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Research Article

Distribution and effects of nematode management on plant parasitic nematodes in selected old and moribund cocoa farms in South Western Nigeria

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This study was carried out to study the distribution and evaluate effects of nematode management strategies. Initial sampling was conducted to determine the types, frequency and population of plant-parasitic nematodes associated with old cacao plantation. Ten genera of plant-parasitic nematodes were recovered in Ibadan which included *Meloidogyne* spp., *Pratylenchus* spp., *Helicotylenchus* spp., *Paralongidorus* spp., *Eutylenchus* spp., *Scutellonema* spp., *Hemicyclophora* spp., *Xiphinema* spp., *Longidorus* spp. and *Anguillulina* spp. The most widely distributed genus in Ibadan was *Meloidogyne* spp. (67%), followed by *Anguillulina* spp. (50%) and *Paralongidorus* spp. (33%). Thirteen genera of plant-parasitic nematodes were encountered in Owena, which included *Meloidogyne* spp., *Pratylenchus* spp., *Helicotylenchus* spp., *Paralongidorus* spp., *Eutylenchus* spp., *Scutellonema* spp., *Hemicyclophora* spp., *Xiphinema* spp., *Longidorus* spp., *Anguillulina* spp., *Psilenchus* spp., *Tetylenchus* spp. and *Heterodera* spp. *Meloidognye* spp. was the most predominant in Owena soil with a frequency rating of 75%, this was followed by *Hemicyclophora* spp.(33%) and *Eutylenchus* spp. (25%). To evaluate the effect of nematode management on nematode population there were seven treatments (CPH, CPH+ NL(80:20), CPH+NL(90:10), CPH+Carbofuran (C), CPH+NL(80:20)+C, CPH+(90:10)+C, Carbofuran only and control) with four applications. The application of organic amendment significantly (P=0.05) reduced the population of nematode when compared to carbofuran (as comparison) and the untreated (control).

Key words: cocoa pod husk, neem, nematodes, frequency, population.

INTRODUCTION

Cocoa (*Theobroma cacao* L.) farming in Nigeria reached its peak in the early seventies, and has ,since then, been on the steady decline. Many reasons have been adduced for this serious problem. Two, however, stand out very glaringly and these are: the age of the old cocoa farms and the difficulties encountered by farmers in rehabilitating old cocoa farms and establishing new ones. Many reasons have been put forward by soil scientists as being responsible for the problem encountered in rehabilitating old farms. The prominent reason is the accumulation of copper ions in the soil which due to spraying copper fungicides to control the black pod disease of cocoa in the old farms and soil infertility.

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One area of research that has been very much neglected in the search for solution to rehabilitation and establishment problems is the effect of plant-parasitic nematodes on young cacao seedlings and the effect of years of uncontrolled multiplication of these microorganisms on adult trees. Studies in the past have shown that plant-parasitic nematodes cannot be ignored without repercussion in the search for sustainable solution to this problem (Afolami, 1981, 1993, Afolami and Ojo, 1984, Orisajo and Afolami, 2008).

Nigerian cocoa output has declined from over 300,000 tonnes to 155,000 tonnes with average annual growth rates of cocoa output decline from 8.3% during the 1997-2001 periods (Daramola, 2004). However, the small increase in production observed between 2002 and 2005 is still below expectation. Studies (Opeke 1987, 2003, 2005 and Wood and Lass, 1989) on sustainable cocoa production have made it known that the maintenance of production in Nigeria deserves a good standard husbandry for rehabilitation of old and moribund cocoa trees. Many of the cocoa farms in West Africa and Central Africa are old (more than 40 years) and have low yields which due to the age of the trees, as well as other factors such as poor maintenance, pests and diseases. Primarily, because the peasant holder farmers, who serve as the main pivot to the industry, were already deserting which due to old age of both cocoa trees and peasant farmers, soil degradation, prevalence of diseases and pests among others. Root-knot disease caused by root-knot nematodes, *Meloidogyne* spp, are well-known as causing disease of many tropical and sub-tropical plants. *Meloidogyne* spp are the most important nematodes of cacao which due to their pathogenicity and wide distribution in cocoa producing regions (Campos & Villain, 2005). They are common pests of cacao in West Africa (Whitehead, 1969 not found; Asare- Nyako & Owusu, 1979; Fademi et al., 2006). Symptoms of *M. incognita* damage on cacao seedlings are dieback, stunting, wilting, chlorosis and reduction in size of the leaves, and galling of the root or complete death of the seedlings (Afolami & Caveness, 1983; Orisajo & Fademi, 2005; Orisajo et al., 2007).

