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Full Length Research Article

PHYTO-PARASITIC NEMATODES OF BELL PEPPER PLANT AND FARM SOIL IN ABUA, RIVERS STATE, NIGERIA

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ABSTRACT
Bell pepper farming significantly contributes to economic development in Abua. However, phyto-parasitic nematodes are endemic in the area and affect quality of crop yield. Hence, this study was undertaken to investigate the dynamics of occurrence of nematodes in bell pepper roots and soil samples of the farms in Abua. Roots and soil from the root rhizosphere were simultaneously collected at 0-20 cm depth using an improvised soil auger and knife. Modified sieve plate technique was employed for nematode detection and a pictorial key was used for nematode identification at the genera level. An overall nematode abundance of 746 nematodes in the soil around the root region and 216 nematodes in the root tissues of the bell peppers were recorded. *Gracilachus* species (10.6 %) was more prevalent in the soil, and *Meloidogyne* species (35.2 %) exhibited the highest population in roots. The study found that Abua's cultivated soil is susceptible to nematode infestation, limiting crop performance. The nematodes showcased root burrowing which is an inherent pattern for survival. The result on root nematodes across the five bell farms surveyed was not significant ($p > 0.05$). The result opined that farmers in Abua, Rivers State, should understand the role of the soil nematodes and implement soil improvement strategies for improved crop performance and rural economic development.

Keywords: Phyto-parasitic, nematodes**,** farm, rhizosphere, Rivers State, roots

INTRODUCTION

The bell pepper crop constitutes a prominent vegetable crop in Abua, Rivers State, and is used globally. In Abua, bell pepper farming is comparable to cattle rearing in the northern part of Nigeria, as it is rare to find a farmer without a bell pepper farm. The crop serves as a primary source of livelihood for the local rural inhabitants of Abua in Rivers State, and has had a significant impact on the local economy of the Abua people. The crop has been gaining popularity recently because of its significance as a spice and its impact on the rural economy in several parts of the world, including Nigeria (Jean, 2005; Tewksbury *et al*., 2006; Norman *et al*., 2009). Raising bell peppers is lucrative and beneficial once it is done adequately and free from pest infestations. Nevertheless, plant-feeding nematodes have often caused poor yield of bell pepper farms.

Parasitic nematodes are soil-borne parasites of agronomical significance, as they survive on plant tissues. Their presence threatens crop survival and limits growth and yield (Adam *et al*., 2013; Ekine *et al*., 2020; Orluoma *et al*., 2023). Health disorders due to nematodes could threaten the performance of bell peppers and drastically influence yield. Stanton & Graham (2014) reported that bell peppers are susceptible to nematodes. Also, Sitepu & Mustika (2000) reported that a great number of nematodes infect vegetable crops including bell peppers in fields. They compound crop destruction because of their ability to inflict injuries in association with other soil-dwelling pathogens (Imafidor & Ekine, 2016; Aminanyanaba *et al*., 2015; El-Sheriny, 2011), and constitute a significant threat to food production than insect pests.

Considering the attack of phyto-parasitic nematodes on crops having their roots in the soil, farmers must be knowledgeable about the role of these tiny soil worms by deploying soil nutrient improvement to achieve quality crop performance. Destruction of plant rhizosphere by these soil worms can prompt poor food production and limit supply. Adverse effects of their action on crops may propel food scarcity and can result in famine. However, the identification of incumbent species in an area can serve as a guide for proper strategy in propounding adequate control mechanisms. Therefore, this study aimed at assaying roots of bell pepper plants and soil samples from some farms in Abua for the identification of endemic nematodes.

MATERIALS AND METHODS

Study Area

The survey of phyto-parasitic nematodes of bell pepper plant and farm soil was carried out in Abua. This area is one of the localities with upland that produces food and vegetables which are supplied to the teaming population in Rivers State, Nigeria. Abua is located 42 kilometers from Port Harcourt, which is the administrative capital of Rivers State. The residents of Abua are mostly farmers who earn a living from the tilling of the soil. The geographical coordinates of Abua is 4º49.502´N, 6º39.067´E.

