

The Impact of Organic Soil Amendments on Population Densities of Plant Parasitic Nematodes and Okra Yield

Abstract:

Damaged okra plant roots as a result of plant parasitic nematodes infection leads to a reduced water and nutrients intake. The impact of some organic soil amendments on population densities of plant parasitic nematodes and okra yield was investigated between March and December 2013, in Ghana under natural field conditions. Randomized Complete Block Design (RCBD) with three replications was used. Treatments effect on plant height, number of leaves, stem girth and dry shoot weight of okra were not different from that of the control. Neem (*Azadiracta indica*) seed and cocoa (*Theobroma cacao*) bean testa powder suppressed population densities of *Meloidogyne* species, *Pratylenchus coffeae*, *Rotylenchulus reniformis* and *Helicotylenhus multicintus* in 100 cm³ rhizosphere soils and 5 g roots weight. Suppression in population densities of the plant parasitic nematodes did not translate into economic field improvement.

Key words: Okra yield; organic amendments; plant parasitic nematodes; population densities.

1. INTRODUCTION

Okra (*Abelmoschus esculentus*) is found in nearly every market in Ghana. It is an important constituent of most local dishes and one of the important vegetables with tremendous nutritional values. It is successfully grown across the forest, transitional and savanna zones of the sub region. In Ghana, okra is among the non-traditional export crops of importance, constituting

approximately 0.02% of Gross Domestic Product [1] and the fourth most popular vegetable crop after tomatoes, pepper, and garden eggs [2].

Okra is however, extremely susceptible to plant parasitic nematodes (PPN) infection. *Meloidogyne* species especially cause conspicuous galls to form on the roots and the roots succumb to other microbial infections leading to rotting [3]. The damaged roots result in a reduced water and nutrients uptake. The leaves would suffer and the plants struggle to put on marketable fruits.

Most okra growers employ crop rotation and synthetic nematicides to combat the plant parasitic nematodes menace. Crop rotation has been used with a measure of success, but the extensive host range of the soil-borne pests makes selection of rotational crops difficult [4]. Export markets are also increasingly concerned about chemical residues in vegetable products from African markets [5]. Environmental hazards and consumers health as a result of abuse of chemical nematicides demands alternative methods of managing plant parasitic nematodes [6].

Some organic soil amendments (OSA) have been useful for the management of soil-borne pests. They are harmless to humans, livestock and the environment. They are also used for improving soils' physical conditions and adding to soil nutrients content. OSA promotes the growth of saprophytic nematodes and nematode trapping fungi which attack larvae of some genera of PPN.

In this work, the impact of neem seed and cocoa bean testa powder on population densities of plant parasitic nematodes and yield of okra was investigated.

2. METHODOLOGY

2.1 Study site

The experiment was sited at Fumesua ($06^{\circ} 43' \text{N}$, $01^{\circ} 36' \text{W}$) in the Ejisu-Juaben Municipality of the Ashanti Region, Ghana. The area falls in the semi-deciduous forest zone and experiences a bi-modal rainfall regime. Fumesua soils belong to the “Bomso series” Ferric Acrisol with an average pH of 4.7 [7]. The land had been cropped to *Zea mays* in the last two cropping seasons. Common weed species at the site were *Imperata cylindrica* and *Euphorbia heterophylla*. The major rainfall season is usually from April to August whilst the minor from September to November annually. The entire study was under rain-fed conditions.

2.2 Field layout and soil sampling

The experimental field was manually slashed with cutlass and all above-ground biomass removed until the soil surface was revealed. Randomized Complete Block Design (RCBD) with three replications separated by 2 m alleys was used. Planting distance used was (1 x 1 m). Each plot measured (3 x 4 m) with 2 test and 2 border rows. Each row contained 5 hills and a total of 20 hills per plot. Total land area was 499 m^2 (26 x 19 m). Representative soil samples were taken from each plot to determine the initial and final nematode population densities. Soil sampling was done along the Z-plane up to about 20 cm deep with a soil augur.

2.3 Treatments

Air-dried neem seeds and cocoa bean testa were pounded separately into near powder. They were measured into; 80g neem seed powder (NSP), 40g NSP, 80g cocoa bean testa powder (CBTP), 40g CBTP and control (unamended plot) to make up the experimental treatments. The

treatments were applied 3 weeks before okra seeds were sowed as spot application at about 2 inches away from each hill.

2.4 Cultural practices and data collection

Three seeds were sown per hill and thinned out to one after germination. The plot was kept weed-free throughout the study with hoe and cutlass. Insect pests were managed with Cypercal 50 (Cypermethrin 50 g/l; EC) insecticide. Morphological data were collected on six tagged plants randomly selected from the test rows on each plot. Plant height and stem girth were taken at fortnightly intervals. Dry shoot biomass was taken after fresh shoot samples were oven-dried at 80°C for 48 h. Second, third and fourth stage nematodes per 100 cm³ rhizosphere soil and 5 g root weight were determined. Mature okra pods were harvested and quantified accordingly every other day. Yield of okra fruits was expressed as weight of produce per plot and subsequently converted to tons/ha.

