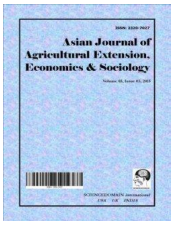

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# Awareness Status of Plant-parasitic Nematodes Occurrence and Damage among Farmers in Benue State, Nigeria

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***Authors' contributions***

*This research was carried out in collaboration between all authors. Author COE designed the study, managed analyses of the study and wrote the first draft. Author JIO edited the manuscript and provided laboratory guide while author POU supervised collection and collation of all field-based data. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aim:** Benue state is reportedly one of the most agrarian-inclined states in Nigeria. With almost all economic crops cultivated largely in rural communities within the state, the activities of pests and diseases continue to devastate most fields. Among these pests are plant-parasitic nematodes (PPNs). Hence the study was conducted to accentuate the prevalence and degree of PPN occurrence in Benue state for the first time.
**Methodology:** Using well-structured questionnaires 120 farmers were interviewed in six Local Government Areas (LGAs) in Benue State covering 12 districts to divulge the level of PPN awareness among rural farmers and in addition, the extent of PPN damage on their fields. Laboratory-based microscopy study was used to identify common PPN genera on farmers' fields.
**Results:** Among the results obtained, it was shown that of the number of respondents interviewed throughout the twelve districts, only 10% of farmers in 7 LGAs have heard of PPN as soil-borne

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damage-causing organism. In Tsambe, Mbatian, Mbaityu, Ukpekpe and Ibilla LGAs only 20% of the farmers have heard of nematode. Microscopy studies showed that average extent of nematode damage on plant roots and presence was 4.1 out of a scale of 1.0 to 5.0. A total of 7 families comprising 10 genera of plant-parasitic nematodes were recovered from composite root and soil samples collected from surveyed areas.

**Conclusion:** The level of awareness on plant-parasitic nematode occurrence and damage in Benue State is very low even though devastations on economic crops grown within the State is high. There is an urgent need to increase information dissemination among farmers within the studied state on PPNs with attendant campaigns on their management.

*Keywords: Plant-parasitic nematode; awareness; damage; extension; Benue State; Nigeria.*

## 1. INTRODUCTION

Nematodes are pseudocoelomate unsegmented worms, commonly described as thread-like, typically approximately 5 to 100 µm thick and at least 0.1 mm but less than 2.5 mm long [1]. Their roles in bioturbation, nutrient decomposition, nutrient mineralization, food web interactions and parasitism have been well documented [2,3,4]. They can be categorized into free-living nematodes in terrestrial, marine and freshwater habitats, and as parasites of animals (animal-parasitic) and plants (plant-parasitic). In agriculture, plant-parasitic nematodes (PPN) have been reported to be harmful to most economic crops and recent study has shown that root-knot nematodes are the most deleterious PPN in Africa with a wide plant host range [5].

A major global challenge in the coming years will be to ensure food security and to feed the increasing human population. Nowhere will the need to sustainably increase agricultural productivity in line with increasing demand be more pertinent than in resource-poor areas of the world, especially Africa, where populations are most rapidly expanding [6]. Although a 35% population increase is projected by 2050 (World Bank 2008), an increase in food demand in the order of 75% is anticipated, due to economic development and changes in food preferences [7].

Just like most countries in Africa, Nigeria is made up of predominantly agrarian communities cut across its thirty-six states and capital. Among these states, Benue largely known for its high level of agricultural activities represents one of the states with the highest number of farmers; hence associated pest problems are not uncommon. Even though some measure of crop yields have been obtained in the past, one of the besetting tasks confronting agricultural scientists within the state is development of sustainable agricultural approaches that will simultaneously increase crop yield and mitigate pests and disease populations [8].

