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CONTROL OF BURROWING NEMATODE INFECTION OF *MUSA SPP* AS AFFECTED BY PLANTING DEPTH AND POULTRY MANURE RATES IN MGBAKWU, ANAMBRA STATE.

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Abstract
Yield and control of burrowing nematode disease of Musa spp as affected by planting depth and poultry manure rates as soil organic amendment were studied in a 3x3x2 factorial experiment in a randomized complete block design with six replicates. The organic amendments were applied in two Musa spp. The poultry manure was apllied at the rate of 0 t/ha, 5 t/ha and 10 t/ha while the planting depth were 30cm, 45cm, and 60cm respectively. The 0 t/ha of poultry manure served as the control. The result of the analysis showed that burrowing nematode population density and its infection on Musa spp varied among the organic amendment applied. The same was true for yield and other yield components. Planting depth of 60cm and 10 t/ha poultry manure efficiently controlled the activities of burrowing nematode and therefore improved yield.

Keywords: *Burrowing nematode, Musa spp, ultisol*

INTRODUCTION

Musa species; banana (*Musa AAB*) and plantain (*Musa ABB*) are major staple food in developing countries especially in Western and Central Africa (FAOSTAT, 1996). They are believed to have originated in Asia. They are perennial mono-cotyledonous herb, which could be between 2-4m tall, taking the appearance of trees as they mature. The pseudo-stem is a cluster of cylindrical aggregation of leaf stalk bases that are packed together closely. The leaf sheath continues into the leaf petiole, which terminates with the leaf lamina commonly called the leaf. The corm/rhizome is the true stem and is located under the apical meristem in the soil. The leaf lamina is large, can be up to 3m long and 1m wide (Swennen and Wilson, 1983) and has parallel veins from the mid-rib to the leaf edge. The leaf lamina easily tears along the veins in windy conditions giving it a shredded appearance. As the plant grows, old leaves dry up and drop beside the pseudo-stem.

They rank as the fourth most important global food commodity after rice, wheat and maize in terms of gross value of production (Araya and Waele, 2005). Throughout history Musa has provided humans with food, medicine, clothing, tools, shelter, furniture, paper, and handicrafts. It could be termed the "first fruit crop" as its cultivation originated during a time when hunting and gatherings were still the principal means of acquiring food.

Banana and Plantain thrive well in environment with 60-100% relative humidity and require 1,300 to 3,600mm of annual rainfall (Swennen and Wilson, 1983). Although they require a high amount of water for good production, it does not do well in poorly drained soil. In water logged land, the pseudo-stem rots easily and the plant dies. In the Niger delta region of Nigeria, where they are important staple crops, the plant is prone to flooding, a common feature of the mangrove. They are tasking on soil nutrients and perform well in organic soil. It requires nitrogen, phosphorus, potassium, calcium, magnesium and high organic matter for good vegetative development and high yield. Decline in soil fertility is an important edaphic factor that has been identified as a limiting factor of sustainable plantain production.

The total world production of *Musa* was put at 88 million tonnes in 2001 with at least 65% of this classified as bananas and 35% as plantains (FAO, 2002). Plantain production in West and Central Africa accounts for over 70% of the world production (lescot, 1998). Plantain is the most economical source of carbohydrate in terms of cost per hectare, per tone and per calorie in sub-Sahara Africa (Gold, 1993). A major advantage of the crop is its availability the whole year round, though seasonal variation occurs in the volume of the harvest. In West Africa, plantains are grown mainly on smallholder farms and backyard gardens for local consumption while surpluses are for local trade. More commonly however, plantain is put in backyard gardens.

Over the years a myriad of problems tend to militate against the production of this crop especially in the tropics. Some of these problems are weeds. Robinson (1996) mentioned that weeds are a major constraint in the production of this crop for subsistence farmers. In West Africa, weed growth is very prolific and lack of effective weed control is a key factor that reduces yield and this leads to overall yield decline. Banana and plantain are highly susceptible to damage by strong wind, which may cut the pseudostem at different portions along its length, especially in the presence of predisposing biotic factors. The pseudostem may break at the mid region of the length, at the base of the inflorescence or close to the base of the pseudostem (Olaniyi, 2005). Sometimes, the pseudostem breaks with immature bunch and leaves shredded by the wind. In the field system, nearby trees serve as wind breaks and break the wind speed, thereby reducing the effect on the plants. The banana weevil (*Odoiporus longicollis*) is an important agent that predisposes plantain pseudostem to breakage by wind. The banana weevil (Odoiporus longicollis) bores through the pseudostem leaving dark lesions on the pseudostem (Padmanaban and Sathiamoorthy, 2001). It is common for the pseudostem to break at this point. Attack by the pseudostem weevil often results in breaking of pseudostem of plants bearing immature bunch, which additionally may have started to ripen. It is likely that generally believed wind broken plantain pseudostems may have been orchestrated by weevil damage.

Other limiting factors to plantain and banana production are the occurrences of pests and diseases pressure that reduce yield drastically by more than 30 to 50% (Olaniyi,2005). Black Sigatoka disease is considered the most economically important disease of banana worldwide, causing typically over 50% yield loss (Chukwu, 1997). The fungus grows on the leaves producing dark spots and causes the fruits to ripen prematurely. Banana *Xanthomonas* Wilt (BXW) attacks almost all varieties of Musa, destroying the fruits and devastating the crop. It was first identified in Ethiopia in the 1970s, but spread rapidly to other parts of the Great Lakes region after reaching Uganda in 2001. *Fusarium* wilt has had a huge impact on the world banana trade and is found in every banana/plantain producing area. It is spread through corms used for planting. Another major banana and plantain pests is the burrowing nematode. This nematode species attacks the plant's roots, resulting in whole plant toppling or reduced yield (Olaniyi, 2005).

The equally important pests of plant parasitic nematodes have received little attention mainly due to the limited information on their occurrence and distribution in West Africa. Among the many reported causes of damage to Musa roots, nematode parasitism appears to be the most serious and widespread in the producing areas (Araya and Waele, 2005). These nematodes are capable of destroying the whole root system (Gowen and Queneherve, 1990). Yet, the subsistence farmer has minimal control over the nematode pests, their infestation rate and associated yield decline (Araya and Waele, 2005).

