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The distribution of plant-parasitic nematodes of *Musa* spp. in Nsukka Agricultural Ecological zone, Enugu State, Nigeria

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Studies on the root nematodes of *Musa* spp. in Nsukka Agro-ecological zone of Enugu state, Nigeria, was carried out in sixteen towns located in this zone. The study involved collecting data on the distribution, incidence and abundance of nematode parasites on *Musa* spp., generating information on geo-physical, agricultural and historical data in the study area, examining nematode egg mass burden in *Musa* spp. roots and determining the physico-chemical properties of the soil as well as evaluating thier relationships with nematode density. This was obtained through questionnaire admistration to the farmers and root sample collection from sixteen towns in the study area. The collection of the root samples were done from tree villages in each town, three sites in each village and three sampling units in each site giving rise to 144 units each for *Musa* spp. (Banana and plantain). Both cluster and statified random sampling methods were used to collect root samples. The soil samples were used for physico-chemical analyses and nematode extraction. The Baerman's funnel method was used to estimate the nematode population in the root and soil samples. Data generated were subjected to descriptive statistics involving two way analysis of variance, calculation of means and standard deviation, the least significant differences at 5% probability level. Regression analysis was performed with the aid of the Statistical Package for Social Sciences (SPSS). Results of field survey showed that on the average, 67.51% of *Musa* spp. were grown in homestead while 24.65% were grown in farmlands, with 7.87% grown in the wild. Nematode parasites were evenly distributed with Meloidogyne spp and Radopholus similis as the most dominant and diverse species. Integrated management concept among other recommendations were proffered to reduce or probably eliminate the spread of nematode parasite and inproved yield of the *Musa* spp. plant.

Key words: Root nematodes, distribution, physico-chemical properties, *Musa* spp., Nsukka Agro-ecological zone.

INTRODUCTION

Nematodes are worms of the large phylum nematode such as round worm or thread worm. They are the most numerous multicellular animals on earth (De Waele and Elsen, 2007). A handful of soil will contain thousands of

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the microscopic worms, many of them parasites of insects, plants or animals. Bridge (2000) found out that there are 17 species of *Musa* root nematodes in Africa that are recognized to have possible economic importance of which most attention was directed at *Radopholus similis, Pratylenchus goodeyi, Pratylenchus coffeae, Helicotylenchus multicinctus, Hoploaimus pararobustus and Meloidogyne* spp.

The root-knot group of nematodes is the most serious plant parasitic nematodes because of their adaptability, pathogenicity, worldwide distribution in temperate and tropical climates and extensive host range that includes most economic plants (Filipjev and Schuurmans, 1941).

Banana weevil *Cosmopolites sordidus* (Germar), *Coleoptera curculionidae*) and parasitic nematodes are often found together on the same banana mat (Hill and Waller, 1999). Musabyimana et al. (2000) in Kenya have recognized both pests as major constraints to banana production, causing up to 85% yield loss in banana. However, Nigerian Agriculture is under the burden of destructive root nematodes that is rather known as plant parasitic nematode (Agrios, 2005). Adediran et al. (2005) conducted a study in three agro- ecological zones of South Western Nigerian to evaluate the effect of Siam weed (*Chromolaena odorata*) and mucuna (*Mucuna utilis*) cover/fallow crops on plant parasitic nematode population with natural bush regrowth as control. They identified eleven genera of nematodes and three, *Meloidogyne*, *Pratylenchus* and *Helicotylenchus species* as predominant across the trial locations. Other important genera present were, *Scutellonema*, *Tylenchorhynchus* and *Rotylenchus species*.

Moreover, *Musa* spp. (that is, banana and plantain) are among the viable fruits presenting the best means of getting foreign exchange by most tropical developing countries like Nigeria. Not only are they revenue yielding, they are important food commodities. They are versatile crops in the tropics that are vended and consumed all over the world as food (Unprocessed) or processed into chips, dodo, flour, etc (Ogazi, 1996; Arias et al, 2003). Due to globalization, they have been exported from the producer countries to large consuming world. The dramatic growth of both the urban and rural populations in Nigeria provides a good opportunity for increased production of the *Musa* spp. for internal consumption and export.

