routine physical and chemical laboratory analysis as described by Carter (1993).

Characteristics of the tomato and sources of planting materials

The variety of tomato used for the study was the Omu-Aran local which was obtained at the local market of Omu-Aran. The variety attain maturity between 60 and 70 days after transplanting, with a long harvesting period and high yield potential (indeterminate). It is also known to have intermediate resistance to fusarium wilt. The amendment used was a formulated organic fertilizer produced and obtained from microbiology department of Landmark University. NPK 15:15:15 and grow bags were obtained from an agro-allied shop located in Omu-Aran market.

Mineral analysis of composted cocoa pod

Laboratory analysis of the amendments used for the experiments was carried out to determine its nutrient compositions. The analysis was done for pH, N, P, K, Ca, Mg, Zn, and C:N (AOAC, 2003)

Raising and transplanting of Seedlings

The tomato seed was raised in the nursery at the screen house of Teaching and Research Farm Landmark University Omu-Aran using a sterilized soil. The seed was sowed on the 9th March, 2021 and two healthy seedlings were transplanted per bag three weeks after sowing which was later thinned to one seedling per bag after they have established.

Application of amendments and experimental design

Composted cocoa pod was applied based on the layout two weeks before transplanting to allow for their nutrient release, while NPK 15:15:15 was applied two weeks after transplanting to give room for the stability of the transplanted seedlings. Four levels of composted cocoa pod were applied at 0, 5, 10 and 15 t ha^{-1} and 200 kg NPK ha^{-1}. The equivalent of 0, 5, 10 and 15 t ha^{-1} of composted cocoa pod per bag was 0, 3.25, 6.5, and 9.75 g per 10 kg of soil while 200 kg NPK ha^{-1} is equivalent to 0.05 g per planting bag. The bags were arranged in the screen house in accordance with a completely randomized design (CRD), using 30 cm by 60 cm inter- and intra-row spacing. Treatments were replicated four times.

Harvesting

Mature and ripped fruits were harvested at intervals of five days for four weeks before the experiment was terminated. Harvested fruits were weighed with the aid of automated weighing balance of maximum capacity of 2100 g, readable at 0.01 g, and a model by OHAUS Corporation, USA.

Observation and Data Collection

The following vegetative and yield parameters were taken during the study – plant height, number of leaves, number of days to flowering, number of days to fruiting, number of fruits, and weight of fruits. A sample of each treatment was thereafter taken to the laboratory for quality determination.

Determination of nutrient compositions of tomato fruits

Mature and ripped fresh tomato fruits were collected based on treatments and taken to the laboratory of Landmark University, Nigeria for analysis. Mature, ripe and fresh tomato fruits were collected, oven-dried for 24 hours at 80°C, and ground in a Willey mill. Mineral elements were determined according to the methods as recommended by the Association of Official Analytical Chemists (AOAC, 2003).

Statistical Analysis

The data collected were subjected to one-way statistical analyses of variance (ANOVA) using statistical Analysis Software (SAS, 2002). The significant treatment means were compared using Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

RESULTS AND DISCUSSION

Initial Soil Properties

The pre-planting soil analysis is as shown in Table 1. The pH of the soil was slightly acidic, the nitrogen content of the soil was very low, the available phosphorus was high, and the exchangeable K was also low while the exchangeable Na, Ca and Mg were all suitable. The organic matter was low. The

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soil is high in sand with relatively low values in both silt and clay; hence the textural class is Sandy Loam.

Table 1: Physico-chemical properties of the initial soil

Parameter	2019	Parameter	2019
Sand (%)	69.2	Organic matter (%)	1.88
Silt (%)	14.5	K (cmol·kg)	0.14
Clay (%)	16.3	Ca (cmol·kg)	2.45
Textural class	Sandy loam	Mg (cmol·kg)	0.34
pH (H_2O) 1:1	5.62	Available P (mg·kg)	9.71
Total nitrogen (%)	0.15	Zn (mg·kg)	0.33

Mineral components of the amendments used in the experiment

The results of the laboratory analysis of composted cocoa pod is shown in Table 2. The results showed that the amendment contained varying nutrient elements in ranges suitable for plant growth and development.

Table 2: Chemical composition of composted cocoa pod

Nutrients %	pH	N	P	K	Ca	Mg	Zn	C:N
Composted cocoa pod + poultry dropping	7.30	9.18	0.62	1.22	14.00	4.80	3.46	13.40

Effect of composted cocoa pod and NPK fertilizer on plant height and number of leaves of tomato plant

Table 3 and 4 shows the effect of application of varying levels of amendment and NPK fertilizer on plant height and number of leaves of tomato. Application of the amendment significantly resulted in taller plants and more number of leaves though there was no significant difference between the two parameters when 6.5 g of CP+PM, 9.75 g of CP+PM, and 5 g of NPK were applied except for NPK on number of leaves. Control treatment gave the least values for the two parameters.

The significant increase in the vegetative parameters could also be due to better availability of soil nutrients in the rhizosphere, especially nitrogen and phosphorus which have enhancing effect on the vegetative growth of plants by increasing cell division, elongation and varietal variability to absorb nutrient from the soil (Yahaya *et al*., 2010). It could also be as a result of as a result of application of composted cocoa pod which increased soil organic matter and enhanced microbial activities leading to increased soil nutrients availability (Ziblim *et al*. 2013). Similar result was by Ojeniyi *et al*. (2007) where they reported that organic manures are the major sources of nitrogen, phosphorus, potassium, calcium and magnesium in many Tropical countries.

Effect of composted cocoa pod and NPK fertilizer on the flowering, fruiting and yield parameters of tomato plant

Application of composted cocoa pod and NPK fertilizer significantly influenced the yield parameters. The yield and yield-contributing variables differed significantly among the treatments and were enhanced by the application of composted cocoa pod and NPK fertilizer (Table 5). Application of 6.5 g of CP+PM, 9.75 g of CP+PM, and 5 g of NPK showed better performance in enhancing the number and weight of fruits when compared with the control, though the number of days to flowering were reduced.

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Organic fertilizers that are made from animal excreta or other agricultural wastes are usually used to improve the structure and stability of the soil as well as to enhance the yield and quality of the crop (Marzouka and Kassem 2018). It is well known that the growth and yield of vegetable crops is affected by the quality and quantity of fertilizers used (Chang *et al*., 2010). In this study, application of organic amendments at higher rates performed favourably with inorganic fertilizer.

Table 3: Effect of composted cocoa pod and NPK fertilizer on plant height of tomato

	Plant Height (cm)				
Treatments (g/bag)	4WAT	6WAT	8WAT	10WAT	12WAT
0 g of CP+PM	16.95c	21.50c	25.75c	26.20c	30.44c
3.25 g of CP+PM	18.36bc	25.67b	40.47b	44.44b	49.74b
6.5 g of CP+PM	21.44a	34.22a	53.78a	65.44a	72.11a
9.75 g of CP+PM	22.38a	35.88a	54.38a	67.19a	75.20a
5 g of NPK	21.19a	35.75a	53.88a	65.88a	73.63a

Means with the same letter(s) in a column are not significantly different at $p \leq 0.05$.
WAT = weeks after planting, CP= cocoa pod, PM= poultry manure.

Table 4: Effect of composted cocoa pod and NPK fertilizer on number of leaves of tomato plant

	Number of Leaves				
Treatments (g/bag)	4WAT	6WAT	8WAT	10WAT	12WAT
0 g of CP+PM	2.50c	4.55c	6.05c	7.20c	15.90c
3.25 g of CP+PM	3.94bc	7.78b	12.39b	17.56b	20.78b
6.5 g of CP+PM	5.27a	8.83a	17.94a	24.77a	28.22a
9.75 g of CP+PM	5.44a	8.38a	17.94a	24.81a	29.75a
5 g of NPK	4.63b	7.38b	12.25b	18.5b	21.00b

Means with the same letter(s) in a column are not significantly different at $p \leq 0.05$.
WAT = weeks after planting, CP= cocoa pod, PM= poultry manure.

Table 5: Effect of composted cocoa pod and NPK fertilizer on the flowering, fruiting and yield parameters of tomato plant

Yield Parameters				
Treatments (g/bag)	Days to flowering	Days to fruiting	Number of fruits/plant	Weight of fruits/plant (g)
0 g of CP+PM	19.60b	34.05b	9.50c	500.34d
3.25 g of CP+PM	19.33b	32.11a	12.00b	910.39c
6.5 g of CP+PM	22.11a	30.61a	17.44a	1225.11a
9.75 g of CP+PM	22.19a	30.44a	18.50a	1350.39a
5 g of NPK	21.87a	30.13a	17.00a	1150.25b

Means with the same letter(s) in a column are not significantly different at $p \leq 0.05$.
CP= cocoa pod, PM= poultry manure.

Increase in the fruit yield of tomato as a result of the application of high rate of composted cocoa pod could be attributed to some major mineral elements and micronutrients needed for plant growth and development that are present in the amendment (Atakora *et al*., 2014). Increase in tomato weight could be attributed to taller plants and more number of leaves produced making the plant to trap more sunlight for photosynthesis and transporting assimilates to the fruits.

Effect of composted cocoa pod and NPK fertilizer on the flowering, fruiting and yield parameters of tomato plant

Results of the analysis of the mineral composition of tomato fruits after harvest is as shown in Table 6. Ca, Mg, K, and Zn content of fruits were higher in bags applied with composted cocoa pod than the control treatment. Application of 6.5 g of CP+PM, and 9.75 g of CP+PM significantly ($p \leq 0.05$) resulted in higher values for all the mineral elements. The highest K content was recorded with the application of NPK which was statistically identical to 6.5 g of CP+PM, and 9.75 g of CP+PM. Analysis of composted cocoa pod revealed that it contained adequate quantity of both macro and micronutrients needed for the cultivation of tomato when compared with inorganic fertilizer. The finding revealed that application of organic amendment significantly increased the nutrient constituents of tomato fruits. This might have been due to the fact that the organic amendments provided micronutrients, such as zinc, iron, copper, manganese, at optimum levels (Yadav *et al.,* 2003).

Table 6: Effect of composted cocoa pod and NPK fertilizer on the mineral composition (mg/100g) of tomato fruits yield parameters of tomato plant

Treatment (g/bag)	Ca	Mg	K	Zn
0 g of CP+PM	0.67c	0.65c	0.01c	0.12d
3.25 g of CP+PM	1.45b	1.40b	0.04b	0.25b
6.5 g of CP+PM	1.60a	2.30a	0.07a	0.30a
9.75 g of CP+PM	1.62a	2.35a	0.08a	0.32a
5 g of NPK	0.70c	1.30b	0.08a	0.18c

Means with the same letter(s) in a column are not significantly different at $p \leq 0.05$.
CP= cocoa pod, PM= poultry manure.

CONCLUSION

The high nutrient content of the composted cocoa pod was identified as the main factor for increasing vegetative parameters, yield and mineral elements of tomato. The result of the vegetative, yield and mineral composition of tomato indicated that composted cocoa pod improved growth and development. This study therefore revealed that application of 6.5 g of CP+PM and 9.75 g of CP+PM improved all the parameters tested better than the application of inorganic fertilizer. It can therefore be concluded that application of 6.5 g of CP+PM will be more economical and could sustain soil fertility than inorganic fertilizer.

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EFFECT OF SITE-SPECIFIC APPLICATION OF N AND K FERTILIZERS ON THE GROWTH AND YIELD OF CASHEW AT OCHAJA, KOGI STATE NIGERIA

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ABSTRACT

The soil is sandy loam with the average values of sand, silt and clay were 888, 20 and 92g/kg respectively. The soil was deficient in Nitrogen (N) and Potassium (K) with values of 0.41g/kg soil and 0.012cmol/kg soil respectively at 0-40cm depths. The values were used to compute fertilizer rates for cashew at 54kgN/ha and 84kgK$_2$O/ha. Application of N fertilizer had significant depressive effect on the pH of soil at both soil depths compared to the control and when N and K fertilizers were applied jointly. Similarly, application of potassium-based fertilizer with or without Nitrogen fertilizer gave marginal increase of 5.4% in the pH of the soil. Also, application of N and K fertilizers significantly (P<0.05) affected total soil nitrogen at 0-20cm soil depth. The total N ranged from 0.5g/kg to 0.7g/kg soil across the fertilizer treatments. N and K fertilizers did not significantly improve the available Phosphorus (P) in the soil across the fertilizer treatments. The exchangeable K in the soil followed a similar trend of available P across the various treatments. The nut yield of cashew was significantly (P<.05) improved as a result of Nitrogen fertilizer applied alone without K and the control. Application of N only deficient nutrients gives better result in terms of efficiency than blanket application of fertilizer without recourse to native fertility of the soil.

INTRODUCTION

Cashew is an important commodity crop with great potentials as foreign exchange earner and source of industrial raw materials with the prospect of becoming a major commercial tree crop in Nigeria. Cashew as a result of its wide adaptation is often grown in very poor soils and this has affected its survival and establishment (Topper, *et al.* 2001). Cashew cultivation is variously limited by both biotic and abiotic factors particularly in poor soils. The soils upon which cashew is grown are of poor to low fertility level, this is due to the misleading assertion that cashew can survive in any soil regardless its fertility status. In most cashew plantations, productivity is largely dependent on natural soil endowment as fertilizers are not part of its production input system (Ibiremo *et al.,* 2017, Agbongiarhuoyi *et al.,* 2014). Consequently, the soils upon which cashew are cultivated were maintained through litter fall and other natural endowment which hinders the crop from realizing its full potentials. In cashew production, fertilizer is rarely used as an input in the production system and when it is used blanket application is employed. Hence, application of fertilizer is inevitable for the replacement of soil nutrients that are being mined through apple and nut harvest annually. This can be achieved through fertilizer application based on soil test value. At Ochaja substation, the site being considered is deficient in nitrogen and potassium and for effective management of the soil, the addition of nitrogen and potassium based fertilizers will enhance its productivity. Conventionally, the use of solid fertilizers of major nutrients of nitrogen, phosphorus and potassium are common with few farmers that use fertilizers on the crop in Nigeria. The objectives of the study were to evaluate the effect of application of N and K fertilizers based on soil test value on the yield of cashew and to assess its effect on soil properties.

MATERIALS AND METHODS

Soil samples were collected randomly within the plantation at Ochaja and the samples were processed and analyzed for both physical and chemical characteristics using standard laboratory procedures using IITA laboratory manual (1982). The fertilizer computed was based on the analytical result of samples at 0-20cm soil depth. The result of the analysis indicated that the total nitrogen was 0.04g/kg soil which is in adequate to sustain cashew as it requires 1g/kg soil and the available P was adequate while the exchangeable potassium was also deficient having a value of 0.012cmol/kg which is far below the critical of 0.12cmol/kg soil. From these values, four treatment combinations were formed from two rates of nitrogen fertilizer and two rates of potassium fertilizer that were applied to young cashew trees in the field. The Nitrogen fertilizer was applied at 0 and 54 kgN/ha while the

Potassium was applied at 0 and 84kgK/ha and the treatments were arranged in a RCBD with 3 replications and crop morphological parameters, nut yield and soil nutrient characteristics would be measured. The fertilizers were applied in two splits application. The first dose was applied in June while the second dose was applied in September of 2019 and 2020. Initial plant growth parameters were taken to form the basis for assessing the effect of the fertilizer treatments. The data collected were subjected to ANOVA and means were separated using LSD at 5% level of probability.

RESULTS AND DISCUSSION

The pre-cropping soil characteristics indicated that the soil is sandy loam with the average values of sand, silt and clay were 888, 20 and 92g/kg soil respectively (Table 1). The pH is slightly acidic and very close to neutral with a mean value of 6.7 while the organic carbon (OC) was low with an average value of 0.82g/kg soil. The OC in block B was higher that the OC in Block A. The total Nitrogen in the soil was 0.41g/kg soil which is below the critical value of 1g/kg soil. The deficiency of 0.6g/kg soil will require 54kg N for optimum production while the mean value for available P was 5.28mg/kg soil. This value is above the level required by cashew for optimum productivity. The average value of potassium was 0.012cmol/kg soil. The deficiency of 0.108cmol/kg requires 84kg/ha. The exchangeable calcium ranged from 1.26 to 2.26cmol/kg across the soil depth of 0-40cm with a mean value of 1.68cmol/kg. The mean value of exchangeable Mg was 0.29cmol/kg across the two soil depths. The pH of the soil at the two soil depths of 0 - 20 and 20 - 40cm was significantly ($p<0.05$) affected by application of nitrogen and potassium fertilizers ($P<0.005$). Application of N fertilizer had significant depressive effect on the pH of soil at both soil depths compared to the control and when N and K fertilizers were applied jointly. This could be as a result of the property of urea fertilizer that lowers soil pH as observed by Agbede (2009) and Adejumo, (2010). Similarly, application of N and K fertilizers significantly ($P < 0.05$) affected total soil nitrogen at 0 - 20cm soil depth. However, the effect was not significant at 20 - 40cm soil depth. Specifically, the total soil N in places where urea was applied seemed to be lower than the control (without fertilizer). The high level of sand in the soil might be the reason for low retention of applied N which is contrary to the observation by Adejumo, (2010) that application of urea increases total soil N. The soil available P was significantly ($P < 0.05$) influenced ($P<0.05$) by the application of N and K fertilizers across the two soil depths. Application of potassium alone depressed significantly ($P<0.05$) the available P at both depths (Table 2). The available P at both depths in the control plot was higher than when either of the fertilizers was applied. The initial soil P content was high, that informed its non-inclusion in the fertilizer formulation. The exchangeable K at both soil depths was not significantly affected by the application of N and K (Table 2). The exchangeable K ranged from 0.09 to 0.16 cmol/ kg soil at the two soil depths. The nut yield of cashew was significantly ($P < .05$) improved as a result of nitrogen and potassium fertilizers (Figure 1). Specifically, application of N fertilizer enhanced the nut yield of cashew significantly compared to the control. Similarly, N application increased the nut yield of cashew significantly ($P<0.05$) than when K alone or N and K fertilizer were applied together. The application of N enhanced the growth of cashew which translated to increase in the nut yield of cashew. This observation is consistent with the result obtained by Adejumo, (2010) in the improvement of the yield of cashew by N application.

CONCLUSION

Application of fertilizer based on the result of soil test and the need of the site in question will give an optimum result in terms fertilizer use efficiency and improve crop yield relative to blanket application of fertilizer without recourse to native nutrients of the soil.

Table 1: Initial soil physical and chemical properties of the cashew plot

Block	Soil Depth (cm)	Sand g/kg soil	Silt g/kg soil	Clay g/kg soil	pH	O.C g/kg	Total N g/kg	Ava.P Mg/kg	Exch K^+ Cmol/kg	Exch Ca^{2+} Cmol/kg	Exch Mg^{2+} Cmol/kg	CEC Cmol/kg	Base saturation %
A	0-20	885.20	22.80	92.00	6.7	0.78	0.07	5.03	0.012	2.26	0.35	2.78	95.83
A	20-40	895.20	12.80	92.00	6.8	0.66	0.02	5.20	0.011	1.73	0.29	2.18	95.05
B	0-20	895.20	12.80	92.00	6.6	0.97	0.05	5.35	0.012	1.26	0.27	1.70	92.81
B	20-40	875.20	32.80	92.00	6.7	0.86	0.02	5.55	0.012	1.34	0.25	1.15	91.62
Mean x		**887.70**	**20.30**	**92.00**	**6.7**	**0.82**	**0.04**	**5.28**	**0.012**	**1.65**	**0.29**	**1.95**	**93.83**

Table 2: Influence of Nitrogen and Potassium fertilizers on some soil chemical properties at Ochaja cashew plot

Treatment	**pH (H_2O)**		**Total N (g/kg)**		**Available P mg/kg**		**Exchangeable K cmol/kg**	
Soil depth	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm	0-20cm	20-40cm
N_0K_0–T1Control)	5.13	4.94	0.07	0.03	11.17	10.35	0.16	0.10
N_1K_0-T2	5.77	4.77	0.05	0.03	10.22	9.74	0.14	0.11
N_0K_1-T3	5.27	5.17	0.07	0.03	7.39	8.98	0.14	0.09
N_1K_1-T4	5.54	5.37	0.05	0.04	9.37	10.32	0.13	0.10
LSD (P<0.05)	0.19	0.20	0.01	0.02	0.72	0.60	0.01	0.01

Legend: N_0K_0–T1Control), N_1K_0-T2, N_0K_1-T3, N_1K_1-T4

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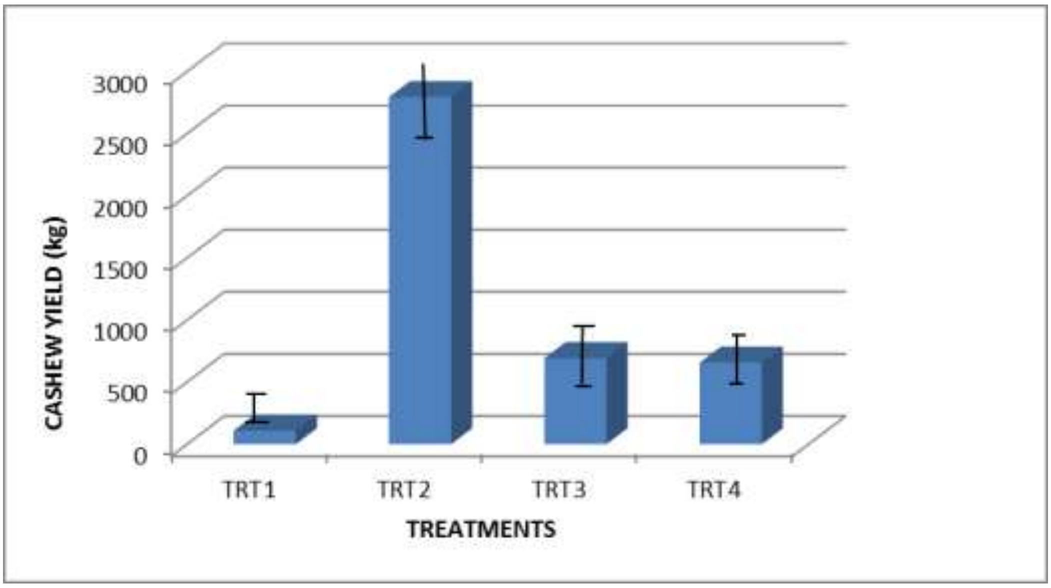

Figure 1: Effects of Nitrogen and Phosphorus based fertilizer on raw cashew yield (kg)

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REVALIDATING APPLICATION MODALITIES FOR ORGANIC FERTILIZERS AND EFFECTS ON OKRA PERFORMANCE

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ABSTRACT

Demystifying appropriate application modality for organic fertilizers is a major limiting factor to their use. The pot trial composed of two organic fertilizers: Poultry manure (tagged Pm containing 19.5 and 19.4g/kg N and P respectively) and compost (tagged Comp containing 10.5 and 15.7g/kg N and P respectively). Each was applied using three modalities: Nitrogen (tagged NM), phosphorus (tagged PM) and tonnage (TM) modalities at three application rates: Lower (tagged L), Optimum (tagged O) and Higher (tagged H) rates. The results were compared with conventional chemical fertilizer (CF) at similar rates. Optimum application rate regardless the organic fertilizer or application modality supported highest soil and plant parameters compared to lower and higher rates with the organic fertilizers been superior to the conventional CF. Compost and Pm using TM and NM respectively produced highest okra fruit weights while TM and NM enhanced soil total N and available P in Pm and compost treated soils respectively. The PM consistently produced least soil and plant parameters.

Key words: Compost; Application modality; Organic fertilizers; Okra fruit weight

INTRODUCTION

Organic fertilizers are plant nutrient sources obtained from the raw, biologically and/or thermally modified plant and animal wastes. Its forms include manure (such as farm yard, green manure, sludge and slurries), compost (including plain and fortified compost types such as phospho-compost) and biochar. They are multi-nutrient fertilizers containing nitrogen, phosphorus, exchangeable bases and micronutrients essential for plant growth. These nutrients are sometimes in lower concentrations compared to those of chemical origin. They are however superior to chemical fertilizers in their generally high organic matter contents which are of importance in enhancing soil aggregate stability (Ewetola *et al.,* 2019), carbon sequestration (Oyeyiola *et al.,* 2017; Oyeyiola 2017; Oyeyiola and Omueti 2016), microbial activities and CO2 emission mitigation from soils (Goeschel, 2016; Adesodun *et al.,* 2015; Niggli *et al.,* 2009).They are also well documented to contribute significantly to enhanced vegetable crop yield and quality (Oyeyiola *et al.,* 2020; Aluko *et al.,*2020; Khandaker *et al.,* 2017)

Despite all these benefits associated with organic fertilizers, their use in Nigerian soil is limited. The right modality for their field application remains a major bottle neck. Use of tonnage modality (e.g. 2.5, 5.0 and 10 t/ha) is widely used by researchers (Aluko *et al.,* 2020; Kakar *et al.,* 2020; Oyeyiola, 2017; Atijegbe *et al.,* 2014). Recently the use of selected nutrient components in the organic material especially the nitrogen and phosphorus contents have been proposed. There is however no reported work where these application modalities have been compared to know which is optimal for okra production in Nigerian soils. Assessing which of tonnage and nutrient (N and P) component application modalities that will compare favorably with the recommended conventional chemical fertilizer (NPK 15:15:15 spiked with urea) for okra production was the focus of this experiment.

MATERIALS AND METHODS

Soil sampling, preparation and routine analysis

The experimental top soil (0-15cm depth) was sampled from the Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Nigeria during the 2019 cropping season. The soil was prepared and subjected to routine analysis following standard procedures described by IITA (1978). The soil has near neutral pH value (6.8), deficient in total N (0.15 g/kg), organic carbon (1.7 g/kg) and Mehlich extracted available P (9.02 mg/kg). The soil was, however, sufficient in exchangeable bases with sandy loam textural class.

Treatments, experimental design and set up

The pot trial composed of two organic fertilizers: Poultry manure (tagged Pm containing 19.5 and 19.4g/kg N and P respectively) and compost (tagged Comp containing 10.5 and 15.7g/kg N and P respectively). Each was applied using three modalities: Nitrogen (tagged NM), phosphorus (tagged PM) and tonnage (TM) modalities at three application rates: Lower (tagged L), Optimum (tagged O) and Higher (tagged H) rates. Chemical fertilizer NPK 15:15:15 augmented with urea applied at three similar application rates and unamended soil that received no fertilizer were included. The trial was a one-way experiment arranged in completely randomized design with three replications. The fertilizer treatments and quantities applied per 5 kg soil are summarized in Table 1. After appropriate treatment applications, okra seeds were sown to achieve a plant per pot and were nurtured to maturity. Data were taken on fresh fruit, dry root and shoot weights per pot while total N and available P were determined in the soil samples collected at harvesting. Data were subjected analysis of variance using Genstat statistical package and means separated by LSD at 5% probability level.

Table 1: Equivalent quantities of organic fertilizers applied using nitrogen, phosphorus and tonnage modalities and chemical fertilizer at three application rates

Application modality	N, P and K application rate description	Fertilizer quantities (g/pot) Compost	Poultry manure	Chemical fertilizer
Nitrogen modality				
Lower rate	30:15:15	7.10	3.85	-
Optimum rate	60:30:30	14.30	7.69	-
Higher rate	90:45:45	21.30	11.55	-
Phosphorus modality				
Lower rate	30:15:15	0.69	0.84	-
Optimum rate	60:30:30	1.39	1.69	-
Higher rate	90:45:45	2.07	2.52	-
Tonnage modality				
Low rate	2.5 t/ha	6.25	6.25	-
Optimum rate	5.0 t/ha	12.50	12.50	-
Higher rate	7.5 t/ha	18.75	18.75	-
NPK 15:15:15 spiked with urea				
Lower rate	30:15:15	-	-	0.25 NPK + 0.09 Urea
Optimum rate	60:30:30	-	-	0.50 NPK + 0.17 Urea
Higher rate	90:45:45	-	-	0.75 NPK + 0.26 Urea

RESULTS AND DISCUSSION

Comparison of selected soil and plant parameters from soils amended with organic fertilizers using different application modalities with chemical fertilizer at lower application rate

The performance of the organic fertilizer treatment was significantly reduced under low application rate regardless the application modality compared to the conventional chemical fertilizer applied at similar lower rate (Fig. 1). The situation was severe on fruit production of the plant in the compost applied using phosphorus modality (PM) such that the plant could not produce any fruit. This treatment received the least quantity (0.7 g) of the organic fertilizer which seem not sufficient to supply enough nitrogen to carry the plant through its vegetative stage let alone reproductive stage. This 0.7 g compost received using PM will only deliver 2.94 kg N/ha to the plant which is far below the 29.82 and 26.46 kg N/ha received by plants raised under nitrogen (NM) and tonnage (TM) modalities. Lower application produced least soil and plant parameters across all the treatments tested. At lower rate, poultry manure applied using TM however produced higher soil available P and fruit weight while NM favored higher soil total N and total dry biomass. In compost treated soil, TM consistently supported highest soil available P, fruit weight and total dry biomass with NM highest in soil total N.

Comparison of selected soil and plant parameters from soils amended with organic fertilizers using different application modalities with chemical fertilizer at optimum application rate

The two organic fertilizers applied using different modalities produced superior soil and okra yield parameters over conventional chemical fertilizer applied at similar optimum rate ad unamended soil (AC) except fruit weights from poultry manure and compost applied using PM and NM respectively and total N and available P from compost applied using PM as shown in Fig. 2. Poultry manure using NM and compost at NM produced fruit weights and total dry biomass 194.5 and 114.3% respectively over the conventional chemical fertilizer. Poultry manure at PM and compost at N modality enhanced soil total N and available P by 31.7 and 296.3% respectively over chemical fertilizer.

Generally, optimum application rate across all the treatment tested produced better soil and plant parameters compared to lower and higher rates. At optimum application rate however, poultry manure at NM and PM supported highest fruit weight and soil total N respectively while TM favored highest soil available P and total dry biomass. For compost, NM supported highest total dry biomass, soil total N and available P while TM gave highest okra fruit weight.

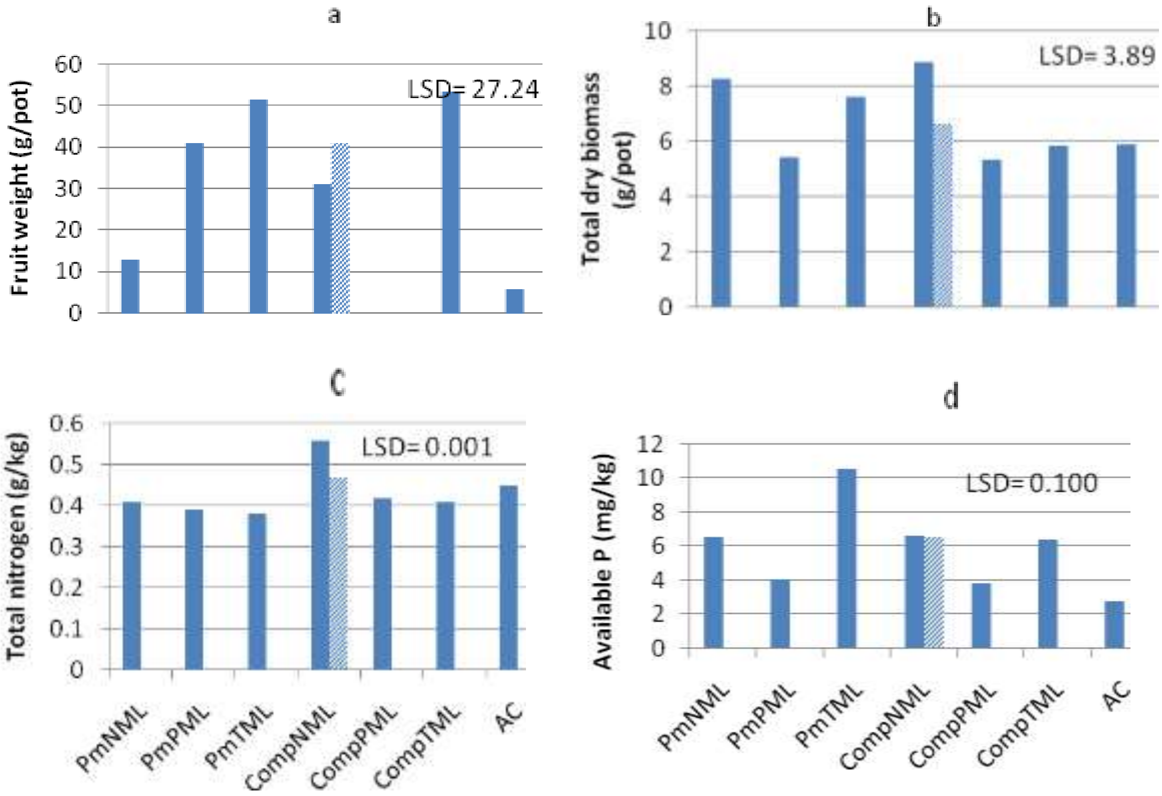

Fig. 1. Comparison of selected plant (a-b) and soil (c-d) parameters from soils amended with organic fertilizers using different application modalities with chemical fertilizer at lower application rate

NB: Crossed bar is chemical fertilizer treated soil

Comparison of selected soil and plant parameters from soils amended with organic fertilizers using different application modalities with chemical fertilizer at higher application rate

At high application rate, all the organic fertilizer combinations enhanced soil and okra yield parameters over the conventional chemical fertilizer and unamended soil except compost at PM (for fruit weight, total dry biomass and total N) and poultry manure at both NM and PM (total N) as shown in Fig. 3. Poultry manure at NM and compost at TM increased fruit weight and total dry biomass of okra by 120.5 and 52.4% respectively over chemical fertilizer at similar high rate. With reference to soil characteristics, poultry manure at TM enhanced total N by 14.3% while compost at NM was 322 % higher in improving available P over chemical fertilizer treated soil.

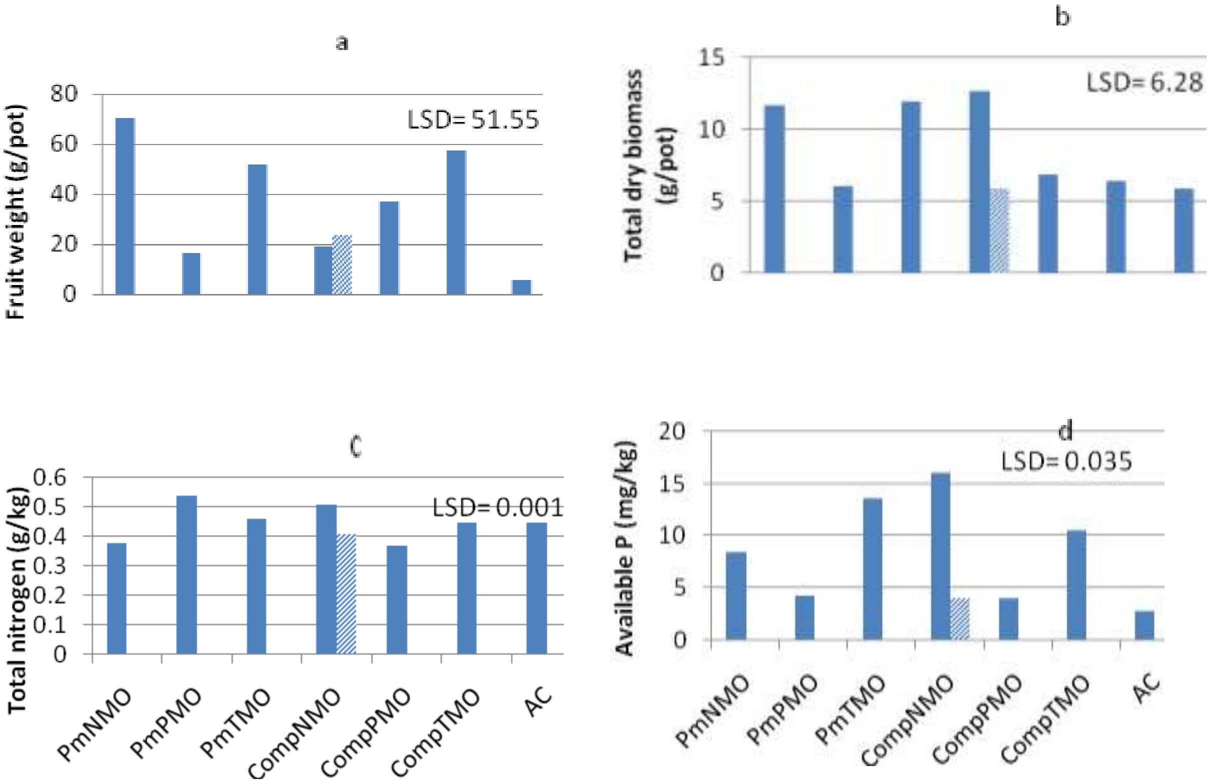

Figure 2. Comparison of selected plant (a-b) and soil (c-d) parameters from soils amended with organic fertilizers using different application modalities with chemical fertilizer at optimum application rate

NB: Crossed bar is chemical fertilizer treated soil

The selected soil and plant parameters were generally lower at higher application rate for the organic and chemical fertilizers although, both organic fertilizers outperformed the conventional chemical fertilizers. Poultry manure applied using the NM supported higher okra fruit weight and total dry biomass while TM had higher total N and available P over the others. The NM in compost treated soil produced higher okra fruit weight and soil available P while TM enhanced soil total N and total dry biomass of okra over other application modalities. The PM was the poorest for both organic fertilizers.

CONCLUSION

Okra plants raised under all the organic fertilizer combinations at the three application rate out-performed the chemical fertilizer with tonnage and nitrogen application modalities been superior to phosphorus modality. However, tonnage application modality favoured better performance in uncomposted organic fertilizers such as the poultry manure while nitrogen modality was optimal for composted organic fertilizer.

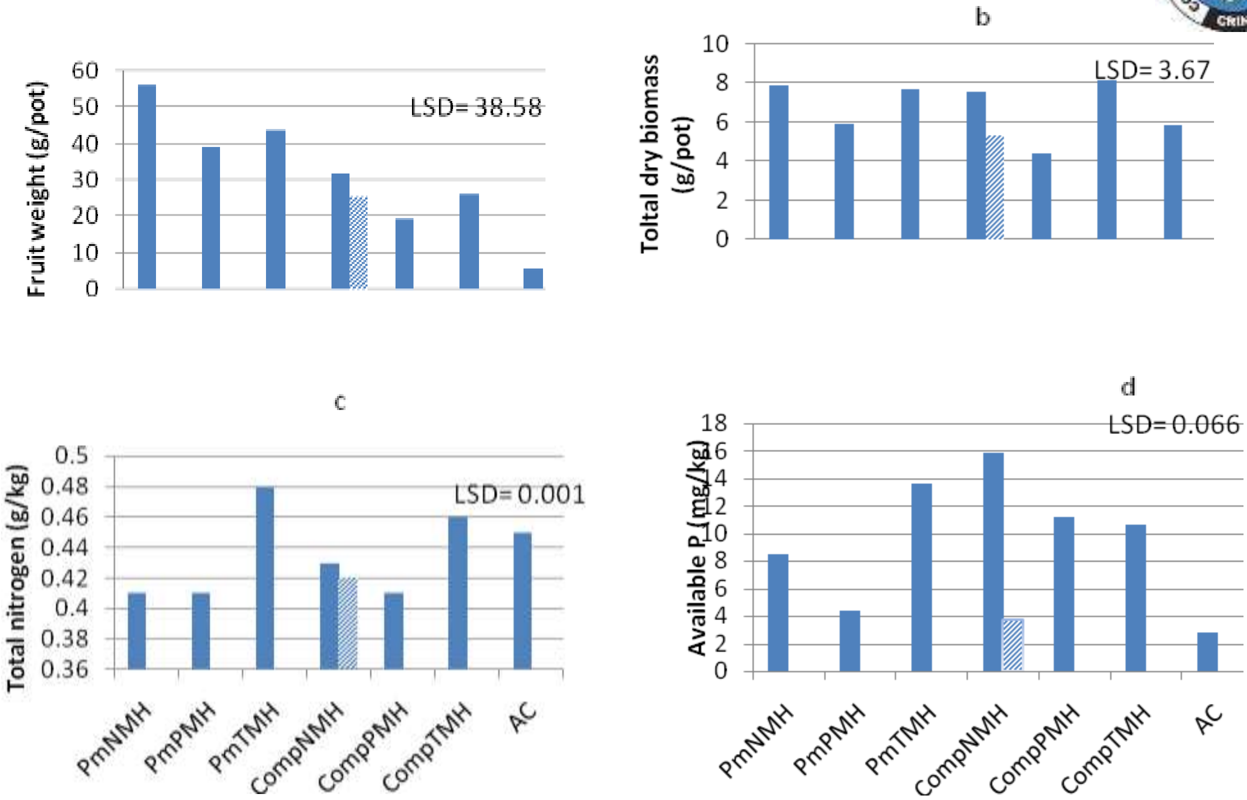

Figure 3. Comparison of selected plant (a-b) and soil (c-d) parameters from soils amended with organic fertilizers using different application modalities with chemical fertilizer at higher application rate

NB: Crossed bar is chemical fertilizer treated soil

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THE POTENTIAL OF ORGANIC FERTILIZERS ON THE NUTRIENT CONTENT OF COFFEE (*COFFEA CANEPHORA* L.) SEEDLINGS

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ABSTRACT

The effect of three organic fertilizers namely; Chromoleana odorata (Siam weed), Pennisetum purpureum (Napier grass) and cow dung were evaluated on the shoot and root nutrient content of Coffea Canephora seedlings at the rate of 0.5 and 10tha[1]. The result showed that, application of each of the organic fertilizers singly or combined significantly ($P \leq 0.05$) improved the nutrient content of Coffea Canephora seedlings. Application of Chromoleana odorata alone or in combination with either the two organic fertilizers improved nutrient content of the shoot mostly when applied at 5t ha[1]. The P content of the shoot increased between 0.23 – 0.24% and the K content between 0.25 – 0.27%. The exchangeable cations showed considerable increase Ca 0.26 – 0.27% and Mg 0.25 – 0.26%. The nutrient content of the root showed a similar trend of increase but most significant with plants that received Chromoleana odorata organic fertilizer based treatments. Organic fertilizers therefore can serve as good nutrient source supplement for coffee seedling production in the humid tropic.

Key word: *Chromoleana odorata* (Siam weed), *Pennisetum purpureum* (Napier grass)

INTRODUCTION

Coffee is one of the important agricultural produce traded worldwide (Mellissa, 2002) and stand as the second commodity in the market. This is why (Sara Lee, 2003) noted the essence of enhancing productivity of Coffee since it would be economically rewording to producing countries. More so, Coffee is mainly a cash crop produced by low income small scale farmers who are faced with the problems of inadequate funds, lack of modern cultural practices and nutritional requirement of Coffee for their desired growth, yield and quality. Coffee production worldwide has been found to require additional external input in form of fertilizers. Over the years, the high cost of inorganic fertilizers (Charles, 2001) has led to poor yield. This is primarily because coffee exerts a lot of demand on the soil in terms of nutrient uptake. The use of various materials as fertilizers has been reported to improve the soil fertility and increased yield (Obatolu and Agboola, 1990; Daniel, 2005). These organic materials are cheaply available within the reach of farmers. This study therefore evaluated the effect of three organic fertilizers on the shoot and root nutrient content of *Coffea Canephora* seedlings.

MATERIALS AND METHODS

A Greenhouse study was carried out at Cocoa Research Institute of Nigeria, Ibadan $7^0 10'$N, $3^0 52'$E) located at an altitude of 122m above mean sea level (abmsl) during the 2020 cropping season. The soil has been classified as Alfisol (Soil Survey Staff, 1990), belonging to Oba series (Smyth and Montgomery, 1962). Bulk soil samples were collected at a depth of 0 – 30cm, air – dried, crushed and sieve to pass through 2mm sieve and analysed before the experiment (Table 1). The plant materials used in compounding the organic fertilizers were *Chromoleana odorata* Siam weed (C), *Pennisetum purpureum* napier grass (P) and cow dung (D) respectively. The plant materials were freshly harvested, chopped to 5cm size, sun – dried and milled using Glen – Creston stainless hammer mills. The cow dung was collected at Bodija cattle market, Ibadan and packed in jut bags. The cow dung was later cured, sun – dried and milled. Ripe Coffee berries were collected from matured Coffee *Canephora* tree (Quillo variety). The berries were collected, depulped and sown (pre – nursed) in seed tray filled with river sand for six weeks. Five kilograms (Kg) of air – dried soil were weighed each into 5-litre size plastic pots perforated at the bottom. Three levels of the organic fertilizer viz; 0, 11 and 22g corresponding to 0, 5 and 10t ha[1] were each weighed out and applied as sole and in combinations in the ratios of 1:0:0; 1:1:0 and 1:1:1 for 5tha[1] and 2:0:0, 2:2:0 and 2:2:2 for 10tha[1] respectively and a control. The treatments were laid out in a complete replicated four times. The organic fertilizers were mixed with the soil in the 5-litre plastic pots and arranged before bare root coffee seedlings were transplanted into each pot and watered. Agronomic data (Plant height, leaf area, number of leave and stem diameter) for six months after which total sampling was done. The

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seedling in each pot were uprooted, washed and separated into shoot and roots, enveloped and oven – dried at 68^{0}C for 48hrs. The oven – dried plant samples were later milled and analysed. The particle size analysis was carried out according to (Bouyoucous, 1965). The soil pH was carried out following (Schofield and Tylor,1955) procedure while the organic carbon was analyzed using chromic acid digestion method (Allison,1965). The total N was determined using the Macro – Kjeldhal apparatus as described by (Bremner, 1965) and the exchangeable cations (K, Ca and Mg) using NH_4OAC (Chapman, 1965) methods. Similarly, the plant analysis was carried by; Percent N by using Micro - Kjeldhal apparatus (Bremner, 1965), percent P by dry ashing (Jackson, 1970) and the percent K, Ca and Mg in the plant tissue were determined using the digest under percent P determination above respectively.

Table 1: Physical and chemical characteristics of the soil used

Depth Cm	pH H_2o	Sand ←	Silt	Clay gkg	Org.C	Total N →	Avail.P mg/kg	Exch, K ←	Ca Cmol/kg	Mg →
0-15	6.2	712	74	214	1.5	0.22	4.00	0.09	0.12	1.70

RESULTS AND DISCUSSIONS

Some physical and chemical properties of the soil used are presented in Table 1 and the nutrient content of the organic materials used in compounding the organic fertilizers in Table 2. Results from the study on the agronomic and dry matter yield is presented in Figure 1.

Application of sole organic fertilizers and the various combinations at 5tha[1] significantly ($P\leq0.05$) increased the N content of the shoot between 50 - 58% where *Chromoleana odorata* was applied as sole and in combination with *Pennisetum purpureum* and cow dung above the control (Table 3). This may be as a result of the high N content of the organic materials (Table 2). There was no significant difference in the P and Ca content across the treatments. This may be attributed to the magnitude of cations absorption by higher plants (Samuel and Werner, 1978).

Table 2: Nutrient Content of organic fertilizers materials used.

	N ←	P	K (%)	Ca	Mg →	Cu ← mg/kg	Zn →
Cow dung	1.29	0.60	0.88	1.57	0.43	36.60	284.00
Pennisetum purpureum	2.00	1.80	3.20	0.27	0.58	35.20	225.00
Chromoleana odorata (Siam weed)	2.47	0.21	3.08	1.21	0.76	48.10	391.00

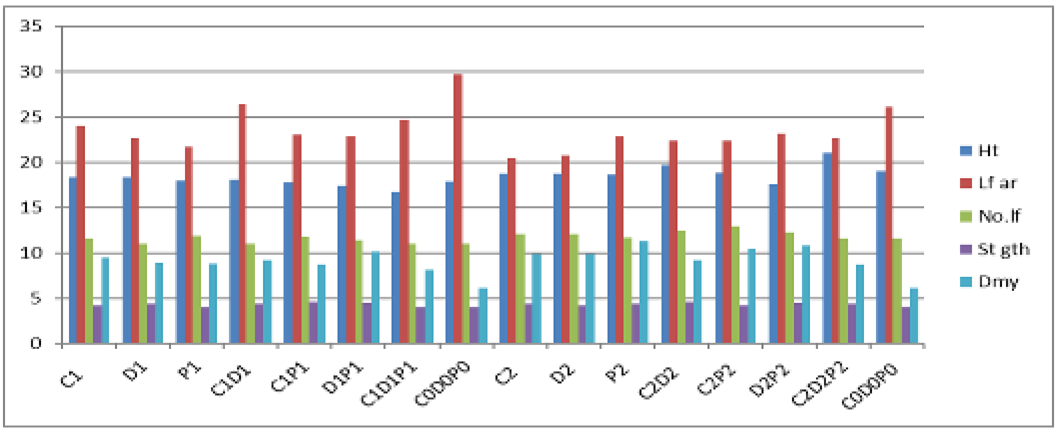

Figure 1: Effect of three organic fertilizers on the growth and dry matter yield of coffee seedlings

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There was an increase in the range of 0.22 0.24% and 0.27 – 0.28 for K at 5t/ha compared to the application at 10tha^{1}. The K content increased significantly in the shoot where the combination of the three organic fertilizers ($C_1D_1P_1$) was applied 0.27% at 5tha^{1} and 0.28% at 10tha^{1} respectively. Similarly, the Mg content in the coffee seedling shoot showed a considerable increase. This finding is consistent with that earlier reported by (Brady and Weil, 1999; Jayarama, 2003). The rooting system of coffee trees is known to be concentrated within the 40cm depth of the soil. The addition of sole and the combination of the organic fertilizers enhanced the root growth significantly ($P \leq 0.05$) especially with the treatment *Chromoleana odorata* with *Pennisetum purpureum* (C_1P_1) and cow dung and *Pennisetum purpureum* (D_1P_1) at 5tha^{1}. There was a similar increase of 40% in the root N above other treatment and the control at 10tha^{1}. Similarly, where *Chromoleana odorata* (C_2) and the combination with cow dung (C_2D_2) showed an increased in the root N content (Table 3 & 4).

Table 3: Effect of different combination of three organic fertilizers on shoot nutrient content of coffee seedlings at 5t/ha and 10t/ha

Treatments	N	P	K	Ca	Mg
5t/ha					
C_1	0.50a	0.23a	0.25b	0.28a	0.25a
D_1	0.49a	0.22a	0.25b	0.28a	0.20b
P_1	0.48ab	0.24a	0.26a	0.28a	0.23b
C_1D_1	0.54a	0.23a	0.26a	0.28a	0.17c
C_1P_1	0.58a	0.24a	0.24c	0.27a	0.23b
D_1P_1	0.46b	0.23a	0.27a	0.27a	0.19bc
$C_1D_1P_1$	0.55a	0.24a	0.25b	0.27a	0.18bc
$C_0D_0P_0$	0.24c	0.24a	0.26a	0.27a	0.16d
10t/ha					
C_2	0.50a	0.23b	0.23b	0.26a	0.17b
D_2	0.48ab	0.23b	0.24ab	0.27a	0.21a
P_2	0.49a	0.22b	0.26a	0.26a	0.20a
C_2D_2	0.48ab	0.23b	0.23b	0.25a	0.17b
C_2P_2	0.51a	0.24b	0.21b	0.23b	0.18b
D_2P_2	0.46b	0.23b	0.22b	0.24b	0.23a
$C_2D_2P_2$	0.46b	0.26a	0.17c	0.19c	0.18b
$C_0D_0P_0$	0.24c	0.24b	0.28a	0.27a	0.16c

Means within the same column, followed with same letter are not significantly different from each other at 5% level of significance (New Duncan's Multiple Range Test). C = *Chromoleana odorata*; D = Cow dung; P = *Pennisetum purpureum*; O = Control; 1 = 5t/ha;2 = 10t/ha

There was no significant increase in the root P in all the treatments at both rate of application this may be as a result of the fate of P in the soil which is either slowly release or easily fixed. The exchangeable cations showed a significant increase especially where *Pennisetum purpureum* (P_1), the two *Chromoleana odorata* and the combination with cow dung (C_1D_1), *Pennisetum purpureum* and the combination with cow dung (P_2D_2) and the control were applied. There was no significant difference ($P \leq 0.05$) in the root Ca content across the treatments. The treatment that received *Chromoleana odorata* (C_1) application at 5tha^{1} significantly increased the root Mg content ($P \leq 0.05$) than all other treatments. Similarly, application of the organic fertilizers at 10tha^{1} on showed significant difference in all the treatment except where *Pennisetum purpureum* (P_2). Similar trend was observed for Ca and Mg content in the root content at 5tha^{1}. The Mg content was highest where alone cow dung (D_2) was added at 10tha^{1}. A significant correlation(r=0.05) was observed between the root N content and dry matter yield (Table 5) of coffee seedlings except P. All other nutrient element considered showed a negative correlation with the dry matter yield. Hence the study revealed that, of each of the three organic fertilizers either singly or in combinations enhanced coffee seedling growth resulting in high dry matter yield but most at 5tha^{1}. These organic fertilizers can serve as good nutrient supplement for coffee production with the imminent scarcity of inorganic fertilizers.

Table 4: Effect of each and different combination of three organic fertilizers on root nutrient content of coffee seedlings at 5t/ha and 10t/ha

Treatments	N	P	K	Ca	Mg
5t/ha					
C_1	0.38b	0.25a	0.11b	0.16b	0.26a
D_1	0.40a	0.25a	0.15b	0.16b	0.22b
P_1	0.37b	0.25a	0.13b	0.18b	0.24a
C_1D_1	0.35b	0.25a	0.14b	0.20a	0.22b
C_1P_1	0.40a	0.24a	0.18a	0.20a	0.20b
D_1P_1	0.39ab	0.25a	0.13b	0.20a	0.20b
$C_1D_1P_1$	0.39ab	0.26a	0.14b	0.20a	0.20b
$C_0D_0P_0$	0.27c	0.25a	0.17b	0.13c	0.20b
10t/ha					
C_2	0.40a	0.26a	0.15a	0.18c	0.20c
D_2	0.36ab	0.26a	0.15a	0.18b	0.20c
P_2	0.39ab	0.25a	0.15a	0.18ca	0.27a
C_2D_2	0.39ab	0.25a	0.15a	0.27a	0.15d
C_2P_2	0.38b	0.24a	0.16a	0.26a	0.20c
D_2P_2	0.37b	0.25a	0.16a	0.26a	0.24b
$C_2D_2P_2$	0.40a	0.24a	0.16c	0.27c	0.13d
$C_0D_0P_0$	0.27c	0.25a	0.17a	0.13d	0.20c

Means within the same column, followed with same letter are not significantly different from each other at 5% level of significance (New Duncan's Multiple Range Test). C = *Chromoleana odorata*; D = Cow dung; P = *Pennisetum purpureum*; O = Control;1 = 5t/ha;2 = 10t/ha

Table 5: Pearman rank correlation analysis of shoot and root nutrient content of coffee seedlings.

	Total N	Avail. P.	K	Ca	Mg
Shoot	0.41*	0.53**	- 0.02^{ns}	-0.20^{ns}	-0.21^{ns}
Root	0.58*	0.13^{ns}	-0.07^{ns}	-0.14^{ns}	0.02^{ns}

CONCLUSION

The significant correlation observed between the dry matter yield, shoot and the root N content of coffee seedlings showed that, the addition of the organic fertilizers enhanced the growth of the seedling resulting in high dry matter yield especially at 5tha[1].

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INFLUENCE OF MULCH AND ORGANIC FERTILIZER ON THE GROWTH, BIOMASS AND YIELD OF GINGER (*ZINGIBER OFFICINALE*) IN AN ALFISOL IN IBADAN, SOUTHWEST NIGERIA

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ABSTRACT

Ginger is a medicinal spices crop rich in anti-inflamatory and antioxidant compounds such as gingerols, betacarotene, caffeic acid, vitamins and minerals. Plant growth and yield of crops like ginger are affected by level of soil fertility and cultural practices such as mulching. Although, management practices such as mulching and application of organic fertilizer (OF) improve soil quality and enhance crop yield. Limited information is available on the combined effects of Chromolena odorata mulch (CM) and organic fertilizer on the yield of gnger. Therefore, the combined effects of Chromolena odorata mulch and organic fertilizer on ginger growth, biomass and yield were investigated. Field experiment involving three of levels of Chromolena odorata mulch (0, 15 and 30 t/ha) and five rates of commercial organic fertilizer (0, 10, 15, 20 and 25 t/ha) was carried out at National Horticultural Research Institute, Ibadan. The N, P and K composition of organic fertilizer are 1.7, 1.2 and 2.4 % respectively. The experiment was a 3 x 5 factorial in a split plot design with three replicates. Organic fertilizer was applied two weeks before planting. The Chromolena odorata mulch was applied immediately after planting. Data were collected at four weeks' interval plant height, number of leaves, number of tillers, above and below biomass and rhizome ginger yield. The results showed that plant height ranged from 18.8 cm (0 t/ha CM) to 27.2 cm (30 t/ha CM) and 18.9 cm (0 t/ha OF) to 26.9 cm (25 t/ha OF). Number of leaves range from 11.1 (0 t/ha CM) to 13.7 (30 t/ha CM) and 11.1 (0 t/ha OF) to 13.9 (25 t/ha OF). Above ground biomass ranged from 34 kg/ha (0 t/ha CM) to 70.8 kg/ha (30 t/ha CM) and 34.9 kg/ha (0 t/ha OF) to 69.7 kg/ha (25 t/ha OF). Rhizome yield ranged from 3.6 t/ha (0 t/ha CM) to 7.2 t/ha (30 t/ha CM) and 4.7 t/ha (0 t/ha OF) to 6.9 t/ha (25 t/ha OF). Plant height, number of tiller, number of leaves and rhizome yield in 30 t/ha CM + 25 t/ha OF (30.9±0.5 cm, 6.8±0.2, 15.2±0.1 and 8.3±0.1 t/ha respectively) were significantly higher than other treatments.

Key words: biomass, *Chromolena odorata*, fertilizer, ginger, yield

INTRODUCTION

One of the major constraints to crop production in the tropics is the low fertility status of most of the soils which is a reflection of the low level of organic matter, nitrogen, phosphorus and exchangeable cations (Agbede and Adekiya, 2009). The challenge of food production in continuous cropping systems in the humid and sub-humid tropics of Nigeria is to manage the fragile soils to ensure sustained productivity without reverting to the bush fallow or shifting cultivation of traditional agriculture (Ndaeyo *et al.,* 1995).

Ginger (*Zingiber officinale* Roscoe) of the family Zingiberaceae is indigenous to warm tropical climates, particularly southeastern Asia. It is a monocotyledon with a slender perennial herb-like habit, but is usually grown as an annual. It is an erect plant propagated through its rhizomes which are underground. It contains stalkless leaves and attains a height of 2-3 feet (60-90cm), it is popularly known in countries like Jamaica and Europe, but it is assumed to have originated from tropical Asia. It benefits from manuring and does well when irrigated (Adegbola *et al*., 1972). Ginger is an important spice used as a condiment in vegetable preparations. Ginger tea is also used as a carminative and in the symptomatic treatment of colds. The oil and oleoresins obtained from ginger are also used in many food items, soft drinks and beverages (Singh *et al*., 2008). Ginger is basically considered to thrive best on rich medium loams with good supply of humus. High humidity throughout the crop period is necessary.

The decline of soil organic matter with cropping is a major factor affecting sustainability of many cropping systems in sub Saharan Africa (Buyanovzky *et al.,* 1984). Studies also indicate that soil physical, biological and chemical properties can sustainably be improved through the improvement of soil organic matter (Paul 1984). This can be done through practices like mulching and addition of manures (Unger 2001). Also studies carried out indicated positive effect of organic wastes on soil productivity. For instance, Mbah and Onweremadu (2009), reported that soil-incorporation of calliandra and leucaena green biomass with or without fertilizer increased total soil nitrogen by 1-8% over a period of four years.

Mulching is an effective method of manipulating crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Awodoyin and Ogunyemi, 2005). Awodoyin and Ogunyemi (2005) have reported that the weed control efficiency of different types of mulch in cayenne pepper production ranged from 27% to 97%. According to Ojeniyi (1995) and Agboola *et al*. (1992), soils in Nigeria suffer deficiencies common to tropical soils. These include low organic matter content, shallow depth and high acidity. About 63% of the agricultural soils in Nigeria are low in productivity and over 90% are Alfisols and Ultisols that are low in organic matter and have low activity clays. There is therefore the need to identify the best rate of organic fertilizer and the level of mulch suitable for ginger production with the ultimate aim of improving productivity.

MATERIALS AND METHODS

This study was conducted at National Horticultural Research Institute, Ibadan (7° 30'N, and 3° 54'E; in an altitude of 234m above sea level), Oyo State. Ibadan is located in the rain-forest agroecological zone (White, 1983). The average mean minimum and maximum temperatures were 22.8°C and 31.9°C respectively. The rainfall is bimodal, with total annual rainfall ranging between 1299.2mm and 1550.6mm. The experimental design was a slit plot design consisting of three levels of mulch as main plot and organic fertilizer treatments as the subplots replicated three times. The plot size was 2 m x 2 m. Ginger bits was planted at a spacing of 20 cm x 25 to a depth of 4 – 5 cm. Three levels of mulch were 0, 15 and 30 t/ha and five different rates of organic fertilizer were 0, 10, 15, 20 and 25 t/ha. The three levels of mulch and five rates of organic fertilizer resulted in 15 treatment combinations. Organic fertilizer was applied by spreading on the soil surface of each plot at different rates of 0, 10, 15, 20 and 25 t/ha two weeks before planting the ginger. Dried mulch was also applied by spreading the mulch material on the soil surface on each plot at different levels of 0, 15 and 30 t/ha immediately after planting on the same day. The mulching material was dried *Chromolaena odonrata* and the organic fertilizer was Alesinloye Asejere organic fertilizer. Weeding was done manually using hand or hoeing. Parameters considered included: plant height, number of leaves, number of branches, stems and leaves biomass and yield. Data were subjected to statistical analysis of variance (ANOVA) using general linear model procedure of the Statistical Analysis System (SAS Inst, 1998). Means were separated using the Duncan's Multiple Range Test (DMRT) at 0.05 level of probability.

RESULTS AND DISCUSSION

The results regarding the physical and chemical soil analyses at the time of cultivation indicated that the soil was loamy sand in nature, with pH of 5.7, a level suitable for many tropical crops. The organic carbon of 17.3 g/kg and total nitrogen of 1.3 g/kg were low. The available P of 8.5 cmol/kg was low. The exchangeable bases (K, Ca, Mg and Na) (0.1, 0.3, 0.3 and 0.1 cmol/kg respectively) were low. The extractable minerals such as Zn and Mn were high. Table 1a shows ginger plant height as influenced by mulch and different rates of organic fertilizer application. Significant differences were observed at the various weeks of observation after planting. Plant height was significantly affected by levels of mulch with 30 t/ha of mulch treatment having the highest value of 36.6 cm and 0 t/ha mulch having the least value of 28.3 cm. Also, significant differences were observed among the plant heights with different rates of organic fertilizer at 4 to 24 WAP. Interaction between mulch and organic fertilizer application did not significantly influence the plant height. Table 1b presents the combined effect of mulch and organic fertilizer on plant height. Mulch at 30 t/ha and organic fertilizer at 25 t/ha combination had the highest plant height 30.9 cm, followed by mulch at 15 t/ha and organic fertilizer at 25 t/ha with plant height 27.7 cm and least by mulch at 0 t/ha and organic fertilizer at 0 t/ha (control) with plant height of 14.7 cm. The same trends of observation were observed in number of leaves. The highest average number of leaves of ginger plant was also observed in 30 t/ha of mulch and 25 t/ha of organic fertilizer (Table 2).

Table 1a: Effect of mulch and organic fertilizer application on the plant height (cm) of ginger

	Weeks after planting					
Treatments (t/ha)	4	8	12	16	20	24
Mulch (M)						
0	6.0[c]	12.0[c]	17.0[c]	22.5[c]	27.1[c]	28.3[c]
15	8.4[b]	16.7[b]	23.1[b]	30.4[b]	33.7[b]	34.0[b]
30	10.1[a]	20.1[a]	26.2[a]	34.2[a]	36.1[a]	36.6[a]
Organic Fertilizer (OF)						
0	6.2[d]	12.4[d]	17.6[d]	23.6[d]	26.2[d]	27.4[d]
10	7.7[c]	15.4[c]	20.9[c]	28.3[c]	30.7[c]	31.6[c]
15	8.2[bc]	16.3[bc]	22.1[bc]	29.2[bc]	32.5[bc]	33.2[bc]
20	8.9[b]	17.8[b]	24.1[ab]	31.1[ab]	35.2[ab]	35.8[ab]
25	9.7[a]	19.4[a]	25.6[a]	32.9[a]	36.9[a]	36.8[a]
M x OF	NS	NS	NS	NS	NS	NS

Means followed by the same letter in the same column under each factors are not significantly different by Duncan Multiple Range Test at P < 0.05 (DMRT). NS = Not significant.

Table 1b: Combined effects of mulch and organic fertilizer application on plant height (cm) of ginger after planting

	Organic fertilizer (t/ha)					Mulch
Mulch (t/ha)	0	10	15	20	25	Mean
0	14.7	17.5	18.9	20.8	22.1	18.8
15	19.3	23.5	24.3	27.0	27.7	24.4
30	22.9	26.2	27.5	28.7	30.9	27.2
Organic fertilizer mean	18.9	22.4	23.6	25.5	26.9	

LSD (P < 0.05) for comparing effects of mulch = 1.7
LSD (P < 0.05) for comparing effects of organic fertilizer = 2.2
LSD (P < 0.05) for comparing effects of mulch x fertilizer = NS

Table 2: Combined effects of mulch and organic fertilizer application on number of leaves of ginger after planting

	Organic fertilizer (t/ha)					Mulch
Mulch (t/ha)	0	10	15	20	25	Mean
0	9.5	10.7	10.9	12.0	12.5	11.1
15	11.5	12.5	13.1	13.9	14.1	13.0
30	12.2	13.3	13.8	14.1	15.2	13.7
Organic fertilizer mean	11.1	12.2	12.6	13.3	13.9	

LSD (P < 0.05) for comparing effects of mulch = 0.6
LSD (P < 0.05) for comparing effects of organic fertilizer = 0.7
LSD (P < 0.05) for comparing effects of mulch x fertilizer = NS

Between 8 and 24 WAP, significant differences (P < 0.05) were observed among the above ground biomass mean levels of mulch treatments and also observed among the above ground biomass treated with organic fertilizer (Table 3). The same trends of observation were observed in below ground biomass of ginger. Mulch and organic fertilizer interaction did not have significant influence on above ground biomass between 8 and 16 WAP. However, interaction between mulch and organic fertilizer had significant effect on above ground biomass at 24 WAP. Combination of 30 t/ha mulch and 25 t/ha organic fertilizer treated plots gave the highest quantity of the above ground biomass and the least value was obtained from control plot (Table 3).

Table 3: Combined effects of mulch and organic fertilizer application on above ground biomass (kg/ha) of ginger after planting

	Organic fertilizer (t/ha)					Mulch
Mulch (t/ha)	0	10	15	20	25	Mean
0	12.5	24.3	35	46.6	51.4	34.0
15	39.5	55.4	62.7	69.4	73.1	60.0
30	52.9	60.6	73.6	82.4	84.5	70.8
Organic fertilizer mean	34.9	46.8	57.1	66.2	69.7	

LSD (P < 0.05) for comparing effects of mulch = 4.0
LSD (P < 0.05) for comparing effects of organic fertilizer = 5.2
LSD (P < 0.05) for comparing effects of mulch x fertilizer = 20.9

Yields of ginger as affected by mulch and organic fertilizer application are presented in Table 4a and b. Significant difference (P < 0.05) were observed among the mean treatments. Mulch applied at 30 t/ha had the highest rhizome yield mean value of 7.2 t/ha and least value by the control. Organic fertilizer treatment had a significant effect on the rhizome yield with ginger plant fertilized with 25 t/ha organic fertilizer having highest rhizome yield value of 6.9 t/ha while 0 t/ha recorded the least value of 4.7 t/ha. Mulch and organic fertilizer interaction had significant effect on rhizome yield. The high value obtained in 25 tons/ha of organic fertilizer and 30 tons/ha of mulch in plant height, number of leaves, number of tillers, leaves biomass and yield is an indicator that ginger is a soil nutrient exhausting crop and requires heavy mulching and appreciable amount of organic fertilizer to obtain high yield. Cho *et al.,* (1987) opined that the ginger yield was positively correlated with the soil organic matter content. Awodoyin and Ogunyemi, (2005) reported that mulching is an effective method of manipulating crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content. Mulching increased the germination and growth of plants in terms of height and number of tillers. Applications of leaf mulch immediately after planting and 6 weeks after using a total of 20 t/ha of green leaves resulted in 200 percent increase in yield over the nonmulched crop, and this was found sufficient in the ginger growing areas of the higher elevations of Western Ghats, South India (Nybe and Mini Raj 2005).

Table 4a: Effect of mulch and organic fertilizer application on yield (t/ha) of ginger

Treatments (t/ha)	Yield (t/ha)
Mulch (M)	
0	3.6[c]
15	6.2[b]
30	7.2[a]
Organic Fertilizer (OF)	
0	4.7[e]
10	5.1[d]
15	5.5[c]
20	6.1[b]
25	6.9[a]
M x OF	*

Means followed by the same letter in the same column under each factors are not significantly different by Duncan Multiple Range Test at P < 0.05 (DMRT). NS = Not significant, * = significant.

Table 4b: Combined effects of mulch and organic fertilizer application on yield (t/ha) of ginger after planting

Mulch (t/ha)	Organic fertilizer (t/ha) 0	10	15	20	25	Mulch Mean
0	2.6	3.2	3.3	3.9	5.3	3.6
15	5.5	5.8	5.9	6.7	7.2	6.2
30	6.1	6.3	7.4	7.8	8.3	7.2
Organic fertilizer mean	4.7	5.1	5.5	6.1	6.9	

LSD ($P < 0.05$) for comparing effects of mulch = 0.2
LSD ($P < 0.05$) for comparing effects of organic fertilizer = 0.3
LSD ($P < 0.05$) for comparing effects of mulch x fertilizer = 0.1

Studies on the effect of mulching on crop yields are numerous. For example, Lal (1995b) on maize (*Zea mays*), and Mbagwu (2000) on maize and cowpea (*Vigna unguiculata*). For example, Mbagwu (2000) recorded 40% increase in maize grain yield when 2 t/ha mulch were added and of 80 % when 4 t/ha mulch were placed on an Ultisol in Nigeria. He concluded that 2 to 4 t/ha straw mulch are the optimal rate for increasing yields, as no significant change occurred beyond a mulch rate of 2 t/ ha and no benefits were measured from applying higher quantities. Lal (2000) also recorded the increase of maize grain and stover yields with increasing mulch rates but mentioned the limitations of this soil conservation technology as well. As significant changes in soil properties require long periods of time. This agrees with the mulching done at planting which would have been decomposed and nutrients been released slowly for plant uptake because higher microbial activity in organically amended soils is essential for nutrient transformations and increased availability of these nutrients to the plants. Increased nutrient availability in organic manure treatment could also be due to increased dehydrogenase and phosphatase activity. In general, increase in microbial biomass carbon in organic manure amended soils was due to increased availability of substrate carbon that stimulates microbial growth, but a direct effect from microorganisms added through the compost is also possible (Ramesh *et al.,* 2008). In organically managed soils, both macronutrients (N, P and K) and micronutrients (Zn, Cu, Fe, Mn) were available in larger quantities compared to the conventional soils. It is well documented that there is a significant positive correlation between organic matter and micronutrient cation availability (Ramesh *et al.,* 2009).

CONCLUSION

Mulch and organic fertilizer improved soil organic matter and soil aggregation, lowered bulk density and increased soil porosity by elimination of crust formation and improved soil moisture properties which is required for proper growth and yield quality of ginger which is a soil nutrient exhausting crop (Adeleye *et al.,* 2010).

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RESPONSE OF CUCUMBER (*CUCUMIS SATIVUS* L.) CROP TO ORGANIC AND INORGANIC FERTILIZATION IN SUDAN SAVANNA ECOLOGICAL ZONE OF KEBBI STATE

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ABSTRACT

Field experiments were conducted in Aliero area of Kebbi state; during 2019/2020 dry season at Kebbi State University of Science and Technology Aliero (KSUSTA) Orchard (lat. 12°18.64'N; long. 4°29.85'E; 262 above sea level). The aim of the experiment was to study the effect of Cucumber (Cucumis sativus L.) crop to organic and inorganic fertilizer. The treatments consist of three levels of different fertilizer (NPK 15;15;15, poultry and cow dung) plus untreated control, each were designed to supply the recommended nitrogen dose of 120kg N ha^{-1}. The treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications. The plot size is 4 x 3m (12m^2). Space measuring 1.5m is left between blocks and 1m between plots. Results revealed that growth and yield parameters such as Vine length, shoot dry weight, relative growth rate, mean fruit length, fresh fruit yield tha^{-1} and Unmarketable fruits were higher with the application of either poultry manure or NPK fertilizer. It could be concluded that, the application of either poultry manure or NPK fertilizer resulted in the high growth and yield attributes of Cucumber but poultry manure recorded superior performance among the fertilizers while the least fresh fruit yield was by untreated control.

Key words: Cucumber, Poultry manure, Cow dung, NPK, Growth, Yield and Aliero

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a member of the Cucurbitaceae family which is comprised of 118 genera and 825 species. Members of this family are spread mainly in tropical and subtropical regions of the world (Wang *et al*., 2007). According FAO (2006), the most important cucurbits in terms of world total production are water melon (*Citrullus lanatus* L.), cucumber (*Cucumis sativus* L.) and melon (*Cucumis melon* L.). The world's largest cucumber producer is China with 48,000 million kilograms which is 73% of total global production. Russia is second largest producer with 1,742 million kg (2.68%) followed by Turkey, with a production of 1,600 million kg (2.46%). Spain is in the seventh place with a production of 713 million kilograms of cucumber, which is 1.09% of this vegetables' global production. The Food and Agriculture Organization of the United Nations (FAO, 2016), reported that world cucumber production in 2012 surpassed 65,000 million kg for the first time, reaching 65,134.08 million kilograms. In tropical Africa, its place has not been ranked because of limited use. Fertile soils are used for the cultivation of cucumber; infertile soils result in bitter and misshapen fruits which are often rejected by consumers.

The demand of cucumber (*Cucumis sativus L)* is on the increase due to the continued awareness of the overwhelming importance of cucumber's health benefits along with skin care. But its supply is low because of a number of factors that militate against the production of the crop. The use of organic manure constitutes a constraint to farmer, because of its bulkiness, cost of transportation and handling. This type of problem is solved through the use of either organic or inorganic fertilizer. Generally, excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield and maximum value of growth (Dauda *et al*., 2008). However, the use of inorganic fertilizers alone may cause problems for human health and the environment (Aisha *et al*., 2007). So also, the use of inorganic fertilizer by resource-poor farmers is limited by its scarcity, cost and untimely availability. Cultivation with persistent application of inorganic fertilizers increases soil acidity and soil physical degradation which may reduce crop yield (Sa'idu *et al*., 2011). On the other hand, organic manure can serve as alternative practice to inorganic fertilizers for improving soil productivity (Sarkar *et al*., 2003). The use of organic manure also has their limitations including high risk of infection, high cost of transportation and labour on account of its bulkiness as well as a slow release of nutrients for plant uptake (Adekiya *et al*., 2012). Eneje and Uzoukwu (2012) has observed, the difficulty to meet the crop's nutrient demand with sole organic manure due to the slow nutrient release coupled with limited availability of organic material in many parts of the country.

Considering the cost, unavailability at the time needed and environmental pollution effects of inorganic fertilizers, as well as slow nutrient release coupled with limited availability of organic material in many parts of the country, there is need to look for alternative way of improving soil fertility and crop productivity which are affordable and environmentally-friendly. The aim of present study is, to assess the growth and yield of Cucumber crop as influenced by poultry manure, cow dung and NPK fertilizer in the study area.

MATERIALS AND METHODS

The research was conducted at Kebbi State University of Science and Technology Aliero (KSUSTA) Orchard (lat. 12°18.64'N; long. 4°29.85'E; 262 above sea level). The area has a long dry season that is characterized by cool dry air (Harmattan) that prevails from November to February; and hot dry air extending from March to May. The location is usually used for cultivation of vegetable and cereal crops. The treatments consist of three levels of different fertilizer (NPK 15; 15; 15, poultry and cow dung) plus untreated control, each were designed to supply the recommended nitrogen dose of 120kg N ha^{-1}. The treatments were laid out in a Randomized Complete Block Design (RCBD) with three replications.

The experimental site was ploughed and harrowed in other to obtain good tilt. The land was leveled and constructed into seed beds; water channels were constructed to facilitate free and efficient water movement and uniform distribution on the plots. The plot size is 4 x 3m ($12m^2$). Space measuring 1.5m is left between blocks and 1m between plots. Each plot contained 4 ridges 1.5m apart the two inner ridges constituted the net plot, the size of plot was 42 meter by 12m and spacing of 60x40cm that is 60cm inter row spacing and 40cm intra row spacing. Prior to sowing, the seeds were treated with Apron star at the rate of 10g of the chemical per 100g of seed, in other to protect the Cucumber seeds from soil borne diseases and pests. Four seeds were sown per hole at a depth of 2 to 4cm. After two weeks of germination, the seedlings were thinned to two plants per stand.

Weeds were controlled manually using hand hoe at 3 and 6 WAS and occasional hand pulling when necessary to ensure weed free plots. Compound fertilizer (NPK 15:15:15) was used. The rates 800kg ha^{-1} and 400kg ha^{-1} were applied according to the treatments in two equal split doses. The first dose was applied at 2 weeks after sowing (WAS) and the second dose at 5 WAS. Cucumber plants were also protected against insect pests and diseases by regular spraying of appropriate mixture of *Cypermerthrin* plus dimethoate at the rate of 4ml L^{-1} of water at 10days interval prior to flowering and 5days interval continuously after flowering till maturity. Cucumber fruits for fresh consumption were harvested before they are fully mature, depending on the variety, which was between 1–2 weeks after flowering. Harvesting was done between 3 to 4 days. Data were recorded on Vine Length, Shoot dry weight, Relative growth rate, Mean fruit length, Total fruit yield tha^{-1}, and Unmarketable fruits.

RESULTS AND DISCUSSION

Soil Physical and Chemical Properties of Experimental Site

Physical and chemical properties of soils of study locations prior to the experiments are presented in Table 1. The result indicated that particle size distribution at the location was dominated by sand, with values of 63.3 and 61.7% during 2019 and 2020, respectively. For silt particles, it was 24.9 and 28.2%, respectively. Least particle size distribution was observed with clay having recorded 11.8% for 2019 and 10.1% for 2020. The soils during 2019/2020 were found to be sandy loam. This suggests that the soil in both locations has high macro porosity and low ability to retain water. Soil pH during 2019 (7.46) and 2020 (6.11) indicated that the soil during 2019 was slightly alkaline while that of 2020 was slightly acidic. Organic carbon, total N, available P and Ca were observed to be low in both locations. Exchangeable Mg was moderate, while exchangeable K and Na were higher in both 2019 and 2020.

Chemical Composition of Cow Dung (CD) and Poultry Manure (PM)

Chemical compositions of manures prior to the experiments during 2019/2020 dry season are presented in Table 2. The result indicated that, cow dung and poultry manure contained organic manure carbon (g kg^{-1}) with values of 4.13 and 4.46 while 3.26 and 3.96. Cow dung pH (7.60 and 6.94) and poultry manure (6.20 and 6.45) indicated that cow dung was slightly alkaline while poultry manure was slightly acidic. However, the result indicated that poultry manure contained high amount of total N (1.83 and 1.73mg kg^{-1}) than cow dung (1.02 and 1.09mg kg^{-1}). So also, Cow dung contained high amount of potassium (3800 and 3600mg kg^{-1}) than poultry manure (2500 and 2350mg kg^{-1}) but amount of phosphorus is higher in poultry manure (8.04 and 7.84mg kg^{-1}) than cow dung (4.51 and 4.98mg kg^{-1}). The result shows an indication of the organic manure's capability of improving the soil nutrient status.

Table 1: Experimental site physical and chemical properties of soil during 2019/2020 dry session

	2019	2020
	0–30cm depth	
Particles size Analysis		
P^H	6.60	6.11
Organic Carbon %	1.04	0.87
Organic Matter %	1.79	2.01
Total N %	0.084	0.093
P mg/kg	0.93	1.05
CaCmol/kg	0.50	0.78
Na Cmol/kg	0.52	0.62
Mg Cmol/kg	0.80	0.74
K Cmol/kg	1.95	2.56
CEC Cmol/kg	8.40	8.94
Sand %	63.3	61.7
Silt %	24.9	28.2
Clay %	11.8	10.1

Table 2: Chemical Composition of cow dung (CD) and poultry manure (PM)

Character	Cow dung		Poultry manure	
	2019	2020	2019	2020
Organic carbon (g kg^{-1})	4.13	4.46	3.26	3.96
P^H	7.60	6.94	6.20	6.45
Total N (mg kg^{-1})	1.02	1.09	1.83	1.73
Na (mg kg^{-1})	155	175	140	150
K (mg kg^{-1})	3800	3600	2500	2350
Ca (mg kg^{-1})	0.85	0.95	0.55	0.75
P (mg kg^{-1})	4.51	4.98	8.04	7.84

Effect of Organic and Inorganic Fertilization on Growth

Fertilization is among the various agronomic practices that influences growth and fruit yield of cucumber. Balanced nutrient management significantly increased cucumber fruit yield. Organic manures supply nutrients as well as improving the soil physical and chemical conditions (Belay *et al*., 2001). Fertilizers (organic and inorganic) play important role in enhancing vegetative growth, starch synthesis as well as translocation. Results revealed significant effect ($P\leq0.05$) of fertilization on Vine length at 8 and 10WAS in both 2019 and 2020 presented in Table 3. At 6WAS, at 2019, application of Poultry manure significantly ($P\leq0.05$) produced the tallest plants (12.35cm) followed by the Cow dung (11.98cm) which was followed by NPK (10.29cm). Shortest plants were recorded from the untreated control (7.48cm). But at 8WAS, application of Poultry manure (37.94cm) and Cow dung (34.36cm) recorded the statistically similar height of plants followed by the application of NPK (33.11cm) while the untreated control gave significantly shorter plants (19.56cm). At 2020, at 6

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and 8WAS, plant height was similar irrespective of fertilizer levels, except the untreated control which gave significantly shorter plants. This may be attributed to the higher nitrogen content of Poultry manure (Table 2) and balanced nutrients in NPK fertilizer which enhanced vegetative growth (Ahmed *et al*., 2007).

Table 3: Vine length of cucumber crop as influenced by organic and inorganic fertilization during 2019/2020 dry season

Treatment	Vine Length (cm)			
	2019		2020	
	6WAS	8WAS	6WAS	8WAS
Fertilizer				
Control	7.48c	19.56b	7.67b	45.78b
Poultry manure	12.35a	37.94a	15.40a	75.89a
Cow Dung	11.98ab	34.36a	18.98a	67.89a
NPK(15;15;15)	10.29b	33.11c	15.51a	69.20a
SE±	**0.461**	**1.857**	**0.706**	**1.233**

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

A significant effect ($P \leq 0.05$) of fertilization as regard to Shoot dry weight of Cucumber was observed (Table 4) during 2019/2020 dry seasons. At 6WAS, at 2019, application of Cow dung manure significantly ($P \leq 0.05$) produced recorded the higher values (1.53g) followed by the application of poultry manure (1.50g) which in turn was higher than the application of NPK (1.22g). Lowest value was recorded from the untreated control (1.00g). But at 8WAS, application of Cow dung (3.32g) and NPK fertilizer (3.30g) recorded the statistically similar values with respect to shoot dry weight followed by the application of poultry manure (2.71g) while the untreated control gave significantly lowest values with respect to shoot dry weight (1.20g). At 2020, at 6 WAS, application of NPK significantly ($P \leq 0.05$) produced the higher values (3.02g) followed by the application of poultry manure (2.99g) which in turn was higher than the application of cow dung (2.98g). The lower values of shoot dry weight were recorded by the untreated control (2.71g). But at 8WAS, application of NPK Fertilizer (3.86g) and Poultry manure (3.69g) recorded the statistically similar shoot dry weight followed by the application of Cow dung (3.68g) while the untreated control gave significantly minimum value of shoot dry weight (2.71g). Higher values of Shoot dry weight observed with the application of Cow dung indicate that, the Cow dung mineralization aids in soil nutrient buildup which in turn leads to improved nutrient availability to crops and it also shows that the Cow dung manure was readily available in the best form for easy absorption by the plant roots which boost the growth of the cucumber plant. This observation concurs with the works of Makinde and Ayoola (2012) which reported that, the higher values of shoot dry weight obtained from plants could likely due to higher rates of manure which improved the soil conditions for crop establishment as well as released adequate nutrient elements for growth and yield components of plant.

Table 4: Shoot Dry Weight of Cucumber crop as influenced by organic and inorganic fertilization during 2019/2020 dry season.

Treatment	Shoot Dry Weight (g)			
	2019		2020	
	6WAS	8WAS	6WAS	8WAS
Fertilizer				
Control	1.00c	1.20c	2.27b	2.71b
Poultry manure	1.50a	2.71b	2.99a	3.69a
Cow Dung	1.53a	3.32a	2.98a	3.68a
NPK(15;15;15)	1.22b	3.30a	3.02a	3.86a
SE±	**0.094**	**0.076**	**0.042**	**0.047**

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

Results revealed significant effect (P≤0.05) of fertilization with respect to Relative Growth Rate during 2019/2020 dry seasons showed in Table 5. At both 2019 and 2020, Relative growth rate was similar irrespective of fertilizer levels and the untreated control throughout the sampling period. This could be attributed to the significant role played by NPK, Poultry manure and Cow dung in the improvement of soil fertility, nutrient uptake and enhancing production of assimilates during growth. This means that the higher the nutrients applied to the soil, the higher the growth characters. This observation is consistent with works of Aduloju *et al*. (2010) who reported and attributed increased growth of crop plants to the release of more nutrient elements through the moisture that has been made available by the manure.

Table 5: Relative Growth Rate of Cucumber crop as influenced by organic and inorganic fertilization during 2019/2020 dry season.

Treatment	Relative Growth Rate ($gg^{-1}day^{-1}$)			
	2019		2020	
	8WAS	10WAS	8WAS	10WAS
Fertilizer				
Control	0.49ab	0.53a	0.54a	0.59ab
Poultry manure	0.42ab	0.48b	0.54a	0.58b
Cow Dung	0.50a	0.56a	0.54a	0.61a
NPK(15;15;15)	0.51a	0.55a	0.56a	0.61a
SE±	**0.004**	**0.003**	**0.005**	**0.003**

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

Effect of Organic and Inorganic Fertilization on the Yield

Results revealed significant effect (P≤0.05) of fertilization with respect to Mean fruit length during 2019/2020 dry seasons showed in Table 6. At 2019, higher mean fruit length was obtained from the application of Cow dung (17.66cm) followed by the application of poultry manure (16.68cm) which in turn higher than the application of NPK (15.97cm) while the lowest mean fruit length was recorded by the untreated control (11.78cm). But at 2020 Mean fruit length was similar irrespective of fertilizer levels while the untreated control recorded the lowest value (18.59cm). This may be attributed to the higher nitrogen content of Poultry manure (Table 2) and balanced nutrients in NPK fertilizer which enhanced yield characters (Ahmed *et al*., 2007).

Table 6 Mean fruit length of Cucumber crop as influenced by Varieties during 2019/2020 dry season

Treatment	Mean Fruit Length (cm)	
	2019	2020
Fertilizer		
Control	11.78d	18.59b
Poultry manure	16.68b	20.27a
Cow Dung	17.66a	19.36ab
NPK(15;15;15)	15.97c	19.69ab
SE±	**0.295**	**0.315**

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

A significant effect (P≤0.05) of fertilization as regard to Total Fruit yield tha^{-1} of Cucumber was observed (Table 7) during 2019/2020 dry seasons. At 2019, application of poultry manure gave a significantly (P≤0.05) higher fruits yield (4.59t ha^{-1}) followed by the application of both NPK (4.35t ha^{-1}) and Cow dung (4.28t ha^{-1}), while the untreated control recorded the lowest yield (1.58t ha^{-1}). At 2020 trial, application of NPK gave a significant (P≤0.05) higher fruits yield (16.74t ha^{-1}) followed by the application of Poultry manure (15.84t ha^{-1}) which in turn higher than the application of Cow dung (14.36t ha^{-1}), the untreated control recorded the significant lower yield (5.90t ha^{-1}). This could be attributed to the significant role played by NPK fertilizer in the improvement of soil fertility, nutrient uptake and enhancement of crop yields and the role played by Poultry manure in terms of improving the soil physical properties by reducing soil temperature and bulk density, this shows that poultry manure was readily available in the best form of easy absorption by the plant roots. This observation agreed with the work of Muhammad *et al.* (2018) who stated that, the application 120kg of N from poultry manure improves moisture availability which results in improved nutrient release to plants for increased yield. The significant positive yield response of Cucumber to NPK could likely attributed to the role of applied NPK in enhancing production of assimilates during growth and consequent partitioning of these assimilates to Cucumber fruits. Shehata *et al.* (2012) reported that higher NPK fertilizer doses resulted to increase in the uptake of N, P and K nutrients which enhanced the Cucumber yield.

Table 7: Total Fruit yield tha^{-1} of Cucumber crop as influenced by Varieties during 2019/2020 dry season

Treatment	Total Fruit yield tha^{-1}	
	2019	**2020**
Fertilizer		
Control	1.58c	5.90c
Poultry manure	4.59a	15.84a
Cow Dung	4.28b	14.36ab
NPK(15;15;15)	4.35b	16.74a
SE±	**0.66**	**0.66**

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT. *= Significant at 5%, NS= not significant. WAS= Weeks after sowing

CONCLUSION

Based on the results of this study, it could be concluded that, the application of either poultry manure or NPK fertilizer resulted in the high growth and yield attributes of Cucumber but poultry manure recorded superior performance among the fertilizers while the least fresh fruit yield was by untreated control

RECOMMENDATION

From the findings of this study, it could be recommended that the application of either poultry manure or NPK fertilizer could be adopted for higher Cucumber fruit yield in the study area.

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GROWTH, YIELD AND NUTRIENT UPTAKE OF AMARANTH (*Amaranthus caudatus*) AS INFLUENCED BY ORGANIC FERTILIZERS ON SANDY LOAM IN ONDO, NIGERIA

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ABSTRACT

Continuous use of mineral fertilizers on tropical soils results in soil acidity and pollution of underground environment. Organic fertilizers, such as compost, are good sources of plant nutrients for sustainable crop production and healthy underground environment. Thus, the focus of this study was to evaluate the influence of different organic fertilizers on growth, yield and nutrient uptake of amaranth (Amaranthus caudatus). The experiment was conducted at the experimental field of the Wesley University, Ondo, Nigeria. The study had five fertilizer treatments viz: rice bran based compost (RBC), conventional compost (CC), moringa leaf (ML), NPK 20-10-10 and the control (no soil additive). The treatments were laid out in a Randomized Completely Block Design with three replicates. The treatments were applied at the rate of 100 kg N ha^{-1} and the effects on nutrient uptake, biomass yields, plant height, number of leaves, as well as stem girth were observed. Analysis of variance (ANOVA) was carried out and significantly different means were separated using Duncan's Multiple Range Test (DMRT) at the 5 % probability level. The results of the analyses revealed that compost treatments (RBC and CC) produced similar plant height (37.2 cm and 29.5 cm), number of leaves (26.4 and 29.5 per plant) and stem girth (11.1 cm and 10.1 cm) at 8 weeks after sowing of amaranth. However, the above values were higher than those for ML and NPK (23.6 cm and 23.6 cm), (18.5 and 22.5 per plant) and (9.3 cm and 6.1 cm) with respect to plant height, number of leaves and stem girth of the crop. Also, RBC treated soils had the highest mean fresh biomass yield of amaranth plants, leaves (0.3 kg ha^{-1}), stem (0.2 kg ha^{-1}) and root (0.2 kg ha^{-1}) while ML had the lowest fresh biomass yield; leaves (0.07 kg ha^{-1}), stem (0.04 kg ha^{-1}) and root (0.04 kg ha^{-1}). In terms of nutrient uptake, N, P and K uptake of amaranth were significantly enhanced with fertilizer treatments compared to the control. Rice bran based-compost improved nutrient uptake as much as conventional compost. RBC application resulted in highest growth and yield of green amaranth. It is therefore reasonable to recommend the use of rice bran based-compost as an alternative to the recommended NPK dose for production of amaranth.

Key words: Fertilizer materials, sandy loam, *Amaranthus caudatus*, biomass yields, nutrient uptake.

INTRODUCTION

Sustainable agriculture is, nowadays, an urgent requirement to minimize the environmental pollution that has increased as a result of unhealthy agricultural practices such as extensive use of mineral fertilizers. Mineral fertilizers are important for plant nutrition; however, they are also a potential sources of environmental pollution, particularly mineral-nitrogen (N) fertilizers. In addition, farmers are suffering from declining soil fertility and increasing soil salinization. Consequently, management of poor soil fertility in arid and semi-arid regions needs many effective solutions. The challenge of sustainable agriculture is more serious in developing countries, including Nigeria. This is due to the extensive use of mineral fertilizers, low rainfall, high evaporation rate, poor irrigation water and poor water management in these regions (Rady *et al.,* 2013). Attention is, therefore, focused on using various forms of composts as partial substitutions to mineral fertilizers. These practices have been recommended (Ojo *et al.,* 2014; Smith *et al.,* 2015) under normal or saline conditions in arid and semi-arid regions as sources of nutrients, because these soils inherently have low organic matter and low mineralization (Okusami *et al.,* 1997), due to high alkalinity and low rains. The beneficial effects of this practice in terms of improved crop productivity, soil fertility and sustainability, and balanced plant nutrition have been reported (Moyin-Jesu, 2015 and Semida *et al.,* 2015).

Agricultural dry residues such as rice bran residue and sunflower plant parts (i.e leaves and stems) are produced in large amounts as a by-product of crop productions in arid and semi-arid regions (Semida *et al.,* 2015). Majority of these agricultural residues are disposed by burning, mulched in crop fields, or discarded. In addition, some are used in animal feed, mulched in crop fields or are discarded. However, an attractive usage of all these residues/wastes is composting after they are mixed with some organic and mineral components, such as farm yard manure to produce organic composts (Akanbi *et al.,* 2007). Semalulu *et al.* (2011) had defined the composting as a biological process of aerobic decomposition, which degrades labile organic matter to carbon dioxide, water vapour, ammonia, inorganic nutrients and a stable organic material containing humic like substances. Compost has several advantages over mineral fertilizers, such as nutrient availability, uptake efficiency and quality of yields produced by crop. (Akanbi *et al.,* 2007).

Amaranth is one of the most popular vegetable crops grown in the Middle Eastern countries for human diet due to its rich source of proteins, carbohydrates, and nutrients. Its cultivation requires considerable amounts of nitrogen so that the crop can grow well, and leaves acquire the dark green color sought by consumers. Production usually involves the use of inorganic nitrogen fertilizers in quantities ≥150 kg N ha^{-1}, being one of the most critical elements in plant growth and quality (Rouphael *et al*., 2018). Nitrogen plays a significant role in biosynthesis of secondary plant metabolites such as phenols, ascorbate, and glutathione as well as antioxidant enzymes such as glutathione reductase (Ibrahim *et al.,* 2012; Argyropoulou *et al.,* 2015). Thus, cultivation of amaranth and other different crop plants under soil application with composts, as a partial alternative to mineral-NPK fertilizers, has the potential to increase crop production and soil sustainability (Abdelhamid *et al.,* 2004 and Smith *et al.,* 2015). This practice promotes higher plant growth and productivity while reducing mineral fertilizer use, crop production cost and indirectly increasing income. Therefore, the objective of this study was to assess the effects of various organic fertilizer applications on the growth, yield and nutrient uptake of amaranth plants grown on sandy loam soil.

MATERIALS AND METHODS

The trial was carried out at the Department of Agriculture, Wesley University, Ondo, Nigeria (Lat. 6°51'N and Long. 3°42'E). Ondo is located in the tropical rain forest ecological zone of Nigeria, characterized with bimodal rainfall distribution with distinct dry and rainy seasons. The zone has an average annual rainfall of 1532±227 mm over a period of 10 years (2011 to 2021), average temperature ranges of 2.2 ℃ (max. temp.; 27.8 ℃, min temp.; 25.6 ℃) and average relative humidity of 86.1% over the same period (NASA-Power, 2016). The vegetation is classified into two; low and top layers. The low layer vegetation is characterized with abundance of herbs, shrubs and grasses while the top layer is characterized with valuable economic trees such as *Chlorophora excelsa*, *Eucalyptus marginata*, *Khaya ivorensis* among others (Sowunmi and Akintola, 2010).

Rice bran compost (RBC) was prepared using windrow aeration composting method based on the standardized procedure adopted for use at the organomineral preparation plant as described (Omueti *et al*. (2000). Briefly, rice bran was measured by volume and mixed with cattle dung (CD) in ratio 1:3 inside the windrow. The rice bran was piled up in layers with CD, turned manually and sprinkled with water once in a week with moisture content maintained at 60% Field capacity (Fadare *et al*., 2000). The monitoring of the composting commenced immediately after heap building. The temperature builds up in each composting bin was measured daily at 11:00 hour with the aid of a thermometer dipped to a depth of about 0.35m in three different parts of the compost pile and the average temperature value was thereafter obtained. The pH of the pile was determined fortnightly using a pH meter in aqueous extract of 5g decomposing samples with distilled water at solid: water ratio of 1:4 (w.v) according to Guerra-Rodriguez *et al*. (2000) and Banout *et al*. (2008). At eight weeks when the temperature of the pile dropped to that of ambient temperature and remained relatively constant over a period of two weeks, compost samples were randomly taken from the pile, homogenized and labeled.

The conventional compost used as a check was also a company's product, obtained from Alesinloye Compost Company, Alesinloye market, Ibadan, Oyo State, Nigeria. Moringa leaves were harvested at the Department of Agronomy, University of Ibadan, Nigeria and then air dried for five days to reduce the moisture content. Chemical analyses of the composts and moringa leaves (Table 1) were carried out using standard procedures (Okalebo *et al.,* 1993; Bremner, 1996; Thomas, 1996).

Table 1. Chemical analysis of the composts and moringa leaf

Parameters	Rice bran compost	Conventional compost	Moringa leaf
pH (H_2O)	7.9	9.7	na
Total C (gkg^{-1})	110	170	na
Total N (gkg^{-1})	17	12	28
Available P (gkg^{-1})	10	8	4
Exchangeable cations (gkg^{-1})			
K	1.19	17	19
Ca	10.5	3.2	19
Mg	8.1	1.0	2
Na	8	4	2
Extractable micronutrients ($mgkg^{-1}$)			
Mn	390	393	4.4
Fe	11600	1670	53
Zn	50	186	11
Cu	80	78	8
C:N ratio	64	140	na

na - not applicable

The physical and chemical analyses of the pre-treated soil was also carried out using standard procedures (Hendershot and Lalande, 1993; Bremner, 1996; Nelson and Sommers, 1996; Thomas, 1996; Gee and Or, 2002) and are shown in Table 2. The Wesley University Ondo soil was low in N, P and organic carbon, but marginal in K (FFD, 2012). The textural class was sandy loam based on USDA textural triangle (Soil Survey Division Staff, 1993).

Table 2: Some physical and chemical properties of soil used for the experiment

Parameters	Value
pH (H_2O)	6.3
Org C (gkg^{-1})	5.5
Total N (gkg^{-1})	0.4
Available P (mg/kg)	6.9
Exchangeable cations ($cmolkg^{-1}$)	
K^+	0.4
Ca^{2+}	3.5
Mg^{2+}	0.9
Na^+	0.4
Extractable micronutrients ($mgkg^{-1}$)	
Mn	400
Fe	83
Zn	1.0
Cu	0.8
Particle size distribution (gkg^{-1})	
Sand	779
Silt	158

Clay	63
Textural class (USDA)	Sandy loam

The treatments applied were rice bran-based compost (RBC), conventional compost (CC), moringa leaves (ML) and NPK 20-15-15 mineral fertilizer at 100 kg N ha^{-1} each. All the fertilizer materials were milled into powder before application. The amaranth variety planted was obtained from National Institute of Horticultural Research (NIHORT), Ibadan, Nigeria and the design was randomized complete block replicated three times to give 15 experimental plots. Each plot size was $2m^2$. Seeds of green amaranth were drilled in 20 cm rows and thinned to one plant per stand two weeks after sowing, giving a plant population of 55 stands per plot. The inter-row spacing was also 20 cm equivalent to 250, 000 plants/ha. The compost treatments were applied a week before sowing while the inorganic fertilizer was applied at one weeks after sowing (WAS) and weeding was carried out as necessary. Data were collected on growth parameters; plant height (cm), number of leaves/ plant, stem girth (cm) at 4, 6 and 8 WAS and biomass (fresh and dry yields). At 8 WAS, the roots were carefully removed and washed. Thereafter, root, leaves and stem were oven-dried at 70°C until constant weight. After oven drying, the materials were milled and analyzed for N, P and K concentrations.

Nutrient uptake in leaves was calculated using the formula: Nutrient uptake = % nutrient concentration x dry matter yield ($kgha^{-1}$).

Data were statistically analyzed and significantly different means were separated by Duncan's Multiple Range Test (DMRT) at 5 % probability level.

RESULTS

Effects of various organic fertilizers on amaranth plant height, number of leaves and stem girth.

The result showed significant differences among the treatment means for all the parameters (Table 3). The result of the fertilizer treatment on height, number of leaves and stem girth of amaranth are presented in Table 3. With respect to the plant height, the result showed that there were significantly differences ($p<0.05$) among the treatment means in 4, 6 and 8 weeks after sowing (WAS). At 4 WAS, the RBC gave the highest mean plant height (21.9 cm) which was significantly taller than CC (17.5 cm), ML (14.9 cm) and NPK (13.8 cm). The control gave the shortest plant (10.2 cm). However, at 6 WAT, RBC gave the highest mean plant height (32.6 cm) which differ significantly from other treatments apart from CC (25.3 cm) while the control gave the significantly lowest plant height (12.4 cm). A similar result was obtained at 8 WAT.

In terms of number of leaves, at 4 WAT, RBC gave the highest mean number of leaves (15.3) which differ significantly from other treatments. The control treatment resulted into significantly lowest mean value of number of leaves (8.4). However, at 6 WAT, RBC gave the highest number of leaves (23.1) which differ significantly from other treatments apart from CC (20.2) while the control gave the significantly lowest number of leaves (9.4). A similar result was obtained at 8 WAS.

The result obtained in stem girth showed that at 4 WAS, RBC gave the highest mean value of (7.5 cm) stem diameter which did not differ significantly from CC (6.5 cm) but significantly higher than ML (5.2 cm), NPK (4.0 cm) and control (2.5 cm). At 6 WAT, RBC still gave the highest mean stem diameter of amaranth (10.5 cm) which was not significantly different from ML (9.2 cm) but higher than others. The control treatment resulted into significantly lowest mean value of stem diameter (3.5 cm). At 8 WAT, there were significant differences ($p<0.05$) among the treatment means. The RBC still gave the highest mean stem diameter (11.1 cm) which was not significantly different from CC (10.1 cm) but significantly higher than other treatments.

Table 3: Effects of fertilizer treatment on growth performance of Amaranth at different weeks after planting

Treatment	Plant height (cm)			Number of leaves			Stem girth (cm)		
	WAS								
	4	6	8	4	6	8	4	6	8
Control	10.2d	12.4c	15.2c	8.4d	9.4c	12.3c	2.5b	3.5c	3.9c
Rice-bran based compost	21.9a	32.6a	37.2a	15.3a	23.1a	26.4a	7.5a	10.5a	11.1a
Conventional compost	17.5b	25.3a	29.5a	13.5b	20.2a	23.6a	6.5a	8.7b	10.1ab
Moringa leaf	14.9bc	19.7b	23.6b	11.8c	14.9b	18.5b	5.2b	9.2ab	9.3b
NPK (20:10:10)	13.8c	19.5b	23.6b	10.8c	14.1b	22.5b	4.0b	5.5c	6.1c

Means with the same letter (s) in the column are not significantly ($p<0.05$) using Duncan's Multiple Range Test.
WAS= weeks after sowing

Effects of various organic fertilizers on amaranth fresh and dry biomass yield.

The result showed that there were significantly differences ($p<0.05$) among the treatment means across all the parameters (Fig. 1). With respect to fresh biomass yield, RBC produced the highest mean of fresh weight of leaves (0.3 $kgha^{-1}$) which was significantly different from others, while the control gave the lowest significant fresh weight of leaves (0.03 $kgha^{-1}$). It was also noted that in both fresh root and stem, RBC performed significantly than other treatments. With dry biomass yield (Fig. 2), RBC gave the highest mean value (0.04 $kgha^{-1}$) of dry weight of leaves which was significantly different from other treatments. The control gave the lowest (0.005 $kgha^{-1}$) significant value. A similar result was obtained in dry root and stem.

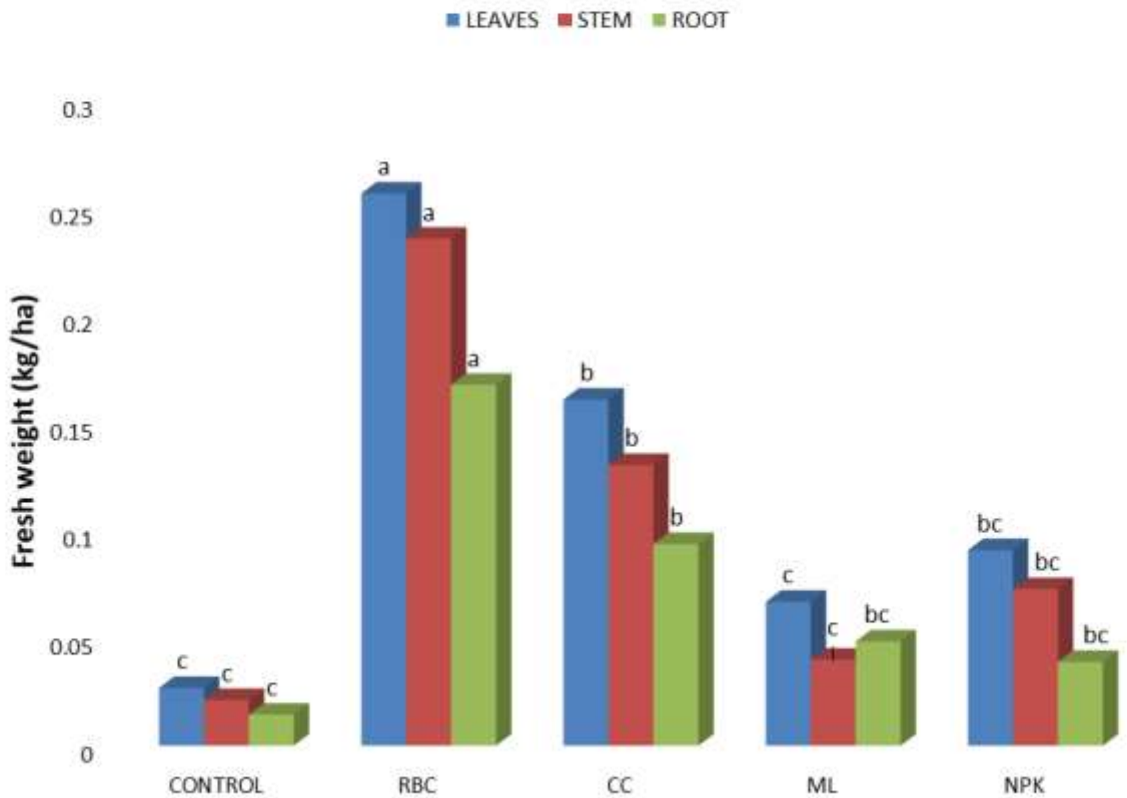

Figure 1: Effects of the treatments on fresh biomass yield
Legend: RBC= Rice bran based compost, CC= Conventional compost, ML= Moringa leaves, NPK= NPK 20 - 10 - 10. Means with the same alphabet are not significantly different at p<0.05

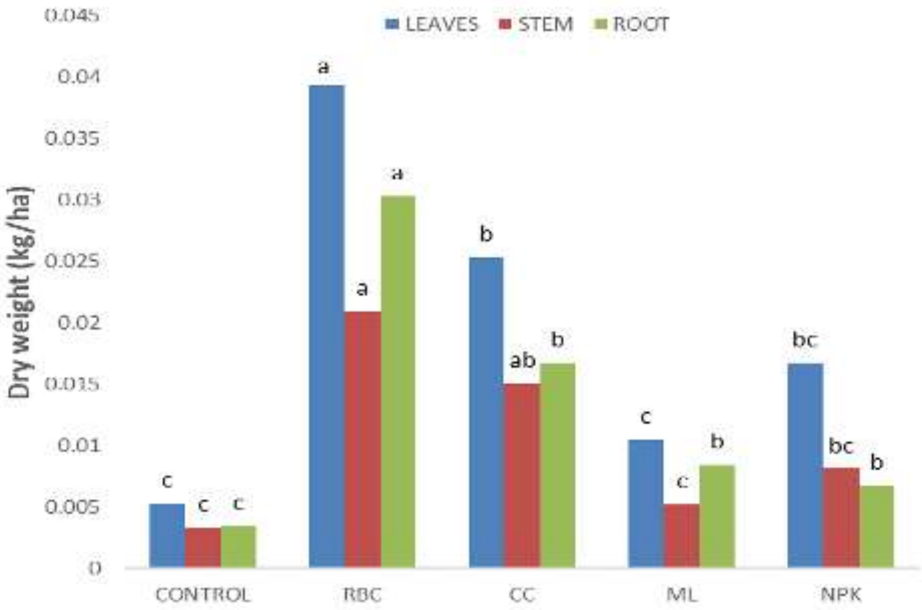

Figure 2: Effects of the treatments on dry biomass yield
Legend: RBC= Rice bran based compost, CC= Conventional compost, ML= Moringa leaves, NPK= NPK 20 - 10 - 10. Means with the same alphabet are not significantly different at $p<0.05$

Nitrogen, Phosphorus and Potassium concentration (gkg^{-1}) and uptake ($kgha^{-1}$) in the amaranth leaves at 8 weeks after transplanting as influenced by various organic fertilizers.

The result of the N, P and K concentrations and uptake in the tissue of the amaranth plants due to the different fertilizer treatments is shown in Table 4. With the nitrogen content, RBC gave the highest nitrogen content (39.3 gkg^{-1}) which was not significantly different from CC (32.1 gkg^{-1}). However, ML (28.2 gkg^{-1}) was not significantly different from NPK (24.9 gkg^{-1}) which was significantly higher than the control (3.1 gkg^{-1}). However, application of organic fertilizers showed no significant differences in the nutrient contents of phosphorus and potassium.

With the nitrogen uptake, RBC treatment gave the highest nitrogen uptake (1.5 $kgha^{-1}$) which was not significantly different from CC (0.8 $kgha^{-1}$). However, ML (0.3 $kgha^{-1}$) and NPK (0.4 $kgha^{-1}$) were not significantly different from one another and that of control gave the lowest nitrogen uptake (0.01 $kgha^{-1}$). In phosphorus and potassium uptake, RBC gave the highest value (0.4 and 1.3 $kgha^{-1}$). Also, the result showed no significant difference among the CC, ML and NPK in phosphorous and potassium uptake.

Table 4: Nutrient content (gkg^{-1}) and uptake ($kgha^{-1}$) of amaranth as influenced by organic fertilizers.

Treatment	Nutrient content (gkg^{-1})			Nutrient uptake ($kgha^{-1}$)		
	N	P	K	N	P	K
Control	3.1c	10.5	32.2	0.1c	0.1c	0.2c
Rice-bran based-compost (RBC)	39.3a	10.9	32.9	1.5a	0.4a	1.3a
Conventional compost (CC)	32.1ab	9.33	35.2	0.8a	0.2b	0.9b
Moringa leaf (ML)	28.3b	10.7	34.0	0.3bc	0.2b	0.4c
NPK (20:10:10)	24.9b	11.8 ns	34.2 ns	0.4b	0.2b	0.5bc

ns: not significant. Means with the same letter(s) in a column are not significantly different at 5 % level of probability by Duncan Multiple Range Test (DMRT).

DISCUSSION

Adding compost to the soil increased the crop yields compared to the mineral fertilizer and control. This increase was a function of the dose of compost applied and shows the importance of the use of organic matter, in particular RBC recognized to be rich in nutrients. The obtained yields with the soil show that with the use of compost, it is possible to sustainably increase the yields of amaranth. The results indicate that the applied compost has the potential to be used as a fertilizer. The results indicate that the most effective compost was obtained from RBC. A number of reports illustrated that composts obtained from solid organic waste are capable to increase nutrient supply and meet subsequent plant demand in soil (Iglesias-Jimenez and Alvarez, 1993; Mylavarapu and Zinati, 2009). Moreover, sufficient amount of cowdung which serve as nitrogen source was present in the compost and it increased the morphological growth and development of vegetables. In this study, RBC exhibited a significant influence on growth characteristics of vegetables at different growth period. The improved growth characteristics of amaranth plants produced as a result of RBC could be attributed to the enhanced decomposition of the RBC and mineralization of nutrients (Abdelhamid *et al.*, 2004; Ojo *et al.,* 2014). In unfertilized soil, amaranth plants did not grow well. The leaves of the plants were very small and chlorotic presenting a yellowish color, probably due to nitrogen deficiency. The addition of organic compost to soil significantly increased the plant growth. Weinfurtner (2001) also reported a positive effect of organic compost on yield.

However, plants grown only with NPK and ML had lesser biomass yields (fresh and dry weights) than those grown with composts. The high increase in biomass yields due to the addition of RBC could be related to the increase of availability of nitrogen source (cowdung) throughout the growing season. The high biomass (fresh and dry yields) in treatments with RBC and CC applications, shown that amaranth yield is very dependent on the nitrogen source that is embedded in the composts. Therefore, this can be a strategy to reduce greenhouse emissions due to the use of the compost, as pointed out by Gruda (2019). It also indicates that the application of composts allowed obtaining a high amaranth biomass yields. Also Xu *et al.* (2005) in a study on yield and quality of leafy vegetables grown with organic fertilizers reported that vegetables grown with organic fertilizers grew better and resulted in a higher total yield than those grown with chemical fertilizers. Similar result was also found in a study by Magkos *et al.* (2003) who evaluated the dry matter yields of several vegetables and found that organically cultivated crops had higher yields than those grown conventionally.

Application of fertilizer increase the supply of nutrients which ultimately result in greater nutrient uptake. Plant growth and development depend on nutrient supply and in general enhances good yield. The findings with regard to nutrient uptake by amaranth revealed that the uptake of N, P and K were higher with the application of composts and NPK but least with control plants indicating short supply of these nutrient elements to amaranth in the control plots. This is in agreement with the findings of Kayode *et al.,* (2018) that the application of compost improved N, P and K uptake of amaranth. The application of nitrogen led to an increase in leaf nutrient concentration of N. Leaf N concentration in plants of the RBC was 73% higher than in the plants fertilized with nitrogen fertilizer. The increase in leaf nitrogen concentration may be related to an increase in the availability of nitrate in root medium, since is know that when the nitrate is taken by plants roots, nitrogen uptake is enhanced (Jones, 2016). In the case of leaf P, concentrations were above the sufficiency range. This was probably due to the high availability of P in soil and the addition of organic compost to the soil. The addition of organic compost to soil can increase water-extractable soil P by direct addition, dissolution, displacing sorbed, or reducing sorption capacity for P (Adler and Sikora, 2003). Organic matter is a source of phosphorus and it may reduce P sorption (Gorgin *et al.,* 2011). It may increase P uptake by plants since it forms complexes with organic phosphate and increases the volume of soil that plant roots explore (Ouni *et al.,* 2014). In spinach, Maftoun *et al.*, (2005) also reported that the addition of municipal waste compost to soil led to an increase in P uptake. While the highest K uptake was observed in plots that received recommended rates of RBC but not significantly different from the applied CC.

CONCLUSION

The result revealed that the performance of RBC followed the same pattern across the plant growth and with no significant difference in CC. Amaranth growth increased with inorganic fertilizer application but was not affected by nitrogen source of ML. RBC led to an increased in fresh and dry biomass yields and nutrient uptake of amaranth plants. NPK and ML had no influence in the biomass yields and nutrient uptake. RBC is a veritable source of plant nutrition. It is easily available, affordable and harmless to soil ecosystem. It would be best to use RBC for crop production to minimize the harmful effects of NO_3^- to humans from the use of NPK. The RBC showed promise, as an alternative to recommended dose of NPK fertilizers, for amaranth production and also for the benefits of human nutrition and health. It is therefore reasonable to recommend the use of rice bran based-compost (RBC) as an alternative to the recommended NPK dose for production of amaranth.

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EFFECT OF DIFFERENT RATES OF LIQUID ORGANIC (SUPERGRO) FERTILIZER ON THE GROWTH AND YIELD OF CHILI PEPPER (*CAPSICUM ANNUM*)

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ABSTRACT

This study was carried out to determine the effects of different rate of liquid organic fertilizer (SuperGro) on the growth and yield of chili pepper (Capsicum annum). The experiment was laid out on Randomized Complete Block Design with four experimental treatments replicated three times. The treatments were applied at 2days, 2 weeks, 4 weeks, and 6 weeks after transplanting. Data collected were plant height (cm), number of leaves, number of branches, stem girth (mm), days to 50% flowering, weight of fruit (kg), number of fruits, length of fruit (cm) and width of fruits (cm). The results of the data collected and analyzed shows that supergro at rate of 2ml/3litres of water per plot had the highest yield, growth performance and cost effective than other treatments therefore it is recommended for the production of chili pepper in Ikorodu, agroecological zone, Lagos State.

Key words: liquid organic fertilizer, SuperGro, chili pepper, growth and yield.

INTRODUCTION

One of the main problems faced by the pepper farmers is the high cost of production due to the use of inorganic fertilizers (Smith, 2015). Plant growth and development are dependent on supply of nutrient, availability of nitrogen and phosphorous are among the major limitations for crop production (Murphy *et al.,* 2017), which is aggravated under environmental stresses, mainly water stress. Application of chemical fertilizers alone can supply only one or two nutrient elements to the crop. On the other hand, supplying only organic inputs can improve soil physical and biological environment but suffers from drawback of low content of plant nutrients (Weider *et al.,* 2015). However, in the modern days, when agriculture is motivated not only for production, but also accounts for the sustainability of all the resources including soil for the generations to come. Consequently, the yield of the crops is declined. Super Gro is a natural liquid fertilizer which was developed to ensure the enhancement of crops and agricultural productivity both in quality and quantity. It is a natural fertilizer that increase agricultural yield more compare to synthetic or chemical fertilizer. Super Gro is a 100% organic liquid fertilizer, which is made from poultry droppings and sea bird guano. Being made from organic matter with absolutely no chemicals added to it, it is 100% safe to use on any vegetables or crop. Super Gro can be applied to any plant, tree, vegetable and even grass that require fertilization (Super Gro User manual). The use of chemical fertilizers has been many times reported for degrading soil and water resources. Moreover, organic farming is both a philosophy and a system of agriculture, which avoids or largely excludes the use of synthetically produced fertilizers, pesticides and to the maximum extent possible relies upon crop rotations, crop residues, animal manures, legumes, green manures, off farm organic wastes, mineral bearing rocks and bio-fertilizers to maintain soil productivity and to supply plant nutrients (Mitchell *et al.,*2016). In this context, this study is aim to investigate the response of growth and yield performance of chili pepper as affected by different rates of liquid organic fertilizer under Ikorodu agro-ecological zone.

MATERIALS AND METHODS

Experimental location, land preparation, experimental design and treatments

The experiment was carried out at the Teaching and Research Farms of Lagos State Polytechnic, Ikorodu, Lagos State Nigeria. The experiment was laid out in a Randomized Complete Block Design (RCBD) on a total area of land measuring 159.5m^2 which was divided into 3 blocks of 14.5m x 3m (43.5m^2), each plot size was 3m x 3m (9m^2) to give a total number of 12plots. Liquid organic fertilizer (Super Gro) was obtained from NEOLIFE NIG. LTD located at Makoko, Lagos and applied to the plant using foliar application at 2DAT (Days After Transplanting) and 2WAT (Weeks After Transplanting). That is, fertilizer was applied directly to the foliage (leaves) in a liquid form using garden hand sprayer of about 5Litres tank capacity at 2weeks interval.

Crop establishment and maintenance

Chili pepper seeds were obtained from an open market, Sabo, Ikorodu, Lagos. Seeds were sown in the nursery using broadcasting method of sowing and were later transplanted into the main field of cultivation using dibbling method of sowing with spacing of 0.6m x 0.5m to give total number of 30 plant stands (Smith, 2015). Manual weeding was carried out at three (3) weeks interval. Pest and disease were controlled using Cypermethrin (insecticide) and Z-Force (Fungicide) at two (2) weeks interval to ensure effective chemical control on devastating pest and fungi disease. In addition, good sanitation was implemented throughout the study so as to avoid entrance of pathogen in the study area (Smith, 2015).

Data collection and Statistical Analysis

Eight (8) plant stands was randomly sampled and tagged per plot for data collection. Data were collected at 2, 4, 6 and 8WAT (Weeks After Transplanting). Data that were collected include:

Growth Parameters; number of leaves. plant height (cm), stem girth (mm), and number of branches. Yield Parameters; days to 50% flowering, length of the fruits (cm), fruits diameter (mm), weight of fruits per plot (kg).

Data collected were subjected to Analysis of Variance (ANOVA), and means of treatments were compared using Duncan Multiple Range Test (DMRT) at 5% level of probability using SAS (version 9.4).

RESULTS

Effects of supergro application rate of *Capsicun annum* on number of leaves, stem girth and plant height at 2, 4, and weeks after transplanting

Statistical analysis showed that there was no significant effect of the treatments on number of leaves of Chili pepper. Table 4.1 showed that Chili pepper plants grown with 2ml/3Lwater of super grow produced the highest mean number of leaves (8.44) at 2 WAT, followed by 8.39 mean number of leaves obtained from Chili pepper plants grown with 2ml/2L of water of supergro. The least mean number of leaves (8.00) was obtained from Chili pepper plants grown with 2ml/1.5Lwater of supergro.

The different application rates of supergro did not significantly influence the stem girth of Chili pepper. Table 1 revealed at 2 WAT, that Chili pepper treated with 2ml/3Lwater of supergroproduced the thickest mean stem girth of 1.62 mm, while the least mean stem girths of 0.37 mm, was produced by Chili pepper plants treated with no supergro.

There was also no significant effect of supergro application rate on plant height of Chili pepper. It was shown in table 1 that Chili pepper plants grown with 2ml/3Lwater of super grow produced the tallest plants with mean value of 8.51 cm at 2 WAT, followed by 8.07 cm mean plant height obtained from Chili pepper plants grown with 2ml/1.5Lwater of supergro. The least mean plant height (6.84) was obtained from Chili pepper plants grown with no supergro application.

Table 1: Effects of supergro application rate of *Capsicum annum* at 2 weeks after Transplanting

Manure Types	No. of leaves	Stem girth (cm)	Plant height (cm)
2ml/3Lwater	8.44	1.62	8.51
2ml/2Lwater	8.39	1.09	7.30
2ml/1.5Lwater	8.00	0.48	8.07
No application	8.06	0.37	6.84
Significance	NS	NS	NS

Statistical analysis showed that there was no significant effect of the treatments on number of leaves of Chili pepper. Table 2 showed that Chili pepper plants grown with 2ml/3Lwater of super grow produced the highest mean number of leaves (15.97) at 4 WAT, followed by 15.17 mean number of leaves obtained from Chili pepper plants grown with 2ml/1.5Lwater of supergro. While the least mean number of leaves (13.43) was obtained from Chili pepper plants grown with no supergro application.

The different application rates of supergro did not significantly influence the stem girth of Chili pepper at 4 WAT. Table 2 revealed at 4 WAT, that Chili pepper treated with 2ml/2Lwater of supergroproduced the thickest mean stem girth of 2.05 mm, while the least mean stem girths of 1.38 mm, was produced by Chili pepper plants treated with no supergro application.

There was a significant difference in the effects of Supergro application rates on number of branches of Chili pepper plants at 4 WAT. However, Chili pepper grown with 2ml/2Lwater of supergrosignificantly produced the highest mean number of branches (3.40) than 3.37 and 3.11 mean number of branches produced by Chili pepper plants treated with 2ml/1.5Lwater of supergro and with no supergro application respectively. The least mean number of branches was produced by chili pepper treated with 2ml/3Lwater of supergro.

There was also no significant effect of supergro application rate on plant height of Chili pepper. It was shown in table 2 that Chili pepper plants grown with 2ml/3Lwater of super grow produced the tallest plants with mean value of 13.44 cm at 4 WAT, followed by 12.96 cm mean plant height obtained from Chili pepper plants grown with 2ml/1.5Lwater of supergro. The least mean plant height (11.02) was obtained from Chili pepper plants grown with no supergro application.

Table 2: Effects of supergro application rate on the growth of *Capsicum annum* at 4 weeks after Transplanting

Manure Types	No. of leaves	Stem girth (cm)	No. of branches	Plant height (cm)
2ml/3Lwater	15.97	1.60	2.51b	13.44
2ml/2Lwater	13.87	2.05	3.40a	11.63
2ml/1.5Lwater	15.17	1.88	3.37ab	12.96
No application	13.43	1.38	3.11ab	11.02

Values represent treatment means. Means were separated using Duncan multiple range test and means within a column followed by different letters are significantly different at P≤0.05.