Opeke (2003), observed that prime-forest land for cocoa cultivation is vertically exhausted and that research is needed on how to rejuvenate the exhausted cocoa soils for successful and profitable cocoa cultivation. He further stated that most of the existing cocoa farms in the country nave passed the age of profitable production. He asserted that, most of the rehabilitation efforts so far had not been successful as desired and that research is needed to identify the problems and proffer solution. (Ogunlade *et al.,* 2012).

Therefore, the broad objective of this study is to study distribution and include nematode management strategies in the rehabilitation (old, moribund cocoa plantation) and new establishment programs of the cocoa-producing states of the country in order to increase productivity.

MATERIALS AND METHODS

Experimental site

The experiment was carried out in two different locations: Cocoa Research Institute of Nigeria (CRIN) Headquarters, Ibadan (latitude 07^{O}10'N, longitude 03^{o}52'E, altitude 122 meters above sea level, maximum temperature 26-35^{0}C, minimum temperature 15-24^{0}C, relative humidity 50-89%) and a farmer's farm in Owena, Ondo State (latitude 07^{0}N, longitude 05^{0}70'N, altitude 22.5 meters above sea level, maximum temperature 28-34^{0}C, minimum temperature 18-23^{0}C, relative humidity 69-80%).

Experimental design

Both experiments were laid out in a Randomized Complete Block Design (RCBD) with three blocks to test the effect of nematode control for improved productivity of trees in established plantations. Eight treatments were investigated and each treatment was applied to four cacao trees in each block in a ring at the base of trees at the beginning of the rains in
April/May. The treatments are:

1. Cocoa Pod Husk (CPH) Only at 0.5kg/tree.
2. CPH Fortified with Neem Leaf (90:10) at 0.45kg + 0.05kg/tree, respectively
3. CPH fortified with Neem Leaf (80:20) at 0.40kg + 0.10kg/tree, respectively
4. CPH at 0.5kg/tree + Carbofuran at 50g/m^2
5. CPH Fortified with Neem Leaf (90:10)+Carbofuran at 0.45g + 0.05kg + 50g/tree, respectively
6. CPH fortified with Neem Leaf (80:20)+Carbofuran at 0.40 + 0.10 + 50g/tree, respectively
7. Carbofuran only (50g/m^2)
8. No application (control treatment)

CPH was applied at the rate of 5kg N/ha = 500kg CPH/ha (i.e. 0.5kg/tree).and Neem
Leaf at 41.6kg/ha

There were 96cacao trees per block thus, giving a total of 288 cacao trees in the three blocks per location. Representative soil samples was collected from the experimental fields, processed and assayed in order to know effects of the treatments on nematode population.
The experiment was monitored for two years.

Collection and storage of soil samples

Soil samples were also taken from the rhizosphere of plants at 0-25cm deep. 500g of soil was then taken from

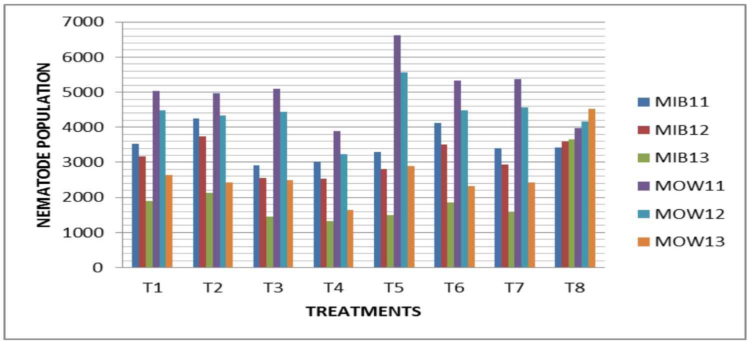

Figure 1. Effect of treatments on *Meloidogyne* spp. population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION.
MIB=*Meloidogyne* Spp Ibadan, MOW= *Meloidogyne* Spp Owena

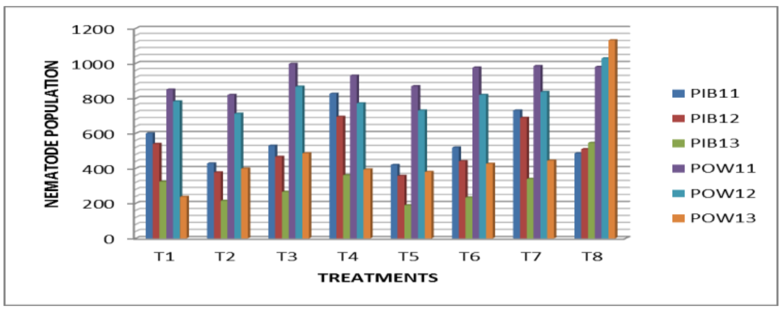

Figure 2. Effect of treatments on *Pratylenchus* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, PIB=*Pratylenchus* spp Ibadan, POW= *Pratylenchus* spp Owena

each plant and then kept in polyethylene bags. Samples was then be stored at 8-10^{o}C for laboratory assay.

