ABUNDANCE OF PLANT-PARASITIC NEMATODES FROM RHIZOSPHERE OF PEPPER PLANTS AS INFLUENCED BY SOIL PHYSICAL AND CHEMICAL PROPERTIES IN PARTS OF NIGER STATE, NIGERIA

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ABSTRACT

A survey was conducted to investigate the effect of physico-chemical properties of soil on the incidence and infestation of plant-parasitic nematodes on Pepper, Capsicum spp from two local government areas (LGAs) of Niger State, Nigeria. One hundred and twenty soil and plant root samples were randomly collected from pepper fields and examined. Results showed that six genera of plant-parasitic nematodes were recorded. The most frequently observed and widely distributed nematode species were *Helicotylenchus multicinctum* followed by *Meloidogyne* spp. and *Scutellonema bradys* with frequencies of occurrence of 48.2, 34.8 and 12.6 % respectively. Highest nematodes population density of 405 in 100 ml soil was recorded from Maje followed by Annaba with 205, both in Magama LGA, while the lowest nematodes of 20 in 100ml soil were recorded from Nagwamatse in Kontagora LGA. Correlation analysis revealed a weak relationship between soil physico-chemical properties and nematode population density with maximum value of r = 0.38. The results also showed that apart from the direct influence of the host plant, soil properties play an important role in the distribution, abundance, and structure of plant parasitic nematode communities. This demonstrates the potential of nematodes as bio-indicator organisms of soil health.

1 INTRODUCTION

Pepper belongs to the family Capsicum and is a member of Solanaceae family (1). The genus Capsicum consists of approximately 31 species of which the five domesticated species are *C. annuum* L., *C. baccatum, C. chinense, C. frutescens* L., and *C. Pubescen.* (2). Pepper is an important agricultural crop not only because of its economic importance but also due to the nutritional and

medicinal value of its fruits as well as being an excellent source of natural colours and antioxidant compounds (3). It is the world's second important vegetable, ranking after tomatoes and it is the most produced type of spice flavouring and colouring for food while providing essential vitamins and minerals (3, 4).

The nutritional value of pepper merits special attention as it is a rich source of vitamins A and E (5). Both hot (*Capsicum fruitescens* L) and sweet peppers (*Capsicum annum* L.) contain more vitamin C to prevent flu colds than any other vegetable crop (4). In many households, pepper provides the only needed flavour to enhance intake of otherwise diets. In addition to the uses of pepper as food, (4) pointed out that pepper is used for cosmetic production, condiment and medicine as well as ornamentals in gardens.

Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of the African production and the major area of production is Northern Nigeria (6). Pepper is one of the five most important vegetable crops used in Nigeria as condiment and food flavour. The different varieties of pepper provide income for women and children who cultivate it in large quantities (7).

Plant Parasitic Nematodes (PPNs) alone or in combination with other factors reduce crop productivity and they cause farmers and nursery men thousands of naira in crop loss annually (8). The damage of crop caused by PPNs depends on agro-climatic conditions, host susceptibility, pathogenicity and other climatic factors (9). The PPNs have been of great concern, as they are responsible for yield loss of about 20 – 94 % (10). They cause various malfunction in plants in the form of stem and root galling, perforation of leaves, stunted plants, chlorosis, and are also responsible for weak stem of plants, leading to poor plant yield, thereby increasing production cost (11). The PPNs are plant feeders that reduce crop growth and productivity. Majority of PPNs feed mainly on below ground plant parts like bulbs, roots and tubers (12, 13). However, the root lesion nematodes burrow into the root, where they feed and cause damage within the plant roots (14). However, after infection, plants and roots may die in the end of the season, and then root lesion nematode migrates out into the soil (11). Reports on nematode infestation indicate that PPNs exist in a poly specific manner (15, 16).

Ideally nematode management programme is species-specific and as such identification of nematode species present in any given field is important. The role of nematodes in limiting vegetable production depends largely on the farming system used, the chemical and/or physical environment in the soil (17), and on the climate (18). Report by (19) showed that the intensity of the relationship between PPN community and soil type varied with the nematode species and that nematode reproduction was positively correlated with relative humidity and negatively correlated with air temperature. Also, the workers observed that soil texture is the most important factor influencing the presence of some nematode species and these environmental factors affect the ability of nematodes to parasitise and reproduce on their host.