Burrowing nematode feeding destroys anchor roots and makes plants susceptible to toppling, especially when fruiting or during strong winds. Additional aboveground symptoms in bananas and plantains caused by root damageinclude slow sucker formation, delayed fruiting, smaller fruit and reduced bunch weight, and a shortened plant life. *Radopholus similis* kills feeder roots and creates reddish-brown lesions on larger root surfaces, both at the point of entry and throughout the cortex. Nematodes do not invade the central cylinder (stele), but heavy infestations can girdle and destroy roots. Eventually, burrowing nematodes can migrate from roots into the rhizome causing black, circular lesions, hence the name blackhead disease. Emerging roots may be attacked as they grow out of the infected rhizome.

Nematodes inflict wounds (lesions) on the root as they penetrate the epidermis. However, nematode-related damage symptoms differ with the groups of nematodes. Sedentary endoparasites maintain a close relationship with the host plant and this often results in hypertrophy and hyperplasia of the cells (Dropkin, 1989). The most common sedentary endoparasites on *Musa* are *Meloidogyne* species whose presence is easily recognized by galls produced on the host species. Migratory endoparasites migrate through the root cortex during the process of feeding. This leads to expansion of lesions that coalesce into large necrotic patches. Secondary pathogens take advantage of the nematode-caused lesion to invade the roots resulting in purplish to reddish-black necrosis and eventual decay. The lesion caused by *R. similis* and *pratylenchus* species extend to the stele but do not penetrate it, while those of *H. multicinctus* are more superficial and generally confined to the root cortex (Gowen and Queneherve, 1990). Root necrosis may result in premature death of the root or root fracture at points where it girdles the root. The necrosis interferes with water and nutrient passage thereby affecting growth and vigour. This in turn leads to reduced bunch size and lengthening of the vegetative crop cycle (Gowen and Queneherve, 1990)

Losses due to plant parasitic nematode in plantain usually result from toppling of fruit bearing stems by wind or heavy rainfall, following destruction of the primary roots by the nematode (Chandler,1995). The importance of plant parasitic nematode may differ from region to region and is believed to be influenced by environmental factors such as soil texture, soil fertility, moisture, temperature, pH and soil biota (Lowe, 1992; Queneherve, 1993). Cultivars grown as well as management practices may exacerbate losses (Gowen, 1993; Rotimi, 1996). Much work still needs to be done to understand the complexities of the nematode species profile and shift the processes involved in root damage and factors influencing them. The subsequent losses in plantain due to the activities of these nematodes need to be properly quantified.

Yield losses on sweet desert banana, the important *Musa* species in the international trade have been demonstrated by increased yield after nematicide applications (Sarah, 1989; Gowen and Queneherve, 1990). Control of plant parasitic nematodes with nematicides is economic for these export bananas. However, with plantain grown at subsistence level based on low input farming, it becomes prohibitive for the resource poor farmer to engage in the capital-intensive chemical control. The application of these chemicals could also be hazardous to him as a result of his lack of skill and the environment. The best option for him is the use of resistant cultivars which is cheap management method. Developing cultivars resistant to plant parasitic nematodes has only been partially successful and only for R. similis (Pinochet, 1988). Up till now, plantain cultivars resistant to nematicides have not been developed and sources of resistance are still being sought in the *Musa* germplasm (Stoffelen, 2000). The complexities of the nematode species composition on plantain make the development of a nematicide-resistant cultivar a complicated, difficult and slow task. Understanding this complex species composition vis a vis host parasitic relationship is important for resistance breeding work. Also the assessment of yield losses caused by plant parasitic nematodes on the crop is necessary to profer appropriate cultural practices for effective management of the nematodes.

There is need to increase banana and plantain production to meet the demand of the people. One way of meeting this target is by application of nitrogen rich organic manure such as poultry manure and use of appropriate planting depth during transplanting. Poultry manure has long been recognized as desirable organic fertilizer because it contains many of the elements required to grow plant. Pure poultry manure (1 t/ha) free from litter when fresh has been known to supply 12kg of Nitrogen, 8kg Phosphorus and 5kg of potassium (Ghebrieyessus,*et. Al.,*2002). The ability of such animal manure to increase soil fertility and serve as soil amendment by adding organic matter to the soil cannot be overemphasized. Land application of manure can produce crop yield equivalent to those obtainable with inorganic fertilizer. Peirce (1987) recommended the use of 10-15 ton/h of animal or green manure equivalent for optimum production of cucumber, when applied in combination with inorganic fertilizer. Unfortunately, information on the poultry manure rates for intensive production of banana and plantain in the humid tropical environment of Mgbakwu in Anambra State has been scanty. This gap in information needs to be filled in other to make advances in banana and plantain production in Nigeria.

Planting depth has been observed as an important factor determining the burrowing nematode infection on banana and plantain plants. The higher the depth, the more compact the soil layer thereby making it difficult for nematode penetration. Though, information regarding the appropriate planting depth is fragmentary in this part of the tropics. Swennen (1990), suggested plant holes with a minimum size of about 30cm x 30cm x 30cm, which have not eluded the snapping and toppling off of banana and plantain. Hence, need for increased planting depth.

Problems Statement
Plantain and banana are two most important sources of carbohydrate and iron in our daily diet. Its production has not been optimally achieved in Nigeria; this is due to pest and disease attack. Burrowing nematode (*Radopholus similis)* has been reported as one of the most important limiting factors to plantain and banana production, leading to about 70% loss (Olaniyi, 2005). Information on burrowing nematode (*Radopholus similis)* damage/infection on plantain and banana is still fragmentary in this part of the tropics despite its endemic nature and need to be addressed.

Justification of the study
Musa species plays a vital role as a major staple food crop in this part of the tropic. Its production is usually hampered by pests and diseases (Araya and Waele, 2005). Bunch yield are often low particularly under unprotected farmers field condition. Musa yield is low in Nigeria where incidence of pests and disease originating from the forest vegetation are pronounced (Obiefuna, 1991).

Olaniyi, (2005) reported that *Radophulus similis* has caused significant reduction in banana and plantain. Total crop failure has been recorded in some farm lands in Nigeria (Chukwu, 1997). Infections of *Radopholus similis* nematodes usually predispose *Musa* plants to an array of other pathogens (Araya and Waele, 2005). Majority of Musa species are found highly susceptible to *Radopholus similis*. Hence, the needs for this research work.

