

Plant-Parasitic Nematodes Associated With Pepper (*Capsicum* spp) in Benue State

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ABSTRACT. This study was carried out to provide some information on the occurrence, diversity and abundance of plant-parasitic nematodes on pepper in Benue State. A survey of pepper-producing farms was carried out between July and September, 2009. Eleven Local Government Areas (LGA) were surveyed, two villages per Local Government Area and two farms per village that produced large quantities of pepper. Five soils samples were taken with hand trowel per farm, at 10-15cm from the base of the plants and at depth of 15-20cm. Pepper plants were uprooted with a hand trowel, five root samples per each farm were taken. A total of 220 samples were collected, bagged and labelled. The nematodes were extracted from the soil samples using the Pie-pan method, and maceration and pie-pan methods were used for the roots. The extracted nematodes were fixed, quantified and identified to genera at the Nematology Laboratory of the International Institute for Tropical Agriculture (IITA), Ibadan. Nematode population density and percentage nematode populations were estimated. The identified nematode genera were *Pratylenchus*, *Meloidogyne*, *Helicotylenchus*, *Tylenchus*, *Paratylenchus*, *Aphelenchus*, *Aphelenchoides*, *Scutellonema*, *Hoplolaimus*, *Criconemoides*, *Rotylenchulus*, *Tylenchulus* and *Hirschmanniella*. The most prominent genera in the soils and root samples were *Pratylenchus*, *Meloidogyne*, *Helicotylenchus*.

Keywords: *Helicotylenchus*, *Meloidogyne*, pepper, plant-parasitic nematodes, *Pratylenchus*

INTRODUCTION

Pepper, (*Capsicum spp.*), is one of the fruit vegetables grown in Benue and other States of Nigeria, for human consumption, supply of raw materials and commercial activities (Fayemi, 1999; FAOStat. 2009). Pepper is used also for medicinal, storage and pest control purposes (Fayemi, 1999; Nworgu, 2006; Odugbemi and Akinsulire, 2006). Pepper production is being threatened by biotic and abiotic factors such as insects, fungi, bacteria, weeds, viruses, nematodes, soil type, soil fertility and soil moisture (Terry-Kelly and Boyhan, 2009).

Plant-parasitic nematodes are an extremely important factor in vegetable production worldwide and in many areas a major factor requiring the use of pesticides (Sikora and Fernandez, 2005; Baimey *et al.* 2009). Yield losses of 74-78% and 100% in pepper production due to root-knot nematodes have been reported (Sogut and Elekcioglu, 2007; Olabiyi and Oyedunmade, 2008).

There is the lack of information on the occurrence, diversity and distribution of plant-parasitic nematodes on pepper in Benue State and Nigeria; thus the need for this study.

MATERIALS AND METHODS

Sampling sites and procedure

The survey was carried out in Benue between July and September 2009. Eleven Local Government Areas namely; Apa, Agatu, Buruku, Gboko, Guma, Konshisha, Makurdi, Ohimini, Otukpo, Tarka and Ushongo which were selected on the basis of production and the number of cultivars grown (Baimey *et al.*, 2009). Two villages per Local Government Area and two farms per village were visited. Five soil samples, 200 ml soil each taken in zig-zag nature from the pepper plots with the aid of hand trowel 10-15cm from the base of the plants, at the depth of 15-20cm (Ali and Sharma, 2003). The pepper plant were uprooted with the aid of hand trowel (Coyne *et al.*, 2007), and five root samples per farm were taken. The soil and root samples were bagged and labelled, and a total of two hundred and twenty-two samples were collected.

Nematode extraction and procedure

Nematodes were extracted from soil and root samples for 24- 48 hrs. Each soil sample, 200 cm³ was thoroughly mixed and the Pie-pan method (Whitehead and Hemming, 1965) was used, and the root samples washed, cut into small pieces and maceration method (Coyne *et al.*, 2007) and Pie-pan method (Whitehead and Hemming, 1965) were used. The extracted nematodes were killed and fixed by adding equal amounts of boiling water to the nematode suspension with four percent formaldehyde (Fourie *et al.*, 2001; Baimey *et al.*, 2009).

