Futo Journal Series (FUTOJNLS)
e-ISSN :2476-8456 p-ISSN : 2467-8325
Volume-2, Issue-1, pp- 17 – 31
www.futojnls.org

Research Paper July 2016

Effect of Tillage and Organic Manure Sources on Termites Infestation on Cassava (*Manihot Esculenta Crantz.*) Stems in a Cassava Field in Owerri, Southeastern Nigeria

Ogbedeh, K.O[1]., Epidi, T.T[2]., Ihejirika, G.O[1]., Obilo, O.P[1]. Ezeibekwe, I. O[3]., Ogwudire, V.E[1] and Dialoke, S.A[1].

[1]*Dept. of Crop Science and Technology, Federal University of Technology,Owerri*
[2]*Dept.of Crop Production, Niger Delta University, Wilberforce Island, Yenagoa, Bayelsa State.*
[3]*Dept. of Plant Science and Biotechnology, Imo State University, Owerri.*
E-mail: ogbekenn@yahoo.com

Abstract

Effect of tillage and organic manure sources on termite infestation on cassava (Manihot esculenta Crantz.) stems in a cassava field in Owerri, Nigeria, was investigated in this study. The field trials were carried out in 2007, 2008 and 2009 respectively at the Teaching and Research Farm of the Federal University of Technology Owerri. The experiment was laid out in a 3x6 split-plot factorial arrangement fitted into a randomized complete block design (RCBD) with three replications. Treatments consisted three tillage methods (zero, flat and mound), two rates of municipal waste (1.5 and 3.0 tonnes/ha), two rates of Azadirachta indica (neem) leaves (20 and 30 tonnes/ha), control (0 tonnes/ha) and carbofuran.Data were collected on sprouting percentage, termite incidence and severity. Result shows that carbofuran significantly recorded highest sprouting percentage in 2007 (51.4 %), while A. indica leaves in 2008 and 2009 maintained highest sprouting percentage (80.1 and 87.1 %).Least sprouting percentages were maintained in control plots (30.2, 61.2 and 70.4 %). Similarly carbofuran in 2007 suppressed termite incidence especially at 4 and 8 WAP (14.9 % and 20.0 %) on cassava stems. In 2008 and 2009 A. indica leaves at 30 t/ha depressed termite incidence and severity most. Zero tillage consistently suppressed termite incidence and severity than mound and flat especially at 8, 12 and 16 WAP respectively.

Key words: Cassava, incidence, severity, termites, tillage,

1.0 Introduction

Cassava (*Manihot esculenta Crantz.*) is a perennial woody shrub with an edible root which grows in tropical and sub-tropical areas of the world. It has the ability to grow on marginal lands and can tolerate long dry spell (IITA, 2000). However, cassava does well on well drained, rich and friable loamy soils (Akinsanmi, 1987).

In Africa, cassava provides a basic daily source of dietary energy and has gained popularity as one of the most important root crops in Nigeria especially in the Southern States (Nwokoma, 1998). Cassava is the second most important staple food in sub-Saharan Africa and accounts for more than 100 calories per day in the diet of an individual (IITA, 1988).

Cassava roots are processed into a wide variety of granules, pastes, flour etc. or consumed freshly boiled or raw. It is used in the production of starch, garri, 'foo-foo', wet and dry chips (Nwokoma, 1998). The fresh cassava tuber can be used considerably as a source of feed for livestock (sheep, goats, cattle, pigs etc.). In many rural households, cassava peel is fed to domestic animals (Ihekoronye & Ngoddy, 1985).

Cassava can be planted on mounds, ridges, flat or bedding up (Mathew & Penny, 1998). No-tillage, reduced tillage and conventional tillage have been tested in different ecosystems with variable results in terms of yield (Ofori, 1973). In the traditional farming systems where cassava is usually one of the many crops being grown, pest control is often given a low priority and so cassava receives minimal pesticide application. Under such conditions yields are often low (Henry, 1995). Arthropod pests and diseases are major factors causing this yield reduction (Belloti *et al*; 1999). In the humid lowlands, the predominant diseases of cassava include: cassava mosaic virus (CMV), cassava bacterial blight (CBB), cassava anthracnose disease (CAD) and root rots. Major insect pests of cassava include green mite (CGM: *Mononychellus* spp.), elephant grasshopper (*Zonocerus elegans* L. and *Zonocerus variagatus* Thumb.), cassava mealybug (CM: *Phenococcus manihotis*) and termites (Hillocks & Thresh, 2002).

Termites attack on field, tree crops and on forestry especially in the semi and sub-humid tropics cause significant yield losses (Harris, 1971; Johnson *et al*., 1981). Termites however are serious pests to cassava especially in newly planted fields where they severely damage or weaken the cuttings resulting in poor stands establishment (Onwueme, 1978). Cassava which is grown from cuttings is constantly attacked by *Macrotermes*, *Odontotermes* and *Pseudocanthotermes* by hollowing out stems at ground level (UNEP/FAO, 2000). *Microtermes* spp. and *Ancistrotermes* spp. have diffuse subterranean nests and attack plants below ground by entering the root system and tunneling up the stem, hollowing it out and frequently filling it with soil. Nweke *et al.* (1994) stressed that, cassava field planted early or late in the rainy season often have poor establishment record because termites feed on the planted cuttings.

