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Incidence of Plant-Destructive Nematodes and Associated Damages on Yams Grown in Nasarawa State, North-Central Nigeria

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ABSTRACT

Plant-parasitic nematodes (PPNs) are an important threat to yam (*Dioscorea* spp.) production in Nigeria. With the aim to establish the diversity of plant-parasitic nematode genera affecting yam tubers, for control and resistance screening purposes, surveys were conducted in the main yam- producing local government areas (LGAs) of Nasarawa. A total of 54 yam farms were surveyed for PPNs and their associated damage on yam using multi-stage sampling technique. Three communities each, in Lafia, Keana, Kokona, Awe, Obi and Doma LGAs were assessed for the incidence of PPNs and their associated damages on yam. A total of 54 farmers' fields and 60 yamtubers were assessed in the study. The survey revealed that the eleven PPNs genera were recoveredfrom the soil and tubers of infected yam included Pratylenchus, Hoplolaimus, Helicotylenchus, Criconema, Meloidogyne, Rotylenchus, Scutellonema, Xiphenema, Tylenchulus, Trichodorus and Rotylenchus. Meloidogyne (75.29%, Scutellonema (57.20) and Pratylenchus (44.55%), in order of descending ranking, had the highest incidences across the six LGAs. The destructive activitiesof these nematodes lead to in unattractive, verrucose or knobby appearances on infected yam tubers, thereby resulting in low to extremely low tuber quality of marketable yams in Nasarawa State.

Keywords: Survey; Plant-parasitic nematodes; *Discorea* spp; Yam; Nasarawa

Introduction

Cultivated yam (*Dioscorea* spp.) belongs to the family Dioscoreaceae, genus Dioscorea and orderDioscoreales. According to Martin [1] and Olorunsanya [2], yam has over 600 species of which about six are identified as economically important staple and edible as major source of carbohydrate to man's diet. The edible species are *Dioscorea rotundata* (white yam), *Dioscorea alata* (water yam), *Dioscorea cayenensis* (yellow yam), *Dioscorea bulbifera* (aerial yam), *Dioscorea japonica* (Japanese yam) and *Dioscorea esculanta* (lesser yam or Chinese yam). Out ofthese, white yam and water yam are species widely grown in the coastal region of rainforest, woodsavanna and southern guinea savanna agro-ecological zones of Nigeria [3]. Benue, Nasarawa, Kwara, Taraba, Kogi and Niger have been reported to be the major yam-producing states in Nigeria[4].

Yam is a valuable source of carbohydrate and may be barbecued, roasted, fried in oil, grilled, boiled, baked, smoked, pounded into paste (“fufu”) or grated and made into a dessert. It may be cooked or fried with rice, beans, plantain, sweet potato, lamb, chicken and butter nut as squash soup [5,6]. It can be boiled, roasted and eaten with oil, vegetable or sauce. The tubers may be peeled and sliced into tiny pieces and dried to very low moisture contents and milled into flour andflakes [7]. The tubers may be peeled and prepared into porridge and cooked with traditional spicesand served for the sick and aged as appetizer. Despite the importance of yam, it is majorly plaguedby activities of crop pests and diseases in field and storage environments [8]. Yam is prone to infection right from the seedling stage through to harvesting and even after harvesting, in storage[9]. Amongst the various constraints to production of yam, nematode pests are of significant importance [10-12].

Survey information of nematode-induced damages associated with yam cultivation in Nasarawa state are either not readily available or timeworn to engender further research and policy development that will ensure maximum returns along the yam value chain. It is also clear from recent findings that desert encroachment lines and climate change which has led to gradual shifts in agro-ecologies may have also impacted on disease spread in yam-producing communities [13].It is against this backdrop that the survey was conducted to determine the presence, distribution, and extent of damage caused by plant-parasitic nematodes on selected yam fields in Nasarawa state, north-central Nigeria.

Materials and methods

Study area

This study was conducted in Nasarawa state, north-central Nigeria. Nasarawa state is located between latitudes 7° and 9° N and longitudes 7° and 10° E. It shares boundaries with Benue state to the south, Kogi state to the west, the Federal Capital Territory (FCT) to the north-west; Kadunaand Plateau States to the north-east, and Taraba state in the south-east (Figure 1). Nasarawa state has a land area of 12,000 square kilometers and is divided into thirteen Local Government Areas(LGAs). The 2006 population census pegged the state’s population at 1,863,275. Agriculture is the dominant occupation of the inhabitants of Nasarawa state. Some of the major agricultural products in the state include yam, cassava, maize, sorghum, millet, rice groundnut cowpea, soya beans, sesame, melon, sweet potato, mango, cashew, sugarcane, oil palm, cattle, sheep, goats, poultry, pigs and fisheries [14].