The present study was, therefore, set up to obtain an up to date status on nematode population dynamics, their infestation levels as well as relationship with soil properties in order to develop an effective pepper nematode management strategy for pepper farmers in Niger State.

2 MATERIALS AND METHODS

A systematic survey was conducted to investigate out reliable estimate of pepper field infested with plant parasitic nematodes in pepper growing areas of Anaba, Maje, Ibeto, Nagwamatse, Farin shinge and Lioji areas of Niger state.

2.1 Field sampling

During the surveys, root and soil samples were carefully collected from 30 different localities having

extensive pepper cultivation from randomly selected fields to access the incidence, intensity and distribution pattern of plant parasitic nematodes. For each field sampled, an area of 500m^2 was marked and a hand trowel used to collect 10-15 cores in "W" pattern around pepper plants at the depth of 10 cm. The soil cores were carefully mixed in a 5- litre bucket, and 250 ml cup full of the mixture taken into a plastic bag labeled with the name of the pepper cultivar and the site number for transportation to the laboratory for assay. A total of 60 samples were collected in all.

2.2 Nematodes isolation and counting

Nematode extraction from soil was carried out using the method described by (20). From each bulk sample, about 200 cm of soil sample covered in cheese cloth and placed in a tray on top of a 2 mm mesh and approximately 100 ml of water added to it until the mesh was slightly covered with water and this enabled the soil to contact the water for 24 hours to allow the nematodes to crawl out of it. In order to count the number of nematodes, the triplicate of 1ml from 100 ml homogenised suspension was taken in to Huxley nematode counting slide and observed under a compound light microscope, with 10X magnification on Nikon's Eclipse 50i microscope (Kent, WA) as described by (21). Average of three counts was expressed as the mean population density of the nematodes per 100 ml.

2.3 Determination of nematode population density:

The absolute frequency, absolute density and prominence value of the nematodes were calculated using the methodology of (22) as given below:

$$\text{Absolute frequency} = \frac{e}{n} \times 100$$

Where e = total number of samples containing a given nematode species and, n = total number of samples at a given site

$$\text{Absolute density} = \frac{\text{Number of nematodes in all samples}}{\text{Number of sample collected}} \times 100$$

Prominence value = Absolute density X √Absolute frequency/10

2.4 Soil Analysis

From the remaining bulk soil samples, 300 g soil subsamples were taken each, air dried and ground to fine powder. The samples were used to analyse the soil chemical properties such as organic carbon, pH, organic matter and also the texture of the soil according to the method of (23).

2.5 Statistical analysis

All data were subjected to analysis of variance (ANOVA) using statistical software package SPSS 16. The relationships between nematode diversity and population density and soil physico-chemical properties were assessed by correlation analysis using SPSS

3 RESULTS AND DISCUSSION

Six genera of plant-parasitic nematodes namely: *Helicotylenchus multicinctum, Meloidogyne sp, Scutellonema. bradys, Xiphinema sp., Tylenchulus sp.* and *Pratylenchus sp* were encountered in this study (Table I). Analysis of samples by local government shows that the six (6) genus/species were identified in the three surveyed villages of Magama Local Government Area. In Kontagora LGA, only three genera/species were encountered among the three sites which were *Meloidogyne sp, H. multicinctum,* and *S. bradys*

Of the six parasitic nematodes genera encountered, the spiral nematodes (*Helicotylenchus multicinctus*) were found to be predominant in the soil samples as they accounted for up to 48.2% of

the overall nematode population with the PV of 315.6. This was followed by *Meloidogyne sp.* with 34.8%, *S. bradys* with 12.6%, *Xiphinema* sp. and *Tylenchulus* sp with 2.0% each and *Pratylenchus sp.* with 0.40% with the following PV of 144.2, 51.7, 3.5 and 0.31, respectively (Table 2)

Different occurrence dynamics were found for the root samples (Table 2) of which the root-knot nematodes were found predominant, accounting for up to 195 mean population density of the total number of nematodes isolated. This was followed by *H. multicinctus* with 75 and *S. bradys*, with 15 respectively. *Xiphinema* spp., *Tylenchulus* spp and *Pratylenchus* spp were not detected in the root samples.

