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MANAGEMENT OF PLANT PARASITIC NEMATODES IN OKRA (*Abelmuschus esculentus* L. MOENCH) USING NEEM LEAF POWDER AND CARBOFURAN IN SUDAN AND NORTHERN GUINEA SAVANNAH, NORTH EASTERN NIGERIA

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ABSTRACT

Field experiments were carried out during the 2013 cropping season at Teaching and Research Farm, University of Maiduguri and at Lassa, Askira Uba local Government Area, Borno State to investigate the use of neem leaf powder (NLP) and carbofuran alone and in combination as amendment in managing plant parasitic nematode infecting four varieties of okra (*Abelmoschus esculentus* L. Moench) (Alau, Eklenson, Lady`s finger and Utonkon). The experiment was carried out in split plot design replicated 3 times. Result indicated that NLP and carbofuran in combination were more effective for nematode suppression with a reduction factor of 86.3 % and 89.6 % in Maiduguri and Lassa, respectively. Application of NLP and carbofuran at 0.5 ton/ha and 1 kg a.i/ha resulted in highest fruit weight (4.42 kg in Maiduguri and 4.45 kg in Lassa) and the lowest fruit weight was observed under control plots. In Lassa and Maiduguri, Alau and Eklenson variety of okra respectively treated with the combination of NLP + carbofuran recorded the highest fruit weight and lowest number of galls in both locations. It was concluded that appropriate management of plant-parasitic nematodes will promote higher fruit yields in okra.

Keywords: Carbofuran; Management; Okra; Plant parasitic nematodes

INTRODUCTION

Okra, (*Abelmoschus esculentus* L. Moench) known in many English-speaking countries as lady's fingers, is a flowering plant in the mallow family. The plant is cultivated in tropical, sub-tropical and warm temperate regions around the world (Rashid *et al*., 2002; NRC, 2006). It is among the most heat and drought tolerant vegetable species in the world and tolerates soils with heavy clay and intermittent moisture and frost can damage the pods. Okra is a good source of Vitamins C, A and B complex as well as iron and calcium. Potassium, Na, Mg and Ca are the principal elements in pods, which contain about 17 % seeds. Presence of Fe, Zn, Mn and Ni also has been reported (Moyin-Jesu, 2007). Okra is subjected to attack by many insects and pathogens including fungi, viruses, mycoplasmas and nematodes (Hussain *et al*., 2011; Ahmad *et al*., 2012; Arain *et al*., 2012; Iqbal *et al*., 2012; Srivastava *et al*., 2012). The most widespread and economically important are the root-knot nematodes (*Meloidogyne* spp.). In Nigeria, Sikora and Fernandez (2005) reported

severe infection of root-knot disease caused by *Meloidogyne* spp and root knot nematodes are responsible for yield losses up to 27 % in okra. Nematodes are probably the major obstacle to the production of sufficient food and fibre crops in Nigeria and many developing nations (Mohammed and Umar, 2012). Nematologists have now paid more attention to the study of organic materials in the management of plant-parasitic nematodes (Abubakar and Adamu, 2004) due to the toxic effects of synthetic nematicides.

The objective of this study was to evaluate the efficacy of NLP in suppressing plant parasitic nematode population along with carbofuran; to evaluate the efficacy of each of NLP and carbofuran in comparison to a combination of 50 % each (of the neem leaf powder and carbofuran) for the management of plant parasitic nematode and to assess the effect of the treatment on growth and yield of the Okra.