Objectives of the study
- To determine the effect of poultry manure and planting depth on the severity of burrowing nematode of banana and plantain.
- To determine the effect of burrowing nematode infection on Musa specie yield and yield components.
- To ascertain the interactive effect of planting depth and poultry manure rates onburrowing nematode infection attack on Musa species.

Experimental Site
The experiment on the effect of planting depth and poultry manure rates on Musa specie as affected by burrowing nematode (*Radopholus similis)* was carried out at the Teaching and Research Farm of the Agricultural Technology Department, Anamabra State Polytechnic, Mgbakwu; located at latitude $05^{0}28'$ North, longitude $7^{0}02'$ East and 90.9m (ASL) in the Tropical Rainforest Zone of South Eastern Nigeria. Annual mean rainfall at the location averages 1995mm (1800mm-2190mm).

Soil Analysis
Soil samples at 0-15cm depth were randomly collected from the sites accordingto Young (1976), using soil auger before tillage operation. The soil samples were bulked and a composite sample obtained, air dried and passed through a 2mm diameter sieve. The samples were subjected to laboratory analysis for the determination of physical and chemical properties of the soil.

Nematode Population Density in the Study Area
This was done at the juvenile stage and the egg stage, using Bearman's funnel technique before planting. The study area was described by Agu, 2008 as naturally infested by root nematodes.

Land Preparations
The experimental field was manually cleared with cutlass, stumped and the trash packed. The land was marked into 6 blocks each measuring 36 m x 3 m. Each of the blocks was divided into eighteen (18) plots of 3m x 2m each. Planting hole of diameter 60 cm x 60 cm was dug using shovel at different depth of 60cm, 45cm and 30cm for transplanting of the test crop. There were a total of one hundred and eight plants in all.

Treatments and Experimental Design
The treatments consist of three (3) planting depths: 30 cm, 45 cm and 60 cm depth and three (3) different rates of poultry manure: zero (0) ton/ha, 5 tons/ha and 10 tons/ha also, two species of Musa (AAB and ABB). The zero (0) ton/ha combination served as the control. Hence a 2×3×3 factorial experiment in Randomized Complete Block Design with six replicats. Three (3) planting depth, three (3) poultry manure rates and two varieties of Musa spp. (AAB and ABB) were combined in all possible ways to give Eighteen (18) treatments combinations.

Preparation and Application of Poultry Manures
The poultry manure used were air dried in an open garage. The cured poultry manure were weighed into three different rates of 0kg poultry manure/6m^2, 3kg poultry manure/6m^2, 6kg poultry manure/6m^2 , representing 0 ton/ ha, 5 tons/ha and 10 tons/ha respectively. A representative sample of the cured poultry manure will be analyzed in the laboratory for the determination of available Ca, Mg, K, Na, Al, H, Organic Carbon, Organic Matter, N, P, and ph.

The poultry manure was applied to each of the plots according to the calculated rates before transplanting of the suckers. The poultry manure were lightly worked into the prepared planting depths and allowed for two weeks before transplanting to make sure heat was not released to the transplanted suckers.

Transplanting
The suckers were transplanted at the rate of one sucker per planting hole to give plant population of 1167plants per hectare.

Growth and Yield Parameters Measured Includes
(i) Plant height at 3, 6, 9, and 12 months after transplanting:
(ii) Leaf Area at 3, 6, 9, and 12 months after transplanting (cm^2):
(iii) Weight per hand
(iv) Weight per bunch:
(v) Weight per yield
(vi) *Radophulus similis* infection assessment:
(vii) Nematode population density at harvest as affected by treatments:

Infection Assessment
The experiment was terminated 24 months after transplanting of the suckers. By this time all the plants have produced fruits and ratoons. In assessing the extent of root infection by burrowing nematode (*Radopholus similis)* in each treatment, the root systems were carefully recovered intact. Adhering soils were gently removed from the roots by rinsing in water. Root systems were individually scored according to Agu and Ogbuji (1996) in which,
0 = 0% root decay (no infection)
1 = 1 -10% root decay (Rare infection)
2 = 11-20% root decay (Light infection)
3 = 21-50% root decay (Moderate infection)
4 = 51-70% root decay (Severe infection)
5 = ≥70% root decay (very severe infection)

Data Analysis
Data obtained were subjected to statistical analysis using GENSTAT 2007 Discovery Edition 3 (Genstat, 2007) Soft ware.

Results
Table 1: Showed the effect of poultry manure and planting depth on plant height of *Musa* species at 3, 6, 9 and 12 months after planting. From the result, plant species and poultry manure had significant effect. Plant species interaction with poultry manure equally had significant effect while planting depth and other interactions were not significant. The table shows that plantain plants that received 10 t/the of poultry manure had the highest plant height at 3 months after planting with the value of 2.11m, followed by plantain that received 5 t/ha with the value of 1.90m. The least plant height was recorded from no poultry manure (control) which had the value of 1.79m.

Banana plant treated with 10t/ha of poultry manure produced the highest plant height with the value 1.69m followed by banana plants that received 5 t/ha that had the value (1.67m) and the least was recorded on the plots with no poultry manure (control) with the value of 1.66m.

The result equally showed that plantain plants planted at 45cm depth produced the highest plant height (1.98m), followed by 30cm planting depth that had the value 1.92m. The least was recorded from 60cm planting depth with the value 1.91m. Banana plants planted at 30cm planting depth had the highest plant height with the value 1.69m, followed by 60cm with the value 1.67m while the least was 45cm planting depth that had the value 1.66m. The result equally showed that plantain plants planted at 45cm depth produced the highest plant height (1.98m), followed by 30cm planting depth that had the value 1.92m. The least was recorded from 60cm planting depth with the value 1.91m. Banana plants planted at 30cm planting depth had the highest plant height with the value 1.69m, followed by 60cm with the value 1.67m while the least was 45cm planting depth that had the value 1.66m.

Result of plant height at 6 months after planting showed that plant species and poultry manure had significant effect (>0.05). Plant species interactions with poultry and plant depth were also significant whereas plant depth and other interactions were not significant. The table showed that plantain plants that received 10 t/ha of poultry manure had the highest plant height at 3 months after planting with the value of 2.34m, followed by plantain plants that received 5 t/ha of poultry manure with the value of 2.10m.The least plant height was recorded from no poultry manure (control) which had the value of 1.98m.