The imperative of export and industrial use of *Musa* spp. demand that good quality fruits are produced. A major constraint to achieving the above goal is plant parasitic nematodes. They attack these plants parts causing crop losses as well as open up the tissues of these plants to bacterial, fungal and viral disease (Pinochet and Stover, 1980; Rotimi, 2003). All these combine to affect growth, yield and the quality of *Musa* spp. in this part of the world. Consequently, *Musa* spp.. is attacked by a complex of numerous species of parasitic nematodes (Bridge, 1993). These nematodes not only display unique geographic ranges but vary in their timing as well as site of attack within the host root system (Sarah et al., 1993). A large number of fungi have been found associated with lesions in roots of *Musa* spp., *Fusarium Oxsponim* being one of the more common species (Mateille and Folkertsma, 1991; De Luca et al., 2012). However, several studies of plant parasitic nematodes have been carried out in different places. Studies in South America and South East Asia indicates that the most important constraints to these *Musa* spp. are soil nematodes, the root-knot nematodes and *Fusarium* moulds coupled with insect infestation (Devos et al., 1978; Coyne et al, 2007; Mobambo et al, 2010; Sayed Abdul Rahman et al., 2014). In Africa, Cameroun, West and Central Africa benefitted immensely from the trade in the *Musa* spp. (banana and plantain) and researchers reports that nematodes are some of the pests of the crop to be studied and controlled (Kamira et al., 2013). At least three nematodes have been mentioned in Cameroun viz: *Radopholus similis*, *Pratylenchus goodeyi* and *Meloidogyne* spp. (Fogain, 2000, 2001).

In parts of Nigeria, very deep insight activities of these nematodes have been obtained. These parasites have been identified as either acto or endo parasitic, and they are either migratory or sedentary. They also showed that research has gone beyond producing a check list of the offending parasites but have also been focused on nematode surveys in various farming systems, geographical locations, habitats and crop hosts including *Musa* spp. (Ogbuji and Ezekwesili, 1977; Obiefuna and Ndubuizu, 1979; Ezekwesili and Anya 1980; Ogbuji, 1983; Rotimi, 2003; Rotimi et al., 2004a, b, 2005, 2006; Olaniyi, 2008; Tanimola et al., 2013).

Speijer et al. (2001) studied plant parasitic nematodes associated with plantain (*Musa* spp..) in Southern Nigeria and their relative importance compared to other biotic constraints. Their results showed that the predominant nematodes found were: *H. multicinctus* which occurred at all 68 sites sampled. *H. pararobustus* occurred at 64% of the sites, *P. coffeae* occurred at 50% of the sites, *R. similis* occurred at 46% of the sites, while *Meloidogype* spp., (second stage juveniles) were found at 68% of the sites. *P. coffeae* was more common in the West and Mid-west of Southern Nigeria, while *R. similis* was more common in the East. They concluded that *P. coffeae* followed by *R. similis* are the major biotic constraints to plantain production and those higher losses are anticipated from these nematodes than by either *Mycosphaerella* spp.., the cause of black sigatoka or *C. sordidus*. Similarly, Elsen and De Waele (2002) noted that out of the nematodes that parasitize bananas throughout the world, that *R. similis* and *P. coffeae* are the most damaging, causing severe yield losses in crops grown commercially and for local consumption.

Inspite of the above studies, the distribution, incidence and characteristics of these parasites in south eastern