MATERIALS AND METHODS

The Study Area

The experiment was conducted at the Teaching and Research Farm, University of Maiduguri, Maiduguri (Latitude 11^{o} 15' and Longitude 13^{o} 51' E) Borno State, Nigeria and Lassa, Askira Uba Local Government Area, (Latitude 10^{o} $63^{'}$ N and Longitude 12^{o} $87^{'}$ E) in Borno State, Nigeria. The selected land was previously cropped with tomatoes, onion, carrot, garden egg, okra and cowpea and the soil of the area was found to be sandy loam with a pH of 6.8 and the temperature was 26.4^{o}C with a low average annual rainfall of 657.3mm and prolong dry season supports fewer trees and shorter grasses than the northern guinea savannah (Sowumin and Kintola, 2010). In Lassa, Northern Guinea Savannah, the average annual temperature and rainfall of 27.3^{o}C and 1051.7mm, respectively where the wet season last for 6-8 months (Sowunmi and Kintola, 2010). In northern guinea savannah the soil was clay-loam. It has a moderate pH values (6-6.7). The selected land for the experiment in Lassa was previously cropped with tomatoes and cowpea.

Data Collection

The initial (before application of treatments) and final (after crop harvest) nematode population were determined by taking three core samples with a soil auger to a depth of 20 cm in a zig-zag pattern from each experimental plot, bulked and labeled. The soil samples collected from each plot were analysed in the laboratory to determine the plant parasitic nematode population. The White-Head and Hemming (1965) method of nematode extraction was used.

Five plants per plot were randomly selected for determination of growth and yield parameters. The parameters measured included shoot length (cm), fresh shoot weight (g), root length (cm), fresh and dry root weight (g) and fresh fruit weight (kg) per unit area.

Data Analysis

All data collected (except on nematode population) were subjected to Analysis of Variance (ANOVA) appropriate to split-plot design using Statistix Version 9.0. Difference between means was determined using the least significant difference (LSD) Statistic ($P\leq 0.05$).

Gross margin was determined by employing partial farm budget analysis as adopted by Okoruwa *et al*. (2005), the mathematical expression of which is given as:
$Gm = TR - VC$

Where Gm = Gross margin

TR = total revenue

VC = Variable cost

RESULTS AND DISCUSSION

Population of Soil Nematodes

Table 1 shows that at both locations (Maiduguri and Lassa) the nematicide soil amendments reduced the population of soil nematodes compared with that found in the control treatment. The effect of NLP at the rate of 1 ton/ha, carbofuran at the rate of 2 kg a.i. /ha, and combination (NLP 0.5 ton/ha and carbofuran at 1 kg a.i. /ha) on nematode population infecting okra shows that NLP at 1 ton/ha suppressed the population of nematode by 56.8 % and 56.6 % in Maiduguri and Lassa, respectively. Carbofuran was able to reduce soil nematode population by 69.4 % in Maiduguri and 67 % in Lassa. NLP and carbofuran in combination was more effective for nematode suppression with a reduction factor of 86.3 % and 89.6 % in Maiduguri and Lassa, respectively. The untreated plots produced the highest nematode population. For the effect of varieties on the soil nematode population, results show that all the varieties suppressed the nematode population in both locations. The nematode population was suppressed by 67.79 % and 24 % with a reproduction factor of 0.32 and 0.75 under Eklenson and Alau okra varieties, respectively, in Maiduguri, while in Lassa Alau and Lady's finger suppressed the nematode population by 79.51 % and 35.80 % with a reproduction factor of 0.20 and 0.64, respectively.

The reproductive factor (RF) in both location (Maiduguri and Lassa) showed that NLP and carbofuran in combination exhibited the least nematode population with 0.14 in Maiduguri and 0.10 in Lassa followed by sole carbofuran with 0.31 and 0.33 in an increasing order, while NLP gave 0.43 in both locations. Also the control treatment with 2.26 in Maiduguri and 1.91 in Lassa showed the highest in the reproductive factor parameter.