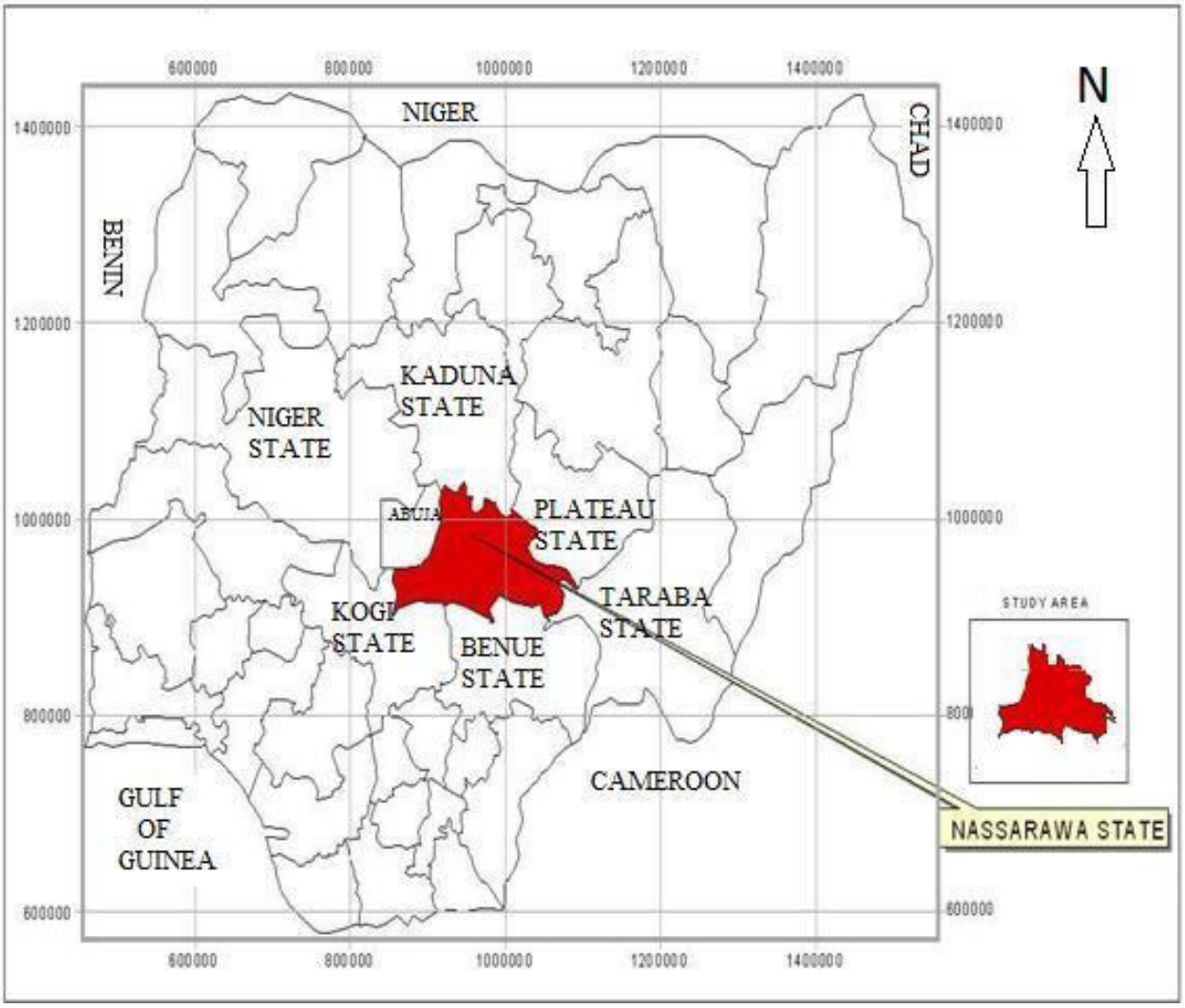

Figure 1: Map of Nasarawa State, Nigeria (Source: 15)

