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Testing Seasonal Disparity as a Determinant of Phyto-Parasitic Nematode Dynamics in an Agroecosystem

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Abstract

Soil inhabiting organisms, including phyto-parasitic nematodes are highly sensitive to abiotic stimuli impacting the conduciveness of the soil ecosystem. Stimuli such as seasonal disparities may favour nematode survival at one point, and pose survival threat at some other point and vice versa. Therefore, this study tested the effects of seasonal disparity as a critical driver of phyto-parasitic nematode dynamics in an Agroecosystem. Soil samples were collected using a modified soil auger and nematode extraction was carried out using the modified Bearman's technique. Result shows higher occurrence of phyto-parasitic nematodes at wet season when compare with the prevalence during the dry season. However, vertical distribution of nematodes saw higher populations at 16-30 cm core depth when compare with distribution at 0-15 cm depth at dry season. However, results on the vertical distribution of nematodes during the wet season was contrary as seen in dry season. The study revealed that nematode dynamics and species distribution across core depth are influenced by edaphic parameters, which are directly regulated by seasonal disparity. The study established that disparity in season constitute a significant force predicting nematode dynamics in agroecosystems. Wet season raises survival chances of juvenile, ensure adequate water content in soil and increases nematode populations. The dry season post some level of stress on phyto-parasitic nematodes, which could restrain motility, compel down ward migration, prompt anhydrobiosis and intensifies root tissue penetration. Seasonal disparity can prompt a shift in microbial associations to the survival advantage of certain species of phyto-parasitic nematodes and inhibits the populations of other species in the ecosystem.

Keywords: Agroecosystem, Nematode dynamics, Phyto-parasitic nematodes, Seasonal disparity, Soil ecology.

Introduction

Phyto-parasitic nematodes are agronomical parasites incumbent in soil ecosystem. They have been grouped among the most abundant organisms occupying every ecological habitant (Pires et al., 2022; Bardgett & Van der Putten, 2014). They are versatile in nature, engaging in complex food web interactions. The interactive nature of phyto-parasitic nematodes makes them effective indicators of soil wellness and ecosystem functioning (Gonzalez et al., 2025; Zhang et al., 2024; Khanum et al., 2021). Plant parasitic nematodes are critical players in agricultural ecosystem, facilitating nutrient mineralization and regulating microbial associations in soil with direct implications on crop performance (Elling, 2013; Nilusmas et al., 2020). Beside been significant in the recycling of nutrient and biodiversity, phyto-parasitic nematodes are serious pests of crops. Their presence in agroecosystems is threating to food security. These soil inhabiting organisms, inflicts crops with various degree of injuries and impair crop performance in terms of yield and food production. The activities of phyto-parasitic nematodes compromised crop performance, causing significant decline of agricultural productivity (Afzal & Mukhtar, 2024; Pires et al., 2022) to the detriment of food security. Afzal and Mukhtar, (2024) identifies plant parasitic nematodes as primary contributors to worldwide crop damage, intensifying food insecurity. Nevertheless, the activities plant parasitic nematodes in soil ecosystem can be impacted by seasonal discrepancies. Therefore, analysis on nematode survival trend and properties supporting their propagation such as seasonal disparity can essentially be beneficial to the rural farmers and support practice toward adequate management strategy to enhance food security. It will enhance the farmers awareness on the appropriate season of cultivation to ameliorate yield.

It is obvious that disparity in seasonal cycle can display influence on every ecosystem. This is conspicuously seen through fluctuations in basic soil properties such as moisture content, temperature and microbial community structure (Jia et al., 2020; Shokoohi et al., 2019) which also affects nutrient flow. The fluctuations on edaphic features due to change in seasonal cycle directly impact on the sequence of events in the soil ecosystem and influences the biotic elements in favour or against nematode survival (Emeriewen & Ekine, 2025). In Nigeria, seasonal disparity which is accompanied by a switch from raining or wet season to sunshine or dry season can directly improve or hinder the flow of nutrient in soil and impact on nematodes in positive or negative manner, vice versa. In their reports, Ekine and Ezenwaka (2024), Chen et al. (2021) and Ankrom et al. (2020) summits that, seasons with adequate moisture content in soil can prompts optimum nutrient

availability and increases interactions of soil organisms and can relief crop plant of parasitic attacks. Nutrient availability keeps plants parasitic nematodes away from disturbing plant tissues and rather concentrate more on the available nutrient within the root rhizosphere (Emeriewen & Ekine, 2025). Emeriewen and Ekine, (2025) further reports that seasons with limited water content in soil constrain nutrient flow and leave nematodes with limited nutrient to survival on. This scenario increases nematode borrowing into root tissues, and can lead to decline in crop performance and poor yield.