Statistical analysis showed that there was no significant effect of the treatments on number of leaves of Chili pepper. Table 3 showed that Chili pepper plants grown with 2ml/3Lwater of super grow produced the highest mean number of leaves (40.17) at 6 WAT, followed by 36.73 mean number of leaves obtained from Chili pepper plants grown with 2ml/1.5Lwater of supergro. While the least mean number of leaves (28.94) was obtained from Chili pepper plants grown with no supergro application.

The different application rates of supergro did not significantly influence the stem girth of Chili pepper at 6 WAT. Table 3 revealed at 6 WAT, that Chili pepper treated with 2ml/2Lwater of supergroproduced the thickest mean stem girth of 2.86 mm, while the least mean stem girths of 2.05 mm, was produced by Chili pepper plants treated with no supergro application.

There was no significant difference in the effects of Supergro application rates on number of branches of Chili pepper plants at 6 WAT. However, Chili pepper grown with 2ml/2Lwater of supergroproduced the highest mean number of branches (7.41) than 6.39 mean number of branches produced by Chili pepper plants treated with 2ml/3Lwater and2ml/1.5Lwater of supergro. The least mean number of branches (5.48) was produced by chili pepper treated with no supergro application.

There was also no significant effect of supergro application rate on plant height of Chili pepper. It was shown in table 3 that Chili pepper plants grown with 2ml/1.5Lwater of super grow produced the tallest plants with mean value of 20.87 cm at 6 WAT, followed by 16.60 cm mean plant height obtained from Chili pepper plants grown with 2ml/3Lwater of supergro. The least mean plant height (16.20) was obtained from Chili pepper plants grown with no supergro application.

Table 3: Effects of supergro application rate on the growth of *Capsicum annum* at 6 weeks after Transplanting

Manure Types	No. of leaves	Stem girth (cm)	No. of branches	Plant height (cm)
2ml/3Lwater	40.17	2.56	6.39	16.60
2ml/2Lwater	33.09	2.86	7.41	16.57
2ml/1.5Lwater	36.73	2.65	6.39	20.87
No application	28.94	2.05	5.48	16.20
	NS	NS	NS	NS

Values represent treatment means. Means were separated using Duncan multiple range test and means within a column followed by different letters are significantly different at P≤0.05.

Effects of supergro application rate of *Capsicum annum* on number of days to 50% flowering

Table 4 showed that there was no significant difference in the effects of supergro application rate on number of days to 50% flowering. However, *Capsicum annum* grown with no supergro application had the shortest days to flowering of mean value 46 days, followed by Chili pepper plants grown with 2ml/3Lwater of supergro which had 46.33days as mean number of days to 50% flowering. While the mean longest days to 50% flowering (47.33 days) was observed from Chili pepper plants grown with 2ml/2Lwater and 2ml/1.5Lwater of supergro.

Effects of supergro application rate on number of fruits of *Capsicum annum*

Chili pepper grown with 2ml/3Lwater of supergro significantly produced the highest number of fruits with mean value of 15.67 than 5.67 mean number of fruits obtained from Chili pepper grown with 2ml/1.5Lwater of supergro which was also significantly different from 3.33 and 1.33 mean number of fruits obtained from Chili peppergrown with no supergro application and 2ml/2Lwater (Table 4).

Effects of supergro application rate on fruit length(cm) of *Capsicum annum*

There was no significant difference among the treatment means of fruit length. Chili pepper grown with 2ml/3Lwater of supergro produced the longest fruits with mean value of 7.05 cm, followed by 2.88 cm mean fruit length obtained from 2ml/1.5Lwater of supergro -grown Chili pepper. The shortest fruits with mean value of 1.91 cm was obtained from Chili pepper grown without supergro application (Table 4).

Effects of supergro application rate on fruit width (cm) of *Capsicum annum*

Chili pepper grown with 2ml/3Lwater of supergro produced the fattest fruit with mean value of 3.86 mm, followed by 2.82 mm mean fruit width obtained from Chili pepper grown with 2ml/1.5Lwater of supergro which was not significantly different from 2.39 mm and 1.85 mm mean fruit width obtained from Chili pepper grown with 2ml/2Lwater and no supergro application (Table 4).

Effects of supergro application rate on fruit yield (kg) of *Capsicum annum*

Chili pepper grown with 2ml/3Lwater of supergro produced the highest fruits weight with mean value of 0.14 kg/plot, but not significantly different from 0.02 kg/plot mean fruits weight obtained from 2ml/1.5Lwater of supergro -grown Chili pepper and the least fruits weight with mean value of 0.01 kg/plot was obtained from Chili pepper grown with 2ml/2Lwater and without supergro application.

Table 4: Effects of supergro application rate on yield component of *Capsicum annum*.

Application rate	Days to 50% Flowering	NF	FL (cm)	FD (mm)	FWg (kg)
2ml/3Lwater	46.33	15.67	7.05	3.86	0.14
2ml/2Lwater	47.33	1.33	2.35	2.39	0.01
2ml/1.5Lwater	47.33	5.67	2.88	2.82	0.02
No application	46.00	3.33	1.91	1.85	0.01
	NS	NS	NS	NS	NS

DISCUSSION

This study revealed that the agronomic growth and yield of Chili pepper were not significantly affected by the different rates of supergro application used in this study except number of branches at 4 weeks after Transplanting and number of fruits. However, the differences observed among the growth and yields could therefore be implicated by the effects of other possible factors such as spatial variation in soil fertility and other soil properties, but not the application rates effects of supergro (Gulser 2015).

The non-significance is however in contrast with the findings of Toonsiri *et al*. (2016) who observed significant difference in the growth and yield of plants as affected by liquid fertilizers application.

CONCLUSION

It can be concluded statistically, based on the outcome of this study that no application rate of super gro among the rates experimented is better than the other.

RECOMMENDATION

It can be recommended base on the performance of the *Capsicum annum* plants to the 2ml/3Lwater of supergro in terms of yield and other growth be adopted for use. Although, there were no significant differences in the effects of the three supergro application rates tested in this study.

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EARLY GROWTH PATTERN OF FOUR ACCESSIONS OF SABA *(SABA SENEGALENSIS)* IN RESPONSE TO SEVEN FERTILIZER RATES IN THE NURSERY

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ABSTRACT

This study was carried out at the Department of Crop Science Teaching and Research Farm, Faculty of Agriculture, University of Nigeria, Nsukka to evaluate early growth pattern of four accessions of Saba sourced from Kabba, Okoro, Unosi and Oforachi in Kogi State in response to seven fertilizer rates in the nursery. The experiment was a 4x7 split plot in CRD with five replications. Data collected were: vine length, number of leaves and number of branches at 2, 3, 4, 5, 6 and 7 months after transplanting (MAT). Analysis of variance results indicated Oforachi accession had the longest vine (19.9 and 27.4 cm) at 2 and 3 MAT, respectively. More leaves (6.9) was obtained from Kabba accession at 2 MAT which was statistically similar with 6.8 recorded from Unosi. At 3 MAT, Unosi took the lead with 12.6. Unosi had more number of branches (1.4, 4.8 and 5.6) at 3, 6 and 7 MAT, respectively. Application of 50 t ha^{-1} of PM produced the longest vine (19.9 and 45.9 cm) at 2 and 5 MAT. Application of 40 t ha^{-1} of PM had more branches (5.0) at 6 MAT but similar with 4.8 obtained from 50 t ha^{-1}. However, application of 40 and 50 t ha^{-1} of PM produced more branches (6.1) at 7 MAT. Conclusively, Unosi accession had more number of leaves and highest number of branches and could be recommended for famers. Application of 50 t ha^{-1} of PM that enhanced better growth could be appropriate for Saba seedling.

Key words: Accession, *Saba senegalensis*, fertilizer rates, growth

INTRODUCTION

Saba senegalensis is an African indigenous large, woody plant that belongs to the family Apocynaceae (Arbonnier, 2000). It is found in the wild of Africa and distributed across Nigeria, Burkina Faso, Côte d'Ivoire, Gambia, Guinea, Guinea-Bissau, Ghana, Mali, Niger, Senegal, and Tanzania (Fatim *et al.,* 2019). It is a climber that usually seeks support from other plant species to rest upon and grow, but the seeds germinate in places where there is no support and therefore the plant manages to grow at the place where it sprouted (Baiyeri *et al.,* 2019). In Nigeria, it is found largely in North central and Southern parts of the country (Baiyeri *et al.,* 2019). It is known as 'Utu' by the Igbo of southeastern Nigeria, 'Ibo' by Okun-Yoruba of north central Nigeria (Baiyeri *et al.,* 2019).

It is an acidulous fruit that is very popular with the population; it is tasty, sweet sour with yellow pulp when ripe and can be consumed as such or can be processed into puree, nectar, jams and preservers (Arbonnier, 2000 and Tanor, 2001). The fruit is rich in vitamin A, vitamin C, dietary fiber and contains minerals such as potassium, magnesium and calcium (Omale *et al.,* 2010; Fatim *et al.,* 2019). The presence of active compounds in *Saba* fruit could play an important role in the prevention and treatment of certain vitamin deficiencies and metabolic diseases (Kini *et al.,* 2008). In some West African nations, it can be mashed and used for porridge (Bandoma, 2009). The latex is used to treat pulmonary diseases and tuberculosis; the leaves can cure chronic headache, wounds, food poisoning and vomiting (Kerharo, 1964 and Baiyeri *et al.,* 2019). It also has the potential of contributing to soil and water conservation (Baiyeri *et al.,* 2019).

Despite the importance of *Saba senegalensis*, the crop has not been brought under cultivation like the other indigenous species in Nigeria due to lack of adequate knowledge on their propagation, fertilizer requirement, climatic requirement, agronomic practices and pests. Yield of any crop is determined by its nutritional requirements and sustaining the yield and quality of a new crop requires appropriate crop management practices, especially soil fertility management (Ani and Baiyeri, 2008; Ndukwe and Baiyeri, 2020). Soil nutrients could be supplied in organic or inorganic form (chemical fertilizers and lime) and in combinations (Aba *et al.,* 2020). It has been established that soil amendments using both organic and inorganic sources (otherwise known as integrated plant nutrition system) supports the best crop performance (Shiyam *et al.,* 2010; Osundare *et al.,* 2015). The combined application of manure with mineral fertilizers supports the prompt release of applied nutrients to satisfy crop nutrient demand (Mohammed, 2002). However, to the best of our knowledge, this is the first report on growing of Saba seedlings under different fertilizer rates in Nigeria. Therefore, investigations into Saba fertilizer requirement in the nursery can provide valuable information that can encourage the domestication of this wild species for commercial cultivation and prevent it from going into extinction. Therefore, the objective of this study was to determine the effect of organic and inorganic fertilizers on early growth pattern of *Saba senegalensis* in the nursery.

MATERIALS AND METHODS

Experimental site: The experiment was conducted in the Department of Crop Science teaching and research farm of University of Nigeria, Nsukka (07° 29'N, 06° 51'E, and 400 m above mean sea level). A study (Uguru *et al.,* 2011) characterized Nsukka to have lowland humid tropical conditions with bimodal annual rainfall distribution, which ranges from 1155 to 1955 mm with a shift in the second peak of rainfall from September to October. A mean annual temperature of 29°C to 31°C and relative humidity that ranges from 69 to 79% also prevail in Nsukka.

Collection of plant material: Fully matured Saba fruits (see Fig. 1) for the study were harvested from the wild in four Local Government Areas (LGAs), they are Kabba in Kabba Bunu LGA, Okoro in Ijumu LGA, Unosi in Ajaokuta LGA and Oforachi in Igala Mela/Odollu LGA of Kogi State. The fruits from each location were collected from different liana in the same forest. After the seeds were extracted, the seeds were planted in pre-nursery and after emergence, thirty-five uniformly sized seedlings per accession was transplanted into the nursery in October 2020 where polyethylene bag of size 48 x 38.5 cm was used for each seedling. The polyethylene bags were filled with 12.0 kg soil and doubled for reinforcement. The experiment was a 4x7 split plot in CRD with five replications. The main plot were the seven fertilizer application rates (0 t ha^{-1}, 20 t ha^{-1} of PM + 200 kg ha^{-1} of NPK (20:10:10), 30 t ha^{-1} of PM, 30 t ha^{-1} of PM + 100 kg ha^{-1} of NPK, 30 t ha^{-1} of PM + 150 kg ha^{-1} of NPK, 40 t ha^{-1} of PM and 50 t ha^{-1} of PM) and the sub plot were the four accessions of Saba (Kabba, Okoro, Unosi and Oforachi). Equivalent weights of poultry manure rates were proportioned by referring the weight of the potting medium to the weight of sliced furrow of one hectare (2 242 000 kg) and multiplying by the chosen rate per hectare. Fertilizers were applied at the required quantity one month after transplanting to the nursery.

Data collected were: vine length, number of leaves and number of branches at 2, 3, 4, and 5 months after transplanting. All the data collected were subjected to the analysis of variance (ANOVA) following the procedures outlined for split plot in CRD using GENSTAT Discovery edition 3 Release 7.22 DE (GENSTAT, 2008). Significant treatment means were compared using least significant difference (LSD) at 5 % level of probability.

Figure 1: *Saba senegalensis* whole fruit and yellowish fruit pulp with seeds

RESULTS

Effect of accession and fertilizer rates on vine length (cm) of *Saba senegalensis* seedlings at 2, 3, 4, 5, 6 and 7 months after transplanting is presented in Table 1. Accession had significant ($p<0.05$) effect on vine length of Saba only at 2 and

3 MAT. Oforachi accession had the longest fine (19.9 and 27.4 cm) at 2 and 3 MAT, respectively while Kabba accession produced the shortest height of 16.4 and 23.0 cm.

Table 1: Effect of accession and fertilizer rates on vine length (cm) of *Saba senegalensis* at 2, 3, 4 and 5 months after transplanting

	Vine length in months after transplanting					
Accession	2	3	4	5	6	7
Kabba	16.4	23.0	29.6	38.2	45.9	52.5
Oforachi	19.9	27.4	34.2	44.2	50.2	54.5
Okoro	16.7	24.0	29.7	39.5	47.3	52.1
Unosi	18.3	24.8	31.6	39.6	47.1	52.3
LSD (0.05)	1.86	3.14	NS	NS	NS	NS
Fertilizer rates						
0 t ha^{-1}	16.7	23.3	28.5	37.1	49.1	50.8
20 t ha^{-1}	17.7	24.2	29.0	38.1	45.3	50.7
30 t ha^{-1}	17.2	24.1	32.0	38.0	46.0	48.5
30 t ha^{-1} + 100 kg ha^{-1}	18.6	25.3	32.8	43.0	50.8	56.4
30 t ha^{-1} +150 kg ha^{-1}	17.0	23.7	30.1	41.0	49.8	55.2
40 t ha^{-1}	17.8	24.6	32.5	39.7	47.4	56.3
50 t ha^{-1}	19.9	28.3	34.2	45.9	50.0	52.1
LSD (0.05)	2.03	NS	NS	6.075	NS	NS

NS-non-significant

Fertilizer rates significantly ($p<0.05$) affected vine length of Saba at 2 and 5 MAT but all other months did not vary statistically. Sole application of poultry manure at 50 t ha^{-1} produced the longest vine of 19.9 and 45.9 cm at 2 and 5 MAT. The shortest vine (16.7 and 37.1 cm) was obtained from plants grown in plots without any amendment. Interaction of accession x fertilizer rates on all the growth parameters measured were not significantly influenced across the months (Tables not shown for want of space). Effect of accession and fertilizer rates on number of leaves of *Saba senegalensis* seedlings at 2, 3, 4, 5, 6 and 7 months after transplanting is presented in Table 2. Number of leaves differed significantly with the accession at 2 and 3 MAT but statistically similar at 4, 5, 6 and 7 MAT. More leaves (6.9) was obtained from Kabba accessions at 2 MAT which was statistically similar with (6.8) recorded in Unosi accession, Okoro accession had the least (5.1). However, at 3 MAT, Unosi accession took the lead (12.6) with respect to number of leaves produced by Saba plants. The least number of leaves at 3 MAT was attributed to Oforachi accession with 9.2. Poultry manure application rate had no significant ($p>0.05$) effect on number of leaves of Saba seedlings at 2, 3, 4, 5, 6 and 7 MAT.

Table 2: Effect of accession and fertilizer rates on number of leaves of *Saba senegalensis* at 2, 3, 4 and 5 months after transplanting

	Number of leaves in months after transplanting					
Accession	2	3	4	5	6	7
Kabba	6.9	11.3	15.1	22.4	29.3	33.5
Oforachi	6.4	9.2	14.8	23.6	28.8	32.3
Okoro	5.1	9.6	13.2	20.7	26.8	30.6
Unosi	6.8	12.6	16.4	26.2	32.2	37.4
LSD (0.05)	1.0	2.4	NS	NS	NS	NS
Fertilizer rates						
0 t ha^{-1}	6.7	12.0	14.4	24.4	29.2	30.6
20 t ha^{-1}	6.4	10.5	14.7	21.8	28.9	33.6
30 t ha^{-1}	6.0	9.9	12.5	20.0	25.1	28.3
30 t ha^{-1} + 100 kg ha^{-1}	7.2	11.3	16.5	23.4	28.4	34.0
30 t ha^{-1} +150 kg ha^{-1}	6.1	9.4	13.8	23.2	30.1	35.0
40 t ha^{-1}	6.3	11.9	16.8	26.2	34.6	40.1
50 t ha^{-1}	5.6	10.0	15.5	23.6	28.8	32.5
LSD (0.05)	NS	NS	NS	NS	NS	NS

NS-non-significant

Table 3 presents the effect of accession and fertilizer rates on number of branches of *Saba senegalensis* seedlings at 2, 3, 4, 5, 6 and 7 MAT. Number of branches was not affected by the accessions at 2, 4 and 5 MAT but significantly different at 3, 6 and 7 MAT. More number of branches were attributed to accession collected from Unosi with 1.4, 4.8 and 5.6 at 3, 6 and 7 MAT, respectively while Oforachi had the least of 0.3 and 3.1 at 3 and 6 MAT, respectively. However, accession from Kabba had the least (4.3) at 7 MAT.

Number of branches was not influenced by the fertilizer rates at 2, 3, 4 and 5 MAT but differed at 6 and 7 MAT. Sole application of poultry manure at 40 t ha^{-1} had the highest number of branches (5.0) at 6 MAT while combination of 30 t ha^{-1} PM + 100 kg ha^{-1} NPK had the least of (2.8). However, application of 40 and 50 t ha^{-1} of PM produced greater number of branches (6.1) at 7 MAT, the least (3.8) was obtained where no fertilizer was applied (0 t ha^{-1}).

Table 3: Effect of accession and fertilizer rates on number of branches of *Saba senegalensis* at 2, 3, 4 and 5 months after transplanting

	Number of branches in months after transplanting					
Accession	2	3	4	5	6	7
Kabba	0.3	0.9	1.2	1.8	3.5	4.3
Oforachi	0.0	0.3	1.8	2.6	3.1	4.5
Okoro	0.0	1.0	2.0	2.8	3.7	4.9
Unosi	0.4	1.4	2.3	2.9	4.8	5.6
LSD (0.05)	NS	0.7	NS	NS	0.9	1.1
Fertilizer rates						
0 t ha^{-1}	0.2	1.1	1.3	2.5	3.5	3.8
20 t ha^{-1}	0.2	1.0	1.5	1.6	3.3	4.8
30 t ha^{-1}	0.0	1.0	1.4	2.2	3.5	4.4
30 t ha^{-1} + 100 kg ha^{-1}	0.2	1.1	1.9	2.0	2.8	4.4
30 t ha^{-1} +150 kg ha^{-1}	0.1	0.2	2.1	2.6	3.6	5.2
40 t ha^{-1}	0.2	0.7	2.3	3.5	5.0	6.1
50 t ha^{-1}	0.4	1.2	2.6	3.3	4.8	6.1
LSD (0.05)	NS	NS	NS	NS	1.3	1.5

NS=non-significant

DISCUSSION

The study revealed that variability probably existed among the accessions in some growth traits assessed at different months. Unosi accession significantly produced more leaves and greater number of branches than others. The variability observed in some growth parameters in this study could be attributed to genetic difference in the accessions of Saba. This conforms with the result of Maforikan *et al.* (2018) who reported that genetic variation among the individual and within the different population are likely to influence seedling growth in Baobab from Benin. Results of Baiyeri *et al.* (2015) showed accessional differences in seedling emergence, early growth and leaf proximate composition of *M. oleifera* in Nsukka which could probably be due to variations in the genetic potentials of the accessions. Another study Nwofia and Okwu (2015) reported genotypic variation in early seedling growth of five *Carica papaya* morphotypes from Umudike. Observation from Suthar *et al.* (2019) revealed significant genotypic differences in seedlings growth and biomass production in 15 guar accessions in Texas. Genetic variation in any given crop population is essential to successfully select and manage yield improvement programs (Idahosa *et al.,* 2010; Ndukauba *et al.,* 2015).

The results obtained in this study revealed that organic and inorganic fertilizers significantly influenced some growth attributes measured. Sole application of poultry manure at 50 t ha^{-1} increased vine length of *Saba senegalensis* at 2 and 5 MAT. Also, sole application of 40 or 50 t ha^{-1} of PM produced more branches at 7 MAT. Increase in early growth of Saba with the sole application of poultry manure at 50 t ha^{-1} than other treatment combinations indicated that these rate provided adequate nutrients to the seedlings in the nursery since the plants depend solely on the nutrient given which the roots of the plants were able to absorb and used for growth and development. The results obtained in this work corroborates with the findings of Baiyeri *et al.* (2015) who found that application of the highest rate of organic manure at 20 t ha^{-1} increased growth parameters in *Moringa oleifera* grown as pot plant in Nsukka. The result also agreed with the report of Husseini *et al.* (2016) who observed that organic manure provided enough nutrients that perhaps contributed to the high leaf yield of Baobab seedling in the nursery from Ghana. Adebayo *et al.* (2011) found that organic amendment increased both the vegetative and dry matter yield of *M. oleifera* in the nursery. Stevens *et al.* (2018) reported that application of organic manure significantly influence growth and leaf yield of *Moringa oleifera* in Nsukka.

CONCLUSION

Some distinct differences in growth traits of four accessions of Saba were obtained, these variations were probably linked to the genetic makeup of the accession which warrant selection. Unosi accession that had more number of leaves and highest number of branches could be recommended for famers that may intend growing Saba for commercial purpose. It resulted that 50 t ha^{-1} of PM enhanced better growth which indicates that Saba seedlings require high dosage of nutrients in the nursey for early growth and development since the plants are solely dependent on the nutrient supplied. Therefore, this rate could be appropriate for early seedling growth of *Saba senegalensis*.

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INFLUENCE OF NITROGEN AND INTRA-ROW SPACING ON THE GROWTH ATTRIBUTES OF ROSELLE (*HIBISCUS SABDARIFFA* L.)

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ABSTRACT

An experiment was conducted during the rainy season at the Research farm of the Institute for Agricultural Research (IAR), Samaru, Zaria to determine the effect of nitrogen fertilizer and intra-row spacing on the growth attributes of Roselle (Hisbiscus sabdariffa L.). The treatments consisted of four rates of nitrogen (0, 60, 120 and 180 kg N ha$^{-1)}$ and three intra-row spacing (45, 60 and 75 cm). The treatments were arranged in a randomized complete block design and replicated three times. The results showed that the application of 180 kg N ha^{-1} had significant effect on plant height and number of branches. Intra-row spacing of 45 cm significantly influenced on plant height, number of leaves and number of branches. Based on the results obtained 120 kg N ha^{-1} at 60 cm can be used for the production of Roselle in Samaru.

Key words: Intra-Row, Growth, Roselle, Nitrogen

INTRODUCTION

Roselle (*Hibiscus sabdariffa L*) is one of the most important traditional leafy vegetable in the tropics and sub-tropics. It belongs to the Malvaceae family and it is believed to have originated from Africa (Grubben and Denton, 2004). Roselle plays a great role in the socio economic life of many Africans when it comes to the diet, especially people from Nigeria, Ghana, and Sudan (McClintock, 2004). In spite of the fact that Roselle is a multi-product crop with diverse nutritious, medicinal and economic benefits, its productions in Nigeria is still under subsistence practices. Nitrogen fertilizer plays critical roles in plant nutrition. The most profound influence of nitrogen on crop grown is attributed to its direct positive effect on cell division, elongation and expansion, synthesis of Amino acid, enzymes and chlorophyll molecules (John *et al.,* 2006). A report by Dempsey (1964) for instance indicated that Kenaf a related crop to Roselle is a heavy feeder and soil depleting crop. Therefore, the response potentials of the Roselle to nitrogen fertilization in the savannah are very high.

MATERIALS AND METHODS

An experiment was conducted during the rainy season at the Research farm of the Institute for Agricultural Research (IAR), Samaru, Zaria to determine the effect of nitrogen fertilizer and intra-row spacing on the growth attributes of Roselle (*Hisbiscus sabdariffa L.*). The treatments consisted of four Nitrogen fertilizer rates (0, 60, 120, and 180 kg N ha^{-1}) and three Intra-row spacing (45, 60 and 75 cm) laid out in a randomized complete block design (RCBD) and replicated three times.

Agronomic Practices

The field for the experiment was harrowed and ridges were made at the inter row spacing of 75cm. The seeds were sown manually at spacing of 25, 60 and 75 cm x 75cm apart as per treatments. Weeding was done manually using hoe at 3 WAS and ridge molding at 8 WAS. Basal application of phosphorous fertilizer using SSP 18 % P_2O_5 at the rate of 60 kg ha^1 and Potassium using Muriate of potash K_20 at the rate of 32 kg ha^{-1} both were applied before sowing as per stands. While Nitrogen using Urea 46 % N was applied at 3 and 6 WAS as per treatment.

Data Collection

Data were collected on Plant Height (cm), Number of branches per plant, Number of leaves per plant, Leaf area Index (LAI) P^{-1}, Crop growth rate (CGR g^{-1} wk^{-1}), Relative growth Rate (RGR g^{-1} wk^{-1}). The data collected were subjected to statistical analysis of variance (ANOVA) and treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS

The effect of nitrogen fertilizer and intra-row spacing on the plant of Roselle is shown in Table 1. The result shows that application of nitrogen fertilizer had no significant effect throughout the sampling periods except at 9 WAS where application of 180 kg N ha^{-1} produced the tallest plants. While effect of intra-row spacing on plant height showed that 45 cm produced the tallest plant at 6 and 9 WAS which was at par with 60 cm.

Table 2 shows the effect of nitrogen fertilizer and intra-row spacing on number of leaves per plant, the result shows that application of nitrogen fertilizer had no significant effect on number of leaves throughout the sampling periods. Intra-row spacing of 45 cm produced the most number of leaves only at 3 and 9WAS. The interaction was not significant.

Table 1: Effect of nitrogen fertilizer rates and intra-row spacing on plant height of Roselle

TREATMENT	3WAS	6WAS	9WAS	12WAS
Nitrogen(kg ha^{-1})				
0	14.07	21.10	39.33b	51.44
60	13.62	19.43	37.81b	50.70
120	13.51	18.33	38.22b	56.36
180	14.14	18.07	48.36a	61.33
SE±	0.976	1.323	2.715	3.970
Spacing (cm)				
45	15.14	21.55a	45.61a	56.60
60	13.47	18.55ab	40.66b	56.22
75	12.91	17.60b	36.52b	52.05
SE±	0.656	0.015	2.442	1.591
N x S	NS	NS	NS	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

Table 2: Effect of nitrogen fertilizer rates and intra-row spacing on number of leaves per plant of Roselle

TREATMENT	3WAS	6WAS	9WAS	12WAS
Nitrogen(kg ha^{-1})				
0	12.29	26.66	57.22	70.33
60	11.35	23.33	54.80	68.56
120	12.56	21.33	62.56	84.11
180	11.74	25.48	54.22	76.67
SE±	1.170	2.371	5.642	6.240
Spacing (cm)				
45	14.47a	30.22a	64.50	81.05
60	11.10b	22.27b	52.33	75.41
75	110.41b	20.10b	52.33	67.83
SE±	0.803	2.181	3.943	4.491
N x S	NS	NS	NS	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

Table 3 shows the effect of nitrogen fertilizer and intra-row spacing on Leaf Area Index, the result shows that application of nitrogen fertilizer had no significant effect on number of leaves throughout the sampling periods. The effect of Intra-Row spacing had significant effect on Leaf Area Index, but there was no significant effect in interaction. Application of nitrogen fertilizer had no significant effect on number of leaves throughout the sampling periods except at 9 WAS where application of 180 kg N ha^{-1} produced the number of branches (Table 4). The Influence of intra-row spacing on number of branches was not significant throughout the sampling periods except at 6 and 9 WAS where 45cm intra-row spacing produced the highest number of branches. interaction was not significant.

Table 3: Effect of nitrogen fertilizer rates and intra-row spacing on number of Leaf Area Index of Roselle

TREATMENT	3WAS	6WAS	9WAS	12WAS
Nitrogen(kg ha^{-1})				
0	0.18	0.62	1.31	1.85
60	0.19	0.58	1.20	1.87
120	0.17	0.55	1.51	2.28
180	0.31	0.66	1.36	2. 03
SE±	0.050	0.121	0.159	0. 182
Spacing (cm)				
45	0.09b	0.99a	1.71a	2.27a
60	0.37a	0.52b	1.25b	1.97ab
75	0.17b	0.30b	1.07b	1.78b
SE±	0.044	0.116	0.184	0.203
N x S	NS	NS	NS	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

Table 4: Effect of nitrogen fertilizer rates and intra-row spacing on number of Branches of Roselle

TREATMENT	3WAS	6WAS	9WAS	12WAS
Nitrogen(kg ha^{-1})				
0	2.22	7.00	11.67b	15.00
60	2.33	5.77	11.89b	13.89
120	2.11	5.33	11.89b	14.00
180	2.22	6.22	14.33a	16.11
SE±	0.479	0.546	0.782	0.914
Spacing (cm)				
45	2.75	7.50	13.92	15.42
60	2.08	5.75	12.33	14.83
75	1.83	5.00	11.08	14.00
SE±	0.384	0.417	0.726	0.616
N x S	NS	NS	NS	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

The effect of nitrogen fertilizer and intra-row spacing on net assimilation rate of Roselle is shown in Table 5. The result shows that application of nitrogen fertilizer had no significant effect on net assimilation rate throughout the sampling periods. The response net assimilation rate to varying intra-row spacing was significant at 3-6 and 6-9 WAS where intra-row spacing of 45cm produced the highest net assimilation rate. While interaction was not significant.

Table 5: Effect of nitrogen fertilizer rates and intra-row spacing on number of Net Assimilation Rate of Roselle

TREATMENT	3-6WAS	6-9WAS	9-12WAS
Nitrogen(kg ha^{-1})			
0	0. 84	3.32	5.27
60	1.07	3.76	6.16
120	1.15	4.79	7.67
180	1.04	4.08	6.65
SE±	0.168	0.735	1.596
Spacing (cm)			
45	1.27a	2.97b	2.27a
60	1.02ab	5.11a	1.97ab
75	0.79b	3.82ab	1.78b
SE±	0.127	0.486	0.992
N x S	NS	NS	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

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Table 6: Effect of nitrogen fertilizer rates and intra-row spacing on number of Crop Growth Rate of Roselle

TREATMENT	3-6WAS	6-9WAS	9-12WAS
Nitrogen(kg ha^{-1})			
0	0. 84	3.32	5.27
60	1.07	3.76	6.16
120	1.15	4.79	7.67
180	1.04	4.08	6.65
SE±	0.168	0.735	1.596
Spacing (cm)			
45	1.27a	2.97b	2.27a
60	1.02ab	5.11a	1.97ab
75	0.79b	3.82ab	1.78b
SE±	0.127	0.486	0.992
N x S	NS	NS	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

Relative growth rate as influenced by Nitrogen fertilizer and Intra-Row spacing is shown Table 7. The results showed that application of nitrogen fertilizer had no significant effect on Relative growth rate throughout the sampling periods. The Influence of intra-row spacing on Relative growth rate was significant at 6-9 WAS where intra-row spacing 60cm had the highest Relative growth rate. Interaction was not significant.

Table 7: Effect of nitrogen fertilizer rates and intra-row spacing on number of Relative Growth Rate of Roselle

TREATMENT	3-6WAS	6-9WAS	9-12WAS
Nitrogen(kg ha^{-1})			
0	0.45	0.70	0.97
60	0.48	0.71	0.96
120	0.47	0.74	0.01
180	0.47	0.74	0.98
SE±	0.043	0.027	0.041
Spacing (cm)			
45	0.51	0.72ab	0.94
60	0.48	0.76a	1.04
75	0.41	0.68b	0.95
SE±	0.040	0.023	0.025
N x S	NS	NS	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

DISCUSSION

Application of 180 kg N ha^{-1} produced the tallest plants, more number of branches and leaves. Crop growth rate, relative growth rate, net assimilation rate and leaf area index significantly increased with increased Nitrogen rate. The positive influence of Nitrogen on these parameters may associated with its role in promoting rapid vegetative growth and its direct effect on chlorophyll (John *et al.,* 2006). Ndayako (1997) reported significant increase in number of branches, number of leaves, leaf area and leaf area index were enhanced by nitrogen application. According to McClintock (2004), Nitrogen fertilizer application result in greater leaf area index whenever it is applied to actively growing plant in a vegetative condition. The effect of Nitrogen fertilizer could also be attributed to increase in leaf number and size. Since Nitrogen is involved in the synthesis of chlorophyll molecules, its application increases the crops ability to intercept more solar energy and increase CO_2 assimilation. The effect of Nitrogen fertilizer on net assimilation rate during initial stages of growth was in agreement with Mc Caleb (2005), who reported that, for a wide range of crop varieties net assimilation rate is relatively constant. The decrease in net assimilation in the later growth stages could be attributed to increased leaf senescence and increased photosynthesis. Intra-Row spacing of 45cm produced the tallest plants, more number of branches and leaves as well as higher growth rate, relative growth rate, net assimilation rate and leaf area index. This could be due to the fact that closer spacing gave room for better light interception for vegetative growth. This agreed with the findings of Giginyu *et al.* (1999) who reported that, plant height, canopy spread and number of branches per plant of Roselle were observed to be significantly influenced by varying intra-row spacing.

CONCLUSION

Based on the results obtained 120 kg N ha^{-1} at 60 cm can be used for the production of Roselle in Samaru.

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EFFECT OF MYCORRHIZA INOCULATION WITH NITROGEN FERTILIZER APPLICATION ON THE GROWTH AND YIELD OF TURMERIC

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ABSTRACT

Turmeric is an important spice crop throughout the world and Nigeria is among the leading producers of the crop. However, there is paucity of information on its fertilizer requirement as well as mycorrhiza inoculation on its development. The study was therefore to examine the influence of mycorrhiza inoculation with nitrogen (N) fertilizer application on the growth and yield of turmeric. The experiment was conducted inside pots with 5 levels of nitrogen (0, 45, 90, 135 and 180 kg N/ha), and 2 levels of mycorrhiza inoculation (with and without). The experiment was arranged in a 5 × 2 factorial fitted into a completely randomized design with three replications. Data were obtained on the plant height, number of tillers, dry above-ground biomass yield and rhizome yield. All data were subjected to analysis of variance using SAS PROC. GLM and significant treatment means separated using LSD values. Mycorrhiza inoculation with nitrogen applications significantly enhanced the dry above-ground biomass yield and rhizome yield. Mycorrhiza inoculation beyond 135 kg N/ha application no longer have any significant effect on the growth and yield of turmeric. The yield obtained with the application of 180 kg N/ha with and without mycorrhiza inoculation is not significantly different from the application of 135 kg N/ha with mycorrhiza inoculation. Hence, application of 135 kg N/ha with mycorrhiza inoculation will be beneficial to turmeric production under the same condition.

Key words: Nitrogen, above-ground biomass, turmeric, yield

INTRODUCTION

Turmeric (*Curcuma long* L.) a spice crop, it originates from the Indian subcontinent (Bose *et al*., 2008). It can grow under various conditions up to 1600 m above sea level with a temperature range of 20 to 40 ^{0}C and rainfall above 1500 mm (Olojede *et al*., 2005). Turmeric has multiple uses which include culinary, cosmetic, medicinal purposes as dye among others. It is the major constituent for the popular curry meant for adding flavour to our meals. It can also be used as dye and/or colouring agent. The main active compound of turmeric is the curcumin. Research has shown that turmeric can be used in treatment of so many medical problems and conditions ranging from constipation to skin diseases. It can be used in the treatment of wounds, infection, dysentry, arthrithis, jaundice, liver problems, cancer, Alzheimer's diseases etc. (Hermann and Martine, 1991; Osawa *et al*., 1995). Nitrogen (N) is about the most important nutrient element required by plants. It is a major part of all amino acids, which are the building blocks of all proteins, including the enzymes, which control virtually all biological processes. It is also essential for carbohydrate use within plants. The beneficial effect of mycorrhiza inoculation on growth and development of plants has been documented (Osonubi *et al*., 1995; Fagbola *et al*., 1998; Arihara, 2000). The beneficial effects of mycorrhiza inoculation include: synergistic interaction with other beneficial soil microorganisms, enhanced nutrient absorption and increased resistance to plant diseases. There is however, little information on the contributions of mycorrrhiza inoculation on the growth and yield of turmeric. This study was therefore aimed at determining the interactive effect of nitrogen and mycorrhiza inoculation on the growth and yield turmeric.

MATERIALS AND METHODS

A pot experiment was conducted at the National Horticultural Research Institute (NIHORT), Ibadan using approximately 5 kg soil. Pre-cropping soil analysis was done using standard procedures. The experiment was a 5 × 2 factorial arranged in a completely randomized design. The experiment was replicated three times. The factors include 5 levels of N (0, 45, 90, 135 and 180 kg N/ha), and 2 levels of mycorrhiza inoculation (with and without). The mycorrhiza inoculation was done at planting with the turmeric rhizome while the N was applied at 2 equal split dose a month and 3 months after planting. The source of the N was urea. Data were collected on plant height, number of leaves, rhizome yield and the above-ground dry biomass yield.

All data were subjected to analysis of variance using SAS software 9.2 version and significant treatment means separated using LSD.

RESULTS AND DISCUSSION

The effect of mycorrhiza inoculation with N application on the plant height of turmeric was not well pronounced. There was a slight increase in the plant height with mycorrhiza inoculation beyond 90 kg N/ha at 2 and 3 months after planting, while at 4 months upwards the increase occurs from 45 kg N/ha. Increase in plant height with N application and mycorrhiza inoculation ceases at 5 months after panting. However, there was a significant increase in the plant height with the application of 135 kg N/ha with mycorrhiza inoculation in all the months examined. Application of 180 kg N/ha with mycorrhiza inoculation gave the highest plant height at 5 months after planting, it was however not significantly different from the application of 135 kg N/ha with mycorrhiza inoculation. It was discovered that inoculation of mycorrhiza beyond N application at 135 kg N/ha was no longer effective (Figures 1-4). This implies that N application beyond 135 kg N/ha is the required quantity required by the crop but in other to minimize fertilizer input and still get the adequate result application of 135 kg N/ha with mycorrhiza inoculation may be suitable.

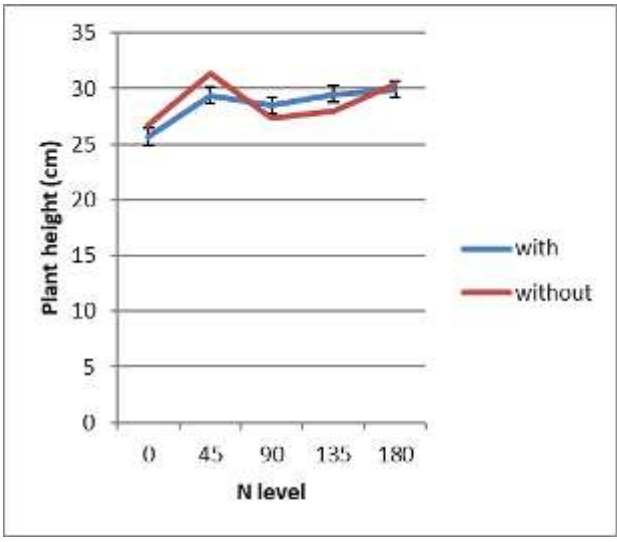

Fig. 1: Plant height of turmeric at 2 MAP

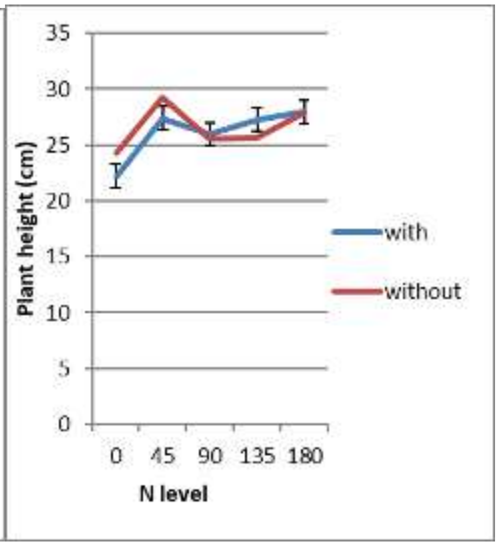

Fig. 2: Plant height of turmeric at 3 MAP

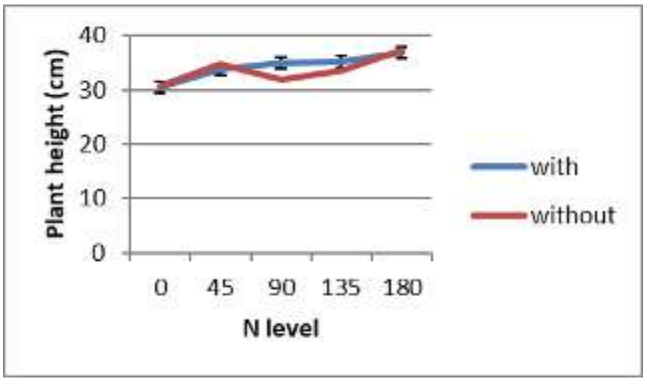

Fig. 3: Plant height of turmeric at 4 MAP

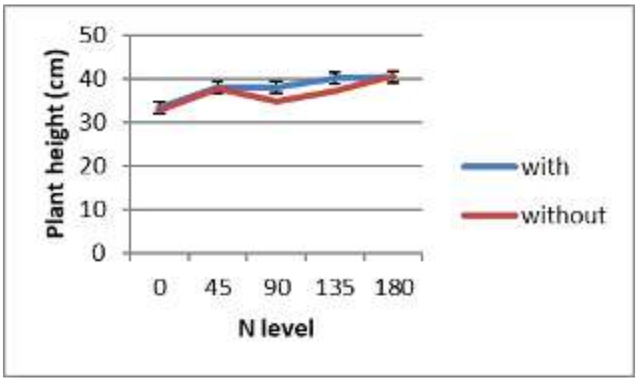

Fig. 4: Plant height of turmeric at 5 MAP

There was a contrasting effect in the number of tillers with mycorrhiza inoculation and N application. However, it was observed that the significant increase discovered in the number of tillers beyond

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the application of 135 kg N/ha with mycorrhiza inoculation was rapid within the first 4 months after planting. The rate of increase however decreases at the fifth month. At two months after planting there was an increase in the number of tillers with mycorrhiza inoculation. However, between the application of 90 and 135 kg N/ha with mycorrhiza inoculation, there was no effect in the number of tillers. While at three and four months after planting there was a decrease in the number of tillers with mycorrhiza inoculation between N application at 45 – 135kg N/ha before further increase (Figures 5-8).

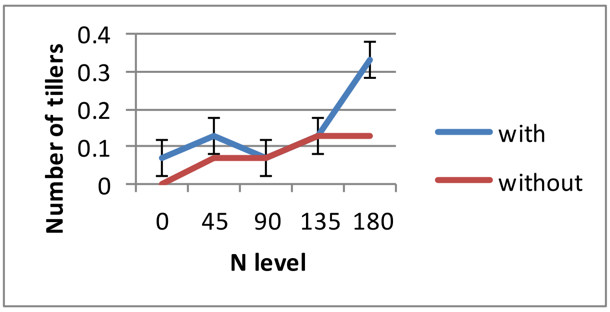

Fig. 5: Number of tillers of turmeric at 2 MAP

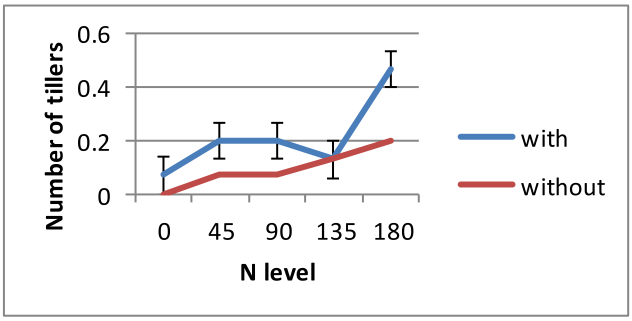

Fig. 6: Number of tillers of turmeric at 3 MAP

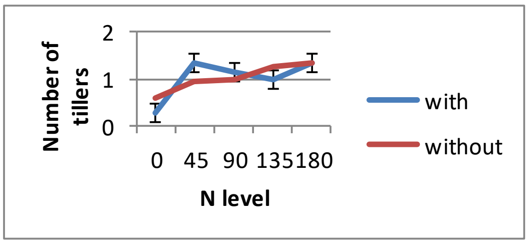

Fig. 7: Number of tillers of turmeric at 4 MAP

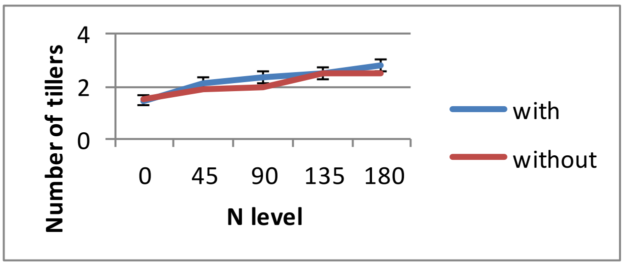

Fig. 8: Number of tillers of turmeric at 5 MAP

There was a consistent increase in the dry biomass yield with N application and mycorrhiza inoculation. Application of 135 kg N/ha with mycorrhiza inoculation gave a significantly higher dry biomass yield. Mycorrhiza inoculation with increased N application beyond 135 kg N/ha was no longer effective. The increase in the dry biomass yield with mycorrhiza inoculation was as a result of the increase in number of tillers with N application. Mycorrhiza inoculation with N application significantly enhanced the rhizome yield. The highest rhizome yield was with the application of 180 kg N/ha with mycorrhiza inoculation, this was however, not significantly different from the application of 135 kg N/ha with mycorrhiza inoculation (Figures 9, 10). This corroborates the findings of Ortas, 2012 that mycorrhizal inoculation can be used in reducing chemical fertilizer inputs on crops.

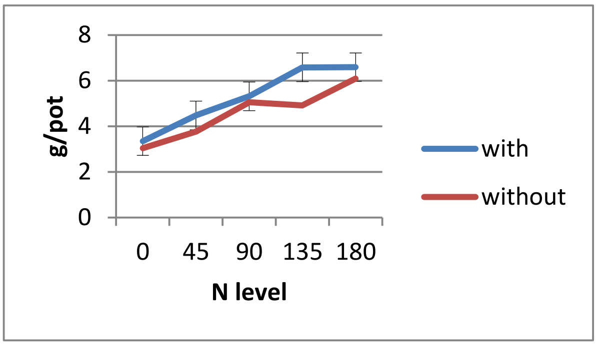

Fig. 9: Curcumin content of turmeric at maturity

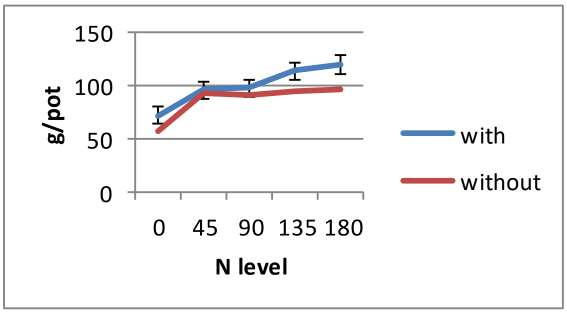

Fig. 10: Rhizome yield of turmeric

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CONCLUSION

The effect of mycorrhiza inoculation with N application on the plant height and number of tillers was not clearly shown in the study, this might be as a result of the presence of native mycorrhiza in the soil used for the study. However, mycorrhiza inoculation with N application at 135kg N/ha gave the best index and yield of turmeric.

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INFLUENCE OF NITROGEN ON THE PRODUCTION OF PINEAPPLE (*ANANAS COMOSUS* VAR. SUGARLOAF) SLIPS ON AN ALFISOL IN IBADAN, NIGERIA

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ABSTRACT

Pineapples are majorly propagated asexually from different parts of the plant like the crown, suckers, stumps and slips. This trial was carried put to evaluate the influence of nitrogen on the production of slips in pineapple C.V. sugarloaf. The trial was conducted at NIHORT, Ibadan as a single factor experiment with six (6) nitrogen levels of 0kgN/ha, 120kgN/ha, 240kgN/ha, 360kgN/ha, 480kgN/ha and 600kgN/ha laid out in a randomized complete block design with 3 replications. Basal application of phosphorus at 30kg P_2O_5/ha with Single Super Phosphate (SSP) and potassium at 70kg K_2O/ha with Muriate of Potash (MOP) as their sources were applied after transplanting. The nitrogen treatments were applied in 3 splits during the life span of the trial. Pre-cropping soil sampling were done on the soil (an alfisol) and the samples were analysed for physical and chemical properties. Yield data were collected and analysed. Data on number and weight of slips were obtained 60 days after harvesting the fruits. The results showed that there was no significant difference in the mean number of slips, mean weight of slips and number of slips produced per hectare though the 600kgN/ha treatment gave the highest mean number of slips (13.22) and number of slips produced per ha (528,933) while 240kgN/ha recorded the best slip weight (579.25g). No significant effect of the N treatments was observed in yield although 480kgN/ha recorded the best yield at 52t/ha. With basal application of phosphorus (30kg P_2O_5/ha) and potassium (70kg K_2O/ha), urea applied at 600kgN/ha is recommended for optimal production of sugarloaf pineapple slips while 480kgN/ha is suggested for fruit yield.

Key words: pineapple slips, sugarloaf, nitrogen, alfisol

INTRODUCTION

Pineapple (*Ananas comosus* [L.] Merrill) is a fruit predominantly produced in sub-tropical countries. The fruit contributes to more than 20% of the tropical fruit production worldwide with 25.5 million tons (FAO, 2016). There are eight countries in West Africa producing pineapples, with Benin being the third largest fresh pineapple producer (next to Ghana and Nigeria) in 2018 with 372,507 tons (FAO, 2018). It is the most economically important plant in the family *Bromeliaceae* (Bartholomew *et al*., 2003). Pineapples are herbaceous perennials and are cultivated throughout the year mainly asexually by the use of vegetative propagules like crowns, slips, hapas or suckers (Bartholomew *et al*., 2003). Reinhardt *et al.* (2017) submitted that slips are a good sources of planting material as long as the overly large vestigial fruits at their base are removed before planting, as they may rot after planting under wet soil conditions. Table 1 shows the different vegetative parts of the pineapple plant, their location on the plant and maturity periods. The sugarloaf pineapple (Figure 1) cultivar is characterized by dark green, erect and spiny leaves with a long peduncle (±35cm). It produces many slips (8-12) around the base of the fruits during its reproductive phase. The pulp of the fruit is soft, white and juicy with a high sugar content of 12-16^{o} brix. (Junghans, 2010). Sugarloaf is also tolerant to drought, nematodes and mealybug wilt.

Table 1: Pineapple vegetative parts, maturity period and their location on the plant

S/N	VEGETATIVE PARTS	LOCATION ON THE PINEAPPLE PLANT	MATURITY PERIOD
1	Slips	Below the fruit on the peduncle or basal eye of the fruit	12-13 months
2	Collars		14-16 months
3	Ground Suckers (ratoon)	Shoots produced from the stem just above the ground	12-14 months
4	Suckers or Side Shoots	Produced from the above ground portion of the stem	18-20 months
5	Crown	Short stem and leaves growing from the apex of the fruit	24 months

Figure 1: A sugarloaf pineapple plant showing its reproductive parts

Typical plant densities for pineapples range from 29,000 to 86,000 plants per hectare (Bartholomew *et al.* 2003). Densities are usually based on the intensity of agricultural practices and planned use of the fruit. In Brazil, plant densities for perola (sugarloaf) range from 31,700 to 41,600 for single row spacing and 26,300 to 51,200 for double row spacing (Cunha and Reinhardt, 2004) while in Nigeria, the recommended spacing is 100cm X 50cm X 50cm giving a plant density of 40,000 plants per hectare. The lack of availability of these planting materials for large areas of land informed this study to ensure availability of both the fruits and slips of sugarloaf pineapples.

MATERIALS AND METHODS

The experiment was conducted between 2009 and 2011 at the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria, with latitude 7° 22'N and longitude 3° 58'E. Ibadan is located in the derived Savanna Zone (Transition forest ecosystem of Nigeria). The soil of the study location is grouped under the Alfisol soil order. The experiment was a single factor experiment laid out in a randomized complete block design (RCBD) and replicated three times. The factor was the different levels of nitrogen (N) with urea (46% N) as the nitrogen source. The six N treatments were 0kgN/ha (control), 120kgN/ha (16g/plant), 240kgN/ha (32g/plant), 360kgN/ha (48g/plant), 480kgN/ha (64g/plant) and 600kgN/ha (80g/plant). The N treatments were applied in 3 splits. Basal application of phosphorus at 30kg P_2O_5/ha with Single Super Phosphate (SSP) and potassium at 70kg K_2O/ha with Muriate of Potash (MOP) as their sources. The field was ploughed, harrowed and bedded. Pre-cropping soil sampling was done and the samples were subjected to routine laboratory analysis. The soil parameters analysed for were particle size distribution, soil texture, bulk density, available phosphorus, total nitrogen, organic carbon, base saturation, exchangeable bases, exchangeable acidity, cation exchange capacity and micronutrients. The pineapple cultivar used was sugarloaf and planted on beds at spacing of 50 cm X 50 cm. Yield data were collected at specific intervals based on maturity index for pineapples and the yield components obtained were fruit weight and crown weight. At 60 days after harvesting the fruits, data on the number of slips and weight of slips were collected. Data were analysed using ANOVA at $\alpha_{0.05}$ with means separated with Fishers LSD.

RESULTS AND DISCUSSION

Pineapple Soil Requirements and Pre-Cropping Test Results

The soil was moderately acidic (5.8) with low levels of total nitrogen, available phosphorus (P) and exchangeable potassium (K) (Table 2). The organic carbon content was moderate at 1.36%. The soil was sandy loam with 12% clay and 72.6% sand, while the bulk density was 1.47g/cm^3 which was slightly above the ideal bulk density for sandy loam soils (1.40g/cm^3). The porosity was within the ideal range at 44.53%. The micronutrients were also low in the soil with the exception of manganese (Mn). Pineapples are sensitive to excess water in the soil (Souza and Reinhardt, 2007) hence the porosity of 44.53% favours good root growth and development. The crop also tolerates high aluminium and Mn in the soil (Malézieux and Bartholomew, 2003), hence the Mn level of 92.4mg/kg is tolerable for the plant. Nitrogen is important in the vegetative growth and development of the plant including the slips and suckers after fruiting in *perola* or sugarloaf variety (Souza and Reinhardt, 2007) while potassium has a significant effect on fruit quality. Phosphorus deficiency on the other hand caused reduction in growth in all the parts of the plant. The soil was thus applied basal doses of P and K in this study while N was varied.

Table 2: Pre-cropping soil test results

Parameters	Test Values
pH (H2O)	5.8
Organic Carbon (%)	1.36
Total Nitrogen (%)	0.31
Available Phosphorus (mg/kg)	0.58
Calcium (cmol/kg)	6.56
Magnesium (cmol/kg)	0.86
Sodium (cmol/kg)	0.32
Potassium (cmol/kg)	0.24
Exchangeable Acidity (cmol/kg)	0.8
Cation Exchange Capacity (cmol/kg)	8.78
Base Saturation (%)	90.89
Manganese (mg/kg)	92.4
Iron (mg/kg)	4.3
Copper (mg/kg)	2.0
Zinc (mg/kg)	6.1
Sand (%)	72.6
Silt (%)	15.4
Clay (%)	12.0
Bulk Density (g/cm^3)	1.47
Porosity (%)	44.53
Texture	Sandy loam

Effect of Nitrogen of Yield of Sugarloaf Pineapple

The 480kgN/ha treatment recorded the best mean fruit weight of 1.3kg though there was no significant effect of the N treatments on the mean fruit weight. The best yield per ha was also obtained with the 480kgN/ha treatment at 52t/ha fresh fruit yield (Table 3). The control recorded the largest crown weight though the fruit weight was the least. This could be attributed to the basal application of P and K which boosted the growth and development of the plant.

Table 3: Effect of nitrogen levels on some yield parameters of sugarloaf pineapple

Treatments	Mean Fruit Weight (kg)	Mean Crown Weight (g)	Yield (t/ha)
Control (No Fertilizer)	0.99a	**127.22a**	39.87a
120kgN/ha (Urea)	1.03a	105.74ab	41.33a
240kgN/ha (Urea)	1.20a	124.76ab	48.00a
360kgN/ha (Urea)	1.12a	104.60ab	44.93a
480kgN/ha (Urea)	**1.30a**	107.92ab	**52.00a**
600kgN/ha (Urea)	1.07a	102.59b	42.93a

Effect of Nitrogen on Number and Weight of Sugarloaf Pineapple Slips

There was no significant effect of the N treatments on the mean number of slips per plant, mean number of slips per hectare and the mean slip weight per plant (Table 4). The 600kgN/ha treatment gave the highest mean number of slips per plant (13.22) and highest number of slips per hectare at 528,933. The highest mean slip weight at 579.25g was recorded with 240kgN/ha treatment while the least weight of 460.76g was obtained under 360kgN/ha. Other factors could have contributed to these results including the prevailing weather conditions, nutrient drift etc. The non-significant effect of the N treatments also shows the characteristic nature of the pineapple C.V. sugarloaf's slip. The production capacity with minimal application of nutrients as seen in the result of the control treatment.

Table 4: Effect of nitrogen levels on number and weight of slips of sugarloaf pineapple

Treatments	Mean Number of Slips/plant	Mean Number of Slips/ha	Mean Slip Weight (g)
Control (No Fertilizer)	12.34a	493,733a	483.98a
120kgN/ha (Urea)	11.48a	459,200a	469.85a
240kgN/ha (Urea)	12.14a	485,733a	**579.25a**
360kgN/ha (Urea)	11.80a	475,200a	460.76a
480kgN/ha (Urea)	11.58a	463,333a	499.56a
600kgN/ha (Urea)	**13.22a**	**528,933a**	530.01a

CONCLUSION

Pineapples are primarily grown for their fresh fruits which is a good source of vitamins and minerals. The additional benefits of the planting materials from the slips after harvesting the medium sized fruits is good basis for choosing the variety. One hectare of land with a population density of 40,000 plants can give over 500,000 slips which can plant up to 12.5 ha.

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EFFECT OF NITROGEN FERTILIZER RATE AND SPACING ON THE GROWTH AND YIELD OF ONION (*ALLIUM CEPA* L.) IN DADINKOWA

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ABSTRACT

Field trial was conducted at the Teaching and Research Farm of Federal College of Horticulture Dadinkowa during 2020 wet season to evaluate the effect of Nitrogen Fertilizer Rates and Spacing Intervals on the Growth and Yield on Onion. The experiment consisted of three Nitrogen fertilizer rates (80kg, 100kg and 120kg/ha) and three Spacing Intervals (15x30cm, 20x30cm and 25x30cm) laid in Randomized Complete Block Design (RCBD) in three replications of nine plots each making up a total number of 27 plots. 1m space was left between replications and 0.5m between plots of 1mx2m (2m^2). The results revealed that significant difference was recorded for Nitrogen on Plant Height, Number of Leaves, Bulb Diameter, Yield per Plot and Yield per Hectare. However, there was no significant difference on Collar Girth and Bulb weight. For spacing interval, significant difference was recorded on Plant Height and Collar Girth while the rest of the parameters measured were not significant. Interaction between the two factors was significant on Plant Height, Number of Leaves, Collar Girth and Bulb weight but no significant difference was recorded on Bulb diameter, Yield per plot and Yield per Hectare. Further research was recommended.

Key words: Nitrogen, Spacing, Growth, Yield, Collar Girth, Bulb Diameter.

INTRODUCTION

The onion (*Allium cepa* L.) is a vegetable crop grown for its pungent bulbs and flavorful leaves. It belongs to the genus *Allium* of the family*Alliaceae*or *Amaryllidaceae* (Welbaum, 2015; Boukary *et al.,* 2012). Onion is one of the most important vegetable crops commercially grown in the world. It probably originated from Central Asia between Turkmenistan and Afghanistan where some of its relatives still grow in the wild. Onion from Central Asia, the supposed onion ancestor had probably migrated to the Near East (Bagali *et al.,* 2012). In the country, the crop is believed to be more intensively consumed than any other vegetable crops (Joosten, *et al., 2011)*. Moreover, the onion contributes to the commercialization of the rural economy and creates jobs opportunities for young people in the country (Nikus and Mulugeta, 2010). According to Hussaini *et al*., (2000) the crop ranks second in importance after tomatoes among the vegetables in Nigeria.

The requirement of plants for nitrogen is mostly satisfied either from soil and or application of nitrogen fertilizer. In this regard, Minister of Agriculture (2015) Spacing is an important aspect regarding onion production and quality. Researchers indicated that wider spacing helped the individual plant to utilize more water, nutrients, air and light for their growth and development than those closer spaced plants (Devulkar, 2013). Optimization of plant population is therefore important to avoid competition between plants for growth factors as well as to utilize available cropland efficiently without wastage (Awas, *et al.,* 2010).

According to Tegen, *et al*. (2016) the proportion of medium-sized bulbs which are preferred by consumers was low at this intra-row spacing. A Recommended the spacing of 40 cm x 20 cm x 10 cm between furrows, row and plants, respectively, for the production of onion in Ethiopia without considering the status of soil fertility and environmental conditions of the growing areas. However, onion bulbs produced using this intra-row spacing are mostly bigger in size (>160g) which are not preferred by consumers for home consumption (Tegen, *et al,*.2016). There is no definite spacing adopted by onion farmers in the study area and this affects the number of stands per given area which is directly related to yield of Onion. Similarly, fertilizer application rate particularly nitrogen varies between one farm land and another farm in the same area. These affects cost of production, leads to unnecessary expenses and affect profit return. Therefore, this research will help a lot in coming up with the most suitable spacing for onion cultivation and the appropriate nitrogen rate for application by farmers in the study area for maximum production at affordable cost and high profit. The study was conducted to find out the most suitable spacing for onion production, to find out the appropriate nitrogen fertilizer rate for onion production and to evaluate the interaction between spacing and fertilizer rates.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Research and Training Farm of Federal College of Horticulture Dadinkowa in Yamlatu Deba local Government area of Gombe State located at latitude 11^{o} to 30 "E at and longitude 10^{o} to 20 "N with altitude of 240 meters above the sea level and annual rainfall of 760 to 1100mm. Optimum temperature range between 24^{o}c to 48^{o}c and the soil type of the area is predominantly loamy.

Treatment and Experimental Design:

The experiment consisted of three level of nitrogen (80, 100, and 120 kg/ha^{1}) fertilizer and three spacing (15 cm x 30 cm, 20 cm x 30 cm and 25 cm x 30 cm) laid in Randomized Complete Block Design (RCBD) in 3 replications. The plots size was 1m x 2m (2m^{2}) with 1m space between the replications and 0.5 m between plots. Total number of plots was 27.Data were collected from the five randomly sampled and tagged plants within each plot at 2 weeks' intervals on plant height, number of leaves, collar girth, bulb weight, bulb diameter, yield per plot which was extrapolated to yield per hectare

$$\frac{\text{Yield per plot}}{\text{plot size (m2)}} \times \frac{10{,}000}{1000}$$

Data Analysis

Data obtained were subjected to analysis of variance using Genestat. Means were separated using least significant difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

The results in Table 1 were on the effect of Nitrogen Fertilizer Rates and Spacing interval on the Growth and Yield of Onion. The results showed that highly significant difference was recorded on plant height at harvest for both the factors. Significant difference was also recorded on number of Leaves, Bulb Diameter, Yield per Plot and yield per hectare. However, there was no significant difference on Collar Girth and Bulb weight for Fertilizer rates while for spacing significant difference was recorded on plant height and collar girth only while the rest of the parameters remained not significant.

Table 1: Effect of Nitrogen Fertilizer Rates and Spacing Intervals on the Plant Height, Number of Leaves, Collar Girth, Bulb Weight, Bulb Diameter, Yield Per Plot and Yield Per Hectare at Harvest of Onion in Dadinkowa During 2020 Wet Season.

Treatments	PH	NL	CG	BW	BD	YYP	YPH
Nitrogen Rate							
80kg	35.57	6.18	3.72	31.3	21.12	30.98	309.78
100kg	30.61	6.63	3.75	37.3	21.57	31.22	312.22
120kg	34.92	6.43	3.68	38.6	21.58	31.22	312.22
P<f	**	**	NS	NS	*	**	**
LSD	0.982	0.2651	0.1834	9.72	0.4051	0.0976	0.976
Spacing							
15x30cm	34.82	6.34	3.76	37.0	21.28	31.10	311.00
20x30cm	33.68	6.44	3.54	35.1	21.58	31.10	311.67
25x30cm	32.61	6.45	3.85	35.2	21.40	31.16	311.56
P<f	**	NS	**	NS	NS	NS	NS
LSD	0.982	0.2651	0.1834	9.72	0.4051	0.0976	0.976
Interaction							
NT x SP	**	**	**	*	NS	NS	NS

Key: **=highly significant, *=significant, NS=not significant, NT= Nitrogen, Sp=spacing
PH= Plant Height, NL= Number of Leaves, CG= Collar Girth, BW= Bulb Diameter,
BD= Bulb Diameter, YPP= Yield per Plot, YPH= Yield per hectare

The results were in agreement with the findings of Jilani *et al*., (2010); Morsy *et al*. (2012) especially on plant height, number of leaves, bulb diameter, yield per plot and yield per hectare who reported that 120 kg N ha^{1} appeared higher values of plant height, number of leaves per plant, bulb diameter and days to maturity as compared to adding of 90 kg ha^{1}. However, the result contradicts that of Jilani *et al.*, 2010) on collar girth and bulb weight who reported that Application of higher

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nitrogen of 120 kg ha[1] recorded the maximum bulb size while the minimum bulb size was recorded in control and that of Aliyu *et al,* (2008) who reported an increase of onion bulb weight with increased nitrogen rate. The results also revealed that there was significant difference for spacing on plant height and collar girth, but no significant difference was recorded on number of leaves, bulb weight, bulb diameter, yield per plot and yield per hectare. This result is contrary to the findings of Dereje *et al*. (2012) who indicated that total yield per hectare increased as plant density increased although yield of the individual plants and their components were significantly reduced. The results also indicated that there was significant difference on interaction between Nitrogen and spacing for plant height, number of leaves, collar girth and bulb weight. However, interaction between the two factors showed no significant difference on bulb diameter, yield per plot and yield per hectare.

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INFLUENCE OF DIFFERENT NITROGEN SOURCES ON THE GROWTH AND YIELD OF TWO OYSTER MUSHROOMS

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ABSTRACT

Mushroom cultivation is a means of income generation, assurance of food security and enhanced livelihood. This study was aimed at investigating the influence of different nitrogen sources on the growth and fructification of Pleurotus ostreatus and Pleurotus pulmonarius. These mushrooms were cultivated on sawdust substrate and experiment laid out in a complete randomized design (CRD) in replicates of three. The fertilizers used were urea, liquid organic fertilizer and total plus (6-1-2 liquid inorganic fertilizer) while water served as the control. Biological Efficiency (BE) and Production Efficiency (PE) followed the same trend. The highest BE (18.75%) was recorded in inorganic fertilizer while the least was observed in the control. Furthermore, the heaviest fruit weight (65.67 g) was observed in inorganic fertilizer as the least (38.00 g) was recorded in the control. Pleurotus pulmonarius produced higher number of fruits than P. ostreatus (7.50 and 5.00 respectively). The fruit weight recorded in P. pulmonarius was heavier than that of P. ostreatus. Inorganic fertilizer was the best nitrogen source in this investigation.

Key words: Inorganic and organic fertilizer, *Pleurotus ostreatus*, *Pleurotus pulmonarius*, urea

INTRODUCTION

Cultivation of mushroom can generate income, enhance livelihood of local communities and ensure food security (Reyes *et al*., 2009). Mushrooms can be cultivated on palm-bunches, straw, corn cobs or mixtures thereof (Idowu, 2003) and on various unfermented cellulose and lignin containing wastes (Gregori *et al*., 2007). Other substrates include water hyacinth and banana leaf (Idowu *et al*., 2015). Mushrooms are non-traditional horticultural crops of high quality proteins, high fibre value, vitamins and minerals (Narayanasamy *et al*., 2009). They have nutritive values and some medicinal properties which include relief for stomach ailments, fever, asthma, smallpox, high blood pressure and cancer (Wong *et al*., 2011). They are known to promote good health in traditional Chinese medicine (Isikhuemhen *et al*., 2000). The addition of external nutrients increases the productivity of some low-yielding mushroom varieties (Carrasco *et al*., 2018). De Leon *et al*. (2017) stated that the addition of supplements will substantially increase the yield per unit weight of mushroom. Carbon and nitrogen are the two main macronutrients needed by fungi for structural and energy requirements (Carrasco *et al*., 2018). The increasing demand for dietary protein, inadequate commercial mushroom production and forest extinction gave birth to mushroom scarcity. Therefore, this investigation was aimed at exploring some sources of nitrogen to enhance the commercial production of mushroom for the availability of dietary protein.

MATERIALS AND METHODS

Mushroom spawn

The spawn of the two mushrooms (*Pleurotus ostreatus* and *Pleurotus pulmonarius*) were collected from the Mushroom unit laboratory, NIHORT, Ibadan.

Collection of substrate

The investigators sourced for the substrate (sawdust) used in this research studies at Sanngo sawmill, a major plank market within Ibadan metropolis in Oyo State, Nigeria.

Growth of the mycelia

The collected sawdust substrate was composted for a month by moistening it with water to about 65%. 1 kg of the composted sawdust was weighed into heat-resistant transparent polythene bags of size 35 x 10 cm. The neck of the bag was made of heat resistant PVC (polyvinyl choride) tube and plugged with a cotton wool. Before each of the bags was inoculated with 100 g of the mushroom separately, they were autoclaved at 121^{o}C for 15 minutes and allowed to cool to room temperature. The bags were kept in the vegetative room for about a month where the mycelia ramified in the substrates.

Preparation of the fertilizer

The following fertilizers were used in this investigation: urea, liquid organic fertilizer obtained from vegetable programme in NIHORT and total plus (6-1-2 liquid inorganic fertilizer). While 5 g of urea was dissolved in 1 litre of water, 5 mls each of liquid organic fertilizer and total plus were separately dissolved in 1 litre of water. A total of 3 litres, each of the fertilizers, was used for this research study. 3 litres of water was used as the control. The fertilizers and the water control were added to the substrate (sawdust) separately.

Experimental/ Research Design

The experiment was laid out in a complete randomized design (CRD) in replicates of three.

Data Analysis

Analysis of the data collected was done using ANOVA and significant means were separated using Duncan's multiple range test.

RESULTS AND DISCUSSION

The nitrogen sources promoted the growth and yield of the two oyster mushrooms (*Pleurotus pulmonarius* and *Pleurotus ostreatus*) on the sawdust substrate but at varying degrees. Roy *et al*., (2013) stated that phosphorus and nitrogen promote root and vegetative growth of crops. While the shortest number of days for full mycelial colonization (23.83 days) was observed in the control, the longest (25.50 days) was recorded in urea (Table 1). The highest (18.75%) Biological Efficiency (BE) was recorded in inorganic fertilizer while the least was recorded in the control (Table 1). Production Efficiency (PE) followed the same trend. The heaviest fruit weight (65.67 g) was observed in inorganic fertilizer followed by that of organic fertilizer (53.67 g) which was significantly different from what was recorded in urea (49.50 g) while the least (38.00 g) was recorded in the control (Table 1). This might be attributed to nitrogen supplied by inorganic fertilizer which aided nutrient uptake by mushroom mycelial for fruit body production. The widest width of pileus (7.75 cm) was recorded in organic fertilizer which was not significantly different from that of control (7.25 cm). The smallest was observed in inorganic fertilizer (6.37 cm). It was observed that the mycelial density of *P. pulmonarius* was heavier than that of *P. ostreatus*. Mycelial density is directly proportional to mushroom yield (Thomas *et al*., 1998). Thus, *P. pulmonarius* recorded a heavier fruit weight than *P. ostreatus* (Figure 1) and the BE recorded in *P. pulmonarius* was also significantly different from that of *P. ostreatus* (16.69% and 12.64% respectively). PE followed the same trend (Table 2).

Table 1: Effects of the various nitrogen sources on the fructification of the mushrooms on the sawdust substrate

TREATMENTS	F. COL	INI	BE	PE	NF	FW	WP	LS
Urea fertilizer	25.50	29.00	13.72	5.10	6.50	49.50	6.75	5.67
Organic fertilizer	25.00	28.67	15.33	6.07	6.33	53.67	7.75	5.50
Inorganic fertilizer	25.00	28.50	18.75	6.92	7.00	65.67	6.37	5.08
Control	23.83	28.12	10.86	4.31	5.33	38.00	7.25	5.25
LSD	1.62	1.50	0.79	0.47	0.93	4.02	0.84	0.68

Where, F. COL= Full mycelia colonization (Days), INI= Primordia initiation (Days), BE= Biological Efficiency (%), PE= Production Efficiency (%), NF= Number of fruits, FW= Fruit weight (g), WP= Width of pileus (cm) and LS= Length of stipe (cm)

Table 2: Effects of the nitrogen sources on *Pleurotus pulmonarius* and *Pleurotus ostreatus*

MUSHROOM SPECIES	Number of fruits	Width of pileus (cm)	Length of stipe (cm)	Full mycelia colonization (Days)	Primordia initiation (Days)	Biological Efficiency (%)	Production Efficiency (%)
P	7.50	7.06	5.71	24.75	28.42	16.69	6.40
OST	5.08	7.00	5.04	24.92	28.75	12.64	4.79
LSD	0.66	0.60	0.48	1.15	1.06	0.56	0.33

P= *Pleurotus pulmonarius*, OST= *Pleurotus ostreatus*

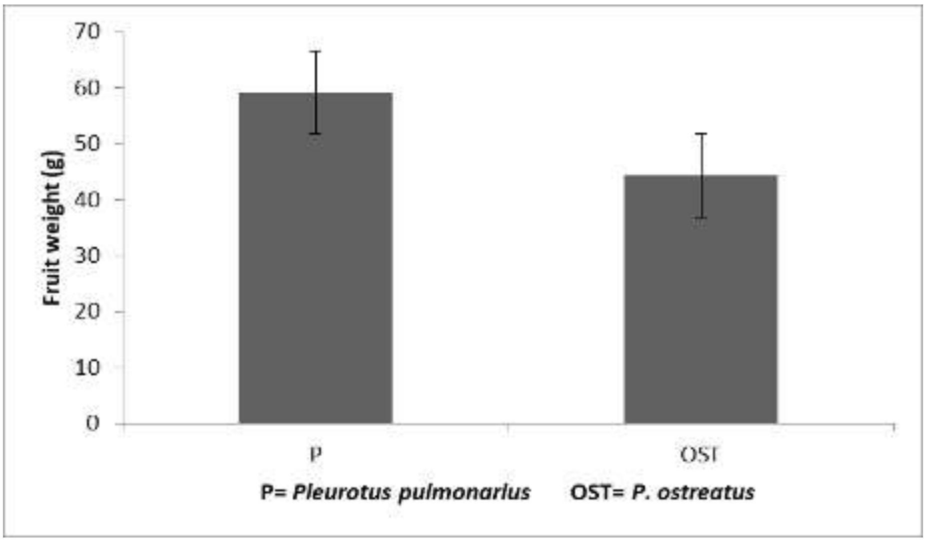

Figure 1: Effect of the nitrogen sources on the fruit weight of *Pleurotus pulmonarius* and *Pleurotus ostreatus*

CONCLUSION AND RECOMMENDATION

The highest number of fruits and heavier fruit weight were recorded in inorganic fertilizer. *P. pulmonarius* performed better than *P. ostreatus* in this investigation in terms of BE, PE, number of fruits, length of stipe and fruit weight. Therefore, total plus (6-1-2 liquid inorganic fertilizer) was the best in this investigation.

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EFFECT OF NITROGEN RATES ON GROWTH, FRUIT AND DAYS AFTER ANTHESIS ON SEED QUALITY OF TWO OKRA (*ABELMOSCHUS ESCULENTUS* L. MOENCH) VARIETIES

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ABSTRACT

The Field trial was conducted at the Teaching and Research Farm of the Federal University of Technology, Minna (Southern Guinea Savanna ecological zone of Nigeria) during the 2019 cropping seasons. The experiment was laid out in a Randomized Complete Block Design and replicated three times. The treatments consisted of two okra varieties (NHAe47-4 and LD 88), five rates of nitrogen fertilizer (0, 30, 60, 90 and 120 kg N ha^{-1}). Each plot measures 2×5.25 m (10.5m^2) comprising of eight ridges with 3 replications. Parameters measured included Number of fresh fruits, Weight of fresh fruits, Fresh fruit diameter, Weight of seed and 100–Seed weight determination. Lab Experiment consist of treatments with factorial combinations of two okra varieties (NHAe47-4 and LD 88), and seven fruit harvesting stages (14, 21, 28, 35, 42, 49 and 56 days after anthesis) arranged in a Completely Randomized Design (CRD) and replicated four times. Seed storage and germination percentage was determined. Data collected were subjected to analysis of variance (ANOVA) using SAS Statistical package 9.2. At 5% level of probability means were separated using Student- Newman Keuls (SNK) Test. Application of 90 - 120 kg N ha^{-1} gave better fruit size and seed yield of okra. Fruits of LD88 harvested at 42 days after anthesis had a better germination percentage than fruit of other harvesting day. With the result of this study, okra growth, fruit and seed yield can be improved by application of 90 kg N/ha.

Key words: Okra, Nitrogen, Fruit and Days after anthesis

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is a flowering plant in the Malvaceae family, commonly known by several names in different parts of the world. *Abelmoschus esculentus* and *Hibiscus esculentus* are the Latin binomial names for Okra (Kumar *et. al,* 2010). Okra is usually called "Kubewa" in Hausa, "Ila" in Yoruba and "okwuru" in Igbo speaking languages in Nigeria. Okra is also known as ladies' finger originated from Ethiopia (Sathish and Eswar, 2013) and was then propagated in North Africa, in the Mediterranean, in Arabia and India by the 12th century BC (Tripathi *et al*., 2011). It is one of the most widely known and utilized species of the family Malvaceae (Iyagba *et al*., 2013) and an economically important vegetable crop grown in tropical and sub-tropical parts of the world. The nutritional compositions of okra include calcium, protein, oil, carbohydrates, iron, magnesium and phosphorus (Omotoso and Shittu, 2007). Okra plant grows preferably in well-drained humus rich fertile soil with pH ranging from 5.8 to 6.8 (Abidi *et al,* 2014).

Nitrogen is the second most absorbed nutrient by vegetables and plays a fundamental role in their yield (Souza *et al*., 2017). In addition, N considerably mobilizes the process of flower opening, fruit setting and fruit development. Seed development influences the seed performance (Bita and Maryam 2011). Seed maturation, however, is closely associated with fruit maturation and complete fruit drying (Ashok *et al.,* 2005). The Non-availability of good seeds remains a constraint to wide cultivation of vegetables in Africa (Ibrahim and Oladiran 2011). The viability of most farmers' seeds is usually poor because of the low level of adequate production techniques (Yakubu and Abubakar 2017). The stage of harvest of okra fruit has a significant influence on the quality of its seed. Agrawal (1980) stated that okra seed pod should be harvested when they are dry (i.e. about 35 (DAA), days after anthesis). Delayed harvest may lead to low germination and vigour due to adverse weather conditions in okra (Dias *et al*., 2006). The poor germination of early-harvested seeds could have been due to the large proportion of immature seeds in these sets of seeds (Ibrahim and Oladiran, 2011). The objectives of the study were to determine the effect of nitrogen rates on fruit and days after anthesis on seed quality of two okra varieties.

MATERIALS AND METHODS

Field experiment was conducted at the Teaching and Research Farm of the Federal University of Technology, Minna (latitude 9^o 51 ^{1}N and longitude

6° 44 ¹E) during the 2019 cropping seasons (May-Sept). Soils in Minna originated from basement complex rocks and generally are classified as Alfisols (Lawal *et al*., 2012). The seed quality testing was carried out after the field work in the laboratory of the Department of Crop Production, Federal University of Technology, Minna, Niger State. Soil samples were collected from 0-15cm depth with an auger from 10 points along four diagonal transects. The samples were bulked into four composite samples. The samples were then air dried and sieved through 2mm and 0.5mm sieve. The samples were analyzed for particle size distribution, pH 1:2 (H_2O and $CaCl_2$), Organic carbon, total nitrogen, available phosphorus, exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, Na^+), exchangeable acidity (Al^{3+} + H^+) and effective cation exchange capacity following the procedures described by Agbenin (1995). Seeds of two okra varieties (NHAe 47-4 and LD 88 were sourced from the National Horticultural Research Institute (NIHORT) Ibadan, Oyo State Nigeria.

The land was manually cleared followed by ploughing with a tractor. Ridges of 2m length at 75 cm apart were made in each plot. The plots size was 2m × 5.25 m (10.5m^2) comprising of 8 ridges. The treatments were a factorial combination of two okra varieties (NHAe47-4 and LD 88), Five N levels, (0, 30, 60, 90 and 120 kg ha^{-1}) laid out in Randomized Complete Block Design (RCBD) with three replications. Three seeds were manually sown per hole at 0.5m apart and later thinned to one seedling per stand at two weeks after planting (2WAP). Phosphorus and potassium fertilizer at 50 kg ha^{-1} each was applied in all the plots at 2WAP as basal application using single super phosphate and muriate of potash respectively. Urea was applied in two split doses (at 2 and 4WAP) to supply Nitrogen at different rates (0 kg N ha^{-1}, 30 kg N ha^{-1}, 60 kg N ha^{-1}, 90 kg N ha^{-1} and 120 kg N ha^{-1}). Weeding was carried out at two weeks' intervals manually. Incidence of insect pests was kept down with the application of Zap® a.i (Lambda Cyhalothrin 25g/L), at 0.005kg a.i/ha. The insecticide was applied as from 2WAP till harvesting stage.

The parameters measured/recorded includes:

1. Number of fresh fruits – Number of fresh fruits per plot was be determined by counting fruits harvested per plot, each harvest was done at five days' interval.
2. Weight of fresh fruits – Weight of fresh fruits per plot was be determined by weighing fruits at each harvest per plot using mettler weighing balance and the sum of all the weights was recorded.
3. Fresh fruit diameter- Fruit diameter per plot was determined by measuring the fruit with the use of a Vernier caliper at the point where the fruit is wider (middle).
4. Weight of seed – The Weight of seeds per fruit is aimed at determining the seed yield. This was determined by weighing the seeds on Mettler balance; the sum of all the weights was calculated and recorded per plot.
5. 100–Seed weight determination- Four replicates of 100 seed from each seed lot was counted and weighed on a Mettler balance.

Lab Experiment consist of treatments with factorial combinations of two okra varieties (NHAe47-4 and LD 88), and seven fruit harvesting stages (14, 21, 28, 35, 42, 49 and 56 days after anthesis) arranged in a Completely Randomized Design (CRD) and replicated four times.

Fruit tagging and harvesting- Flowers were date tagged on the field immediately they open on the plants daily which is an index of anthesis. Successfully tagged flowers was harvested at different maturity stages 14, 21, 28, 35, 42, 49 and 56 DAA from the first positions on the mother-plant. Seed handling - Following each harvest on the field, fruit diameter and length was measured using the venier caliper and means of the respective parameters were recorded.

Number of seeds per fruit was recorded by counting the number of seeds per fruit and means were recorded.

The weight of seeds per fruit were taken using a Mettler balance; the sum of all the weights will be calculated and recorded per plant. Fruits were broken to extract the seed.

Seed storage -Samples of seeds of each of the treatment combinations were put in small open plastic plates measuring 300 ml and then placed in an incubator at 35 °C and relative humidity of 90 %. This was aimed at accelerating the ageing of the seeds to determine the relative longevity of the seeds of the different lots (Delouche and Baskin, 1973). The seeds were stored in this environment for 4 weeks and seed samples were drawn for

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germination test prior to storage and at two weeks' intervals after wards for 4 weeks.

Seed germination test - Samples were drawn from the containers in storage for germination test at 0, 2, and 4 weeks after storage. This was done by counting four replicates of 30 seeds each of the treatment combinations which was placed on filter paper moistened with distill water in plastic Petri-dishes. Germination counts was taken every-other-day and results were expressed in percentages.

The data collected were subjected to analysis of variance (ANOVA) using SAS Statistical package 9.2. At 5% level of probability means were separated using Student- Newman Keuls (SNK) Test.

RESULTS

Table 1 shows the results of the physical and chemical properties before land preparation. The soil of the site was sandy loam in texture with a moderate pH indicating the soil was slightly acidic. Soil organic carbon (SOC) was low with moderate contents of total soil nitrogen and available phosphorus. The ECEC of the soil was also found to be low.

Table 1: Physiochemical properties of the soil sample of the experimental field.

Soil Properties	Values
Particle Size distribution (g kg^{-1})	
Sand	815.5
Silt	109
Clay	78
Textural class	SL
pH (1:2)	
H2O	6.7
Kcl or Cacl	5.5
Total N (g kg^{-1})	1.21
Organic C (g kg^{-1})	4.5
Available P (mg kg^{-1})	8.25
Exchangeable bases (C mol kg^{-1})	
Ca2+	3.75
Mg2+	3
k+	0.07
Na+	0.17
Exchangeable acidity (C mol kg^{-1})	
Al3+ H+	0.8
ECEC	8.2

SL: Sandy loam

In Table 2, Nitrogen significantly affected the number of fruits produced, the number of fruits produced increased with the increase in rate of nitrogen to the mother plant. However, application of 120 kg N ha^{-1} recorded the higher number of fruits while 0 kg N ha^{-1} recorded the lowest number of fruits. Variety significantly influenced fresh fruit weight as fruits from LD88 (595.28g) were heavier than fruits obtained from NHAe47-4 (447.25g). Nitrogen also significantly affected this trait as the weight of fruit increased with the increasing rate of nitrogen application with 120kg N ha^{-1} producing heavier fruits (739.90g). Variety had significant effect on fresh fruit diameter, as fruit from NHAe47-4 (10.81cm) were bigger than fruits obtained from LD88 (10.47cm). Variety also significantly affected weight of seed per fruit and 100 seed weight; seeds of fruit obtained from NHAe47-4 (3.03g) are heavier than seeds of fruit obtained from LD88 (2.92g) whereas for 100 seed weight, seeds obtained from LD88 (4.20g) are heavier than that of NHAe47-4 (3.85g). Weight of seed per fruit and 100 seed weight increased with an increase in fertilizer application.

Table 2. Effects of nitrogen application on growth and fruit yield parameters in two varieties of okra evaluated in the study

	Number of fresh fruit per plot (Net plot)	Fresh fruit weight per plant (g)	Fresh fruit diameter per fruit (cm)	Weight of seed (g)	100 Seed weight (g)
Variety					
NHAe47-4	13^{b}	447.25^{b}	10.81^{a}	3.03^{a}	3.85^{b}
LD88	17^{a}	595.28^{a}	10.47^{b}	2.92^{b}	4.20^{a}
+ SE	0.05	9.43	0.05	0.06	0.01
N rate (kgha^{-1})					
0	8^{e}	283.50^{d}	8.87^{d}	0.71^{e}	1.68^{e}
30	9^{d}	358.47^{c}	9.83^{c}	1.39^{d}	2.27^{d}
60	17^{c}	517.45^{b}	10.93^{b}	3.05^{c}	3.66^{c}
90	19^{b}	707.00^{a}	11.78^{a}	4.61^{b}	5.92^{b}
120	22^{a}	739.90^{a}	11.78^{a}	5.12^{a}	6.59^{a}
+ SE	0.07	14.91	0.70	0.10	0.02
Interaction					
Variety*Anthesis	NS	NS	NS	NS	NS

Means with the same alphabet in the same column are not significantly different at ($p \le 0.05$) level of probability. SE = Standard Error, N: Nitrogen Var: Variety.

Significant variations in viability maintenance between the two varieties were recorded. At the onset and up to 4 weeks of storage, LD88 germinated significantly higher than NHAe47-4 (Table 3). Following storage for 4 weeks, germination values for the two varieties were similar. Prior to storage seed from fruit of NHAe47-4 has a lesser germination (49.21%) percentage compared to two (2) week of storage (54.9%) but higher than that of four (4) weeks storage period (33.00%). With respect to days after anthesis, there was significant effect on storage period prior to storage. At 14 days after anthesis, a significant increase in viability of seed was recorded down to (42) days after anthesis, which recorded the highest germination percentage (79.25%). It began to decline at forty-nine (49) days after anthesis (60.45%) and 56 days after anthesis (55.00%). This indicates that beyond 42 days after anthesis seed begin to lose its viability.

Table 3. Effect of harvesting at different days after anthesis on germination percentage of two okra varieties at storage period 0, 2, and 4 weeks

Storage Period (Weeks)			
Week	**0**	**2**	**4**
Variety			
NHAe47-4	49.21^{b}	54.9^{ba}	33.00^{b}
LD88	66.16^{a}	58.09^{a}	36.53^{a}
+ SE	1.09	2.18	0.87
DAA			
14	30.90^{e}	38.90^{c}	25.75^{d}
21	48.25^{d}	48.65^{bc}	27.25^{d}
28	57.00^{c}	56.25^{b}	34.00^{c}
35	72.95^{b}	57.15^{b}	35.65^{cb}
42	79.25^{a}	75.45^{a}	52.80^{a}
49	60.45^{c}	61.35^{b}	39.90^{b}
56	55.00^{c}	57.90^{b}	28.00^{d}
+ SE	2.04	4.08	1.63
Interaction			
Variety*Anthesis	*	NS	NS

Means with the same alphabet in the same column are not significantly different at ($p \le 0.05$) level of probability. SE = Standard Error, N: Nitrogen, Var: Variety, DAA: Days after anthesis.

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DISCUSSION

Maintaining optimum plant population and nitrogen fertilization dose are most important elements in improving productivity of okra. Optimum plant density is the key element for higher fruit yield of okra, as plant growth and yield are affected by nitrogen fertilization (Khan *et al*., 2013). The research conducted by Atif and Nahed (2016) revealed that increase in nitrogen fertilizer from the control (0 N) to 160 kg N ha^{-1} significantly increased total fruit yield. LD88 recorded higher seed yield compared to NHAe47-4 according to the research by Khan *et al*. (2002) that a higher okra fruit and seed yield is the function of size of the fruits and nutrition of the mother-plant during growth on the field. Rao *et al.* (2017) advised that seeds should be harvested at proper time to ensure their quality in terms of germinability and vigour. However, (Passam *et al.,* 2010) reported that fruits harvested even before physiological maturity and allowed some days of post-harvest ripening may produce good quality seeds since seed development continues in fleshy fruits owing to continuous supply of nutrients and food reserves from fruit to seed. A study conducted by (Seal *et al.,* 2013) noted that there is a positive linear correlation between fruit weight and seed dry weight on kiwifruit. They stated that flowers that open earlier have a larger ovary and set larger seeds leading to large fruits explaining that this may be because of either their innate superiority or their position on the vine. The decline in seed viability after a storage period of 49 days is indicative of seed deterioration which is linked with disruption of cell organelles due to free radical production in the cells of embryos (Bewley and Black, 2012). However, for okra seed production, fruits are left on the mother plant until they are dry before harvested. The seed crop requires the right stage of maturity followed by proper drying to ensure high germinability after harvest and storage. This is because seed longevity is known to be influenced by the initial seed quality, which is affected by the production procedure (Bortey and Dzomeku, 2016). The results of this study showed that germination, longevity and high seedling emergence were best maintained in seeds from plants to which 90 and 120 kg N ha^{-1} were applied to their mother plants during growth on the field.

CONCLUSION

It can be concluded from this study that application of 90 –120 kg N/ha gave better fruit size and seed yield of okra. Fruits of LD88 harvested at 42 days after anthesis had a better germination percentage than fruit of other harvesting day. Application of 90kg N/ha to okra is therefore suggested for good growth, improved fruit and seed yield in the studied zone.

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RESPONSE OF TOMATO *(LYCOPERSICUM ESCULENTUS)* TO VARYING LEVELS OF NITROGEN FERTILIZATION AND SPACING IN SUDAN SAVANNA AGRO-ECOLOGY OF NIGERIA

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ABSTRACT

Tomato (Lycopersicum esculentum) yields are limited by poor soil nutrition with nitrogen being the most limiting nutrient required in large quantities. The study was aim to investigate the Response of tomato fruit to varying levels of nitrogen and spacing on yield and quality in Hadejia sudan savanna of Nigeria. Plants were grown in at Department of Horticulture research and demonstration field in two consecutive years under irrigation 2019/2020 and 2020/2021, each year cultivation commenced in November to February. The nitrogen rates 0, 30, 60 and 90 kg N ha^{-1} applied in two splits. Spacing was 20x30, 30x30, 40x30 and 50x30 cm. The experimental design was a Randomized Complete Block Design, with a Split-Plot arrangement with main plots as nitrogen levels and spacing the sub plots in three replications. Fruit yield and quality data were taken after each harvesting. Number of marketable fruits was significantly affected by spacing in both seasons. Nitrogen of 60 kg ha^{-1} and spacing of 40 x 30 cm had the highest mean fruit numbers in second year. Nitrogen of 60 kg N ha^{-1} and spacing of 50 x 30 cm had the highest fruit yield in first year. Marketable unit fruit weight was highest in first year, at 50 x 30 cm. The study was significant to farmers producing tomatoes under greenhouse, to maximize on profits by scaling down nitrogen fertilizer use to attain high yields and quality of marketable tomato fruits using appropriate spacing.

Key words: Tomato, nitrogen, spacing, fertilization, yield

INTRODUCTION

Tomatoes are a vegetable crop. It belongs to the Solanaceae family. The Solanaceae family includes plants such as tomatoes, Irish potatoes, and egg plants, among others. A tomato is increasingly becoming important as a food, medicinal and industrial crop (FAO, 2001). Tomato production in Nigeria is mainly under field conditions, where changes in climatic conditions do not allow realization of economic yield. There are fluctuations in the supply of tomatoes in the market, which lead to market glut during in season and shortage during off-season (Nonnecke, 1989). Determinate cultivars may grow up to 2 m in height and are erect with restricted flowering and fruiting, and are suitable for field conditions. The stem of indeterminate cultivars grows indefinitely, reaching to more than 10 m within one year, making it ideal for long season continuous cropping as they flower and fruit regularly and evenly (Rick and Butler, 1956). Indeterminate tomatoes, vegetative growth and reproductive development proceed concomitantly during the greater part of the plant life. A strong competition between developing leaves and apical meristem influences both the earliness of harvest and total yields. High assimilate availability under high light intensity conditions stimulates both meristem activity and leaf growth (Hussey, 1963a), but when plants are source-limited (under high temperature and low light), young leaf growth is favoured at the expense of apical development. Continuous removal of young leaves counteracts this effect (Hussey, 1963b, Kinet, 1977).

With increasing plant populations, intra-plant competition becomes more important and eventually only flowers on the earliest clusters set fruits. These early yields increase as plant population increases, because there are more early clusters per unit area. Nitrogen is the most limiting nutrient to crop production (Pionke *et al.,* 1990). Like many vegetables, tomato is often heavily fertilized. Large amounts of nitrogen are often lost to leaching below the root-zone of vegetable crops (Pionke *et al.*,1990). Also, nitrogen fertilization, along with early season weed control, allows rapid crop establishment and growth, which is critical for the crop to suppress late-emergence weeds (Itulya *et al.,* 1997). Nitrogen deficiency can seriously decrease yield and crop quality. The nitrogen composition of plant tissue has important nutritional consequences, since plants are a major source of proteins in human diet (Below, 1995). Nitrogen is also a constituent of a large number of important compounds found in living cells, such as (enzymes) amino acids and nucleic acids (RNA and DNA) (Lea and Leegold, 1993). Hence, nitrogen is critical in improving growth, yield and quality of vegetable crops.

Tomato has always been a popular vegetable since its introduction in Hadejia, both in fresh market and processing industry. Tomato is the highest vegetable income earner produced annually in Hadejia (Anonymous, 2003). Most commercial tomato cultivars are selected on the basis of their yield potential over a wide range of growing conditions. Weather patterns influence tomato production in the field due to seasonality. Knowledge of optimum spacing and nitrogen fertilizer will enhance production by increasing yields and possibly improving quality of tomatoes under protected structures. Although tomato is an important crop in Jigawa state little is known of its specific nitrogen (urea) fertilizer requirement, Spacing, growth, yield and quality of tomatoes as well as pest and disease prevalence.

In this study it was assumed that high levels of urea (46:0:0) result in increased yields and quality. Intra-plant spacing of tomato influences tomato yield and quality more than inter-plant spacing. The study was aimed at determining if tomato growth, yield and quality could be increased by manipulation of nitrogen fertility levels and plant spacing under field conditions in Hadejia. Thus the specific objectives of the study were to determine: The effects of nitrogen levels on growth, yields and quality of tomatoes, the effects of spacing on growth, yield and quality of tomatoes.

MATERIALS AND METHODS

The experiment was conducted during the 2019/2020 and 2020/2021 dry season at Department of Horticulture research and demonstration field, Binyaminu Usman Polytechnic Hadejia within a latitude of 12^0 22'N and 12^0 24' N and longitude of 7^0 46' E and 10^0 E within the Sudan savanna on a sandy clay loam soil, having 0.56% organic matter, 0.06% nitrogen, 5.25ppm Phosphorus and 0.32 Potassium. The seeds were obtained at Jigawa Agricultural Supply Company (JASCO) Hadejia office. The seedling was raised in a nursery bed of 3 x 4m2 the seed were sown by drilling method. The nursery bed was watered and also kept free of weeds. Typha grass was used as mulch in preventing directs sun rays on the seedlings. Karate was used in controlling insects in the nursery at the rate of 100ml per 20 litre of water. Land was ploughed to a depth of 20 to 30 cm to kill weeds. Soils with hard pan within 150 cm of the soil layer require deep soil cultivation using a chisel plough or double digging. Well rotten farm yard manure and single super phosphate was used to improve soil organic matter and structure for effective tomato growth. The seedlings were nurtured till they attain the age of 4 weeks old and transplanted to the field using ball of earth method during transplanting at varying spacing.

Trenches 0.5 m wide by 0.8m deep lined with Polythene were used to separate the main plots to prevent nitrogen moving from one plot to another. Mulching of each plot was done on the day of transplanting by placing the polythene film and covering its sides with soil. Holes were opened at planting time on the poly film depending on the spacing recommendation for each plot. Triple supper phosphate (TSP) 23 kg P ha^{-1} was used for planting. The nitrogen: 0, 30, 60 and 90 kg N ha^{-1} inform of urea (46%) was split-applied after dissolving in water to avoid loss of ammonia to the atmosphere through volatilization due to high greenhouse temperatures. The splits of 30, 60 and 90 kg N ha^{-1} was applied two weeks after transplanting and two weeks later. All plots were applied with Muriate of Potash after two weeks at the rate of 305 kg K ha^{-1}. The inter-row and intra-row spacing (in cm) were: 20x30, 30x30, 40x30 and 50x30cm. The plots measured 3 m by 1.5 m. The experimental design was a randomized complete block design, split-plot arrangement in three replications. The main plots were nitrogen fertilizer levels, while spacing formed the sub-plots.

Tomatoes 35 cm high were trained to a single stem twisted around a sisal twine suspended from wires stretched horizontally and parallel to the tomato beds. Poles (2.2 m high) spaced at 4 m supported the wires at 35 cm apart and 2 m high. At the bottom, each string was tied directly to another wire running horizontally at 30 cm from the ground. Pruning was done regularly.

All plots received equal amounts of water, which was applied on the same day to avoid variations. Before planting, the plots were watered uniformly until field capacity was reached and thereafter plots were installed with irrigation drip tubes on the soil surface. Discharge rate for the drip lines was 2 litres per minute.

Harvesting began when first fruits reached breaker stage and done twice per week from all plants in the centre row; outer rows and plants at the end of each plot served as guard rows. All the fruits harvested per 3 x 1.5 m area were counted and weighed separately on each harvesting date. Fruits were separated into two lots of marketable and unmarketable fruits.

Fruits were graded soon after harvesting, based on size using a vernier caliper. Fruits were categorized in large (>8 cm) in diameter (Thompson, 1996). Marketable fruits were picked at breaker stage. Unmarketable fruits were those with physiological disorders such as cracks and blossom end rot or other types of blemish. Fruits from each category were counted and weighed separately. Marketable fruits were those with fruit size >4cm, without cracks, blemish, disease incidence, and other physiological disorders.

Thirty harvested fruits from each plot were randomly selected and their firmness determined using a penetrometer (Bishops Instrument, Italy). Readings were recorded in kilograms $m^{-2.}$ Fruits stored at 20^{oC} were measured every two days to determine the storage life. Fruit firmness was monitored throughout the ripening period. Total soluble solids content of the juice of 30 randomly selected, table ripe tomato fruits per plot was measured using a hand refractometer (0-30% brix). The fruit surface was cut using a knife, and juice squeezed into the refractometer. The reading was recorded and fruits with 4–9% brix were considered to have high quality.

Data Analysis

All data were subjected to the Analysis of Variance using MSTAT-C computer programme and where the F-test was significant, either Least Significant Difference or the Duncan's Multiple Range Test depending on the number of means did separations.

RESULTS AND DISCUSSION

Tomato yield and quality are affected by fertility and spacing among other factors. Nitrogen levels affect many attributes in tomato quality and yield such as fruit firmness, fruit size, total soluble solids, number of fruits per plant and marketable fruit yield. Austin (1970) showed that close spacing and high fertility levels are required to increase total yields and number of fruits per plant. Results (Tables 1) indicate that nitrogen had no significant effect on marketable fruits in both seasons. Spacing significantly affected the number of marketable fruits in both seasons.

Table1. Effect of nitrogen (N) levels and spacing (S) on number of marketable fruits per $4.5m^2$ during 2014 and 2015 season

Spacing (Cm)	Nitrogen levels (kg ha-1)							
	2017/2018 Season				2018/2019 season			
	0	30	60	90	0	30	60	90
20x30	207e**	275e	249e	209f	245e**	255e	308e	237e
30x30	188e	292e	278e	216f	202fg	212f	230f	233e
40x30	220e	228f	268e	275e	223f	253e	250f	267e
50x30	189e	194f	192f	188f	183g	162g	233f	194f

* Values not followed by a letter within a factor are not significantly different according to the F-test at P <.0.05.
** Values followed by the same letter within a letter series are not significantly different at P <0.05, according to the Duncan's Multiple Range Test. a, b, c, d represent nitrogen level and e, f, g, h represent spacing.

Spacing of 50 x 30 cm had the highest significant number of marketable fruits in 2017/18 season, while spacing of 40 x 30 cm had the highest number of marketable fruits in 2018/19 season (Tables 1). The difference could be attributed to the number of early fruits produced by spacing of 30 x 30 cm which had high density. The crop was infested by bacterial wilt in 2018/19 season and the crop was not harvested to completion. Spacing of 50 x 30 cm in both seasons had the lowest number of marketable fruits. As plant density increased, the total yields were highest but the numbers of marketable yields were not as high compared to wide spacing. This is in agreement with West and Pierce (1988) who showed that total season yields increased as plant population increased to an optimum level (20,000 plants) per hectare. They pointed out that increases in density generally increase both early and total yields per hectare. Mack and Varseveld (1982) also reported that yields are greater for high population than for low populations. Mohammed and Zeineb (1988) observed that in-row spacing had no effect on marketable yield presented as percentage weight of total yield.

Tomato yields are highly responsive to the application of nitrogen (Anderson *et al.,* 1999). Nutrient requirement of the tomato is an important factor if large quantities of high quality fruits are to be produced effectively and efficiently annually. Nitrogen fertilizer levels increase total marketable yields (Wien and Minotti, 1988). In the current study nitrogen levels had no significant influence on marketable fruit yields in both seasons (Tables 1). These could be attributed to the fertilizer form used. The fertilizer used in the study was urea dissolved in water before application. Urea is well documented to be subjected to excessive nitrogen losses particularly under conditions of high soil pH, high temperature, excessive soil drying and wetting and high clay content (Ali *et al.,* 1990). High temperature conditions prevalent during season 1 of the study may have promoted measurable gaseous losses of ammonia (NH_3) and release to the atmosphere (after the application of fertilizer).

Table 2. Effect of nitrogen (N) levels and spacing (S) on fruit size (cm) during 2014 and 2015 season

Spacing (Cm)	Nitrogen levels (kg ha-1)							
	2017/2018				2018/2019			
	0	40	80	120	0	40	80	120
20x30	5.0bg**	5.3ah	5.2ah	4.9bh	5.1h**	5.3g	5.2h	5.1h
30x30	5.5df	5.9bf	6.1af	5.7cf	6.2e	6.7f	6.7e	6.4f
40x30	5.0bg	5.5ag	5.5ag	5.4ag	5.4g	5.3g	5.5g	5.5g
50x30	6.1be	6.2be	6.4ae	5.9ce	6.4f	7.1e	6.6f	6.5e

* Values not followed by a letter are not significantly different according to the F-test at $P < 0.05$.
** Values followed by the same letter within a letter series are not significantly different at $P<0.05$, according to the Duncan's Multiple Range Test. a, b, c, d represent nitrogen level and e, f, g, h represent spacing.

Spacing significantly affected fruit size, with the closest spaced plants having the smallest fruits, while the widest spaced plants had the largest fruits in both seasons (Table 2). Tomato plants in 2018/19 Season had larger fruits than 2017/18 season. The fruits harvested in 2019 season were the early fruits in the lower trusses which tend to be bigger than the later formed fruits as the crop had bacterial wilt infection. The number of fruits measured was also less compared to 2018 season, where all the fruits were harvested for the entire season, measured and the average fruit size computed. The decrease in size due to close spacing was in agreement with observations by Moore *et al*. (1957) who reported that close spacing was accompanied by a reduction in fruit size. Studies by Fery and Janick (1970) indicated that increasing plant population in the field or greenhouse increased the early and total yields per unit area, but decreased the number of fruit set per plant and fruit size.

Plots without nitrogen and those with the highest nitrogen level had the smallest fruit size (Tables 2). This was in agreement with Vittum and Tapley (1953), who observed that increasing the fertility level considerably reduced the average size per fruit. They suggested that at the high fertility level plants were able to set so many fruits per plant that the gross drain of minerals and carbohydrates was larger and resulted in smaller fruits. The decrease in fruit size was greater at low fertility level than at higher levels.

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Akanbi *et al.,* (2007) stated that fruit size is genetically and environmentally controlled through successive phases of fruit development and is positively correlated with amount of N-element available for plant use during fertilization, cell mitotic activity and enlargement. N availability affect sink function of the fruit and these play a role in the control of carbohydrate accumulation in tomato. These later activity determines the number, size and chemical components of fruits. Cell numbers and size contribute to fruit size. Small fruits are related to low cells; hence a fruit with sufficient amount of nitrogen, the number and size of cells are bound to be high. In the study fruits which had no nitrogen application were small compared to those with nitrogen application. The high nitrogen level application reduced fruit size could be due to the growth of vegetative matter which might have shifted the sink to the leaves instead of the fruits.

Table 3. Effect of nitrogen (N) levels and spacing (S) on total soluble solids (TSS) during 2014 and 2015 season

Spacing (Cm)	Nitrogen levels (kg ha-1)							
	2017/2018 Season				2018/2019 season			
	0	40	80	120	0	40	80	120
20x30	3.7dg**	4.0cg	4.2af	4.1bg	4.0c**	4.1b	4.2a	4.0c
30x30	3.9cf	4.2bf	4.3ae	4.3af	3.9c	4.2a	4.2a	4.1b
40x30	3.7cg	4.0bg	4.1ag	4.0bd	3.8d	4.0b	4.2a	3.9c
50x30	4.0ce	4.3be	4.3be	4.4ae	4.1a	4.1a	4.1a	4.1a

* Means not followed by a letter are not significantly different according to the F-Test at $P < 0.05$.
** Means followed by the same letter within a letter series are not significantly different at $P < 0.05$, according to the Duncan's Multiple Range Test. a, b, c, d represent nitrogen level and e, f, g, h represent spacing

Plant spacing in 2019 season had no significant effect on total soluble solids. During 2019 season the total soluble solids were lower than in 2018 season. This may be attributed to plant growth differences due to seasonal changes during the trial period. Solar radiation received during 2018 season influenced the supply of leaf assimilates, because when solar radiation is high, both dry matter and sugar content of the fruit are at their highest (Ho and Hewitt, 1986). Also the bacterial infection may have hindered nutrient uptake which contribute to the TSS.

In the current study, nitrogen levels applied had significant influence on the total soluble solids. Mohammed and Zeineb (1988) indicated that soluble solids contents of fresh tomato fruits were not appreciably affected by nitrogen application. This is in agreement with the study as the differences in the TSS are not very high. Garison *et al.* (1967) indicated that nitrogen tends to decrease the percent total soluble solids in the juice and increases titratable acidity.

A study carried out by Erdal *et al.* (2007) indicated that TSS contents increased with nitrogen applications. The lowest TSS values were obtained from zero N applications. Total soluble contents are an indicator of mineral nutrient concentration in fruit and these values generally increase with fertilization. Erdal *et al* (2007) also indicated that TSS was highest with fruits that have received higher N levels than other levels of N. Nitrogen being a constituent of protein and amino acids it directly affects the TSS. These indicate the reason for low TSS in the zero nitrogen application in the current study.

CONCLUSION

Based on the findings of this study, it was concluded that Heavy application of nitrogen does not necessarily increase yields of tomatoes; therefore, farmers save some nitrogen fertilizer by applying lower rates than 80 kg N ha^{-1} without adversely affecting yields. Spacing of 50 x 30 cm gave high yields and made it easier to carry out cultural and agronomic practices efficiently. Heavy application of nitrogen (120 kg ha-1) reduces fruit size and the fruit firmness. Low nitrogen levels reduce fruit total soluble solids. It is thus recommended that Nitrogen levels between 40 and

80 kg N ha-1 be applied under field condition in Hadejia and a Spacing of 50 x 30 cm should be adopted as it gives hig yields.

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NITROGEN AND INTRA-ROW SPACING INFLUENCE ON THE YIELD COMPONENTS OF ROSELLE (*HIBISCUS SABDARIFFA L*)

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ABSTRACT

The field trial was conducted during the rainy season at National Horticultural Research Institute (NIHORT) Bagauda (11^0 53 N and 8^0 14 E 440 M above sea level) located in the Sudan Savanna ecological zones of Nigeria to determine the effect of nitrogen fertilizer and intra-row spacing on the yield components of Roselle (Hisbiscus sabdariffa L.). The treatments consisted of four rates of nitrogen (0, 60, 120 and 180 kg N ha$^{-1)}$ and three intra-row spacing (45, 60 and 75 cm). The treatments were arranged in a randomized complete block design and replicated three times. The results showed that the application of 180 kg N ha^{-1} and 120 kg N ha^{-1} showed significant effect on number of pods per plant, seed yield and calyx yield ha^{-1}. Intra-row spacing was insignificant on the yield components. Based on the results obtained 120 kg N ha^{-1} can best be used for the production of Roselle in Samaru.

Key words: Calyx, Components, Roselle, Nitrogen

INTRODUCTION

Roselle (*Hibiscus sabdariffa L*) belongs to the Malvaceae family and is one of the most important traditional leafy vegetable in the tropics and sub-tropics. It is believed to have originated from Africa (Grubben and Denton, 2004). It is grown in predominantly in mixture with other crops in which its specific nutrients and planting space are hardly considered, since it is considered a minor crop in the mixture the calyx and seeds yield are generally low (Fasoyiro *et al.*, 2005) therefore only a blanket Nitrogen Provision of sufficient quantities of nitrogen encourage rapid vegetative growth and regulate the uptake of P and K growth of most crops is limited more often by nitrogen deficiency than other nutrients because of the relatively large amount of required by plants nitrogen deficiency results in stunted growth, restricted, restricted root system with small yellow and chlorotic leaves. While excessive supply of nitrogen can encourage luxuriant vegetative growth, delays crop maturity and increased succulence. Nigerian Savannah is characterized by low soil Nitrogen with mean of 0.051% (John *et al.,* 2004). inter and intra-row spacing are applied by farmers since recommended planting spacing for better yield of Roselle are not available. Provision of sufficient quantities of nitrogen encourage rapid vegetative growth and regulate the uptake of P and K growth of most crops is limited more often by nitrogen deficiency than other nutrients because of the relatively large amount of required by plants nitrogen deficiency results in stunted growth, restricted, restricted root system with small yellow and chlorotic leaves. While excessive supply of nitrogen can encourage luxuriant vegetative growth, delays crop maturity and increased succulence. Nigerian Savannah is characterized by low soil Nitrogen with mean of 0.051% ((John *et al.,* 2004)).

MATERIALS AND METHODS

The field trial was conducted during the rainy season at National Horticultural Research Institute (NIHORT) Bagauda (11^0 53 N and 8^0 14 E 440 M above sea level) located in the Sudan Savanna ecological zones of Nigeria. The treatments consisted of three Intra-row spacing (45, 60 and 75 cm) and four Nitrogen fertilizer rates (0, 60, 120, and 180 kg N ha^{-1}) laid out in a randomized complete block design (RCBD) and replicated three times.

Data Collection

Data were collected on number of calyx per plant, dry calyx yield (kg ha^{-1}), 1000-grain weight (g) and seed yield kg ha^{-1}. The data collected were subjected to statistical analysis of variance (ANOVA) and treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Agronomic Practices

The field for the experiment was harrowed to obtain a fine tilth. Ridges were made at the inter row spacing of 75cm. The field then sub divided into plots and replications according to the experimental layout. The seeds were dressed with Apron star at one sachet (10g) to 3kg of Roselle and were sown manually at spacing of 25, 60 and 75 cm x 75cm apart as per treatments. A pinch of seeds was dropped in each planting hole and covered lightly with soil, later they were thinned to two plants per stand at 3 weeks after sowing. Pre-emergence herbicide Atrazine + Metalochlor (Primextra Gold) at the rate of 2 kg a. i ha^{-1} was used immediately after sowing, and weeding was done manually using hoe at 3 WAS and ridge molding at 8 WAS. Basal application of phosphorous fertilizer using SSP 18 % P_2O_5 at the rate of 60 kg ha^1 and Potassium using Murate of potash K_20 at the rate of 32 kg ha^{-1} both were applied before sowing as per stands. While Nitrogen using Urea 46 % N was applied at 3 and 6 WAS as per treatment. There was incidence of pest in the experimental site and was controlled with the use of chemical as recommended (Cypermethrin at the rate of 2.1 kg ai ha^{-1}). Incidence of disease was not observed during the trial. Harvesting was done manually when the crop attained physiological maturity, the stalks were cut at the ground level with cutlass and the panicles were separated by cutting them from the stalks and were allowed to dry, threshing was done manually by beating gently with a stick and the grain were separated from the chaff by winnowing.

RESULTS

Table 1 shows the effect of nitrogen fertilizer rates and intra-row spacing on number of pods per plant of Roselle. Application of 180 kg N ha^{-1} produced the highest number of pods per plant but at par with 120 kg N ha^{-1}. Intra-row spacing and interaction did not influence number of pods per plant. Likewise, application of 180 kg N ha^{-1} produced the highest Dry Calyx Yield but at par with 120 kg N ha^{-1}. Intra-row spacing and interaction did not influence Dry Calyx Yield (Table 2).

Table 1: Effect of Nitrogen Fertilizer Rates and Intra-Row Spacing on Number of Pods per Plant of Roselle.

TREATMENT	(g)
Nitrogen (kg ha^{-1})	
0	11.11d
60	15.66c
120	25.55b
180	30.77a
SE±	1.373
Spacing (cm)	
45	20.25
60	20.19
75	21.16
SE±	2.270
N x S	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

Table 2: Effect of Nitrogen Fertilizer Rates and Intra-Row Spacing on Dry Calyx Yield (kg ha^{-1}) of Roselle.

TREATMENT	(g)
Nitrogen (kg ha^{-1})	
0	123.75c
60	179.19bc
120	237.56ab
180	274.91a
SE±	22.08
Spacing (cm)	
45	199.37
60	215.15
75	197.04
SE±	13.213
N x S	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

Table 3 shows the effect of nitrogen fertilizer rates and intra-row spacing on 1000-Grain Weight (g) of Roselle. The showed that application of Nitrogen, Intra-Row spacing and Interaction between them did not influence 1000-Grain Weight (g). In the same manner, application of 180 kg N ha^{-1} produced the highest Seed yield kg ha^{-1} but at par with 120 kg N ha^{-1}. Intra-row spacing and interaction did not influence Seed yield kg ha^{-1} (Table 4).

Table 3: Effect of Nitrogen Fertilizer Rates and Intra-Row Spacing on 1000-Grain Weight (g) of Roselle.

TREATMENT	(g)
Nitrogen (kg ha^{-1})	
0	31.96
60	31.64
120	32.73
180	34.45
SE±	0.945
Spacing (cm)	
45	23.63
60	23.46
75	30.45
SE±	0.695
N x S	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

Table 4: Effect of Nitrogen Fertilizer Rates and Intra-Row Spacing on Seed yield kg ha^{-1} of Roselle During the 2016 Rainy Season.

TREATMENT	
Nitrogen (kg ha^{-1})	
0	126.99b
60	141.95b
120	175.43ab
180	209.70a
SE±	18.740
Spacing (cm)	
45	158.48
60	176.52
75	155.56
SE±	19.127
N x S	NS

Means followed by the same letter (s) within treatment group are not significantly difference at 5 % level of probability according to DMRT. NS = not significant (P=0.05).

DISCUSSION

Application of 180 kg N ha^{-1} at par with 120 kg N ha^{-1} produced the highest Seed yield and Calyx yield per hectare. This could be attributed to the fact there was translocation of assimilates from the vegetative parts to the seed and calyx. Application of Nitrogen also increased number of calyx (pods) per plant and calyx yield per hectare. The corroborated the findings by Ndayako (1997) at Samaru (Guinea Savannah) and Okosun *et al.* (2006) in the rainforest zone of Nigeria, who reported significant increase in the yield of calyces and its components with increase in Nitrogen fertilizer application. However, 1000 seeds weight were not affected by Nitrogen fertilizer rates, the increase in the number of calyces could be due to the direct effect of Nitrogen in photosynthesis to reproductive sink. Intra-row spacing did not influence seed and calyx yield per hectare from the results but Semsiri *et al.* (2000) reported that, intra-row spacing of 60cm gave the highest yield and more calyces per plant.

CONCLUSION

Based on the results obtained 120 kg N ha^{-1} can best be used for the production of Roselle in Samaru.

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YIELD AND YIELD COMPONENTS OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) VARIETIES AS INFLUENCED BY INTRA-ROW SPACING IN SUDAN SAVANNAH, NIGERIA

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ABSTRACT

This research was conducted to examine the growth and yield response of sunflower (Helianthus annuus L.) varieties to varying intra-row spacing in the Sudan savannah zone of Nigeria. The trial was conducted in two different locations, Kano University of Science and Technology (KUST) research farm and Binyaminu Usman Polytechnic (BUPOLY) Hadejia practical farm during 2019 raining season. Four varieties of sunflower (SSL803, SSL806, SSL807 and SSL809) were planted at varying intra-row spacing of 20cm, 30cm, 40cm, 50cm and 60cm. Split plot design was adopted for the research, with variety allocated to the main plot while intra-row spacing to sub plots, treatments were replicated three times. The result of the experiments shows no significance statistical difference in most of the yield components between the varieties in both locations. The oil was extracted through ether extraction method and the percentage was calculated.

Key words: Yield components, Sunflower, Varieties and Spacing

INTRODUCTION

Sunflower (*Helianthus annuus* L.) originated in western North America; it is thought to have been domesticated around 1000 B.C. by Native Americans. Spanish explorers brought the sunflower to Europe in 1510. However, it was not until the late 1800, when the flower was introduced into the Russian Federation that the sunflower became a food crop. In 1860, Russian farmers made significant improvements in the way the crop was cultivated. At that time, they became the world's largest producer of sunflower seeds (Schneiter and Miller, 2010). According to Robert (2007) sunflower was probably first introduced to Europe through Spain, and spread through Europe until it reached Russia where it was readily adapted. Selection for high oil in Russia began in 1860 and was largely responsible for increasing oil content from 28% to almost 50%. The high-oil lines from Russia were reintroduced into the United State which rekindled interest in the crop.

The economic importance of sunflower cannot be over emphasized as an important oilseed crop worldwide. The fresh green plants can be fed as silage or fodder to livestock. The seed which can be eaten raw or roasted contains 36 - 45% oil depending on the variety and can be used in salad, cooking oil, margarine, lubricant, paint vanishes and soap production. The decorticated seed cake is a good source of protein (35%) for livestock, especially when made from whole seed. The crop is also a good source of nutrition which is used in food preparation, feeding livestock and poultry (FAO, 2010). Confectionery sunflower varieties have seeds that are larger, easier to dehull, lower in fat and are typically striped or white (Ford, 2011).

Sunflower oil is one of the vegetable oil in the world though it was not seen as a vegetable oil source in the U.S until the last 50 years, and really began to be significantly grown for this purpose about 25 years ago (Robert, 2007). After the oil is extracted from the sunflower seed which is about 40 to 45% of the seed by weight, the remaining seed material (meal) is fed to livestock. The nutrient value of sunflower meal depends primarily on the type of processing it has gone through. If part or all of the hulls remained on the seed prior to oil extraction, then the meal will have higher fibre content but lower protein and fat. Solvent extracted sunflower meal will have a protein percentage around 41% if dehulled, and around 28% if hulls are left on the seed. Fat content of solvent extracted meal is roughly 1%, and roughly 9% in mechanically pressed seed meal (Burton, 2008). Oil from sunflower was regarded to be cholesterol free and is valued as one of the healthy vegetable oil in the world and the sunflower seeds are used for the production of confectionaries (Berglund, 2007). This work is designed to investigate the oil content of some varieties of sunflower (*Helianthus annuus* L.) obtained from Bagauda and Hadejia locations.

MATERIALS AND METHODS

The research was conducted at Bagauda research farm at Bagauda village, Kano state which lies between latitude 11 40'N and longitude 8 16' E and BUPOLY Hadejia research farm, Hadejia town Jigawa state which lies between latitude 12 26' 59''E and longitude 10 02' 39'' E to evaluate the response of sunflower *(Helianthus annuus* L.*)* varieties to varying intra-row spacing in the Sudan savannah zone of Nigeria.

The treatments of the research consist of variety SSL803, SSL806, SSL807 and SSL809 which were allocated to the main plot and intra-row spacing of 20cm, 30cm, 40cm, 50cm and 60cm allocated to subplot. Split plot design was selected involving three replications, where each replication consists of four main plots each of 4.5m x 3m represented by 6 ridges. The method of data collection adopted was observation procedure, where 5 selected plant samples were tagged and observations were recorded as needed in the experiment. The data on growth and yield characters were collected at 4, 6, 7 and 8 weeks after sowing and also at harvest.

A sample of the threshed seeds from each subplot were cleaned and dried to reduce the moisture content. The sample seeds were crushed manually and the nuts were separated from the chaff. The nuts were then grounded into flour and wrapped with filter paper and then inserted into a soxlalet apparatus thereby adding ether solution to extract the oil through ether extraction method. This was done for each sample from all subplots in the experiment. Variety SSL809 produces higher oil at Bagauda while variety SSL807 at Hadejia. The results of the treatments were subjected to analysis of variance using SAS software. The oil percentage was calculated using the formula given:

$$\% \text{ Fat} = \frac{W1 - W2}{W1} \times 100$$

Where W1 = weight of sample before extraction (g), W2 = weight of sample after extraction (g).

RESULTS AND DISCUSSIONS

Skoric *et al.* (2007) reported that the performance of varieties tested over several environments is the best basis for selecting sunflower hybrids. The choice should consider yield, oil percentage, maturity, seed size, lodging and disease resistance. The results of the effects of variety and intra-row spacing on head diameter, number of seeds per head, grain yield and oil percentage of sunflower *(Helianthus annuus* L.*)* at Bagauda and Hadejia showed that almost all of the characters assessed during the experiment were not significantly affected by the treatments (Table 1). At Bagauda the variety SSL809 produced the highest percentage of oil when compared to the other varieties. But at Hadejia, variety SSL807 recorded higher oil percentage than the other varieties. The results revealed that oil percentage was not significantly affected by intra-row spacing at both locations of the experiment (Table 2). The findings of this work is in accordance to that of Smith (2008) who reported that sunflower grown in rows 22, 30, or 38 cm apart did not differ in seed yield, oil percentage, large seed percentage, seed weight, height, or flowering date.