Sample collection

A total of 54 yam farms were surveyed for plant-parasitic nematodes (PPNs) and their associateddamage on yam. The survey was conducted between October to December, 2018 and January to February, 2019 in Nasarawa state using multi-stage sampling technique. Six local government areas (LGAs) in the state were selected based on available yam field data at the Nasarawa State Agricultural Development Programme. The LGAs included Lafia, Keana, Kokona, Awe, Obi andDoma. From each LGA three communities were visited and three yam farms were assessed in each community for plant-parasitic nematode occurrence and damage on yam. In each farm, 10 plants were randomly selected from which four core samples from the rhizosphere of each plant were collected using a soil auger along the four cardinal directions at the base of each plant in order to cover as much of the rhizosphere as possible. Three tubers were collected from each surveyed farm. The four soil samples weighing 150 g each were collected to a depth of 30 cm with garden trowels and bulked into a composite sample of 200 g. Samples from each farm were pooled and sealed in well-labelled plastic bags and protected from the sun [16]. Areas featuring high weed concentrations, areas next to terraces, and those containing limestone deposits, organic matter, andwater features were avoided for sample collection.

Nematode extraction and identification

Extraction of nematodes from soil samples was done using the modification of Whitehead and Hemming tray method [17]. Two plastic sieves of same diameter (15 cm) with a double-ply tissuepaper sandwiched in between the two sieves. The set of sandwiched sieves was later placed in analmost flat plastic bowl 20 cm in diameter having a slight depression at its center circumference. Fifty-four (54) of these set-ups were prepared and labelled appropriately using sliced pieces of masking tape which were attached to the edge of the top sieve and base of the bowl. Composite soil samples (200 g/sample) obtained from yam farms

were carefully, and separately poured into each designated labelled set-up. At the base of the set-up, i.e., through the outer side of the basal sieve, 200 ml of distilled water was gently poured to the tip of the depressed circumference of thebowl. The set-up was Nematodes were also isolated from the tubers collected during the survey. Tuber cores (1 cm wideand 2 cm deep) consisting of yam skin, its sub-cutaneous layer and associated roots were peeled-off from each tuber using a sterilized knife recurrently, for each tuber sample. Cores from each farm were bulked to obtain composite core of 50 g. The cores were rinsed briefly in distilled waterto remove soil, before they were finely chopped with a sterilized knife and placed on a modified Baermann's sieve [18] for 72 hours. Nematode extracts were collected daily and poured in appropriately labelled McCartney bottles kept in a refrigerator that was maintained at 25 °C and replaced with fresh water on each occasion. Nematode suspensions for each sample were combined, reduced to 25 ml and nematode population densities assessed from 3 x 2 ml- aliquots using a light microscope. Roots were first rinsed in tap-water to remove soil debris, dabbed dry with a paper towel and cut into approximately 2 cm pieces with a knife.

Results

The results as depicted in Table 1 show that eleven (11) plant-parasitic nematode genera were recovered from samples obtained from infected yam fields in Nasarawa State, Nigeria. The nematode genera included Pratylenchus, Hoplolaimus, Helicotylenchus, Criconema, Meloidogyne, Rotylenchus, Scutellonema, Xiphenema, Tylenchulus, Trichodorus andRotylenchus. These plant-parasitic nematodes (PPNs) were found at different levels of incidence in yam fields surveyed. On the average, the highest incidence level of the PPNs was recorded in Lafia LGA (25.59%) followed closely by Obi LGA (24.81%) while the least incidence level was recorded in Awe LGA (18.14%). Meloidogyne, Scutellonema and Pratylenchus were the only nematode genera consistently recovered from yam fields in all the LGAs assessed in the study, having incidence levels of 75.29%, 57.20% and 44.55%, respectively. The other nematode generaoccurred sparingly, in fact the survey outcome showed that Tylenchulus was only recovered from Awe LGA (7.20%) while Trichodorus was only recovered from Lafia LGA (12.12%) and Doma LGA (7.13%).Average population densities of PPNs recovered from soil were higher than those recovered fromthe tubers except for Meloidogyne whose population was higher in the tubers (Table 2). The totalpopulation densities when compared across locations showed that Lafia had the highest population of PPN (43 PPNs/combined composite) and closely followed by Keana (32 PPNs/combined composite) and Doma LGA (30 PPNs/combined composite).In terms of specific generic population, it was observed that Meloidogyne spp. were the most populated (91 nematodes/combined composite) closely followed by Scutellonema (88 nematodes/combined composite), Pratylenchus (37 nematodes/combined composite) and Rotylenchulus (33 nematodes/combined composite). The damage observed as a result of PPN attack on infected yamssurveyed are pictorially presented in Figure 2. Damage included soft rot (Figure 2A), concomitantroot-knot nematode-induced galls and soft rot (Figure 2B), necrotic lesions (Figure 2D) and abnormal proliferation of rootlets. There destructive activities result in unattractive, verrucose or knobby appearances on white yam, thereby resulting in low to extremely low tuber quality of marketable yams.

