TERMITE POPULATION DYNAMICS IN ARENIC KANDIUDULTS AS INFLUENCED BY TILLAGE AND ORGANIC MANURE SOURCES IN A CASSAVA (*MANIHOT ESCULENTA* CRANTZ.) FARM

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ABSTRACT
Termites have been identified as one of the major pests of cassava in Nigeria especially on infested soils. Termite Population Dynamics in Arenic Kandiudults as Influenced by Tillage and Organic Manure Sources in a Cassava Farm in Owerri, Southeastern Nigeria, was investigated in this study. Three years of field trials were carried out in 2007, 2008 and 2009 cropping seasons 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. The TMS 4 (2)1425 was the cassava cultivar used. Treatments consisted three tillage methods (zero, flat and mound), two rates of municipal waste (1.5 and 3.0 tons/ha), two rates of *Azadirachta indica* (neem) leaves (20 and 30 tons/ha), control (0 tons/ha) and a unit dose of carbofuran (chemical check). Result shows that carbofuran significantly (P=<0.0001) recorded least termite population per square meter after tuber harvest, whereas *A. indica* leaves and municipal waste increased termite population per square meter. Also, cassava tuber yield was significantly influenced with application of *A. indica* leaves and municipal waste than carbofuran and control, while termite population per square meter and tuber yield were not affected by tillage method.

Key words: Termites, Manures, Tillage, Population, Cassava, Arenic Kandiudults and Owerri

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, cattles, pigs etc.). In many rural households, cassava peel is fed to domestic animals (Ihekoronye and Ngoddy, 1985).

Cassava can be planted on mounds, ridges, flat or bedding up (Mathew and Penny, 1998). No-tillage, reduced tillage and conventional tillage have been tested in different ecosystems with variable results in terms of yield (Ofori, 1973). However, acceptable yields have been obtained for small farmers using zero tillage , while no significant differences in yields have been obtained between conventional tillage (plough and harrow) and different forms of reduced tillage (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. The major insect pests are cassava green mite (CGM: *Mononychellus* spp.), elephant grasshopper (*Zonocerus elegans* L. and *Zonocerus variagatus* Thumb.), cassava mealybug (CM: *Phenococcus manihotis*), a wide range of rodents and termites (Hillocks and 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). Yams and cassava which are grown from tuber and cuttings respectively are constantly attacked by *Amitermes*, a predominantly root feeding specie. *Ancistrotermes, Macrotermes, Odontotermes* and *Pseudocanthotermes* are also involved in damaging the maturing crops, as well as by hollowing out stems at ground level.

A survey of the distribution of termites in the country by Malaka (1973) has revealed that certain species are restricted to a particular vegetation zone while some are distributed all over the zones. For instance, rainforest appears to have more dominant species than other vegetation zones. About 26 species have been recorded from the Guinea Savanna (ODM,1997) and of which only 10 are dominant. Altogether 120 species of termites have been identified in Nigeria (Logan, 1992) out of which only 20 damage crops and building

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. In Nigeria, Ohiagu (1984) evaluated the effectiveness of four insecticides in termite control in maize plot on the bases of reduction in termite population, foraging activities, fungus comb biomass, percent lodged plants and damaged cobs and grain yield. The study revealed that aldrin was the most effective insecticide followed by carbofuran which is the less persistent insecticide. However, the environmental contamination and health hazards associated with these termicides led to their condemnation in many parts of the world (Umeh, 2002).

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. All these are used to reduce termite densities in the vicinity of the plants.

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, and Gunasekaran, 2007).

However, the adoption of tillage practices and organic manure sources such as the use of municipal waste and neem leaves to regulate termite population density in cassava field by our local farmers has not been tried in our farming systems. Therefore, the need to determine the influence of tillage and organic manure sources on termite population dynamics in cassava field in Owerri, Imo State, Southeastern Nigeria, forms the objective of this research.

