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Nematode Pests of Cassava (*Manihot esculenta* Crantz) in Three Local Government Areas of Rivers State in Nigeria

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ABSTRACT

Many plant-parasitic nematodes (PPNs) have been reportedly associated with cassava in different geographical areas, but they vary in types and population over time and space due to changes in landuse patterns, farming systems, amongst others. There is the need for extensive and current investigation on PPNs of cassava in most cassava-growing areas in Nigeria to ensure their proper management. The study identified and determined recent occurrence of plant-parasitic nematodes associated with cassava in three Local Government Areas (LGAs) of Rivers State in Nigeria in the growing season of 2013. Soil and root samples of cassava were collected from 27 cassava-growing farms across the three LGAs. Plant-parasitic nematodes were extracted, identified and their population determined using standard procedures. Five PPN genera were found associated with cassava: Helicotylenchus, Meloidogyne, Pratylenchus, Scutellonema, and Gracilacus. Gracilacus spp. and Pratylenchus spp. were the predominant PPNs ($P \leq 0.05$) in the soils and roots of cassava, respectively. The significant occurrence and abundance of Gracilacus species might indicate it as one of the emerging key nematode pests of cassava in Rivers State.

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INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is of the family Euphorbiaceae and the fourth most important crop for farmers in the tropics after rice, wheat and sugar (Alves, 2002; FAOSTAT, 2010). World production of cassava was 230 million tons in 2008 (FAO, 2008) and it is consumed by up to a billion people globally (FAOSTAT, 2010). Nigeria is the largest producer of cassava in the world (FAOSTAT, 2013) and the crop is very important in the diets of most Nigerians and Africans (Kormawa and Akoroda, 2003; FAOSTAT, 2013).

In Sub-Saharan Africa, cassava is mainly a subsistence crop grown for food by small-scale farmers who sell the surplus. Apart from food, cassava is very versatile and its derivatives like starch are applicable in many types of products such as confectionery, sweeteners, glues, plywood, textiles, paper, biodegradable products monosodium glutamate, and drugs. Cassava chips and pellets are used in animal feed and alcohol production (IITA, 2009).

Despite being the largest producer of cassava in the world, Nigeria has not found a place among the five countries (India, Cook Island, Lao Peoples Democratic Republic, China [Taiwan province] and Suriname) delivering highest yields (FAOSTAT, 2013). Africa's yields are the lowest in the world standing at only 10 tonnes per hectare compared to 26 tonnes per hectare in India (Ahmadu and Idisi, 2014). Pests and pathogens, such as insects, viruses, bacteria and plant parasitic nematodes (PPNs), amongst others contribute to decline in cassava yield (Coyne, 1994; Nicol *et al*., 2011). Plant-parasitic nematodes are responsible for over US$ 100 billion in annual crop loses worldwide (Sasser and Freckman, 1987). They reduce crop yield globally by 11% (Agrios, 2005).

Plant-parasitic nematodes (PPNs) most frequently found associated with cassava are *Meloidogyne incognita, M. javanica, Pratylenchus brachyurus, Rotylenchulus reniformis, Helicotylenchus erythrinae* and *H. dihystera* (McSorley *et al.,* 1983; Coyne, 1994). Evidence indicates that, root-knot nematodes (*Meloidogyne* spp.) are the most important group of nematodes affecting cassava as they are found in abundance around the roots of cassava (McSorley *et al.,* 1983).

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The study of PPNs on cassava is generally scarce in relation to those of other crops. However, nematological work on cassava has recently been receiving more attention and this is justified given the great importance of the crop nowadays globally. Furthermore, PPNs are becoming a recognized greater problem on crops due to awareness and as the use of agricultural land become more intense (Caveness, 1982). Also, changes in PPNs occurrence and density are inevitable over time and space due to changes in landuse patterns, farming systems, climate, amongst others. This study was carried out to identify and determine the recent occurrence and population of plant-parasitic nematodes (PPNs) associated with cassava in three LGAs of Rivers State.