Collection of samples

Collection of Bell pepper Plant Roots

Five monoculture farms with bell peppers plants were randomly selected and marked as A-E. Soil and root nematodes were surveyed in each of these farms. In each farm, twenty five bell pepper plants were uprooted, and the roots were removed using a kitchen knife.

Collection of Farm Soil Samples

At the same time and place, twenty five soil samples were collected from the root regions of the bell pepper plant in each farm, and were placed individually in white water proof bags labeled against the bell pepper plants (1-25) across the five farms. The soil was collected at a depth of 0-20 cm using an improvised soil auger. These roots and soil samples were carried to the laboratory for nematode detection.

Nematode Extraction

The nematodes from soil and roots were extracted using Modified Sieve Plate method, as described by Ekine *et al.* (2020).

Soil samples were thoroughly examined, and all non-soil particles

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were removed, leaving behind only the soil particles. Bulk samples for each farm, A-E, were obtained by mixing the 25 soil samples collected from each farm in different plastic rubbers labeled with the respective farm site. Each bulk soil sample yielded 50 samples mounted on the sieve plates, making a total of 250 mounted samples from the five farms. Similarly, bulk root samples for each farm were obtained by mixing the roots of the 25 bell pepper plants. The roots were carefully checked, washed in running water, and blended for 20 seconds using an electric blender at low speed. A total of 50 mounted samples were derived, with each farm yielding 10 mounted samples. These samples were wrapped in tissue paper and placed on plastic plates containing water with sieves. The setup was left uninterrupted for 48 hours. After 48 hours, both soils and roots were removed, and the nematode liquors were emptied into specimen bottles and preserved in 5% formalin for viewing after the liquors settled at the bottom of the specimen bottles.

The nematodes were identified using a pictorial key according to Mekete *et al.* (2012), and the viewing was done with a light microscope.

Data analysis

Results in this survey were presented using simple percentages, and the significant level of nematode abundance against bell pepper farms was analyzed with Analysis of Variance, using SPSS software, version 21.

RESULTS

Dynamics in nematode occurrence in the soil and roots of bell peppers

The total abundance of the nematode in the study was 962 within 15 genera. The entire 15 nematode genera were found in soil and 6 reappeared in roots (Table 1 and 2). The result shows higher dynamics of nematodes in soil than the root across the five bell pepper farms (Fig. 1). The nematode populations in this study were *Scutellonema* species, *Meloidogyne* species, *Hoplolaimus* species, *Heterodera* species, *Helicotylenchus* species, *Rotylenchus* species, *Longidorus* species, *Tylenchorhynchus* species, *Criconema* species, *Radopholus* species, *Pratylenchus* species, *Gracilachus* species, *Caloosia* species, *Ditylenchus* species and *Tylenchus* species.

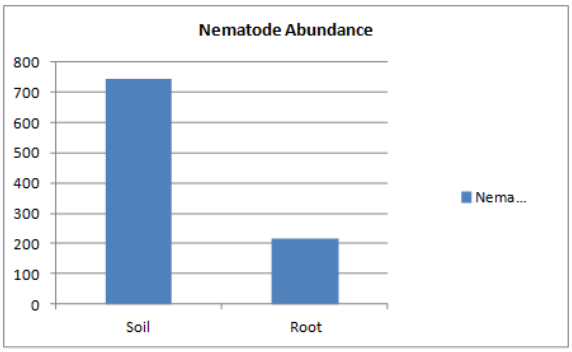

Fig. 1: Overall population of nematodes in soil and roots of bell pepper plants

Populations of nematode pest in soil samples of bell pepper farms

Soil evaluation in this survey reported a total of 740 nematodes from 15 genera. From the study result, 159 (21.3 %) nematodes occurred in farm A, 134 (18.0 %) in farm B, and 140 (18.8 %), 150 (20.1 %) and 163 (21.8 %) species were extracted from farms C, D, and E respectively. Nematodes recovered from the soil in this study were *Scutellonema* species, *Meloidogyne* species, *Hoplolaimus* species, *Heterodera* species, *Helicotylenchus* species, *Rotylenchus* species, *Longidorus* species, *Tylenchorhynchus* species, *Criconema* species, *Radopholus* species, *Pratylenchus* species, *Gracilachus* species, *Caloosia* species, *Ditylenchus* species and *Tylenchus* species. *Gracilachus* species, 79 (10.6 %), occurred most in the soil among all the nematodes recorded (Table 1).