Nematode Identification

The extracted nematodes were identified to the genera level at the Nematology Laboratory of the International Institute for Tropical Agriculture (IITA) Ibadan, using the schemes of Mai and Lyon (1975), Mai and

Mullin (1996), Stirling *et al.* (2002) and Hunt *et al.* (2005) with the aid of Olympus compound microscope. The nematode suspensions were mixed using a magnetic stirrer and one 2 ml aliquot was drawn from each suspension into a counting slide for the identification and quantification of the extracted nematodes.

Percentage frequency and percentage nematode population were calculated as follows:

$$\text{Percentage frequency} = \frac{n}{N} \times 100\%$$

Where n= number of times an individual nematode occurred in all samples

N= sample size

$$\text{Percentage nematode population} = \frac{\sum n_i}{TN} \times 100\%$$

Where $\sum n_i$ = Individual nematode population of all the same (Ononuju and Fawole, 1999; Adegbite *et al.*, 2006).

RESULTS

The frequency of occurrence of the plant-parasitic nematode genera associated with pepper in Benue State was found to vary (Table 1). In the soils of Apa LGA *Meloidogyne* (31.4%) and *Pratylenchus* (20.7%) were the most frequently encountered and *Mesocriconema* (1.4%) was the least frequently encountered.

Table 1. Mean percentage frequency rating of identified plant-parasitic nematodes associated with pepper in 11 LGAS of Benue State (200ml soil and 10g roots)

| LGA | Plant-parasitic nematodes genera | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------|----------------------------------|-------|-------|-------|--------|-------|-------|-------|-------|------|---------|------|-------|------|--------|------|-------|------|--------|------|---------|------|-------|------|--------|------|---|
| | Meloid | | Praty | | Helico | | Tylen | | Aphel | | Aphelen | | Hoplo | | Paraty | | Scute | | Hirsch | | Tylench | | Rotyl | | Cricon | | |
| | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | |
| Apa | 31.4 | 38.8 | 20.7 | 26.3 | 12.6 | 10.6 | 10.6 | 12.6 | 8.5 | 6.5 | 3.4 | - | 3.6 | 9.2 | 2.6 | - | 6.5 | - | - | - | - | - | - | - | - | 1.4 | - |
| Agatu | 35.2 | 34.4 | 21.8 | 22.5 | 12.5 | 12.6 | 10.5 | 4.6 | 6.0 | 10.0 | 3.4 | - | 3.4 | 8.4 | 2.6 | 4.6 | 4.6 | 2.1 | - | - | - | - | - | - | - | - | - |
| Otukpo | 30.3 | 30.3 | 24.4 | 35.5 | 14.4 | 12.4 | 10.6 | 8.3 | 6.4 | 6.8 | 3.6 | - | 3.6 | 5.1 | 2.6 | 1.6 | 3.6 | - | - | - | - | - | - | - | - | - | - |
| Ohimini | 34.6 | 35.4 | 24.2 | 26.6 | 16.4 | 14.8 | 10.5 | 11.7 | 5.4 | 4.4 | 2.0 | - | 2.0 | 7.4 | 1.0 | 3.0 | 4.2 | - | - | - | - | - | - | - | - | - | - |
| Gboko | 30.6 | 38.4 | 22.6 | 26.4 | 12.4 | 11.4 | 8.4 | 6.5 | 6.4 | 5.1 | 2.2 | - | 5.2 | 8.4 | 3.2 | - | 6.4 | 4.0 | - | - | 2.5 | - | - | - | - | - | - |
| Tarka | 23.1 | 38.6 | 31.4 | 24.5 | 14.6 | 16.4 | 10.4 | 10.4 | 4.8 | 6.0 | 4.2 | - | 3.2 | 5.1 | 2.1 | - | 5.2 | - | - | - | 1.0 | - | - | - | - | - | - |
| Guma | 32.9 | 35.6 | 29.4 | 26.4 | 15.4 | 11.4 | - | 9.8 | 6.5 | 5.4 | 2.7 | - | 3.6 | 3.8 | 4.0 | 3.0 | 4.2 | 4.2 | 1.3 | - | - | - | - | - | - | - | - |
| Buruku | 30.5 | 36.6 | 24.6 | 30.4 | 10.4 | 16.8 | 15.1 | 10.5 | 8.2 | 2.5 | 3.2 | - | 2.5 | 3.2 | 2.4 | - | 4.6 | - | 2.0 | - | - | - | - | - | - | - | - |
| Ushongo | 31.6 | 30.6 | 26.4 | 28.8 | 13.0 | 12.6 | 8.6 | 10.2 | 7.2 | 6.4 | 2.0 | - | 4.4 | - | 2.0 | 2.8 | 4.8 | 6.8 | - | - | - | - | - | 1.2 | - | - | - |
| Makurdi | 29.6 | 33.5 | 30.2 | 30.2 | 12.8 | 11.5 | 10.2 | 8.4 | 5.8 | 4.8 | 2.0 | - | 3.8 | 5.2 | 2.1 | 2.5 | 4.7 | 2.4 | - | - | - | - | - | - | - | - | - |
| Konshisha | 33.6 | 35.2 | 27.0 | 26.4 | 14.3 | 13.4 | 8.4 | 10.8 | 4.8 | 9.8 | 1.4 | - | 3.6 | 3.2 | 2.0 | 2.0 | 4.0 | - | - | - | - | - | - | - | - | - | - |
| Total - | 343.4 | 387.3 | 282.7 | 303.8 | 148.8 | 143.9 | 103.3 | 103.8 | 70 | 67.7 | 30.1 | - | 40.1 | 59 | 26.6 | 195 | 52.8 | 19.5 | 3.3 | - | 3.5 | - | - | 1.2 | 1.4 | - | - |
| X - | 31.2 | 35.2 | 25.7 | 27.6 | 13.5 | 13.0 | 9.3 | 9.4 | 6.3 | 6.1 | 2.7 | - | 9.0 | 5.3 | 2.4 | 1.7 | 4.8 | 1.7 | 0.3 | - | 0.3 | - | - | 0.1 | 0.1 | - | - |
| SD - | 11.2 | 9.5 | 11.0 | 24.0 | 5.2 | 6.5 | 11. | 47.2 | 5.1 | 6.9 | 2.7 | - | 2.8 | 8.8 | 2.3 | 5.0 | 5.4 | 7.4 | 2.1 | - | 2.4 | - | - | 1.1 | 1.3 | - | - |
| SE - | 3.3 | 2.9 | 3.3 | 7.2 | 1.2 | 1.9 | 3.42 | 2.2 | 1.5 | 2.1 | 0.8 | - | 0.8 | 2.6 | 0.7 | 0.5 | 1.6 | 0.2 | 0.1 | - | 0.1 | - | - | 0.0 | 0.0 | - | - |