3.1 Population densities of nematodes from Six villages in two Local Government Areas of Niger state

From the results in Fig.1 it shows that Maje village had the highest population density of nematodes wit 405 followed by Anaba with 205, Farin Shinge with 175), Lioji with 75, Ibeto with 40 and Nagwamatse with 20 was the least.

3.2 Physico-chemical properties of soils under pepper production in the surveyed areas and their relationship with nematode population density.

The physico-chemical analyses of soil samples revealed three types of soil texture in the surveyed pepper production areas viz: sandy soil with 760- 840 **g kg** $^{-1}$of sand, Silt with 60-120 **g kg** $^{-1}$ and 40-120 **g kg** $^{-1}$ of Clay. Soil pH ranged from 6.4 to 6.7 across the surveyed locations, except Maje in Magama LGA with where it was 7.0. Table 3. shows the coefficients of correlation of physical and chemical soil properties in relation to population densities of the most important nematodes recovered from soil and root samples. Correlation of population densities of plant parasitic nematodes from sandy soil was weak with r values for *Helicotylenchus multicinctum* of 0.19, *Meloidogyne,* 0.21, *S. bradys,* - 0.23, and - 0.76 for *Xiphinema* sp.

Silt soil was negatively correlated with populations of *Meloidogyne* sp., *Xiphinema* sp. and positively correlated with *S. bradys*, with r coefficients – 0.83, - 0.50 and 0.40 respectively. For Clay, *Xiphinema* sp. correlated significantly with r = 1.00**, and negatively correlated with *H. multicinctum*, with r = -0.34, while *Meloidogyne* and *S. bradys* r values were 0.34 and 0. 65 respectively. With the exception of *Xiphinema* sp. that correlated positively with pH, *H. multicinctum*, *Meloidogyne and S. bradys* correlated negatively.

Organic Carbon had weak correlations with nematodes densities with r = 0.1 to 0.37, and correlated negatively, only with *Xiphinema sp.* with r = -0.76. On the other hand, total nitrogen was positively correlated with population densities of PPNs with r values ranging from 0.28 to 0.69 and negatively correlated with r = -0.02 for *H. multicinctum.* Soil sodium correlated negatively with *Meloidogyne sp* and *Xiphinema* sp with r = - 0.24, *H. multicinctum*, with r = - 0. 76 and *S. bradys* with r = 0.41.

The population density of PPNs was mostly negatively correlated with soil chemical properties for K, Mg, Ca and Avail P with r values ranging from -0.23 to -0.87, except for *H. multicinctum,* r = - 0. 80*, *Meloidogyne spp.*, with r = 0. 82 and *Xiphinema sp* r = 0.80 correlated positively with Mg.

In the present study, prevalence of the major economically important pepper nematodes, *Helicotylenchus multicinctum, Meloidogyne, S. bradys, Xiphinema sp., Pratylenchus sp.*and *Tylenchulus sp* was established. The six genera/species of plant-parasitic nematodes were associated with pepper plant from Magama and Kontagora LGAs of Niger State. The biological diversity observed in this study is comparable to the one reported by (24). In another study on biodiversity of PPNs associated with pepper by (25.) twelve PPNs were found from rhzosphere soil and roots of pepper from Diffa and Dosso regions of Niger republic. Of these, three were endoparasites

(*Meloidogyne*, *Pratylenchus* and *Ditylenchus*), one semi-ectoparasite (*Rotylenchulus*) and the remaining were ectoparasites, even though *Scutellonema clathricaudatum* has endoparasitic characteristic and it falls into 10 families.