Extraction of nematodes from soil

An aliquot of 250cm^{3}soil from each sampled plot was assayed for nematodes using Coyne *et al.,* (2007) tray modification of the Baermann funnel technique to determine the population of nematodes.

RESULTS

From the initial soil sampling done in the two locations, thirteen different genera of plant-parasitic nematodes were encountered, ten from Ibadan and thirteen from Owena. The encountered thirteen genera included: *Meloidogyne* spp., *Pratylenchus* spp., *Helicotylenchus* spp. *Paralongidorus* spp., *Eutylenchus* spp., *Scutellonema* spp., *Hemicyclophora* spp., *Xiphinema* spp., *Longidorus* spp., *Anguillulina* spp., *Psilenchus* spp., *Tetylenchus* spp. and *Heterodera* spp.

Effects of organic amendments and carbofuran on nematode population

Nematode population was significantly (P≤0.05) reduced by CPH, CPH+NL(80:20), CPH+NL(90:10), CPH+Carbofuran (C), CPH+NL(80:20)+C, CPH+NL(90:10)+C and Carbofuran only. The degree of nematode reduction varied among nematode species and also in the two locations. (Fig 1 – 11). Percentages decrease in nematode population both in Ibadan and Owena were shown in Tables 1 and 2. All the treatments CPH, CPH+NL(80:20), CPH+NL(90:10), CPH+Carbofuran (C), CPH+NL(80:20)+C, CPH+NL(90:10)+C and Carbofuran only, had a significant effect on nematodes population in the two locations.

The results showed that CPH+NL(90:10) significantly (P<0.05) reduced the population of *Meloidogyne* spp. even above the conventional nematicide, Carbofuran (65 and 53.4% respectively), this was followed by CPH+NL(80:20)+C (58.4%). In the same vein, CPH+NL(80:20) and CPH+NL(80:20)+C signficantly

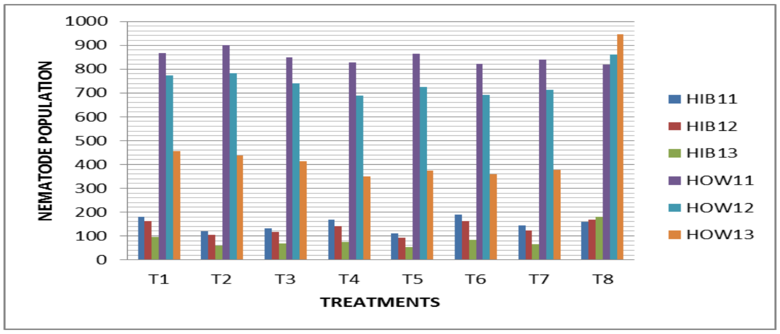

Figure 3. Effect of treatments on *Helicotylenchus* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, HIB=*Helicotylenchus* spp. Ibadan, HOW= *Helicotylenchus* spp. Owena

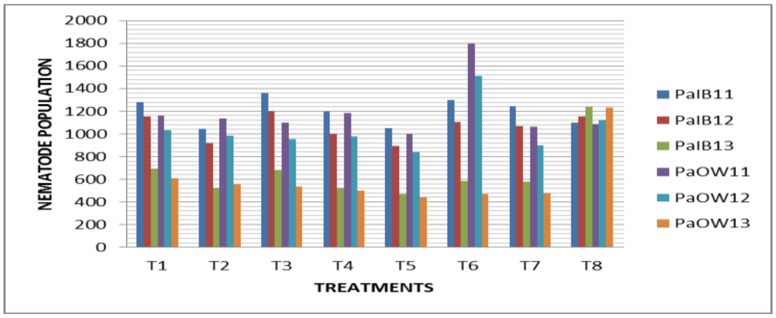

Figure 4. Effect of treatments on *Paralongidorus* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State. T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION,PaIB=*Paralongidorus* spp.Ibadan, PaOW= *Paralongidorus* spp. Owena.

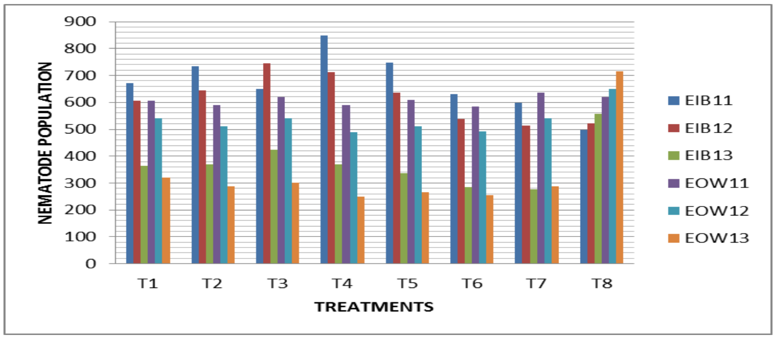

Figure 5. Effect of treatments on *Eutylenchus* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State. T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, EIB= *Eutylenchus* spp. Ibadan, EOW= *Eutylenchus* spp. Owena

reduced the population of *Pratylenchus* spp. (60.8 and 60.8%, respectively) and the untreated plot (33%) in Ibadan. Similar observations was recorded in Owena for *Pratylenchus* spp. with CPH+NL(80:20) and CPH+NL(80:20)+C having a significant reduction in population over carbofuran (63.8 and 64%, respectively).