Despite the awareness that nematodes are ecologically responsive organisms, it is still unclear how disparity in seasonal cycle influence nematode assemblage in soil ecosystem. Research focus in the study area has been on the general assemblage and species assessment of plant parasitic nematodes with no proper evaluation of the influence of seasonal discrepancies on nematode survival sequence and abundance in soil. Also, literatures in the study area have commonly treated the effects of edaphic factors on phyto-parasitic nematodes in isolation with no link to how seasonal disparity could impact soil factors and influences nematode dynamics and distribution.

A change in seasonal cycle can potentially shift equilibrium among trophic groups and support the emergence of opportunistic species. It can also potentially inhibit the populations of sensitive taxa depending on the cycle either favourable or advert. For instance, dry season pose a harsh condition for the phyto-parasitic nematodes in soil and compel the pests to take refuge in root tissues for the sustenance of life (Emeriewen & Ekine, 2025) which implies lower populations in soil. However, adequate moisture at wet season improves microbial associations and enhances the populations of phyto-parasitic nematodes which increases injuries in crop plants. The primary factors known to support nematode dynamics in soil which includes moderate soil water, adequate temperature and nutrient flow are inherently altered by seasonal variations. Therefore, this study is aimed at testing the influence of seasonal disparity on nematode dynamics in agro- ecosystems.

Materials and Methods

Study area: This study was conducted in agricultural land in Abua. Abua is an ethic nationality in Rivers State, Nigeria with the geographical coordinates: 4.956^{o} N (Latitude) and Longitude 6.634^{o}E. The residence of Abua are mostly farmers particularly on crop cultivation. Abua experience rainy and dry seasons. In Abua, crop cultivation is carried out all through the year irrespective of season.

Sampling / soil collection: The study sampled soil from agricultural land in Abua. The sampling was done between November, 2024 - February, 2025 for dry season and June-September, 2025 for wet season. Soil was collected at 0-20 cm core depth and 21-40 cm core depth during the dry and wet seasons respectively.

Nematode extraction Procedure: The study adopted the modified Bearman's extraction technique as documented in Imafidor and Ekine (2016) for nematode extraction.

The collected soil was attentively examined to remove debris. The soil was then raped in tissue paper placed on a mesh supported on a plastic rubber plat with water. The water in the rubber plats were set in such a way that the soil raps were wet but not immerse. The set up was allowed undisturbed in the laboratory for two days. After the two days, the soil raps were removed and thrown away and the nematode liquor emptied into specimen bottles, fixed in two drops of 20% formalin for microscopic examination. The liquor was then examined for phyto-parasitic nematodes using the x4, x10 and x40 objectives of electronic microscope on a glass slide.

Identification of nematodes: The identification and counting of nematodes was done to genera level using pictorial keys according to Mekete et al. (2012).

Data Analysis

Nematode prevalence was gotten using n x 100/N. The test for significance on nematode dynamics in relation to season was done in the special package for social science version 23 using paired sample t-test at 95 % significance within and between seasons. Shannon Winner diversity index analysis was done using ∑pi x Inpi and evenness was displayed using H/Hmaxi.

Results

Nematode assemblage at dry season

During the dry season, 216 nematodes were reportedly extracted from the agricultural soil in Abua. These nematodes were vertically distributed between 0.15 cm (42.1%) and 16 -30 cm (58.9%) core depths. Parasitic nematodes observed during the dry season were *Pratylenchus* 41 (19.0), *Meloidogyne* 37 (17.1%), *Ditylenchus* 5 (2.3%), *Heterodera* 25 (11.6%), *Tylenchus* 18 (8.3%), *Longidorus* 33 (15.3%), *Helicotylenchus* 19 (8.8%) and *Hemicyclophora* 38 (17.6%). Nematode distribution at dry season against core depth was statistically significant $p<0.05$.