Nematode genera	Incidence of PPN in each Local Government Area (%)		21-40 yrs		41-60 yrs		61-75 yrs		Total	
	xIncidence		n	%	n	%	n	%	n	%
(%)	0	0.0%	1	2.5%	0	0.0%	0	0.0%	1	1.6%
	Lafia	Keana	Obi	Kokona	Doma	Awe		0.0%	3	4.8%
Pratylenchus	27.24	33.51	67.24	43.62	60.17	35.53	44.55	0.0%	2	3.2%
Hoplolaimus	13.40	11.33	0.00	0.00	15.21	11.00	8.49	0.0%	2	3.2%
Helicotylenchus	55.15	23.00	51.24	0.00	0.00	0.00	21.57	0.0%	2	3.2%
Criconema	0.00	0.00	13.50	0.00	0.00	0.00	2.25	0.0%	1	1.6%
Meloidogyne	77.11	67.38	70.66	83.02	73.44	80.13	75.29	0.0%	5	8.1%
Rotylenchus	0.00	0.00	0.00	23.50	0.00	17.11	6.77	0.0%	1	1.6%
Scutellonema	63.10	55.25	70.26	55.00	51.01	48.55	57.20	0.0%	1	1.6%
Xiphenema	0.00	0.00	0.00	0.00	11.11	0.00	1.85	0.0%	1	1.6%
Tylenchulus	0.00	0.00	0.00	0.00	0.00	7.20	1.20	0.0%	2	3.2%
Trichodorus	12.12	0.00	0.00	0.00	7.13	0.00	3.21	100.0%	31	50.0%
Rotylenchulus	33.33	52.14	0.00	35.12	22.12	0.00	23.79	0.0%	4	6.5%
y Incidence (%)	25.59	22.06	24.81	21.84	21.83	18.14		0.0%	6	9.7%

x = average incidence of nematode across LGA; *y* = average incidence of plant-parasitic nematodes within LGA

Table 1: Plant-parasitic nematode genera recovered from yam fields in six local government areas of Nasarawa state and their incidence levels

LGA		Density of plant-parasitic nematode										Avr.x
Praty.	Hopl.	Helico.	Crico.	Meloid.	Roty.	Scutellonema	Xiphi.	Tylenchulus.	Trichodorus		Rotylenchulus	
Lafia	43	22	23	0	82	0	77	0	0	17	43	28
Keana	51	17	8	0	48	0	79	0	0	0	37	22
Obi	31+++	0	24	22	23	0	86	0	0	0	0	17
Kokona	22	0	0	0	20	18	117	0	0	0	18	18
Doma	33	18	0	0	20	0	103	42	0	20	33	24
Awe	22	12	0	0	27	31	64	0	11	0	0	15
Avr.y	34	12	9	4	37	8	88	7	2	6	22	
	Tuber (50 g root)											
Lafia	11	2	13	0	112	0	0	0	0	17	13	15
Keana	4	10	4	0	88	0	0	0	0	0	7	10
Obi	3	0	11	0	43	0	0	0	0	0	10	6
Kokona	0	0	0	0	30	0	0	0	0	0	6	3
Doma	3	1	0	0	28	0	0	0	0	20	11	6
Awe	0	0	0	0	27	0	0	0	0	0	17	4
Avr.y	4	2	5	0	55	0	0	0	0	6	11	
	Total population											
Lafia	54	24	36	0	194	0	77	0	0	34	56	43
Keana	55	27	12	0	136	0	79	0	0	0	44	32
Obi	34	0	35	22	66	0	86	0	0	0	10	23
Kokona	22	0	0	0	50	18	117	0	0	0	24	21
Doma	36	19	0	0	48	0	103	42	0	40	44	30
Awe	22	12	0	0	54	31	64	0	11	0	17	19
Avr.y	37	14	14	4	91	8	88	7	2	12	33	