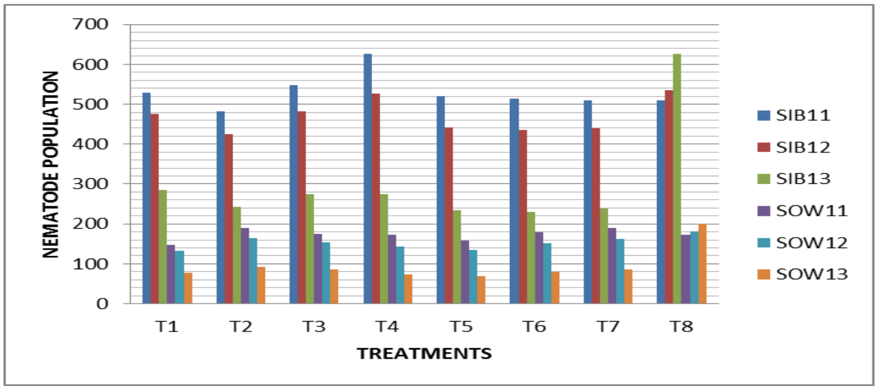

Figure 6. Effect of treatments on *Scutellonema* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, SIB=*Scutellonema* spp. Ibadan, SOW= *Scutellonema* spp. Owena

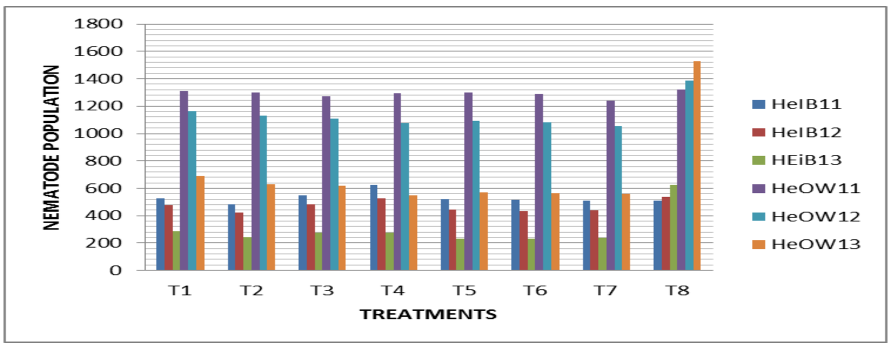

Figure 7. Effect of treatments on *Hemicyclophora* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, HeIB=*Helicotylenchus* spp. Ibadan, HeOW=*Helicotylenchus* spp. OWENA.

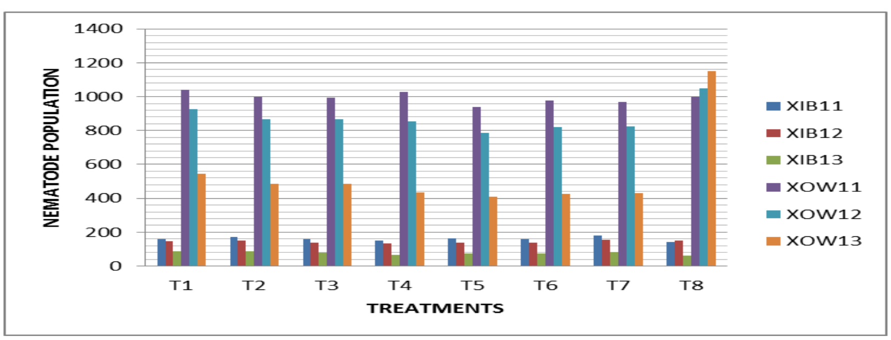

Figure 8. Effect of treatments on *Xiphinema* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, XIB=*Xiphinema* spp. Ibadan, XOW= *Xiphinema* spp. Owena

CPH+NL(80:20)+C showed an outstanding performance over the tested conventional nematicide by significantly reducing the population of *Helicotylenchus* spp. by 71.6% in Ibadan, however, this amendments was able to reduce