MATERIALS AND METHODS

Study sites and Laboratories:

The survey on PPNs associated with cassava was carried out using the multi-stage random sampling method from April to May 2013 in three Local Government Areas (LGAs), Obio/Akpor, Emohua and Ikwerre, of Rivers State, Nigeria. These LGAs were selected because they are some of the major cassava producing areas in Rivers State. Three communities per LGA were randomly selected and three farms growing cassava in monoculture per community were considered in the survey. In Obio/Akpor LGA, Alakahia, University Park (University of Port Harcourt) and Rukpokwu communities were sampled; whereas in Emohua LGA, Egbeda, Elele/Alimini and Emohua were sampled. In Ikwerre LGA, Aluu, Omagwa and Isiokpo communities were surveyed. The LGAs surveyed are presented on a map of LGAs in Rivers State (Fig. 1).

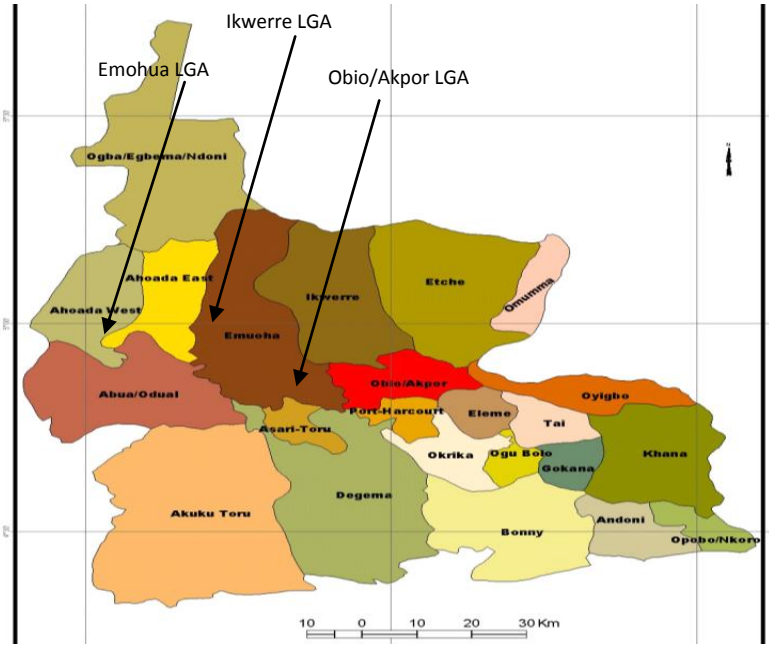

Fig. 1: Map of Rivers State showing the three Local Government Areas (LGA) surveyed for plant-parasitic nematodes of cassava.

Rivers State lies on latitudes range 5 20' 0"N and 5 45' 0"N, also on longitudes range of 6 20' 0"E and 7 35' 0"E. Rivers State enjoys tropical hot monsoon climate due to its latitudinal position. The tropical monsoon climate is characterized by heavy rainfall from April to October ranging from 2000 mm to 2500 mm with high temperature all the year round and a relatively constant high humidity.

The following Laboratories were used for various analyses: Research Laboratory of the Department of Crop and Soil Science, Faculty of Agriculture, University Port Harcourt, Rivers State, for soil and root extraction of plant-parasitic nematodes; Nematology Research Laboratory of International Institute for Tropical Agriculture, Ibadan (IITA), Oyo State, Nigeria for the identification of PPNs.

Collection of cassava roots and soil samples:

Twenty cassava stands were randomly selected per farm for collection of soil and root samples. Soil samples (250 ml per cassava stand) of the randomly selected cassava were collected per farm from the rhizosphere of cassava roots with hand trowel, bulked in polythene bag and properly labeled for the purpose of identification. A total of nine soil samples

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were collected per LGA and 27 samples across the three LGAs. Tender roots of cassava were collected with knives alongside with soil at the same farm locations. The root samples collected were also bulked together in the same polythene bag containing soils of a particular farm location so as to preserve the roots prior to further processing in the Laboratory.

Extraction of plant-parasitic nematodes from soils and roots of cassava:

The extraction of plant-parasitic nematodes from soil was conducted using the pie-pan method [14](Whitehead and Hemming, 1965) and slightly modified by Coyne *et al.* (2007). Sieves were used to filter out stones and debris from soil. The bulked soil sample per farm was thoroughly mixed in a plastic container and 200 ml of soil was measured out using a beaker. Facial tissue was placed in a plastic sieve such that the base of the sieve was covered and later placed on a plastic plate. The 200 ml soil was poured on the tissue in the sieve and water was poured to the extraction plate by the side of the sieve in other to wet the soil. The set-up was left undisturbed for 48 hours in the Laboratory.