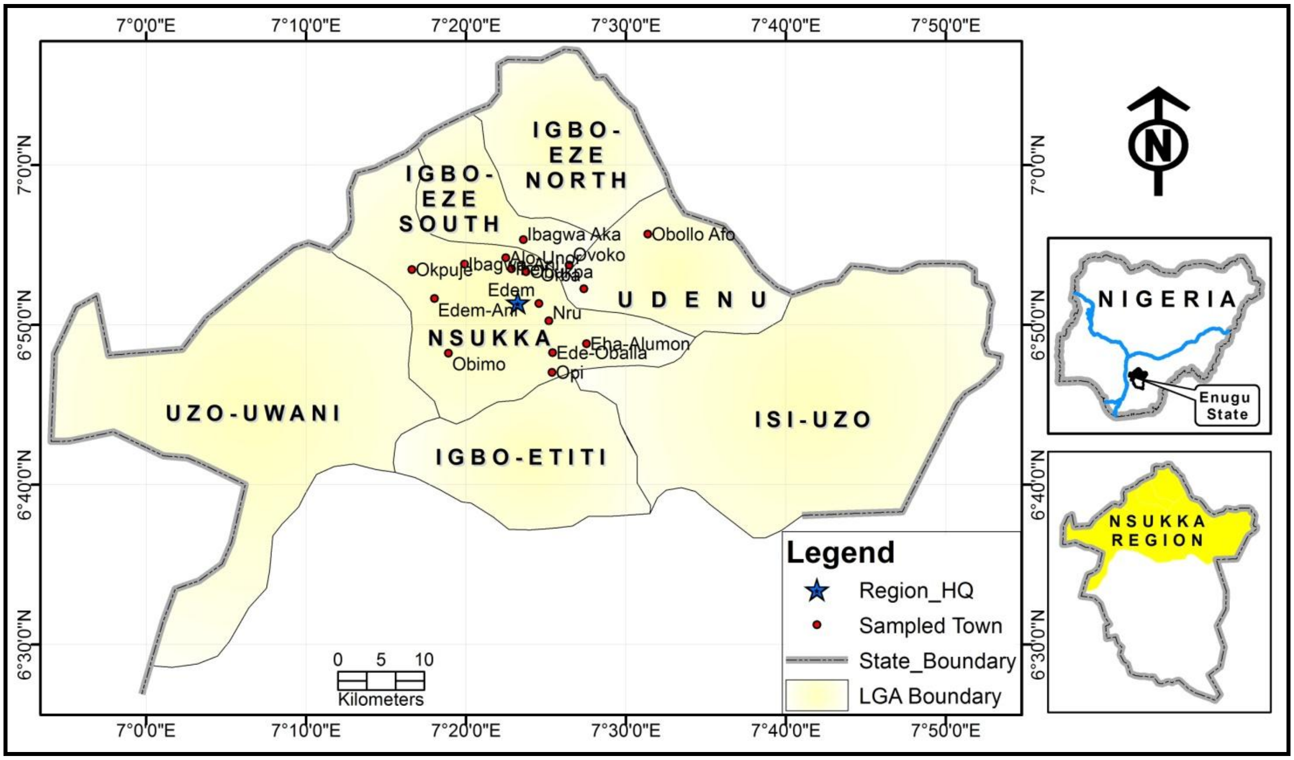

Figure 1. Map of Nsukka Agro-ecological zone showing the sampled areas. Source: Geography Department, University of Nigeria, Nsukka.

Nigeria, especially in Nsukka agricultural ecological zone have not been well documented and that creates a gap in literature and forms the crux of this study. There is need therefore, for adequate knowledge about the distribution of these plant parasitic nematodes of *Musa* spp. and the damages they could cause, including ways of eliminating or eradicating these nematodes for optimum yield of *Musa* spp. in this part of the world.

The aim of this research therefore is to study the distribution of plant parasitic nematodes of *Musa* spp. in Nsukka Agricultural Ecological zone. This can be achieved through the following objectives:

1) To generate information on geo-physical, agricultural and historical information concerning the study area.
2) To determine the physico-chemical properties of the soil as well as their relationships with nematode population extracted from the soil.
3) To profer solutions on ways to control nematode infestation on *Musa* spp. in the study area.

MATERIALS AND METHODS

The study area is Nsukka agricultural ecological zone of Enugu State, Nigeria. It lies between longitude 7°20^{1}E and 7°29^{1}E and latitude 6°54^{1}N and 7°00^{1}N (Figure 1). The area is predominantly made up of sedimentary formations which fall into two main groups; the Ajali sandstone and Nsukka formation (Reyment, 1965). The general relief of the study area is rugged, which is part of the Udi-Nsukka plateau of the Nsukka-Okigwe cuesta, where remnants of the "African" planation surface are represented by summits of the residual hills (Ofomata, 1985). The main occupation of the inhabitants of the study area is agriculture which is characterized mainly by subsistence agriculture.

Sampling procedure

The research comprised of field surveys and laboratory analyses to study the nematode parasites of *Musa Spp* in Nsukka Agro Ecological zone. For each of the species of the *Musa* spp. that is, banana and plantain, samples were collected from sixteen randomly selected towns in Nsukka Agro ecological zone. Three villages in each town and three sites in each village were visited. These gave rise to total of one hundred and forty four (144) sampling sites each for banana and plantain genotypes. The sampling sites visited were as shown in Table 1.

These villages are the places in Nsukka Agro Ecological zone where *Musa* spp. are produced in large quantities and this informed the choice of these sites.