Banana plants treated with 10 t/ha of poultry manure produced the highest plant height with the value 1.87m, followed by banana plants that received 5 t/ha that had the value 1.85m. The least was recorded on the plots with no poultry manure (control) with the value of 1.83m. The result equally showed that plantain plants planted at 5cm depth produced the highest plant height with the value 2.19m, followed by 30cm planting depth that had the value 2.13m. The least value was recorded from 60cm planting depth with the value 2.11m. Banana plants planted at 30cm depth had the highest plant height with the value 1.87m, followed by 60cm planting depth that had the value 1.85m. The least value was recorded from 45cm planting depth that had the value 1.8m. With regards to plant species, plantain plants produced significantly higher plant heights with the mean value of 2.14m compared with the banana plants that had the mean value of 1.85m.

Result of plant height at 9 months after planting showed that plant species and poultry manure had significant effect. Plant species interaction with poultry manure and planting depth were also significant whereas planting depth and other interactions where not significant. The table showed that plantain plants treated with 10 t/ha of poultry manure had the highest plant height with the value 2.60m, followed by plantain plants that received 5 t/ha of poultry manure with the value of 2.34m. The least plant height was recorded from no poultry manure (control) that had the value 2.31m.

Banana plants treated with 10 t/ha of poultry manure had the highest plant height with the value 2.09m, followed by banana plants that received 5 t/ha of poultry manure that had the value 2.06m. The least plant height was recorded from banana plants that received n poultry manure (control) which had the value 2.04m. The result equally showed that plantain plants planted at 45 cm depth produced the highest plant height with the value of 2.43m; this was followed by 30 cm planting depth that had the value 2.37m while the least was 60cm planting depth with the value 2.35cm. Banana plants planted at 30cm planting depth had the highest plant height with the value 2.08m, followed by banana plants planted at 60cmdepth that had the value 2.06m. The least plant heights were recorded from banana plants planted as 45cm depth that had the value 2.05m.

With regard to species, plantain plants produced significantly higher plant height with the mean value 2.38m, when compared with the banana plants that had mean value of 2.06m.

Result of plant height at 12 months after planting showed that plant species and poultry manure had significant effect (>0.05). Plant species interaction with poultry manure and planting depth were also significant whereas planting depth and other interactions where not significant. The table showed plantain plants treated with 10 t/ha of poultry manure had the highest plant height with the value of 3.59m, followed by plantain plants the received 5 t/ha of poultry manure that had the value of 3.23m. The least plantain plant height was recorded from no poultry manure (control), which had the value 3.05m. Banana plants treated with 10 t/ha of poultry manure had the highest plant height with the value 2.88m, this was followed by banana plant that received 5 t/ha of poultry manure which had the value 2.84m, the least banana plant height was recorded from no poultry manure (control) that had the value 2.82m.

The result equally showed that plantain plants planted at 45cm depth had the highest plant height with the value of 3.9m, followed by 30cm planting depth that had 3.07m. The least plant height was height recorded from plantain at 60cm depth with the value 3.04m. Banana plants planted at 30cm depth had the highest plant height with the value 2.87, followed by banana plants that were planted in 60cm depth with the 2.84m. The least plant height was recorded from banana plants that were planted in 45cm depth with the value 2.83m.

Plantain plants produced significantly higher plant height with the mean value of 3.29m when compared with the banana plants that had mean value of 2.85m.

Table 1: Effect of Poultry Manure and Planting Depth on Plant Height of *Musa Species* at 3, 6, 9 and 12 Months after Planting

Parameters	Plant Height at 3 MAP (M)	Plant Height at 6 MAP (M)	Plant Height at 9 MAP (M)	Plant Height at 12 MAP (M)
Species				
1	1.93	2.14	2.38	3.29
2	1.67	1.85	2.06	2.85
LSD 0.05	0.032	0.036	0.040	0.055
Poultry Manure				
0	1.72	1.91	2.12	2.93
5	1.79	1.98	2.20	3.04
10	1.90	2.11	2.34	3.23
LSD 0.05	0.040	0.044	0.049	0.067
Planting Depth				
30	1.81	2.00	2.23	3.07
45	1.82	2.01	2.24	3.09
60	1.79	1.98	2.20	3.04
LSD 0.05	0.032	0.035	0.039	0.054
Spp x Pm				
Spp1 x 0	1.79	1.98	2.21	3.05
x 5	1.90	2.10	2.34	3.23
x 10	2.11	2.34	2.60	3.59
Spp2 x 0	1.66	1.83	2.04	2.82
x 5	1.67	1.85	2.06	2.84
x 10	1.69	1.87	2.09	2.88
LSD 0.05	0.052	0.058	0.064	0.088
Spp x Pd				
Spp1 x 30	1.92	2.13	2.37	3.27

x 45	1.98	2.19	2.43	3.36
x 60	1.91	2.11	2.35	3.24
Spp2 x 30	1.69	1.87	2.08	2.87
x 45	1.66	1.84	2.05	2.83
x 60	1.67	1.85	2.06	2.84
LSD 0.05	0.045	0.050	0.055	0.076
Pm x Pd				
0 x 30	1.73	1.91	2.13	2.94
x 45	1.76	1.94	2.16	2.99
x 60	1.69	1.87	2.08	2.87
5 x 30	1.76	1.94	2.16	2.99
x 45	1.81	2.00	2.23	3.07
x 60	1.79	1.99	2.21	3.05
10 x 30	1.93	2.14	2.38	3.29
x 45	1.89	2.10	2.33	3.22
x 60	1.88	2.08	2.31	3.19
LSD 0.05	0.059	0.065	0.072	0.100

Key: Spp: Species Pm: Poultry Manure Pd: Planting Depth MAP: Months after Planting

Table 2: showed the effect of poultry manure and planting depth on leaf area of Musa species at 3, 6, 9 and 12 months after planting. From the result, poultry Manure and planting depth had significant effect while plant species and interactions were not significant. The table shows that plantain plants that received 10 t/ha poultry manure had the highest leaf area at 3 months after plants with the value of 2342.94cm^{2,} followed by plantain plants that received 5 t/ha poultry manure that had leaf area of 2175.64cm^2. The plantain on the control plots had the smallest leaf area (1459.14cm^2). However, banana plants that received 10 t/ha poultry manure had the highest leaf area with the value of 3020.81cm^2. This was followed by the banana plants that were treated with 5t/ha poultry manure that had leaf area of 2587.28cm^2. Smallest leaf area was recorded on the banana plants in the control plots (1338.75cm^2), With regards to planting depth, plantain planted in 60cm depth had the highest leaf area with the value 2161.17cm-^{2}, followed by plantain plants that was planted in 30cm depth with the value 1914.17cm^2. The 45cm planting depth had the least leaf area. Banana plants planted in 60cm depth had the highest leaf area 2543.56cm^2, followed by 45cm planting depth that had the value 2506.19cm^2. The least leaf area recorded on 30cm depth with the value 1897.08cm^2.

