SPATIAL AND TEMPORAL DISTRIBUTION OF PLANT-PARASITIC NEMATODES ASSOCIATED WITH BANANA AND ORANGE FROM ORCHARDS IN IBADAN, NIGERIA.

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Abstract

The distribution of nematode populations associated with banana and sweet orange trees were assessed in this study. Soil and root samples were collected from sweet orange trees and banana plants from the University of Ibadan (UI); Forestry Research Institute of Nigeria (FRIN), Ibadan; International Institute of Tropical Agriculture (IITA), Ibadan; National Institute of Horticultural Research (NIHORT) Ibadan; and a farmer's orchard at Omi-Adio near Ibadan in order to determine the plant-parasitic nematodes associated with them over time and space. The samples were taken during the rainy season and the dry season. Soil samples were taken at depths of 0-10, 11-30 and 31-50 cm and 0, 50 and 100 cm away from the plant bases. Nematodes were identified and counted. Thirteen plant-parasitic nematodes were associated with both plants with Pratylenchus sp., Helicotylenchus sp. and Meloidogyne sp. being the most abundant in both seasons. However, the nematode populations in the dry season were significantly fewer than in the rainy season. Plant-parasitic nematodes associated with banana were more abundant at shallow depths (10-20 cm) and at nearer distances to the plant (0-50 cm). In orange trees, however, nematodes were deeper in the soil (30-50 cm) and at further distances from the tree (up to 1 m). The distribution of nematodes over time and space in both plants differ, probably due to the rooting system of the plants, and should be taken into consideration when sampling for root and soil pathogens.

Key words: nematode distribution, nematode population, *Musa sp. Pratylenchus sp.* orchard

Introduction

Fruits provide vital nutrients for health and well-being of mankind; nutrients that may not be provided adequately from the staple diets of most Africans. The trees that produce these fruits therefore need to be sustainably maintained. Fruit tree orchards can be productive for longer years if nematodes diseases are detected early and managed. Understanding the nematode parasites of the fruit-bearing trees is closely linked in maintaining the productivity of such trees. Plant-parasitic nematodes contribute significantly to the decline in productivity of orchards. When well-managed, citrus orchards can be productive for more than60 years (Mabbett, 2012) and banana for up to 15 years (Bathan and Lantican, 2010). Yield losses due to *nematodes* are in the range of 10% to 30% in citrus orchards (Verdejo-Lucas and McKenry, 2004). Older citrus trees slowly decline and reduce in fruit production while young trees grow poorly if replanted into nematode-infested soils (Duncan and Cohn, 1990).*Nematodes were detected* in 14 of the 17 banana production sites surveyed, this represented 82% of the whole production area in Côte d'Ivoire(Gnonhouri*et al.*, 2009). The banana orchard lifetime was almost two times longer in locations where no or low nematode populations were found compared to where densities were high. The yield responses reported with nematicide applications to dessert and cooking bananas have been up to 275% greater than untreated controls (Gowen *et al.*, 2005). In Nigeria, plant-parasitic nematodes can account for between 50-90% yield loss in *Musa* spp. due to late and reduced fruiting and toppling over of plants as a result of weakened roots(Speijer *et al.*, 1997; Speijer and Fogain, 1999; Olaniyi 2011).

Nematode damage is often overlooked because the above-ground symptoms are non-specific and difficult to distinguish from effects of other factors. Nematode populations usually exist in patches of high population densities. Thus typical symptoms include poor vigour in patches of few to dozens of trees. This patchy, uneven growth caused by plant-parasitic nematodes may occur within an orchard with uniform soil conditions. It is therefore important to confirm that such symptoms are caused by nematodes by taking samples from orchards in time and space intervals.

Knowledge of the vertical, horizontal and seasonal distribution of plant-parasitic nematodes is important in order to determine nematode species and populations associated with plants and how they are distributed around their hosts. This information is key to determining if management options are necessary and what specific management option would be appropriate for specific nematode-host situation. This is particularly important since many cultural control measures such as fallowing or rotation are not practical for tree crop systems.