To meet up with the demands of food supply, most research foci have targeted mitigation of plant-parasitic fungi, bacteria and weeds with little attention to plant-parasitic nematodes, the hidden enemy which account for huge losses in most economic crops. For example in a review of intractable biotic constraints to crop production in Africa, not a single mention of nematodes was made [9], while for potato crop in the UK alone, it is estimated that cyst nematodes, *Globodera rostochiensis* and *G. pallida*, account for an estimated ~$70 million per annum or 9% of UK production [10]. Reports on losses due to nematode attack remain scanty in most publications. Almost 28 years after findings of study were documented; the estimated 12.3% global annual yield loss due to PPN according to Veech and Dickson [11] is still widely referred to till date even though possibilities of PPN inocula accumulation over the years in crop fields, hence possibility of higher values of yield loss. Therefore for a state that is so entrenched in agriculture, mostly practiced by farmers with little or no formal education, awareness campaigns on PPN-related field problems is highly needful. Howbeit, with the formation and uprise of different nematological societies in Africa, this trend may drastically change and provide a more nematode-inclusive integrated management system of field pests and diseases. It is against this backdrop that this study was conducted to obtain information on farmers' knowledge and ability to identify nematode-related damage under field conditions plus the degree of PPN infestation on sampled farmers' fields in Benue state as a case study.

## 2. METHODOLOGY

### 2.1 Description of Study Area

Benue exemplifies a tropical environment that favours a wide spectrum of crops including vegetables, cereals, legumes, oil crops, tree crops and its typical roots and tubers [12], hence it is popularly referred to as the "Food Basket of the Nation" on the basis that agriculture is the main economic activity. With an estimated population of approximately 4.3 million people largely made up of farm families, majority of whom live in rural areas and are directly or indirectly involved in subsistence agriculture characterized by small farm holdings with an average farm size of 1.5-2.0 ha, the State is largely agrarian [13]. This research was carried out in three zones in Benue state – Zone A, B and C.

The study involved the use of both primary and secondary data in obtaining information necessary for analysis. Primary data were obtained by the use of structured questionnaires which was administered to the respondents. The questionnaires were structured in three sections; section "A" sought to obtain personal information on social-economic characteristics of the farmer respondents. Section "B" presents questions on the level of awareness of nematode. Section "C" presents questions on commonly utilized chemicals.

Secondary data relevant to this study were obtained from Journals, research reports, textbooks and Benue State Agricultural and Rural Development Authority (BNARDA) publications. Using multi-stage random sampling technique, a total of one hundred and twenty (120) small-scale farmers were selected for the study from six (6) local government areas (LGAs) of the State, which included; Vandeikya and Ukum (Zone A), Gwer-East and Gboko (Zone B), Okpokwu and Oju (Zone C) comprising two (2) districts per LGA as shown in Table 1 and Plate 1. A random selection of 10 farmers from each district in the study area was adopted. This study was conducted between June, 2014 and February, 2015 in 6 LGAs of Benue state.