Table 1: Nematode assemblage at dry season

	Depth related	**assemblage**	
Nematode genera	**0-20 cm (%)**	**21-40 cm (%)**	**Total (%)**
***Ditylenchus* spp**	5 %.0)	0	5 (2.3)
***Heterodera* spp**	4 (4.4)	21 (16.8)	25 (11.6)
***Helicotylenchus* spp**	12 (13.2)	7 (5.6)	19 (8.8)
***Hemicyclophora* spp**	21 (23.0)	17 (13.6)	38 (17.6)
***Longidorus* spp**	8 (8.8)	25 (20.0)	33 (15.3)
***Meloidogyne* spp**	16 (17.6)	21 (16.8)	37 (17.1)
***Pratylenchus* spp**	18 (19.8)	23 (18.4)	41 (19.0)
***Tylenchus* spp**	7 (7.7)	11 (8.8)	18 (8.3)
Total	**91 (100)**	**125 (100)**	**216 (100)**

Pv = .223

Occurrence of Nematodes in Agroecosystem During Wet Season

During the wet season, nematode occurrence was 310. These parasitic pests were unevenly distributed across the core depths sampled. For 0-15 cm core depth, a total of 217 (70.0%) were recovered and 93 (30.0%) were noticed from 16-30 cm core depth respectively. The phyto-parasitic nematode genera so reported were *Meloidogyne* 54 (17.4%), *Heterodera* 46 (14.8%), *Globodera* 33 (10.6%), *Hoplolaimus* 28 (9.0%), *Scutellonema* 28 (9.0), *Xiphenema* 27 (8.7%), *Rotylenchus* 22 (7.1%), *Tylenchorhynchus* 20 (6.5), *Ditylenchus* 18 (5.8), *Helicotylenchus* 14 (4.5), *Aphelenchus* 12 (3.8%) and *Pratylenchus* 8 (2.6%).

Table 2: **Occurrence of nematodes in agroecosystem during wet season**

	Depth related assemblage		
Nematode genera	**0-20 cm (%)**	**21-40cm (%)**	**Total (%)**
Meloidogyne spp	42	12	54 (17.4)
Heterodera	31	15	46 (14.8)
Globodera	21	12	33 (10.6)
Hoplolaimus	21	7	28 (9.0)
Scutellonema	22	6	28 (9.0)
Xiphenema	17	10	27 (8.7)
Rotylenchus	11	11	22 (7.1)
Tylenchorhynchus	12	8	20 (6.5)
Ditylenchus	18	0	18 (5.8)
Helicotylenchus	14	0	14 (4.5)
Aphelenchus	2	10	12 (3.8)
Pratylenchus	6	2	8 (2.6)
Total	**217**	**93**	**310**

Pv - .121

Nematode Dynamics During Dry and Wet Seasons in Agroecosystem

Soil analysis in this study revealed a total of 526 nematodes during dry and wet seasons. Out of the 526 nematodes recovered, 216 (41.0 %) were seen during the dry season and 310 (59.0%) were reportedly seen at wet season.

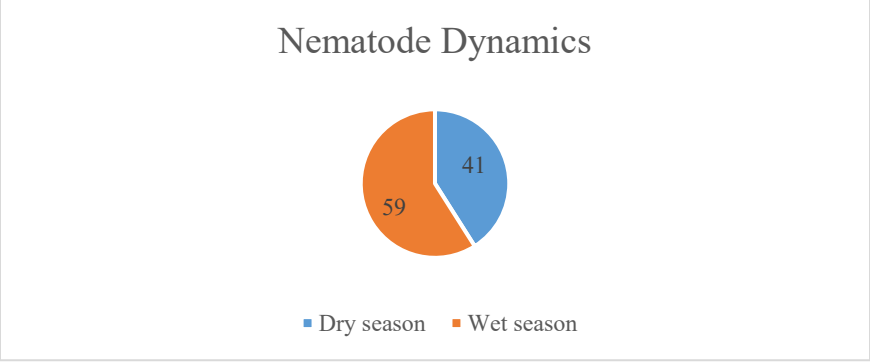


Fig 1: Nematode dynamic during dry and wet seasons in agroecosystem

Discussion

Soil inhabiting organisms including phyto-parasitic nematodes are highly sensitive to abiotic stimuli impacting on the conduciveness of the soil ecosystem. Stimuli such as seasonal disparities may favour survival at one point and could pose survival threat at some point and vice versa. Therefore, this study tested the effects of seasonal disparities as a driving force of phyto-parasitic nematode dynamics in agroecosystems. The study established that nematode population dynamics and species distribution across core depth are greatly influenced by edaphic parameters such as adequate soil water content and optimum temperature which are directly regulated by seasonal variability.