After the extraction period, the water in the plate was poured into a labeled conical flask and the suspension containing nematodes was allowed to settle. The suspension in the flask was decanted to a volume of 10 ml and the suspension containing the nematodes was carefully poured into vials. The concentrated suspension of water and nematodes from the soil or roots were killed by heat and preserved with equal volume of boiling 4% formaldehyde pending identification and counting.

The extraction of plant-parasitic nematodes from cassava roots was carried out using the modified maceration and extraction tray method (Whitehead and Hemming, 1965; Coyne *et al.,* 2007). The roots of cassava were rinsed with distilled water in order to get rid of dirt and soil particles and chopped into small pieces of 1-2 cm. 10 g sub-sample was weighed out from each sample using a Mettler balance® and blended in a Kenwood® electric blender with water enough to cover the blades. The mixture obtained after blending was poured into the tissue paper in the sieve to facilitate extraction of nematodes using the pie-pan method (Whitehead and Hemming, 1965) as described earlier. The set-up was left for 48 hours and the resulting suspension poured into a beaker. After five hours, the suspension in the beaker was decanted to reduce the volume to about 10 ml and poured into vials. The concentrated suspension of water and nematodes from the soil or roots were killed by heat and preserved with equal volume of boiling 4% formaldehyde pending identification and counting.

Identification of plant-parasitic nematodes:

Plant-parasitic nematodes identification was carried out as described by Dropkin and Smith (1980) at Nematology Laboratory of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Aliquot of 2 ml suspension was pipette into a Doncaster counting dish (Doncaster, 1962).The counting dish was placed under a dissecting microscope and compound microscope alternately for identification using Bell's Key (Bell, 2004) and counting of plant parasitic nematodes. Identification was done to genus level and multiple tally counter was used to count the nematodes. The population of nematodes were extrapolated to arrive at the total number of PPNs in the cassava roots or soil.

Data analysis:

Data from nematode counts were transformed using $\log_{10}$ (X+1) and analysed using analysis of variance (Anova) and descriptive statistics (% frequency and mean) with SAS (2009). Frequencies of occurrence of plant-parasitic nematodes in the samples collected were also determined using the formula stated by Norton (1978):

$$\text{Relative Frequency} = \frac{\text{Frequency of occurence of a species}}{\text{sum of frequency of all species}} x \frac{100}{1}$$

$$\text{Absolute Frequency} = \frac{\text{No. of samples containing a species}}{\text{No. of samples collected}} x \frac{100}{1}$$

Results:

Occurrence of plant-parasitic nematodes on cassava in Obio/Akpor, Emohua and Ikwerre LGAs of Rivers State.

Soil samples in Obio/Akpor LGA, showed that *Meloidogyne* spp. and *Helicotylenchus* spp. had the highest frequency of occurrence (FOC) each, whereas, *Pratylenchus* spp., *Scutellonema* spp. and *Gracilacus* spp. recorded the least FOC (Table 1). However, all the plant-parasitic nematode (PPN) genera identified in the cassava soil in Obio/Akpor LGA were not found in the roots of cassava (Table 1).

In soil of cassava farms in Emohua LGA, *Gracilacu*s spp. was the predominant PPNs with FOC of 50%, but *Pratylenchus* spp. and *Meloidogyne* spp had FOC of 33 and 17%, respectively. However, *Helicotylenchus* spp. and *Scutellonema* spp. were not encountered in the soils of cassava in Emohua LGA (Table 2). The evaluation of the roots of cassava showed that *Gracilacus* spp. had the highest FOC in

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Emohua LGA since the nematode genera occurred in all the roots collected (Table 2).

In soil collected from cassava farms in Ikwerre LGA, *Scutellonema* spp. was the predominant genera of PPNs with the highest FOC. *Meloidogyne* spp., *Helicotylenchus* spp. and *Gracilacus* spp. had the same FOC which was lower than that of *Scutellonema* spp. (Table 3). Although *Pratylenchus* was not found in the soil, it was the only PPN genera found in the roots of cassava in Ikwerre LGA (Table 3).

Table 1: Frequency of occurrence of plant-parasitic nematodes in the soil and roots of cassava in Obio/Akpor LGA in Rivers State.