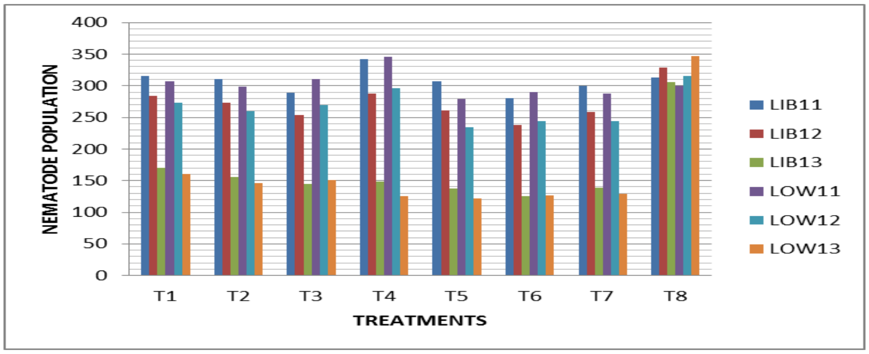

Figure 9. Effect of treatments on *Longidorus* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, LIB=*Longidorus* spp. Ibadan, LOW= *Longidorus* spp. Owena

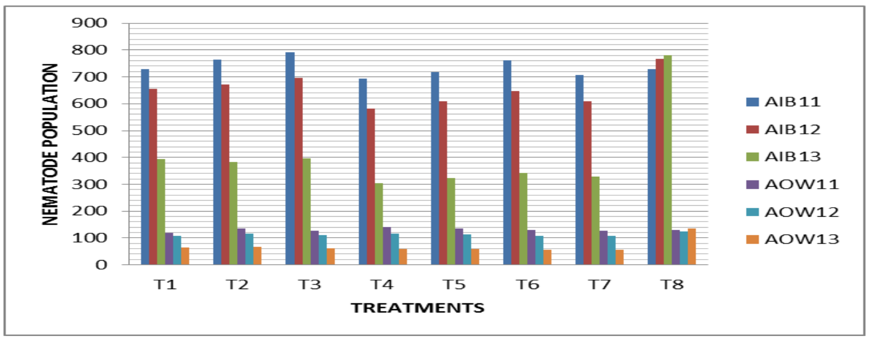

Figure 10. Effect of treatments on *Anguillulina* spp population in old Cocoa plantion both at CRIN Headquarters Ibadan and Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, AIB=*Anguillulina* spp. Ibadan, AOW= *Anguillulina* spp. Owena.

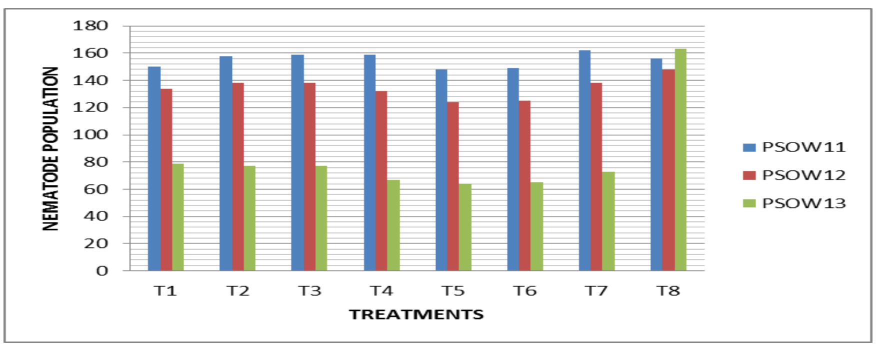

Figure 11. Effect of treatments on *Psillenchus* spp population in old Cocoa plantion at Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, PSOW= *Psillenchus* spp. Owena.

the population by 59.1% in Owena, this was closely followed in Ibadan by CPH+NL(80:20) with a reduction percentage of 68.3% and in Owena by CPH+NL(90:10)+C with a reduction percentage of 61.8% (Table 1). CPH+NL(80:20)+ significantly reduced the populations of *Paralongidorus* spp. by 59.3% and this was followed by CPH+NL(80:20) with a reduction percentage of 57.8% in Ibadan (Table 1). In Owena,

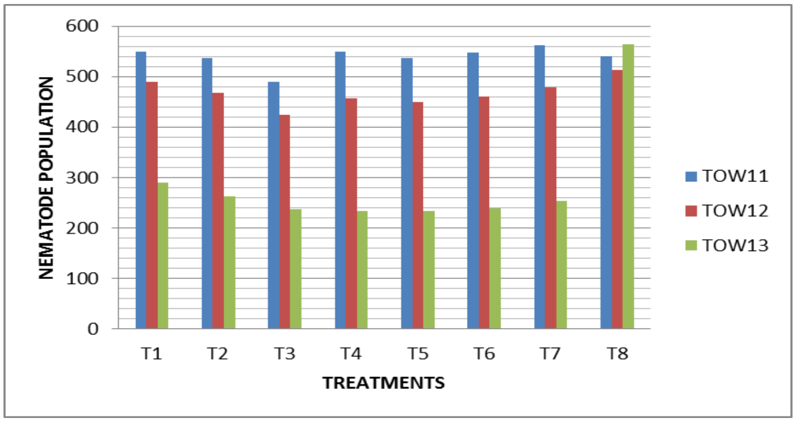

Figure 12. Effect of treatments on *Tetylenchus* spp population in old Cocoa plantion at Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20),T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, TOW=*Tetylenchus* spp. Owena.