Umeh (2002) stated that effective control measures applied against termites rely principally on the use of organo-chlorine insecticides like aldrin, dieldrin, lindane, chlordane etc. Due to increase in environmental awareness demanding reduction in the use of commercial pesticides (Hansen, 1987), non-chemical control of termites is attracting renewed interest worldwide. Logan *et al.* (1990) stated that non-chemical control among other things attempts to reduce termite numbers in the vicinity of the plants. According to UNEP/FAO (2000), initial methods of termite control involved deep plowing or hand tillage, pre-planting tillage, removal of the queen and/or destruction of the nest, flooding or burning the mounds with straw to suffocate and kill the colony among others.

Tamil-Solai *et al*. (1998), Widhotz *et al*. (1983) and Schmutterer (1990) reported that one of the alternatives to usage of synthetic organic pesticides is to tap plant resources which have evolved astonishingly diverse array of pesticides but safe pest control molecules. Adding organic matter to the soil could provide alternative food to which termites will be attracted, thereby reducing levels of attack on the main crop (Potter, 1997). According to Belloti *et al*. (1999), improvement of soil particularly by greater use of municipal waste may not necessarily reduce termite numbers, but may well reduce crop damage by providing an alternative source of food. Neem (*Azadirachta indica* A. Juss) has attracted global attention due to its strong and inherently safer insecticidal properties in the environment and less prone to the problem of pest resistance than the synthetic insecticides. The neem products are biodegradable, relatively less toxic and easily available (Srivastav, 2007). Neem derivatives supply nutrients and also serve as an important source of biopesticide (Chandrasekaran, & Gunasekaran, 2007).

However, the adoption of tillage practices and organic manure sources such as the use of municipal waste and neem leaves to tackle termite problem in cassava field by our local farmers has not been tried in our farming systems. Therefore, the need to determine the effect of tillage and organic manure sources on termite infestation on cassava stems in a cassava field in Owerri, Imo State, South-Eastern Nigeria, forms the objective of this research.

2.0 Materials and Method

The field experiment was carried at the Teaching and Research Farm of the Federal University of Technology Owerri, Imo State, Southeastern Nigeria during the 2007, 2008 and 2009 cropping seasons respectively. The University is located between Latitude 4^0 40' and 8^0 15' N and Longitude 6^0 40' and 8^0 15' E (FDALR, 1985). It is of the humid tropics characterized by wet and dry seasons. Rainy season usually begins in mid- March and ends in November with a little dry spell (August break) occurring in August. Minimum and maximum annual temperatures are 22.5 ^{0}Cand 31.9 ^{0}C respectively with Relative Humidity of about 82.6 % (Nwosu & Adeniyi, 1980). The soils of the area is characterized by deep porous red soils derived from coastal plain sands (Benin formation) which are highly weathered, low in mineral reserve and natural fertility (Ofomata, 1975).The experimental site lies within the lowland areas of South-Eastern Nigeria (Ofomata, 1975) and is naturally infested with termites.

Before planting, bulked soil sample was collected randomly from the experimental site from a depth of 0-20cm (top soil) for determination of initial soil physical and chemical properties. Soil pH was determined electronically by glass electrode in pH meter in distilled water suspension using a soil: liquid ratio of 1:2.5 (IITA, 1979) and pH in 0.1 N kcl using also soil: liquid ratio of 1:2.5 (Hendershot *et al*., 1993). Exchangeable cations were estimated as described by Thomas (1982) while cation exchange capacity (CEC) was obtained by summation of the cations. Base saturation was estimated as a sum of basic cations while Total Exchangeable Acidity (TEA) was obtained by summation of acidic cations (Hendershot *et al*., 1993). Organic carbon was measured by Walkley and Black Wet digestion method (Nelson & Sommers, 1982). Values of organic carbon were multiplied by a factor of 1.724 to obtain organic matter (Wakley & Black, 1934). Total nitrogen was measured by Microkjedahl digestion method (Bremner & Mulvaney, 1982), while available phosphorus was determined by Bray II method (Olsen & Sommers, 1982). Particle size distribution of soils was determined by hydrometer method (Gee & Bauder, 1986).

The experimental design was split-plot in a 3x6 factorial arrangement fitted into a Randomized Complete Block Design (RCBD) with three replications. Different tillage practices (zero, flat and mound) constituted the main plot treatments (Factor A) while two rates of municipal waste (1.5 and 3.0 tonnes/ha), neem leaves (20 and 30 tonnes/ha), control (0 tonnes/ha) and termidust (carbofuran: chemical check) made up the sub-plot treatments (Factor B). Hence, there were a total of eighteen treatment combinations consisting of three main plot treatments and six sub-plot treatments. There were three replications and a total of 54 plots.

Land preparation for the three years trials were carried out manually. Subsequently the total field area measuring 65.5 x 16 m or 0.11 ha was mapped out using a 50 m tape. Thereafter, experimental plots measuring 74.5 m^2 (main plots) were marked out with 1m inter plot alleys separating plots. Within each main plot a total of six sub-plots each measuring 4x3 m (12 m^2) were marked out with a 0.5 m distance separating each sub-plot. There were a total of nine main plots and 54 sub-plots. Improved IITA cultivar, TMS 4(2)1425 procured from the National Root Crops Research Institute (NRCRI) Umudike, Umuahia, Abia State was used in the trial. Planting was done on zero tillage, flats and mounds at a planting distance of 1x1 m (10,000 plants/ha) sole. Specifically, each experimental plot of 4x3 m (12 m^2) contained plant population of twelve (12) stands per plot. The municipal waste and neem leaves were incorporated into the soil four days and one week before planting respectively. Allocation of the various treatments to the plots was done using table of random numbers at different rates as specified above. Weeding was carried out at 4, 12 and 18 WAP respectively by hoeing.