Result of leaf area at 6 months after planting showed that ABB and AAB plants treated with 5t/ha of poultry manure produced leaf area which were significantly (>0.05) higher (2486.44cm^2, 2956.89cm^2) than those treated with no poultry manure (1667.59cm^2, 1530.00cm^2). The same was true for those treated with 10 t/ha poultry manure. ABB and AAB plants treated with 10t/ha poultry manure also gave leaf area that were significantly (>0.05) higher than those treated with 5t/ha. There were however no species effect on the leaf area at 6 months after planting. The same was true for species and poultry manure interaction. On the other hand, ABB and AAB planted in 60cm depth produced leaf areas which were significantly (>0.05) highest than those planted in 45cm and 30cm. Result of leaf area at 9 months after planting showed that poultry manure and planting depth had significant effect whereas species and interactions were not significant. From the table plantain plants that received 10t/ha poultry manure had the highest leaf area with the value of 3123.93cm^{2}, followed by plantain that received 5t/ha poultry manure that had leaf area of 2939.06cm^2. The plantain on the control plots had the smallest leaf area. However, banana plants that received 10t/ha and 5 t/ha poultry manure (4027.74cm^2, 3449.70cm^2) had significantly higher leaf area when compared with the control (1783.00cm^2) plots. With regards to planting depth, plantain planted in 60cm (2881.56cm^2) were significantly higher in leaf areas at 9 months after planting followed by 30cm depth that had 2552.22cm$^{2.}$. The least was recorded from plantain plants planted at 45cm depth with the value of 2536.52cm^2. Banana plants planted in 60cm depth had the highest leaf area with the value 3391.41cm^2, this was followed by 45cm depth with the value 3341.59cm^2 and the least recorded in 30cm depth with the value 2529.44cm^2. Results of leafs area at 12 months after planting showed that ABB and AAB plants treated with 5t/ha of poultry manure produced leaf area which were significantly (>0.05) higher than those treated with no poultry manure (control). The same was true for those treated with 10t/ha poultry manure. ABB and AAB plants treated with 10t/ha poultry manure also gave leaf area that were significantly higher than those treated with 5t/ha. There was however no species significant effect on the leaf area at 12 months after planting. The same was true for species and manure interaction. With regards to planting depth, ABB and AAB planted in 60cm depth had the highest leaf area with the value of 3457.87cm^2, 4069.69cm^2, followed by ABB that was planted in 30cm depth and AAB planted in 45cm depth. The least was recorded in ABB with 45cm depth 3043.82 and AAB with 30cm depth with the value 3035.33cm^2. There was also no species and planting depth interaction.

Table 2: Effect of Poultry Manure and Planting Depth on Leaf Area of *Musa Species* at 3, 6, 9 and 12 Months

Parameters	Leaf Area at 3 MAP (cm)	Leaf Area at 6 MAP (cm)	Leaf Area at 9 MAP (cm)	Leaf Area at 12 MAP (cm)
Species				
1	1992.57	2277.23	2656.77	3188.12
2	2315.61	2646.41	3087.48	3704.98
LSD 0.05	426.126	487.002	568.169	681.802
Poultry Manure				
0	1398.94	1598.79	1865.26	2238.31
5	2381.46	2721.67	3175.28	3810.33
10	2681.88	3065.00	3575.83	4291.00
LSD 0.05	425.582	486.379	567.442	680.931

Planting Depth				
30	1905.62	2177.86	2540.83	3049.00
45	2204.29	2519.19	2939.06	3526.87
60	2352.36	2688.41	3136.48	3763.78
LSD 0.05	315.600	360.685	420.800	504.960
Spp x Pm				
SPP1 X 0	1459.14	1667.59	1945.52	2334.62
X 5	2175.64	2486.44	2900.85	3481.02
X 10	2342.94	2677.65	3123.93	3748.71
Spp2 X 0	1338.75	1530.00	1783.00	2142.00
X 5	2587.28	2956.89	3449.70	4139.64
X 10	3020.81	3452.35	4027.74	4833.29
LSD 0.05	596.528	681.746	795.370	954.445
Spp x Pd				
Spp1 X 30	1914.17	2187.62	2552.22	3062.67
X 45	1902.39	2174.16	2536.52	3043.82
X 60	2161.17	2469.90	2881.56	3457.87
Spp2 X 30	1897.08	2168.10	2529.44	3035.33
X 45	2506.19	2864.22	3341.59	4009.91
X 60	2543.56	2906.92	3391.41	4069.69
LSD 0.05	511.195	584.223	681.594	817.913
Pm x Pd				
0 X 30	1117.92	1277.62	1490.56	1788.67
X 45	1229.17	1404.76	1638.89	1966.67
X 60	1849.75	2114.00	2466.33	2959.60
5 X30	2095.96	2395.38	2794.61	3353.53
X 45	2516.12	2875.57	3354.83	4025.80
X 60	2532.29	2894.05	3376.39	4051.67
10 X 30	2503.00	2860.57	3337.33	4004.80
X 45	2867.58	3277.24	3823.44	4588.13
X 60	2675.04	3057.19	3566.72	4280.07
LSD 0.05	603.767	690.020	805.023	966.028

Key: Spp: Species Pm: Poultry Manure Pd: Planting Depth MAP: Months After Planting

Table 4: showed the effect of poultry manure and planting depth on weight per hand, weight per bunch and yield per hectare of Musa species at harvest. From the result plant species and poultry manure had significant effect. plant species interaction with poultry manure equally had significant difference whereas planting depth and other interactions where not significant. Plantain plants treated with 10t/ha of poultry manure had the highest weight per hand with the value of 3.065kg, followed by plantain plants treated with 5t/ha of poultry manure with the value 2.954kg. The least weight was obtained by plantain plants treated with no poultry manure that had the value 2.709. Banana plants treated with 10t/ha of poultry manure had the highest weight per hand with the value 1.707kg, followed by banana plants treated with 5t/ha of poultry manure that had the value 1,622kg. The least value was obtained from banana plant treated with no poultry manure with the value 1.614kg.