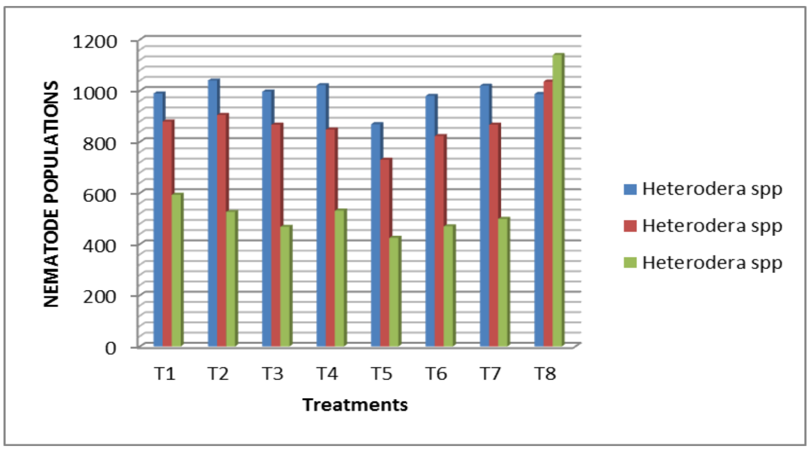

Figure 13. Effect of treatments on *Heterodera* spp. population in old Cocoa plantion at Owena Ondo State.
T1=CPH, T2=CPH+NL(80:20), T3=CPH+NL(90:10), T4=CPH+CARBOFURAN, T5= CPH+NL+C(80:20), T6= CPH+NL+C(90:10),T7=CARBOFURAN ONLY and T8=NO APPLICATION, TOW=*Tetylenchus* spp. Owena.

CPH+NL(80:20)+C had the highest reduction percentage of 61.1% which was followed by carbofuran (58.7%) (Table 2). CPH+NL(90:10)+C, was able to reduce the population of *Eutylenchus* spp. by 59.2% above the conventional nematicide, carbofuran (56.6%), this was followed by CPH+Carbofuran in Owena. Carbofuran had the highest reduction percentage in Ibadan over the other treatments. For *Scutellonema* spp. in Owena, CPH+NL(80:20)+C significantly reduced the population of *Scutellonema* spp. by 61.5% this was followed by CPH+NL(90:10) with reduction percentage of 59%.(Table 2). In Ibadan, CPH+NL(80:20) and CPH+NL(90:10)+C, all had a similar effect on the nematode, with a reduction percentage of 61.2% and carbofuran 61%. For *Hemicyclophora* spp., carbofuran had the highest reduction percentage of *Eutylenchus* spp. by 59.2% above the conventional nematicide carbofuran (56.6%), this was followed by CPH+Carbofuran in Owena. Carbofuran had the highest reduction percentage in Ibadan over the other treatments. For *Scutellonema* spp. in Owena, CPH+NL(80:20)+C significantly reduced the population of *Scutellonema* spp. by 61.5% this was followed by CPH+NL(90:10) with reduction percentage of 59%.(Table 2). In Ibadan, CPH+NL(80:20) and CPH+NL(90:10)+C, all had a similar effect on the nematode, with a reduction percentage of 61.2% and carbofuran 61%. For *Hemicyclophora* spp., carbofuran had the highest reduction percentage of 62.6% and this was followed by CPH+NL(90:10) with a percentage of 60.1% in Ibadan. CPH+NL(90:10)+C in Owena, for

Table 1. Percentage reduction or increase in plant-parasitic nematodes population due the application of the tested treatments in Ibadan.

