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Populations of Derived-parasitic Nematodes on Sweet Potato (*Ipomoea batatas)* Cultivated Fields in Offa, Offa Local Government Area, Kwara State, Nigeria

Abiodun Rasheed Omokanye and Benefit Onu

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Abstract: *This study was aimed at ascertaining the soil medium and stems of the test plant to determine the populations of derived-parasitic nematodes associated with sweet potato in Offa, Kwara South, Kwara State. Three sweet potato fields monoculture designated sites-F1, F2 and F3 were randomly selected for the study. Soil was collected between 6-7:30 am each day once every seven days for four months. Twenty-five soil and Twenty-five stems samples were collected from each sweet potato field making a total of one hundred and fifty samples. The soil was collected using hand trowel while Cutlass was used in collecting stems. The sieve plates technique was employed for nematode extraction, and nematodes were identified by the use of a pictorial key. A total of 650 nematodes representing 11 genera were recovered from soil and stem samples. Root Knot/Meloidogyne species 73 (16.3%) had the highest prevalence followed by Cyst nematode/Heterodera species 65 (14.5%) while Stem Lesion/Aphelenchoides basseyi species 2 (0.4%) showed the least prevalence in soil. However, Stem Lesion/Pratylenchus species was reported more often than any other species in stems with a total affluence of 51 (25.2%) followed by Burrowing nematodes/ Radopholus similis species with 44 (21.8%) while Ditylenchus dipsaci species occurred less than all other species with 10 (5.0%); an observation which is ascribed to a nematodes survival strategy. The result shows that soil nematodes are an important pest of sweet potato in the Offa Local Government Area. Others may include, Bursaphelenchus xylophilus, Rotylenchulus reniforms, Xiphinema index, Necobbus aberrans, Aphelenchoides basseyi and Globodera spp). Hence, should be considered in pest control programs.*

Keywords: *Ipomoea batatas, Offa Local Government, Fields, Sweet Potato, Incidence, parasitic nematodes.*

Abiodun Rasheed Omokanye
Department of Environmental Management and Earth Toxicology, Federal University, Otuoke, Yenagoa, Bayelsa State, Nigeria
Email: omokanyeta@fuotuoke.edu.ng
Orcid id:0009-0000-6849-1262

Benefit Onu
Department of Biology, Federal University Otuoke, Bayelsa State, Nigeria
Email: benefitonu28@gmail.com

1.0 Introduction

Sweet Potato, *Ipomoea batatas* is an important dicotyledonous plant, from the convolvulaceae family, grown for its tuberous roots in tropical, sub-tropical and warm temperate regions all over the world (Makete, 2012). The stems of Sweet Potato are eaten all over the world because of itstheir nutritional benefits to the human body. Root-knot nematodes of Sweet Potato are white to yellow and live amongst the storage stem. Although tiny, these nematodes can be seen without a magnifying glass (Nzeako, 2018). They are over winter as eggs in the soil and complete their life cycle in about 30 days. Since a single female can lay up to 3,000 eggs, a severe infestation of root-knot nematodes in Sweet Potato can seriously damage a crop. Root-knot nematodes are most abundant in sandy soils, signs of root-knot nematodes include stunted growth and yellowing of leaves. The symptoms often mimic those of a plant with a nutrient deficiency (Alabi, 2018). Various management approaches are available to mitigate root knots such as Nematicides, such as Evangeline and Bienville are commercially available and use resistance Sweet Potato varieties. Root-knot makes the roots distorted and cracked with a tough texture (Mary, 2012).

Amy (2018) reported that Sweet Potato stems contain vitamins and minerals which are required in small quantities for normal body functioning and development. The Sweet potato is grown in Nigeria because of its economic value and is a major raw material in many industries that can extract, refine and use its Fiber for cooking, while its roots, stem and leaves silages or reminisce are good for biodiesel fuel (Alabi, 2018). The bye-products from Sweet Potato, extracted succulent can be used in the production of Yam Flour, Bean Cake, edibles and peanut flour, and can also serve as an animal feed (Waterworth, 2017). The seeds from Sweet potatoes are often used as snacks in Nigeria; and can be roasted, fried, boiled or processed into cadies (Jackie, 2017; Bonnierant, 2010). Sweet Potato is a valuable food that if properly packaged, could help in solving the problem of global food insecurity.

