EFFECT OF SEVEN ELITE CASSAVA (*MANIHOT ESCULENTA CRANTZ*) VARIETIES TO INFECTION BY *MELOIDOGYNE* SPP. AND OTHER NEMATODES IN THE FIELD

A. K. Akinsanya* and S. O. Afolami

Department of Crop Protection, Federal University of Agriculture, P.M.B. 2240, Abeokuta, Ogun State, Nigeria. (Current address: Department of Environmental Biology, Augustine University, P.M.B 1010, Ilara-Epe 106101, Lagos State, Nigeria); *Corresponding author: Korede.akinsanya@ augustineuniversity.edu.ng

ABSTRACT

Akinsanya, A. K., and S. O. Afolami. 2018. Effect of seven elite cassava (*Manihot esculenta crantz*) varieties to infection by *Meloidogyne* spp. and other nematodes in the field. Nematropica 48:50-58.

Cassava (*Manihot esculenta* Crantz) has seldom received attention by nematologists because of the erroneous belief that it was too hardy to be significantly damaged by nematodes. In this study, cassava varieties (TMS 98/0505, TMS 01/1368, TMS 98/0510, TMS 30572, TME EB419, TMS 95/0289, and TMS 98/0581) from the International Institute of Tropical Agriculture were evaluated for their field response to infection by *Meloidogyne incognita* and 10 other plant-parasitic nematodes (PPN) at the Federal University of Agriculture, Abeokuta. Cassava growth and yield were compared in naturally infested PPN plots treated with and without carbofuran (3 kg a.i./ha). *Aphelenchoides*, *Tylenchus*, *Longidorus*, *Pratylenchus*, *Hoplolaimus*, *Rotylenchus*, *Helicotylenchus*, *Trichodorus*, *Xiphinema*, *Meloidogyne,* and *Scutellonema* were identified in the soil. Infected plants were scored for galling (as a result of *Meloidogyne* infection only) on 1-5 rating scale. Carbofuran-treated plots had significantly ($P\leq$ 0.01) lower final densities of *Meloidogyne* and other PPN, and no galls were observed on feeder roots. The majority of crop growth and yield improved in plots treated with carbofuran. Significantly fewer storage roots rotted, and yield of all the cassava varieties was significantly higher (4.05-6.10 kg/plot) in carbofuran-treated plots compared to untreated plots (2.33-4.95 kg/plot). The average tuber yield of the carbofuran-treated and untreated plots was 51.3 and 34.1 T/ha, respectively, and the difference was significant across varieties (TMS 01/1368 and TMS 30572). This work suggests that cassava production can be improved by controlling nematodes in the field.

Key words: carbofuran, cassava, *Meloidogyne*, plant-parasitic nematodes, yield

RESUMEN

Akinsanya, A. K., y S. O. Afolami 2018. Efecto de siete variedades de élite de yuca (*Manihot esculenta* crantz) en la infección por *Meloidogyne* spp. y otros nematodos en el campo. Nematropica 48:50-58.

La yuca (*Manihot esculenta* Crantz), rara vez ha recibido atención por parte de nematólogos debido a la creencia errónea de que era demasiado resistente para ser dañada significativamente por los nematodos. En este estudio, se evaluaron las variedades de yuca (TMS 98/0505, TMS 01/1368, TMS 98/0510, TMS 30572, TME EB419, TMS 95/0289 y TMS 98/0581) del Instituto Internacional de Agricultura Tropical para su respuesta de campo a la infección por *Meloidogyne incognita* y otros diez nematodos fitoparásitos (PPN) en la Universidad Federal de Agricultura, Abeokuta. El crecimiento y rendimiento de la yuca se compararon en parcelas PPN infestadas de forma natural tratadas con y sin carbofurano (3 kg a.i./ha). *Aphelenchoides*, *Tylenchus*, *Longidorus*, *Pratylenchus*, *Hoplolaimus*, *Rotylenchus*, *Helicotylenchus*, *Trichodorus*, *Xiphinema*, *Meloidogyne* y *Scutellonema* se identificaron en el suelo. Las plantas infectadas se evaluaron en la formación de agallas (como resultado de la infección con *Meloidogyne* solamente) en una escala de calificación de 1-5. Las parcelas tratadas con carbofurano tuvieron densidades finales significativamente menores ($P\leq$0,01) de *Meloidogyne* y otros PPN y no se observaron agallas en las raíces alimentadoras. La mayoría del crecimiento del cultivo y el rendimiento mejoraron en parcelas tratadas con carbofurano. Significativamente menos raíces de almacenamiento se pudrieron y el rendimiento de todas las variedades de yuca fueron significativamente mayor (4.05-6.10 kg / parcela) en parcelas tratadas con carbofurano en comparación con parcelas no tratadas (2.33-4.95 kg / parcela). El rendimiento promedio de tubérculos de las parcelas tratadas con carbofuran y no tratadas fue de 51.3 y 34.1 T / ha respectivamente y la diferencia fue significativa entre las variedades (TMS 01/1368 y TMS 30572). Este trabajo sugiere que la producción de yuca puede mejorarse controlando los nematodos en el campo.