NEMATODE GENERA	Percentage reduction/increase in nematode population						
	CPH	**CPH+NL(80:20)**	**CPH+NL(90:10)**	**CPH+CARBOFURAN**	**CPH+NL(80:20)+C**	**CPH+NL(90:10)+C**	**CARBOFURAN**
Meloidogyne spp.	49.9*	46.5*	65.0*	57.8*	58.5*	49.5*	53.4*
Pratylenchus spp.	36.3*	60.8*	51.8*	13.6*	60.8*	51.4*	33.0*
Helicotylenchus spp.	44.4*	68.3*	65.0*	48.9*	71.6*	51.7*	62.2*
Paralongidorus spp.	45.2*	57.8*	49.1*	49.8*	59.3*	51.4*	50.4*
Eutylenchus spp.	33.3*	28.3*	41.2*	19.9*	29.2*	41.4*	47.8*
Scutellonema spp.	49.3*	61.2*	59.1*	42.8*	59.6*	61.2*	61.0*
Hemicyclophora spp.	48.8*	50.3*	60.1*	51.8*	54.7*	51.2*	62.6*
Xiphinema spp.	46.9*	48.1*	53.7*	51.9*	51.9*	53.1*	45.1*
Longidorus spp.	47.7*	64.3*	68.1*	50.2*	65.6*	67.8*	57.1*
Anguillulina spp.	52.5*	52.4*	68-6*	55.7*	56.2*	53.3*	50.5*

*Significantly reduced over control

Table 2. Percentage reduction or increase in plant-parasitic nematodes population due the application of the tested treatments in Owena.

NEMATODE GENERA	Percentage reduction/increase in nematode population						
	CPH	**CPH+NL(80:20)**	**CPH+NL(90:10)**	**CPH+CARBOFURAN**	**CPH+NL(80:20)+C**	**CPH+NL(90:10)+C**	**CARBOFURAN**
Meloidogyne spp.	48.2*	50.5*	51.6*	51.0*	34.1*	48.2*	51.9*
Pratylenchus spp.	54.9*	63.8	56.9	54.	64.0*	60	58.3*
Helicotylenchus spp.	50.7*	56.3*	59.7*	53.6*	59.1	61.8	56.7*
Paralongidorus spp.	50.3*	50.0	56.	50.2*	61.1*	57.5*	54.5*
Eutylenchus spp.	53.5*	55.6*	57.0*	58.2*	56.7*	59.2	56.6*
Scutellonema spp.	56.0*	52.5*	59.0	51.5*	61.5*	57.5*	54.5*
Hemicyclophora spp.	51.0*	56.2*	56.3*	56.4*	55.5*	57.	60.2*
Xiphinema spp.	51.3*	58.7*	58.9*	53.7*	60.7*	59.2*	58.4*
Longidorus spp.	52.4	70.0*	68.0	56.8*	71.2*	69.	62.0*
Anguillulina spp.	55.1*	52.2*	59.6*	48.	52.9*	61.8*	56.6*
Psilenchus spp.	49.7*	61.3*	52.8*	49.7*	56.4*	60.1	51.1*
Tetylenchus spp.	61.2*	54.4*	58.9*	46.5*	55.5*	55.0*	52.3*
Heterodera spp.	48.0*	53.9*	58.9*	53.4*	62.7*	58.8*	56.2*

*Significantly reduced over control

Hemicyclophora spp. had a reduction percentage of 57.6% which was followed by CPH+Carbofuran (56.4%). For *Xiphinema* spp., CPH, CPH+NL(80:20), CPH+NL(90:10), CPH+Carbofuran (C), CPH+NL(80:20)+C, CPH+NL(90:10)+C and arbofuran only, showed a reduction percentage of 51.3, 58.7, 58.9, 53.7, 60.7, 59.2 and 58.4 respectively in Owena while in Ibadan, CPH, CPH+NL(80:20), CPH+NL(90:10), CPH+Carbofuran (C), CPH+NL(80:20)+C, CPH+NL(90:10)+C and arbofuran had reduction percentage of 46.9, 48.1, 53.7, 51.9, 51.9, 53.1 and 45.1% respectively. For *Longidorus* spp., CPH, CPH+NL(80:20), CPH+NL(90:10), CPH+Carbofuran (C), CPH+NL(80:20)+C, CPH+NL(90:10)+C and arbofuran had areduction percentage of 47.7, 64.3, 68.1, 50.2, 65.6, 67.8 and 57.1% respectively in Ibadan and 52.4, 70.0, 68, 56.8, 71.2, 69.2 and 62%, respectively in Owena. For *Anguillulina* spp. CPH+NL(90:10)+C significantly reduced the population over other treatments by 61.8%, this was followed by CPH+NL(90:10) with a reduction percentage of 59.6% in Owena. In Ibadan CPH+NL(90:10) also had the highset reduction percentage over other with a percentage of 68.6%. For *Psilenchus* spp. the highest reduction percentage was recorded in CPN+NL(80:20) and CPH+NL(90:10)+C with a reduction percentage of 61.3 and 60.1% respectively (Table 2). For *Tetylenchus* spp. CPH had a reduction percentage of 61.2% this was followed by CPH+NL(90:10) with a percentage of 58.9%. CPH+NL(80:20)+C was able to reduce the population of *Heterodera* spp. by 62.7% above the conventional nematicide Carbofuran (Table 1).