Pre-tested and validated questionnaire were administered alongside sample collections to randomly selected farmers to generate geo-physical, agricultural and historical information concerning the sample sites, crops and habitats. Five (5) farmers were randomly samples from the 48 sites making a total of 240 farmers sampled for the study.

Root sample collection

Cluster and stratified random sampling methods were used to

Table 1. The sampling sites.

S/N	Towns	Villages 1	Village 2	Village 3
1	Nsukka	Umuoko	Umunengwa	Amokwe
2	Ibagwa-Ani	Ugbene	Eham	Umueze
3	Alor-uno	Udeaguoba	Umuoke	Umuezedim/Ugbene
4	Okpuje	Umueze	Amaho	Umuelu
5	Edem	Obeke	Amaowu	Eziozi
6	Nru	Amadim	Amukpocha	Owerre-enu
7	Eha-Alumona	Amuomumi	Amundi	Odobido Umabor
8	Ede-Oballa	Amama	Umunagu	Amaho
9	Obukpa	Umuezekwe	Ajuona	Agu-Udele
10	Opi	Agbaozalla	Ibeku	Idi
11	Obimo	Ajuona	Umuayiko	Ogwuoda
12	Obollo	Iheakpu	Umutenyi	Ogwu
13	Orba	Owerre-Ezeoba	Amube-Oham	Amuji lagwu-Oham
14	Ovoko	Ajuona	Amachara	Amaebo
15	Iheaka	Likke	Iheaka	Obollo
16	Ibagwa-Aka	Ndoke	Ikolo	Amebo

collect root samples from each site. Fresh root samples were collected from seven randomly selected communities out of the sixteen communities earlier surveyed. The root samples were washed with tap water to remove sand and debris. 20 cm length or root was cut into smaller pieces and gently teased with pestle in laboratory porcelain mortar. The mashed root was washed into a muslin cloth and placed on the plastic dish following the modified Baermann's method. The experimental set up was allowed to stand undisturbed for one day (overnight). The debris was removed and the extracted water allowed to sediment. Clear excess water was decanted. An aliquot (5 µg) of the nematode suspension was pipetted into an improvised counting dish with an aid of a micro pipette. The suspension was kept shallow. The suspension on the counting dish was placed on the dissecting stereo – microscope using the lowest convenient magnification and with under stage lighting to enable the nematodes to be seen more clearly. The nematodes (adults or juveniles) were counted and recorded. The nematodes were also captured with mounted digital photographic camera which was later processed in a colour laboratory. The pictures were scanned and further processed using the computer software called Adobe photo shops. The nematodes were identified and classified with help of a practical plant nematology field and laboratory guide as well as assistance from experts.

Soil sample collection

Soil samples were collected at a depth of 20 cm from each of the locations where plant root samples were collected. The three soil samples collected from each site were bulked together into a composite sample for each site. These gave rise to a total of forty eight composite samples, each for banana and plantain genotypes. The sample collection was done the year 2012.

Laboratory soil analyses

Laboratory soil analyses were carried out to determine the physical and chemical characteristics of the soil samples. Extraction of nematode larva from the soil was carried out using the modified Bearman's funnel Laboratory Root analyses were also carried out for the fixing and extraction of nematode eggs, and for identification and classification of nematodes.

Data analysis

All data collected were subjected to analysis of variance (ANOVA) using General statistics (GENSTAT) Discovery Edition. Means were separated using the least significant Difference (FLSD) at 5% probability level. Regression analysis and other descriptive statistics were performed with the aid of the statistical package for social sciences (SPSS) version 16.

RESULTS

The result of the study shows that the farmers in the study area cultivate mostly on homestead habitat followed by farmland which is just a few distance from the backyard and very little production goes on in the wild. There is concentration of *Musa* spp. around the homestead, within the surveillance of the farmer, probably to avoid volunteer harvesting by thieves as informed by the respondent farmers. From meteorological information of the study area in the year 2012, rainfall was very high in August and September, high in June, moderate in April, May and July and basically no rains in January, February and December. During the peak of the sample collection in June, the relative humidity was very high at approximately 81%. Average soil temperatures for the month was within the normal range. Average volumetric soil water content (m/sec), was moderate and so on.

