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Seasonal Effects on the Vertical Distribution of Eelworms in Soil Cultivated with Bell Peppers

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Abstract
The study examined eelworm richness in soil across three core depths at dry and wet seasons, drawing inferences on the effects of seasons on the vertical distribution of the agronomical parasites. Soil samples were collected randomly from the rhizosphere of bell pepper at 0-10 cm, 11-20 cm and 21-30 cm core depths at dry and wet seasons using a soil auger. The extraction of eelworms was by the use of the modified sieve plate technique and a pictorial key was used for identification to the genera level. The concentration of eel worms during the dry season was 20.4%, 33.6% and 46.0 % in 1-10 cm, 11-20 cm and 21-30 cm core depths respectively; exhibiting downward migration. During the wet season, there was a steady decrease in the population of eelworms down the soil core depths, 49.3% at 1-10 cm, 37.2 % at 11-20 cm and 13.5 % at 21- 30 cm. Species diversity of eelworms was unevenly distributed across the core depths within seasons. The actual distribution against each core depth was significant within and between seasons ($p < 0.05$). The study opined that seasonal variations impact eelworms' richness and distribution across core depths in soil.

Keywords: Bell pepper, Core depth, Eelworms, vertical distribution,

Introduction

Eelworms, also known as plant parasitic nematodes, are agronomically significant obligate parasites that can infest every crop having anchorage in soil (Imafidor & Ekine, 2016; Gregory et al., 2017; Adegbite et al., 2018). Although there are species of economic benefit the plant-feeding group is more pronounced. Phyto-parasitic eelworms have been implicated as pests of crops worldwide. The presence of these worms is threatening to global food security. They are regarded as the hidden enemy of the farmer (Coyne et al., 2018; Orluoma et al., 2023); this is because they antagonise the farmer's effort. Control for these minute soil worms seems challenging since the measure at which they establish damage on crop plants is not conspicuous. Hence, the farmer is saddled with the burden of achieving the right management strategy and curbing the plague imposed on society by the activities of these eelworms. Eelworms are generally known for effective parasitism with field crop plants of proximal affiliations and preference. That is, the absence of certain plant crops in the field due to unfavourable conditions that may result from changes in seasons could mean a lack of enough source of nourishment for active metabolic activities for certain species of eelworms and may result in the death of such species. The developmental order of plant crops could impact the profusion sequence of the eelworms of preference and facilitate or impair propagation about seasons and root system of the crop plant of specificity.

Crops are easily influenced by injuries emanating from the activities of eelworms (Gregory et al., 2017). Hence, understanding the relationship between crop root depths and the season of eelworm activeness and core depth distribution of species may be significant in setting up a control mechanism for the parasites and enhancing crop performance. Eel worms are mainly migratory, relying on soil moisture and temperature which are directly regulated by season. That is, determining eel worms' active season with its corresponding depth of occurrence could benefit the farmer on farming time and appropriate crop variety for cultivation with a good knowledge of crop root system in the soil. Hence, taking a critical look at the distribution of eelworms against seasons could put the farmer in a better position and facilitate management mechanisms. Therefore, this study is aimed at surveying soil around the roots region of bell peppers to determine the effects of seasons on the vertical distribution of eelworms.

Materials and Methods

This survey was conducted in the research area of the Biology department, Ignatius Ajuru University of Education, Port Harcourt, Rivers State. The location lies between 155- 200 km north of old Port Harcourt Township, the capital city of Rivers State. The area experiences two seasons, dry (November – April) and wet (May –October). The research area (20 cm - 15 cm) was portioned into four plots. These plots were designated A, B C, and D. In each plot, four beds were made and bell pepper cultivated. The study was carried out between January – March (dry season) and July – September 2023 (wet season).

Soil samples were collected randomly from the rhizosphere of bell pepper at 0-10 cm, 11-20 cm and 21-30 cm core depths across the four plots in the research area using a soil auger. A total of fifty soil samples were collected in each period of sampling (ten samples in each plot) per season, making a total of one hundred and fifty samples with total soil samples of three hundred. The soil samples were packed into properly labelled waterproof bags to form a bulk sample and subsequently transported to the laboratory for eel worms' extraction. Eel worms were extracted using the modified sieve plate technique as described by Ekine et al. (2018) and identification of eelworms at the general level was done using a pictorial key (Mekete et al., 2012).

Eelworm frequency of occurrence within core depths was ascertained using a simple percentage (n x 100/N). However, the significance of eel worms' distribution within seasons across core depths was tested using ANOVA; while the independent t-test was used to test the significance of the influence of seasons on eel worms' abundance between seasons.