Praty. = Pratylenchus; Hopl. = Hoplolaimus; Helico. = Helicotylenchus; Meloid. = Meloidogyne; Roty. = Rotylenchus; Xiphi. = Xiphinema Avr.x = Approximated average count to across rows; Avr.y = Approximated average count across columns

Table 2: Population density of plant-parasitic nematodes recovered from 150 cc soil rhizosphere and 10 g of yam in six local government areas (LGAs) of Nasarawa state, Nigeria

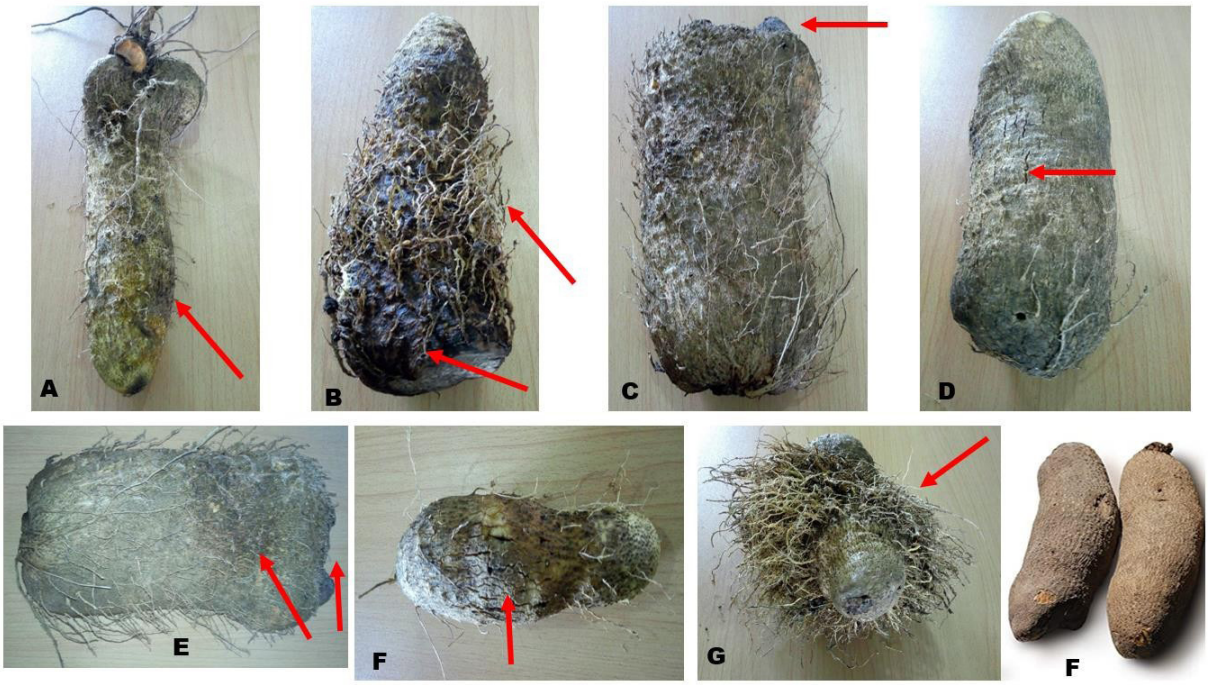

Figure 2: Some tubers of yams collected during the survey showing: (**A**) tuber soft rot symptom; (**B**) concomitant root-knot nematode induced galls and soft rot; (**C**) soft rot; (**D**) necrotic lesion; (**E**) soft rot; (**F**) necrotic lesion; (**G**) proliferation of rootlets and (**F**) healthy looking yam tubers

Discussion

Yam (Dioscorea spp.) constitute one of the most important food crops in the tropics and most important group of staple foods especially in the yam zone (25°N and 25°S) of West Africa [19]. The bulk of the global Yam production is concentrated in West Africa, with Nigeria producing the largest proportion followed by Ghana and Cote d'Ivoire [20]. Nasarawa State contributes immensely to the production of yams in Nigeria. However, published empirical data on incidences and associated parasitic nematode damages on yams grown from the State appeared almost nonexistent despite alarming reports from other yam-producing States in Nigeria. The need for baseline information or re-appraisals of the statuses and spread of plant-parasitic nematodes (PPNs) associated with yam cultivated in yam producing areas of Nigeria cannot be overemphasized. The baseline information will provide future directions which will ensure the design of specific nematode-induced disease management strategies for curbing the menace of infections in yam fields in the state. The current study has again demonstrated the abundance of plant-destructive nematode genera fields of economic crops.