Sweet Potato cultivation in Nigeria encounters multiple obstacles, among these are infections by plant nematodes. Plant nematodes are widespread and may survive at all conditions making their existence possible in every season worldwide (Gardening, 2013; Abdel-Momen and Starr, 2014; Mary, 2012). There is no doubt that about 35% of food crop loss in Nigeria could out-rightly be attributed to the actions of plant pathogenic nematodes (Imafidor and Ekine, 2016). Nematodes are pathogenic worms in soil; they survive on soil-dwelling organisms including the stem content of Sweet Potato. They are tiny, and their tininess has prompted pest control agencies to miss them in control programs which in turn has put their population on the increase than every other organism in the soil. Sometimes, if root-knot nematodes infest the plants early in the growing season, small galls may be seen, if they can be found in the larger storage roots. For a sure diagnosis, it is necessary to split the small stem lengthwise and look for a swollen female nematode embedded in the stem. Usually, the areas surrounding the nematodes are dark and the nematode itself looks a bit like a pearl nestled into the flesh of the root. Derived nematodes in soil constitute a threat to the farmer relying on soil produce for food, as in subsistence farming. This is because nematodes do not look back in causing waste to the farmer. They are capable of rendering the immune system of the strongest plant weak thereby creating a channel for infection by other microbes which ordinarily would not have been able to parasitize the crop (Amy, 2018; Mary and Brooks, 2019).

Several species of these tiny organisms-nematodes in the soil have been reported in Sweet Potato fields in West Africa with a species of notable effect being the root-knot nematode (Imafidor and Ekine, 2016). *Meloidogyne* species commonly known and called root-knot nematode has been proven to have more destructive potency than any other nematode species on crops including Sweet Potato (Luc, 2012; Imafidor and Ekine, 2016) and has also been reported in Sweet Potatoes cultivated fields in Nigeria. This species is responsible for imperfection in the stem tip of Sweet Potato Stem. With high damage levels recorded for *Meloidogyne* species on Sweet Potato in Nigeria, the predominant species on Sweet Potato cultivated soil has been *Xiphinema index* species, yet the rate at which it could cause damage is not clear. Nevertheless, a clear view of the nematode pattern of abundance under Sweet Potato fields is necessary for developing a good cultural management technique for rural farmers. However, this study is aimed at ascertaining the population assemblage of derived-parasitic nematodes of Sweet Potato (*Ipomoea batatas*).

2.0 Materials and Methods

2.1 Study area

This study was carried out in three Sweet Potato cultivated fields, designated as F1, F2 and F3 in Offa community in Offa Local Government Area of Kwara State, Nigeria. In each field, the duration of fallow and type of previous crops cultivated was noted after having an interview with the farmers from each farm site. Site F1 is located $8^{o}47^{\prime}21^{\prime\prime}$N, $8^{o}40^{\prime}52^{\prime}$E, site F2 is $8^{o}49^{\prime}52^{\prime\prime}$N, $8^{o}39^{\prime}15$ E and site F3 is located $8^{o}50^{\prime}35$N, $8^{o}39^{\prime}11$E. The inhabitants of the Offa community are predominantly farmers mostly on Sweet Potato as a source of income. They are first before Oyun and Ifelodun in Sweet Potato production in Ibolo Land. The area experiences an annual average rainfall range of 2000 – 2500mm and a temperature range of 27 – 32^{o}C which encourages rainforest vegetation type.

2.2 *Ethical approval*

Ethical approval for the collection of samples from the selected farms was sought from the farm owners. The harvested Sweet Potato stands were paid for. The Olofa of Offa community was consulted and permission was given concerning bush entry and environmental degradation.

2.3 *Collection of soil samples*

Soil samples were collected randomly from the rhizosphere of the Sweet Potato in each field with the aid of a hand trowel. A total of fifty soil samples were collected from each Sweet Potato cultivated field. Soil samples were collected from the stem rhizosphere at depths 0-15 cm in the early hours (6:30-7:30 am) each day once every seven days for four months. The soil samples were packed into properly labelled waterproof bags and were transported to the laboratory for nematode extraction. In each field, ten Sweet Potato stands were uprooted, and the stems were collected with the aid of a cutlass at the same time from the same location as the soil samples. The samples were placed into a well-labelled polythene bags and were transported to the laboratory for nematode extraction.