Key: Meloid=*Medoidogyne*, Praty=*Pratylenchus*, Helico=*Helicotylendus*, Tylen=*Tylenchus*, Aphel=*Aphelenclus*, Aphelen=*Aphelenchoides*, Hoplo=*Hopolaimus*, Paraty=*Paratylenchus*, Scute=*Scutellonema*, Hirsch=*Hirschmaniella*, Tylench=*Tylenchulus*, Rotyl=*Rotylenchulus*, Crico=*Criconemoides*

From the roots *Meloidogyne* (38.8%) and *Pratylenchus* (26.3%) were the most frequently encountered and *Aphelenchus* (6.5%) was the least frequently encountered (Table 1). The most frequently encountered from the soils of Agatu LGA were *Meloidogyne* (35.2%) and *Pratylenchus* (21.8%) and *Paratylenchus* (2.6%) was the least frequently encountered while, from the pepper roots the most frequently encountered were *Meloidogyne* (34.4%) and *Pratylenchus* (22.5%) and *Scutellonema* (2.1%) was the least frequently encountered. In the soils of Otukpo LGA the most frequently encountered were *Meloidogyne* (30.3%) and *Pratylenchus* (24.4%) and *Paratylenchus* (2.6%) was the least frequently encountered, while from the roots *Meloidogyne* (30.3%) and *Pratylenchus* (35.5%) were the most frequently encountered and *Paratylenchus* (1.6%) was the least frequently encountered.