Nematode genera	Medium	Sample containing species	Absolute frequency	Relative frequency
Meloidogyne spp.	Soil	6	66.7	29
Pratylenchus spp.		3	33.3	14
Helicotylenchus spp.		6	66.7	29
Scutellonema spp.		3	33.3	14
Gracillacus spp.		3	33.3	14
Total			233.3	100
Meloidogyne spp.	Roots	0	0	0
Pratylenchus spp.		0	0	0
Helicotylenchus spp.		0	0	0
Scutellonema spp.		0	0	0
Gracillacus spp.		0	0	0
Total			0	0

Table 2: Frequency of occurrence of plant-parasitic nematodes in the soil and roots of cassava in Emohua LGA in Rivers State.

Nematode genera	Medium	Sample containing species	Absolute frequency	Relative frequency
Meloidogyne spp.	Soil	3	33.3	17
Pratylenchus spp.		6	66.7	33
Helicotylenchus spp.		0	0	0
Scutellonema spp.		0	0	0
Gracillacus spp.		9	100	50
Total			200	100
	Roots			
Meloidogyne spp.		0	0	0
Pratylenchus spp.		0	0	0
Helicotylenchus spp.		0	0	0
Scutellonema spp.		0	0	0
Gracillacus spp.		3	33.3	100
Total			33.3	100

Table 3: Frequency of occurrence of plant-parasitic nematodes in soil and roots of cassava in Ikwerre LGA in Rivers State.

Nematode genera	Medium	Sample containing species	Absolute frequency	Relative frequency
Meloidogyne spp.	Soil	3	33.3	20
Pratylenchus spp.		0	0	0
Helicotylenchus spp.		3	33.3	20
Scutellonema spp.		6	66.7	40
Gracillacus spp.		3	33.3	20
Total			166.6	100
	Roots			
Meloidogyne spp.		0	0	0
Pratylenchus spp.		6	66.7	100
Helicotylenchus spp.		0	0	0
Scutellonema spp.		0	0	0
Gracillacus spp.		0	0	0
Total			66.7	100

Frequencies of occurrence of plant-parasitic nematodes in soil and roots of cassava across three LGAs of Rivers State

Gracilacus spp. was the highest frequently occurring PPNs in soil of cassava farms across the three LGAs followed by *Meloidogyne* spp., then *Pratylenchus* spp., *Helicotylenchus* spp. and *Scutellonema* spp. with FOC of 17% each (Table 4). However, *Pratylenchus* spp. was the highest occurring PPN genera in the roots of cassava across the three LGAs, followed by *Gracilacus* spp., whereas, *Meloidogyne*, *Helicotylenchus* and *Scutellonema* were not found (Table 4).

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Table 4: Frequencies of occurrence of plant-parasitic nematodes in soil and roots of cassava across three LGAs in Rivers State, Nigeria.

Nematode genera	Medium	Sample containing species	Absolute frequency	Relative frequency
Meloidogyne spp.	Soil	12	44.4	22
Pratylenchus spp.		9	33.3	17
Helicotylenchus spp.		9	33.3	17
Scutellonema spp.		9	33.3	17
Gracillacus spp.		15	55.6	27
Total			199.9	100
Meloidogyne spp.	Roots	0	0	0
Pratylenchus spp.		6	22.2	66.7
Helicotylenchus spp.		0	0	0
Scutellonema spp.		0	0	0
Gracillacus spp.		3	11.1	33.3
Total			33.3	100

Sample size=27

Population of plant-parasitic nematode genera in each of the three LGAs of Rivers State:

Five PPNs genera associated with cassava; *Meloidogyne*, *Pratylenchus*, *Helicotylenchus*, *Scutellonema* and *Gracilacus* were encountered across three LGAs (Obio/Akpor, Emohua and Ikwerre) in Rivers State. Out of these, *Gracilacus* spp. recorded the highest population in soil which is significantly higher than those of *Helicotylenchus* spp., *Meloidogyne*, *Pratylenchus* and *Scutellonema* (Fig. 2). For cassava roots, *Pratylenchus* had the highest population, followed by *Gracilacus* while other PPNs were absent in the roots of cassava (Fig. 3).