Table 1: Effect of Neem Leaf Powder and Carbofuran on the total population of soil nematode in Maiduguri and Lassa during 2013 wet season

Treatments	Initial population (Pi)	Final Population (Pf)	Change in Population (%)	Reproduction Factor (RF)
		Maiduguri		
Nematicide				
NLP	132	57	-56.81	0.43
Carbofuran	147	45	-69.39	0.31
NLP + Carbofuran	160	22	-86.27	0.14
Control	163	369	126.44	2.26
Variety				
Alau	74	56	-24.32	0.75
Eklenson	59	19	-67.79	0.32
Lady`s figure	64	48	-25.00	0.75
Utonkon	52	27	-48.07	0.51
		Lassa		
Nematicide				
NLP	166	72	-56.61	0.43
Carbofuran	194	64	-67.06	0.33
NLP + Carbofuran	192	20	-89.56	0.10
Control	209	400	91.33	1.91
Variety				
Alau	83	17	-79.51	0.20
Eklenson	72	21	-70.83	0.29
Lady`s finger	81	52	-35.80	0.64
Utonkon	80	45	-43.75	0.56

Values are means of three replicates; Percentage change in population= $\frac{Pf-Pi}{Pi}$ x 100; + = Increase in population; - = Decrease in population

Table 2: Effect of NLP, Carbofuran and NLP + Carbofuran on Soil Population of Identified Nematode Genera during the 2013 Wet Season in Lassa and Maiduguri

Treatment	Pi	Pf	%Change	Pi	Pf	%Change	Pi	Pf	%Change
					Maiduguri				
	Meloidogyne spp			*Longidorus spp*			Microbivorous		
NLP	15	6	-60	44	19	-56.8	63	30	-52.4
Carbofuran	17	5	-70.6	31	31	-64.5	54	40	-25.9
NLP + Carbofuran	18	3	-83.3	57	5	-91.2	54	14	-74.1
Control	24	31	29.16	61	61	93.4	73	130	78.1
					Lassa				
	Helicotylencus spp			*Hoplolaimus spp*			Microbivorous		
NLP	22	6	-72.7	12	9	-25	98	40	-59.2
Carbofuran	17	3	-82.4	18	12	-33.3	121	51	-57.3
NLP + Carbofuran	18	1	-94.4	25	4	-84	166	54	-67.5
Control	18	47	161.1	31	85	174.2	71	200	181.7

Values are means of three replicates; + = Increase in population; - = Decrease in population

Percentage change in population= $\frac{Pf-Pi}{Pi}$x100; Pi= Initial population; Pf =Final population

Effect of Soil Amendment on Fresh Fruit Weight of Different Varieties

Application of NLP, carbofuran and combination of NLP + Carbofuran were found to suppress all population of the identified nematode genera in both locations of the experiment. Under NLP soil population of *Meloidogyne spp* was suppressed by 60 % in Lassa, while *Longidorus spp* was reduced in Maiduguri by 56.8 % (Table 2). NLP and carbofuran in combination were able to suppress the population of *Meloidogyne spp* and *Longidorous spp* by 83.3 % and 91.2 %, respectively in Maiduguri. While *Helicotylenchus spp* and *Hoplolaimus spp* were suppressed by 94.4 % and 84 %, respectively in Lassa under the same treatment. Application of carbofuran at the rate of 2 kg a.i/ha reduced population of *Meloidogyne spp*, *Longidorus spp*, *Helicotylenchus spp*, and *Hoplolaimus spp* in both locations by 70.6%, 64.5%, 82.4%, and 33.3%, respectively.

The population of microbivorous species was also suppressed under all treatments in Maiduguri except under the control, which was similar to the trend observed in Lassa. In both locations (Maiduguri and Lassa), application of NLP and carbofuran in combination at the rate of 0.5 tons/ha and 1 kg a.i/ha 3 G reduced the population of microbivorous by 74.1 % and 67.5 %, respectively followed by sole application of carbofuran and NLP. Increase in population of microbivorous was observed in control treatment by 78.1 % in Maiduguri and 181.7 % in Lassa.