Many plant parasitic nematode species are important pests of orchard crops. They damage the plant by directly attacking roots and subsequently predisposing them to secondary infections by bacteria and fungi, by causing replant and preplant problems of orchards and also by transmission of plant viruses. The economically important species belong to the genera *Criconemella*, *Meloidogyne*, *Pratylenchus*, *Xiphinema*, and *Trichodorus* and are widely distributed in fruit orchards throughout the world (Nyczepir and Becker 1998; *Lišková1, 2007*). The plant-parasitic nematodes associated with banana and sweet orange trees were sampled over space and seasons in order to provide information on the types numbers and distribution of these nematodes on banana, and orange orchards in Ibadan.

Materials and Methods

Collection of Samples

Banana (*Musa sp.*) and orange (*Citrus sinensis*) plants in four locations around Ibadan were sampled for the plant-parasitic nematodes. The sampling was conducted from groves and orchards at the International Institute of Tropical Agriculture (IITA), University of Ibadan (UI), Nigerian Horticultural Institute (NIHORT) and a farm in Omi Adio. Ten individual trees per fruit tree were sampled in each location using a half cylinder soil auger 30 cm long and 5 cm wide. Sampling was done at depths of 0-10, 11-30, and 31-50 cm and at 0, 50 and 100 cm away from the trunk base. Samples were taken along an X-shaped line drawn from the base of each plant, and four samples were taken per sample point around each tree, these were bulked to make a composite sample for each sampling point per tree. Samples were taken in the dry season (January to February) and in the rainy season (July to August). Samples of feeder roots weighing 5-10 g were taken also from the ten trees per tree species sampled in each location. Root and soil samples were placed together in polythene bags (70 cm x 40 cm). Samples per depth and distance were collected in separate bags, properly labeled and taken to the Nematology Laboratory of the Department of Crop Protection and Environmental Biology, University of Ibadan for processing.

Nematode extraction from soil and root samples

Each soil sample was thoroughly mixed and 200 cm^3 was measured out for extraction. Soil extraction was by the tray method (Whitehead and Hemming 1965; Coyne *et al*., 2007). Roots were examined for nematode damage and root pieces showing symptoms of galling or necrosis were selected and placed in a little water in petri dishes. These roots were later teased in order to observe sedentary endoparasites. The remaining roots were then rinsed and allowed to drain over paper towels. Then they were then chopped into 1-2 cm pieces and weighed. Extraction of the weighed roots was done using the tray method as previously mentioned. After 48 hrs the nematode extracts were poured into beakers and allowed to settle overnight. The extracts were then concentrated to 10 mls for counting.

Data Collection and analyses of data

Counting was performed by viewing 2 ml aliquots of each extract dispensed in a counting slide under a microscope at x100 magnification (10x objective by 10x eye piece). Tally counters were used for the enumeration while identification was done using the nematode key of Mai *et al.* (1996). Roots were scored for presence or absence of nematode damage. Descriptive statistics and analysis of variance (ANOVA) were used as appropriate for the data generated. Means were separated using LSD at 5% probability where necessary.