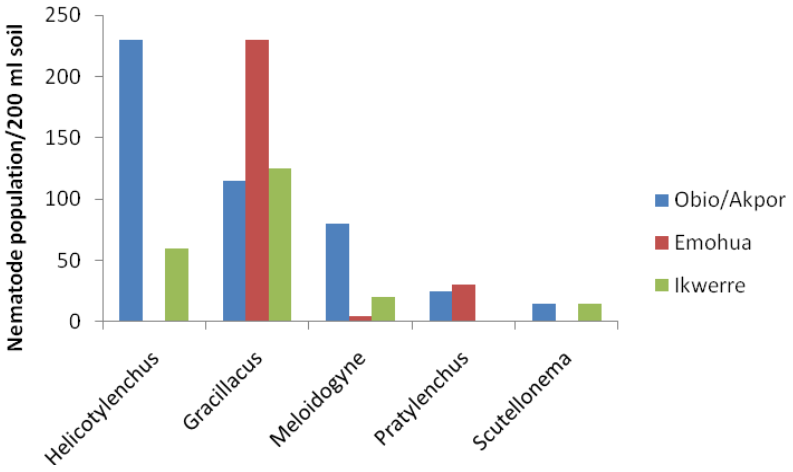

Fig. 2: Population of plant-parasitic nematode genera in soil of each of the three LGAs in Rivers State

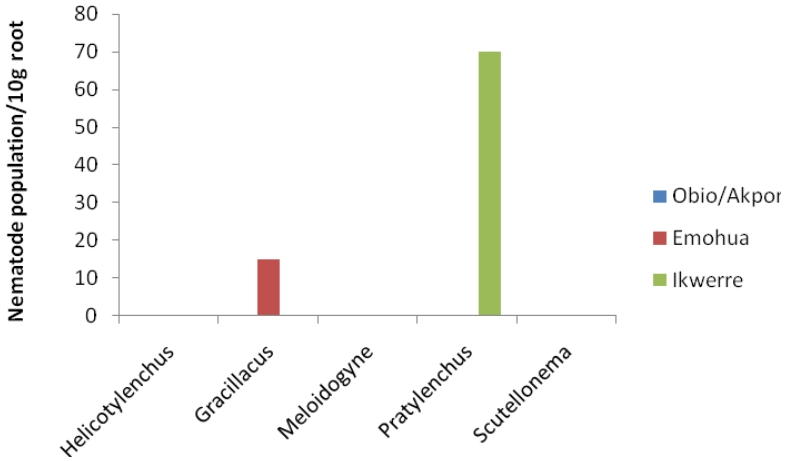

Fig. 3: Population of plant-parasitic nematode genera in roots of each of three LGAs in Rivers State

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Mean population of nematode genera in soils and roots of cassava across the three LGAs:

In soil grown with cassava across the three LGA surveyed, *Gracilacus* spp. had the highest population among the genera of PPNs encountered, followed by *Helicotylenchus* spp., *Meloidogyne* spp. and the least population in *Scutellonema* spp. (Table 5). The mean population of *Pratylenchus* spp. in roots of cassava was higher ($p \leq 0.05$) than that of *Gracilacus* spp., whereas *Helicotylenchus* spp., *Meloidogyne* spp. and *Scutellonema* spp. were not encountered in the roots of cassava across the three LGAs (Table 5).

Mean population of PPNs in soil and roots of cassava in each of the three LGAs:

Obio/Akpor LGA had the highest mean population of PPNs in the soil, which was not significantly higher ($P \leq 0.05$) than population recorded in Emohua and Ikwerre LGAs (Table 6). However, Ikwerre LGA had the highest mean population of PPNs on cassava roots which was not higher ($P \leq 0.05$) than PPNs found on cassava in Emohua and Obio/Akpor LGAs (Table 6). Comparatively, the mean population of PPNs in soil grown with cassava across the three LGAs was higher than in roots of cassava (Table 6).

Table 5: Mean population of plant-parasitic nematode genera in soil and roots of cassava across three LGAs in Rivers State.

Nematode genera	Medium	
	Soil	Root
Gracillacus spp.	52.2	7.8
Helicotylenchus spp.	32.2	1.7
Meloidogyne spp.	11.7	0
Pratylenchus spp.	6.1	0
Scutellonema spp.	3.3	0
LSD ($P \leq 0.05$)	27.4	3.8

Table 6: Mean population of plant-parasitic nematodes in soil and roots of cassava in each LGA.