The mechanical and chemical analysis of soils of the study area under the particle size analysis showed that

Table 2. Rotated component matrix of principal component analysis for the physical and chemical properties of the soil samples.

Physical and chemical properties	Components			
	1	2	3	4
Clay	-0.357	0.029	0.712	0.051
Silt	-0.059	-0.477	0.360	0.051
Fine sand	0.004	0.050	0.903	0.034
Coarse sand	0.140	-0.020	**-0.965**	-0.078
H_2O	0.861	-0.066	-0.312	-0.118
KCL	0.726	0.204	-0.493	-0.075
Carbon	0.020	0.824	-0.012	0.152
Organic matter	0.019	**0.949**	0.104	0.094
N	0.382	-0.240	0.130	-0.621
Na^+	0.333	0.466	0.511	-0.273
K^+	0.564	0.730	-0.-49	-0.084
Ca^{2+}	0.822	0.452	0.254	0.083
Mg^{2+}	0.565	0.757	0.125	-0.093
Cation exchange capacity	0.615	0.410	0.447	0.232
Base salt%	0.556	0.503	-0.490	-0.115
H^+	0.087	0.080	0.059	**0.773**
Phosphorus	**0.871**	0.105	-0.215	-0.106

Total variance explained by the four components is appraximately 79.60%

the soils for the communities fall under (3) textural classes viz: Sandy soil, sandy-loam soil and loamy soil. The percentage soil organic matter and organic carbon were generally low. Most of soils of the communities were acidic in reaction whether the pH value was measured in H_2O or in NaCl (5.8-8.7 for pH value in H2O and 5.2-7.5 for pH value in NaCL). The contents of the major elements in the soil (N, exchangeable baases- Na^+, K^+, Ca^{2+}, Mg^{2+} and exchangeable acidity-H^+) were rather low. The percentage base salt was quite high with most soils saturated ranging above 80%. Percentage base salt saturation was quiet high with most soils saturation ranging above 80%. Total phosphorus was moderately high with most soils measuring above 30ppm. The Cation Exchange Capacity (CEC) of the soils was rather low with 14.0 m/100 g as the highest record.

Relationship between nematode density and some geo-physical and agricultural information of the sampling sites

The extraction of highest nematode larval density in the homestead compared with farmland and wild habitats, flat topography compared with slightly sloppy or steep slope topography and dark brown soil compared with brown and light brown soils could be due to the fact that they receive more organic manures which apart from increasing plant vigour also provide a conducive environment for nematodes. Dark brown colour in soils mostly confers a measure of fertility and also confirms that there was a judicious amount of organic matter (humus) in the soil which in turn favours nematodes habitation. Rotimi (2003) also obtained a similar result.

The rotated component matrix was used to determine what the set of components represents. The first component correlated highly with phosphorus. The second component correlated highly with organic matter. The third component correlated highly with coarse sand and the fourth component correlated highly with H^+ and this suggests that we can focus on these four components in further analysis. The percentage of variance accounted for by the four components is 79.6% approximately 80%. This implies that the four components explain nearly 80% of the variability in nematode density attributable to the original seventeen variables (Table 2).

Although the variables selected from the results of the PCA suggests using phosphorus, organic matter, coarse sand and H^+ but for further analysis, silt was included as well because it was the only variable that was selected in a stepwise multiple linear Regression Analysis that includes all the seventeen variables. The regression method selected only silt as the significant factor to nematode density. The model built adequately based on the fact that the p-value of the F- test conducted on the adequacy of the model is less than 0.05. The model has r-square of 0.392, which implies that about 39% of the variation in nematode density was attributed to silt (Table 3).

Table 3. Stepwise multiple linear regression result for Nematode density.

Regression equation					
Density			21504.00 - 1126.50 × silt		
R-square			39.2%		
		Analysis of overalll equation			
Source	**DF**	**SS**	**MS**	**F**	**P-Value**
Regression	1	1.269E8	1.269E8	9.009	0.010
Residual error	14	1.972E8	1.409E7		
Total	15	3.241E8			
		Analysis of individual predictors			
Predictor	**Coefficient**	**SE(ccoefficient)**	**T**	**P-value**	
Constant	21504.00	3325.283	6.467	0.000	
Silt	-1126.50	375.313	-3.001	0.000	

Df, Degree of freedom; SS, sum of squares; MS, means square; F, F-test value.