Palabras claves: carbofuran, *Meloidogyne*, nematodos fitoparásitos, rendimiento, yucca

INTRODUCTION

As with many tropical crops, a wide range of nematode species has been reportedly associated with cassava, *Manihot esculenta* Crantz, from many different geographical areas. The nematode species associated with cassava are presented in various reports, the most comprehensive of which include those by Hogger (1971), Caveness (1980), McSorley *et al*. (1983), Bridge *et al*. (1991), and Coyne *et al*. (2003). The plant-parasitic nematodes (PPN) most frequently found associated with cassava are *Meloidogyne incognita*, *M. javanica*, *Pratylenchus brachyurus*, *Rotylenchulus reniformis*, *Helicotylenchus erythrinae,* and *H. dihystera*. *Meloidogyne incognita* and *M. javanica* are the most important PPN in terms of abundance, followed by *P. brachyurus*, *Helicotylenchus* spp. and *R. reniformis* (McSorley *et al*., 1983). Whereas these PPN maybe common, cassava has been considered too hardy to be significantly damaged by these PPN.

This experiment was conducted to assess the field response of seven elite cassava varieties from the International Institute of Tropical Agriculture (IITA) to *Meloidogyne incognita* and other PPN.

MATERIALS AND METHODS

Location of study, source of cassava stems, and field layout

The research was conducted at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta, Nigeria. Seven cassava varieties (TMS 98/0505, TMS 01/1368, TMS 98/0510, TMS 30572, TME EB419, TMS 95/0289, and TMS 98/0581), which were obtained from IITA, Ibadan, were planted, and the experiment was laid out in a randomized complete block design (RCBD) with four replicates. A well-drained sandy loam soil was selected, and the field was ploughed and harrowed to provide sufficient tilt for good root growth. A field size of 27 m x 18 m was measured from the harrowed land. Selected cassava stems were planted and evenly spaced on a 1×1 m grid in 3x1 m plots with 2-m pathways between replications giving 8 plants per plot.

Soil sampling from plots and nematode counting

Soil samples were collected with the aid of a soil auger to a depth of 30 cm before cassava was planted. Five soil samples collected in the central area of each plot, in a figure-of-five pattern were bulked and assayed for nematodes using the Whitehead and Hemming (1965) modified tray Baermann technique. Two hundred and fifty grams of the composite soil sample were weighed and separately placed in two plastic sieves sandwiched with double-ply nematode extractor tissue paper in a plastic bowl containing 250 ml of water. The samples were left for 24 hr after which the sieves with soil were removed from the plastic bowl. The nematode suspension obtained was poured into a labeled nalgene bottle and was left for 5 hr for the nematodes to settle at the bottom. The supernatant was siphoned off with the aid of a 3-mm inner diameter rubber tubing inserted into the spout (Caveness, 1975). The concentrated suspensions were stored at 10°C for nematode population determination and were identified within 4 wk.

Treatment application

A 7×2 factorial experiment consisting of seven cassava varieties (TMS 98/0505, TMS 01/1368, TMS 98/0510, TMS 30572, TME EB419, TMS 95/0289, and TMS 98/0581) and two levels of nematicide (F_0= 3G carbofuran at zero level and F_1= 3G carbofuran at 60 g/plot) was established. The cassava varieties were known to be resistant to Cassava mosaic virus and Cassava brown streak virus. Carbofuran was incorporated prior to planting at 60 g/plot (3 kg a.i./ha) using the granular formulation, and a second treatment was applied 3 months after planting. A control was maintained where no nematicide was applied.