CONCLUSION

Sunflower produce high quality vegetable oil and livestock feeds. After oil is extraction from the sunflower seed which is about 40 to 45% of the seed by weight, the remaining seed material (meal) is fed to livestock (Burton, 2008). This study examined the level of oil content of sunflower in percentage as affected by variety and spacing at Bagauda and Hadejia locations. Based on the findings of the study, the results showed that the effects of variety and spacing on oil contents of sunflower was not statistically significant in both location of the experiments, this implies that the differences in between is just by chance. Hence any of the variety tested can perform very well in the experimental sites with good management.

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Table 1: Effect of Variety and Intra-raw spacing on Head Diameter (cm) and Number of Seeds/Head of Sunflower (*Helianthus annuus* L.) at Bagauda and Hadejia during the 2019 wet season

TREATMENT	BAGAUDA Head diameter	HADEJIA	BAGAUDA No. of seeds /head	HADEJIA
Variety				
SSL 803	19.45a	22.02a	1731.13a	1570.33a
SSL 806	19.10a	21.31a	1746.40a	1554.73a
SSL 807	20.45a	22.73a	1851.73a	1661.33a
SSL 809	19.33a	21.73a	1728.07a	1516.80a
S.E±	0.97	0.67	54.01	71.77
LOS	NS	NS	NS	NS
Inter-row spacing (cm)				
20	17.62b	21.53a	1758.92a	1566.7a
30	19.04ab	21.64a	1738.25a	1505.5a
40	21.42a	21.69a	1812.67a	16.41.6a
50	19.19ab	22.42a	1743.42a	1579.5a
60	20.66a	22.46a	1768.42a	1585.8a
S.E±	0.87	0.60	48.29	64.17
LOS	NS	NS	NS	NS
Interaction (VxSP)	NS	NS	NS	NS

LOS= level of significance, NS = Not significant

Table 2: Effect of Variety and Intra-row spacing on Grain Yield (t/ha) and Oil Percentage (%) of Sunflower (*Helianthus annuus* L.) at Bagauda and Hadejia during the 2019 wet season

TREATMENT	BAGAUDA Grain Yield	HADEJIA	BAGAUDA Oil Percentage	HADEJIA
Variety				
SSL 803	1.05ab	0.27a	46.86a	42.25a
SSL 806	0.88b	0.21b	43.95a	42.22a
SSL 807	1.03ab	0.27a	46.67a	42.59a
SSL 809	1.16a	0.31a	46.87a	42.39a
S.E±	0.11	0.02	1.65	0.62
LOS	NS	NS	NS	NS
Inter-row spacing (cm)				
20	1.08a	0.38a	46.35a	41.21b
30	1.16a	0.27b	46.60a	41.53ab
40	1.06a	0.26b	47.09a	42.89ab
50	0.97a	0.21b	43.18a	42.97ab
60	0.89a	0.21b	47.22a	43.22a
S.E±	0.10	0.02	1.47	0.55
LOS	NS	**	NS	NS
Interaction (VxSP)	NS	NS	NS	NS

LOS= level of significance, NS = Not significant, ** = Highly significant

EFFECT OF NITROGEN CONTENTS OF UREA, NPK 15.15.15 AND NPK 20:10:10 ON THE GROWTH AND YIELD OF *TELFAIRIA OCCIDENTALIS* HOOK F. IN AWKA

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ABSTRACT

Leaching of soil nitrogen contributes to poor soil fertility. The experiment was conducted to investigate the effect of different inorganic fertilizer rates on the growth and yield of fluted pumpkin fertilizer. Ten treatments consisted of three rates of NPK 15:15:15 fertilizer (200, 400 and 600 kg ha^{-1}), three rates of NPK 20:10:10 (150, 300 and 450 kg ha^{-1}), three rates of urea (65.21, 130.44 and 175.65 kg ha^{-1}) and control (zero application). The experimental design was a Complete Randomized Design and replicated three times. The different inorganic fertilizer rates supplied 30, 60 and 90 kg ha^{-1} of nitrogen respectively. Growth and yield parameters peaked at the application of inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen and declined at 90 kg ha^{-1} of nitrogen. Application of 400 kg ha^{-1} of NPK 15:15:15 fertilizer produced highest plant yield (0.43 t ha^{-1}) followed by 130.44 kg ha^{-1} of urea (0.42 t ha^{-1}) while 300 kg ha^{-1} of NPK 20:10:10 (0.19 t ha^{-1}) produced lowest plant yield (0.15 t ha^{-1}). Therefore, for improved growth and yield of Telfairia occidentalis in Awka, the application of 400 kg ha^{-1} of NPK 15:15:15 is recommended, and in the unavailability of NPK 15:15:15, 130.44 kg ha^{-1} of Urea is recommended.

Keywords: Nitrogen content, inorganic fertilizer, fluted pumpkin

INTRODUCTION

Telfairia occidentalis is a tropical vine grown in West Africa as a leaf vegetable and for its edible seeds. *Telfairia occidentalis* is a member of the Cucurbitaceae family and is indigenous to southern Nigeria (Akoroda, 2008). The tender shoots, succulent leaves and immature seeds are cooked and consumed as a vegetable. The leaves are used alone or together with okra and *Irvingia gabonensis* or *egusi*. Soils of Awka, Nigeria are acidic, low in mineral reserves with low cation exchange capacity and base saturation (Onweremmadu *et al.,* 2006). Poor soil fertility lowers growth and yield of fluted pumpkin because nitrogen, phosphorus and potassium are the major essential elements required for physiological mechanisms for *Telfairia* growth and yield (Akanbi, 2007) and where they are deficient, *Telfairia*'s growth and yield are impaired (Ike *et al.,* 2017). Rural farmers use organic manure such as poultry droppings, pig slurry cow dung etc to improve soil productivity and yield of *Telfairia occidentalis* (Ndor *et al.,* 2013). However, organic manure cannot meet the crop requirement for the teeming Nigerian population (FPDD, 1989) and as a result there is need for the use of inorganic fertilizer for commercial *Telfairia occidentalis* production. Fluted pumpkin requires high amount of nitrogen and potassium for the production of high leaf and pod yield respectively (Vine, 2013). Olaniyi *et al.,* (2011) reported 60 kg ha^{-1} of nitrogen in combination with 45 kg ha^{-1} of phosphorus had more significant effect on the production of fluted pumpkin for optimum yield of fluted pumpkin in southwest Nigeria. Most farmers prefer the use of NPK 15:15:15 to single fertilizers in fluted pumpkin production because it is more convenient for farmers to apply fertilizer nutrients in one single formulation (FPDD, 1989). However, the use of NPK 15:15:15 in fluted pumpkin production is threatened by its scarcity. Therefore, the objective of this study is to determine other alternative nitrogen supplying inorganic fertilizer to NPK15:15:15.

MATERIALS AND METHODS

This experiment was carried out was at the Teaching and Research Farm of the Department of Crop Science and Horticulture, Nnamdi Azikiwe University, Awka during the dry season of February, 2021. The seeds of *Telfairia occidentalis* were obtained from *Mgbarimgba* market at Eke-Awka. The accession is called *ugu Mgabkwu*. Cement bags were thoroughly washed; half filled with top soil and used in planting *Telfairia occidentalis* seeds. A relatively homogenous soil was maintained by bagging a thoroughly mixed top soils from one spot. One custard bucket filled with water was used to irrigate each bag morning and evening. The same quantity of water was applied in all treatments and replications. Ten treatments consisted of inorganic fertilizers;

Urea (65.21, 130.44 and 175.65 kg ha^{-1}), NPK 15:15:15 (200, 400 and 600 kg ha^{-1}), NPK 20:10:10 (150, 300 and 450 kg ha^{-1}) and zero application of NPK fertilizer which served as the control. Each rate in the organic fertilizer supplied 30, 60 and 90 kg ha^{-1} of nitrogen respectively. The experimental design was Completely Randomized Design (CRD). The bags served as plots and were arranged in a row of 10 bags which were replicated three times making it a total of 30 bags for the experimental set up. Fertilizers were applied using ring method, placed 5 cm away from the plant stem one week after seedling emergence. Staking was done a month after planting and the trellis method of staking was adopted. The following data were collected on *Telfairia occidentalis* samples four weeks after planting; vine length, leaf area, number of leaves, girth, fresh leaf weight, fresh vine weight and fresh plant yield weight. Data were collected on a two weekly basis, from one week after the application of different fertilizer treatments. Data collected were analyzed using Genstat, 2007 software and means were separated using Least Significant Difference (LSD) at 5% level of probability.

RESULTS

The number of leaves at 4WAP was not significantly ($p < 0.05$) affected by the application of different inorganic fertilizer rates (Table 1). On mean value basis, the application of urea at the rate of 130.44 kg ha^{-1} produced highest number of leaves (11.33), followed by the application of 65.21 kg ha^{-1} of urea of ha (10.67), while 450 kg ha^{-1} of NPK 20:10:10 produced lowest number of leaves (7.67). Different inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen showed that 130.44 kg ha^{-1} of urea (11.33) produced highest number of leaves, followed by 400kg ha^{-1} of NPK 15:15:15 (10.33) while 300 kg ha^{-1} of NPK 20:10:10 (9.33) produced lowest number of leaves. Similar trend was observed at 6 and 8 WAP. The vine length at 4, 5, 6, 7, 8 and 9 WAP was not significantly ($p < 0.05$) affected by the application of different inorganic fertilizer rates (Table 1). On mean value basis, at 4 WAP, the application of urea at the rate of 130.44 kg ha^{-1} produced longest vine (27.60 cm), followed by the application of 300kg ha^{-1} of NPK 20:10:10 (23.70 cm), while 450 kg ha^{-1} produced shortest vine (7.00 cm). Different inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen showed that 130.44 kg ha^{-1} of urea (27.60 cm) produced longest vine, followed by 300 kg ha^{-1} of NPK 20:10:10 (23.70 cm) while 400 kg ha^{-1} of NPK 15:15:15 (21.00 cm) produced shortest vine.

At 6 WAP, on mean value basis, the application of urea at the rate of 130.44 kg ha^{-1} produced longest vine (42.20 cm), followed by the application of 400kg ha^{-1} of NPK 15:15:15 (40.20 cm), while 450 kg ha^{-1} produced shortest vine (12.00 cm). Different inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen showed that 130.44 kg ha^{-1} of urea (42.20 cm) produced longest vine, followed by 400kg ha^{-1} of NPK 15:15:15 (40.20 cm) while 300 kg ha^{-1} of NPK 20:20:20 (30.00 cm) produced shortest vine.

At 8 WAP, on mean value basis, the application of 400 kg ha^{-1} of NPK 15:15:15 (60.70 cm) produced longest vine, followed by the control (50.80 cm), while 450 kg ha^{-1} produced shortest vine (16.20 cm). Different inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen showed that 400 kg ha^{-1} of NPK 15:15:15 (60.70 cm) produced longest vine followed by 130.44 kg ha^{-1} of urea (49.30 cm), while 300 kg ha^{-1} of NPK 20:20:20 (32.80 cm) produced shortest vine.

Leaf fresh weight at 9 WAP was not significantly ($p < 0.05$) affected by the application of different inorganic fertilizer rates (Table 1). On mean value basis, the application of application of 400 kg ha^{-1} of NPK 15:15:15 (30.30 g) produced highest fresh leaf weight, followed by urea at the rate of 130.44 kg ha^{-1} (27.00 g), while 150 kg ha^{-1} of NPK 20:10:10 produced lowest fresh leaf weight (7.50 g). Different inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen showed that 400 kg ha^{-1} of NPK 15:15:15 (30.30 g) produced highest fresh leaf weight; followed by 130.44 kg ha^{-1} of urea (27.00 g), while 300 kg ha^{-1} of NPK 20:10:10 (10.30 g) produced lowest fresh leaf weight.

Vine fresh weight at 9 WAP was not significantly ($p < 0.05$) affected by the application of different inorganic fertilizer rates (Table 1). On mean value basis, the application of application of 130.44 kg ha^{-1} (14.70 g) produced highest fresh vine weight, followed by 400 kg ha^{-1} of NPK 15:15:15 (13.30 g), while 450 kg ha^{-1} of NPK 20:10:10 produced lowest fresh vine weight (3.00 g). Different inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen showed that 130.44 kg ha^{-1} of urea (14.70 g) produced highest fresh vine weight, followed by 400 kg ha^{-1} of NPK 15:15:15 (13.30 g), while 300 kg ha^{-1} of NPK 20:10:10 (8.70 g) produced lowest fresh vine weight.

Table 1: Effect of different inorganic fertilizer rates on number of leaves, vine length and vine girth, leaf weight (g plant^{-1}), vine weight (g plant^{-1}) and plant yield (t ha^{-1})

Inorganic fertilizers (kg ha^{-1})	Number of leaves			Vine length (cm)			Leaf weight (g plant^{-1})	Vine weight (g plant^{-1})	Plant yield (t ha^{-1})
	4 WAP	6 WAP	8 WAP	4 WAP	6 WAP	8 WAP	9 WAP	9 WAP	9 WAP
O	9.00	13.33	21.3	16.3	38.5	50.8	19.30	13.00	0.32
Urea									
65.21	10.67	15.00	23.7	13.2	33.0	40.0	22.00	12.30	0.34
130.44	11.33	16.00	26.0	27.6	42.2	49.3	27.00	14.70	0.42
175.65	9.33	13.00	16.3	17.2	25.3	33.8	16.00	8.00	0.23
NPK 15:15:15									
200	10.33	14.33	17.3	15.2	28.0	44.5	11.30	9.00	0.21
400	10.33	15.33	24.3	21.0	40.2	60.7	30.30	13.30	0.43
600	9.33	13.00	18.7	10.4	19.3	36.2	7.70	7.00	0.15
NPK 20:10:10									
150	8.67	13.67	14.7	9.2	17.5	18.3	7.30	3.30	0.11
300	9.33	14.33	20.5	23.7	30.0	32.8	10.30	8.70	0.19
450	7.67	12.33	13.0	7.4	12.0	16.2	12.70	3.00	0.15
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

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Telfaira occidentalis yield at 9 WAP was not significantly ($p < 0.05$) affected by the application of different inorganic fertilizer rates (Table 1). On mean value basis, the application of application of 400kg ha^{-1} of NPK 15:15:15 (0.43 t ha^{-1}) produced highest plant yield, followed by 130.44 kg ha^{-1} (0.42 t ha^{-1}), while 450 kg ha^{-1} of NPK 20:10:10 (0.15 t ha^{-1}) and 600 kg ha^{-1} of NPK 15:15:15 (0.15 t ha^{-1}) produced lowest plant yield. Different inorganic fertilizers that supplied 60 kg ha^{-1} of nitrogen showed that 400 kg ha^{-1} of NPK 15:15:15 (0.43 t ha^{-1}) produced highest plant yield, followed by 130.44 kg ha^{-1} of urea (0.42 t ha^{-1}) while 300 kg ha^{-1} of NPK 20:10:10 (0.19 t ha^{-1}) produced lowest plant yield.

DISCUSSION

The application of NPK 15:15:15 fertilizer produced improved growth and yield parameters than other inorganic fertilizers used in the experiment. This could be attributed to the balanced supply of nitrogen, phosphorus and potassium from the NPK 15:15:15 fertilizer required for improve growth in fluted pumpkin. Ike *et al.,* (2017) reported that the major nutrients required by fluted pumpkin are nitrogen, phosphorus and potassium. Inadequate supply of any of these nutrients during fluted pumpkin growth is known to have negative impact on the reproductive capability, growth and yield of the plant (Vine, 2013). NPK fertilizer has been used to improve the growth and yield of *Telfairia occidentalis* (Edu *et al.,* 2015; Ndor *et al*., 2013).

CONCLUSION

From the experiment, both the growth and vegetative yield parameters were not significantly affected by the different inorganic fertilizers rates. However, observed differences confirmed earlier reports that 60 kg ha^{-1} of nitrogen produced optimum yield in *Telfairia occidentalis* in southeastern Nigeria. Application of nitrogen above 60 kg ha^{-1} declined growth and yield of *Telfairia occidentalis* irrespective of the inorganic fertilizer used to supply the nitrogen. Among the three inorganic fertilizers used in the experiment, 400 kg ha^{-1} of NPK 15:15:15 still remained the best for optimum *Telfairia occidentalis* growth and yield seconded by 130.44 kg ha^{-1} urea while 300 kg ha^{-1} of NPK 20:10:10 was the least.

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RESPONSE OF ONION *(ALLIUM CEPA* L.*)* TO VARYING LEVELS OF NPK FERTILIZER AND FARM YARD MANURE IN HADEJIA VALLEY JIGAWA STATE

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ABSTRACT

An Investigation was carried out at Binyaminu Usman Polytechnic Hadejia teaching and research farm, Jigawa State within Hadejia River Valley Irrigation Project Area, in the Sudan savannah ecological zone of Nigeria during dry season of 2019/2020. The treatments were made up of four levels of NPK fertiliser (0 – 0 – 0 – 0, 80 – 40 – 40, 100 – 50 – 50 and 120 – 60 – 60 Kg/ha) and two levels of Farm Yard Manure (FYM), (0 and 2.5 tons/ha). The results indicated that application of NPK up to 120 – 60 – 60 NPK produced the tallest onion plants. Similarly, number of levels/plant was significantly higher when 120 – 60 – 60 Kg NPK/ha was applied. However, number of days to maturity was significantly delayed by application of NPK. Bulb fresh weight and yield were increased significantly up to the highest NPK applied (120 – 60 – 60). The results further showed that manure had significant effect on number of leaves and bulb fresh yield only for which higher values were recorded with the application of 120 – 60 – 60 NPK/ha.

Key words: Onion, Bulb, Fertilizer and Farm Yard Manure

INTRODUCTION

Onion is one of the most important vegetable commonly used in every household. It is used in every home in every part of the world. Its nutrient value is higher than some vegetable like carrot and cabbage. It contains edible starch but appreciable quantities of protein and vitamins A, B and C. Onion bulb can be eaten fresh of cooked. It is also used for preparing soup or stew. It is used for the treatment of several diseases. High dosage of opinion and low dosage of aspirin is good in the treatment of hypertension. It is commonly found in almost all Nigeria dishes as spice and appetizer. Onion is believed have originated in Asia, possibly in the Iran. Of the tropics very early cultivation is known to have occurred in Egypt and India. Cultivated in all parts including the drier areas were they are grown using irrigation (Tindale, 1983). The bulb is a truncated stem formed from thicken leaf base. The outer layers are thin while the inner ones are without blades and could be 10cm or more in diameter. Leaves are alternate and are produced from conical based steam. They are cylindrical in nature and becoming hollow along its upper part. The flowers are borne on scalps 30 – 100cm in height protected by terminal umbels. The inflorescence produces numerous flowers in segment with ovaries, petals and styles. Seeds are smooth, black wrinkled when dry. The embryo is curved and germination is epigeal. Approximate weight of 100 seeds is 4gm.The objective of the study is to evaluate the response of onion to NPK fertilizer and Farm Yard Manure at Hadejia Valley.

MATERIAL AND METHODS

The experiment was conducted at Binyaminu Usman Polytechnic Hadejia teaching and research farm, Jigawa State within Hadejia River Valley Irrigation Project Area. The treatments were made up of four levels of NPK fertiliser (0 – 0 – 0 – 0, 80 – 40 – 40, 100 – 50 – 50 and 120 – 60 – 60 Kg/ha) and two levels of Farm Yard Manure (FYM), (0 and 2.5 tons/ha). They were laid randomly in plots using Randomize Complete Block Design (RCBD) and replicated three times.

Nursery beds (1m x 2m) were prepared. Before sowing quantity of manure and fertilizer (NPK) was applied. The seed were drilled 5cm apart. The beds were then mulched. The mulching materials were removed after the seedlings have fully emerged. Meanwhile the beds were kept weed free and watered regularly. A local variety onion was used. When the seedlings were about 6 weeks old, they were transplanted to already prepared basins, irrigated to field capacity before transplanting. Healthy onion seedlings of about 7 – 10cm tall (6 weeks old) were selected for transplanting.

Fertilizer application: the sources of NPK fertilizer were NPK 15:15:15 and Urea (46%). All the treatments were applied in single dose at 4 weeks after transplanting. The manure treatments were applied during land preparation. The plots were irrigated to field capacity at weekly interval. Weeds were controlled manually throughout the growing period using small onion hoes.

After transplanting plant height was taken at 8 WAT (Weeks After Transplanting) from ground level to the tip of the longest leaf using a 30cm metre ruler. Mean of four plants was taken from each plot at 2 weeks' interval. Mean bulb height and diameter were determined from five randomly selected bulbs from each plot. In the same way mean bulb weight was determined. Bulb yield (kg/ha**)** was determine by expressing the bulb weight per plot into Kg/ha. The data generated was subjected to analysis of Variance (ANOVA) and where treatment means significant, values were compared using DMRT.

RESULTS

Plant weight of onion was not significantly affected by application of NPK fertilizers at 8 and 10 WAT (Table 1). However, at 12 WAT application of 120 – 60 – 60 kg/ha produced significantly taller plant treated with 100 – 50 – 50 and 80 – 40 – 40 kg/ha which were at per while plots treated with zero fertilizer had the shortest plant. At 14 WAT plant treated with NPK at rate of 0 and 80 – 40 – 40 kg/ha had similar height. However, application of 100 – 50 – 50 kg/ha produced significantly taller plants but when the dose was further increased to 120 – 60 – 60 kg/ha the difference was not significant. Although plots treated with manure had the tallest plants, the differences among the treatment were not significant across the sampling periods.

Onion leaves were not affected by application of NPK fertilizers between 8 and 12 WAT. However, at 14 WAT application of 80 – 40 – 40 kg/ha produced significantly higher number of leaves/plant which were statistically similar with plants treated with 100 – 50 – 50 kg/ha (Table 2). A further increase to 120 – 60 – 60 kg/ha however, resulted in a significant increase in number of leaves/plant. Up to 12 WAT number of leaves/plant was not significantly affected by manure application. At 14 WAT however, plants treated with manure produced significantly higher number of leaves/plant.

Table 1 Response of Onion to NPK fertilizer and Farm Yard Manure on Plant height (cm) at Hadejia

Treatment	Plant height at			
	8 WAT	10 WAT	12 WAT	14 WAT
NPK Levels				
0 – 0 – 0 kg/ha	16.77	21.12	25.27b	31.47c
80 – 40 – 40 kg/ha	17.92	24.65	31.20a	36.47b
100 – 50 – 50 kg/ha	17.52	26.00	30.83a	38.43b
120 – 60 – 60 kg/ha	20.10	28.60	34.00a	48.03a
SE±	1.23	1.78	1.08	0.91
FYM Levels				
0.0 kg/ha	18.81	25.47	30.46	37.58
2.5 kg/ha	17.34	24.72	30.19	39.62
SE±	1.30	1.03	0.50	0.86

Means followed by the same letter (s) within a column are statistically similar at 5% level of probability using DMTR.FYM = Farm Yard Manure

Plants treated with NPK fertilizers at the rate of 120 – 60 – 60 and 100 – 50 – 50 kg/ha had statistically similar and longer maturity period compared with the other treatments which were also at par. Manure application had no effect on maturity of onion. Only application of up to 120 – 60 – 60 kg/ha had significant effect on bulb height. Application of up to 100 – 50 – 50 kg/ha did not produced significantly wider diameter compared with plants that did not receive NPK treatment (Table 3). However, increasing the dose from 100 – 50 – 50 to 120 – 60 – 60 kg/ha produced significantly wider bulb diameter. Application manure had no effect on bulb diameter of onion. Application of 80 – 40 – 40 kg/ha produced bulbs which were significantly heavier than the control treatment. A further increase to 100 – 50 – 50 kg/ha did not produce a significant difference, however, at 120 – 60 – 60 kg/ha the difference was significant. Manure application had no effect on bulb weight onion. Bulb yield of onion was significantly affected by application of NPK fertilizer. Each successive increase in NPK fertiliser dose resulted in a significant increase in onion fresh yield up to the highest dose. Similarly, application of manure resulted in a significant increase in bulb fresh yield of onion (Table 3).

Table 2. Response of Onion to NPK fertilizer and Farm Yard Manure on number of leaves per plant at Hadejia

Treatment	Number of leaves per plant at			
	8 WAT	10 WAT	12 WAT	14 WAT
NPK Levels	5.03	5.85	6.93	8.12c
0 – 0 – 0 kg/ha	5.03	5.90	8.10	9.78b
80 – 40 – 40 kg/ha	5.28	6.12	7.32	9.78b
100 – 50 – 50 kg/ha	5.08	6.72	7.55	12.40a
120 – 60 – 60 kg/ha	0.28	0.28	0.82	0.37
SE±				
FYM Levels				
0.0 kg/ha	5.35	6.25	7.32	9.13b
2.5 kg/ha	4.97	6.04	7.63	10.91a
SE±	0.24	0.28	0.54	0.16

Means followed by the same letter (s) within a column are statistically similar at 5% level of probability using DMRT.FYM = Farm Yarld Manure

Table 3. Response of Onion to NPK fertilizer and Farm Yard Manure on number of days to Maturity, bulb height and diameter, bulb weight and bulb yield at Hadejia.

Treatment	Days to Maturity	Bulb height	Bulb diameter	Bulb weight	Bulb Yield
NPK Levels					
0 – 0 – 0 kg/ha	101.7b	6.9b	10.2a	39.8c	12057d
80 – 40 – 40 kg/ha	105.0b	7.8b	11.0b	61.5b	15634c
100 – 50 – 50 kg/ha	124.2a	7.9b	11.7b	73.6b	21669b
120 – 60 – 60 kg/ha	116.7a	10.3a	15.2a	112.5a	25851a
SE±	3.34	0.461	0.507	5.83	568.6
FYM Levels					
0.0 kg/ha	105.8	7.95	11.36	65.9	16517b
2.5 kg/ha	117.9	8.51	12.63	77.9	21088a
SE±	3.32	0.407	0.613	3.88	1609.2

Means followed by the same letter (s) within a column are statistically similar at 5% level of probability using DMRT.FYM = Farm Yard Manure.

DISCUSSION

The growth of onion is known to be influence by application of essential fertilizers elements up to optimum levels. In this experiment onion attributes exhibited varying degree of response to fertilizer could be due to the fact that all the elements (NPK) are needed for normal growth and high yield of onion (Amans, 1982). The fresh bulb yield of onion did not increase beyond 100 – 50 – 50 kg/ha probably because the optimum requirement had been met. This result corroborated with a similar study by Mohammed and Miko (2005) in the same locality which showed that onion needed 100kg N /ha for optimum productivity.

The result indicated that manure had significant effect on the yield of onion. This is not unexpected because addition of manure to the soil helps to improve its fertility and physical properties. The lack of significant effect of manure on most of the yield attributes could be because the quantity was relatively small (2.5 tons) compared to values (4 – 10 tons) recommended by Abbey and Kanton (2003) and Sharma (2003).

CONCLUSION

The results of the present investigation indicated that application of NPK fertilizer at the rate of 100 – 50 – 50 kg/ha gave higher bulb fresh yield of onion. It further indicated that application of manure at that rate of 2.5 tons/ha supported higher productivity of onion fresh yield, thus application of NPK fertilizer and FYM, at 100 – 50 – 50 kg/ha and 2.5 tons/ha respectively, could be recommended for higher yields of onion under the climatic condition of Hadejia, Jigawa State.

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RESPONSE OF CUCUMBER (*CUCUMIS SATIVUS* L.) TO DIFFERENT LEVELS OF COW DUNG AND NPK 15:15:15 FERTILIZER IN NORTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

In this study, response of cucumber to cow dung and NPK 15:15:15 fertilizer was evaluated during the 2020 wet season at the Horticulture Section of Samaru College of Agriculture, Ahmadu Bello University, Zaria. The treatments consisted of four levels of NPK (0, 100, 150 and 200 kg/ha) and cow dung (0, 10, 20, 30 tha^{-1} and 100kg/ha of NPK + 15 t/ha cow dung) laid out in a randomized complete block design (RCBD) with three replicates. Data collected on vine length, number of leaves, number of branches, number of fruits per plant and fresh fruit yield. Results of the study showed significant (p<0.05) differences between parameters assessed and among the cow dung and NPK fertilizer rates. Application of 30 t/ha of cow dung gave the highest fruit yield (39.33 t/ha) while combination of 15 t/ha of cow dung with 100 kg NPK (29.02 t/ha); the two treatments were thereby found to be adequate in enhancing growth and yield of cucumber at Samaru.

Key words: Cucumber, NPK 15:15:15, Cow dung, Samaru, Northern Guinea Savanna

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the most popular fruit vegetables in the Cucurbitaceae family (Eifediyi and Remison, 2010). Apart from its palatability, it is very important to humans for its medicinal value as diuretic and active drug for secreting and promoting the flow of urine (Nweke and Nsoanya, 2015). Cucumber also reduces the risk of heart attack and help in digestion of food (Sodimu, 2020), it promotes healthy hair growth, soften the skin and may be use for curing of skin infection such as eczema, weight loss and to expel intestinal worm (Shrivastava and Roy, 2013). Cucumber production requires fertile soil of moderate to high nutrient levels in order to achieve high yields (Nweke and Nsoanya, 2015). Although the use of inorganic fertilizer has associated with soil degradation, nutrient imbalance, acidity apart from its high cost and unavailability to resource poor farmers (Ojeniyi, 2000). On the other hand, organic manure can sustain crop production through better nutrient recycling and soil physical improvement (Maritus and Vleic, 2001) but is usually requires in a larger quantity and slow in releasing nutrients (Khalid *et al*., 2014). Against this background, there is need to study the effect of different rates of cow dung and NPK fertilizers on cucumber production with view of making appropriate recommendation(s) to cucumber farmers in Samaru metropolis.

MATERIALS AND METHODS

Site Location and Climate

The experiment was conducted during 2020 wet season at the Horticulture Section, Samaru College of Agriculture, Ahmadu Bello University, Zaria. The study area lies within latitude 11°09'52'' – 11°10'22'' N and longitude 07°38'05'' – 07°38'22'' E with 684 – 697 m above sea level. The area is situated in the Northern Guinea Savanna ecological zone with a mono-modal rainfall pattern and a long term mean annual rainfall of about 1,011± 161 mm concentrated entirely in five months (May/June–September/October) and mean daily temperature of 24°C (Oluwasemire and Alabi, 2004).

Treatments and Experimental Design

The treatments consisted of four levels of NPK (0, 100, 150 and 200 kg/ha) and cow dung (0, 10, 20, 30 tha^{-1} and 100kg/ha of NPK with 15 tha^{-1} of cow dung) laid out in a randomized complete block design (RCBD) replicated three times.

Land preparation, planting and fertilizer application

The experimental site was cleared, ploughed, harrowed to fine tilth and ridged with a plot size 3 m x 2 m. The inter- and intra-row spacing was 0.75 m and 0.5 m respectively. Two seeds of 'market-moore' variety were planted per hole and later thinned to one per stand. The cow dung was applied according to the respective rates per plot and left to thoroughly decomposed for two weeks before planting. The NPK 15:15:15 fertilizer was applied at two weeks after planting using band placement method. Weeding, application of insecticides and other cultural practices were done as at when required. Trellising was done to support the cucumber vine by fastening it to stakes; this also help to keep cucumber fruit off the ground (to prevent rotting).

Pre-planting soil sampling, cow dung and analysis

The soil samples were collected using soil auger at 0 – 20 cm depth. The samples collected were bulked to obtain a composite sample. The soil composite and cow dung samples were air dried, crushed, screened through a 2-mm sieve and prepared for manure and soil characterization following standardized procedures described by Okalebo *et al.* (2002).

Data collection and Statistical analysis

Data on vine length (cm), number of leaves per plant, number of branches per plant, number of fruits per plant and fresh fruit yield (t/ha) were recorded. The data collected were subjected to statistical analysis of variance (ANOVA) and treatment means were separated using new Duncan Multiple Range Test (SAS Institute, 2000).

RESULTS

Characteristics of the study soil

Initial physical and chemical properties of the experimental soil used in the study are presented in Table 1. The soil type was sandy loam; the soil reaction (pH) in water was slightly acid (6.5), low in organic carbon content (11.24 g kg^{-1}) and total nitrogen (0.98 g kg^{-1}). The available phosphorous (8.00 mg kg^{-1}) and exchangeable bases were relatively moderate according to FMARD (2012) rating.

Table 1: Initial soil properties at Experimental site in Zaria and Cow dung used in 2020 cropping season

Parameter	Clay	Silt	Sand	Textural class	pH water	O.C	T.N	A.P	K^+	Ca^{++}	Mg^{++}
	← (g kg^{-1}) →					← (g kg^{-1}) →		(mg kg^{-1})	← (cmol kg^{-1}) →		
Soil	80	200	720	Sandy Loam	6.5	11.24	0.49	96.54	0.11	1.79	0.74
Cow dung	n. d	n. d	n. d	n. d	n. d	n. d	0.98	1,133	0.3%	n. d	n. d

O. C = organic carbon, T.N = total nitrogen, A.P = available phosphorus, n. d = not determined

Effect of NPK fertilizer and Cow dung at different levels on Growth and Yield of Cucumber

Vine length (cm)

The effect of NPK 15:15:15 and cow dung at different levels is as presented in Table 2. Application of (100 kg NPK/ha with cow dung at 15 t/ha) significantly produced the highest length (139.97 cm) closely followed by cow dung at 30 t/ha while the lowest mean was produced by the control treatment (0 kg NPK/ha or 0 t/ha of cow dung). Successive addition of either NPK fertilizer or cow dung significantly led to increase in vine length.

Number of leaves per plant

Table 2 shows that there was a significant difference ($p<0.05$) between the means, due to application of NPK fertilizer or cow dung at different levels. The control significantly produced the lowest mean at maturity (23.53), while application of cow dung at 30 t/ha produced the highest mean (85.07). An increase in either NPK fertilizer or cow dung significantly led to increases in number of leaves per plant.

Number of branches per plant

The effect of NPK fertilizer and cow dung on number of branches per plant is as presented in Table 2. It shows significant difference ($p<0.05$) among the different rates of NPK fertilizer and cow dung. The control treatment (0 kg N/ha) produced significantly the least number (1.30) while application of cow dung at 30 t/ha produced the highest mean values (10.17) and this is closely followed by combined application of (100 kg NPK/ha with cow dung at 15 t/ha).

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Table 2: Effect of NPK fertilizer and Cow dung at different rates on growth and yield of Cucumber

Treatment	Vine length (cm)	Number of leaves per plant	Number of Branches	Number of fruits per plant	Fresh fruit yield (t/ha)
Control	42.30h	23.53h	1.30g	2.67h	7.17g
NPK at 100 kg/ha	55.76g	34.70g	2.97f	3.85e	9.56f
NPK at 150 kg/ha	74.57f	39.30f	3.87ef	4.15de	10.44f
NPK at 200 kg/ha	82.67e	49.30e	4.30e	4.78d	14.67e
Cow dung at 10 t/ ha	104.97d	59.30d	6.30d	6.44c	18.83d
Cow dung at 20 t/ ha	116.07c	72.73c	7.30c	8.00b	25.22c
Cow dung at 30 t/ ha	129.73b	85.07a	10.17a	10.04a	39.33a
(NPK at 100 kg/ha + Cow dung at 15 t/ ha)	139.97a	80.63b	8.87b	8.63b	29.06b
SE (+/-)	1.2700	0.8405	0.3286	0.2831	0.548

Means followed by the same letter (s) in the column are not significantly different using DMRT at $p \leq 0.05$

Number of fruits per plant

N fertilizer significantly influenced total fresh fruit weight as presented in Table 2. The 100 kg N/ha produced significantly the highest (20.27 kg/ha) followed by 200 kg N/ha (18.60 kg/ha) and the control treatment recorded the least mean values (14.58 kg/ha).

Fresh fruit yield (t/ha)

Table 2 shows a significant difference ($p<0.05$) among the NPK fertilizer and cow dung rates on fresh fruit yield per hectare of cucumber. The control treatment (where neither fertilizer nor cow dung) was applied gave significantly lowest mean values (7.17 t/ha) on fresh yield per hectare. On the other hand, application of cow dung at 30 t/ha gave significantly the highest mean values (39.33 t/ha) in fresh fruit yield per hectare of cucumber. This is followed by the combined application of NPK fertilizer at 100 kg/ha with cow dung at 15 t/ha.

DISCUSSION

The soil of the experimental site is generally low in fertility status especially organic carbon, total nitrogen and available phosphorus which are usually due to low clay content coupled with rapid mineralization, continuous cultivation as common to soils of northern guinea savanna (FMARD, 2012). The significant response of the observed parameters to N, P and K application could be attributed to the role of N, P and K play in enhancing vegetative development in crops especially in soil with low nutrient status similar to the report by Ikeh *et al*. (2012) who claimed that low nutrient status might have contributed to the good performance of the crop.

Generally, the parameters observed significant increased with increasing levels of NPK fertilizer and cow dung in this study. Similar findings were also reported by Nweke and Nsoanya (2015) and Ikeh *et al*., 2012 on cucumber. They reported the maximum vine length was recorded due to enhanced synthesis and availability of sufficient growth nutrients from inorganic fertilizer. The result showed that cucumber responded well and better to the application of cow dung than NPK fertilizer in all parameters observed and this could be due to high nutrient content in cow dung especially organic matter, total nitrogen (N), phosphorus (P) and exchangeable potassium (K) which are higher than those in mineral fertilizer (NPK). This conform with the work of Ewulo (2005) who reported that poultry dropping contain high amount of N and P which are required for healthy growth, development and yield of crops. In addition, combined effect of cow dung and NPK fertilizer appears to be the second best in all the parameters observed in this study and this is similar to the study conducted by Nweke and Nsoanya (2013) who reported highest leave area index and grain yield when combined poultry manure and NPK fertilizer on maize.

CONCLUSION

Based on this research finding, it can be concluded that application of 30 t/ha of cow dung is adequate in enhancing growth and yield of cucumber. However, integrating cow dung at 15 t/ha with 100 kg NPK 15:15:15/ha will assist cucumber farmers at Samaru.

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INFLUENCE OF SIX POULTRY MANURE RATES ON EARLY GROWTH RESPONSE OF *SABA SENEGALENSIS* (L.) SEEDLINGS IN POT AND GROUND NURSERIES

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ABSTRACT

Saba Senegalensis is a fruit producing plant still in the wild; it has the potential of contributing to nutritional and food security of the rural populace as well as enhancing their economy. Two experiments were carried out to determine early growth response of the seedlings to different poultry manure rates in pot and ground nurseries. The experiments were conducted at the teaching and research farm of the Department of Crop Science, University of Nigeria, Nsukka. Seedlings were previously raised in a pre-nursery experiment conducted in a high tunnel. Topsoil amended with poultry manure (PM) at six different rates (0, 10, 20, 30, 40 and 50 t/ha) constituted the pot experiment. In the ground nursery seedlings were transplanted and two weeks later treated with five (0, 10, 20, 30, 40 t/ha) PM rates. The experiments were laid out in a complete randomized design (CRD) with 10 replications per PM rates. Periodical data on the number of leaves, vine length and the number of branches were taken after application of PM. Application of 30t/ha showed a substantial increase in all growth parameters by the 34th week in the pot nursery while for the ground nursery it was 40t/ha that showed a massive improvement in all morphological characteristics by the 34th week. Optimum PM rate for growing certified seedlings of Saba Senegalensis for plantation establishment was 30t/ha for pot nursery and 40t/ha for ground nursery.

Key words: Nursery method; Poultry manure; Seedlings growth differential

INTRODUCTION

Saba senegalensis is a fruit producing plant of the Apocynaceae family native to the Sahel of sub Saharan Africa. It grows wild in the forests of western Africa. It is called Saba, Zaban or Weda depending on the region. It grows predominantly in Burkina-Faso, Senegal, Nigeria, Cote d'ivoire, Gambia, Guinea, Mali, Niger, Guinea-Bissau and Ghana (AFTD-Agro forestry tree, 2011). Its fruit is highly valued in Senegal and Gambia. The fruit of Saba is very rich in antioxidants especially vitamin C. The fruit is tasty and sweet sour with yellow pulp when ripe (AFTD-Agro forestry Database, 2011). The latex of Saba is used to treat pulmonary diseases and tuberculosis. The leaves can cure chronic headache, wounds, food poisoning and vomiting. Fula of Senegal use the leaves in preparation of sauces and condiments (Kerharo et al, 1964).

Saba grows predominantly on Riverbanks and in Woodlands (Burkill, 2013). It is propagated through seeds though in some cases the vines are used. Deforestation and the degradation of the natural habitats of Saba plants are threatening its existence. The fruit is highly prized and in parts of Africa, they are important to the rural economy and many are trucked or carried in baskets to sell in the cities (Burkill, 2004). Despite the rural importance of the fruit of *Saba senegalensis* for food security and ethno-medicine the fruits are still harvested from the wild often times in competition with monkeys that consume the fruit. This crop still grows in the wild and there are needs to make attempts to bring it to regular cultivation culture.

Currently, there are no organized horticultural standards for raising healthy and well-grown seedlings for transplanting into the field in Nigeria. Thus, the objective of this experiment was to evaluate the early growth response of *Saba senegalensis* to six different poultry manure rates.

MATERIALS AND METHODS

Two experiments were carried out at the Teaching and Research farm of the Department of Crop Science, University of Nigeria, Nsukka, located in the derived savanna zone (Latitude 7.4, Longitude 6.9 and 475m altitude) of Nigeria.

Fully ripe Saba fruits were acquired from Kogi State in the middle belt of Nigeria. Fruits of similar sizes, maturity and stage of ripening were selected for the study. The seeds were extracted and mucilage was removed by rubbing with sawdust. Afterwards the seeds were disinfected in 10% dilution of sodium hypochlorite. Seedlings from a pre-nursery were utilized for a pot and ground nursery experiments. The experiments were laid out in a completely randomized design with six poultry manure [PM] rates (0, 10, 20, 30, 40 and 50 t/ha) for the pot nursery and five PM rates (0, 10, 20, 30 and 40 t/ha) for the ground nursery, respectively. Data collected were number of leaves, number of branches and vine length. The vine length was measured with the aid of a measuring tape. While number of leaves and branches were count data. Data were measured two weeks after manure application and subsequently on 4-week-intervals; data collection was terminated 34 and 22 weeks after manure application for pot and ground nursery, respectively.

RESULTS

Growth performance in pot nursery (Table 1) was expectedly poorer in seedlings without manure application, however 30 t/ha PM elicited higher number of leaves and longer vines; highest number of branches was however associated with 50 t/ha. Results of these growth parameters (data not shown) indicated significant manure rates effect on number of leaves from the 14th week, vine length and number of branches from the 18th week to the 34th week when data collection was terminated.

Growth performance in ground nursery (Table 2) was also, expectedly poorer in seedlings without manure application, however 40 t/ha PM elicited higher number of leaves and longer vines; highest number of branches was associated with 20 t/ha. Data measured (not shown) revealed that in the ground nursery number of leaves varied significantly with manure rates between the 10th and 14th week; whereas significant treatment effect was recorded for vine length between the 6th and 22nd weeks, number of branches varied throughout the duration of measure.

Table 1: Effect of manure rates on Saba seedlings growth parameters 34 weeks after manure application in pot nursery

Manure rate t/ha	Number of leaves	Vine length (cm)	Number of branches
0	23.9	35.0	1.5
10	49.4	51.6	6.3
20	36.1	51.6	3.8
30	54.3	62.5	5.3
40	53.0	54.3	4.5
50	40.7	42.0	6.7
$LSD_{(0.05)}$	**12.9**	**11.0**	**3.0**

Table 2: Effect of manure rates on Saba seedlings growth parameters 22 weeks after manure application in ground nursery

Manure rate t/ha	**Number of leaves**	**Vine length (cm)**	**Number of branches**
0	19.0	24.7	2.4
10	24.2	25.9	2.7
20	23.8	36.5	4.5
30	21.3	36.7	2.8
40	24.6	44.1	2.2
$LSD_{(0.05)}$	**NS**	**8.0**	**1.8**

NS: Non-significant at 5% probability level

DISCUSSION

The application of poultry manure evidently increased the number of leaves, vine length and the number of branches in both the pot and ground nurseries. The control treatment (0t/ha) expectedly had the least values of all the morphological characteristics.

Findings of this experiment elucidated the importance of poultry manure to the production of certified seedlings of Saba. The significant poultry manure effect on the number of leaves, vine length and number of branches in these experiments is in agreement with the findings of Baiyeri and Tenkouano (2007), Ndukwe *et al.* (2011) and Aba *et al.* (2011) that animal manure is a valuable source of crop nutrients and organic matter which can improve the soil biophysical conditions making the soil more productive and sustainable for plant growth.

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EVALUATION OF POULTRY MANURE APPLICATION RATES ON GROWTH AND YIELD OF TOMATO (*SOLANUM LYCOPERSICUM*) VARIETIES IN ABEOKUTA

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ABSTRACT

An experiment was carried out in 2020 at the upland section of farm of the Federal University of Agriculture, Abeokuta, Nigeria to determine the effect of poultry manure application rates on growth and yield of four tomato varieties. The experiment was arranged in a Randomized Complete Block Design (RCBD) and replicated three times. Four varieties of tomato are, Roma-VF, UC-82B, Beske, and Kerewa tested with organic fertilizer at 0t/ha, 1t/ha and 2t/ha incorporated into the soil a day before planting. Growth data were collected at two weeks' intervals on vegetative parameters of plant height, leaf area, number of leaves and stem girth for 8 weeks after planting while yield data collected at harvested were number of fruits, fruit weight and fruit size. All data collected were analyzed using ANOVA and separation of mean was done using Duncan's multiple range test at 5% level of probability. The result showed that there were significant (p<0.05) differences in growth and yield parameters in response to poultry manure rates. Variety Roma had the highest number of fruits when tested at all level of manure application rates with 2t/ha having the highest fruit weight followed by Kerewa at same rate of manure compared to other varieties. In terms of vegetative parameters, Roma had the highest values throughout the experiments. The result shows that different varieties of tomato differ from each other and outperform each other when different nutrient composition is made available, varieties Roma and Kerewa had higher nutrient use efficiency and are therefore recommended at 2 t/ha poultry manure application.

Key words: Tomato, poultry manure, vegetative parameters, growth, yield

INTRODUCTION

Tomato belongs to the Solanaceae family along with other economically important crops such as pepper, eggplant and potato. The tomato was classified by Miller (1754) as Lycopersicon esculentum and renamed by Child (1990) and Peralta and Spooner (2006) as Solanum lycopersicum (Díez & Nuez, 2008). The cultivated tomato, Solanum lycopersicum L., is the world's most highly consumed vegetable due to its status as a basic ingredient in a large variety of raw, cooked or processed foods. Tomatoes are grown both in most home gardens and commercially as one of the words most popular vegetables. The tomato crop has a great importance in the world, and its production, in 2013, reached 163.9 million tons and average yield of 34.7 tons per hectare (FAO 2013). In 2014, the global area cultivated with tomato was 5 million hectares with a production of 171 million tonnes, the major tomato-producing countries being the People's Republic of China (hereafter "China") and India (FAOSTAT, 2017).

Tomato can be grown in a variety of geographical zones in open fields or greenhouses, and the fruit can be harvested manually or mechanical means. Under certain conditions (e.g. rejuvenation pruning, weeding, irrigation, frost protection), this crop plant can be perennial or semi-perennial, but commercially it is considered an annual (Garcia et al., 2015). The tomato was cultivated and consumed in Mexico well before the arrival of the Spanish. The tomato has passed from uncertain acceptance to its arrival in Europe to occupying first place among horticultural crops at the present. Asia is by far the continent with the greatest production, producing 50% of the total, with Europe ranking as the second (17.5 %), followed by Central and North America (12.3 %), Africa (11.7 %), Latin America and the Caribbean (7.8 %) and Oceania (0.05 %). China is the main producer of tomato, followed by the US, Turkey, India and Italy (Díez & Nuez, 2008).

Tomatoes (Solanum Lycopersicum) are consumed as either fresh fruit by themselves, in salads, as ingredients in many recipes, or in the form of various processed products such as paste, whole-peeled tomatoes, diced products, and various forms of juices and soups. Tomato may contribute to a healthy, well-balanced diet as it has a few calories and is a source of vitamin A, vitamin C, and minerals. It provides small amounts of the vitamin B complex, such as thiamin, riboflavin, and niacin (Sainju and Dris, 2006). Tomato is also a source of iron. Yellow tomatoes have higher vitamin A than red ones, but red tomatoes contain lycopene, an anti-oxidant compound that may contribute to protect against cancer (Naika et al., 2005). Recent studies suggest that lycopene reduces the risk of prostate cancer (Miller et al., 2002). Consumption of tomatoes can reduce the risk of developing gastroenteric diseases, such as colon, rectal, and stomach cancer. Finally, it is easily digestible and its bright color stimulates appetite (Sainju and Dris, 2006). Then tomato is a favorite garden plant in many parts of the world, an important source of vitamins and nutrients and an economically important agricultural commodity. Food is one among the most important basic necessities of man. For Nigeria to meet the millennium development goal in food production, food including tomato must be readily available. Low soil fertility could threaten the security of food production and supply. Soil fertility is a major overriding constraint that affects all aspects of crop production (Mbah, 2006).

In the past years, inorganic fertilizer was advocated for crop production to ameliorate low inherent fertility of soils in the tropics. In addition to being expensive and scarce, the use of inorganic fertilizer has not been helpful in intensive agriculture because it is often associated with reduced crop yield, soil acidity and nutrient imbalance (Ojeniyi, 2000; Ano and Agwu, 2005; Agbede et al., 2008). The need to use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide (Ayoola and Adeniyan, 2006). Large quantities of organic wastes such as poultry manure are available especially in urban centers and are an effective source of nutrients for vegetables such as tomato (Adediran et al., 2003). Soil fertility status varies considerably with different ecological zones. Infact, even in the same zone, there are micro-differences in soil characteristics. The crop yield response to organic waste is highly variable and depends on the types of wastes, crop type and species, soil type and climate conditions (Adediran et al., 2003).

For Nigeria to meet the millennium development goal in food production, food including tomato must be readily available. Low soil fertility could threaten the security of food production and supply. Tomato cultivars differs from one another in terms of size, color, leaves, time of maturity, resistance to diseases and several other vegetative reproduction phases. Poultry waste as an organic manure is becoming popular due to its effectiveness of solving the plant nutritional problem and also effective on the growth, development and fruit yield of crops. The main objective of this study is to increase the growth and yield of tomato while the specific objectives was to evaluate the growth and yield of both local and exotic tomato varieties in response to rates of poultry waste application at Abeokuta southwestern Nigeria.

MATERIALS AND METHODS

The experiment was carried out at federal university of agriculture Abeokuta at upland fadama site (Lat 7º15'N and long 3º 25'E). Four varieties of tomato were planted on raised bed. The varieties were sourced from OjaAgbe: the varieties are

1. Uc82b (V1)
2. Roma vf (V2)
3. Kerewa (V3)
4. Beske (V4)

The experiment was arranged in a randomized complete block design format with three replicates. These involved four varieties of tomato and manure treatment at three different rates of 0,1 and 2 tonnes/ha, this makes twelve treatment combinations as listed below

V1M1, V1M2, V1M3, V2M1, V2M2, V2M3, V3M1, V3M2, V3M3, V4M1, V4M2 and V4M3.

The land was cleared and beds were made manually using hoe and cutlass, the individual plot dimension was measured as 2m by 2m and the total plot area was 46m by 12m, which summed up to 552m2. The seeds were planted in the local nursery made under a shade closer to the allocated plot for 4weeks. The seedlings were transplanted on the beds at a spacing of 60cm by 50cm and the beds were 1m apart.

Soil sample of the experimental site was collected using soil auger at a depth of 0 to 15cm, sieved, air dried and packed before taken to the laboratory for analysis of physical and chemical properties of nutrient composition.

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TABLE 1: Chemical component of the soil and organic fertilizer used

Soil composition	Values	Organic Manure
Sand (%)	75.4	-
Silt (%)	20.1	-
Clay (%)	4.5	-
pH	6.2	-
Total N (%)	0.175	0.38
Org. C(%)	0.625	-
Org. M(%)	1.078	-
Av. P (mg/kg)	17.38	0.48
Ex. A(mEq/100g)	0.3	-
Na (cmol/kg)	0.311	-
K (cmol/kg)	0.486	2.13
Ca (cmol/kg)	0.273	11.33
Mg (cmol/kg)	0.351	2.32
Mn (mg/kg)	1.112	-
Zn (mg/kg)	6.892	-
Fe (mg/kg)	0.816	-
Cu (mg/kg)	0.024	-

Supplying for seedling that failed to survive during the first week of planting was carried out with new ones at two weeks after transplanting. Manure application was applied a day before transplanting. Side placement was used, 2cm depth was dug, the manure was placed and earth was used to cover it up. Weeding and other cultural practices were carried out as appropriate.

Data was collected at two weeks' interval starting from two weeks after transplanting. Three plants were tagged from individual plots; data was recorded on Plant height, Number of leaves, Stem girth, Leaf area, Fruit set, Average fruit weight, Friut quality and Total Fruit yield per hectare.

The data collected were statistically analysed using Analysis of Variance (ANOVA) and the treatment means were separated for each parameter using Duncan Multiple Range Test (DMRT).

RESULTS

Effect of varietal differences on plant height (cm) of tomato varieties: The effect of varietal differences on plant height (cm) as portrayed in table 2 shows significant ($p<0.05$) difference at 8WAP with Beske having the least plant height (40.09) while Roma and kerewa had the highest plant height of 60.99 and 60.24 respectively throughout the period of experiment.

Effect of varietal differences on stem girth (cm) of tomato varieties: The effect of varietal differences on stem girth(cm) as portrayed in table 3 below. There was a significant ($p<0.05$) difference at 4WAP to 8WAP. Beske has the least stem girth (60.09) while Roma has the highest value for stem girth (0.88) throughout the period of experiment.

Effect of varietal differences on leaf area (cm) on tomato varieties: The effect of varietal differences on leaf area as portrayed on the table 4 below. There was a significant ($p<0.05$) difference among the varieties at 4WAP to 8WAP with Uc82b having the highest leaf area (15.05) while Beske had the least leaf area value (7.51) throughout the period of experiment.

Effect of varietal differences on number of leaves of tomato varieties: The effect of varietal differences on number of leaves as portrayed on the table 5 below. There was a significant ($p<0.05$) difference among the varieties at 2WAP to 8WAP with Roma having the highest number of leaves (273.71) while Beske had the least value for number of leaves (106.52) throughout the period of experiment.

Table 2: Effect of varietal differences on plant height(cm) of tomato varieties

	Weeks after planting			
varieties	2	4	6	8
BESKE	15.85b	22.52b	34.69b	40.09b
KEREWE	17.00ab	36.91a	44.96ab	60.24a
ROMA	19.79a	41.96a	52.55a	60.99a
UC82B	17.62ab	38.21a	51.34a	53.30a

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance.

Table 3: Effect of varietal differences on stem girth(cm) of tomato varieties

Weeks after planting				
Varieties	2	4	6	8
BESKE	0.31a	0.38b	0.50b	0.60b
KEREWA	0.34a	0.59a	0.66a	0.87a
ROMA	0.36a	0.64a	0.73a	0.88a
UC82B	0.33a	0.58a	0.74a	0.81a

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance.

Table 4: Effect of varietal differences on leaf area on tomato varieties

	Weeks after planting			
varieties	2	4	6	8
BESKE	1.43a	3.43b	5.67b	7.51c
KEREWA	2.71a	8.13ab	9.24ab	12.55ab
ROMA	2.73a	8.75a	9.51ab	10.07bc
UC82B	1.88a	10.08a	12.42a	15.05a

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance.

Table 5: Effect of varietal differences on number of leaves of tomato varieties

		Weeks after planting		
varieties	2	4	6	8
BESKE	25.30a	41.37b	91.52c	106.52c
KEREWE	22.48a	70.74ab	133.93bc	217.97ab
ROMA	29.52a	88.92a	225.00a	273.71a
UC82B	23.04a	63.74ab	186.07ab	174.18bc

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance.

Effect of poultry manure rates and varietal differences on plant height of tomato varieties: The effect of the manure rate and varietal differences on the plant height is portrayed in table 6 below. There was significant ($p<0.05$) differences in plant height among the different varieties throughout the period of observation. Kerewa at given rate of 1t/ha had the highest plant height with (73.67) as compared to other varieties, however Beske at given rate of 2t/ha had the lowest plant height (35.34) as compared to other varieties during the period of observation.

Effect of Poultry manure rates and varietal differences on leaf area of tomato varieties: The effect of the manure rate and varietal differences on leaf area is portrayed in table 7 below. There was significant ($p<0.05$) differences in leaf area among the different varieties throughout the period of observation. Uc82b at given rate of 2t/ha and

Kerewa at given rate of 1t/ha had the higher Leaf area with (17.86 and 16.82 respectively) as compared to other varieties, however Beske at given rate of 2t/ha, 1t/ha and 0t/ha and Roma at given rate of 0t/ha had the lowest Leaf Area (7.20,7.19,7.35 and 7.41 respectively) as compared to other varieties during the period of observation.

Effect of Poultry manure rates and varietal differences on number of leaves of tomato varieties: The effect of the manure rate and varietal differences on number of leaves is portrayed in table 8 below. There were significant ($p<0.05$) differences in number of leaves among the different varieties throughout the period of observation. Kerewa at given rate of 1t/ha and Roma at given rate of 2t/ha had the highest number of leaves with (359.35 and 343.90 respectively) as compared to other varieties and rates, however Beske at given rate of 2t/ha, 1t/ha and 0t/ha and kerewa at given rate of 0t/ha had the lowest number of leaves (108.78, 136.44, 74.33 and 122.89 respectively) as compared to other varieties and rates during the period of observation.

Table 6: Effect of Poultry Manure Rates and varietal differences on Plant Height(cm) of Tomato Varieties

		Weeks after planting			
TREATMENT		2	4	6	8
BESKE	0t/ha	17.06ab	23.22cd	37.30ab	43.22bcd
	1t/ha	16.83ab	26.05bcd	36.04ab	41.72cd
	2t/ha	13.67b	18.28d	30.72b	35.34d
KEREWA	0t/ha	13.22b	30.80abcd	42.49ab	52.71abcd
	1t/ha	16.47ab	36.98abc	56.11a	73.67a
	2t/ha	21.31a	42.97ab	36.28ab	54.33abcd
ROMA	0t/ha	17.00ab	36.27abcd	47.27ab	56.87abcd
	1t/ha	20.39a	44.73a	54.93a	64.61ab
	2t/ha	21.97a	44.89a	55.45a	61.50abc
UC82B	0t/ha	16.87ab	30.28abcd	44.37ab	49.83bcd
	1t/ha	17.49ab	41.50ab	54.98a	52.46abcd
	2t/ha	18.50ab	42.86ab	54.69a	57.62abc

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance.

Table 7: Effect of Poultry manure rates and varietal differences on leaf area of tomato varieties

	Weeks after planting				
TREATMENT		2	4	6	8
BESKE	0t/ha	1.03bc	3.49bc	6.21bc	7.99c
	1t/ha	2.12abc	5.22abc	5.75bc	7.20c
	2t/ha	1.15bc	1.58c	5.04c	7.35c
KEREWA	0t/ha	1.13bc	5.11abc	6.06bc	8.04bc
	1t/ha	2.00abc	7.16abc	11.68abc	16.82a
	2t/ha	5.00a	12.12a	9.96abc	12.79abc
ROMA	0t/ha	0.58c	5.73abc	6.89bc	7.41c
	1t/ha	4.12ab	9.23abc	10.29abc	9.82abc
	2t/ha	3.49abc	11.31ab	11.34abc	12.97abc
UC82B	0t/ha	1.20bc	5.06abc	6.89bc	10.80abc
	1t/ha	2.22abc	12.34a	14.23ab	16.50ab
	2t/ha	2.22abc	12.84a	16.13a	17.86a

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance.

Table 8: Effect of poultry manure rates and varietal differences on number of leaves of tomato varieties

		Weeks after planting			
TREATMENT		2	4	6	8
BESKE	0t/ha	26.22abc	41.22bc	94.33cd	108.78c
	1t/ha	31.78a	59.45abc	123.56bcd	136.44c
	2t/ha	17.89bc	23.44c	56.66d	74.33c
KEREWA	0t/ha	17.11c	47.00abc	96.22cd	122.89c
	1t/ha	21.56abc	90.56ab	242.22ab	359.35a
	2t/ha	28.78abc	74.67abc	63.33d	171.66bc
ROMA	0t/ha	24.67abc	77.78ab	145.77abc	187.33bc
	1t/ha	33.00a	92.78ab	255.33a	289.89ab
	2t/ha	30.89ab	96.22a	273.89a	343.90a
UC82B	0t/ha	24.11abc	46.33abc	155.32abc	155.55bc
	1t/ha	24.55abc	73.22abc	220.22abc	1833.22bc
	2t/ha	20.44abc	71.67abc	182.67abcd	183.78bc

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance

Effect of poultry manure rates and varietal differences in stem girth(cm) of tomato varieties: The effect of the manure rate used on the stem girth is portrayed in table 9 below. There was significant ($p<0.05$) differences in plant height among the different varieties throughout the period of observation. Kerewa at given rate of 1t/ha had the highest stem girth with (1.10) as compared to other varieties and rates, however Beske at given rate of 2t/ha had the lowest stem girth (0.57) as compared to other varieties and rates during the period of observation.

Effects of poultry manure rates and varietal differences on number of fruits and fruit weight : The effect of manure rate and varietal differences as portrayed in table 10 below shows a significant($p<0.05$) differences in number of fruits and fruit weight, Roma variety shows high response to 1t/ha and 2t/ha of manure rate with the value 95 and 92 respectively compared to the other varieties at different rates however Roma variety given 2t/ha of manure rates shows a high response to the fruit weight with the highest value 3.35 compared to other varieties at different rates throughout the period of experiment

Table 9: Effect of poultry manure rates and varietal differences in stem girth(cm) of tomato varieties

		Weeks after planting (WAP)			
TREATMENTS		2	4	6	8
BESKE	0t/ha	0.33abc	0.39cd	0.53cd	0.64cde
	1t/ha	0.30abc	0.41cd	0.51d	0.58de
	2t/ha	0.29bc	0.33d	0.44d	0.57e
KEREWA	0t/ha	0.27c	0.43cd	0.59bcd	0.71bcde
	1t/ha	0.35abc	0.61abcd	0.89a	1.10a
	2t/ha	0.40ab	0.73ab	0.51d	0.81abcde
ROMA	0t/ha	0.28c	0.50abcd	0.59bcd	0.72bcde
	1t/ha	0.41a	0.67abc	0.78abc	0.96ab
	2t/ha	0.39abc	0.75a	0.83ab	0.94abc
UC82B	0t/ha	0.31abc	0.45bcd	0.60bcd	0.74bcde
	1t/ha	0.32abc	0.64abc	0.82ab	0.79abcde
	2t/ha	0.35abc	0.65abc	0.79abc	0.89abcd

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance

Table 10: effect of poultry manure rates and varietal differences on number of fruits and weight of fruits (t/ha)

		NUMBER OF FRUITS	FRUITS WEIGHT (t/ha)
TREATMENTS			
BESKE	0t/ha	19c	1.23bc
	1t/ha	22c	1.35bc
	2t/ha	18c	0.93bc
KEREWA	0t/ha	23c	0.98bc
	1t/ha	40bc	2.57ab
	2t/ha	20c	0.98bc
ROMA	0t/ha	71ab	1.31bc
	1t/ha	95a	1.74bc
	2t/ha	92a	3.35a
UC82B	0t/ha	18c	0.71c
	1t/ha	21c	0.65c
	2t/ha	24c	1.77bc

Mean followed by the same alphabets in a column are not significantly different by DMRT at 5% level of significance

DISCUSSION AND CONCLUSIONS

Hidden hunger is becoming major problem in Africa and tomato is one of the fruit vegetables that contains essential nutrient that can address this problem. The fertility status of the soil is expected to benefit from poultry manure application since the manure is known to improve soil organic matter and macro-nutrient qualities of the soil. It was found that 2 t/ha poultry manure gave the most growth and highest fruit yield among all poultry manure levels. Soil pH tended to reduce with a rise in the amount of poultry manure suggesting that poultry manure lead to increased acidity in the soil. Excess N in the soil and soil acidity could cause nutrient imbalance in the tomato crop and a reduction in the uptake of certain nutrients (Ewulo et al., 2008).

The poultry manure could have supplied micronutrients which are essential for tomato growth and yield. Stephenson et al. (1990) and Oladotun (2002) reported that poultry manure contains macro and micro nutrients such as N, P, K, S, Ca, Mg, Cu, Mn, Zn, Bo and Fe. Agele (2001) also found that poultry manure litters resulted in better growth and yield of tomato than NPK fertilizer alone. In this study tomato performed well under application of poultry manure at different rates in terms of vegetation parameters. However, 1 t/ha of manure rate applied to tomato shows a great response on yield even under unfavorable climatic conditions.

This study showed that application rate of poultry waste had significant effect on growth and yield of tomato varieties especially Roma and Kerewa, hence the two rates and varieties are recommended to farmers in Abeokuta for tomato cultivation with higher yields.

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GROWTH AND YIELD OF THREE VARIETIES OF KENAF AS INFLUENCED BY APPLICATION OF POULTRY MANURE

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ABSTRACT

Field trials were conducted during the 2017 wet season at the Research farms of the Institute for Agricultural Research, Samaru and Kadawa to assess the response to application of poultry manure at different rates on growth and yield of three selected kenaf varieties. The treatment consists of four poultry manure rates (0, 2, 4 and 6 t ha^{-1}) and three kenaf varieties- Ifeken 400, Ifeken D1 400 and Girin danani. The trial was a 4 × 3 factorial laid out in a randomized complete block design and replicated three times. Plots supplied with 6 t ha^{-1} poultry manure significantly produced (p< 0.05) taller plants, higher shoot dry weight, seed weight plant^{-1}and seed yield. Although no statistical difference was observed among varieties during the growth stages (plant height and shoot dry weight) across sampling periods except in Samaru, at 3 and 6 weeks after sowing (plant height), where Girin danani produced significantly taller plants than other varieties. The interactions between varieties and poultry manure was significant on shoot dry weight in Samaru. However, Girin danani variety significantly produced (p <0.05) higher seed weight plant^{-1} of (125.88 and 135.92 g ha^{-1}) and seed yield of (209.7 and 226.5 kg ha^{-1}) in both locations, compared with Ifeken 400 and Ifeken D1 400 varieties. Based on the results obtained from this trail, the application of 6 t ha^{-1} poultry manure and Girin danani variety resulted in higher growth and seed yield in both locations. Therefore, the use of Girin danani variety and 6 t ha^{-1} poultry manure can be adopted by farmers in the Northern guinea and Sudan Savanna agro ecological zones to enhance the growth and seed yield of kenaf.

Key words: Growth, Seed Yield, Poultry manure, Kenaf and Varieties.

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) also called Bimly, Bimlipatum, Jute and Deccan Hemp is a member of the Hibiscus family (*Malvaceae*) and indigenous to Africa. It is an annual fibre crop (Alexopoulou *et al.*, 2000). The name kenaf is of Persian origin and is used to signify both the tall annual plant (*Hibiscus cannabinus* L.) with large flowers, characteristic of the Mallow family, and the bast fibre obtained from its stem (Angelini *at al.*, 1998). The genus Hibiscus is widespread, comprising of some 200 annual and perennial species. Francis *et al.*, (2010) reported that kenaf is closely related to cotton (*Gossypium hirsutum* L.) and okra (*Hibiscus esculentus* L.). Manzanares *et al*. (1997) reported that kenaf is one of the important fibre crops next to cotton and is cultivated for its core and bast fibres. Recently, the interest in growing kenaf has been increasing throughout the world for its elevated fibre content (Alexopoulou *et al.*, 2000). It is a fast growing crop and has high potential as an industrial crop (Manzanares *et al.*, 1997). The residual core fraction is used as biomass for energy production (Danalatos and Archontoulis, 2005). Kenaf is traditionally grown in east-central Africa, west Asia and in several southern states of America for fibre and seed oil production. It is also an excellent forage crop (Muchow and Wood, 1980), containing 18-30% crude leaf protein and stalk protein 5.8-12.1% (Ogbonnaya *et al.*, 1997). Investigations have indicated that Nigerian savanna soils are largely deficient in major essential nutrients like nitrogen, phosphorus and potassium. Making it necessary to supply and enrich the soil with applied nutrients using inorganic and organic sources such as poultry, cow and goat manure. The use of inorganic fertilizer is constrained by factors such as unavailability of the right type, at the right time, and at affordable cost, as well inadequate credit facilities for the farm inputs (Chude, 1999). Hence organic manure is a better alternative and a necessary option for improved crop production especially in the Guinea Savannah of Northern Nigeria. Poultry manure is relatively cheap, readily available to small holder farmers and improve soil physical properties compared to inorganic fertilizers, similarly the increasing demand for poultry manure was due to its health benefits and risk-free characteristics especially in vegetables and fruits production. Poultry manure has been found to have higher nutrients concentration (Iken and Amusa, 2004). Although in Nigeria research work on poultry manure recommendation for kenaf production is not available, however improve and high yielding kenaf varieties have been developed such as Ifeken 400 and Ifeken D1 400 through conventional breeding by the Institute of Agricultural Research and Training Ibadan, Oyo State which is affiliated to Obafemi Awolowo University. Research work on these varieties was mostly conducted in the rainforest agro ecology and derived Savanna agro ecological zones of the country. There is the need to extend the cultivation of these varieties in the northern and Sudan Savanna agro ecological zones of Nigeria, hence the use of Ifeken 400 and Ifeken D1 400 to investigate their adaptability in the zones. Based on this, the present study was conducted to determine the appropriate rate of poultry manure and suitable variety in growing kenaf for seed in the Northern guinea and Sudan savannah agroecological zones of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at the Institute for Agricultural Research (I.A.R) Farm, Samaru, (Latitude 110 11N Longitude 07' 38 E, 686m) above sea level in Kaduna State and at Kadawa, (Latitude 110 39 N Longitude 08' 27 E, 500m) above sea level in Kano State, in the northern Guinea and Sudan savannah ecological zones of Nigeria, respectively during the 2017 wet season (Kowal and Knabe, 1972). The treatments consisted of four rate of poultry manure (0, 2, 4 and 6 tons ha^{-1}) and three varieties of kenaf (Ifeken 400, Ifeken D1 400, and Girin danani). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The gross plot size was 4m x 3 (12m^2) while the net plot was 2 x 3 (6m^2).

The experimental field was cleared and harrowed twice, and raised seed beds were constructed according to plot size above. The poultry manure was applied 7 days before planting by mixing the manure thoroughly with the soil with a hoe in each plot as per treatment basis. Seeds were sown manually on 26th July, and 2nd August, 2017 wet season at the rate of 3 seeds per hole, at an intra-row spacing of 25cm and inter-row spacing of 50cm. Sowing was done on flat land after harrowing and the plants were thinned to 2 plants per stand at 3 weeks after sowing. Data was collected on plant height, shoot dry weight, seed weight plant^{-1} and seed yield were subjected to statistical analysis of variance (F-test) as described by (Snedecor and Cochran, 1967) to test significance of treatment effects. The treatment means were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS

Plant Height

The effects of varieties and poultry manure rate on the mean height of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 1. A significant difference between varieties at 3 and 6 WAS in Samaru. At 3 WAS, Girin danani significantly produced taller plants, than Ifeken D1 400 and Ifeken 400 which were statistically similar. At 6 WAS the production of tall plants by Ifeken 400 was significant, while Girin danani significantly produced taller plants than Ifeken D1 400. At Kadawa, no significant difference was observed between varieties on plant height of kenaf at all sampling periods. Application of poultry manure significantly influenced the height of kenaf at 3 and 6 WAS in Samaru and 3-12 WAS at Kadawa. Where the application of 6 t ha^{-1} poultry manure produced taller plants than other rates. The interactions between varieties and poultry manure rate on the mean height of kenaf was not significant throughout the period of study.

Table 1: Effects of varieties and poultry manure rate on the mean height of kenaf at Samaru and Kadawa during the 2017 wet season

	Plant Height (cm)							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety (V)								
Ifeken 400	41.47b	140.41a	168.05	180.02	48.28	151.59	174.92	201.02
Ifeken D1 400	41.56b	137.12b	164.15	178.40	45.92	151.91	176.52	202.72
Girin danani	43.78a	138.73ab	162.88	175.55	45.03	152.71	174.68	198.11
SE±	0.681	0.980	3.375	4.490	1.231	3.983	3.888	4.463
Poultry manure(t ha^{-1})								
0	36.57b	132.82c	160.42	172.80	39.31c	141.92b	162.73c	178.24b
2	43.87a	138.18b	161.73	174.00	45.62b	156.81a	171.22bc	186.08b
4	43.82a	140.45ab	165.42	177.74	47.97b	154.37ab	182.11ab	216.86a
6	44.82a	143.56a	172.53	187.39	52.74a	155.17ab	185.44a	221.28a
SE±	0.787	1.132	3.897	5.185	1.422	4.599	4.490	5.154
Interaction								
V x M	NS	NS	NS	NS	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT.
WAS = Weeks after sowing NS = Not significant ** = significant at 1%

Shoot dry weight

The effects of varieties and poultry manure rate on the mean shoot dry weight of kenaf during the 2017 wet season at Samaru and Kadawa is presented in Table 2. No significant difference between varieties was recorded at all sampling periods in all locations. Application of poultry manure significantly influenced shoot dry weight of kenaf at 9 WAS in Samaru where the application of 4 t ha^{-1} poultry manure produced a significantly higher shoot dry weight than at 0 t ha^{-1}; but statistically at par with plots applied with 2 and 6 t ha^{-1}. The least shoot dry weight was recorded on plots with 0 t ha^{-1}poultry manure application. There was a significant difference on the application of poultry manure on the shoot dry weight of kenaf at all sampling periods in Kadawa. At 3 WAS, the application of 2 t ha^{-1} poultry manure produced significantly higher shoot dry weight than plots with 0 t ha^{-1}; but statistically at par with plots applied that had 4 and 6 t ha^{-1} poultry manure application. However, at 6, 9 and 12 WAS, shoot dry weight of kenaf generally increased with increasing rate of poultry manure from 0 to 6 t ha^{-1}. Shoot dry weight was significantly higher in plots with 6 t ha^{-1} poultry manure than on those with 0 t ha^{-1}. There was no significant difference on shoot dry weight from plots with 6 t ha^{-1} of poultry manure application and those applied with 2 and 4 t ha^{-1}. The lowest shoot dry weight was recorded on plots with 0 t ha^{-1}.

The interactions between varieties and poultry manure rate on the mean shoot dry weight of Kenaf was significant at 9 and 12 WAS in Samaru is presented in Table 3. At 9 WAS, the combination of poultry manure rate and varieties had a significantly higher shoot dry weight with Ifeken 400 and 2 t ha^{-1} poultry manure; and was statistically similar with the variety Girin danani applied with poultry manure at 2 and 4 t ha^{-1}. The lowest shoot dry weight was recorded with Ifeken D1 400 which had 2 t ha^{-1} poultry manure. At 12 WAS, Ifeken 400 applied with 2 t ha^{-1} poultry manure applicationproduced the highest shoot dry weight; but was statistically at par with Girin danani which had poultry manure at 2 and 4 t ha^{-1}poultry manure applicationand Ifeken D1 400 at 0 t ha^{-1}. The lowest shoot dry weight was recorded with Ifeken 400 at 0 t ha^{-1}.

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Table 2: Effects of varieties and poultry manure rate on the mean shoot dry weight of kenaf at Samaru and Kadawa during the 2017 wet season

	Shoot dry weight (g)							
	Samaru				Kadawa			
Treatment	**3WAS**	**6WAS**	**9WAS**	**12WAS**	**3WAS**	**6WAS**	**9WAS**	**12WAS**
Variety								
Ifeken 400	11.24	15.95	23.94	25.68	11.48	14.99	18.96	23.69
Ifeken D1 400	11.56	16.12	20.99	24.43	11.30	15.24	18.21	22.63
Girin danani	10.98	16.82	23.25	25.58	11.30	14.75	18.78	23.69
SE±	0.549	0.859	0.698	0.815	0.168	0.427	0.474	0.993
Poultry manure(tha^{-1})								
0	10.87	14.82	20.35b	23.89	10.94b	12.47c	15.33c	20.37b
2	11.14	17.20	23.29a	26.86	11.61a	14.11bc	18.97b	22.85ab
4	11.84	17.03	23.35a	26.12	11.39ab	15.29b	19.52ab	24.38a
6	11.19	16.13	22.51ab	23.97	11.51ab	18.11a	20.72a	25.81a
SE±	0.634	0.992	0.806	0.942	0.194	0.569	0.548	1.147
Interaction								
V x M	NS	NS	**	**	NS	NS	NS	NS

Means in a column of any set of treatment followed by different letter (s) are significantly different at 5% level using DMRT. WAS = Weeks after Sowing, ** = significant at 1%, NS = Not significant

Table 3: Interaction between varieties and poultry manure rate on the mean shoot dry weight of kenaf at 9 and 12WAS at Samaru during the 2017 wet season

	9 WAS			
Treatment	**Poultry manure (t ha^{-1})**			
Variety (V)	0	2	4	6
Ifeken 400	19.41cd	27.35a	22.87bc	22.84bc
Ifeken D1 400	22.33bc	15.97d	23.37bc	22.29bc
Girin danani	19.31cd	26.45ab	23.92a-c	22.42bc
SE± 1.398				
12 WAS				
Treatment	**Poultry Manure (t ha^{-1})**			
Variety (V)	0	2	4	6
Ifeken 400	21.39d	31.63a	26.86bc	23.59b-d
Ifeken D1 400	26.93a-c	21.92cd	25.31b-d	23.58b-d
Girin danani	23.34b-d	27.20ab	26.98ab	24.76b-d
SE± 1.631				

Means followed by the same letters do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT)

Seed weight plant^{-1}

The effects of varieties and poultry manure rate on mean seed weight per plant of Kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 4. A significant difference was recorded between varieties at both locations. At Samaru, Girin danani produced significantly higher seed weight of Kenaf than Ifeken 400, butwas statistically at par with Ifeken D1 400. Similarly, Ifeken D1 400 recorded statistically the same seed weight per plant with Ifeken 400. However, at Kadawa, Girin danani significantly recorded the highest seed weight per plant over Ifeken D1 400 and Ifeken 400. Ifeken D1 400 recorded significantly higher seed weight per plant compared to Ifeken 400. The application of poultry manure significantly increased the seed weight per plant at both locations. At Samaru, the application of 6 t ha^{-1} poultry manure significantly produced the highest seed weight per plant of Kenaf. The application of 2 and 4 t ha^{-1}, recorded seed weight per plant that were statistically at par with each other; while the least seed weight per plant was observed on plots applied with 0 t ha^{-1}.

At Kadawa, seed weight per plant significantly increased with poultry manure rate from 0 to 6 t ha^{-1}. The interaction effect between varieties and poultry manure rate on seed weight per plant of Kenaf was not significant in both locations.

Table 4: Effect of varieties and poultry manure rates on the mean seed weight per plant of kenaf at Samaru and Kadawa during the 2017 wet season.

	Seed weight per plant (g)	
Treatment	**Samaru**	**Kadawa**
Variety		
Ifeken 400	119.81b	125.94c
Ifeken D1 400	121.22ab	130.35b
Girin danani	125.88a	135.92a
SE±	1.764	0.663
Poultry manure(t ha^{-1})		
0	108.10c	112.25d
2	122.81b	124.17c
4	122.34b	136.50b
6	135.97a	150.02a
SE±	2.037	0.766
Interaction		
V x M	NS	NS

Means in a column of any set of treatment followed by difference letters are significantly difference at 5% level using DMRT. NS = Not significant

Seed yield

The effects of varieties and poultry manure rate on the mean seed yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season is presented in Table 5. A significant difference was observed between varieties at both locations, in which Girin Danani produced higher seed yield ha^{-1} than other varieties that were tested. Application of poultry manure significantly influenced seed yield at both locations. The application of 6 t ha^{-1} poultry manure significantly showed the highest seed yield against other treatments.

Table 5: Effect of varieties and poultry manure rates on mean seed yield per hectare of kenaf at Samaru and Kadawa during the 2017 wet season.

	Seed yield per hectare (kgha^{-1})	
Treatment	**Samaru**	**Kadawa**
Variety		
Ifeken 400	199.6b	209.9c
Ifeken D1 400	203.2ab	217.2b
Girin danani	209.7a	226.5a
SE±	2.744	1.106
Poultry manure(t ha^{-1})		
0	180.1c	187.0d
2	204.6b	206.9c
4	205.5b	227.5b
6	226.6a	250.0a
SE±	3.169	1.277
Interaction		
V x M	NS	NS

Means followed by the same do not differ significantly at 5% level of probability according to Duncan Multiple Range Test (DMRT). NS = Not significant

DISCUSSION

The positive response of growth components such as (plant height and shoot dry weight) to poultry manure application from 2 to 6 t ha^{-1} at both locations could be attributed to the beneficial role of manure in providing soil nitrogen, phosphorus, potassium and other essential nutrients, which in turn improved growth and development of the plants during the trial. This is in consonance with the findings of Adekunle et al. (2014) who reported that the application of manure from 10-20 t ha^{-1} significantly increased the growth attributes of kenaf. The interaction between varieties and poultry manure was significant on shoot dry weight, where the combination of Ifeken 400 and 2 t ha^{-1} poultry manure produced higher shoot dry weight in Samaru. This could be probably due to the morphology of the variety and its ability to utilize the nutrients supplied by the poultry manure for rapid growth and development. This is in agreement with the findings of Mubarak (2014b) who reported that higher shoot dry weight was obtained in clemson spineless variety of okra as a result of the morphology of this variety which was taller than Ex Samaru 4 and it contributes to the weight of the variety (clemson spineless). Seed yield ha^{-1} was observed to increase significantly with the application of 6 t ha^{-1} of poultry manure at both locations. This could be due to the appreciable amount of essential nutrients in the poultry manure (N, P, K, Ca and Mg) and the favourable weather conditions during the 2017 wet season that favored the quick decomposition of the manure. This result conforms to earlier findings by Atif et al. (2015) who reported a higher yield of jute mallow when poultry manure was applied. The significant differences recorded among the three kenaf varieties in terms of their growth and yield such as plant height, shoot dry weight, seed weight plant^{-1} and seed yield of kenaf is attributed to differences in the genetic composition of the varieties used. This is in line with the study of Akinfasoye et al. (1997) who reported that the differences in yield parameters of crops are attributed to the cultivars grown and their genetic make-up.

Girin danani produced higher seed weight plant^{-1} and seed yield than Ifeken 400 and Ifeken D1 400 at both locations. Apart from the genetic composition of the variety which plays an important role in the potential yield of the crop, the differences in the rate of nutrient absorption and utilization among the three varieties and environmental variations could greatly influence the yield of kenaf. This result agrees with the finding of Williams (2004) who observed differences in yield of kenaf varieties due to different genetic make-up of these varieties.

CONCLUSION

Kenaf variety Girin danani showed superiority over Ifeken 400 and Ifeken D1 400 on all the growth and yield components in this study. The study further confirmed the valuable contribution of poultry manure, where the application of 6 t ha-1 poultry manure had the best results of all parameters in both locations.

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INFLUENCE OF ORGANIC FERTILISER APPLICATION ON THE LEVEL OF HEAVY METALS IN CUCUMBER (*CUCUMIS SATIVUS* L.) PRODUCTION AND ITS RISK ASSESSMENT

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ABSTRACT

A field study was carried out at the experimental site of National Horticultural Research Institute, Idi-ishin, Ibadan, Oyo State, Nigeria, to assess the heavy metals concentration in cucumber planted using organic fertilisers to enhance its production and determine its health risk index (HRI) and target hazard quotient (THQ) if consumed. There were four treatments: Poultry manure (PM), Composted cow dung (CCD), Liquid Organic fertilizer (LOF) and the control (CTR) which were laid out in a randomised complete block design replicated three times. Heavy metal analyses were determined in all the samples of the fertilisers and the soil before use as well as the cucumber after harvest using standard procedures. Results were analysed using ANOVA at p<0.05. LOF and CTR had the least values of heavy metals (0.08 and 0.00) mg/kg while others ranged from 0.30 and 0.31 mg/kg. The CCD had the highest value (Chromium (Cr): 110.27 mg/kg) while the CTR had 0.00 mg/kg of Lead (Pb). All fertilisers treatments had higher values of heavy metals above FAO/WHO standard. The heavy metals concentration ranged from 12.9 mg/kg of Pb to 3.0 mg/kg of Cadmium (Cd) in the soil and 145 mg/kg of Zinc (Zn) to Not Detected (ND) in both Cd and Pb (for PM and LOF) in the fertilisers. HRI and THQ for heavy metals in the fertiliser treatments for cucumber were <1 although Pb was highest 0.45 and 0.88 for both HRI and THQ. Consumption of cucumber grown with the fertiliser treatments could not have health impact (HRI and THQ <1) but continuous consumption could lead to bioaccumulation of heavy metals especially Pb in the consumers. It is however suggested that liquid organic fertilisers should be used in other to have safe and quality cucumber.

Key words: Health risk, Hazard Quotient, Soil, Cucumber

INTRODUCTION

Cucumber (*Cumunis sativus* L.) is one of the main fruit that is eaten raw, cooked or in salad. The presence of terpenoid, a main phytochemical constituent in cucumber possesses medicinal effectiveness against malaria, viral, bacterial and fungal agents (Egwaikhide, 2010) as obtained from its extract (Ankita *et al*., 2012). Soils are enhanced by applying fertilisers that supply additional plant nutrients and also boost the plant growth. Organic fertilisers (OFs) are composed mainly of plant and animal waste. Application of OFs to the soil has shown a positive influence on the growth and yield of crops (Udoh *et al*., 2005); alongside a slight increase in human food chain toxicity (Brady and Weils, 2002). This is because they contain not only major elements necessary for plant nutrient but other variable qualities of heavy metals (Ali *et al*., 2013) which increase up the food chain. Heavy metals become toxic when they are not metabolised by the body and accumulate in the tissues. These pollutants cannot be excreted efficiently in the human body hence they build up (Godfrey *et al*., 2003) leading to ill health, diseases and finally death. This study was therefore conducted to assess the heavy metals concentration in cucumber, associated with the health risk index and target hazard quotient.

MATERIALS AND METHODS

Experimental Site Description

The experiment was carried out at the National Horticultural Research Institute (NIHORT) Jericho, Ibadan, Oyo State, Nigeria. The area lies between Latitude 7^0 54^1 N, Longitude 3^0 54^1 E and 213m above sea level in the Greenwich meridian, its average rainfall is about 1250 mm, while average mean temperature is 26 ^{0}C. The average relative humidity is 74.53%

Treatments and Experimental design

Seeds of cucumber (NAGANO F1) and LOF were purchased from Agrotropics Seed Company Bodija, Ibadan. The PM was collected from NIHORT poultry farm while the CCD was purchased from Aleshinloye Fertiliser Company, Ibadan. The treatments were: LOF at 500 ml/ha, CCD at 20 tons/ha, PM at 20 tons/ha as recommended by Adeniyi (2014) and the CTR (without organic fertiliser). The experiment was laid out in a randomised complete block design with each of the four treatments replicated three times.

Analysis of Heavy Metals in Samples

Heavy Metals Determination in Cucumber and Soil

Maturity of cucumber fruits were determined from very greenish colour to yellowish green and were harvested by plucking randomly at 6-8 weeks after sowing. Harvested fruits were collected together to form a composite sample. Soil samples were randomly collected from the depth of 0-15 cm using calibrated soil auger. They were randomly looped together to form a composite and taken to the Toxicology Research Laboratory of Crop Protection and Environmental Biology, University of Ibadan for air drying and digestion using the AOAC, 2005 and taken to the multidisciplinary central research laboratory for heavy metals determination using Atomic Absorption Spectrophotometry (AAS) using the Roychowdhury and Tah (2011) method.

Determination of Health Risk Index and Target Hazard Quotient

DIM = (C_{metal} × C_{factor} × $D_{food\ intake}$) ÷ ($B_{average\ weight}$) (Rattan *et al.*, 2005; USDA, 2007). Where C_{metal} = Conc. in plants (mg/kg), C_{factor} = Conversion factor (0.085) (Sajjad Khan *et al.*,2009). $D_{food\ intake}$ = Daily intake of vegetables (kgd^{-1}), 100g was used (Lanre-Iyanda and Adekoye, 2013). $B_{average\ weight}$ = average body weight (kg), 60kg (ESFA, 2012). HRI = DIM ÷ RfD (US-EPA, 2013).

$$THQ = \frac{EF \times ED \times FIR \times C}{RFD \times WAB \times TA}$$

Where: EF = Exposure Frequency $350\frac{days}{year}$ ED = Exposure Duration = 54 years (average life time of Nigerian Population) FIR = Food Ingestion Rate (vegetable consumption values for South western adult in Nigeria is 60g/person/day) WAB = Average Body Weight = 60 Kg for adult TA = Average exposure time for non-carcinogens (ED × $365\frac{days}{year}$ (Oguntona, 1998). If HRI and THQ is <1, the exposed population is said to be safe and if ≥1, the population will experience health risk (IRIS, 2003).RfD = Oral Refence Dose

Statistical Analysis

Results were analysed using analysis of variance and means were separated at a probability of five percent (5%) level of significance using Duncan Multiple Range Test

RESULTS AND DISCUSSION

Heavy metals in Organic Fertilisers before planting

The range of heavy metals in the fertilisers were from ND in both LOF and PM in Cd and Pb; 349.78 in Cr (Table 1). This is in consonance with Ogabiela *et al.*, 2009 that organic fertilisers had the highest Cr value although its uptake could be within the permissible limit. Cd and Pb was only detected in CCD while Zn and Cr occurred in all the fertilisers.

Table 1: Comparison of some heavy metals concentration in the Fertilizers Used

Fertilizer	mg/kg Cu	mg/kg Zn	mg/kg Cr	mg/kg Cd	mg/kg Pb	mg/kg Ni
Compost	23.00	145.00	310	3.00000	80.0000	11.0000
Poultry	15.00	106.00	16	ND	ND	5.0000
Liquid	216.025	60.625	349.175	ND	ND	15.625
WHO	90.260	800-1200	--	15-40	200-400	--
EPA	1500	--	1200	--	300	--

Heavy metals present in soil samples ranged from 12.9 in Pb to 3.0 in Cd (Pb>Cr>Zn>Cd) and were above the WHO/FAO2001 standard this is in line with Olatunji*et al.*, 2013 and Radwan and Salama, 2006 which carried out a survey of various fruits and vegetables for heavy metals in the soil (Table 2).

Table 2: Some heavy metals concentration in the soil sample before fertilizer application

No	mg/kg Cr	mg/kg Zn	mg/kg Cd	mg/kg Pb
SOIL	12.80	5.856	3.0	12.9
WHO	-	0.3	-	0.1
EU (2001)	-	-	3.0	300

Heavy Metals Concentration in Cucumber

The CTR had the highest Zn values (9.17 mg/kg) which varied from other fertilizer treatments (4.39-5.35 mg/kg). LOF had the lowest Cd (0.15 mg/kg) while the control had the highest value (0.47 mg/kg) with significant difference amongst the treatments (Table 3). CCD had the highest value for Cr (110.28 mg/kg) while the CTR had 92.86 mg/kg as the lowest with significant difference. The sample trend was observed in the value of Pb (3.66 mg/kg) in CCD while it had 0.00 mg/kg in the CTR. Dotse *et al*., 2010 investigated Pb, Cu, Cr, Zn and Cd in different vegetables, cucumber included and found that Pb contents exceeded the permissible limit which is in consonance with the CCD.

Table 3: Some heavy metals concentration in the Cucumber

Fertilizer	mg/kgZn	mg/kgCr	mg/kgPb	mg/kg Cd
Compost	5.01	110.27	3.66	0.30
Poultry	4.39	109.85	1.12	0.31
Liquid	5.35	103.52	0.08	0.15
Control	9.17	92.86	0	0.47
EU	50	1	0.43	0.2
NAFDAC	50	-	2	-
FAO/WHO, 2016	9.4	2.3	0.1	-

Result on the HRI and THQ revealed all heavy metals less than 1 (<1) below the tolerable limit as presented in figure 1-4. The high transfer values for Cr from soil to fruit indicates a strong accumulation of the receptive metals in the region as reported by Fayinminnu and Adekunle-Jimoh (2015). Pb indicated the highest value for its HRI and THQ which if accumulated could be detrimental. An important aspect of assessing risk to human health from potentially toxic metals is the knowledge of the dietary intake of the metals (DIM) (Cherfi *et al*., 2014; Chery *et al*., 2008). Health quotient has been a useful parameter for evaluation of risk associated with consumption of metal contaminated food crops (Chary *et al*., 2008 and Zhuang *et al*., 2009). The existential potential for chromium and lead contamination and toxicity raises the issue of future monitoring (Udousoro and Essien, 2015).

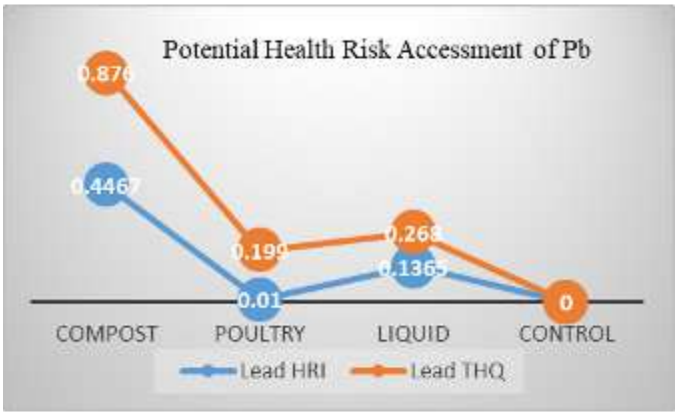

Figure 1. Potential Health Risk Assessment of Lead (Pb) through ingestion of *Cucumis sativus* fruit

Footnote: HRI = Health Risk Index and THQ = Target Hazard Quotient.

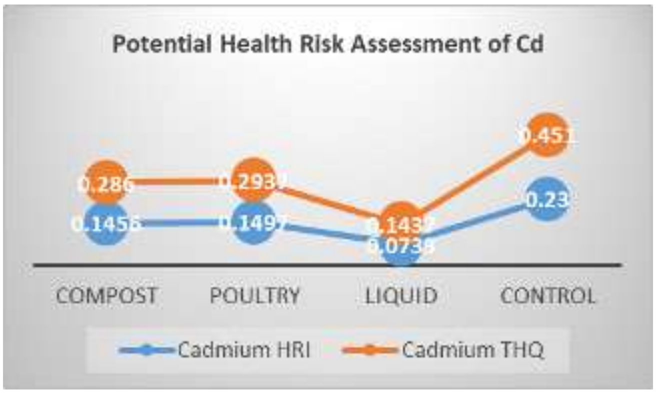

Figure 2. Potential Health Risk Assessment of Cadmium (Cd) through ingestion of *Cucumis sativus* fruit

Footnote: HRI = Health Risk Index and THQ = Target Hazard Quotient.

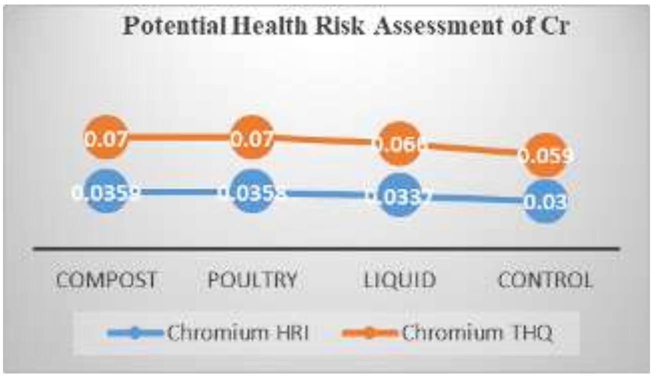

Figure 3. Potential Health Risk Assessment of Chromium (Cr) through ingestion of *Cucumis sativus* fruit

Footnote: HRI = Health Risk Index and THQ = Target Hazard Quotient.

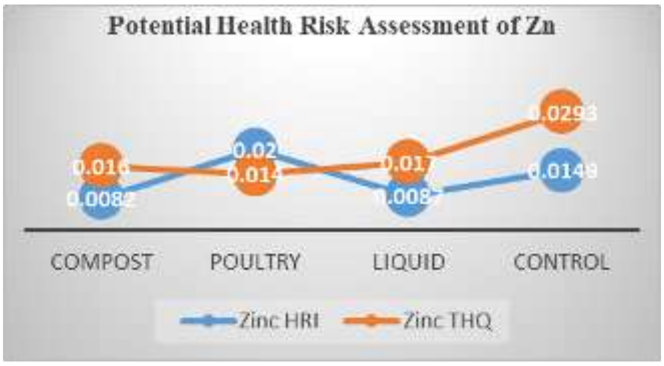

Figure 4. Potential Health Risk Assessment of Zinc (Zn) through ingestion of *Cucumis sativus* fruit

Footnote: HRI = Health Risk Index and THQ = Target Hazard Quotient.

CONCLUSION AND RECOMMENDATION

Cucumber fruit could contribute to bio-accumulation magnification of cadmium and chromium in humans. Although the human health risk and target hazard quotient associated with cucumber fruit production were negligible (health quotient<1), it was observed that Pb in the fruit presented the highest values for the THQ and HRI in the study area. Also instances where cucumber is planted for the influx harvesting of fruits at a short period of time, LOF be used at the recommended rate of 500ml/ha which was best suitable for tolerable heavy metals in cucumber fruits a unique significant difference in output.

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EFFECTS OF ORGANIC AND INORGANIC SOIL AMENDMENTS ON THE LYCOPENE CONTENT OF INTERCROPPED TOMATO VARIETIES

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ABSTRACT

Lycopene, a red pigment carotenoid is one of the most important antioxidants that is contained in ripe tomato fruits. Field experiments were conducted to investigate the effects of NPK 15-15-15 fertilizer and poultry manure on the lycopene content of two tomato varieties. The study was conducted at the National Horticultural Research Institute, Ibadan, (Lat. 7^0 30'N; Long. 3^0 50'E) during the 2011 and 2012 cropping seasons. The experiments were design as 2x2x5 factorial in Randomized Complete Block and arranged in Split–Split plots, comprising of two cropping systems two tomato varieties (Uc82B and Ibadan local) and soil amendments (0, 60, and 120 kg N/ha NPK 15-15-15 and 10 and 20 tons/ha poultry manure). The application of 20 t/ha poultry manure showed the highest value of lycopene while the non application of any form of soil amendment resulted in the lowest.

Key words: Lycopene. Intercropping, NPK 15-15-15 fertilizer, poultry manure, Uc82B, Ibadan local.

INTRODUCTION

Consumption of tomato products has been associated with decreased risk of some cancer types (Vinson *et al.,* 1996), because of the nutrients contained it. Tomatoes have been reported to be an important source of many nutrients such as lycopene. Lycopene is the red pigment carotenoid which is also responsible for the characteristic red colour of most tomato varieties (Rahayu et al., 2018). Intercropping tomato with appropriate crops, would lead to increased productivity and reduced risk of total crop failure, it may also affect the fruit quality, although according to (Woese, 1997), differences between varieties and other environmental conditions had greater influence on fruit quality than did the different cultivation systems. Adoption of improved varieties and agro technique also makes increased productivity attainable. Tomato responds well to additional fertilizer applied and it is reported to be a heavy feeder of NPK (Hebbar *et al*., 2004), deficiency of which is a major production constraint in some soils (Lester, 2006). Different kinds of fertilizer and application methods are reported to have different effects on the yields and quality of tomato fruits (Lester, 2006). Therefore, the objective of this research work is to determine the effects of intercropping system and application of organic and inorganic soil amendments on the yield and Lycopene content of two varieties of tomato (Uc82B and Ibadan local).

MATERIALS AND METHODS

Soil and Poultry Manure Analysis

The soil sample and cured poultry manure were analyzed for total nitrogen, pH, organic carbon, available P, exchangeable Ca, K, Mn, Na, and Mg. Total N. Analyses were carried out using the standard analytical laboratory procedure of IITA (IITA, 1994).

General Treatments and Experimental Design

The study was conducted at the National Horticultural Research Institute (NIHORT), Jericho, Idi-Ishin, Ibadan. NIHORT is located in the rainforest savanna transition zone and falls approximately on latitude 7^0 30'N and longitude 3^0 50'E. It is at altitude 168m above sea level. Two varieties of tomatoes :(Uc82B and Ibadan local) were intercropped with maize cultivar SAMMAZ 14.

The experiments were design as 2x2x5 factorial in Randomized Complete Block and arranged in split–split plots and replicated three times. The experimental factors include; cropping system (Sole and Intercrop), variety (Ibadan local and Uc82B) and soil amendment which consisted of 0, 60 and 120kg N/ha NPK 15-15-15, 10 and 20t/ha of Poultry Manure. Incorporation of organic manure into soil involved digging the poultry manure into the soil using spade fork two weeks before planting. The NPK 15-15-15 fertilizer was applied by ring placement into drills 5 cm deep and 7.5 cm away from the plant and covered with soil, 3WAT.

Lycopene

The milled tomato samples were reconstituted in distilled water and mixed thoroughly. Lycopene in the samples was extracted by hexane-acetone-ethanol (2:1:1, v: v: v) mixture, following the method of Sharma and Le Maguer (1996). The absorbance of hexane solution containing Lycopene was measured at 472nm on a Spectrophotometer (Unikon 930, Kontron, Italy). Using hexane as a blank. The Lycopene concentration was calculated using its specific extinction coefficient (E 1%1cm) of 3450 in hexane. Data were subjected to analysis of variance using GenStat Discovery Edition 4 (2011). Significant means separated by the least significant difference at 5% probability level ($LSD_{0.05}$).

RESULTS

Effects of cropping system, soil amendment and variety on tomato fruits yield.

The results of the pre-treatment soil analysis of the experimental site of this study also indicated low N, P, and K: Total N (0.30, 0.65 g/kg); Available P (8.09, 12.5); Exchangeable K(0.23, 0.13cmol). The poultry manure used contained N (2.90, 2.92g/kg); Ca (3.55, 2.57g/kg); Mg (0.55, 0.43g/kg); P (1.65, 1.55g/kg) and K (1.80, 1.83g/kg) in 2011 and 2012 respectively.

Effects of cropping system, variety and soil amendments on tomato Lycopene content

The results show that Ibadan local tomato variety produced significantly higher lycopene contents than Uc82B in the two years of the study, while the antioxidant varied significantly with the application of the different forms and rates of soil amendment with the application of 20 t/ha poultry manure showing the highest value and non-application of any form of soil amendment resulting in the lowest value (Table 1). The application of 0 and 120 kg N/ha NPK and 10 t/ha PM resulted in significantly higher lycopene contents in Ibadan local than in Uc82B, while the application of 60 kg N/ha NPK and 20 t/ha PM resulted in similar lycopene contents in the two tomato varieties (Table 2). However, under the intercropping system (Table 2), the application of 0 and 120 kg N/ha NPK and 10 t/ha resulted in significantly higher contents of lycopene in the Ibadan local than in Uc82B which variety showed higher lycopene content with the application of 60 kg N/ha NPK, while the application of 20 t/ha PM showed similar lycopene contents in the two varieties. In 2012 (Table 2) revealed that when the tomatoes were planted as sole crops, the application of any form and rate of soil amendments resulted in significantly higher lycopene contents in the Ibadan local than in the Uc82B, with the exception of the application of 60 kg N/ha NPK with higher lycopene content in Uc82B than in Ibadan local. Although under the intercropping system (Table 2), the application of the soil amendments resulted in significantly higher lycopene contents in Ibadan local than in the Uc82B, with the exception of the application of 20 t/ha PM which resulted in similar lycopene contents in the two varieties.

Table 1. Main effects of cropping system on tomato fruits Lycopene content in 2011 and 2012

		Lycopene content (mg/g)	
Cropping System		**2011**	**2012**
Sole crop		13.14	10.92
Intercrop		12.55	10.56
	$LSD_{0.05}$	ns	ns
Variety			
Ibadan Local		13.69	11.67
Uc82B		12.00	9.80
	$LSD_{0.05}$	0.35	0.37
Soil amendment			
0 kg /ha		10.82	8.67
60 kg N/ha NPK		11.65	11.84
120 kg N/ha NPK		12.24	9.33
10 t/ha PM		13.07	10.55
20 t/ha PM		16.44	13.30
	$LSD_{0.05}$	0.94	0.55

PM=poultry manure, least significant difference at 5 percent probability level ($LSD_{0.05}$)

Table 2. Interactive effects of sole system, variety and soil amendment on Lycopene content of tomato fruit in 2011 and 2012

			Lycopene content (mg/g)	
Cropping system	**Variety**	**Soil Amendment**	**2011**	**2012**
Sole	Ib. Local	0 kg /ha	13.66	12.00
		60 kg N/ha NPK	11.96	9.93
		120 kg N/ha NPK	14.65	12.40
		10 t/ha PM	13.90	12.10
		20 t/ha PM	17.40	14.70
	Uc82B	0 kg /ha	8.27	6.36
		60 kg N/ha NPK	10.73	12.80
		120 kg N/ha NPK	11.39	8.84
		10 t/ha PM	12.38	9.35
		20 t/ha PM	17.07	10.80
Intercrop	Ib. Local	0 kg /ha	12.42	9.59
		60 kg N/ha NPK	10.00	13.00
		120 kg N/ha NPK	12.25	8.82
		10 t/ha PM	14.95	11.90
		20 t/ha PM	15.68	13.80
	Uc82B	0 kg /ha	8.95	6.71
		60 kg N/ha NPK	13.89	11.60
		120 kg N/ha NPK	10.66	7.31
		10 t/ha PM	11.04	8.86
		20 t/ha PM	15.63	13.80
		$LSD_{(0.05)}$	1.52	1.06

PM=poultry manure, least significant difference at 5 percent probability level ($LSD_{0.05}$)

DISCUSSION

The low nutrient content of the soil especially in the year 2011 may be attributed to the established fact that plant nutrient is limiting in most of the Nigeria farmlands as observed (Obigbesan, 2000). The nutrients composition of the poultry manure used for this study suggested that it was adequate to improve the soil fertility, thereby enhancing the performance of the tomato crop. The two tomato varieties responded differently to the different soil amendments, confirming their different genetic background as Passam *et al*. (2007) observed that tomatoes' response to a particular nutrient vary with cultivars. The results obtained in this study also suggested that there are no appreciable evidences for cropping system effect on Lycopene content in contrast to the report of Barrett *et al*. (2007) who found significant impacts of production system on lycopene. But its levels varied significantly with the different variety of tomatoes in agreement with the previous findings in which Lycopene content of tomatoes were found to vary between cultivars which may be due to their genetic background and differences, (Rahayu *et al.* (2018), Helyes *et al.*, 2012, George *et al*., 2004). Toor *et al*., (2006), had noted that fertilizer sources can have a significant effect on tomato quality; in affirmation this study showed some significant differences in value. that the application of 20 t/ha poultry manure gave the highest value, similar values have been reported even with lower quantity (10.0 t ha^{-1}) by Yadava *et al*. (2012), indicating that organic manure is an effective source of antioxidants especially lycopene.

CONCLUSION

Ibadan local tomato variety is a better source of lycopene content than Uc82B; poultry manure as an organic fertilizer supplied better lycopene than the inorganic fertilizer. In conclusion, in addition to other benefits of organic manure antioxidant content of tomato fruits may be improved by its application.

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COMPARATIVE INFLUENCE OF HUMAN URINE, OTHER ORGANIC AND INORGANIC FERTILIZER SOURCES ON THE GROWTH AND PRODUCTIVITY OF POTTED AND FIELD TRIALS OF *MORINGA OLEIFERA*

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ABSTRACT

The significance of organic and inorganic nutrients for crop growth and productivity cannot be overemphasized. Pot and field trials were carried out in the department of crop science university of Nigeria, Nsukka. The Pot experiment was laid out in a completely randomized design (CRD) in 15 replications while the field experiment was laid out in a randomized complete block design (RCBD) in 3 replications. These studies were designed to compare the effect of organic and inorganic fertilizers on the performance of Moringa oleifera in pot and field. Human urine, poultry manure and pig manure were applied as organic sources while NPK 15:15:15 served as inorganic fertilizer. Poultry manure and pig manure were incorporated into the soil at the rate of 10t/ha according to their appropriate requirements, 4 weeks before planting. Similarly, 4 parts of water was mixed with 1 part of human urine and 240t/ha of NPK 15:15:15 was applied in two split doses as well as a control experiment. Two seeds of Moringa.oleifera were planted for both pot and field trials. Results of the Analyses of variance (ANOVA) indicated significance ($P<0.05$) among treatments with respect to most of the component traits measured. Poultry manure significantly ($P<0.05$) influenced the morphological, physiological and yield parameters of Moringa oleifera compared to other treatments used in both experiments. Poultry manure gave the highest plant height of 103.0 cm and 133.4 cm for experiments 1 and 2, respectively while its application also gave the highest stem girth of 5.11 cm and 4.9 cm in both experiments 1 and 2 respectively, compared to human urine, pig manure and NPK 15:15:15, which gave relatively lower values. The control had the least plant height and stem girth in both experiments. However, results from these experiments affirmed that the use of both organic and inorganic fertilizer could positively enhance crop growth, yield and productivity. It also confirmed the use of human urine as a substitute for nitrogenous chemical fertilizers.

INTRODUCTION

Moringa oleifera is a evergreen, fast growing and drought resistant plant which belongs to the *Moringaceae* family. It can reach a maximum height of 7-12 m and a diameter of 20-40 cm at chest height additionally, it is perennial in nature. The stem is normally straight and branches at a height of 1.5 to 3 m (Fuglie and Sreeja, 2011). *M. oleifera* is a highly nutritious and medicinal plant with great agricultural, industrial and domestic uses (Moyo *et al*., 2011, Ndubuaku and Ndubuaku, 2011). Almost every part of moringa tree has been consumed by humans' overtime. It has been used for various domestic purposes as well as alley cropping, animal forage, water purification, machine lubrication (oil), manufacture of perfume, and hair care products. Besides culinary and other domestic uses, several biological properties ascribed to various parts of this tree have been reviewed in the past. It grows best in loamy or sandy loam soil and can tolerate poor but not water-logged soils.

Due to its popularity and the increasing demand for organically grown food products, the prospect of using organic fertilizer in growing this crop is very bright as the application of organic fertilizers not only produces high and sustainable yield, but also improves soil fertility and productivity (Sanwal *et al.,* 2007). One of such organic fertilizer which is in abundance and at the same time, if not properly disposed, poses health hazard is human urine. Urine is an aqueous solution, made up of more than 95% water, with the remaining constituents made up of urea, creatinine, dissolved ion (chlorine, sodium, potassium etc) inorganic and organic compounds or salts (Richert *et al*., 2010). It is a liquid product of the human body that is secreted by the kidneys which contains large amounts of soluble nutrients – macro and micro nutrients (Gensch *et al.,* 2011).

Human urine makes an excellent high nitrogen liquid fertilizer for crop growth. It is rich in nitrogen and can be used to fertilize numerous crops. Human urine contains other nutrients like phosphorus, potassium, magnesium, calcium.

Thus, these nutrients present in urine could be useful as fertilizers. In general, pure human urine contains very few enteric microorganisms if there is no faecal contamination ((Höglund, 2001). Urine has been successfully used to fertilize other crops like cucumber, cabbage, lettuce, maize, wheat and tomatoes in addition to okra. The use of urine as a fertilizer is not a new phenomenon. Therefore, human urine can go a long way to assist in the growth, yield and production of okra in both small and large scale.

Despite its numerous uses and benefits already mentioned, human urine still remains unpopular in Nigeria and has not been fully exploited, it is sometimes neglected as a result of lack of awareness which formed the basis for this study. More so, much emphasis has been on the use of organic manure and chemical inorganic fertilizers in enhancing the growth and yield potentials of *Moringa oleifera*. Little or poor attention so far has been given to the use of human urine as an organic fertilizer on the growth and performance of perennials like *Moringa oleifera* Lam, owing to its poor knowledge and utilization. This thereby formed the backbone of this study for which the objectives were to compare the effects of human urine, poultry manure, pig manure, NPK 15:15:15 and control on the growth and performance of *Moringa oleifera* in both pot and field trials.

MATERIALS AND METHODS

Two experiments were conducted in the research farm at the Department of Crop Science, University of Nigeria, Nsukka. Nsukka is situated on latitude $06^0$51'E, longitude $07^0$29'N and altitude 475m above sea level. It is characterized by lowland humid conditions with bimodal annual rainfall distribution of about 1500mm. The mean annual temperature ranges from 20^0C to 30^0C and relative humidity from 70% to 80% (Baiyeri *et al*., 2008). It has a derived savanna ecology.

Urine Collection and Treatment

Human Urine was collected from a private home with no form of faecal cross contamination, stored for a period of three months, and then treated by two methods which were extended storage and solar inactivation (GTZ, 2009). These treatment methods entailed the storage and exposure of collected urine samples to solar radiation for a period of three months (WHO 2016). This was necessary to inactivate pathogens, degrade micropollutants and also remove pathogenic microorganism. (Rainey*, et al.,* 2005, GTZ, 2009)

Soil and manure analyses

Samples of soil were collected from different mapped spots on the experimental field from where soil used for the potted trials were collected to a depth of 20 cm. The collected soil samples were made into a composite mix. A phsico-chemical analysis was carried out on sub-sample taken from the composite mix to determine the particle sizes (clay, silt, fine sand and coarse sand). Additionally, samples of collected human urine, pig manure and poultry manure was analysed for the determination of nitrogen, phosphorus, potassium calcium, and magnesium content. The soil pH was determined using a Beckman's zeromatic pH meter. Analyses were carried out at the labouratory of the Department of Soil Science, University of Nigeria Nsukka, Enugu State, Nigeria.

Pot Trial

This experiment was laid out in a completely randomized design (CRD) with five treatments. Each treatment was replicated 15 times. 75 poly bags were perforated at the bottom and both sides, filled with 10 kg of top soil. Two seeds of *Moringa oleifera* were planted in each of the poly bags already filled with soil. These Moringa plants were thinned to one plant per bag at two weeks after seedling emergence. 12 litres of water was mixed with 3 litres of human urine in a calibrated bucket. One litre of the urine-water mixture was used to fertilize the Moringa in the poly bags for urine treatment three, six, and nine weeks after planting in three split doses. This was applied 5 cm away from the plant**.** 10 t/ha each of poultry manure and pig manure was incorporated into the soil in the polybags according to their respective treatments. This was done four weeks before planting. 240 kg/ha of NPK 15:15:15 was applied per bag to the Moringa plant in a ring form three, six and nine weeks after planting in three split doses.

Field Trial

This experiment was laid out in a randomized complete block design (RCBD) with three replications. Two seeds of *Moringa oleifera* were planted at a plant spacing of 80 cm x 80 cm, these Moringa plants however, was thinned to one plant at two weeks after seedling emergence. Each treatment plot measured 2.8m x1m.

One litre of human urine was mixed with 4 litres of water in a calibrated bucket. One litre of the urine-water mixture was used to fertilize the Moringa plants three, six and nine weeks after planting in three split doses. This was applied 5 cm away from the plant**.** 10 t/ha of poultry manure and pig manure was incorporated into the soil according to their respective treatments. This was done four weeks before planting. 240 kg/ha of NPK 15:15:15 was applied to the Moringa plant in a ring form three, six and nine weeks after planting in three split doses.

Growth and yield parameters

Morphological, physiological and yield data were collected on stem girth, plant height, number of leaves, number of fruits, number of seeds, harvest dry weight, and seed weight of *Moringa oleifera* in both the pot and field trials.

Statistical analyses

Data generated were subjected to analysis of variance (ANOVA) following procedures outlined for a randomized complete block design and a complete block design using GenStat Discovering Edition 4 (GENSTAT 2011). Significance of the treatment means were separated using Fisher's least significant difference (F-LSD) at 5% probability level as described by Obi (2002). Yield parameters were further modeled with genotype-genotype-environment (GGE) biplot analyses (Yan 2001)

RESULTS AND DISCUSSIONS

The textural class of the experimental site was sandy loam, the soil was acidic and basically had low essential plant nutrients. More so, the poultry manure and pig manure used were high in pH, while the organic carbon and organic matter content in poultry manure were relatively higher than that of pig (Table 1). The physico-chemical analyses depict that human urine is alkaline with a pH of 9.8mg/l (Table 2).

Table 1: Physico-chemical properties of pre-planting soil, poultry manure, and pig manure

Physico-chemical properties	**Values**		
	Soil	**Poultry Manure**	**Pig Manure**
Textured class	Sandy loam		
Clay (%)	19.00	-	-
Silt (%)	6.00	-	-
Fine sand (%)	19.00	-	-
Coarse sand (%)	56.00	-	-
Chemical properties			
Soil pH (in H_2O)	4.90	11.30	9.70
Soil pH (in KCl)	3.80	10.30	9.10
Total carbon (%)	1.07	31.54	18.55
Total organic matter (%)	1.84	54.38	31.99
Total nitrogen (%)	0.04	1.32	0.63
Available phosphorus	13.06	0.09	0.04
Exchangeable bases in mg/100g soil			
Sodium (Na^+) (mg/100g)	0.05	0.21	0.15
Potassium (K^+)(mg/100g)	0.08	0.37	0.28
CEC %	11.20		
Calcium(Ca^{2+})(mg/100)	0.60	6.00	1.60
Magnesium (Mg^{2+})(mg/100g)	2.40	4.60	2.40
Base saturation (%)	27.95		
Exchangeable acidity in me/100g			
Hydrogen (H+)	3.60	-	-

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Table 2: Physico-chemical properties of Human Urine sample.

Physico-chemical properties	Values
	Human Urine
Soil pH (in H_2O)	9.8 (mg/l)
Total carbon	65.34 (mg/l)
Total organic matter	110.92(mg/l)
Total nitrogen	43.05 (mg/l)
Exchangeable sodium	2.11 (mg/l)
Exchangeable potassium	3.24 (mg/l)
Exchangeable calcium	12.03 (mg/l)
Exchangeable magnesium	9.60 (mg/l)
Available phosphorus	10.01 (mg/l)

Analysis of human urine (table 2) further showed the presence of organic matter, carbon and nitrogen. Human urine is a rich source of plant-available nitrogen with appreciable amount of phosphorus, potassium, magnesium, calcium, zinc and iron. Therefore, it can substitute for inorganic fertilizers (Kirchmann and Pittersson, 1995). It is a mixture of more than 200 organic and inorganic compounds that include nitrogen, phosphorous, and sulphur elements in various vitamins, hormones, organic acid and salts. Most of these compounds have concentrations higher than 10mg/L, and correspond to a mass of about 36.8 g/L. The remaining compounds only represent approximately 0.25 g/L (Putnam, 1971).

The availability of nutrients in the soil could be greatly influenced by soil pH and the proportionality of the physicochemical properties of the soil. The soil physical and chemical properties are shown in Table 1. Results depict that the soil acidity was high and there was deficiency in nitrogen and organic matter. This development could be attributed to the continuous erodibility of the top soil. This agrees with the work of Yusulf *et al.* (2017) which explained that the variation in soil structure and the removal of topsoil as a result of erosion could lead to nutrient removal and environmental degradation in a long run.

Nsukka is generally notable for its acidic soils (Baiyeri *et al*., 2007), which impedes nutrient availability to plants (Baiyeri *et al.,* 2006). The total nitrogen from analysed soil was very low compared to the critical level of 0.1% in Nigeria (FMANR, 1990) as this suggests the need for increased supply of N in the soil to enhance growth and yield. This prospect was met with the application of both organic and inorganic fertilizer types which led to increased yield potentials of M*oringa oleifera* both in pots and on the field (Tables 3 and 4).

The variation in fertilizer types had a great influence on the growth response of *M. oleifera* and the quality of fruits produced thereof. Among the fertilizer types, poultry manure exhibited the highest performance with respect to the morphological, physiological and yield traits measured compared to other treatments utilized in both experiments. This was closely followed by pig manure and human urine which also influenced the growth and yield component traits measured in both experiments compaired to NPK 15:15:15 and control (Tables 3 and 4).

Table 3: Effect of fertilizer types on number of leaves, plant height (cm) and stem girth (cm) for *Moringa oleifera* pot trial

Manure types	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP
Number of leaves						
Control	2.73	3.17	3.83	4.83	9.08	10.92
NPK 15:15:15	3.46	3.92	5.25	7.17	10.5	12.5
Pig Manure	3.97	4.5	6.33	9.58	11.58	14.08
Poultry Manure	4.56	5.25	7.98	12.52	13.55	16.42
Human urine	3.58	5.08	6.65	10.16	12.11	14.67
$LSD_{(0.05)}$	0.367	0.526	0.847	1.567	1.011	1.116
Plant height						
Control	6.33	8.67	17.75	18.00	20.25	21.00
NPK 15:15:15	7.71	22.21	44.25	56.08	65.50	70.92
Pig Manure	7.50	23.79	50.25	54.00	60.83	71.58
Poultry Manure	8.29	25.70	76.25	82.42	92.25	103.08
Human urine	7.21	25.67	46.58	58.17	60.92	74.83
$LSD_{(0.05)}$	1.42	6.18	9.96	7.99	8.57	10.14
Stem girth						
Control	0.94	1.12	1.78	1.77	2.24	2.60
NPK 15:15:15	1.52	2.57	3.17	3.51	3.74	3.98
Pig Manure	1.54	2.64	3.45	3.47	3.89	4.11
Poultry Manure	1.76	2.86	3.62	3.92	4.58	5.11
Human urine	1.46	2.64	3.41	3.81	3.97	4.14
$LSD_{(0.05)}$	0.210	0.307	0.308	0.270	0.294	0.367

WAP: Weeks after plant

Table 4. Effect of fertilizer types on number of leaves, plant height (cm) and stem girth (cm) for *Moringa oleifera* field trial.

Manure types	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP
Number of leaves						
Control	3.1	3.9	4.8	8.4	10.5	12.6
NPK 15:15:15	3.1	4.3	5.3	8.8	11.0	13.2
Pig Manure	3.6	4.6	5.5	9.1	11.2	13.2
Poultry Manure	3.7	7.1	9.2	11.9	14.3	16.9
Human urine	3.6	6.1	7.0	10.6	12.5	15.1
$LSD_{(0.05)}$	NS	0.81	0.93	0.93	1.08	1.16
Plant height						
Control	5.8	7.3	25.1	41.1	45.6	58.0
NPK 15:15:15	6.0	8.1	32.0	50.1	66.8	68.8
Pig Manure	6.2	9.0	28.8	59.8	59.3	107.8
Poultry Manure	6.5	11.4	58.8	74.1	82.0	133.4
Human urine	6.3	9.8	33.2	44.8	60.2	95.2
$LSD_{(0.05)}$	NS	1.65	12.06	27.45	25.75	46.26
Stem girth						
Control	0.8	1.5	1.9	2.2	2.5	3.1
NPK 15:15:15	1.0	1.6	1.9	2.0	2.2	3.2
Pig Manure	1.0	1.7	2.0	2.7	3.0	4.8
Poultry Manure	1.7	2.3	2.6	2.9	3.5	4.9
Human urine	1.4	2.0	2.3	2.7	2.8	4.8
$LSD_{(0.05)}$	0.7	NS	NS	NS	1.08	1.55

WAP: Weeks after planting, NS: non-significance at 5% probability level

The biplot however, explained 96.1% of the total existing variation depicting that deductions from it are reliable. Poultry manure greatly influenced the number of seeds, harvest dry weight, seed weight and number of fruits in both pot and field trials. This was distinctly revealed from the biplot that the application of manure could improve greatly the yield of *Moringa oleifera* (Figure 1). This agrees with the work of Adebayo *et al.* (2011) who stated that the vegetative and dry matter yield of *M. oleifera* was substantially enhanced through the application of organic amendment. In a study of the efficacy of different levels of poultry manure on the growth and yield of *Citrillus lanatus*, in Nigeria, it was observed that the application of poultry manure significantly enhanced growth parameters, vigor and number of fruits during two seasons (Dauda *et al.,* 2008).