	Medium	
Local Government Area	Soil	Root
Obio/Akpor	25.8	0
Emohua	14.7	0.8
Ikwerre	12.2	3.9
LSD ($P \leq 0.05$)	16.5	1.8

Mean population of plant-parasitic nematodes on cassava in the three LGAs:

Cassava farms in Obio/Akpor LGA had the highest total population (soil and roots) of plant-parasitic nematodes but this was not higher ($P \leq 0.05$) than the population obtained from Ikwerre and Emohua LGAs (Fig. 4).

Mean population of plant-parasitic nematode genera across the three LGAs in Rivers State:

The result of the mean population of nematodes across the three LGAs in Fig. 5 shows that, *Gracilacus* spp. had the highest population and this was significantly higher than ($p \leq 0.05$) population of the other plant-parasitic nematodes encountered; *Helicotylenchus* spp., *Pratylenchus* spp., *Meloidogyne* spp. and *Scutellonema* spp.

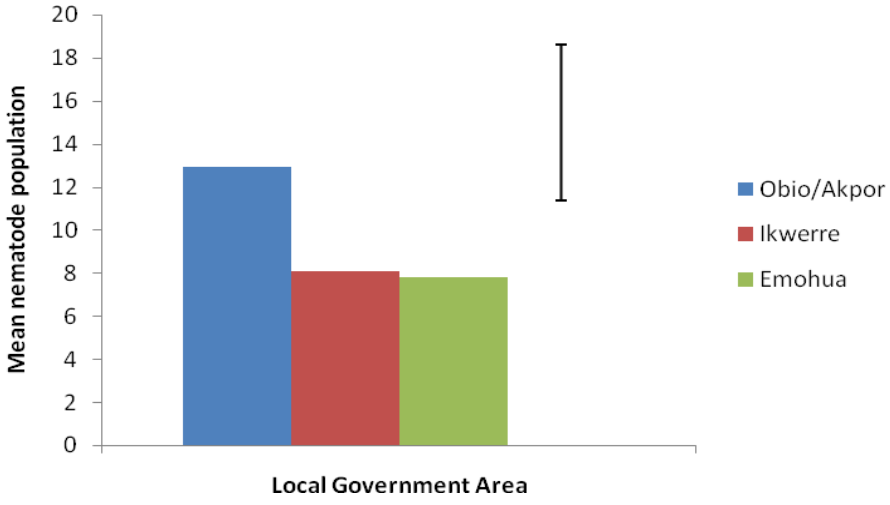

Fig. 4: Comparative population of plant-parasitic nematodes associated with cassava in Obio/Akpor, Ikwerre, Emohua LGAs.

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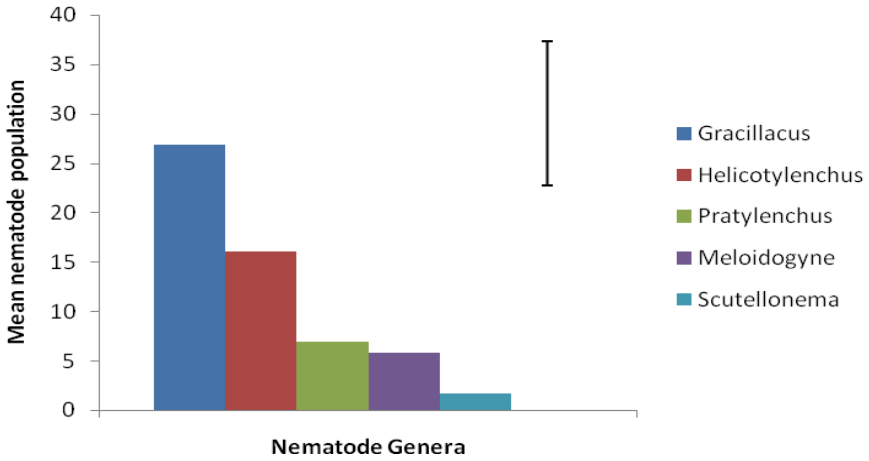

Fig. 5: Mean population of plant-parasitic nematodes per genera associated with cassava across three LGAs in Rivers State.