Sprouting count percent or number of cuttings successfully sprouted at two weeks after planting per plot was determined by counting and recording the number of cuttings that sprouted or showed signs of sprouting over the total number of cuttings planted per plot multiplied by 100 as follows;

$$\textbf{Sprouting percentage} : \frac{\textbf{Number of sprouted cuttings per plot}}{\textbf{Total number of cuttings planted per plot}} \times \frac{100}{1}$$

Termite incidence (%) on cassava stems was determined at four weeks intervals. This was carried out by counting and recording appropriately number of cassava stems with evidence of termite infestation divided by the total number of plants planted per plot multiplied by 100:

$$\textbf{Termite incidence} = \frac{\textbf{Number of plants infested per plot}}{\textbf{Total number of plants per plot}} \times \frac{100}{1}$$

Termite severity was also determined at four weeks intervals. This was obtained by using the observation and scoring method ranging from 0 to 5 according to Ferd and Herwit (1980) as follows;

Severity estimation	(%) Scale	Interpretation
00	No infestation	
1- 20	1	Slight infestation
21 - 40	2	Moderate infestation
41 - 60	3	Extensive infestation
61 - 80	4	Very extensive infestation
81 - 100	5	Plant completely infested

Data collected were subjected to analysis of variance (ANOVA) using Mix-Model procedure of Statistical Analysis Software system (SAS) as described by Little *et al*. (1996) whilemeans were separated using Least Significant Difference (L.S.D) procedure at 5% level of probability.

3.0 Results

Result of the soil physical and chemical analysis of the study site is shown in Table1. The soil pH (both in water and Kcl) was low which indicates an acidic soil. Also, the soil contained low level of effective cation exchange capacity (ECEC) (≤ 10 meq/100 g soil) and relatively high level of Aluminum. Characteristically, the soil is low in mineral reserves and naturally infertile, hence belongs to the sand textural class. This implies that the soil natural fertility status is poor. This observation is in conformity with Ohiri (1992) who reported that soils in Imo, Abia and Akwa Ibom States are characterized by low pH, low organic carbon and low exchangeable cations.

Table 1: Pre-Planting Soil Physical and Chemical Analysis of the Experimental Site (Top Soil 0-20 cm)

Properties	Content	values
pH in water (1:2.5 soil/water)		5.08
pH in KCl (1:2.5 Soil/Kcl)		4.48
Percentage organic carbon		1.50
Percentage organic matter		2.59
Total Nitrogen (%)		0.12
Available phosphorus (ppm) Bray No. 2		5.28
Exchangeable Cations (Meq/100g Soil)		
Potassium (K)		0.14
Calcium (Ca)		1.50
Magnesium (Mg)		0.90
Sodium (Na)		0.08
Total exchangeable Bases (TEB)		2.62
Hydrogen (H)		0.12
Aluminum (Al)		0.38
Total exchangeable acidity (TEA)		0.50
ECEC		3.12
Percentage slit in water		2.00
Percentage clay in water		9.00
Percentage sand in water		89.00
Textural class		Sandy
Percentage slit in calgon		3.00
Percentage clay in calgon		15.00
Percentage sand in calgon		82.00
Textural Class		Loamy Sand

Table 2 shows that there were significant (P < 0.05) mean differences in sprouting percentage for both years 2007 and 2008 due to manure sources as well as in 2009 (P < = 0.05). Also sprouting percentage count differed significantly (P < 0.05) due to tillage. Carbofuran and *A.indica* leaves (30 t/ha) maintained highest sprouting percentages in 2007 (51.4 %) and 2008 (80.1 %) respectively. In 2009, best sprouting percentage was obtained with *A. indica* leaves at 30 t/ha (87.1 %). In 2008, zero tillage was better than mound in sprouting percentage count. However, control (no manuring) plots consistently recorded least sprouting count in both years. It was observed that the prevalent termite specie in the study site *M. bellicosus* continually caused huge economic damage to the planted cuttings resulting in weak and uneven sprouting leading to the initial scanty shoot establishment.

The best sprouting percentage achieved with carbofuran in 2007 could partly be attributed to the fact that the associated active ingredients were released soon after application to the surrounding environment of the planted cuttings which offered quick termicidal action and protection on the cuttings against termite attack compared to organic manures. The efficacy of carbofuran as seed dressing chemical against termites has been tested by Kolade (2002) and suggested to be an alternative to Aldrin. Equally, in 2008 and 2009 when the organic manures were fully biodegraded in the soil and possibly offered some residual action, *A. indica* leaves at 30 t/ha repelled and protected the cuttings from the attacking termites. This agrees with the report by Jacobson (1986) that most of the pests control achieved by neem derivatives was through feeding inhibition and repellency.

Also, the obvious wide population gaps created in the field especially in plots where no manuring was done (control) suggests reduced sprouting as a result of unprecedented termites attack on the planted cuttings. This observation is in conformity with Schmutterer *et al*. (1978) who claimed that cassava cuttings consisting of cut pieces of stems are damaged inside and outside by *Odontotermes*, *Microtermes* and *Macrotermes* species to such an extent that no shoot can form and large population gaps arise in the field. This view was also upheld by Onwueme (1978) and Nweke *et al*. (1994). Cilss (1986) stressed that several termite species in most parts of Africa cause considerable damage during crop emergence and at any phonological stage. Sudden wilting and scattered emergence can be the result of the underground activities of this group of pests.