With respect to planting depth plantain plants planted at 60cm depth had the highest weight per hand with the value 2.95kg, this was followed by plantain plants planted at 45cm and 30cm depth that had 2.89kg respectively. Banana plants planted at 45cm on depth had the highest weight per hand with the value 1.695kg, followed by banana plants planted at 60cm depth that had the value 1.630kg. The least was obtained from banana plants planted at 30cm depth that had the value 1.618kg.

Result of weight per bunch showed that plants species and poultry manure had significant effect. Plant species interaction with poultry manure equally had significant effect whereas planting depth and other interactions were not significant. Plantain plants treated with 10t/ha of poultry manure had the highest weight per bunch with the value 6.13kg, followed by plantain plants treated with 5t/ha of poultry manure that had the weight of 5.91kg. The least weight per bunch was recorded from plantain plants that received no poultry manure which had the value 5.42kg. Banana plants treated with 10t/ha of poultry manure had the highest weight per bunch with the value 3.41kg, followed by banana plants treated with 5t/ha of poultry manure that had the value 3.24kg. The least weight per bunch was recorded from banana plants treated with no poultry manure that had the value 3.23.

With respect to planting depth, plantain plants planted at 60cm depth had a higher weight per bunch with the value 5.89kg, while plantain plants planted at 45cm and 30cm had the same weight value of 5.78kg respectively. Banana plants planted at 45cm depth had a higher weight per bunch with the value 3.39kg, followed by banana plants planted at 60cm depth with the value 3.26kg. The least weight per bunch was recorded from banana plant planted at 30cm depth with the value 3.34kg.

Results of yield per hectare showed that plant species, poultry manure and planting depth had significant (>0.05) effect. Plant species interaction with poultry manure and planting depth equally had significant (>0.05) effect whereas poultry manure interaction with planting depth had no significant (>0.05) effect. Plantain plants treated with 10 t/ha of poultry manure produced the highest yield with the value 11.65 t/ha, followed by plantain plants that received 5 t/ha of poultry manure that had the value 11.25. The least yield was obtained from plantain plots treated with no poultry manure that had the value 10.29 t/ha. Banana plots treated with 10 t/ha of poultry manure produced the highest yield with the value 6.49 t/ha, followed by 5 t/ha of poultry manure that had the value 6.164 t/ha. The least was obtained from no poultry manure (control) that had the value 6.13 t/ha.

Plantain plants planted in 60cm depth had the highest yield 11.19 t/ha, followed by plantain plants planted in 45cm depth that had the value 10.99 t/ha. The least yield was obtained from plantain plants planted in 30cm depth that had the value 10.98 t/ha. Banana plants planted in 45cm depth had the highest yield with the value 6.44 t/ha, followed by banana plants planted in 60cm depth that had the value 6.19 t/ha. The least yield was recorded in banana planys treated in 30cm depth that had the value 6.15 t/ha.

Table 3: Effect of Poultry Manure and Planting Depth on weight per hand, weight per bunch and yield per hectare of *Musa Species.*

Parameters	Weight per hand (kg)	Weight per bunch (kg)	Yield per hectare (t/ha)
Species			
1	2.91	5.82	11.05
2	1.65	3.30	6.26
LSD 0.05	0.222	0.444	0.843
Poultry Manure			
0	2.16	4.32	8.21
5	2.29	4.58	8.70
10	2.39	4.77	9.07
LSD 0.05	0.103	0.206	0.391
Planting Depth			
30	2.25	4.51	8.57
45	2.29	4.59	8.71
60	2.288	4.58	8.69
LSD 0.05	0.083	0.167	0.316
Spp x Pd			
Spp1 x 0	2.71	5.42	10.29
x 5	2.95	5.91	11.23
x 10	3.07	6.13	11.65
Spp2 x 0	1.61	3.23	6.13
x 5	1.62	3.24	6.16
x 10	1.71	3.41	6.49
LSD 0.05	0.231	0.462	0.877
Spp x Pd			
Spp1 x 30	2.89	5.78	10.98
x 45	2.89	5.78	10.99
x 60	2.95	5.89	11.19
Spp2 x 30	1.62	3.34	6.15
x 45	1.70	3.39	6.44
x 60	1.63	3.26	6.19
LSD 0.05	0.23	0.451	0.856
Pm x Pd			
0 x 30	2.19	4.37	8.06
x 45	2.12	4.24	8.31
x 60	2.18	4.35	8.27
5 x 30	2.27	4.54	8.68
x 45	2.28	4.57	8.63
x 60	2.31	4.62	8.78
10 x 30	2.42	4.85	8.96
x 45	2.36	4.72	9.21
x 60	2.38	4.75	9.03
LSD 0.05	0.15	0.306	0.899

Key: Spp: Species Pm: Poultry Manure Pd: Planting Depth MAP: Months after Planting

Table 4: showed the effect of poultry manure and planting depth on *R. similis* population density and *R.similis* infection assessment of Musa species. From the result, R. similis population density at 6 months after planting showed that plant species, poultry manure and planting depth had significant (>0.05) effect. Plant species interaction with planting depth equally had significant (>0.05) effect whereas other interactions were not significant. Plantain plants treated with 5 t/ha of poultry manure had the least R. similis population density with the value 71.47, followed by plantain plants treated with 0 t/ha (control) of poultry manure which had the value 71.71. The highest R. similis population density was observed from 10 t/ha of poultry manure which had the value 72.61..

Banana plants treated with 5 t/ha of poultry manure also had the least R. similis population density with the value 91.88, followed by banana plants treated with 10 t/ha of poultry manure that had the value 92.17. The highest R. similis population density was observed from the control plots with the value 92.27.

Plantain planted at 60cm depth had the lowest R. similis population density with the value 68.79, followed by plantain planted at 45 cm depth which had the value 71.96. The highest R. similis population density was observed from plantain plants that were planted in 30 cm depth with the value 75.05. Banana plants planted at 60 cm depth had the least R. similis population density with the 88.00, followed by banana plants that were planted in 45 cm depth with the value 91.40. The highest value was observed from the plantain plants planted at 30cm depth that had the value 96.93.