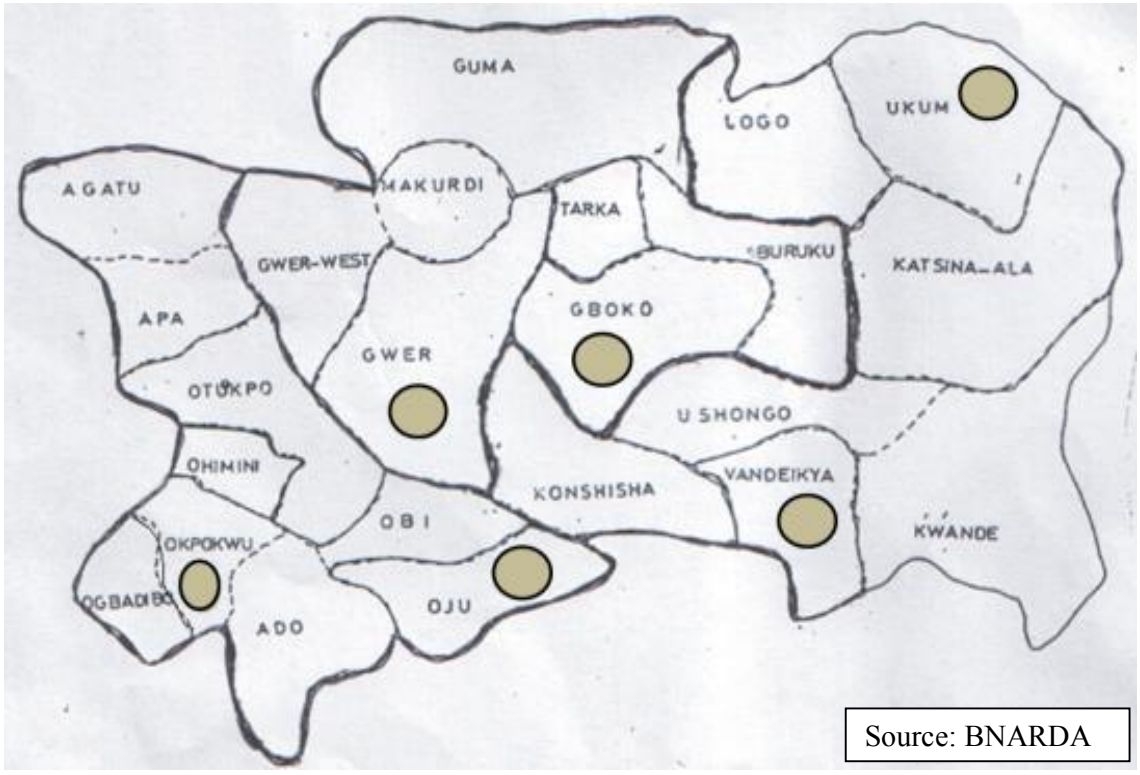



**Plate 1. Map of Benue State showing local government areas where study was conducted (green circles)**

## 2.2 Validation of Research Instrument

The data for the study were validated by pilot testing and by passing the research instrument through erudite agricultural extension experts at the Department of Agricultural Extension and Communication, University of Agriculture, Makurdi to ensure that it possessed both face and content validity.

## 2.3 Collection of Root and Soil Samples for Nematode Extraction

Soil and root/tuber samples, when possible were randomly taken from fields where tree crops, cereals, vegetables, root and tuber crops, and legumes were grown. Twenty (20) soil and root samples each from six (6) local government areas were collected at a depth of 5-20cm for all crops except tree crops in which sampling went as high as 50cm using auger. Each sample was placed in a plastic bag and properly labelled according to district and farm location of collection. All bags were arranged inside a cooler containing iced water to prevent samples from fast desiccating. Samples were then transported to Crop Protection Laboratory of the University of Agriculture, Makurdi where nematodes were extracted from the soil using Modified Baerman's Tray Method.

**Table 1. Designation of study areas**

| Zone | Local government area | District |
|---|---|---|
| A | Vandeikya | Tsambe and Mbadade |
| | Ukum | Shelev and Mbatian |
| B | Gwer East | Mbasombo and Shough |
| | Gboko | Ukpekpe and Mbaityu |
| C | Okpokwu | Ugbokolo and Edumoga |
| | Oju | Ainu and Ibilla |

*n = 120 respondents in total, 40 respondents/Zone*

## 2.4 Nematode Extraction and Identification

Extraction of nematodes from soil samples was done using the modification of WhiteHead and Hemming (1965) tray method [14]. Two plastic sieves of same diameter with a double-ply tissue paper sandwiched in between was setup. The setup was later placed in a plastic bowl of a bigger diameter. Soil samples were thoroughly mixed to obtain homogenous composite afterwards 200 g of each sample was distributed into the setup and left undisturbed for 48 hours. Collected roots/tuber samples were peeled into small pieces and thoroughly mixed according to district of collection. These samples were weighed and placed in an electric blender with just enough water to cover the blades for about 5 seconds bursts and tougher roots for two 10 second bursts, waiting for the suspension to settle briefly between the two blendings. Blended suspension of roots was poured into a beaker, rinsing out the blender container of all debris each time using a water bottle.

In a similar setup, suspensions of roots were then evenly spread into the inner sieves and water was introduced into each plastic bowl containing the sieves until the soil was sufficiently wet but without flooding the setup. The setup were left undistured for 18 hours after which sieves were swiftly removed leaving the nematode suspension in the bowl. The suspension was then poured into 500 ml Nalgene wash bottles and water added to bring the suspension to a fill level after which the suspension was left to settle for a minimum period of 5 hours siphoning. During the siphon process, a rubber tube of 3cm inside diameter filled with water was slipped into the sprout of the Nalgene bottles to begin siphoning until the siphoning process breaks at the factory-fixed level, leaving the cocentrated nematode suspension at the bottom of the Nalgene bottle. The nematode suspension was then transferred into 25 ml of McCartney bottle from which nematodes were picked, mounted on permanent slides and identified under a digital compound microscope. Attached to the microscope was a camera used for image capturing with the aid of TSView v. 6.1.3.9. Mai and Lyon [15] and Mekete et al. [16] were used as guide during nematode identification.