Tables 3 and 4 show that significant (P < 0.05) differences existed in termite incidence and severity on cassava stems due to the effect of manure sources in all the field trials. Result indicates that of all the manure sources *A. indica* leaves at both rates (20 and 30 t/ha) and carbofuran (termidust) consistently maintained least termites incidence and severity on growing cassava stems compared to plots where municipal waste was applied at 4 WAP. However, carbofuran showed better performance in 2007 in suppressing termite incidence. There were no significant differences (P > 0.05) due to tillage and manure, except in 2007 where mound significantly (P < 0.05) recorded highest termite incidence than other tillage methods. Non- manure plots on the other hand maintained highest termite incidence and severity in all cases.

Table 2: Effect of Tillage and Manure Sources on Sprouting (%) of Cassava cuttings at 2 WAP in 2007, 2008 and 2009

	2007				2008				2009			
Manure sources	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	45.1	43.0	49.2	45.8	74.4	57.6	76.4	69.4	55.6	77.8	77.8	73.2
Municipal waste (3.0 t/ha)	45.3	45.0	50.7	47.0	73.2	71.6	80.3	75.0	63.9	69.5	61.1	64.8
A. indica leaves (20 t/ha)	41.1	40.6	46.8	42.8	75.9	71.1	83.4	76.8	80.6	88.9	69.5	79.6
A. indica leaves (30 t/ha)	42.7	42.9	45.0	43.5	86.0	71.3	82.9	80.1	75.0	86.1	80.6	87.1
Carbofuran	52.1	49.9	52.2	51.4	75.0	76.5	79.9	77.1	88.9	83.4	88.9	80.6
Control	27.7	29.9	33.1	30.2	63.2	55.7	64.8	61.2	80.6	72.2	66.7	70.4
Mean	42.3	41.9	46.2		74.6	67.3	77.9		74.1	79.6	74.1	
$LSD_{(0.05)}$ Tillage (T)		6.61^{ns}				5.82				14.77^{ns}		
$LSD_{(0.05)}$ Manure source (M)		3.75				6.37				14.57		
$LSD_{(0.05)}$ (T × M)		7.86^{ns}				10.90^{ns}				25.39^{ns}		

Table 3: Effect of Tillage and Manure Sources on the Incidence of Termites (%) on cassava stems at 4 WAP planting in 2007, 2008 and 2009

	2007				2008				2009			
Manure sources	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	39.2	39.2	38.2	39.3	33.4	33.4	30.6	32.4	16.7	11.8	11.7	13.4
Municipal waste (3.0 t/ha)	38.2	38.2	36.1	39.3	30.6	38.9	27.8	32.4	16.7	13.9	11.1	13.9
A. indica leaves (20 t/ha)	23.9	23.9	19.2	22.6	25.0	30.6	22.3	25.9	5.6	2.8	9.7	6.0
A. indica leaves (30 t/ha)	12.3	12.3	12.5	16.6	16.7	30.6	27.8	25.0	5.6	8.4	9.0	7.6
Carbofuran	11.4	11.4	12.4	14.9	33.4	33.4	30.6	32.4	8.9	9.7	11.9	10.2
Control	56.4	56.4	54.8	56.1	50.0	52.8	47.2	50.0	25.7	30.6	26.0	27.4
Mean	30.2	35.3	28.8		31.5	36.6	31.0		13.2	12.9	13.2	
$LSD_{(0.05)}$ Tillage (T)		4.30				11.54^{ns}				5.70^{ns}		
$LSD_{(0.05)}$ Manure source (M)		6.50				11.06				5.37		
$LSD_{(0.05)}$ (T × M)		10.70^{ns}				19.38^{ns}				9.44^{ns}		

Table 4: Effect of Tillage and Manure Sources on Termite Severity (Scoring) on Cassava Stems at 4WAP Planting In 2007, 2008 And 2009

	2007				2008				2009			
Manure source	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	1.58	2.08	2.08	1.86	1.11	1.14	1.05	1.10	0.26	0.33	0.25	0.28
Municipal waste (3.0 t/ha)	1.42	2.17	2.17	1.78	0.88	0.92	0.83	0.88	0.20	0.44	0.18	0.27
A. indica leaves(20 t/ha)	1.00	1.67	1.67	1.17	0.61	0.89	0.50	0.67	0.07	0.08	0.12	0.09
A. indica leaves(30 t/ha)	0.50	1.33	1.33	0.83	0.58	0.89	0.39	0.62	0.07	0.12	0.09	0.10
Carbofuran	1.00	1.67	1.67	1.14	0.67	0.81	0.53	0.67	0.07	0.12	0.13	0.11
Control	1.75	3.00	3.00	2.40	1.83	1.92	1.53	1.76	0.90	1.11	0.80	0.94
Mean	1.21	1.99	1.39		0.95	1.09	0.81		0.26	0.37	0.26	
LSD $_{(0.05)}$ Tillage (T)		1.07 ^{ns}				0.45 ^{ns}				0.26 ^{ns}		
LSD $_{(0.05)}$ Manure source (M)		0.39				0.40				0.14		
LSD $_{(0.05)}$ (T × M)		1.09 ^{ns}				0.72 ^{ns}				0.30 ^{ns}		

This trend was maintained at 8, 12 and 16 WAP (Tables 5, 6, 7, 8, 9 and 10). However at 8 and 12 WAP there were significant ($P < 0.05$) differences in termite incidence due to treatment interactions and termite severity due to tillage practice. Furthermore, at 16WAP termite incidence differed significantly ($P < 0.05$) due to tillage in 2007 as well as termite severity ($P < 0.05$). Result indicates that in 2008 and 2009, *A.indica* leaves at 30 t/ha consistently maintained least termite incidence and severity. Equally, at 8, 12 and 16 WAP zero tillage consistently gave best suppressive action on termite incidence and severity than mound and flat. For the treatment interaction, control and mound produced highest termite incidence (38.3 %) especially in 2009 at 8 WAP.