Measurement of crop growth parameters

Data were collected at 12, 24, and 36 wk after planting (WAP) on plant height and plant girth of five randomly selected plants in each plot. At harvest, the five randomly selected plants from each plot were assessed for mean plant height, plant girth, plant weight, number, and weight of marketable and non-marketable storage roots. Plant height was measured to the tallest point of pre-harvested plants using a wooden ruler. Girth was measured at 10 cm above the soil surface of the five randomly selected plants from each plot using a venire caliper. Stem and leaf material per plant was weighed together and recorded as plant fresh weight. Harvested storage roots were sorted into unblemished non-marketable (small) and marketable storage roots. Deformed storage roots (not conforming to 'normal' shape, physically twisted) and those affected by root rot were counted and weighed separately. Total yield was computed from all harvested marketable and non-marketable storage roots obtained from all plants in each plot.

Nematode population density and damage assessment

Nematode population densities were assessed shortly before planting (Pi) and at harvest (Pf) from five sampling points per plot as described earlier. Population of nematodes at harvest (Pf) was assessed from the same five randomly selected plants. Soil from plots was bulked into a composite sample. The soil was mixed thoroughly in a basin before sub-sampling 250 g of soil for nematode extraction. Nematodes were recovered from the soil sub-sample, using a modified Baermann technique. All samples were examined after a 24-hr extraction period. The nematodes were counted using a stereo-microscope (40×) and identified using a compound microscope (400×). Nematode damage indices were measured from roots of the five randomly selected plants. Fibrous/feeder roots were assessed for *M. incognita* galling damage and scored on a scale of 0-5 gall index (Taylor and Sasser, 1978). The number of galls per 50-cm length (using approximately five separate root pieces) was counted to provide a measure of infection intensity. Fibrous/feeder roots were gently tapped free of soil, chopped into 1-cm pieces, and mixed thoroughly before sub-sampling. Nematodes were recovered from 10 g of fresh root sub-sample, using a modified Baermann technique (Hooper, 1986). All root samples were examined after a 24-hr extraction period with the nematodes counted using a stereo-microscope and identified using a compound microscope.

Statistical analysis

Data were analyzed for variance, and means were separated using Least Significant Difference (LSD). Afolami's (2000, 2004) modification of the quantitative scheme for resistance rating by Sasser *et al*. (1984) was used for assigning crop varieties into resistance categories based on crop yield, Reproduction Factor (R), and Gall Index (GI).

RESULTS

Initial population (Pi) of nematodes recorded from the experimental plots was generally less than 18 individuals of each nematode per 250 g of soil (Fig. 1A). *Meloidogyne* was the most prevalent PPN discovered in the field experiment followed by *Pratylenchus*, *Helicotylenchus* and *Scutellonema*. *Trichodorus* spp. and *Tylenchus* spp. had the lowest populations (Fig. 1A). Carbofuran application significantly ($P \leq 0.05$) suppressed nematode population in all the plots treated during the experiment (Fig. 1B). *Meloidogyne* spp. and *Pratylenchus* spp. had the highest population levels in both treated and untreated plots while *Trichodorus* sp. and *Xiphinema* sp. had the lowest population (Fig. 1B). Application of carbofuran and the resultant nematode population suppression led to improvement in cassava growth as expressed in taller ($P \leq 0.05$) and more robust cassava plants (Table 1). Stem girth ranged from 1.75-2.38 cm at 3 months after planting (MAP) to 2.78-3.68 cm at 6 MAP, 3.15-3.90 cm at 9 MAP and 3.43-4.28 cm at 12 MAP. Carbofuran treatment caused some increase in top fresh weight of all the cassava varieties (Table 2). However, the increase was significant ($P \leq 0.05$) only in TMS 98/0505, TMS 01/1368, and TMS 95/0289. No differences ($P > 0.05$) in number of marketable storage roots among the cassava varieties treated with carbofuran was observed with the exception of TMS 30572. Although the number of non-marketable storage roots was higher in the untreated plots than the treated, there were no differences ($P > 0.05$) when compared with treated plots except in cassava variety TME EB419. Carbofuran treatment increased the weight of marketable tubers in all the varieties compared with their untreated counterparts. No differences ($P > 0.05$) were observed in the weight of marketable storage roots among the cassava varieties treated with carbofuran except for TMS 95/0289 (Fig 2). The weight of non-marketable storage tubers in the treated plots were not different ($P > 0.05$) when compared with their untreated counterparts (Table 3). Carbofuran treatment reduced the number of roots in all the varieties compared with their untreated counterparts although the differences were not significant statistically (Table 4; Fig. 3). The yield of TME EB419 was greater than the untreated plots ($P > 0.05$). Cassava variety TMS 98/0505 and TMS 98/0510 had the highest yield whereas TMS 95/0289 had the lowest (Table 4). *Meloidogyne incognita* galling was only recorded in some of the