Table 3: Effect of Soil amendment of NLP, NLP + Carbofuran and Carbofuran on root galls of different varieties of Okra in Lassa and Maiduguri during 2013 Wet Season

Treatment	Root galls		Combined
	Maiduguri	Lassa	
Nematicide (A)			
NLP	6.92^{b}	6.92^{b}	6.92^{b}
Carbofuran	1.83^{c}	4.58^{c}	3.21^{c}
NLP + Carbofuran	1.08^{c}	0.33^{d}	0.58^{d}
Control	27.67^{a}	39.75^{a}	34.46^{a}
SE	0.48	0.78	0.66
Variety (B)			
Alau	12.75^{a}	6.58^{d}	10.42^{b}
Eklenson	5.67^{d}	14.17^{b}	9.92^{b}
Lady's finger	8.25^{c}	19.50^{a}	13.83^{a}
Utonkon	10.83^{b}	11.33^{c}	11.00^{b}
SE	0.53	0.69	0.60
Interaction A x B	ns	ns	

Values are means of three replicates; NS = Not significant

The reduction, in nematode population observed in this study could have been the direct effect of NLP + carbofuran. This is in conformity with the observations made by Akhatar and Alam (1991), who reported that there was suppression in the population of plant parasitic nematodes when soil was treated with oil seed cakes and leaves of neem (*Azadirachta indica*) and castor (*Ricinus communis*) and the nematicidal carbofuran. This finding also agrees with Gambo (1998), who reported that degradation of neem leaves significantly reduced the number of root-knot nematodes population in the soil. The use of carbofuran in managing nematode is effective, although it is relatively short-lived, and its

conventional solid and liquid formulations are effective for short duration only. Effects of carbofuran on nematodes activity is restored after degradation or dilution of the carbamates in the plant rhizosphere (Sikora and Hartwig, 1991; Extoxnet 2001).

The results in Table 3 shows that all the nematicide treatments significantly ($P \leq 0.05$) suppressed galling of the okra roots in both locations (Lassa and Maiduguri). The highest reduction in number of galls per root system was obtained in plots treated with NLP and carbofuran in combination followed by carbofuran and NLP, significantly more number of galls was observed in the untreated control plot. The results also show that no significant difference between plots treated with NLP and carbofuran in combination and carbofuran alone in Maiduguri. Significant difference was observed between the plot treated with NLP and the untreated plot. There was significant ($P \leq 0.05$) effect on root galls of different varieties of okra. The highest number of galls was observed in Lady's finger and Alau in Lassa and Maiduguri, respectively while less galls was observed in Alau and Eklenson at Lassa and Maiduguri, respectively. The control plots recorded the highest mean galling index in both varieties and locations; this might be due to lack of deterrent on the roots of the control plants. Nematodes were able to invade the root, feed and reproduced on it thereby forming giant cells or root knot disease. In a similar finding Hussain *et al*. (2011) reported that *Azadirachta indica* and *Calotropis procera* (Ait) caused maximum reduction in number of galls, egg masses and reproduction factor of nematodes.

Table 4: Effect of Carbofuran, Carbofuran + NLP and NLP as soil amendment on fresh fruit weight of different varieties of Okra in Lassa and Maiduguri during 2013 wet season

Treatment	Fresh fruit weight (kg)		Combined
	Maiduguri	Lassa	
Nematicide (A)			2.45^{c}
NLP	2.40^{c}	2.48^{c}	4.43^{a}
NLP + Carbofuran	4.42^{a}	4.45^{a}	3.42^{b}
Carbofuran	3.40^{b}	3.44^{b}	1.33^{d}
Control	1.41^{d}	1.25^{d}	0.02
SE	0.03	0.04	
Variety (B)			
Alau	2.53^{d}	3.32^{a}	2.92^{b}
Eklenson	3.33^{a}	2.75^{c}	3.04^{a}
Lady's finger	3.02^{b}	2.54^{d}	2.78^{c}
Utonkon	2.74^{c}	3.01^{b}	2.88^{b}
SE	0.03	0.02	0.01
Interaction (A x B)	*	*	

Values are means of three replicates; * = Significant at 5 % level of probability