The suppression of termite activities (incidence) by carbofuran is probably because the chemical barriers in the soil around the roots prevented damage to cassava stems by termites. This is in conformity with UNEP/FAO (2000) that placing chemical insecticidal barriers in the soil around the roots prevented damage to plants by subterranean termites. Umeh (2002) stated that effective control measures applied against termites rely principally on the use of synthetic insecticides. However the efficacy of carbofuran apparently diminished over time in the field. This also agrees with Ohiagu (1984) that the effectiveness of carbofuran depends on accurate timing and frequency of application. It is also possible that an appreciable amount of this chemical was lost to water erosion during the wet season as high rainfall and flooded condition were witnessed in the field during this period. This collaborates the views of Mbagwu (1992) who reported that water erosion is the most active in ultisols of Southeastern Nigeria where leaching and erosion have constantly depleted soil nutrients and other associated valuables.

Also, the outstanding suppressive action of *A. indica* leaves on termites incidence and severity on cassava stems especially in years 2008 and 2009 suggests that as an organic manure, neem leaves within these periods ultimately achieved residual status in the soil through biodegradation. This implies that the degraded by-product (metabolites) of neem leaves probably released into the soil environment some chemical active ingredients (Azadirachtin) that could act as repellant, antifeedant or toxicant to termites. This in agreement with the earlier findings by Saxena (2007) that unlike toxic insecticides neem derivatives (materials) do not kill the pests, but incapacitate or neutralize it via varied cumulative behavioral, physiological and cytological effects ranging from repellency to feeding deterrence. Srivastav (2007) also reported that neem products are biodegradable, relatively less toxic and easily available and contain

Azadirachtin which is efficacious against key pests of coleopteran, diptera, orthoptera, lepidoptera, termites etc.

Similarly, the reduction of termite incidence and severity on cassava stems by zero tillage compared to mound and flat could be attributed to the fact that natural habitat of these termites were little or not disturbed at all and hence were never exposed to the surface, thereby reducing their mobility and foraging activities. This agrees with Akingbola (2004) who stressed that though flat planting and mounding may be advisable for highest field tuber yield, termites tend to be less of a problem in no till. Several authors like Black & wood (1989), Kooyman & Onck (1987) and Wood *et al.* (1977) further confirmed that when natural vegetation is cleared and the land cultivated, the nest of mound-building termite species with deep subterranean nests and with the ability to survive on particular crop residues remain and increase. Equally, mounding and deep ploughing dislodges termites from their natural habitat thereby exposing them to the surface and probably leading to possible increase in their foraging activities (UNEP/FAO, 2000).

On the other hand, the highest level of termite incidence and severity on cassava stems witnessed in plots where no manuring was done implies that termite activities in cassava field were more devastating compared to areas that received manure treatment. Termites especially *M. bellicosus* attacked and inflicted economic injuries on stems of growing cassava plants. This attack was observed to be more extensive during dry season than in wet season. Taylor (1977) and UNEP/FAO (2000) reported that termite activities are more extensive during dry season (drought) than wet season because the plant is weakened by water stress. Cilss (1986) further confirmed that when clearing the soil under the plant, a network of termite galleries is observed especially in poor soils and under persistent drought conditions.

3.0 Conclusion

Soil status of the experimental site was generally poor as it was characterized by low pH, low organic carbon and exchangeable cations. Carbofuran recorded highest sprouting percentage in year 2007, while in years 2008 and 2009, highest sprouting percentage was produced by *A.indica* leaves. Termite incidence and severity on cassava stems were significantly suppressed in plots where carbofuran was applied in year 2007. However, its efficacy decreased with time.

Equally, application of *A. indica* leaves especially at 30t/ha depressed the foraging and damaging activities of termites on cassava stems in 2008 and 2009 than other treatments. This was as a result of the feeding inhibition brought about by the presence of Azadiractin in neem leaves as a degraded by-product. Zero tillage on the other hand suppressed termite incidence and severity more than mound and flat. It is envisaged that a follow-up study will be carried out to investigate the effect of these treatments on termite incidence and severity on quality and yield of cassava.

Table 5: Effect of Tillage and Manure Sources on the Incidence of Termites (%) on Cassava Stems at 8 WAP in 2007, 2008 and 2009

	2007				2008				2009			
Manure source	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	1.58	2.08	2.08	1.86	1.11	1.14	1.05	1.10	0.26	0.33	0.25	0.28
Municipal waste (3.0 t/ha)	1.42	2.17	2.17	1.78	0.88	0.92	0.83	0.88	0.20	0.44	0.18	0.27
A. indica leaves(20 t/ha)	1.00	1.67	1.67	1.17	0.61	0.89	0.50	0.67	0.07	0.08	0.12	0.09
A. indica leaves(30 t/ha)	0.50	1.33	1.33	0.83	0.58	0.89	0.39	0.62	0.07	0.12	0.09	0.10
Carbofuran	1.00	1.67	1.67	1.14	0.67	0.81	0.53	0.67	0.07	0.12	0.13	0.11
Control	1.75	3.00	3.00	2.40	1.83	1.92	1.53	1.76	0.90	1.11	0.80	0.94
Mean	1.21	1.99	1.39		0.95	1.09	0.81		0.26	0.37	0.26	
LSD $_{(0.05)}$ Tillage (T)		1.07 ^{ns}				0.45 ^{ns}				0.26 ^{ns}		
LSD $_{(0.05)}$ Manure source (M)		0.39				0.40				0.14		
LSD $_{(0.05)}$ (T × M)		1.09 ^{ns}				0.72 ^{ns}				0.30 ^{ns}		