## 2.5 Data Analysis

The data were analysed with the aid of descriptive statistical tools such as means, percentages and frequency Tables using SPSS version 16.

# 3. RESULTS AND DISCUSSION

## 3.1 Socioeconomic Characteristics of Respondents

Socioeconomic characteristics of respondents were captured in questionnaires administered to farmers and findings are presented in Table 2. Findings show that, both females (42.5%) and males (57.5%) were into farming activities in the

study area. This is in line with previous reports that both men and women make significant contributions to farming output under small-scale livelihood agricultural systems [17,18]. Farming was the predominant occupation (60.8%), although some respondents were also involved in other occupations such as civil service (10.8%), private sector (4.2%) and self-employment (2.5%) jobs. About 15% engaged in part-time farming alongside their major occupation. A large proportion of the respondents were married (85.8%), while others were either unmarried (1.7%), widows (1.7%) or widowers (9.2%). A similar study observed that the marital status of a farmer could have significant influence on production decisions. They opined that in African traditional society, married men are considered to be more responsive since it is assumed that a person having family would want to have the best results that would translate to more output and consequently income to meet family needs [18,19].

Information on household size of respondents showed that 34.2% had between 8 and 11 persons living under the same roof or family compound. There were also families with household sizes greater than fifteen (30.8%) and less or equal to three (7.5%). Although the study didn't make enquiry as to the number of farmers' children actively involved in farming, previous reports show that agrarian activities under small-scale livelihoods are supported by most members of the household [20,21]. Hence from the study, it can be inferred that the number of available labour was high in the study areas. About 30% of the respondents had 21 –30 years of farming experience while 8.3% had over

30 years of farming experience. This implies that the farmers should be conversant with the average performance of soil on which they cultivate. Knowledge of the prominent visible pests, drainage characteristics and fertility gradient are normally known by the farmers given the long period of cultivation [22].

In terms of farmers' income, 47.5% earned between ₦51,000 and ₦150,000 per annum. Only 10.8% earned over ₦250,000 per annum. A wide range of crops were cultivated in the study areas and these included tree crops (12.5%), cereals (12.5%), vegetables (9.2), root and tubers (49.2%) and legumes (16.7%).

Based on farm hectarage under cultivation, 34.2% of respondents cultivated on 8 to 11ha across the districts, 6.7% cultivated on farmlands larger than 11ha. Ninety-seven (97) percent of respondents employ chemical control combined with other cultural methods in mitigating pests and weed problems on their farmland. Conversely, 23% do not use pesticides and herbicides but rely solely on cultural practices. On overall, the frequencies of respondents which employ cultural methods as a means of pest and weed control are presented in Table 2. About 70% maintain weed-free or repressed weed diversity on their farmlands by field sanitation, 25% plant resistant varieties, 44.2% practice rotational cropping to mitigate pest problems and about 21.7% boost crop health while as an indirect way of ensuring repressed populations of field pests and diseases or their inocula.

Table 3 showed the level of education of respondents in the six local government areas in Benue State. From the findings, on average, more than half of the respondents had no formal education (51.7%). However, a few were educated up to primary (13.3%), secondary (25%) and tertiary (10%) levels.

### 3.2 Nematode Awareness Status

Table 4 indicates nematode awareness level among farmers and the extent to which surveyed fields were infested with plant-parasitic nematodes. Results revealed that of the number of respondents interviewed throughout the twelve districts, only 10% have heard of nematode as a soil-borne damage-causing organism in Mbadade, Ugbokolo, Edumoga, Mbasombo, Shough, Shelev and Ainu. Although only 20% of respondents in Tsambe, Mbatian, Mbaityu, Ukpekpe and Ibilla have heard of nematode, findings showed that none of the respondents have seen a nematode before the period of this survey in nine districts except in Edumoga, Mbasombo and Mbaityu where only 10% of the respondents had seen a nematode pictorially. Knowledge of plant-parasitic nematode infection was extremely low in all districts studied. The major reasons for this low level of awareness may not be far-fetched as itemized in De Waele and Elsen [23], viz: microscopic nature of plant-parasitic nematodes, atypical above-ground symptoms caused by PPN, multispecies of nematode populations, PPN association/interation with other soil-borne pathogens, inadequate trained taxonomists in nematology, complexity of nematological surveys, lack of logistic and financial resources.