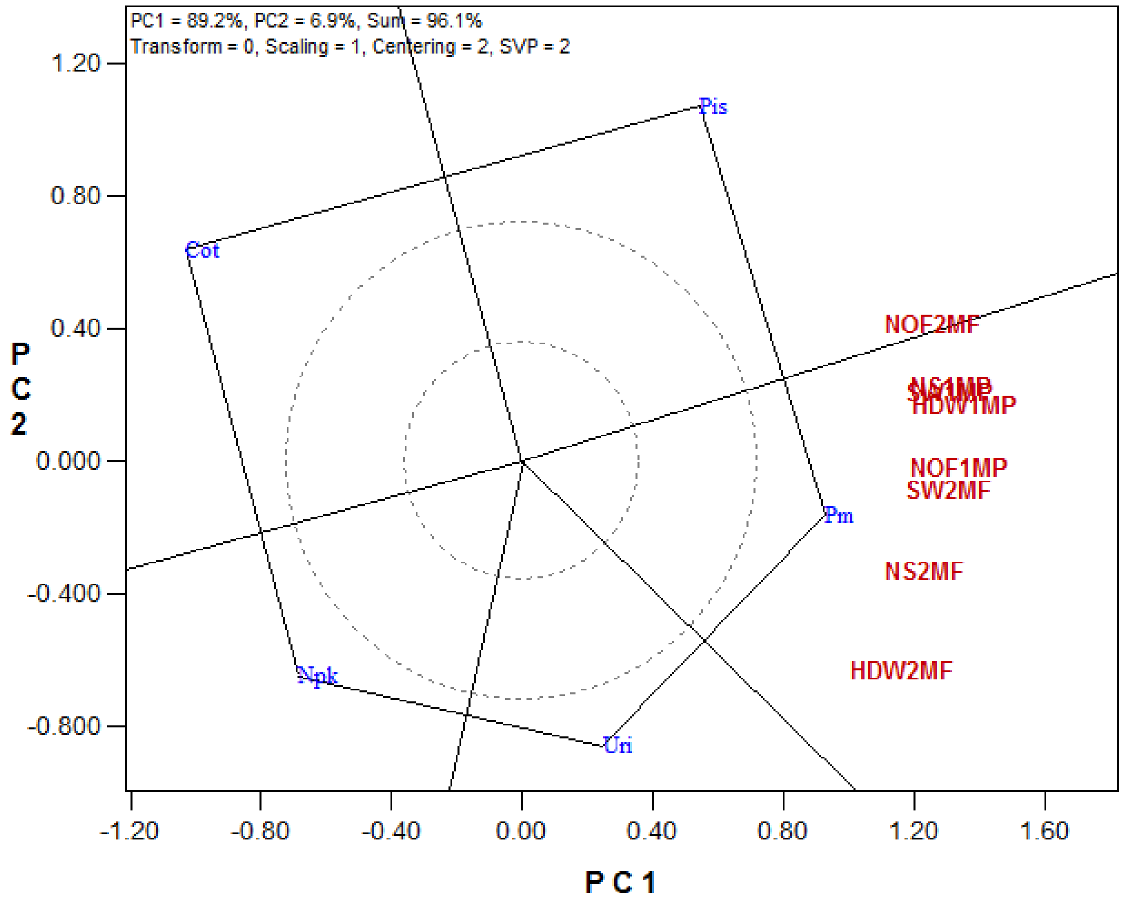

Fig 1: Bi-plot analyses of effect of fertilizer types on yield of moringa Pot and sole

CONCLUSION

The growth and productivity of *M. oleifera* could be subject to the application of organic and inorganic amendments to enhance their growth and productivity. Organic fertilizers mainly poultry manure, human urine and pig manure portrayed superiority in their morphological, physiological and yield performances compared to inorganic fertilizers (NPK 15:15:15) as well as control. Results obtained suggest that human urine could serve as a good substitute for nitrogen enriched chemical fertilizers in acidic soils because of its alkaline nature.

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EFFECT OF DIFFERENT SOIL AMENDMENT ON THE GROWTH AND YIELD OF JUTE MALLOW (*CORCHORUS OLITORIUS* L.)

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ABSTRACT

Jute mallow though an indigenous vegetable is now gaining more recognition especially because of its medicinal value. It therefore becomes imperative to give more attention to the production of the crop in an appropriate soil environment for it optimum yield. A field experiment was conducted at the experimental site of Federal College of Agriculture Moor Plantation Ibadan to determine the effect of different soil amendment on the growth and yield of Corchorus olitorius. Randomized complete Block Design was used for the experiment with four treatments replicated three times. The treatments used were Urea, NPK 15: 15:15, poultry manure all at the rate of 20 kg N /ha and no treatment. Parameters taken were plant height, number of leaves, leaf area and fresh weight of harvested Jute mallow. Result obtained showed that treatment had effect on plant height of jute mallow as from 5 weeks after sowing, (WAS) in which plants treated with poultry manure were taller than control although statistically similar with those of urea and NPK. Also, the plants responded positively to fertilizer application where poultry manure significantly gave higher value of leaf area (42.53cm²) which was comparable with those of NPK and urea but higher than the control (15.46cm²). Number of leaves were significantly higher with plants treated with urea at par with those of NPK and poultry manure while control had the least significantly. Urea produced the highest fresh weight of Jute mallow (1777.78 kg/ha) which was not significantly different from the plants treated with NPK and poultry manure while control has the lowest yield (188.89kg/ha). With the world campaign of organic food, this study recommends the use of poultry manure at the rate of 20 kg/N / ha for optimum production of jute mallow since it competes favourably with the use of urea and NPK.

Key words: Jute Mallow, Poultry Manure, Urea, fresh Weight, *Cochorous olitorius*

INTRODUCTON

Jute mallow an important leafy vegetable is found in wild and cultivated forms in many tropical countries of Africa and Asia (Schippers, 2000). The leaves are rich in minerals like calcium, glucose, Magnesium and Iron. It also contains high percentage of vegetable protein. It prevents anemia, and can be used as effective alternative drug to treatment of chronic cystitis, fever, gonorrhea and tumor (Gruben 2004). Jute fibre can also be gotten from the stem due to its strength, and durability (Edmunds 1990). The composition of *Corchorus olitorius* leaves per 100 g of fresh edible portion is: 80.4 g water, 58 kcal of energy, 4.5 g protein, 0.3 g fat, 12.4 g carbohydrate, 2.0 g, fibre, Ca 360mg, P 122mg, Fe 7.2 mg beta carotene 6410µg, thiamin 0.15 mg, riboflavin 0.53 mg, niacin 1.2 mg ascorbic acid 80 mg. the leaves also contains vitamins A, C, and E which are antioxidants and protects the body from degenerative diseases. Vitamin E slows down aches and pains associated with aging and increases stamina. (Leung et al. 1968). Jute mallow, being a leafy vegetable, require nitrogenous fertilizer for its vegetative growth and yield (Tisdale and Nelson, 1990). Jute requires 20 kg/ ha of N (Whitlock et al., 2003).

The use of inorganic fertilizer to increase the use of crops has been found to be effective as a short term solution which demands consistence use on a long term basis (Waswa et al., 2007). The composition and especially micro nutrient content of *Corchorus olitorius* are strongly influenced by external factors such as soil fertility and fertilization. Nitrogen fertilizer greatly improves the micro nutrient content especially that of Fe, P, Ca, carotene and vitamin C (Leung et al. 1968). On the other hand, organic waste has been seen as a viable alternative to chemical fertilizer since it has a long term productivity in soil conservation and improvement in soil fertility for sustainable food security (Akanbi, 2003).

Nitrogen is present in so many inorganic fertilizers in different proportions for instance, ammonium nitrate has NPK rating of 34-0-0, Urea on the other hand has an NPK rating of 46-0-0 (Bot and Benites, 2005). Therefore, looking at the appropriate source of nitrogen for the production of jute mallow becomes necessary. Also, the limitation of inorganic fertilizer and the effect it has on the soil makes it to become imperative to look at other sources of fertilizing the soil. This drive motivates this work which aimed at determining the effect of different soil amendment on the growth and the yield of jute mallow (*Corchorus olitorius*)

MATERIALS AND METHODS

Study area

A field experiment was conducted at Federal College of Agriculture, Ibadan South West of Nigeria (Latitude 7° 22°N; Longitude 3° 58"E and 275 m above sea level). The experiment was carried out in 2019 cropping season. After land preparation by ploughing and harrowing, the plot was marked out and site laid out in a randomized completely block design with four treatments replicated three times.

The experimental site was 13.5mx11m while the plot size was 3x3m^2 with 0.5m between plots and 1m between replicates. The treatments consist of four levels of zero application of fertilizer, urea, NPK, and poultry manure all at the rate of 20kg/ha. The poultry dung was applied a week before sowing; NPK and Urea fertilizer were applied two weeks after sowing. The quantity of each fertilizer used was based on the quantity of nitrogen (N) present in each material used as treatment. Urea has 46 % N so; 43.48 kg/ha was used. NPK contains 15% N, hence 133.33kg/ha was used. The quantity of N in the poultry manure was 0.0168 % hence 1190.76kg/ha was used. The seeds were sown by broadcasting.

Five plants were randomly sampled and tagged for observation for growth and yield parameters at 4, 5 and 6 weeks after sowing. The parameters taken were: plant height (cm), number of leaves, leaf area (cm^2), and fresh weight of *Corchorus olitorius* (kg).

Data collected were statistically analyzed using ANOVA to test the level of significance of treatments on the measured parameter and the significant means were compared and separated using Duncan Range Multiple Range Test (DRMRT) at 5% level of significance.

RESULTS AND DISCUSSION

The result of the pre cropping soil in table 1 showed that the soil is slightly acidic with a pH of 6.24, total Nitrogen is very low hence the soil needs more N for the production of the test crop, available Phosphorus of relatively okay, exchangeable bases are equally low. The nutrient composition of the poultry manure is shown in table 2 below and it was discovered that the nitrogen content was low.

Table1. Physical and Chemical Properties of Pre Cropping Soil

Parameters	Values
pH	6.24
Total carbon g/kg	1.57
Total nitrogen g/kg	0.157
Available Phosphorus mg/kg	10.63
Exchangeable Cation cmol/kg	
Sodium Na+	0.49
Potassium K+	0.31
Calcium Ca2+	2.90
Magnesium Mg2+	2.83
Exchangeable acidity H+ (cmol/kg)	0.10
CEC (cmol/kg)	4.63
Particle size distribution (g/kg)	
Sand	667.6
Clay	124.8
Silt	207.6
Textural class	Sandy loam

Effect of treatment on plant Height (cm), number of leaves, leaf area (cm^2) and fresh weight (kg) of *Corchorus olitorius*.

It was observed that at 5 and 6 WAS, treatment effect was significant on the plant height of *Corchorus olitorius* (table 3). Plants treated with poultry manure were significantly (<0.05) taller than zero application but were not statistically different from those treated with urea and NPK. This result underscores the fact that Jute mallow responds well to fertilization, particularly nitrogen (Ogunrindé and Fasinmirin, 2011).

Table 2: Chemical Properties of Poultry Manure

Properties	Value
Calcium (%)	4.20
Magnesium (%)	1.96
Potassium (%)	0.18
Sodium (%)	0.30
Copper (mg/kg)	28700
Zinc (mg/kg)	200
Manganese (mg/kg)	410
Total Nitrogen (%)	0.017
Phosphorus (%)	0.75
Iron (mg/kg)	4800

Table 3: Effect of different Soil amendment on plant height (cm), number of leaves and leaf area (cm²) of *Corchorus olitorius*

Treatment	4WAS	5 WAS	6 WAS
Plant Height (cm)			
Urea	12.35a	23.82a	29.93a
NPK	11.51a	20.99a	29.45a
Poultry	13.51a	24.09a	31.21a
Control	10.72a	19.70b	23.53b
Number of leaves			
Urea	12.50a	16.34a	19.00a
NPK	11.50a	15.66a	17.34a
Poultry	10.84a	15.5a	18.84a
Control	5.42b	9.17b	11.08b
Leaf area (cm²)			
Urea	6.80a	27.59a	36.53a
NPK	8.46a	28.08a	38.01a
Poultry	8.31a	27.81a	42.53a
Control	6.75a	14.63b	15.46b

Means followed by the same letter are not significantly different from each other at 5% level of probability using DMRT, WAS= weeks after sowing.

At 5WAS, *Corchorus olitorius* responded to the treatment applied with respect to the number of leaves produced in which it was observed that plants treated with urea produced the highest number of leaves which was at par scientifically with those treated with NPK and poultry manure but significantly (<0.05) different from those with zero application (Table 3). This also reconfirmed the role of nitrogen in promoting vigorous vegetative growth in leafy vegetables (Tisdale and Nelson, 1990).

Effect of treatment on leaf area of *Corchorus olitorius* revealed that at 5WAS, plants treated with NPK produced wide leaves which are statistically the same with those of urea and poultry manure but are significantly (<0.05) different from zero application. At 6 WAS, treatment of *Corchorus olitorius* with poultry manure produced plants whose leaves are wider (<0.05) than zero application but were at par with those treated with urea and NPK (Table 3). This also showed that nitrogen stimulates formation of new leaves and increases the size of plant. Other reseachers have also discovered that chicken manure contains basic nutrients required for enhancing growth and yield of crops (Sharpley and Smith 1991). Also, application of chicken manure increases carbon content, water holding capacity, aggregation of soil, and decreases bulk density (Egerszegi, 1990). Poultry manure also increases the water soluble and exchangeable potassium and magnesium which enhance crop yield (Jackson, 1999).

Table 4 showed the effect of treatment on the yield of fresh weight of *Corchorus olitorius*. It was observed that plants treated with urea produced yield which was significantly (<0.05) higher than that treated with zero application but was at par statistically with those treated with NPK and poultry manure. The reasons for increased leaves yield could be due to the increased solubilization effect of urea which makes the nitrogen available to the crop which could lead to the built up of sufficient food reserves for the developing sinks and better portioning towards the developing leaves. This result corroborates the work of Emuh (2013).

Table 4: Effect of different Soil amendment on fresh weight of *Corchorus olitorius* (kg/ha)

Treatment	Fresh weight (kg/ha)
Urea	1777.78a
NPK	1366.67a
Poultry	1388.89a
Control	188.89b

Means followed by the same letter are not significantly different from each other at 5% level of probability using DMRT, WAS= weeks after sowing.

CONCLUSION AND RECOMENDATION

The result of this study showed that *Corchorus olitorius* responded well to application of nitrogen fertilizer either in the organic or inorganic form. It was also discovered that, poultry manure, though with the least percentage of N in this study, produced the same result statistically with those of inorganic fertilizer. Application of poultry manure is therefore recommended in this study for optimum yield of *Corchorus olitorius* since it competes favourably with urea in yield and it is purely organic.

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KING TUBER MUSHROOM (*PLEUROTUS TUBERREGIUM*) PRODUCTION AND PROXIMATES ON TWO STRAW BASED SUBSTRATES

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ABSTRACT

The cultivation of Pleurotus tuberregium with Guinea grass (Panicum maximum) in comparison to rice (Oryza sativum) without nutrient supplementation was investigated. The effect of straw type on mycelia growth, sclerotial yield, biological efficiency (BE) and nutritional quality were determined. Two types of straws, Guinea grass and rice straws were compared, Rice straw recorded higher sclerotia yield (81.63g) than the Guinea grass (75,32g). Days to substrate colonization and sclerotial initiation were shorter by by two and eleven days respectively. Mushroom yield () and BE () were higher on rice straw (). However, it was found out that from the proximate content (protein, fat, ash, potassium, sodium, phosphorus and zinc) were also higher in mushroom sclerotia harvested from Guinea grass than those obtained from the rice straw based substrate. Comparing the rice straw with the guinea grass, rice straw yielded about 4% more sclerotia under the same cultivation condition than Guinea grass.

Key words: *Pleurotus tuberregium,* ricestraw, guinea grass, yield and nutritional analysis

INTRODUCTION

Mushrooms are believed to be nature's gift for mankind, highly nutritious with high culinary value. Mushrooms are believed to be a bridge between plant and animal kingdom and believed not to be plant or animal. Their cell wall contains chitin instead of cellulose and they lack the green pigment (chlorophyll) as found in other green plants. The quality of their protein is equivalent to that of animal protein containing all the essential amino acids (Quimio *et al,* 1990). The medicinal value of mushrooms made them important in the modern day medicine as most species are medicinal. In recent times, people are now very conscious of their health and mushrooms being an health food, is gaining ground more than ever before (Adrock, 2019). This made it imperative to popularize its cultivation on readily available agro- industrial wastes in the country. Mushroom cultivation is becoming popular because of its low inputs; its cultivation can be highly profitable because of the tropical climate which is suitable for the cultivation of tropical varieties especially the oysters, shiitake reishi mushrooms (). Mushroom production can be profitably considered in areas where land is a limiting factor especially in the peri-urban and urban areas. Among the available mushrooms species that can be grown in Nigeria, is *Pleurotus tuberregium,* which can grow on a wide variety of agro-industrial wastes with considerable lignocellulose content. This work was undertaken because of the need to identify suitable and abundantly available growth media for the production of *P. tuberregium' Panicum.* Guinea grass (*panicum maximum*), also known as panic grass is a tropical pereniall turft grass that is rhizomatous at the base. It is used as forage for animals. It is usually found growing luxuriantly by the road sides abandoned farm lands especially in the rain forest belt of Africa. This study evaluates the productivity and nutritional quality of *P. tuberregium* on Guinea grass (*Panicum maximum*) in comparison to its growth and nutritional quality on rice straw (*Oryza sativum*).

MATERIALS AND METHODS

Pure culture of the mushroom (*P. tuberregium*) was obtained by tissue culture isolation from a young and healthy fruiting body which was placed on prepared potato dextrose agar (PDA) medium and incubated at room temperature for seven days to allow the fungal mycelium to grow out of the basidiocarp. This was subcultured into fresh PDA medium which was incubated and after it was fully ramified, it was refrigerated until needed (Raguphati *et al,* 2016).

Mother spawn was prepared by soaking sorghum seeds overnight. The soaked seeds were drained and filled in 200ml capacity bottles which were plugged with cotton wool, wrapped in aluminum foil. The prepared bottles were sterilized at 121^{0}C for fifteen minutes. After cooling down to ambient temperature (25^{0}C), The bottles were inoculated with the freshly prepared culture above to give the mother spawn. Sorghum seeds were prepared as outlined above, and were inoculated with the mother spawn to generate the planting spawn.

Substrate preparation

Luxuriantly growing Guinea grass were harvested, chopped into sizes of about 3-5cm and air dried. Rice straw was also collected from International Institute of Tropical Agriculture, Ibadan, Nigeria. These were also chopped (3-4cm) and dried. The chopped substrates were separately soaked and added with 1% calcium carbonate. These were stuffed into heat resistant polyethylene bags (300g/bag) held in place with polyvinyl rings and plugged with cotton wool with eacc treatment replicated seven times. The bags were pasteurized (70^0C for five hours), cooled overnight and inoculated with the freshly prepared planting spawn of *P. tuberregium* the following day. After inoculation, the bags were moved to the incubation room to allow for its vegetative growth. At the expiration of twelve weeks' incubation period, the fully ramified bags with balls of sclerotia of the mushrooms were opened and sclerotia were separately harvested from the bags and weighed. Some of the harvested sclerotia were dried and powdered for proximate content analysis.

The experimental design was a completely randomized design with seven replications. The following data were collected: mycelial growth/day, the number of days required for the initiation of scleroium, the number of days required for total harvest, sclerotial yield, and biological efficiency. The data were analyzed using the SAS statiscal package. Means were compared using Duncan's multiple range test. Biological efficiency was measured using the formula below:

Biological efficiency (%) = total sclerotial yield/ substrate dry weight × 100

RESULTS AND DISCUSSION

Optimum daily mycelia growth (0.71cm), shortest time required to complete mycelia colonization (28.33 days) and days to sclerotia initiation (64.67days) were observed on rice straw based substrate which are statistically higher than that obtained on Guinea grass, 0.60, 29.67, 75.33 respectively. Comparing the rice straw with the Guinea grass straw, the rice straw yielded about 8% more sclerotia (81.63g) than the Guinea grass (75.32%) This result was similar to earlier findings by Tupatler (2006) who reported higher oyster mushroom yield on rice straw than wheat. The biological efficiency also followed the same trend with higher efficiency on rice straw (66.63%) and lower (61.48%)on Guinea grass. (Table1).

Table 1: Effects of different straw types on growth and yield of *Pleurotus tuberregium*

Treatment	Mycelia extension/ day (cm)	Days to media colonization	Days to sclerotia initiation	Sclerotia yield (g)	Biological Efficiency (%)
Rice straw	0.71	28.33^{b}	64.67^{b}	81.63^{a}	66.63^{a}
Grass straw	0.60	29.67^{a}	75.33^{a}	75.32^{b}	$61..48^{b}$

This also agrees with earlier studies by Somashekha, *et al, (*2020) who evaluated different agricultural wastes including rice straw and guinea grass for mushroom cultivation. His results indicated higher mushroom yield and biological efficiency on rice straw than guinea grass. The nutritional quality of the mushroom's sclerotia harvested from Guinea grass based substrates were observed to be better interms of the macro nutrient contents. The most abundant of the macro-nutrients was potassium (Table 2).

Table 2: Macronutrient composition of *Pleurotus tuberregium* grown on rice and grass straw

Treatment	K (%)	Na (ppm)	Mg (%)	Ca (%)	P (ppm)
Grass straw	0.33^{a}	102.88^{c}	0.09^{b}	0.15^{b}	0.24^{a}
Rice straw	0.26^{c}	90.22^{d}	0.12^{a}	0.24^{a}	0.20^{b}

The proximate content (protein, fat ash and phosphorus) of the sclerotia harvested on guinea grass were found to be better than those from rice straw (Fig. 1). Zinc content was also more on scerotia from Guinea grass, the copper was comparable to that obtained on rice straw sustrate (Fig. 2).

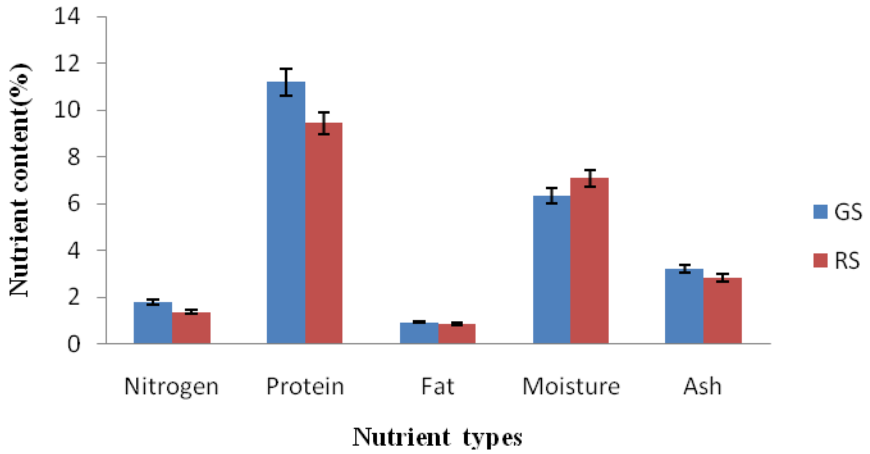

Fig 1: Proximate composition of *P. tuberregium* grown on rice and wheat straws

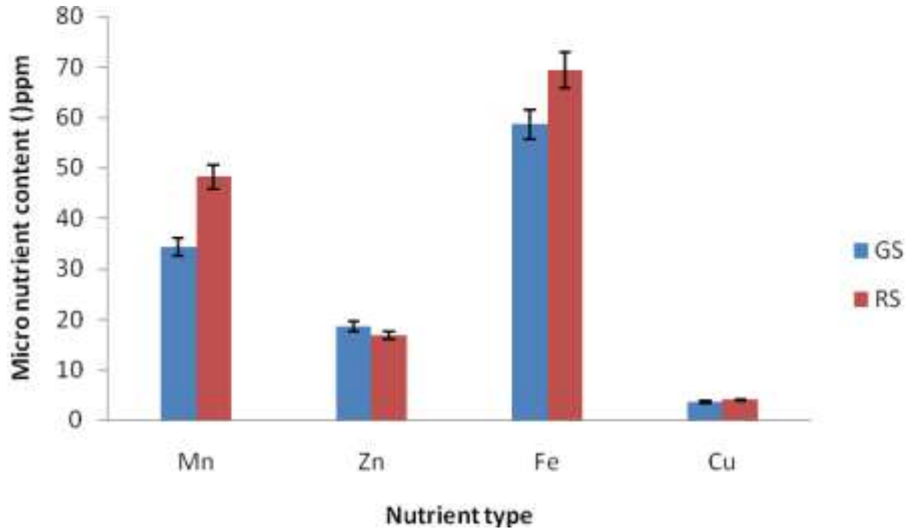

Fig 2: Micronutrient composition of *P. tuberregium* grown on different agricultural wastes

CONCLUSION

In conclusion, the major findings in this work indicated rice straw to be the best substrate for the cultivation of *Pleurotus tuberregium* in terms of mycelia growth rate, time required for substrate colonization, sclerotia yield and biological efficiency. The nutritional quality of mushroom harvested from Guinea grass were higher than those harvested from rice straw.

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EFFECT OF PIG MANURE AND POULTRY LITTER ON THE GROWTH AND YIELD OF MILLET

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ABSTRACT

A study on the effect of different levels of pig manure and poultry litter at (0,5 and 10t/ha) was carried out at the Teaching and Research farm of the Plateau State College of Agriculture, Garkawa during the 2019 cropping season. Application of the organic manures had significant effects (P≤ 0.05) on the number of leaves, plant height, stem diameter, number of seeds per plant and seed yield t/ha. The use of poultry litter significantly increased seed yield (5.00 – 5.10 t/ha) compared to the control (0 t/ha). Hence application of 5t/ha of poultry litter and pig manure was recommended for optimum yield of millet in Garkawa.

Key words: Pig manure, Poultry litter, Millet, Garkawa

INTRODUCTION

Millet is one of the cherished drought resistant cereals in Nigeria (Aduna, 2011). Millet is grown extensively in Nigeria due to its low requirement for the major needed elements (Gupta, 2010). It is consumed fresh, roasted, boiled, sundried or pounded as "fura" "dambo" or fermented "Akamu" (Agbato, 2003). The production of millet in Nigeria is declining due to poor soils and unpredictable weather conditions (Badi 2019). While there is a decline in food production, particularly with staple crops like millet, the population of the country is increasing geometrically (Batino, 2004). This is basically due to land degradation and soil infertility. Use of organic manures is one of the ways of addressing this situation as they are cheap availability, within the reach of a common farmer, less toxic and with no negative effect on the environment. The objective of this study therefore is to look into the effect of pig manure and poultry litter on the yield of millet.

MATERIALS AND METHODS

The experiment was conducted during the 2019 cropping season at Garkawa (latitude and longitude east of the equator at the experimental and Research Farm of the Plateau State College of Agriculture, Garkawa. Pig manure and poultry litter at 0,5, and 10t/ha were used for the study. Millet seeds were obtained from National Seeds Council, Jos. The experiment was laid in a Randomized Complete Block Design with 3 replications. The land was harrowed and then ridged at 75cm apart. Intra-row spacing was at 20cm. weeding was done manually at 3 and 6 WAS. Similarly, other management practices like thinning, supplying, application were done according to Oduori, (2005). Growth and yield characters like plant height, number of leaves, stem diameter, number of heads, number of seeds and 1000 seed weight were taken. The data collected were subjected to Analysis of variance. Significant means were separated using least significant difference (LSD) as recommended by Gomez and Gomez, (1984).

RESULTS AND DISCUSSION

There was significant difference (P≤0.05) in plant height, stem diameter and number of leaves than the control (Tables 1-3). This could probably be due to the fact that poultry litter and pig manure contains all the available nutrients needed for the growth and yield of millet, which are readily available to crops. Camberdella (2004) reported that organic manures contain the essential elements required for the growth of cereals.

Similarly, organic manure had significant effect on yield characters like: Number of heads, number of seeds and 1000 seed weight (Table 4). This is probably because organic manures stay in the soil for a long period of time (Murray, 2008).

Table 1: Effect of Pig and Poultry Manure on Number of Leaves of Millet at Garkawa

	Weeks After Sowing (WAS)		
Treatment	2	6	10
Pig Manure t/ha			
0	1.30	3.01	3.01
5	3.29	8.11	10.42
10	3.28	8.17	10.60
SLSD (P≤0.05)	0.107	0.404	1.184
Poultry Manure			
0	2.28	3.01	3.01
5	3.28	8.12	10.43
10	3.26	8.18	10.71
SED+_	0.024	0.137	0.146
LSD (P≤0.05)	0.107	0.40.4	1.184

Table 2: Effect of Pig and Poultry Manures on Plant Height of Millet at Garkawa

	Weeks After Sowing (WAS)		
Treatment	2	6	10
Pig Manure t/ha			
0	4.26	9.73	69.29
5	9.51	21.86	163.40
10	9.51	21.60	163.43
SLSD (P≤0.05)	1.640	4.866	8.703
Poultry Manure t/ha			
0	3.95	10.54	69.29
5	9.44	48.73	173.07
10	9.41	40.40	167.17
LSD (P≤0.05)	1.640	4.866	8.703

Table 3: Effect of Pig and Poultry Manures on the Stem diameter (cm) of Millet in Garkawa

	Weeks After Sowing (WAS)		
Treatment	2	6	10
Pig Manure t/ha			
0	0.58	0.59	1.41
5	1.01	1.21	3.20
10	1.02	1.21	3.21
LSD (P≤0.05)	0.132	0.095	0.095
Poultry Manure t/ha			
0	0.58	0.59	1.42
5	1.03	1.22	3.23
10	1.02	1.22	3.23
LSD (P≤0.05)	0.132	0.095	0.095

Table 4: Effect of Pig and Poultry Manures on the Number of Heads, Number of Seeds and 1000 Seed Weight of Millet at Garkawa

	Weeks After Sowing (WAS)		
Treatment	NH	NS	1000 Seed Weight
Pig Manure t/ha			
0	1.02	116.11	2.04
5	3.02	383.73	3.81
10	3.02	390.63	4.01
SLSD (P≤0.05)	1.02	24.483	1.02
Poultry Manure			
0	1.02	116.10	2.04

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5	3.01	392.73	3.91
10	3.02	393.73	4.02
LSD (P≤0.05)	1.02	24.483	1.02

NH[2] = Numbers of Heads, NS = Numbers of Seeds

CONCLUSION

It was concluded that pig manure or poultry litter be applied at 5t/ha for optimum production of millet in Garkawa.

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EFFECT OF MANURE RATES AND VARIETY ON THE GROWTH AND YIELD OF CUCUMBER (*CUCUMIS SATIVUS L.*) IN DADIN KOWA GOMBE STATE

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ABSTRACT

A field trial was conducted in Federal College of Horticulture Dadin kowa Gombe State to determine the effect of manure rates on growth and yield of two cucumber varieties during 2020 Wet Season in Dadin kowa. It consisted of two (2) varieties of cucumber (market more 76 and market more D.O.T) and four (4) levels of manure rates (0t/ha, 12t/ha, 18t/ha and 24t/ha). The treatment was combined in factorial and laid in a Completely Randomized Block Design (RCBD) with three replications making up a total of twenty-four plots. The plots size was 3x3 with 1m space between replication and 0.5m between plots. The result of the research showed that, there was no significant difference between the two cucumber varieties throughout the study period. On the other hand, the results for the manure rates had indicated that there were highly significant differences among the manure rates used for the study. It is clear that, the higher the rate the higher the performance on all the parameters measured (vine length, number of leaves, number branches, and fruit weight). However, it is suggested that similar research be conducted in the study area and other places to ascertain this fact.

Key words: Cucumber. varieties, vine

INTRODUCTION

Cucumber (*Cucumis sativus* L.) belongs to the family of Cucurbitaceae. It is ranked the eighth most grown vegetable crop around the world; after maize, sugar beet, cassava, tomatoes, watermelons, sweet potatoes, and dry onions (Edom 2017). It is an important vegetable that is cultivated globally. It has creeping vine that bears large leaves, which form canopy above the cylindrical fruits. In African including Nigeria, it is unranked probably due to inadequate production volume when compared to other European countries Ume 2017). It is cultivated in almost all the agro-ecological zones of Nigeria ranging from coastal to savannah zones. The savanna zone of Nigeria has the greatest potential for its production due to moderate rainfall. However, research has proved that it can grow in some southern parts of Nigeria that had moderate rainfall (Enujeke 2013). The importance of cucumber to mankind can be categorized into three namely: food, medicine and industry. Like food, it is either eaten raw or prepared in various forms especially as components of the vegetable salad. In medicine, it is used to fight against cancers (breast-ovarian, uterine and prostate); treatments for diabetics, skin irritations; rehydrate the body and regain one's self from dryness (Omeh 2017 and Shetty. 2002). Its benefits concerning other health and medical conditions are widely documented (Olorun; 2017, Holmes 2000 and Edom 2017) noted that it is important in cosmetic industry for the manufacture of soaps, lotions, shampoos and fragrant. Three major cucumber varieties widely grown are slicing, pickling, and burpless (Wikipedia. 2017). However, there are different cultivars found in the market globally, and they emanate from these three major varieties (Wikipedia. 2017). Despite the importance of this vegetable crop, lack of specific rate of sheep and goat manure and high cost of inorganic fertilizer had constituted a major constraint to its production in the study area. Therefore, this study was conducted to with objective in mind to determine the effect of different rate of sheep and goat manure on growth and yield of cucumber and also to determine the best variety of cucumber in the study area for recommendation to the farmers

MATERIALS AND METHODS

Site Characteristics

The experiment was conducted at Teaching and Research Farm of Federal College of Horticulture Dadinkowa, Gombe State. The area lies approximately 260 m above sea level is located between latitude 10°15' North and longitude 11°15' East. The climate of the area is semi-arid zone, which is characterized by a wet and dry season. October to March is the major dry season. The mean annual rainfall is 1,500mm and the mean temperature is 35°C. (URBDA,2015)

Treatments and Experimental Design

The experiment consisted of two factors: variety (Market more 76 and Market more D.O.T) and the manure rates (0t/ha, 12t/ha, 18t/ha and 24t/ha). The two factors and their levels gave 8 treatment combinations which were laid out in a randomized complete block design (RCBD) and was replicated three times.

The land was cleared and harrowed twice to obtain a fine tilth. Beds were marked out using a measuring tape, rope and pegs. Each plot measured 3 x 3m (9m^2) in size with a distance of 0.5m between the plots and 1m between replicates. Six plots were obtained in a replicate, given a total of 18 plots. Before sowing the crop, soil samples were taken in a "Z" shape within the experimental area following the procedure of IFDC (2003) at a depth of 0-30cm using a tubular auger.

The plants were sown at the rate of three to four seeds per holes at a spacing of 30cm by 0.5m. Weeds were controlled at regular intervals after planting. The crops were staked and insecticide was also applied to control insect pest. Data was collected on vine length, number of leaves, number of branches, number of flowers, fruit and weight of fruits. All the data collected were subjected to analysis of variance (ANOVA) using Genstat statistical package and least significant difference (LSD) was used where there was significant difference to separate the means.

RESULTS AND DISCUSSION

The result in Table 1 indicated that there was no significant difference ($P< 0.05$) between the two cucumber varieties used throughout the study period on all the characters measured. This might be due to similarities of varieties in term of morphology, nutrients and environmental requirement of the crop. The results corroborate with the findings of Imran *et al*., (2017) who work on six varieties of cucumber at the Department of Horticulture, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthanand and found that, there was no significant different between the varieties used. The manure rates on the other hand indicated a significant difference throughout the growing period on all the characters measured. This had indicated the importance of organic manure in term of growth and yield of cucumber. The result is in line with the findings of Funch *et al*., (1998) who reported that vine length increased to addition of organic matter. The result had also corroborated with the findings of Abdulkadir *et al.,* (2020) and Henry (2000) whose all reported that, the application of sheep and goat manure significantly ($P>0.5$) increased the number of branches per plant over the control. Similarly, this finding is in line with the findings of Jilani *et al.,* (2009), Ayooba and Adeniran (2006) and Deksissa *et al.,* (2008) who reported that increase in manure rate can lead to increase in cucumber yield.

CONCLUSION

It could be concluded that application of organic manure to Dadin kowa soils can be sustain and enhance cucumber production especially 24t/ha. This is similarly applicable not only to Dadin kowa land but other areas with similar soil types.

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Table 1: Effect of Manure Rates on growth and yield of Two Cucumber Varieties in Dadin kowa

TREATMENT	V L	NL	NB	NFR
VARIETY(V)				
1	122.5	46.69	28.17	36.30
2	124.1	47.38	29.80	37.25
LS	NS	NS	*	NS
LSD	9.48	5.093	1.515	11.764
MANURE RATES(T/HA)				
1	103.0c	34.03 d	21.98 c	27.03 c
2	119.2b	42.33 c	25.08 b	28.43 c
3	130.9a	52.10 b	32.14 a	42.80 b
4	140.0a	59.67 a	36.75 a	46.8 a
LS	**	**	***	***
LSD	8.72	3.779	3.348	3.933
INTERACTIONS				
VxM	NS	NS	NS	*

M=Manure, V1=Variety 1 market more 76. V2=Variety 2 market more D.O.T. LS=Level of Significance VL = Vine length (cm) NL= Number of leaves. NB= Number of branches NFR=Number of fruits

GROWTH AND YIELD OF CUCUMBER (*CUCUMIS SATIVUS*) AS INFLUENCED BY NEEM (*AZADIRACHTA INDICA*) AND MEXICAN SUNFLOWER (*TITHONIA DIVERSIFOLIA*) MANURE

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ABSTRACT

Cucumber (Cucumis sativus L.) is a widely cultivated plant which belongs to the family Cucurbitaceae (gourd family). It is an annual, creeping vine that grows up on trellis or other supports, wrapping around them with thin, spin tendrils. The objective of this study was to evaluate the growth and yield of cucumber in response to varying combination ratio of two plant based fertilizer. The plant based organic fertilizer (Tithonia diversifolia leaves and Azardirachta indica leaves) collected at NIHORT Research farm Ibadan, Oyo state, air dried and milled separately into powder form, different ratios were weighed for each organic fertilizer, combined and incorporated into the soil 2 weeks before planting. The experiment was laid out in a factorial arrangement fitted into randomized complete block design with three replicates. The trial consisted of 2 varieties of cucumber (Marketer and Market more) and 6 treatments comprising Mexican sunflower and Neem leaf at combination of 100%T + 0%N, 75%T + 25%N, 50%T + 50%N, 25%T + 75%N, 0%T + 100%N and Control (no plant extract) making 12 treatments. Results obtained showed that all the growth and yield parameters measured were significantly influenced by application of the fertilizer, significant differences (P <0.05) was observed among the cucumber varieties. Fertilizer combined at 25%N + 75%T applied to marketer had significant (p <0.05) effect on yield components of cucumber. However, application of 100%T significantly (P <0.05) produced the highest fruit yield (14.65 kg).

INTRODUCTION

Soil fertility depletion among the small holder production in Africa is one of the causes of the reduction in per capita food production. Tanimu *et al.* (2007) reported that shortage and high cost of inorganic fertilizers have limited its use among small holder farmers in Nigeria. To this Ogbonna (2008) reported that organic fertilizer contributes to the increase in yield of crop by up to 80% as this also depends on the rate of application of the organic fertilizer. Also the use of organic manures on agricultural lands has been reported to have great advantages in nutrient recycling, improving soil structure and promoting biological activities of the soil which in turn improves the overall soil health, enhance the growth and productivity of the crop (Arisah *et al*., 2003). Idem *et al*. (2012) has it that sometimes, application of organic manure serves as an alternative practice to inorganic fertilization and this in turn improves the soil structure. In most tropical soil, organic manure has been known to become the determinant for improving soil fertility (Ikpe and Powel, 2002; Uwa, 2013). However, the increasing demand and consumption of cucumber has become quite necessary to identify potential plant materials as alternatives to inorganic fertilizer. The trial was done to assess the influence of Neem and Mexican flower organic manures as soil amendment on growth, yield and yield component of cucumber.

MATERIALS AND METHODS

A field trial was conducted between September and November 2018 at the Vegetable Research Farm of National Horticultural Research Institute (NIHORT), Ibadan, Oyo state located in the rain-forest agro-ecological zone ($7^{0}33^{1}$N and $3^{0}56^{1}$E 168 m above sea level). Mexican sunflower leaves [*Tithonia diversifolia (*Hemsl.) A. Gray] and neem [*Azardirachta indica* A. Juss] were air dried and milled separately as each treatment was weighed at 100% (2kg), 75% (1.5kg), 50% (1kg), and 25% (0.5kg) which was combined at different ratios for varying combinations these was incorporated into the soil and left for 2 weeks to decompose before planting. The experiment comprised of twelve (12) treatments laid out in a factorial arrangement and replicated three times. The field was disc-ploughed twice, harrowed and sprayed with systemic herbicide force-up (a.i glyphosate) at the rate of 250 ml to 18 liters of water using a knapsack sprayer before planting two weeks after. Plot size was 2m x 2m ($4m^2$) while the experimental field size was 17m x 17m ($289m^2$). Boarder was raised at the sides of each plot to avoid washing away of the treatments by rainfall. Seeds of two cucumber hybrids; (Marketer and Market more (Technisem company) were planted at a spacing of 50cm x 50cm giving rise to 25 plants per plot with a corresponding population of 1156 plants. Weeding was carried out manually with hoe at 3 and 6 weeks after sowing, vines were staked using bamboo tree cuttings at 4 weeks after sowing. Data collected included: plant height (cm), leaf area (cm), stem diameter (cm), number of leaves per plant while at harvest fruit yield, fruit length (cm) and fruit weight (g) were determined. The data were subjected to analysis of variance, and where appropriate, means separated using Duncan multiple range test

RESULTS

The varietal differences were observed as marketer performed better than market more. Also among the organic fertilizer used, it was observed that 100% Tithonia (T) significantly (P <0.05) influenced the Leaf Area, stem diameter, number of leaves, fruit width and the fruit yield of cucumber (Table 1). However, 75% T and 25% N also significantly (P <0.05) influenced plant height (67.86 cm), LA (129.12) stem diameter (7.2 cm), though this was not significantly (P <0.05) different from 100%T and fruit width (44.2 cm) in table 1. Also the performances of the varieties on the organic fertilizer showed that marketer performed better with organic fertilizer than the marketmore (Fig 1). The interaction effect of the varieties against the organic manure on yield components and yield of cucumber shows that marketer significantly (P <0.05) performed better than marketmore (Table 2). The use of 100%T on marketer showed that it influenced the stem diameter (7.8 cm), number of leaves (23) and fruit width of cucumber (49.60 cm). while 25%T x 75%N significantly (P <0.05) produced the highest fruit yield (20kg) of marketer. Also from table 2 it showed that with marketmore under the organic manure combination with 100%N it influenced the stem diameter of cucumber (7.44 cm) though this was not significantly (P <0.05) different from 100%T, 57%T + 25%N, 50%T + 50%N with marketer and 100%T, 75%T + 25%N with marketmore. Also in it was observed that 100%T with marketmore gave significantly (P <0.05) higher fruit yield (11.23 kg) when compared with other combinations with market more.

Table 1: Influence of neem and mexican sunflower manure on yield and yield component of cucumber

Source	Plant height (cm)	Leaf area (cm)	Stem diameter (cm)	Number of leaves	Fruit yield (kg)	Fruit length (cm)	Fruit width (cm)
Varieties							
Marketer	68.95a	134.77a	6.98	18.22a	14.67a	23.96a	43.55a
Marketmore	53.10b	99.69b	6.75	14.10b	6.73b	19.64b	38.58b
LSD (P <0.05)	0.36	7.68	Ns	0.38	0.72	1.03	0.23
Organic fertilizer							
100% T + 0 % N	64.21c	152.54a	7.48a	19.23a	14.65a	18.79cd	46.26a
75% T + 25% N	67.86b	129.12b	7.2ab	15.02d	8.00d	20.20c	44.20b
50% T + 50% N	62.00d	97.73c	7.06bc	17.10b	8.90cd	25.60a	41.12c
25% T + 75% N	61.35e	117.62b	6.54de	15.70c	11.23b	25.13a	36.51e
0% T + 100% N	70.25a	118.29b	6.73cd	15.02d	12.2b	22.97b	39.07d
0% T + 0% N	39.88f	88.00c	6.12e	14.85cd	9.26c	18.09d	39.23d
LSD (P <0.05)	0.62	13.31	0.42	0.67	1.25	1.79	0.39

Table 2: Interaction effect of neem and mexican Sunflower manure on yield and yield component of cucumber

Interaction	Stem diameter (cm)	Number of leaves	Fruit yield (kg)	Fruit length (cm)	Fruit width (cm)
Marketer					
100% T + 0 % N	7.82a	23.4a	18.06b	14.74h	49.60a
75% T + 25% N	7.41ab	15.5bd	6.90fg	14.76h	47.46b
50% T + 50% N	7.42ab	18.86b	9.26e	31.31a	42.8c
25% T + 75% N	5.88e	15.60d	20.00a	20.28e	38.08f
0% T + 100% N	6.03e	17.43c	18.16b	17.39fg	40.37d
0% T + 0% N	5.96e	18.46b	15.67c	19.35efg	42.93c
Market more					
100% T + 0 % N	7.14bc	15.06de	11.23d	22.84d	42.84c
75% T + 25% N	7.10bc	14.13e	9.10e	25.67c	40.93d
50% T + 50% N	6.70cd	15.33d	8.53ef	19.90ef	39.44e
25% T + 75% N	7.21bc	15.80d	2.46h	29.90ab	34.94h
0% T + 100% N	7.44ab	12.60f	6.23g	28.56b	37.77f
0% T + 0% N	6.29de	11.70f	2.85h	16.83gh	35.54g
LSD	0.59	0.95	1.76	2.53	0.56

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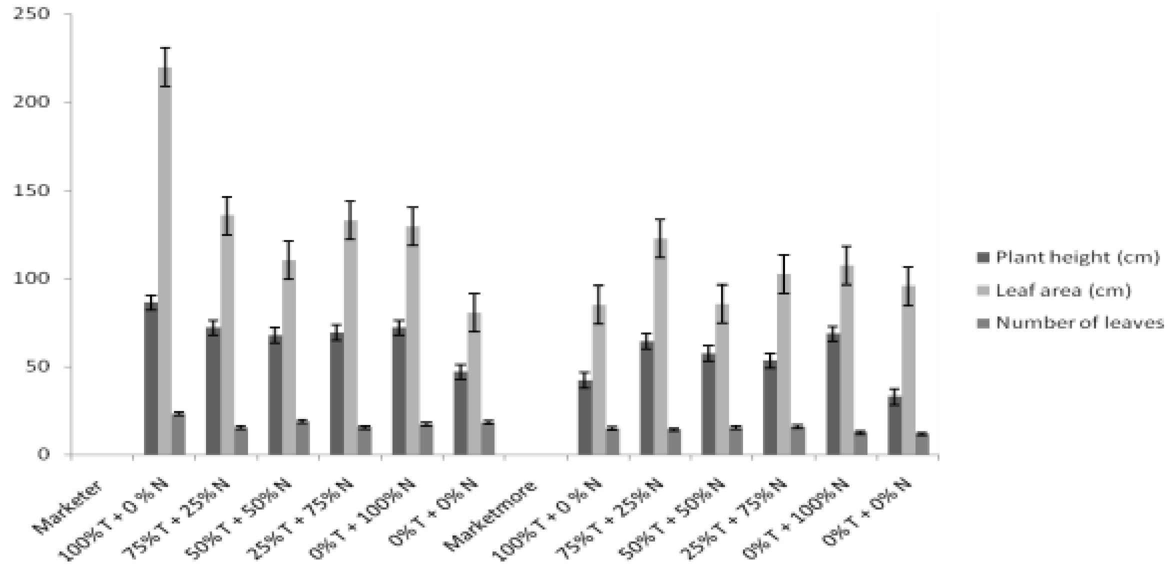

Figure 1: Interaction effect of Neem and Mexican Sunflower manure on the growth of cucumber

DISCUSSION

Neem leaves as manure could be used for the preparation of vermin-compost having both fertilizer and pesticidal potential (Oyekunle and Abosede, 2012). This is in agreement with our finding as 25%T and 75%N as organic manure had significant (P <0.05) influence on the fruit yield of cucumber. However, it was observed that the complete usage of Mexican sunflower gave higher fruit yield than when mixed with 25% Neem and when 50% of each was used. This is also in line with the finding of James *et al.* (2000) who reported that Mexcan sunflower can increase the yield of crops. With the findings of the trial it has shown that its use as green manure can increase the production of vegetable crops as it will maintain soil moisture, fertility and productivity. Lokanadhan *et al.* (2012); Oyekunle and Abosede (2012) also reported that neem leaf manure is gaining popularity amongst small holder farmers in Nigeria as this is because it is observed to be environmentally friendly, has pesticidal potential and could increase the nitrogen and phosphorus in the soil. The result has shown that plant products are non-polluting, less toxic and biodegradable with no hazardous residues in the soil, water and air. Generally, the response of the crops showed that the soil responded better when the organic manure was applied (Moyin-Jesu *et al.,* 2012), as this corresponded with our findings as better performance of cucumber treated with the organic manure in the field against zero plots. Also the trial is in support with the reports of Schipper (2000) and Awodun (2007) that the application of organic manure significantly influenced the growth and yield of fluted pumpkin.

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EFFECT OF TITHONIA COMPOST RATES ON GROWTH AND FRUIT YIELD OF TWO CULTIVARS OF LONG CAYENNE PEPPER

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ABSTRACT

An experiment aimed at determining the organic fertilizer rate that will optimize growth and yield of two cultivars of long cayenne pepper was carried out at the National Horticultural Research Institute (NIHORT), Ibadan between 2007 and 2008. The experiment was a 2 × 4 factorial arrangements in RCBD with three replications comprising of two pepper cultivars (NHV-1A and NHV-1F) and four rates of Tithonia compost (0, 45, 90, 135 kg N/ha). Seedlings were transplanted six weeks after sowing at a spacing of 0.5 m × 0.5 m. Five plants were randomly selected and tagged for data collection on growth, yield and yield components. Data collected were subjected to analysis of variance and significant means were compared with LSD (P< 0.05). Results from this study showed that no significant difference existed between the accessions of pepper used in terms of plant height but there was significant difference in terms of number of leaves, branches and leaf area. Varying rates of tithonia compost significantly affected growth of long cayenne pepper. Number of leaves and leaf area decreased with decreasing rate of tithonia compost. Tithonia compost significantly affected fruit yield and yield components of long cayenne pepper except mean fruit weight. Long cayenne pepper with tithonia compost application rate of 90 kgN/ha had significantly higher number of fruit/plant, fruit weight/plant and fruit yield (158, 790.3 g and 30.25 t/ha respectively). It can then be concluded that for optimum performance of long cayenne pepper 90 – 135 kg N/ha from Tithonia compost organic fertilizer should be applied.

INTRODUCTION

Pepper production and its consumption have consistently increased annually worldwide dating back to the 20 century because of its importance as vegetable, spice and industrial raw materials (Wien, 1997). Pepper is usually cultivated as annual vegetable crop all over the world, but it grows and yields better in the tropical region of the world. Pepper forms a major integral part of our daily diet and a vital component of stew and soup consumed by all and sundry in Nigeria. Pepper fruits are consumed fresh, processed or dried (Grubben and El-Tahir, 2004). Pepper production requires high level and readily available soil mineral nutrients for optimum growth and yield. The primary nutrients considered essential for optimum growth and yield of pepper species includes nitrogen, phosphorus and potassium (Grubben and El-Tahir, 2004). All these nutrients listed are inherently low in tropical soils as a result of low organic matter content, especially in Nigeria. However, this can be improved through some agricultural practices such as application of fertilizers among others. Inorganic fertilizers are costly (especially to the low resource farmers), not easily accessible and often unavailable at critical time when it is most needed couple with the fact that the negative environmental effect limits it use. Moreover, the application of inorganic fertilizers could not replenish soil micro nutrient that often become depleted by growing crops consequently causing reduction in the crop productivity and yield (Sikora and Szmide 2001).

The nutrients content in various organic fertilizers are released gradually unlike inorganic fertilizers; make nutrients available in every developmental levels of pepper. In the recent time, farmers use organic fertilizers because of the potential advantages ascribed to organic based fertilizers. Moreover, some of the inorganic fertilizers applied are absorbed by plants while the left over dissolved into the environment (surface water, atmosphere and ground water) as pollutants, affecting the ecosystem. Organic wastes that exist in Nigeria varied from domestic waste, industrial waste to farm left overs (plant and animal residues) (Adediran *et al.* 2003). Organic fertilizers have been reported to improve soil structure, enhance long-term productivity as well as plant biodiversity and provide essential nutrients to plant, leading to better quality of plant and fruits, especially of *Capsicum annuum* (Enwall *et al.,* 2005; Alabi, 2006). The objective of this study was to determine the organic fertilizer rate that will optimize growth and yield of two cultivars of long cayenne pepper.

MATERIALS AND METHODS

This study was conducted at the National Horticultural Research Institute (NIHORT), Idi-Ishin, Jericho, Ibadan (7° 33´ N; and 3° 56´ E 168 m above sea level) between 2007 and 2008. The site, lies within savannah: forest transition ecology of Nigeria. Pre-cropping soil sample was randomly taken at the depth of 0-15 cm for the analysis of its physical and chemical properties. Seeds of the two accessions of the two long cayenne pepper cultivars (NHV-1A and NHV-1F) used in the study were high yielding and early maturing cultivars developed in NIHORT. Nursery trays were filled with sterilized and sieved, well mixed component of organic manure, rich virgin soil and gutter sand devoid of pebbles in a proportion of half top soil, one quarter manure and one quarter gutter sand. (NIHORT, 1986). Seeds of the two cultivars were sown in separate trays and watered once daily for the first 14 days, and once in two days thereafter till the time of transplanting at six weeks after sowing (WAS).

The experiment was a 2 × 4 factorial arrangements in RCBD with three replications comprising of two pepper cultivars (NHV-1A and NHV-1F) and four levels of Tithonia compost (0, 45, 90, 135 kg N/ha contained in 0, 2.81, 5.6, 8.43 t/ha respectively) of the compost material. Each replicate consisted of eight plots of 3 m × 2 m (6 m^2) each resulting in total experimental area of 23 m × 13 m (299 m^2). The plots were 1 m apart while replicates were separated 2 m apart. Vigorous and healthy seedlings of the crop were transplanted at one plant per stand using a distance of 0.5 m × 0.5 m which was equivalent to 40,000 plants per hectare. Tithonia based compost fertilizer were applied to each plot one week before pepper seedlings were transplanted. Weeding was done by hoe weeding and harvesting of ripe fruits was carried out twice a week. Five plants were randomly selected and tagged for data collection on plant height (cm), number of leaves, branches, stem diameter (cm), leaf area (cm^2), mean fruit weight (g), fruit diameter (cm), fruit length (cm), number of fruits/plant, fruit weight/plant (g), number of seeds/fruit, 1000 seed weight (g) and fruit yield (t/ha). Data collected were subjected to analysis of variance and significant means were compared with LSD ($P< 0.05$). Leaf area was calculated using linear regression equation estimator model $Y = 0.60 \times L \times B$ (where Y = leaf area, L = leaf length from apex to base and B = leaf breath at the widest part) (Salau *et al.,* 2008).

RESULTS AND DISCUSSION

Results from this study showed that no significant difference existed between the accessions of pepper used in terms of plant height but there was significant difference in terms of number of leaves, number of branches and leaf area. NHV-1F had significantly higher number of leaves than NHV-1A while NHV-1A had significantly higher number branches and leaf area than NHV-1F (Table 1). Furthermore, varying rates of tithonia compost significantly affected growth of long cayenne pepper used in this study. Plants with application of 45 kg N/ha significantly increased in height than 0, 90 and 135 kg N/ha. Moreover, plants treated with 45 kg N/ha produced the tallest plants followed by those treated with 135 kg N/ha and 90 kg N/ha (Table 1).

Number of leaves and leaf area decrease with decreasing rate of tithonia compost in order of 130 kgN/ha > 90 kgN/ha > 45 kgN/ha > 0 kgN/ha (Table 1). Number of branches per plant increased with increase in fertilizer rates except that the effects of 135 kg N/ha and 90 kg N/ha were not significantly different. Fertilizer rates of 135 kg N/ha, 90 kgN/ha and 45 kg N/ha were significantly better than the control while the least occurred when plants were not fertilized (Table 1).

The long cayenne pepper accessions used in this study were significant different from each other only in terms of fruit length, fruit diameter and number of fruits per plant while no significant difference existed among the pepper accessions in terms of 1000 seed weight, fruit weight per plant, mean fruit weight and fruit yield. Accession NHV-1A produced significantly thicker and longer fruits than accession NHV-1F while accession NHV-1F produced significantly higher number of fruits per plant than NHV-1A (Table 2). Tithonia compost significantly affected fruit yield and yield components of long cayenne pepper except mean fruit weight (Table 2). Fruit diameter and fruit length increase with increasing rate of tithonia application in the order of 0 kgN/ha < 45 kgN/ha < 90 kgN/ha < 135 kgN/ha. There was no significant difference in the 1000 seed weight of long cayenne pepper with tithonia compost application at any of the rates used but all these produced fruits with significantly higher 1000 seed weight than those with no tithonia compost application (Table 2). Long cayenne pepper with tithonia compost application rate of 90 kgN/ha had significantly higher number of fruit/plant, fruit weight/plant and fruit yield (158, 790.3 g and 30.25

t/ha respectively) than pepper with other rates of tithonia compost application and those without application of tithonia compost. Pepper without application of tithonia compost had the least number of fruit/plant (114), fruit weight/plant (595.7 g) and fruit yield (21.23 t/ha) while no significant difference existed between pepper with no application of tithonia compost and those with 45 kgN/ha in terms of fruit weight/plant and fruit yield. Roy *et al*. (2011) observed that length of fruit and breadth, and average fruit weight of pepper respectively increased with organic fertiliser rates to 100 and 150 kg N/ha. Additionally, this could be a pointer that high rate of tithonia based organic fertiliser may be needed for pepper growth and yield in soils used. Kathrin *et al*. (1998) recommended the use of high organic fertiliser rates on tropical soils for high performances of crops due to poor nutrient status of the soils.

CONCLUSION

Tithonia compost fertilizer at 90 kgN/ha and 135 kgN/ha gave similar but significantly higher pepper yield than other lower fertilizer rates. Hence, 90 kgN/ha is recommended for economics of production of the long cayenne pepper used in this study. It is concluded that for optimum performance of long cayenne pepper 90 – 135 kg N/ha from Tithonia compost organic fertilizer should be applied.

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Table 1: Effect of cultivar and tithonia compost rates on growth parameters of two long cayenne peppers cultivars

Treatment	Plant height (cm)	Number of leaves	Number of branches	Leaf area (cm^2)
Cultivar				
NHV-1A	59.07	130.11	9.38	880.50
NHV-1F	57.57	136.17	7.90	835.90
$LSD_{0.05}$	ns	4.24	0.71	13.63
Organic fertilizer rates (kg N/ha)				
0	46.05	88.22	5.96	662.30
45	64.81	128.29	7.39	766.90
90	61.29	141.84	9.84	888.00
135	61.13	174.21	11.37	1115.50
LSD(P≤0.05)	2.74	5.64	0.43	13.84

Table 2: Effect of cultivar and tithonia compost rates on fruit yield and yield components of long cayenne pepper

Treatment	Fruit diameter (cm)	Fruit length (cm)	1000 seed weight (g)	No. of fruits /plant	Fruit weight/plant (g)	Mean fruit weight (g)	Fruit yield (t/ha)
Cultivar							
NHV-1A	3.10	7.10	0.62	133.73	732.8	6.76	26.78
NHV-1F	2.76	6.61	0.59	150.69	609.7	6.54	24.05
LSD(P≤0.05)	0.23	0.26	ns	6.33	ns	ns	ns
Organic fertilizer rates (kg N/ha)							
0	1.59	4.84	0.45	113.78	595.7	7.25	21.23
45	2.70	6.81	0.63	151.05	600.6	6.11	22.68
90	3.38	7.53	0.67	157.73	790.3	6.45	30.25
135	4.04	8.25	0.67	146.27	698.5	6.78	27.50
LSD(P≤0.05)	0.19	0.25	0.05	3.28	10.21	ns	2.41

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INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT (INM) ON GROWTH PERFORMANCE OF AFRICAN BREADFRUIT (*TRECULIA AFRICANA* (DECNE)) IN THE ORCHARD

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ABSTRACT

A field experiment was conducted at National Horticultural Research Institute, Ibadan to evaluate the influence of integrated nutrient management on growth performance of African breadfruit seedlings in the orchard. The treatments consisted of (1) NPK I5:15:15 (0.45 t/ha), (2) Compost (15 t/ha), (3) Sawdust (25 t/ha), (4) Plastic mulch (1,632 kg/ha), (5) NPK + Compost, (6) NPK + Sawdust, (7) NPK + Plastic mulch, (8) NPK + Sawdust + Plastic mulch, (9) NPK + Compost + Plastic mulch, (10) Control (No fertilizer application). These treatments were applied to the transplanted seedlings at three Months After Transplanting (MAT). The experimental design was Randomized Complete Block Design (RCBD) in three replications. Data were collected on plant height (PH), number of leaves (NL), and weed dry weight (WDW). Data collected were analysed using descriptive statistics and ANOVA at $\alpha_{0.05.}$ *Results obtained revealed that, significantly taller plants above 2m was recorded from plots treated with NPK+sawdust+plastic mulch, sawdust, and NPK+compost, while the shortest plant was recorded from plots treated with NPK+compost+plastic mulch. Highest NL (105.3) was observed from plots treated with NPK+sawdust+plastic mulch and was not significantly different when compared with other treatments. The WDW ranged between 40.0 g/m2 (plastic mulch) to 180 g/m2 (sawdust). However, plastic mulched plots recorded the least WDW, which was significantly lower when compared with other treatments. Combination of appropriate and compatible different nutrient sources enhanced the growth performance of african breadfruit in the orchard.*

Keywords: Breadfruit, Integrated nutrient management, Growth performance, Weed dry weight, Fertilizer

INTRODUCTION

African breadfruit, the nutritious fruit is an energy-rich food, high in complex carbohydrates and rich in dietary fibre, Ca, K, Mg, thianin and niacin. Some varieties are also a good source of antioxidants and carbohydrates. A balanced fertilizer programme can add to soil fertility and prevent nutrient deficiencies and excess stress during the growing season. Using conventional NPK fertilizer and organic fertilizer reduce nutrient leaching, which often takes place in time of high rainfall. The most economically important product of the breadfruit tree is the fruit which is a nutritious, high energy food. A 100g edible portion of boiled breadfruit flesh provides 114 kcal, mainly from carbohydrates, 4.9g of dietary fibre, and appreciable amount of minerals such as calcium, the B vitamins and essential fatty acids. Breadnut seeds are also nutritious because they have a high content of both carbohydrate and approximately 8g fat, 17g protein, 3.2g dietary fibre and useful amounts of minerals, including potassium and phosphorous (Breadfruit Production Guide FAO, 2015).

With the view of an increase in land scarcity and water shortage, most of the agriculture plans depend on the use of chemical fertilizers and the production of new high-yielding crop varieties. Yet, both components are much expensive and do lead to higher pressure and more responsibilities for the financial investments and consequently lead to an increase in the total costs. Meanwhile, the price of fertilizers increases, year by year, due to the higher amount of fertilizers needed in the second and third seasons as compared with that in the first season to maintain the current yield production at economical level.

Integrated nutrient management (INM) is a scheme that refers to a safest way to dispose off crop residues and produce high-quality compost by a balanced and integrated use of both sources of fertilizers together in combinations (organic and inorganic fertilizers) for maintaining soil fertility and providing plants with an optimum level of nutrients required over all of cycle life to sustain the yield productivity. The key component of the INM goal is to reach the most effective and homogeneous combination that could lead to good management and be an effective target of the fertilizers, sufficient and balanced use of their quantity and quality, and be straightforwardly up taken by plants for higher yield without jeopardizing soil native nutrients or polluting the environment. It is ultimately viable to achieve such a target through the wise application of integrated nutrient management (INM) approach, which is known as a balanced mixture of organic, inorganic, and bioorganic microorganisms in combinations in different practices (Janssen, 1993).

Moreover, application of inorganic fertilizers is not a pragmatic option for many poor farmers in different regions worldwide, because many poor farmers do not have enough money to pay the claim of fertilizer price, besides its scarcity and unavailability in times of need.

Integrated nutrient management is also described as the technique of using minimum effective dose of suffcient and balanced quantities of organic and inorganic fertilizers in combination with specific microorganisms to make nutrients more available and most effective for maintaining high yields without exposing soil native nutrients and polluting the environment. Furthermore, many benefits can also be gained from using integrated nutrient management. INM can act as the driving forces, able to support the plans of converting marginal lands into productive ones, therefore fulfilling the strategy agenda of increasing cultivated land.

Furthermore, integrated nutrient management is a tool which can offer good options and economic choices to supply plants with suffcient amounts of most macro- and micronutrients and also can reduce the dose of chemical fertilizers, create favourable soil physiochemical conditions and healthy environment, eliminate the constraints, safeguard the soil nutrient balance in the long run to an optimum level for sustaining the desired crop productivity, and find safety methods to get rid of agriculture wastes (Selim and Al-Owied, 2017; Selim, 2018)

Therefore, it is inevitable to properly manage the nutrient balance and weed infestation in breadfruit orchards in order to protect the trees from nutrient in-balance and competition with persistent/pernicious weeds. More so, there is dearth of information on performance of breadfruit trees to different nutrient sources. It is against this background that this study was proposed. Therefore, the objective of this study is to determine the influence of different nutrient sources on the growth performance of juvenile african breadfruit trees in the orchard.

MATERIALS AND METHODS

The study was conducted at National Horticultural Research Institute (NIHORT), Ibadan, N7°24ꞌ23.50872ꞌꞌ LAT, LONG E3°50ꞌ32.08884ꞌꞌ LONG 213 meters above sea level, Ibadan lies in the derived savannah of South west Nigeria. The area is characterised with bimodal rainfall distribution, which peaks in July and September. The early rains occur between April and July, while the late rain occurs from September to November. The soil in the experimental area belongs to the main soil series of Egbeda, Olorunda, , Iwo, Makun, Etioni and Iregun (Smyth and Montgomery, 1962). They are classified as Alfisols (Soil Survey Staff, 1990) and Lixisols (FAO/UNESCO, 1986).

The treatments consisted of (1) NPK I5:15:15 (0.45 t/ha), (2) Compost (15 t/ha), (3) Sawdust (25 t/ha), (4) Plastic mulch (1,632 kg/ha), (5) NPK + Compost, (6) NPK + Sawdust, (7) NPK + Plastic mulch, (8) NPK + Sawdust + Plastic mulch, (9) NPK + Compost + Plastic mulch, (10) Control (No fertilizer application). These treatments were applied to the transplanted seedlings at three Months After Transplanting (MAT). The experimental design was Randomized Complete Block Design (RCBD) in three replications. Data was collected on plant height, number of leaves, number of branches, collar diameter, and weed dry weight. The treatments were applied once in a year and repeated in the second year. All data collected were subjected to SAS programme using Analysis of Variance, and the means were separated using Duncan Multiple Range Test (DMRT) at ($p<0.05$) probability level.

RESULTS

Breadfruit plots treated with NPK + Sawdust + Plastic mulch recorded significantly taller plants of 2.1m. This was significantly higher when compared with other treatments. The plots treated with NPK + Compost and plots treated with NPK + sawdust produced similar results (1.5m) which was not significantly different from each other. The least plant height (0.7m) was recorded from plots treated NPK during the first cropping season. At the second cropping season, taller plants above 2m (208.7m, 206.3m, 204.7m) were recorded NPK + sawdust + plastic mulch, sawdust and NPK + compost respectively. Breadfruit trees with the shortest height was recorded from plots treated with NPK + compost + plastic mulch. This was not significantly different from other treatments (Table 1).

Table 1: Effects of integrated nutrient and weed management on growth parameters and weed dry weight in juvenile african breadfruit orchard

Treatments	PH 1	PH 2	NB 1	NB 2	WDW
NPK 15:15:15	0.7d	120.7a	4.0a	8.7bc	150.0a
Compost	1.6ab	68.0a	8.7a	18.0a	156.7a
Sawdust	1.4abc	206.3a	8.4a	13.0abc	180.0a
Plastic mulch (PM)	1.0bcd	149.7a	9.0a	10.7abc	40.0c
NPK + Compost	1.5abc	204.7a	10.3a	12.7abc	143.7ab
NPK + Sawdust	1.5abc	195.3a	4.8a	23.7a	126.7ab
NPK + PM	1.3bcd	190.3a	7.3a	7.0bc	86.7bc
NPK + Sawdust + PM	2.1a	208.7a	11.0a	10.7abc	85.0bc
NPK + Compost + PM	0.8cd	119.3a	7.3a	9.7bc	63.3c
Control	1.4abc	128.3a	9.7a	13.0abc	126.7ab

Means followed by the same letter in a column are not significantly different by DMRT at ($p<0.05$)
PH = Plant height. NB = Number of branches. WDW = Weed dry weight.

Significantly more branches (11.0) was recorded from plots treated with NPK + sawdust + plastic mulch and this was not significantly different from other treatments, while plots treated with NPK 15:15:15 recorded the least number of branches during the first cropping season. during the second cropping season, a significantly higher number of branches (23.7) was observed from plots treated with NPK + sawdust, while the lowest was recorded from plots treated with NPK + plastic mulch (Table 1). Highest number of leaves (105.3) was recorded from breadfruit plots treated with NPK + Sawdust + Plastic mulch and was not significantly different from other treatments and the control (Figure 1). No significant difference was observed among the treatments for collar diameter (Figure 2). The observed increase in the height of trees can be attributed to the synergistic relationship, slow release of nutrients, availability and eventual uptake by the trees. The usage of compost and sawdust conserves moisture and the nutrients therein while, the plastic mulch prevents leaching and volatilization.

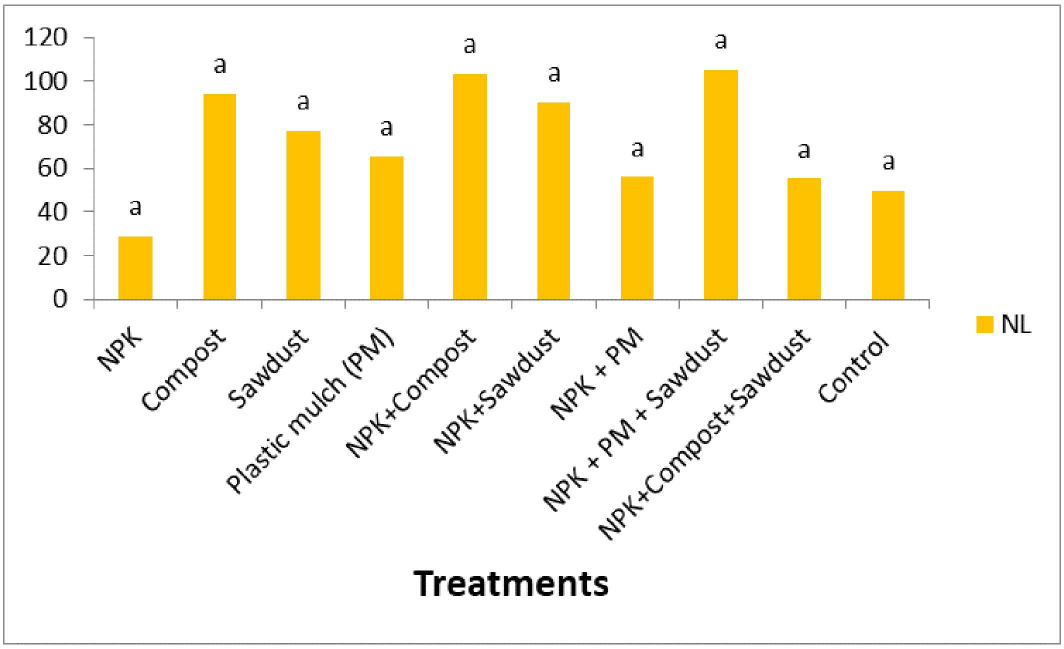

Figure 1: Effects of integrated nutrient management on number of leaves of juvenile breadfruit trees in the orchard

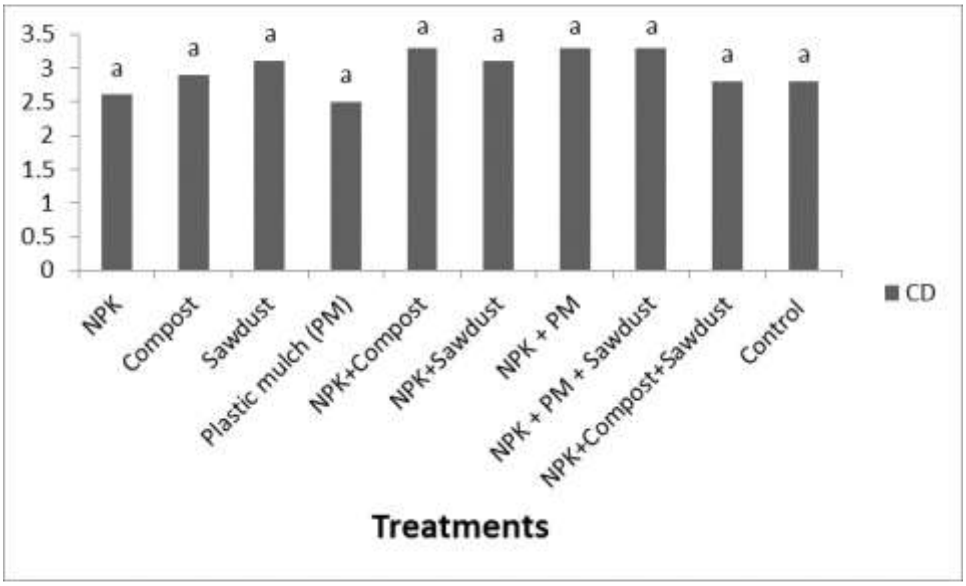

Figure 2: Effects of integrated nutrient management on collar diameter of juvenile breadfruit trees in the orchard

The weed dry weight ranged between 40.0 g/m^2 (plastic mulch) to 180 g/m^2 (sawdust). However, breadfruit plots mulched with plastic mulch recorded the least weed dry weight which was significantly lower when compared with other treatments. The observed decrease in the performance of trees treated with NPK alone can be attributed to the presence of weeds as reflected in the weed dry weight. Akobundu (1987), noted that NPK fertilizer application encouraged more weed growth. The author also noted that NPK application coupled with weed's inherent competitive ability results in more weed growth, as well as the control. Also, Alamu *et al*, (2012), reported that citrus plots that received 0.45 tha-1 NPK 15:15:15 recorded the highest weed density.

CONCLUSION

Breadfruit plots treated with NPK + Sawdust + Plastic mulch performed better than other nutrient source and combinations, while plots treated with NPK 15:15:15 alone gave the lowest performance and this may be attributed to effects of weed pressure on the trees as it is reflected in the weed dry weight.

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EFFECT OF PLANT SPACING AND COW DUNG RATE ON GROWTH AND YIELD OF WATERLEAF (*TALINUM TRIANGULARE* JACQ*)* IN GOMBE, NIGERIA

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ABSTRACT

Field experiment was conducted during the dry season at the Demonstration Farm of the Department of Agricultural Education Federal College of Education (Technical), Gombe to evaluate the effect of plant spacing and organic manure rate on the growth and yield of waterleaf. Treatments included three intra row spacing (5cm, 10cm and 15cm) and four cow dung levels (0,1,2 and 3 t/ha) which were laid in a randomised complete block replicated three times. Data collected were subjected to analysis of variance (ANOVA) using STAR statistical package. The results on plant height, plant girth, leaf area, number of flowers per plant, total fresh and dry weights showed there was no significant difference (P ≤ 0.05). However, number of leaves per plant and number of branches per plant were significant (p<0.05). Waterleaf intra row spaced at 5cm and applied 3t/ha cow dung produced highest number of leaves per plant (67) and number of branches (17) respectively. Therefore, for optimum production of waterleaf, spacing of 25cm x 5cm and cow dung rate of 3t/ha should be used and hereby recommended for farmers in the study area.

Key words: plant spacing, cow dung, growth, yield, waterleaf

INTRODUCTION

Waterleaf (*Talinum triangulare*) is a cosmopolitan non – conventional invasive plant (Souza and Lorenzi, 2012) adapted to hot and humid climate and poor quality soil (Amorim *et al*., 2013). It belongs to the Portulacaceae family which is a relatively small family (30 genera and 400 species) of the Caryophyllales order, but it has widespread distribution (Amorim *et al*., 2013). In the southern part of Nigeria, it is used singly in the preparation of sauces and stews and in mixed vegetable soups in combination with other vegetables; in the later it serves as softener of other vegetable species (Aja *et al*., 2010).

Talinum is adaptable throughout the country. It is best suited in a wet tropical environment with partial shade (Fontem, 2014). It is well adapted to the hot and humid climate and the poor quality soil, which makes its cultivation an important economic activity for small growers (Amorim *et al*., 2013). Waterleaf is eaten as a vegetable throughout the tropics including many countries in West and Central Africa and it is cultivated abundantly in Nigeria and Cameroon (Akachuku and Fawusi, 2015).

Talinum is said to stimulate egg production in fowls (Irvine, 2010). According to Leung *et al.* (2018), the leaves of waterleaf contain per 100 g edible portion: water - 90.8 g, energy – 105 KJ (25 kcal), protein - 2.4 g, fat - 0.4 g, carbohydrate - 4.4 g, fibre - 1.0 g, calcium – 121 mg, phosphorus - 67 mg, iron - 5.0 mg, thiamin - 0.08 mg, riboflavin - 0.18 mg, niacin - 0.3 mg, ascorbic acid – 31 mg. Sridha and Lakshminarayana (2013) also gave a report on high total lipids, essential oils, and alpha-tocopherols and beta-tocopherols in waterleaf. Water leaf is highly riched in crude proteins, crude fibres (Enete and Okon, 2010). And the minerals present contribute to high anti-oxidant values of water leaf (Enete and Okon, 2010). Medicinal properties of water leaf have been ascertained by many researchers to contain chemical substances like (flavonoids, alkaloids and tannins) that help in the management of cardiovascular diseases, such as Stroke, Obesity (Aja *et al*., 2010).

Farmers find it difficult to maintain a standard fertilizer regime in the cultivation of water leaf as they often supplement organic manure with mineral fertilizers. Cow dung is rich in minerals and ranges from greenish to brackish, often darkening after exposure to the air; it contains high level of ammonia (Braadbaart *et al*., 2012 and Dittrich and Helden, 2012). The increasing demand for waterleaf due to urbanization has therefore pushed farmers into small and medium scale production of waterleaf in Akwa Ibom State. Consequently, to obtain optimum yield, organic fertilizers are being developed by farmers from farm and city wastes for vegetable production. Also, organo-mineral fertilizers (OMF) in which organic wastes are fortified with inorganic N or NP fertilizers are being utilized by crop farmers. Organic and organo-mineral fertilizers have been reported to significantly increase yield of vegetables such as pepper (*Capsicum annum*), tomato (*Lycopersicon esculentus*), okra (*Abelmoschus esculentus*), egusi-melon (*Cucumeropsis mannii*) and amaranthus (*Amaranthus cruentus*) (Oluwole *et al*., 2019).

Plant spacing is a very important measure a farmer can employ to optimize yield of crops, yet this is often neglected by the local farmers. It has been shown that one of the most critical aspects of optimizing crop growth and indeed yield is maintaining adequate crop geometry in terms of spacing. According to Schippers (2013) proper spacing allows for less competition from weeds. Schippers (2013) also suggested that in waterleaf, if the soils are fertile or when manure is used in such a way that plants develop rapidly with large leaves, spacing should be increased to about 25 cm x 25 cm. According to Nadi and Lal (2013) lower densities encourage weed growth, reduce production and have less beneficial effects on the soil.

Plant spacing and organic manure rates affect the growth and yield components of water leaf Orluchukwu and Poripo (2014). Various spacings 25cm x 10cm, 25 x 20cm, 25 x 30cm and 3cm x 5cm depending on organic manure rates and the ecological zone had been recommended for waterleaf production (Orluchukwu and Poripo, 2014 & Aniefiok *et al*., 2013). The dry matter yield of waterleaf decreased as the spacing increased with 25cm x 30cm spacing giving the lowest dry matter yield and the closest spacing of 25cm x 10cm giving the highest dry matter yield (Orluchukwu and Poripo, 2014). Most research efforts on waterleaf production in the study area have focused on resource utilization (Udoh *et al,* 2015). There has been a paucity of information on the effect of plant spacing and organic manure rate on the growth and yield of waterleaf (*Talinum triangulare*) in the study area. Hence this study is being conducted to evaluate the effect of plant spacing and organic manure rate on the growth and yield of waterleaf (*Talinum triangulare*).

MATERIALS AND METHODS

The experiment was conducted at the Students' Demonstration Farm of Federal College of Education (Technical) Gombe Latitude 12^0 30´N and longitudes 8^o 45´E) between the months of June and September, 2019. The state climate is generally warm, with temperatures not exceeding 40^o C during the months of March – May. The topography is mountainous, undulating and hilly to the south east and flat opens plains in the North central. The vegetation is generally sudan savannah grassland with concentration of wood land in the South east and South West and annual average rainfall is 850mm.

Treatment consists of four rates of cow dung (0, 1, 2, and 3 tonnes/hectare) and spacing (25cm x 5cm, 25cm x 10cm and 25cm x 15cm) to give treatments combinations of twelve. The treatments were laid out in a Randomized Complete Block Design (RCBD) replicated three times. The plot size 3.94m x 0.3m with spacing within and between plots 25cm and 50cm respectively. Prior to planting, soil sample were randomly collected at 0 – 25cm, bulked and mixed thoroughly for physical and chemical analyses. Two weeks old Water leaf seedlings were obtained from the market and transplanted to the plots according to the treatment spacing, while the cow dung treatments were applied two weeks before transplanting. Weeding and other agronomic practices were promptly carried out. At maturity stage, the waterleaf plants were harvested by hand pulling. The growth and yield parameters collected were plant height, number of leaves per plant, leaf area (cm^2), number of branches per plant and total fresh weight. Data obtained were subjected to statistical analysis of variance (ANOVA) using STAR software and the means were separated Least Significance Difference (LSD) at 5% level of probability ($p<0.05$).

RESULTS

Physical and Chemical Properties of the Experimental Site and Cow Dung Used

The physic-chemical analysis of the soil (Table 1) showed that the soil was sandy loam in texture with 82.80%, 4.56% and 12.64% of sand, silt and clay respectively. It is slightly acidic with a pH of 6.72, low in available phosphorus (9.25 mg/kg), total nitrogen (0.06) and organic carbon (0.56 %). The soil is also low in most of the exchangeable bases, calcium (2.83 cmol/kg), magnesium (0.72 cmol/kg), sodium (0.11 cmol/kg) and potassium (0.28 cmol/kg). These values imply that the soil used for the trial was low in most of the nutrients which were beyond the critical levels (Enwezor *et al*., 1989) and at such will lead low fertility.

Table 1: Physical and Chemical Properties of the Experimental Site during the Experiment

Soil Properties	Values
Physical Composition (%)	
Sand	82.8
Silt	4.56
Clay	12.64
Textural class	Sandy loam
Chemical composition	
pH in water	6.72
Organic carbon (g/kg)	0.56
Total nitrogen (g/kg)	0.06
Available phosphorus (mg/kg)	9.25
EC (dS/m)	0.116
Exchangeable bases (cmol/kg)	
Ca^{++}	2.83
Mg^{++}	0.72
K	0.28
Na	0.11
Base saturation (%)	0.116

The composition of the cow manure is indicated on Table 2. The results showed that the pH value is slightly alkaline (7.86), organic carbon (32.1 %) total nitrogen (1.87 %), available phosphorus (1.16) and exchangeable bases (Ca 0.33; Mg 0.04; K 0.26).

Table 2: Chemical composition of cow manure used during the experiment

Chemical composition	Cow
pH in water	7.86
Organic carbon (%)	32.16
Total nitrogen (%)	1.87
Available phosphorus (%)	1.16
Potassium (%)	0.26
Calcium (%)	0.33
Magnesium (%)	0.04
Iron (%)	4.29
Manganese (mg/kg)	2.11
Copper (mg/kg)	0.27
Zinc (mg/kg)	0.48

Results on number of leaves per plant showed no significance difference ($P \leq 0.05$) at week 1, 2 and 3 weeks after transplanting (WAT) while there was significant difference ($p<0.01$) and ($p<0.05$) at 4 and 5 WAT respectively (Table 3). At 4 and 5 WAT, plants spaced at 25 x 5cm and applied with 3t/ha cow dung recorded the highest number of leaves per plant of 52 and 67.33 respectively. The least number of leaves per plant were obtained from plants intra row spaced at 15cm and 10cm applied 0 t/ha with 30.00 and 50.67 for 4 and 5 WAT respectively. Results on plant height showed no significant difference ($P \leq 0.05$) throughout the measuring periods. Nevertheless, plants intra row spaced 5cm and applied 3t/ha cow dung appeared to be tallest (Table 4). Plant girth showed no significant difference ($P \leq 0.05$) throughout the measuring periods (Table 5). Nevertheless, plants intra row spaced 5cm and applied 3t/ha cow dung appeared to be thickest. Number of branches shows no significant difference ($P \leq 0.05$) at week 1, 2, 3 and 4 WAT but showed significance difference ($p<0.05$) at 5 WAT (Table 6). Plants intra row spaced at 5cm and applied 3t/ha recorded highest number of branches per plant (17.33) followed by those intra row spaced of 15cm and applied 3t/ha with 17 branches per plant, while branches were obtained from those spaced at 10cm with zero cow dung. The results on leaf area showed there was no significant difference (P ≤ 0.05) throughout recording periods (Table 7). Results on the effect of plant spacing and organic manure rates on the number of flowers per plant, fresh yield and total dry weights are presented on Table 8. The results indicated no significance difference (p>0.05) on the number of flowers per plant, total fresh and dry weights.

Table 3: Effect of Plant Spacing and Organic Manure Rates on the Number of Leaves per Plant

Treatment	WEEKS AFTER TRANSPLANTING (WAT)				
	1	2	3	4	5
5cm + 0t/ha	11.33	15.67	23.33	40.00a	56.00ab
5cm + 1t/ha	13.33	17.00	21.67	42.67ab	65.00a
5cm + 2t/ha	11.33	17.00	22.33	34.67ab	58.00ab
5cm + 3t/ha	11.33	16.67	24.00	52.00a	67.33a
10cm + 0t/ha	12.67	17.67	22.33	30.00b	50.67b
10cm + 1t/ha	11.33	14.00	19.33	39.33b	60.00a
10cm + 2t/ha	10.67	17.67	25.33	45.00a	61.67a
10cm + 3t/ha	6.67	14.33	23.00	38.67b	56.67b
15cm + 0t/ha	11.33	16.67	21.00	43.67a	62.67a
15cm + 1t/ha	8.67	17.33	22.67	51.67a	65.67a
15cm + 2t/ha	9.33	15.00	19.33	32.67a	50.67b
15cm + 3t/ha	8.33	15.00	19.67	40.00b	66.00a
L S	NS	NS	NS	**	*
S E	2.04	2.38	2.39	16.58	4.56
C V (%)	23.79	18.09	13.32	5.57	9.30

Table 4: Effect of Plant Spacing and Organic Manure Rates on the Plant Height of Water Leaf (cm)

Treatment	WEEKS AFTER TRANSPLANTING (WAT)				
	1	2	3	4	5
5cm + 0t/ha	9.23	10.70	14.23	23.40	24.07
5cm + 1t/ha	8.33	10.77	14.33	24.67	25.30
5cm + 2t/ha	8.03	10.63	15.73	23 00	24.63
5cm + 3t/ha	8.83	10.67	14.63	24.53	27.00
10cm + 0t/ha	9.13	11.77	15.53	22.37	23.33
10cm + 1t/ha	8.50	10.87	12.87	22.67	23.43
10cm + 2t/ha	8.50	10.10	16.37	23.10	25.03
10cm + 3t/ha	8.47	11.13	14.27	23.53	25.13
15cm + 0t/ha	7.93	10.37	14.43	24.67	24.80
15cm + 1t/ha	8.50	10.47	14.20	24.93	26.57
15cm + 2t/ha	9.87	10.93	15.33	24.23	24.90
15cm + 3t/ha	8.03	11.40	14.47	24.53	25.30
L S	N S	N S	N S	N S	N S
S E	0.99	1.22	1.47	1.56	1.39
C V (%)	14.12	13.83	12.29	8.03	6.84

DISCUSSIONS

The highest number of leaves per plant recorded for intra row spaced of 5 cm applied 3t/ha cow dung indicated that close spacing with adequate manure enhanced growth of waterleaf. This finding is in agreement with those of Schippers (2013), Orluchukwu and Poripo, 2014 and Aniefiok *et al*. 2013 who found that close spacing and adequate manuring enhanced more leaves production and dry matter in waterleaf. Similar result was presented by Ndaeyo *et al.,* (2013) shows that at 3, 6, 9 and 12 WAP, the leaf area of waterleaf differed significantly (P < 0.05) among the different fertilizer treatments. Furthermore, the result showed closely spaced plants with adequate manuring enhance good growth and more branches per plant. This is because as more leaves are active photosynthetically, more assimilates are produced enhance growth and more branches per plant. This is in agreement with the findings of Ndaeyo *et al.,*

(2013) who stated that at 3, 6, 9 and 12 WAP, there were significant differences in the number of branches per plant (P ≤ 0.05) among the different fertilizer treatments. He also stated that at 9WAP, 5tha-1 poultry manure (PM) produced 24-75% more branches than other treatments whereas at 12WAP, the number of branches from the 300kgha-1 NPK + 1.25tha-1 PM plot superseded other treatments by 52-78%. The control treatment had the least number of branches per plant. This finding is contrary to those of Malik *et al*. (2016) who found that more branches were produced at wider spacing in waterleaf.

Table 5: Effect of Plant Spacing and Organic Manure Rates on the Plant Girth of Water Leaf (cm)

Treatment	WEEKS AFTER TRANSPLANTING (WAT)				
	1	2	3	4	5
5cm + 0t/ha	1.23	1.47	2.13	2.50	2.73
5cm + 1t/ha	1.33	1.63	2.13	2.73	3.17
5cm + 2t/ha	1.10	1.47	2.10	2.57	2.80
5cm + 3t/ha	1.20	1.60	2.23	2.80	3.57
10cm + 0t/ha	1.30	1.47	1.97	2.63	2.87
10cm + 1t/ha	1.23	1.50	2.10	2.63	3.03
10cm + 2t/ha	1.33	1.50	2.17	2.87	3.27
10cm + 3t/ha	1.20	1.63	2.13	2.90	3.10
15cm + 0t/ha	1.30	1.60	2.23	3.00	3.20
15cm + 1t/ha	1.20	1.47	2.27	3.20	3.40
15cm + 2t/ha	1.40	1.60	2.27	3.27	3.10
15cm + 3t/ha	1.20	1.47	2.10	2.90	3.17
L S	NS	NS	NS	NS	NS
S E	0.11	0.12	0.14	0.23	0.24
C V (%)	11.24	9.90	8.53	10.26	9.80

Table 6: Effect of Plant Spacing and Organic Manure Rates on the Number of Branches per Plant

Treatment	WEEKS AFTER TRANSPLANTING (WAT)				
	1	2	3	4	5
5cm + 0t/ha	3.00	4.00	7.33	13.00	14.67ab
5cm + 1t/ha	3.00	4.33	5.67	11.00	14.33ab
5cm + 2t/ha	3.00	4.00	7.67	10.33	12.33b
5cm + 3t/ha	2.67	4.00	6.67	11.67	17.33a
10cm + 0t/ha	4.00	4.67	7.00	9.00	12b
10cm + 1t/ha	2.67	4.33	7.00	11.67	16a
10cm + 2t/ha	2.33	4.67	7.33	10.33	15ab
10cm + 3t/ha	1.67	4.33	6.67	10.67	14ab
15cm + 0t/ha	2.67	4.00	7.33	11.00	15.33a
15cm + 1t/ha	2.00	5.00	7.33	12.33	16.67a
15cm + 2t/ha	2.00	5.33	7.67	11.33	14.33a
15cm + 3t/ha	2.00	4.33	8.00	13.33	17.00a
L S	NS	NS	NS	NS	*
S E	0.55	0.42	1.02	1.40	1.50
C V (%)	26.31	11.82	17.57	15.12	12.34

CONCLUSION

The result of this study indicated that plant spacing and cow dung affects growth dry matter yield of waterleaf. Optimum growth and leaf production were recorded from plants intra row spaced at 5 cm and applied 3t/ha cow dung. Therefore, for optimum production of waterleaf spacing of 25cm x 5cm is recommended for the farmers in the study area.

Table 7: Effect of plant spacing and organic manure rates on the leaf area of water leaf (cm²)

Treatment	WEEKS AFTER PLANTING (WAT)			
	2	3	4	5
5cm + 0t/ha	3.57	9.26	15.44	21.30
5cm + 1t/ha	4.04	7.57	15.77	20.09
5cm + 2t/ha	3.67	8.06	14.23	17.62
5cm + 3t/ha	4.52	7.36	18.47	21.17
10cm + 0t/ha	4.43	8.92	13.35	18.13
10cm + 1t/ha	3.57	7.33	14.30	18.75
10cm + 2t/ha	3.95	8.37	16.95	19.92
10cm + 3t/ha	3.50	7.58	15.59	20.73
15cm + 0t/ha	3.49	7.07	14.16	19.24
15cm + 1t/ha	3.90	8.33	15.60	18.46
15cm + 2t/ha	3.87	8.86	15.79	19.80
15cm + 3t/ha	3.08	6.46	14.06	18.14
L S	NS	NS	NS	NS
S E	0.66	1.02	1.67	1.37
C V (%)	21.42	15.83	13.32	8.62

Table 8: Effect of Spacing and cow Dung on Number of Flowers per Plant, Total Fresh Weight and Total Dry Weight

Treatment	Flowers per Plant	Total Fresh Weight (Kg)	Total Dry Weight (Kg)
5cm + 0t/ha	59.70	5.49	3.13
5cm + 1t/ha	46.77	7.79	3.71
5cm + 2t/ha	54.43	7.62	3.47
5cm + 3t/ha	51.20	8.24	4.7
10cm + 0t/ha	60.30	6.85	3.27
10cm + 1t/ha	55.23	5.28	3.14
10cm + 2t/ha	47.80	7.64	3.37
10cm + 3t/ha	38.03	4.92	3.57
15cm + 0t/ha	45.80	9.09	3.65
15cm + 1t/ha	38.80	8.78	3.37
15cm + 2t/ha	39.23	8.12	2.61
15cm + 3t/ha	25.37	6.05	2.87
L S	NS	NS	NS
S E	85.48	1.87	0.6
C V (%)	22.33	31.70	21.9

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A REVIEW OF SOILS AND FERTILIZER MANAGEMENT RESEARCH ON COCOA (*THEOBROMA CACAO* L.) PRODUCTION IN NIGERIA

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ABSTRACT

Cocoa (Theobroma cacao) an important economic crop in Nigeria, contributes significantly to the Gross domestic product (GDP) of the nation. The productivity had been variously affected by soil fertility status and fertilizer management. This paper reviewed the soil requirements and characterization of cocoa, fertilizer management for cocoa and agronomic practices for growing sustainable cocoa as well as some gaps were identified for further research. Research revealed that cacao requires a deep well drained soil with a high nutrient content, rich in organic matter. Recommended fertilizer for cocoa on land cleared from forest are 4g P/tree. For land previously cropped with cocoa or other arable crops, the recommended fertilizer applications are: 10Kg N+4Kg P+4Kg K per tree in the first year. In the second and third year after planting, 10g P per tree was recommended when grown on the land cleared from forest and 25gN+4gP+3g K/ tree on land previously cropped. Forth and six – year- old plantation 11-23g P/ tree is recommended. When land grown with cocoa is cleared from forest, 50-100g N+12g P +25gK/tree is recommended. Cocoa pod husk has showed to improve soil fertility due to it high content of potassium (K). Result has it that NPK fertilizer applications had a positive impact on the growth and development of cocoa seedlings. Area for further research include development of fertilizer use in cocoa rehabilitation and efficiency of various cocoa varieties

Key words: *Cocoa, Soil characterization, fertilizer management, organic matter and shade management*

INTRODUCTION

Cocoa has become a vital export crop for many countries, particularly in West Africa, which produces over 65% of the world cocoa. It is also a major foreign exchange earner for some Central and South American countries and for South and South East Asia (Wood,1985). Over 80% of all cocoa is produced by smallholder farmers. Cocoa provides employment in many rural communities and pays school fees of farmers' children. Smallholder cocoa is grown mostly under shade trees and either inter-cropped or grown in a semi-natural agro-forestry setting and hence, is a particularly rich and stable habitat for many species (biodiversity).

Soil requirements and characterization for cocoa

Cocoa is a forest crop and so it is suited to forest soils. Hence, it is exceptionally demanding in its soil requirements. Most tropical forest soils consist of accumulated plant nutrients in the top few centimetres. When forests are cleared, the nutrients are rapidly released, giving the soil a high fertility for a few years. Cacao requires a deep well drained soil with a high nutrient content, while the top soil should be rich in organic matter. Hardy (1958), reported that the depth of root-penetrable soil should be at least five feet, but deeper soils are required where annual rainfall is low, especially if the soils tend to be rather sandy (Charter, 1953). In Nigeria the cacao soils should also have a clayey texture, preferably with sandy clay loam within 4 inches of the soil surface and a sandy clay below 10 to 15 inches to ensure that the trees have an adequate moisture supply during the dry months (Smyth and Montgomery 1962). It is important to select an appropriate site before establishing a cocoa farm. The process of selecting a suitable site, the following could be useful hints such as presence of earthworms cast in the site since this gives an indication for humus soils and type of trees growing in the area among other things. The following soil characterizations are standards for cocoa cultivation, these include adequate internal drainage, the proportion of coarse elements in the soil and good soil texture (sandy-clayey mixture).

Soil texture and depth

The soil texture influences the soils ability to store water and nutrients. Clayey soils generally contain more organic matter and nutrients than sandy soils (Feller and Beare 1997), which increases the vigour of the trees (Wessel 1971). Sandy soils are more susceptible to leaching (Aranguren *et al*., 1982). Clayey soils have a large moisture holding capacity, while sandy soils have good drainage. The water stored in clayey soils may not be easily available to the plants and the release of water to the plants is slower and more even than in sandy soils (Wessel

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1971; Wood 1985). Cocoa trees usually form a thick tap root up to a depth of 1.5m or more and hence require deep soils (Wessel 1971; Wood 1985). Even deeper soils are required when annual rainfall is low, especially when the water holding capacity is poor i.e. on sandy soils (Wessel 1971). Cocoa roots tend to root deeper in soils with a sandy topsoil than with a clayey topsoil, as sandy soils dry out to a greater depth during dry months. When the development of the tap root is restricted, the trees lack physical support and may fall over (Wood, 1985).

Soil moisture

Cocoa is sensitive to both drought and water logged soil (Carr andLockwood 2011; Gattward *et al.* 2012; Wood and Lass, 2001). Water logging, which may occur during the wet season in some regions, leads to inadequate soil aeration (Evans and Murray 1953). Water logging may prevent the initial growth and establishment of cocoa, and will reduce pod production in mature cocoa (Almeida and Valle 2007). Both water logging and drought may lead to nitrogen deficiency symptoms in cocoa (Evans and Murray 1953).

Soil nutrient requirements for cocoa production

Wessel (1971) reported that to achieve high productivity, Cocoa requires a soil abundant in nutrients. The importance of other soil characteristics, such as pH, is largely due to their influence on the availability of nutrients. In many cocoa growing regions, soil nutrient content without fertilizer application is poor, especially if the soil has been under cultivation for a long time (Hartemink and Donald, 2005; Baligar *et al.,* 2006). Although nutrients have different functions in the development of the tree (e.g. canopy formation, flowering, pod production), all nutrient deficiencies will ultimately lead to decreased yields. Annual nutrient requirements to replace nutrients exported from the system can be calculated using nutrient balance. Nutrient balance analysis in establishing fertilizer recommendations is based on the principle of replacement: the nutrients added in fertilizers should replace the nutrients leaving the system. To calculate fertilizer requirements using this method, only information about yields is required. Due to its simplicity, this is an attractive approach. Fertilizer recommendations for cocoa of some authors are largely based on the nutrient balance method, as their recommendations depend solely on the harvest obtained (Hardy in De Geus, 1973; von Uexküll and Cohen, 1980). However, the use of nutrient deficiency in soil is another method, where the critical level is considered for computation of fertilizer specific to the site under consideration.

pH

The availability of some plant nutrients is greatly affected by soil pH. The ideal soil pH is close to neutral, and neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5. It has been determined that most plant nutrients are optimally available to plants within this 6.5 to 7.5 pH range (Jensen and Thomas, 2010). Many nutrients become less available with increasing acidity while others become more available, which can lead to toxicity of these nutrients (Wood 1985; Baligar *et al.* 2006). The optimum range for growing cocoa is said to be pH 6.0-7.5 (Wood, 1985). Although according to Shamshuddin *et al.* (2004), cocoa is very sensitive to acidity, Wood (1985) argues that cocoa is tolerant to acid conditions as long as the soil provides adequate nutrients. High rainfall can lead to nutrient leaching and acidity of soils (Snoeck *et al.,* 2010). In the Nigerian cocoa belt, the annual precipitation of 1,150-1,650 mm can be considered to be less than ideal for cocoa production. However, this low rainfall is also the main reason why the Nigerian soils have not lost all their bases by leaching (Wessel, 1971). Generally, cocoa production will cause acidification (a lowering of pH) of the soil. Examples are decreases from pH 6.8 under forest to 5.5 after 10-15 years of cocoa cultivation in Nigeria (Hartemink and Donald, 2005).

Organic matter

Large amounts of nutrients, and in particular N, are present in the soil in organic form. Organic matter improves the structure of the soil, facilitates aeration and determines the capacity of the soil to hold water and exchange nutrients (Wood, 1985). Thus, soil organic matter plays crucial role in maintaining soil fertility (Van Noordwijk *et al.* 1997). Most of the soil organic matter is found in the topsoil. Wessel (1971) found that under cocoa the soil content of total N, organic P, CEC, and the sum of exchangeable bases (within certain pH limits) are all strongly positively correlated with the organic matter content of the soil.

The soil organic matter initially declines rapidly as a result of erosion, decreased litter supply and increased mineralisation in the exposed soils. Ahenkorah *et al.* (1974) found significant

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reductions of C in the range of 40-60% (from 4 to 2% in the 0-5 cm layer and from 2 to 1% in the 5-10 layer) within 15 years of cocoa production.

Soil fertility and Fertilizer management in cocoa production

Soil nutrition in cocoa plantation often reduce as a result of continuous cultivation of cocoa. Wessel (1971) reported steady decline in almost all the nutrients with length of cultivation. Omotoso (1975) showed that a crop of 1000kg dry cocoa beans removed about 20KgN, 4KgP and 10KgK and where the method of harvesting (as in Nigeria) involves the removal of pod husks from the field, the amount of K (potassium) removed is increased more than five folds. According to Olson (1970), fertilizer could increase food production by at least 50%. In a recent work conducted by Opeyemi *et al*. (2005) an effective use of fertilizer on cocoa would help not only to improve yield but also has the advantages of profitability, product quality and environmental protection. Fertilizer practices were recommended by Cocoa Research Institute of Nigeria, (CRIN, 1986). In the year of planting, 4g P/tree was recommended when grown on land cleared from forest and 10kgN+4kgP+4kgK/tree when grown on land previously cropped with cocoa or other arable crops. In the second and third year after planting 10g P/tree was recommended when grown on land cleared from forest and 25gN+4gP +3gK/tree on land previously cropped. Fourth and six-year old plantation 11-23g P/tree was recommended. Where land grown with cocoa was cleared from forest, while 50-100g N+12g P+ 25gK/tree was recommended on land previously cropped. Rehabilitation of old cocoa farm requires a lot of fertilizer input especially when the soil is marginal for cocoa production. In Nigeria, there is still no standard approach to this. Recent work on the use of organic fertilizer from animal and plant sources indicated that cocoa seedling was positively enhanced by the application of cow dung compared with cocoa pod husk (Ibiremo *et al*. 2004). Ogunlade *et al.* (2006) also indicated that organic sources of nutrient and organic -based N (Neem) fortified pacesetter fertilizer were more efficient than inorganic NPK fertilizer in increasing N, P and K uptake and growth of cocoa seedling.

Use of compost: Composting involves using waste materials from the household such as cocoa pod husks, cassava, yam, sweet potato peelings). Compost can be applied to the planting hole when planting cocoa or to mature farms if one can produce enough compost. One can make compost with a mixture of many materials including cocoa pod husks, empty oil palm fruit bunches, wood ash, charcoal dust, rice straw, poultry dropping, cattle manure, sheep manure, corn stubble or any other waste available in large quantities. Cocoa pod husks contain a lot of potassium which the cocoa trees remove from the soil (Ogunlade, *et.al* 2006).

Agronomic practices for growing sustainable cocoa

There are no 'silver bullets' or simple solutions to these diverse and complex problems that currently affect the cocoa industry. Practices that will bring about sustainable cocoa production are: Pruning and shade management. This practice determines the shape of the tree, it maximizes the nutrient distribution towards pods and helps in preventing some pest problems.

Gaps in knowledge

Considering the vast experimental work done on cocoa nutrition and fertilizer management, a number of research effort should be made to determine the critical values or what nutrient is present in the cocoa leaf and soil nutrient composition otherwise called site specific fertilizer recommendation.

Recommended research

Research can be carried out on development of fertilizer use in cocoa rehabilitation and fertilizer use efficiency of the various cocoa varieties.

CONCLUSION

Selection of suitable site is key to successful cocoa establishment which involves presence of high organic matter (humus), adequate depth of 1m and above is texturally suitable for proper root development.

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QUANTIFICATION OF KOLA POD HUSK BEING GENERATED IN KOLA PLANTATIONS IN NIGERIA

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ABSTRACT

A study was conducted at Cocoa Research institute of Nigeria, Ibadan, to determine the quantity of Kola pod husk being generated in kola plantations in Nigeria on wet and dry basis. Kola pods were collected from various kola plantations across major kola producing communities in Southwest Nigeria. The harvested pods were broken to remove the Kola nuts. The fresh and dry weights of kola pod husks and kola nuts were recorded individually in order to determine the percentage contribution of the fresh and dry kola pod weights to the Kola pod. Results indicated that kola pod husk contributed between 30-40% and 20-30% to kola pod on wet and dry weight basis respectively. Therefore, fresh kola nuts constitute 60 to 70% of kola pod. This suggests that though farmers neither take nor record quantity of kola pod husk generated on their farms, the record of fresh kola nuts yield can be used to estimate the quantity of kola pod husk generated on farmers' farm.

Key words: Kola pod husk, Kola producing states, wet and dry weight, kola nuts.

INTRODUCTION

Kolanut is a major cash crop for many farmers in parts of Western Nigeria as observed by Agboola 1979. Nigeria is the world's largest producer of kola nut. Kola-pod husk (KPH) is a by-product during Kola nut production. The pod husk, has been a farm waste to date. In Nigeria, kola pods are harvested, and collected at a central point within the farm where pods are broken, kolanuts removed and husks are discarded as waste. It is either left on the farm to rot or burnt. Instead of allowing these agricultural waste to be a source of menace to humanity, harnessing this by- product and utilizing them under adequate conversion techniques can make the to become useful. Kola pod husk can be used in the formulation and compounding of livestock (especially fish) feed and for the production of soap (Yahaya et al, 2001, Hamzat et al 2001). Kolanut pod husk can also be used as an organic fertilizer (Ipinmoroti 2007, Makinde, 2013). kolanut husk meal has high potential for consideration as possible substitute for conventional feed stuff such as maize in the nutrition of broilers Olubamiwa et al, 2011. Some other products obtained from KPH include biogas and substrates for microbial enzyme production and medicines Considering the diverse uses of KPH, it is necessary to know the quantity being produced for planning purpose. The knowledge of the quantity available will also guide the entrepreneur who might want to use Kola pod husk as raw material for the production of some of the derivatives earlier mentioned.

Most farmers in Nigeria do not keep records of kola pod husks being produced on their farms. Most farmers have information on the weight of kola nuts produced on their farms. The relationship between the kolanut weight and kola pod husk can be used to determine the percentage contribution of husk to kola pod. Therefore, the aim of this study is to determine the quantity of kola pods being produced by the farmers on the farm using the relationship between the dry and wet weight of kola nuts and kola pods.

MATERIALS AND METHODS

Ripe and ready to harvest kola pods were harvested from randomly selected kola plantations in kola growing communities covering five cola producing States in southwestern Nigeria: Ondo, Oyo, Osun, Ogun and Ekiti States. Eight locations were visited altogether with ten pods harvested per location. The fresh pods were weighed using a battery operated sensitive digital scale. Thereafter the cola pods were cracked to open up the pods and the nuts were removed and weighed. The percentage weight of the wet KPHs that were generated by the wet cola pods was then determined using the equation below.

$$\% \text{ Weight KPH (wet basis)} = \frac{W_h}{W_p} \times 100$$

Where Wh = weight of KPH on wet basis

Wp = Total weight of the fresh kola pod

Kolanuts from each pod were placed in a plate and dried at room temperature. Pod husks were also dried until constant weight was obtained, after about 14 days. Dried KPH and kola nuts from each of the pods were weighed separately using a battery operated sensitive digital scale. The percentage of dry pod husk was determined using the equation below:

$$\%\ \text{Dry KPH} = \frac{W_{dh}}{W_{dp}} \times 100$$

Where W_{dh} = weight of KPH on dry basis

W_{dp} = Total weight of the kola pod on dry basis

This was done for each of the 80 pods collected from 8 Kola plantations, the frequency distributions, means and standard deviations were determined as well.

RESULTS AND DISCUSSION

Most of the kola pods evaluated had between 20.1-40% fresh kola pod husk (Table 1). This implies kola pod husk contributed between 20-40% on wet basis to kola pods. The percentage mean of fresh KPH ranged from 28.78 to 41.16. The % fresh KPH of between 30.1 to 40% occurred most frequently with a mean value of 62.5%. (Table 2)

Table 1: Quantity of Fresh Pod Husk in Kola Pods

Locations	0-20%	20-40%	>40%	Total	mean	Std dev	minimum	maximum
1		10		10	31.48	2.96	28.85	36.04
2	3	7		10	28.78	10.60	14.26	38.5
3		6	4	10	41.16	8.33	32.98	53.36
4		7	3	10	39.20	3.85	35.91	45.98
5		10		10	31.44	5.82	22.17	33.22
6		10		10	32.24	10.93	24.51	39.97
7		10		10	30.04	4.35	25.03	32.76
8		10		10	31.41	2.25	29.23	34.31
Total	3	70	7	80				

Table 2: Percentage mean of fresh KPH

% fresh kph	Frequency	Percentage
0-20	3	3.75%
20.1-30	18	22.50%
30.1-40	50	62.50%
40.1-50	7	8.75%
>50	2	2.50%
Total	80	
Mean		33.80%
Standard Deviation		7.06%
Range		14.26-53.36%

CONCLUSION

Kola pod husk contributed 33.80% and 23.20% to kola pod on wet and dry weight basis respectively. Hence, fresh kolanuts constitutes approximately 66.20%of kola pod. Therefore, a farmer can determine the quantity of kola pod husk generated annually from the annual record of fresh kola nut yield.

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CORRELATION STUDY AMONG GROWTH AND YIELD CHARACTERS WITH YIELD OF SESAME (*SESAMUM INDICUM L*) GROWN IN 2015, 2016 AND 2017 RAINY SEASONS IN DADIN KOWA, GOMBE STATE OF NIGERIA

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ABSTRACT

A field trial was carried out for three years (2015, 2016 and 2017) during the rainy seasons at the research and demonstration farm of Federal College of Horticulture, Dadin Kowa, Yamaltu Deba local government area, Gombe State. The aim of the study was to investigate the effect of variety and intra row spacing on the performance of sesame. The experiment consisted of two varieties (E8 and NCRIBen04E) and three intra-row spacings (5cm, 10cm and 15cm). The two varieties and three row spacing were factorially combined and laid in a complete randomized block design with three replications. During the study period, growth characters such as plant height, number of leaves, leaf area, and number of branches were measured. Similarly, yield characters such as number of flowers and capsules, 1000 grain weight and grain yield were also recorded. All the characters studied significantly correlated with grain yield, except number of leaves, number of capsules and 1000 grain weight. Plant height, number of secondary branches and number of flowers correlated positively with grain yield while number of primary branches correlated negatively with grain yield. Therefore. from the results of the trial it could be concluded that, some characters like plant height, primary branches, and number of flowers had contributed to the grain yield of sesame and it revealed that the higher the flower the higher the grain yield in sesame.

Key words: Correlation, Sesame, Variety, Spacing.

INTRODUCTION

Sesame (*Sesamum indicum* L.) it is one of the oldest cultivated oilseed crops in the world it belongs to the family *Pedaliaceae*. Its known as beniseed in West Africa has been recognized as crop with high economic potential, especially in Nigeria where it is both used as a source of raw material for the industry and a reliable foreign exchange earner. In Nigeria, the crop is locally called *Ridi*, *Ekuku* and *Isasa* by the Hausas, Yorubas and the Igbos, respectively. Majority of sesame growers in the study area use local varieties which are low yielding when compared to the improved varieties made available by modern Agriculture. There are also discrepancies among farmers on the suitable row spacing, as different genetic variability of the crop in terms of growth habit exists. It is only of recent that its commercial cultivation captured the attention of farmers especially in North-eastern parts of Nigeria. Because of the relatively low documented scientific information on the production of sesame in the study area, the present study will attempt to fill the knowledge gap especially relating to acceptable varieties, the proper plant spacing and best methods of weed control.

The present investigation was carried with the following objectives. study simple correlation between growth and yield characters with grain yield of sesame

MATERIALS AND METHODS

Field experiment was carried out for three years during the rainy seasons of 2015, 2016 and 2017 at the research and demonstration farm of Federal College of Horticulture, Dadin Kowa Gombe State Nigeria. Dadin-Kowa is located at latitude 10^0 15'N and longitude 11^0 15'E in the northern Guinea savannah zone of Nigeria (GPS 2015). The climates in the region consist of two distinct seasons, rainy season (May to October) and dry season (November to April). Average annual rainfall in the study area is 1021.80mm, mostly distributed between the months of May and October, while the mean daily temperature ranges from 22^0 C to 35^{0}C (UBRBDA, 2008).

The experimental material used in this research consist of two varieties (E8 and NCRIBEN 004E) which were sourced from National Cereals Research Institute Badeggi, Bidda, (NCRIB) Niger State. The experiment consisted of two factors: variety (E8 and NCRIBen004E), Intra row spacing (5, 10 and 15cm). The two factors and their levels gave 6 treatment combinations which were laid in a randomized complete block design with three replications.

At the beginning of each trial during the three years, the land was cleared and harrowed twice to obtain a fine tilth. During layout of the experiment, pegs and ropes were used to demarcate plot boundaries, lay out plots and block boundaries. Each plot measured 3 x 3m (9m^2) in size with a distance of 0.5m between the plots and 1m between replicates. Six plots were obtained in a replicate, given a total of 18 plots.

Before sowing the crop in each year, soil samples were taken in a "Z" shape within the experimental area following the procedure of IFDC (2003) at a depth of 0-30cm using a tubular auger. The samples obtained were first air-dried, thoroughly mixed, ground and then sieved for analysis of physical and chemical properties in the laboratory as described by Page *et al.,* (1983). During the analysis, the following properties were determined: Size distribution (soil class), soil pH, organic carbon, total nitrogen, available phosphorous, potassium, cat-ion exchange capacity (CEC) and exchangeable bases to determine the fitness of the soil for sesame production (Appendix I).

In each plot, plants in the two outer rows from each side of the plot were taken as border rows. Ten plants randomly selected from the three central rows in each plot were then tagged using masking tape and from these sample stands all the data were collected and measured. Growth characters like plant height, number of leaves, leaf area etc were recorded at an interval of two weeks commencing from 4WAS, until harvest, yield characters like number of capsules, seed weight etc. were only taken once at harvest.

Analysis of variance (ANOVA) was used to analyze all the data collected as described by Gomez and Gomez (1984) and to test for the significant effect of all the treatments. Where there were significant differences among the means of the different treatments, they were separated using Duncan's Multiple Range Test (DMRT) following the procedure of Duncan (1955).

RESULTS AND DISCUSSION

Simple correlation between growth and yield characters of sesame taken in 2015, 2016 and 2017 rainy seasons is presented in Table 1. Characters taken were plant height, number of leaves, number of pods, primary branches, plant height, secondary branches, number of flowers, 1000 grain weight and grain yield. All the characters studied significantly correlated with grain yield, except number of leaves, number of capsules and 1000 grain weight. Plant height, number of secondary branches and number of flowers correlated positively with grain yield while number of primary branches correlated significantly negatively with grain yield.

Table 1: Simple Correlation among growth and yield characters with yield of Sesame grown in 2015, 2016 and 2017 rainy seasons

Characters	Correlations
Grain yield	
Plant height	0.2735**
Number of Leaves	0.0924ns
Primary Branches	-0.1996*
Secondary Branches	0.1630*
Number of flowers	0.4271**
Number of capsules	0.0660ns
Number of capsules	0.0660ns
1000 grain weight	0.0943ns

* = Significant at 0.05 probability. ** = Significant at 0.01 probability. NS=Not Significant

Plant height, primary branches, and number of flowers had contributed to the grain yield of sesame, hence these among other factors should be considered in the selection for high yield capacity in sesame production as described by Olowe (2004). In a related study, the relationship between seed yield of sesame crop and various growth and yield parameters were reported by several researchers. Engin *et al.*, (2010) in a study conducted in Australia involving 345 sesame genotypes originating from 29 different sesame producing countries worldwide, he reported that, plant height, number of branches and 1000 seed weight had a positive significant correlation with seed yield. In another correlation studies conducted in Nigeria by Muhamman *et al*., (2009) it was revealed that, number of branches, plant height and leaf area had a positive correlation with seed yield of sesame crop, while 1000 seed weight showed a non-significant relationship with seed yield. Subramanian and Subramanian (1994), reported that, seed yield had a positive significant correlation with number of capsule, number of primary branches, number of seed per capsule and 1000 seed weight. It was also reported by Adeyemo *et al.,* (1992) that seed yield had a significant correlation with number of capsule, seed yield per plant, number of seed per capsule, number of primary branches and 1000 grain weight.

CONCLUSION

A field trial was carried out for three years during the rainy seasons of 2015, 2016 and 2017 at the research and demonstration farm of Federal College of Horticulture, Dadin Kowa, Yamaltu Deba local government area, Gombe State. The aim of the research was to study the effect of variety, and intra row spacing on performance of sesame. The two varieties were E8 and NCRIBen04E while the three intra-row spacing were 5, 10 and 15cm During the investigation, growth characters such as plant height, number of leaves, leaf area, number of branches and leaf area index were measured. Yield characters such as number of flowers, number of pods, 1000 grain weight and grain yield were also recorded. Therefore, from result of this study it could be concluded that, some characters like plant height, primary branches, and number of flowers had contributed to the grain yield of sesame. Moreover, it was revealed that, the higher the flower, the higher the grain yield in sesame.

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EFFECT OF VARIATION IN ONSET AND CESSATION DATES ON GINGER YIELD IN KACHIA AREA OF KADUNA STATE

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ABSTRACT

Climate change has been observed as one of the most serious environmental threats facing mankind worldwide with the likelihood of reducing agricultural production in the tropics. It brings with it changes in weather patterns that can have serious repercussions on humanity, upsetting seasonal cycles and harming ecosystems and water supply, thereby affecting agriculture and food production in a number of ways. Extreme weather events such as thunderstorms, heavy winds, and floods devastate farmlands and can lead to crop failure. As weather becomes fiercer and storms increase in frequency and intensity, it poses a significant impact on global and regional food production of both stable food and cash crops performance in tropical sub-humid climatic zone. However, the extent and nature of this impact still remain uncertain. In this study, records of ginger yield and rainfall in Kachia Local Government Area of the southern Kaduna area of Kaduna State, for a period ten years (2001-2010) were evaluated. Onest and cessation equation was adopted to derive the onset and cessation dates as well as the length of rainy season. Trend lines and linear trend equations were fitted to show the magnitude and direction of rainfall effectiveness indices and ginger yield. Correlation analysis showed that there is a relationship between the rainfall effectiveness indices and ginger yield. The results of the study showed that the trend in onset dates ($y=1.5939x +42462$), cessation dates ($y= 0.384x + 41916$), length of rainy season ($y=2.8424x +79.267$), annual amount of rainfall ($y=18.429x + 1635$) and ginger yield ($y=0.2721x + 7.8733$), were at increase. The correlation coefficient (r) between onset date and ginger yield ($r=0.34$) showed a strong positive relationship, cessation dates and ginger yield ($r= -0.20$) showed a negative relationship, length of rainy season and ginger yield ($r=0.38$) showed a positive relationship and the annual amount of rain and ginger yield ($r=0.19$) showed a weak positive relationship. Based on these results, the study suggests that ginger yield in the study area is high at early onsets and longer rainy seasons.

Key words: Ginger yield; Rainfall variability; Onset and cessation dates; Length of season

INTRODUCTION

Agriculture is one of the most weather sensitive human socio-economic activities substantially affected by climate variability and change globally (Adamgbe and Ujoh, 2013; Lalego *et al*., 2019). Climate change and climate variability are projected to contribute to increased drought episodes, food insecurity, irreversible decline in herd sizes, and deepening poverty (Ayanlade *et al*., 2009). In the Sub-Sahara African region, where 63% of the population continues to depend on rain fed agriculture, climate variability and change remain the major challenges hampering agricultural productivity, with direct influence on the quantity and quality of production (Sani and Chalchisa, 2016; Fadina and Barjolle, 2018). Africa is one of the most vulnerable continents to the current climate variability with strong economic impacts (Mustapha *et al*., 2012). This vulnerability is accentuated by developmental challenges such as endemic poverty, ecosystem degradation and limited access to capital, markets, infrastructure and technology (Juana *et al*., 2013; Fadina and Barjolle, 2018). Also, the events of climate change and variability lead to substantial losses of both crop and livestock causing agricultural activities to be at high risk, unattractive and unbeneficial to the majority of small-holder farmers (Assoumana *et al*., 2016; Gebreeyesus, 2017). Hence, Climate determines whether or not rain fed agriculture will be feasible and the type of crops that can be successfully cultivated in a given area (Omonijo, 2014).

Rainfall variability has been defined as the variations in the mean state and standard variation of the occurrences of extremes of rainfall on all spatial and temporal scales beyond that of individual precipitation events (Odjugo, 2010;

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Atiyong, 2018). Theoretically, there are three different forms of rainfall variability namely spatial, inter-annual and intra-annual variability (Ayanlade *et al*., 2009). Spatial variability is the differences in total rainfall received between places structurally located within a given region, Inter-annual rainfall variability is the annual deviation from long-term averages or the differences in rainfall between years, while intra-annual rainfall variability refers to the distribution of rainfall within a year. Since Nigeria's agriculture is predominantly rain-fed, agricultural production is therefore heavily dependent on the seasonal characteristics of rainfall which has been shown to diminish in amount and duration as one move from the south to the northern part of the country (Sanni *et al*.,2012; Atiyong, 2018). Intraseasonal and interannual variability methods have been employed to monitor rainfall patterns in rainy seasons in the subhumid areas of Africa and to assess the potential threat of rainfall variability to food security (Kyei-Mensah *et al*., 2019).

Nigeria is a tropical country characterized by alternating dry and rainy seasons; with the annual rainfall less than the amount of the water that a crop would require to transpire during the growing season (Hamzat *et al*., 2017). Rainfall variability from season to season therefore adversely affects the sustainability of a variety of agricultural crops grown in Nigeria, particularly in the northern part of the country, which results in low productivity (Yunusa *et al*., 2017). Notably among such water loving crops is ginger. Ginger (Zingiber officinale Roscoe) is a herbaceous perennial crop, grown as an annual crop for its spicy underground rhizomes, which contain volatile oil, fixed oil, pungent compounds, resins, starch, protein, and minerals (Fumen, 2003; Onu and Simonya, 2017). Grown mostly in southern Kaduna Sate, the traditional home of ginger in Nigeria (Ayodele and Sambo, 2014), ginger requires an annual rainfall of 1500mm or more and a rainfall duration well distributed between 2 and 4 months for sustainable and higher yield (Atiyong, 2018).

Studies have been conducted on the changing rainfall patterns by many researchers notably, Abaje *et al*. (2010), Abaje *et al*. (2015), Leonard *et al.* (2015), Mkonda and He (2017), Yunusa *et al.* (2017), Murtala and Abaje (2018), Kyei-Mensah *et al*. (2019), among others. Results of these studies show that there is an annual change in the occurrences of wet and dry season regimes in Sub-Saharan Africa, annual decadal and inter decadal variations in rainfall and a general decline in rainfall amount in the West-African sub-region, particularly Nigeria. The variability in rainfall which may result in either a decrease or increase in the rainfall trend in different regions of the world have resulted in reduction of water levels or total dry up of some perennials and seasonal rivers and lakes (Atiyong, 2018). Nigeria's agriculture has been observed to largely depend on climate to function and that precipitation, solar radiation, wind, temperature, relative humidity and other climatic parameters affect and solely determine the global distribution of crops, livestock as well as the productivity and sustainability of agricultural lands (Aderibigbe, 2016).

Although, it may seem as if there is little or nothing could be done to minimize variability in rainfall since most of its causes are natural, there is need for in-depth study and understanding of spatio-temporal rainfall variability as well as its significant impacts on crop yield. It should also be noted here that, in spite of great advancement in the understanding and dealing with the problem of rainfall variability impact on crop yield at the international level, awareness and concern for the problem at national and local levels remain poor or in some cases non-existent (Ayanlade *et al*., 2009). This research work, therefore, attempts to look at the rainfall variability impact on ginger yield with particular reference to Kachia Local Government Area of Kaduna state, for a period of ten years (2001-2010)

MATERIALS AND METHODS

Data Collection

Data and information for this study were obtained between the months of June and August, 2016 from verbal questions to farmers and use of secondary sources. The secondary data on average rainfall and ginger yield for the study area (Kachia LGA) were obtained from two sources; climatic data on rainfall for a period of 10 years (2001-2010) and ginger yield for the same period, from the Department of Hydrology Hydrology (Meteorological Unit), Kaduna State Water Board and Kaduna State Agricultural Development Project (KADP) respectively.