Table 6: Effect of Tillage and Manure Sources on Termite Severity (scoring) on Cassava Stems at 8 WAP in 2007, 2008 and 2009

	2007				2008				2009			
Manure sources	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	2.22	2.64	1.96	2.27	1.11	1.14	1.05	1.10	0.25	0.36	0.29	0.30
Municipal waste (3.0 t/ha)	1.81	2.50	1.48	1.93	0.88	0.92	0.83	0.88	0.20	0.28	0.22	0.23
A. indica leaves(20 t/ha)	1.64	2.49	1.11	1.75	0.61	0.89	0.50	0.67	0.06	0.10	0.04	0.07
A. indica leaves (30 t/ha)	1.30	1.69	1.14	1.37	0.58	0.89	0.39	0.62	0.03	0.06	0.03	0.04
Carbofuran	1.83	2.05	1.19	1.69	0.67	0.81	0.53	0.67	0.06	0.08	0.03	0.05
Control	3.27	3.33	3.00	3.20	1.83	1.92	1.53	1.76	0.94	1.14	1.02	1.03
Mean	2.01	2.45	1.65		0.95	1.09	0.81		0.26	0.34	0.27	
LSD $_{(0.05)}$ Tillage (T)		0.54				0.45 ^{ns}				0.07 ^{ns}		
LSD $_{(0.05)}$ Manure source (M)		0.63				0.40				0.11		
LSD $_{(0.05)}$ (T × M)		1.06 ^{ns}				0.72 ^{ns}				0.17 ^{ns}		

Table 7: Effect of Tillage and Manure Sources on the Incidence of Termites (%) on Cassava Stems at 12 WAP in 2007, 2008 and 2009

	2007				2008				2009			
Manure sources	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	50.7	50.7	47.3	48.4	52.8	58.4	50.0	53.7	15.8	17.0	19.5	17.4
Municipal waste (3.0 t/ha)	50.7	50.7	48.1	51.5	58.4	59.0	52.8	56.7	11.5	20.8	17.8	16.7
A. indica leaves(20 t/ha)	37.4	37.4	33.6	36.7	38.9	42.9	36.1	39.3	5.6	11.0	0.0	5.5
A. indica leaves(30 t/ha)	29.8	29.8	28.1	28.9	35.4	42.8	33.4	37.2	3.4	9.7	0.0	4.4
Carbofuran	29.5	29.5	27.0	31.2	25.0	27.8	19.5	24.1	6.4	13.2	0.0	6.5
Control	77.4	77.4	76.1	77.5	64.1	67.9	61.8	64.6	43.8	48.0	39.7	43.8
Mean	45.9	47.9	43.3		45.8	49.8	42.3		14.4	19.9	12.8	
$LSD_{(0.05)}$ Tillage (T)		3.85 ns				10.29 ns				6.74 ns		
$LSD_{(0.05)}$ Manure source (M)		5.29				13.06				4.70		
$LSD_{(0.05)}$ (T × M)		8.79^{ns}				21.88^{ns}				9.00^{ns}		

Table 8: Effect of Tillage and Manure Sources on Termite Severity (scoring) on Cassava Stems at 12 WAP in 2007, 2008 and 2009

	2007				2008				2009			
Manure sources	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	2.65	3.95	1.75	2.78	2.08	2.50	1.81	2.13	0.43	0.48	0.57	0.50
Municipal waste (3.0 t/ha)	2.67	3.15	2.62	2.81	1.86	2.50	1.64	2.00	0.27	0.59	0.42	0.43
A. indica leaves (20 t/ha)	1.76	2.32	1.43	1.84	1.44	1.66	1.19	1.43	0.07	0.22	0.00	0.10
A. indica leaves(30 t/ha)	1.33	2.18	0.67	1.39	1.11	1.50	0.97	1.19	0.05	0.11	0.00	0.05
Carbofuran	1.67	2.00	1.56	1.74	1.58	1.67	0.89	1.38	0.10	0.26	0.00	0.12
Control	4.12	4.85	3.50	4.16	3.12	3.28	3.11	3.17	1.12	1.32	1.08	1.17
Mean	2.37	3.08	1.92		1.87	2.18	1.60		0.35	0.50	0.34	
$LSD_{(0.05)}$ Tillage (T)		0.91				0.64^{ns}				0.10		
$LSD_{(0.05)}$ Manure source (M)		0.89				0.76				0.11		
$LSD_{(0.05)}$ (T × M)		1.55^{ns}				1.28^{ns}				0.19^{ns}		

Table 9: Effect of Tillage and Manure Sources on the Incidence of Termites (%) on Cassava Stems at 16 WAP in 2007, 2008 and 2009.