The most frequently encountered from the soils of Ohimini LGA were *Meloidogyne* (34.6%) and *Pratylenchus* (24.2%) and *Paratylenchus* (1.0%) was the least frequently encountered, while *Meloidogyne* (35.4%) and *Pratylenchus* (26.6%) were the most frequently encountered and *Paratylenchus* (3.0%) was the least frequently encountered from pepper roots. The most frequently encountered from soils of Gboko LGA were *Meloidogyne* (30.6%) and *Pratylenchus* (22.6%), and *Aphelenchoides* (2.2%) was the least frequently encountered, while *Meloidogyne* (38.8%) and *Pratylenchus* (26.4%) were the most frequently encountered and *Scutellonema* (4.0%) was the least frequently encountered

from the pepper roots. The most frequently encountered from soils of Tarka LGA were *Pratylenchus* (31.4%) and *Meloidogyne* (23.1%) and *Tylenchulus* (1.0%) was the least encountered, while the most frequently encountered from the pepper roots were *Meloidogyne* (38.6%) and *Pratylenchus* (24.5%) and *Hoplolaimus* (5.1%) was the least frequently encountered.

The most frequently encountered from the soils of Guma were *Meloidogyne* (32.9%) and *Pratylenchus* (29.4%) and *Hirschmaniella* (1.3%) was the least frequently encountered, while from the pepper roots *Meloidogyne* (35.6%) and *Pratylenchus* (26.4%) were the most frequently encountered and *Paratylenchus* (3.0%) was the least frequently encountered. The most frequently encountered from the soils of Buruku LGA were *Meloidogyne* (30.5%) and *Pratylenchus* (24.6%) and *Hirschmaniella* (2.0%) was the least frequently encountered, while from the pepper roots the most frequently encountered were *Meloidogyne* (36.6%) and *Pratylenchus* (30.4%) and *Aphelenchus* (2.5%) was the least frequently encountered. The most frequently encountered from the soils of Ushongo LGA were *Meloidogyne* (31.6%) and *Pratylenchus* (26.4%) and the least frequently encountered were *Aphelenchoides* and *Paratylenchus* (2.0%) each, while from the pepper roots the most frequently encountered were *Meloidogyne* (30.6%) and *Pratylenchus* (28.8%) and *Rotylenchulus* (1.2%) was the least frequently encountered.

The most frequently encountered from the soils of Makurdi LGA were *Pratylenchus* (30.2%) and *Meloidogyne*

(29.6%) and *Aphelenchoides* (2.0%) was the least frequently encountered, while *Meloidogyne* (33.5%) and *Pratylenchus* (30.2%) were the most frequently encountered and *Scutellonema* (2.4%) was the least frequently encountered from pepper roots. The most frequently encountered from the soils of Konshisha LGA were *Meloidogyne* (33.6%) and *Pratylenchus* (27.0%) and *Aphelenchoides* (1.4%) was the least encountered, while *Meloidogyne* (35.2%) and *Pratylenchus* (26.4%) were the most frequently encountered and *Paratylenchus* (2.0%) was the least frequently encountered among from the pepper roots.

The nematode population of the plant-parasitic nematode genera associated with pepper from 200 ml soils and 10g pepper roots were not even (Table 2). In the soils from Apa LGA the highest in population were *Meloidogyne* (2,200 J₂) and *Pratylenchus* (2,000 J₂) and the least was *Criconemoides* (200 J₂), while *Meloidogyne* (160 J₂) and *Pratylenchus* (100 J₂) were highest and *Helicotylenchus* and *Hoplolaimus* (40 J₂) the least respectively from pepper roots. The nematode population from the soils of Agatu LGA were *Meloidogyne* (2,400 J₂) and *Helicotylenchus* (1,800 J₂) were the highest, and *Paratylenchus* (200 J₂) the least, while from the pepper roots were *Meloidogyne* (170 J₂) and *Pratylenchus* (90 J₂) were highest and *Hoplolaimus* and *Scutellonema* (20 J₂) respectively were the lowest. The nematode population of the plant-parasitic nematodes from the soils of Otukpo LGA were *Meloidogyne* and *Helicotylenchus* (1,600 J₂) respectively were the highest, and *Paratylenchus* (400 J₂) was the least, while