From the data collected on the distribution of plant root nematodes in the study area (indices of diversity and dominance); in *Musa* spp., the diversity indices of these parasites were derived using Shanon- Weiner model with the formular (n/N) (LN(ni/N). The outcome shows that there was high diversity index (1.7497) for the whole plant parasitic nematodes in the study area and *Meloidogyne* spp. is the nematode with the highest diversity index.

Again from the distribution of nematode species in roots samples of *Musa* spp. from sixteen towns in Nsukka Agro Ecological zone, the survey for the parasites show that altogether, eight nematode spaces from six genera were isolated. The result of the chi-square test for equality of proportions (density) of the species clearly indicates that the proportions of nematodes species are significantly different ($p < 0.05$). From the result, *Meloidogyne* spp. was taken as the dominant nematode specie in Nsukka Agro Ecological zone. A study of Table 4 shows that *Meloidogyne* spp. was the most frequently encountered nematode (34.4%) while *Scute vonema* spp. was the least abundant specie in the study area. This distribution is also shown in Figure 2.

Table 5 brings together the soil nematode larval density and the root nematode egg mass density. It was shown that in all cases of recorded densities, nematode egg mass was always higher than the nematode population density (adult and larva). Again since the values of the slope in the resulting regression equation are approximately zero, there is no significant linear relationship (no effect) between nematode population density and mean root weight of *Musa* spp*.*

DISCUSSION

Like most *Musa* spp. plants in the tropics, this study has shown a high level of parasitization by root nematodes and indicates that of all the prevailing parasites, *Meloidogyne* was the most prevalent nematode species extracted from the studied sited. This is folowed by *R. similis, Rotylenchus* spp*., H. milticinctus, Pratylenchus* spp. etc. This is supported by earlier reports by Lowe (1992) and Speijer et al (2001a) which states that *H. multicinctus* and *Meloidogyne Musa* spp. are ubiquitous in Nigeria. Rotimi et al. (2005) recorded that *P. coffea, R. similis, H. multicinctus* and *Meloidogyne* spp. were the key nematodes in Southern Nigeria. *Meloidogyne* is the specie considered to be of significant effect in Nsukka agro-ecological zone since it was recorded as the highest dorminant and diverse specie.

Musa spp. production in Nigeria is predominantly practiced by peasant farmers who cannot normally afford high cost dependent inputs like fertilizers, herbicides, synthentic pesticides including nematicides, improved planting materials, etc. The farmers in the study area cultivate mostly on homestead habitat which is just a few distance from the backyard and very little production goes on in the wild. Concentration of *Musa* spp. around the homestead, within the surveillance of the farmer is probably to avoid volunteer harvesting by thieves as informed by the respondent farmers. Similar finding was reported by Swennen and Vuylsteke (1998) who found that crop production is normally on a small scale field production or in backyard gardens. This result also indicates that *Musa* spp. are not planted in an intensive and organized pattern like other food crops such as yam, cassava, etc, which have more regular pattern of production.

The smallholder' lands are often marginal and due to rising population pressure which leads to shortened fallow period, there are the consequences of declining soil fertility and high soil acidity. This is evident from the high pH values obtained from the chemical soil analysis

Table 4. Distribution of nematode species in roots samples of *Musa Spp* from seven randomly selected towns in Nsukka Agro Ecological zone.

Nematode specie/0.05 mL aliquot	Population density	Percentage population (%)
Meloidogyne Spp.	288	34.4
Radopholus similis	201	24.0
Rotylenchus reniformis	86	10.3
Rotylenchus borealis	102	12.2
Pratylenchus goodeyi	26	3.0
Pratylenchus coffeae	49	5.9
Helicotylenchus multicintus	72	8.6
Mesocriconema specie	13	1.6
Total	**837**	**100.0**

Chi-Square test value is 592.63 with p-value of 0.0000.