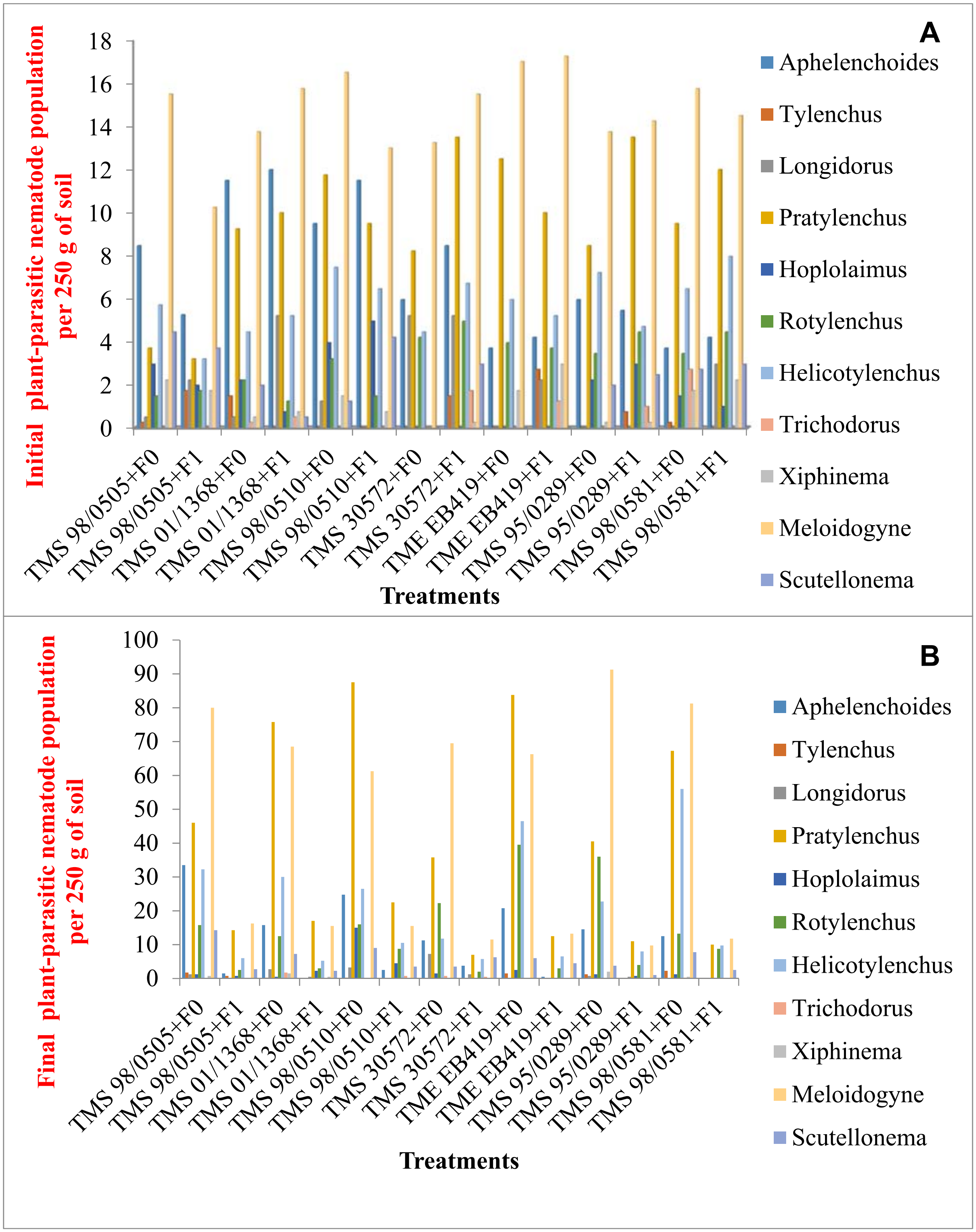

Fig. 1. Initial and final population of plant-parasitic nematodes at planting (Pi) and at harvest (Pf). A: Initial population of plant-parasitic nematodes at planting (Pi) and their population per 250 g of soil in the field. B: Final population of plant-parasitic nematodes at harvest (Pf) and their population per 250 g of soil in the field plots with seven cassava varieties grown for 12 months.