MATERIALS AND METHODS

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^i and 8^0 15^i N and Longitude 6^0 40^i and 8^0 15^i E (FDALR, 1985). It is of the humid tropics characterized by wet and dry seasons. The dry season starts in mid November and terminates in mid March, while 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 22.5^0C and 31.9^0C respectively with Relative Humidity of about 82.6% (Nwosu and 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). Soils were earlier classified as Isohyperthermic Arenic Kandiudults (Onweremadu *et al*., 2010). The experimental site lies within the lowland areas of Southeastern Nigeria (Ofomata, 1975). The site is naturally infested with termites.

Before planting, bulked soil sample was collected randomly from the experimental site from a depth of 0-20 cm (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 0.1N Kcl using also soil: liquid ratio of 1:2.5 (Hendershot *et al*., 1993). Exchangeable cations were got by the method described by Thomas (1982) and summation of cations gave the cation exchange capacity (CEC). Base saturation was estimated as a sum of basic cations. 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 and Sommers, 1982). Values of organic carbon were multiplied by a factor of 1.724 to obtain organic matter. Total nitrogen was measured by Microkjedahl digestion method (Bremner and Mulvaney,1982), while available phosphorus was determined by Bray II method (Olsen and Sommers, 1982). Particle size distribution of soils were determined by hydrometer method (Gee and Bauder, 1986).

Initial termite population count was carried out within a quadrat of 1x1m. Each quadrat was randomly marked out and demarcated with strong and durable pegs in about 20 locations randomly selected in the study site. Termite attractants namely; soft woods (dry cassava stems), plantain stems and leaves, grasses (maize straw, groundnut haulms, guinea grass etc.) were placed within each sampling area and allowed for a period of one week. Heaps of woods and grasses were upturned in the early hours of the morning between 6.00 am and 8.00 am Nigerian time and the termite population counted and recorded. The mean number of adults and nymphs counted in each of the twenty sampling areas was considered as initial termite population per square meter in the study site (Ezulike *et al*., 1991, UNEP/FAO, 2000). Also, this procedure was repeated after harvest. However, in this case about five quadrat (sampling) areas were marked out randomly within each sub-plots. Adults and nymphs found in each were counted and recorded. Equally, the mean number of termites counted in the five quadrat areas per plot was considered as the population per square meter.

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) were the main treatments (Factor A). Two rates of municipal waste (1.5 and 3.0tons/ha), neem leaves (20 and 30 tons/ha), control (0 tons/ha) and termidust (carbofuran: chemical check) were the sub-treatments (Factor B).

Hence, there were a total of eighteen treatment combinations consisting of three main treatments and six sub-treatments. There were three replications and a total of 54 plots.

Land preparation for the three years trial was carried out manually. Subsequently the total field area measuring 65.5x 16m or 0.11ha was mapped out using a 50m tape. Thereafter, experimental plots measuring 74.5m^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 4x3m (12m^2) was marked out with a 0.5m distance separating each sub-plot. There were a total of nine main plots and fifty four sub-plots made up of three blocks separated by distance of 1m apart. 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 1x1m (10,000 plants/ha) sole. Specifically, each experimental plot of 4x3m (12m^2) contained plant population of 12 stands/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 weeks after planting respectively by hoeing. Cassava tubers produced during 2007, 2008 and 2009 trials were harvested at twelve months after planting. Data collected were subjected to analysis of variance (ANOVA) using Mix-Model procedure of Statistical Analysis Software system (SAS) (Little *et al*., 1996). Means were separated using Standard Error of Difference at 5% level of probability.

RESULTS AND DISCUSSION

Result of the selected soil physical and chemical analysis of the study site is shown in Table 1. 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) (less than 10meq/100g soil) and relatively high level of Aluminium. 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.

Further more, the poor nutrient status of the experimental site suggests a limiting factor for high productivity of roots and tuber crops in the area. This is in line with Ofomata (1975) who stated that the soils of Southeastern states are characterized by deep, porous red soils derived from coastal plain sands which are highly weathered, low in mineral reserves and natural fertility. This observation was further confirmed by Onweremadu *et al*. (2010) who had earlier classified soils of Southeastern Nigeria as Isohyperthermic Arenic Kandiudults.

Result also shows that no significant ($P=<0.0001$) difference existed in termite population per square meter after cassava tuber harvest due to tillage and treatment interaction effects in all the years of field trials. However, there was significant ($P=<0.0001$) differences due to effect of manure sources in years 2007, 2008 and 2009 respectively (Table 2).