Result of R. similis population density at 12 months after planting showed that plant species, poultry manure and planting depth had significant (>0.05) effect. Plant species interaction with planting depth equally had significant (>0.05) effect whereas other interactions were not significant.

Plantain plants treated with 5 t/ha of poultry manure had the least R. similis population density with the value 133.48, followed by plantain plants treated with 10 t/ha of poultry manure which had the value 136.56. The highest R. similis population density was observed from the control plots which had the value 175.85.

Banana plants treated with 5 t/ha of poultry manure also had the least R. similis population density with the value 201.26, followed by banana plants treated with 10 t/ha of poultry manure that had the value 223.93. The highest R. similis population density was observed from the control plots with the value 246.61.

Plantain planted at 45cm depth had the lowest R. similis population density with the value 126.92, followed by plantain planted at 60 cm depth which had the value 143.19. The highest R. similis population density was observed from plantain plants that were planted in 30 cm depth with the value 175.51. Banana plants planted at 60 cm depth had the least R. similis population density with the 185.07, followed by banana plants that were planted in 45 cm depth with the value 217.46. The highest value was observed from the plantain plants planted at 30cm depth that had the value 269.28. Results obtained in the assessment of two *Musa* species (*Musa ABB* and *Musa AAB*) as affected by planting depth and poultry manure rates for susceptibility/resistant to *R.similis* infection in *R. similis*nematode endemic soil are shown in table 4.11. The two Musa species responded differently to R. similis nematode damage.Results on R. similis assessment showed that plantain plants treated with 10 t/ha and 5 t/ha of poultry manure had light infection while the control plots were moderately infected. Banana plants treated with 5 t/ha of poultry manure had moderate infection while those treated with 10 t/ha and no poultry manure was severely infected.

Plantain plants that were planted in 45 cm depth and 60 cm depth had light infection while 30 cm depth were moderately infected. Banana plants that were planted in 45 cm and 60 cm depth had moderate infection while 30 cm depth was severely infected.

Table 4: Effect of poultry manure and planting depth on *R. similis* population density and *R. similis* infection assessment of *Musa Species*.

Parameters	R. similis population density at 6 MAP	R. similis population density at 12 MAP	R. similis infection assessment at harvest
Species			
1	71.93	148.54	2.537
2	92.11	223.93	3.833
LSD 0.05	1.605	20.288	0.3433
Poultry Manure			
0	81.99	211.09	3.611
5	81.68	167.37	2.861
10	82.39	180.24	3.083
LSD 0.05	0.795	19.416	0.3332
Planting Depth			
30	85.99	222.39	3.806
45	81.68	172.19	2.944
60	78.39	164.13	2.806
LSD 0.05	1.069	16.013	0.2745
Spp x Pd			
Spp1 x 0	71.71	175.58	3.000
x 5	71.47	133.48	2.278
x 10	72.61	136.56	2.333
Spp2 x 0	92.27	246.61	4.222
x 5	91.88	201.26	3.444
x 10	92.17	223.93	3.833
LSD 0.05	1.690	27.661	0.4721
Spp x Pd			
Spp1 x 30	75.05	175.51	3.000

x 45	71.96	126.92	2.167
x 60	68.79	143.19	2.444
Spp2 x 30	96.93	269.28	4.611
x 45	91.40	217.46	3.722
x 60	88.00	185.07	3.167
LSD 0.05	1.844	25.069	0.4269
Pm x Pd			
0 x 30	85.87	238.63	4.083
x 45	81.78	199.78	3.417
x 60	78.33	194.90	3.333
5 x 30	85.54	219.19	3.750
x 45	81.49	146.32	2.500
x 60	78.01	136.60	2.333
10 x 30	86.56	209.36	3.583
x 45	81.78	170.49	2.917
x 60	78.84	160.88	2.750
LSD 0.05	1.685	29.223	0.5011

Key: Spp: Species Pm: Poultry Manure Pd: Planting Depth MAP: Months after Planting

Discussion

Result of this study showed that increased application of poultry manure as soil organic amendment ameliorated R. similis infection and improved *Musa* growth and productivity. This may be due to a combination of poultry manure and appropriate planting depth. Agu, (2008) reported high ammonium content in poultry manure which steadily decreased root nematode damage on African yam bean and increased yield at increased application rates. Improved plant heights, leafiness, number of leaves and stem girths of banana and plantain plants with increasing rates of poultry manure suggested improved nutrient status of the soil due to application of poultry manure. According to Ghebrieyessus (2003), poultry manure can increase soil nitrogen by as much as 0.25% although the quantity of the poultry manure applied was not stated. This may also be attributed to the sufficient release of nutrients particularly N.P.K contained in the poultry manure applied, as these nutrients improve the growth and yield of crops. This result is in line with the findings of Agbede *et al.* (2008) who found out that the number of fruits and leaves of crop significantly increased with increase in the concentration of poultry droppings. In comparison with the control, poultry manure treated plots had significantly higher number of trusses, flowers and fruits per plants than the control plots. Odeleye *et. al*., (2005) reported that application of organic manure significantly affected Okra leaf area. Asawalam *et. al*., (2007) also reported that significant increase in Okra leaf area when grown on soil amended with poultry and goat manure. The increase recorded for leaf area and leaf area indices on application of organic manure demonstrated the ability of the soil organic amendment to control *Radophulus similis* infection and improve water and mineral uptake from the soil. Agu (2007) achieved total control of root-gall nematode disease on application of 3.00 t/ha of poultry manure.

Normally growth performance of crop plant is generally known to influence yield positively. Dhingra and Asmus (1983) observed that it is the dry matter accumulated in the vegetative parts of legumes that becomes partly translocated to the fruit portion. Although, banana and plantain are *Musa* species which has not been attributed to legumes characteristics, its vegetative performance can as well be result in good fruit yield performance. This explains why banana and plantain treated with 5t/ha and 10t/ha poultry manure significantly produced more number of fruits and higher fresh fruit weight than the control. From the result of the present research experiment, 5t/ha and 10t/ha poultry manure are the best for banana and plantain production in Mgbakwu.