There was significant ($P \leq 0.05$) increase in yield in response to all treatments, compared to untreated plots (Table 4). Results of the two experiments show that plots treated with NLP and carbofuran in combination produced the highest fruit weight (4.42 kg and 4.45 kg in Maiduguri and Lassa respectively) followed by plots treated with carbofuran (3.40 kg in Maiduguri and 3.44 in Lassa) and NLP than the untreated control plot. This may have been due to the ability of carbofuran and neem leaf powder to suppress the nematodes as a result of the presence of phytochemicals and increased fertility of soil which resulted in

increased fruit weight. The least fruit weight was recorded in control. This was probably due to nematode activity at the root zone, which affected the performance of the roots and this translated into low yield by the control plants. This agrees with the findings of Adesiyan *et al*. (1990) who reported that nematode can affect the performance of crops by reducing its quality and quantity. Alau and Eklenson varieties of okra produced the highest fruit weight in Lassa (3.32 kg) and 3.33 kg in Maiduguri, respectively. The lowest fruit weight was recorded in Lady's finger and Alau okra variety in Lassa and Maiduguri, respectively.

Cost-benefit Analysis

In Lassa, the application of NLP + Carbofuran in combination gave the highest economic gain (Table 5). It shows that application of NLP + carbofuran in combination resulted in economic gain of N20, 650.00 over control in Lassa. Also, application of carbofuran resulted in a gain of N21, 830.00 as against a gross margin of N1, 850.00 recorded under control. The Table also shows that in Lassa, the economic gain for the tested okra varieties ranged from N17, 330.00 for Lady's finger to N26, 900.00 for Alau.

In Maiduguri, NLP + carbofuran in combination recording a gross margin of N37, 340.00 gave the highest economic return (Table 6). Carbofuran ranked the second with a gross margin of N22, 350.00 followed by NLP and the least economic return was recorded under control. The gross margin of the okra varieties in Maiduguri were N28, 510 for Eklenson, N24, 790 for Lady's finger, N18, 910 for Alau and N7, 930 for Utonkon.

Table 5: Total Cost, Revenue and Gross Margin of Using Okra Varieties and Nematicide on Okra Pods in Lassa

Treatments	Value of output ha (₦)	Total Cost ha (₦)	Gross Margin ha (₦)
Nematicide (A)			
NLP	29,760.00	14,900.00	14,860.00
Carbofuran	41,280.00	19,450.00	21,830.00
NLP + Carbofuran	39,900.00	17,400.00	22,500.00
Control	15,000.00	13,150.00	1,850.00
Variety (B)			
Alau	39,840.00	13,150.00	26,690.00
Eklenson	33,000.00	13,150.00	19,850.00
Lady's finger	30,480.00	13,150.00	17,330.00
Utonkon	36,120.00	13,150.00	22,970.00

Table 6: Total Cost, Revenue and Gross Margin of Using Okra Varieties and Nematicide on Okra Pods in Maiduguri

Treatments	Value of output ha (₦)	Total Cost ha (₦)	Gross Margin ha (₦)
Nematicide (A)			
NLP	28,800.00	14,950.00	13,850.00
Carbofuran	40,800.00	18,450.00	22,350.00
NLP + Carbofuran	53,040.00	15,700.00	37,340.00
Control	16,920.00	11,450.00	5,470.00
Variety (B)			
Alau	30,360.00	11,450.00	18,910.00
Eklenson	39,960.00	11,450.00	28,510.00
Lady's finger	36,240.00	11,450.00	24,790.00
Utonkon	19,380.00	11,450.00	7,930.00

CONCLUSION

It is evident from this research work that soil amendment of neem leaf powder and carbofuran in combination is very effective in suppressing plant parasitic nematode and also profitable. It is therefore concluded that farmers should adopt and practice the application of neem leaf powder and carbofuran in combination into the soil on their farms where nematodes have been destructive to crop production since these methods are to be easy and economical in controlling plant-parasitic nematodes and enhances maximum crop production.

REFERENCES

Abubakar, U. and T. Adamu (2004). Control of *Meloidogyne incognita* (Kofoid and White) Chitwood on tomato (*Lycopersicon lycopersicum* Kast) using camel dung. *Journal of Tropical Bioscience,* 4:1-3.

Adesiyan, S.O., F. E. Caveness, M. O. Adeniji and B. Fawole (1990). *Nematode Pest of Tropical Crops*. Heinemann, Ibadan. 144 pp.