**Table 2. Socioeconomic characteristics of respondents in the study areas**

| Characteristic | | Frequency | Percentage (%) | Characteristic | | Frequency | Percentage (%) |
|---|---|---|---|---|---|---|---|
| **Sex** | | | | **Household size** | | | |
| | Male | 69 | 57.5 | | ≤ 3 | 9 | 7.5 |
| | Female | 51 | 42.5 | | 4 – 7 | 37 | 30.8 |
| **Occupation** | | | | | 8 – 11 | 41 | 34.2 |
| | Full-time Farming | 73 | 60.8 | | 12 – 15 | 8 | 6.7 |
| | Part-time Farming | 18 | 15.0 | | > 15 | 22 | 18.8 |
| | Civil Servant | 13 | 10.8 | | MV | 3 | |
| | Private Sector Employee | 5 | 4.2 | **Farming experience Years)** | | | |
| | Others | 3 | 2.5 | | ≤ 10 | 17 | 14.1 |
| | MV | 8 | | | 11 - 20 | 32 | 26.6 |
| **Marital status** | | | | | 21 - 30 | 36 | 30.0 |
| | Married | 103 | 85.8 | | >30 | 10 | 8.3 |
| | Divorced | 1 | 0.8 | | MV | 25 | |
| | Separated | 0 | 0 | **Annual Income (₦)** | | | |
| | Widow | 2 | 1.7 | | ≤ 50,000 | 28 | 23.3 |
| | Widower | 11 | 9.2 | | 51,000 – 150,000 | 57 | 47.5 |
| | Unmarried | 2 | 1.7 | | 151,000 – 250,000 | 16 | 13.3 |
| | MV | 1 | | | >250,000 | 13 | 10.8 |
| | | | | | MV | 6 | |
| **Farm Size (ha)** | | | | **Crops grown** | | | |
| | 0 - 3 | 9 | 7.5 | | Tree | 15 | 12.5 |
| | 4 – 7 | 37 | 30.8 | | Cereal | 15 | 12.5 |
| | 8 – 11 | 41 | 34.2 | | Vegetable | 11 | 9.2 |
| | >11 | 8 | 6.7 | | Root and Tuber | 59 | 49.2 |
| | MV | 25 | | | Legume | 20 | 16.7 |
| **Use of chemical control** | | | | [a]**Type of chemicals used** | | | |
| | Yes | 97 | 80.8 | | H only | 4 | 4.1 |
| | No | 23 | 19.2 | | F only | 1 | 1.0 |

| Characteristic | | Frequency | Percentage (%) | Characteristic | | Frequency | Percentage (%) |
|---|---|---|---|---|---|---|---|
| **Use of other control methods** | | | | | I only | 0 | 0.0 |
| | Field Sanitation | 84 | 70.0 | | N only | 0 | 0.0 |
| | Use of Resistant Varieties | 30 | 25.0 | | R only | 0 | 0.0 |
| | Crop Rotation | 53 | 44.2 | | I + H | 19 | 19.6 |
| | Soil Amendments | 26 | 21.7 | | H+F | 3 | 3.1 |
| | | | | | I+H+F | 62 | 63.9 |
| | | | | | I+H+N | 1 | 1.0 |
| | | | | | I+H+F+N | 7 | 7.2 |

*MV = Missing Value; H = Herbicide; F= Fungicide; I = Insecticide; N = Nematicide; Rodenticide. a = total sample size (n) = 97*