Although Pratylenchus, Meloidogyne and Scutellonema were recovered from all the study locations, findings from this study showed that Meloidogyne had the highest incidence in yam fields surveyed in Nasarawa State. This finding agrees corroborates the report of Adegbite et al. [21] who found that Meloidogyne, Scutellonema and Pratylenchus in rank of descending order, were the most widely distributed plant-parasitic nematodes in yam fields in Edo, Ekiti and Oyo states of Nigeria. Over time, several workers had reported that Meloidogyne, Scutellonema and Pratylenchus are highly prevalent on yam fields. Their destructive activities result in unattractive, verrucose or knobby appearances on white yam, thereby resulting in low to extremely low tuber quality of marketable yams. In an analogous study conducted in Benue State, Isegbe et al. [22] revealed that only five nematode genera were recovered from marketed yam tubers namely Scutellonema, Meloidogyne, Pratylenchus and Tylenchus. Scutellonema was reported has having the highest incidence on yam. In contrast, the current investigation, in addition to using fresh yam tubers also made use of the rhizosphere of the yam plant and was able to recover eleven plant- parasitic nematode genera with Meloidogyne having the highest incidence.

Adegbite et al. [23] reported that of the ten PPNs recovered from yam fields in Ogun and Osun States, Scutellonema was the most widely distributed while Alabi et al. [24] documented Meloidogyne as the most prevalent PPN encountered in their study. In a study carried-out by Duru et al. [25], it was reported that seven genera of PPNs were recovered with Pratylenchus as the most prevalent species, followed by Meloidogyne and then, Scutellonema. Imafidor and Mukoro [26] reported that the most encountered PPNs on yam fields, in order of descending ranking, was Pratylenchus, Scutellonema and Meloidogyne. Hinmikaiye et al. [27] reported that of the five PPNs recovered, Meloidogyne was the most prevalent plant-parasitic nematode genus in a survey conducted on yam fields in Kogi State, Nigeria. Contrastingly, the survey did not encounter Scutellonema, a nematode popularly linked to yam. Like other previous studies [28] although with divergent plethora of differential genera composition, this current study encountered, in order of descending ranking, Rotylenchulus, Helicotylenchus, Hoplaimus, Rotylenchus, Trichodorus, Criconema, Xiphinema and Tylenchulus as PPN associated with yam fields in Nasarawa State.

Although it may be argued that given the nature of variable spatial distribution of plant-parasitic nematodes communities in soils, disparity of environmental soil variables, in-situ effects of climate change, global warming and climate variability, the outcomes of surveys may synchronously be changing as well. Hence there is need for a re-appraisal of site-specific concomitant plant-parasitic nematode communities prior to planting operations. The damages associated with the parasitic activities of these nematodes poses a serious threat to yam production in the State and calls for a concerted effort from all stakeholders in the yam value chain.

Conclusion

This study has documented for the first time, the extent to which yam cropping systems in Nasarawa State are impacted by the deleterious activities of phyto-parasitic nematode communities. A total of eleven plant-parasitic nematode genera were recovered from surveyed yam fields in Nasarawa State. These included, in descending order of ranking, Meloidogyne, Pratylenchus, Scutellonema, Rotylenchulus, Helicotylenchus, Hoplaimus, Rotylenchus, Trichodorus, Criconema, Xiphinema and Tylenchulus. The total population densities when compared across locations showed that yam fields in Lafia had the highest population of PPN closely followed by Keana LGA. The associated damages on yam tubers obtained from the study calls for a collaborative effort among ac-

tors in the yam value chain. The Federal Ministry of Agriculture and Rural Development (FMARD) must work hand-in-hand with the Nasarawa State Ministry of Agriculture and Water Resources to increase awareness of nematode-related problems and promote veritable measures for their control to forestall quantitative and qualitative yield losses.

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