Results

Eel worms' distribution across the various core depths during dry and wet seasons

Eel worms' richness in this study was 1,365. Among the 1,365 eel worms encountered, 655 representing 48.0% were reported at dry season where 20.4%, 33.6% and 46.0% were extracted from 1-10 cm, 11-20 cm and 21-30 cm core depths respectively. The wet season recorded a total eel worms' assemblage of 710 (52.0%). Of the 710 eelworms recorded at the wet season, 49.3% were revealed in 1-10 cm core depth, while 11-20 cm core depth had 37.2% and 21-30 cm core depth recorded 13.5%. The study recorded 11 genera of eelworms, among which 9 genera were found both in dry and wet seasons while 2, *Scutellonema* and *Rotylenchus* species were peculiar to the wet season only(Table 1).

Table 1: Eel worms distribution in core depths between dry and wet seasons

	Eel worms	**1-10 cm (%)**	**11-20 cm(%)**	**21-30 cm (%)**	**Total (%)**
Dry season	*Radopholus*	11 (8.3)	18 (8.2)	32 (10.6)	61 (9.3)
	Hoplolaimus	17 (12.7)	5 (2.3)	41(13.6)	63 (9.6)
	Longidorus	25 (18.7)	4 (1.8)	20 (6.6)	49 (7.5)
	Ditylenchus	21 (15.7)	25 (11.4)	31 (10.3)	77 (11.8)
	Meloidogyne	32 (23.8)	38 (17.3)	28 (9.3)	98 (15.0)
	Pratylecnhus	0	37 (16.8)	40 (13.3)	77 (11.8)
	Heterodera	21 (15.7)	41 (18.6)	51 (16.9)	113 (17.2)
	Tylecnhus	7 (5.2)	33 (15.0)	32 (10.6)	72 (11.0)
	Helicotylenchus	0	19 (8.6)	26 (8.6)	45 (6.8)
	Total	**134 (20.4)**	**220 (33.6)**	**301 (46.0)**	**655 (48.0)**
	Pv = .26				
Wet season	*Heterodera*	31 (8.9)	19 (7.2)	4 (4.2)	54 (7.6)
	Hoplolaimus	27 (7.7)	20 (7.6)	11 (11.5)	58 (8.2)
	Longidorus	37 (10.6)	11 (4.2)	17 (17.7)	65 (9.2)
	Ditylenchus	15 (4.3)	28 (10.6)	12 (12.5)	55 (7.7)
	Meloidogyne	40 (11.4)	31 (11.7)	20 (20.8)	80 (11.3)
	Pratylecnhus	34 (9.7)	21 (8.0)	9 (9.4)	64 (9.0)
	Radopholus	50 (16.6)	27 (10.2)	0	77 (10.9)
	Tylecnhus	32 (9.1)	21 (8.0)	3 (3.1)	58 (8.2)
	Helicotylenchus	29 (8.3)	16 (6.0)	8 (8.3)	53 (7.5)
	Rotylenchus	19 (5.4)	39 (14.8)	8 (12.5)	66 (9.2)
	Scutellonema	36 (10.3)	31 (10.3)	12	79 (11.1)
	Total	**350 (49.3)**	**264 (37.2)**	**96 (13.5)**	**710 (52.0)**
	Pv = .04				

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Concentration of eelworms across the soil core depths in dry and wet seasons

The study observed a steady downward migration of eelworms during the dry season, as the concentration of eelworms was 20.4%, 33.6% and 46.0 % in 1-10 cm, 11-20 cm and 21-30 cm core depths respectively. During the wet season, there was a steady decrease in the population of eelworms down the soil core depth. The core depth population concentration was 49.3% at 1-10 cm while 11-20 cm and 21- 30 cm had 37.2 % and 13.5 % respectively (Fig. 1).