	2007				2008				2009			
Manure sources	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	51.0	52.5	47.4	50.3	51.2	58.8	50.9	53.6	13.8	25.0	25.6	21.5
Municipal waste (3.0 t/ha)	50.7	54.0	49.1	51.3	53.6	59.7	53.3	55.5	14.5	18.2	14.8	15.8
A. indica leaves(20 t/ha)	37.9	40.4	33.9	37.4	41.7	43.0	36.3	40.4	9.7	10.4	2.8	7.6
A. indica leaves(30 t/ha)	30.3	30.8	28.4	29.8	36.1	42.9	34.4	37.8	2.8	8.4	0.0	3.7
Carbofuran	30.0	34.6	27.7	30.8	30.6	33.4	25.0	29.7	8.4	12.5	6.9	9.2
Control	80.1	80.7	77.7	79.5	66.7	72.8	63.9	67.8	49.9	52.8	45.8	49.5
Mean	46.7	48.8	44.0		46.6	51.8	44.0		16.5	21.2	16.0	
$LSD_{(0.05)}$ Tillage (T)		2.43				12.11 ^{ns}				5.94 ^{ns}		
$LSD_{(0.05)}$ Manure source (M)		4.46				8.30				5.87		
$LSD_{(0.05)}$ (T × M)		7.24 ^{ns}				16.00 ^{ns}				10.22 ^{ns}		

Table 10: Effect of Tillage and Manure Sources on Termite Severity (scoring) on Cassava Stems at 16 WAP in 2007, 2008 and 2009 .

	2007				2008				2009			
Manure sources	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean	Flat	Mound	Zerotill	Mean
Municipal waste (1.5 t/ha)	3.90	4.12	2.78	3.60	2.08	2.50	1.81	2.13	0.41	0.57	0.69	0.56
Municipal waste (3.0 t/ha)	3.34	3.67	3.33	3.45	1.86	2.50	1.64	2.00	0.35	0.38	0.42	0.39
A. indica leaves(20 t/ha)	2.28	2.45	1.67	2.14	1.44	1.66	1.19	1.43	0.17	0.15	0.03	0.12
A. indica leaves(30 t/ha)	2.45	2.51	2.39	2.45	1.11	1.50	0.97	1.19	0.03	0.11	0.00	0.05
Carbofuran	3.83	3.90	2.12	3.28	1.58	1.67	0.89	1.38	0.15	0.24	0.12	0.17
Control	4.22	4.31	4.22	4.25	3.12	3.28	3.11	3.17	1.40	1.58	1.25	1.41
Mean	3.34	3.49	2.75		1.87	2.18	1.60		0.42	0.51	0.42	
$LSD_{(0.05)}$ Tillage (T)		0.49					0.64 ^{ns}				0.20 ^{ns}	
$LSD_{(0.05)}$ Manure source (M)		1.10					0.76				0.17	
$LSD_{(0.05)}$ (T × M)		1.77 ^{ns}					1.28 ^{ns}				0.31 ^{ns}	

References

Akingbola, K. C. (2004). Major insect pests of cassava in Africa: Biology and control. John Willey and sons, Chichester. 91-156.

Akinsanmi, O. (1987). Certificate in Agricultural Science. William Clowes and sons limited, London. Beccles and Colchester. 94-95.

Belloti, A.C., Smith, L., & Lapointe, S.L. (1999). Recent Advances in cassava pest management. Annual Review of Entomology (44): 343-370.

Bremner, J. & Mulvaney, G.S. (1982). Nitrogen Total. In: Page, A.I., Miller, R.H. and Keeney, D.R (eds.). Methods of Soil Analysis, Part 1.*American Society of Agronomy* Madison. WI. (9), 595-624.

Chandrasekaran, B. & Gunasekaran, K. (2007). Neem derivatives in organic Agriculture. Proceedings of the world neem conference held in Coimbatore, India 2007.10-20

Ferd, J.E., & Herwit, D. (1980). In Band, D.A. (ed.) *Vicia faba: Feeding valuesProcessing and viruses*. The Hague Martinus Nihoff. 125-130.

FDALR (Federal Department of Agricultural Land Resources) (1985). The reconnaissance soil survey of Imo State (2: 250). Soils report. 133

Gee, G.W. & Bauder, J.W. (1986). Particle Size Analysis. In: Klute, A.(ed.). Methods of Soil Analysis Part 1. *American Society of Agronomy*, Madison WI. 91-100.

Hansen, M. (1987). Escape from the pesticidal treadmills alternatives to pesticides in developing countries. New York Institutes for consumer policy. 185.

Harris, W.V. (1971). Termites. Their recognition and control. Second edition, London, Longmans. 186.

Hendershot, W.H., Lalande,H. & Duquette (1993). Soil Reaction and Exchangeable Acidity. In: Carter, M.R. (ed.). Sol Sampling and Methods of Analysis. Canadian Society of Soil Science, Lewis Publishers, London. 141-145.

Henry, C. (1995). Global cassava sector. Constraints and estimated future. R and D benefits CIAT, Cali Columbia. .

Hillocks, R. J. & Thresh, J. M. (2002). Cassava. Biology, production and utilization. Natural resources institute, University of Greenwich, Kent UK.

Ihekoronye, A. I. & Ngoddy, P. O. (1985). Integrated food science and technology for the tropics. London Macmillan ed. Ltd. 270-272

IITA (International Institute of Tropical Agriculture) (1979). Selected Methods of Soil and Plant Analysis. IITA manul Series No. 1. IITA, Ibadan Nigeria. 71.

IITA (International Institute of Tropical Agriculture) (1988). IITA Ibadan: Priority and Strategies. 1988-2000. IITA Ibadan, Nigeria. In: Product Development for Root and Tuber crops Africa. (3), 193-195.