**Table 3. Level of education of respondents in the six local government areas (LGAs) studied**

| LGA | District | Level of education | | | |
|---|---|---|---|---|---|
| | | No formal education (%) | Primary education (%) | Secondary education (%) | Tertiary education (%) |
| Vandeikya | Tsambe | 40 | 30 | 30 | 0 |
| | Mbadade | 60 | 20 | 20 | 0 |
| Okpokwu | Ugbokolo | 70 | 0 | 30 | 0 |
| | Edumoga | 60 | 10 | 20 | 10 |
| Gwer East | Mbasombo | 50 | 10 | 10 | 30 |
| | Shough | 40 | 10 | 20 | 30 |
| Ukum | Mbatian | 60 | 10 | 20 | 10 |
| | Shelev | 40 | 40 | 20 | 0 |
| Gboko | Mbaityu | 70 | 0 | 20 | 10 |
| | Ukpekpe | 60 | 10 | 20 | 10 |
| Oju | Ainu | 40 | 20 | 40 | 0 |
| | Ibilla | 30 | 0 | 50 | 20 |
| Percentage Average (%) | | 51.7 | 13.3 | 25.0 | 10.0 |

**Table 4. Nematode awareness status and damage on farmers' fields in districts under study**

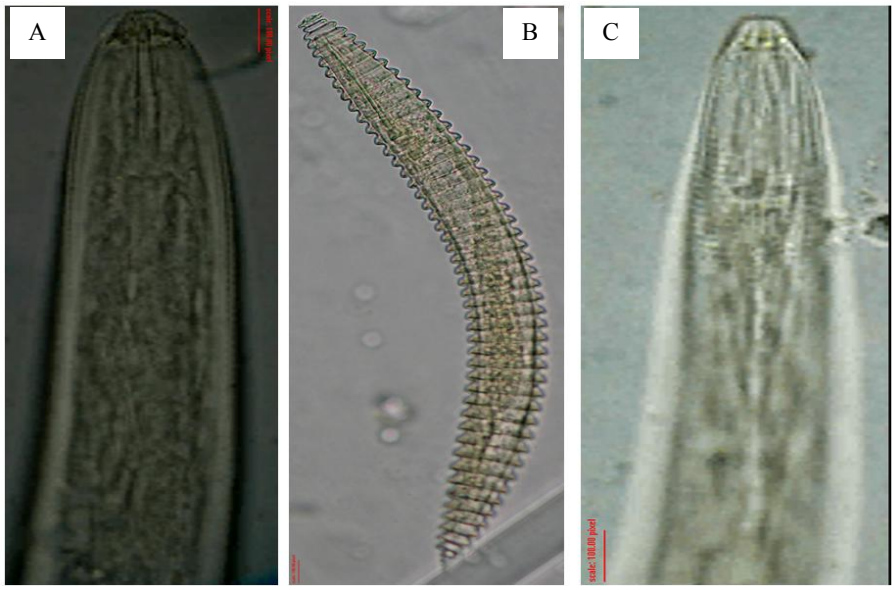
| Districts | Percentage of farmers that have heard of nematode before survey | Percentage of farmers that have never heard of nematode prior to survey | Percentage of farmers that have seen a nematode either pictorially or in a laboratory before survey | Ability to identify nematode-related problem (%) | Average extent of nematode damage on plant root |
|---|---|---|---|---|---|
| Tsambe | 20.0 | 80.0 | 0.0 | 0.0 | 3.4 |
| Mbadade | 10.0 | 90.0 | 0.0 | 0.0 | 4.3 |
| Ugbokolo | 10.0 | 90.0 | 0.0 | 0.0 | 4.5 |
| Edumoga | 10.0 | 90.0 | 10.0 | 0.0 | 3.8 |
| Mbasombo | 10.0 | 90.0 | 10.0 | 0.0 | 4.1 |
| Shough | 10.0 | 90.0 | 0.0 | 0.0 | 3.0 |
| Mbatian | 20.0 | 80.0 | 0.0 | 0.0 | 4.1 |
| Shelev | 10.0 | 90.0 | 0.0 | 0.0 | 5.0 |
| Mbaityu | 20.0 | 80.0 | 10.0 | 0.0 | 3.7 |
| Ukpekpe | 20.0 | 80.0 | 0.0 | 0.0 | 4.0 |
| Ainu | 10.0 | 90.0 | 0.0 | 0.0 | 4.0 |
| Ibilla | 20.0 | 80.0 | 0.0 | 0.0 | 5.0 |
| Average (%) | 14.0 | 85.8 | 2.5 | 0.0 | 4.1 |