Table 1: Nematode pest in soil of bell pepper farms in Abua

Nematodes	Farm sites					Overall occurrence
	A (%)	B (%)	C (%)	D (%)	E (%)	
Rotylenchus	6 (14.3)	4 (9.5)	0	20 (47.6)	12 (28.6)	**42 (5.6)**
Tylenchorhynchus	16 (27.1)	8 (13.6)	21 (35.6)	6 (10.2)	8 (13.6)	**59 (7.9)**
Longidorus	26 (54.2)	0	12 (25.0)	10 (20.8)	0	**48 (6.4)**
Meloidogyne	12 (20.7)	10 (17.2)	16 (27.6)	10 (17.2)	10 (17.2)	**58 (7.8)**
Criconema	8 (22.2)	0	6 (16.7)	12 (33.3)	10 (27.8)	**36 (4.8)**
Heterodera	9 (17.0)	0	14 (26.4)	9 (17)	21 (39.6)	**53 (7.1)**
Tylenchus	16 (25.8)	13 (21.0)	4 (6.5)	15 (24.2)	14 (22.6)	**62 (8.3)**
Ditylenchus	20 (28.2)	24 (33.8)	7 (9.9)	8 (11.3)	12 (16.9)	**71 (9.5)**
Gracilachus	7 (8.9)	22 (27.8)	18 (22.8)	11 (13.9)	21 (26.6)	**79 (10.6)**
Scutellonema	0	9 (17.6)	3 (5.9)	14 (27.5)	25 (49.0)	**51 (6.8)**
Helicotylenchus	13 (18.8)	20 (29.0)	15 (21.7)	13 (18.8)	8 (11.6)	**69 (9.2)**
Caloosia	6 (17.6)	4 (11.6)	6 (17.6)	12 (35.3)	6 (17.6)	**34 (4.6)**
Radopholus	12 (30.6)	0	11 (28.2)	10 (25.6)	6 (15.4)	**39 (5.2)**
Hoplolaimus	0	8 (50.0)	7 (43.8)	0	1 (6.3)	**16 (2.1)**
Pratylenchus	8 (27.6)	12 (41.4)	0	0	9 (31.0)	**29 (3.9)**
Total	**159 (21.3)**	**134 (18.0)**	**140 (18.8)**	**150 (20.1)**	**163 (21.8)**	**746**

% = n/N x 100 (n = Individual nematode occurrence, N = total nematodes extracted)

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Nematodes of bell pepper roots in farms in Abua

Root assessment in this study showed a total of 216 nematodes from 6 genera. Among the 216 nematodes, 56 (25.9 %) were recovered in farm A, farm B had 43 (19.9 %) and farms C, D, and E reported 60 (27.8 %), 39 (18.1 %) and 18 (8.3 %) respectively. *Pratylenchus species,* 76 (35.2 %), *was* the most prevalent nematode in the roots of the bell pepper plants. The occurrence of nematodes in the of bell pepper roots was not significant across the five surveyed farms (P > 0.05) (Table 2).

Table 2: Root nematodes of bell pepper plants

Farm sites	Total number of nematodes detected.	*Meloidogyne* (%)	*Radopholus* (%)	*Ditylenchus* (%)	*Pratylenchus* (%)	*Helicotylenchus* (%)	*Hoplolaimus* (%)	F	Sig.
A	**56 (25.9)**	8 (32.0)	13 (36.1)	15 (62.5)	20 (26.3)	0	0	7.557	0.000
B	**43 (19.9)**	0	12 (33.3)	0	13 (17.1)	13 (35.1)	5 (14.6)		
C	**60 (27.8)**	3 (12.0)	7 (19.4)	9 (37.5)	20 (26.3)	11 (29.7)	10 (55.6)		
D	**39 (18.1)**	11 (44.0)	4 (11.1)	0	15 (19.7)	0	9 (24.3)		
E	**18 (8.3)**	3 (12.0)	0	0	8 (10.5)	4 (10.8)	3 (16.7)		
Overall Pop.	**216**	**25 (11.6)**	**36 (16.6)**	**24 (11.1)**	**76 (35.2)**	**37 (17.1)**	**18 (8.3)**		