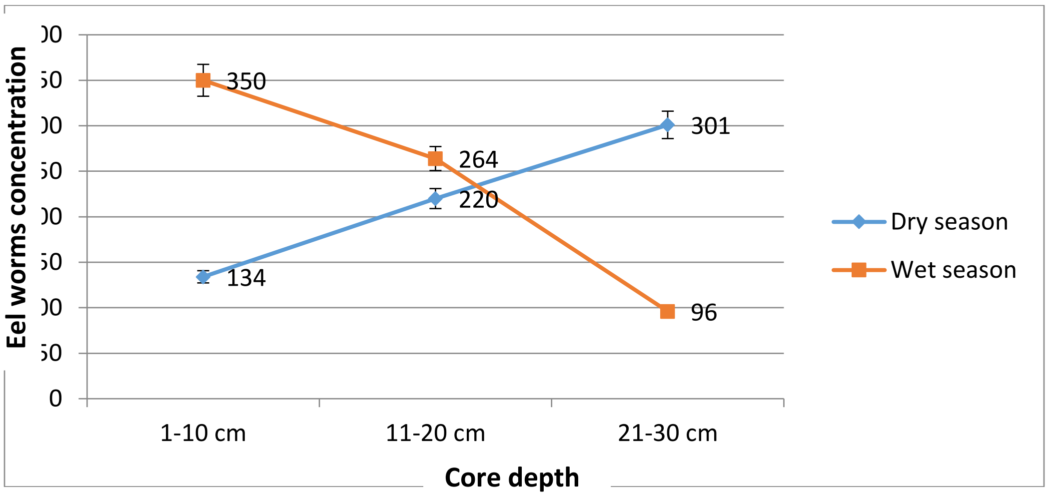

Fig. 1: Concentration of eelworms across the soil core depths in dry and wet seasons

Diversity of eelworms across each core depth within seasons

The distribution of eelworms across the core depths within seasons showed disparities among species. For instance, during the dry season, the assemblage of *Meloidogyne* species (23.8%) was most prevalent at 1-10 cm core depth, while *Heterodera* species (18.6%) recorded a greater population in 11-20 cm core depth (Fig. 2). However, at the wet season, *Radopholus* species (16.6%) displayed lofty populations in 1-10 cm core depth, while *Rotylenchus* species (14.8%) were the most prevalent in 11-20 cm core depth and *Meloidogyne* species (20.8%) showed highest richness at 21-30 cm core depth (Fig. 3). The actual distribution of eelworms against each core depth was statistically significant within and between seasons at ($p < 0.05$).