2.4 *Nematode extraction*

Nematodes were extracted using the sieve plate method (Imafidor and Ekine, 2016). The soil samples in each sample bag were poured into a 5-10cm plate and were thoroughly mixed. A measure of 10g of soil was taken. The 10g of soil was spread evenly on a circle of tissue paper supported on a plastic sieve standing in a plastic plate. Water was added to the extraction plate gently until the soil was wet but not immersed. The extraction set-ups were left undisturbed for 48 hours, the soil was removed and the supernatant was discarded. The nematode aliquots were emptied into clean grease-free specimen bottles and allowed to sediment, then fixed with 5 % formalin and stored for microscopic examination. 0.1ml of the nematodes aliquot were taken with a pipette, placed on glass slides and observed using x4 and x10 objectives of light microscope.

The Sweet Potato stems from each sample bag were thoroughly washed in tap water to remove soil particles, and cut into 2cm segments before removing a 5g fresh mass sub-sample. The 5g sub-sample of the stem was macerated in an electric blender for 10-20 seconds at low speed. Each macerated sub-sample of the stem was spread evenly on a piece of tissue paper supported on a plastic sieve standing on a plastic plate. Water was added to the plate until the samples were wet but not immersed. The set-up was left undisturbed for 48 hours. The stem samples were removed, discarded and the nematode suspension was poured into a clean specimen bottle and fixed with 5% formalin and stored. 0.1ml of the nematode aliquot was taken with a pipette and placed on a glass slide and examined for nematode species using the x4 and x10 objectives of a light microscope.

2.5 *Identification of nematodes*

Sweet Potato Nematodes were identified using the light microscope of x4 and x10 objectives, and identification was done using a pictorial key or chart, according to Siddiqi (2010) and Mekete (2012).

2.6 *Data analysis*

The analysis of data was done using analysis of variance (ANOVA) in SPSS and Shannon Winernner's index (H= pi x lnpi, E = H/H_{maxi}).

3.0 Results and Discussion

3.1 Percentage abundance of soil nematodes in sweet potato

Plant Parasitic nematodes were reported in all the samples viewed in this study with a total of 448 nematodes from 11 species and genera. The nematode species encountered in this study were *Globodera spp., Meloidogyne spp., Bursaphelenchus xylophilus, Nacobbus aberrant, Heterodera spp., Radopholus spp., Helicotylenchus spp., Criconema spp., Pratylenchus spp., Rotylenchus spp., Scutellonema spp., Tylenchus spp.* and *Ditylenchus spp.* Among the 448 nematodes recovered, 140 (31.25%) were encountered in Farm site F1 while Farm site F2 reported 91 (20.3%) and 217 (48.4%) were extracted in Farm site F3. The individual nematodes recovered in farm site F1 were *Gracilachus* species-26 (18.6%), *Meloidogyne* species-27 (19.3%), *Heterodera* species- 24 (17.4%), *Radopholus* species-8 (5.7%), *Helicotylenchus* species-21 (15.0%), *Criconema* species-6 (4.3%), *Pratylenchus* species-16 (11.4%) and *Rotylenchus* species-12 (8.6%). Site F2 recorded *Heterodera* species as the most frequently encountered nematode with 26 (28.6%), followed by *Ditylenchus* species with 15 (16.5%) while *Tylenchus* species were the least in occurrence with 2 (2.2%). Other species also recorded in F2 were *Gracilachus* species 11 (12.0%), *Pratylenchus* species 11 (12.0), *Meloidogyne* species 10 (10.9%), *Helicotylenchus* species 10 (10.9%) and *Scutellonema* species 6 (6.6%). In site F3, 217 (48.4%) were extracted among which *Meloidogyne* species show the highest occurrence with 36 (16.6%) closely followed by *Helicotylenchus* species with 34 (15.6%) while *Ditylenchus* species had 30 (13.8%) and *Scutellonema* species showed the least population with 12 (5.5%). Also reported in farm site F3 were *Radopholus* spp., *Gracilachus* spp, *Rotylenchus* spp, *Criconema* spp, *Pratylenchus* spp and *Heterodera* species which had 24 (11.1%), 20 (9.2%), 19 (8.8%), 16 (7.4%), 13 (5.9%) and 13 (5.9%) respectively. Eleven derived-parasitic nematode genera were reported across the three sweet potato fields sampled in Offa. These nematodes were unevenly distributed in terms of species' actual incidence and profusion, occurring in all the Sweet Potato fields where soil and stems were collected and analysed. The nematodes so recovered in this study have been reported in many parts of the globe where Sweet potatoes are cultivated including Nigeria (Chang, 2017). The occurrence of derived-parasitic nematodes in all the sites in this study could be attributed to favourable environmental conditions. The result suggests that derived-parasitic nematodes are true pests of sweet potatoes in Offa. Alabi (2018) reports that nematodes are capable of surviving in every cultivated field with pleasant soil conditions, especially in the tropics of Africa. The most prevalent species encountered in this study was *Meloidogyne* species (18.0%) followed by *Helicotylenchs* species (14.6%) while *Tylenchus* species (1.8%) recorded the least in abundance (Fig 2). In a similar study, Cheryl (2012) recorded higher populations of *Pratylenchus* species than any other nematode elsewhere in the world. This observed difference could be attributed to the location and season of research. The abundance of *Meloidogyne* in the present study could be ascribed to the versatile nature of the genus. This observation conforms with Imafidor and Ekine (2016) which states that *Meliodogyne* is versatile and could survive in every agricultural field not minding season.