Data Analysis

Data Analysis Linear regression was used to determine the linear trends of rainfall and ginger yield in order to compare people's perception of climate change and the observed change (Atiyong,

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2018). The formula for the linear regression is given as:

$$y = a + bx \quad (1)$$

Where, a is the intercept of the regression line on the y-axis and b is the slope of the regression line. The values of a and b were determined.

To further examine the nature of the rainfall trends, the Standardized Anomaly Index (SAI) was used. It provided an area-average index of relative rainfall yield based on the standardization of rainfall totals. Similarly, the relationship between rainfall and ginger yield in the study area was tested using Pearson's product moment correlation coefficient.

Both data were transformed to a common base [log 10]. The rainfall data was segregated into specific rainfall effectiveness indices such as Onset, Cessation and Duration of Rainy season and were derived as adopted by Walter (1967). To examine the trends, Onset and Cessation dates, annual rainfall, length of rainy season and ginger yield, were subjected to trend lines and fitted linear trend line equations. Each of the parameters was plotted graphically to show the direction and magnitude of impact of change on the parameters in the area. Correlation analysis was used to show the relationship between the rainfall effectiveness indices and ginger yield, using the statistical package for social scientist (SPSS) software.

RESULTS AND DISCUSSION

Table 1 shows the precipitation parameters (Annual rainfall, Onset Date, Cessation Date and Length of rainy season) and ginger yield

Table 1: Rainfall and ginger yield data analysis

Year	Annual Rainfall (mm)	Onset Dates	Cessation Date	Length of rainy Season Days	Ginger yield (Tons/ha)
2001	983.47	11th April	24th September	83	8.20
2002	1474.92	10thApril	12th November	61	8.50
2003	1814.76	26th March	29thOctober	117	8.50
2004	1684.09	17th April	25th October	99	8.50
2005	3279.11	16th March	22nd October	89	9.20
2006	1745.23	22nd April	18th October	94	10.00
2007	1620.23	16th April	16th October	93	10.00
2008	1675.5	23rd April	15th October	88	10.10
2009	1568.1	15th April	24th October	112	10.70
2010	1517.95	17th April	22nd October	113	10.00

Annual Rainfall Amount

The analysis in Table 1 shows that the highest observed annual trend of rainfall amount within the study period was 3279.11 mm in 2005, while the lowest amount was 983.47mm in 2001. This result conforms to the report of NEPC (1999) which maintained that ginger produces well at rainfall of 1000-1500mm distributed evenly over 6-8 months.

Onset Dates

The result shows that the rainy season started as early as 16th march in 2005 and the latest onset date was 23rd April 2008 with an average onset date of 11th April.

Cessation Dates

The termination of the rainy season as shown in table 1 shows that the end of the wet season was earliest in 2001, on the 24th of September while the 12th of November, 2002 marked the latest termination date with average cessation date of 20th October.

Length of Rainy Season

The result also shows that the length of the rainy season generally falls between 80- 120 days with the average of 95 days each year. The longest wet season recorded during the study period was 117 days in 2003 and the shortest duration was 61 days in 2002.

Ginger Yield

Ginger yield as presented in the analysis shows that the largest ginger harvest was recorded in

2008 a production of with 10.10ton/ha while the least harvest was 8.20ton/ha in 2001.

The result in Figure 1 indicates a late onset. The linear trend line equation (y=1.5939x +42462) shows that the onset dates are on the increase thus, implying delay in the commencement of ginger cultivation therefore risking effective production/

Trends of Precipitation Effectiveness Indices and Ginger Yield

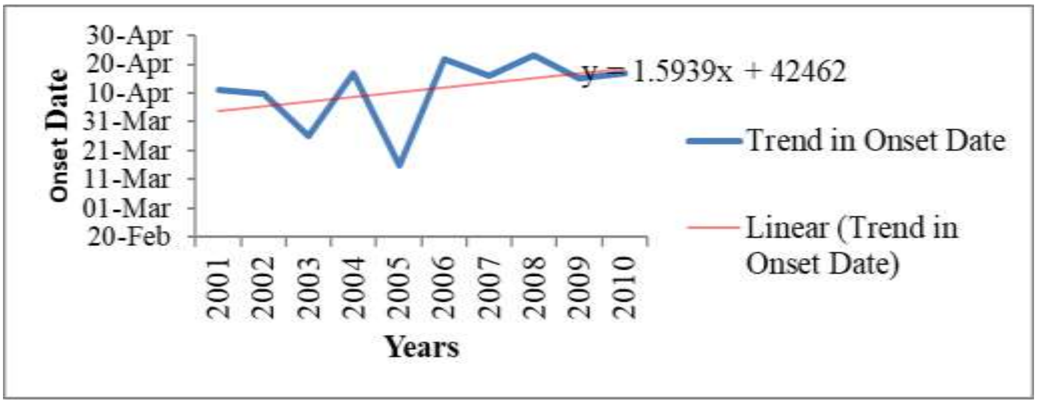

Figure 1: Trend in onset date

Trends in Cessation Dates

The cessation dates of the rainy season in the study area as presented in Figure 2 shows that there was an early termination in September, 2001 a very late termination in November, 2002. The linear trend line equation (y= 0.384x + 41916) shows increasing trends of cessation dates. This trend suggests a leverage for optimum ginger yield as the late cessation of rain may compensate for the late onset.

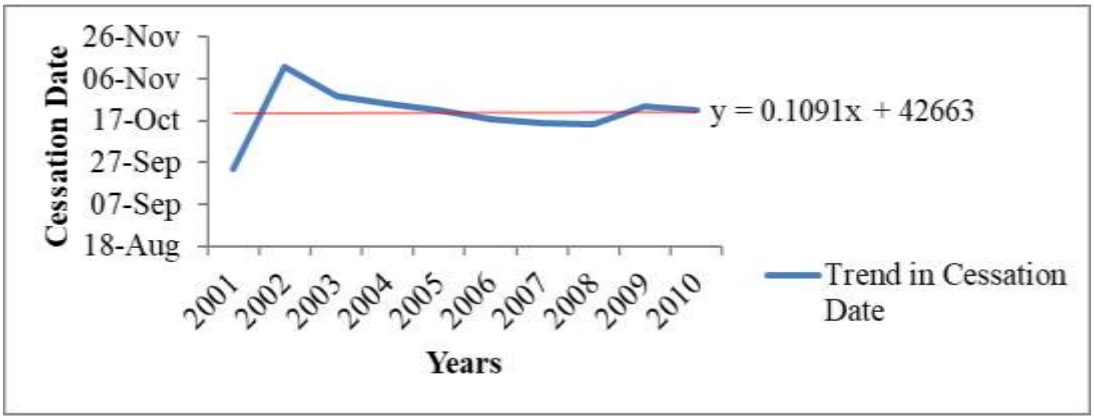

Figure 2: Trend in cessation date

The analysis in Figure 3 shows that there was a very short period of rainy season in 2001 and 2002, while the longest wet season was experienced in 2003. The linear trend line equation (y=2.8424x +79.267) show increase in length of wet season especially from 2008-2010. This trend implies a great chance for higher yield in ginger production as the requirements tend to be met through a longer rainy season.

Trend in Annual Rainfall

The result in Figure 4 shows that the lowest amount of rainfall received within the study period was in 2001, it increased until the highest amount was recorded in 2005. The amount fell in 2006 through 2010. Conversely the linear trend line equation (y=18.429x + 1635) indicates an increase in rainfall amount. This trend shows a consistency in the increase of rainfall amount, thereby ensuring security in water requirements of ginger.

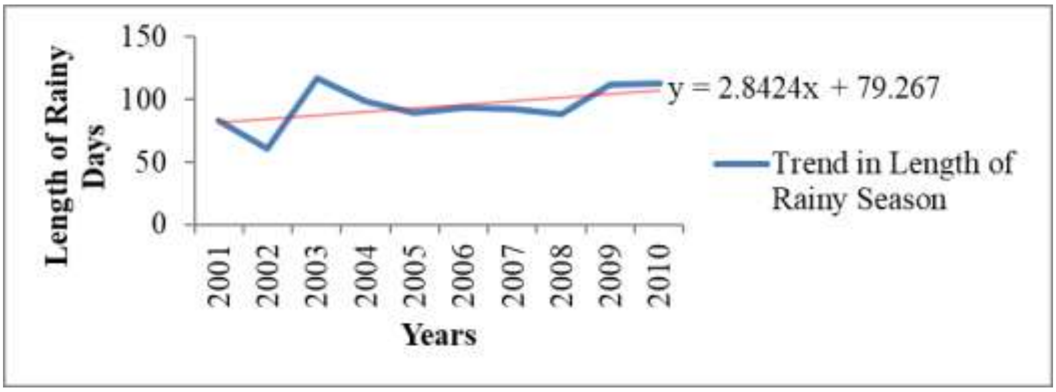

Figure 3: Length of rainy season

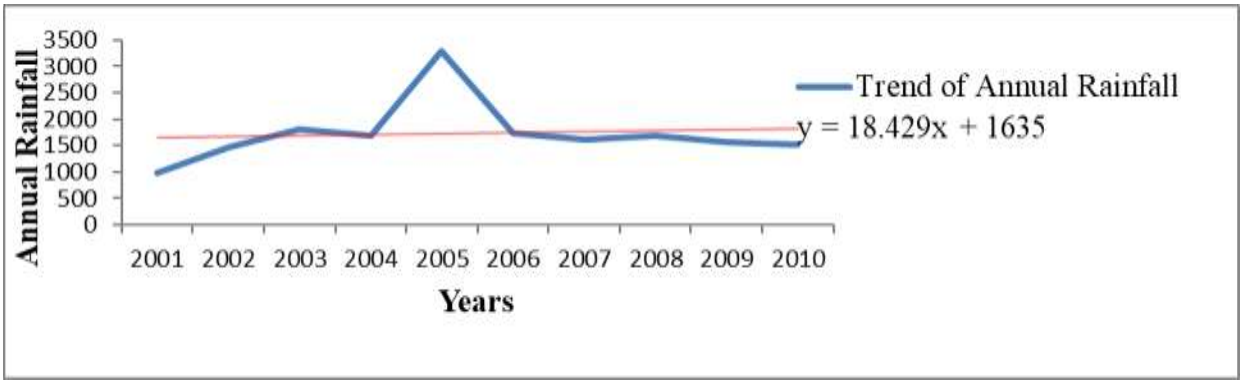

Figure 4: Trend in annual rainfall

Trend in Annual Ginger Yield

The result presented in Figure 5 clearly indicates an increase in the annual yield of ginger within the study period. While the least yield was recorded in 2001, there was increase in yield through to 2010. The linear trend line equation (y=0.2721x + 7.8733) confirms the obvious fact of an increase pattern.

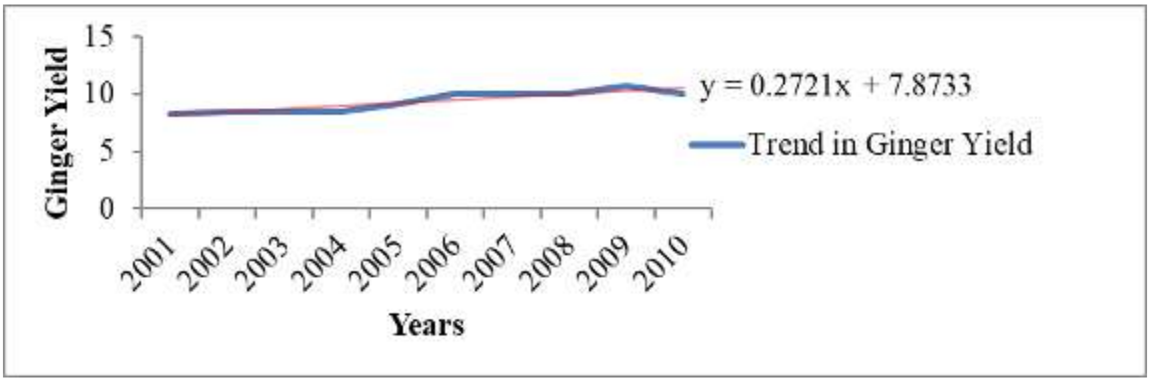

Figure 5: Showing trend in annual ginger yield

The Relationship between Ginger Yield and Rainfall Effectiveness Indices

The correlation values in Table 2 shows that there is a weak positive relationship between ginger yield and the annual amount of rainfall (r = 0.19) in the area. The onset date shows a strong positive relationship (r = 0.34) with the yield of ginger implying, the earlier the onset, the better chances of higher yield. The cessation date shows a negative relationship (r = -0.20) with the yield of ginger implying that if the rains terminated at earlier dates it will hamper optimum yield of ginger. The length of the rainy season on the other hand shows strong relationship (r = 0.38) with ginger yield. This means that, increase in the yield of ginger is encouraged by increase in the length in raining season.

Table 2: Correlation matrix of ginger yield and rainfall indices

Parameters	R-value
Annual rainfall	0.190
Onset date	0.335
Cessation date	- 0.198
Length of rainy season	0.383

CONCLUSION AND RECOMMENDATIONS

The study has shown that there is wide variability in onset and cessation of growing seasonal rainfall with a negative trend with upward rising of temperature in the study area, which has huge implications in soil moisture, potential evapotranspiration, and heat stress on crops. Consequently, the variations in rainfall pattern have had enormous impacts on ginger yields. Although cessation, duration and amount of annual rainfall influenced the yield of ginger, the major determinant of the yield variability was found to be the onset date of the rainy season. This is partly due to the fact that farmers are less informed and are only motivated by the commencement of the rains which cause them to begin planting late. This affects the growing period of the crops, as the wet season often comes to the end while the crops are still growing thereby resulting in lower yields. To minimize the effect of rainfall variability and enhance ginger yields in the study area and Kaduna state, at large, below are some suggestions:

i. The National Meteorological Agency (NMA) should provide forecasts of onset and cessation of growing season in all the 23 local government areas of the state. At present, the weather forecast in Nigeria is lacking. The forecast has not been able to give precise rainfall onset, cessation, and its impact on crop yields. Such information could guide farmers, agriculture extension officers, and crop breeders on the type of adaptation strategies to initiate and to enhance crop yields and food security in the country.

ii. The national and county governments should sensitize farmers on climate/weather variability and monitoring of crop-climate relationship in the area in other to achieve improved crop yield.

iii. Irrigation to supplement crop water requirements should be promoted.

iv. In view of high correlation and maximum temperature, crops that are tolerant to heat stress should be bred for farmers in the study area.

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COFFEE PRODUCTION IN A DIVERSIFYING NIGERIA ECONOMY

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ABSTRACT

Coffee was introduced to Nigeria around 1859 and is mostly cultivated in the lowland areas for Robusta (Coffea canephora) and Highland areas for Arabica (Coffea arabica). Apart from its health benefits, coffee has contributed to Nigeria economic growth as one of the major export crops. However, this contribution has diminished over the years due to poor quality of planting materials, soil quality, land acquisition, bean quality, unstable and unfavourable government policies which result in poor marketing. These had adversely affected the livelihood of coffee farmers and eventually led to abandonment of the crop. However, CRIN research efforts have produced high yielding compatible coffee clones from 3 Robusta varieties {Niaoulli (M10), Java (T1049) and Quillou (C90, C36 and C111)} which have resulted in increase in coffee yield from 500-1360kgha^{-1}. Efforts on multiplication of improved planting materials, sensitization of farmers' interest to establish new plantations, development of improved rehabilitation techniques are recent ways of increasing production. Nigeria has over 1.5million ha that is suitable for coffee production and 13 of the existing 36 States in Nigeria are commercially suitable for coffee cultivation. Though majority of farms are old, moribund and unproductive, markets are also unorganized. The current policy of the government to diversify the economy is a strong opportunity to arouse farmers' interest, while influence of climate change is a factor that deserves urgent attention. In view of the strengths and opportunities that abound in coffee production, the current administration should give coffee the pride of place in her diversification policy.

Key words: Climate change, coffee yield, foreign earnings, rehabilitation, sustainable production

HISTORY

Coffee is a member of the large Rubiaceae family, within which it constituted the C*offea* genus with different species. Notably among the species in Nigeria are *Coffea Arabica* and *Coffea canephora* (Robusta). Coffee was introduced to Nigeria in the colonial times around the same time as cocoa in 1859. Coffee is one of the most important export crops for Africa and Latin America countries. It is the 2nd traded commodity in the world after oil and the 2nd consumed liquid after water as eight million tons is consumed each year globally.

In Nigeria, Coffee occupies a significant area of land covering about 270,000 hectares of land with an average production of 174000 metric tons yearly. It is commercially grown in 13 States namely; Taraba, Kogi, Ondo, Oyo, Ogun, Osun, Edo, Kwara, Ekiti, Adamawa, Plateau, Abia and Cross River as shown in Figure 1. However, Coffea Arabica is grown only on Mambilla Plateau and Obudu hills while Robusta is grown in low altitude.

The earlier production was reflected in the export figure of 1896 as 5.5 metric tons, 25.5 mt in 1901(Williams, (1989). It was reported by World Coffee Press 2015, that the Nigeria coffee industry has been on a steady downward slide since mid-1960s, from a production of 100,000 bags in 1964 to almost zero 2014.

IMPORTANCE

Coffee as a beverage is the second most consumed liquid after water in the world and the second important crop commodity after cocoa traded in the world market. Once upon a time, the trade in Coffee created numerous millionaires. It is on record that Kabba Coffee was noted in the world market in the 60s and released markets, middlemen and Coffee merchants in many parts of the country. The Coffee trade was source of livelihood to the farmers before the liberalization of the marketing board. Many Coffee traders built numerous houses and they were able to send their children to places such as the United Kingdom to study. The markets popularity grew in leaps and bounds. With respect to international trade, Coffee products are exported to Congo Brazzaville, Gambia, United States of America (USA), Saudi Arabia, Germany, United Kingdom, Pakistan, Turkey, France, The Netherlands, Cote d'Ivoire, Chad and Senegal.

Similarly, the contribution of coffee to export trade in Nigeria has declined over the years due to low levels of output and export. It is recognized that poor marketing and inadequate technical know-how of the management practices are the major factors responsible for the poor performance of the coffee sector in Nigeria. However, there is a growing demand for coffee globally and low stocks, supply constraints and new price floors are also prevalent. There are great opportunities for Africa and especially Nigeria by tapping from the success story in Vietnam and Brazil.

The health importance of coffee cannot be overemphasized. The biggest source of antioxidants in the western diet, it helps in burning fat, it guards against gout, it improves energy level and make you smarter and alert, improves physical performance, may lower the risk of type II diabetes, can protect you from Alzheimer's disease and dementia, may lower the risk of Parkinson's, has protective effect on liver, lowers the risk of some types of cancer, does not cause heart disease and may lower the risk of stroke, a cup of coffee contains essential nutrients: Riboflavin (Vitamin B2) 11% of the RDA, Pantothenic acid (Vitamin B12) 6% of the RDA and Manganese and Potassium 3% of the RDA.

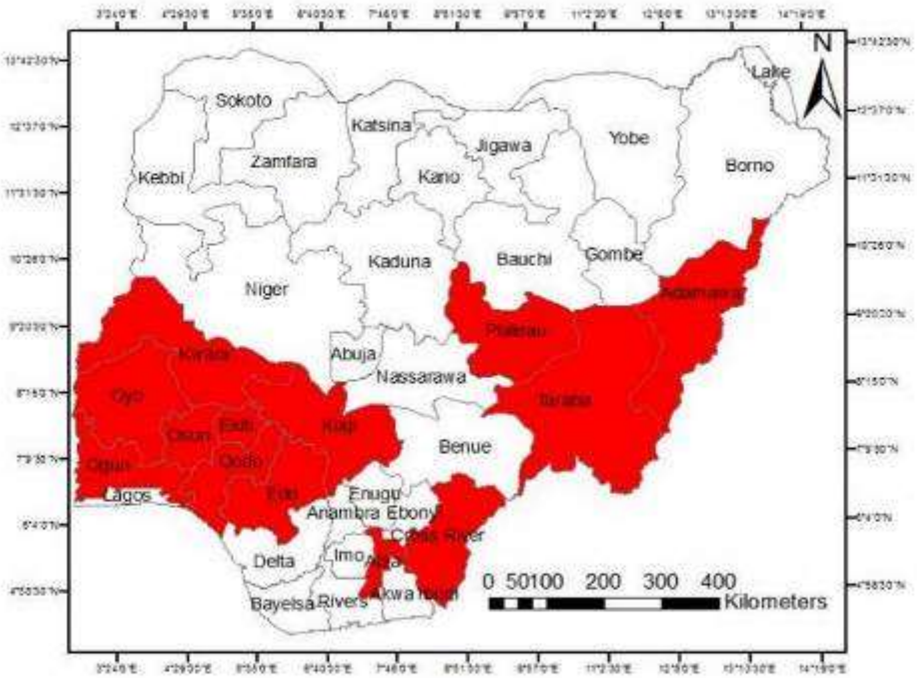

Figure 1: Showing Coffee growing area (CRIN, 2014)

PROBLEMS

The problem of coffee production in Nigeria started in the 60s, when the crude oil was discovered and by 70s when the oil boom started, the Federal Government started shifting their attension from Agriculture. This resultantly resulted into farm abandonement, by youth who have the strength for farming, leaving aged farmers on the farm. In the 70s, Commodity board was also proscribed leading to the liberalisation of the price; a free for all marketer to bargain. However, as if these are not enough; the enterprise was faced with poor planting material, emmerging pest infestation, soil depletion that resulted in low yield. Coffee production undertake value addition to attrack good market, hence a good processing method is required to market a quality berry. Farmers are faced with problem of good processing method, while the influence of climate change is not in favour of farmers.

POTENTIALS OF COFFEE IN NIGERIA

Nigeria coffee was noted in the world market for its quality as this crop grows easily without or less use of chemical. Coffee is produced predominantly by the small scale farmers in the highland of Mambilla Plateau in Taraba state (Williams, 1998). In the world trade, Arabica coffee is of the greatest economic importance and account for 4% of export in Nigeria. According to The United States Department of Agriculture (USDA), Nigeria produced 35,000 bags of coffee in 2014,

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representing an increase of 16.67% over the 30,000 bags produced in 2013. Coffee production in Nigeria peaked at 95,000 bags in 1964 and has been dropping steadily since 2000, remaining below 60,000 bags on annual basis. The stakeholders within the system have attributed the poor development to apathy which has caused Nigeria its membership position in International Coffee Council.

Amongst 95% of Nigerian coffee farmers, incompatibility problem has been observed to be a major factor limiting yield to 600-800/g/ha. This makes investment in coffee production less profitable (Omolaja, 1999). Omolaja (1999) observed that to mitigate this development, coffee berries selection from appropriate compatible clones is essential for establishment of polyclonal plantation that could yield about 2-3 tons per hectare.

World coffee exports amounted to 8.79 million bags in January 2015, compared with 8.77 million bags in January 2014 of which Brazil is leading in coffee export followed by Vietnam and Colombia (ICO, 2015). On a global scale, Nigeria is very much a minority player in terms of global export, this is however, mainly due to the fact that majority of the small scale farmers has lost interest in the cultivation of coffee. This stems from some production constrains in coffee such as poor market for Nigeria coffee, fire outbreak, poor policy, drought, poor processing, poor access to farm credits, low income from coffee among others.

Considering the climatic advantage, the country is blessed with and coupled with the ever increasing demand for coffee at the world market of which coffee ranks second after oil, coffee production in Nigeria can be increased tremendously to improve on the livelihood of farmers and increase the foreign earnings of the country.

Soil as a major factor of declining coffee production in Nigeria

The role of Cocoa Research Institute of Nigeria among other mandates includes research into all aspect of coffee production in the following area, Agronomy, Breeding, Entomology, Soil and Plant Nutrition, Pathology, processing /utilization, marketing and above all helping farmers to solve production problems (Carlos et al., 2015; Adejumo et al., 2005; USDA, 2015). Most crucial factors considered in crop production are the suitability of the soil (Ipinmoroti et al., 2013). Over the years, various findings have shown that, soil supporting coffee production in Nigeria Alfisol and oxisol for coffee canephora often referred to as lowland coffee mainly produced in the low laying areas of Nigeria underlined by acid crystalline rocks of basement complex with basaltic rocks of varied thickness (Daniel, 2009). While Ultisol is for coffee arabica (high land coffee), the soils are mostly underlined by granite gneiss (Obatolu, 2001), with soil and foliar critical nutrient established (Carlos, 2015). In respect of Coffee species, almost 99.9% of the farms are privately owned mostly planted in the fifties (Obatolu, 1999) presently overgrown, unproductive and uncared for as a result of dearth of market for their produce resulting in low yield farmer's pest and disease infestation cutting down them down to replace with arable and Tea in case of Arabica. The poor earnings, absence of infrastructures, old and low financial base has all to improper processing method - dry processing with none of the farmers attempting to wet process their products despite the fact that, it is the best method that produces high grade coffee. Over the years, research effort on rehabilitation of old farms have been carried out and recommended i.e. 30cm coppicing with paint coating of the coppiced surface. Currently, efforts are geared towards sensitizing and training of farmers on the rehabilitation methods, use of organic fertilizers in rejuvenation of old farms as well as fabricating of wet processing machines aimed at improving the quality of coffee produced in Nigeria.

INTERVENTIONS

Cocoa Research Institute of Nigeria has the mandate to improve coffee production through development of new cultivars, value addition and further dissemination to end-users. Sensitisation and campaign programs are going on in the growing areas to increase farmers' knowledge and farm practices through capacity building.

The intervention programme being proposed is to improve the livelihood and income of the Coffee farmers. This will come through the adoption of new improved varieties, training on Good Agricultural Practices (GAP) as well as increased value addition to Coffee export. The action plan will provide support to researchers, input suppliers, Coffee farmers, marketers, processors, pharmaceutical companies and many other users of Coffee either in its raw or pocessed form.

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1. Provision of planting materials with respect to the species of interest. Arabica coffee (seeds and seedlings) and Robusta coffee (Cuttings and grafting).
2. Seed garden has been designed to increase the yield output of coffee production thereby increases the premium attached to the commodities. Seed garden is established on the compatibility evaluation of available varietes of Robusta coffee (*Coffea canephora*) in Nigeria, which will increase the yield output from the current 600kg/Ha to 1,360kg/Ha.
3. Selection and introduction of self compatible varieties of *Coffea arabica* which are rust resistance are currently established in the institute germplasm at Mambilla plateau, Taraba state. The seedlings are raised for collection from the farmers.
4. Hybridistion and mutation breedings to produce a hybrid and mutant variety are ongoing. This is to produce varieties that could withstand the imminent change in climatic condition.

RECOMMENDATIONS

1. Inter cropping of compatible clones has a resisted in yield of up to 1.3 metric tons per ha compared with yield range in Africa at 250-347 kg/ha (ACRN, 2001). Combined clone includes C111, C36, T1049 and M10 in an augmented design.
2. Rehabilitation of old/unproductive coffee farms by coppicing at 30 cm has led to improved growth and bean yield
3. Rehabilitation through improved chupon regeneration by grafting is presently encouraging (Famaye et al, 2015)
4. Alley cropping of coffee with some fast growing leguminous shrubs like leucaedea, cajanus, Albizia are also encouraging. The result is a pointer to cultivation of coffee on marginal soils thereby discouraging encroachment to the available forest lands in producing states

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SIMULATING CACAO (*THEOBROMA CACAO* L.) HYBRIDS FIELD SPACING/S BASED ON SOME MORPHOLOGICAL VARIABLES IN THE NURSERY

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ABSTRACT

The standard plant spacing recommendation for cocoa over the years has been either 3.1m by 3.1m (1,040 stands/ha) and 3m by 3m (1,111 stands/ha). The existing spacing have not put into consideration morphological variations that might exist in the latest hybrids released by the Cocoa Research Institute of Nigeria (CRIN) relative to older hybrids. To project the likely field spacing for these hybrids, an experiment was initiated in December, 2020 with the cacao hybrids of TC1(A); TC2(B); TC3(C); TC4(D); TC5(E); TC6(F); TC7(G); TC8(I) and F3 Amazon (H) as control laid out in a Completely Randomized Design (CRD) in 3 replicates with a total treatment unit of 27. Polythene bags of 25cm by 12.5cm filled with sieved forest topsoil. 2 seeds were sown per bag and reduced to one after germination. Germination percentage was taken fortnightly for 4 weeks after sowing. Subsequently, morphological variables of height, stem diameter, number of leaves and leaf area were measured fortnightly as well. Morphology variation in terms of height, stem diameter and leaf area were noticed-there was stability in growth by 4-6 months in the nursery, an indication that the seedlings were physiologically mature for transplanting to the field. Destructive sampling done at 6-month period revealed no significant difference in shoot and taproot length while root wet weight and lateral root length were different($P \leq 0.05$). The lateral root length is in the order of 13.41cm (F3) >12.13cm (TC6) >10.33cm (TC1) > 10.31cm (TC4) >10.25 (TC8) > 9.55cm (TC3) > 8.9cm (TC7)>7.31cm (TC5) > 5.5 cm (TC2) revealing variation among the hybrids. This indicates the likelihood of different plant spacing (population densities per hectare) in the following order: 1,445, 2,710, 1,563, 1,447, 2,041, 1,230, 1,667 and 1,456 for TC1 to TC8 respectively compared with 1,040 or 1,111 stands/ha in F3 Amazon. These results have indicated higher densities for the TC series relative to what is obtainable in F3 Amazon. A field trial to validate these results is suggested.

Key words: Cacao, morphology, lateral root, hybrids, F3 Amazon, nursery, spacing.

INTRODUCTION

Cacao (*Theobroma cacao L.*) is a crop of global significance economically and nutritionally. It was believed to have been introduced to Nigeria by a native Chief Squiss Banego in 1874(Howes, 2010). The crop is a small to medium-sized tree of 8-10 m high belonging to the family Malvaceae (Naturland, 2000). It was reported to be of significance in food, beverage and pharmaceutical industries (Kumar *et al*, 2004). For a country like Nigeria it contributes the most in agricultural sector than any other commodity crops. Research interest is growing in compliance to good agronomic practices (GAP) as cultivation is expanding. Among the aspect of cacao cultivation that deserves research attention is optimization of plant population per unit area of land which is a function of spacing adopted for such crop. The ideal spacing in crops gives the best remunerative per unit area of land (Ayegboyin *et al*, 2020). Introducing new hybrids is lso an important consideration for yield optimization. However, getting the optimal spacing for the hybrids is critical to realising the genetical potential as access to sunlight, moisture and nutrients is critical (Khunba *et al*, 2021). Existing spacing for cocoa in Nigeria are 3.1m x 3.1m (1040stands/ha) and 3.0m x 3.0m (1111stands/ha). The eight new cacao hybrids released for farmers by CRIN since 2011 have not been evaluated for spacing differential (CRIN, 2011). These hybrids are genetically early maturing, high yielding, pests resistant, highly adaptable and of high bean quality(CRIN,2011). There is therefore the need to establish hybrid specific spacing for these new breeds to actualise their potentials. Since these hybrids varies in their morphological attributes viz: plant height, stem diameter, leaf area, taproot length and lateral root length. The latter especially may contribute significantly to likely spacing on the field. This study therefore intends to simulate the spacing for these hybrids based on their morphological performances especially the lateral root length in the nursery.

MATERIALS AND METHODS

This experiment was conducted from December, 2020 to June 2021 at the Central Nursery of the Cocoa Research Institute of Nigeria (CRIN). The experiment was a completely randomized design(CRD) consisting of eight cacao hybrids as treatments namely: TC1(A); TC2(B); TC3(C); TC4(D); TC5(E); TC6(F); TC7(G); TC8(I) and F3 Amazon (H) as the control treatment which were replicated three times giving treatment units of 27. Black polythene bags of 25cm by 12.5cm were filled with forest top soil and arranged on the nursery beds, watered and 2 seeds sown per bag and reduced to one at germination. The seedlings were watered every other day; Germination percentages were determined at fortnight interval for 4 weeks after sowing. Morphological data of plant height, stem diameter, number of leaves, leaf area were taken fortnightly. At the end of a 6-month period, destructive sampling was done with shoot and root wet weight taken, taproot and lateral root length measured. To estimate cacao spacing from the lateral root length of the genotypes, mathematical law of simple proportion was applied where lateral root length of the F3 Amazon was related to the recommended spacing of 3m x 3m(1111stands/ha). Result from this was used to generate spacing for the TC series. Data collected were subjected to Analysis of Variance (ANOVA) using SAS 2010 Statistical page and means separated using Duncan Multiple Range Test (DMRT) at P≤0.05.

RESULTS AND DISCUSSION

Table 1 reveals the percentage seed germination within four weeks after sowing (WAS), at 2WAS, TC 7 had attained 100% germination while germination of >60% was attained in the order TC1 (86.67%)>F3(80%)>TC4, TC1, TC8 (73.33%)>TC3(60%).The least as at 2WAS was in TC5 (20%) and TC2 (26.67%). By the fourth week after sowing 100% germination was obtained for TC1, TC3, TC7 and F3 Amazon(Control); 93.33% in TC4, TC6 and TC8 while the least was in TC2(80%) and TC5(73.33%). Tables 2 - Table 6 revealed morphology variation in terms of height, stem diameter and leaf area- there was stability in growth, an indication that the seedlings were physiologically mature for transplanting to the field by 4-6 months in the nursery (Naturland, 2021). The variation in leaf area confirmed the work of Lotode and Muller (1983) inherent genetic variation in cacao seedlings. At the end of a 6-month nursery period, destructive sampling was done with shoot and root wet weight taken as well as taproot and lateral root length measured. Also there was no significant difference (P≤0.05) in the plant shoots wet weight and taproot length while there were significant differences in the root wet weight and lateral root length. The lateral root length was in the order of 13.41cm (F3) >12.13cm (TC6) >10.33cm (TC1) > 10.31cm (TC4) >10.25 (TC8) > 9.55cm (TC3) > 8.9cm (TC7)>7.31cm (TC5) > 5.5 cm (TC2) revealing variation among the hybrids. Table 6 indicates the likelihood of different plant spacing (population densities per hectare) in the following order: 1,445, 2,710, 1,563, 1,447, 2,041, 1,230, 1,667 and 1,456 for TC1 to TC8 respectively compared with 1,111 stands/ha in F3 Amazon. Spacing in crops determines whether it is low or high density, 3m x 3m practiced in Nigeria is described as low density (Kamaldeo *et al*, 2003). These results have indicated higher densities for the TC series relative to what is obtainable in F3 Amazon. Our suggesting higher density planting is more genotype specific as against the recommendations of Ayegboyin *et al* (2020); Lin *et al* (1986) who suggested higher density planting for TC series in Nigeria and cocoa hybrid in Malaysia when they are not fully matured. TC2 as indicated in Table 6 can be planted at a projected spacing of 1.92^2 (2,710 stands/ha) based on its compactness in the nursery, ditto TC5 (2,041stands/ha and TC7 (1,667stands/ha). There was no significant difference in taproot length among the treatments though TC6 (23.15 cm) and TC5 (16.43 cm) had the highest and lowest taproot length respectively, this is an indication that the TC series can survive were F3 Amazon survives however TC 6 and TC 5 may survive dry spell better than others especially when there is irrigation in the dry season. Lotode and Muller (1983) had reported those plantations established through seeds/seedlings are inherently divergent in terms of growth habit, vegetative behaviour fruit characteristics and potential yield.

CONCLUSION

Root weight and lateral root length play a significant role in plant spacing and plant density per unit area of land. The lateral root length in this experiment is in the order of 13.41cm (F3) >12.13cm (TC6) >10.33cm (TC1) > 10.31cm (TC4) >10.25 (TC8) > 9.55cm (TC3) > 8.9cm (TC7)>7.31cm (TC5) > 5.5 cm (TC2) revealing variation among the hybrids. The following plant spacing (population densities per hectare) are recommended: 1,445, 2,710, 1,563, 1,447, 2,041, 1,230, 1,667 and 1,456 for TC1 to TC8 respectively compared with 1,111 stands/ha in F3 Amazon. Since plant spacing in cacao determines whether it is low or high density. These results have indicated higher densities for the TC series relative to what is obtainable in F3 Amazon especially TC2 (2,710 plant/ha) and TC 5(2,041 plants/ha). Field evaluation and validation of these results is however very important as a follow up study.

Table 1: percentage emergence of cacao hybrids seeds

Treatments	2WAS	4WAS
A	86.67	100.00
B	26.67	80.00
C	60.00	100.00
D	73.33	93.33
E	20.00	73.33
F	73.33	93.33
G	100.00	100.00
H	80.00	100.00
I	73.33	93.33

Table 2: Duncan grouping, height of cacao hybrids seedlings (Cm^2)

4WAS	8WAS	12WAS	16WAS	20WAS	24WAS
19.12a F	22.50a F	24.77a H	28.27a H	29.53aH	35.72a H
18.97a H	22.48a G	23.87ab G	27.20a G	28.57aD	31.99a D
18.42ab C	22.15ab H	23.35ab F	26.18ab F	28.17aA	31.58a A
17.97ab I	20.52abc C	22.65ab D	26.18ab D	28.13aF	29.33a F
17.78ab G	20.00abc A	22.42ab A	24.98ab I	26.30aG	29.13a G
17.02ab D	19.95abc E	21.98ab E	24.53ab A	26.00aI	27.83a I
15.97ab A	19.63bc D	21.83ab I	24.18ab E	25.80aB	27.02a B
15.50b E	19.52bc I	21.33ab C	23.40ab C	24.75aE	27.00a E
15.47b B	18.78bc B	20.15b B	21.57b B	24.02aC	26.85a C

Means with the same letter are not significantly different.

Table 3: Duncan Grouping, number of leaves of cacao hybrids seedlings

4WAS	8WAS	12WAS	16WAS	20WAS	24WAS
5.33 G	9.00a D	10.50a H	14.50a E	12.67a C	16.63a C
5.17 D	8.17a G	9.67a G	13.83a B	12.00a D	13.67a H
4.83 H	8.17a F	9.33a A	12.67a D	9.50a E	12.00a D
4.67 E	7.33a A	9.33a D	12.18a C	9.33a F	11.50a I
4.67 A	7.00a C	9.00a B	11.18a H	9.33a A	11.33a G
4.00 B	7.00a B	8.83a E	10.67a G	9.33a G	10.17a F
4.00 C	6.67a E	7.50a C	10.50a A	8.67a I	10.17a E
4.00 F	6.67a H	7.18a I	10.33a F	8.50a B	9.83a A
4.00 I	6.50a I	7.00a F	9.83a I	8.50a H	8.33a B

Means with the same letter are not significantly different.

Table 4: Duncan Grouping, stem diameter (mm) of cacao hybrids seedlings

4WAS	8WAS	12WAS	16WAS	20WAS	24WAS
4.03a F	4.44a G	5.16a G	5.67a G	6.36a H	6.86a H
4.03a E	4.38a H	5.08ab H	5.56a H	5.83a G	6.60a I
3.89a H	4.33a F	5.07ab F	5.45ab F	5.83a D	6.57a A
3.66a G	4.29a E	4.83abc E	5.27ab D	5.77a F	6.52a F
3.65a I	4.20a C	4.70abc I	5.18ab E	5.75a A	6.22a B
3.54a B	4.10a B	4.69abc D	5.01ab I	5.64a E	6.21a G
3.54a D	4.03a D	4.49abc C	4.92ab A	5.64a I	6.18a D
3.35a C	4.00a I	4.41bc B	4.87ab C	5.48a C	6.03a C
3.27a A	3.77a A	4.25c A	4.60b B	5.35a B	5.97a E

Means with the same letter are not significantly different.

Table 5: Duncan Grouping, leaf area of cacao hybrids seedlings

4WAS(Trt)	8WAS	12WAS	16WAS	20WAS	24WAS
37.14a (G)	43.80a F	36.72a F	52.57a H	50.94a H	50.63a B
33.68ab (I)	41.83a A	34.62ab I	45.93ab F	40.90ab A	47.42ab H
32.48abc (H)	36.77ab C	33.99ab A	45.72ab I	40.27ab F	47.17ab A
31.19abc (F)	35.46ab G	32.61ab G	41.87ab D	39.13ab G	44.65ab F
24.73abcd (D)	35.38ab H	32.26ab D	40.48ab G	33.57ab D	42.84ab I
24.16abcd(C)	34.31ab I	30.73ab C	38.48ab A	30.99ab I	38.97ab G
21.74cd (A)	31.14ab D	29.65ab H	35.95ab B	30.00ab B	34.10ab C
19.23cd(B)	25.11b B	25.88bc E	29.63b E	23.45b C	32.79ab D
17.51d (E)	25.08b E	20.11c B	29.61b C	19.33b E	18.23b E

Means with the same letter are not significantly different.

TABLE 6: Duncan grouping, showing mean fresh shoot weight, means fresh root weight, mean root length, mean lateral root length of the cacao hybrids and estimated spacing and plant population/ha

Trt	Shoot Wgt (g)	Root Wet wgt(g)	Taproot Length (cm)	Lateral Root Length (cm)	Estimated plant spacing (m)	Estimated Plant population/ha
TC1	6.17a	2.17ab	21.50a	10.33abc(TC1)	2.63^2	1,445
TC2	3.83a	2.17ab	21.12a	5.50c	1.92^2	2,710
TC3	5.17a	2.00ab	18.97a	9.55abc	2.53^2	1,563
TC4	6.67a	1.83ab	20.10a	10.31abc	2.63^2	1,447
TC5	3.83a	2.17ab	16.43a	7.31bc	2.21^2	2,041
TC6	8.00a	2.67ab	23.15a	12.13ab	2.85^2	1,230
TC7	5.50a	1.67b	19.83a	8.90abc	2.45^2	1,667
TC8	5.50a	2.17ab	22.83a	10.25abc	2.62^2	1,456
F3	9.67a	3.83a	23.13a	13.41a	3.00^2	1,111

Means with the same letter are not significantly different.

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REMOTE SENSING AND GIS FOR FIRE BEHAVIOUR ON COCOA (*THEOBROMA CACAO*) PLANTS AT THE COCOA PLANTATION AT THE COCOA RESEARCH INSTITUTE OF NIGERIA, IBADAN, OYO STATE

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ABSTRACT

Fire is regarded as an ecological disturbance which is mostly anthropogenic. Cocoa plantation is being razed yearly with fire, thus leading to enormous reduction in its production and biodiversity losses. Globally in the tropics, about 98 million ha of forest are affected by fire, and damage caused to cocoa plantation is very devastating and control is difficult. Therefore, the use of remote sensing and also GIS for fire behavior at the Cocoa research institute of Nigeria, Ibadan (CRIN) were assessed. This study was carried out at CFC cocoa plantation section at CRIN, 2021. The digital 20m contour interval [also known as Digital Terrain Model (DTM)] was used to obtain the elevation, slope and aspect using ArcGIS for basic calculations. Aspect map shows direction (i.e. how slope direction influences fire behavior) and also, degree of steepness of the slope, and each category is symbolized using different colours (red, orange, yellow, gray, green), degree of slope is mapped with saturation of colors (steeper slopes are brighter). ArcGIS 10 was used to identify separately time of each fire from 2010 to 2021 to estimate the fire frequency in a space of twelve years and time of last fire (from the Landsat images) was determined. From the maps obtained using the ArcGIS, contours on the elevation shows layers which was depicted by different colours to shows the levels (flat or steep), indicating also that the areas of fire burns, irrespective of their elevation. The lowest elevation was depicted in green colour, and ranged between 131-133 meters above sea level (MSL) and highest in white colour from 148-150 MSL respectively, and no obvious ridges and valley seen. The degree of slope was represented from 0-90º. The lower the values the flatter the terrain is (in green) and the higher values, indicates the high degree of steepness in the area (in red) which likely to experience intense fire burns. The aspect map indicated the direction of the slope in a clockwise direction from the north (0-360º) and back to north and areas with no slope and are flat was assigned a -1. However, the imagery generated indicated eleven (11) fire outbreaks had occurred from the year 2010 to 2021 on the study site. This study attempts to integrate the use of remote sensing and GIS to monitor fire behavior on cocoa plantation. Movement of the slope in the northern direction indicates that the area gets more sun, thereby making the soils and litters very dry and predisposed to high fire intensity than the southern or eastern slopes. These findings will be a baseline for further research, also helps to identify high risk areas for better prevention and management to reduce losses to fire outbreaks.

Key words: Forest fire, Ecological disturbance, Remote sensing, ArcGIS 10, Elevation, Slope

INTRODUCTION

Fire is an ecological disturbance that affects the ecosystem functions (i.e. irregular destruction of the ecosystem), composition and structure thereby causing alterations in the ecosystem. However, fire has an ecological role in the ecosystem, it influences the development of the plant community, nutrient availability and biological diversity. Hence, fire is considered necessary for vegetation succession. Uncontrolled fire can cause serious adverse effects to the ecosystem at large. Most fire is caused by accidental introduction through anthropogenic sources which have a sweeping effects on the vegetation, plant arrangement, and likely to reduce plant bulk in subsequent years. Fire has been known to change landscape structure (species composition) thus affecting diversity of plants and animals (micro and macro) in the ecosystem (Bowman *et al*., 2016).

The introduction of remote sensing and GIS techniques in fire management in cocoa production is a new concept for proper planning to help reduce the risks of fire occurrences in cocoa plantations, and also for monitoring the process of restoration. GIS is used to capture and analyse information of the burnt area and its environs and it also displays geographic facts visually. ArcGIS presents the data in maps for quick evaluation (which involves the cause of the fire, how or factors responsible for the spread) and state of the vegetation after the fire. Globally in the tropics, about 98 million ha of forest were affected by fire in 2015 and Africa and South America having about two third of the burnt area (about 65 million ha burnt). In Nigeria, reports of International Forest Fire News (IFFN, 2006) reported that Cocoa, and other cash crops were seriously destroyed by wildfire. Although, the information on statistics of fire records are scare. Geomatics (2000) also reported high fire outbreaks in the dry season in Nigeria which is characterized by high temperature, low humidity, high combustibles and wind. In the Savannah, dry season is between October-April, and November-March in the rainforest (Balogun *et al*., 2004). However, the peak for the two ecological zones is January to February. Rainfall and relative humidity are very important factor to determine the intensity of fire burns. A change in this pattern due to climate change could result to wildfire outbreak in Agricultural forests. Fire is without any doubt a major challenging global concern. A change in the climatic factors plays an important role in burning (both in direct and indirect ways), hence it determines when and how fire burns.

It is no new news that fire is a big threat to cocoa production, effective prevention of fire from gaining access to the cocoa plants is of paramount importance both on the long or short term basis. Hence this informs the objective of this study to generate elevation, slope and aspect maps of the burnt areas to monitor fire behaviour in the areas, also using remote sensing and GIS to monitor fire behavior on cocoa plantation at the CRIN.

STUDY SITE

The study was conducted at the Cocoa Research Institute of Nigeria headquarters, Ibadan (CRIN), on CFC cocoa plantation section. CRIN is in the rainforest zone, located on latitude 7º 30'N and longitude 3º 54'E at an altitude of 200 m above sea level (Mokwunye *et al*., 2011; Azeeze, 2016). Annual mean temperature is about 25º, rainfall 1200mm and relative humidity 76% (Ajewole *et al*., 2010). On the 18th February, 2021, the CFC cocoa plantation plot at CRIN was razed by fire, fire got about 60% (4.22 ha) of the plot which is about 7 ha area of land. However, the remaining 40% was just under fallow, the fire virtually got all the cocoa plantation in that area.

MATERIALS AND METHODS

A spatial analyst was engaged to generate elevation, slope and aspect maps of the study area, using the digital 20m contour interval [also known as Digital Terrain Model (DTM)] and ArcGIS 10 for basic calculations and the detailed information gathered as follows:

From existing data sets, the Arc GIS 3D was used to generate new surfaces. Surfaces which was viewed as normal grids or as TINs (Triangulated Irregular Networks). After the surface data has been created, it can be utilized for future analysis, such as enhanced visualization, such as creating a shaded relief, or more complex analysis. The contour, slope, and aspect maps are all useful data that was generated using the Arc GIS 3D. These enable us to efficiently relate our data to real-world elevation and examine how these various surfaces may affect the ecosystem.

RESULTS AND DISCUSSION

Elevation

The polylines on the elevation map represents locations with same magnitude of data sets. The contours show locations of same values (as shown below). This shows the steepness of an area which also infers the rate of spread of fire in the plantation. At the CFC, ranged between 131-133 meters above sea level (MSL) and highest in white colour from 148-150 MSL respectively. However, the elevation of a given area is associated with temperature, moisture in form of rainfall and wind which in turn influences the vegetation. In observing fire behaviour, areas with high altitude have less severity of fire intensity.

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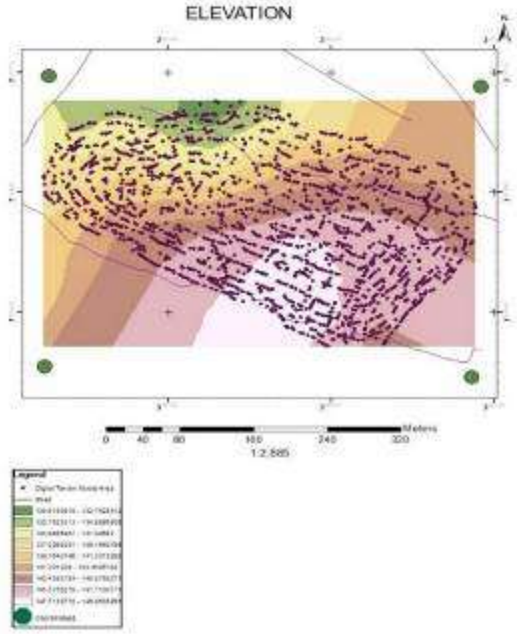
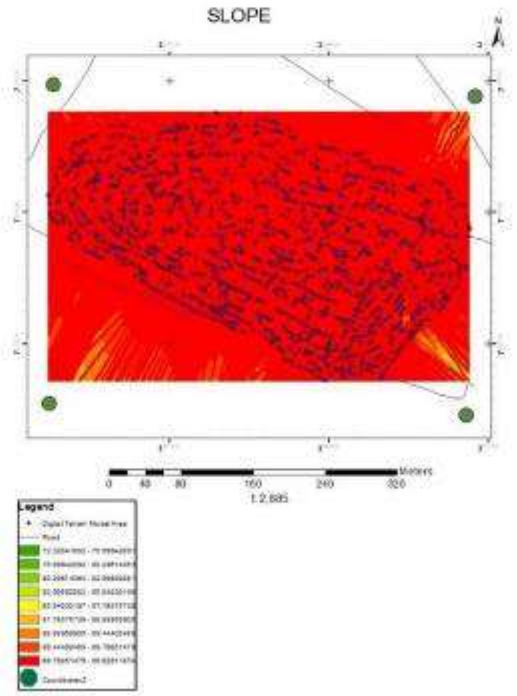


Slope

The slope is calculated in degrees of percentages. It identifies the maximum rate of change in a given area. Generating a slope map after a fire outbreak helps to suggest the areas that will be susceptible to runoffs which could result to erosion (as indicated below). However, the degree of a slope is between 0-90º, and a lower value indicates a flatter topography and higher values indicates degree of steepness. These two parameters influence how fire is spread out during an outbreak. Fire tends to move faster up the slope and slower down the slope. Also, rate of fire is likely to increase in areas with high slope values which is associated with strong wind effects.



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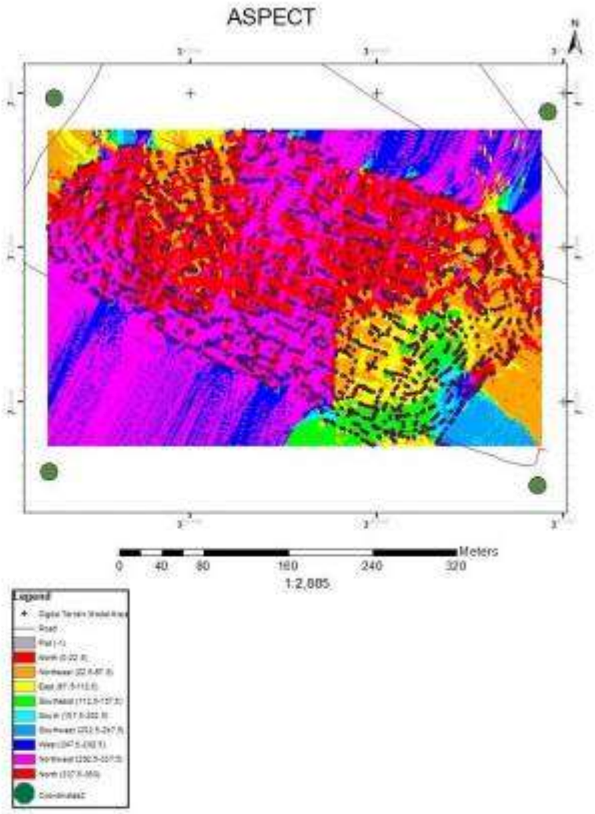
Aspect

Aspect indicates the direction of slope which correlates with the amount of sun that reaches it. It is expressed in degrees from 0-360 measuring clock wisely from the north (shown below). Areas of no slope has a -1 value, i.e. there is no data available. Areas facing the South experiences more sun, high temperature, low rain and high wind at a direct angle than the North facing. Hence, vegetation in the south facing slopes are drier. However, the north facing slopes gets sunlight at a lesser angle such that a little sun is spread out at a large expense of area. These factors influence the high fire outbreaks in such areas.



Fire Frequencies (2010-2021)

Fire is a major concern and a big challenge to plantation management globally. The outbreaks of fire recorded at the CFC cocoa plantation from the year 2010 to 2021 sums up to twelve (12) with the February 2021 fire having the most devastating effect (60% burnt). This virtually implies that fire occurs every year since 2010. Fire outbreaks is favoured subsequently by increased temperatures, relative humidity and wind thus leading to global warming a serious global challenge. Also, this has also determined the loss of species diversity in the area (loss of plant species) and introduction of some invasive weed species (vegetation mapping results in subsequent paper) and risk of soil erosion.

CONCLUSIONS AND RECOMMENDATION

This research work was initiated immediately after the fire incidence in February 2021 at CRIN. Remote sensing used provided the vegetation data, while GIS processing made it possible to create fire maps to monitor fire behaviour. This work will serve as a baseline to further research on how best to manage and reduce fire outbreaks in the cocoa plantation.

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GENDER INVOLVEMENT AND ECONOMIC VALUATION OF TOMATO VALUE CHAIN IN AKINYELE LOCAL GOVERNMENT AREA, OYO STATE

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ABSTRACT

This study assessed the level of involvement and economic valuation of tomato value chain with distinct reference to gender characteristics in Akinyele Local Government Area, Oyo State Nigeria. The study used a structured questionnaire for data collection from a survey of 160 tomato households in Akinyele LGA of which 96 were women and 64 were men. Descriptive and gross margin analyses were carried out to analyze the study. According to the findings, women played a leading role in marketing, processing, packaging and publicity/promotion while men played a leading role in production and distribution value chain activities, as this development favours respective tomato households' economic welfare accordingly. The study therefore recommended among other things that there should be robust public-private collaboration with relevant tomato value chain stakeholders so as to improve processing, packaging and promotion of tomato.

Key words: tomato, gender, value chain, economic, valuation

INTRODUCTION

The role of women in agricultural production especially in sub-Sahara Africa cannot be over emphasized giving credence to their mode of managing their own farms as well as providing their labour to their husband's fields. Irrespective of the prevalence of a gender bias regarding their access to resource, women involvement remains an indelible factor to be reckoned with as far as agricultural development is concerned. All over the world, gender issues in the development of agriculture and women's role and contribution to agriculture have taken a central stage among scholars, professionals and policy makers. Despite the wide range of literature available, the importance of agriculture to the economic development in Africa and the critical role that rural women play within this sector still constitute an attractive research agenda (Ndoye, 2010).

In Sub-Saharan African countries, where agriculture provides food for the majority of the population, a strong growth in agriculture is needed to drive their process of economic development. Therefore, agriculture must be the leading sector for overall growth, poverty alleviation, and the reduction of income disparities. Given this background, promoting agricultural production across board is essential. Above all, considering the far-reaching fluctuations in the world food situation that is ravaging Africa more than any other region, a deserved attention should be given to the agricultural supply chain, both for food crops and market-oriented crops. In fact, cash crops, with high added value products like horticultural products, offer opportunities to boost the agricultural growth in developing countries like Nigeria, where horticulture is a key element of the agricultural sector.

However, the key role of women in the agricultural sector, calls for more gender-sensitive approaches and policies particularly with respect to horticultural crops along its value chain in Nigeria. Value chain encompasses full range of activities from the production, distribution, processing, transporting and value addition, finally to the end consumer. Tomato is one of the most important popular vegetable crops in Nigeria. The major problems confronting the tomato value chain were found to be low prices, high perishable nature, lack of access to credit, poor quality of tomatoes, inadequate storage and processing facilities, inadequate transportation facilities, dispersed nature of supply and high interest rate (Emam, 2011). In sum, the aforesaid reasons usually justify the relevance of this study, which aims at analyzing tomato value chain along gender perspective.

Gender is assessed on the basis of men and women who engage in tomato with a view to draw a comparison analysis between the two gender categories among households (comprising producers, processors, distributors, marketers, promoters and consumers) in tomato value chain. Therefore, given credence to the severe nationwide food crisis and the marketing challenges, emerge three main research questions addressed in this study, related to (i) the socio-economic characteristics of households in tomato value chain in Akinyele Local Government Area

(LGA) (ii) the level of involvement in tomato value chain between men and women and (iii) economic valuation of tomato value chain with distinct reference to gender dominance.

MATERIALS AND METHODS

The study used a structured questionnaire for data collection from a survey of 160 tomato households in Akinyele LGA of which 96 were women and 64 were men. The respondents were tomato households that engaged in a variety of tomato crops value chain activities. The sample frame covers the producer (who takes actual responsibility of producing tomato); the intermediate/middlemen (who gathers various quantities of produce from different producers and sells them to large-scale traders, processors, retailers and processors); the wholesaler (who purchases large amounts of products with better financial and information capacity); the retailer (who sells small quantities of tomato products either directly to individual, household or institutional consumers); and the consumer (who purchases the products for consumption). Descriptive and gross margin analyses were carried out to analyze the study.

In calculating the gross margin across each tomato value chain activities to compare their economic valuations, we subtracted the total cost (cost of direct materials used, direct labour, equipment costs, utilities cost, distribution cost involved in all the value chain activities from total revenue (i.e. total income generated per month) and divided that number by total revenue. The result was expressed in percentage. In addition, this financial analysis was built on naira per kg of fresh tomato while the processed tomato (tin and or sachet) were measured based on their equivalent naira per kg of the fresh tomato. For instance, if a 10kg of fresh tomato is sold at N5, 000, the quantity of processed tin or sachet tomato that would be sold at that same N5, 000 were taken as their equivalent kg within a particular period.

RESULTS AND DISCUSSION

Table 1: Socio-economic characteristics of tomato households

Item	Frequency	Percentage
Household's head sex		
Male	71	44.4
Female	89	55.6
Household's head age		
≤ 20 21 - 40 41 – 60 61 – 80	10 88 40 22	6.3 55.0 25.0 13.7
Household's head year of education		
No Formal Education Primary Secondary Tertiary	3 36 90 31	1.9 22.5 56.3 19.4
Marital status		
Single Married Separated	41 102 17	25.6 63.8 10.6
Tomato land area cultivated (ha)		
< 0.5 – 1 1.5 – 3 3.5 – 6 6.5 – 9 9.5 – 12 > 12	38 57 28 15 12 9	23.8 35.6 17.5 9.4 7.5 5.6

Field Survey 2021

Table 2: Level of involvement in tomato value chain activities

Value chain activities	Male	Female	Means	Standard deviation
Production	66	40	4.2	0.04
Processing	44	31	1.2	0.01
Packaging	45	30	1.2	0.01
Marketing	112	30	4.1	0.03
Distribution	56	47	3.3	0.02
Publicity/Promotion	23	44	1.1	0.01

Field Survey 2021

Data on the level of involvement in tomato value chain activities using 5 point Likert scale were reflected in Table 2. The overall results show averages of 4.2, 4.1, 3.3 and 2.8 for production, marketing, distribution, processing/packaging and publicity/promotion respectively with their low standard deviations. This indicates that production and marketing were the main value chain activities that were predominant among tomato households in the study area. This result therefore suggests that other value addition activities like processing, packaging, publicity/ promotion were not maximally explored. This is however logical since the bulk of these tomato households were mainly rural entrepreneurs who operate an informal market system with little educational background and technical knowhow. So, processing/packaging and activities that involve washing, sorting, crushing, preheating system, packing rebranding etc were carried out by few that may have tomato dryer fabricated machines or those that are working mainly in tomato processing industries. In the same vein, based on gender-specific representations, a great gender gap and disparity were identified in particular with regard to production and marketing as most men participated in production of tomato than in marketing and vice-versa. Though, there were some households who combined various value chain activities together across the gender line.

Table 3: Economic valuation of tomato value chain

Value chain activities	Male (%)	Female (%)	Financial analysis of tomato per naira/kg (N)		
			Average total revenue	Average total cost	Gross margin
Production	69.4	30.6	71,670	491260	32%
Processing	39.4	60.6	41,350	35110	15%
Packaging	39.4	60.6	26,550	20,230	23%
Marketing	33.5	72.5	70,670	40,260	43%
Distribution	54.4	45.6	37,477	24,465	34%
Publicity/Promotion	46.3	53.7	14,123	10,543	25%

Field Survey 2021

This study goes a step further by focusing particularly on economic valuation of each value chain in tomato business per month putting the percentage of gender participation into consideration. Though, some of the value chain activities that relate to processed tomato as far as this study is concerned include processing, packaging and publicity/promotion. Further, due to the sharp fluctuation of tomato prices, and its seasonal characteristics, average values of both total revenue and total cost per month were used for the computation of its gross margin analysis. The study delimits the rate of demand and supply of tomato but focuses on value chain activities with higher gross margin value in relation to gender participation in the study area.

In terms of economic valuation, the higher the gross profit margin the better. Therefore, tomato households who engaged in marketing activity has higher gross margin than the others indicating that they did well in managing their cost of sales. It also shows that these households have more to cover for operating, financing, and other costs. Considering the gender dichotomy, the tomato households that concentrated in marketing activity were dominated by women (72.5%) meaning that tomato marketing favours women folk than men in term of economic valuation.

Further, using this economic valuation trajectory in relation to gender participation statistics, publicity/promotion, packaging and processing in that order also favour women folk than men while, distribution and production activities in that sequence favour male folk than women in the study area. These outcomes therefore suggest that women are more favoured and predominant in tomato value chain activities than men. On the other hand, men are more involved in some of the rigorous value chain activities as this may be due to their nature and tendency to undertake risk than women.

CONCLUSION AND RECOMMENDATIONS

Based on the findings, the study therefore concluded that production and marketing were the main value chain activities while processing, packaging, publicity/promotion activities leave much to be desired among tomato households in the study area. Also, women played a leading role in marketing, processing, packaging and publicity/promotion while men played a leading role in production and distribution value chain activities, as this development favours respective households' economic welfare accordingly. The study therefore puts forward to decision makers a number of recommendations for a better participation and economic valuation of tomato households. Firstly, there should be robust public-private collaboration with relevant tomato value chain stakeholders so as to improve processing, packaging and promotion of tomato. Likewise, more men should be encouraged in production activities through provision of necessary inputs and technology to enhance their production capacity as there should be a friendly off-taker mechanism network for women to boost their marketing potentials.

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GENDER DIFFERENTIAL IN SWEET POTATO PRODUCTION IN OYO STATE, NIGERIA

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ABSTRACT

The study examined gender differential in sweet potato production in Oyo state, Nigeria. Data were collected with the aid of questionnaire and interview guide from 120 respondents comprising of 60 males and 60 female sweet potato farmers using multistage sampling techniques and analysed using descriptive statistics, multiple regression analysis and Z-test. Results revealed that 37.5% of male and 61.6% of the farmers had no formal education with mean age of 45 and 41 years respectively. A total of 85% of males and 76.7% of females were married, with an average household size of 8 and 6 persons, mean farming experience of 26 years for males and 21 years for females, and cultivated an average farm size of 1.39ha (male) and 0.77ha (female) while the mean income realised per season for the male and female sweet potato farmers were ₦325,285.12 and ₦226, 882.66 respectively. Factors influencing output of male farmers were household size, farm size, off-farm activities and extension services while that of female farmers were age, access to loan, other occupation and land ownership. It was therefore recommended that efforts should be intensified at implementing policies aimed at improving female farmers' access to land and other production inputs in the study area. Training of more female extension agents who can work freely with the female farmers in the area of timely dissemination of improved production technologies in sweet potato production should be undertaken by both the local and state governments in the study area.

Key words: Gender differentials; sweet potato; multiple regression, Oyo

INTRODUCTION

Gender is synonymously used with sex to denote the condition of being male and female (Ogunniyi *et al.,* 2013). Gender participation is a term that describes the roles and activities of men and women according to traditions and beliefs of a particular culture (Olagunju *et al.,* 2013). Issues on gender were of utmost concerns in the early seventies with the introduction of programs such as Women in Development (WID), Women and Development (WAD), Gender and Development (GAD) to address the problem of gender inequality, provide resources and create activities for women (United Nations Development Programme (UNDP), 2014). Subsequently, efforts were made to place both men and women on equal grounds in all project activities (Yisa *et al.,* 2020).

Sweet potato (*Ipomoea batatas (L) Lam*) is an important food and feed crop in sub-Sahara Africa (SSA) and ranks fourth after maize, bananas, and cassava (Food and Agricultural Organization (FAO), 2015). Nigeria ranks second among the world's largest producers of sweet potato with 3.4 million metric tons annually (World atlas, 2019). It requires low inputs of land, labour, capital and less management in its production activities; it performs well on marginal soils and irregular rainfall, more productive than most other crops (Baruwa, 2016). Sweet potato production is a gender activity involving both men and women in its production activities. However, the roles played are task specific, with the women carrying out menial activities such as planting, weeding, harvesting, processing, storage and marketing of crops while the men are more involved in strenuous tasks such as bush clearing, land preparation, tree felling, stumping among others (Oyugi *et al.,* 2015;) Studies (Obisesn, 2014; Albertson, 2016) have shown that men and women adopt new technologies at different rates, considering their diverse needs, socio-cultural context, access to available resources, unequal workloads and decision making power. The allocation and distribution of farm incentives are done with gender bias, Agarwal (2017) reported a great disparity between women and men in the size of land holdings as well as their involvement in agricultural production. Olagunju *et al.,* (2013) submitted that agricultural production will increase substantially if the contribution of men and women are taken into account equitably when allocating productive resources. Hence, this study was undertaken to examine gender differential in sweet potato production in the study area. It specifically described the socio-economic characteristics and determined factors influencing income from sweet potation production by gender in the study area. The hypothesis which states that, there is no significant difference in the involvement of male and female farmers in sweet potato production activities in the study area was also tested.

MATERIALS AND METHODS

Study Area: The study was conducted in Oyo State, Nigeria. Oyo State is an inland state in South-western Nigeria, with its capital at Ibadan. It is bounded in the north by Kwara State, in the east by Osun State, in the south by Ogun State and in the west partly by Ogun State and Republic of Benin. Oyo State is located on longitude 7.8500N and latitude 3.9330E, and covers approximately an area of 28,454 square kilometers and a population of 5,580,894 people at 2006 census. Agriculture is the main occupation of the people of Oyo State. The climate in the state favours the cultivation of crops like maize, yam, cassava, cocoyam, sweet potato, millet, rice, plantains, cocoa, palm produce, cashew and so on.

Sampling Procedure and Data Collection: A multistage sampling procedure was used for this study. The first stage involved the purposive selection of Oyo West and Atiba Local Government Areas of Oyo State due to the prominence of sweet potato production in the LGAs. The second stage involved the random selection of three villages each from the selected LGAs making a total of 6 villages. At the third stage, simple random sampling technique was used to select 20 sweet potato farmers (10 males and 10 females) from each of the selected villages making a total of 120 (60 males and 60 females) respondents for the study. Data were collected with the aid of questionnaire and interview schedule in the study area.

Analytical Techniques: Descriptive statistics such as mean scores was used to describe the socio-economic characteristics of the respondents, Z-test analysis was used to ascertain gender differential in sweet potato production activities in the study area while multiple regression analysis was used to determine the factors influencing output from sweet potato production in the study area. The model is specified as:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \ldots\ldots\ldots + \beta 12X12 + \mu$$

Where: Y = Income (₦); X1 = Age of farmers (years), X2 = Educational level (years), X3= Household size (No of people), X4 = Farming experience (years), X5 = Farm size, (hectares) , X6 = Other occupation (1 if farming only, 0 otherwise), X7 = Type of labour used (1 if hired, 0 otherwise), X8 = land ownership (1 if yes, 0 otherwise), X9 = Membership of cooperative society (1 if yes, 0 otherwise), X10 = Extension contact (1 if yes, 0 otherwise), μ = Random sampling error term.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

The result in Table 1 reveals a mean age 45 and 41 years respectively for the male and female farmers in the study area. This implies that the farmers were still in the productive age. This is in consonance with the findings of Michael (2014); Nwaobiala *et al.,* (2019) that farmers were young, active and capable of undertaking activities involved in cassava farming which is also a tuber crop. The result also indicates that the farmers had one form of education or the other, while majority (62.5%) of the male were educated, 61.6% of the female farmers had no former education which implies that male farmers were more educated than their female counterparts in the study area. This result agrees with the findings of Oyewo *et al.,* (2018) that male farmers had higher literacy level experience which may help in improving the adoption of new technologies by the farmer, while the female level of education may affect their production level negatively. Majority of the farmers were married with mean household size of 8 and 6 persons for the male and female farmers respectively. Majority (96.7%) of the male farmers owns their farmland while only 39.2% of the female farmers own farmlands. This could have effect on the area of land cultivated to sweet potato and possible expansion of the enterprise as well as income in the study area.

Table 1: Selected socio economic characteristics of the respondents

Variable	Male	Female
Age	45	41
Education	62.5	38.4
Marital status (married)	85	76.7
Household size	8	6
Farm size	1.39	0.77
Farming experience	28.5	20.7
Farming only	75.2	35.1
Hired labour	41.7	62.8
Access to loan	26.9	11.6
Cooperative membership	21.7	44.3
Extension contact	26.4	18.7
Land ownership	96.7	39.2
Income	325, 285.12	226,882.66

Source: Field Survey Data, 2021

Factors influencing output from tuber crop production in the study area

Table 2 shows the regression estimates of the determinants of income from sweet potato production for the male and female farmers in the study area. The semi-log functional form was chosen as the lead because the model had the highest value of coefficient of determination R^2, highest number of significant variables conforming with the a priori expectation and significant F-value. The R^2 values of 0.794 (male) and 0.747 (female) imply that about 79% (male) and 75% (female) of the variations in the income from sweet potato production were jointly explained by the variables included in the model. The F value of 6.271(male) and 5.711 (female) were significant at 1% level of probability indicating goodness of fit of the regression line.

Result in Table 2 reveals that education of the male farms had a positive significant relationship with income at 5% alpha levels. This implies that income of the male farmers increases with their educational level in the study area. Educated farmers are more likely to adopt new technology and innovations leading to increased income in the study area. The coefficients of farm size for the male and female farmers were positive and significant at 1% alpha levels respectively. This implies that income from sweet potato production increases with increase in the size of farmland cultivated. This result corroborates the findings of Olagunju *et al.,* (2013) that increase in the availability of farm land for sweet potatoes leads to increase in the farm output for female and male farmers in Osun State. Likewise, the coefficient of other occupation and ownership of farmland were positive and significant at 5% level of probability for the male farmers. This implies that income increases with ownership of farmland and the male farmer engaging in farming as the sole occupation in the study area. The coefficient of other occupations engaged in by the male farmers was positive and significant at 5% alpha levels. This is because the male farmers were able to concentrate fully on their farming activities as its their only source of income. However, the coefficient of age of the female farmers had a negative significant relationship with income in the study area. This implies that income from sweet potato production decreases with age of the female farmers. This agrees with Mbah (2011) that output declines with advancement in age. In the same vein, the coefficient of land ownership ($p<0.05$) had an indirect relationship with income. This implies that income of the female farmers decreases with land ownership, this is so because majority of the female farmers did not own a farmland in the study area. Also, extension visit had a negative significant relationship with income of the female farmers at 5% level of probability implying that income decreases with insufficient visits from extension officers in the study area.

Table 2: Determinants of factors influencing output from sweet potato production

	Male		Female	
Variables	**Coefficient**	**t-ratio**	**Coefficient**	**t-ratio**
Constant	-8.216	-1.672	-6.324	-0.082
Age	0.046	1.566	-0.830	-2.077**
Education	0.087	2.163**	-0.187	-1.176
Household size	0.007	0.403	0.013	1.541
Experience	0.017	0.346	-0.036	-0.231
Farm size	1.252	2.798***	0.824	2.518***
Occupation	0.278	2.318**	-0.058	-1.348
Type of labour	0.038	0.607	0.044	0.255
Owns land	0.260	2.285**	-0.672	-2.425**
Cooperative	-0.012	-1.159	1190.098	0.003
Extension	0.240	1.423	-1.0613	-2.147*
R^2	0.794		0.747	
Adj. R^2	0.715		0.686	
F value	6.271		5.711	

Source: Field survey data, 2021

Gender differential in sweet potato production activities

The result in Table 3 shows that there was significant difference in the level of involvement of male and female farmers in sweet potato production activities (Z=-6.23, P< 0.01). It can therefore be inferred that the level of involvement in sweet potato production in Oyo State varies by sex. The mean level of involvement of 24.510 and 17.231 for the male and female farmers implies that male farmers were more involved in sweet potato production activities than female in the study area. This finding contradicts the null hypothesis which states that there is no significant difference in the level of involvement of male and female farmers in sweet potato production activities. The alternative hypothesis is therefore accepted. This result confirms the findings of Audu (2009) that women trailed behind men in their participations in farming activities and production of food and cash crops. Yisa *et al.,* (2020) reported that male farmers were more technically efficient than their female counterpart and thus, had higher gross income per hectare in cassava production in Abia State, Nigeria

Table 3: Gender difference in level of involvement in sweet potato production activities

Level of involvement	Mean	Standard deviation	Z-test
Male	24.510		-6.23
Female	17.231		

Source: Field survey data, 2021

CONCLUSION

This study has established that there is gender differential in sweet potato production activities in the study area. It was revealed that male farmers were more involved in sweet potato production activities than their female counterparts. Education, farm size, other occupation and ownership of farmland influenced male farmers' income from sweet potato production while age, farm size, ownership of farmland and extension visits were the major influencing income of female farmers. Therefore, efforts should be intensified at implementing policies aimed at improving female farmers' access to land and other production inputs in the study area. Training of more female extension agents who can work freely with the female farmers in the area of timely dissemination of improved production technologies in sweet potato production should be undertaken by both the local and state governments in the study area.

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SOCIO-ECONOMIC VARIABLES OF COCOA FARMERS IN CROSS RIVER STATE, NIGERIA

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ABSTRACT

The study assessed the socioeconomic variables of cocoa farmers in Akamkpa Local Government Area (LGA) of Cross River State, Nigeria. The study employed a multistage random sampling technique to select cocoa farmers. The first stage was a purposive selection of the LGA. A total of eighty-seven (87) cocoa farmers were randomly selected in the LGA. Well-structured questionnaires were used to elicit information from the farmers. Data were collected on age of the farm, age of the farmers, marital status of farmers, household size, farming experience, educational level, membership of farmers' association, farm distance and tenure type. The level of education (2±1.0 years), mean age of farmers (48±8.7 years), membership of farmers in an association as well as the low mean age of farms (18±5.6 years) in the study area pointed to a potential increase in the level of productivity. It is recommended that more women be encouraged to partake in cocoa production in Akamkpa LGA as their involvement may bring about more efficiency in cocoa farming or cultivation. In addition, membership of farmers' association is encouraged as this will make them present a common front in making and having their demands met by the government and thus improve cocoa production specifically in Akamkpa LGA and generally in Cross River State.

Key words: Cocoa farmers, Socio-economic variables, Cross River State, Nigeria

INTRODUCTION

Cocoa (*Theobroma cacao)* hails from the Amazon basin. It has enjoyed world wide spread and popularity especially in the tropical zones due to its economic value in the world market (Ojo and Sadiq, 2010). Cocoa came into Nigeria in the year 1887 and has since been one of the major cash crops cultivated in the country. Nigeria is the fourth largest cocoa producing country in the world after Cote d'Ivoire, Ghana and Indonesia (Afolayan, 2020). According to Olatuyi (2020), that cocoa is produced in fourteen out of the thirty-six states in Nigeria with Ondo, Cross River, Osun and Oyo states being four of the top producing states. In addition, about 96 percent of the total cocoa produced in the Nigeria is exported to the international market while about 10 percent is processed in Nigeria (Olatuyi, 2020). Cross River state is the second largest producer of cocoa in Nigeria. The state is made up of eighteen (18) Local Government Areas (LGAs). Cocoa production is concentrated in fourteen (14) of the LGAs. This implies that the state is to be reckoned with when it comes to cocoa production in the country (http://www.crossriverhub.com/about-akamkpa-local-government/, accessed on 07.01.2021). Notably, most poor people from less developed countries (LDCs) reside in rural areas and make their living from agriculture. The role of the agrarian sector and institutional settings in general, and the rural poor, in terms of socioeconomic and demographic factors in particular, are of central importance in economic development. Traditionally, the agriculture sector and rural economy especially in LDCs, have been characterized by the predominance of a small landowning class, tenants, sharecroppers, and landless labourers who are at the core of the poverty problem (Imran *et al.,* 2009). Meanwhile, Krishna *et al* (2016) considered gender, age, income and education as the main attributes of socioeconomic variables. Similarly, socioeconomic status has been operationalised in a variety of ways, most commonly as education, social class, or income (Alexander *et al.,* 2017). Therefore, the study assessed the socio-economic variables of cocoa farmers in Cross River State.

MATERIALS AND METHODS

The study was carried out in Akamkpa Local Government Area (LGA) of Cross River State, Nigeria in 2016. Akamkpa LGA is one of the fourteen (14) cocoa producing LGAs in Cross River State. It is located between Latitudes: 5°001[1] and 5°481[1] North of the equator; and Longitudes 08°001[1] East of the equator. The LGA has a landmass of 4,943.04 sq km and a population of over 150, 000 persons according to the last population census (Aboh and Effiong, 2019). The LGA is characterised by a couple of rural areas with

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about 260 villages and about 30 different clans (http://www.crossriverhub.com/about-akamkpa-local-government/, accessed on 07.01.2021). Furthermore, the study employed a multistage random sampling technique to select cocoa farmers in the study areas. The first stage of the sampling technique was a purposive selection of the LGA. This is because of the volume of cocoa production in the LGA. The second stage was a random selection of three villages (Osomba, Ojork and New Ndebiji) within the LGA. The third stage was a random selection of eighty-seven (87) cocoa farmers in the LGA. Primary and secondary data were used for the study. Well-structured questionnaires were administered to the cocoa farmers for the primary data. Data were collected on age of the farm, age of the farmers, marital status of farmers, household size, farming experience, educational level, membership of farmers' association, farm distance and tenure type of farmers in the study area. Data was analyzed using simple descriptive statistics (means, frequencies, percentages and standard deviation).

RESULTS AND DISCUSSION

Table 1 shows the socio-economic characteristics of cocoa farmers in Akamkpa Local Government Area (LGA) of Cross River State. The table reveals that majority of the farmers (84%) were men. This result is in conformity with Girei *et al* (2013) who reported that in Africa, men are more in a crop that is perceived to have commercial value. The implication of this is that cocoa farming in the study area is largely dominated by the male gender. Moreover, the mean age of the farmers is 48 years, which implies that cocoa farmers in the LGA are still in their productive years and thus cocoa production in the study area is expected to be on the increase. However, this finding is not in consonance with those of Adeogun *et al* (2010) and Adebiyi and Okunlola (2013) who reported that cocoa farmers in some selected states of Nigeria were advanced in age; a good example being cocoa farmers in Oyo State of Nigeria who had passed their productive ages. Similarly, the table reveals that about 75 percent of cocoa farmers in Akamkpa LGA had formal education, though at the primary school level. The implication of this is that the farmers may not have adequate information on good agricultural practices with regard to cocoa production. However, it was revealed that majority of the respondents (89.70%) belonged to one farmers' group or the other, implying that they are likely to access information on improved production methods and procedures from their professional associations. This result is in tandem with Akinpelu (2019) who reported that about 76.50% of cassava farmers also belonged to one professional association or another. Membership of farmers' groups would afford farmers the opportunity of sharing information on modern production techniques, methods of purchase items in bulk and modes of exchanging labour (Onubuogu *et al.,* 2013). It would also help them to share information easily and be able to make demand on matters of a collective common welfare (Esiobu *et al*., 2014). Moreover, the expectation is that membership of farmers' organizations would influence farmers' adoption of improved technologies. Contrarily, Ahmed and Anang (2019) reported that membership of farmers group brought about a lower adoption of improved maize varieties. Furthermore, the table reveals an average household size of six persons, implying that farmers may sometimes utilize members of their households as labour for some operations relating to cocoa production or farm rehabilitation. This may reduce the production costs that would have been incurred in hiring for farm work. Mean age of cocoa farms in the study area was about 18 years. What this means is that the cocoa farms are in their productive years. This is contrary to findings by Adeogun *et al* (2010) who reported that cocoa farmers in selected states of Nigeria had aged trees that are older than thirty (30) years, thus implying diminishing returns on production over time. Finally, it was revealed that about 55.17% of the farmers have their farms located far from home. This is expected because cocoa is unlike any arable crop that can be cultivated close to the house. Similarly, fertile lands for cocoa production are typically in the forests as land close to the village areas are usually dedicated to building residential houses.

CONCLUSION AND RECOMMENDATION

The study assessed the socioeconomic variables of cocoa farmers in Akamkpa Local Government Area of Cross River State. The level of education, mean age of farmers, membership of farmers in an association as well as the low mean age of farms all pointed to a potential increase in the level of productivity. Cocoa farmers in Akamkpa LGA have a productive low mean age, which means that they have age on their side and can afford to improve their level of productivity. It is recommended that more women be encouraged to partake in cocoa production in Akamkpa LGA as their involvement may bring about more efficiency in cocoa farming or cultivation. In addition, it is recommended that those yet to join farmers' association be encouraged as this will make them present a common front in making and having their demands met by the government. The associations could also serve as an avenue for government to reach or extend any form of assistance to smallholder farmers in the study area. These recommendations could help improve cocoa production specifically in Akamkpa LGA and generally in Cross River State.

Table 1: Socio economic characteristics of Cocoa Farmers in Akamkpa Local Government Area, Cross River State

Variables	Frequency	Percentage (%)	Mean
Gender (Dummy)			
Male	73	84.00	
Female	14	16.00	
Total	**87**	**100.00**	
Age of Farmer (Years)			**48(±8.7)**
≤ 29	4	5.00	
30-39	8	9.00	
40-49	34	33.00	
Above 50	46	53.00	
Total	**87**	**100.00**	
Marital Status			
Married	79	90.80	
Single	4	4.60	
Divorced	4	4.60	
Total	**87**	**100.00**	
Educational Level (No of years)			
Primary	65	75.00	
Secondary	18	21.00	
Tertiary	4	5.00	
Total	**87**	**100.00**	
Membership of Farmers' Group (Dummy)			
Yes	78	89.70	
No	9	10.30	
Total	**87**	**100.00**	
Household Size (No. of persons)			**6(±3)**
1-5	49	56.00	
6-10	35	40.00	
Above 10	3	4.00	
Total	**87**	**100.00**	
Age of cocoa farm (Years)			**18(±6)**
1-20	66	76.00	
Above 20	21	24.00	
Total	**87**	**100.00**	
Tenure System			
Own Land	87	100.00	
Total	**87**	**100.00**	
Farm Distant (Dummy)			
Homestead Farm	39	44. 83	
Distant Farm	48	55. 17	
Total	**87**	**100.00**	

Source: Field Survey, 2016 Figures in Parenthesis are Standard Deviations

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COMPARATIVE ECONOMIC ANALYSIS OF NATIONAL CENTRE FOR AGRICULTURAL MECHANIZATION (NCAM) MECHANICAL RICE THRESHER

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ABSTRACT

The study was carried out in Kwara State. Primary data was collected through a well-structured questionnaire. A multi-stage random sampling technique was used. A convenience sampling techniques was used in administering a total of 200 questionnaires to rice farmers and agro-processors within the selected communities. Findings from the study showed that 75.8% of the respondents were males while 24.2% were females. Majority of the respondents (77.8%) have farming as their main occupation, while others engaged in other occupations apart from farming. 22.2% of the respondents had 1 – 8 years of rice processing experience, while 3.0% of the respondents had between 9 – 11years of experience and majority of the farmers 74.7% had above 12 years of rice processing experience. The study further revealed that the cost of using manual thresher was about 63% higher than NCAM thresher. While the average total revenue of rice threshed was #103,079.00 and #138,125.00 respectively. This gives a profit of #82,869.00 manually and #125,295.00 NCAM thresher. The findings in this study clearly showed that using NCAM mechanical rice thresher is more profitable and economic efficient in the study area.

Key words: Rice Farmers, Agro- Processors, Mechanical Rice Thresher, NCAM, Economic Analysis

INTRODUCTION

Rice is both a food and a cash crop for farmers, contributing to smallholders' revenues in the major producing areas of Nigeria. Rice is grown approximately on 3.7 million hectares of land in Nigeria, covering 10.6 percent of the 35 million hectares of land under cultivation, out of a total arable land area of 70 million hectares; 77 percent of the farmed area of rice is rain-fed, of which 47 percent is lowland, while 30 percent upland (World Bank, 2014). Although rice production in Nigeria has boomed over the years, there has been a considerable lag between production and demand level with imports making up for the shortfall (World Bank, 2014). Recently, Central Bank of Nigeria (CBN) banned importers from accessing foreign exchange markets in 55 categories of items, including rice. Any attempt at addressing the issues of rice production in Nigeria, must of necessity concentrate on efforts to stimulate adoption of rice processing technologies among our rice farmers. However, the most important step in the application of the new technology is the awareness of the economic incentives accruable from it such as its profitability, convenience, adaptability, durability, etc. Most rice farmers (90 percent of total) in Nigeria are smallholders, applying a low input strategy to agriculture, with minimum input requirements and low output (Adeniyi, 2015). The Federal Government of Nigeria through several measures in trying to improve rice production from subsistence to commercial production has laid emphasis on increasing the use of modern rice farming technologies such as power tillers, tractors, improved seeds, SAWAH technology, rice processing machines, etc. In line with this, the National Centre for Agricultural Mechanization (NCAM) Ilorin has made remarkable efforts in the establishment of rice processing Centers across the six geo-political zones in Nigeria, equipped with rice threshers and other rice processing machines for value addition. Hence, this study is being carried out to assess the economic analysis of NCAM mechanical thresher in the rice processing system using the established NCAM rice processing centers as a case study.

MATERIALS AND METHODS

The study was carried out in Kwara State. Primary data was collected through a well-structured questionnaire. A multi-stage random sampling technique was used. A total of 5 communities were sampled; namely Pategi, Lade, Godiwa, Edogi and Sapefu. These communities were selected purposely based on their high rice production and processing activities as well as the fact that these communities are where NCAM rice processing centers are located. A convenience sampling techniques was used in administering a total of 200 questionnaires to rice farmers and agro-processors within the selected communities.

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The data were analyzed using descriptive statistics and budgetary analysis. The gross margin model was employed. The gross margin (GM) is the difference between the total revenue (TR) and the total variable cost (TVC). The gross margin model is expressed mathematically as:

GM = TR – TVC--eqn 1

Where, GM = Gross Margin (N/ha)

TR = Total Revenue

TR= PQ (P= price per unit output and Q=total quantity of output)

TVC = Total Variable Costs (N/ha)

While the profit/ net income model states;

π = Gross margin – TFC--eqn 2

Where, π **=** Profit or Net Income (N)

TFC = Total Fixed Cost (N/ha).

Profitability ratio was further used to examine the costs and return of the farmers. This is because gross margin though necessary but is not a sufficient tool to determine the profitability level of an enterprise.

Hence the model is presented thus:

$$\text{Gross Profit Ratio} = \frac{\text{Gross Margin}}{\text{Total Revenue}} \times 100 \text{ --eqn 3}$$

RESULTS AND DISCUSSION

The socio-economic characteristics of rice farmers directly or indirectly affect their farming operations. Results from Table 1 indicate that about 75.8% of the respondents were males while 24.2% were females which are in line with the findings of Matanmi et al, 2011 that rice production in Pategi is dominated by men. This implies that the sex distributions of the rice farmers in that area are predominantly towards male respondents. Result from table 1 also revealed that majority (71.2%) of the respondents are within their productive age (31-50 years). This is an advantage since they are still in the age at which they are supposed to be energetic, more mentally alert in learning new technology than the older farmers and hence can be actively involved in processing activities. This result is in line with studies of Adam, 2018, Ben-Chendo, 2017, Igboji, 2015 and Agwu, 2004 that age is an important determinant of social-economic status, people wane in energy as they advance in age. Majority of the respondents (80.8%) were married while 6.1% were single, 8.1%, 3.0% and 2.0% were widowed, divorced and separated. This implies that the respondents are responsible according to the societal standard and therefore are likely to have some experience of life. The result further revealed that majority (65.6%) had family size ranging from 4 to 10 implying that they have enough family labour for processing activities. This agrees with the studies of Adam and Bidoli (2017); Giroh *et al*., (2011) which established that household size is not significantly related to adoption but reported that socio-economic status of farmers is positively and strongly related to adoption. The data on educational status revealed that about 92.1% are literates. Positive correlation has been found between education and adoption of new technology as elucidated by Junge *et al.,* (2009) and Olaolu *et al*., (2011). Also, Agbamu, (2006) asserted that there is an inverse relationship between formal education and adoption of technologies.

The result from the study also shows that majority of the respondents (77.8%) have farming as their main occupation, while others engaged in other occupations apart from farming. The implication of this is that, instead of the respondents to plough back the money or income realized from rice processing into investment in agriculture, they invest the extra income in other business which will serve as sources of income to sustain them during the off season period. Table 1 also shows that 22.2% of the respondents had 1 – 8 years of rice processing experience, while 3.0% of the respondents had between 9 – 11years of experience and majority of the farmers 74.7% had above 12 years of rice processing experience. Generally, this implies that farmers in the selected communities had long period of experience which is in line with the research study carried out by Igboji, (2015).

Table 1: Socio-Economic Characteristics of the Respondents

Variables	Frequency	Percentage (N=198)
Gender		
Male	150	75.8
Female	48	24.2
Age		
<20	10	5.1
21-30	37	18.7
31-40	54	27.3
41-50	77	38.9
>50	20	10.1
Marital Status		
Single	12	6.1
Married	160	80.8
Divorced	6	3.0
Widowed	16	8.1
Separated	4	2.0
Household Size		
≤3	48	24.2
4-6	64	32.3
7-10	66	33.3
>10	20	10.1
Educational Status		
No formal Education	14	7.1
Arabic/Islamic Education	60	30.3
Adult Education	10	5.1
Primary Education	22	11.1
Secondary Education	24	12.1
Tertiary Education	68	34.3
Occupation		
Farming	154	77.8
Artisans	6	3.0
Trading	12	6.1
Civil servant	4	2.0
Student	14	7.1
Agro-service provider	8	4.0
Experience		
≤2years	6	3.0
3-5years	30	15.2
6-8years	8	4.0
9-11years	6	3.0
≥12years	148	74.7
Income		
Farming	127	64.1
Trading /business	49	24.7
Salary	22	11.1
Cooperative		
Yes	156	78.8
No	42	21.2
Credit		
Relatives	78	39.4
Local money lender	17	8.6
Agricultural agencies	5	2.5
Cooperatives	40	20.2
Friends	26	13.1
Banks	4	2.0
No	28	14.1

Source: Field Survey, 2020

This could increase their knowledge, experience and subsequent adoption of NCAM rice threshing technology. The findings from the study further shows that majority (78.8%) of the respondents belonged to one farmers' group (farmer cooperative, thrift cooperative services) or the other and majority have spent about 5 years being member of the cooperative society while 21.2% of the respondents were not members of any farmers' group/cooperative. The implications of non-membership are that the potential of social-network through farmers group as source of agricultural related information has not been fully utilized. This observation is in line with the studies conducted by Agwu (2004), Odoemenem, (2007) and Salasya *et al*., (2007). The result indicated that majority 66.2% of the respondents did not have access to credit while the remaining 33.8% had access to credit facilities. Negash, (2007) confirmed that access to credit is statistically significant to the adoption of improved technologies.

The result from Table 2 revealed that almost all of the respondents (96%) reported that there were differences in their output as a result of adopting NCAM rice thresher. This could be due to the fact that NCAM rice thresher is efficient, faster, reliable and eliminate the drudgery associated with manual threshing which all the respondents reported is most stressful.

Table 2: Output from Adoption of NCAM Rice Thresher

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	190	96.0	96.0	96.0
	No	8	4.0	4.0	100.0
	Total	198	100.0	100.0	

Profitability of Analysis of Rice Thresher

The profitability ratio was used to examine the cost and returns of rice threshing in the study area. The analysis enabled us to determine whether rice threshing is profitable in the study area or not. It equally helps to elucidate the advantage of using NCAM rice thresher over the manual threshing. The cost components include the costs of labour, transportation, bag, drum, fuel and tarpaulin. Labour accounted for 39.6% manually and 23.4% while usingNCAM rice thresher. Also 22.8% and 35.9% of the cost of rice threshing is spent on transportation. Bags are used by farmers to pack the rice before and after threshing. This constitutes 7.7% manually and 14% NCAM rice thresher of the total cost incurred in rice threshing. NCAM rice thresher was higher because wastages of rice were minimal. The rent of the threshing drum and tarpaulin accounted for 18% manually, while 16.4% was incurred on fuel. Other minor expenses are purchase of bowl, brooms, thread and needles (Table 3).

The average total cost of rice threshed was N20,210.00 manually and N12,830.00 NCAM thresher. The cost of using manual thresher was about 63% higher than NCAM thresher. While the average total revenue of rice threshed was N103,079.00 and N138,125.00 respectively. This gives a profit of N82,869.00 manually and N125,295.00 using NCAM thresher.

The gross profit margin of NCAM mechanical thresher is 0.907 (90.7%). A high gross profit ratio is an indication that the farmers are selling their produce at high profit level. Hence, the farmer are expected to have sufficient funds to pay for operating expenses such as wages, utilities and rent while having high turnover in the study area.

CONCLUSION

The overall purpose of this study was aimed at determine the comparative economic analysis of NCAM Mechanical rice thresher and manual thresher amongst rice farmers and processors in Kwara state. The findings in this study clearly showed that using NCAM mechanical rice thresher is more profitable and economically efficient in the study area. It is therefore recommended that rice farmers and agro-processors should be encouraged to use NCAM Mechanical Rice Thresher.

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Table 3: Cost and Returns Analysis of Manual and NCAM Rice Thresher

ITEM	MANUAL		NCAM RICE THRESHER	
	Amount (#)	% of total cost	Amount (#)	% of total cost
Labour	8,000.00	39.6	3,000.00	23.4
Transportation	4,600.00	22.8	4,600.00	35.9
Bag	1,560.00	7.7	1,800.00	14.0
Drum	2,000.00	9.9	-	-
Tarpaulin	2,000.00	9.9	-	-
Fuel	-	-	2,100.00	16.4
Bowl, broom, thread, needle	2,050.00	10.1	1,330.00	10.3
Total cost	20,210.00		12,830.00	
Total returns	103,079.00		138,125.00	
Gross margin	82,869.00		125,295.00	
Gross Profit Ratio	80.4%		90.7%	

Source: Field Survey, 2020

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COMPETITIVENESS OF COFFEE PRODUCTION IN KOGI STATE OF NIGERIA

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ABSTRACT

The study investigated the competitiveness of coffee production in the study area. The project was carried out among coffee farmers in Kogi State of Nigeria. Simple random sampling technique was used to collect data from the farmers. Data were collected from the respondents with the aid of structured questionnaire and the data obtained from the questionnaire were analysed using Descriptive analysis, Private Profitability and Private Cost Ratio. Majority (92.59%) of the respondents were above 50 years while majority (70.37%) of the farmers were having formal education. However, 81.48% of the farmers are having farm size 5 hectares and below. The result of Private Profitability was positive in all the three management systems while the Private Cost Ratio (PCR) was less than one in all the management systems considered. The study concluded that coffee production is highly competitive in the study area.

Key words: Coffee, Production, Competitiveness, Policy Analysis Matrix

INTRODUCTION

Coffee as a crop is a member of the family Rubiaceae, a large family of over 5500 species widely distributed in the tropics. There are three species of coffee grown for commerce, these are *Coffee arabica*, which is highland coffee and it grows very well at altitude of 600m and above, it has a mild taste and is more fragile; *Coffee canephora* (popularly known as *Coffee robusta*), this is more resistant and is lowland coffee thriving best at the altitude range of 0 to 750m above sea level and the third species is Coffee liberica which is a mild-altitude coffee thriving best at an altitude of 400m to 600m (Opeke, 2005). However, *Coffee arabica* produces the best quality of coffee and still supplies the bulk of the world coffee, but it grows well only at cooler air temperature (Akinbode, 1980). According to Milford (2004), the coffee tree can be grown only in warm areas without frost or sudden temperature shifts, and it also needs plenty of rain. This explains why it is a common export commodity for countries in tropical areas, and an unsuitable one for the rest of the world.

The vast majority of coffee production has its roots in colonialism, during which missionaries or colonialists usually imported the plant. Coffee then became a "cash crop, planted and harvested by serfs or wage laborers on large plantations, then exported to imperial countries" (James, 2000). Consequently, governments, ethnic relations and general ways of life were changed in these countries because of the shift to the new reliance on coffee production. However, with the growth of the United States economy, the market for exporting coffee also expanded. Therefore, coffee became a major source of income for many countries in Central and South America, Africa, and South Asia where colonialism was present and the environment was ideal for coffee trees (Cleland, 2010). Meanwhile, the coffee plant originated in Ethiopia. However, coffee-drinking habits had spread to Europe by the 17th century.

However, the producers of these coffee beans are often small-scale farmers who are reliant on faceless consumers, large corporations and an ebbing market for their income and resources. Meanwhile, empirical studies have shown that smallholders in developing countries face numerous constraints due to the pervasive imperfections of markets. Increasing evidence shows that through collective action, smallholders can reduce transaction costs of accessing input and output markets, adopt efficiency-increasing and value-adding technologies, and tap into high-value markets associated with certification and labeling (Kersting and Wollni, 2012; Wollni and Zeller, 2007;). In the early 2000s, a historic world market price slump hit millions of coffee farmers hard, especially smallholder producers in Africa and Latin America (Ponte, 2002). The volatility of coffee markets in combination with poor production infrastructure and services have sunk the majority of coffee producers in developing countries in low-input-low-output cycles and structural poverty. Similarly, coffee is a traditionally worldwide traded cash crop with new emerging markets; many coffee-producing developing countries such as Nigeria are struggling with production and marketing of the crop. In addition, smallholder coffee growers face high transaction cost, lack of market information, poor infrastructure, and weak capital markets. Moreover, imperfect competition in which farmers are getting paid less for their produce than they would in a competitive situation occurs among the smallholder coffee growers in Nigeria. When this effect is added to the other aforementioned factors that are characteristic of the coffee industry, we can perhaps understand why, to many of these farmers, this situation must seem unfair. The objective of the study was therefore to determine how competitive coffee production is in the study area.

MATERIALS AND METHODS

The project was carried out among coffee farmers in Kogi State. Ijumu Local Government Area (LGA) was purposively selected from the State and from the LGA, Iyamoye community was also purposively selected because coffee farmers are mostly concentrated in the community. Simple random sampling technique was used to collect data from a total of 81 farmers randomly selected from the community. Data were collected from the respondents with the aid of structured questionnaire and the data obtained from the questionnaire were analysed using Descriptive analysis as well as Policy Analysis Matrix (PAM). The constituents of PAM that were used in this study are Private Profitability and Private Cost Ratio.

Descriptive Statistics was used to describe the socio-economic characteristics of the farmers while Private Profitability and Private Cost Ratio were used to determine the competitiveness of coffee production in the study area. However, for ease of comparism of these indices, two coffee production management systems were considered, these are Self owned and Inheritance production systems.

PAM is a product of two accounting identities, profit, defined as the difference between revenue and cost while the other measure the effect of the divergences (distorting policies and market failures) as the difference between observed parameters and parameters that would exist if the divergence were removed (Monke and Pearson, 1989).

Private Profitability (PP) – This demonstrates the competitiveness of the agricultural system given current technologies, prices of input and output and policy

$$\prod = \sum Y_i^{\,p} P_i^{\,p} - (\sum a_{ij} P_j^{\,P} + \sum a_{ij} P_k^{\,P})$$

..................(1)

Where:

$\prod$ = Private Profit;

$Y_i^p P_i^p$ = Value of output produced at private prices;

$\Sigma a_{ij} P_j^p$ = Cost of tradable inputs used at private prices;

$\Sigma a_{ij} P_k^p$ = Cost of domestic factors used at private prices.

If Private Profit < 0, which is negative private profit, this shows that the product is not competitive given current technologies, prices of inputs and outputs, and policy and that operators are earning subnormal rate of return when private profit = 0, operators are earning normal profit while when private profit > 0, that is positive private profit. The positive private profit implies that the product is competitive given current technologies, prices of inputs and outputs, and policy and the producers are earning positive returns and this should lead to expansion of the system.

4.5.1.2. Private Cost Ratio (PCR) - This shows the private efficiency of the farmers or the marketers and is an indication of how much one can afford to pay domestic factors (including a normal returns to capital) and still remain competitive.

$$PCR = \frac{\sum a_{ij} P_k^{\,p}}{Y_i^{\,p} P_i^{\,p} - \sum a_{ij} P_j^{\,p}}$$

....(2)

Where:

$\Sigma a_{ij} P_k^p$ = Cost of domestic factors at private prices;

$Y_i^p P_i^p$ = Revenue at private prices;

$\Sigma a_{ij} P_j^p$ = Cost of tradable inputs at private prices.

PCR < 1 indicates that the product is highly competitive given current technologies, inputs and output prices and policy and that entrepreneurs are earning excess profits. It shows that the entrepreneur can pay for all the domestic factors including bank loan and its interest with the operation still remaining competitive. The PCR > 1 implies entrepreneurs are making losses, that is after paying for the domestic factors, the operation is no more competitive PCR = 1 indicates the breakeven point.

RESULTS AND DISCUSSION

The result of the socio-economic characteristics of the farmers is shown in Table 1. The table shows that only 7.41% of the total respondents are of age 50 years and below indicating that the proportion of youths among the respondents is low. Meanwhile, 77.77% of the total respondents were above 60 years of age. Hence, 77.77% of the farmers were above the productive age of 60 years. The lowness in the proportion of the youths is a bad pointer to coffee production efficiency as younger farmers are more active on farm work than the aged ones. Table 1 also shows that 100% of the respondents were males. This is quite obvious in that farm work is a tedious work and is only men that could cope effectively with it. Apart from this, most of the farms were inherited and some traditional cultures permit only the male children to inherit farms. As regards the educational level of the respondents, the result of the analysis shows that 70.37% of the respondents were having formal education. This would improve the efficiency of the farmers in as much that literate farmers would find it easier to adopt new technologies on coffee than the illiterate ones. The analysis on farm size shows that 81.48% of the respondents had farm size of 5 hectares which shows that most of the farmers are small scale farmers. Table 1 also shows that 66% of the farmers had the age of their farms greater than 30 years showing that most of the farms are old and hence the farm's productivity would reduce, therefore such farms needs to be rehabilitated. As regards farming experience, 96.7% of the farmers were having more than ninety years of experience on coffee farming. This is a good pointer to an increased productivity. Table 1 also revealed that majority (85.19%) of the farmers had inherited farms while just 14.81% established their farms themselves.

The result of the competitiveness analysis as shown on table 2 showed that coffee production is highly competitive in the two coffee farm ownership types considered. This is because the Private Profitability (PP) and the Private Cost Ratio (PCR) result is positive and is less than one respectively in all the farm ownership types. Considering the values of PP, coffee production in the two ownership types is highly competitive since the values are very high in the two ownership types. However, coffee production is more competitive in self owned type of ownership because the value of Private Profitability is the higher between the two ownership types (N241,192.86). This is followed by inheritance type of ownership with PP value of N104,850.00. The values of Private Cost Ratio showed that coffee production in the two ownership types is highly competitive, meanwhile, the lower the PCR the higher the competitiveness. Therefore, coffee production in self ownership is more competitive since it is having the lower PCR (0.089). This is followed by inheritance type of ownership with PCR of 0.166. Looking at the values of both the PP and PCR together, it clearly showed that coffee production is more competitive in self ownership than inheritance type of ownership given current technologies, prices of inputs and outputs, and the prevalent government policies.

CONCLUSION

Majority of the respondents are formally educated and this is a good pointer towards high productivity and thus increases the competitiveness in coffee production. Also, most coffee farmers in the study area were small scale producers, this is because majority of the farmers were having farm size of five hectares and below. Coffee production in the study area is highly competitive. However, coffee production in self ownership management system is the most competitive of the two types of farm ownership. In as much that coffee production in the study area is highly competitive, it is hereby recommended that government should give farmers incentives to expand their coffee farms as majority of the farmers are small scale farmers (having less than 5 hectares of land). The incentives may include provision of soft loans as well as subsidized inputs.

Table 1. Socio-economic variables of coffee farmers

Variables	Frequency	Percentages
Age of farmers (years)		
≤ 50	6	7.41
51-60	12	14.82
61-70	21	25.92
> 70	42	51.85
Total	81	100.00
Sex		
Male	81	100.00
Female	0	0
Total	81	100.00
Educational level		
No formal education	24	29.63
Primary education	18	22.22
Secondary education	15	18.52
Tertiary education	24	29.63
Total	81	100.00
Size of farm (Ha)		
≤ 5	63	81.48
5.1-10	18	18.52
> 10	0	0.00
Total	81	100.00
Age of farm ((years)		
≤ 10	6	7.41
11-20	6	7.41
21-30	3	3.70
31-40	21	25.93
> 40	45	55.55
Total	81	100.00
Farming experience (years)		
≤ 10	1	3.70
11-20	0	0
21-30	9	11.11
31-40	15	18.51
41-50	18	22.22
> 50	38	44.46
Total	81	100.00
Type of ownership		
Self-owned	12	14.81
Inheritance	69	85.19
Total	81	100.00

Source: Field survey, 2019.

Table 2. Competitiveness of Coffee Production Systems

Coffee Production Systems	Private Profitability (PP)	Private Cost Ratio (PCR)
Self-Owned	241,192.86	0.089
Inheritance	104,850.00	0.166

Source: Field survey, 2019.

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ECONOMIC ANALYSIS OF FARM EFFICIENCY ON THE PROFITABILITY OF COFFEE PRODUCTION IN KOGI, NIGERIA

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ABSTRACT

The studies examine the effect farm Efficiency on the profitability of coffee production in Kogi, Nigeria. There have been a lot of studies on efficiency of annual crops with little attention given to perennial crops such as coffee Multi stage sampling technique using purposive and simple random sampling proportionate to size was used to select four hundred respondents for the study. Data collected included those of socio- economic characteristics of farmers and their production. The data collected were analyzed using descriptive statistics and Net Revenue (NR) Results revealed that majority (77.8%) are male. Only eight percent of them had farming experience of less than 10 years in coffee production. The coefficient of farm income is statistically significant and positive in determining the profitability of coffee production in the study area. The coefficient of male gender is statistically significant and positive in determining the profitability of coffee production in the study area. Fire incidence and climate impact were the major constraints to production of coffee. The study recommended that government should support expanded production of coffee to other potential areas, government and other lending agencies should also do more in assisting the farmers with soft loans in order to reduce the problem of inadequate capital among the farmers and adoption of climate change and adaptation strategies should be used by farmers in order to reduce the incidence of fire outbreak climate impacts.

Key words: Coffee, Farm Efficiency, Profitability

INTRODUCTION

Agriculture is the mainstay of the Nigerian economy from the standpoint of its various contributions to the economy. Coffee is a member of the Rubiaceae family.It has two major species in Nigeria, *Coffea arabica and Coffea canephora (robusta).* Coffee plant is native of Africa. The origin of Coffee arabica has been traced to Ethiopia in the 9th century while *Coffee robusta* is believed to have come from Central Africa. Coffee was introduced to Nigeria around 1859 and is mostly cultivated in the lowland areas (*Coffea canephora*) and Highland areas (*Coffea arabica*). Coffee growing and drinking started in Ethiopia. Today, it is an important commodity and a popular beverage in the world. Coffee is one of the most important export crops in Africa and Latin America countries (Opeke, 2005). It was introduced to Nigeria around the same time as cocoa. It is commercially grown in 13 States namely; Taraba, Kogi, Ondo, Oyo, Ogun, Osun, Edo, Kwara, Ekiti, Adamawa, Plateau, Abia and Cross River (CRIN, 2014). According to the United States Department of Agriculture (USDA) among 95% of Nigerian coffee farmers, compatibility problem has been observed to be a major factor limiting yield to 600-800 kg /ha. This makes investment in coffee production less profitable (Omolaja, 1999). The empirical results become useful tools for policy makers in agricultural planning and this will lead to better production performance and overall productivity. A study of this nature is however, very pertinent because it gives the actual picture of the effects of farm efficiency on the profitability of coffee production which will help address coffee value chain issues. The findings from this study suggest solutions to the constraints encountered by the coffee farming households in Nigeria.

Objectives of the study

The overall aim of the study is to examine the effect of farm efficiency on the profitability of coffee production in Kogi, Nigeria

The specific objectives of the study are to:

(a) examine the socio-economic characteristics of coffee farmers in the study area;

(b) estimate the effect of farm efficiency on the profitability of coffee production.

MATERIALS AND METHODS

The study was carried out in Kogi State, Nigeria, It's capital is Lokoja, located in north central of Nigeria, Kogi State occupies a total land area of 29,833 square kilometres. The wet season ranges from the month of April to October while the dry season is between November and March. The annual rainfall is between 1000mm and 1500mm, the annual temperature varies between 27°C and 37°C with

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relative humidity between 30 and 40% in January and rising between 70 and 80% in July to August. The soil in the study area is predominantly sandy loam in texture. The study made use of primary and secondary data. A multi-stage sampling technique was used for the study. In the final stage of sampling, simple random sampling proportionate to size was again used to select the respondents that were administered structured questionnaire and the final sample size for the study is 400 (Ijumu,116, Kabba –Bunu,139 and Yagba East,145) The data collected were analyzed using descriptive statistics and Net Revenue (NR)

To Estimate the Effect of Farm Efficiency on the Profitability of Coffee Production.

The Tobit model: If a continuous random variable X has pdf f(x) and a is a constant, thenS

$$f(x/x>a)=\frac{f(x)}{\Pr ob(x>a)}$$

If x has a normal distribution with mean μ and standard deviation σ, then

$$\Pr ob(x>a)=1-\Phi\left(\frac{a-\mu}{\sigma}\right)=1-\Phi(\alpha)$$

Where α = (a-μ)/σ and φ(.) is the stardard normal cdf. The density of the truncated normal distribution is then

$$f(x/x>a)=\frac{f(x)}{1-\Phi(\alpha)}=\frac{(2\pi\sigma^2)^{-1/2}e^{-(x-\mu)2/(2\sigma^2)}}{1-\Phi(\alpha)}=\frac{\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)}{1-\Phi(\alpha)}$$

Where φ(.) is the standard normal pdf. The truncated standard normal distribution, with μ = 0 and σ= 1. Likewise, the discrete random variable is the truncated at Zero Poisson distribution,

$$\Pr ob|Y=y/y>0|=\frac{(e^{-\lambda}\lambda^y)/y!}{\Pr ob[Y>0]}=\frac{(e^{-\lambda}\lambda^y)/y!}{1-\Pr ob[Y=0]}=\frac{(e^{-\lambda}\lambda^y)/y!}{1-e^{-\lambda}},\lambda>0,y=1,\ldots$$

Implicit form;

$Y^*_{ij}= \beta'X + \varepsilon_i$ $\quad\quad$ $\varepsilon i \sim N(0,\sigma^2)$

$Y_{ij} = Y^*_{ij}$ $\quad\quad$ for $Y^*_{ij} > Y_i$

$Y_{ij}= Y_i$ $\quad\quad$ for $Y^*_{ij} \leq Y_j$

Where

Y = The profitability index ($\frac{NI}{TR}$) as a proxy of farm profit (ratio in figure).

X_1= Farm income (naira)

X_2 = No of products for sale per farm (coffee)

X_3 = Total value of all the products sold in the last session (naira)

X_4 = Total amount of money spend on production in last session (naira)

X_5 = Age of the farmer (number)

X_6 = Educational level of the farmer (number of year spent in school)

X_7 = Sex of the farmer (male = 1; 0 if otherwise).

X_8 = Household size (number)

X_9 = Size of the farm $\quad$ X_{10} = Amount of loan accessed in last production year (naira)

X_{11} = Experience in coffee farming (year) X_{12} = Presence of other occupation (yes = 1; 0 if otherwise

RESULTS AND DISCUSSION

Table 1 showed that majority of the respondents, (77.8%) were male while 22.2% were females. This tends to show that any likely increase in farm efficiency of Coffee production would be as a result of the predominant involvement of male farmers who are most likely to be more agile than their female counterparts. This implies that coffee farming activities in the study area is gender sensitive.

Table 1: Distribution of Respondents by Sex

Sex	Frequency	Percentage
Male	311	77.8
Female	89	22.2
Total	**400**	**100.0**

Source: Field Survey, 2019

Only eight percent of them had farming experience of less than 10 years in coffee production. Thus suggesting that with the relatively long exposure, it is expected that most farmers must have mastered the skills required for success in their coffee production business (Table 2).

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Table 2: Distribution of Farmers According to Years of Experience

Farming Experience	Frequency	Percentage
<10 years	32	8.0
11-20 years	121	30.3
21-30 years	122	30.5
31-40 years	77	19.3
41-50 years	39	9.8
>50 years	9	2.3
Total	**400**	**100.0**

Source: Field Survey, 2019

Out of the 12 variables modeled, only farm income and male gender were statistically significant in determining the profitability of coffee production in the study area. The coefficient of farm income is statistically significant and positive in determining the profitability of coffee production in the study area. This showed a direct relationship between farm income and the profitability of coffee production in the study area. This implies increase in the farm income will lead to increase in the profitability of coffee production in the study area (Table 3).

Table 3: Effect of Farm Efficiency on the Profitability of Coffee Production.

Variables	Co-efficient	t value	Marginal effect
Constant	0.208	0.491	0.208
Farm income	0.113**	2.026	0.113
Number of products for sale per farm	0.019	0.051	0.019
Total value of all the products sold in the last session	0.014	0.338	0.014
Total amount of money spend on production	-0.017	-0.722	-0.017
Age of the farmer	0.227	0.866	0.227
Educational level of the farmer	0.091	0.816	0.091
Sex of the farmer	0.847*	1.687	0.847
Household size	-0.000	-0.455	-0.000
Size of the farm	-0.048	-0.845	-0.048
Amount of loan accessed in last production year	0.000	0.242	0.000
Experience in coffee farming	0.000	0.105	0.000
Presence of other occupation	-0.036	-0.051	-0.036

Sources: Field Survey, 2019. * = Significant at 10%. ** = Significant at 5%. *** = Significant at 1%

The coefficient of male gender is statistically significant and positive in determining the profitability of coffee production in the study area. This showed a direct relationship between male gender and the profitability of coffee production in the study area. This implies that coffee production in the study area tends to increase with more involvement of male gender in the study area.

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ANALYSIS OF THE COST AND RETURNS IN GARDEN EGG PRODUCTION: A PANACEA FOR VIABLE RURAL LIVELIHOOD IN RINGIM LOCAL GOVERNMENT AREA OF JIGAWA STATE, NIGERIA

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ABSTRACT

The study determined the costs and returns of garden egg production in Ringim Local Government Area (LGA) of Jigawa State, five (5) villages/wards out of the ten (10) wards in Ringim LGA were purposely selected where sixty-four (64) garden egg farmers were randomly selected. Findings revealed that, the ages of the farmers within the range of 19-26 years was the highest (34.3%). Majority of them (62.5%), were married where 32.8% attained primary school and only 12.5% attained tertiary school. About 92% of the farmers cultivate less than 1 hectare revealing that most of the farmers were small scale producers. However, g*arden egg production was found to be profitable with Gross margin of N93,775 per hectare. Return per naira invested was found to be N1.95. Constraints such as lack of government support, inadequate capital, lack of improved varieties, high cost of inputs, pests and disease incidences, lack of market and storage facilities were identified to be hindering the possible growth of the crop in the area. Conclusively, garden egg production, if well harnessed, could serve as an engine room for sustainable promotion and upliftment of the rural livelihood in the area. It is recommended that government should provide the garden egg farmers with modern irrigation facilities and farm inputs to boost its production and increase income generation.*

Key words: Cost and Return, Garden egg Production, Jigawa State

INTRODUCTION

The name ― Garden eggplant was derived from the shape of the fruits of some varieties which are white and shaped like chicken eggs, (Chen et al., 2001) The plant, (Solanum spp) is a vegetable with increasing popularity in the world (Pessarakli and Dris, 2003). Production of Garden egg is highly concentrated with 90% of output coming from five countries. China is the top producer (58% of world's output), India is the second (25%) other countries are Iran, Egypt, and Turkey. More than 4,000,000 acres (i.e. 1,600,000 ha) are devoted to its cultivation in the world. Garden egg is one of the greatest foods, in terms of health benefits as it is packed with vitamins, minerals and other nutrients. Some of the major problem facing farm production in Nigeria include lack of classified data and information on the suitability, adaptability and performance of commercially available agricultural products against this background, viability of a sustainable rural livelihood promotion could benefit immensely with empirical evidence of the cost and returns in garden egg production as incurred by its farmers living in the rural area.

Objectives of the Study

The main objective of the study is to examine the cost and returns of garden egg production in the Ringim LGA of Jigawa State. The specific objectives are to:

i. Describe the socio–economic characteristics of garden egg producers.
ii. Determine the costs and returns of garden egg production.
iii. Examine the problems associated with garden egg production.

MATERIALS AND METHODS

Study Area

Ringim Local Government Area of Jigawa State, Nigeria, is located in the North-western part of the State. It is about 6,494 km^2. Ringim is semi-arid, characterized by wet season from May to September. The annual rainfall ranges from 600mm to 759mm. The region falls within the Sudan savanna vegetation zone. Hausa and Fulani constitute the major ethnic groups. The area has a fertile land for both wet and dry season farming activities and the people in the area also engaged in marketing as well.

Methods of Data Collection

Primary data were collected using questionnaires. Information obtained include socio economic characteristics, costs and returns, input-output relationship and constraints affecting garden egg production.

Sampling Techniques and Sampling Sizes

A multistage sampling procedure was used for the study. The first stage involved a purposive selection of five (5) wards out of ten (10) in the Local Government Area these are; Dabi, Karwai, Gabarin, Zangon Kanya, and Yanduste, the selection was based on the intensity of garden egg production in the area. At the last stage a simple random selection was done to select 50% of the total population of 126 farmers. Therefore, a total of sixty-four (64) garden egg farmers were randomly selected to represent the sample size as shown in Table 1.

Table 1: Sampling Frame and Sampling Size

Village/Ward	Number of registered farmers	Sampling Size (50%)
Dabi	20	10
Karwai	25	13
Gabarin	26	13
Yandutse	20	10
Zangon Kanya	35	18
Total	126	60

Sources Field Survey: 2019

Data Analysis
Descriptive Statistics

These are concerned with scientific methods for summarizing, presenting and analysing data as well as drawing valid conclusions and making reasonable decisions on the basis of such analysis. This is done using mean, percentage and frequency distribution.

Mean; this is the sum values in the data group divided by the number of values, thus,

$$\overline{X} = \frac{\Sigma fx}{\Sigma f} \quad \text{...} (1)$$

Farm Budgeting Techniques

Gross margin and Return per naira invested were used to determine the costs and returns associated with garden egg production. Mathematical representation of the above tools is as follows:

Gross margin:

$$GM = TR - TVC \quad \text{..............................} (2)$$

Where,

GM = gross margin

TR= total revenue

TVC = total variable cost

While,

Return per naira invested:

$$RI = \frac{GM}{TVC} \quad \text{...}(3)$$

Where,

RI = Return per naira invested

GM = Gross margin

TVC = Total variable cost

RESULTS AND DISCUSSION

Socio–economic Characteristics of Garden Egg Producers

The socio economic variables being analysed here were: Age, Farm size, Household size, Experience, Marital status, Labour, Ownership, Sources of finance and level of education. Socio–economic characteristics data of the garden egg producers like their age, sex marital status household size, occupation, level of education, farm size, and farming experience were described in Table 2.

Table 2: Socio–economic Characteristics of Garden Egg Producers

Variable	Frequency	Percentage (%)
Age		
19 – 26	22	34.37
27 - 34	16	25
35 – 42	17	26.52
43 – 50	5	7.81
51 – 58	4	6.21
Marital Status		
Married	40	62.5
Single	12	18.7
Divorce	5	7.8
Widower	7	10.0
Education Attainment		
Qur'an	19	29.6
Primary	21	32.8
Secondary	16	25
Tertiary	8	12.8
Household size		
0-5	35	54.6
6-10	16	25
11-15	7	10.9
16-20	4	6.25
21-25	2	3.1
Farming Experience (Years)		
2-7	25	39
8-13	19	29.6
14-19	11	17.1
20-25	6	9.3
26-31	3	4.6
Total	**64**	**100**

Sources Field Survey: 2019

Discussion of Socio-economic characteristic of Garden Egg Producers

The result shows that majority of the farmers (60.89%) fall within the age range (19-42years) that is termed economically active by FAO (1992), while the remaining (13.3%) of the farmers are beyond the economically active stage. At this stage in life, Anyawu et al. (2001) recognized that people are more likely to be energetic and have the capacity to use innovation. The result in Table 2 shows that most of the garden egg producers (62.5%) were married and the remaining percentage (18.7%) are single. The marital status of the farmers shows that majority of the farmers are having a sense of responsibility and it also shows that garden egg production is a means of livelihood for most farmers in the area. The result shows that a substantial number of garden egg producer (32.8%) in the area have primary education while 25% have secondary education and 29.6% have attended Qur'an school. By implication, reasonable number of farmers in the area should be able to understand the use of improved technologies and apply it to achieve increased production. Through education, the quality of labour is improved and with it the propensity to adopt new techniques (Tijani et al., 2006; Hyuha, 2006). The result in Table 2 shows that majority (54.6%) of the farmers' household sizes falls within the range of 1-5, and 25% of the farmers' household sizes falls within the range of 6-10. The result shows that majority of the farmers were having extended families. It also shows that certain percentage of the farmers will utilize their family size as their source of labour. However, Oladeepo and Oluwaranti (2012) reported that 7-12 size of household of cassava farmers is found in the southern part of Nigeria. Table 2 also showed that most (76.5%) of the producers had farming as the source of income and 23.4% were involved in other business after farming such as welding, black smiting and teaching.

Costs and Returns

Costs and returns refer to the expenses incurred and revenues generated by a farm firm. Costs and returns analysis is used to determine the ability of a farm to earn profit. A profit is what is left of the revenue which a farm generates after it pays all expenses directly related to the generation of the revenue. Table 3 gives the results of the costs and returns analysis per hectare of garden egg production.

Table 3: Average Cost and Returns of Garden Egg Production per Hectare

Variable cost	Unit price(N)	Quantity	Total cost/ha	Percentage total cost
Seed(Kg)	300	2	600	1.04
Fertilizer(Kg)	8000	100	16000	28.7
Pesticide(ltr)	4000	2	8000	6.26
Labor(Man-day)	500	30	15000	26.0
Sack	40	100	4000	6.95
Fuel(ltr)	145	225	32625	56.76
				100
Total Variable Cost			**76,225**	
Returns				
Output(bag)	1000	170	170,000	
Total revenue			**170,000**	
Gross margin			**93775**	
ROI			**1.95**	
Gross farm ratio			**0.33**	

Source: Field survey, 2019

The results in Table 3 show that total cost of producing garden egg per hectare was N76,225, the total revenue was found to be N170,000 and the gross margin was N93,775. That means the profit was N93,775, signifying that garden egg production in the area is profitable. Return on investment, ROI of 1.95 indicated that for every N1 invested in garden egg production, a return of N1.95 is expected.

Constraints Affecting Garden Egg Production

The field of agriculture is bound to be constrained by many factors ranging from natural to manmade factors. Garden Egg production in Ringim LGA is no exception to these factors; hence Table 4 presents the factors that are militating against garden egg production in the area

Table 4: Constraints Affecting garden egg Production in Ringim LGA

Variable	Frequency	%
Poor Government support	60	100
Inadequate capital	53	88.3
Lack of improved varieties	50	83.3
Poor market	30	50

Source: Field survey, 2019 * Multiple responses

The farmers were found to be constrained by the following factors: Inadequate Government support (100%), inadequate capital (88.3%), Lack of improved varieties (83.3%), and poor market. These are the major constraints that are militating against the production of garden egg in the area. Combating these constraints will pave way to higher production of the nutritious vegetable and ultimately increase income for the rural populace thereby promoting viable rural livelihood.