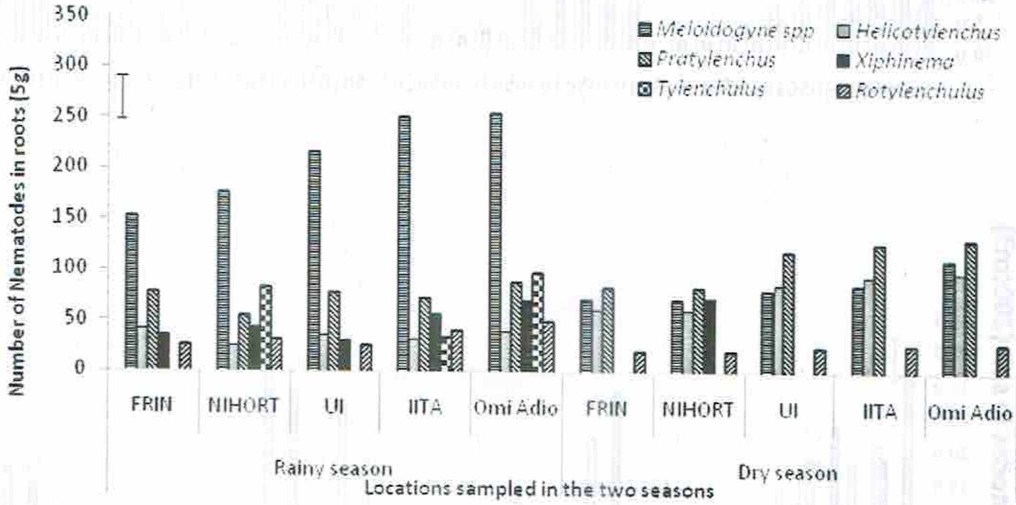

Figure 1. Populations of nematodes associated with roots of banana and orange plants growing in locations within Ibadan in the rainy (August-September) and dry (December-January)season. Bars (Values) are means of 10 samples; Error Bar = $LSD_{(0.05)}$.

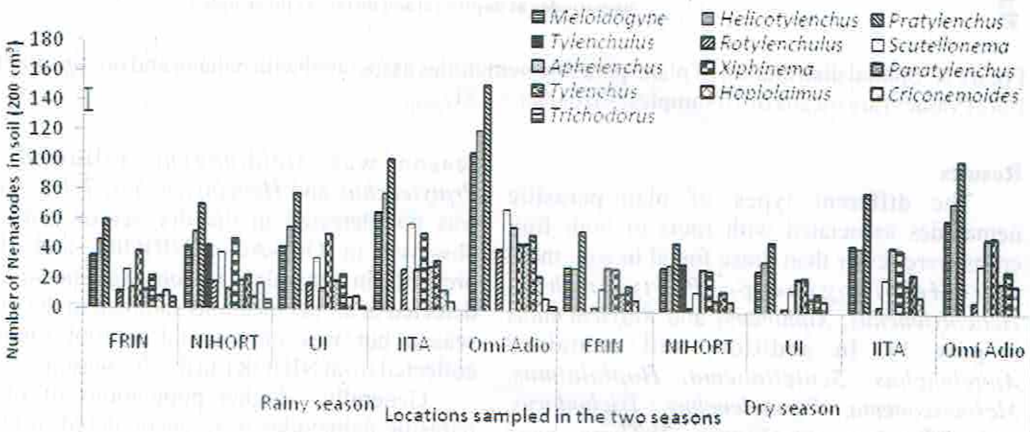

Figure 2. Nematode populations in soil from banana and citrus orchards located in Ibadan during the rainy (August-September) and dry (December-January)season.