Meloidogyne (110 J₂) and *Pratylenchus* (100 J₂) were the highest, and *Hoplolaimus* (30 J₂) was the least from pepper roots. The nematode population from the soils of Ohimini LGA the highest were *Pratylenchus* (2,800 J₂) and *Meloidogyne* (1,800 J₂) and the least was *Paratylenchus* (400 J₂), while from the roots the highest were *Meloidogyne* (90 J₂) and *Pratylenchus* (70 J₂) and *Aphelenchus* and *Hoplolaimus* (10 J₂) respectively were the least. The highest mean population from the soils of Gboko LGA were *Meloidogyne* and *Pratylenchus* (1,600 J₂) respectively, and *Tylenchulus* (200 J₂) was the least, while from the roots the highest were *Meloidogyne* (110 J₂) and *Pratylenchus* (100 J₂) and *Scutellonema* (10 J₂) was the least. The highest nematode population from the soils of Tarka LGA were *Pratylenchus* (2,400 J₂) and *Meloidogyne* (2,200 J₂), and *Tylenchulus* (200 J₂) was the least, while *Meloidogyne* (80 J₂) and *Pratylenchus* (70 J₂) were the highest and *Hoplolaimus*, *Tylenchus* and *Aphelenchus* (20 J₂) were the least respectively, from pepper roots. In the soils of Guma LGA, the highest nematode population were *Pratylenchus* (1,600 J₂) and *Meloidogyne* and *Helicotylenchus* (1,200 J₂) respectively.

Table 2. Mean population density of identified plant-parasitic nematodes association with pepper in 11 LGAS of Benue State (200ml soils and 10g roots)

| LGA | Plant-parasitic nematodes genera | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------|----------------------------------|--------|---------|-------|---------|-------|---------|-------|---------|-------|---------|------|--------|-------|--------|-------|--------|------|--------|------|---------|------|-------|------|--------|-------|------|------|
| | Meloid | | Praty | | Helico | | Tylen | | Aphel | | Aphelen | | Hoplo | | Paraty | | Scute | | Hirsch | | Tylench | | Rotyl | | Cricon | | | |
| | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root | Soil | Root |
| Apa | 2200 | 160 | 2000 | 100 | 1400 | 40 | 2000 | 70 | 1000 | 50 | 1000 | - | 600 | 40 | 400 | - | 800 | - | - | - | - | - | - | - | - | - | 200 | - |
| Agatu | 2400 | 170 | 1200 | 90 | 1800 | 40 | 2200 | 30 | 1600 | 50 | 400 | - | 600 | 20 | 200 | 30 | 600 | 20 | - | - | - | - | - | - | - | - | - | - |
| Otukpo | 1600 | 110 | 1400 | 100 | 1600 | 40 | 1400 | 40 | 1400 | 40 | 1400 | - | 1000 | 30 | 400 | 40 | 800 | - | - | - | - | - | - | - | - | - | - | - |
| Ohimini | 1800 | 90 | 2800 | 70 | 1600 | 30 | 2400 | 30 | 1600 | 10 | 1000 | - | 800 | 10 | 400 | 40 | 1200 | - | - | - | - | - | - | - | - | - | - | - |
| Gboko | 1600 | 110 | 1600 | 100 | 1400 | 20 | 2000 | 40 | 1000 | 20 | 800 | - | 800 | 30 | 600 | - | 800 | 10 | - | - | 200 | - | - | - | - | - | - | - |
| Tarka | 2200 | 80 | 2400 | 70 | 800 | 40 | 1800 | 20 | 1600 | 20 | 400 | - | 1200 | 20 | 1000 | - | 800 | - | - | - | 200 | - | - | - | - | - | - | - |
| Guma | 1200 | 80 | 1600 | 80 | 1200 | 30 | - | 20 | 1200 | 20 | 200 | - | 800 | 40 | 200 | 10 | 800 | 20 | 200 | - | - | - | - | - | - | - | - | - |
| Buruku | 1600 | 90 | 1400 | 100 | 1200 | 10 | 2400 | 40 | 1200 | 30 | 600 | - | 600 | 10 | 600 | - | 600 | - | 200 | - | - | - | - | - | - | - | - | - |
| Ushongo | 2200 | 110 | 1400 | 70 | 1200 | 20 | 2400 | 20 | 1000 | 30 | 400 | - | 800 | - | 400 | 30 | 600 | 20 | - | - | - | - | - | - | 10 | - | - | - |
| Makurdi | 1400 | 110 | 1600 | 90 | 1600 | 20 | 1600 | 40 | 1000 | 20 | 400 | - | 1000 | 30 | 600 | 20 | 600 | 10 | - | - | - | - | - | - | - | - | - | - |
| Konshisha | 1600 | 100 | 1400 | 80 | 1400 | 30 | 1400 | 20 | 800 | 30 | 200 | - | 1000 | 10 | 400 | 20 | 600 | - | - | - | - | - | - | - | - | - | - | - |
| Total - | 19800.0 | 1200.0 | 18800.0 | 950.0 | 15200.0 | 320.0 | 19600.0 | 370.0 | 13400.0 | 320.0 | 6800.0 | - | 9200.0 | 240.0 | 5200.0 | 190.0 | 8200.0 | 80.0 | 400 | - | 400 | - | - | - | 10.0 | 200.0 | - | - |
| X - | 1800.0 | 109.0 | 1709.0 | 86.3 | 1381.8 | 29.0 | 1781.8 | 33.6 | 1218.1 | 29.0 | 618.1 | - | 836.3 | 21.8 | 472.7 | 17.2 | 745.4 | 7.2 | 36.3 | - | 36.3 | - | - | - | 0.9 | 18.1 | - | - |
| SD - | 1232.8 | 94.2 | 2326.1 | 29.2 | 2750.2 | 33.0 | 2217.2 | 47.4 | 914.5 | 33.0 | 1215.0 | - | 620.8 | 41.9 | 708.3 | 51.1 | 572.0 | 28.6 | 255.8 | - | 25.5 | - | - | - | 9.5 | 190.6 | - | - |
| SE - | 373.6 | 28.5 | 704.8 | 8.8 | 833.3 | 10.0 | 671.9 | 14.3 | 277.1 | 10.0 | 368.1 | - | 188.1 | 12.7 | 214.6 | 15.5 | 173.3 | 3.6 | 7.5 | - | 7.5 | - | - | - | 0.1 | 7.7 | - | - |