CONCLUSION

Findings of this study revealed that garden egg production is profitable. It is however, dominated by male who were at their active age. Most of them have attended one form of education with an average farming experience of up to seven years. Fuel and fertilizer constitutes the highest percentage of the farm inputs. Constraints identified to be hindering the growth of the crop were not unsurmountable and if solved can provide increase in returns and higher production. As such the following recommendations were given.

- Garden egg producers should be trained in proper farm record and management to better organise their production activities.
- Relevant Government and non-governmental agencies should assist garden egg producers in the supply and timely distribution of farm inputs such as fertilizer, improve seeds and pesticides.
- Government should provide the garden egg producers with modern irrigation facilities so as to overcome irrigation problem faced by the producers.

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GROSS MARGIN ANALYSIS AND NUTRITIONAL BENEFITS OF COCOYAM: CASE STUDY OF IDO LOCAL GOVERNMENT AREA OF OYO STATE

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ABSTRACT

This study examined the Gross profit analysis and nutritional importance of cocoyam in the study area. A total of 70 respondents in Omi Adio markets in Oyo were interviewed using a structured questionnaire. Data were analyzed using descriptive, and inferential statistical tools. Gross margin analsis was used to estimate the profitability of the trade. The result showed that about 77% of the respondents were females with the mean age of 40 years. About 40% had secondary education while 33% had primary education. The mean of the farming experience of the correspondents is 15 years. Result also revealed that the benefit cost ratio of the cocoa yam business is 1.85. This shows that for every #1 the farmer spent on the cocoa yam business, he or she will be able to generate 1.85 return with gross margin of 0.85. It nutritional components can be concluded from this study that cocoyam is a good remedy for diabetis. It is also used in the control of blood pressure and boosting of immune system amongst others.

Key words: Cocoyam, Nutritional content Gross Margin Analysis.

INTRODUCTION

Cocoyam (Colocasia spp) is a taproot of edible aroid famiy(Araceae). This crop is an important food crop across many countries in SSA, particularly in Nigreria, Ghana and Cameroon. Cocoyam is one of the most accepted and cultivated root and tuber crops, almost everywhere throughout the tropics and in over 65 countries of the world (Pollock et al., 2000). It is ranked third in importance, after cassava and yam in many West and Central African countries (Adisa et al., 2011).

Nigeria and Ghana are the world's leading countries in cocoyam production (Oke and Bolarinwa, 2012) where it is mostly grown amongst smallholder farmers and contributes immensely to address the problem of food insecurity. After yam and cassava, cocoyam is the third important staple crop and a cheaper substitute for yam, especially during lean periods. when there is food scarcity. Cocoyam, in addition to cassava and yam, is one of the staple foods in Nigeria It is widely cultivated in the country because its production is favored by the country's soil and climate. Cocoyam is a common food plant that has a long history of cultivation cultivars of two species *colocasia (Taro)* and *xanthosoma.* They are widely grown for food and consumed particularly during periods preceding harvest which underscores its importance as a possible substitute for the crop (Sefa- Dedeh *et al.,* 2004). Cocoyam is often intercropped with perennial cash crops like cocxoa, banana, oil palms becaus it can tolerate shade, especially at the early stage of these plantations. Cocoyam tubers are uesd in same ways like other root and tuber like yam, potato and cassava. It is eaten in cooked form and can also be converted into other product and can be used industially such as industrial starches (Lawal,2004), good substiture for maize as binding agent in the manufacture of tablets (Subhadhirasakul et al; 2001) production of baby foods amongst others. They are widely grown for food and consumed particularly during periods preceding harvest which underscores its importance as a possible substitute for the crop (Sefa- Dedeh *et al.,* 2004).

Cocoyam is an important staple crop especially among the low-income earners in the tropical regions of the world (Adeboyejo *et al.,* 2020). This crop is essentially cultivated by women who are mostly resource poor with minimal access to agricultural inputs. A gender efficiency analysis of smallholder cocoyam farmers in Eastern state of Nigeria revealed a ratio of 3:1 for female against male farmers (Dimelu et al; 2008). However, as cocoyam attracts more economic value, the ratio of men to women is increasing. Cocoyam also has a lot of nutritional benefits. This study whilst xtraying some of the nutritional benefits, also examines the profitability of cocoyam marketing, especially among the women.

Nutritional profile of cocoyam

When compared with other major root and tuber staples, cocoyam is postulated to have superior nutritional value especially in terms of their protein digestibility and mineral composition (Calcium, Phosphorous and Magnesium) (Lim, 2016). According to Opara (2003), Xanthosoma sagittifolium can generally be regarded as an appreciable (middle range) source of dietary energy, proteins, and vitamins. It is said to be high in potassium, zinc, and nicotinic acid as well as a low inhibitor of trypsin compared to other edible aroids. Cocoyam offers vitamins and soluble fibers which is a perfect complementary element for all type of meals (Talwana *et al.,* 2009).

The nutritional potential of cocoyam could be adequately tapped by diversifying its utilization through the development of new food products for different food industries and market needs. Two such industries which could be targeted are the snack and complementary (baby) foods sector. Both are currently thriving markets and utilizing cocoyam would go a long way to produce culturally acceptable and nutritious food products to enhance the variation of products for sustained food and nutrition security. The leaves of cocoyam, especially, are a food resource with potential health benefits that could be applied in the pharmaceutical industry. Similarly, the cormels, flours, and starches could be explored in the snack and complementary food industries utilizing their peculiar processing properties, ease of crop production, and storability, as well as their nutritional value.

Cocoyam is rich in starch which makes it an excellent source of carbohydrate. It contains dietary fiber and higher protein content than the most of the other tropical root crops. Cocoyam is nutrient dense which is why it is recommended for consumption because it is vital for maintaining a healthy immune system which helps our body utilize the nutrient ingested. Dietary fiber helps bowel movement and aids digestion. Cocoyam also have appreciable amount of protein, thiamine, copper, calcium, niacin, manganese, vitamin B6, vitamin C, A and E as well as riboflavin, magnesium, phosphorus, iron, zinc and potassium. (James *et al.,* 2019).

Table1. Nutritional facts of cocoyam per 100g (Nigeria Food composition table 2017)

	Nutrient Value	Percentage
Energy	130kcal	
Carbohydrate	11.9g	48%
Protein	8.5g	35%
Fat	1.9g	17%
Water	66.3g	
Dietary fiber	6.7g	
Sodium	136mg	
Potassium	259mg	
Vitamin B1	3.6mg	
Vitamin B2	0.3mg	
Vitamin B6	2.5mg	
Vitamin C	35.1mg	
Calcium	154mg	
Iron	6.5mg	
Zinc	2.2mg	
Phosphorus	132mg	
Magnesium	215mg	

MATERIALS AND METHODS

The study was conducted in Omi Adio Market, Ido Local Government Area. Cocoyam marketers were purposively selected and interviwed using snowball' method. Structured questionnaire was administered to 100 selected traders. Descriptive statistics such as frequency and mean were used to analyse the data. Gross margin analysis was used to determine cost and return as well as the profitability of cocoyam marketing.

RESULTS AND DISCUSSION

The demographic characteristics of cocoyam marketers is as summarized in table 2. The characteristics of respondents considered include sex, age, marital status, household size as well as educational status.

Table 2: Demographic Characteristics of cocoyam marketers

Gender	**Frequency**	**Percentage**
Male	21	30.0
Female	49	70.0
Total	**70**	**100**
Age		
Below 20	1	1.43
21-35	27	38.57
36-50	32	45.71
51-65	8	11.43
Above 65	2	2.86
Total	**70**	**100**
Marital status		
Single	9	12.86
Married	50	71.42
Widow	9	12.86
Divorced	2	2.86
Total	**70**	**100**
Household size		
1-5	45	64.29
6-10	18	25.71
11-15	7	10.00
Total	**70**	**100**
Years spent in school		
No formal education	12	17.14
1-6	21	30.00
7-12	27	38.57
12 and above	10	14.29
Total	**70**	**100**

Source: Field Survey Data (July, 2021).

The result revealed that majority of the cocoyam marketers (70%) were females. This may be due to the fact that the sale of the crop enhances women income capacity even as cocoyam is already named as a 'female' crop. The distribution of the cocoyam marketers in the study area revealed that majority of them were within the age range of 36 to 50 years. This showed that were within the productive stage of their life. Also, most (71%) of the respondents them were married with household size comprising between one and five people. This implies that they have access to family labour in carrying out marketing functions.

Table 3 is the result of the gross margin and benefit cost analysis of cocoyam marketing.

Table 3: Benefit- Cost Analysis of Cocoyam Marketing

Scale of operation	**Average cost(#)**	**Average revenue (#)**	**Gross margin(#)**	**Benefit Cost Ratio**
Small scale	80,000	134,320	54,320	1.68
Medium scale	276,987	496,453	219,466	1.79
Large scale	735,211	1,406,459	671,248	1.91

Assumption: Average variable cost is the cost incurred in getting the cocoyam to the market and this includes the cost price of the cocoyam corms, cost of transportation and cost of loading and offloading. The revenue is the selling price of the cocoyam multiplied by quantity of the cocoyam sold.

The result revealed that the average gross margin of the small-scale marketers is **#**54,320 while the gross margin of the medium scale is **#**219,466 while that of the large scale marketers is **#**671,248. The return on cocoyam marketing however, can be better explained using financial ratio, especially benefit-cost ratio that relate the relationship between cost and revenue. Benefit cost ratio explain the revenue generated with every #1 cost incurred in the marketing of cocoyam.

The benefit cost ratio of the small, medium and large scale marketers of cocoa yam are 1.68, 1,79 and 1.91 respectively. This implies that small, medium and large scale cocoyam marketers will generate 168%, 179% and 191% of the total cost incurred as revenue. This implies that small, medium and large scale cocoyam marketers are able to generate 68%, 79% and 91% profit margin from the marketing of cocoyam after deducting cost.

CONCLUSION AND RECOMMENDATION

The gross margin of cocoyam marketing is a profitable business with high relatively good gross margin. Thus, trade in cocoyam is a profitable venture that should be promoted. There is need to also encourage the consumption of cocoyam because of the inherent health benefits. In addition to the associated nutritional and health advantages, even the potentials of cocoyam as an important staple for food and income security remains underexploited. There is need to change the narrative about cocoyam because of its importance to the livelihoods of millions of people are either under-estimated or under-reported and therefore unappreciated.

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ECONOMIC POTENTIALS OF FIVE VARIETIES OF WATER MELON PRODUCTION IN SUDAN SAVANNAH ECOLOGICAL ZONE NIHORT BAGAUDA, KANO STATE

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ABSTRACT

The study was carried out at the National Horticulture Research Institute (NIHORT) Bagauda Kano state. (Latitude 11^0 33in, Longitude 8^0 231E, with altitude of 481m) in the 2018 cropping season. This was to determine the economic potential of Five varieties of water melon in Sudan Savanna ecological zone Kano. 1kg seed of water melon were sown directly on 4m^2 plots with ridges of 0.75cm by 1m spacing in Randomized Complete Block Design (RCBD) replicated three times. All agronomic practices were carried out according standard practice. Result obtained showed that, Kaolack (2.6t/ha) with production cost of ₦35920 gave the return of ₦164,080. It is followed by Sugar baby (2.0t/ha) with a return of ₦42,280 and Oranaise variety (2.7t/ha) with a return of ₦23,280. Charleston Grey (2.4t/ha) and Grey bell (1.4tha) a return of ₦11,280 and ₦6,280, respectively. The net return showed that, Kaolock gave highest economical return and therefore its production is more profitable and economically viable in Sudan Savanna agro-ecological zone.

Key words: Water melon, Economical, Varieties, cropping.

INTRODUCTION

Water melon (*Citrullus lanatus*) (Thumb) is an important vegetable grown for its large fruit. It is a vine – like climber and trailer herb, which has origin in the hot, dry region around the Mediterranean. According to USA (2000), production in 1991 was estimated at 1.9 million tons with a monetary value of $26.8million, as the crop is cultivated both for its large fruit and vegetative parts which are highly nutrition (Schippers, 2000; Ben *et al*., 2006). In 2002, worldwide production dramatically increases to about 90million tons, with an average production of 25 tons' ha' (FAO, 2003). The production of water melon is increasing in Nigeria (Oguntola, 2006) and Kano state is one of the most important area of its production. It has been reported that melon production is usually more profitable when intensively managed (Clough, 1992; Robinson and Decker – Wilters 1997; Hochmuth *et al.,* 2001; Bolin and Brandenberger, 2001). Intensive crop management is characterized by a combination of cultural practices at different level of usage, cultural practices such as irrigation, cultivation and spacing, choice of variety and control of weeds, insect, pest and disease play important roles in determining yield in water melon (Taylor et al., 2003). The threshold plant population beyond which yield does not increase depending on environment factors, many varieties of watermelon exist with shapes, skin colour conotene content (Miles, 2004) and wide variety of water melon have been cultivated in topics. (Zohary & Hopf, 200). The variation in the performance of varieties in vine crop has been widely documented by scholars (Manyrong, 1997; Ajisefinani, 2004) which could be composition owing to their different genetics different varieties of water melon will respond differently to various growth factors and mixture. Tindall (1983) recommended several varieties to growers but only few have gained popularity in Nigeria. Those include sugar baby, Oranaise, Kaolack, Charlesten Grey, and Grey ball. Although studies confirmed production practice are common (Ben et al., 2006, Wieners, 1990).

Water melon widely grown display types of translucid flesh with very high water content, a sweet taste and red or sometimes yellow in colour, they are very refreshing when eaten in hot climates. They are relished by many people across the world as a fresh fruit. This is because water melon is known to be low in calories but highly nutrition and thirst quenching. It also contains vitamin C and A in form of the disease fighting beta carotene and works in conjunctions with other plant chemicals not found in vitamins and minerals supplements. Potassium is also available in it and is believe to help in the control of blood pressure and possibly prevent strokes (FAO 2007). The water melon requires a good spadesful manure or compose and hence the need to incorporate it in the soil before planting (Greensil, 1976). The soil must be fertile with good organic matter content sandy loam texture and well drained (Messian, 1992). The largest production of the crop comes from the northern part of Nigeria where the suitable agro ecology is found. Nevertheless, water melon could also thrive in other ecologies with intensive management and is still economically feasible (Adekunle *et al.,* 2004). It is widely grown in the northern part of the country perhaps due to the average rainfall there. The potential of water melon as a cash producing crop is enormous for farmers especially those residing near the urban areas (Abubakar, 2010). The aim of the studies to determines the economic potential for the water melon production in Sudan savannah.

MATERIALS AND METHODS

The study was carried out at the National Horticulture Research Institute (NIHORT) Bagauda Kano state. (Latitude 11^0 33in, Longitude 8^0 231E, with altitude of 481m) in the 2018 cropping season. This was to determine the economic potential of Five varieties of water melon in Sudan Savanna ecological zone Kano. 1kg seed of water melon were sown directly on $4m^2$ plots with ridges of 0.75cm by 1m spacing in Randomized Complete Block Design (RCBD) replicated three times. All agronomic practices were carried out according standard practice. Application of fertilizer NPK 20:10:10 and Urea 46:0:0 were applied at recommended rates. All the five varieties of water melon were evaluated to determine the benefits potentials of each variety using (N.P.V.).

$$\text{N.P.V.} \;= \left(\frac{B-C}{(i+r)t}\right)$$

Where B= Benefit, C= cost, i= Interest rate and t= Time.

Positive N.P.V. means viable venture

Negative N.P.V. means not viable return

RESULTS AND DISCUSSION

The result obtained showed that, the experimental field was characterized as sandy loam (Table 1). Table 2 showed the production input of the five varieties of water melon. A higher production cost was observed in Kaolack while the remaining varieties maintained a uniform production cost. The variation in the production cost of Kaolack could be due to the value of the variety being the most desired and production pressure due to demand attracting higher cost. The output (yield) and net profit per hectare is presented in table 3. All the varieties were profitable that of Kaolack was outstanding which agreed with Bolin and Brandenberger, (2001) who reported that water melon production is profitable. Kaolack performed the best among the varieties.

Table 1: Chemical and Physical Properties of the Soil

Chemical Characteristics	Value
Ca^{2+}	2.24
Mg^{2+}	1.13
K^{+}	0.025
Na^{+}	0.40
Physical Characteristics	Percentage
Sand	86.70
Silt	8.20
Clay	4.10
Texture	Sandy loam

Table 2: Cost estimate analysis of water melon varieties

INPUT/VARIETY	input	Kaolack	Oranaise	Grey bell	Sugar baby	Charlestone grey
Land Rent	2,000	2,000	2,000	2,000	2,000	2,000
Seed Rate	100gm	1,500	1,300	1,300	1,300	1,300
Planting	2100	2100	2100	2100	2100	2100
Weeding	12,000	12,000	12,000	12,000	12,000	12,000
Fertilizer	100kg/ha	10,500	10,500	10,500	10,500	10,500
Insecticide	4.151/ha	4,000	4,000	4,000	4,000	4,000
Water use 8 Jerry can	202.5	120	120	120	120	120
Insecticide spry 1/ha	1/ha					
Harvesting	2,200	2,200	2,200	2,200	2,200	2,200
Seed processing	1,500	1,500	1,500	1,500	1,500	1,500
Total		**35,920**	**35720**	**35720**	**35720**	**35720**

Table 3: Economics analysis of cost input – output estimate per Naira

Varieties	Input cost/ha (N)	Output t/ha(N)	Gross benefit (N)	Net benefit (N)
Kaolack	35,920	2.6	200,000	164,000
Oranaise	35,720	2.7	59,000	23,280
Grey bell	35,720	2.5	42,000	6,280
Sugar baby	35,720	2.0	78,000	42,280
Charlestone grey	35,720	1.4	47,000	11,280

CONCLUSION AND RECOMMENDATION

Kaolack (2.6t/ha) with production cost of N35920 and net return of N164,080, performed the best among the varieties in the study area which require minimum input and gives profitable output. Therefore, the variety is recommended to be cultivated for more profit in Sudan savanna agro-ecological zone.

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GROWTH RESPONSE AND ECONOMIC BENEFITS OF FEEDING GRADED LEVELS OF ALKALI-TREATED COFFEE PULP TO WEANER RABBITS

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ABSTRACT

Growth response and economic viability of dietary inclusion of alkali treated coffee pulp in growing rabbit diet was evaluated. Thirty-six (36) mixed breed weaner rabbits of mean live weight of 534.5g were randomly grouped into four treatments (1,2,3 and 4). Alkali treated coffee pulp were mixed into four experimental diets at 0%, 4%, 8% and 12% inclusion levels and fed to weaner rabbits for a period of twelve weeks. Treatment 1 rabbits were fed Diet 1, while Treatment 2, 3, and 4 were respectively fed diets 2,3, and 4diets 1(0 %), 2(4%), 3(8%), and 4(12%) inclusion levels. Each of the treatments was replicated thrice, with three rabbits per treatment. Feed and water were given ad libitum. At the end of the feeding period, growth performance and feeding economy were assessed. Mean daily weight gain of weaners fed diet 1 was the highest (22.22g), while least value was recorded for T4. Mean value for cost/kg wt. gain for T4 (N101.78k) was however the best. Although cost per kilogramme weight gain of the rabbit was best in T1 (control), cost per kg. feed was highest. Consequently, it is cheaper to produce a kilogramme meat of rabbit using diet 4. Livestock farmers (particularly rabbit farmers) can gain more as return on investment by substituting expensive basal ingredients like maize with alkali-treated coffee pulp.

Key words: Economic viability, Weaner rabbits, Cost per kg. feed, Alkali-treated coffee pulp

INTRODUCTION

Many tropical countries including Nigeria are marked by low per capita animal protein intake resulting from rapid human population growth and shortfall in livestock production (FAO, 2004). The large animals (cattle goat and sheep) production has not been able to meet the animal protein requirement of the increasing population growth because of their long production cycle (Opong Anene, 2010). It may however be met by engaging in farming of livestock with short production cycle like rabbits and other monogastric animals. Production and consumption of rabbits has been described as an authentic way of mitigating animal protein insufficiency in the tropics (Ajala *et al*., 2004). Rabbits have a short production cycle with high litter size. If rabbits are left to produce unrestrainedly, they can produce for about five to six times in a year with average of six to seven offspring per period. Their meat has low cholesterol, low fat, low energy and high protein value (Adeyemo *et al*., 2013). Despite these potential and good attributes, high price of conventional feed ingredients is a major factor limiting the production of rabbit in the tropics (Ani *et al*., 2011). The problem has been worsened due to the increasing competition among human, other livestock and industry for the conventional feed stuffs such as maize, soybean and groundnut. Increasing human population is undoubtedly aggravating the case of feedstuff shortage in the livestock sector of the country (Touleun *et al*., 2007). This problem has been the major stimulants for the continuous search for agricultural waste materials which one would have been thrown away without a second thought.

Coffee pulp is inherently rich in fibre, proteins, carbohydrates and minerals especially potassium but also contains appreciable amount of anti-nutritional factors such as caffeine, tannins and polyphenols (Roussos *et al*., 1998). Coffee pulp is a by-product of coffee crop which is obtained during the pulping operation of the coffee cherries to remove the beans. The pulp is always considered as valueless waste; they are often burnt and sometimes cause serious disposal problem (Negesse *et al*., 2009). Previous researches on feeding untreated coffee pulp to ruminant showed negative results in growth performance owing to the presence of anti-nutritional factors (Sauza *et al*., 2004). A challenge therefore for animal nutrition scientists is investigation into processing of coffee waste with the aim of reducing the anti-nutritional factors to the minimum safe level of the animals. It is based on this premise that this research was embarked upon to determine the economic benefits of weaner rabbits fed graded levels of alkali treated coffee pulp meal.

MATERIALS AND METHODS

About 25kg of coffee pulps were collected from the coffee pulping centre, Cocoa Research Institute of Nigeria, Ibadan. The pulps were sterilized in an autoclave at 121^0C for 15 minutes, allowed to cool. The solutions of high concentration of potash

(K_2CO_3) was made by soaking cocoa pod ash in water overnight at ash: water ratio 1:3. The potash was allowed to mixed, dissolved into the water and waited for the solids to sink to the bottom. The water was then poured off gently, and then sleeping 25kg of sterilized coffee pulps in it for a period of 12 hours. The pulps were then removed, washed, sun dried and stored in jute bags until it was used. Thirty-six (36) mixed breed weaner rabbits were purchased from Adeeko Farm, Ibadan, Oyo State. Before the commencement of the experiment, the rabbits were acclimatized for seven days. During this period, rabbits were all fed control diets and were also treated against endo and ecto-parasites using sodex (dewormer) and ivomectin respectively. The animals were randomly divided into four treatment groups. Each group comprised of nine rabbits. Each group was further sub-divided into three, such that replicate groups of three rabbits were obtained for each sub-group with three rabbits per replicate. The alkali treated coffee pulp (ATCP) was mixed into rabbits ration at 0, 4, 8 and 12% inclusion level designated T_1, T_2, T_3 and T_4(table 1). All diets were formulated to meet the nutritional requirements of weaner rabbits based on (NRC, 2007) recommendations and the experimental diets were offered to rabbits twice in a day at about 7:00 am and 4:30 pm. The animals were allowed *ad libitum* access to feed and water throughout the trial. The trial lasted for 84 days. Data collected from this study were subjected to statistical analysis (SAS, 2008 version 9.2) and significant means were separated using Duncan multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Results of the growth performance of weaner rabbits fed alkali-treated (K_2CO_3) coffee pulp based diets is shown on Tables 1 and 2, while 3 show the economic benefits of the feeding trial. Highest value for feed intake was recorded on treatment 2. Reduced quantity of feed intake was noticed as the level of coffee pulp inclusion increases, although this was not significant. Similar observation was also reported by Ogana *et, al* (2020). From this result, treatment of coffee pulp in alkaline solution is suspected to have improved the nutrient content of the husk and hence better utilization. This is because rabbit fed diet 3 consumed more quantity of feed than the control. This is in agreement with Adeyina *et. al* (2005) which said that reduction of anti-nutritional (theobromine) content of feed ingredient, will undoubtedly increase the intake of such feed ingredient (Adeyina *et al*., 2010). At 12% inclusion level of alkali-treated pulp (Diet 4), average daily feed intake was however noticed to decrease correspondingly from T1 to T4. Several authors have reported same as the ash content of feed increases progressively with increased inclusion of fibrous feedstuff in animal diet. (Devender (1978); Day and Dilworth (1984). This was evidenced in the mean live weight gain of fed rabbits. Although the average daily feed intake of treatment 1 (control) was the lowest, average daily weight gain of weaners fed diet 1 was the highest. Ogana *et. al*. (2020) asserted this fact, when graded levels of treated cocoa husk meal were fed weaner rabbits. Although highest feed intake and best feed conversion ratio (6.92) was reported in the diet with no cocoa husk. The difference was however not significant at P< 0.05. Feed conversion efficiency of diet 1 was the best (5.35), but not significant across table. This shows that biologically, diets 1 – 3 were similarly utilized as the control.

From the economic point of view, cost of producing a kilogramme of the experimental feed was significantly lower on diets 3 and 4, which contained 8 and 12% alkali treated coffee pulp respectively. The cost of pre-treating coffee pulp was so small at this experimental level and the calculation of cost of producing a kilogramme was based on prevailing market prices of the ingredients. The cost was found to be lowest on diet 4. Cost /kg of diet 4 was significantly lower than all others in the study. Consequently, livestock farmers (particularly rabbit) can gain more as return on investment by substituting expensive basal ingredients like maize with alkali-treated coffee pulp. In this study, price per tonne of compounded feed decreased from the control (Diet 1) to Diet 4. Thus, the economic viability of the practice is justified by the use of cheaper feed to produce similar kilogramme weight of rabbit meat.

Table 1: Feed composition and calculated nutrient values of the experimental diets

Parameters	T_1	T_2	T_3	T_4
Maize	38.00	37.00	36.00	36.00
Soybean meal	27.00	26.55	25.85	25.00
Fish meal	3.35	2.80	2.50	2.50
CPM	0.00	4.00	8.00	12.00
Rice bran	28.00	26.00	24.00	20.85
Bone meal	2.50	2.50	2.50	2.50
Premix	0.25	0.25	0.25	0.25
Salt	0.50	0.50	0.50	0.50
Methionine	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Crude protein	18.06	18.03	18.05	18.01
Gross energy	3003.05	3001.00	3000.55	2999.85
Crude fibre	10.95	11.05	11.10	11.25

Table 2: Growth performance of rabbits as influenced by experimental diets

Parameters	T 1	T2	T3	T4	SEM
Daily Feed intake	95.2[a]	99.5[a]	97.1[a]		3.04
Daily wt gain	22. 22[a]	17.80[a]	16.48[a]	14.46	0.98
FCR	5.35[a]	5.78[a]	5.59[a]		0.34
Live wt (g)	2034[a]	2042[a]	2014[a]		73.8

Means along rows, followed by same letter are not significantly different at P≤ 0.05. SEM = Standard Error of Means .

Table 3: Economic analysis rabbit as influenced by experimental diets

Parameters	T 1	T2	T3	T4	SEM
Feed Intake	8.04b	8.57a	8.68a	7.20c	0.12
Weight gain	1384.7c	1516.3b	1866.3a	1214.7d	15.05
Cost per kg wt gain(N)	1427.7a	1300.2b	1017.8d	101.78c	17.45
Total cost of feed (N)	1969.6a	1971.6a	1899.5b	1444.8c	8.65

Means along rows, followed by same letter are not significantly different at P≤ 0.05. SEM = Standard Error of Means

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A META-ANALYSIS OF FARMERS' SOCIAL ECONOMIC STATUS (SES) AFFECTING COFFEE PRODUCTION, PROCESSING AND UTILIZATIION IN KOGI STATE, NIGERIA USING DATA MINING

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ABSTRACT

Coffee is a popular beverage choice among many people not only because of its distinctive aroma and flavor, but also for its numerous health benefits. However, while coffee utilization and consumption around the world continues to rise, it is at low ebb in Nigeria. One of the major factors limiting coffee uptake and consumption both for industrial and domestic use is the deplorable state of production of Nigeria-grown coffee. As a result, this paper examined how farmers' socio-economic statuses impact coffee production and processing, and subsequently, utilization and consumption in Kogi State through extensive meta-analysis and data mining. For this research, secondary data were generated from three original articles. The secondary data were analyzed using descriptive statistics. Results revealed that 70.12% of the farmers were over 50 years of age with moderate to no formal education exposure. By extension, only 92.5% had formal training on coffee production. In addition, many of the farmers (82.84%) depended on their personal savings for coffee production and exploration. Consequentially, only 55% of the farmers focused solely on farming activities for income source, out of which many grew coffee alongside other crops. Taken with other variables such as mode of land inheritance, access to available market, and financial facilities, the study discovered that the low socio-economic statuses of farmers greatly impede coffee production and processing in Nigeria. As a result, the threshold of production and the quality of coffee beans falls below the desired industrial specifications. It is therefore, expedient for stringent measures such as favorable policies, increased access to incentives, capital, and loan facilities, efficient extension programs and step-down of new technologies through formal trainings, and improved market accessibility, processing and utilization to be in place, especially by the government, to resuscitate and alleviate coffee production and consumption in Nigeria. Once coffee quality is assured, domestic and industrial consumption and utilization will improve.

Key words: Coffee processing, Coffee quality, Farmers' Socioeconomic status, Coffee production

INTRODUCTION

Coffee is the highest trading food product, and the choicest beverage by many consumers (Ballis, 2019). The high level of consumption and subsequent increased demand of coffee stems from its associated medicinal benefits. These include energy level improvement (as a stimulant), reduction of the human body's oxidative stress, and its crucial role in the alleviation of cardiovascular diseases and cancers (Nuhu, 2014). While the international community recorded a 1.9 % increase in coffee consumption to 167.58 million (60kg) bags for 2020/2021, (International Coffee Organization, 2021), coffee consumption in Nigeria is pegged at around a predicted 1000 tonnes per annum (Ang, 2016). This value is very low, compared to coffee consumption in other countries. For instance, France, a country with less than one-third of Nigeria's population, recorded a total coffee consumption level of about 366,000 tonnes in 2015 (Ang, 2016). One of the reasons for this low coffee utilization and coffee in the country is strongly attached to the inability of Nigeria coffee farmers to meet up with the required coffee demand and the deplorable processing quality of the locally-sourced coffee. While many factors may be responsible for this outcome, this paper seeks to investigate the impact of farmers' socio-economic status on their ability to meet up with production, processing, and utilization demands in Kogi State with secondary data obtained using data mining.

MATERIALS AND METHODS

This meta-analysis is based on secondary data synthesis and multi-study review adapted from three studies (Aderolu *et al.,* 2014; Mohammed, Ayanlere, & Ekenta, 2013; Ayoola, Ayoola, & Ladele, 2012). All studies of interests performed quantitative research using a combination of descriptive and explorative survey approaches. Researchers (Aderolu *et al.,* 2014; Mohammed, Ayanlere, & Ekenta, 2013; Ayoola, Ayoola, & Ladele, 2012) focused on factors influencing production along with marketing of coffee in Kogi, Nigeria. Mohammed, Ayanlere, & Ekenta (2013) emphasized the importance of making coffee production profitable. The authors also examined the factors hindering the profitability of farmers cultivating coffee. All studies provided reliable data collection procedures and insights on the salient factors that debilitate the sailing of coffee production in Nigeria as well as feasible recommendations to correct these aberrations. No author declared a conflict of interests. This study is primary a descriptive in nature with extensive use of descriptive analysis using statistical tool such as frequencies with a minimal manipulation of variables. Due to the population focus of the primary data employed in this study, this paper narrows its lenses, to a great extent, on Kogi State, and largely Kabba-Bunu Local Government Area. The Kabba-Bunu Local Government area is identified as a house to the highest number of coffee producers in the state.

RESULTS

The Table 1 below shows the results at a glance.

Table 1: Socio-economic variables

Social Economic Variables		**Percentage distribution (%)**
Age	21-30	4.44
	31-40	10.11
	41-50	15.33
	51-60	21.78
	>61	48.34
Gender	Male	88.22
	Female	11.78
Educational level	No formal education	22.44
	Primary	27
	Secondary	30.67
	Tertiary	19.89
Marital status	Married	98
	Single	2
Family size	1-5	24
	6-10	50.67
	11-15	20.67
	>16	4.67
Occupation	Sole Farming	55
	Farming plus others	45
Other Variables		
Formal coffee training and exposure to new technologies	Yes	7.5
	No	92.5
Size of Coffee Farm	<1	26.78
	1-10	68.22
	>10	5
Source of farming finance	Personal savings	82.84
	Commercial Banks	3.5
	Cooperative Society	6
	Family & Friends	7.67
Mode of land acquisition	Inherited	90.56
	Purchase	6.44
	Lease	3
Source of Labor	Family	29.53
	Hired	66.91
	Friends	3.56
Market Source	Direct	4.5
	Cooperatives and Government Agents	19.5
		76
Processing Method	Dry Processing	87.5
	Wet Processing	12.5

Data mining (2021)

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Many of the farmers, about 48 % of farmers were >61, followed by the 51-60 age bracket with a frequency distribution of 21.78 %. The youths had the lowest population with only 4.44 % for the 21-30 years' age bracket. The results revealed a great disparity in the participation level of males and females in coffee production. A significant proportion of the sampled coffee farmers were males with a percentage distribution of 88.22 %.

A moderate exposure to education was observed among the surveyed farmers. Many attended schools up to the secondary level with percentages of 22.44 %, 27 %, 30.67 %, and 19.89 % for no formal education, primary, secondary, and university tiers, respectively. Only 7.5 % of the farmers have formal training on coffee training and new technologies. That leaves 92.5 % farmer with no formal coffee production and new technologies training.

Approximately 98 % of farmers are married with an average family size of 6-10 (over 50 % of farmers). Although the average farmer's income could not be ascertained, other parameters such sources of finance for coffee cultivation and production, link to coffee market, and mode of land inheritance were used in evaluating farmers' financial statuses. About 82.84 % of the farmers depend on their personal savings for their coffee farms production activities. Most coffee farmlands were passed on to current owners through inheritance (90.56 %), and their sizes largely varied between 1 to 10 hectares (68.22 %, mean 1.5 ha). Additionally, 87.5% used the dry method for their coffee processing while the rest 12.5 % opted for the wet processing technique. Many of the farmers (76 %) accessed ready coffee markets through agents who serve as middlemen while just 4.5 % farmers directly marketed their products. The efforts of the government and cooperative societies only resulted in creating 19.5 % market availability for the farmers. Nevertheless, 66.91 % of the evaluated farmers relied on the expertise of hired hands in coffee cultivation.

DISCUSSION

The socioeconomic status (SES) is a classification system that depicts the social and economic standing of a person in the society in relation to others. Variables such as income level, level of education, work experience, type of work, type of place of residence, and social status in the community are indicators of an individual socioeconomic status (Darin-Mattsson, Fors, and Kåreholt, 2017). Regardless, measures and indicators of socio-economic statuses vary from one location and culture to another (Omonijo *et al.,* 2015). However, income, education, and occupation are commonly employed across board, including Nigeria, to determine an individual's socioeconomic status. Classification based on socioeconomic variables reveals three distinct classes of SES namely: High SES, middle SES, and low SES.

According to Ayoola, Ayoola, & Ladele (2012), *C. arabica* cultivation is primarily undertaken by small-scale farmers (low SES), and this is confirmed in this study. The farmers' socioeconomic status (SES) is pivotal to several decisions including the success rate of cultivation and processing through application of new technologies, appropriate agronomy practices, size of farmland available for coffee cultivation, and finance ploughed into cultivation. Of special importance is the choice of efficient coffee processing procedures.

In this research, many of the respondents were advanced in age, with a significant proportion above 50 years. This implies a disinterest and lack of youthful participation in coffee production. Unfortunately, this factor can negatively impact output as the older age groups may have lesser strength and capacity to bear the rigorous agricultural endeavor. As a result, there may be less enthusiasm to pursue long-term coffee investment which will directly and consistently reduce production output. The direct effect of this is the inability of farmers to meet up with the local demands of coffee. To improve the country's coffee production and subsequent utilization, manpower resources must be revived through extensive inclusion of the youths in various coffee production programs.

In the same regard, literacy level in farmers is an advantage as it can boost the uptake and adaptation of novel, advanced and technical practices, particularly in coffee processing. Although no wide margin existed among the four tiers of the educational system used in Nigeria among the farmers, an absolute consideration of farmers' exposure still reveals a low literacy level among them. The low literacy level, combined with non-existing formal training on coffee and exposure to new technologies, has a direct and proportional effect on the processing technique adopted. The wet processing technique is the preferred method for coffee due to the excellent quality of the final product (Koskei, Patric, & Simon, 2015). As a result, wet-processed coffee are better priced, up to 20% premium and utilized, compared to dry-processed coffee (Duguma & Aga, 2019). In this case, a significant proportion of the farmers are still on the old dry-processing template, implying that many coffee produced are of inferior quality. Hence, they may not appeal to consumers because of the possible low-quality of final products from such coffee beans. According to Ang (2015), Nigeria has a growing coffee consumption culture but many of the coffee consumed are imported. The reason for this incidence, as well as the inability of local industries to use locally sourced coffee, as given by the Secretary-General of the National Coffee and Tea Association of Nigeria, is the low-quality of coffee (Oyibo, 2018). However, the low quality can be linked to the low and inefficient processing techniques adopted by farmers. This phenomenon can be greatly improved with adequate exposure to formal education, trainings, and proper dissemination of new technologies. The government must set up enticing and incentive-rich platforms to retain education-wise farmers in coffee processing. Otherwise, coffee processing will continue its downward spiral movement as farmers with the hope of better jobs will move out from the sector.

Coffee processing, like many other agricultural ventures, is labor-demanding. However, many farmers, as shown by Ayoola, Ayoola, & Ladele (2012), and Mohammed, Ayanlere, & Ekenta (2013) complain of shortage of manpower. As a result, they opt for a large family system, depending on the children for cheap labor. The demerit this phenomenon holds is that many farmers may not put in concerted efforts to procure paid expertise for adequate management, which in turn, has an overall adverse effect on product cultivation and processing.

Lastly, the lack of adequate funding for coffee farmers poses a huge setback in the ability of the farmers to produce high quality coffee products. Many of them depend on their meager savings for the agricultural exploits. Hence, they will source for cheap methods and quantity over quality and excellence which may come at a greater price.

In conclusion, low socioeconomic status of farmers is a great impediment to coffee production, processing, and subsequently, utilization both for commercial and personal purposes.

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ASSESSMENT OF THE SOCIO-ECONOMIC VARIABLES OF CASHEW FARMERS IN KOGI STATE, NIGERIA

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ABSTRACT

The study assessed the socio-economic variables of cashew farmers in Kogi State. Two towns within Kabba-buni Local Government Area (Araromi-wata and Okebukun) were purposively sampled. These areas are known for the cultivation, production and marketing of cashew. A total sampling frame of seventy-five respondents was used. Structured interview schedules were used for data collection. Data were analyzed using descriptive statistics (frequency, mean, percentages and standard deviation). Age of farmers, educational level, farm size, household size, gender, membership of an association, and marital status of farmers constituted major socio-economic variables among cashew farmers in the study area. However, age, educational level, household size and farm size of the farmers have their mean values as 52±14, 2±0.16, 6±3, 5.7(±10.6), respectively. It is thus important for the government and other development partners in cashew production to develop policies that will enable the farmers to increase their farm holdings for higher productivity since they are still in their productive years. Adult literacy programmes should be encouraged and introduced to the study area to increase the educational level of farmers. Farmers that are members of association should be encouraged to participate more as this will go a long way in price determination for increased profit and access to trainings on improved production packages.

Key words: Cashew, Socio-economic variables, Farm holdings, Government

INTRODUCTION

Cashew (*Anacardium occidentale* L.) originated from Brazil in South America. It is commonly grown in tropical countries of Africa; Nigeria inclusive. It is a broad-leafed evergreen tree crop that thrives well in poor soils and dry sandy locations. There are tons of write-ups and studies about Nigeria's agricultural misadventure. However, we can bring some focus to a segment that can be regarded as a low hanging fruit in the Agricultural sector – Cashew. Nigeria is one of the largest producers of Cashew in the World. Furthermore, the International Nut and Dried Fruit Council (INC) in 2014 valued the global cashew market a whopping $4.69 billion. It is difficult to assess the production volumes across the various producing nations but the Food and Agriculture Organization (FAO) estimates that the production of raw cashew nuts (RCN) has grown from 0.29 million tons in 1961 to 2.60 million tons in 2013 and West Africa's share of the market has tripled in the past decade. Cashew grows almost everywhere in Nigeria but it is concentrated primarily across the three southern geopolitical zones as well as the middle belt. The major producing Nigerian states are Benue, Kogi, Kwara, Oyo, Enugu, Abia, Anambra, Ekiti and Imo. The National Cashew Association of Nigeria (NCAN) reported that Nigeria earned US$ 402 million (N144.7billion) from the export of RCN to Vietnam and other countries in 2017. In addition, the National Bureau of Statistics (NBS, 2017) reports that cashew exports increased by 463 percent from N2.4bn in first quarter 2017 to N13.5bn in second of 2017 on a quarter-on-quarter basis. The production of cashew can solve economic, social and environmental problems in Nigeria.

Cashew contributed less than 2 percent to total agricultural exports in the first quarter but contributed 45.4 percent to the sectorial export in the second quarter and 8.2 percent of total non-exports. The value makes the product the seventh-largest export product in the second quarter of 2017. Price per tonne of cashew nuts was put at US$1,800 and the Price per tonne of processed cashew was put at about US$12,000.

Traditionally too, the agriculture sector and rural economy especially in least developed countries (LDCs), have been characterized by the predominance of a small landowning class, tenants, sharecroppers, and landless labourers who are at the core of the poverty problem (Imran et al., 2009). Meanwhile, Krishna et al (2016) considered gender, age, income and education as the main attributes of socioeconomic variables. Similarly, socioeconomic status has been operationalized in a variety of ways, most commonly as education, social class, or income (Alexander et al., 2017). Therefore, the study assessed the socio-economic variables of cocoa farmers in Kogi State. Meanwhile, farmers' decisions with respect to production and land use are intensely guided by socio-economic factors. On many occasions, the farm size of farmers affects agricultural productivity. This is usually common when the land in question is fragmented, that is, if the land is divided into smaller pieces and allocated to individual farmers. The size of the farms makes mechanized and commercialization farming almost impossible on such land (Marocchino, 2009). In addition, the productivity of farmers to some extent could be attributed to the farmers' years of experience. According to Carter (2009) productivity is achieved, if a farmer is versed in his farming business. That is he cultivates his crops at ease with little or no assistance from extension agents. He has full knowledge of his farming calendar, cropping system, as well as land use patterns and/or system. This therefore underpins the necessity to carry out the research work on the variables of the cashew farmers in the study area. The objective of the study was to profile the socio economic variables of cashew farmers in the study area.

MATERIALS AND METHODS

The study was conducted in Kogi State, Nigeria. The state is in the north central region and falls in to the guinea savannah and tropical rain forest agro ecological zone of the country. Two towns within Kabba-buni Local Government Area (Araromi-wata and Okebukun) were purposively sampled. These areas are known for the cultivation, production and marketing of this crop. Forty farmers were randomly sampled from each of the towns. A total sampling frame of eighty respondents was used. Structured interview schedules were used for data collection from respondents. Data were collected on socio economic variables such as age, educational level, gender, household size, farm size and membership of farmers' group, respectively. Additional information was gathered through informal discussions with the farmers and by personal observations of the crop in some of the farmers' fields. However, during the process of data cleaning only seventy-five questionnaires were used for analysis and data were analyzed using descriptive statistics such as frequency, means, percentages and standard deviation.

RESULTS AND DISCUSSION

Table 1 shows the socio-economic variables of cashew farmers in Kabba-buni Local Government Area (LGA) of Kogi State, Nigeria. The table reveals that majority of the farmers (89.33%) were men. This result is in conformity with Akinpelu et al (2021) who reported that majority of cashew farmers (62.50%) in Oyo State were male. In addition, Lawal et al (2019) affirmed that majority (77.01%) of cocoa farmers in Boki Local Government Area of Cross River State are male. This aligns with the submission by Girei et al (2013) who reported that men are more in a crop that is perceived to have commercial value in Africa. The implication of this is that cashew farming in the study area is largely dominated by male gender and probably because cashew is a cash and perennial crop. However, the result is contrary to Ibekwe (2008) who observed that women play a vital role in food production. Moreover, the mean age of the farmers is 52 years. This also conforms to the findings of Akinpelu et al (2021) who reported 53 years as the mean age for cashew farmers in Oyo State. Osuji et al (2013) also reported that age might have a tremendous influence on productivity, efficiency and utilization of farm resources. The implication of this is that cashew farmers in the study area appear to be in their productive years. The result of the average farm size (5ha) put into cultivation by farmers may perhaps be due to the fact that land owners are reluctant to put their farms into the cultivation of perennial crops. This assertion corroborates Osuji et al (2013) who submitted that majority of the food crop farmers operated on a small scale bases (cultivating less than 3.0 hectares). Similarly, the table reveals that about 44 percent of the farmers had no access to formal education with average years of educational level being about 2 years. This also conforms to Akinpelu et al (2021). The implication of this is that the farmers may perhaps not have access to agricultural production and market information system (MIS) with respect to both production and marketing of the crop. Furthermore, the table reveals an average household size of 6 persons. This conforms with Osuji et al (2013) and Ibitoye et al (2012). It however deviates from the findings of Akinpelu et al (2021). They reported an average household size of 7 and 8 persons in their study on the socio-economic variables of arable and cash crop farmers in Imo, Kogi and Oyo States, respectively. This implies that the farmers may

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perhaps utilize members of the household as labour for some operations relating to the production and marketing of the crop. This tends to perhaps reduce some labour and transaction costs that may be incurred on the crop. Moreover, the table shows that about 70 percent of the farmers belong to one association or the other. The implication of this is that the farmers will be able to get needed improved production packages from the association as well as basic information on the production, processing technique and marketing of cashew in the study area.

Table 1: Socio economic variables of Cashew Farmers in Kogi State

Variables	Frequency	Percentage (%)	Mean
Gender			
Male	67	89.33	
Female	8	10.67	
Total	**75**	**100.00**	
Age (Years)			
21-30	5	6.67	
31-40	11	14.67	
41-50	24	32.00	
Above 50	35	46.67	
Total	**75**	**100.00**	**52(±14)**
Marital Status			
Single	2	2.67	
Married	73	97.33	
Total	**75**	**100.00**	
Education (No of years)			
No Education	13	44.00	
Primary	15	20.00	
Secondary	9	12.00	
Tertiary	18	24.00	
Total	**75**	**100.00**	**2(±0.16)**
Membership of Farmers'Group			
Yes	53	70.67	
No	22	29.33	
Total	**75**	**100.00**	
Household Size (No. of Persons)			
1-5	42	56.00	
6-10	18	24.00	
Above 10	15	20.00	
Total	**75**	**100.00**	**6(±3)**
Farm Size (Hectares)			
1-5	42	56.00	
6-10	5	6.67	
Above 10	28	37.33	
Total	**75**	**100.00**	**5.7(±10.6)**

Source: Field Survey, 2016. Figures in Parenthesis are Standard Deviations

CONCLUSION

The study assessed the socio-economic variables of cashew farmers in Oyo State. Age, educational level, household size, farm size, gender and membership of association constituted the socio-economic characteristic factors influencing cashew farming in the study area. More efforts should be made to encourage youth to take up cashew farming as an enterprise to bridge the gap that will be created by the ageing farmers. In addition, adult literacy programme should be introduced to the study area to increase the educational level of farmers. Similarly, farmers should be given incentives to increase their farm holdings for higher productivity. Farmers that are members of association should be encouraged to improve on their participation as this will go a long way in price determination for increased profit and access to training on improved production packages. This will encourage and improve cashew farmers' access to market information and as such will be able to sell the crop for more profits.

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ACCESS TO FINANCE AND RESILIENCE OF HORTICULTURAL HOUSEHOLDS TO ECONOMIC SHOCKS DURING COVID-19 PANDEMIC IN NIGERIA

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ABSTRACT

Economic shocks such as those facilitated by the COVID-19 pandemic pose severe threats to livelihoods and efforts to achieve food and nutrition security in Nigeria. However, dearth of empirical evidence exists on how access to finance could play a major role. The study examined the economic shocks, coping mechanisms and the relationship between access to finance and resilience to economics shocks among horticultural farming households in Nigeria during COVID-19 pandemic. Secondary data from the 2019 Nigeria General Household Survey-Panel and the COVID-19 National Longitudinal Phone Survey, 2020 was utilized. A total of 2,656 horticultural households were stratified and used for the study. Data was analyzed using descriptive and correlation analysis. Findings showed an increasing trend in the share of households affected by economic shocks such as income loss. A mix of more negative mechanisms such as reducing food consumption than the positive ones (relying on savings) were employed and could increase vulnerability. Although, only 33% had access to finance, results showed that access to finance could increase the resilience of horticultural households to economic shocks. The study recommends the need to strengthen the financial access of horticultural farming households to build resilient food systems and recover from the negative consequences of shocks during the COVID-19 pandemic and against future crises.

Key words: Horticultural households, Economic shocks, Financial access, Resilience, COVID-19, Nigeria

INTRODUCTION

Horticultural sector in Nigeria has evolved as a vital component of agriculture. Through activities such as production, distribution, marketing, processing and utilization of fruits, vegetables, spices, ornamentals and landscape plants, the sector offers a wide array of economic opportunities to Nigeria's over 202 million people (World Bank, 2019a). While agriculture significantly contributes about 22% to Nigeria's gross, the horticultural sector has potentials to achieve food and nutrition security, generate income and foreign earnings, employment, crop diversification, agribusiness development, poverty reduction and sustain livelihoods (World Bank, 2020; Ibeawuchi et al., 2015). Despite these potentials and efforts of the Government of Nigeria to transform agriculture, the horticultural sector is quite under developed due to challenges such as scattered production, poor access to finance leading to low investments, low inputs and yields and high postharvest losses (Ibeawuchi et al., 2015). In addition to a failing infrastructure, limited access to markets, major dependence on rain-fed and labour intensive production system and a lack of policy coherence (van der Waal, 2015).

Recently, these challenges are further exacerbated by the COVID-19 pandemic with the first confirmed case in Nigeria on February, 27, 2020 (NCDC, 2021). Since then, the Nigerian Government had implemented various measures such as social distancing, lockdowns, limited mobility and restricting market access to specific days to curb the spread of COVID-19 (Reuters. 2020). Although, agriculture related activities (including horticulture) are termed "essential" and are exempted from lockdowns, the lockdown measures created greater challenges to economic activities including farm labour availability, livelihoods, disruptions in agricultural input and output markets and increases in food insecurity, affecting more vulnerable households, with impacts expected to continue through 2021 and into 2022 (World Bank, 2021). While the pandemic poses severe challenges to most horticultural value chain activities due to the high perishability of horticultural crops, it also presents an opportunity to fast-track horticultural transformation to build its resilience in the face diverse challenges, including the food insecurity of Nigerians and a changing climate.

Building resilience refers to how financial services allow people to prepare for economic shocks, respond to them, adapt and recover afterwards (Gash and Grey, 2016). While, economic shocks such as those presented by COVID-19 pandemic may reduce income, deplete resources, and viable livelihood opportunities, households in developing countries use a variety of strategies to cope with shocks. Some of the strategies include income diversification, sale of assets, using savings, reallocating labor, borrowing from friends, families and financial institutions, reducing food consumption, buying on credit and selling livestock (Gash and Grey, 2016). Access to financial services such as savings, credits and insurance have progressively been touted as an operative way to recover from negative economic shocks, invest in modern technology, capture economic opportunities, access knowledge and best practices which can increase productivity (Van der Waal, 2015). However, no study has examined the relationship between access to finance and resilience of horticultural households to economic shocks during COVID-19 pandemic in Nigeria. In order to fill the research gap, this paper aims to examine the economic shocks experienced by horticultural households, coping strategies and the relationship between access to finance and resilience of horticultural households to economics shocks during COVID-19 pandemic in Nigeria. Findings from this study would provide insights into policy responses to strengthen the resilience of horticultural households in the face of current and future economic crises.

MATERIALS AND METHODS

The study analyzed secondary data from the World Bank Living Standards Measurement Study and the Integrated Surveys on Agriculture (LSMS-ISA) comprising the 2019 Nigeria General Household Survey-Panel (GHS -Panel, Wave 4) and the COVID-19 National Longitudinal Phone Survey (NLPS) 2020 (World Bank, 2019b; 2020b). The study utilized round one and round eight of the Nigeria COVID-19 NLPS collected from 20 April - 11 to May 2020 and from 5 to 21 December 2020 respectively. The households interviewed in the COVID-19 NLPS were drawn from the sample of agricultural households interviewed in 2019 GHS-Panel. The extensive data collected in the GHS-Panel just over a year prior to the COVID-19 pandemic provides a rich set of background information on the Nigeria COVID-19 NLPS agricultural households which can be leveraged to assess the effects of the pandemic. For the purpose of this study, the agricultural households were first stratified into horticultural households and non-horticultural households. Next, a total of 2,656 horticultural households were stratified and utilized for the study. Information on horticultural crop farming activities, economic shocks, coping mechanisms and access to finance during the COVID-19 pandemic were obtained and analyzed using descriptive and correlation analysis.

RESULTS AND DISCUSSION

COVID-19 and economic shocks of horticultural farming households

Results (Fig. 1) showed that as at April, 2020 (after the start of the COVID-19 pandemic in Nigeria), 30% of the horticultural farming households have been affected by various economic shocks. These include job/ income loss, disruption of farming activities, increase in price of major food items consumed, increase in the price of farm inputs, fall in the price of farm output, non-farm business closure, looting of cash and other property, illness, injury, or death of income earning member of household and "others" such as breakdown of equipment and limited funds. However, by December, 2020 the proportion of households affected by these shocks had increased to 34%. This suggests that horticultural farmers are likely to become more vulnerable to economic shocks as the COVID-19 pandemic extends which could also affect their livelihood opportunities and abilities to cope with or recover from shocks.

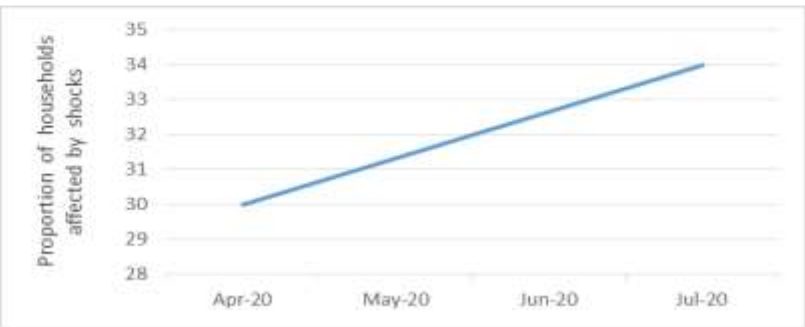

Figure 1: Exposure to shocks during COVID-19 pandemic

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Categories of coping mechanisms

Findings showed that the most common strategies employed by horticultural households to cope with economic shocks (Fig. 2) are reducing food consumption, doing nothing, reliance on savings and engaging in other income activities. "Others" include reducing production to subsistence, cutting down on farm inputs and selling outputs at giveaway prices. According to Gash and Grey (2016), coping mechanisms could be categorized into positive and negative. The use of positive coping mechanisms such as relying on savings and diversifying economic activities lead to the resilient pathway through which households are able to recover from shocks and become better. Conversely, the negative coping mechanisms such as reducing food consumption, selling of assets or outputs at giveaway prices lead to the vulnerability pathway whereby households become worse off than before resulting in outcomes such as food and nutrition insecurity, poor health and economic status. Results showed that overall, a mix of more negative mechanisms than the positive ones (29%; 30%), sole negative (15%; 22%) and sole positive (5%; 6%)) mechanisms were employed as at April and July, 2020 respectively by horticultural farming households.

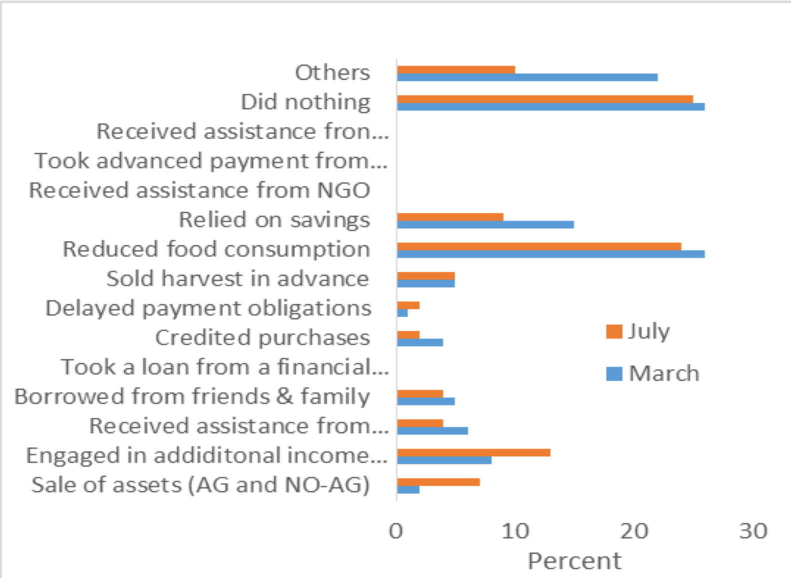

Figure 2: Distribution of respondents by use of coping mechanisms

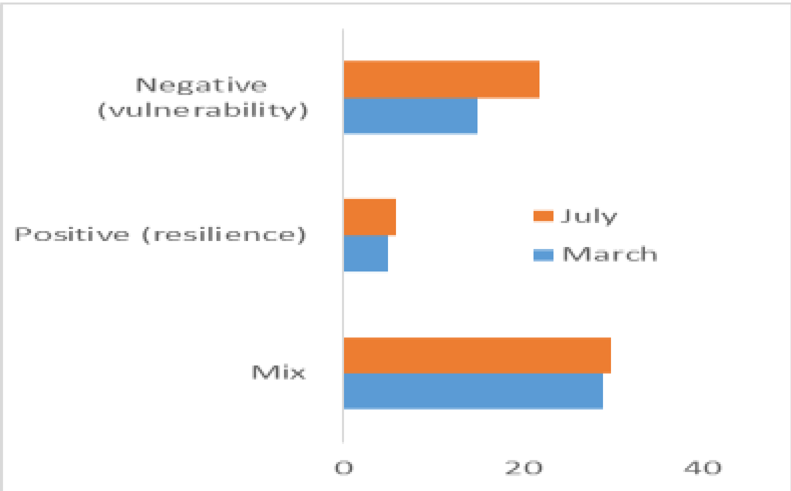

Figure 3: Categories of coping mechanisms

Access to finance and resilience of horticultural households to economics shocks

While more than three-quarter (78%) of horticultural households in this study indicated that the coronavirus outbreak constituted a major threat to the finances, only 33% had access to finance (Table 1). According to Demirguc-Kunt and Klapper (2013), access to financial services, such as credit, savings and insurance facilitates several livelihood opportunities which include consumption smoothening, savings and capital accumulation, reduce exposure to shocks and investment in economic opportunities. Overall, a positive relationship exists between access to finance and resilience of horticultural farming households. The insignificance of the relationship could be because only a small share (4%) of households who have access to finance use sole positive mechanisms (which has a resilience pathway). Notwithstanding, evidence suggests that access to finance has the potential to strengthen the resilience of horticultural households to cope with and recover from economic shocks during COVID-19 pandemic.

Table 1: Relationship between access to finance and resilience to economic shocks

	% Coping mechanism								% Pooled access to finance
	Sole +ve	Inc_div	Rely_sav	Assist_ friends	Borrow_ friends	Took a loan	Assist_ NGO	Assist_ Govt	
Access to finance	4.27 (38)	0.82 (7)	4.06 (36)	1.53 (14)	1.94 (17)	0.02 (0)	0.15 (1)	0.15 (1)	33.34 (885)
Estimated correlation	0.008	-0.053	0.016	0.012	-0.005	-0.002	0.034	0.016	
P-value	0.684	0.002	0.429	0.546	0.796	0.989	0.167	0.447	

Source: Authors' estimation

Note: Sole +ve = sole positive mechanism; Inc_div = Income diversification; Rely_sav = Rely on savings; Assist_NGO = Received assistance from NGO; Assist_Govt = Received assistance from Government

The significant negative relationship between access to finance and income diversification implies that most households would only diversify income sources to cope with shocks but invest in horticultural farming with increased access to finance which further confirms the viability of horticultural production.

CONCLUSION

Findings suggests that more horticultural farming households are likely to become vulnerable to economic shocks as the COVID-19 pandemic prolongs due to an increasing trend in the share of households affected by shocks. Moreover, the majority could be limited in their abilities to maximize economic opportunities and recover from shocks due to a low level of access to finance. Findings suggest a crucial policy issue to address if the goal is to build the resilience of horticultural farmers in Nigeria against economic shocks and to achieve important outcomes such as food and nutrition security. The use of sole negative coping mechanisms or a mix of more negative mechanisms than the positive ones would in due course retard the progress made so far in transforming horticulture, make farmers worse off than before and could lead to the total collapse of the sector. The study recommends the need to strengthen the financial access of horticultural farming households to build resilient food systems and recover from the negative consequences of economic shocks during the COVID-19 pandemic and against future crises.

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COMPLIANCE WITH COVID-19 PROTOCOLS AMONG YOUTHS INVOLVED IN FOOD SECURITY COMPETENCE ENHANCEMENT INITIATIVES DURING LOCKDOWN IN OYO STATE

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ABSTRACT

Embarking on food security competence-enhancement initiatives were expedient during COVID-19 lockdown. This study assessed the level of compliance with COVID-19 protocols among selected youths involved in various food-security competence-enhancement initiatives during lockdown in Oyo state. Purposive sampling technique was used to select 138 registered members of Oyo state Young Agropreneur (OYAP) who participated in at least one food security competence-enhancement initiative during the lockdown. Questionnaire using Google form was sent to e-mail addresses of the participants with one-week response framework. The 33 (23.9%) questionnaire returned was analyzed using descriptive and inferential statistics. Most (84.8%) respondents were male with average age of 31.72±6.91 years. Majority (84.8%) have agriculture-related profession with 30.3% having first degree and were OYAP members for two years (63.6%). Participation in farmer business school (81.8%) ranked highest while citrus and pineapple value chain (21.1%) ranked lowest among the six food security competence-enhancement initiatives. Highest ranking COVID-19 protocol complied with were use of nose mask (78.8%) and hand washing (60.6%) while removal of cloth worn out on getting home (30.3%) ranked last. Rating of COVID-19 protocols compliance was high among 66.7% of the respondents. There was significant relationship between compliance with COVID-19 protocols and educational level of the respondents (R = 2.102, p = 0.045). Continuous public health education to enhance compliance with COVID-19 protocols in public and private places is advocated to enhance sustainable food security and health.

Key words: Young agropreneur, COVID-19 protocols, competence, health education

INTRODUCTION

Food security exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). Food security dimensions are availability, accessibility, utilization and stability (FAO, 2006). Food security is one of the key focus of the Economic Recovery and Growth Plan (ERGP) and Agriculture Promotion Policy (APP) of the current government of Nigeria (Ministry of Budget and National Planning, 2017; Federal Ministry of Agriculture and Rural Development, 2016).

However, the advent COVID-19 epidemic from China in late 2019, later declared as worldwide pandemic on March 11 2020 came with social and economic challenges across all sectors including agriculture with food insecurity risks (World Health Organization, 2020; Olajide-Taiwo, 2020). Government of several countries including Nigeria employed restriction of movement as a strategy to curb spread of the disease. Oyo state government in Nigeria also follow suit in observing the lockdown for some time. Howbeit, some essential and economic activities such as agriculture and food security-related were allowed.

During the lockdown in Oyo state, several food security competence-enhancement initiatives were carried out in order to forestall COVID-19-induced food insecurity. The significance of competence enhancement as a guarantee for continuous food security cannot be overemphasised (Olajide-Taiwo et al, 2009). Food security competence-enhancement initiatives for sustainable food security despite COVID-19 and lockdown was essential in Oyo state. Hence, there was the need to choose between adherences to COVID-19 protocols when embarking on food security competence-enhancement initiatives during lockdown or face food insecurity during and after the lockdown. This study focus on Oyo state Young Agroprenure (OYAP) who participated in at least one food security competence-enhancement initiative during the lockdown. The general objective of this study was to assess compliance with COVID-19 protocols among youths involved in food security competence-enhancement initiatives during lockdown in Oyo state. Specifically, the study addressed the following objectives:

i. Analyse personal characteristics of youths that are involved in food security competence-enhancement initiatives during lockdown.

ii. Examine the food security competence-enhancement initiatives the youths embarked upon during lockdown.
iii. Determine their compliance with COVID-19 protocols when embarking on food security competence-enhancement initiatives during lockdown.
iv. Identify the factors responsible for level of compliance to COVID-19 protocols among the youths.

MATERIALS AND METHODS

Population of the study include all the 138 registered members of Oyo Young Agropreneur (OYAP) who participated in at least one food security competence-enhancement initiative during lockdown in Oyo state. Purposive sampling of all the participants was made due to small population size. Data were collected using Google form-designed questionnaire sent to their email addresses. They were given a timeframe of one week to respond. Items assessed in the questionnaire include respondents' personal characteristics, participation in food security competence-enhancement initiatives and observance of COVID-19 protocols. Observance of COVID-19 protocols was measured using a list of five COVID-19 protocols. Respondents were requested to indicate their frequency of observance of the protocols during food security competence enhancement initiatives as "Yes, very frequent" = 3, "Yes, frequent" = 2, "Yes, not frequent" = 1 or "No" = 0. This give Maximum COVID-19 Protocol Observance Score (COVID-19 POS) = 15 and Minimum = 0. Mean score and above = "High" COVID-19 POS while scores below the mean = "Low" COVID-19 POS. The 33 (23.9%) questionnaire returned within one week was analysed using descriptive (frequency counts, percentages) and inferential (linear regression) statistics.

RESULTS AND DISCUSSION

Personal information

Most of the respondents were male (84.8%). Almost half (48.5%) were between 31 - 40 years' age bracket with an average age of 31.7±6.91 years. Professionally, majority (84.8%) have agriculture-related background and most of them (63.6%) have been members of OYAP for two years. They have one form of education or the other up to post graduate level (Table 1). The personal characteristics of the youth portrays a well-informed, energetic and professionally advantaged group of people in agriculture. The conspicuously high educational status of the youth is capable of positioning them to have access to various forms and sources of information about COVID-19 and the implications for their health and performance in agriculture.

Table 1: Personal Characteristics of Respondents

Variable	Category	Frequency	Percentage
Sex	Male	28	84.8
	Female	5	15.2
Age (Years)	21 – 30	15	45.5
	31 – 40	16	48.5
	41 and above	2	6.0
Mean age	31.72		
Standard deviation	6.91		
Profession	Agriculture-related	28	84.8
	Others	5	15.2
Year of OYAP membership	1	5	15.2
	2	21	63.6
	3	7	21.2
Mean year of OYAP membership	2.1		
Standard deviation	0.17		
Membership status	Executive	15	45.5
	Non-executive	18	54.5
Educational qualification	MSc	9	27.3
	BSc	10	30.3
	HND	6	18.2
	OND	4	12.1
	Others	4	12.1

Participation in food security competence-enhancement initiatives

The youths were involved in a total of six food security competence-enhancement initiatives during the lockdown in Oyo state. Out of these initiatives, participation in farmer business school ranked first involving 81.8% of the youths while participation in citrus and plantain value chain involving 21.2% of the youths ranked last (Table 2). The consciousness of majority of the youth to involve in famer business school could be adduced to the paradigm shift in agriculture from being a way of life to being a business in Nigeria (Oredipe, 2013). Agribusiness with emphasis on value chain was brought to the front burner through Agricultural Transformation Agenda (ATA) of Goodluck Ebele Jonathan-led administration. This metamorphosed into Agriculture Promotion Policy (APP) of the Muhammadu Buhari-led government in the country. Agriculture value chain is now seen as a means to transform the economy through import substitution and job creation among other benefits (Federal Ministry of Agriculture and Rural Development, 2016; Oredipe, 2013).

Table 2: Ranking of Respondents According to their Participation in Different Food Security Competence-enhancement Initiatives during Lockdown

Initiative	Yes	No	Rank
Farmer business school	27 (81.8)*	6 (18.2)	1
Snail production	22 (66.7)	11 (33.3)	2
Organic tomato production	18 (54.5)	15 (45.5)	3
Maize production	14 (42.4)	19 (57.6)	4.5
Research grant writing	14 (42.4)	19 (57.6)	4.5
Citrus and plantain value chain	7 (21.2)	26 (78.8)	6

*Figures in parentheses are percentages

Compliance with COVID-19 protocols among the youths

Compliance with COVID-19 protocols when participating in food security competence-enhancement initiative during lock down in Oyo state was high among 66.7% of the youths (Figure 1). All the respondents complied with use of face mask, washing of hands and physical distancing at the venue of training. Although, level of compliance varies from one person to another. Most of them very often complied with use of face mask (78.8%) followed by washing of hands (60.6%) and physical distancing (57.6%). Less than half very often complied with bathing (45.5%) and removal of cloth (30.3%) at home when they return from training venue. Generally, the level of compliance to the COVID-19 protocol was higher at the training venue than at home (Table 3). This could be due to enforcement at the training venue while the home provided a more relaxed atmosphere.

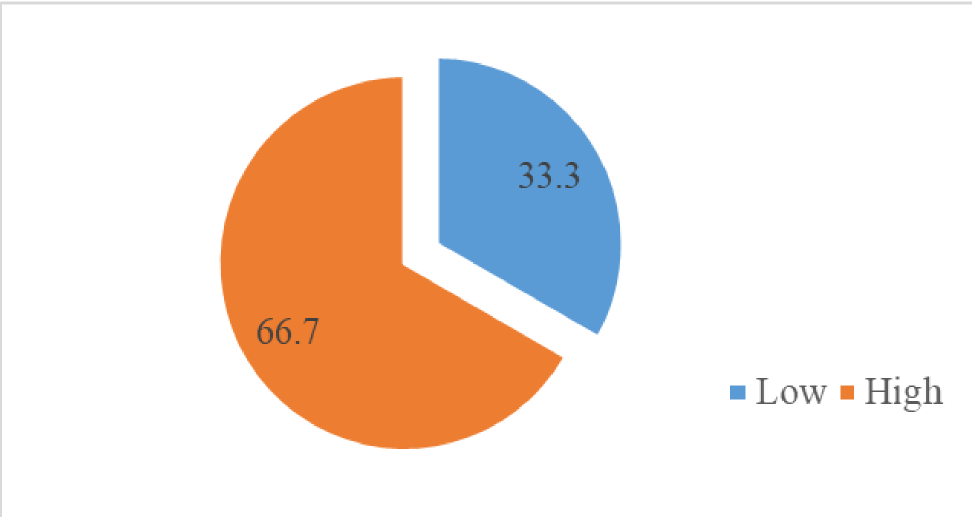

Figure 1: Rating of COVID-19 compliance among respondents in percentages (n = 33)

Table 3: Percentage Distribution of Respondents According to their Compliance with COVID-19 Protocols (n = 33)

Compliance	COVID – 19 Protocols				
	Use of face mask	Washing of hands	Physical distancing	Removal of cloth at home	Bathing at home
No	0.0	0.0	0.0	21.2	9.1
Yes, not often	12.1	6.1	15.2	30.3	15.2
Yes, often	9.1	33.3	27.3	18.2	30.3
Yes, very often	78.8	60.6	57.6	30.3	45.5

Factors responsible for level of compliance to COVID-19 protocols among the youths

Compliance with COVID-19 protocols among the respondents was significantly related with level of education (R = 2.102, p = 0.045). Other personal variables of the respondents did not have any significant effect on their compliance (Table 4). Level of education enhances assimilation and response to changes especially in novel cases such as COVID-19 (Olajide-Taiwo, 2015; Glanz and Rimer, 2005). The level of education of the youths is very high, this could be responsible for their high level of compliance with the COVID-19 protocols especially at the training venues.

Table 4: Regression Analysis Showing Correlation between Compliance with COVID-19 Protocols and Selected Personal Characteristics of the Respondents

Model	Standardized Coefficient	R	Significance (p)
Constant		1.561	0.131
Sex	0.089	0.482	0.634
Age	0.030	0.160	0.874
Level of education	0.401	2.102*	0.045
Profession	- 0.032	- 0.173	0.864
Year of OYAP membership	- 0.023	- 0.119	0.906
Participation in food security competence-enhancement initiative	0.148	0.751	0.459

*Significant at 0.05 level

CONCLUSION AND RECOMMENDATIONS

Compliance with COVID-19 protocols was high among the youths when engaging in food security competence-enhancement initiative during lockdown in Oyo state. Less compliance with COVID-19 protocols took place among them outside the venue of the competence-enhancement activities. Educational qualification contributed significantly to observance of COVID-19 protocols among the youths. Hence, there should be continuous public health education to enhance compliance with COVID-19 protocols among the populace to enhance sustainable food security and health.

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TREND OF COCOA BEANS PRODUCTION IN WEST AFRICA

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ABSTRACT

Cocoa production was important to the economy of Nigeria in the past. Cocoa was a major foreign exchange earner for Nigeria in the 1950s, 1960s but due to investments in the crude oil sector in the 1970s and 80s, Nigeria's share of world output declined. Cocoa contributed 0.05% to GDP in 2016 from 0.3% in 2010. The contribution of cocoa to Nigeria's agricultural GDP continues to decrease and attention continues to shift from cocoa production. This study therefore examined the trend of cocoa production in West Africa. Frequencies, percentages and charts were used for analysis in this study. Data on area of land cultivated (hectares), yield(kg/ha) and production in tonnes were used in the study. Secondary data from FAO (Food and Agricultural Organisation) were used for this study. Four countries with the highest cocoa beans production were selected for this study. They are Cote d'Ivoire, Ghana, Nigeria and Cameroun. Fifty-eight years of cocoa beans production were presented in the data (1961-2018). The average land cultivated over the years for the four countries were 1,475,304, 1,333,895, 857,036.9 and 447,355.5 hectares respectively. The average yield was Cote d'Ivoire (5200.12hg/ha), Ghana (3332.69hg/ha), Nigeria (2819.15hg/ha) and Cameroun (2831.59). The average production in tonnes Coted'voire (813,349), Ghana (453,507), Nigeria (270,561.8) and Cameroun (146,328). Nigeria ranked third in area of land, yield and production, this in spite of the country's vast land mass and high production level a few decades ago. The right policies should be put in place to boost cocoa beans production in Nigeria; this way, cocoa will once again help contribute to Nigeria's GDP as it did in the past. It will also regain the central place it occupied in the West African sub-region.

Key words: Area, Cocoa Beans, Production, West Africa, Yield

INTRODUCTION

Cocoa (*Theobroma cacao)* is a tropical perennial tree crop which is the product of the fruit of the cocoa tree. Cocoa is a native to the Americas and was a valuable crop in the earliest South American cultures. It is one of the major agricultural exports from West Africa. West Africa is the world leader because it produces over 99% of African cocoa. Over the past many decades, many West African nations, have remained in the forefront of cocoa production far higher than other areas of the globe with the growth of 2-3 million tons since the 2000s (Fountain and Hütz-Adams, 2015). In West Africa, cocoa is mainly grown by smallholder farmers who traditionally planted their cocoa at random under thinned forest shade. It is a low input cultivation system which uses the forest soil fertility and the existing shade. This simple method explains that cocoa is cultivated on about six million ha of the West African forest zone which provides about 70 percent of the total world production. The by-products of cocoa beans (liqueur, paste, butter, cake and powder) are raw materials in the chocolate industry and its best-known end product is chocolate. Cocoa beans are produced in tropical zones around the Equator, where the hot and humid climate conditions are well suited for growing cocoa trees. About 70 percent of the world's cocoa beans are produced from four West African countries namely Côte D'Ivoire, Ghana, Nigeria and Cameroon. Côte d'Ivoire and Ghana are the two largest producers of cocoa, accounting for more than 50 percent of the world´s cocoa followed by Nigeria and Cameroon. West African production of cocoa is dominated by Côte d'Ivoire. In 2005, 1.3 million tonnes of cocoa were produced by Côte d'Ivoire, Ghana produced 600,000 tonnes, which gave almost 60% of the world's cocoa. Nigeria produced 175,000 tonnes and Cameroon 166,000 tonnes. These four countries are among five primary producers of cocoa in the world. In 2016, Côte D'Ivoire alone produced approximately 1.6 million metric tons of cocoa beans. In terms of annual production size, the eight largest cocoa-producing countries are Côte D'Ivoire, Ghana, Indonesia, Nigeria, Cameroon, Brazil, Ecuador and Malaysia. These countries represent 90 percent of world production. Production from Côte D'Ivoire alone is 40 percent of the world's market share and constitutes 1.2 million metric tonnes per annum (UNCTAD, 2009). In 2000, 80 percent of the commodity exports from Côte D'Ivoire was raw cocoa which was over 50 percent of all exported goods and services, and 21 percent of GDP (Bogetic *et al.*, 2007). The cocoa production increased from about 2,000,000 tons in 2000 to about 3,000,000 tons in 2010.

Cocoa flourishes well only in hot, rainy climates with cultivation generally confined to areas not more than 20 degrees north or south of the equator. The ideal climatic conditions for the growth of cocoa is a mean shade temperature of 27°C, with daily variation less than 8°C, and well-distributed rainfall of at least 12 cm (Kishore, 2010). Annual rainfall between 1,100mm and 3,000mm with a dry season not more than three months with the minimum rainfall level of about 100mm per month is required for good output. Cocoa is usually grown directly from the seed but can also be grown from seedlings raised in nurseries. When the seedlings grow to a height of about 5 cm or so, they are transplanted at a distance of about 3 or 4 meters (Lundstedt *et al.* 2009). The Shady plants can also be planted in between the rows, in order to protect the young plants from strong winds and direct rays of the sun. The most commonly grown type of cocoa may give a first small yield after about five years, though the period considerably varies with local conditions and farming methods. But a full crop cannot be expected for at least ten years. The economic life span of the cocoa tree is not known; but under the best conditions of weather, soil and management, it can be kept almost in indefinitely bearing (Kishore, 2010). The world production of cocoa beans has experienced irregular pattern due to heavy dependence on weather in production, low farm-gate prices, pests and diseases. For example, in 2003/04 season, the global production of cocoa beans continued to rise for the fourth successive year, with output exceeding the recorded production levels of 2002/03 by almost 10 percent to reach 3.5 million tons (ICCO, 2003). ICCO reported that in 2003/04, Cote D'Ivoire defied fears of decline and instead recorded a substantial increase to reach 1.4 million tons, despite two years of political and social unrest. During the same season, good weather, higher farm gate prices, combined with effective government-backed of mass spraying of crops contributed to a substantial increase in yields, propelling Ghana's output to a record of 736,000 tons. However, during 2006/07 season, world production dropped by almost 9 percent from the previous season to 3.4 million tons, mainly as a consequence of unfavourable weather conditions in many cocoa producing areas (ICCO Annual Report, 2006/07).

In the last several years, cocoa output rose to significant levels in the producer nations around the world. Beginning in 1960, world cocoa production has surged notably between 1.2 to 3.6 million tonnes. This increment occurred amidst many shocks triggered by fiscal restructuring programmes, proliferation of crop infestations, plant viruses and price market manipulation, much of which have impacted yield. The key producers in the equator where cocoa beans are grown with dominance of global output consists of West African nations of Cote d'Ivoire (39%) and Ghana (21%) (Lass, 2000; ICCO, 2014). West Africa being a prominent production area stretches from Guinea to Cameroun where most cocoa plants thrive (Ashitey, 2012). The other marginal producing nations in the continent of Africa with lesser profile and output are concentrated throughout the Sub-Saharan region. All in all, the cocoa marketplace transactions are categorized particularly by substantial presence of production activities flourishing in areas where yearly global output hinges on variabilities and attributes of the West African climate (Hatløy *et al.*,2012). In the process, over the past many decades, many West African nations, have remained in the forefront of cocoa production far higher than other areas of the globe with the growth of 2-3 million tons since the 2000s (Fountain and Hütz-Adams, 2015).

Objective of the study

The main objective is to assess the trend of cocoa beans production in West Africa.

The specific objective of the study is to compare cocoa yields/production among cocoa producing countries in West Africa.

Hypothesis Testing: There is no significant difference in the means of yield of cocoa beans in Cote d'Ivoire, Ghana, Nigeria and Cameroun.

MATERIALS AND METHODS

The study area is West Africa. Data from Food and Agriculture Organisation (FAOSTAT, 2020) was used for analysis in this study. Data on area harvested, production and yield of cocoa was used for this study. Data on cocoa from years 1961-2018 was used for analysis. Four countries with the highest cocoa production in West Africa were considered in this study. The countries are Cote d'Ivoire, Ghana, Nigeria and Cameroun. Descriptive

Statistics including frequency, percentage and charts were used in this study.

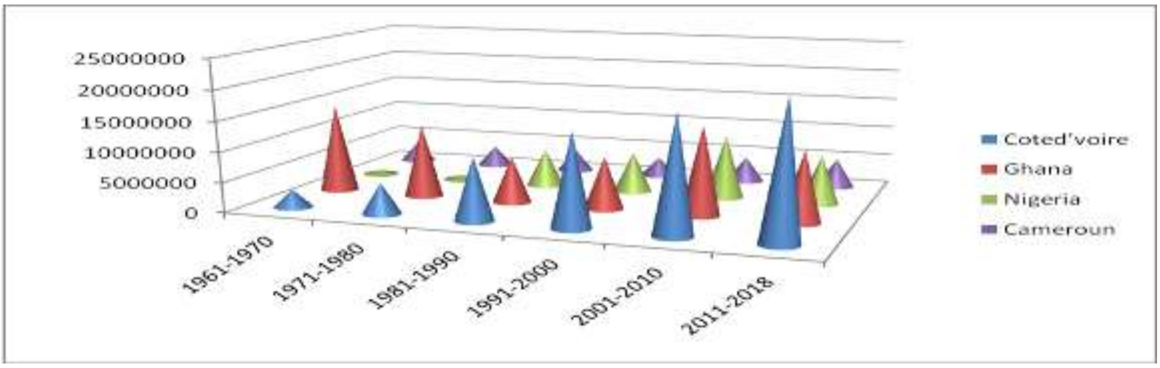
RESULTS AND DISCUSSION

Table 1 presented the area of land harvested for cocoa beans in West Africa. Between 1961-1970 Nigeria had the least area harvested for cocoa beans while Ghana had the highest. This was the period that Nigeria made a lot of money from the sales of cocoa beans locally and internationally. This showed that Nigeria despite low area compared to other countries still maximised their production and returns from it. From 1981-2018, even though the area of land harvested for cocoa beans increased yet the contribution of cocoa sale, export and agriculture to the economy dwindles. Figure 1 showed the trend of area of land harvested for cocoa beans in West Africa. As shown in the diagram the area of land for Coted'voire has been increasing over the years no wonder they are the highest producer in West Africa.

Table 1: Area of land harvested for Cocoa Beans in West Africa

Year	Coted'voire	Ghana	Nigeria	Cameroun
1961-1970	2963130	14749100	700000	3458000
1971-1980	5161670	12170000	700000	3502556
1981-1990	10439250	7741053	6379500	3830690
1991-2000	15463866	8769888	6792100	3248289
2001-2010	19258971	14775520	10648067	4316749
2011-2018	22389614	11795649	8196464	4921193
Average	1475304	1333895	857037	447356

Source: FAOSTAT, 2020 Note: Area is in hectares.



Source: FAOSTAT, 2020

Figure 1: Area of land harvested for Cocoa Beans in West Africa

Table 2 showed the production of Cocoa beans in West Africa. Between 1961-1970 Nigeria had the second highest cocoa beans production after Ghana and still contributed a whole lot to the economy even when Ghana's economy had that time been not buoyant. In 2011-2018 Nigeria s now the third largest with Ghana being the second. Ghana's economy has greatly improved while Nigeria's economy is dwindling and agriculture contributing less than 5% to her GDP. In Figure 2 for other West African countries their production levels were increasing over the years but this is not so for Nigeria. Even though the production levels increased over the years but it starts to dwindle down from 2011-2018.

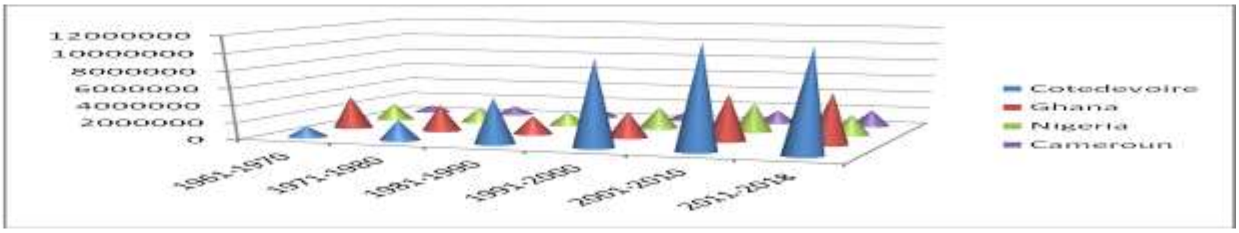
Table 2: Production of Cocoa Beans in West Africa

Year	Cote d'Ivoire	Ghana	Nigeria	Cameroun
1961-1970	1210241	3854200	2033180	809163
1971-1980	2386241	3191920	1840000	1049063
1981-1990	5324593	2241058	1622200	1094101
1991-2000	9976343	3113255	2661800	1048628
2001-2010	11896716	5507276	3512020	1577102
2011-2021	17946374	8521497	3272828	2817179
Average	813349	453507	270562	146328

Source: FAOSTAT, 2020 Note: Production in kg/ha

The yield of cocoa beans in West Africa is presented in table 3. In 1961-1970 Coted'voire had the highest average yield of 36887 while Cameroun had the least 21317 tonnes. In 1971-1980, 81-90,91-2000,2001-2010, 2011-2018 Coted'voire keeps having the highest yield. Nigeria keeps being the third largest except in 1991-2000 when she beats Ghana to become the second largest. Figure 3 presented the yield of cocoa beans in West Africa.

The value of F is 408.84 at a significant level p<0.01. The null hypothesis [Ho] which says that there's no significant difference in the yield of cocoa beans in the four West Africa countries is rejected while the alternative hypothesis is accepted. Therefore, there is significant difference in the yield of cocoa beans in Coted'voire, Ghana, Nigeria and Ghana. The difference might be due to the right policies put in place by the country's governments to boost production in their respective countries.



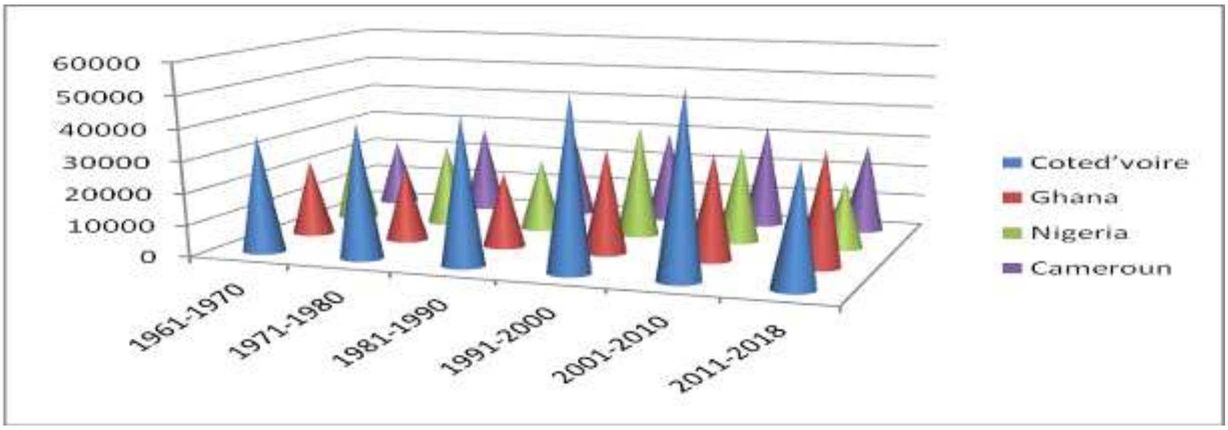
Source: FAOSTAT, 2020

Figure 2: Production of Cocoa Beans in West Africa   Note: Production in kg/ha

Table 3: Yield of Cocoa Beans in West Africa

Year	Coted'voire	Ghana	Nigeria	Cameroun
1961-1970	36887.1	23901.8	29044.4	21317
1971-1980	42152.7	23670	26285.6	27666.6
1981-1990	45889.5	23738.2	23126.3	25988.4
1991-2000	53596.6	33015.1	35756.9	29318.2
2001-2010	56597.1	33505	30481.7	32929.1
2011-2018	37643.38	36248.38	21154.25	28395.25
Average	5200	3333	3159	3173

Source: FAOSTAT, 2020   Note: yield in tonnes



Source: FAOSTAT, 2020

Figure 3: Yield of Cocoa Beans in West Africa   Note: yield in tonnes

CONCLUSION

Nigeria ranked third in area of land, yield and production, this in spite of the country's vast land mass and high production level a few decades ago. The right policies should be put in place to boost cocoa beans production in Nigeria; this way, cocoa will once again help contribute to Nigeria's GDP as it did in the past. It will also regain the central place it occupied in the West African sub-region.

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COBB-DOUGLAS PRODUCTION FUNCTION OF VEGETABLE IN EZZA SOUTH LOCAL GOVERNMENT AREA, EBONYI STATE, NIGERIA

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ABSTRACT

The study estimated Cobb-Douglas production function of vegetable in Ezza south local government area of Ebonyi state, Nigeria. Data were generated from sixty (60) vegetable farmers randomly selected from twelve (12) major Farming communities that make up the LGA with the aid of a well-structured questionnaire. Data were analyzed using Cobb-Douglas production function. From the result, the R^2 (0.463) showed that over 46% of the variations in output were jointly accounted for, by the explanatory variables included in the model. Moreover, land (0.471), seed (0.272) were positive and significant at 1% levels but farm size and fertilizer were positive but significant at 5% level. Herbicide (-0.331) was negative but significant at 5% level while labour (0.054), fertilizer (0.143) and pesticide (0.264) were positive and insignificant. Results also showed that return to scale in vegetable production in the area was 0.873, implied decreasing return to scale in vegetable production in the area.

Key words: Cobb-Douglas, Production function, Vegetable, Ezza South, Ebonyi

INTRODUCTION

Vegetable is one of the important sources of vitamins, minerals, dietary fiber and are essential in prevention of diseases (Abdulai, 2006). Vegetable production is of great economic importance as its value chain can provide income and reduces poverty and unemployment (Schreinemacher et al., 2018). Vegetable production has the potential to increase food security and create employment (Smith and Eyzayuirre, 2007). Insufficient intake of fruit and vegetables is estimated to cause around 14% of gastrointestinal cancer deaths, about 11% of ischemic heart disease deaths and about 9% of stroke deaths (WHO, 2020). The World Health Organization recommended con-sumption of 400 g of fruits and vegetables daily to maintain good health. Vegetables production is profitable, and the actors will require adequate knowledge, capital, and new methods of production.

In economic theory, a production function is described in terms of maximum output that can be produced from a specified set of inputs, given the existing technology available to the farm (Battese, 1992). In general, a production function is a specification of how the quantity of output behaves as a function of the inputs used in production. This concept can be applied at the level of individual farms. Various specific mathematical forms have been put forward for the production function, but the most commonly used is that developed by Charles Cobb and Paul Douglas in the second quarter of the 20th century. Here's their specification:

Y=AKαN1−α0< α <1 ………………..(1)

Here, Y = aggregate output, K = capital input, and N = labor input

Cobb-Douglas Production Function was widely used in economics and productivity studies across many sectors (Dennis et al., 2010). Fraser (2002) saw the omission of technical change in the specification of the Cobb-Douglass model as a serious limitation to the acceptance of its assumptions. By failure to recognize technical change, Amuka et al (2018), Fraser says Cobb and Douglas assumed that technology was constant within the period of their study, which does not hold in the real sense of it. The neoclassical economists also attacked the model on the bases that the productivity theory is more of an abstraction than a quantifiable. Douglass while responding to the criticisms noted that the critics were so hostile even to the extent of recommending for the work to be thrown into the waste basket and further research in it stopped. In the defense of the model, from criticism, Cobb-Douglass model started receiving research interest with positive comments and positive empirical result. Miller (2008) accepts that Cobb-Douglass model is very simple to use and can fit many data sets very well for empirical forecasting. Many studies have equally been done in developing as well as developed countries, trying to validate the Cobb-Douglass model. Results of such studies have differed, making it difficult to make a definite conclusion about the Cobb-Douglass postulation. Hence, up to this point, the applicability of constant returns to scale production as postulated by Cobb-Douglass is still at the centre of research interest around the globe (Amuka et al, 2018).

Cobb-Douglas model was based on the assumption of constant return to scale, implying that in the production decision, whenever the inputs used to produce a given output is doubled, total output will automatically double. Adetunji et al. (2012); Abidemi (2010) and some other studies have been done to validate the applicability of Cobb-Douglass laws of production with Nigerian data. Adetunji et al. used macro data to study the application of laws of production as propounded by Cobb-Douglass model. Their result shows that production function in Nigeria follows the constant returns to scale as predicted by Cobb-Douglass model, which means that doubling input use will double output in the country, hence, the estimation of Cobb-Douglas production function of vegetable in my own Local Government Area, Ezza South LGA, Ebonyi State of Nigeria

MATERIALS AND METHODS

The study was carried out in Ezza South Local Government Area of Ebonyi State. The LGA is made up of twelve (12) farming communities. Agriculture is the mainstay of the economy. According to (NPC, 2006), Ezza south has a population of 133,625 people and the total land mass 324 square kilometers.

A multi-stage random sampling technique was used for the study. The study area is made up of twelve (12) major farming communities to include Amuzu, Amana, Amagu, Ameka, Amezekwe, Amudo, Echara, Ezzama, Ikwuator, Nsokkara, Okoffia and Umunwagu.

Stage1: One (1) village was randomly selected from each of the twelve (12) major farming communities to give twelve (12) villages.

Stage2: Five (5) small scale tomato farmers were randomly selected from each of the twelve (12) villages to give sixty (60) small scale tomato farmers.

Model Specification

$Y=f(x_1, x_2, x_3, x_4, x_5, x_{6,} e)$ ………………(2)

Where,

Y=value of output in naira; X_1=Land (hectarage); X_2=labour (Mandays); X_3=Seed (Naira); X_4=Fertilizer (Naira); X_5=Herbicide (Naira), X_6=Pesticides (Naira)

Cobb-Douglas (Double Log):

$Log\ Y = Log\ a_o + a_1Logx_1+a_2Logx_2+a_3Logx_3+a_4Logx_4+a_5Logx_5+ a_6Logx_{6+}et$……. (3)

Where,

Log = Natural Logarithm; Y = Output; X_1 --- X_5 = Inputs (Variables defined in equation 4); a_1-a_5 = Regression coefficients; et = error term; a_o = Regression constant

RESULTS AND DISCUSSION

Table 1: Cobb-Douglas Production Function of Vegetable in the Study Area

Variables	Coefficients	t-values
Land	0.471	3.291***
Labour	0.054	0.283***
Seed	0.272	2.763***
Fertilizer	0.143	1.248^{NS}
Herbicide	-0.331	-2.483**
Pesticide	0.264	1.622^{NS}
Constant	7.360	9.423***
R^2	0.463	

Source: Field Survey, 2020

NOTE: *** and ** = 1% and 5% level of significance respectively, ^{NS} = Not significant

From the table, the R^2 value of 0.463 showed that over 46% of the variations in output were jointly accounted for, by the explanatory variables included in the model. However, land (0.471), labour (0.054) and seed (0.272) were positive and significant at 1% levels. This implied that increase in the three production inputs would lead to increase in the output of vegetable in the study area. Herbicide (-0.331) was negative and significant at 5% level. This implied that usage of the input should be minimized if output is to increase. Furthermore, fertilizer (0.143) and pesticide (0.264) were positive and insignificant, meaning that, with or without, the two inputs factors, output of vegetable could increase in the area. These findings were in consonance with FAO (1998), that land is the most fundamental resource in the rural economy and that, though, very important cannot be productive without labour and other production inputs.

Table 2: Return to Scale in Vegetable Production in the Study Area

Variables	Production Elasticities
Land	0.471
Labour	0.054
Seed	0272
Fertilizer	0.143
Herbicide	-0.331
Pesticide	0.264
Total (Return to Scale)	**0.873**

Source: Field Survey, 2020

From table 2, the coefficients of Cobb-Douglas production function were used as production elasticities. The sum of individual coefficients of Cobb-Douglas production inputs was used as a measure of return to scale in vegetable production, hence, return to scale was 0.873. This implied decreasing return to scale in vegetable production in the study area, meaning that continuous addition of the specified production inputs would result in a decrease in the output of vegetable in the long run. This result agreed with Akpan et al., (2012) whose work had 0.644 as return to scale in waterleaf production and maintained that, continuous increase in the utilization of the specified production inputs would result in a decrease in waterleaf output in the long run.

CONCLUSION AND RECOMMENDATIONS

From the major findings of the study; land, labour and seed were found to play a major role in vegetable production. There was a decreasing return to scale in vegetable production in the area. The study recommended Government and individual assistance to the farmers in the area of access to loan, land, improved varieties of seed and other production inputs.

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FOOD INSECURITY STATUS AMONG COCOA FARMING HOUSEHOLDS IN ONDO STATE, NIGERIA

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ABSTRACT

The study examined food insecurity status among cocoa farming households in Ondo State, Nigeria. Although studies abound on food security however there is a dearth of knowledge on food insecurity, therefore, a necessity for this study. Multi-stage random sampling technique was used to select respondents (farmers) for the study. The first stage was the purposive selection of three Local Government Areas (LGAs) from the State. Second stage was the random selection of 15 cocoa producing communities from the three selected LGAs, while the third stage was the random selection of 400 cocoa farming households from the selected communities (the selection was proportionate to size). Data were collected with the use of structured questionnaire. The data collected were analyzed using descriptive statistics, Food Security Index and Surplus/Shortfall Index. The study revealed that 63.5% of the respondents were above 50 years of age and the mean age of the farmers was 58 years. Also, majority of the respondents (73.8%) were male and 86.8% of the respondents were married. Some (41.75%) of the farming households were having more than 8 members per household and the mean family size was 8 persons per household. Most (55.0%) of the respondent households were food secured while 45.0% were food insecure. Shortfall index revealed that food insecure households fell short of the calorie requirement by 18.0%. The study recommended that effective household size management and family planning should be encouraged by the cocoa farming households to reduce their household size. This can be organized by government health workers and NGOs through rigorous campaign and seminars.

Key words: Food insecurity, status, cocoa, farming households, household size.

INTRODUCTION

Agriculture is the mainstay of the Nigerian economy. It provides employment for over 60 percent of the population. Apart from this, it also provides food for the teeming population, primary products that serve as raw-materials for agro-allied industries, generates income for the rural dwellers and also serves as an important source of scarce foreign exchange through agricultural exports (Oluyole, 2009). During the 1960s, agriculture contributed about 85.5% of the total export and hence became the major source of foreign exchange earnings. However, by 1984, its contribution to export dropped to 2.6 percent while in 2004, the contribution dropped to as low as 0.81 percent. However, the production figure of cocoa (as an important agricultural product) as at 2014 was 48,000 metric tonnes (ICCO, 2015). The progressive reduction in the contribution of agricultural export to the total export was due to the withdrawal of priority attention hitherto given to agriculture and the consequent dependence on oil sector since its discovery in the late 60's. The withdrawal of priority to the agricultural sector which resulted in the reduction of agricultural production has led to the reduction in food supply. Also, the growing urbanization and rapid population growth rate have affected the Nigerian economy negatively and put pressure on attaining sufficiency in food production from the country's agriculture. Consequently, food production has failed to respond adequately to food demand, thus creating food supply-demand gap. Food is a basic necessity of life. Its importance at the household level is obvious enough since it is the basic means of sustenance. However, it has been established that the quantity and quality of food consumed by households affects their health and economic well-being. This in turn have significant repercussions on the general level of economic activities and productivity, leading to food insecurity. According to Esobhawan (2007), food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preference for an active and healthy life. The main goal of food security is for individuals to be able to obtain adequate food needed at all times and to be able to utilize the food to meet the body's need.

Food security is of three folds. These are food availability, food accessibility and food utilization. Thus, the highest state of food security requires not only making food available, but the food must be accessible and also should be nutritiously well utilized within the body system. However, lack of access to enough quality food leads to food insecurity. According to Oluyole (2009), food insecurity is the inability of a household or nation to

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meet largest consumption levels in terms of quantity and quality of food in the face of fluctuating production, prices and incomes. Hence, food insecurity is the limited or the uncertain availability of nutritionally adequate and safe foods. According to Oluyole (2009), cocoa farming households in Nigeria had to grapple with the problem of food insecurity due to the fact that cocoa farmers do not have well established farming system with cocoa cultivation. The reason being that the shade that is being provided by cocoa trees (especially at the mature stage of cocoa) do not allow food crops grown under it to do well, (Ojo, 2005). The effect of this is food shortage which invariably leads to food insecurity among cocoa farming households thus the need for empirical investigation to know the extent of food insecurity in the study area. This study therefore finds it quite imperative to determine the food insecurity status among rural cocoa farming households to ascertain its severity.

Objectives of the study

1. To analyze the socio-economic characteristics of the respondents in the study area;

2. To analyze the extent of food insecurity among the cocoa farming households.

MATERIALS AND METHODS

The study was carried out in Ondo State, Nigeria. The state has 18 Local Government Areas (LGAs), out of which, 15 LGAs produce cocoa. The study made use of primary and secondary data. Primary data were collected through the administration of structured questionnaire to respondents while the secondary data were obtained from secondary sources such as Journals, Nigerian Bureau of Statistics, Central Bank of Nigeria and Annual Reports of Cocoa Research Institute of Nigeria. A multistage sampling procedure was adopted in the selection of the respondents. The first stage was the purposive selection of three Local Government Areas based on the predominance of cocoa producing activities in these areas. These areas were Idanre, Okeigbo/Ileoluji and Ondo East. The second stage was the simple random sampling technique to select 15 communities that is, 5 communities per Local Government Area while the third stage was the proportional selection of 400 farmers from the 15 communities (the selection was proportionate to size). Data were collected from the selected farmers with the aid of structured questionnaire and the data retrieved from the questionnaire were analysed using Descriptive statistics (such as frequencies and percentages), Food Insecurity Index and Surplus/Shortfall Index

Food Security Index

This was generated from the Cost-of-Calorie (COC) function proposed by Greer and Thorbecke (1986).

$$\ln X = a+bC \text{ ……………………….(i)}$$

Where:

X = Food expenditure (N);

C = Calorie consumption (Kcal.).

From the COC function, Z was calculated.

Hence,

$$Z = e^{(a+bL)} \quad \text{…………………….(ii)}$$

Where:

Z = Cost of minimum recommended energy level (N)

L = Recommended daily energy level (2450kcal.) (FAO, 2007);

a = Intercept;

b = Coefficient of the calorie consumption;

e = A mathematical constant (2.71828).

Any household whose average cost of daily calorie consumption is equal to or more than Z is said to be food secure, while any household with average cost of daily calorie consumption lower than Z is said to be food insecure.

Surplus/Shortfall Index

This tool was used to measure the extent to which a household is food secure or insecure. The Index is given as:

$$P = 1/N\sum_{J=1}^{m} G_j \quad \text{……………………….(iii)}$$

$$G_j = (X_j - L)/L \text{………………………….(iv)}$$

Where:

P = Surplus/Shortfall Index;

L = Recommended daily per capita requirements (2450Kcal.);

G_j = Calorie deficiency faced by household$_j$;

X_j = Per capita food consumption available to household$_j$;

N = Number of households that are food secure (for Surplus index) or food insecure (for Shortfall index).

In implementing food security policies and programmes, the value of the index could be monitored over time and compared among the different groups of population.

RESULTS AND DISCUSSION

Table 1 shows the socio-economic characteristics of the farmers. It shows that 63.5% of the respondents were above 50 years of age and the mean age of the farmers was 58 years. This shows that most of the farmers in the study area were relatively old which will have a consequent effect on their productivity. Hence, there's need to encourage youths into cocoa farming in the area. Table 1 also revealed that 73.8% were male headed households while the female headed households constituted 26.2% of the sampled farming households. This implies that male headed households dominated cocoa farming sector in the study area. This finding is in line with Oluyole (2009) who attributed the dominance of the males over the females to the fact that male children are considered as those that can inherit farm lands in the study area. Distribution of the respondents by marital status indicated that 86.8% were married, 5.0% were single, 2.3% were divorced/separated and 6.0% were either widowed or widower. This shows that most of the respondents in the study area were married, which made them to have more hands for farming operations. Furthermore, 44.0% of the households had 5-8 members, 14.25% had 1- 4 household members while 41.75% of the farming households were having more than 8 members. The mean family size of 8 persons indicated that the respondents maintain large household size which may have negative effect on their food status and increase their probability of being food insecure.

Table 1. Socio-economic characteristics of the respondents

Variables	Frequency	Percentage
Age of household head (Years)		
< 30	16	4.00
31-40	33	8.25
41-50	97	24.25
51-60	90	22.50
61-70	77	19.25
71-80	51	12.75
> 80	36	9.00
Total	400	100.00
Sex		
Male	295	73.80
Female	105	26.20
Total	400	100.00
Marital Status		
Single	20	5.00
Married	347	86.80
Divorced/Separated	9	2.20
Widowed/widower	24	6.00
Total	400	100.00
Household size		
1-4	57	14.25
5-8	176	44.00
> 8	167	41.75
Total	400	100.00

Sources: Field data, 2019.

Table 2 presents the food insecurity status among the sampled households. Based on the daily calorie (R) of 2450 Kcal., it was observed that 55.0% of the households were food secure while 45.0% were food insecure. The average household daily per capita calorie intake for the food insecure and food secure households in the study area were 1845.63Kcal and 2964.60Kcal respectively. This shows that food insecure households consume lesser calorie to what is considered as minimum requirement (2450Kcal) while the average calorie intake for food secure households was 2964.60Kcal which is higher than the minimum required calorie for human development. The food surplus/shortfall index (P) which measures the extent of deviation from the food security line, shows that the food secure households exceeded the calorie requirement by 31.0%, while the food insecure households fell short of the required calorie by 18.0%. Also, the mean household size of the adult equivalent was 6.35 for the food secure households and 9.92 for the food insecure households. This is in line with *a priori* expectation that larger households with more population are likely to be food insecure. Food Security Index (FSI) for the food secure households in the study area was calculated to be 1.31 while it was 0.82 for the food insecure households. Also, the average household size for the population was 8 persons; while the food secure households have an average household size of 6 and the food insecure households have average size of 10 persons.

Table 2: Summary of Food Insecurity Status for Cocoa Farming Households

Variables	Households	Status
Food Security Indices	Food secure	Food Insecure
Recommended daily per capita calorie intake	2450Kcal.	
Number of households	220	180
Percentage of households	55.0	45.0
Mean of household size	6.35	9.92
Mean household daily per capita calorie consumption (Kcal)	2964.60	1845.63
Food Security Index	1.31	0.81
Shortfall Index	-	0.18

Source: Field data, 2019.

CONCLUSION AND RECOMMENDATION

The study revealed that 63.5% of the respondents were above 50 years of age and the mean age of the farmers was 58 years. This shows that most of the farmers in the study area are relatively old which will have a consequent effect on their productivity. Hence, there's a need to encourage youths into cocoa farming in the area. Also, majority of the respondent households (73.8%) were male headed households and 86.8% of the respondents were married. Most (41.75%) of the farming households were more than 8 members and the mean family size was 8 persons per household. Most (55.0%) of the respondent households were food secured, while 45.0% were not food secure. The food secure households had an average daily per capita calorie consumption of 2964.60Kcal which exceeded the minimum calorie expected by 31.0% while the farming households that were food insecure had an average daily per capita calorie consumption of 1845.63Kcal which was lower than the minimum calorie requirement by 18.0%.

It is recommended that effective household size management and family planning should be encouraged by the cocoa farmers to reduce their household size. This can be organized by government health workers and NGOs through rigorous campaign and seminars.

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ATTITUDE OF WOMEN COCOA FARMERS TOWARDS AGRICULTURAL EXTENSION SERVICES IN ONDO STATE, NIGERIA

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ABSTRACT

The study diagnosed the attitude of cocoa women farmers in Ondo Sate Nigeria towards agricultural extension services. Multistage sampling procedure was used to select 60 respondents, from which information were solicited, using a well-structured questionnaire. The study was purposely carried out in the state being the highest cocoa producing area in Nigeria while three highest cocoa producing LGA were purposively selected. Similarly, simple random sampling technique was used to select the two highest cocoa producing communities in each LGA. Snowball techniques were used to select 10 women cocoa farmers per community, to give sample size of 60 respondents. The study revealed a mean age of 43.29 ±11.04 and majority (78%) were married. Respondents' (60%) primary occupation was farming. Respondents (62.78%) completed both primary and secondary school. Majority of the respondents (81.67%) were aware of the agricultural extension services. Eight major constraints debarring cocoa women farmers' participation in extension services were identified, among them were finance where all respondents (100%) attested as the major challenge, gender inequality (98.30%) and lack of collateral (75%). Respondents (68.33%) had medium attitude towards the extension services in the study area. Furthermore, there were negative and significant relationship between women cocoa farmers' attitude and the agricultural extension services programme, on distribution of improved cocoa pods ($r = -0.5$; $p< 0.01$), loan and credit facilities ($r = -0.346$; $p= 0.01$) and market channel (($r = -0.318$; $p<0.01$). Government should provide equal opportunity on training for both genders, this will encourage women cocoa farmers to participate and their farming needs will be met.

Key words: Agricultural extension, attitude, cocoa, Nigeria and women farmers.

INTRODUCTION

Agricultural extension services still do not attach much importance to reaching women farmers or women on the farm. Policy makers and administrators typically still assume that men are the farmers and women play only "supportive role" as farmers' wives (Samanta, 1994). Agricultural extension strategies traditionally have focused on increasing production of cash crops such as cocoa, by providing men with training, information, and access to inputs and services. Nigeria is the fourth cocoa producing countries the world (FAOSTAT, 2015). In cocoa production, women are responsible for more than half the world's food production, overal to 60 to 80% of basic foodstuff in Africa (Fresco, 1998). Despite all the socio-cultural factors militating against their accessibility to basic resources needed, for sustainable livelihood to perform triple role as producers, reproducers and community service provider. Yet women's substantial contribution continues to be systematically marginalised and undervalued in conventional agricultural and economic policies, while men's contribution remains the central, often the sole, focus of attention. Nigerian agriculture aims at involving women in agricultural production, but facing lack of women participating in agricultural extension progammes; although, some activities were put in place to bringing women farmers into the forefront of agricultural production programmes. It is however, difficult to really specify, where the problems of ineffective delivery of agricultural extension services to women farmers lie.

Though, so many factors are responsible for poor dissemination of extension service to women farmers, it is quite beneficial to note that the attitude of cocoa female farmers might as well be a contributing factor to ineffective delivery of extension service programme. Attitude can be defined as the degree of positive or negative effect, associated with psychological objects, However, it is pertinent to note that, the success of any extension programme depends largely on the attitude of the duo (Clientele and Agent) (Oladosu, 2006).

Several studies and researches have been carried out on the attitude of women farmers to agricultural extension programmes, (Barasa, 2006). There has been little or no farm-level information regarding their attitude to extension services particularly, in a

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male-dominated cash crop like cocoa. This paper aims to bridge this information gap by assessing the attitude of women cocoa farmers in the study areas towards extension services. The Objectives of this study are to: Identify the socio-economic characteristics and awareness of cocoa women famers on extension services. Examine the constraints faced by cocoa women farmers in accessing extension services. Determine the attitude and access the impact of extension services on women cocoa farmers. The hypothesis of the study was stated in a null form: There is no significant relationship between the attitude of women cocoa farmers and their access to basic extension services.

MATERIALS AND METHODS

Multi-stage random sampling methods was used in selection of respondents for the study. The study was purposely carried out in Ondo state being the highest cocoa producing state in Nigeria. The classification is based on CRIN cocoa survey (CRIN, 2007). Three highest cocoa producing Local Government Areas were purposively selected. In each community, 10 women coco farmers (of which primary and secondary occupation was cocoa farming) were randomly selected. Idanre (Owena 10 and Ipinlerere 10), Odigbo (Bolorunduro 10 and Agbala 10) and Ondo West (Abusoro 10 and Kajola 10). Thus giving rise to 60 respondents. Descriptive statistics such as frequencies, percentages, mean, standard deviation and inferential statistics used was correlation analysis to test for the significant relationship between the attitude scores of cocoa women farmers and their access to basic extension services in the study areas.

RESULTS AND DISCUSSION

The socio economic characteristics of cocoa women farmers

Table 1 showed that, 50% of cocoa women farmers' age were between 31-50 years (x=43.29 ± 11.04). This indicated that most of the women in this study areas, were in their middle age group, and can actively participate in cocoa farming. About 78.33% were married having husbands and children to cater for. This trend seems to agree with the findings of Fabiyi *et. al* (2007) where about 50% of the sampled women were married. However, on their level of education, majority of the respondents (61.67%) have completed both primary and secondary school education, while only 6.67% have attended tertiary institution. Majority of the respondents were Christian 50.00%. Millett (1997) opined that religion is used as a way of legitimising male dominance and patriarchy has God on its side.

Majority (60.00%) chose farming as their primary occupation, while 40.00% combined other occupations with farming. This implies that farming constitutes their basic source of livelihood in the study area, which requires effective extension services. Respondents with household size ranging from 1-10 constituted the majority with the percentage of 76.66, this may have an advantage on the area of supply of farm labour. The findings also showed that 63.33% of the respondents have been farming for about 11-15 years, this is due to gender discrimination, which put women at a disadvantage. Majority of the respondents (78.33%) belonged to farmers group, by implication being a member of a group or society should facilitate their access to basic extension services.

Awareness

Table 2 shows the respondents' level of awareness on basic extension services, majority (81.67%) were aware of the extension services. This implies that cocoa women farmer was quite familiar with the services rendered by extension agents, however, the type of services received were not channeled towards women farming needs.

Constraints

Table 3 shows that all the respondents (100%) attested that, financial constraint was their major problem. The population of 75.00% respondents identified lack of collateral in granting loans as a constraint, Gender inequality, (98.30%) of respondents attested that household demands always debar them from attending extension programs, Administrative bottle necks (65.00%) while unavailability of extension agents was seldom a problem (28.33%), but their availability does not always channel towards women farmers felt needs also, such program is usually dominated by men, because extension services have predominantly male staff. This was supported by the studies of Barasa, 2006 that, despite the significant role played by women in agricultural production, processing and marketing in Nigeria, men have continued to dominate farm decision making.

Table 1: Respondents socio-economic characteristics

Variable	Frequency	Percentage	Mean	Std. Dev
Age				
21-30	11	18.33	43.29	11.04
31-40	17	28.33		
41-50	13	21.67		
51-60	18	30.00		
Level of Education				
Primary uncompleted	7	11.67		
Primary completed	30	50.00		
Secondary uncompleted	11	18.33		
Secondary completed	7	11.67		
Tertiary	4	6.67		
Marital status				
Single	2	3.33		
Married	47	78.30		
Divorced	9	15.00		
Widowed	2	3.33		
Religion				
Christianity	36	60.00		
Islam	20	33.30		
Traditional adherents	10	16.67		
Occupation				
Farming (primary)	36	60.00		
Farming (secondary)	24	40.00		
Household size				
1-5	23	38.33		
6-10	23	38.33		
11-15	13	21.67		
16-20	1	1.67		
Farming experience				
1-5	4	6.67		
6-10	18	30.00		
11-15	38	63.33		
Farmers group				
Yes	47	78.33		
No	13	21.67		

Source: Field Study 2020.

Table 2: The level of awareness among coca women farmers

Awareness	Frequency	Percentage
Yes	49	81.67
No	11	18.33
Total	60	100

Source: Field Study 2020

Attitude

Table 4 shows the attitudinal scores of cocoa women farmers towards extension services. Majority 68.33% have medium attitude. Only 15.00% have high attitude while low attitude constitutes about 16.67%. This (medium attitude) may be due to their past experience from extension agents in service delivery, where majorly, men benefitted from the extension services than women. This may contribute to their inability to have high attitude towards agricultural extension services. Attitudinal barriers against women as described by Amaechina (2002) are deeply rooted in patriarchal-based socialisation where men are considered superior to women in socio-economic activities, resulting in low women presence in decision making bodies.

Table 3: Constraints experienced by cocoa women farmers: Always (A), Seldom (S) and Never (N).

Variables	A	S	N
Financial constraints			
F	60	-	-
%	100.00	-	-
Lack of collateral			
F	45	15	-
%	75.00	25.00	-
Gender inequity			
F	59.	1	-
%	98.30	1.67	-
Household demands			
F	59	1	-
%	98.30	1.67	-
Administrative bottlenecks			
F	39	21	-
%	65.00	35.00	-
Unavailability of extension agents			
F	17	22	-
%	28.33	36.67	-
Unavailability of improved technologies			
F	24	13	23
%	40.00	21.67	38.33

Source: Field study 2020.

Table 4: Attitude of cocoa women farmers towards extension services.

Variables	Score	Frequency	Percentage
High	≥23.52	9	15.00
Medium	≤23.52≥15.44	41	68.33
Low	≤15.44	10	16.67

Source: Field study 2020. Mean = 19.48. Std. dev. =4.04 Maximum=26. Minimum =13

Impact of extension

In table 5, home economics, health and social issues with majority of 78.33%, were the prominent services rendered by extension agents to the respondents, it is often assumed that home economics services can substitute for agricultural training and information for women. Furthermore, respondents of (51.67%) attested that extension services had improved their storage facilities. Respondents 41.67%, received training on how their income and revenue can be increased, the women farmers further explained that, trainings were received alongside cocoa value chain. However, 38.33% of the respondents felt the impact of extension services on improved technologies. This is due to the fact that cocoa production is a male-dominated crop and consequently, women are often marginalised. In the same vein, only 35.00% of the respondents have felt the impact of extension services on accessing credit facilities, women were often viewed as not credit worthy and if they needed to be granted loan, it is with the assistance of their husbands. On technical-know-how (25.00%) while effective use of chemicals (15.00%), this explained the gender discrimination and cultural factor placing women on the rear position. Jack (2013), stated that, when new technologies result in a more profitable crop, or when a new processing machine increases income, evidence shows that, men often appropriate them.

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Table 5: Impact of extension services on coca women farmers

Variables	Frequency	Percentage
Improved technologies	23	38.33
Increase in income and revenue	25	41.67
Access credit facilities	21	35.00
Better storage facilities	31	51.67
Knowledge and technical-know-how	15	25.00
Decrease in outbreak of pest and diseases	24	40.00
Effective use of chemicals	9	15.00
Home economics, health and social issues	47	78.33

Source: Field study 2020.

Correlation Analysis showing linear relationship between the attitude of cocoa women farmers and their access to extension services

Table 6 showed that, there was an inverse relationship between access to improved cocoa hybrid pods and their attitude towards these services. This indicated that the women cocoa farmers have negative attitude towards this service, with the low strength of the relationship of 25.1% at P<0.01. This implies that, as there is increase in the distribution of improved cocoa pods by extension agents, there is decrease in the attitude of women. This can be deduced from table 3 above, where 70% of respondents, do not have access to this service. The respondents have negative attitude on how to acquire loan and credit facilities, the low strength of the relationship of 12.0% at p≤0.01by implication, women are seen as not credit worthy, as seen in table in 3.

Table 7: Correlation analysis on attitude of cocoa women farmers and their access to extension services.

Variable	Pearson correlation coefficient r	Coefficient of determination r^2	Precision	Percentage
Improved cocoa pods	-0.501**	0.251	000	25.1
Loan and credit facilities	-0.346**	0.120	000	12.0
Provision of market channel	-0.318**	0.101	000	10.1

Source: Field study 2020. **Correlation significant at 0.01 level.

Provision of market channel is negatively and significantly related to the attitude of cocoa women farmers in the study area. In which, the strength of the relationship was only 10.1% P≤0.01. This implies that, there was inverse relationship between the variable Increase in extension service on market channel influences the attitude of women cocoa farmers towards it, also, as seen in table 3, majority of the respondents (85%) do not have access to loan and credit facilities. Women are often marginalised and often reluctant to attend such programme, due to some constraints such as, household chores, sex preference by extension agents and inadequate number of women in cocoa farming as well as extension agents. Rafferty, (1988) reported that, agricultural extension programmes and other supporting services have traditionally, concentrated more on educating male farmers, and hence farm women still largely depended on their husbands for information on farm inputs and other resources necessary for farm decision making.

CONCLUSION

Majority of the cocoa women farmers were in their productive age and actively involved in cocoa production. They have medium level of attitude towards agricultural extension services, despite their level of awareness of the training programmes, health and social issues, and home economics skills have continued to be the most accessible extension services they benefitted majorly from. Major constraints debarring cocoa women farmers from attending training programs were capital, gender inequity and household demands. Based on the findings of this study, the following were recommended; women should be recognised as farmers, not only as farmers' wives. There should be provision of training in agriculture for women to acquire new skills and adjust schedules to fit women's existing workloads, not just home and family welfare topics. Better working relationships between extension agents and women cocoa farmers should be established, as this would enable them to voice their demands to fit their agricultural needs. Women cocoa farmers' seminars should be organised to share ideas with researchers and field staff, to promote farmer-to-farmer discussion among women. Extension agents who are not only technically competent and up-to-date, but who empathise with the needs of women farmers should be deployed, to facilitate participation of women in extension programmes.

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SOCIO-ECONOMIC FACTORS INFLUENCING WOMEN PARTICIPATION IN AGRICULTURAL PRODUCTIVITY IN SOME YAM PRODUCING AREAS OF EBONYI STATE

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ABSTRACT

This work studies the information on social economic factors affecting female participation in yam production in Ebonyi State, Nigeria. Respondents (150) were selected by random sampling using a structured questionnaire. Data was analyzed using descriptive statistics and Multiple Linear Regression. Majority of the respondents (72.7 %) were married. Highest number (47.3 %) of respondents were within >40 years of age. Highest number (38 %) of the respondents had no formal education. Highest number (41.3 %) of respondents earned between N100,000 and N199,000. Most of the respondents (44 %) had less than 2 hectares of land. Majority (43.3 %) of the women respondents had farming as the primary occupation. Majority (34%) of the respondents had between 11and 15 years of farming experience. Precision of the model that evaluates the factors influencing women farmers' participation in yam production shows that the variable in the model accounts for 91.1 % of the variations. Age, household size, educational level and primary occupation significantly affects involvement of women in participating in yam production in Ebonyi State.

Key words: Socio-economic factors, women participation, yam producing areas

INTRODUCTION

Nigeria has one of the lowest recorded female labour force participation rates well below that of their foreign counterparts. They have no or minimal part in decision making process regarding agricultural development, food security and food production. Gender inequality is therefore dominant in the sector and this constitute a bottleneck to agricultural development. The involvement of males and females in seed yam production activities and in different parts of the yam value chain is shaped by socially defined norms of behaviour, social roles and responsibilities (Ewuziem and Ironkwe, 2019). They face difficulties than men in gaining access to resources such as land, credit and improved inputs. Oladosu *et al*. (2018) analyzed gender differentials in accessing agricultural production resources among yam farmers However, there is need to determine the socio-economic problems influencing women participation in agricultural productivity in some yam producing areas of South-Eastern Nigeria. This work is therefore an attempt to contribute to the investigation of the socio-economic issues affecting women participation in yam production in Ebonyi State.

MATERIALS AND METHODS

Survey was carried out in Ebonyi State located in South-Eastern part of Nigeria which lies within latitudes 5° 40' and 6° 45' North and longitudes 7°30' and 8°30'East with mean temperature ranging between 27° to 30° C. Temperature is highest from February to April and it is about 31° C (Ogbodo, 2013). Agriculture is a major industry in Ebonyi State, an estimated eighty-five per cent of the population earn their living from agricultural activity). Crops grown in the area include; rice, yam, cassava, cocoyam, groundnut, cowpea and vegetables.

Sampling technique

A multi-stage sampling technique described by Aidoo (2009) was employed in the study with a sample group 150 respondents formed in the following manner:

1. Purposive and systematic sampling of three Local Government Areas (LGAs) in Ebonyi (Abakaliki, Afikpo and Izzi) State Nigeria where yams are currently grown intensively.

2. Simple random sampling were used to select 50 respondents from LGA

Data Collection

Data for this study was obtained by use of structured and validated questionaaire.

Data Analysis

Descriptive statistics was used to analyze socio-economic characteristics of respondents. Multiple linear regression model was used to determine social economic factors affecting female participation in yam production using Statistical Package for Social Scientist (SPSS version 21).

Simple model specification for the study is given as;

Y =α + β1logX1 + β2log X2 + β3log X3 + β4 logX4 + β5log X5+ β6 logX6 + β7log X7 + β8 logX8 + ϵ ………………eqn 1

Y = 1 if the person participated in Agriculture and Y = 0 if otherwise Variables X1…X8 represent;

X1 = Marital status (1 for married, 0 for otherwise), X2 = Age (years), X3 = Educational Level (years), X4 =Annual income (naira), X5 = Farm area (ha), X6 = Yam farming experience (years), X7 = Household size (number), X8 = Primary occupation, $\beta 1 - \beta 8$ are the slope coefficients of the regressors or multipliers that describe the size of the effect the independent variables are having on depensent variable, α represents the vertical intercept.