The stems of Sweet Potato reported nematodes across the farm sites where samples were collected for the research. A total of 202 nematodes from 6 species and genera were found occurring in this study. Among these, 49 (24.3%) were extracted in site F1 while farm site F2 showed 65 (32.2%) nematodes and 88 (43.6) species were reported from site F3. The nematode species reported were *Pratylenchus* species with the highest species abundance of 51 (25.2%) closely followed by *Meloidogyne* species with 44 (21.8%) while *Helicotylenchs* species, *Radopholus* species, *Ditylenchus* species, *Rotylenchus* species and *Tylenchus* species were 30 (14.9%), 24 (11.9%), 22 (10.8%), 21 (10.4%) and 10 (5.2%), respectively. In this study, the sum of 650 nematodes was reported occurring in stem rhizosphere and stem tissues of Sweet Potato. Four hundred and eight nematodes representing 75.1% were reported in soil (stem rhizosphere) among which 189 (29.1%) were found in site F1 while 156 (24.0%) nematode species were extracted from site F2 and site F3 yielded a total of 305 (46.9%) species. However, 202 (24.9%) nematodes were recovered from the stem tissues of Sweet Potato across the farm sites where samples were collected in the study with 24.3%, 32.2% and 43.6% representing percentage extraction from sites F1, F2 and F3 respectively.

Table 1: Population of plant nematode of groundnut in Egbolom

Nematode species		**Farms**		**Total**		
	F1 (%)	F2 (%)	F3 (%)		F	Sig
					3.773	.035
***Gracilachus* spp**	26 (18.6)	11 (12.0)	20 (9.2)	57 (12.7)		
***Meloidogyne* spp**	27 (19.3)	10 (10.9)	36 (16.6)	73 (16.3)		
***Heterodera* spp**	24 (17.4)	26 (28.6)	13 (5.9)	63 (14.1)		
***Radopholus* spp**	8 (5.7)	0	24 (11.1)	32(7.1)		
***Helicotylenchus* spp**	21 (15.0)	10 (10.9)	34 (15.6)	65 (14.5)		
***Criconema* spp**	6 (4.3)	0	16 (7.4)	22 (4.9)		
***Pratylenchus* spp**	16 (11.4)	11 (12.0)	13 (5.9)	40 (8.9)		
***Rotylenchus* spp**	12 (8.6)	0	19 (8.8)	31 (6.9)		
***Scutellonema* spp**	0	6 (6.6)	12 (5.5)	18 (4.0)		
***Tylenchus* spp**	0	2 (2.2)	0	2 (0.4)		
***Ditylenchus* spp**	0	15 (16.5)	30 (13.8)	45 (10.0)		
Total	**140 (31.25)**	**91 (20.3)**	**217 (48.4)**	**448 (75.1)**		

3.2 Stem nematodes actual incidence of derived parasitic nematodes of Sweet Potato in Offa:-

There were variations in the distributions of nematodes in soil and stem across the Sweet Potato cultivated fields from site to site. More nematodes were reported from site F3, 217 (48.4%) followed by site F1 which recorded 140 (31.25%) species while 91 (20.3%) were found occurring in site F2. This result indicates that nematode actual incidence in soil is unpredictable and could be influenced by unapparent factors in soil. The variation in the distribution of nematodes could be attributed to nematode feeding patterns and survival strategies. The distribution of stem nematodes in this study followed a similar pattern as seen in soil such that site F3 showed the highest assemblage 88 (43.6%) while site F2 had 65 (32.2%) and 49 (24.3%) were reported from site F1. This observation was statistically significant (p< 0.05). The uneven distribution of stem nematodes in this study could be attributed to edaphic factors (Starr, 2010; Chales, 2012).