IITA (International Institute of Tropical Agriculture) (2000). IITA research priorities and strategies 2000-2005, IITA Ibadan Nigeria. htt://www.iita.org/crop/cassava.htm

Jacobson, M. (1986). Neem tree. Natural resistance par excellence. In Natural resistance of plants to pests. Role of allelochemicals. M. B. Green and P. A. Hedin (Eds.). ACS Symposium series . *American Chemical Society*, (296), Washington, D.C. USA.

Johnson, R. A., Lamb, R. W. & Wood T.G. (1981). Termites damage and crop loss studies in Nigeria: a survey of damage to groundnuts. Tropical pest Management 27: 325-342.

Kolade, K. O. (2002). Evaluationof neem (*Azadirachta indica*, A. juss) seed kernel oil (NSKO) for the control of stem borers of maize. *Seasonal publication of the entomological society of Nigeria*, 34.54-60.

Kooyman, C., & Onck, R.F.M. (1987). The interactions between termite activity, Agricultural practices and soil characteristics in Kissii District, Kenya. Agricultural University Wageningen papers. The Netherlands, 87(3), 120-122.

Little, R.C., Milliken, G.A., Stroup, W.W., & Wolfinger, R.C. (1996). SAS System Inc. for Mix-Models. Statistical System Inc. Carry, North Carolina, USA. 633.

Logan, J. W., Cowie, R.H. & Wood, T.G. (1990). Termite (isopteran) control in agriculture and forestry by non-chemical methods: a review Bulletin of Entomological Research, 80: 309-330.

Mathew, S. N. & Penny, A. (1988). Tropical and sub-tropical foods. London Macmillan ed. Ltd.20.

Mbagwu, J.S.C. (1992). Improving the productivity of a Degraded ultisols in Nigeria using organic and inorganic Amendments. Part 1. Chemical properties and maize yield. *Bio resource Technol*, 42, 149-154.

Nelson, D.W. & Sommers, I.E. (1982). Total Carbon, Organic Carbon and Organic matter. In: Page, A.I., Miller, R.H. and Keeney, D.R. (eds.). Methods of Soil Analysis. Part 2. *American Society of Agronomy*, Madison. WI. 539-579.

Nwokoma, S.N. (1998). Nigeria's staple foods Nigeria. Spring Field Publishers. 10-13.

Nwosu, A.C. & Adeniyi, E.O. (1980). Imo State. A survey of resources for development. NISER Ibadan. 310.

Ofomata, G.E.K.(1975). Landforms regions. In: Ofomata, G.E.K. (ed.) Nigeria in map: Eastern State Ethiope publishing House Benin city. 31-33.

Ofori, C. S. (1973). The effect of ploughing and fertilizer application on yield of cassava (*Manihot esculenta*). Ghana Journal of Agricultural Sciences 6, 21-24.

Ohiagu, G.H. (1984). In: Badejo, M.A. (2002). Termites and man-who wins? Occasional publication of the Entomological Society of Nigeria.. (34) 30-42.

Onwueme, I. C. (1978). Strategies for increasing cocoyam. In: Nigeria food basket in cocoyams in Nigeria. Tropical root crops in a developing country. 35-42.

Olsen, S.R. & Sommers, R.E. (1982). Phosphorus. In: Page A.I., miller, R.H. and Keeney, D.R. (eds.). Methods of Soil Analysis. Part 2. *American Society of Agronomy*, Madison, WI..403-430.

Potter, M.F. (1997). Termites. Handbook of pest control. 8th ed. (Cleave land). Franzak and Foster Co. 2-6.

Saxena, R.C. (2007). Behavioral, physiological and cytological Effects of neem materials on insect pests. Proceeding of world neem conference, November, 2007, Coimbatore, India. 34-41.

Schmutterer, H. (1990). Properties and potential of natural insecticides from the neem tree, *Azadirachta indica*. Annual Review, Entomology. 109: 390-400.

Srivastav, R. D. (2007). Neem in pest management. Procedings of the world neem conference India. 197-209

Tamil-Solai, P.K., Selvaraj Paudian, R. & Charles Manoharan, A. (1998). Toxicity evaluation of pesticides salotrap, neem gold, Nimbecidine and Nimbex against the larvae and pupae of culex quinque fasciatus say. In: Biopesticides in insect pest management (Ed.). S. Ignacimuthu and Aloksen. Phoenix publishing House pvt. Ltd, New Delhi. 46-50.

Thomas, G.W. (1982). Exchangeable Cations. In: Page, A.I., Miller, R.H. and Keeney, D.R. (eds.). Methods of Soil Analysis, Part 2. *American Society of Agronomy*, Madison, WI. 159-165.

Umeh, V. C. (2002). The need for an integrated management programme for termites in West Africa. Occasional publication of the Entomological Society of Nigeria 9th-13th October 2000. Nigeria Institute for oil palm research (NIFOR) Benin city, Nigeria. 71-76

UNEP/FAO(2000). Global IPM facility workshop on termite biology and management. Retrieved from htt://www.chem.unep.ch/pops/termites/termite intro.htm

Walkley, A & Black I. A (1934). An examination of the Degtuarrett method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Sci. 37; 29-38.

Widholtz, M., Budavari, S., Blumetti, R.F. & Otterbein, E.S. (1983). The Merck index, 10th edition, Merck and Co., Rahway, New Jersey, 27, 665: 1191-1192

Wood, T.G., Johnson, R.A. & Ohiagu, C.E. (1977). Populations of termites (isoptera) in Natural and agricultural ecosystem in Southern Guinea savanna near Mokwa, Nigeria. *Geo-Eco-Trop*., 1, 139-148.