RESULTS AND DISCUSSION

Socio-economic characteristics of the respondents

Results of socio-economic characteristics of the respondents (Table 1) show that Majority of the respondents (72.7 %) were married whereas 27.3 % were not married. The dominance of women in the study area can be attributed to the restrictions that bar women from gaining access to agricultural resources. This agreed with the report of Zaidi *et al*. (2016) that women are considered to be dependents.

Highest number (47.3 %) of respondents were within >40 years of age, while the least number (6.7 %) of women yam farmers were within 25 to 30 years of age. The more number of older yam farmers reported might be attributed to practice of gender norms, which encourage only married women to have access to farmland. Some social and cultural norms, such as land acquisition might affect the number of farmers involved in agricultural productivity (Ameh and Iheanancho 2017).

Majority (38 %) of the respondents had no formal education, while 14% had tertiary education. This shows that most of the women farmers in the study area did not undertake any form of formal education.

Table 1: Socio-economic characteristics of respondents

Variable	Frequency	Percentage
Marital status		
Not married	41	27.3
Married	109	72.7
Age (years)		
25 -30	10	6.7
31 - 35	29	19.3
36 - 40	40	26.7
>40	71	47.3
Educational level		
No formal education	57	38.0
Primary	41	27.3
secondary	31	20.7
tertiary	21	14
Annual income (N)		
< 100,000	26	17.3
100,000 – 199,000	62	41.3
200,000 – 299,000	45	30
300,000 and above	17	11.3
Farm area (ha)		
<2	66	44
2 - 6	59	39.3
>6	25	16.7
Farm experience (yrs)		
<5	13	8.7
5- -10	27	18
11 - 15	39	26

16 - 20	59	39.3
>20	12	8
Household size (No)		
1 - 5	34	22.7
6 - 10	76	50.7
>10	40	26.7
Primary occupation		
Farming	65	43.3
Business	34	22.7
Civil service	41	27.3
Student	10	6.7

Women yam farmers (41.3 %, 30 %, 17.3 % and 11.3 %) earn annual income that ranged from N100,000 to N199,000, 200,000 to 299,000, <100,000 and 300,000 and above. Low income adversely affects productivity because it leads to low capital investment.

Most (44 %) of the respondents had less than 2 hectares of land, while 39.3 % had farm area that ranged between 2 and 6 hectares. This implies that most of the women were small-scale farmers.

The respondents (39.3 %, 26 %, 18 %, 8.7 % and 8 %) had farm experience that ranged from 16 to 20, 11 to 15, 5 to 10, <5 and >20 years. This shows that most of the women farmers have reasonable farming experience which will have positive impact on productivity.

Majority (50.7 %) of the respondents had the household size of between 6 and 10 while less number (22.7 %) had 1 and 5 household size. This observation further re-affirmed the claim that majority of the women farmers were married.

Majority (43.3 %) of the respondents were farmers while 6.7 % were students. This observation is supported by the earlier report that majority (72.7 %) of the respondents were married who engage in agriculture to generate income for household food.

The variables in the model that evaluates the factors influencing women farmers' participation in yam production (Table 2) accounts for 91.1 % of the variations observed. Age, educational level, household size and primary occupation significantly ($p < 0.05$) affected women participation in yam production in the study area.

Table 2: Multiple regression analysis of the factors influencing women farmers' participation in yam production

Socio-economic variables	Coefficients	Standard error	t-value	Sig.
Age	0.41	0.06	3.21	0.002
Educational level	-0.28	.06	-2.10	0.038
Household size	-0.82	0.05	-10.64	0.000
Farming experience	0.27	0.06	1.73	0.087
Farm area	0.02	0.06	0.18	0.860
Annual income	-0.17	0.05	0.87	0.872
Primary occupation	-0.42	0.05	-3.49	0.001
Constant	1.45	0.06	23.66	0.000

R^2 = 0.830; Adj. R^2 = 0.822; R = 0.911; F-statistics = 99.22

CONCLUSION AND RECOMMENDATIONS

This study has shown that yam productivity in the study area was dominated by married women that were above 40 years of age and with no formal education. Majority of the respondents were small-scale farmer with annual income that ranged from N100,000 to N199,000 and cultivated less than 2 hectares of land. Farming was the primary occupation of the majority of the respondents who had reasonable farming experience. Age, educational level, household size and primary occupation were key determinants of women participation in yam production in the study area. To ensure sustainable food security it is recommended that government should enact a law ensure that land and all other resources are made available to women farmers.

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SOCIO-ECONOMIC VARIABLES OF CASHEW FARMERS IN OSUN STATE, NIGERIA

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ABSTRACT

The study assessed the socio-economic variables of cashew farmers in Osun State. Four towns within Ejigbo Local Government Area (Ika, Igbon, Ejigbo and Ilawo) were purposively sampled. These areas are known for the cultivation, production and marketing of raw cashew nuts (RCN). A total sampling frame of sixty-eight respondents was used. Structured interview schedules were used for data collection. Descriptive statistics such as frequency, mean, percentages and standard deviation were employed in data analysis. Age of farmers, educational level of farmer, farm size, household size, gender, membership of association, and marital status of farmers constituted major socio-economic variables among cashew farmers in the study area. However, age, educational level, household size and farm size of the farmers have their mean values as 53±16.0, 2±1.0, 6±4.0, 5±8.0, respectively. It is thus important for government and other development partners in cashew production to develop policies that will enable the farmers to increase their farm holdings for higher productivity since they are still in their productive years. Adult literacy programme should be introduced and encouraged in the study area to increase the educational level of farmers. Farmers that are members of association should be encouraged to participate more as this will go a long way in price determination for increased profit and access to trainings on improved production packages.

Key words: Cashew, Socio-economic variables, Government, Development Partners

INTRODUCTION

Cashew (*Anacardium occidentale* L.) originated from Brazil in South America. It is commonly grown in tropical countries of Africa; Nigeria inclusive. It is a broad leafed evergreen tree crop that thrives well in poor soils and dry sandy locations. There are tonnes of write-ups and studies about Nigeria's agricultural misadventure. However, we can bring some focus to a segment which can be regarded as a low hanging fruit in the Agricultural sector – Cashew. Nigeria is one of the largest producers of Cashew in the World. Furthermore, the International Nut and Dried Fruit Council in 2014 valued the global cashew market a whopping $4.69 billion. It is difficult to assess the production volumes across the various producing nations but the Food and Agriculture Organisation (FAO) estimates that the production of raw cashew nuts (RCN) has grown from 0.29 million tons in 1961 to 2.60 million tons in 2013 and West Africa's share of the market has tripled in the past decade (SB Morgen, 2016). Cashew grows almost everywhere in Nigeria but it is concentrated primarily across the three southern geopolitical zones as well as the middle belt. The major producing Nigerian states are Benue, Kogi, Kwara, Oyo, Enugu, Abia, Anambra, Ekiti and Imo. The National Cashew Association of Nigeria (NCAN) reports that Nigeria earned US$ 402Mn (N144.7bn) from the export of raw cashew nuts to Vietnam and other countries in 2017. In addition, National Bureau of Statistics (NBS, 2017) reports that cashew exports increased by 463 percent from N2.4bn in quarter one of 2017 to N13.5bn in quarter two of 2017 on a quarter-on-quarter basis. The production of cashew can solve economic, social and environmental problems in Nigeria.

Cashew contributed less than 2 percent to total agricultural exports in quarter one but contributed 45.4 percent to the sectoral export in the quarter two and 8.2 percent of total non-exports. The value makes the product the seventh largest export product in quarter two of 2017. Price per tonne of raw cashew nuts was put at US$1,800 and Price per tonne of processed cashew nut was put at about US$12,000.

Traditionally too, the agriculture sector and rural economy especially in Least Developed Countries (LDCs) have been characterized by the predominance of a small landowning class, tenants, sharecroppers, and landless labourers who are at the core of the poverty problem (Imran *et al.,* 2009). Meanwhile, Krishna *et al* (2016) considered gender, age, income and education as the main attributes of socio-economic variables. Similarly, socio-economic status has been operationalised in a variety of ways, most commonly as education, social class, or income (Alexander *et al.,* 2017). Therefore, the study assessed the socio-economic variables of cashew farmers in Osun state. Meanwhile, farmers' decisions with respect to production and land use are intensely guided by socio-economic factors. On many occasions, the farm size of farmers affects agricultural productivity. This is usually common when the land in question is fragmented, that is, if the land is divided into smaller pieces and allocated to individual farmers. The size of the farms makes mechanized and commercialization farming almost impossible on such land (Marocchino, 2009). In addition, the productivity of farmers to some extent could be attributed to the farmers' years of experience. According to Carter (2009) productivity is achieved, if a farmer is versed in his farming business. That is he cultivates his crops at ease with little or no assistance from extension agents. He has full knowledge of his farming calendar, cropping system, as well as land use patterns and/or system. The objective of the study was to profile the socio-economic characteristics of cashew farmers in the study area.

MATERIALS AND METHODS

The study was conducted in Osun State, Nigeria. The state is in the south west agroecological region and falls in to the tropical rainforest zone of the country. Four towns of Ika, Igbon, Ejigbo and Ilawo were purposively sampled. These areas are known for the cultivation, production and marketing of this crop. Seventeen farmers were randomly sampled from each of the communities. A total sampling frame of sixty-eight respondents was used for analysis. Structured interview schedules were used for data collection from respondents. Data were collected on socio-economic characteristics such as age, educational level, gender, household size, farm size and membership of farmers' group, respectively. Additional information was gathered through informal discussions with the farmers and by personal observations of the crop in some of the farmers' fields. Data were analyzed using descriptive statistics such as frequency, means, percentages and standard deviation with the aid of STATA Version 12.0.

RESULTS AND DISCUSSION

Table 1 shows the socio-economic characteristics of cashew farmers in Ejigbo Local Government Area (LGA) of Osun State, Nigeria. The table reveals that majority of the farmers (95.59%) were men. This result is in conformity with Akinpelu *et al* (2021) who reported that majority of cashew farmers (62.50%) in Oyo State were male. In addition, Lawal *et al* (2019) affirmed that majority (77.01%) of cocoa farmers in Boki Local Government Area of Cross River State are male. This is in consonance with the submission by Girei *et al* (2013) who reported that men are more in a crop that is perceived to have commercial value in Africa. The implication of this is that cashew farming in the study area is largely dominated by male gender and probably because cashew is a cash and perennial crop. However, the result is contrary to Ibekwe (2008) who observed that women play a vital role in food production. Moreover, the mean age of the farmers is 53 years. This also conforms to the findings of Akinpelu *et al* (2021) who reported 53 years as the mean age for cashew farmers in Oyo State. Osuji *et al* (2013) also reported that age might have a tremendous influence on productivity, efficiency and utilization of farm resources. The implication of this is that cashew farmers in the study area appear to be in their productive years. The result of the average farm size (5ha) put into cultivation by a little above 83 percent of the farmers may perhaps be due to the fact that land owners are reluctant to put their farms into the cultivation of perennial crops. This assertion corroborates Osuji *et al* (2013) who submitted that majority of the food crop farmers operated on a small scale bases (cultivating less than 3.0 hectares). Similarly, the table reveals that about 40 percent of the farmers had no access to formal education with average years of educational level being about 2 years. This also conforms to Akinpelu *et al* (2021). This implies that the farmers may perhaps not have access to agricultural production and market information system (MIS) with respect to both production and marketing of the crop. Furthermore, the table reveals an average household size of 6 persons. This is in conformity with Osuji *et al* (2013) and Ibitoye *et al* (2012). It however deviates from the findings of Akinpelu *et al* (2021). They reported an average household size of 7 and 8 persons in their study on the socio-economic variables of arable and cash crop farmers in Imo, Kogi and Oyo States, respectively. The implication is that the farmers may perhaps utilize members of the household as labour for some operations relating to production and marketing of the crop. This has the tendency to perhaps reduce some labour and transaction costs that may be incurred on the crop. Moreover, the table shows that about 64.71 percent of the farmers belong to one association or the other. The implication of this is that the farmers will be able to get needed improved production packages from the association.

Table 1: Socio-economic characteristics of Cashew Farmers in Kogi State

Variables	Frequency	Percentage (%)	Mean
Gender			
Male	65	95.59	
Female	3	4.41	
Total	68	**100.00**	
Age (Years)			**53(±16)**
21-30	8	11.76	
31-40	9	13.24	
41-50	10	14.71	
Above 50	41	60.29	
Total	68	**100.00**	
Marital Status			
Single	10	2.67	
Married	57	97.33	
Divorced	1	1.47	
Total	**75**	**100.00**	
Education (No of years)			**2(±1.0)**
No Education	27	39.71	
Primary	18	26.47	
Secondary	18	26.47	
Tertiary	5	1.47	
Total	68	**100.00**	
Membership of Farmers'Group (Dummy)			
Yes	44	64.71	
No	24	35.29	
Total	68	**100.00**	
Household Size (No. of Persons)			**6(±4)**
1-5	33	48.53	
6-10	30	44.12	
Above 10	5	7.35	
Total	**68**	**100.00**	
Farm Size (Hectares)			**5(±8)**
1-5	57	83.80	
6-10	4	5.90	
Above 10	7	10.39	
Total	**68**	**100.00**	

Source: Field Survey, 2016. Figures in Parenthesis are Standard Deviation

CONCLUSION

The study assessed the socio-economic variables of cashew farmers in Osun State. Age, educational level, household size, farm size, gender and membership of association constituted the socio-economic characteristic factors among cashew farmers in the study area. More efforts should be made to encourage youth to take up cashew farming as an enterprise to bridge the gap that will be created by the aging farmers. In addition, adult literacy programme should be introduced to the study area to increase the educational level of farmers. Similarly, farmers should be given incentives to increase their farm holdings for higher productivity. Farmers that are members of association should be encouraged to improve on their participation as this will go a long way in price determination for increased profit and access to trainings on improved production packages. This will encourage and improve cashew farmers' access to market information and as such will be able to sell the crop for more profits.

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ASSESSMENT OF SEEDLINGS PRODUCTION AS A MEANS OF ECONOMIC ENHANCEMENT AMONG FARMERS IN IBADAN METROPOLIS

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ABSTRACT

Seedlings production is a means of self-employment opportunity that generates income with relatively low investment expenditure for farmers. The objective of this study is to investigate seedlings production as a means of economic enhancement of farmers in the study area. Data were collected using well-structured questionnaires administered to seventy-eight (78) nursery owners in five urban local governments which are North East, Ibadan North, Ibadan Northwest, Ibadan Southeast and Ibadan Southwest. Descriptive statistics such as percentage and frequency distribution were used to analyse data objectives while the economic evaluation of nursery activities were estimated using Gross margin (GM) and Rate of return (RORT). The result showed that most of the respondents were within the age bracket of 21-30 years (29.5%) and 31-40 years (29.5%) respectively. The result also revealed that men involved in the establishment of the business (seedlings production) (78.2%) while majority of the respondents had tertiary education which accounted for (56.4%). It can also be deduced from the result that majority of the respondents were married (61.5%). The seedlings identified at the various nurseries consisted of twenty-one (21) species which were categorized under; ornamental plant (10 species), tree crops plant (9 species) and two (2) forest species. The economic analysis from this study showed that the rate of returns (RORT) was high with the highest returns on Umbrella tree (#1000). The study further revealed that the major constraints faced by the respondents in the study area were inadequate water supply, unavailability of enough land space and inflation. The other factors that affect the output of the seedlings production are change in weather condition, marketing and high cost of labour. Against these odds, establishment of nursery and seedlings production business is an attractive business to the people in the metropolis and specifically to the unemployed youths. Therefore, there is great need for Government and NGOs to provide enabling environment for the farmers in order for them to expand the existing nursery and adoption of this enterprise in order to reduce poverty and unemployment in the society.

Key words: Assessment, seedlings, production, economic enhancement

INTRODUCTION

Nurseries have the common goal of producing plant material for improving sites and establishment of plantation. They are established to produce seedlings, grown under favourable conditions at germination and early growth stage before transplanting to the field for planting purpose. Seedlings plant production nurseries can be an informal, small- scaled arrangement or a large commercial enterprise that vary in size, facilities (supplies, tools, equipment, etc.), types of seedlings produced, and operations (Larinde and Ruth, 2014). High quality seedlings are fundamental to the successful establishment of orchards and plantations, both for timber production and reforestation of degraded land/environments. Recently, the production of both cut flowers and home plants has continued to increase steadily in most urban and metropolises. The importance of ornamental plants in human life cannot be over-emphasized. Ornamental plants are not only sources of medicinal herbs (Fakayode *et al*., 2008) but also serve as environmental stimulants that trigger pleasant memories. These plants also play crucial role in cooling the atmosphere through the evapo-transpiration process on their leaves and other parts thereby preventing health hazards (Omokhua *et al,* 2002).

People are increasingly realizing the need for planting trees, shrubs and grasses for different purposes, especially in the urban and metropolises. Plant seedling nurseries provide employment opportunity for the urban youths. The job including skilled-labour such as green-house and nursery managers and jobs for individuals involved in the cultivation and marketing of the ornamental plants (Fakayode *et al.,*2008).

To the nurserymen, gone are the days when forestry was seen as a business with a long gestation period between the time of investment and the time of dividend. Small-scale nursery establishments are highly profitable business ventures in Nigeria due to the short time between the production and sale of most of the plants involved (Aiyeloja and Larinde, 2006).

However, the contribution of nursery enterprise (which is a self-employment business) in economic development both to the individual and to the nation's economy cannot be overemphasized (Babalola, 2008). Nursery establishments are highly profitable business ventures in Nigeria due to the short time between production and sale of most of the plants involved (Aiyeloja and Larinde. 2006). Despite all the great potentials of the ornamental plants business to improve the economy of nations, the sector in Nigeria has been hampered by many problems. It has also received very little attention in the nation's perspective plan for agricultural development (Oseni, 2004). This research work focuses on the assessment of the seedlings production as a means of economic enhancement among farmers in the study area. The objectives of research work are to examine socio-economic status of the farmers, the factors affecting the output of seedlings plant production and profitability level of the seedlings production.

MATERIALS AND METHODS

The study was conducted in Ibadan, the capital city of Oyo State. The city consists of five local governments within the metropolis which are North East, Ibadan North, Ibadan Northwest, Ibadan Southeast, and Ibadan Southwest. The city of Ibadan is located approximately on longitude 3°55 East of the Greenwich Meridian and latitude 7°23 North of the Equator at a distance some 145 kilometers Northeast of Lagos. The population of Ibadan metropolis at 2016 is estimated to be 3.16 million. The primary data were gathered by the use of well-structured questionnaire that was administered to the respondents during the field work. Multi-Stage sampling procedure was used to sample the respondents for proper data collection during the field survey which include; identification of nursery, selection of the farmers/ horticulturist. Seventy-Eight (78) well-structured questionnaires was randomly distributed to the respondents and allowed them to have equal chance when the survey was being carried out.

The rate of money return was estimated using the formula;

$$RORT = \frac{TR - TC}{TC} \times 100$$

Where TR = Total revenue and TC = total cost.

RESULTS AND DISCUSSION

Table 1 shows that there are more males (78.2%) in seedlings production than females (21.8%) in the study area. It is attributed to the fact that activities involved in seedlings plant production might be tedious and could be handled by men than female. The age distribution shows that less than 20 years (1.3%), 21-30 years (29.5%), 31-40 years (29.5%), 41-50 years (10%), 51-60 years (10%), and 60 years and above (6%). This implies that respondents within the age bracket 21-30 and 31-40 have the highest percentage (29.5%) and more involved in seedlings production. This contradicts the proposition of Gantam and Medhur (2000) who said that older people of age are more in to farming than younger people in Africa. The table further shows that about (56.4%) of the respondents had access to tertiary education followed by secondary (20.5%), primary (9%), others (7.7%), and no formal education (6.4%) respectively. This reveals that the literate level of the respondents in the study area was above 50%; average which has enhances increase in knowledge of the respondents in the study area. Therefore, it corresponds to the findings of Adejoba and Oyewale, (2012) as the level of education attainment increase also level of knowledge increases. The result also revealed that the respondents' family size of 3 has the highest percentage of (34.6%) while respondents with family size of 1 had the lowest percentage of (12.8%). This implies that the family size of most respondents is not fairly large and these enable them not to get a better source of income and also they cannot rely on their family size for labour, this is in agreement with Sunderlin, (2005). The respondents' year of farming experience reflected that majority of the farmers had experience within 1-10 years with the highest percentage of (51.3%). This contradicts the propositions of Ogboma (2010) who said that personal experiences were the source of information used by the farmers.

Table 1: Socio-Economics Characteristic of Respondents

Variable	Frequency	Percentage
SEX		
Male	61	78.2
Female	17	21.8
Total	**78**	**100**
AGE (YEARS)		
Less than 20	1	1.3
21-30	23	29.5
31-40	23	29.5
41-50	15	19.2
51-60	10	12.8
Above 60	6	7.7
Total	**78**	**100**
Total	**78**	**100**
EDUCATIONAL LEVEL		
No formal Education	5	6.4
Primary School	6	9
Secondary School	16	20.5
Tertiary	44	56.4
Others	7	7.7
Total	**78**	**100**
FAMILY STATUS		
Head of Family	55	70.5
Wife	11	14.1
Others	12	15.4
Total	**78**	**100**
EXPERIENCE (YEARS)		
1-10	40	51.3
11-20	22	28.2
21-30	12	15.4
31-40	4	5.1
Total	**78**	**100**

Source: Field survey, 2020

The result of the economic analysis from this study shows that Ornamental seedlings had the highest economic value of 47.62% which mean the seedlings are widely used within Ibadan metropolis, followed by Tree crop seedlings with 42.86% economic value and forest tree species had 9.52% economic value as the lowest (Table 2). Ornamental plants ranked the highest as a result of its patronage and accrued profit. The rate of returns (RORT) which is the ratio of money gained from an investment relative to the amount of money invested was high with the highest returns on Umbrella tree (N1,000), King palm (N900), Queen palm (N900), Golden palm (N900), Step tree (N900), Flamboyant (900), and Ficus (N900). The highest quantities of seedling species produced per year were Ixora (3000) and the lowest seedlings produced were Pawpaw and Guava which were 70 in quantity per year. It showed that Juja pine was not among the seedlings with highest returns yet it was produced in higher quantities due to high demand for these species. Forest plantation seedlings are produced in small quantities due to low demand; however, they generate high return whenever sold. This strongly agreed with the findings of Ephraim et al. (2018) who reported that forest plantation seedlings generated high returns whenever sold.

Table 2: Mean Values of economic Analysis for seedling Produced in the Study Area

Seedlings species	Quantity sold Per annum	Production cost (N)	Selling price/ seedling (N)	Total Revenue (N)	Gross Margin (N)	RORT
Tree crops (42.86%)						
Coconut	100	80,000	2000	200,000	120,000	150
Citrus	400	40,000	600	240,000	200,000	500
Cashew	100	5,000	300	30,000	25,000	500
Mango	500	50,000	600	300,000	250,000	500
Pawpaw	70	3,500	250	17,500	14,000	400
Pear	100	5,000	300	30,000	25,000	500
Sour sop	100	5,000	300	30,000	25,000	500
Oil palm	2000	100,000	300	600,000	500,000	500
Guava	70	3500	200	14,000	10,500	300
Ornamental plants (47.62%)						
King palm	2000	100,000	500	1,000,000	900,000	900
Queen palm	2000	100,000	500	1,000,000	900,000	900
Masquerade tree	1000	50,000	300	300,000	250,000	500
Ixora	3000	150,000	300	900,000	750,000	500
Step tree	2500	125,000	500	1,250,000	1,125,000	900
Juja pine	2000	200,000	400	800,000	600,000	300
Flamboyant	500	25,000	500	250,000	225,000	900
Golden palm	1000	50,000	500	500,000	450,000	900
Ficus	2000	100,000	500	1,000,000	900,000	900
Umbrella tree	1000	50,000	550	550,000	500,000	1000
Forest tree (9.52%)						
Gmelina	100	5,000	200	20,000	15,000	300
Teak	200	10,000	200	40,000	30,000	300

Source: field survey, 2020

Table 4 shows the major factor affecting nursery establishment in the study area. The table revealed that only 47.4% of the respondents with variable constraint on inadequate fund. While the remaining constraints listed had mostly severe constraints on major factors affecting nursery establishment as follows: water shortage 51.3%, poor transportation 48.7%, lack of labour 43.59%, lack of technical know-how 43.59, marketing of the products 51.28, high costs of labour 46.2%, and inflation had severe constraints. This result agrees with the finding of Onyekwelu (2001), there is need to reform government policies, incentives, extension service, provision of seeds. Also tackling others problems like inadequate fund, water shortage, inflation and poor transportation during raining season.

CONCLUSION

Based on this study, plant nursery enterprise is a viable means of income in Nigeria, which one can engage in as a mean of self-employment instead of depending on Government for white collar jobs. Most of the nursery operators and owners were young and agile individuals. Twenty-one species; 10 Ornamental species, 9 tree crops species and 2 forest species were identified in the study area. These species were considered indicators of marketable seedlings species in the study area. Employment and income generation were the major reason why most of the respondents engaged in seedlings production. Apart from income generation, nursery as a business is another means of conservation of plant species and it has a great role in the control of environmental problem. The economic analysis from this study shows that the rate of returns (RORT) was high with the highest return on Umbrella tree (N1,000), King palm (N900), Queen palm (N900), Golden palm (N900), Step tree (N900), Flamboyant (N900), and Ficus species (N900). Thus, commercial nursery business in the study area can be greatly improved upon, since it is concentrated mostly in the hands of young individuals. There is great need for adoption of this enterprise in order to reduce unemployment and enhance economic status of the farmers in the study area. It can also be concluded that many of the farmers are however faced with some problems which influence their productions of seedlings production as rightly stated in the results. It is therefore recommended that land acts are to be reformed by government to get more people to engage in seedlings plant production and there is need for Government and NGOs to assist nursery operators with loan to start up or expand the existing nursery business.

Table 3: Factors affecting nursery establishment

S/N	FACTORS	VARIABLES CONSTRAINT	SEVERE CONSTRAINT	MILD CONSTRAINT	NOT A CONSTRAINT
1	Inadequate fund	37 (47.4)	36 (46.1)	5 (6.4)	0 (00)
2	Water shortage	17 (21.8)	40 (51.3)	20 (25.6)	1 (1.3)
3	Poor Transportation	29 (37.2)	38 (48.7)	9 (11.5)	2 (2.6)
4.	Lack of labour	17 (21.8)	34 (43.59)	25 (32.05)	2 (2.56)
5	Lack of technical Know-how	5 (6.4)	33 (42.31)	17 (21.8)	23 (29.49)
6	Marketing of the Products	20 (25.64)	40 (51.28)	10 (12.82)	8 (10.26)
7	High cost of Labour	29 (37.2)	36 (46.2)	11 (14.1)	2 (2.6)
8	Inflation	29 (37.2)	35 (44.9)	13 (16.7)	1 (1.3)

Source: Field Survey, 2020

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ASSESSMENT OF CAPACITY ENHANCEMENT OF YOUTHS AND WOMEN IN TOMATO AND GINGER VALUE CHAIN IN KANO STATE

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ABSTRACT

Tomato and ginger are front line vegetables in Nigeria serving daily culinary and health needs of the populace. However, being highly perishable crops they are exposed to high post-harvest losses. Thus, this underscores the need for strengthening capacity of producers, marketers and processors in order to curb this wastage. A training program was organised with different modules to address identified needs. A total of 67 participants consisting of women and youths (male and female) along the value chain were trained. Majority (64.2%) of the participants were males, within 21-30 years (44.4%) and an average age of 27.7years. Most (68.7%) of the trainees were involved in farming as major occupation with an average of 10 years farming experience (75%). The mean pre-score in tomato production was 1.48±1.599 while the post-assessment score was 2.49±1.561. The pre and post- assessment score in ginger processing was 0.45±0.610 and 0.99±1.022. The result of the t-test showed a significant difference in the knowledge of the participants in tomato production (t= 4.312, p= 0.00), marketing and record- keeping (t= 9.079, p<0.00). Tomato and ginger value chains in Nigeria can be positioned for the desired boost towards achieving economic diversification when capacity of major actors are strengthened.

Key words: Horticulture, value chain, vegetables, spices and capacity building

INTRODUCTION

Vegetables are important for human health because of their vitamins, minerals, phytochemical compounds, dietary fiber content (thehumanisia.com., 2021) and also other health benefits such as: improved digestive health, lower blood pressure, lower risk of heart disease, diabetes control. (WebMd, 2020). Vegetables are considered as protective supplementary food. They produce taste, increase appetite and protect against degenerative diseases. They can neutralise the acids produced during digestion of proteins and fats. (Venkatesh, 2020). Vegetables are an important feature of Nigerian's diet that a traditional meal without it is assumed to be incomplete (Badmus and Yekini, 2011). Vegetable crops are grown in many parts of the world contributing significantly to income security and the nutritive diet of many households. Vegetable crops such as tomatoes, okra, pepper, cabbage etc. are widely cultivated in most part of the Sub-Sahara Africa, particularly by small scale farmers in most states of Nigeria (Adeolu and Taiwo 2009; Giroh et al., 2010). In Nigeria, vegetable production has been on-going for decades, providing employment and income for the increasing population especially during the long dry season. However, production is constrained by inadequate infrastructure, agronomic and socio-economic variables (Sabo and Zira, 2009).

Spices on the other hand are dried seed, fruit, root, bark or vegetative substance used in nutritionally insignificant quantities as a food additive for the purposes of flavoring. (NIHORT, 2009). They are functional foods, that can be demonstrated to have a beneficial effect on certain target functions in the body beyond basic nutritional requirements (Lobo et al., 2010). Spices occur in a variety of flavor, color, and aroma contributing a wide range of nutrients to foods (Mann, 2011). They enhance and complement flavor in foods with no detrimental effect on the organoleptic quality of the food (Kaefer and Milner, 2011).

Tomato is a very healthy crop used to prepare so many delicacies in Nigeria which makes it an important crop in Nigeria. While some eat it raw, others use it to cook stew, jollof rice, salad, and so many other delicacies. (Agricincome.com, 2019). Tomato value chain development is one of the best agricultural investment option in the country due to high demand and guaranteed good returns on investment. Commercial tomato production has contributed to employment in the country (Infoguide Nigeria, 2021).

Ginger is one of the important crops for export, food and nutrition security in Nigeria. The Nigerian ginger has been adjudged one of the best in the world, and is highly regarded in the international market for its quality and highly medicinal value. Specifically, its aroma, purgency and high oil and aleoresin content are other distinct features of ginger products from Nigeria.The active ingredient, gingerol is known to help fight infections, lower blood sugar and reduce heart risks. It is also used in the brewery/beverage, cosmetic and the cooking industries (Statistics,2020).

Nigerian farmers can tap into the $3billion global ginger market to earn foreign exchange as the country explores opportunities to grow its non-oil exports opportunities. Nigeria's ginger production is put at 31 million metric tons while demand is put at 65 million MT, leaving a supply-demand gap of 34 million MT. According to Egugozie,2021 the overall policy objective of the ginger production programme includes increase in productivity and to promote small, medium and large-scale (SME) commercial production of the crop. Globally, the face of the farmer has been changing over the past 30 years to reflect rural demographics, as well as evolving gender and generational dynamics. Women in developing countries produce 80% of household food (World Bank, 2014) and play a key role in household food security (Meinzen-Dick et al., 2011). Yet women – as well as youth – have less access to productive resources, capital, and fewer opportunities to apply their skills and knowledge (FAO, IFAD & ILO 2010; World Bank & IFPRI, 2010). A significant proportion of rural youth in particular are underemployed or unemployed, have marginal income, or limited career prospects (AGRA, 2015; Bennel, 2007). Thus, there is a pertinent need to build capacity of stakeholders to enable them key into economic diversification plan of the Federal Government. A training program was therefore organised for unemployed youths and women with the overall aim of enhancing capacity of trainees on tomato and ginger production and value addition, and with the following specific objectives:

1. To determine pre and post training knowledge of participants.
2. To identify socio-economic characteristics of respondents

MATERIALS AND METHODS

The training and empowerment program was organised for selected beneficiaries in Bagauda, Kano State, North West agricultural zone of Nigeria. Crops of focus which were tomato and ginger had comparative advantage in the zone. Training modules included improved nursery practices of tomato, value addition of tomato and ginger and record keeping. Sixty-seven trainees comprising unemployed youths and women along the value chain were trained. Structured questionnaires were used to elicit information on social characteristics, pre and post knowledge of participants. Data obtained was subjected to descriptive and inferential statistics.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Most (67.2%) of the respondents were from Kano state followed by Kaduna (31.4%) while only very few of the respondents were from Kebbi and Taraba states (1.5%). Majority of the participants were within 21-30 years with an average age of trainees of 27.7years. This is an indication that the trainees are young, and may be open to innovations in agricultural value chain development. Most (64.2%) of the participants were male while 35.8% were female. This indicates the dominance of the male folks in the tomato and ginger value chain. This is expected considering the cultural practices in the area in which men are actively involved in agricultural value chain. Almost all the respondents were educated with one form of education. Most (47.8%) of the trainees had tertiary level of education, secondary (41.8%) and primary (9.0%). The education level may help them to understand improved practices in agricultural value chains. Most (50.7%) of the respondents were single with a family size of <5 and 6-10 persons in their respective households (39.5%). The major occupation of the participants was farming (68.7%), student (14.9%) and 11.9% of the trainees were unemployed. Most of the trainees had 6-10 years of farming experience with an average of 10 years. More than half (53.7%) of the trainees belonged to society such as cooperative society (Table 1)

Pre and post training knowledge of trainees

The mean pre score in tomato production was 1.48±1.599 while the post-assessment score was 2.49±1.561 indicating an increase in knowledge of the trainees in tomato production. The pre and post-assessment score in tomato marketing and record-keeping was 0.99±1.981 and 5.57±3.594. An increase in knowledge was also observed on aspects taught in ginger value chains. The pre and post- assessment score in ginger processing was 0.45±0.610 and 0.99±1.022. There was also an increase in the knowledge of the participants in ginger marketing and record keeping. The overall pre assessment score was 5.13 while the post score was 16.64. This showed improvement in the knowledge of the trainees in tomato and ginger value chains (Table 2).

Table 1: Distribution of respondents according to their socio economic characteristics

Socio economic characteristics	Frequency	Percentage %	Mean
State of respondents			
Kaduna	21	31.4	
Kano	44	67.2	
Kebbi	1	1.5	
Taraba	1	1.5	
Age of respondents			
≤20 years	19	28.4	
21-30 years	30	44.4	
31-40 years	12	18.0	27.7
41-50 years	3	4.5	
51-60 years	3	4.5	
Sex of respondents			
Male	43	64.2	
Female	24	35.8	
Highest educational level			
Primary	6	9.0	
Secondary	28	41.8	
Tertiary	32	47.8	
Others	1	1.5	
Marital status			
Single	34	50.7	
Married	33	49.3	
Family size			
≤5 person	24	39.5	
6-10 person	24	39.5	7
11-15 person	6	9	
16-20 person	3	4.5	
Nil	10	14.9	
Religion			
Christianity	17	25.4	
Islam	50	74.6	
Major occupation			
Farming	46	68.7	
Trading	2	3.0	
Civil servant	1	1.5	
Student	10	14.9	
Unemployed youth	8	.11.9	
Other income generating activities			
Trading			
Farming	11	16.4	
Artisan	34	50.7	
Nil	3	4.5	
	19	28.4	

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Years of farming experience ≤5 years 6-10 years 11-15 years 16-20 years 21-25 years 26-30 years 31-35 years	 23 27 5 6 3 2 1	 34.5 40.5 7.5 9.0 4.5 3.0 1.5	10
Membership of society No Yes	 31 36	 46.3 53.7	

Source: Field survey, 2019

Table 2: Mean Score of participants in Tomato and Ginger value chains

Items taught	Mean/Standard deviation Pre Score	Mean/ Standard deviation Post Score
Tomato production	1.48±1.599	2.49±1.561
Tomato marketing and record keeping	0.99±1.981	5.57±3.594
Ginger processing	0.45±0.610	0.99±1.022
Ginger marketing and record keeping	2.07±2.771	6.75±4.561
Total score	5.13±4.448	16.64±9.184

Source: Field survey, 2019

Test of difference between pre and post training knowledge of participants in tomato and ginger value chain

The result of the t-test showed a significant difference in the knowledge of the participants in tomato production (t= 4.312, p= 0.00), marketing and record- keeping (t= 9.079, p<0.00) (Table 3). This indicated an increase in knowledge of the trainees in tomato production and marketing. A significant difference was also observed in the knowledge level of the participants in ginger processing (t=4.029, p<0.00) and ginger marketing (t= 8.068, p=0.00). There was also a significant difference in the overall knowledge score of the participants (t=9.784, p=0.00). This indicated improvement in the knowledge of the participants in the commodities value chain. Olajide-Taiwo *et al*, (2018) also observed a significant difference in participants' knowledge after training on ginger and turmeric value chains. Chang (2015) also emphasized that most of the issues in agricultural value chains may be addressed by equipping smallholder farmers with the necessary skills through education and training. Loiruck (2013) stressed the importance of skills, technical and financial support in enhancement of agricultural production.

Table 3: T test of difference between pre and post training assessment score among the trainees

Variables	Mean	Standard deviation	Standard error mean	T value	DF	Sig value
Post score vs pre score tomato production	1.015	1.927	0.235	4.312		0.00**
Post score vs pre score tomato marketing and record keeping	4.582	4.131	0.505	9.079		0.00**
Post score vs pre score ginger processing	0.537	1.092	0.133	4.029	S	0.00**
Post score vs pre score ginger marketing and record keeping	4.672	4.740	0.579	8.068	66	0.00**
Post total score vs total pre score	11.507	9.627	1.176	9.784		0.00**

Source: Field survey, 2019 **Significant at 1%.

CONCLUSION AND RECOMMENDATION

The study concluded that majority of the participants were indeed youths and males with one form of education or the other. They were experienced in farming as well as marketing and processing depending on which of the value chain they are involved in. There was an increase in the knowledge of the respondents on tomato production, marketing and record keeping. In the same vein there was increase in knowledge of ginger production across the value chain. Therefore, specialized training programs should be incorporated as part of economic diversification package so as to increase the knowledge and skill of the stakeholders involved in horticultural value chains to boost their livelihoods.

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MARKETING OF RAW CASHEW NUTS FOR INCOME GENERATION AMONG FARMERS IN KOGI STATE OF NIGERIA

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ABSTRACT

Marketing of raw cashew nuts (RCNs) in Nigeria is not properly coordinated due to the activities of middle men and liberalization policy on commodity crops. This results in market failure and reduction in price of nuts thereby affecting farmers' income. The study addressed marketing problems of raw cashew nuts in order to enhance farmers' livelihood. A multistage sampling procedure was adopted to purposively select 132 cocoa farmers from Dekina, Ofu and Ankpa Local Governments Areas of Kogi State. Data were collected with interview schedule and analysed using descriptive and inferential statistics. The mean age of respondents was 44 years. Majority (61.3%) of the respondents sold 80kg bag of raw cashew nuts for between N50,000-59,000 in 2017, 34.9% sold at N30,000-39,000 in 2018 and majority (90.1%) sold below N20,000 in 2019. This suggests a sharp drop in the prices of RCNs. Fraud from local buyers and absence of organized market were found to be major factors affecting marketing of RCNs. A significant relationship exists between the activities of middle men buying raw cashew nuts and income realized from sales of cashew nuts by farmers ($r=0.146$, $p=0.038$ at $p\leq0.05$). The role of the middlemen in the cashew marketing process is responsible for low pricing of RCNs which reduced the income accruable to farmers. Recommendation was that the National Cashew Association of Nigeria and the Federal Government should help monitor the activities of middle men during marketing.

Key words: Marketing, raw cashew nuts, farmers, Kogi State

INTRODUCTION

Agricultural marketing is the performance of all the activities involved in the flow of agricultural products and services from the initial points of production until they reach the hands of the ultimate consumers. Poor trading systems of some crops and their products partly leads to the inherent inefficient agricultural commodity marketing in Nigeria. Cashew earned Nigeria N144.7 billion ($402 million) from the export of raw cashew nuts (RCNs) to Vietnam and other countries in 2017 and the country exported 220,000 tonnes of RCNs in 2017 (Adeniji, 2018). This is about 90 percent of its total production when compared with 160,000 tonnes exported in 2016. Nigeria produced between 200,000 to 240,000 MT of raw cashew nut annually while 20,000 MT are processed within the country (AgWeek, 2020). Nigeria is a major and growing player in the cashew industry with rising market share in global cashew production, with an annual average production increase of 5% (NEPC, 2018). The export value of cashew nuts supplements the income of about 50,000 farmers and an additional 55,000 people who are employed along the value chain (Adeigbe *et al.,* 2015). Cashew nuts worth N5.26 billion were exported in Nigeria in the fourth quarter of 2020.

The marketing of RCNs involves several players and channels in the value chain. Major players consist of farmers, local buying agents, processors, exporters, sub sector associations, cooperative societies and other service providers. It starts from the sale of raw cashew nuts by gatherers and farmers to the local buying agents, retailers, wholesalers, processors and the exporters. Majority of raw cashew nuts are exported. There are around 11 Nigeria based exporters of raw cashew nuts. They buy nuts from licensed buyers and exporters, make arrangements with License Buying Agents (LBAs) in different locations before start of a new cashew season. Olam Nigeria Limited is the largest exporter of cashew from Nigeria that accounts for more than 30% of the total raw nuts exports. Century Exporters Ltd, Elephant Group, Colossus Investments and ITP Ltd are the other emerging raw cashew nuts exporters among others. The marketing of raw cashew nuts is not well organized in Nigeria due to the activities of middle men and the liberalization policy of the commodity value chains. This results in market failure and price volatility. Market failure is a condition in which a market does not efficiently allocate resources to achieve the greatest possible consumer satisfaction. It manifests in four forms; public good, market control, externality and imperfect information (NSW Market failure guide, 2017). In Nigeria, foreigners' encroachment at the farm gates is posing serious limitations in the proper marketing of cashew nuts. Foreign buyers are mostly exporters which influences the local buyers to exploit the farmers. This has led to price chaos that destabilises the procurement system and improper post-harvest practices particularly drying of raw nuts.

Farmers are compelled to sell their nuts to buyers at reduced prices dictated by local traders. However, products of cashew tree (kernel and apple) are grossly under utilised for income generation, food and nutrition security. In Nigeria, farm gate price of traded nuts in 2021 lies between 380-450 Naira per kg (AfriCashewSplits, 2021). However, the aforementioned price range is a bit better than the situation two years back when cashew was sold at around N20,000 per 80kg bag which discouraged most cashew producers. This study was demand driven because of recent interaction with cashew farmers in Kogi State. The farmers complained of low pricing of raw cashew nuts, search for reliable buyers during harvesting. In the 4th edition of the World Cashew Convention and Exhibition held in Macau China 2018, it was reported by Adeniji that Nigerian farmers were among those paid low price for RCNs when compared with other major producing countries. If this trend and imbalance continues, farmers will shift attention from cashew production to other businesses and this will affect market supply. This scenario is likely to lead to drop in quality and destroy the overall value chain of cashew.

It is against this backdrop that the study was designed to address the factors affecting marketing of raw cashew in order to enhance income of farmers in their farming enterprise.

The specific objectives were to:

1. Describe the socio-economic characteristics of farmers in the study area.

2. Examine income generation trend of farmers from raw cashew nuts.

3. Investigate the factors faced by farmers in marketing of raw cashew nuts.

Statement of Hypothesis: H_O: There is no significant relationship between the activities of middle men buying raw cashew nuts and income realised from the sales of cashew nuts by farmers.

MATERIALS AND METHODS

Study Area: The study was conducted in Kogi State and it is well known for cashew production. Other farm produce grown include: cocoa, oil palm, maize, cassava, yam, melon and rice. Agriculture is the mainstay of the state with capital at Lokoja. The State is located on the intersecting point of longitude 70 49'N and latitude 60 44'E on the map of Nigeria. Kogi State Government (2021).

A multistage sampling technique was adopted. Kogi State was chosen because it is the highest cashew producing State in Nigeria. The next stage was to select three Local Government areas from the eastern zone of the state due to the high concentration of cashew production and marketing activities in these areas. A systematic random sampling was used to select 48 farmers from Dekina, 44 from Ofu and 40 from Ankpa Local Government areas based on a list of cashew production from the Kogi State branch of the National Cashew Farmers Association of Nigeria (NCAN). Farmers were selected from two villages each from the LGAs. In all, 132 respondents were selected. Data were collected from the respondents with interview schedule and analysed using descriptive and inferential statistics.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

Table 1 reveals that greater percentage of the respondents (61.3%) were between the age categories of 31-50 years, while minority of the respondents (21.2%) were above 50 years of age. The mean age of respondents was 44 years. This age distribution implies that most respondents were still in their youthful age in producing cashew. It was discovered that 67.4% of the respondents were males with 32.6% female. Male farmers dominating cashew production is probably due to the nature of intense and time consuming activities. A large proportion of the respondents were married (95.5%). This is expected as majority of the respondents were adults. Thirty percent of the respondents had no formal education while 23.5% and 37.1% had primary and secondary education respectively with 10.6% of the respondents having tertiary education. This result is supported by Adebayo *et al*, (2020). They reported that age and educational qualification had influence on the marketing of raw cashew nuts among cashew farmers in Kwara State of Nigeria. A mean of about 18 years of farming experience was obtained. This shows that cashew farmers in the study area were experienced in the business. The mean household for the farmers was 9 persons with average farm size of 6.6 hectares. Household size provides cheap labour for agricultural activities.

Table 1: Socio-economic characteristics of respondents N=132

Variables	Frequency	Percentage	Mean
Age in Years			44.2
≤ 30	22	16.7	
31-40	40	30.3	
41-50	39	29.5	
51-60	17	12.9	
Above 61	14	10.6	
Sex			
Male	89	67.4	
Female	43	32.6	
Marital Status			
Single	4	3.0	
Married	126	95.5	
Widowed	2	1.5	
Educational Status			
No Formal Education	40	30.3	
Primary Education	31	23.5	
Secondary Education	49	37.1	
Tertiary Education	12	9.1	
Farming Experience in Years			17.5
< 10	35	26.5	
11-20	67	50.8	
21-30	28	21.2	
Above 31	2	1.50	
Household size			9.27
1-5	20	15.2	
6-10	74	56.1	
11-15	27	20.5	
Above 16	11	8.40	
Farm size(ha)			6.65
1-5	72	54.6	
6-10	32	24.2	
11-15	20	15.2	

Source: Field survey, 2019

In Table 2, majority (61.3%) of the farmers sold bag of raw cashew nuts for N50,000-59,000, in 2017, 34.9% of farmers sold bag of cashew for N30,000-39,000 and majority (90.1%) sold bag of cashew below N20,000 in 2019. This is reflected in the mean of N13,607 which is also low for 2019. This suggests that there was a sharp drop in the prices of cashew in the study area in the years under consideration. This is low especially when compared with the cost of production coupled with rising inflation affecting goods and services. The implication of this result could be as a result of major factors identified in this study which was reflected in Table 4. It could also be related to cheap price paid for Nigerian RCNs at the international market. This attests to why Indians and Vietnamese buyers are always in the country during every cashew trade season. The finding was supported by Adeniji (2018) in the 4th edition of the World Cashew Convention and Exhibition held in Macau China.

Table 2: Money sold per bag of raw cashew nuts in 2017, 2018 and 2019

Price per 80kg bag of raw cashew nuts in Naira (N)	2017		2018		2019	
	F	%	F	%	F	%
≤ 20,000	6	4.50	6	4.50	123	93.1
21,000-29,000	1	0.80	34	25.8	2	1.50
30,000-39,000	7	5.30	45	34.1	3	2.30
40,000-49,000	39	29.5	35	26.5	1	0.80
50,000-59,000	78	59.1	9	6.80	2	1.50
≥ 60,000	1	0.80	3	2.30	1	0.80
Mean price (N)	45,780		37,984		13,607	

Source: Field survey, 2019 F= Frequency % Percentage

Factors affecting marketing of raw cashew nuts

The distribution of respondents according to factors determining marketing of raw cashew nuts is shown in table 3. The result revealed that majority of the respondents had mean values of 1.88, 1.80, 1.76, 1.74 and 1.66 which follows the respective order: fraud from local buyers, no organized market for selling cashew nuts, poor marketing information, lack of training on cashew nuts marketing and no value addition to raw nuts as major factors determining marketing of raw cashew nuts in Cross River State. The result suggests that the aforementioned variables impact marketing of raw cashew nuts in the study area. This result is supported by a market information system (MIS) expert with the African Cashew Alliance (ACA), Fitzpatrick, (2021). He reported that poor market information in cashew causes low farm gate prices which affect the income and livelihood of farmers.

Table 3: Factors affecting marketing of raw cashew nuts N=132

Factors	Major Factor		Minor Factor		Not a Factor		Mean
	F	%	F	%	F	%	
a. Fraud/insincerity from local buyers	120	90.9	8	6.10	4	3.00	1.88
b. Poor quality of raw cashew nuts	30	22.7	34	25.8	68	51.5	0.71
c. No value addition to raw cashew nuts	103	78.0	13	9.80	16	12.1	1.66
d. Lack of training on cashew nuts marketing	95	72.0	21	15.9	16	12.1	1.74
e. Poor marketing information	106	80.3	15	11.4	11	8.3	1.76
f. No organized market for selling cashew nuts	113	85.6	12	9.10	7	5.30	1.80
g. Poor farm road network to transport cashew nuts	68	51.5	34	25.8	30	22.7	1.35

Source: Field survey, 2019 F Frequency % Percentage

Activities of middlemen buying raw cashew nuts from farmers

The result of the activities of middlemen buying raw cashew nuts from farmers shows that buyers motivate farmers to sell raw cashew nuts to them coupled with insincerity and buying cashew nuts at lower prices (Table 4). The motivation is in form of providing inputs and loan advance which is a commitment for selling RCNs to the buyers during harvesting season. This system makes farmers to accept whatever price they are offered. This finding is in line with Premium Times (2021) who reported that middlemen decide the priced they are willing to buy cashew nuts from farmers. Also, Fitzpatrick (2021) added that buyers take advantage of the uncoordinated system to exploit cashew farmers by offering them lesser prices for RCNs during purchase.

Table 4: Activities of middlemen buying raw cashew nuts from farmers

Activities of middlemen	Percentage
1. Insincerity of cashew buyers	92.4
2. Buyers motivating farmers to sell raw cashew nuts	98.5
3. Buyers pre-funding cashew farmers	48.5
4. Buying raw cashew nuts at lower prices	97.7

Source: Field survey, 2019

Correlation between activities of middlemen marketing raw cashew nuts and income realised by farmers

The result in table 5, shows that a significant relationship exists between the activities of middle men buying raw cashew nuts and income realized from sales of cashew nuts by farmers. This implies that the more the middle men were insincere in buying cashew nuts from farmers, the lesser the income that will be realized by farmers. This finding is also similar to a study conducted by Adebayo et *al* (2020). They reported that unstable price was a major challenge to cashew marketing in Nigeria. Also, Agbongiarhuoyi *et al* (2020) reported that low prices offered to farmers could affect sustainability of cashew in Nigeria. In terms of household size which was also significant, means that the higher the household size, the more the income that will be used for labour to do cashew farm operations. However, the income realized by farmers in this study was low.

Table 5: Correlation between activities of middlemen marketing raw cashew nuts and income realised by farmers

Variables	r value	P value
Activities of middle men buying cashew	-0.146	0.038**
Household size	0.188	0.009**

Source: Field survey, 2019

CONCLUSION AND RECOMMENDATION

It could be inferred from the study that most cashew farmers had primary and secondary education with small scale farm sizes. The major factors affecting raw cashew nuts marketing of farmers were fraud from cashew buyers, lack of organized market for selling raw cashew nuts, poor marketing information, and lack of training on cashew nuts marketing respectively. The role of the middlemen in the cashew marketing process is responsible for low pricing of RCNs which reduced the income accruable to farmers. It is therefore recommended that NCAN and the Federal Government should help monitor activities of middle men during marketing. They should be empowered by the two bodies to add value to RCNs in order to improve farmers' livelihood.

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ANALYSIS OF WHOLESALE TOMATO MARKETING IN YAMALTU-DEBA LOCAL GOVERNMENT AREA, GOMBE STATE, NIGERIA

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ABSTRACT

The study was carried out to analyse wholesale tomato marketing in Yamaltu-Deba Local Government Area, Gombe State, Nigeria with the objective of estimating the market margin of tomato as well as identify the challenges facing the business. A multistage sampling technique was used to select fifty tomato marketers from the study area. Information was obtained from the sampled marketers through the use of a structured questionnaire. Descriptive statistics and Shepherd-Futrel model for marketing efficiency were used for data analysis. The result revealed that 56% of the respondents were male, married (84.00%) and were between the age of 31 to 50 years (64%) with the mean age of 40 years. Most (60%) of the respondents had less than 10 years of marketing experience in tomato. Marketing analysis result showed that average revenue, cost, gross margin, market margin and coefficient of marketing efficiency were ₦523,264.32, ₦442,452.80, ₦80,811.52, 39.85 and 84.56%, respectively implying that tomato marketing was profitable in the study area. Although the business was profitable, yet it faced some challenges which include perishability, low pricing and seasonality of tomato. Addressing these challenges will further increase the profit made by the marketers.

Key words: Tomato, market margin, efficiency, cost.

INTRODUCTION

Tomato (*Lycopersion esculentum* mill) is one of the leading vegetable crops in Nigeria. The production of tomato in Nigeria increased from about 2, 632,500 tons in 2016 to 3,816,009 tons in 2019, making it one of the highest producing countries in Africa (FAOSTAT, 2019). The crop is of high nutritional values and it is rich in vitamins, mineral and fibre. It is widely used in varieties of dishes as raw, cooked or processed products in Nigeria. Marketing of agricultural produce covers the services involved in moving the products from the farmgate to consumer. It enables farmers as well as middlemen to earn income with which they purchase other useful goods and services (Ebe, 2007). However, marketing of vegetable crops, including tomato, is quite complex and risky due to perishable nature of the produce, seasonal production and bulkiness (Meena and Singh, 2014). Market efficiency is the maximization of input-output ratio in marketing. It can also be defined as the movements of crops and livestock from producers to consumers at lowest cost content with the provision of services consumer desires (Ejiola, 2001). The inputs of marketing are the various resources employing in performing the various marketing services and the costs of these services are marketing costs. While the outputs are the benefits or satisfaction created or value added to the commodity as it passes through the marketing system (Giroh, 2010). Efficiency in marketing is an indication of productive utilization of resources, and, could help to harmonize demand and supply and stimulate production. A market is efficient if the ratio of value of output to value of input is maximized through marketing system (Giroh, 2010). Considerable attention has not been given to marketing of tomato in Yamaltu-Deba Local Government Area, hence, this study was carried out to analyze the wholesale tomato marketing in the LGA. In order to achieve the main objective of the study, the following specific objectives were set. one, to describe the socio-economic characteristics of tomato marketers; two, to determine the index of marketing efficiency; three, to identify the challenges faced by tomato marketers.

MATERIALS AND METHODS

Study Area

The study was carried out in Yamaltu-Deba Local Government Area (LGA), Gombe State. Yamaltu-Deba is one of the eleven Local Government Areas in the State with its headquarters in Deba. According to NBS (2009), the result of 2006 census indicated a population of 255,726 for Yamaltu-Deba LGA. The LGA covers an area of about 1,981 square kilometers and lies at latitude 11^{0}31' N and longitude 11˚24' E with the temperature ranges from 20^{0}C to 31^{0}C. The LGA hosts parts of the lake

Dadinkowa. It shares boundaries with parts of Borno State to the North, Balanga LGA to the South, Gombe and Akko LGAs to the East (Erie *et al*, 2019). Yamaltu-Deba LGA has a vibrant trade sector and hosts a number of markets (Manpower, 2021). The target population was tomato marketers.

Sampling technique

A multistage sampling technique was used in the choice of individual respondent. The first stage was purposive selection of Yamaltu-Deba LGA from eleven LGA in Gombe state. Yamaltu/Deba was selected because it is known for production of tomato and hosts one of the major markets for the commodity in the state. The second stage was random selection of five food markets in the LGA based on size of tomato sales-Kwandon, Dadin-kowa, Zambuk, Deba and Kuri markets. The third stage involved random selection of ten wholesale tomato marketers from each market, making a total of fifty.

Data source and analysis

Primary data were used for this study. Data were collected by the use of well-structured questionnare. Respondents were asked to indicate socio-economic characteristic (sex, age, marital status, educational level, year of marketing experience, quantity purchased and sold, prices, various costs i.e. transportation, stall rent, and challenges encountered in tomato marketing. Data analysis involved the use of descriptive and budgetary analysis. The descriptive analysis was used to analyze socio-economic characteristics of marketers and challenges to tomato marketing (Objectives I and III) while marketing efficiency analysis was used for Objective II. Descriptive analysis involved the use of frequency counts, percentages, mean and charts. In order to identify the challenges faced in tomato marketing, the marketers were asked to indicate the severity of each problem on 3-pont rating scale. The values were assigned to point as follows: Very severe=3, Severe= 2 and Not severe=1. The challenges were ranked based on the mean score. Marketing efficiency was estimated following Shepherd-Futrel model, as used by Ugwumba, 2009 and Layade *et al*, 2017. The model is considered as an accurate measure of marketing efficiency. It is expressed as the coefficient of total cost of marketing to total revenue expressed in percentage term. The coefficient of market efficiency (CME) indicates the percentage of sale revenue absorbed by costs. The lower the CME, the higher the level of efficiency and value added and vice-versa.

$$CME = \frac{TC}{TR} \times 100 \quad \text{...(1)}$$

Where,

CME= Market efficiency

TR=Total Revenue

TC=Total Cost

RESULTS AND DISCUSSION

Socio-economic characteristics distribution of respondents

Findings in table 1 revealed that most of the marketers were within the age range of 31-50years with mean age of 40years. This is an indication that tomato marketing in the study area enjoys involvement of young matured persons who can engage in marketing activities of tomato. Fifty-six percent of the respondents were male, indicating that men engage more in the wholesale marketing of tomato in the study area. This is in conformity with finding of Adeoye and Ibe (2015) who reported that 67.5% of the wholesale tomato marketers were male. Over 84% of those engaged in tomato marketing were married, implying that most of the respondents have responsibilities. 70% of the respondents had formal education while 30% did not. The result indicates that majority of respondents were literate and this could assist them in effective communication in doing their business (Asogwa and Okwoche, 2012). In term of experience, 60% had between less than 10 years in the business, indicating a relatively high knowledge in tomato marketing. This suggests that year of experience in tomato marketing will help the marketers to envisage, understand and manage the risk in business. Similarly, the result is in support of Nse-Nelson *et al* (2016) who stated that the greater the year of marketing experience, the more knowledgeable the marketer in minimizing costs and maximizing the benefits.

Table 1: Socio-economic characteristics of tomato marketers in the study area

Variable	Frequency	Percentage
Sex		
Male	28	56.00
Female	22	44.00
Total	50	100.00
Marital status		
Single	08	16.00
Married	42	84.00
Total	50	100.00
Age (years)		
Less than 21	02	04.00
21-30	08	16.00
31-40	14	28.00
41-50	18	36.00
51-60	07	14.00
61-70	01	02.00
Above 70	-	-
Total	50	100.00
Mean≈40		
Educational level		
No formal education	15	30.00
Primary education	14	28.00
Secondary education	14	28.00
Tertiary education	07	14.00
Total	50	100.00
Years of experience in tomato marketing		
Less than 10	30	60.00
10-19	12	24.00
20-29	05	10.00
30-39	01	02.00
Above 39	02	04.00
Total	50	100.00

Source: Field survey, 2020.

Cost and return analysis of tomato

In table 2, Coefficient of marketing efficiency obtained indicates that 84.56% of the total revenue was absorbed by marketing cost. This implies that the marketing efficiency in the study area is low (15.44%). It could be further inferred that the value added was 15.44% and this is the productivity of resources invested in the tomato marketing. In order to increase efficiency of fresh tomato marketing system in the study area, those measures that will increase revenue and reduce marketing cost could be adopted.

Table 2: Summary of Costs and return of tomato per month

Variable	Amount
Average Quantity Sold (kg)	6824
Average price of tomato per kg	76.68
Average Total Marketing Cost (₦)	442,452.80
Average Total Revenue (₦)	523,264.32
Gross Margin (₦)	80,811.52
Market margin (%)	39.85
Coefficient of Marketing Efficiency (%)	84.56

Source: Calculation from field survey data 2020.

Challenges facing okra marketing

In table 3, the challenges experienced by tomato marketers in descending order are high perishability nature of tomato, low pricing, insufficient capital for their business, inadequate supply due to seasonality, and high transportation cost. Perishability remains one of the major problems of agricultural produce which makes it difficult to keep fresh the produce for long period and this is also linked to problem of seasonality (Nse- Nelson, 2016). Measures to ameliorate these problems should be implemented by relevant authorities.

Table 3: Challenges facing tomato marketing in the study area

S/N	Challenges	Not severe	Severe	Very severe	Mean score	Standard Deviation	Mean rank
1	High perishability nature of tomato	16(32.00)	25(50.00)	9(18.00)	1.84	0.69	1st
2	Low pricing	18(36.00)	27(54.00)	5(10.00)	1.74	0.63	2nd
3	Insufficient capital for business	26(52.00)	18(36.00)	6(12.00)	1.60	0.69	3rd
4	Seasonality	29(58.00)	15(30.00)	6(12.00)	1.54	0.71	4th
5	High transportation cost	32(64.00)	17(34.00)	1(2.00)	1.38	0.53	5th

Source: Field survey, 2020.

CONCLUSION

The study revealed a low marketing efficiency in the study area, as larger percentage of their revenue is gulped by costs of marketing. In order to increase efficiency of fresh tomato marketing system in the study area, efforts should be targeted towards increasing efficiency of tomato marketing system in the study area by putting in place measures that will increase revenue and reduce marketing cost.

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EFFICIENCY OF COFFEE MARKETING AND FARMERS LINKAGE IN NIGERIA

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ABSTRACT

The study investigated the efficiency of coffee marketing and farmers Linkage in Nigeria, two local government areas of kogi state were purposively chosen and data from thirty coffee farmers in each of the local government where collected using structured questionnaire and focused group discussions. Result analysis show that majority are male (90.2%) and of average age of 69years and most has no formal education. The farms are old and most of them have over 50years of farming experience. Most of them sold to coffee agent buyers who buy at critical low price. There is low demand for coffee due to low price and low quality of coffee produced. The price offered, the perceived amount by farmers and the buyers are critical factors that affect market efficiency of coffee. Furthermore, there is little or no efficiency in the marketing of coffee in the study area. Good and efficient market should be organized for the farmers as well as educate and encourage the youths to go into coffee production.

Key words: Coffee farmers, efficiency, market, coffee buyers

INTRODUCTION

Coffee is rated second in trade volume in the world after oil nevertheless; records have shown that the Productivity level and income in the Nigeria coffee farm household have been too low over the years. Coffee growing and drinking started in Ethiopia in the 9th century. Today, it is an important commodity and a popular beverage in the world. Over 2.25 billion cups of coffee are consumed in the world every day (Ponte Stefano, 2002). Over 90% of coffee production takes place in developing countries, while consumption happens mainly in the industrialized economies. Worldwide, about 25 million small producers rely on coffee for a living. In spite of coffee demand globally and known to be second to oil in world trade volume and despite over 110 varietal coffee plants available in the Mambila plateau, Nigeria coffee production has been on decline over the years as compared with her counterpart producing countries whose output has been on the increase (Lewin et al., 2004). Statistics also shows that coffee contribution to Nigeria's agriculture has been on decline ICO (2015). A study carried out on West and Central Africa coffee production shows that while Cameroon and Côte d'Ivoire produce 48,240 tons from 175,000ha of land and 171,000 tons from 480,000ha respectively, Nigeria records 5,400tonnes from a 3,750ha. A critical factor in the rather low and declining coffee productivity in Nigeria is a serious lack of market demand for Nigeria coffee, which is a critical factor in the stimulation of coffee production in Nigeria. Furthermore, the coffee marketing in Nigeria has been found to be inefficient due to small buyers of coffee who influence coffee price at the detriment of the farmers, also lack of adequate financing, imperfect market information, low quality coffee/ quality differentiation among others are the determinant factors affecting the efficiency of coffee marketing in Nigeria (Ayoola, 2012).

Nestlé Nigeria dominates coffee sales in Nigeria. The company's Nescafé is popular among coffee consumers in Nigeria because it was the first coffee brand in the country and has built up strong brand loyalty. These attributes gave the company a dominant 84% share of off-trade volume sales in 2011(Euromonitor international, 2012). As such there is the need to collaborate with the company and with government intervention through CRIN to form a good link between the processors and manufacturers and farmers so as to make the coffee market more efficient and thus making coffee production more desirable. Nigeria is blessed with the natural and human resources to produce coffee. Low market demand for coffee is believed to have led to the abandonment of coffee plantation in Nigeria. It is the lack of understanding of the efficient market for coffee produced in Nigeria that necessitates this study.

Against the above background therefore, the study seeks to:

1. Ascertain the various factors that are affecting the efficiency of coffee marketing in Nigeria, with

the bid to increasing coffee output and enhancing the livelihood of the farmers

2. Determine the socioeconomic characteristics of the coffee farmers in the study area

3. To make policy recommendations that will enhance coffee demand in Nigeria and put the country on top as one of the coffee producing nation, particularly that there exists a great potential in natural and human resources for achieving such fit.

MATERIALS AND METHODS

Kogi State was purposively chosen for the study. The study is targeted at coffee producers in the chosen State. In carrying out the study, primary data was used in collecting relevant data through questionnaire administration and focus group discussion. Two local governments (kabba and Ijumu) were purposively sampled in the state. Thirty coffee producers were randomly sampled in each of the local government to make a total of sixty respondents. The data collected were analyzed using both descriptive and quantitative method of analysis

Data Analysis

Descriptive Statistics (mean, standard deviation and simple frequency tables), was used in the analyses of the socio-economic variable and agronomic practices while partial correlation analysis was used to ascertain the factors that affects the market efficiency of coffee marketing in the study area.

DISCUSSIONS

Table 1 show the socioeconomics characteristics of the coffee farmers in the study area. Results analyzed shows that majority (90.2%) of the respondents are male farmers and most of them (31.1%) only acquire adult education. This implies that most do not have formal education therefore may not readi.ly adopt new innovation improving coffee production. Of the total respondents, 73.8% constituting the majority farms both cash and arable crops. This has to a very large extent help in improving the livelihood and food security of the farmers. The result further shows that most (61.3%) of the coffee farmers have between 21-30ha of coffee farms. However, most of the plots are not optimally utilized for coffee production mainly due to low coffee demand. Majority are primarily farmers with an average age of 69 years of age and with majority (54.1%) having farming experience of above 50 years. This shows that most of the farmers are aged and well above productive age hence low coffee productivity for coffee in the study area. These findings corroborate with Ayoola (2012) that the majority of the coffee farmers (about 53 percent) were above the age of 50 years and about 72 percent had been involved in coffee production for at least 15 years and none of the farmers had any formal training in coffee production. This equally indicate the reason for the low outputs of which majority produce between 1-5bags of 80kg jute bags between the 2016-2018 cropping season.

Most (29.5%) of the farmers source their coffee seedlings from the agricultural development project (ADPs) hence the agency is much closer to the farmers as compared to other agencies such as IITA, CRIN etc. Further analysis indicates that most (43.2%) of the farmers are faced with the problem of low demand for their coffee while (38.3%) attest to the fact that low/poor price of coffee was a major reason for low production. Farmers therefore where not motivated to produce coffee due to low demands for farmers' coffee and which is as a result of poor quality of processed coffee (most of the farmers practiced dry coffee processing of which wet processing is highly desirable) this also adduced to the fact that majority could not sell their coffee produce.

Furthermore, the result on table 1 shows the descriptive statistic of the farmers. The table shows that the farmer receives between an average of sixty-four naira and ninety-five naira on a kilogram of coffee between the 2016-2019 seasons. This is far low compared to the international coffee price and could therefore not compensate for farmers' expenses in the coffee production and processing.

Table 2 shows the correlation analysis carried out to show that the amount coffee farmers receives has significant effect on the distance to market at 1% level of significance implying that the farmers really go to market due to far distance (3-5km) and perhaps old age (average of 69 years), hence there are chances that the farmers receives low price for the coffee hence showing in efficiency in the marketing of coffee. Furthermore, the correlation between who buys coffee and the amount offered is significant at 10% while the perceived reasonable amount by farmers and the farmer's age is significant at 1% indicating a very strong variable affecting the efficiency of coffee marketing. Thus the marketing of coffee is not as efficient as expected due to the critical factors affecting the farmer's price for coffee, unorganized market, age of farmers etc.

Table 1: The Socio-Economic Characteristics of the Coffee Farmers

Frequency Table		
Socio Economic Characteristics		
Variable	Numerical Values	Percentage
Gender		
Male	55	90.2
Female	6	9.8
Total	60	100
Educational level		
Primary education	16	27.8
Secondary education	14	23.0
Tertiary education	11	18.0
Adult education	19	31.1
Total	60	100
Primary occupation		
Farming	45	73.8
Artisan	8	14.7
Civil Servant	7	11.5
Total	60	100
Farm size		
1-10ha	5	8.2
11-20Ha	4	6.6
21-30ha	38	61.3
31-40ha	12	19.7
Above 40ha	2	3.3
Total	60	100
Age of farm		
1-5 YEARS	12	19.7
5-10YEARS	17	27.9
10-15YEARS	18	29.5
15-20YEARS	3	4.9
20-25YEARS	11	18.0
Total	60	100
Farming experience		
1-10YEARS	5	8.2
11-20YEARS	4	6.6
21-30YEARS	5	8.2
31-40 YEARS	8	13.1
41-50 YEARS	6	9.8
ABOVE 50 YEARS	33	54.1
Total	60	100
Source of coffee materials planted		
CRIN	12	19.6
IITA	11	18.0
ADP	18	29.5
FELLOW FARMERS	10	16.4
CHEMICAL MARKET SELLERS	10	16.4
Total	60	100
Problems farmers are facing		
Low Coffee Products/Materials	6	9.8
Lack of Credit Facilities	13	21.3
Low Market Demand	27	43.2
Lack of Modern Processing Equipment	9	14.8

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OTHERS	5	8.2
Total	60	98.4
What responsible for low coffee sales		
Government policy	16	26.6
Low Coffee Price	23	38.3
No Enough Buyers	16	26.6
Rejection Due To Poor Quality	5	8.3
Total	60	100
Average Quantity of coffee produced		
1-5BAGS	35	57.4
5-10BAGS	11	18.0
10-15BAGS	13	21.3
15-20BAGS	1	1.6
Total	60	98.4
System	1	1.6
Total	61	100.0
Descriptive Statistics		
	Mean	Std. Deviation
Price per kilo 2016	67.1667	90.44320
Price per kilo 2017	87.5000	136.11592
Price per kilo2018	94.6667	110.90486
Age	68.7000	14.13530

Table 2: variables affecting marketing efficiency of coffee farmers

		age	gender	buyers	Perceived reasonable price	Price/kilo 2018	Distance from market	Educational level	Size of farm
Age	Correlation	1.000	-.384	-.055	.393	-.094	.235	-.113	-.035
	Significance (1-tailed)	.	.001	.339	.001	.240	.036	.197	.395
	df	0	57	57	57	57	57	57	57
Gender	Correlation	-.384	1.000	-.042	-.322	-.037	-.207	-.330	-.258
	Significance (1-tailed)	.001	.	.376	.006	.389	.058	.005	.024
	df	57	0	57	57	57	57	57	57
Buyers	Correlation	-.055	-.042	1.000	.086	.188	-.188	.152	.002
	Significance (1-tailed)	.339	.376	.	.258	.077	.077	.125	.495
	df	57	57	0	57	57	57	57	57
Perceived reasonable price	Correlation	.393	-.322	.086	1.000	.159	.088	-.003	.051
	Significance (1-tailed)	.001	.006	.258	.	.114	.254	.491	.351
	df	57	57	57	0	57	57	57	57
Price/kilo 2018	Correlation	-.094	-.037	.188	.159	1.000	-.377	.066	-.207
	Significance (1-tailed)	.240	.389	.077	.114	.	.002	.309	.057
	df	57	57	57	57	0	57	57	57
Distance from market	Correlation	.235	-.207	-.188	.088	-.377	1.000	-.092	.157
	Significance (1-tailed)	.036	.058	.077	.254	.002	.	.245	.117
	df	57	57	57	57	57	0	57	57
Educational level	Correlation	-.113	-.330	.152	-.003	.066	-.092	1.000	.104
	Significance	.197	.005	.125	.491	.309	.245	.	.217

	(1-tailed)								
	df	57	57	57	57	57	57	0	57
Size of farm	Correlation	-.035	-.258	.002	.051	-.207	.157	.104	1.000
	Significance (1-tailed)	.395	.024	.495	.351	.057	.117	.217	.
	df	57	57	57	57	57	57	57	0

CONCLUSION AND RECOMMENDATION

The study carried out shows that the coffee farmers has no organized and efficient market for their coffee and this has affected the price /amount the farmer receives for coffee per kilogram and thus by extension low coffee production. It is therefore recommended that government /agencies should help in the organization of good market for the farmers, encourage youths to go into coffee since there is high demand globally as well as provide extension training for the farmers furthermore, price sensitization is highly recommended for the farmers through there cooperatives and extension agents.

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NIGERIA COFFEE FARMERS' SKILL GAP ANALYSIS ON COFFEE PROCESSING: IMPLICATION TO EFFECTIVE MARKET DRIVE

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ABSTRACT

This study was conducted to examine the skill gap in appropriate coffee processing method among coffee farmers in Nigeria and deduce effective method for good market drive. Specifically, the farmers' socio-economic characteristics were identified with their knowledge and practices in three processing methods available. Two hundred and twenty twenty-five (225) coffee farmers were randomly selected and interviewed through the use of structured interview schedule, from five coffee producing states. Frequency counts and percentages were used in describing the data collected, while Pearson's Correlation Co-efficient (r) was used to determine the relationship between their knowledge and practice of the processing methods in use. Prominent practice sequence in the appropriate processing method (wet processing) revealed; harvesting (100%), sorting (87.6%), pulping (15%), soaking (15.8%), washing (16.2%) and drying to12% Moisture Content (74.5%). However, the following knowledge in processing methods were revealed; wet processing (18%); semi wet processing (25%) and dry processing (85%). More so, the study revealed positive and significant relationship (r=.181; p<0.01) between the knowledge of processing method and practice. It was however deduced that the major problem of coffee marketing is inadequate knowledge in appropriate wet processing method. Hence there is a skill gap in the knowledge of wet processing. More training on wet processing method is required for Nigeria Coffee farmers to compete favourably in the World Market.

Key words: Coffee, Skill gap, Processing, and Market

INTRODUCTION

The genus *Coffea* contains more than 100 species, only two of which, *Coffea arabica* L (*Arabica* coffee) and *Coffea canephora* Pierre (*Robusta* coffee) are commercially cultivated. It is an economic important crop grown in over 70 countries of the World and consumed throughout the world (Opeke, 2012). In Nigeria, Arabica and Robusta coffees account for about 4% and 94% of the total production respectively (Alli; *et al*, 2021). Coffee is one of the major cash crops produced in Nigeria for which very little information is available. In this circumstance, the International Coffee Organization (ICO) and other related organizations have for long been basing the production, processing methods and export figures for Nigerian coffee on mere estimates and assumptions. However, the production is faced with soil depletion, prevalence of pests and diseases, inappropriate processing technology, which has resulted in poor marketing and consequently led to abandonment by farmers. Improper post-harvest processing and poor handling of coffee have been identified as the major cause of poor coffee quality which leads to the problem of coffee marketing in Nigeria. As a result of poor marketing, the income of the coffee farmers has drastically reduced. Hence, many of the coffee farmers have either abandoned their farms or replaced coffee plants with other economic crops (such as castor oil plants). Coffee bean of lower quality cannot attract good premium in the coffee international market. In fact, in actual coffee market crisis, quality is the best guarantee for negotiating a better price. It is estimated that 40% of the quality of coffee is determined in the field, 40% at the post-harvest primary processing, and 20% at secondary/export processing and handling including storage. In order to enhance quality and market value of Nigerian coffee, improved primary processing by the farmers at the village level is a prerequisite (Kamard and Kalita, 2017).

There are three major Coffee processing methods that determine the qualities of coffee beans for the World Market (CoffeeAM.com, 2021).

a. Processing by the Wet Method: This involves harvesting, sorting, pulping, soaking in water (wet fermentation), washing, and drying to moisture content of about 12%.

b. Processing by the Semi- Wet Method: This involves harvesting, sorting, pulping, heaping in basket (dry fermentation), washing, and drying to moisture content of about 12%.

c. Processing by the Dry Method: This involves harvesting, sorting and drying to moisture content of about 12%.

Justification

Despite the favourable climatic conditions, and long history of Robusta production in Nigeria, green coffee beans quality is declining from time to time due to improper pre-and post-harvest management practices. At this backdrop, it is important to determine the skill gap in processing among Nigeria coffee farmers to enhance quality coffee bean for a sustainable coffee production and improved livelihood.

Objectives

1. Identify socioeconomic characteristics of respondents

2. Ascertain respondents' knowledge on three processing methods of coffee

3. Establish respondents' coffee processing method

4. Determine the constrains faced by respondents in practicing wet processing method in the study area

MATERIALS AND METHODS

Thirteen states are known for coffee production in Nigeria. Though it has been established that all the 22 states where cocoa is being grown can also grow coffee, hence the remaining nine are considered as emerging states (CRIN, 2010). For the purpose of this study, 13 states are considered as the growing States. Multistage sampling procedure was engaged in selecting the respondents:

Stage 1: Five states were purposively selected from the 13; Ekiti, Kogi, Osun, Plateau and Taraba states, being areas currently known for coffee growing on commercial level

Stage 2: During Cocoa Research Institute of Nigeria sensitization program in each of the State, 45 respondents were randomly selected from the list of attendance using the first 45 odd numbers. The data were subjected to descriptive analysis and Pearson Correlation to determine relationship between knowledge and practice of the farmers processing method.

Skill gap analysis was carried out by identifying the respondents' level of skill as against the appropriate stages of wet processing methods.

RESULTS AND DISCUSSION

The result in Table 1 show a mean age 45 $\pm$ 12 years of respondents, which is an indication that middle aged people are gradually involved in farming as against previous studies (Agbongiarhuoyi, *et, al*; 2006) that Nigerian farmers were made up of aged people. However, majority (85%) of the respondents were male while 84% were literate, able to read and write. The ability to read and write enhances performance through training; though majority (88%) have never been trained on wet processing.

Table 1: Showing some respondents' socio-economic characteristics

S/N	VARIABLES	FREQUENCY	PERCENTAGE	MEAN	SD
1	**Age**				
	<30	25	11	45	12
	31-40	58	26		
	41-50	70	31		
	51-60	42	19		
	>60	30	13		
2	**Sex**				
	Male	191	85		
	Female	34	15		
3	**Level of education**				
	Non formal	36	16		
	Primary	74	33		
	Secondary	60	27		
	Tertiary	42	19		
4	**Training on wet processing**				
	Yes	26	12		
	No	199	88		

Source: Field survey, 2019

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Farmers' practices

Figure 1 shows the respondents' stage by stage practices in appropriate method of coffee processing. From the results, activities involving dry processing, harvesting (100%), sorting (87.6%) and drying to 12% moisture content (74.5%) were highly carried out, while activities that involve wet processing; pulping (15%), soaking (15.5%) and washing (16.2%) were not seriously practiced. However, Goto and Fukunaga (1986) and CoffeeAM (2021) differently asserted that pulping, soaking and washing add value to coffee bean.

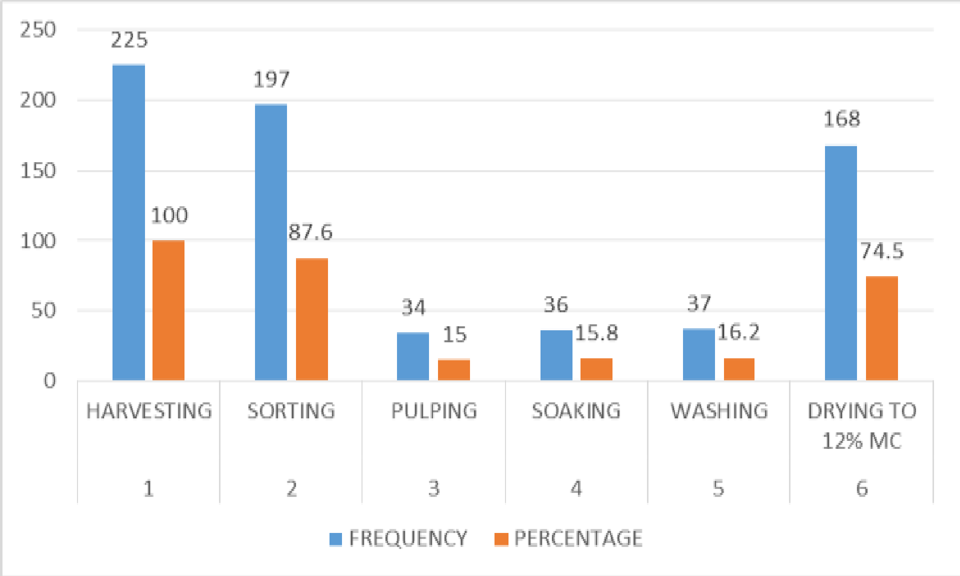

Figure 1: Respondents' practices in wet processing sequence

Source: Field survey, 2019

Knowledge in processing method

Figure 2 shows comparison between respondents' knowledge and practices in the three processing methods among coffee farmers. Among the farmers, dry processing was prominent with Majority (85%) having knowledge on dry processing, with about (25%) having knowledge on semi wet while only (18%) had knowledge on wet processing. However, it only indicated that only 10% of the respondents practice wet processing. This low knowledge in wet process is evident in their responses to their practices wet processing sequence.

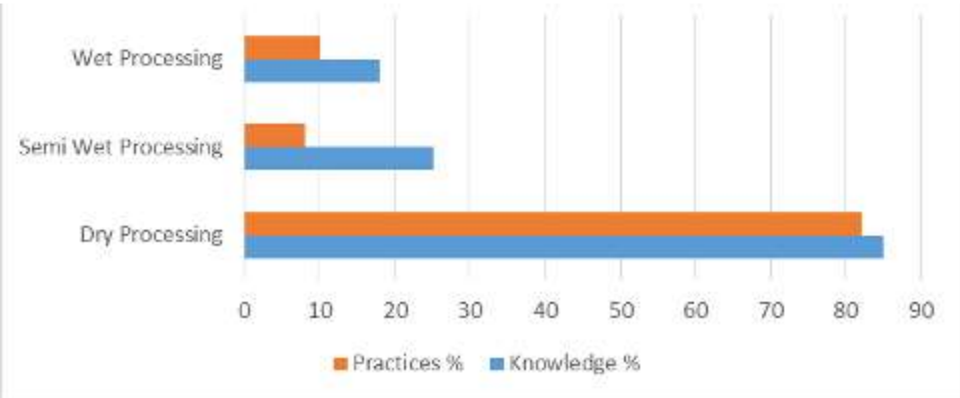

Figure 2: Respondents' knowledge and practices in the three processing methods among coffee farmers

Source: Field survey, 2019

Relationship between Knowledge and practices

The result on Table 2 shows a positive and significant relationship at r=0.181; p<0.01 between knowledge of processing and farmers practices; when knowledge increases good and appropriate practices increase.

Table 2: Pearson correlation describing relationship between respondents' knowledge and practise of processing method

Variable	r	r^2
Coffee processing Methods	.181	.007

Source: Field survey, 2019

CONCLUSION

The study concludes that though majority of the respondents were literate with no training on wet processing method and practise dry processing method.

IMPLICATIONS AND RECOMMENDATIONS

Consequent to the result of the study, coffee farmers will be facing more challenges at both the local and international market. The more cherished green coffee from wet processing accrues premium prices and improves farmers' livelihood. However, to improve quality of bean and consequent good market value, there should be creation of awareness of profitability in coffee production, establish Public Private Practice, through market driven coffee production, building farmers' capacity on wet processing through participatory and learning Action.

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AN ASSESSMENT OF THE EFFECT OF COVID–19 ON VEGETABLE MARKETING IN KABBA, KOGI STATE, NIGERIA

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ABSTRACT

This study investigated the effects of Covid–19 on the demand and supply of vegetables in Kabba, Kogi state. Data were randomly collected from 60 vegetables sellers through well-structured questionnaires and interview. Measure of central tendency such as mean, frequency, percentage as well as likert-scale analysis was used. Result from the analysis revealed that majority (90%) of the respondents were male while 10% were female, with a mean age of 30 years. Majority (75%) of the sellers were illiterate, with an average selling experience of 7 years. Majority (90%) of the respondents do not belong to social organization. Majority (100%) of the respondents had no extension contact. Majority (95%) of the sellers had no access to credit, with a mean income of 147,000 naira. During the pandemic (80%) vegetables consumption and sales was very low. Effects of Covid–19 on the demand–side shock include job losses, reduced income of the consumers, price of the commodities, depleted purchasing power, insufficient savings, high demand and size of the population while on the supply –side shock include price of the commodity, labour shortages, cost of transportation, government policy, goals of the seller, disruptions to transportation and distribution networks, disruptions due to movement and travelers restrictions, created food insecurity and thickening of border. As cases of contagion increase, governments take more drastic measures to stop the spread of the virus, also influencing the global food system. Therefore, it is recommended that sellers should form a cooperative in other to access inputs to increase marketing efficiency and improve their livelihood and to avoid the impact of COVID-19 on sellers, government must increase its support towards (loans or inputs) sellers as well as all the vulnerable households that directly depend on agriculture products for survival.

INTRODUCTION

Vegetables such as cabbage, cucumber and carrot are important vegetables known to mankind for over 4,000 years. Record show that the Ancient Greeks, Romans, Indians and Chinese all valued and used them greatly. Collectively, these vegetables deliver leaf, flower and root vegetables that are eaten fresh, cooked and processed: used as folder and forage, sources of protein and oil used in low fat edible products, for illumination and industrial lubricants, condiments such as mustard, herbs and other flavorings: and soil conditioners as green manure and composting crops and very rich in vitamins. As the COVID-19 pandemic of 2020 unfolds, considerable attention has focused on the resiliency of food supply chains in a time of crisis. Food supply chains have needed to adjust rapidly to demand side shocks, including panic buying and changes in food purchasing patterns, as well as plan for any supply side disruptions due to potential labor shortages and disruptions to transportation and supply networks (Breen, 2020). The COVID-19 pandemic is getting worse day-by-day, with interruptions in human activities, a huge death toll, and a direct hit on the global economy. Baum and Robertson (2020) argued that the wreaking havoc due to COVID-19 is not a surprise since pandemics viz Spain flu, Polio, HIV, Severe Acute Respiratory Syndrome (SARS), Zika, the Middle East Respiratory Syndrome (MERS), and Ebola are the recent realities of the modern world. Abdelhed and Zouari (2020) reported that in the past century, death due to viral diseases was far more than the major armed conflicts. The COVID-19 prevention measures such as lockdown, stay-at-home order, mass quarantine, and transport halt are highly challenging in those societies. Many developing countries imposed a short state emergency when the first case was confirmed. The movement of imports and exports is becoming slower or even stopped in some cases. During this economic crisis, the countries have to depend on emergency packages, which might not be adequate to cushion them and their vulnerable population. The transport sector has also halted operations owing to lockdown imposed in several countries and this has disrupted the supply chain for essential goods, especially food (Sachs, 2020; Reardon et al., 2020) and humanitarian aid donated by different agencies.

As the COVID-19 pandemic of 2020 unfolds, considerable attention has focused on the resiliency of food supply chains in a time of crisis. Food supply chains have needed to adjust rapidly to demand-side shocks, including panic buying and changes in food purchasing patterns, as well as plan for any supply-side disruptions due to potential labor shortages and disruptions to transportation and supply networks.

The COVID-19 prevention measures such as lockdown, social distancing, isolation, stay-at-home order, mass quarantine, and transport halt are highly challenging in those societies. Many developing countries imposed a short state emergency when the first case was confirmed. The movement of imports and exports is becoming slower or even stopped in some cases. During this economic crisis, the countries have to depend on emergency packages, which might not be adequate to cushion them and their vulnerable population. The transport sector has also halted operations owing to lockdown imposed in several countries and this has disrupted the supply chain for essential goods, especially food and humanitarian aid donated by different agencies, increase in price of items, increase in perishability of produce amongst others. Most studied on the subject matter have been on foreign land and none in the study area which this study aims to achieve.

MATERIALS AND METHODS

The study was carried out in year 2020 in Kabba town, Kogi State. It is an agrarian community located within the southern guinea savannah ecological zone of Nigeria and is known to have a tropical savannah climate with distinct wet and dry seasons. The study investigated the effects of Covid–19 on the demand and supply of vegetables in Kabba town. Two stages sampling technique were adopted for the study. First, kabba town was purposely selected because of the high rate of demand and supply of these vegetables. Secondly, sixty (60) vegetable marketers were randomly selected. Primary data and secondary data were used in this study. The primary data were collected by the use of structured questionnaires, using face to face interview schedule and information observation with the sellers who engage in selling cabbage, carrot and cucumber. Secondary data was obtained from text books, journals, bulletins, internet and other relevant literature. Data were analyzed using descriptive statistic and likert scale.

Model Specification

$$\text{Percentage (\%)} = \frac{\text{observed frequency x 100}}{\text{Total No frequency}}$$

Mean(x) = $\sum x/n$

Where: $\sum$ = summation, X = individual observation, N = No of observations.

Likert Rating Scale Technique

The effects of Covid –19 on demand-side and supply-side shocks on food supply chains were estimated using the four likert rating scale technique. The mean score of 2.5 was used as the cut off points. Thus the mean score of 2.5 and above was considered serious and very serious while those with mean score below 2.5 are not serious and not very serious.

This can be summarized with the equation become

$$X = \frac{\sum fn}{n} \quad \text{........(4)}$$

Where; X = mean score, $\sum$ = summation, N = frequency

$$\sum fn/n = \frac{1+2+3+4}{4} = 2.5$$

Decision Rule

0.5 - 1.50 = Strongly disagree, 1.51- 2.49 = Disagreed, 2.50-3.00 = Agreed, 3.09 – 4.00. Strongly agreed

RESULTS

Socio economic characteristics of the vegetable marketers in the study area (Table 1) shows that shows that most (83.33%) of the respondents were male while 16.67% were female. Majority (66.67%) of the respondents are between 20-30 years, with a mean age of 30 years. Most (75%) of the marketers sampled were illiterate but cannot be cheated in carrying out their selling activities. Majority (66.67%) of the respondent had between 1 - 10 years marketing experience with a mean marketing experience of 7 years. Most (83.33%) of the respondents do not belong to social organization such as cooperative society while 16.67% belong to vegetable seller's union in the study area. 100% of the respondents had no extension contact. 91.67% of the marketers had no access to credit while 8.33% had access to credit. About (66.67%) of the marketers had between 101,000 – 150,000 yearly income with a mean income of 147,000 naira.

Table 1. Socio-economic characteristics of the respondents in the study area

VARIABLE	FREQUENCY	(%)	MEAN	Total= 60
SEX				
Male	50	83.33		
Female	10	16.67		
AGE				
20-30	40	66.67		
31-40	15	25	30	
41-50	5	8.33		
EDUCATIONAL LEVEL				
Educated	15	25		
Not educated	45	75		
SELLING EXPERIENCE (years)				
1-10	40	66.67		
> 11	20	33.33	7	
MEMBERSHIP ASSOCIATION				
Yes	10	16.67		
No	50	83.33		
EXTENSION CONTACT				
Contact	0	0		
No Contact	60	100		
ACCESS TO CREDIT				
Yes	5	8.33		
No	55	91.67		
YEARLY INCOME (naira)				
50,000 – 100,000	15	25		
101,000 – 150,000	40	66.67	147,000	
151,000-200,000	5	8.33		

Source: Field survey, 2021

Effects of Covid–19 on demand side shock of vegetables in the study area (Table 2) shows that before the pandemic, vegetables consumption (55%) was very high, while during the pandemic it (77.33%) was very low. Effects of Covid – 19 on the demand –side shock include job losses, reduced income of the consumers, price of the commodities, deplete purchasing power, insufficient savings, high demand and size of the population respectively.

Effect of covid–19 on supply side shock of vegetables in the study area (Table 3) reveals that before the pandemic, vegetables sales (55.67%) was high while during the pandemic (75%) was very low. Results revealed that the effects of Covid – 19 on the supply – side shock include price of the commodity, labour shortages, cost of transportation, government policy, goals of the seller, disruptions to transportation and distribution networks, disruptions due to movement and travelers restrictions, created food insecurity and thickening of border.

Covid–19 coping strategies adopted by the marketers during the period in the study area (Table 4). The respondents adopted getting help from people, going outside to work, selling of assets, spend savings, borrow loan for survival and borrowing from friends and relatives for survival during the period. It is a taboo for them and their households to engage in begging, thuggery and prostitution. Several social prevention strategies and Policies were adopted by the government to cope with Covid–19 (Table 5) such as school closing (SC), workplace closing (WPC), cancel public events (CPE), restrictions on gathering (ROG), close public transport (CPT), stay at home requirement (SHR), restrictions on internal movement (RIM) international travel controls (ITC) and lockdown, isolation and social distancing (LISD) were the measures identified as very strict. On the other hand, income support (IS) was considered less strict (rejected) in the study area.

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Table 2. Effects of Covid – 19 on demand side shock of vegetables in the study area

Effect of Covid-19	Frequency	%	Mean	SD	Ranked
How do you rate your level of vegetables consumption before Covid-19 pandemic?					
Low	5	5			
Moderate	10	10			
High	30	30			
Very high	55	55			
How do you rate your level of vegetables consumption during Covid-19?					
Low	58	77.33			
Moderate	10	13.33			
High	5	6.67			
Very high	2	2.67			
Covid–19 effects on demand					
Job losses			3.54	1.89	1st
Deplete purchasing power			3.25	1.80	2nd
Insufficient savings			3.25	1.80	3rd
High demand			3.25	1.80	2nd
Price of the commodity			3.54	1.89	1st
Reduce income of the consumer			3.54	1.89	1st
Size of the population			3.25	1.80	2nd

Source: Field survey, 2021

Table 3. Effect of covid–19 on supply side shock of vegetables in the study area

Effect of Covid-19	Frequency	%	Mean	Ranking
How do you rate your level of vegetables sales before the outbreak of Covid-19?				
Low	0	0		
Moderate	5	8.33		
High	15	25		
Very high	40	66.67		
How do you rate your level of vegetables sales during Covid-19 pandemic?				
Low	45	75		
Moderate	10	16.67		
High	5	8.33		
Very high	0	0		
Price of the commodity			3.54	1st
Labour shortages			3.54	1st
Cost of transportation			3.54	1st
Government policy			3.54	1st
Goals of the seller			3.25	2nd
Disruptions to transportation and distribution networks			3.54	1st
Disruptions due to movement and travelers restrictions			3.54	1st
Created food insecurity			3.54	1st
Thickening of border			3.54	1st

Source: Field survey, 2021

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Table 4. Covid – 19 coping strategies adopted by the marketers during the period in the study area

Prevention measures/strategies	Mean	SD	Remarks
Getting help from people	3.54	1.80	Very high
Going outside to work	3.25	1.80	Very high
Selling of assets	3.54	1.89	Very high
Spend our savings	3.54	1.89	Very high
Loan for survival	3.25	1.80	Very high
Borrowing from friends and relatives	3.25	1.80	Very high
Begging for survival	2.22	2.41	Moderate
Thuggery and prostitution	1.60	2.29	Moderate
Received relief from government during general lockdown	1.60	2.29	Moderate

Source: Field survey, 2021

Table 5. Strategies adopted by government to cope with Covid–19

Policies and strategies	Mean	SD	Remarks
Prevention measures/strategies			
School closing (SC)	3.54	1.89	Very strict
Workplace closing (WPC)	3.54	1.89	Very strict
Cancel public events (CPE)	3.54	1.89	Very strict
Restrictions on gathering (ROG)	3.25	1.80	Very strict
Close public transport (CPT)	3.25	1.80	Very strict
Stay at home requirement (SHR)	3.54	1.89	Very strict
Restrictions on internal movement (RIM)	3.25	1.80	Very strict
International travel controls (ITC)	3.54	1.89	Very strict
Income support (IS)	1.60	2.95	Rejected
Lockdown, isolation and social distancing	3.54	1.89	Very strict

Source: Field survey, 2021

DISCUSSION

COVID-19 disease has a great effect on the actions and activities of humanity and the various preventive measures taken to control the spread of the pandemic hinder the production and distribution of agricultural products. United Nations Sustainable Development Goals (UNSDGs) (UNDP, 2014) noted that 55% of the global population with a majority from developing countries do not have access to social protection. Fraser (2020) added that this vulnerability will aggravate socio-economic losses whose effects will spill to human rights, educational sectors, and to depriving the poor and marginalized of food and proper nutrition. Vegetables marketing, food demand, supply and thus food security is greatly affected due to mobility restrictions, reduced purchasing power, reduced income, job losses, and with a greater effect on the most vulnerable population groups. As cases of covid-19 increase, governments take more drastic measures to stop the spread of the virus, also influencing the global food system. Sachs (2020) reported the measures taken by governments to tackle the spread of covid-19. The halting of the transportation sector owing to the lockdown disrupted the supply of foods and vegetables. Grant (2020) concluded that although the levels of implementing these measures vary, their effects in controlling COVID-19 has been considerably successful.

Majority of the people in the study area are in the active age group of 20-30 years and this will increase marketing in the study area (economically active age brackets). Glauber *et al.,* 2020 stated that consideration should be given socio-demographic characteristics such as gender and identity, age, education, migrant status, employment status, ability status, and household composition as they give deeper insights of how COVID-19 may affect consumer demand for food in Nigeria. The pandemic recorded decrease in demand for vegetables which agrees with the analysis of FAO (2019) that during pandemic, demand for food decreased due to uncertainty and the reduction of people's spending capacity, although this decrease is slight; the situation could worsen if the pandemic continues for a long time, due to reduced income and job losses. Imman (2020) also reported job losses, reduced income of the consumers, deplete purchasing power, insufficient savings and convenience as effects of Covid–19 on the demand side shock.

Supply side shocks identified in this study include price of the commodity, labour shortages, cost of transportation, government policy, goals of the seller, disruptions to transportation and distribution networks, disruptions due to movement and travelers restrictions, created food insecurity and thickening of border agrees with Imman (2020) who reported labour shortages, cost of transportation, government policy, goals of the seller, disruptions to transportation and distribution networks, disruptions due to movement and travelers restrictions, created food insecurity and thickening of border as effects of Covid – 19 on the supply side shock.

The marketers adopted getting help from people, going outside to work, selling of assets, spend of savings, loan for survival and borrowing from friends and relatives respectively as survival strategies during the period. Majority of them did not belong to any cooperative society, seller's union nor had contact with extension services. Saito and Spurling (1993) reported that inadequate access to agricultural information and innovations is a major problem for women in agriculture.

RECOMMENDATION

Extension workers should intensify efforts in disseminating improved marketing information to sellers. Vegetable marketers should form a cooperative in other to access inputs to increase marketing efficiency and improve their livelihood. To avoid the impact of COVID-19 on marketers, the government must increase its support (loans or inputs) towards marketers as well as all the vulnerable households that directly depend on agriculture products for survival. The government should create an enabling socio-economic environment through the provision of social amenities to facilitate economic growth and improve health facilities, thereby increasing local produce, creating job opportunities and increasing GDP.

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EMPIRICAL ESTABLISHMENT OF THE PRODUCTIVITY OF CRIN COCOA HYBRIDS TC_1-TC_8 IN NIGERIA

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ABSTRACT

The study investigated the performance of CRIN Cocoa hybrid Tc_1 – Tc_8 on farmers' farm compared with established on–station performance at CRIN. It specifically explained the variations of performance across the states in the study area, along with farmers' adherence with Good Agricultural Practices (GAP). Using a multistage sampling technique, random selection of 288 tree across 48 cocoa farms that received Cocoa hybrid pods in 2011 for farm establishment in 4 Cocoa producing States were achieved in Cross River, Ondo, Osun and Ogun States of Nigeria. The ages of cocoa trees included in the study were between 5 to 8 years, while farmers were trained to take data for one year. Descriptive statistic was used to analyse the data. Results revealed majority (68.4%) of the respondents exhibiting Fair knowledge of GAP, while about 49.6% practiced GAP. The mean pod yield per tree was 130±14.0 pods with 35±4.0 mean beans per pod. The yield per tree across the States varied in the study area. The study deduced that CRIN hybrid cocoa is significant to sustainable cocoa production, increase in productivity and consequently improved farmers' livelihood in Nigeria.

Key words: Cocoa, productivity, CRIN hybrid, Nigeria

INTRODUCTION

The importance of agriculture to the Nigerian economy cannot be under estimated. In Nigeria, Cacao occupies about 0.6 million hectares and production stands at 383,000 tonnes in 2012 (FAOSTAT, 2014). The average cocoa yield in West Africa is about 0.5 tonnes/ha while for Nigeria it is around 0.4 tonnes/ha. This suggests that yield in Nigeria is low compared to the world average. Cocoa remains the highest foreign exchange earner of all agricultural export crops in Nigeria, cocoa output has declined and one of the factors responsible for this was the fact that soils of cocoa growing agro-ecologies are inherently poor in fertility, rapidly degraded of properties, acidic due to the nature of the parent materials and leached of nutrients due to high rainfall intensity. After its introduction into the zone of West Africa sub- region in 1890, the area planted to cocoa increased rapidly to its present 0.7 million hectare and yield increased to peak of 310,000 tons in 1965 (Daramola, 2004). Many studies have attributed this yield decline essentially to soil nutrients imbalance and poor planting materials (Ayanlaja, 2002 and Ojeniyi, 2010).

Problem Statement

Despite the vast hectares of land been used for Cocoa farming in Nigeria, the productivity has been low. The Cocoa Research Institute of Nigeria (CRIN) introduced new cocoa hybrids named (TC_{1-8}) to the farmers but the empirical determination of the average number of bean per Kg, actual number of dry bean per Kg , number of pods that make on Kg of dry beans and number of pods per tree yield /year per hectares of cocoa hybrids TC_l to TC_8 has not been established in order to determine the simple but very vital information for sustainability, profitability and constraints of its production in Nigeria. To this end, it is essential to determine these parameters at the CRIN headquarter and at the farmers' farms. Therefore, the urgent need to examine critically the yield parameters of these varieties of cocoa. Specifically, this study was based on the objectives to determine average number of cocoa bean in a pod and evaluate number of pod yield per tree per year.

MATERIALS AND METHODS

The study was carried out in four States, purposive sampling technique was used for selection of four states namely Ondo, Ogun, Oyo and Cross River State. In each of the state, 6 local Government areas were selected for sampling. In Ondo state, the local Government area that were covered were Owena, Ile-Oluji/Okeigbo, Idanre, Akure south, Irele and Akure North and for Ogun state; Ijebu North, Ijebu East, Egbado North, Egbado South, Obafemi Owode/Ota and Abeokuta North. While in Oyo state; Oluyole, Atiba, Afijio, Ido Akinyele, and Ogo-oluwa and for Cross River state the local Government areas that were captured are Ikom, Etung, Boki, Obubra, Ogoja and Akamkpa. A total of 24 LGAs were used for the study. However, two farmer's (farm) were randomly selected from the list of those that collected hybrid cocoa pods from

CRIN in 2011 and six trees were tagged from each farmer's farm for the purpose of the study. The respondents were asked to harvest and record the identified Tc1-8 to achieve the study's objectives. In all, 48 farmers' farm were sampled and 288 trees tagged for the study. The farmers were trained on how to take data from the tagged trees, while relevant data on bean in a pod and actual number of pods per tree yield per year were collected to achieve the aims and objectives. The data collected were analyzed using descriptive statistics.

RESULTS AND DISCUSSION

Respondents' knowledge of Good Agricultural Practices

Table 1 shows the respondents' knowledge of GAP, Majority (68.4%) indicated that they have fair knowledge of GAP, while only 14.9% had high knowledge. This is an indication that majority of the farmers who collected the hybrid materials did not follow Good Agricultural Practices, which are requirements for optimum performance of the hybrid. Hence this can contribute to the farmers' low yield.

Table 1: Respondents' knowledge of GAP

Knowledge Level	Scores	Frequency	Percentage
High Knowledge	>46.27	43	14.9
Fair Knowledge	>13.4<46.27	197	68.4
Low Knowledge	<13.4	48	16.7

Source: Field survey, 2020

Yield of pod per tree per year

Figure 1 shows average yield per tree per year. The mean yield per tree per year was 130 pods, while Osun recorded the highest yield (172) and Cross Rivers (156) pods per tree per year however, the least was recorded by Ondo state. This result may be as a consequence of the farmers' knowledge in agricultural practices and handling of the hybrid materials.

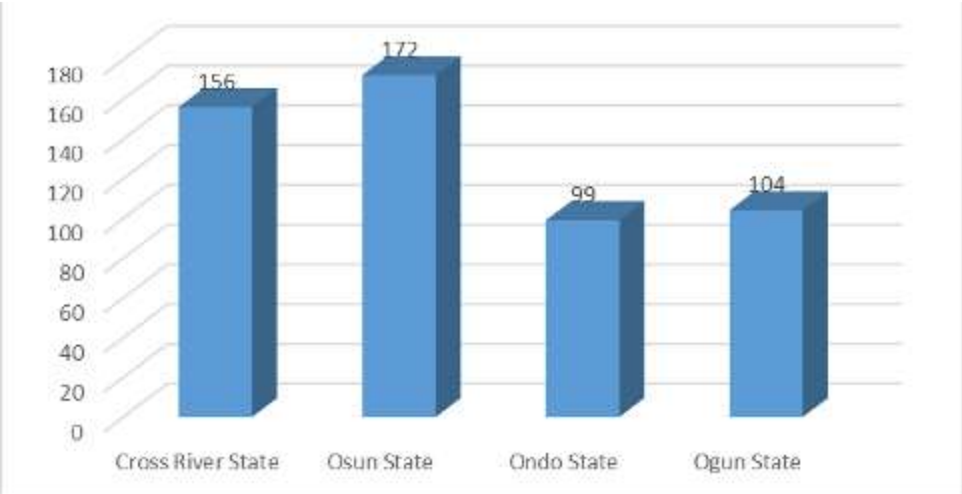
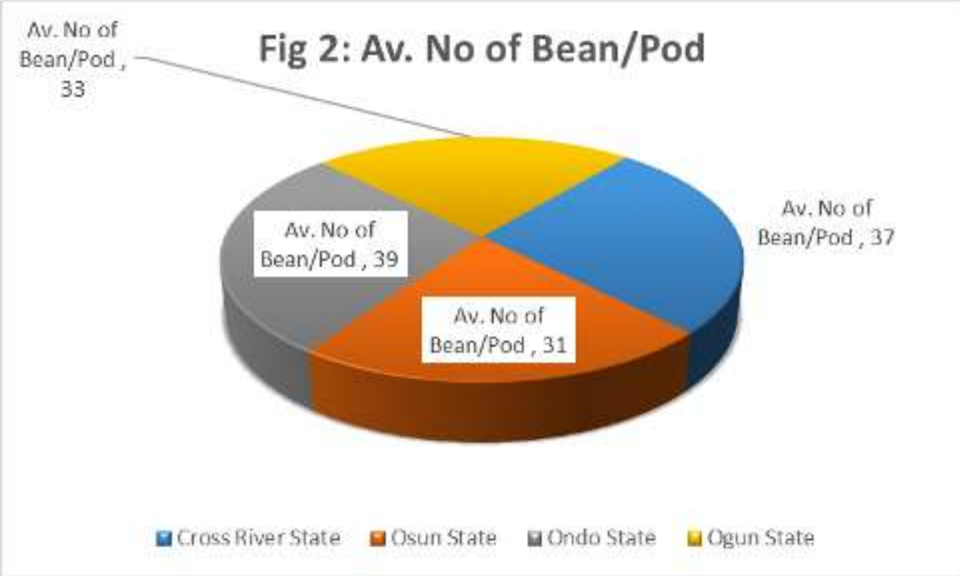


Figure 1. Average yield per tree per year

Source: Field survey, 2020

Average Number of Bean per pod

Figure 2 shows the average number of bean per pod recorded from each state. The highest (39 beans/pod) was recorded from Ondo followed by Cross River (37 beans/pod), while the least was Ogun with 31 beans /pod. However, the mean bean per pod from the study area was 35 beans per pod, this correspond with the quality identified by CRIN 2011.



Source: Field survey, 2020

CONCLUSION

It was concluded that though the majority of the farmers had fair knowledge on Good Agricultural Practices of the hybrid materials, yet the average yield per tree per year (130 pods) while the average bean per pod was recorded to be 35 bean. The results correspond with CRIN assertions on the qualities of the hybrid materials; Tc1-8

RECOMMENDATION

More awareness and training should be made available to the farmers, while the hybrid materials should also be available to the farmers to improve their yield and consequently increase their livelihood

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EFFECT OF POULTRY MANURE AND NPK 15:15:15 ON GROWTH AND YIELD OF WATERMELON (*CITRULLUS LANATUS*) IN DADIN-KOWA, GOMBE STATE

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ABSTRACT

An experiment was conducted at the National Horticultural Research Institute Dadin-kowa Experimental Station, Gombe State to determine the performance of poultry manure and NPK 15:15:15 on growth and yield of watermelon, during 2019-2020 dry season. A randomized complete block design (RCBD) was used consisting 4levels of poultry dropping manure (0, 1, 2, and 3ton/ha) and 3 levels of NPK fertilizer (0, 40, and 60kg/ha), these were replicated 3 times. The parameters observed were vine length, number of leaves, number of branches, fruit weight per plant, fruit diameter and fruit weight per hectare. The result showed that there was significant difference among the treatments used. It further revealed that the combination of 3tons of poultry manure and 60kg of NPK fertilizer was superior in enhancing vine length, number of branches and fruit yield followed by other treatments while the control gave the least of the values.

Key words: Watermelon, poultry manure and NPK 15:15:15. fertilizer

INTRODUCTION

Watermelon is an important vegetable crop in the tr opics; it has its origin from the hot, dry regions around the Mediterranean. Its cultivation has extended to tropical and subtropical regions on the American continent. However, watermelons grown in humid areas are less sweet and tasty than those from hotter drier climates (Anon, 2006). By the 10th Century, watermelons were being cultivated in China, and are today the world largest producer of watermelon. It was believed that African slaves introduced watermelon into the United States of America. Watermelons have the following contents: 73% water. 2.25% protein, 0.2% fat, 9.7% carbohydrate, and 0.8% ash (Purseglove, 1999). The consumption of the edible parts has been reported to promote digestion and help prevent constipation (Fatoken, 1979). Watermelon also use to compliment staple food since it is a good source of vitamin, minerals, and protein (Funso and Bassir, 1998) In general, high nitrogen under high temperature condition promote maleness in flowering and the seeds are rich in fat and protein (Anon, 2005). By world healthiest food (2013), increase in vine length, number of leaves, leaf area and watermelon as well as number of branches were recorded with increase in lycopene, phenolic antioxidants and fertilizer application. This study was designed to evaluate the effect of organic and inorganic fertilizer for the growth and yield of water melon in the study area.

MATERIALS AND METHODS

The trial was conducted during the dry season of 2019/2020 at National Horticultural Research Institute (NIHORT), Dadin-Kowa station, (Latitude 110 14' N and Longitude 110 8' E) with altitude 440m above sea level in Sudan savannah ecological zone of Nigeria. The area is characterized by a mono modal rainfall pattern with medium rainy season period which usually starts in May and extends to October. Treatments used consisted of 4 different levels of poultry manure (0, 1, 2, and 3tons/ha) and 3 levels of NPK 15:15:15fertilizer (0, 40, 60kg/ha). The treatments were in factorial, arranged in a Randomized Complete Block Design in 3 replications. The watermelon was planted at 1.0m by 1.0m, inter and intra-row spacing respectively. Poultry manure was incorporated in to the soil two weeks before planting. Data collected were vine length, number of leaves, number of branches, fruit weight, fruit diameter and fruit yield, these were subjected to analysis of variance (ANOVA) at 5% probability.

RESULTS

The results of the soil analysis of the experimental site showed that the soil textural class was loamy sand (Table 1). The soil pH was slightly acidic (6.2) with low organic carbon of 4.79g kg^{-1} soil. Total N content of was very low. The available phosphorus was low (0.015g kg-1). Mg content was high while K and Ca content were moderate. The CEC of the analysed soil was moderate and ranged between 6.67 to 7.18cmol K^{-1} soil.

Table 1. Physico-chemical properties of the soil of the site

Soil Properties		
	0-15cm	15-30cm
Sand%	83	73
Silt%	13	22
Clay%	4	6
Textural class	Loamy sand	Loamy sand
Chemical properties		
pH	6.6	5.5
Organic matter (g kg^{-1})	8.19	6.14
Total Nitrogen (g kg^{-1})	0.51	0.31
Available P (g kg^{-1})	0.06	0.014
Exchangeable bases(cmol+ kg^{-1})		
Na	0.05	0.02
K	0.22	0.23
Ca	4.30	3.86
Mg	2.14	2.03
CEC	7.18	6.67

Source: Lab Unit, Soil Science Department, ABTU Bauchi

Table 2 shows the effect of NPK and poultry manure on vine length of water melon. The application of 60kg/ha NPK resulted to significant vine length which was however at parity with application of 40kg/ha NPK at 4WAP. Poultry manure usage effect was significant throughout the sampling periods.

Table 2. Effect of poultry manure and NPK 15:15:15 fertilizer on vine length of watermelon in Dadin-kowa, 2019/20 season

Treatments	2 WAP	4WAP	6 wap	8 WAP
NPK (Kg/ha)				
0kg	8.48c	18.92c	29.99c	54.99c
40kg	10.65b	24.76b	36.03b	71.05b
60kg	11.83a	27.01c	44.39a	90.79a
LS	++	++	++	++
S.E	0.29	0.28	1.28	1.56
Poultry Manure (ton/ha)				
0tons	9.30b	22.20c	33.09c	55.67d
1tons	10.28a	23.00bc	32.03c	63.99c
2tons	10.62a	23.62a	38.07b	73.12b
3tons	11.08a	25.42a	44.02a	96.33a
LS	**	**	**	**
S.E	0.33	0.31	1.48	1.81
Poultry manure and NPK 15:15:15(Kg/ha)	**	**	**	**

All means followed by the same letters in the same column are not significantly different using DMRT. NS=Notsignificant

The use of poultry manures at 3t/ha recorded significantly lengthy vines compared to other treatments. The control resulted to the least number of leaves (Table 3). Application of 3t/ha poultry manure at 4WAP produced significant number of leaves compared to other treatments. Treatment with 1, 2 and3t/ha poultry manures resulted to statistically the same number of leaves at 6 and 8 WAP. Generally, there is increase in number of leaves of watermelon with increase in quantity of poultry manure. Table 4 contains the results on yield and yield parameters as influenced by NPK and poultry manures. Fruit yield increased with additional increase in quantity of NPK. Application of 3t/ha NPK produced statistically lengthy fruits while the control recorded the shortest fruit. Poultry manure application at 1, 2 and 3t/ha were statistically the same and better than the control. The fruit yield was significantly affected by NPK and poultry manure. Higher dosage of NPK and cow dung results in increased yield of watermelon while lower yield was observed for the control.

Table 3. Effect of poultry manure and NPK 15:15:15 fertilizer on numbers of leaves on watermelon in Dadin-kowa 2019/20 season

Treatments	2wap	4WAP	6WAP	8WAP
NPK (kg/ha)				
0kg	6.73c	18.33c	40.87c	83.13c
40kg	8.45b	23.34b	48.38b	91.14b
60kg	9.68a	26.95a	55.11a	101.09a
LSD	**	**	**	**
S.E	0.19	0.53	0.71	1.99
Poultry manure (tons /ha)				
0tons	7.17c	20.09b	40.49d	62.77d
1tons	8.09b	21.66b	46.78c	94.59c
2tons	8.29b	24.01a	50.03b	101.38b
3tons	9.61a	25.73a	55.17a	108.41a
LS	**	**	**	**
S.E	0.21	0.60	0.81	2.29
poultry and NPK	**	**	**	**

All means followed by the same letters in the same column are not significantly different using DMRT. NS=Not significant

DISCUSSION

The experiment was designed to evaluate the effect of poultry manure and NPK 15:15:15 fertilizer at different rates for the growth and yield of watermelon while specific different opinions have been expressed with regards to watermelon fertilization using organic manure like poultry manure and cow dung by different authors. Schippers (2000**).** recommended the use of poultry manure for crop production which; was consistent with Kogbe's (1995). Poultry manures have been found to produce higher watermelon fruit yield than cow dung manures. This was attributed to the higher content of nitrogen and phosphorus in poultry manures in addition to its ability to furnish the soil with more magnesium and some trace elements (Purseglove 1995). The influence of fertilizer and manures applications are that fruit yield by fertilizer application are significantly higher compared to the control. This is in accordance with the fertilizer level with the findings of Efediyi (2009) who reported a response to NPK application showed better performance in watermelon flowering to no fertilizer application. It is important to note that spacing has significant effects on watermelon plants in the study area. Therefore, the combination of cowdung and NPK leads to releasd of mineral el ements that established and maintained optimal soil physical condition for plant growth (Enujeke *et al.,* 2013). Bamikole *et al.* (2011) also reported that combination of organic an d inorganic fertilizers significantly increased crop gr owth parameters and yield and attributed it to high l evel of nitrogen supplied by the combination which i s an essential plant nutrient for growth. This is in conformity with the findings of Dean (2004), who reported that, vegetative growth and yield parameters are under the influence of plant spacing. while final fruit weight of watermelon

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is as a result of NPK fertilizer application at the rate of 150 kg NPK/ha.

Table 4. Effect of poultry manure and NPK 15:15:15 fertilizer on numbers of branches on watermelon in Dadin-kowa 2019/20 rainy season

Treatment NPK 15:15:15 (Kg/ha)	2WAP	4WAP	6WAP	8WAP
0kg	3.46c	6.40c	8.73c	10.66c
40kg	4.33b	8.62b	9.89b	12.24b
60kg	5.32a	10.11a	11.28a	13.40a
LS	**	**	**	**
S.E	0.12	0.37	0.27	0.21
poultry manure (ton/ha)				
0ton				
	3.50c	6.84c	8.67b	10.88c
1ton	4.24b	7.99bc	10.18a	11.54c
2ton	4.39b	9.50ab	10.31a	12.41b
	5.57a	9.17a	10.70a	12.41a
3ton	**	**	++	
LS	0.14	0.43	0.30	0.24
S.E				

Treatment NPK 15:15:15Fertilizer	Fruit weight (t-ha)	Numbers of fruit per plant	Fruit diameter.
0ton	3.80c	7.08c	11.16c
40ton	4.45b	8.05b	13.33b
60ton	4.96a	9.70	14.91a
LS	**	**	**
SE	0.13	0.26	0.23
poultry manure (ton/ha)			
0ton	3.69c	7.14c	11.96c
1ton	4.37a	7.68c	12.72bc
2ton	4.76a	8.60b	13.19b
3ton	4.80a	9.68a	14.66a
LS	**	**	**
S.E	0.25	0.33	0.22
poultry NPK 15:15:15	**	**	**

All means followed by thesame letters in the same column are not significantly different using DMRT. NS= Not significant

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CONCLUSION

Therefore, it can be further concluded that watermelon farmers are advised to embark on production and application of poultry manure and NPK 15:15:15 fertilizer that will significantly increase the production of watermelon in their farms in the study area.

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POST TRAINING EVALUATION OF COCOA REHABILITATION METHODS AMONG COCOA FARMERS IN SOUTHERN NIGERIA

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ABSTRACT

A training by CRIN in 2014 in three major Cocoa agro-ecologies in Nigeria exposed cocoa farmers to various rehabilitation techniques viz: Partial replanting; Complete replanting; Phased farm replanting; Planting under old trees; Side grafting; Top grafting and Coppicing of old stands. To evaluate the adoption of the methods and establish the preference by farmers for the rehabilitation techniques, a post training survey was carried out in 2019 through administration of structured questionnaires on farmers' socio-economic characteristics, level of adoption and preference for the rehabilitation techniques. Results revealed that 75.71% of the respondents were below 50 years an indication of vibrant Cocoa farmers' population. 91.90% of the respondents are married which may ensure availability of labour in production activities. On-farm experience, 78.1% of farmers has more than 10 years' experience in Cocoa production. Majority of farmers (83.3%) are formally educated though only 14.29% had tertiary education while 21.43% had secondary education. On knowledge of rehabilitation techniques, 33.81% of the respondents claimed planting under old trees was known to them, while 7.62% claimed they know all the rehabilitation techniques. 9.05% claimed they were taught complete farm replanting. On the source of the rehabilitation knowledge, 58.57% stated they got the knowledge through CRIN, 12.38% through the State Tree Crop Units (STCU) while 11.43% got theirs through friends. On adoption of rehabilitation methods taught 85.24% indicated they have started practicing one form of the rehabilitation techniques or the other. 54.76% of the respondents have adopted planting cocoa seedlings under old plantation, while 15.71% have adopted coppicing method. On preference for the rehabilitation methods, 61.43% prefers planting improved seedling under old plantation while 21.43% prefers coppicing technique. This study has showcased the need for massive rehabilitation of over 600,000ha of cocoa plantations in Nigeria through replanting of improved cocoa hybrids from CRIN for increased cocoa productivity thereby reducing further encroachment into the remaining forest land.

Key words: Cocoa, rehabilitation, adoption, preference, replanting

INTRODUCTION

Cacao (*Theobroma cacao L.*) is an important export commodity crop in Nigeria making her ranked fourth among producing countries in West Africa. It has remained a leading export commodity crops among countries producing it. In Nigeria, more than 200,000 households from 14 active producing States earn their livelihood from the crop (NCDC, 2008). There are however 8 additional emerging States producing the crop (Famaye, 2013). The crop is regarded as the second highest foreign exchange earner after petroleum contributing 38.54% to the national GDP (NEPC, 2011). As important as this crop is to the national economy, production has decline to as low as 450Kg/ha. The decline is as a result of several factors such as old age of plantations, pests' incidence, low yielding genotypes, nutrient depletion(Ibiremo *et al* 2017) and outright plantations abandonment (Adeyemi *et al*, 2017) especially since the advent of oil boom in the 70s. A plot is considered unproductive if the yield has declined to about the quarter of what is obtainable at the peak period of 10-25 years (Olaiya, 2001) while Oduwole (2001) based his own recommendation on the cost/benefit ratio of the plot. In order to bring an unproductive plot into life, rehabilitation processes have to be carried out on the plot. Generally speaking, rehabilitation is defined as the process of bringing an unproductive cocoa plot back to economic productivity (Oluyole *et al,* 2015). Some rehabilitation techniques include: partial replanting; complete replanting; phased farm replanting; planting under old cocoa trees; side grafting; coppicing and top grafting. These practices were demonstrated to farmers in the study areas about six years ago. Therefore, the objective of this study was to post-evaluate these practices on the farmers' farms and to evaluate the extent of adoption of these techniques by the farmers in the study areas.

MATERIALS AND METHODS

The study was carried out in the three cocoa producing States in the southern part of Nigeria, specifically Ondo, Cross River and Osun States.

These are the States where rehabilitation techniques were earlier demonstrated among cocoa farmers. In each of the States, two cocoa producing Local Government Areas (LGAs) were selected making a total of six LGAs selected for the study. There were 35 questionnaires for each community totaling 70 per each State Purposive sampling technique was used to select the 210 respondents from the study area. Structured questionnaire was used to elicit information from the selected respondents. The information collected from the respondents were analyzed with the use of descriptive analysis such as frequency and percentages.

RESULTS AND DISCUSSION

Table 1 shows that 75.71% of the total respondents were of the age 50 years and below showing that the highest proportion of the respondents were still in active age to carry out rehabilitation on their farms. Also 91.90% of the respondents were married indicating that there may be more farm hands to rehabilitate the farms. This is a good development as labour is a major factor in carrying out rehabilitation process. Majority (78.1%) of the farmers are highly experienced on farm work as the proportion has been on farm work for not less than 10 years. However, 83.33% of the farmers are formally educated though only 14.29% had tertiary education while 21.43% completed secondary school education. All these are good indicators towards good adoption of the rehabilitation techniques that were taught. The role of Farmers Field School in information dissemination has also been pointed out (Nwagbue and Akinbile, 2012). Table 2 also indicates that 58.57% of the farmers claimed that they got the knowledge of rehabilitation techniques from CRIN while 12.38% received the knowledge from States Tree Crop Units, this is an indication that the training exercise by CRIN was effective especially the one that will not tamper with harvesting from existing stands. CRIN has been involved in all aspects of cocoa production especially training activities (NEPC, 2011). However, 11.43% of the total farmers got the knowledge of rehabilitation techniques from their friends; training on cocoa rehabilitation has been a recurring activity as most farms are moribund. Meanwhile Table 3 reveals that 85.24% of the farmers have started practicing rehabilitation techniques on their farms after they have been taught. This is a good development as majority of the respondents adopted the techniques. Table 4 indicates that of all the rehabilitation techniques taught, 54.76% of the respondents practiced planting under old trees in their farms while 15.71% practiced coppicing and 1.90% practiced side grafting. This shows that planting under old trees is mostly adopted among the farmers in the study area. There is therefore the need for CRIN to generate enough seedlings of improved cocoa hybrids to be distributed to farmers to rehabilitate the unproductive farms (CRIN, 2017). As shown in Table 6 regarding the rehabilitation methods preferred among the farmers, 61.43% of the farmers preferred planting under old trees than any other rehabilitation techniques and 21.43% preferred coppicing. The former option will discourage further encroachment into the remaining forest land in Nigeria for cocoa production

As revealed in Table 7, 73.33% of the farmers confirmed that they have started harvesting from their rehabilitated plot between 2-3 years after rehabilitation while 12.38 % started harvesting after a year. Table 9 reveals the plot in which planting of new hybrids were planted under old trees, harvesting of pods was carried out as claimed by 55.71%, this is in support of their precocious nature followed by coppicing (16.67%). The low interest in coppicing is that farmers find it difficult to wait for 2-3 years before coppiced plot comes into bearing hence they prefer methods that will still sustain some returns from old stands while the plots are rehabilitated. Table 8 shows poor response to side grafting techniques because they are afraid to take risk; the methods are too technical. Sodre and Gomes (2019) had reported that this technique is not yet well understood despite many studies particularly the mechanisms involving the physiology of the graft and root stock.