Table 2: Population of stem nematode of Sweet Potato in Offa

Nematode species	Sampled	Farms		Total	Fx	significance
	F1 (%)	F2 (%)	F3 (%)		.710	.505
***Meloidogyne* spp**	15 (30.6)	7 (10.8)	22 (25.6)	44 (21.8)		
***Ditylenchus* spp**	8 (16.3)	2 (3.1)	12 (1.4)	22 (10.8)		
***Pratylenchus* spp**	13 (26.5)	32 (49.2)	6 (6.8)	51 (25.2)		
***Rotylenchus* spp**	7 (14.3)	14 (21.5)	0	21 (10.4)		
***Tylenchus* spp**	0	2 (3.1)	8 (9.1)	10 (5.0)		
***Radopholus* spp**	0	0	24 (27.3)	24 (11.9)		
***Helicotylenchus* spp**	6 (12.2)	8 (12.3)	16 (18.2)	30 (14.9)		
Total	**49 (24.3)**	**65 (32.2)**	**88 (43.6)**	**202(24.9)**		

3.3 Actual incidence of parasitic nematodes of Sweet Potato in Offa LGA

In this study, the sum of 650 nematodes was reported occurring in stem rhizosphere and stem tissues of Sweet Potato. Four hundred and eight nematodes representing 75.1% were reported in soil (stem rhizosphere) among which 189 (29.1%) were found in site F1 while 156 (24.0%) nematode species were extracted from site F2 and site F3 yielded a total of 305 (46.9%) species. However, 202 (24.9%) nematodes were recovered from the stem tissues of Sweet Potato across the farm sites where samples were collected in the study with 24.3%, 32.2% and 43.6% representing percentage extraction from sites F1, F2 and F3, respectively. Prominent derived-parasitic nematodes recovered in this study were *Meloidogyne* species 117 (18.0%)-that is, 73 and 44 representing extraction from soil and roots, respectively. Following *Meloidogyne* species was *Helicotylence* species 95 (14.6%), showing 65 in soil and 30 in roots. *Pratylenchus* had 40 and 51 (91 (14%) from soil and roots, respectively. The least occurred nematode in this was *Tylenchus* species 12 (1.8%). Other Phyto-parasitic nematodes extracted were *Heterodera* species 63 (9.7%), *Gracilachus* species 57 (8.8%), *Radopholus* species had 56 (8.6%), *Rotylenchus* species 52 (8.0%), *Ditylenchus* species 67 (10.3%), *Criconema* species were 22 (3.4%) and *Scutellonema* species had 18 (2.8%). Site F3 with the highest number of nematodes has a corresponding history of continuous monoculture of Sweet Potato. This observation depicts that the cropping system is a significant factor contributing to the profusion of derived-parasitic in a given field. The result also confirms that continuous monoculture facilitates nematode buildup in soil and may increase nematode infection rate and damage extend to crops. Elsewhere, Chang (2017) reported a high prevalence of soil nematodes in Sweet Potato monoculture. The assemblage of nematodes in site F2 with a record of ten years of fallow was relatively low (20.3 %) when compared with the occurrence in sites F1 and F3. This observation suggests that fallowing as a farming technique could help in bringing down nematode populations in fields and could enhance crop yield. It also depicts that frequent disturbance of soil by continuous cultivation does impact positively on nematode reproduction and abundance in soil. In separate studies, Starr (2010), and Amy and Asante (2017) reported relatively low populations of nematodes in fallowed sites. Disparity in nematode affluence the parameter sampled was noticed such that more nematodes were reported in soil 488 (68.9%) while 202 (31.1%) were reported in stems. This observation could be ascribed to nematode nutritional affiliation and survival strategy. This result disagrees with Nzeako (2018). *Aphelenchiodes* species has always been reported as a major pest of Sweet Potato in the tropics of Africa and Asia (Cheryl, 2012), but is missing in the present study; an observation which suggests that the inhabitation of plant parasitic nematodes in a place is dynamic and unpredictable. Shannon Winernner's index analysis showed a general possible relationship between the fields investigated and the occurrence of nematode species across the fields in the study areas. Nematodes diversity in this study was 2.853, 2.219 and 2.076 for sites F1,F2 and F3, and evenness were 1.239,0.925 and 0.901, for site F1, F2 and F3, respectively.