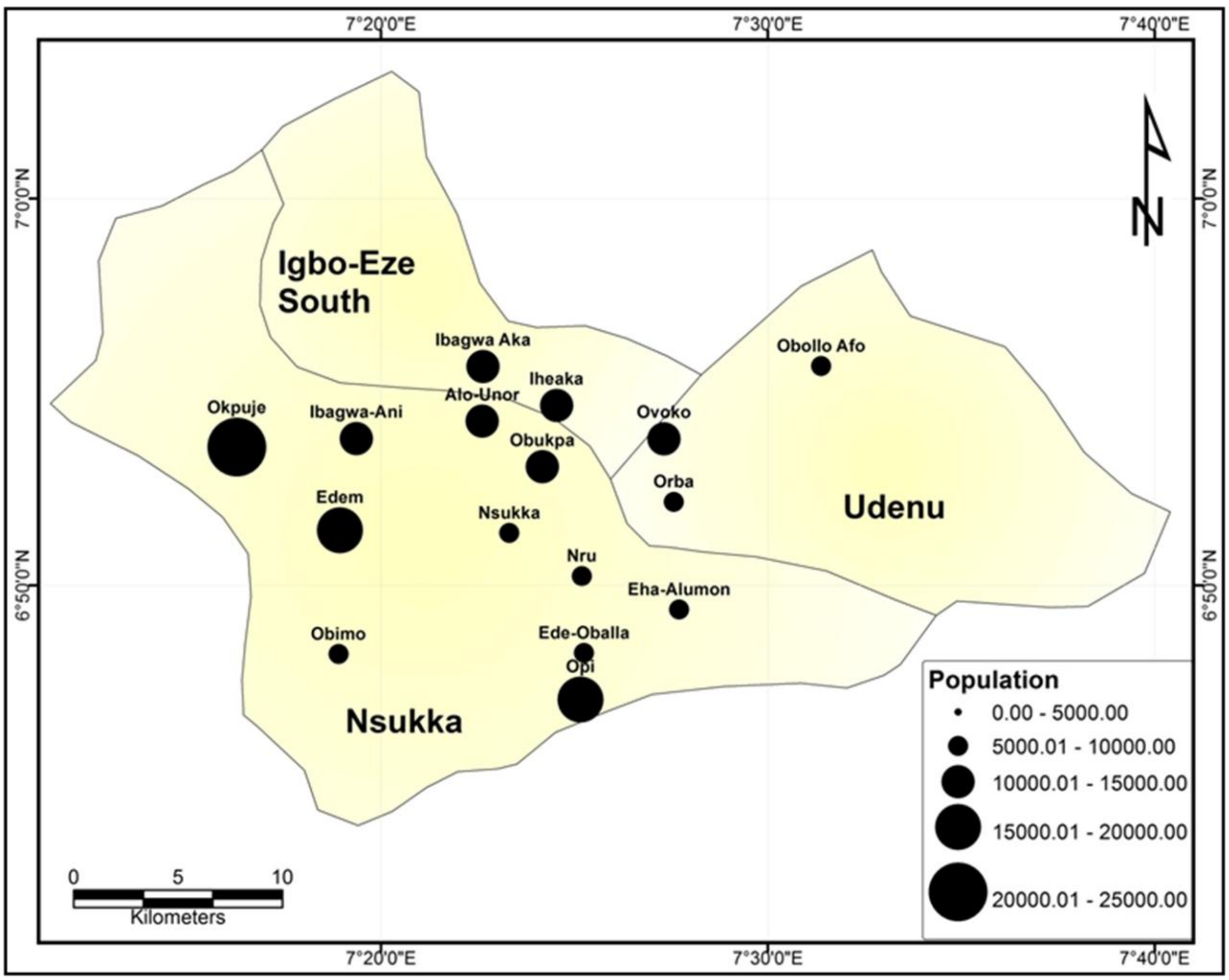

Figure 2. Distribution of nematode species in roots samples of *Musa spp* from seven randomly selected towns in Nsukka Agro Ecological zone. Source: Geography Department, University of Nigeria, Nsukka.

showing the soil samples as acidic in nature. Nematodes do not thrive well in acidic soils. This was evident in the negative correlation between nematode population and soil pH obtained in the study. Moreso, poor fertility status

Table 5. The population density of nematode larva and egg extracted from rhizosphere soils and the roots of *Musa spp*. in Nsukka agro-ecological zone.

Towns	Nematode larvae density	Nematode egg mass
Alor Uno	10,500	30,840
Ede Oballa	8,490	25,680
Edem	15,660	42,300
Eha Alumona	9,510	31,950
Ibagwa-Aka	14,010	30,330
Ibagwa-Ani	17,010	39,330
Iheaka	10,500	29,250
Nru	6,840	34,500
Nsukka	8, 820	26,250
Obimo	8,340	23,550
Obollo Afor	8,340	35,070
Obukpa	10,500	31,950
Okpuje	24,510	35,820
Opi	17,340	31,890
Orba	9,330	20,670
Ovoko	11,160	37,950

of soil aggravates nematode activities on *Musa* spp. (Rotimi et al., 2004a, b).