Throughout the years of field trials, plots without manure treatments (control) consistently maintained highest termite population per square meter with values of 191.3 in 2007, 300.9 in 2008 and 341.1termites/m^2 in 2009 respectively. On the other hand, carbofuran consistently maintained least termites population compared with *A. indica* leaves and municipal waste. This is probably because carbofuran which is known to be less persistent chemical substance could be used as an alternative to aldrin, dieldrin or lindane (organo-chlorine) which have been long used in the past to control termites. This is in line with Umeh (2002) who stated that effective control measures applied against termites rely principally on the use of organo-chlorine insecticides such as aldrin, dieldrin, chlordane etc. Equally, Ohiagu (1984) who evaluated the effectiveness of four insecticides in termite control in maize plots on the bases of reduction in termites population revealed that aldrin was the most effective followed by carbofuran which is the less persistent insecticide.

Result (Table 2) equally indicates that termite population count per square meter increased with the application of manures in each of the three experiments after crop harvest compared with the initial termite population count (77.2 termites/m^2) obtained before planting. This population upsurge could be explained from the fact that the addition of organic matter in the soil via these natural plant materials, provided an alternative food sources to the termites as they feed and degrade these materials to improve the soil physical properties and thereby multiply in their numbers in the process. Various authors have argued that removal of organic matter (residues) increases attack and population and also addition of residues provide alternative food and also encourage population increase. This is in agreement with Brown (1962) and Pearson (1958) who reported that the conflicting principles in termites population are that removal of residues and other debris from the field will reduce potential termite food supplies and subsequent attack, and that leaving residues in the field or adding further organic matter will provide alternative food which the termites will be attracted, thereby reducing levels of attack on the main crop. Equally, 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 (Belloti *et al.,* 1999).

Furthermore, result also revealed that, there was no significant difference (P=<0.0001) on the average weight of cassava tubers per hectare due to tillage and treatment interactions in all the years investigated. However, there was significant difference (P=<0.0001) on the average weight of harvested tubers per hectare due to the effect of manure sources in 2007, 2008 and 2009 cropping seasons respectively (Table 3). *A. indica* leaves at 20 tons/ha produced highest average weight of tubers per hectare (15.2 tons/ha) in 2007, while in years 2008 and 2009, *A. indica* leaves at 30 tons/ha consistently maintained highest average weight of tubers per hectare with values of 15.8 and 20.8tons/ha respectively. Municipal waste at 1.5 tons/ha produced high average weight of tubers per hectare (18.9 tons/ha) in 2009. However, least average weight of tubers per hectare was consistently maintained in plots where no manuring was done (control) in all the field trials.

The outstanding performance of *A. indica* leaves in tuber yield confirms its use as an organic fertilizer which could offer some essential nutrients that are vital to vegetative growth, stem development and tuber yield. This is in line with Dupriez and Deleener (1989) who reported that organic manures and natural materials make outstanding contribution to plant health, as plant find in them a whole range of the substance they need in order to produce and withstand the attack from pests and diseases. This was further confirmed by Haasler (1983) who proposed that in organic agriculture neem leaves has been found to be compatible with bio-fertilizer and all many other inputs and in addition neem biomass add value to the compost used in the farm as organic manure. Equally, amending soil with mature and stable composted materials such as municipal waste has been investigated extensively and has been reported to increase root and tuber crops yield (Bryan and Lance, 1991). Specifically, it has been reported that municipal waste increase both yield and quality of cassava as well as improving soil physical properties (Gallerdolare and Nogales, 1987).

CONCLUSION

Amending soil with *A. indica* (neem) leaves and municipal waste in cassava field increased termite population per square meter after tuber harvest. Carbofuran on the other hand remarkably reduced termite population per square meter when compared with municipal waste and neem leaves. Also, cassava tuber yield per hectare was significantly influenced with the application of *A. indica* leaves and municipal waste than with carbofuran and plots which did not receive any manure treatment. However, tuber yield and termite population per square meter were not influenced by tillage method. It is envisaged that in depth (follow-up) study will be carried out to investigate the influence of soil properties especially soil structure and texture on the proliferation and fluctuation of termite population in cassava farm.