Bars (values) are means of 10 samples. Error bar = $LSD_{(0.05)}$

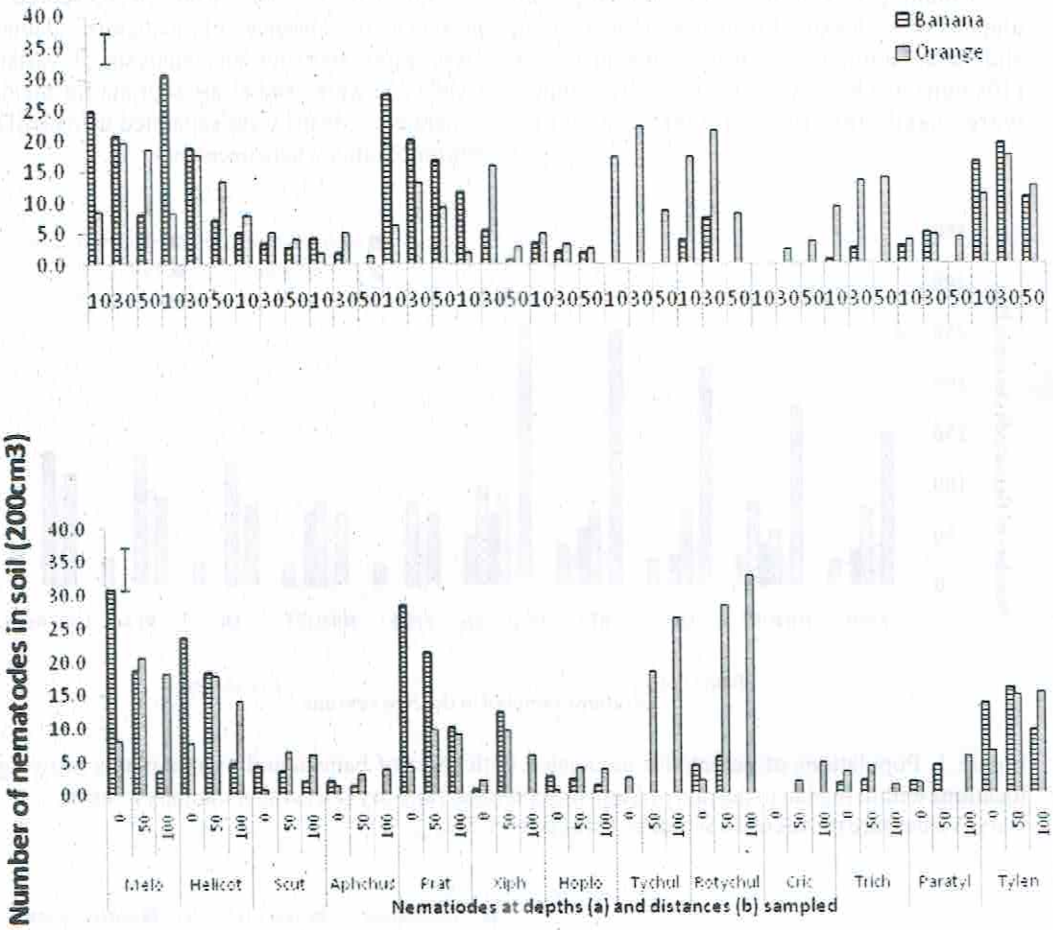

Figure 3. Spatial distribution of plant-parasitic nematodes associated with banana and orange plants. Bars (Values) are means of 10 samples; Error Bar = $LSD_{(0.05)}$.

Results

The different types of plant-parasitic nematodes associated with roots of both fruit crops were fewer than those found in soil, these were *Meloidogyne* sp, *Pratylenchus*, *Helicotylenchus*, *Xiphinema* and *Rotylenchulus* (Figure 1). In addition, soil contained *Aphelenchus*, *Scutellonema*, *Hoplolaimus*, *Mesocriconema*, *Paratylenchus*, *Trichodorus*, and *Tylenchus* spp.(Figure 2).There were significantly more nematodes observed in plant roots collected in the rainy season compared to the dry season (Figure 1). The most abundant nematode genus found in root samples in the dry season was *Meloidogyne* followed by *Pratylenchus* and *Helicotylenchus*. *Tylenchulus* was not detected in the dry season but was observed in Omi-Adio, NIHORT and IITA orchards in the rainy season. *Xiphinema* was detected in all the locations sampled in the rainy season but was only found in root samples collected from NIHORT in the dry season.

Generally, higher populations of plant-parasitic nematodes were encountered in Omi-Adio orchard than other locations and these populations were significantly higher than in Forestry Research Institute of Nigeria (FRIN), Nation Institute of Horticultural Research (NIHORT) and University of Ibadan (UI) but not significantly higher than the populations found in the International Institute of Tropical Agriculture ((IITA) orchards. *Pratylenchus* was the most abundant genus detected in soil samples in both seasons and its population was significantly higher ($P \leq 0.05$) than the populations of other nematodes. This was followed by *Helicotylenchus* and *Meloidogyne* populations with *Helicotylenchus* being more but not significantly so. Most of the other nematodes had a population ranging between 10 – 50 nematodes per 200 cm^3. *Trichodorus* was found in low populations only in the rainy season in all locations except IITA orchard. *Tylenchulus* was found in only one location (NIHORT) and it was detected in the two seasons.