DISCUSSION

The results from this experiment showed that the application of the organic amendment significantly reduced the population of the plant-parasitic nematodes when compared to that of carbofuran and the control. Several authors have posited that organic matter ammendments to soil have beneficial effects on soil nutrients, soil physical conditions, soil biological activity and crop viability, (Kang *et al.,*1981; Hungalle *et al.,* 1986). Accoding to Kerry (1987), addition of organic matter to soil may provide a nutrient source for facultative nematode parasites such as fungi. Akhtar and Malik (2000) observed a reduction in the population density of *Heterodera avenae* on oats, which they ascribed to stimulation of predaciuos fungi, but Galper *et al,* (1991), observed that the effects of soil amendment enhanced soil saprophytic fungi which although not directly parasitic to nematodes, produce enzymes that adversely affect nematode body structure. Rodriguez-Kabana *et al* (1993) also observed that the addition of organic matter to soil stimulates the beneficial activities of bacteria, fungi, algae and other microorganisms. Increased microbial activity in amended soil causes enhanced enzymatic activities and accumulation of decomposition end products and metabolites, which may be detrimental to plant-parasitic nematodes (Akhtar and Malik, 2000). Akhtar and Malik (2000) showed that the effectiveness of nematode suppression by organic amendment generally depends on the amount of amendment used, C:N ratio and the time of decomposition. For wastes or residues with a C:N ratio less than 20:1, N will be mineralized in the form of NH^+_4 or NO^-_3 for absorption and uptake. Rodriguez-Kabana (1982) reported that the nematode management potential of organic soil ammendment is directly related to N content or inversely related to the C:N ratio. According to Akhtar and Malik (2000), nitrogen is the single most important fertilizer input and is required in the largest quantities for crop production. Inorganic fertilizers containing ammonical nitrogen or formulations releasing this into the soil are the most effective for suppressing nematode populations. In aerobic soil, ammonia produced by ammonifying bacteria during the natural decomposition of nitrogeneous organic material has been implicated in plant-parasitic nematode suppression. Ogunlade *et al* (2012) showed that organic amendments release some chemicals into the soil that are directly responsible for nematode control. They also showed that the neem tree (*Azadiractha indica*) contains a group of chemicals known as limonoids, and these compounds have proven highly effective chemical in nematode control. Plants growing in amended soil contained greater concentrations of phenols than those growing in unamended soil and that this may induce disease resistance in roots. The plant-parasitic nematode population levels under organic amendment treatments might have changed for many reasons, including changes in soil properties, nutrient released to plants, increase in predators and parasitic microorganisms, toxic metabolites released from organic amendment breakdown, or health of host crop (Akhtar and Malik, 2000).

Many reports of the use of amendments to control nematodes are from glasshouse experiments rather than field studies, e.g. the use of decaffeinated tea waste and water hyacinth compost to control *M. graminicola* on rice (Roy, 1976). Remarkable reductions in nematode populations and yield increases have been achieved experimentally, such as with the addition of cocoa pod husks and farmyard manure to control *Pratylenchus brachyurus* on maize in Nigeria, (Egunjobi and Larinde, 1975). In field trials in India, oilseed cakes of castor, mustard, neem, and groundnut significantly reduced nematodes on vegetables, mainly *M. incognita* and *Tylenchorhynchus brassicae*, and improved plant growth (Alam, 1991). In Nigeria the prohibitive expense and erratic supply of pesticides in recent years have caused most farmers with small holdings to revert to alternative methods of pest and disease control including organic amendments. The addition of cow dung and poultry manure gives good control of *M. incognita* (Chindo and Khan, 1990; Akpa and Paswal, 1991). Neem cake, with its recognized nematicidal properties, is the most widely reported and effective amendment against nematodes. In India, neem cake at 1 t/ha and press mud (from sugar cane processing) at 10 t/ha (Jonathan and Pandiarajan, 1991) achieved good control in the field of the rice root nematodes, *Hirschmanniella* spp. In the Cardamon Hills, Kerala, India, most cardamom growers use neem cake for nematode control by incorporating 100–250 kg/ha into the soil (Adesiyan and Adeniji, 1976). The coating of yam tubers with wood ash before planting is a traditional practice in Nigeria that can give better growth in the presence of the yam nematode *Scutellonema bradys*, without actually controlling the nematode; the practice is apparently a means of preventing insect damage. However, incorporating cattle manure into yam mounds before planting at a rate of 1.5 kg/mound, which equals 1.89 t/ha, increases yields and significantly decreases nematode populations (Orisajo and Fademi, 2005). From the report of this finding it is obvious that nematode management inclusion in the rehabilitation technique programme in old cacao plantation will bring nematode population below the threshold.

CONCLUSION

Nematode management inclusion in the rehabilitation technique programme in old cocoa plantation will not only bring nematode population below the threshold but also increase both the yield and income of farmer.

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