DISCUSSION

This survey assessed the nematodes of endemicity in soil and roots of bell peppers and identified a total of 962 within 15 genera. These nematode genera were reported from the five bell pepper farms from which soil and roots were evaluated. The result established that bell peppers are vulnerable to nematode pests. From this study, it is factually correct that soil nematodes plague the farms in Abua and deliberate effort must be put in place for the management of these soil worms to guarantee improved crop performance and achieve food security. The populations of these tiny soil worms were higher in soil from farm E (21.8 %). Succeeding farm E in the sequence was farm A (21.3 %) and 20.2 %, 18.8 %, and 18.0 % were seen in farms D, C, and B respectively. The high occurrence of nematodes in the study can be attributed to the farming system, monoculture, which favors nematode build over time. This result concurs with Orluoma *et al.* (2023) which revealed that nematodes replicate more rapidly in the root region of crop plants of a monoculture system than in a mixed cropping system. The appearance of nematode in soil was the same for all the bell pepper farms investigated not minding a similar farming strategy. This remarks implied that field apportionment of nematodes is unpredictable and the profusion of nematodes does not follow any sequence in fields.

The root tissues of bell peppers display 6 nematode genera with a total population abundance of 216. This observation suggests that nematode is a crop plant pest in Abua. The presence of nematodes can inhibit the normal functioning of the root system, predisposing crop plants to opportunistic disease agents and frustrating farmer's expectations. The study further established that cultivated soil in Abua is vulnerable to nematode infestation and crop plants growing on it have narrow chances for high performance. Adamou *et al.* (2013) reported that pepper is susceptible to nematode infestation, and its actions on the crop can be compounded by poor care system by the farmer. Coyne *et al.* (2003) suggest that thirty percent of total crop loss resulting in food insecurity in Africa can be attributed to damages due to nematode infectivity. The most significant nematode implicated in this study was *Gracilachus* species (10.6%) against the occurrence of *Meloidogyne* species, a popular nematode of economic relevance. This scenario is indicative that specific nematode genera can only adapt and survive in places where they can overcome inter-specific competition. The profusion of nematodes can be impacted by competitive conditions and species that are better adapted could dominate (Ezenwaka & Ekine, 2024) The low nematode population in this study depicts that nematodes were able to find sufficient nutrients for survival around the root rhizosphere and borrowing into the root tissues was relatively discouraged. A greater population of root nematodes was extracted from farms A and C. This remark implied that the soil environment was hostile to nematodes and prompted burrowing into the roots of bell peppers as an alternative survival means. Root burrowing, as a pattern of life showcased by these soil nematodes, is inherent to avoid competition and enhance survival chances.

A disparity in nematode proliferation and profusion was observed in soil and root tissues, such that certain genera were peculiar in soil, and some displayed abundance in the root tissues and also in soil. This pattern was observed in all five sampled farms. A relatively higher number of species were commonly found in soil compared with results from roots. This result agrees with (Ekine *et al*., 2018). The difference in the actual population of nematodes in this study could be imputed to species habit of self-sustenance. Nematodes evolve different strategies to keep them lively in soil including root borrowing and steady movement within the root region in soil (Nicol *et al*., 2005).

Evaluation of nematode profusion for specific nematode genera in this study revealed that *Gracilachus* species was the most reported in root rhizosphere and *Meloidogyne* species had a greater number in roots. This result implied that *Meloidogyne* and *Gracilachus* adapt rapidly to their site of feeding. However, the most prevalent in the study was *the Meloidogyne* species. This remark agrees with the preposition that *Meloidogyne* species are adequate for parasitism (Imafidor & Ekine, 2016; Ekine *et al*., 2020) and possess the potential to inflict crop injuries in isolation. A prominent pest of bell peppers, *Radopholus* exhibited a negligible number in this survey compared to the observations for *Gracilachus species* which have never been reported in bell peppers. This observation implies that nematodes survive on the support of the persisting soil factors of a place.

Conclusion

Soil nematodes form a significant pest group affecting bell peppers in Abua. A good knowledge of the relevance of nematodes in detecting crop performance can help the farmer in control strategies and enhance the general wellness of the crop plants.

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