Key: Meloid= *Meloidogyne*, Praty= *Pratylenchus*, Helico= *Helicotylenchus*, Tylen= *Tylenchus*, Aphel= *Aphelenchus*, Aphelen= *Aphelenchoides*, Hoplo= *Hoplolaimus*, Paraty= *Paratylenchus*, Scute= *Scutellonema*, Hirsch= *Hirschmaniella*, Tylench= *Tylenchulus*, Rotyl= *Rotylenchulus*, Cricon= *Criconemoides*.

The least were *Aphelenchoides*, *Paratylenchus* and *Hirschmaniella* (200 J₂) respectively, while the highest were *Meloidogyne* (80 J₂) and *Pratylenchus* (70 J₂) and the least were *Hoplolaimus*, *Tylenchus* and *Aphelenchus* (20 J₂) respectively were from pepper roots. The highest nematode population from the soils of Buruku LGA were *Meloidogyne* (1,600 J₂) and *Pratylenchus* (1,400 J₂), and *Hirschmaniella* (200 J₂) was the least, while *Pratylenchus* (100 J₂) and *Meloidogyne* (90 J₂) were the highest and *Helicotylenchus* and *Hoplolaimus* (10 J₂), respectively were the least from pepper roots.

The highest nematode population from the soils of Ushongo LGA were *Meloidogyne* (2,200 J₂) and *Pratylenchus* (1,400 J₂) and *Aphelenchoides* and *Paratylenchus* (400 J₂) respectively were the least, while *Meloidogyne* (100 J₂) and *Pratylenchus* (70 J₂), and *Rotylenchulus* (10 J₂) was the least from pepper roots. The highest nematode population from the soils of Makurdi LGA were *Pratylenchus* and *Helicotylenchus* (1,600 J₂) respectively and *Meloidogyne* (1,400 J₂) and *Aphelenchoides* (400 J₂) was the least, while *Meloidogyne* (110 J₂) and *Pratylenchus* (90 J₂) were highest and *Helicotylenchus* and *Scutellonema* (20 J₂) respectively were the least from pepper roots. The highest nematode population from the soils of Konshisha LGA were *Meloidogyne* (1,600 J₂), *Pratylenchus* and *Helicotylenchus* (1,400 J₂) respectively and *Aphelenchoides* (200 J₂) was the least, while *Meloidogyne* (110 J₂) and *Pratylenchus* (90 J₂) were the highest, and the least was *Scutellonema* (10 J₂) from pepper roots. The highest nematode population from 200 ml soils and 10g roots are shown in Table 2.