In a similar finding (26) surveyed plant parasitic nematodes communities in vegetable fields from Punjab and recovered nine nematode genera on four vegetable plants; chili and bell peppers (*Capsicum frutescens* L.) cucumber (*Cucumis sativus* L.) and tomato, (*Solanum lycopersicum* L.), grown under plastic tunnels. The plant-parasitic nematodes include, *Pratylenchus penetrans, Aphelenchus avenae, Helicotylenchus dihystera, Radopholus smilis, Hoplolaimus columbus, M. incognita,Meloidogyne javanica , Tylenchorhynchus claytoni* and *Xiphinema* spp. Distortion in the foliage growth in form of stunted growth, leaves chlorosis and wilted plants with lesser fruits were evident in patches were the symptoms recorded. Similar studies by (27) reported a survey of plant parasitic nematodes on five vegetables, pepper, okra, tomatoes, eggplant and onions from the River Benue Valley of Adamawa state, Nigeria and found six nematode genera to be associated with these plants. Of these nematodes genera, *Meloidogyne* sp were found to be most widespread. Other nematodes recovered were *Pratylenchus sp., M. javanica, Helicotylenchus sp., Scutellonema and Longidorus* spp. The present study is not consistent with the result of (28) who surveyed for PPNs associated with *Capsicum* in four districts of Mokwa, Niger state, Nigeria, and is also in contrast to other reported works which recorded *Scutellonema* as the most frequently occurring nematode, followed by *Helicotylenchus* spp., *Meloidogyne* spp., *Criconemela* and *Aphelenchoides* as being most commonly associated with pepper (25, 26).

In the present study, *H. multicinctum* was not only abundant but also widespread suggesting that this parasitic nematode can play a very important role in the decline of pepper production in the surveyed areas where it was predominant. This corroborate earlier works that reported pepper as playing major host to *Helicotylenchus* and eggplant and yard long bean as minor hosts (29).

During the survey in some sites, infected plants were observed to be chlorotic, stunted and wilted. It was also noticed that mixed cropping was common among the farmers enabling individual crops to play host to one or more plant-parasitic nematodes species as seen from the result of the extracted nematodes genera/ species from the present study. Thus, the presence of *Xiphinema spp* on pepper in the survey area calls for concern as several workers have reported that they are potential vectors of virus infecting some Solanaceous crops like, peppers, tobacco and tomato (30, 31, 32). It is reported that these nematodes specifically transmit nepoviruses to Solanaceae (24, 25).

The influence of soil physico chemical properties on population densities of nematode species was also investigated. Phytoparasitic nematodes live their life cycles in the soil rhizosphere, which invariably influences their mobility dynamics, breeding, parasitism and soil-root interaction (33, 34). Geographical locations determine the effect of a community of PPN damages on crop which usually depend on agro-climatic conditions, host susceptibility, pathogenicity and other climatic factors (18). According to (35), seasonal fluctuation determines nematode population in a given area. Thus nematode populations increase with season and nematode movement through large soil pore diameter and soil particle size with ease would be dependent on moisture.

Soil texture is among the factors generally believed to influence PPNs species distribution. Certain species of PPNs prefer soils with higher oxygen content or lighter sandy soil to heavy ones, which may be connected to nematodes preference (36). Studies carried out by (18) showed that soil with different textural classes and chemical composition have influence on how soil physical and chemical properties affect nematode population distribution, density, and community structure. Report by (37)

stressed the potential of nematodes as soil bio-indicator organisms. The workers were of the view that influence of soil textural classes on PPNs is species dependent. In another report by (38) the workers observed *P. loosi* to have higher population levels in lighter soils or sandy loam which enhanced nematode movement. The report further showed that soil textural class was sandy loam and had limited influence only on *Helicotylenchus multicinctum and Meloidogyne spp* as they had higher prominence values. Report by (33) however, found sand percentage to be inversely proportional to *Meloidogyne* spp density from Chilean vineyards.

Of the eight soil chemical properties examined, the population density of *H. multicinctum* was influenced by only Mg, while *Xiphinema spp* was influenced by Clay and Mg respectively, indicating that these nematodes have less sensitivity to soil properties. The present finding may serve as information base to extension specialists and scientists to show that nematodes are major pests of pepper and develop management strategies for increased productivity.

4 CONCLUSION

The present study has established the occurrence and prevalence of plant parasitic nematodes, which may consequently cause severe yield reduction in pepper. The study has also confirmed the importance of parasitic nematodes associated with pepper in the study areas as well as soil property influence on the PPNs. Any developmental programme on pepper production in the surveyed area will take into account management measures against these important pathogens which can be a limiting factor in pepper cultivation.