The plant-parasitic nematodes associated with both plants are quite similar, however, *Tylenchulus* was only associated with orange trees. Populations of *Rotylenchuclus*, *Xiphinema*, *Mesocriconema* and *Trichodorus* where significantly higher in orange trees than in banana. The population of plant-parasitic nematode associated with banana generally reduced with increasing depth. Significantly more *Meloidogyne*, *Helicotylenchus* and *Pratylenchus* were found at depths 0 – 10 cm compared to 11-30 cm while significantly fewer nematodes were found beyond 30 cm deep in banana plants. On the other hand, nematode populations associated with orange had significantly higher populations at depths of 11-20cm compared to either below 10cm or above 30cm. *Pratylenchus*, *Meloidogyne* and *Helicotylenchus* assiciated with banana were most abundant ($p \leq 0.05$) at 0cm from the plant, populations were also well detected 50 cm away from the plant. However, at 100 cm away from the plant, significantly fewer nematodes were found relative to the other sampling points. In the orange orchards, the higher ($p \leq 0.05$) populations of nematodes were found between 50 cm to 100 cm away from the plant with the fewest ($p \leq 0.05$) nematodes found at the 0 cm from the pant.

Discussion

An understanding of the distribution of nematode populations on perennial crops is a major factor, not only in the productivity of the orchards but, in the ability of the orchard to be productive for many years. It also has an implication on the management strategy to be employed for the specific nematodes. The nematodes found associated with citrus in this study, *Meloidogyne*, *Pratylenchus*, *Helicotylenchus*, *Tylenchulus*, *Rotylenchulus*, *Mesocriconema Xiphinema* and *Tricodorus* have also been found associated with the crop in other studies. Dias-Arieira (2010) found *Tylenchulus semipenetrans*, *Meloidogyne*, *Pratylenchus*, *Helicotylenchus*, *Xiphinema*, *Trichodorus*, *Mesocriconema* and *Dolichodorus* associated with citrus in Brazil. In Ghana, nematodes associated with Citrus were *Pratylenchus*, *Helicotylenchus*, *Meloidogyne and Mesocriconema* (Addoh, 1971). In Nigeria however, *Pratylenchus brachyurus*, *Rotylenchus reniformis*, *Helicotylenchus spp*., *Meloidogyne spp*., and *Scutellonema bradys* were reported to be associated with citrus orchards (Nicol *et al*., 2011). It is possible that the systematic method employed in the methods used for this study was able to yield more nematodes than the study of Nicol *et al* 2011. The Nematodes associated with banana from this study were also identified in the study of Ononuju and Fawole(2000) and Olaniyi (2011).No *Radophlus similis* was found in this study as has been reported by Coyne *et al*.(2005) and Olaniyi (2011) although Ononuju and Fawole also did not find *Radopolus sp*. in their survey in Western Nigeria. Additional information provided by this study is that even though nematode populations reduce in the dry season, they can remain at a population high enough to cause damage and can be devastating when combined with the stress imposed on the plant by lack of water. Indeed the symptoms of nematode attack on banana becomes more obvious in the dry season where many plants topple over due to weakened root anchorage.

Sampling for nematodes in banana plants at depths of 10 cm and not more than 50 cm away from the plants pseudostem yields more nematodes than at any other point sampled for in this study. In citrus, nematodes are better sampled for between 10 -20 cm and 50-100 cm from the plant stem. Some studies have recommended that sampling for citrus should be within the edges of the tree canopy (Edwards and Nambier, 2011).However, in this study, it was observed that populations did not increase significantly between 50 cm and 100 cm away from the plant and in fact populations reduced slightly at 100 cm compared to 50 cm for *Pratylenchus*, *Helicotylenchus* and *Meloidogyne*, the most frequently occurring nematodes in orange. Sampling for nematodes has often been generally in the rhizosphere, this study in addition provides specifics on where nematodes are most likely to be found in the *Musa* sp. and *Citrus* spp.

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