### 3.3 Extent of Nematode Damage

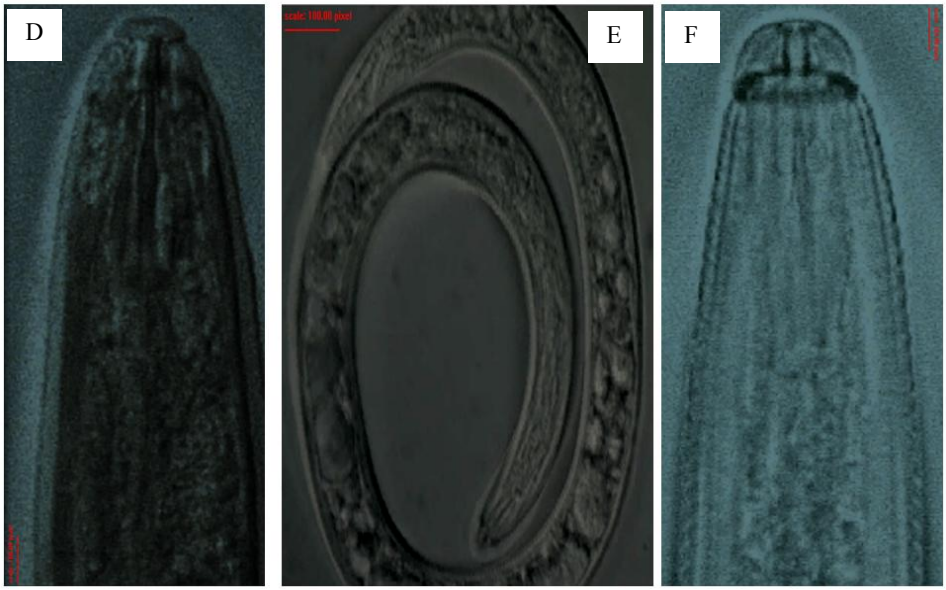
In terms of ability of respondents to identify nematode-related problem, it was found that none of the respondents could identify nematode infection under field conditions (Table 4). However, assessment of nematode damage based on root symptoms showed that most fields were extremely infected with plant-parasitic nematodes; the most common ones encountered are shown in Plates A, B, C, D, E, F, G and H. Average root damage of plants associated with plant-parasitic nematodes was found to be 4.1 on a scale of 1 to 5, indicating high levels of root damage across the twelve districts. In Shelev, nematode infection was found to be highest on surveyed fields.

A total of seven (7) families comprising ten (10) genera of plant-parasitic nematodes (PPN) were

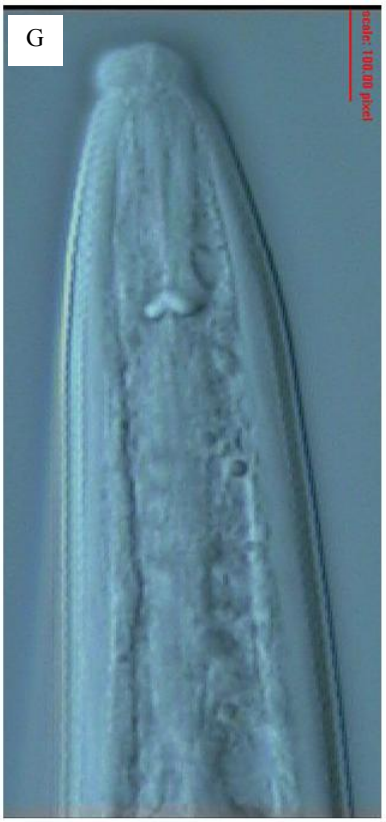
recovered from composite soil samples collected from surveyed areas within six local government areas (LGAs) in Benue State as shown in Table 5. *Meloidogyne* spp. were the most encountered PPN recovered especially from Okpokwu and Gboko LGAs (81-100% occurrence). Rotylenchus and the ring nematode, Criconema had the least spread across the survey areas. Both were not recovered from soil samples obtained from Okpokwu, Gwer-East, Ukum and Oju. Pratylenchus almost followed a similar distribution pattern, but it was not recovered from soil samples obtained from Oju. The list of genera shows that the percentage occurrence of PPN within Benue state is generally high.