Result as shown in this study revealed that phyto-parasitic nematodes display higher assemblage down the soil core depth compare to the observation at surface depth during dry season. This observation can be ascribed to nutrient flow pattern which are directly influenced by disparities in seasons. It is quite obvious that during the dry season water content in soil was limited at surface soil, with a corresponding increase in temperature. However, deep down soil was relatively humid with moderate temperature. This scenario poses survival threat to phyto-parasitic nematodes at surface soil and forces species to display vertical migration deep down for safety. This result agrees with Ekine and Ezenwaka (2024) who reported that increased soil temperature obvious at top soil during dry season compels nematodes into anhydrobiosis and discourages proliferation. During dry season, surface soil usually experiences some level of dryness due to evaporation and continuous down flow of water and nutrient leaving residual organism with limited source of nourishment for active metabolic activities. Since phyto-parasitic nematodes survives on nutritional content in soil and plant tissues, rapid migration down the soil core depth becomes critical for survival each time surface soil get drier due to shift in season.

Phyto-parasitic nematodes were reportedly higher in numbers at top soil during the wet season. Although the distribution was not significant ($p>.05$). This observation suggests that the wet season activate fresh organic input, optimum water content, nutrient circulation and improves higher microbial biomass. Adequate or near optimum water content in soil during wet season support nematode propagation and ameliorate populations. This observation concurs with Kumkum (2024) and Ekine and Ezenwaka (2024) who reported that sufficient water content in soil propels rapid propagation and sedentary movement of nematodes in soil ecosystem. However, fluctuations in soil water contents due to disparity or shift in season can also promote or restrain the populations of plant feeding nematodes in soil (Emeriewen & Ekine, 2025). Overall nematode abundance was higher in wet season compare to dry season. This observation is indicative that the reactions in soil ecosystem at wet season are comparatively favourable for nematodes to thrive. This remark agrees with Emeriewen and Ekine, (2025), Chen et al. (2021), Shearer and Ezenwa (2020) who in different reports summit that wet season accompanied with rainfall ensure the availability of sufficient water in soil and supports nematode development, and enhance assemblage in soil ecosystem. Adequate moisture

prompt optimum temperature for juvenile survival and facilitate sedentary motion and nutrient consumption (Emeriewen and Ekine, 2025; Chen et al., 2021).

Nematode occurrence showed variation with regards to season. For instance, genera such as *Pratylenchus* species (19.0%), *Meloidogyne* species (17.1%), *Hemicyclophora* species (17.6%) and *Longidorus* species (15.3%) displayed higher assemblage during the wet season. However, the populations of *Meloidogyne* species (17.4%), *Heterodera* species (14.8%), *Globodera* species (10.6%) and *Hoplolaimus* (9.0%) were prevalent at dry season. This observation depicts that seasonal disparity is a major index driving nematode dynamics in soil. The prevalence of *Meloidogyne* species (17.4%), *Heterodera* species (14.8%), *Globodera* species (10.6%) and *Hoplolaimus* (9.0%) at dry season suggests that they were able to established by means of tolerance mechanism on environmental stress posts due to change in season. This submission is in conformance with the report of Daramola, et al. (2021). Nevertheless, the appearance of genera such as *Hoplolaimus, Scutellonema, Xiphenema, Rotylenchus,* and *Globodera* which were conspicuously missing during the dry season at wet season implied that soil water supports broader ecological functionality and enhances species richness. The result as seen in this study suggests that a switch in season can shift ecological equilibrium among trophic groups and may promote advantage on certain species and inhibit other species. Considering the overall displayed in this study, it can be established that at wet season, increased water content and adequate flow of nutrient possibly increased the rate of nematode survival within soil and can discourage root infestation when not minding availability. However, severe conditions pose during dry season can intensify root penetration and potentially increases tissue damage as a survival option for phyto-parasitic nematodes against down ward migration. A scenario that could impact crop yield in a negative manner.

Conclusion

Considering the scenario on nematode occurrence with regards to season, the study established that disparity in season constitute a significant force manipulating nematode dynamics in agroecosystems. Wet seasons raises survival chances of juvenile, ensure adequate water content in soil and increases nematode populations. The dry season post some level of stress on phyto-parasitic nematodes which could restrain motility, compel down ward migration, prompt anhydrobiosis and intensifies root tissue penetration. Seasonal disparity can prompt a shift in microbial associations to the survival advantage of certain phyto-parasitic nematodes and inhibits the populations of others in the ecosystem.

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