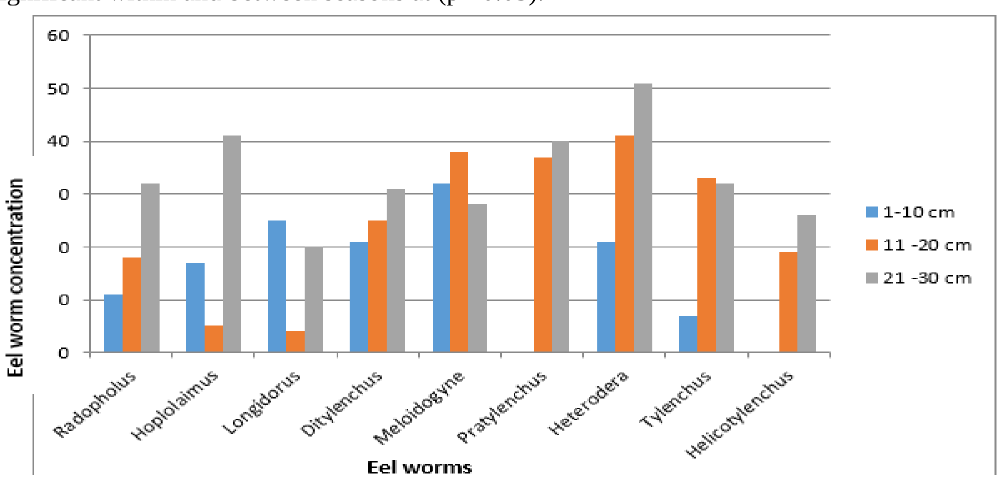

Fig. 2: Diversity of eel worms across each core depth at dry season

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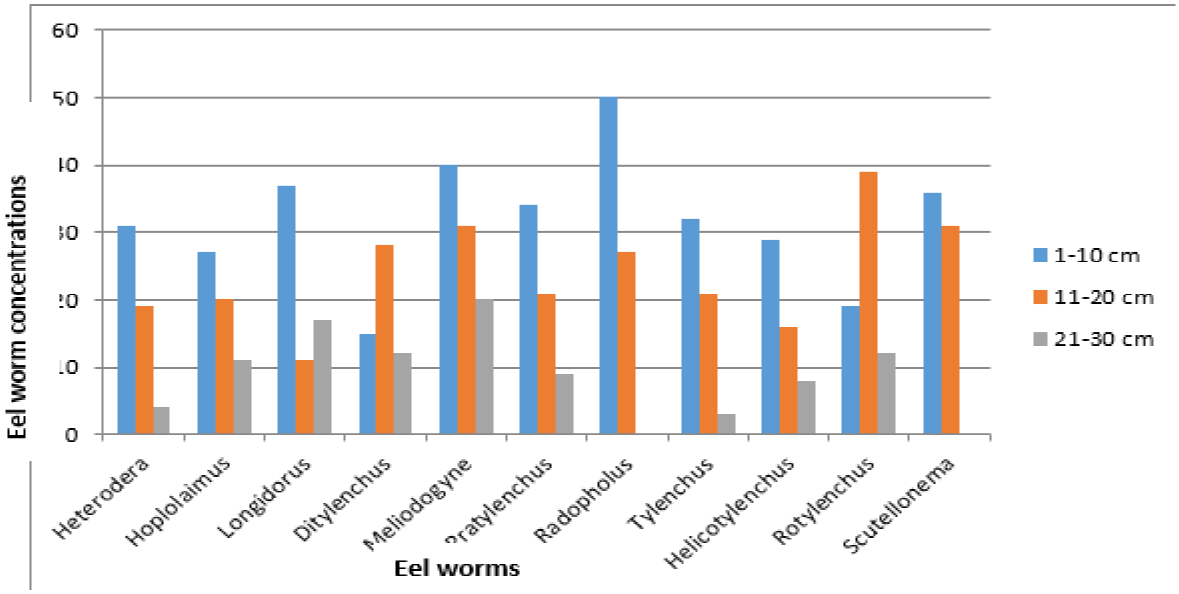

Fig. 3: Diversity of eel worms across the soil core depth at wet season

Discussion

The study examined eelworm richness in soil across three core depths at dry and wet seasons to draw inferences on the effects of seasons on the population distribution of the agronomical parasites. The concentration of eelworms during the dry season was 20.4%, 33.6% and 46.0 % in 1-10 cm, 11-20 cm and 21-30 cm core depths respectively. The low concentration of eelworms at 1-10 cm core depth suggested that field conditions at topsoil were not favourable for nematode propagation. That is to say, during the dry season, nutrient concentration was minimal at topsoil (1-10 cm core depth). Holmstrup et al. (2010) and Gboeloh et al. (2019) stated that eelworms can be well established in soil supporting their propagation and may employ hypobiosis at advert field conditions. The study displayed a high prevalence of eelworm populations down the core depths during the dry season. This result suggests that the frequent sunshine observed during the dry season does not support the survival of the worms at 1-10 cm and 11-20 cm core depths, hence, eelworms exhibit a steady downward migration to stay alive. Cerevkova and Cagnan (2012) opined that nematodes form colonies at the root point and tend to migrate downward as the soil dries. Since eelworms survive on nutritional content in the soil, rapid physical motion of species downward to ensure continual existence is inevitable when moisture content becomes minimal at topsoil and the soil gets drier during dry seasons.

The vertical distribution of eelworms during the wet season showed a contrast compared with the observation in the dry season. There was a steady decrease in the population of eelworms down the soil core depths. The core depth population concentration was 49.3% in 1-10 cm while 11-20 cm and 21- 30 cm had 37.2 % and 13.5 % respectively. This observation suggests that eelworms were able to find enough nourishment for life sustenance at topsoil (1-10 cm core depth) and were discouraged from further downward motion. Andrea and Ludovit (2012) opined that conditions affecting soil factors can predict nematode distribution in soil. The steady decline in eelworm populations down the soil core depths depicts that eelworms are reactive to field conditions in the environment at all seasons and adopt the fastest survival mechanism to remain alive. Fiscus and Neher (2002) stated that eelworms, especially the free-living species, are sensitive to every physical and chemical interruption of the environment.

In this study, the assemblage of eelworms across each core depth was influenced by seasons. Nematodes species diversity was unevenly distributed across the core depths within a season. For instance, during the dry season; the assemblage of *Meloidogyne* species (23.8%) was most prevalent at 1-10 cm core depth and *Heterodera* species (18.6%) and 16.9%) recorded greater populations in 11-20 cm and 21-30 cm core depths respectively. However, during the wet season, *Radopholus* species (16.6%) display lofty populations in 1-10 cm core depth, while *Rotylenchus* species (14.8%) were the most prevalent in 11-20 cm core depth and *Meloidogyne* species (20.8%) was higher in richness at 21-30 cm core depth. The actual distribution of eelworms against each core depth was statistically significant within and between seasons at ($p < 0.05$). This scenario implies that eel worms' distribution in fields can be impacted by predominant forces of the environment and species survival technique which are directly influenced by seasonal changes.

Conclusion

Seasonal changes impact nematode richness and distribution across core depths in soil. The concentration of eel worms during the dry season exhibited a steady downward migration; while during the wet season, there was a steady decrease in the population of eelworms down the soil core depths. The distribution of eelworms with season across core depths was significant at wet and dry seasons and within seasons.

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