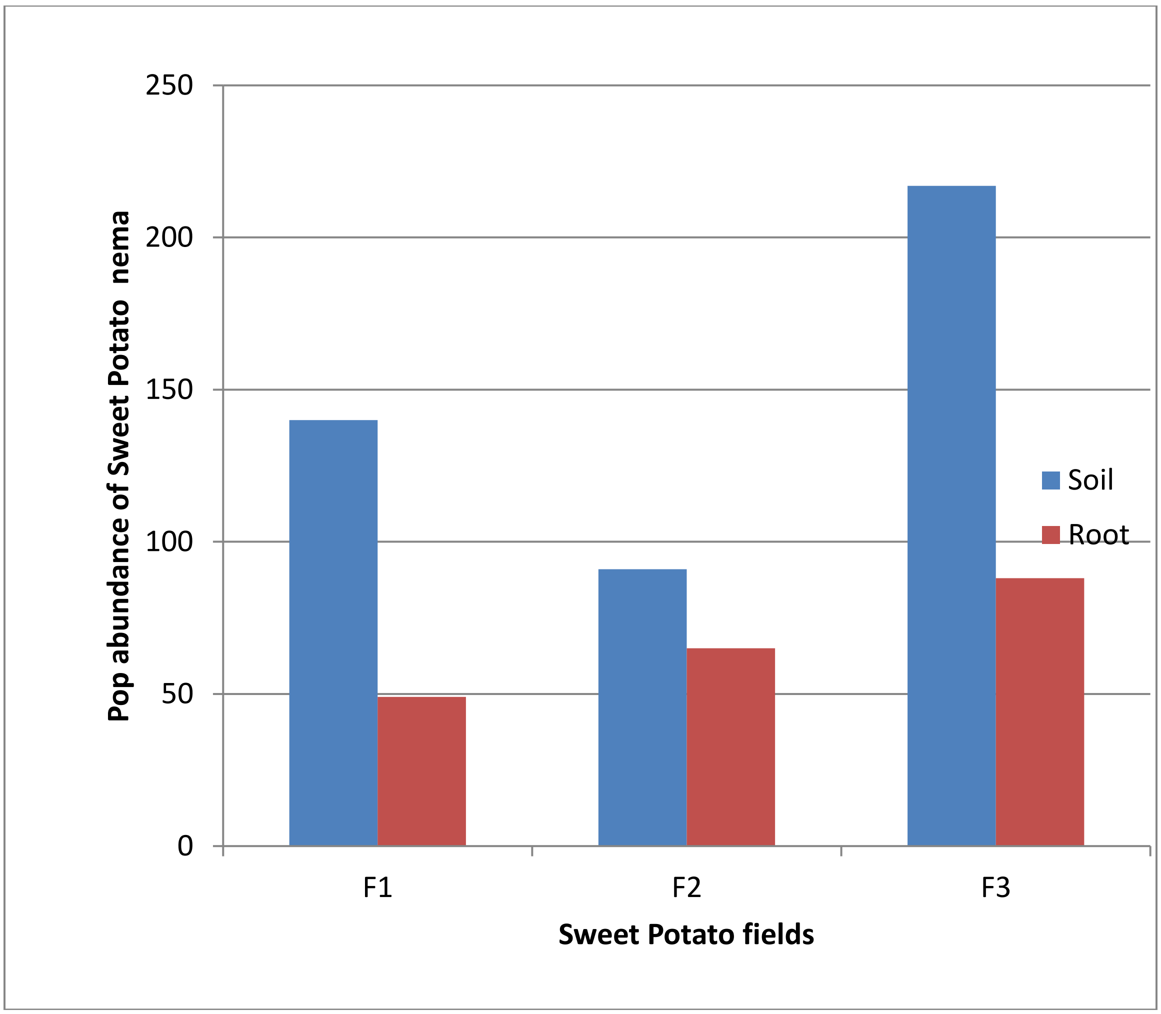

Fig 1: Actual incidence of derived parasitic nematodes of Sweet Potato in Offa LGA