A = Hoplolaimus; B = Criconema; C = Helicotylenchus

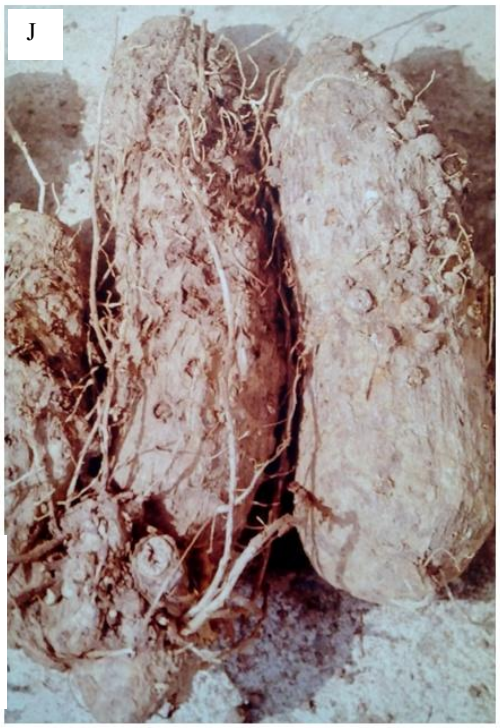



D = Meloidogyne; E = Rotylenchulus; F = Rotylenchus





G = Tylenchorynchus; H = Tylenchulus


I = Tomato (*Solanum lycopersicum* L.) roots showing prominent galls due to infection by *Meloidogyne* spp. obtained from farmers' fields during the survey in Benue State; J = Yam (*Dioscorea* sp. damaged by *Meloidogyne* spp.

**Table 5. Percentage occurrence of plant-parasitic nematode in composite root and soil samples collected from six LGA's in Benue State**

| Nematode genera | Family | Local government areas | | | | | |
|---|---|---|---|---|---|---|---|
| | | Okpokwu | Gwer-East | Ukum | Gboko | Oju | Vandeikya |
| Tylenchulus | Tylenchulidae | ++ | +++ | + | ++ | + | ++ |
| Meloidogyne | Meloidogynidae | +++++ | ++++ | +++ | +++++ | ++ | +++ |
| Scutellonema | Hoplolaimidae | ++++ | ++ | +++ | x | +++ | ++ |
| Xiphinema | Longidoridae | x | x | + | + | + | x |
| Helicotylenchus | Hoplolaimidae | ++ | + | x | x | x | x |
| Rotylenchulus | Hoplolaimidae | +++ | + | +++ | ++ | +++ | +++ |
| Rotylenchus | Hoplolaimidae | x | x | x | + | x | + |
| Pratylenchus | Pratylenchidae | x | x | x | ++ | + | + |
| Tylenchorhynchus | Telotylenchidae | +++ | ++ | ++ | ++ | ++ | +++ |
| Criconema | Criconematidae | x | x | x | ++ | x | + |

*x = Absent; + = 1 – 20%; ++ = 21 – 40%; +++ = 41 – 60%; ++++ = 61 – 80%; +++++ = 81 – 100%*

## 4. CONCLUSION AND RECOMMENDATION

If current efforts by Nigerian Ministry of Agriculture and Environment at improving crop production via mitigation of field pests must be productive in time and space, attention must be given to the insidious activities of plant-parasitic nematodes prevalent on most agricultural fields in Benue State during policy formulation and implementation. The activities of these plant-parasitic nematodes are ravaging and go undetected as clearly demonstrated by this study. Therefore in the light of this widely unknown threat within the State, the need for adequate training of agricultural extensionists in identification of nematode-related field problems, management of plant-parasitic nematode populations (PPN) and identification of PPN via light microscopy is critical. Awareness campaign on the disastrous nature of PPN at all levels along crop production chain will facilitate farmers' consciousness of the existence of PPN and forestall misguided control and management under field and nursery conditions.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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