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Table 1. Occurrence of Plant parasitic nematodes on pepper from different sites in two local government areas of Niger State, Nigeria

Nematode Genera/ specie		MAGAMA			KONTAGORA		
Genera	Species	IBETO	ANABA	MAJE	NAGWAMATSE	FARIN SHINGE	LIOJI
Melodoigyne	*spp*	-	+	+	-	+	-
Helicotylenchus	*H. multicintus*	-	+	+	+	+	+
Scutellonema	*S. bradys*	+	+	+	-	+	-
Xiphinema	*spp*	+	-	+	-	-	-
Tylenchulus	*spp*	+	-	-	-	-	-
Pratylenchus	*spp*	-	+	-	-	-	-

+ presence of nematodes, - absence of nematodes

Table 2. Frequency of occurrence, population density and prominence value of nematode genera and species collected from the soil (100 mL) and root (12 g) samples of pepper plant from localities in parts of Niger state, Nigeria.

Nematode genus/species	Mean Population Density soil 100 mL	Mean Population Density roots 12g	Frequency (%)	Prevalence (%)100 mL soil	**Prominence value (PV)**
Helicotylenchus multicinctum	535	75	48.2	66.7	315.60
Meloidogyne spp	245	195	34.8	16.7	144.2
S.bradys	145	15	12.6	56.7	51.47
Xiphinema spp.	25	-	2.0	10.0	3.53
Pratylenchus spp.	05	-	0.4	3.3	0.31
Tylenchulus spp.	25	-	2.0	3.3	3.53

Table 3 : Correlation coefficients (r) among soil properties and plant parasitic nematodes densities from pepper farms

	Sand	Silt	Clay	pH	Org C	Total N	Na	K	Mg	Ca	Avail P
H. multicinctum	0.19	0.03	-0.34	-0.29	0.28	-0.02	-0.24	-0.30	0.80*	-0.27	-0.86
Meloidogyne spp.	0.21	-0.83	0.34	-0.41	0.37	0.28	-0.46	-0.38	0.82	0.63	0.40
S. bradys	-0.23	0.40	0.65	-0.35	0.15	0.31	0.41	0.04	-0.23	-0.44	0.69
Xiphinema spp	-0.76	-0.50	1.00**	0.32	-0.76	0.69	-0.24	-0.36	0.80	-0.28	-0.87

** - Correlation values are significant at $p < 0.01$

* - Correlation values are significant at $p < 0.05$

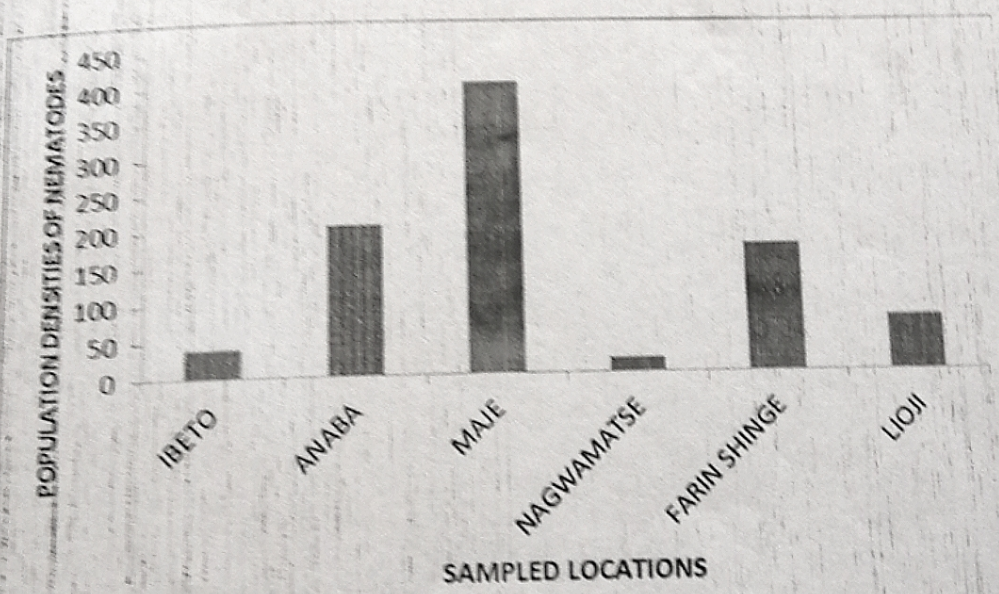

Figure 1 percentage population of Nematodes collected from six villages.

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