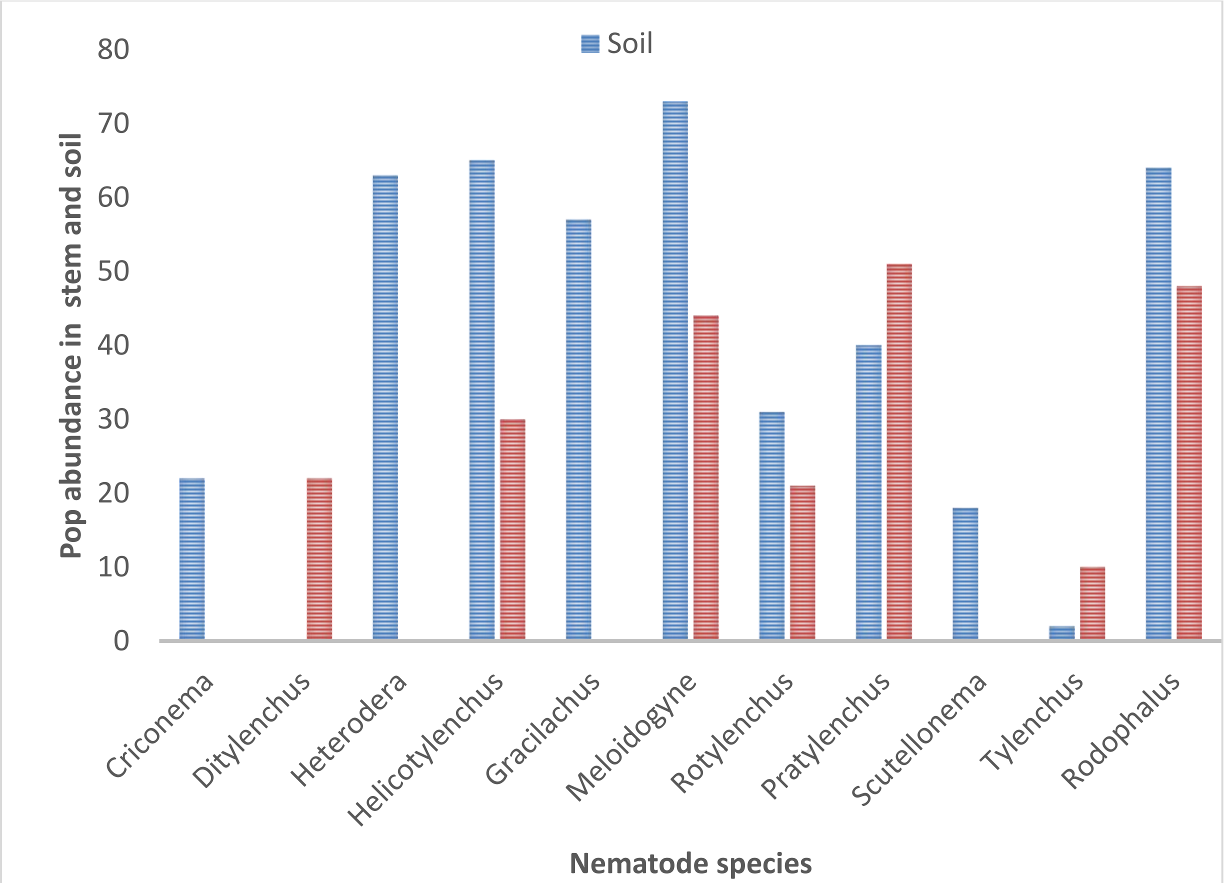

Fig 2: Diversity of derived parasitic nematodes of Sweet Potato in the study

4.0 Conclusion

In conclusion, this study provides valuable insights into the populations of derived-parasitic nematodes associated with sweet potato cultivation in Offa, Kwara State, Nigeria. The research revealed the presence of various nematode species in both soil and stem samples collected from three different sweet potato fields. Among the nematodes identified, root-knot nematodes (Meloidogyne species) were the most prevalent, followed by other species such as cyst nematodes (Heterodera species) and stem lesion nematodes (Pratylenchus species).The findings underscore the importance of considering nematode infestation in sweet potato farming practices, as these pests can significantly impact crop yield and quality. The study suggests that nematode management strategies should be integrated into pest control programs to mitigate their detrimental effects on sweet potato production. Additionally, the research highlights the need for further studies to better understand the dynamics of nematode populations in sweet potato fields and to develop more effective control measures. This study contributes to the body of knowledge on nematode management in sweet potato cultivation, providing valuable information for farmers, researchers, and policymakers involved in agricultural development and food security initiatives in Nigeria and beyond.