Discussion:

Predominant plant-parasitic nematodes on cassava in three Local Government Areas in Rivers State:

The results of this survey shows that plant-parasitic nematodes are one of the major pests of cassava in the three LGAs of Rivers State covered in the study. Of the five genera found associated with cassava in the study areas, *Gracilacus* spp. was the predominant PPNs in the soil, followed by *Helicotylenchus*, *Meloidogyne*, *Pratylenchus* and *Scutellonema* species. This finding is at variance with most of the earlier reports that *Meloidogyne* is the major PPNs of cassava in many different geographical areas (McSorley *et al*., 1983). Other workers from Nigeria and Thailand also reported *Pratylenchus brachyurus* as one of the major nematode pests of cassava followed by *Rotylenchus reniformis*, *Helicotylenchus* spp., *Meloidogyne* spp. and *Scutellonema bradys* (Evans *et al*., 1993; Luc *et al.*, 2005; McDonald and Nicol, 2005; Nicol and Rivoal, 2007).

Comparing nematode abundance in the soil and root samples, *Gracilacus* spp. was the most frequently occurring genera in the soil while *Pratylenchus* which was also present in the soil was the predominant genera found associated with the roots of cassava in the study areas. *Pratylenchus*, the root lesions nematode, is an endoparasite, and this explains its abundance in the roots.

Gracilacus spp. belongs to the order Tylenchida, a pin nematode occasionally found in mint but only differs from *Paratylenchus* by the possession of a longer stylet (Berry and Coop, 2000). Pin nematodes rarely cause damage to plants unless present in very high numbers (Berry and Coop, 2000). The population of *Gracilacus* observed in this survey on cassava was quite high and it might be that cassava is a susceptible host of *Gracilacus* species. The young vermiform female of *Gracilacus* inserts its long stylet into root tissues and remains attached to the root surface by the stylet. The nematode feeds in epidermal, cortical, parenchyma and sclerenchyma cells and induces cell wall thickening. *Gracilacus* spp. is an ectoparasite. The predominance of *Gracilacus* in the soil in the study justifies its ectoparasitic status, but few of the nematode was encountered in the roots of cassava showing that it is not an endoparasite. Information on the parasitic and biological behaviour of *Gracilacus* species in Nigeria is generally scarce. Nematodes previously viewed as benign or non-damaging, are becoming pests as cropping patterns change (Nicol, 2002), so it is vital to carry out studies on emerging nematodes, such as *Gracilacus* species to determine their parasitic status on cassava or nay other crops.

The spiral nematode, *Helicotylenchus* species of the family Hoplolaimidae, was the second most occurring nematode pest found in association with cassava from the study. This nematode has been reported as important pest of plantains and bananas in both temperate and tropical regions where it is widely distributed (Coyne *et al.*, 2007). In this study, *Helicotylenchus* spp. was encountered only in the soil and this corroborated the report by other workers that it is ectoparasitic in its feeding habit (Bridge and Starr, 2007). All life stages of the migratory ectoparasites, except the egg, are parasitic (Bridge and Starr, 2007). Some reports showed that this nematode is also a pest of cassava (Luc *et al*., 2005). *Helicotylenchus erythrinae* together with *P. brachyurus* have been reported to cause significant decreases in total plant weight (including storage roots) of cassava when not managed (De Guiran, 1965). There is still need to ascertain the effect of *Helicotylenchus* species singly on cassava since they are commonly associated with cassava and many other crops.

The root-knot nematode *Meloidogyne* species were another frequently occurring nematode pest encountered in the study after *Helicotylenchus*. *Meloidogyne* species have been reported on cassava from many of the cassava-growing regions of the

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world such as Brazil (Ponte *et al.*, 1980), Venezuela (Crozzoli and Hidalgo, 1992), United States of America (McSorley *et al.*, 1983), Pacific (Bridge, 1988), Mozambique (Van den Oever and Mangane, 1992), Igamda (Bridge *et al.*, 1991), Malawi (Saka, 1982), Nigeria (Caveness, 1982) and Niger (Sikora *et al*., 1988). The root-knot nematodes are sedentary endoparasitic species that are cosmopolitan in distribution and usually have a wide range of host plants. They infect the feeder roots of cassava, causing small galls, and as the females develop within the root tissue and reproduce, so the galls enlarge and coalesce. Although they are sedentary endoparasites, in this study, they were found occurring more in the soil because the second-stage juvenile stage can also be found awhile in the soil prior to invasion of susceptible plant roots.