The influence of the interaction between poultry manure and planting depth on harvested bunch yield can be explained by the effect of the treatment on the number of functional leaves. It is possible that more potassium and other mineral elements were available to the plants under higher poultry manure rates (swennen, 1984; Salau *et al*., 1992; Rotimi *et al*., 1999; Widmer *et al*., 2002). Agu *et. al*., (2013) reported that more leaf production on root nematode controlled tomato plants added to the photosynthetic rate of the plants and characteristically resulted in increased fruit yields. However, higher planting depth is presumed to severely reduced pant parasitic nematode due to un-accessibility to the nematodes (Robinson,1995). Robinson (1996b) noted that bunch dry matter is restricted by low potassium through the reduction of photosynthesis and transport of carbohydrates synthesized from leaves to bunch. Since potassium regulates transfer of nutrients to xylem (Turner, 1987), it appears logical that at harvest more leaves were left on nematode inoculated mulched plants compared with un-inoculated mulched plants. In un-inoculated plants there might be a better transfer of nutrients to the xylem, increasing the efficiency in carbohydrate synthesis and translocation.

Poor yield could be a direct or indirect effect of root damage caused by plant parasitic nematodes. The longer the plant stays in the field, the poorer the root system and hence the lower the efficiency in terms of mineral and water acquisition. The rate of root decay and death is faster if plant parasitic nematodes are present and, hence the deleterious effect of plant parasitic nematodes on the parameters/components of yield irrespective of manuring and planting depth (Olaniyi, 2005). Under poor manure/nutrient conditions, where nutrient availability is limited and nematode pressure high due to the poor root system, assimiliation rate would be depressed and hence finger bulking extended. Plant parasitic nematodes are a major factor reducing the number of fruits per bunch and also the number of hands, while manuring supported more fingers per hand. In inoculated mulched plants, the increased number of fingers per hand compensated for production of fewer hands. However, this increased could still not compensate for the reduced fresh weight and, consequently, the lower total finger fresh weight caused by plant parasitic nematodes in the mulched plants. Fruit size is an important consumer preference trait in the Musa growing regions of West and Central Africa (Chukwu, 1997) and especially in the Nigerian market. Mulch supported heavier and longer finger, indicating larger volumes. It suggested that bunch yield is primarily influenced by volume of individual finger and less by that of the total fingers since number of fingers were significantly similar for both mulched and non-mulched plants. An ample supply of potassium which is an important mineral in the mulched material (Salau *etal*., 1992) has been noted by to enhance fruit size and quality. Similar bunch yield under mulch whether inoculated or un-inoculated with plant parasitic nematodes could have been due to the contribution of heavier, non-edible portion (mainly rachis and peel) to bunch weight in the nematode inoculated mulched plants.

It was observed that 60cm planting depth significantly reduced the population density of *R.similis* in the *Musa* species, this suggest that 60cm depth in combination with 10t/ha poultry manure rate efficiently inhibits the activities of *R. similis* nematode inversion. This could be as a result of the inability of the nematodes to penetrate deep into the soil as a result of compartment of the soil thereby impeding growth and reproduction. Stoffen (2000); report that the higher the soil depth the lower the nematode penetration ability. Fogain (1996); states that susceptibility of a host plant to plant parasitic nematodes is usually assessed as the ability of the root system to sustain nematode reproduction. However, the root system traits of plantain are positively correlated with yield (Blomme, 2000). The root system determines the water and mineral nutrient uptake potential of *Musa* plants (Robinson, 1996a) in view of the amount of these materials available for vegetative growth as vegetative growth in turn governs yield. Oka *et.al.* (2000); equally reported that soil organic amendment was most effective in controlling of *R.similis* nematode infection when compared with other cultural protection practices.

With respect to *R.similis* infection assessment 60cm planting depth with 10t/ha poultry manure rates provided adequate and favourable condition for Musa plants. Olaniyi (2005); reported that *R. similis* nematodes inflict wounds on the root as they penetrate the epidermis of the plant. These nematode related damage symptoms differ with the groups of nematodes. Sedentary endo-parasites maintain a close relationship with the host plant and this often results in hypertrophy and hyperplasia of the cells (Dropkin, 1989). The most common sedentary endo-parasites on Musa are the *R. similis*whose presence is easily recognized by die heart produced on the host plant species. Migratory endo-parasites migrates through the root cortex during the process of feeding. This leads to expansion of lesions that coalesce into large necrotic patches.

Plant parasitic nematodes feeding on plant cells additionally consume nutrients otherwise utilized by the host plant and can in some cases, affect photosynthate partitioning (Hussey and Jamssen, 2002). Although manure application can compensate for nematode effects on certain host plant nutrient levels (Melakeberhan *et. al*., 1988), the increased plant growth due to application of manure can result in higher nematode population densities (Schmitt and Riggs, 1989). On the other hand, mulching enhanced vegetative growth and better root production (Salau *et al*.,1992), this could in turn provide more feeding sites for plant parasitic nematodes. However, unlike manure application, enhanced growth under mulching is not associated with increased nematode population densities. Furthermore, plant nutrition impacted the parasitic nematode community structure. At flower initiation, roots cease to act as primary sink and this could account for the decreased in nematode population densities (Sipes and Schmitt, 1998) and ingress into the roots of other plants on the mat, hence the high nematode population densities extracted from roots of suckers detached from harvested plants. Appropriate soil management could suppress the negative effect of plant parasitic on plantain.

Conclusion

Banana and plantain plants exposed to Burrowing nematode (*Radophulus similis*) can effectively be protected by application of 10t/h of poultry manure. However, banana and plantain has long been described as heavy feeders thus this findings. Also, banana and plantain suckers planted at 45cm and 60cm depth were able to suppress burrowing nematode infection irrespective of the application of poultry manure. Those planting depth resulted in inability of the feeding nematode to penetrate the tap root thereby depriving them of feeding and penetration. Though, plantain plants conferred better protection than the banana. Their yields were better when planted at 45cm depth and 10t/h of poultry manure respectively.

Recommendation

Application of poultry manure at the rate of 10t/ha as soil organic amendment in soils endemic with burrowing nematode is hereby recommended for burrowing nematode disease control on banana and plantain as well as improved yield and yield components.

Higher application rates of poultry manure as soil organic amendments may also be tried in a further study for better yields and higher nematode control on banana and plantain in Nigerian ultisol endemic with burrowing nematode.

Planting depth of 45cm and 60cm is also recommended for efficacious root system and reduced lodging in banana and plantain plants. Further planting depth for more efficacious root system and reduced lodging could also be studied for better control of nematodes and its population density on banana and plantain plants.

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