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Table 1: Selected properties of soils of the study site (Top soil 0-20cm).

Properties	Content values
P^H in water (1:2.5 soil/water)	5.08
P^H 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/100gsoil)	
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
Aluminium (Al)	0.38
Total exchangeable Acidity (TEA)	0.50
ECEC	3.12
Percentage silt	2.00
Percentage clay	9.00
Percentage sand	89.00
Textural class	Sand

Table2: Effect of tillage and manure sources on average termite population per m^2 after harvest in 2007, 2008 and 2009 in Owerri, Southeastern Nigeria

	2007				2008				2009			
Manure sources	**Flat**	**Mound**	**ZeroTill**	**Mean**	**Flat**	**Mound**	**ZeroTill**	**Mean**	**Flat**	**Mound**	**ZeroTill**	**Mean**
Municipal waste (1.5 t/ha)	96.3	91.7	135.7	107.9	159.7	162.3	162.3	161.4	203.0	220.3	229.0	217.4
Municipal waste (3.0 t/ha)	77.3	86.3	105.0	89.6	164.0	225.0	154.0	181.0	168.3	230.3	210.0	202.9
A. indica leaves (20 t/ha)	76.0	73.7	117.0	88.9	119.3	121.7	101.5	114.2	125.7	146.7	185.0	152.4
A. indica leaves (30 t/ha)	58.7	62.3	91.0	70.7	97.3	98.7	95.2	97.1	112.0	116.7	136.3	121.7
Carbofuran	78.0	77.0	97.0	84.0	92.7	100.3	88.3	93.8	108.3	132.3	123.3	121.3
Control	184.5	174.3	215.0	191.3	303.0	306.0	293.7	300.9	330.0	343.3	350.0	341.1
Mean	95.1	94.2	126.8		156.0	169.0	149.2		174.6	198.3	205.6	
S.E.D Tillage (T)		8.62	(**NS**)			14.05	(**NS**)			8.81	(**NS**)	
S.E.D Manure source (M)		8.25	(P=<0.0001)			13.71	(P=<0.0001)			12.17	(P=<0.0001)	
S.E.D (T × M)		15.64	(**NS**)			25.84	(**NS**)			21.17	(**NS**)	

Table3: Effect of tillage and manure sources on average weight of cassava tubers (t/ha) at harvest in 2007, 2008 and 2009 in Owerri, Southeastern Nigeria

	2007				**2008**				**2009**			
Manure sources	**Flat**	**Mound**	**ZeroTill**	**Mean**	**Flat**	**Mound**	**ZeroTill**	**Mean**	**Flat**	**Mound**	**ZeroTill**	**Mean**
Municipal waste (1.5 t/ha)	9.8	7.8	10.2	9.3	13.3	14.7	9.0	12.3	18.5	16.7	21.4	18.9
Municipal waste (3.0 t/ha)	11.3	15.0	7.0	11.1	14.7	14.8	8.3	12.6	17.0	20.2	18.0	18.4
A. indica leaves (20 t/ha)	13.8	19.4	12.5	15.2	14.8	16.7	14.3	15.3	15.2	19.8	20.7	18.6
A. indica leaves (30 t/ha)	11.3	17.7	10.8	13.3	15.7	17.7	14.2	15.8	20.0	21.2	21.3	20.8
Carbofuran	10.8	5.0	8.5	8.1	13.8	11.3	10.5	11.9	11.8	13.3	16.3	13.8
Control	4.2	5.3	6.2	5.2	8.3	8.0	7.7	8.0	10.0	10.7	11.2	10.6
Mean	10.2	11.7	9.2		13.4	13.9	10.7		15.4	17.0	18.2	
S.E.D Tillage (T)		1.49	(**NS**)			2.80	(**NS**)			2.77	(**NS**)	
S.E.D Manure source (M)		2.06	(P=<0.0005)			1.77	(P=<0.0001)			1.51	(P=<0.0001)	
S.E.D (T × M)		3.57	(**NS**)			3.96	(**NS**)			3.66	(**NS**)	