Pratylenchus species (root-lesion nematode) belonging to the family Pratylenchidae, is a migratory endoparasites (Handoo, 1998; Bridge and Starr, 2007) which is also an important pest of cassava. Lesion nematodes have a cosmopolitan occurrence and associated with poor growth and yield reduction in many crops (Nicol *et al.*, 2011). In their review of cassava nematodes, McSorley *et al*. (1983) reported on the various negative effects of *Pratylenchus brachyurus* on cassava production. Coyne (1994) opined that *Pratylenchus brachyurus* is probably the next most important parasite of cassava after root-knot nematodes. These nematodes species are also implicated in the stunting of roots and loss of feeder roots and are considered only to be key pests of cereals, vegetables, and grasses (Coyne *et al.*, 2007). In this study, *Pratylenchus* species were more frequently encountered in the roots of cassava than in the soil and this was in line with Coyne (1994) that posited that lesion nematodes are frequently on cassava causing significant decline in cassava yields. Also, Bridge and Starr (2007) opined that all life stages, except the first-juvenile stage are parasitic and can be found in host roots feeding primarily on cortical tissues of smaller nonsuberized roots. They may also infect tubers and other below-ground organs (Bridge and Starr, 2007). Population densities of *Pratylenchus* spp. are much greater in plant roots than in the surrounding soil because of its migratory endoparasitic feeding habit (Bridge and Starr, 2007). However, it should be noted that varietal differences in susceptibility of diverse crops to *Pratylenchus* occur (Corbett, 1976; Coyne, 1994)

Another nematode pest considered economically important in cassava production is *Scutellonema* spp. which is a migratory endoparasite that attacks both the roots and tubers of plants they infect (Coyne, 1994). This nematode pest is also called the spiral nematode. It has a moderate host range and also regarded or known as a major nematode pest of yam (Adesiyan *et al*., 1990). *Scutellonema* has been reported to be present in high population densities around cassava, but with no supporting evidence of economic damage on cassava (Mcsorley *et al*., 1983; Coyne, 1994).

The total population densities of PPNs for both soils and roots of cassava shows *Gracilacus* spp. as the most frequently occurring nematode genera associated with cassava from the study. Considering the three LGAs, *Gracilacus* has the highest population densities in two of the LGAs (Emohua and Ikwerre) for soil samples while for root samples, *Gracillacus* spp. were only found in Emohua LGA, but in a very low population density. However, *Pratylenchus* species (root-lesion nematode) were the only PPNs found in Ikwerre LGA with a very high population density which makes it the predominant genera in root of cassava from the study. The increased population rate of this nematode may be due to favourable environmental conditions and changes in agronomic practices over time and space. These practices might include planting of resistant cultivars of cassava which might have reduced the reproduction and damage of earlier identified PPNs of cassava such *Meloidogyne* spp.

Factors that influence the virulence of nematodes include the resistance of their host crop and changes in farming conditions. Over the years extensive work have been done on the development of resistant varieties of cassava in Nigeria (Hahn *et al.*, 1981). Also changes in environmental conditions alter the virulence of some species of plant parasitic nematode over time. As stated earlier, information on the condition that favours the proliferation of *Gracilacus* spp. in Nigeria is scarce. The result obtained in the study indicates a shift in most frequently occurring PPNs from *Meloydogyne* spp. to *Gracilacus* spp. It also underscores the need for detailed study on changes in plant-parasitic nematodes' virulence of cassava.

Conclusion:

The study showed five major genera of plant-parasitic nematodes were associated with cassava across the three LGAs surveyed in Rivers State. The PPNs genera are *Gracilacus, Helicotylenchus, Meloidogyne, Pratylenchus* and *Scutellonema*. *Gracilacus* was the most important nematode pest of cassava having the highest frequency of occurrence and mean populations, followed by *Helicotylenchus, Meloidogyne, Pratylenchus* and *Scutellonema. Pratylenchus* spp. had the highest mean population density in the roots of cassava, followed by *Gracilacus* spp., while other PPNs found in the soil were not present in the roots of cassava. The outcome of the study reported *Gracilacus* spp. and *Pratylenchus* spp. as major PPNs in soil and roots of cassava, respectively, and this varied from outcome of previous study that favoured *Meloidogyne* spp. as the major PPNs on cassava. The need for further study on the genera and speciation of PPNs of cassava and their virulence in the 23 LGAs in Rivers State is pertinent. Such study will track either the

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static or changing roles of nematodes previously reported as important pests or unknown as pests of cassava.

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