4.0 References

Abdel-Momen, S.M. & Starr, J.L (2014). Damage Functions for three *Meloidogyne* spp on *Arachis hypogaea* in Texas. *Journal of Netmatology,* 6, pp. 200-207.

Alabi, M. (2018). The Performance of new hybrid yam varieties (*D. rotundata* Poir) under different crop farming systems. *African Journal of Root Tuber Crops,* 10, pp. 46-53.

Amy, G. (2018). Effects of Inter cropping on root knot-nematode disease on Soyabean (*Glycine max* (L) merril). *New York Science Journal* 1(1), pp.43 – 46.

Amy, G. & Asante, J.S, (2017). Nematode dynamics in soil amended with neem leaves and Poultry manure. *Asian Journal of Plant Science*, 4(4), pp. 426-428.

Bonnierant, L. (2010). Nematodes community changes and survival rate under natural fallows in Sudan Sahelian area of Senegal. *Pedobiogia,*

Chang, C. (2017). A Century of Nematologyin: Nematology Advance and Perspective , Tsinghua University Press, Beijing, China. P 90.

Cheryl, C. F. (2012) .Plant-parasitic nematodes on field crops in South Africa. *Fundamentals of Applied Nematology,* 20: pp. 120-131.

Charles, K. (2012). Plant Parasitic Nematodes Of Cassava *Manihot esculenta* Cultivated In Ahoada East Local Government Area In Rivers State, Nigeria. *Applied Science Report,* 7, pp. 15-19.

Gardening, K. (2013) .The Effects *Meloidogyne Javanica* on the growth the tomato cultivar, VC 82803. *African Journal of Applied Zoology and Environmental Biology,* 14, pp. 42-49.

Imafidor, H.O., & Ekine, E.G. (2016). A Survey of the Nematode Pests of the Crop Cassava (*Manihot esculenta*) in Rivers State, Nigeriaa. *African Journal of Applied Zoology and Environmental Biology,* 12, pp. 69-74.

Jackie, R. (2012) Soil nematode populations and root biomass on Cynomys ludovicianus colonies and adjacent uncolonized areas. *Oecologia*, 63: pp. 307-313.

Luc, U. (2012). Introduction to Plant Parasitic Nematodes: *The plant Health Instructor*, pp.20- 42

Makete, E. (2012). Lecture and symposium, presented at the sensitization. *Journal of Applied Zoology and Environmental Sciences, Namibia*

Mary, E. (2012). Nematodes Parasites of Peanuts, Future US LLC, full, 7th floor, 130 West 42nd Street, New York

Mary, E. & Brooks, C. (2019). Plant and Soil Nematodes: Societal Impact and Focus for the Future. *Journal of Nematology*, 26(2): pp. 127-137.

Nzeako, A.B. (2018). Nemesis in household storage, the Africa concern and impact on economy. Unpublished Thesis of PhD, Department of Biology, Nasarawa State University, Keffi

Starr, A. (2010). Development of Fortified Peanut based infant formula of Severely Malnourished Children. America Journal of *Food science and technology,* 17, 65-78.

Siddiq, M.R. (2010). Tylenchida: parasites of plants and insects. *International Journal on Environmental Variabilities*,73, pp. 24-32.

Waterworth, S.O. (2017). Research Progress in Peanut Protein and its Functional Properties. *China Oil and Food*. P 43.

Compliance with Ethical Standards Declarations

The authors declare that they have no conflict of interest.

Data availability

All data used in this study will be readily available to the public.

Consent for publication

Not Applicable

Availability of data and materials

The publisher has the right to make the data public.

Competing interests

The authors declared no conflict of interest.

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Authors' Contributions

Abiodun Rasheed Omokanye and Benefit Onu jointly design the work and were both involved in the field work and experimental aspect of the work.