Table 1. Effect of nematicide treatment on growth of seven cassava varieties grown for 12 months in the field.

	Mean plant height (cm)[w]				Mean stem girth (cm)[w]			
Treatments	3 MAP[x]	6 MAP	9 MAP	12 MAP	3 MAP	6 MAP	9 MAP	12 MAP
TMS 98/0505+F_0[y]	111.80	164.58	193.43	219.75	1.95	3.05	3.25	3.50
TMS 98/0505+F_1[z]	139.75	192.95	215.55	246.00	2.38	3.55	3.88	4.13
LSD (0.05)	15.28 s	28.81s	24.78 s	17.05 s	0.29 s	0.59 ns	0.58 ns	0.55 s
TMS 01/1368+F_0	125.05	200.78	228.95	256.45	1.75	2.95	3.13	3.35
TMS 01/1368+F_1	139.40	207.43	236.00	268.05	1.95	3.20	3.48	3.68
LSD (0.05)	21.75 ns	37.28 ns	40.46 ns	41.15 ns	0.29 ns	0.56 ns	0.61 ns	0.65 ns
TMS 98/0510+F_0	113.60	172.45	193.58	230.75	2.08	2.93	3.50	3.78
TMS 98/0510+F_1	134.75	191.95	255.83	254.50	2.30	3.68	3.90	4.28
LSD (0.05)	18.05 s	38.36 ns	60.24s	44.99 ns	0.56 ns	0.71s	0.78 ns	0.76 ns
TMS 30572+F_0	120.35	177.45	208.03	236.75	1.93	3.13	3.33	3.45
TMS 30572+F_1	141.35	215.18	264.23	257.10	2.13	3.25	3.50	3.90
LSD (0.05)	23.65 ns	31.24 s	41.69 s	18.96 s	0.40 ns	0.45 ns	0.51 ns	0.35 s
TME EB419+F_0	145.55	218.88	280.68	325.45	1.93	2.65	2.95	3.25
TME EB419+F_1	163.15	275.83	311.85	349.93	2.23	2.78	3.23	3.43
LSD (0.05)	29.02 ns	69.19 ns	47.03 ns	22.58 s	0.35 ns	0.45 ns	0.46 ns	0.32 ns
TMS 95/0289+F_0	121.25	188.25	217.70	241.50	1.85	2.88	3.08	3.40
TMS 95/0289+F_1	139.05	206.45	236.95	266.35	2.03	2.83	3.15	3.43
LSD (0.05)	20.83 ns	15.21s	11.20 s	15.38 s	0.37 ns	0.82 ns	0.94 ns	1.04 ns
TMS 98/0581+F_0	130.55	199.73	229.63	264.75	2.03	2.90	3.20	3.40
TMS 98/0581+F_1	139.75	211.75	244.50	275.25	2.30	3.20	3.45	3.68
LSD (0.05)	26.07 ns	16.66 ns	34.83 ns	29.30 ns	0.47 ns	0.44 ns	0.54 ns	0.47 ns

[w]Values are means of four replicates.
[x]MAP= Months after planting
[y]F_0= without carbofuran
[z]F*1*= with carbofuran
LSD= Least Significant Difference: ns= not significant; s= significant

Table 2. Effect of nematicide treatment on fresh shoot (top) weight (kg /plant) of seven cassava varieties grown for 12 months in the field.

Treatments	Mean fresh weight of cassava shoot (kg/plant)[x]
TMS 98/0505+F_0[y]	3.43
TMS 98/0505+F_1[z]	5.48
LSD (0.05)	1.90 s
TMS 01/1368+F_0	1.73
TMS 01/1368+F_1	5.13
LSD (0.05)	1.84 s
TMS 98/0510+F_0	3.88
TMS 98/0510+F_1	4.45
LSD (0.05)	3.42 ns
TMS 30572+F_0	3.03
TMS 30572+F_1	3.45
LSD (0.05)	2.45 ns
TME EB419+F_0	2.28
TME EB419+F_1	2.48
LSD (0.05)	0.72 ns
TMS 95/0289+F_0	2.35
TMS 95/0289+F_1	3.85
LSD (0.05)	1.38 s
TMS 98/0581+F_0	2.98
TMS 98/0581+F_1	2.93
LSD (0.05)	1.87 ns

[x]Values are means of four replicates
[y]F_0= without carbofuran
[z]F_1= with carbofuran
LSD= Least Significant Difference: ns= not significant; s= significant

Table 3. Effect of nematicide treatment on some yield parameters of seven cassava varieties grown for 12 months in the field with and without carbofuran application.