DISCUSSION

The plant-parasitic nematodes identified to be associated with pepper in Benue State were not evenly distributed and of varying population densities (Olabiya *et al.*, 2009), and it is generally assumed that the presence of the host plant is the main determinant of the population density of plant-parasitic nematodes, including soil type and cropping history (Baimey *et al.*, 2009). The majority of farmers cropping pepper in the State have small farm sizes, with continuous cropping of pepper either as sole cropping or mixed cropping with many years of farming. Nematodes are abundant in the soils of Nigeria, many which are parasites of plants including food crops and causing losses in both quantity and quality (Olabiya *et al.*, 2009).

Pepper is a good host for *Meloidogyne* and *Pratylenchus* (Adesiyan *et al.*, 1990; Sikora and Fernandez, 2005; Fawole, 2009) and recorded as important nematode pests on this crop (Sikora and Fernandez, 2005). *Meloidogyne* occurred in all the soil and root samples which conforms to the report that the root-knot nematodes occur whenever and wherever susceptible crops are grown, thus with a wide host range (Castagnose-Sereno, 2002; Barker, 2003). The dominance of *Meloidogyne* over other plant-parasitic on vegetable nematodes have been reported (Machado and Inomoto, 2001; Sikora and Fernandez, 2005). *Meloidogyne* have been identified to be associated with other vegetables and crops (Waliullah, 1992;

Fourie *et al.*, 2001; Baimey *et al.*, 2009; Bhan *et al.*, 2010; Bao and Neher, 2011).

Pratylenchus has been recorded to be associated with vegetables and identified as a nematodes pest of pepper (Adesiyan *et al.*, 1990; Waliullah, 1992; Baimey *et al.*, 2009). *Pratylenchus* was identified from all the soil and root samples in this study. All species of *Pratylenchus* should be considered of potential importance when encountered within the roots (Sikora and Fernandez, 2005), and the greatest damage on crops occurs when the lesion nematode interacts with the wilt-causing fungus, *Verticillium* Spp (Bao and Neher, 2011).

The reniform nematode (*Rotylenchulus*) though record lowest in the nematode population density among the identified plant parasitic nematodes associated with pepper in Benue state is the most important nematode affecting pepper after *Meloidogyne* but it is often neglected or overlooked where it occurs concomitantly with *Meloidogyne* (Sikora and Fernandez, 2005).

Helicotylenchus, *Scutellonema*, *Hoplolaimus* and *Aphelenchoides* have been reported to be associated with vegetable crops (Waliullah, 1992; Sikora and Fernandez, 2005; Baimey *et al.*, 2009) but their damage to vegetable production have not been determined (Sikora and Fernandez, 2005). *Hoplolaimus* is an important and widely distributed ectoparasite causing root damage and reduction of crop yield (Khan *et al.*, 2008).

In a survey conducted for a two year period on pepper crop, the resident

plant-parasitic nematodes in order of occurrence and population were *Meloidogyne incognita*, *Pratylenchus brachyurus* and *Hoplolaimus* spp (Nwanguma *et al.*, 2011).

In conclusion, the plant-parasitic nematodes associated with pepper in Benue State were *Pratylenchus*, *Meloidogyne*, *Helicotylenchus*, *Tylenchus*, *Paratylenchus*, *Aphelenchus*, *Aphelenchoides*, *Scutellonema*, *Hoplolaimus*, *Criconemoides*, *Rotylenchulus*, *Tylenchulus* and *Hirschmanniella* with varying population densities and population.

Implication of the study is that the cultivation of crops in Benue state stands a serious risk of decline in production due to attack and infection by the plant-parasitic nematodes which are abundant in the soils. There is the need for nematologists to be involved in the planning, management and production of crops in the State and Nigeria. Also, enlightenment of the farmers about plant-parasitic nematodes, on their effects and management should be encouraged in Benue State and Nigeria in general.

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