CONCLUSION

Knowledge of cocoa rehabilitation techniques have been imparted into the consciousness of cocoa farmers in the study areas viz: complete replanting, coppicing, planting under old trees, side grafting and top grafting. Of all the techniques, planting under old trees was mostly acceptable; followed by coppicing while the least accepted was side grafting. Top grafting was not adopted at all. We recommend that the two adopted techniques be concentrated upon for now. The former can be achieved through massive production and distribution of seedlings of our new hybrids to farmers in the producing areas to replace old, moribund and unproductive trees. The methods that are being adopted by cocoa farmers will stem the tide of further encroachment into existing forest land in the study areas. The 33.81% of farmers describing the new CRIN cocoa hybrids as higher yielding and none response of 54.29% to the hybrids suggest more sensitization by CRIN and other stakeholders at popularizing the cocoa hybrids.

Table 1. Socio-economic characteristics of the farmers

Variables	Frequency	Percentage
Gender		
Male	163	77.62
Female	47	22.38
Total	210	100.00
Age of the farmers		
≤ 30	50	23.81
31-50	109	51.90
> 50	51	24.29
Total	210	100.00
Marital Status		
Single	13	6.19
Married	193	91.90
Divorced	4	1.90
Total	210	100.00
Farming experience of the farmers		
≤ 10	46	21.90
11-30	107	50.96
> 30	57	27.14
Total	210	100.00
Level of education		
No formal education	35	16.67
Incomplete primary education	21	10.00
Completed primary education	57	27.14
Incomplete secondary education	22	10.48
Completed secondary education	45	21.43
Tertiary education	30	14.29
Total	210	100.00

Source: Field survey, 2018

Table 2: Source of the knowledge on rehabilitation techniques

Variables	Frequency	Percentage
No response	16	7.62
CRIN	123	58.57
State TCU	26	12.38
Fellow farmers	24	11.43
REFILS	3	1.43
Nowhere	6	2.86
FADU	11	5.24
CRIN and fellow farmers	1	0.48
Total	210	100.00

Table 3: whether farmers have practiced any of the rehabilitation techniques

Variables	Frequency	Percentage
No response	20	9.52
Yes	179	85.24
No	9	5.25
Total	210	100.00

Table 4: Rehabilitation techniques practiced by farmers

Variables	Frequency	Percentage
No response	26	12.38
Coppicing	33	15.71
Planting under old	115	54.76
Side grafting	4	1.90
Coppicing, planting under old	18	8.57
Coppicing, side grafting	2	0.95
Planting under old, side grafting	2	0.95
Coppicing, planting under old	10	4.76
Total	210	100.00

Table 5: Reasons why farmers are not practicing side grafting

Variables	Frequency	Percentage
No response	168	80.00
Method difficult	8	3.81
Method costly	7	3.33
Too technical	12	5.71
Afraid to take risk	15	7.15
Total	210	100.00

Table 6: Rehabilitation methods preferred by farmers

Variables	Frequency	Percentage
No response	25	11.90
Coppicing	45	21.43
Planting under old trees	129	61.43
Coppicing +planting under old trees	11	5.24
Total	210	100.00

Table 7: harvesting of pods from any of the rehab methods

Variables	Frequency	Percentage
No response	27	12.86
Yes	154	73.33
No	29	13.81
Total	210	100.00

Source: Field survey, 2018

Table 8: Success recorded in side grafting

Variables	Frequency	Percentage	Cumulative
No response	126	60.0	60.0
0%	18	8.57	68.57
10%	11	5.24	73.81
20%	11	5.24	79.05
30%	14	6.67	85.71
40%	6	2.86	88.57

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>50%	24	11.43	100.00
Total	210		

Table 9: Rating of the new cocoa hybrids released by CRIN

Observation	Frequency	Percentage	Cumulative
No response	114	54.29	54.29
Poor yielding	9	4.29	58.57
Higher yielding	71	33.81	92.38
Similar to the old hybrids	13	6.19	98.57
No yield	3	1.43	100
Total	210	100	

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EFFECTS OF PLANT POPULATION ON LEAF DEVELOPMENT AND PROXIMATE COMPOSITION OF AMARANTH (*AMARANTHUS CRUENTUS* L.)

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ABSTRACT

Plant population affects growth and yield of leafy vegetables; they determine the efficiency of light use, nutrient uptake, water balance and land maximization. A field experiment was conducted at the Federal University of Agriculture, Abeokuta, in 2021 to determine the effects of plant population on leaf area and proximate composition of Amaranth. Treatments comprised of 3 plant populations: 400,000, 200,000 and 100,000 plants/ha using a spacing of 5, 10 and 20 cm intra-row and a constant inter-row spacing of 50 cm, replicated 4 times. Data were collected on number of leaves, leaf area and proximate composition (Moisture, dry matter, ash, carbohydrate, crude fibre and crude protein content) using standard procedures. Data collected were subjected to Analysis of Variance and treatment mean separated using least significant difference (p≤0.05). The number of leaves were similar all through the growing period, ranging from 10 – 11 leaves at 3WAP and 23 – 27 leaves at 4WAP. The leaf area was similar all through the growing period, ranging from 1.25 – 1.59 cm^2 at 2WAP and 42.10 – 51.60 cm^2 at 4WAP. Plant population of 200,000 plants/ha had more carbohydrate (23.89%) and dry matter (11.96 g) content with plants grown at 100,000 plants having the least dry matter (11.4 g) content and the fattest (2.79%). Amaranth planted at 400,000 plants/ha had more ash (29.5%), crude fibre (24.51%) and crude protein (21.33%) content with plants grown at 200,000 plants/ha having the least ash (28.7%), crude fibre (24.01%) and crude protein (20.67%) content. Planting at 100,000 plants/ ha is best for herbage yield. Planting at 200,000 plants/ha is best for optimum carbohydrate and dry matter content, while plants grown at 400,000plants/ ha is best for optimum ash, crude fibre and crude protein content.

Key words: Plant population, leaf area and proximate composition.

INTRODUCTION

Amaranthus cruentus (Linn) is a vegetable crop belonging to the genus *Amaranthus*, of the family *Amaranthaceae* and order *Caryophyllates* (Grubben, 2004). There are two kinds of amaranths i.e. vegetable and grain amaranths (Vorster *et al*., 2008). The center of origin for *Amaranthus* has been considered to be Southern Asia (Indo-Burma region) and Central and South America for most of the varieties that have been held under cultivation since time immemorial (De Candolle *et al*.,1984). Cultivation of amaranths contributes to the vitality of farmlands as they used as pioneer species for the colonization of disturbed lands (NRC, 2006). This characteristic is partly attributed to their C4 mode of photosynthesis, which involves efficient water use. They are photoperiod sensitive and are known to flower during shorter day lengths (Ebert *et al*.,2011). The dry matter content is high (9–22%). The average composition of *Amaranthus cruentus* per 100g edible portion is (averages of about 40 samples): water 84.0 g (78.4–91.3), energy 176 kJ (42 kcal), protein 4.6 g (3.2–6.0), fat 0.2 g (trace–0.6), carbohydrate 8.3 g, fibre 1.8 g (0.4–6.4) (Grubben, 2004). Plant population is the total number of plants present per unit area of land. The yield of a crop is directly influenced by population of plant. Plant height is increased, in high plant concentration due to competition for light. The thickness of leave may reduce due to high plant population, leaf geometry is also altered due to high population pressure (Nazer *et al*., 2016). Amaranthus cruentus is an important leafy vegetable in Nigeria, but the cultivation is erratic and not fixed at a particular population. Experimented reports are sparse on population effects on the leaf development and proximate composition of *Amaranthus cruentus.* The objective of this study was to assess the effects of plant population on leaf development and proximate composition of amaranth; which will serve as a way of improving the nutritive qualities of Nigerian foods.

MATERIALS AND METHODS

The experiment was conducted between May and July 2021, at the research farm of the Federal University of Agriculture Abeokuta (FUNAAB). Soil samples taken randomly up to 15 cm depth from 5 core spots, using soil auger were bulked to have a composite sample. This was air dried and analysed to determine the soil nutrient status. Twelve raised beds of 2.0m x 2.0m each were made. The treatments were arranged in a Randomised Complete Block Design (RCBD) having 3 treatments: 400,000, 200,000 and 100,000 plants/ha using a spacing of 5, 10 and 20 cm intra-row and a constant inter-row spacing of 50 cm, replicated 4 times, making a total of 12 experimental plots. Seeds were planted on beds using the drilling method and later thinned to the different intra row spacings based on the required treatment. Leaf area was determined using non-destructive method developed by Pearcy *et al* (2000): Y = 0.5(L x B) where Y = Leaf area (cm^2), L= Length, B= breadth. Data was collected on number of leaves per plant. Proximate composition: percent moisture, dry matter content, crude fibre, crude protein, carbohydrate content, fat and ash content were determined using the methods of Association of Official Analytical Chemists (AOAC, 2005).

RESULTS AND DISCUSSION

Leaf development

There were no significant differences in the number of leaves between 2 and 4WAP (Fig. 1). However, at 2WAP, the number of leaves per plant was the same (6 leaves/plant). At 3WAP, plants grown at 400,000 plants/ha had about 11 leaves/ha compared to plants grown at 200,000 and 100,000 plants/ha that had 10 leaves/ plants each. At 4WAP, plants grown at 100,000 plants/ha had about 27 leaves/ha compared to plants grown at 400,000 and 200,000 plants/ha with 24 leaves/plant each (Fig. 1). The lowest population had the highest number of leaves with the highest population having the least number of leaves which is in accordance with the report of Innocent *et al*., (2015). At higher planting population competition for sunlight, moisture, nutrient and space si greatly increased which can lead to reduced number of leaves.

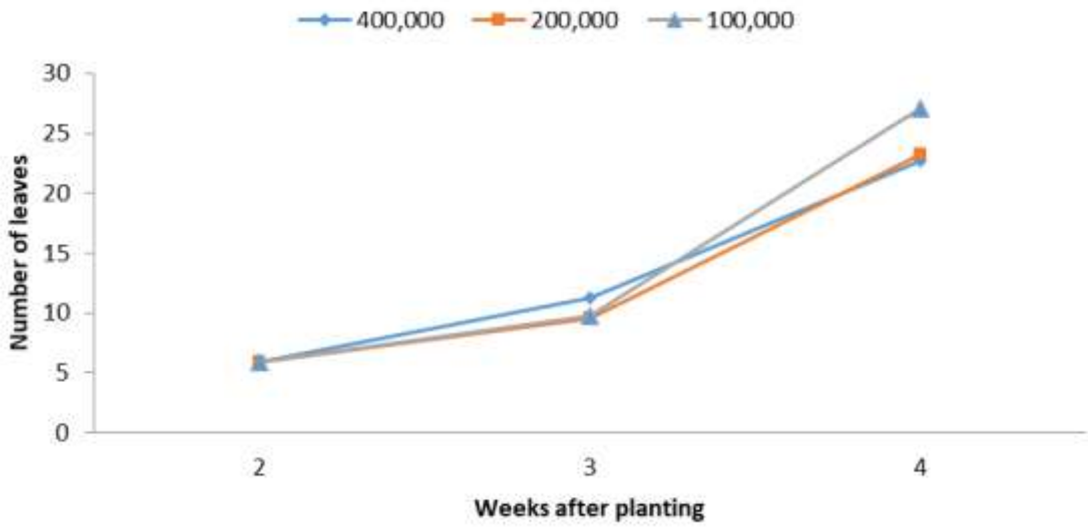

Figure 1: Effects of plant population on number of leaves of *Amaranthus cruentus*

Also, there were no significant differences in leaf area per plant between 2 and 4WAP (Fig. 2). However, at 2WAP, plants grown at 100,000 plants/ha had the widest leaves of 1.56 cm^2 compared to plants grown at 200,000 plants/ha with 1.25 cm^2 wide leaves and 400,000 plants/ha that had 1.56 cm^2 wide leaves. At 3WAP, plants grown at 400,000 plants/ha had the widest leaves of 21.50 cm^2 compared to plants grown at 200,000 plants/ha with 13.80 cm^2 wide leaves and 100,000 plants/ha that had 13.70 cm^2 wide leaves. At 4WAP, plants grown at 100,000 plants/ha had the widest leaves of 51.60cm^2 compared to plants grown at 400,000 plants/ha with 42.10cm^2 wide leaves and 200,000 plants/ha that had 43.20cm^2 wide leaves (Fig. 2). The lowest population size having larger leaves and higer population having smaller leaves is in agreement with the report of Innocent *et al*. (2015). The lowest population having larger leaves may be attributed to nutrient partitioning within the plant;

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with the nutrients being used for leaf development rather than shoot development. Plants compete for necessary growth factors: sunlight, moisture and soil nutrient; the competition for these growth factors are further amplified by the increase in plant population.

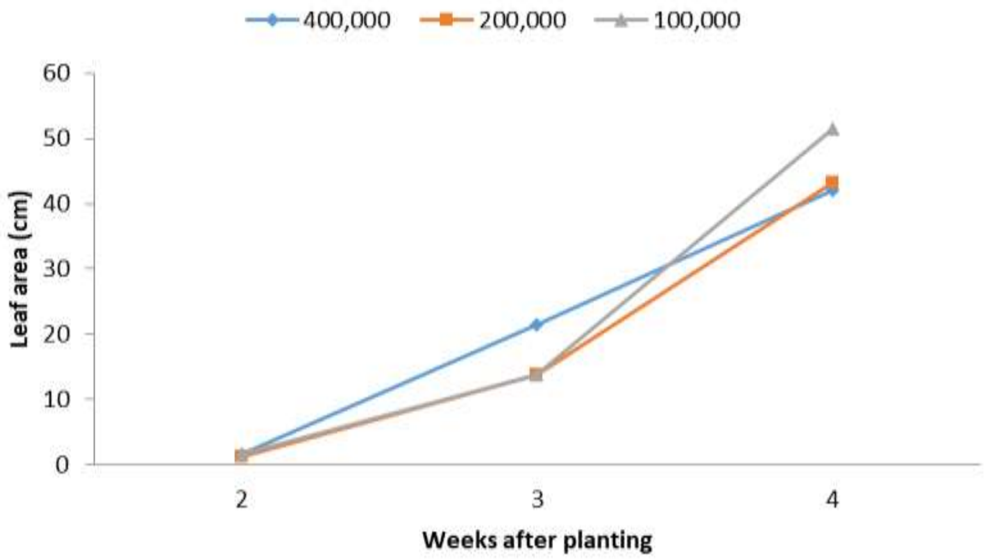

Figure 2: Effects of plant population on leaf area of *Amaranthus cruentus*

Proximate composition

Plants grown at 400,000 plants/ha had significantly higher ash content compared to plants grown at 200,000 plants/ha, but similar to those grown at 100,000 plants/ha (Table 1). The ash content indicates its high inorganic components which contain essential nutrients needed by humans (Asaolu *et al*., 2012). The treatments had no significant effects on the moisture content, fat content, crude protein and dry matter content. However, plants grown at 100,000 plants/ha had higher moisture content and fat content compared with the other plant populations. Plants grown at 200,000 plants/ha had higher dry matter content when compared with the other plant populations while plants grown at 400,000 plants/ha had higher crude fibre and crude protein when compared with the other plant populations (Table 1). Dietary fibre helps to lower cholesterol level, risk of coronary heart diseases, constipation and diabetes (Ebun-oluwa et al., 2007). The crude fat analysis shows that leafy vegetables are poor in lipids and this confirms their relevance as good diets for healthy living (Oluwole *et al*., 2019). Plants grown at 200,000 plants/ha had significantly higher carbohydrate content when compared to plants grown at 400,000 plants/ha, but similar to those grown at 100,000 plants/ha (Table 1). Carbohydrate constitutes a major class of organic compounds which are important for the maintenance of life and also provide raw materials for many industries (Sena *et al*., 1998).

Table 1: Effects of plant population on proximate composition of *Amaranthus cruentus*.

Plants/ha	Moisture	Dry matter	Ash	Fat	Crude fibre	Crude protein	CHO
	% ←						→
400,000	88.20	11.8	29.5	2.72	24.51	21.33	21.94
200,000	88.04	11.96	28.7	2.73	24.01	20.67	23.89
100,000	88.60	11.4	29.41	2.79	24.28	20.87	22.65
lsd (0.05)	NS	NS	0.45	NS	NS	NS	1.46

*NS = Not Significant

CONCLUSION

From this experiment it can be concluded that plant population up-to 400,000 plants/ha had significant positive effect on the ash, crude fibre and crude protein content of *Amaranthus cruentus* which are needed by the body for growth. Plant population of 200,000 plants/ha had significant positive effect on the carbohydrate and dry matter content of *Amaranthus cruentus* with 100,000 plants/ha being optimum for herbage yield.

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A REVIEW ON THE EFFECT OF SOIL AMENDIMENTS IN PLANT NUTRITION AND FOOD SECURITY DURING COVID-19 PANDEMIC IN SOME PART OF NIGERIA

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ABSTRACT

Soil is the most important source and an abode for many nutrients and micro flora. Due to rapid depletion of agricultural areas and soil quality by means of ever-increasing population and an excessive addition of chemical fertilizers, an urgent attention needed to maintain sustainable approaches in agricultural crop production. Biochar is the solid, carbon-rich material obtained by pyrolysis using different biomasses. Biochar have been found in soil around the world as a result of vegetation fires and historic soil management practices and have been thought to poses long term carbon sequestration potential which help combat global warming by holding carbon in the soil. Biochar is also used primarily as a soil amendment to make soil more fertile by increasing soil organic matter, improving soil physical and chemical properties, enhancing plant nutrient availability and increasing soil microbial population and activities thus boosting higher crop yield which in turns result in food availability and preserves arable land diversity. This paper explained the role of biochar in plant nutrition and food security.

Key words: Soil, Biochar, Plant, Nutrition, Food security and Covid-19

INTRODUCTION

The world's population is expected to reach 9 billion by 2050 with the most populated continents of Asia and Africa expected to have a more significant surge in population than other continents ofthe the world (Godfray *et al*., 2010), it will require an increase of 50% in agricultural supply to meet the growing demand (Mueller *et al*., 2012; FAO 2013a; Paul *et al*. 2009; FAO 2009). Agriculture constitutes the backbone of most developing economies. It is the largest contributor to gross domestic product (GDP) the biggest source of foreign exchange, accounting for about 40% of the continent's foreign currency earnings, and the main generator of savings and tax revenues. In addition, about two-thirds of manufacturing value added tax is based on agricultural raw materials. Agriculture remains crucial for pro-poor economic growth in most African countries particularly Nigeria, as rural areas support 70-80 % of total population. More than in any other sector, improvements in agricultural performance have the potential to increase rural incomes and purchasing power for large numbers of people to lift them out of poverty (NEPAD, 2002; Wiggins, 2006). Agriculture is important for food security in two ways: it produces the food people eat and perhaps even more important it provides the primary source of livelihood for 36 % of the world's total workforce. In densely populated countries of Asia and Pacific region, this share ranges from 40-50 % and in sub-Saharan Africa, two-thirds of the working population still make their living from agriculture (ILO, 2007). If crop production in the low-income developing countries of Asia and Africa is adversely affected by climate change, lack of quality inputs such as fertilizers, seeds, herbicides, insecticides and insufficient technical knowledge on best crop production practices by rural farmers in these countries, where the livelihoods of a large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increased. Generally crop growth and development are strongly influenced by various biotic and abiotic stresses such as pest, weeds, drought, high salinity, extreme temperature and soil quality(Thalmann *et al*.2017).Soil is also contaminated by heavy metals through various human activities (Moon *et al*. 2013), such as mining and mineral exploration which negatively affects plant growth and development and ultimately brings low yielding cropping systems(Al-Farraj 2013 and Noman *et al*.2017).The strength of soil is directly related to nutrient availability. Plants require a number of soil nutrients like nitrogen (N), phosphorus (P), and potassium (K) for their growth, but soil nutrient levels may decrease over time after crop harvesting, as nutrients are not returned to the soil. In most developing countries, the soil is not only deficient in micronutrients like NPK but also in secondary nutrients (example sulfur, calcium, and magnesium) and micronutrients (e.g. boron, zinc, copper, and iron),(Pathak *et al*.2010).Thus, to fulfill the shortage, a large amount of chemical fertilizers is added to the soil; however, only a small percent of water soluble nutrients are taken up by the plants and the rest are converted into insoluble forms, making continuous application necessary. The extensive use of chemical fertilizers has led to the deterioration of the environment causing infinite problems. It lowers the nutrient composition of the crops and also degrades the soil fertility in the long run (Harriprasad *et al*.2013 and Yargholi *et al*. 2014).

Besides fertilizers, pesticides are also the basic evil for agriculture, and the adverse effects of pesticides on the environment are truly responsible for influencing the microbial properties of soil. High inputs of fertilizers and pesticides and their long persistence in the soil adversely affect the soil microflora, thereby disturbing soil health and significantly reducing the total bacterial and fungal biomass (Prashar *et al*.2016). Due to long-term treatment with inorganic fertilizers (N and NPK) and/or organic manures, a shift in structural diversity and dominant bacterial groups in agricultural soils has been recorded by (Wu *et al*.2012). Biofertilizers, on the other hand, can reenergize the soil by improving the soil fertility and hence can be used as a powerful tool for sustainable agriculture, rendering agro-ecosystems more stress-free. Additionally, the application of organic amendments to soils, from a remedial point of view, has typically been justified by their relatively low cost, which normally requires other forms of disposal (burial in a landfill, incineration, etc.). Soil amendments must possess properties such as high binding capacity and environmental safety and should have no negative effect on the soil structure, soil fertility, or the ecosystem on the whole (Paz-Ferreiro *et al*., 2013). The use of biochar has been accepted as a sustainable approach and a promising way to improve soil quality and remove heavy-metal pollutants from the soil (Lahori *et al*., 2017). Biochar is a carbon-rich organic material, an organic amendment, and a by-product derived from biomass by pyrolysis under high-temperature and low-oxygen conditions. Biochar is produced through a process called pyrolysis, which basically involves heating of biomass (such as wood, manure, or leaves) in complete or almost complete absence of oxygen, with oil and gas as co-products. However, the quantity of these materials produced depends on the processing conditions. Recently, it has been reported that biochar obtained from the carbonization of organic wastes can be a substitute that not only influences the sequestration of soil carbon but also modifies its physicochemical and biological properties (Garcia *et al*. 2016 and Zhang *et al*.,2017). Biochar has the potential to produce farm-based renewable energy in an eco-friendly way. Specifically, the quality of biochar depends on several factors, such as the type of soil, metal, and the raw material used for carbonization, the pyrolysis conditions, and the amount of biochar applied to the soil (Dabela *et al*., 2012). In addition, the biochar amendment to the soil proved to be beneficial to improve soil quality and retain nutrients, thereby enhancing plant growth (Bananoni *et al*., 2017). Since biochar contains organic matter and nutrients, its addition increased soil pH, electric conductivity (EC), organic carbon (C), total nitrogen (TN), available phosphorus (P), and the cation-exchange capacity (CEC) (Dume *et al*.2016). Earlier, Verheijen *et al*. (2009) reported that the biochar application affected the toxicity, transport, and fate of various heavy metals in the soil due to improved soil absorption capacity. The presence of plant nutrients and ash in the biochar and its large surface area, porous nature, and the ability to act as a medium for microorganisms have been identified as the main reasons for the improvement in soil properties and increase in the absorption of nutrients by plants in soils treated with biochar (Nigusse *et al.,* 2012). Chan *et al*. (2008) reported that biochar application decreased the tensile strength of soil cores, indicating that the use of biochar can reduce the risk of soil compaction. A lot has already been discussed on the benefits of inoculation of rhizobacteria in soil, but the addition of biochar can also provide more nutrients to the soil, thus benefiting the agricultural crops. The mixing of the plant growth-promoting microorganisms with biochar was referred to as the best combination for growth and yield of French beans by Saxena *et al*. (2013). Addition of biochar in the soil can be extremely useful to improve the soil quality, as well as to stimulate the plant growth, and thus, biochar can play an important role in developing a sustainable system of agriculture. Several uses and positive effects of biochar amendment have currently been considered as an effective method to reclaim the contaminated soil (Placek *et al.,* 2016), and to achieve high crop yields without harming the natural environment. The positive influence of biochar on plant growth and soil quality suggests that using biochar is a good way to overcome nutrient deficiency, making it a suitable technique to improve farm-scale nutrient cycles. Therefore, a complete focus is being made to explore the positive effects of biochar amendment on plant nutrition and promotion of food security.

Covid-19 was caused by the virus SARS-CoV-2 which was first identified in Wuhan, Hubei province, China in December 2019 (WHO 2020). As of July 6 2020 more than 11 million cases were recorded with 537,419 death related to covid-19 have been reported in 213 countries (Hopkins, 2020). In Africa, over 470,000 cases have recorded with more than 29,000 cases from Nigeria (Hopkins, 2020). The virus is typically spread from one person to another via respiratory droplets and contact with contaminated surfaces (Guan *et al*., 2020). Covid-19 has led to unprecedented local and global public health measures, such as obligatory movement restrictions, social and physical distancing and prolonged closures of schools and leisure centers among others

Food Security

The 1996 World Food Summit defined food security as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious foods that meets their dietary needs and food preferences for a healthy life." (Barrett, 2010) This definition incorporates several needs: availability of food, access to food, and for the food to be culturally appropriate. There are many factors in today's global environment that exacerbate food security. It is true, we live in an age where we are growing and producing more food than ever before. We have enough food to feed the world's population, but it is not distributed properly nor is all food culturally appropriate across the globe. Local food access differs dramatically and the greatest difference exists between developed and developing countries (Havas *et al*., 2011). The primary reason for this inequity is an income-related difference between these populations (Hazell and Wood, 2008). It must be stated though, that in every country of the world there is hunger, and this often falls along economic and social lines. The underprivileged – be it individuals or countries –often have less. There are three areas of global concern that impact food security: overpopulation, climate change and urbanisation. Areas of the world with the highest birth rates and population such as the developing countries, where demand often exceeds supply, also have the greatest levels of hunger and disease. Local ecosystems provide the resources a population needs for food production, health, environmental management and water. Examples include rangeland, fertile soil, nutrient cycling, and wildlife for hunting, among others. The local ecosystem has a certain carrying capacity, and once this is exceeded the ecosystem becomes stressed and begins to break down. This is defined as ecosystem vulnerability (Ericksen, 2008). The results can include over-farmed soils, denuded grazing lands and dried up or contaminated wells, all of which contribute to an underfed population.

Biochar Production

The ancient method for producing biochar as a soil additive was the "pit or trench" method which created terra preta, or dark soil while this method is still a potential to produce biochar in rural areas, it does not allow the harvest of either the bio-oil or syngas and release a large amount of Carbondioxide, black carbon and other Green house gases (GHGs) into the air (Laird, 2008). Biochar production processes can utilize most urban agricultural or forestry biomass residues such as wood chips, corn Stover, rice or peanut hulls, tree bark, paper mill sludge, animal manure, and recycled organics. In modern times Biochar can be manufactured on a small scale using low-cost modified stoves or kilns or through large-scale, cost-intensive production, which utilizes larger pyrolysis plants and higher amounts of feedstocks. Biochar is produced from several biomass feedstocks through pyrolysis a thermal decomposition of biomass in an oxygen-limited environment, generating oil and gases as by-products (Zhu *et al*., 2018). The dry waste obtained is simply cut into small pieces to less than 3 cm prior to use. The feedstock is heated either without oxygen or with little oxygen at the temperatures of 350–700°C (662–1292°F). Pyrolysis is generally classified by the temperature and time duration for heating; fast pyrolysis takes place at temperatures above 500°C and typically happens on the order of seconds (heating rates ≥ 1000°C/min). This condition maximizes the generation of bio-oil. Slow pyrolysis, on the other hand, usually takes more time, from 30 min to a few hours for the feedstock to fully pyrolyze (heating rates ≤ 100°C/min) and at the same time yields more biochar. The

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temperature range remains at 250–500°C (Brown *et al*., 2011).

The type of biochar produced depends on two variables: the biomass being used and the temperature and rate of heating. High and low temperatures have an unequivocal effect on char yields. It has been noticed that at low temperature (<550°C), biochar has an amorphous carbon structure with a lower aromaticity than the biochar produced at high temperature (Joseph *et al*., 2010). High temperature leads to lower char yield in all pyrolysis reactions (Antal *et al*., 2003). Peng *et al*. (2011) reported the effect of charring duration on the yield of biochar; yield showing a decrease with increasing duration at the same temperature. The pyrolysis process seriously affects the quality of biochar and its potential value to agriculture in terms of agronomic performance or in carbon sequestration. The yield of biochar from slow pyrolysis of biomass has been stated to be in the range of 24–77% (Dutta, 2010 and Stoyle, 2011). The pyrolysis process can be shown as follows:

Biomass (Solid) → Biochar + Liquid or oil (tars, water, etc.) + Volatile gases (CO2, CO, H 2)

Biochar Properties

Biochar is a stable form of carbon and can last for thousands of years in the soil (Shenbagavali and Mahimairaja 2012). It is produced for the purpose of addition to soil as a means of sequestering carbon and improving soil quality. The conditions of pyrolysis and the materials used can significantly affect the properties of biochar. The physical properties of biochar contribute to its function as a tool for managing the environment. It has been reported that when biochar is used as a soil amendment, it stimulates soil fertility and improves soil quality by increasing soil pH, increasing the ability to retain moisture, attracting more useful fungi and other microbes, improving the ability of cation exchange, and preserving the nutrients in the soil (Ajema, 2018). Biochar reduces soil density and soil hardening, increases soil aeration and cation-exchange capacity, and changes the soil structure and consistency through the changes in physical and chemical properties. It also helps to reclaim degraded soils. It has shown a greater ability to adsorb cations per unit carbon as compared to other soil organic matters because of its greater surface area, negative surface charge, and charge density (Liang *et al.,* 2006), thereby offering the possibility of improving yields (Lehmann, 2007). The physical characteristics of biochar are directly and indirectly related to how they affect soil systems. Soils have their own physical properties depending on the nature of mineral and organic matter, their relative amounts, and how minerals and organic matter are related. When biochar is present in the soil mixture, its contribution to the physical nature of the system is significant, affecting the depth, texture, structure, porosity, and consistency by changing the surface area, pore and particle-size distribution, density, and packing (Blanco-Canqui, 2017). The influence of biochar on physical properties of soil directly affects the growth of plants, since the depth of penetration and accessibility of air and water in the root zone is determined mainly by the physical composition of the soil horizons. This affects the soil's response to water, its aggregation, and work ability in soil preparation, dynamics, and permeability when swelling, as well as the ability to retain cations and response to changes at ambient temperature. The smaller the pores on biochar, the longer they can retain capillary soil water. The addition of biochar can reduce the effects of drought on crop productivity in drought-affected areas due to its moisture-retention capacity (Jiyoti Rawat *et al*., 2019). Most research findings on the effect of biochar on soil physical properties point to the improvement of soil bulk density with biochar application (Karhu *et al.,* 2011, Haryani and Gunito 2012, Masulili *et al.,* 2010); water-holding capacity also increased (Karhu *et al.,* 2011). Biochar has high porosity, which allows high water-holding capacity. However, it is hydrophobic as it is dry due to its high porosity and light bulk density. Adding biochar to the soil also improves soil physical property, water permeability, and aggregate stability. Peng *et al*. (2011) reported that, compared with chemical fertilizer application, biochar amendment to a typical Ultisol resulted in better crop growth.

As far as its chemical properties are concerned, biochar reduces soil acidity by increasing the pH (also called the liming effect) and helps the soil to retain nutrients and fertilizers (Lehmann, 2006). The application of biochar improves soil fertility through two mechanisms: adding nutrients to the soil (such as K, to a limited extent P, and many micronutrients) or retaining nutrients from other sources, including nutrients from the soil itself. However, the main advantage is to retain nutrients from other sources. In most cases, the addition of biochar only has a net positive effect on the growth of crops if nutrients from other sources, such as inorganic or organic fertilizers, are used. Biochar increases the availability of C, N, Ca, Mg, K, and P to plants, because biochar absorbs and slowly releases fertilizers (Deluca *et al*. 2015). It also helps to prevent fertilizer drainage and leaching by allowing less fertilizer use and reducing agricultural pollution in the surrounding environment (Cao *et al*.2018). Biochar alleviates the impact of hazardous pesticides and complex nitrogen fertilizers from the soil, thus reducing the impact on the local environment. Good healthy soil should include a wide and balanced variety of life forms, including bacteria, fungi, protozoa, nematodes, arthropods, and earthworms. Recently, biochar has been reported to increase the microbial respiration of the soil by creating space for soil microbes (Slapakova *et al*.2018), and in turn the soil biodiversity and soil density increased.

Benefits of applying Biochar to the Soil

The amendment of soils for their remediation aims at reducing the risk of pollutant transfer to waters or receptor organisms in proximity. The organic material such as biochar may serve as a popular choice for this purpose because its source is biological and it may be directly applied to soils with little pretreatment (Beesley *et al*.2011). There are two aspects which make biochar amendment superior to other organic materials: the first is the high stability against decay, so that it can remain in soil for longer times providing long-term benefits to soil and the second is having more capability to retain the nutrients. Biochar amendment improves soil quality by increasing soil pH, moisture-holding capacity, cation-exchange capacity, and microbial flora (Mensah and Frimpong, 2018).

The addition of biochar to the soil has shown the increase in availability of basic cations as well as in concentrations of phosphorus and total nitrogen (Glaser *et al*., 2002 and Lehmann *et al*., 2003). Typically, alkaline pH and mineral constituents of biochar (ash content, including N, P, K, and trace elements) can provide important agronomic benefits to many soils, at least in the short to medium term. When biochar with a higher pH value was applied to the soil, the amended soil generally became less acidic (Yaun *et al*., 2011). Acidic biochar could also increase soil pH when used in soil with a lower pH value. The pH of biochar, similar to the other properties, is influenced by the type of feedstock, production temperature, and production duration. Another valuable property of biochar is suppression of emissions of greenhouse gases in soil. Spokas *et al*.(2009) reported reduced carbon dioxide production by addition of different concentrations of biochar ranging from 2 to 60% (w/w), suppressed nitrous oxide production at levels higher than 20% (w/w), and ambient methane oxidation at all levels over unamended soil.Bonanomi et al.(2015) reported that biochar is effective against both air-borne (e.g. Botrytis cinerea and different species of powdery mildew) and soilborne pathogens (e.g. *Rhizoctonia solani* and species of *Fusarium* and *Phytophthora*). The application of the biochar derived from citrus wood was capable of controlling air-borne gray mold, *Botrytis cinerea* on *Lycopersicon esculentum*, *Capsicum annuum* and *Fragaria ananassa*. Although there is a shortage of published data on the effects of biochar on soil-borne pathogens, evidence given by Elmer et al. (2010) has shown that the control of certain pathogens may be possible. The addition of biochar in 0.32, 1.60, and 3.20% (w/w) to asparagus soils infested with Fusarium has augmented the biomass of asparagus plants and reduced Fusarium root rot disease (Elmer *et al*.2010). Similarly, Fusarium root rot disease in asparagus was also reduced by biochar inoculated with mycorrhizal fungi (Thies and Riling, 2009). The application of biochar to soil can influence a wide range of soil constraints such as high availability of Al, soil structure and nutrient availability, bioavailability of organic and inorganic pollutants, cation-exchange capacity (CEC), and retention of nutrients. Biochar can also adsorb pesticides, nutrients, and minerals in the soil, preventing the movement of these chemicals into surface water or groundwater and the subsequent degradation of these waters from agricultural activity.

The consequence of biochar addition on plant productivity depends on the amount added. Recommended application rates for any soil amendment should be based on extensive field testing. At present, insufficient data are available for obtaining general recommendations. In addition, biochar materials can vary greatly in their characteristics, so the nature of the particular biochar material (e.g. pH and ash content) also influences the application rate. Several studies have reported a positive effect of using biochar on crop yields with rates of 5–50 tonnes per hectare with appropriate nutrient management (Jyoti *et al*., 2019).

The experiments conducted by Rondon *et al*. (2007) resulted in a decrease in crop yield in a pot experiment with nutrient deficient soil amended with biochar at the rate of 165 tonnes per hectare. An experiment conducted in the United States showed that peanut hull and pine chip biochar, applied to 11 and 22 tonnes per hectare, could reduce corn yields below those obtained in the control plots with standard fertilizer management (Gaskin *et al*., 2010). Thus, the control of the rate of application of biochar is necessary to prevent the negative impact of biochar.

The Combination of Biochar with other Soil Amendments

The combination of biochar with other soil amendments such as manure, compost, or lime before soil application can improve efficiency by reducing the number of field operations required. Since biochar has been shown to sorb nutrients and protect them from leaching (Major *et al*., 2010 and Novak *et al*., 2009), mixing of biochar may improve the efficiency of manure and other amendments. However, Kammann *et al*. (2016) acknowledged in their recent review that very few studies that directly combined organic amendments with biochars were available. They found that co-composted biochars had a remarkable plant growth-promoting effect as compared to biochars when used pure, but no-systematic studies have been done to understand the interactive effects of biochars with non-pyrogenic organic amendments (NPOAs). Biochar can also be mixed with liquid manures and used as slurry. Additionally, combined biochar and compost applications have numerous advantages over mixing of biochar or compost with soil separately. These benefits, according to Liu *et al*. (2012), include more efficient use of nutrients, biological activation of biochar, an enhanced supply of plant-available nutrients by biological nitrogen fixation, reduction of nutrient leaching, and the contribution of combined nutrients in comparison to a single application of compost and biochar. Rubab *et al*. (2017) reported in their study that addition of biochar could decrease the use of Inorganic fertilizers by improving the quality and yield of crops because in their findings they reported that biochar at the rate of 1% and Nitrogen at the rate of 50% provided an optimum output minimizing the economic cost of production. Application of organic fertilizers and biochar showed significantly higher N absorption than sole urea application. Frequent application of organic fertilizers and biochar resulted in significantly higher N absorption than one-time application of organic fertilizers (Widowati *et al*., 2012).

Effects of Biochar on Plant growth, Nutrition and Food security

Several reports have shown that biochar has the capability to stimulate the soil microflora, which results in greater accumulation of carbon in soil. Besides adsorbing organic substances, nutrients, and gases, biochars are likely to offer a habitat for bacteria, actinomycetes and fungi (Thies and Riling, 2009). It has been suggested that faster heating of biomass (fast pyrolysis) will lead to the formation of biochar with fewer microorganisms, smaller pore size, and more liquid and gas components (Nartey et al.2014). The enhancement of water retention after biochar application in soil has been well established (Busscher *et al*., 2010), and this may affect the soil microbial populations. Biochar provides a suitable habitat for a large and diverse group of soil microorganisms, although the interaction of biochar with soil microorganisms is a complex phenomenon. Many studies reported that addition of biochar along with phosphate solubilizing fungal strains promoted growth and yield of Vigna radiata and Glycine max plants, with better performances than control or those observed when the strains and biochar are used separately [Saxena 2013, Saxena 2016 and Saxena *et al*., 2017).

The use of biochar increased mycorrhizal growth in clover bioassay plants by providing the suitable conditions for colonization of plant roots (Solaiman *et al*.2010). Warnock *et al*. (2007) summarized four mechanisms by which biochar can affect functioning of mycorrhizal fungi: (i) changes in the physical and chemical properties of soil, (ii) indirect effects on mycorrhizae through exposure to other soil microbes, (iii) plantfungus signaling interference and detoxification of toxic chemicals on biochar, and (iv) providing shelter from mushroom browsers.It was found that biochar increased the biological N2 fixation (BNF) of Phaseolus vulgaris (Rondon *et al*.2007) mainly due to greater availability of micronutrients after application of biochar. Lehmann *et al*. (2003) reported that biochar reduced leaching of NH4+ by supporting it in the surface soil where it was available for plant uptake. The direct beneficial effects of biochar addition for the availability of nutrients are largely due to the higher content of potassium, phosphorus, and zinc availability and, to a lesser extent, calcium and copper (Lehmann *et al*., 2003). Field and green house research have confirmed the safety and practicability of recycling biochar on arable land in sub Saharan Africa. It has shown that biochar has a lining effect of between 80 and 90 % of the total neutralizing power of lime and can increase plant growth up to 45%. Most soils in Africa are infertile due to acidity and low inorganic matter, therefore continuous cultivation requires many soil additives to correct these deficiencies and the fact that additions such as nitrogen fertilizer often increase the soil pH makes the addition of neutralizing agents such as biochar a necessity on most infertile soils. Biochar has added advantage of being able to replace many of the macro and micro nutrients removed during plant growth and harvest. A number of studies have shown that biochar can increase soil pH, cation exchange capacity (CEC), total N, available P, exchangeable Ca, magnesium, etc. and can reduce Al availability.

Widowati *et al* (2012) reported that biochar application decreased N fertilizer requirement. They also found that organic carbon was increased by biochar application. Similar results were seen with different types of biochar and soil in various regions (Rondon *et al* 2007, Novak *et al* 2009, Cui *et al* 2011, Masulili *et al* 2010, Laird *et al* 2010). The increase in soil carbon through biochar application is attributed to the stability of biochar in the soil, which persists despite microbial action. Sukartono *et al*. (2011) reported that application of biochar improved soil fertility status, especially soil organic C, CEC, available P, exchangeable K, Ca, and Mg of the sandy soils in Lombok, Indonesia. Since biochar is highly porous and has a large specific surface area, its impact on soil CEC and other nutrient that have correlation with CEC is very important. Besides the direct/indirect effect of biochar on soil fertility characteristics, application of biochar contributes to the interaction of soil with microelements such as lead and cadmium. Jiang *et al*. (2012) reported that incorporation of biochar increased Pb(II) adsorption by variably charged soils. Biochar amendment significantly decreased extracted Cd in the soil by 17-47%. Some types of biochar also appear to reduce the mobility of heavy metals such as Cu and Zn (Hua *et al.,* 2009). Novak *et al*. (2009) reported that most soil micronutrient concentrations were not influenced by biochar addition; however, biochar application decreased exchangeable acidity, S, and Zn. Application of organic manure and biochar significantly affected the soil's total N content after harvest. The use of organic fertilizer and biochar increased soil organic matter content and cation exchange capacity which increases the negative charge that contributes to greater absorption of the released nutrients (N urea). These conditions exist as biochar is better at storing nutrient N than organic fertilizers.

Yield was higher when maize was grown on biochar-treated soils. With biochar application, yields obtained with fertilization rates between 90 and 180 kg N ha-1 were similar to each other; less N was used to obtain the same level of yield, which was achieved at maximum dosage. Unused N at maximum dosage was absorbed into the soil because of biochar. The results imply that biochar can play a role in lowering N dosage for maize production (Wani Hadi Utomo and Titiek Islami, 2013). Biochar can increase the value of non-harvested agricultural products (Major *et al*.2005) and promote the plant growth (Lehmann 2003, and Oguntunde *et al*.2004). A single application of 20 t ha^{-1} biochar to a Colombian savanna soil resulted in an increase in maize yield by 28–140% as compared with the unamended control in the 2nd to 4th years after application (Major *et al*. 2010). With the addition of biochar at the rate of 90 g kg^{-1} to tropical, low-fertile ferralsol, not only the proportion of N fixed by bean plants (Phaseolus vulgaris) increased from 50% (without biochar) to 72%, but also the production of biomass and bean yield were improved significantly (Shenbagavalli and Mahimairaja, 2012). When biochar was applied to the soil, a higher grain yield of upland rice (Oryza sativa) was obtained in northern Laos sites with low P availability (Asai *et al*., 2009 and Silber *et al*., 2010). Palansooriya *et al*., (2019) reported that yield of various upland crops which are usually a stable food for most developing countries can be enhanced by biochar-induced increases of nutrients availability and top soil retention/recovery. They went to report that biochar can assist in controlling unsuitable soil acidity, alkalinity, salinity and remediating a contaminated soil while increasing the retention of soil organic carbon, water content and higher crop yield.

Chan *et al.* (2008) reported that increased crop yield is largely attributed to the ability of the biochar to increase N availability. N levels, which were high after the first season, can increase the absorption and efficiency of fertilizer N in the second season (biochar manure and organic waste biochar). The high soil N levels in the second season can increase the absorption and efficiency of fertilizer N in the third season (organic waste biochar). Up to the third season, the soil N level of biochar is still higher than that of organic fertilizers. Biochar application combined with chicken manure could improve some properties of peat and acid sulfate soils. In peat soil, application of biochar (6.25 t ha^{-1}) and chicken manure (1.25 t ha^{-1}) increased soil pH and available soil K. In acid sulfate soil, biochar (5 t ha^{-1}) + chicken manure (0.5 t ha^{-1}) increased soil pH and available soil P and also decreased soluble Fe and iron toxicity symptoms of the rice plant. Improvement of soil properties resulted in an increase of rice growth and yield in swamplands of Indonesia (Nursyams *et al*. 2013). Based on a Soil Research Institute study in Indonesia, the addition of biochar from cocoa skin to maize and padi gogo (as much as 2.5 and 5 t ha^{-1}, respectively) increased yield by 281% (from 0.37 to 1.41 t dried corn grain ha^{-1}) and 150% (from 0.4 to 1 t dry milled rice ha^{-1} (Nurida, 2012).

CONCLUSION

Plant nutrition-based research activities are indispensable in meeting food security needs in the 21st century. The fact that at least 60% of the presently cultivated soils globally have several mineral problems, like toxicities of Al, Mn and Na, and deficiencies ofN, P, K, S, Fe and Zn, makes plant nutrition-based research a major promising research area needed to meet the demand for massive increases in food production required for the growing world population. One of the high priority objectives of plant-nutrition research will be ensuring a long-term sustainable nutrient management system for crop production, and developing more efficient mineral nutrient uptake by crop plants and improving intra and intercellular use of nutrients without detrimentally affecting the environment through the use organic fertilizers such as biochar .Creation of asynergy between plant nutrition and sustainable organic agricultural practices is required to assure a rapid progress towards alleviating food insecurity issues in developing countries this 21st century. Literatures reviewed in this article showed that biochar has high potential in improving soil physical, chemical and biological properties. In an agroindustrial land of most developing countries where most of people work as farmers, there are sufficient amounts and kinds of biomass materials for biochar production. The application of biochar to agricultural land seems suitable. This necessitates further studies to ensure the wide use of this important resource (biochar) by farmers in developing countries to produce quality and healthy food for its populace.

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EFFECTS OF SOWING DATES ON TWO SESAME (*SESAME INDICUM L.*) VARIETIES IN JIGAWA NORTH EAST ZONE OF NIGERIA

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ABSTRACT

The research studied the effect of sowing dates on two sesame (Sesamum indicum L.) varieties in Jigawa North East Zone, conducted in two different seasons 2019 and 2020 both at Binyaminu Usman Polytechnic Hadejia Teaching and Research Farm during 2019 and 2020 raining season. The treatments consisted of two varieties (E8 and Ex-Sudan) and three sowing dates (early July, mid-July and late July). A randomized complete block design (R C B D) with three replications was used. The results showed that in 2019, sesame varieties recorded significant variation; Ex-Sudan produced highest mean values for growth and yield parameters than E8. While early July sowing date recorded significantly higher growth and yield parameters. In 2020, Variety Ex-Sudan produced the highest mean values than E8 for all parameters. Early July sowing resulted in significantly higher growth and yield parameters of the two varieties. Significant interaction was also observed between variety and sowing date in both seasons. It is recommended that farmers at Jigawa North East should adopt Ex-Sudan as their sowing material, early July sowing date is suggested for increasing sesame production in the study area.

INTRODUCTION

Sesame (*Sesamum indicum* L.) belongs to the plant family Pedaliacea and is commonly called beniseed in Nigeria. It is an important oilseed crop believed to have originated from tropical Africa, where there is the greatest genetic diversity. It was later taken at a very early date to India where a secondary centre of diversity was developed (Purseglove., 1996; Nwalem., 2015). The four major states that produce this commodity in Nigeria are Taraba, Jigawa, Nasarawa and Benue. Nigeria is the largest producer of sesame seeds in Africa, and the third largest in the world, with about 580,000 tonnes produced in 2017 (FOA., 2018).

Sesame seeds (approximately 50 percent oil and 25 percent protein) are used in baking, candy making, in cooking and salad oil and margarine. The oil can also be used in manufacture of soaps, paints, perfumes, insecticides and pharmaceuticals. Sesame meal, left after the oil is pressed from the seed, is an excellent high protein (34-50 percent) feed for poultry and livestock (Oplinger*et al.,* 2007; Nwalem., 2015). As a raw export commodity, sesame seed from Nigeria is enjoying a rising profile in the world market where overall global demand has risen to 3.3 million tons. Sesame, like other raw agricultural communities, has over 15% margin in terms of value added products compared to other crops (RMRDC, 2004; Nwalem, 2015).

BOTANICAL DISCRIPTION

Sesame is an annual herb that can grow to heights of 0.3m to 2. 2m (Kafriti and Decker. 2002). The flower is about 3 to 4 cm long, auxiliary with one flower and two exra-floral necteries per leaf axil (Robert, 2002). Some varieties are highly branched, while others are not and they tend to be variable in number depending on the environmental factors. (Alegbejo *et al.*, 2012; Down *et al.*, 2012; Olinger, 1990). The capsules are oblong, 2 to 5 cm long, containing wingless 1.5 to 4 mm long seed with white, yellow, grey, light brown, red brown or black testa with a smooth or reticulate surface (Kafiriti and Decker, 2002). The petiole is about 1.0 to 1.5 cm long (Down *et al.*, 2012). Oplinger *et al.* (1990) observed that the fruits are deeply grooved capsule 3.5 cm in length and contain between 50 to 100 or more seeds. The number of capsule per plant depends on variety and environmental condition. The seed is very small, light in weight (1000 grain weighing 2 to 4 g) and can be white, grey, brown, chocolate or black in colour. Sesame matures in 90-120 days when the plants drop their leaves and the stems and seed capsules turn yellow-brown. This is the time to harvest the plants and dry them in the sun in a sack. As the sun bakes the capsules, they pop open and release their seeds. Threshing the capsules inside a sack gets most of the seeds from the capsules. Finally, the chaff is winnowed from the seeds, and they're ready to be stored.

MATERIALS AND METHODS

The experiment was conducted during 2019 and 2020 rainy season at Teaching and Research Farm of Binyaminu Usman Polytechnic Hadejia, situated at latitude 12^0 27'N and 12 24" N and 7^0 46'E and 10 E and 400 meters' elevation above sea level. The treatment consisted of three sowing dates (early July, mid-July and late July), and two varieties of sesame (E8 and Ex-Sudan). E8 is an early maturing variety and is ready for harvesting within 90 days after sowing. The seed is light brown in colour and seed size is about 3.6mm. Ex-Sudan is a relatively older variety than E8 and originated from Sudan. The seed is white in colour and late maturing variety about (120 days). The treatments were combined and laid out in a Randomized Complete Block Design (RCBD) replicated three (3) times. The mean annual temperature is between 27^{0}C to 30.6^{0}C and soil type is sandy – loam. Composite soil sample from the experimental field was collected at random using soil auger at 0-30cm depths. The soil samples were air dried, sieved and analyzed for physical and chemical properties (pH, Texture, Organic Carbon, Cation Exchange Capacity and Available Phosphorus as described by Black (1965). Information about rainfall maximum and minimum temperature, relative humidity wind speed and sunshine hours of the growing seasons was obtained from metrological station of the Department of General Studies Binyaminu Usman Polytechnic Hadejia Jigawa State. The Data was subjected to Analysis of Variance (ANOVA) as described by Snedecor and Cochran (1967) using SAS. Significant treatment means were separated at 5% level of probability using SNK. Simple and partial correlation studies were also carried out to determine the relationships between various parameters and yield as well as the contributions of the different parameters studied to the grain yield. Plot size was 3m x 2m (6m^2), An alley of 0.5m and 1m was left between plots and replicates, respectively. The land was ploughed and harrowed, to obtain a fine tilt. Ridges 40cm high and 75cm inter row was erected and marked out into replications and plots according to the experimental design. Sesame seed were sown according to the treatments; Early July sowing was done on 1st of July, Mid July sowing was carried on 15th of July and the late July sowing was conducted on 29th of July both at 2019 and 2020 raining season respectably at the experimental sites using 7.0 kg seed rate /ha. The fertilizer was applied using side placement method. Each plot was given N.P.K. 15: 15: 15: fertilizer at the rate of 60: 30: 30 kg ha^1. A based application of the fertilizer at the rate of (30:30:30) kg ha was applied at 3WAS and Urea (45%N) was used to supply the remaining 30 kg N ha^1 at 6 WAS. Weed control was done manually using hoe and hand picking at 3, 6, and 9 WAS. Major pests of sesame are weevil, termites, leaf-feeding caterpillars and rats while its main diseases are Mycoplasma (little leaf disease) and Soil-borne fungal diseases. But no major pest and diseases were encountered during the period of this experimental research. Data were collected from the following characters from the five tagged plants at 6, 8, and 10 WAS the mean values were recorded Plant height, Number of branches per plants, Fresh weight per plant (g), Plant dry weight, Leaf area, and number of capsules per plant at maturity were determined by counting all the capsules of five tagged plants from each plots and the mean values were recorded, Days from sowing to 50% flowering in each plot were noted and recorded, Days from sowing to maturity were noted from each plot and recorded, 1000 seeds of sesame were counted and weighted from each plot and the mean value was recorded, Seed yield per plot within the net plot were harvested and allowed to sundry for two weeks, and was kept in bags upside down in order to avoid seed loss when the capsule open. It was later threshed and weighed and the means values were recorded for each plot, Seed yield per hectare (kgha^1), Harvested plants from the net plot was threshed and add to gross plot to obtain yield per hectare.

RESULTS

The effect of sowing date on plant height at 6, 8 and 10WAS in 2019 and 2020 is presented in table 1. In 2019 the result show that there is no significant effect at 6 and 10WAS for both varieties while at 8WAS Ex-Sudan had significantly higher than E8 per plant while in 2020 E8 variety at 6 and 10WAS is significantly higher than Ex-Sudan and no significant difference at 8WAS in plant height. The table also shows that sowing date had significant effect on plant height both seasons; in 2019, late July produced significantly higher plant height at 6WAS, higher than Mid July while Early July produce significantly shorter plants. At 8WAS however, seeds planted early July produced significantly shorter plants, while the rest of the sowing dates produced significantly higher and similar plant heights. At 10WAS, Mid July sowing produced significantly taller plants then the rest of the sowing dates. Meanwhile, in 2020 raining season considering early and mid-July at 6WAS produced higher plant heights, mid-July at 8WAS and early July at 10WAS. However late sowing date produced significantly shorter plants at 6, 8 and 10WAS.

Table 1: Response of sesame varieties to sowing date on plant height at 2019 and 2020 Raining Seasons (cm)

Treatments	Plant height 2019			Plant height 2020		
	6WAS	8WAS	10WAS	6WAS	8WAS	10WAS
Variety (V)						
E-8	33.250	52.244b	96.794	55.856a	85.472	128.817a
Ex-Sudan	32.606	59.050a	96.389	52.978b	85.533	125.744b
SE±	2.246	3.786	2.309	2.369	1.855	1.879
Sowing Date (SD)						
Early	17.417c	41.567b	89.183b	60.083a	82.333b	154.000a
Mid	31.883b	66.283a	110.992a	56.067a	101.800a	137.567b
Late	49.483a	59.092a	89.600b	47.100b	72.375c	90.275c
SE±	2.751	4.637	2.828	2.901	2.272	2.301
Interaction						
V x S	NS	NS	NS	NS	NS	NS

Means followed by the same letter within a treaptment group are not statistically different at 5% level of probability using SNK. NS = Not Significant * = Significant at 5% probability level ** =Significant at 1% probability level

Days to 50% flowering and Days to Maturity of sesame varieties.

The effect of sowing date on days to 50% flowering and days to maturity of two sesame varieties in 2019 and 2020 raining season is presented in Table 2. In 2019 and 2020 raining season Ex-Sudan variety had higher significant difference than E8 which were ranked second at both season for days to 50% flowering. In 2019 sowing date on days to 50% flowering mid-July sowing date were significantly higher number of days to 50% flowering than early and late July that were statistically similar. While in 2020 sowing dates differed from significantly one another; mid-July sowing date were recorded highest days to 50% flowering and per better than late July sowing date which was recorded second and finally flowed by early July sowing date. The days to maturity on the two varieties Ex- Sudan were significantly at par than E-8 at both two seasons.

Table 2: Response of sesame varieties to sowing date on Days to 50% Flowering and Days to maturity

Treatments	2019 raining season		2020 raining season	
	Days to 50% flowering	Days to Maturity	Days 50% flowering	Days to Maturity
Variety (V)				
E-8	63.00b	96.0b	50.33b	91.7b
Ex-Sudan	77.67a	117.7a	62.33a	112.3a
SE±	4.32	2.70	1.20	0.932
Sowing Date (SD)				
Early	70.00b	106.5b	53.50c	102.0b
Mid	71.00a	108.5a	58.50a	101.5c
Late	70.00b	105.5c	57.00b	102.5a
SE±	0.921	1.002	0.872	0.726
Interaction				
V x S	*	NS	NS	NS

Means followed by the same letter within a treatment group are not statistically different at 5% level of probability using SNK. NS = Not Significant * = Significant at 5% probability level ** =Significant at 1% probability level

Table 3 shows the effect of sowing date on 1000 seed weight, net plot weight and grain yield per hectare of sesame varieties in 2019 and 2020 rainy season. At both seasons variety EX- Sudan performed significantly better than E8 in terms of 1000 seed weight, net plot weight and grain yield per hectare. In 2019, higher 1000 seed weight was obtained from early July sowing date but, mid and late July sowing dates were statistically similar. For net plot weight, early July produced significantly heavier seeds than mid-July sowings while late July sowings significantly produced the lowest seed weight. In 2019 raining season, higher grain yield per hectare was obtained from early July sowing date, mid-July were statistically weighted second and late July significantly produced the lowest grain yield per hectare. While in 2020 raining season variety Ex-Sudan had recorded higher 1000 seed weight, net plot weight and grain yield per hectare than E-8. In 2020 raining season sowing date had significant effect on 1000 seed weight early July were significant heavies than mid-July and late July was significantly recorded lowest. For the net plot weight early July significantly produced heavies weight, mid-July was ranked second and late July was ranked statistically lowest. Grain yield per hectare for sowing date in 2020 raining season early July had resulted significantly higher than mid-July, followed by late July sowing date.

Table 3: Response of sesame varieties to sowing date and sowing method to 1000Seed weight, Net plot weight and Grain yield per hectare in 2019 and 2020 raining season

Treatments	2019 raining season			2020 raining season		
	1000 Seed weight (g)	Net plot weight (g)	Seed yield (kg/ha)	1000 Seed weight (g)	Net plot weight (g)	Seed yield (kg/ha)
Variety (V)						
E-8	2.9722b	89.889b	299.63b	2.6556b	77.556b	258.52b
Ex-Sudan	3.0889a	93.722a	312.41a	3.0556a	107.056a	356.85a
SE±	0.083	3.438	11.458	0.082	2.589	8.629
Sowing Date (SD)						
Early	3.5833a	122.417a	408.06a	3.5583a	154.083a	513.61a
Mid	2.8000b	86.417b	288.06b	2.9333b	83.500b	278.33b
Late	2.7083b	66.583c	221.95c	2.0750c	39.333c	131.11c
SE±	0.101	4.210	140.34	0.101	3.171	10.569
Interaction						
V x S	*	**	**	*	**	**

Means followed by the same letter within a treatment group are not statistically different at 5% level of probability using SNK.
NS = Not Significant * = Significant at 5% probability level ** =Significant at 1% probability level

DISCUSSION

The results of the research showed that there was significant difference of sowing date in both 2019 and 2020 where sesame sown at early July and mid-July at 6WAS produced higher plant height in 2020 season and late July produced shorter plant height at 6,8 and 10WAS. This might be attributed to the optimum environmental condition for the growth and development of the crop. This is in line with earlier observation by Aghili *et al.* (2015) who reported that delayed sowing effect plant height (4%) dry matter yield (8.9%). Similar observation was made by Tahir et al. (2012) who found that the yield attributing parameters were significantly affected by different sowing dates. Similarly, Ogbonna *et al.* (2012) stated that the effect of three sowing date had a significant effect of plant height, number of branches and stem girth. In 2019 season, late July sowing produced significant higher plant height at 6WAS than mid-July sowing while early July sowing produced significantly shorter plant. This may be due to the short drought period experienced at that particular year 2020. Ali and Jan (2014) found that sesame sowing was dependent on the rain water and for that reason the yield be effected due to different sowing date and variety characteristic in response to N application. Number of branches per plant respond to sowing date in 2019 at 6WAS, late July produced significantly higher number of branches while mid-July were recorded second and early July produced shorter per plant. At 8WAS mid-July produced higher number of branches per plant and early July was recorded second and late July produced shorter per plant. At 10WAS early and mid-July produced significantly higher number of branches per plant than late July in 2019 season.

Effect of variety on growth and yield of sesame

On days to maturity for two growing season, E8 variety matured early than Ex-Sudan. This is in contrast to findings of Olowe (1999) who stated that

Ex-Sudan is an extra early sesame for Sudan savannah ecological zone while E8 is a medium maturating variety meant for Northern guinea savannah. Number of capsule were significantly affected in 2019. Where EX-Sudan is significantly higher than E8 this might be in line with the fact that with superiority of variety (Ex-Sudan) in term of days to 50% flowing, days to maturity, 1000 seed weight and net plot weight with higher ability. For capsule length in 2019, Ex-Sudan significantly produced longer capsules than E8. While in 2019 there was no significant effect on capsule length. Number of seeds per capsule was significantly influenced by varieties in 2020 where EX-Sudan produced higher number of seed per capsule though temperature, rail fall and good agronomic practices encourages rapid germination, growth and development of the crop (Olowe, 1999). The 1000 seeds weight was significantly affected by variety at both 2019 and 2020 were Ex-Sudan produced heavier seed than E8. This might be due to the optimum days to 50% flowering, days to maturity and accumulation of dry matter by this variety as it observed in this study. Grain yield per hectare were significantly influenced by varieties both in 2019 and 2020 were Ex-Sudan significantly produced higher grain yield per hectare than E8 variety. This might be in line with superiority of variety (Ex-Sudan) in term of days to 50% flowing, days to maturity, 1000 seed weight and net plot weight, which are expected to lead to greater seed yield per hectare.

CONCLUSION

In conclusion the result of the study showed that although E8 variety flowers and matures earlier than Ex-Sudan at both seasons. Ex-Sudan variety and early sowing produced the highest grain yield per hectare both at 2019 and 2020 raining seasons.

RECOMMENDATION

Based on the results obtained from this study Ex-Sudan variety can be recommended. Similarly, early July planting date is suggested for increasing sesame production in the study area.

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RELATIVE SUSCEPTIBILITY OF EIGHT CASHEW (*ANACARDIUM OCCIDENTALE* L.) ACCESSIONS TO INFESTATION BY *ANALEPTES TRIFASCIATA* (COLEOPTERA: CERAMBYCIDAE) IN NIGERIA

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ABSTRACT

Cashew is an important crop with huge socio-economic potentials capable of improving rural livelihoods, job creation and revenue generation. Its cultivation is plagued by several constraints, prominent amongst the factors is the long horn beetle (LHB), Analeptes trifasciata (Coleoptera: Cerambycidae). The girdling behavior of the LHB leads to breaking off of branches, this usually coincides with the flower initiation period thereby resulting in huge economic loss of yield. Eight cashew accessions namely Brazilian jumbo (BJ), Brazilian extra-large (BeL), Brazilian large (BL), Brazilian medium (BM), Indian large (IL), Indian medium (IM), Indian small (IS) and Indian madras (IMa) in the CRIN cashew germplam plot were evaluated for susceptibility to LHB for two years. Data were taken on number of LHB and damage intensity, thereafter subjected to ANOVA and susceptibility index. IL (0.4) and IM (0.5) accessions recorded highest mean insect count/tree, significantly different from others. BL and BM recorded the lowest insect count/tree, 0.1 and 0.09 respectively though not significantly different the rest. However, BM had high damage intensity. BJ and BeL recorded insect count of 0.2/tree but had the lowest damage intensity of 0.3/tree, while IM recorded the highest mean damage of 0.8/tree. Based on the susceptibility index, BJ and BeL accessions were categorized as moderately susceptible and the other accessions were categorized as susceptible. Generally, all eight cashew accessions showed susceptibility to the LHB. Therefore, development of new varieties with resistant characters to LHB should be a priority

Key words: long horn beetle, girdling, cashew, accessions, susceptibility

INTRODUCTION

Cashew, *Anacardium occidentale* L, is a resilient and fast-growing evergreen tree species belonging to the family Anacardiaceae. It is an important socio-economic crop with immense potential for job creation and revenue generation. However, its cultivation is affected by several factors such as the *Analeptes trifasciata* F. commonly known as the longhorn beetle (LHB) or stem girdler. The longhorn beetle is an economic insect pest of cashew that causes damage on cashew though its' girdling activities on sapwood of main stems and branches (Adeyemo and Okelana, 1989). This is done to provide suitable breeding material for the larvae, in the form of dead wood. In severe cases of infestation, the stems are completely girdled leaving only a central pillar of about half to one-inch-thick which is inadequate to support the full weight of the branch, this leads to snapping off of the upper stem (Asogwa *et al*., 2008). Unfortunately, the incidence coincides with the period of flowering and fruiting in cashew. As a result of its girdling activities, there is significant loss of inflorescences, pseudo-apples and nuts found on the girdled branches. The current control measure is collection and destruction of the LHB and girdled stems (Igbokwe, 1982) but this has drawbacks. Most farmers do not practice this cultural method because of the difficulty associated with collection of the LHB and hanging stem above hand's height. However, an integrated management system which combines two or more approaches will be most appropriate especially for an insect pest of perennial crops such as cashew. The use of host plant resistance as a means of pest control has been successful for tree crop such as cocoa (Anikwe *et al*., 2009). Cashew is classified based on morphological characteristics such as nut size, form of tree, apple colour, fruit-bearing capacity (Aliyu and Awopetu, 2007). There are eight cashew accessions based on nut size and origin. Personal field observations have indicated disparity in the damage caused by the LHB on the eight cashew accessions (pers. comm. 2016). However, there is no known documented information on cashew accession resistant or susceptible to LHB in Nigeria. This necessitated the search for cashew accession(s) that are resistant or susceptible to LHB as the case maybe. This project therefore assessed the relative susceptibility in eight cashew accessions to *Analeptes trifasciata* on the field.

MATERIALS AND METHODS

The relative susceptibility of eight cashew accessions to *Analeptes trifasciata* was assessed on the field for 2 years on a 2.5-hectare Cashew Germplasm plot at CRIN Headquarters, Ibadan. The location lies between the latitude 7°30'N and longitude 3° 54'E at an altitude of 200 m above sea level. The cashew germplasm plantation was established in 2005 and planted in geometry of 6 m by 6 m with a total of 278 stands. The field contained eight cashew accessions which were: Brazilian Jumbo, Brazilian Extra-large, Brazilian Large, Brazilian Medium, Indian Large, Indian Medium, Indian Small and Indian Madras. The size of the field was 60 m x 255 m and was made up of eight blocks containing an accession in each block. Each accession, which was in a block of 60 m x 24 m containing 40 trees, represented the treatments and was separated by 9 m border row of oil palm trees. From each block of accession, a plot size of 12 m x 12 m containing four trees was marked out and replicated three times. The plot was separated between replicates by 12 m border row of cashew trees. In order to rank the susceptibility level, susceptibility index was conducted according to the method of Navik *et al*., (2019) (Table 1).

Table 1. Susceptibility index used for ranking cashew accessions against damage caused by *Analeptes trifasciata*

Susceptibility status	Damage score
Less susceptible	Accessions with damage level less than (mean (x) –SD)
Moderately susceptible	Accessions with damage level between (mean (x) – SD) to mean (x)
Susceptible	Accessions with damage level between mean (x) to mean (x) + SD
Highly susceptible	Accessions with damage level above mean (x) – SD

Footnote: Susceptibility index adopted from Navik *et al*., (2019) with modifications

Data collection: Once in a month, four randomly selected trees per plot were inspected for damage symptoms and presence of the LHB. Data were taken on the number of *Analeptes trifasciata* found on the cashew trees. To assess intensity of damage, three types of girdled attacks were defined.

Type 1 - Girdled stem: this was made up girdled stem where only the bark has been attacked. Type 2 - Girdled and hanging stem: this included stem on which attack has reached the sapwood but the stem remained attached to the tree though hanging.

Type 3 - Girdled and fallen stem: cut stem which had fallen and laid strewn on the ground.

The attacked stems were counted per tree using the following calculation:

Intensity of attack = NGS/TNST

Where NGS- number of girdled stem(s)

TNST = total number of sampled trees

Data obtained on the number of LHB, damage on the accessions were subjected to analysis of variance and means were separated by Student-Newman-Keuls test (SNK).

RESULTS AND DISCUSSION

The number of adult LHB found on the eight accessions was statistically different from one another. Cashew accessions of Indian large and Indian medium nut sizes had the highest mean count /tree of adult *A. trifasciata*, 0.4 and 0.5 respectively and were statistically similar (Figure 1). Mean number of adults found on Indian medium was significantly different from others, Indian large was only significantly different from Brazilian large and medium accessions; the later recorded the lowest counts of adults, 0.1/ tree (Figure 1). In the same vein, Indian medium (0.26) followed by Indian large (0.19) accessions recorded the highest count of male and were not significantly different. The number of males found on Indian medium was significantly higher than the rest of the accessions (Table 2). A similar trend was observed for the females amongst the accessions, where Indian medium recorded the highest number of female which was statistically different from others except the Indian large accession (Table 2). Both males and females were found on all the cashew accessions but with differing levels of damage.

The girdling intensities of *A. trifasciata* was also observed on all the accessions (Table 2). There were significant differences ($P< 0.05$) in the number of cashew stem girdled amongst the accessions. The mean number of girdled stems only (type 1) on Indian madras accession, 0.19 was significantly different from that of Brazilian jumbo, 0.04, Brazilian extra-large, 0.02 Brazilian large, 0.05 and Brazilian medium, 0.06. Accessions such as Indian madras (0.19/ tree), Indian small (0.17/tree) and Indian medium (0.13/tree) showed higher number of girdled stems and were not significantly different from one another (Table 2). All the accessions were attacked with varying levels of damages.

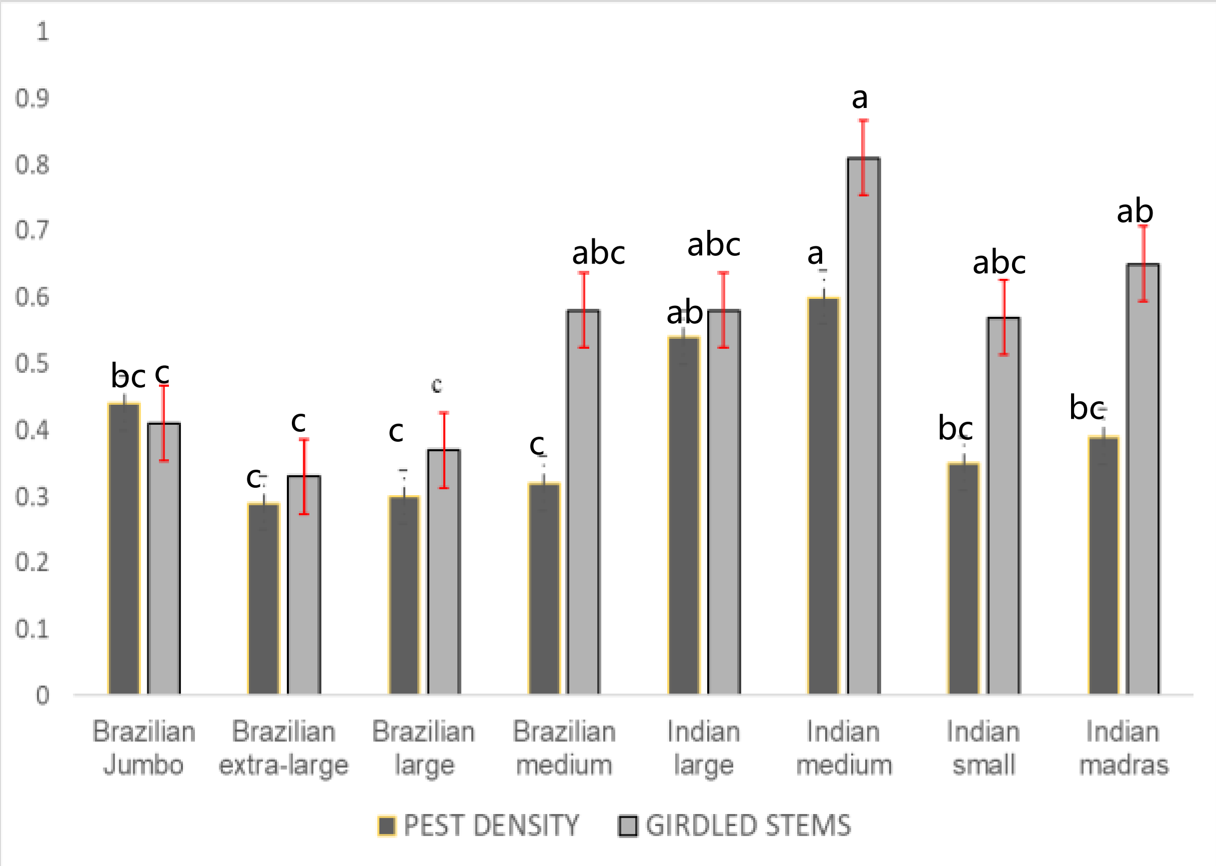

Figure 1. Mean number of *Analeptes trifasciata* and associated girdled stems on eight cashew accessions on the field

Table 2. Mean population density of male and female *Analeptes trifasciata* and girdling intensities on eight cashew accessions

Accessions	Mean nos. of males	Mean nos. of females	Girdled stems	Girdled & hanging stem	Girdled & fallen stem
Brazilian jumbo	0.12b	0.09abc	0.04c	0.2b	0.09a
Brazilian extra-large	0.09b	0.08abc	0.02c	0.18b	0.13a
Brazilian large	0.06b	0.03c	0.05c	0.19b	0.13a
Brazilian medium	0.04b	0.05abc	0.06bc	0.21b	0.18a
Indian large	0.19ab	0.19ab	0.08abc	0.35b	0.14a
Indian medium	0.26a	0.19ab	0.13abc	0.49a	0.18a
Indian small	0.09b	0.09abc	0.17abc	0.29b	0.13a
Indian madras	0.07b	0.07abc	0.19a	0.3b	0.16a

Values with different lower case letter along the columns are significantly different at P<0.05

The number of hanging stems (type 2) showed significant differences (P<0.05) amongst the accessions. For instance, the number of hanging stems recorded on Indian medium accession was the highest and significantly different from others. The highest number of hanging stems recorded in the Indian category was Indian medium accession (0.5), closely followed by Indian large (0.4) and madras accession (0.3). All the Brazilian accessions recorded a mean value of 0.2 hanging branch per tree. The number of fallen stems (type 2) were statistically similar amongst the accessions. Nevertheless, the Indian accessions recorded higher number of fallen stems (Table 2). Generally, the Indian accessions recorded higher damage intensity.

The combination of the girdling activities resulting in damage infestation was highest amongst the Indian accessions with Indian medium accession leading with 0.8 total damaged branch /tree followed by Indian madras accession, 0.7. Indian medium accession was significantly different from all accessions in the Brazilian group except Brazilian medium (Figure 1). Specifically, Indian large and Indian medium accessions recorded more pest density and corresponding high damage intensity such as girdled stems, hanging stems and fallen stems. However, the Brazilian medium with the lowest pest density was observed to have remarkably high damage intensity comparable with all the Indian accessions including Indian medium. The same trend was observed in the case of Indian small and madras. Following the susceptibility index, two categories of susceptibility were identified, namely moderately susceptible accession consisting of Brazilian jumbo and Brazilian extra-large; and susceptible accession category consisting of the rest accessions (Table 3). In a related study, Navik *et al.,* (2019), reported that eighteen cashew cultivars screened for tolerance to apple and nut borer in India showed varying susceptibility status. Furthermore, on the basis of pest density and resultant damage, the Brazilian medium, Indian small and madras accessions can be categorized as highly susceptible. Apart from feeding on the cashew stems, girdling is also done to provide breeding sites for oviposition purpose. The substantial girdling intensity observed on the three highly susceptible cashew accessions further suggests that these accessions are the most favorable accessions for egg-laying, progeny development and survival.

Table 3. Susceptibility status of cashew accessions to *Analeptes trifasciata* on the field

Accessions	Susceptibility status
Brazilian Jumbo	Moderately susceptible
Brazilian extra-large	Moderately susceptible
Brazilian large	Susceptible
Brazilian medium	Susceptible
Indian large	Susceptible
Indian medium	Susceptible
Indian small	Susceptible
Indian madras	Susceptible

CONCLUSION

Generally, all the cashew accessions were susceptible to attack by *A. trifasciata* though in varying levels. While Brazilian jumbo and Brazilian Extra-large were moderately susceptible, the rest of the accessions were susceptible to *A. trifasciata*. The knowledge is expected to have tremendous application in breeding for cashew with better protection against the LHB.

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ALLELOPATHY AS A NATURAL METHOD OF WEED CONTROL: PROSPECTS AND LIMITATIONS

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ABSTRACT

To meet global food requirement as a result of the ever-increasing world population is a major problem of humanity. For this reason, there has been an over dependence on pesticide usage to boost agriculture. Consequently, heavy doses of synthetic pesticides are being deposited in the environment. Although, very effective for their particular purpose, synthetic pesticides are eco-unfriendly and toxic to man, domestic and wild-life, non-target organisms as well as enhancing the potential for pesticide resistance development. Thus, there is need for an alternative that will ensure sustainable crop production while mitigating the environment. Allelopathy involves both sympathetic and pathetic interactions between two plants. These qualities could therefore be harnessed and/or augmented to address the weed problems on our farms to increase yield. With this adoption, the use of synthetic herbicides, although cannot be completely discarded, their use could drastically be reduced to an appreciable level. The prospect of allelopathy as a weed control strategy is therefore hereby discussed.

Key words: Allelopathy, Allelochemicals, Allelochemistry, Weeds, Crops

INTRODUCTION

With the increasing population of the world, achieving food security has become a challenge to mankind. Therefore, the use of little agricultural input to maximize production is the solution to this. Although this approach is satisfying the food demand to almost a desirable extent, but is directly and indirectly causing negative impact on quality of the produce, environment and overall human health. Successful breeding for disease and insect resistant cultivars in combination with development of integrated pest management systems have led to a reduction in the demand for fungicides and insecticides, while herbicide use is still increasing worldwide. Weeds are the most aggressive, troublesome and undesirable element of the world's vegetation and cause enormous reduction in crop yield, wastage of resources and human energy and also a health hazard to human being. Weeds cause great problems to humankind by interfering in food production, health, economic stability, and welfare. The overuse of synthetic herbicides for weed control eventually leads to the evolution of herbicide resistant weeds, which also resulted in growing public concern over their impacts upon human health. It is imperative to find out some natural extract to control this menace, thereby minimizing or avoiding the frequent use of herbicides in the future. In this regard, allelopathic effect of different plants is drawing attention of many researchers in the recent past. The phenomenon of allelopathy has existed for thousands of years. Intensive scientific research into the recognition and understanding of allelopathy has only occurred over the past few decades (An *et al*., 1996). These activities have shown significant prospects for the use of allelopathy being utilized for increasing crop productivity and the quality of food for humans. Also it has decreased our reliance on synthetic pesticides and improving the ecological environment. Recent research has demonstrated possibilities of such prospects in reality, especially in weed control.

ALLELOPATHY

The term allelopathy originated from the Greek word 'allelon' meaning 'of each other' and 'pathos' meaning 'to suffer' and means the injurious effect of one organism upon the other. The term 'allelopathy' was first used in 1937 by Austrian scientist Hans Molisch (Willis, 2010). Allelopathy is any direct or indirect effect by one plant, including micro-organisms, on another through production of chemical compounds that escapes into the environment to influence the growth and development of neighbouring plants (Bahadur *et al*., 2015). It is the detrimental effects of chemical(s) or exudates produced by one living plant species on the germination, growth or development of another plant species or microorganism sharing the same habitat. Allelopathy is therefore the influence, usually detrimental of one plant on another by toxic chemical substances from living plant parts through their release when a plant dies or their production from decaying tissue. Allelopathy is described as the beneficial and deleterious biochemical interaction between plants and microorganisms. The bio-chemicals that are released by plant parts, which may have inhibitory (negative allelopathy) or stimulatory (positive allelopathy), effect on each other. Rice (1984) defined allelopathy as any direct or indirect inhibitory effect by one plant including microorganisms on another through the production of chemical compounds that escape into the environment. These chemicals are usually secondary plant metabolites or byproducts of the principal metabolic pathways in plants. They are non-nutritional and can be synthesized in any plant part, i.e. leaves, stems, roots, bark, seeds, etc. Also Lambers *et al*. (1998) defined allelopathy as the growth suppression of one plant species by another due to the release of toxic compounds. Singh *et al.* (2001) opined that allelopathy refers to any direct or indirect effects of plants on other plants through the release of chemicals and plays an important role in many agro-ecosystems. Allelopathy occurs through the release by one plant species of chemicals which affects other species in its vicinity, usually to their detriment. The plant may exhibit inhibitory or rarely stimulatory effects on germination and growth of other plants in the immediate vicinity. Allelopathy involves the synthesis of plant bioactive compounds, known as allelochemicals, capable of acting as natural pesticides (Macias *et al*., 2007) and can resolve problems such as resistance development in pest biotypes, health defects and soil and environmental pollution caused by the indiscriminate use of synthetic agrochemicals (Dayan *et al*., 2009)

Reports as early as 300 BC document that many crop plants (e.g. chick pea, barley, bitter vetch) destroyed weeds and inhibited the growth of other crop plants (An *et al*.,1996) Contemporary researchers have tended to broader the context of allelopathy to include interactions between plants and higher animals (Rizvi and Rizvi 1992), and have suggested that alleloptahy may be part of a whole network of chemical communication between plants and between plants and other organisms, and that such communication may contribute to plant defense.

ALLELOCHEMICALS

Chemicals that impose allelopathic influences are called allelochemicals. They may be largely classified as secondary plant metabolites, which are generally considered to be those compounds (such as alkaloids, phenolics, flavonoids, terpenoids and glucosinolates) which do not play a role in primary metabolic processes essential for a plant's survival and are produced as offshoots of primary metabolic pathways. Allelochemicals are present in virtually all plant tissues, including leaves, flowers, fruits, stems, roots, rhizomes, seeds and pollen. Under favourable environmental conditions, allelochemicals are released into the environment through the processes of volatilisation, leaching, root exudation, and decomposition of plant residues, thereby affecting the growth of adjacent plants (Bonanomi *et al*., 2006). Several chemicals can be released together and may exert toxicities in an additive or synergistic manner.

In a review of the potential use of allelochemcials as herbicides, Putnam (1988) listed 6 classes of allelochemicals namely alkaloids, benzoxazinones, cinnamic acid derivatives, cyanogenic compounds, ethylene and other seed germination stimulants, and flavonoids which had been isolated from over 30 families of terrestrial and aquatic plants. All these chemicals possess actual or potential phytotoxicity. Rainfall causes the leaching of allelopathic substance from leaves which fall to the ground during period of stress; leading to the inhibition of growth and germination of crop plants (Rice, 1974; Mann, 1987). The readily visible effects of allelochemicals on the growth and development of plants include inhibited or retarded germination rate, seeds darkened and swollen, reduced root or radicle and shoot or coleoptile extension; swelling or necrosis of root tips; curling of the root axis, discolouration, lack of root hairs, increased number of seminal roots, reduced dry weight accumulation and lowered reproductive capacity. These gross morphological effects may be secondary manifestations of primary events, caused by a variety of more specific effects acting at the cellular or molecular level in the receiver plants (Rice, 1974). Different allelopathic compound of some crops, important in weed management are presented below:

Allelochemicals of some important crops

Crops	Scientific name	Allelochemicals	References
Rice	*Oryza sativa* L	Phenolic acids	Rimando et al, 2001
Wheat	*Triticum aestivum* L	Hydroxamic acids	Niemeyer, 1988
Cucumber	*Cucumis sativus* L	Benzoic and Cinnamic acids	Yu & Matsui, 1994
Black mustard	*Brassica nigra* L	Allyl isothiocyanate	Weston, 1996
Buck wheat	*Fagopyrium esculentum* L.	Fatty acids	Weston, 1996
Clovers and Sweet clovers	*Trifolium spp* *Melilotus spp*	Isoflavonids and Phenolics	Weston, 1996
Oat	*Avena sativa* L.	Phenolic acids and Scopoletin	Weston, 1996
Cereals	-	Hydroxamic acids	Weston, 1996
Sorghum	*Sorghum bicolor* L.	Sorgoleone	Netzley and Butler (1986)

Ways in which Allelochemcials are released

In order to have any effect on the target plant, the allelochemicals have to be released from the donor plant. This can happen in different ways:

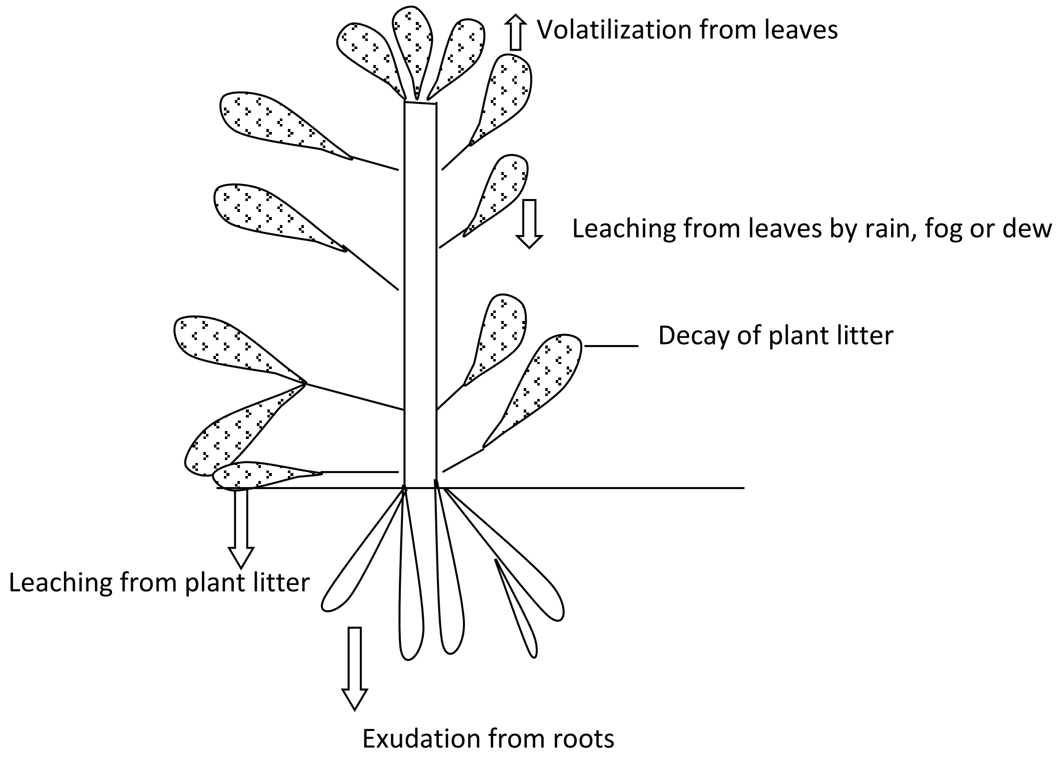
1. Runoff and leachate from leaves and stem of plant. Example, the allelochemicals in the leaves of black walnut, *Juglans nigra*, which are washed off with rain can inhibit the growth of the vegetation under the walnut tree (Bode, 1958).

2. Volatile phytotoxic compounds from the green parts of a plant, e.g. *Salvia leucophylla* and *Artemosia californica* (Halligan, 1973).

3. Phytotoxic compounds from decomposing plant material, such as rye (*Secale cercale*) when used as a mulching material. Apart from shading and keeping the soil moist, rye mulch also inhibits both germination and growth of weeds through release of phytotoxics (Barnes and Putnam, 1986).

4. Phytotoxic compounds released from the plant roots. Rice is an example, where living rice plants are able to suppress weed growth selectively (Navarez and Olofsdotter, 1996).

Source of allelochemicals (Putnam, 1994)



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Types of Allelopathy

1**. Alloallelopathy**: It is inter- specific chemical co-action. Allelochemicals are toxic to other species, other than which release it. E.g. maize (*Zea mays*) is allelopathic to *Chenopodium album* and *Amaranthus retroflexus*; Sorghum to *Abutilon theophrasti, Amaranthus hybridus and Setaria viridus;* rye to *Digitaria sanguinalis* and *Chenopodium album.*

2. **Autoallelopathy**: It is intra-specific chemical co-action. Allelochemicals are toxic to same species from which they are released. E.g. wheat, alfalfa, cowpea, rice, apple, clover and sweet potato are autotoxic. The soil where these crops were previously grown is inhibitive to their growth when replanted or their residues proved autotoxic to them when incorporated.

3**. True allelopathy**: It refers to the release into the environment of chemical compound that are toxic the form they are produced by the plant.

4. **Functional allelopathy:** It refers to the release into the environment of chemical compound that are toxic after chemical modification by microorganisms.

5. **Concurrent/ direct allelopathy:** It refers to the instantaneous direct effect of released toxin from the living plant to another growing in vicinity. It is also called 'living plant effect'. E.g. sorghum (*Sorghum bicolor*) suppresses many weeds growing in the vicinity.

6. Residual allelopathy: It is the effect obtained on the plants growing in succession from the decaying residues, leaf litters, stem, and roots of the previous plants. E.g. sorghum is allelopathic to wheat and *Phalaris minor* and sweet potato (*Ipomoea batatas*) to cowpea.

FORMS OF ALLELOPATHIC INTERACTION

Allelopathic interactions between crops and weeds in agro-ecosystems can be of four types as describes below:

Crop against other crops: Crop against crop allelopathic interaction is likely operative in multiple crop culture like intercropping, mixed cropping and agro-forestry. Therefore, selection of suitable pairs of crops having no allelopathic effect with each other is of paramount importance in crop diversification or crop mixture programme. For example, sunflower has been found allelopathic to groundnut under intercropping situations. Similarly, sorghum is allelopathic to wheat and *Phalaris minor* and sweet potato to cowpea. Volatile compounds from the top of soybean, chickpea and beans reduced the uptake of P by corn plants. Allelopathic effects of pearl millet on the germination and seedling growth of wheat, barley, lentil etc. and aqueous root extract of soybean on rape and mustard.

Crop against weeds: Several crop show allelopathic effects on weeds. For example, sorghum releases hydrocyanic/prussic acid (HCN) and suppresses many weeds growing in vicinity. Barley is more competitive to weeds than wheat. Live barley plants and their root exudates were more inhibitory than aqueous leachates of dead roots. Recently some rice genotypes have already been identified which have allelopathic effects on weeds. Allelopathic effect of crops and weeds on other weeds may be applied to develop natural herbicide.

Allelopatic effects of crops on weeds		
Crops	**Weed species**	**Source of inhibitors**
Maize	*Chenopodium album, Amaranthus retroflexus*	Roots
Cassava	*Amaranthus dubius, Digitaria sanguinalis*	Leaves
Sorghum	*Abutilon theophrasti, Amaranthus hybridus, Setaria viridus*	Shoots and foliages
Rye	*Digitaria sanguinalis, Ambrosia artemisiifolia*	Shoots and foliages
Cucumber	*Echinochloa crusgalli*, *Amaranthus retroflexus*	--
Sweet potato	*Cyperus rotundus, Cyperus esculentus*	--

Weeds against crops: Many weeds impose allelopathic influence on certain crops.

Weeds	Crop	Cause/Source	Effect
Quack grass (*Agropyron repens*)	Maize and potato	Ethylene produced by the activity of microorganism on rhizomes	Decrease uptake of manures (N, K) followed by yield reduction
Wild oat (*Avena fatua)*	Wheat, barley and oat	Root exudates	Growth of leaves and roots of wheat
Bermuda grass (*Cynodon dactylon*)	Barley	Decayed grass residues	Seed germination, root growth
Yellow Nut sedge (*Cyperus esculentus*)	Grain crops, soybean and orchard	Vanillic acid, Hydrobenzoic acid in sedge extract	Root and shoot growth of maize and soybean
Johnson grass (*Sorghum halepense*)	Sugarcane, maize and soybean	Root exudates and decaying residues	Root and shoot growth
Gaint foxtail (*Setaria viridis*)	Maize	Roots and leachates of dead roots	Yield reduction
Cogon grass (*Impereta cylindrical*)	Tomato and cucumber	Root exudates	Inhibit growth
Field bind weed (*Convolvulus arvensis*), Canada Thistle (*Cirsium arvense)*	Cabbage, carrot and tomato	Root exudates	Seedling growth

Weed against other weeds: *Parthenium hysterophorus* is allelopathic to many weeds. Whenenever parthenium invades, it forms a territory of its own replacing all existing flora, grasses and broad-leaved weeds mainly because of its allelopathic effect and competition. Very little or no vegetation could be seen in parthenium dominated areas. Similarly, there are many weeds/wild species, viz., *Amaranthus spinosus, Tagetes minuta, Cassia sericea* which pose strong allelopathic effect on parthenium. Weeds against weed allelopathy have enough importance and could be exploited to control some poisonous problematic weeds like parthenium.

Crop against same crop: The importance step towards avoiding/removing the allelopathic effect of some crops on the same crop species is to stop the continous monocropping of the crops over the years and to encourage crop rotation with diverse crop species. Several crops like wheat, alfalfa, cowpea, rice, apple, clover and sweet potato are autotoxic. The soil where these crops were previously grown is inhibitive to their growth when replanted or their residues proved autotoxic to them when incorporated.

Weed against same weed: The allelopathic effect of weed against same weed is another important intraspecific chemical co-action, which results in weaker stand of a particular weed. However, there is equal possibility that chemical autotoxic to a certain weed, may be toxic to other plants specifically crop plants, otherwise, it will accumulate in soil and develop soil sickness in the long run. *Trifolium repens* for example has autotoxicity**.**

Some Crops Whose Residues Have Been Reported To Be Phytotoxic (Putnam 1994; Duke *et al.*, 2002).

Crops	Affected species
Alfalfa	Alfalfa
Apple	Apple
Asparagus	Tomato, asparagus
Barley	White mustard
Bean	Pea, wheat
Black walnut	Tomato
White clover	Radish
Corn	Several weeds
Cucumber	Several weeds
Rice	Barn yard grass
Smooth brome grass	Several
Sorghum	Fescue
Sunflower	Barely, clover, garden cress, lettuce, redroot pigweed, tomato
Wheat	Several weed

Allelopathic Chemistry

Plants produce a myriad of metabolites of no known utility to their growth and development. They are often referred to as secondary plant metabolites and are defined as compounds that have no known essential physiological functions. Secondary plant metabolites, also known as natural products, are regarded by many as "a vast repository of materials and compounds with evolved biological activity including phytotoxicity" (Duke *et al*., 2002). It is proposed that some of these compounds may be useful directly as herbicides or as templates for herbicide development. According to Duke *et a*l. (2002), they often have unique molecular target sites in plants but have not been developed or used much in agriculture or herbicide development. Acetic acid, the primary component of vinegar, is a contact, burning herbicide that can be used selectively in some crops, example onions and sweet corn. Martan 2 is a clove oil product that shows promise as a natural product herbicide (Evans and Bellinder, 2006). In both cases, success depends on the time of application and the growth stage of the crop and weeds.

Allelochemicals vary from simple molecules, such as ammonia, to the more complex quinones, juglone and the terpenes, camphor and cineole, to very complex conjugated flavonoids such as phlorizin (isolated from apple roots) or the heterocyclic alkaloid caffeine (isolated from coffee) (Thompson 1985). Putnam (1985) lists several chemical groups from which allelopathic agents come: organic acids and aldehydes, aromatic acids, simple unsaturated lactones, coumarins, quinones, flavonoids, tannins, alkaloids, terpenoids and steroids, a few miscellaneous compounds such as long chain fatty acids, alcohols, polypeptides, nucleosides, and some unknown compounds. The diversity suggests several mechanisms of action, a multiplicity of effects, and is one reason for the slow emergence of a theoretical framework. The chemistry of allelopathy is as complex as synthetic herbicides chemistry, but it is a chemistry of discovery as opposed to one of synthesis.

Allelopathic compounds isolated from plants (Putman, 1983)

Common name	Chemical class	Natural source
Acetic acid	aliphatic acid	Decomposing straw
Arbutin	phenolic	Manzanita shrubs
Caffeine	alkaloid	Coffee plants
Camphor	monoterpene	Salvia shrubs
Gallic acid	tannin	Spurge plant
Juglone	quinone	Black walnut trees
Phlorizin	flavonoid	Apple roots
Dhurrin	cyanogenic glucoside	Sorghum plants

Production of Allelochemicals

Production of allelochemicals varies with environment and associated environmental stresses. It can occur in any plant organ (Rice, 1974), but roots, seeds and leaves are the most common sources. Source becomes important for exploitation of allelochemicals for weed control. For example, an allelochemical found in flowers or fruits would have less potential value than if it were concentrated in roots or shoots (Putnam, 1985). For control, soil incorporation of whole plants might create proper distribution regardless of which plant part produced the chemical. The amount is important for control purposes, and if specific effects are to be predicted in the field, total quality and concentration must be determined (Putnam, 1985). Evidence shows that allelochemical production may be greater when plants suffer from environmental stress (Rice 1979). Aldrich (1984) stated that production of allelochemicals is influenced by light intensity, quality, and duration, with a greater quantity produced with high ultraviolet light and long days. Quantities of allelochemicals produced are also greater under conditions of mineral deficiency, drought stress and cool temperatures as opposed to more optimal growing conditions. In some cases, plant affected by growth regulators herbicides may increase production of allelochemicals (Aldrich, 1984).

Because stress frequently enhances allelochemical production, it is logical to assume that stress accentuates the involvement of allelo1qpathy in weed-crop interference and that competition for limited resources may increase allelopathic potential or sensitivity of the weed, the crop or both. Thus, weed – crop competition and allelopathy should be regarded as intimately related components of interference in a crop ecosystem.

Prospects for the Application of Allelopathy in Weed Control

As demands increases for sustainable agriculture and concern grows regarding the extensive use of synthetic chemicals, attention is focused on reducing reliance upon synthetic herbicides and finding alternative strategies for weed management. Allelopathy holds great prospect for meeting some of those demands. Allelopathic potential can be used in several ways in agroecosystems.

Enhance crop allelopathic traits for weed suppression: Putnam and Tang (1986) suggested that allelopathic characteristics are more likely to occur in crop predecessors or "wild types" that have evolved in the presence of allelopathic and competitive influence from other species, while the currently used cultivars would be expected to have diminished or reduced allelopathic capacity. Therefore, it is possible to enhance weed suppressive potential of crop cultivars or to transfer allelopathic characteristics from wild types or unrelated plants into commercial crop cultivars through conventional plant breeding method or other genetic recombination strategies. Research on cucumber and rice germplasm has found large differences in allelopathic potentials among accessions. Olofsdotter and Navarez (1996) stated that certain accessions strongly inhibited weed germination and growth. In some cases, up to 70% population of rice weeds, such as duck-salad (*Heteranthera limosa* (Sw) wild), purple ammania (*Ammania coccinea* Rottb, and broadleaf signal grass (*Brachiaria platyphylla* (Griseb) Nash) were controlled by those accessions with strong allelopathic potential (Dilday, *et al*., 1994). More recently Wu *et al*., (1998) found out in their research that some wheat cultivars were found to significantly inhibit both germination and radical, growth of annual ryegrass. The allelopathic potential of wheat cultivars was positively correlated with their allelochemical (total phenolics) contents.

Use of allelochemicals as natural herbicides or pesticides: Example include pyrethrins extracted from a species of Chrysanthernum and cinmethylin derived from the natural product cineol of certain desert plants. By modifying these allelochemicals, the end product could be more active, selective or persistent. In a review of the potential use of allelochemicals as herbicides, Putnam (1988) listed 6 classes of allelochemicals isolated from over 30 families of terrestrial and aquatic plants. These classes are alkaloids, benzoxazinones, cinnamic acid derivatives, cyanogenic compounds, ethylene and other seed germination stimulants and flavonoids. All these chemicals possess actual or potential phytotoxicity. These allelochemicals have been tested and they possess various biological activities and few barriers to synthesis and production, and hence may be another alternative for developing new herbicides from individual plant allelochemicals.

Use of allelopathic plants in companion cropping: Putnam and Duke (1974) suggested that it is possible to utilize a companion plant that is selectively allelopathic against certain weeds and does not interfere appreciably with crop growth. Rice (1984) listed a number of crop species whose presence or leachates have been shown to have inhibitory effects on a number of weeds. The list includes beets (*Beta vulgaris*), lupin (*Lupinus sp*.), corn, wheat, oats, peas, millet (*Panicum sp*), barley *(Hordeum vulgare* L), rye and cucumber. Weeds in cropping systems are most often considered to be detrimental. However, the interaction of weeds with crops may be positive. In a study where controlled densities of wild mustard (*Brassica compestris* L.) were interplanted with broccoli (*Brassica oleracea* Var. Premium crop), crop yield increased as much as 50% compared with broccoli planted alone (Jimenez – Osornio and Sliessman, 1987).

Use of allelopathic crops in crop rotation: Allelopathic weed control can be implemented by growing allelopathic plants in close proximity to weeds which promote production of these chemicals (Tesio and Ferrero, 2010); or by placing the allelopathic materials obtained from dead plants in close proximity to weeds. The decomposing plant material releases allelochemicals which are absorbed by the target weeds. Allelopathic weed control can also be implemented by growing allelopathic plants in a field for a certain period of time, in order for their roots to exude allelochemicals. Crop rotation is the most important example for such allelopathic weed control (Farooq *et al*., 2011).

Use of allelochemicals in liquid solution: Another way to control weeds through allelopathy includes obtaining allelochemicals in a liquid-solution by dipping the allelopathic chaff in water for a certain period of time. Several researchers have advocated using this way of weed control either alone or in combination with other methods of weed control (Jabran *et al*., 2010; Khan *et al*., 2012; Razzaq *et al.,* 2012).

Use of allelochemicals to stimulate weed seed germination: Chang *et al.* (1986) identified a germination stimulant, a p-benzoquinone compound from a natural host (sorghum) for striga. Ethylene was found to be a very effective germination stimulant. Egley and Dale (1970) demonstrated that ethylene would stimulate striga to germinate in the absence of a host. According to EPlee (1975) this gas at about 1.5kg/ha has been used effectively via a soil injection to trigger "suicidal" germination of striga and to deplete the numbers of dormant seeds in soil. Under growth chamber conditions, ethylene induced germination of common cocklebur (*Xanthium pensylvanicum* Wakkr) and redroot pigweed in soil (Egley, 1986).

Plant residue management: Utilizing residue allelopathy as a management tool may be one of the more readily applicable uses of allelopathy in agroecosystems. Of all the possible strategies involving allelopathy for weed control, management of selectively toxic plant residues is the most successful, effective and readily available (Lovett, 1990). Management methods might include incorporating allelopathic crops in crop rotation, applying phytotoxic mulches, and cover cropping with allelopathic plants or smother crops. An *et al.,* (1996) simulated allelopathic phenomena caused by decaying plant residues. Their plant residues may either inhibit or stimulate plant growth, and that inhibition may be confined to a limited period, i.e., the most severe inhibition by plant residues occurs at the early stages of residue decomposition, whereas at later stages the inhibition declines while stimulation gradually emerges. The inhibition and stimulation periods can be manipulated through a wide variety of management means. This approach has significant potential. For example, by analyzing risk manager may avoid the inhibitory period of decaying residues, thus minimizing their negative effects and await the stimulatory effect to crop plants, thereby enhancing the benefits of residues retention on the soil. By extending the inhibitory period of decaying residue and enhancing its effects, weeds may be controlled.

Allelopathy as a tool for weed management: A living cover crop of spring planted rye reduced early season biomass of common lambsquarters 98%, common ragweed 90% and large crabgrass 42% compared to control plots with no rye (Barnes and Putnam, 1983). Wheat straw has reduced populations of pitted morning glory and prickly sida in no-tillage culture. Lieble and Worsham (1983) suggested that wheat produced an allelochemical that inhibited emergence of several broadleaved species. It is reasonable to assume that many plants have allelopathic potential or some susceptibility to allelochemicals when they are present in the right amount, form, and concentration at the appropriate time. Trials in South Dakota showed that fields planted to sorghum had two to four times fewer weeds the following year than similar fields planted to soybean or corn (Kozlov, 1990). It was proposed that reduced weed seed germination was due to phenolic acids and cyanogenic glucosides given off by sorghum. Walker and Jenkins (1986) also demonstrated that sweet potato residues inhibited growth of sweet potato and cowpea. They stated that decaying residues of sweet potatoes reduced uptake of calcium, magnesium and sulphur by other plants.

Plant pathogens and allelochemicals from plant pathogens and other soil microorganisms can be used as bioherbicides. This possibility has been studied for more than three decades (Hoagland, 2001). A good example of a microbial product is the herbicide biolophos (active ingredient phosphinothricin) which is manufactured by fermentation as a metabolite of the soil microbe streptomyces viridochromogenes (Auld and McRae, 1997). Allelopathy may be used in weed suppressing crops by discovering, incorporating or enhancing would be most useful in crops maintained in high-density monocultures, such as turf grasses, forage grasses or legumes.

Another natural herbicide AAL-toxin, is a natural metabolite produced by *Alternaria alternate* f. sp. *Lycopersic*i, the pathogen that causes stem canker of tomato (Abbas *et al*., 1995) the phytotoxic effects of AAL – toxin was tested on 86 crop and weed species (Abbas *et al*., 1995). Monocots were generally immune to its effects. Black nightshade, jimsonweed, all species of tomato tested, and several other broadleaved plants were susceptible at low doses. Other broadleaved species were susceptible but only at higher doses. Abbas *et al.* (1995) proposed that the differential susceptibility of species to AAL – toxin could be exploited for selective weed control.

Limitations of using Allelopathic Effect

There are many limitations in using allelopathic potential as a weed management tool. The limitations are both because of plant itself, producing allelochemicals and the environmental condition.

1. Abiotic and Biotic factors: Inderjit *et al*. (1999) stated that many abiotic and biotic soil factors have influences on phytotoxic levels of allelochemicals. Various abiotic and biotic factors such as plant age, temperature, light and soil conditions, nutritional status and herbicide treatments influence the production and release of allelochemicals, although allelopathy is considered as a genetically influenced factor (Duke, 1985) while moving in the soil, allelochemicals may undergo transformation is various factors regarding soil environment like physical, chemical, biological and physicochemical properties of soil may influence the activity of allelochemicals. According to Inderjit and Dakshini (1995) many studies on allelopathy, however do not involve soil rather involve an artificial soil substrate. Oleszek and Jurzysta (1987) mentioned the influence of soil texture on phytotoxic effects. Inderjit and Pakshini (1994) found that the amount of water-soluble phenolics in *P. lanceolata* leaf leachate amended soil varied depending on the soil textural classes (clay, sandy – loam, sand and silt loam). Clay mineralogy also plays important role in activity of allelochemicals. The action exchange capacity, moisture holding capacity, concentration of inorganic ion etc are dependable on the

type of clay minerals.

2. Inability of synthesizing the allelochemicals: Many allelochemicals are very much expensive to synthesize inspite of having excellent herbicidal properties as for example, tentoxin (Duke *et al*., 2000).

3. Toxicity: Some allelochemicals are toxic to human beings and are carcinogenic, e.g. AAL – toxin and fumonisin are toxic to mammalian cells (Duke *et al*., 2000). Sorgoleone, for example is reported to cause dermatitis (Inderjit and Bhowmik, 2002).

4. Nutrient availability: The amount of nutrient available to the plant and the efficiency of the plant to utilize the nutrient strongly influence the allelopathic potential of rice plant. Sometimes the deficiency of nutrient favours the production of secondary metabolites as mentioned by Hoagland and Williams (1985). As for example in aerobic P – deficient soil, rice roots excrete organic anions particularly citrate to solubilize and enhance phosphorus uptake (Kirk *et al*., 1999).

5. Autotoxicity: Some allelochemicals affect the growth of the plant itself i.e, autotoxic effect which is another problem in the mechanism of allelopathy. Yu and Matsui (1994) identified autotoxins, including some derivatives of benzoic and cinnamic acids from the root exudates of cucumber. Quan Yu (2003) showed the inhibitory effect of root exudates and aqueous root extracts of cucumber (*Cucumis sativus*) and allelochemicals on root antioxidant enzymes and leaf photosynthesis, transpiration and stomatal conductance in cucumber. Therefore, while studying the role of allelopathy in controlling weeds, the autotoxicity of plants should not be ignored.

CONCLUSION

As the development of weed strategies that make use of allelopathic crop plant is receiving increased attention, there is need to enhance allelopathic traits of crop cultivars through breeding programmes such as transferring allelopathic genes into commercial cultivars through modern biotechnology; to enhance their weed – killing capacity, and to identify and characterize those substances involving in strong allelopathic activity and to use them directly as natural herbicides; or as models for developing new and environmentally friendly herbicides. When this is done, Allelopathy will become an important component in the development of future integrated weed management strategies.

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GROWTH OF COCOA (*THEOBROMA COCOA*) AS INFLUENCED BY NITROGEN FERTILIZER SOURCES AND LEVELS IN OWENA, ONDO STATE

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ABSTRACT

A screen house experiment was conducted in Cocoa Research Institute of Nigeria, Owena, Ondo state to evaluate the influence of nitrogen fertilizer sources and levels on growth of cocoa seedlings. Treatments were a factorial combination of four nitrogen sources (Cocoa pod husk, Kola pod husk, Chromolaena and NPK) and five nitrogen levels (0, 5, 10, 15 and 20 kg N/ha). The 20 treatments were arranged in a randomized complete block design with three replications. Results indicated that Chromolaena resulted in higher number of leaves and leaf dry matter yield than kola pod husk. Only 10 kg N/ha significantly (P<0.05) increased number of leaves by 14 % when compared with 0 kg N/ha. Nitrogen applied at the rate of 10, 15 and 20 kg N/ha increased plant height by 22 % (68.25 cm), 15 % (64.25cm) and 14 % (63.48 cm) respectively when compared with 0 kg N/ha. Similarly, 10, 15 and 20 kg N/ha resulted to 15 % - 19 % higher stem dry matter yield relative to 0 kg N/ha. All fertilizer levels increased root dry matter yield (6.49 - 7.28 g/plant) when compared with 0 kg N/ha with increases of 15 % - 30 %. Fertilizer applied at the rate of 10 kg N/ha also produced the highest plant height (68.25cm), leaf dry matter yield (19.83 g/plant), stem dry matter yield (24.66 g/plant) and total dry matter yield (49.80 g/plant), which was significantly (P<0.05) higher than all other nitrogen levels. Nitrogen fertilizers irrespective of source enhanced growth of cocoa seedlings. Fertilizer applied at the rate of 10 kg N/ha proved to be the most effective nitrogen level.

Key words: Cocoa seedling, nitrogen fertilizer, growth

INTRODUCTION

Cocoa bean is an importance source of beverage and foreign exchange earnings. In 2019, Nigeria produced 350,146 tonnes of cocoa beans with a yield of 258.6 kg/ha (FAOSTAT, 2019). This was low when compared to Cote d'Ivore and Ghana that produced 2,180,000 and 811,700 tonnes of cocoa beans respectively, with cocoa bean yield of 456 kg/ha and 549 kg/ha respectively (FAOSTAT, 2019). One of the challenges of cocoa production in Nigeria is ageing cocoa plantations and unavailability of fertile top soil to establish new cocoa plantations, arising from competition for land for both agricultural and non-agricultural purposes. Nitrogen is one of the most important nutrient in crop production in Sub Saharan Africa (Okalebo *et al*., 2006) and it is required in the largest quantities by cocoa at its early growth stage (Vliet *et al*., 2015). Its availability in adequate quantity at the early growth stage enhances growth and establishment of cocoa. The use of conventional inorganic fertilizer which is a major nitrogen source is plagued with economic, social and political challenges. This coupled with the epileptic operation of the few fertilizer plants in the country that depend on the importation of major raw materials at high cost has also led to high cost of fertilizer. In the 2014 cropping season, Nigeria imported 180,242 tonnes of NPK fertilizer valued at US $138,413,000, 280,206 tonnes of urea valued at USD $118,391,000 and 22,187 tonnes of muraite of potash valued at USD $10,520,000 (FAOSTAT, 2019). There is therefore need to source for alternative nitrogen sources for cocoa. Cocoa pod husk, kola pod husk and Chromolaena are alternative nitrogen sources. There is need to harness their potentials as alternative nitrogen sources and to establish the most effective nitrogen level that would enhance growth of cocoa seedlings. The objectives of this study were to: 1) Evaluate the effects of nitrogen fertilizer sources on growth of cocoa seedlings and 2) Determine the influence nitrogen fertilizer levels on growth cocoa seedlings.

MATERIALS AND METHODS

The study was conducted in Cocoa Research Institute of Nigeria, Owena, Ondo state in the rainforest ecological zone. Treatments were a factorial combination of four nitrogen sources (Cocoa pod husk (CPH), Kola pod husk (KPH), Chromolaena (CO) and NPK) and five nitrogen levels (0, 5, 10, 15 and 20 kg N/ha). These 20 treatments were arranged in a randomized complete block design with three replications. The soil was air-dried passed through a 2 mm sieve and 5 kg weighed into plastic pots. One pre-germinated cocoa seedling was planted per pot. A sub-sample of the soil was taken and analyzed for some of its chemical and physical properties using standard procedures. Data was collected monthly for 7 months on number of leaves, plant height, stem diameter, leaf, stem, root and total dry matter yield. Statistical analysis was carried out on the data collected using Analysis of variance (ANOVA) and significant means separated using Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Soils of the experimental site in Owena was sandy loam and slightly acidic (5.8). The organic carbon content was low with a value of 14.5 g/kg. Total nitrogen and available phosphorus values were low with values of 0.79 g/kg and 5.13 mg/kg, while soil exchangeable K, Ca, Mg were adequate with values of 0.32 cmol/kg, 5.13 cmol/kg, and 0.82 cmol/kg respectively. *Chromolaena* fertilizer significantly ($P<0.05$) enhanced number of leaves of cocoa seedlings only at 7 MAT when compared with KPH fertilizer (Table 1), while only 10 kg N/ha enhanced number of leaves of cocoa seedlings at 7 MAT when compared with 0 kg N/ha. At 2 MAT, NPK was superior to CO and CPH in plant height (Table 1). However, at 4 and 7 MAT, this effect was not significant. Nitrogen applied at the rate of 10, 15 and 20 kg N/ha increased plant height by 22 %, 15 % 14 % respectively when compared with 0 kg N/ha. Fertilizer applied at the rate of 10 kg N/ha also significantly ($P<0.05$) increased plant height when compared with other N levels. This was consistent with the findings of Ogunlade *et al*. (2008) who reported that CPH alone and CPH fortified with neem enhanced plant height, stem diameter and number of leaves of cocoa seedlings relative to no fertilizer. Similar observation was made by Adejobi *et al*. (2013) who reported that cocoa pod ash increased plant height, stem diameter, leaf area, number of leaves, number of branches and shoot dry matter yield.

At 7 MAT, NPK and CO treatments resulted in higher stem diameter than CPH and KPH (Table 1). The influence of N fertilizer source on leaf dry matter yield was significant (Table 2). At 2 and 4 MAT, NPK fertilizer enhanced leaf dry matter yield of cocoa seedlings when compared with other fertilizer sources (Table 3). However, at 7 MAT, both CPH and NPK treated cocoa seedlings produced higher leaf dry matter yield than KPH treated cocoa seedlings with increases of 10 and 11 % respectively. At 2 and 4 MAT, N levels had no significant influence on leaf dry matter yield of cocoa seedlings (Table 2), whereas at 7 MAT, the influence of fertilizer level was significant ($P<0.05$). Increasing N levels from 0 to 5 kg N/ha increased leaf dry matter yield of the cocoa seedlings but the increase was not statistically significant. Further increase of N level to 10 kg N/ha resulted in significantly ($P<0.05$) heavier leaf dry matter yield when compared with no fertilizer control. Fertilizer applied at the rate of 10 kg N/ha produced heavier leaf dry weight when compared with all other fertilizer levels. At 2 and 4 MAT, stem dry matter yield of cocoa seedlings was not influenced by N fertilizer sources and levels (Table 2). However, at 7 MAT, cocoa seedlings applied with CPH fertilizer performed better than other N fertilizer sources with increases of stem dry matter yield of 13 – 17 %. Chromolaena treatment resulted to higher stem dry matter yield than KPH. At 2 and 4 MAT, N levels had no significant influence on stem dry matter yield of cocoa seedlings. At 7 MAT, the effect of N fertilizer levels on stem dry matter yield of seedlings was however significant. Increasing fertilizer levels from 0 to 5 kg N/ha had no effect on stem dry matter yield. Further increase to 10, 15 and 20 kg N/ha increased stem dry matter yield of cocoa seedlings with increases of 15 – 19 % when compared to 0 kg N/ha. Nitrogen applied at the rate of 10 kg N/ha performed better than other N fertilizer rates. Similarly, (Ogunlade *et al.,* 2006) reported that pace setter organic fertilizer alone and fortified with neem leaf and seed applied at the rate of 10 kg N/ha increased, number of leaves, stem diameter and dry matter yield when compared with no fertilizer and NPK fertilizer.

The influence of N fertilizer source on root dry matter yield was significant only at 2 MAT (Table 2) where NPK enhanced root dry matter yield of cocoa seedlings when compared with all other N fertilizer sources, while CPH and CO performed better than KPH fertilizer (Table 2). The effect of N fertilizer levels on root dry matter yield was significant at 7 MAT (Table 2). All N levels had 15 to 30 % higher root dry matter than 0 N kg/ha. Cocoa seedlings treated with 20 kg N/ha produced 12 % heavier root dry matter yield than cocoa seedlings treated with 10 kg N/ha.

Table 1: Number of leaves, plant height (cm), stem diameter (cm) and crop growth rate (g/day) of cocoa seedlings as influenced by nitrogen fertilizer sources and levels in Owena location soil under screen house condition

	Number of leaves			Plant height (cm)			Stem diameter (cm)		
Treatments	2MAT	4MAT	7MAT	2MAT	4MAT	7MAT	2MAT	4MAT	7MAT
Nitrogen fertilizer sources (N)									
Cocoa Pod Husk	17	26	31	42.59	54.64	61.41	0.97	1.38	1.39
Chromolaena odorata	18	26	33	43.68	55.43	60.56	0.99	1.35	1.49
Kola Pod Husk	19	27	29	44.87	57.64	63.71	0.97	1.34	1.39
NPK	18	25	32	45.52	58.67	61.74	0.96	1.39	1.48
LSD (5%)	NS	NS	3.19	1.51	NS	NS	NS	NS	0.06
Nitrogen application levels (L) (kg N/ ha)									
0	18	27	29	43.27	50.67	55.75	0.90	1.34	1.41
5	17	26	31	43.32	51.17	57.53	0.90	1.37	1.44
10	18	26	33`	43.20	54.20	68.25	0.95	1.46	1.49
15	18	26	32	45.56	56.00	64.25	1.06	1.39	1.45
20	19	27	32	45.15	54.66	63.49	1.03	1.41	1.46
LSD (5%)	NS	NS	3.57	1.69	3.77	3.01	0.03	0.08	NS
Interaction									
N X L	NS	NS	NS	NS	NS	NS	NS	NS	*

LSD = Least significant difference, NS =Not significant, MAT= months after transplanting,

Table 2: Leaf dry matter yield (LDMY) Stem dry matter yield (SDMY) Root dry matter yield (RDMY) and Total dry matter yield (TDMY) of cocoa seedlings as influenced by nitrogen fertilizer sources and levels in Owena location soil under screen house condition

	LDMY (g/plant)			SDMY (g/plant)			RDMY (g/plant)			TDMY (g/plant)		
Treatments	2MAT	4MAT	7MAT	2MAT	4MAT	7MAT	2MAT	4MAT	7MAT	2MAT	4MAT	7MAT
Nitrogen fertilizer sources (N)												
Cocoa Pod Husk	10.18	12.35	17.52	9.23	16.94	23.82	2.51	3.48	6.80	20.95	32.55	44.68
Chromolaena odorata	9.67	12.52	16.63	10.13	17.65	21.30	2.55	4.68	6.52	22.97	35.08	44.45
Kola Pod Husk	9.27	12.63	15.92	11.96	17.47	19.74	1.95	3.74	6.02	20.19	33.86	41.38
NPK	11.47	14.17	17.63	11.73	18.30	20.02	2.82	4.17	7.28	26.00	36.63	44.92
LSD (5%)	0.49	0.80	1.10	NS	NS	1.54	0.18	NS	NS	1.50	2.63	NS
Nitrogen application levels (L) (kg N/ ha)												
0	10.33	12.83	16.06	10.68	17.40	19.00	2.45	4.04	5.62	23.64	34.06	40.13
5	10.25	13.08	16.83	13.31	17.33	19.63	2.40	3.68	6.97	22.56	34.00	40.35
10	10.00	13.17	19.83`	9.64	18.21	24.66	2.23	4.86	6.49	20.95	36.43	49.80
15	9.83	12.78	16.83	9.99	18.06	22.64	2.62	3.82	6.89	22.28	34.32	42.97
20	10.25	12.73	16.90	10.19	16.95	22.19	2.60	3.68	7.28	23.21	33.26	42.53
LSD (5%)	NS	NS	1.26	NS	NS	1.89	NS	NS	0.66	NS	NS	3.01
Interaction												
N X L	**	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	*

LSD = Least significant difference, NS =Not significant, MAT= months after transplant

The effect of N fertilizer source was significant on total dry matter yield of cocoa seedlings at all the sampled stages (Table 2). At 2 MAT, CO and NPK performed better than CPH and KPH (Table 2). At 4 MAT, only cocoa seedlings treated with NPK enhanced total dry matter yield of cocoa seedlings when compared with CPH and KPH. However, at 7 MAT, cocoa seedlings treated with CPH performed better than all other N fertilizer sources, while CO and NPK performed better than KPH. There was no significant ($P<0.05$) difference between the various N fertilizer levels at 2 and 4 MAT (Table 2). The influence of fertilizer level on total dry matter yield was significant only at 7 MAT (Table 2) were only 10 kg N/ha increased total dry matter yield by 16 % - 24 % when compared with all other fertilizer levels. This was corroborated by Ipinmoroti *et al*. (2006) who reported that CPH, poultry dropping, and cattle dung enhanced number of leaves, leaf area, root length and total dry matter yield (TDMY) of cocoa with TDMY due to the manures being 29.3 - 55.9 % higher than no fertilizer control. Akanbi *et al*. (2014) also reported that oil palm bunch ash and cocoa pod husk ash enhanced growth of cocoa seedling.

Nitrogen fertilizer irrespective of source enhanced growth of cocoa seedlings. The positive growth response of cocoa seedling to N fertilizer can be attributed to the low N status of soil, which was below the soil critical N level of 1 g/kg N required for cocoa (Egbe *et al*., 1989). The need created by this N deficiency in the soil was met by the applied N fertilizers, hence increase in growth of cocoa seedlings. Fertilizer rate of 10 kg N/ha performed better than all the other N rates. This indicates that cocoa growth need was met at the rate of 10 kg N/ha. The application fertilizer at rates below 10 kg N/ha was therefore inadequate to meet the growth need of cocoa, while above 10 kg N/ha had no additional benefit. Hence the fertilizers were best utilized at the rate of 10 kg N/ha.

CONCLUSION

Nitrogen fertilizer irrespective of source enhanced growth of cocoa seedlings, while all nitrogen levels increased root dry matter yield. Fertilizer applied at the rate of 10 kg N/ha proved to be the most effective rate with higher number of leaves, plant height, leaf, stem, root and total dry matter yield than 0 kg N/ha. Fertilizer applied at the rate of 10 kg N/ha also resulted to higher plant height, stem, leaf and total dry matter yield than all other nitrogen levels.

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