	Marketable storage roots[x]		Non-marketable storage roots[x]	
Treatments	Number	Weight (kg)	Number	Weight (kg)
TMS 98/0505+F_0[y]	8.50	4.35	2.50	0.60
TMS 98/0505+F_1[z]	11.75	5.20	1.75	0.90
LSD (0.05)	4.22 ns	2.29 ns	2.20 ns	1.10 ns
TMS 01/1368+F_0	7.00	2.00	0.75	0.18
TMS 01/1368+F_1	9.50	4.78	0.50	0.23
LSD (0.05)	5.60 ns	3.37 ns	0.93 ns	0.38 ns
TMS 98/0510+F_0	6.75	4.05	1.00	0.28
TMS 98/0510+F_1	7.75	5.40	2.25	0.70
LSD (0.05)	2.95 ns	2.51 ns	3.36 ns	0.92 ns

Table 3. Continued.

Treatments	Marketable storage roots[x] Number	Marketable storage roots[x] Weight (kg)	Non-marketable storage roots[x] Number	Non-marketable storage roots[x] Weight (kg)
TMS 30572+F_0[y]	7.00	2.90	1.25	0.50
TMS 30572+F_1[z]	8.50	4.60	0.50	0.08
LSD (0.05)	0.70 s	3.51ns	2.20ns	0.88 ns
TME EB419+F_0	8.75	2.38	1.00	0.13
TME EB419+F_1	10.75	4.18	0.50	0.10
LSD (0.05)	7.65 ns	1.86 ns	0.32 s	0.28 ns
TMS 95/0289+F_0	7.00	2.53	1.50	0.50
TMS 95/0289+F_1	8.50	3.88	0.50	0.18
LSD (0.05)	2.73 ns	1.27 s	2.23 ns	0.87 ns
TMS 98/0581+F_0	8.25	3.18	2.00	0.60
TMS 98/0581+F_1	10.25	5.03	0.75	0.25
LSD (0.05)	4.55 ns	2.58 ns	2.08 ns	0.55 ns

[x]Values are means of four replications.
[y]F_0 = without carbofuran treatment;
[z]F_1 = with carbofuran treatment.
LSD= Least Significant Difference; ns= not significant; s = significant.

Table 4. Effect of nematicide treatment on yield parameters of seven cassava varieties grown for 12 months in the field with and without carbofuran application.

Treatments	Rotten/Deformed Tubers[x] Number of rotten tubers	Rotten/Deformed Tubers[x] Weight of rotten tubers (kg)	Rotten/Deformed Tubers[x] Weight of deformed tubers (kg)	Yield/Plot[x] Tuber yield
TMS 98/0505+F_0[y]	2.25	0.53	0.08	4.95
TMS 98/0505+F_1[z]	1.00	0.43	0.48	6.10
LSD (0.05)	2.31 ns	0.86 ns	0.77ns	2.54 ns
TMS 98/0510+F_0	0.50	0.08	0.25	2.33
TMS 98/0510+F_1	0.25	0.13	0.10	5.00
LSD (0.05)	0.93 ns	0.32 ns	0.44 ns	3.66 ns
TMS 98/0510+F_0	1.00	0.00	0.00	4.33
TMS 98/0510+F_1	0.75	0.28	1.50	6.10
LSD (0.05)	1.53 ns	0.49 ns	3.67 ns	2.73 ns
TMS 30572+F_0	1.00	0.25	0.25	2.98
TMS 30572+F_1	0.00	0.00	0.08	5.10
LSD (0.05)	1.41ns	0.35 ns	0.63 ns	3.17 ns
TME EB419+F_0	0.75	0.10	0.03	2.50
TME EB419+F_1	0.00	0.00	0.03	4.28
LSD (0.05)	1.52 ns	0.23 ns	0.13 ns	0.82 s
TMS 95/0289+F_0	1.25	0.40	0.10	3.03
TMS 95/0289+F_1	0.25	0.13	0.05	4.05
LSD (0.05)	1.65 ns	0.66 ns	0.27 ns	1.39 ns
TMS 98/0581+F_0	2.00	0.60	0.00	3.78
TMS 98/0581+F_1	0.25	0.13	0.13	5.28
LSD (0.05)	1.83ns	0.52 s	0.30 ns	3.01 ns

[x]Values are means of four replications.
[y]F_0 = without carbofuran treatment
[z]F_1 = with carbofuran treatment.
LSD= Least Significant Difference; ns= not significant; s = significant.