High nematode population pressure in the soil obtained was in line with Rotimi et al. (2004) and Olaniyi (2011) who noted that with increasing moisture level in the soil, the population density of *R. similis* increased and was highest at the field capacity. This indicates that at the peak of the rainy season, nematodes population would be high and this was the situation at the peak of the sample collection in this research. This result was also confirmed by Sehgal and Guar (1995) who reported that soil moisture level is an important factor that modulates *R. reniformis* activities and densities, although there is a need for verified and controlled environmental studies under different field conditions before management decisions are taken. High population densities of nematodes were extracted from *Musa* spp. roots as well as the soils from the rhizosphere of the roots. Rotimi et al., (2006) recovered high population densities of *R. similis* from roots of suckers.

Regression analysis on the effect of nematode number on weight of plant root showed a negative correlation. This implies that nematode egg load is not strongly associated with root weight decrease. Rotimi et al. (2005) reported that nematodes caused 45% root weight reduction. However, Olaniyi (2014) recorded a strong correlation between nematode densities in the rhizosphere soil and root damage and thus concluded that loses due to nematodes have often been underestimated since the soil densities were not often taken into consideration. This research work investigated both nematodes densities in plant roots as well as soils in the rhizosphere of the roots which is in aggrement with Hooper (1990).

CONCLUSION AND RECOMMENDATION

The results from the survey of the distribution of plant-parasitic nematodes of *Musa* spp. in Nsukka agricultural ecological zone, Enugu state, Nigeria reveal that the plant parasitic nematodes are widely distributed on *Musa* spp. in the sixteen (16) communities in the study area, probably through the use of infected planting materials. Also revealed are 8 genera of nematode species; *Meloidogyne* spp., *R. similis, R. reniformis, R. borealis, P. goodeyi, P. coffeae, H. multicinctus* and *Mesocriconema* spp. The most important in relation to root damage were *Meloidogyne* spp., *R.similis* and *R.borealis. Meloidogyne species* had the highest population density. There exist slight changes in the types, distribution and populations of nematodes from one part of Nsukka to another which might be due to environmental factors, soil physio-chemical properties and agronomic practices (Olaniyi, 2014). The effect of nematode damage on production will increase progressively with each follower crop cycles and become more pathogenic as nematodes population continues to build up if no precautionary measures are taken.

Potassium is strongly implicated in heavier bunch yield (Salau et al., 1992) and improved crop quality (Treshow, 1970). Therefore, attempts to develop potassium efficient genotypes of *Musa* spp. could result in improved materials that would combine nematode resistance with high quality yield. Potassium might be an important key element in nematode control in *Musa* spp. as it improves the rigidity of plant organs, increases resistance of plants to diseases and helps plants to withstand environmental stresses such as adverse weather and temperature as well as low soil fertility (Treshow, 1970; Bruehl, 1987; Kirkpatrick et al., 1994; Coyne and Tenkouano, 2005). The farmers should form the habit of applying manures to their crops since it is now an established fact that the plants could benefit from inputs of fertilizers or manure. Optimum level of organic mulching could suppress nematode population and is an attractive approach to the management of plant parasitic nematodes ecology in an integrated management concept (Sarah, 1989).

This study advocates the use of clean and healthy planting materials, possibly tissue culture plants. Quarantine and pre-planting treatments should be observed to prevent emerging nematode parasites surge. IITA with mandate on the crop should hasten efforts in the development and distribution of nematode resistant or nematode tolerant cultivars by classical breeding. The principles of crop rotation in nematode management should be upheld (Sarah, 1989; Gowen et al, 2005). The use of intercropping with certain nematode antagonistic crops such as *Tagetes* spp., Sesame, mustard, etc, has been reported to reduce root knot and *R. reniformis* nematodes. African marigolds (*T. erecta*) have been shown to inhibit the reproduction of root knot and reniform nematodes. The use of trap or antagonistic crops such as crops like *Crotalaria spectabilis* which allows invasion by *Meloidogyne* spp. but does not support development can serve as good trap crops (Hill and Waller, 1999).

Conflict of Interests

The authors have not declared any conflict of interests.

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