Ahmad, Z., F.R. Saifullah, H. Khan and M. Idrees (2012). Chemical and biological control of *Fusarium* root rot of okra. *Pakistan Journal of Botany*, 44(1): 453-457.

Akhtar, M. and M.M. Alam (1991). Integrated control of plant parasitic nematodes on potato with organic amendments, nematicide and mixed cropping. *Nematology Medito,* 19: 169-171.

Arain, A.R., M.M. Jiskani, K.H. Wagan, S.N. Khuhro and M.I. Khaskheli (2012). Incidence and chemical control of okra leaf spot disease. *Pakistan Journal of Bot*any, 44(5): 1769-1774.

Extoxnet (2001). Carbofuran. http://ace.ace.orst.edu/info/extoxnet/pips/carbofur.htm. Available online

Gambo, A.S. (1998). Effect of degradation of neem leaves in the incidence of root-knot nematode, *Meloidogyne* spp affecting okra plants. A Project report submitted to the Department of Crop Protection, University of Maiduguri, Nigeria, pp37.

Hussain, M.A., T. Mukhtar and M. Z. Kayani (2011). Assessment of the damage caused by *Meloidogyne incognita* on okra. *Journal of Animal and Plant Sci*ence, 21: 857-861.

Iqbal, J., M. Sagheer, Mansoor-ul-Hasan and M. Nadeem (2012). Management of *Amrasca biguttula biguttula* (Ishida) on okra, *Abelmoschus esculentus* (L. Monech). *Pakistan Journal of Agricultural Science*, 49: 179-184.

Mohammed, B. A. and I. Umar (2012). Evaluation of some plant materials for the control of root-knot nematode *Meloidogyne javanica* (Kofoid and White, 1919) Chitwood, (1949) on Okra in Yola, Adamawa State, Nigeria. *New Clues in Sciences*, 2: 20-27.

Moyin-Jesu, E.I. (2007). Use of plant residues for improving soil fertility pod nutrients root growth and pod weight of okra *Abelmoschus esculentum* L. *Bioresource Technology*, 98: 2057-2064.

NRC (2006-10-27). *"Okra"* *Lost Crops of Africa: Volume II: Vegetables*. Lost Crops of Africa 2. National Academies Press. 07-15. National Research Council

Okoruwa, V. O; F. O. Obadaki and G. Ibrahim (2005). Profitability of beef cattle fattening in the cosmopolitan city of Ibadan, Oyo state. *Moor Journal of Agricultural Research*, 1: 45-51

Rashid, M.H., L. Yasmin, M.G. Kibria, A.K.M.S.R. Millik and S.M.M. Hossain (2002). Screening of okra germplasm for resistance to yellow vein mosaic virus under field conditions. *Plant Pathology Journal*, 1:61-62.

Sikora, R. A., and J. Hartwig (1991). Mode-of-action of the Carbamate Nematicides Cloethocarb, Aldicarb, and Carbofuran on *H. Schachtii*. 2. Systemic Activity. *Revue de Nématoie*, 14(4): 531–536.

Sikora, R.A. and E. Fernandez (2005). Nematode parasites of vegetables. *In*: M. Luc, R.A. Sikora and J. Bridge (Eds.). *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture*. 2nd Edition, CABI Wallingford, UK. Pp793-825

Sowunmi, F.A and J. O. Kintola (2010). Effect of climate variability on maize production in Nigeria. *Research Journal of Environmental and Earth Sciences*, 2(1): 19-30.

Srivastava, D.S., M. Sehgal, A. Kumar, S. Verma, B.K. Dwivedi and S.P. Singh (2012). Plant-parasitic nematodes associated with tomato and okra fields of Allahabad, Uttar Pradesh, India. *Pakistan Journal of Nematology*, 30 (2): 157-167.

White-Head, A.G. and J.R. Hemming (1965). A comparison of some quantitative methods extracting small vermiform nematodes from the soil. *Annals of Applied Biology*, 55:25-38.