Fig. 3. Cassava variety (TMS 95/0289) grown for 12 months in the field with/without carbofuran application.

V_6F_1 = TMS 95/0289 cassava with carbofuran treatment showing clean cassava tubers (left).

V_6F_0 = TMS 95/0289 cassava without carbofuran treatment showing rotten cassava tubers (right).

untreated plots. In these untreated plots, cassava varieties (TMS 98/0510, TMS 30572, and TMS 98/0581) were severely galled with gall index ranging from 3-4.

DISCUSSION

Results obtained from this study showed that *M. incognita* infection caused significant (*P*<0.05) suppression in some of the growth and yield parameters of the cassava varieties. Despite the relatively low Pi of the PPN, high populations and subsequent low crop performance resulted in significant yield loss 12 months later. Coyne *et al*. (2003) observed that *Meloidogyne* spp., followed by *P. brachyurus* were the most commonly reported root endoparasitic nematodes on cassava. Several species of *Scutellonema* are also commonly recorded at relatively high densities in cassava fields. Numerous nematodes species have been associated with cassava roots and several of these multiply on cassava roots to reach high populations. Extensive lists of these PPN on cassava have been produced (Hogger, 1971; Caveness, 1980; McSorley *et al*., 1983), but little evidence that PPN had a significant effect on yield was published, although root-knot nematodes were suspected to be important. The current study has demonstrated that cassava growth and yield negatively affect PPN occurring naturally in fields. Application of nematicide provided significant benefit to some of the cassava varieties, indicating effective nematode management can provide improvement in yield quantity and quality.

LITERATURE CITED

Afolami, S. O. 2000. Suggestions for the improvement of curret methods of studying and reporting resistance to root-knot nematodes. International Journal of Nematology 10:94-100.

Afolami, S. O., J. J. Atungwu, I. S. Odeyemi, and S. B. Orisajo. 2004. Going beyond gall index in studying and reporting resistance to root-knot nematodes. Nigerian Journal of Plant Protection. 21:25-32.

Bridge J., W. Otim-Nape, and J. Namaganda. 1991. The root knot nematode, *Meloidogyne incognita*, causing damage to cassava in Uganda. Afro-Asian Journal of Nematology 1: 116- 117.

Caveness, F. E. 1980. Plant parasitic nematode on cassava. *In* Ezumah, H.C. (ed.) Proceedings of the Workshop on Cassava Production and Extension in Central Africa. Mbanza-Ngungu, Zaire. IITA, Ibadan. 4:83-106.

Coyne D. L., H. A. L. Talwana, and N. R. Maslen. 2003. Plant parasitic nematodes associated with root and tuber crops in Uganda. African Crop Protection 9:87-98.

Hogger, C. H. 1971. Plant parasitic nematodes associated with cassava. Tropical Root and Tuber Crops Newsletter 4:4-9.

Hooper, D. J. 1986. Extraction of free living stages from soil. Pp. 5-30 *in* Southey, J. F. (ed.) Laboratory methods for work with plant and soil nematodes, Reference Book 402, Ministry of Agriculture, Fisheries and Food. London: Her Majesty's Stationery office.

McSorley, R., S. K. O'Hair, and J. L. Parrado. 1983. Nematodes of cassava, *Manihot esculenta* Crantz. Nematropica 13:261-287.

Sasser, J. N., C. C. Carter, and K. M. Hartman. 1984. Standardization of host suitability studies and reporting of resistance to root-knot nematodes. A Cooperative Publication of the North Carolina State University. Department of Plant Pathology and USAID, Raleigh, NC.

Taylor, A. L., and J. N. Sasser. 1978. Biology, identification and control of root-knot nematodes (*Meloidogyne* species). A co-operative publication of North Carolina state University and USAID, Raleigh, NC.

Whitehead, A. G., and J. R. Hemming. 1965. A comparison of some qualitative methods of extracting small vermiform nematodes from soil. Annals of Applied Biology 55:25-38.

Received:
Recibido: *1/VIII/2017*

Accepted for publication:
Aceptado para publicación: *13/XI/2017*