Determination of nematodes from soil samples followed the modified Baermann funnel extraction method [8]. Eggs were extracted from 5g root weight subsamples [9] and incubated [10] for juveniles. The nematodes in the samples were heat-killed in an oven at 60°C for about 3 minutes and few drops (2 or 3) of 4% formaldehyde (formalin) added. Microscopic examination and counting were done on counting tray [11] with the aid of a tally counter.

Nematode counts were square root transformed $\sqrt{(x + 0.5)}$ to improve homogeneity of variance before ANOVA was performed using GenStat (12.0). Significant mean separation was done with

83 Least Significance Difference (LSD) test ($P=.05$).

84

85 3. RESULTS AND DISCUSSION

86 Agro-meteorological data from the nearest weather station ($6^{\circ} 41' N$, $1^{\circ} 33' W$; altitude: 261.4
87 m) over the study period has been presented (Table 1).

88

89 **Table 1. Agro-meteorological data from nearest weather station (2013)**

0900 hrs					1500 hrs				
Temperature ($^{\circ}C$)				RH	Temperature ($^{\circ}C$)		Rainfall [†] (mm)	Vapour Pressure (mbs)	
Max.	Min.	Dry bulb	Wet bulb	(%)	Dry bulb	Wet bulb			
31.8	22.0	25.2	23.0	82	31.0	24.2	1,379.1		25.7

90 Max. = Maximum temperature, Min. = Minimum temperature, RH = Relative humidity.

91 [†] = Total rainfall.

92 Genera of plant parasitic nematodes recovered from initial soil samples in the order of abundance
93 were; *Rotylenchulus reniformis*, *Pratylenchus coffeae*, *Meloidogyne* spp. and *Helicotylenchus*
94 *multicinctus* (Fig. 1).

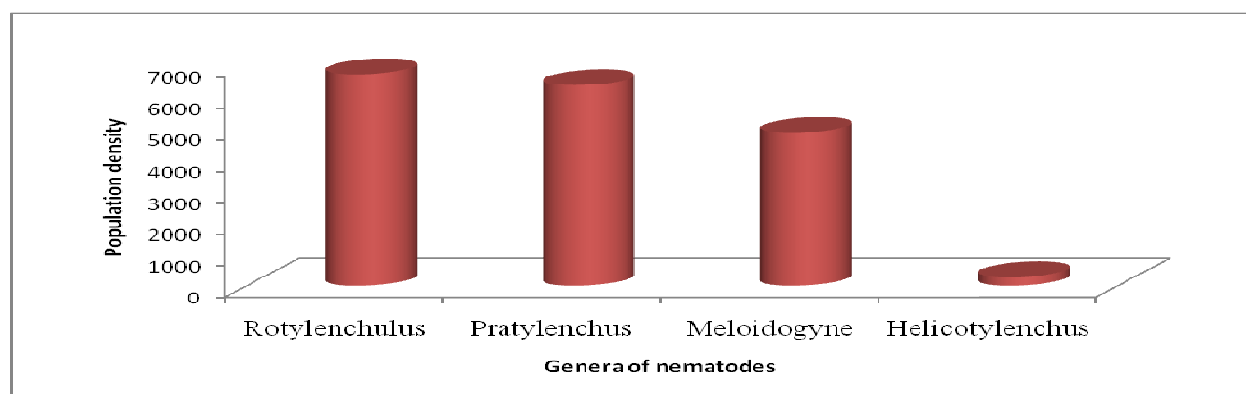


Fig. 1. Initial plant parasitic nematodes population densities. *Rotylenchulus reniformis*, *Pratylenchus coffeae*, *Meloidogyne* species and *Helicotylenchus multicinctus*

Differences in okra plant height, number of leaves, stem girth and dry shoot weight in both the major and minor seasons (Fig. 2 and 3) were not different among the treatments.

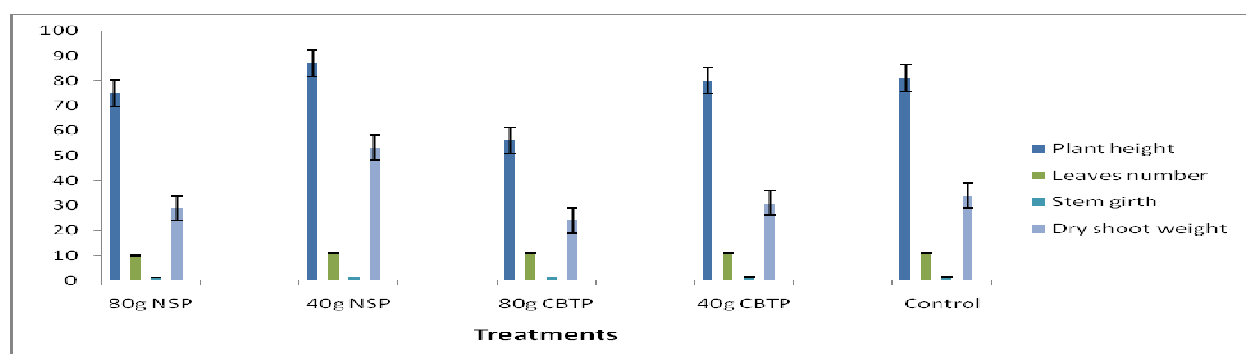


Fig. 2. Morphological parameters recorded in the major season

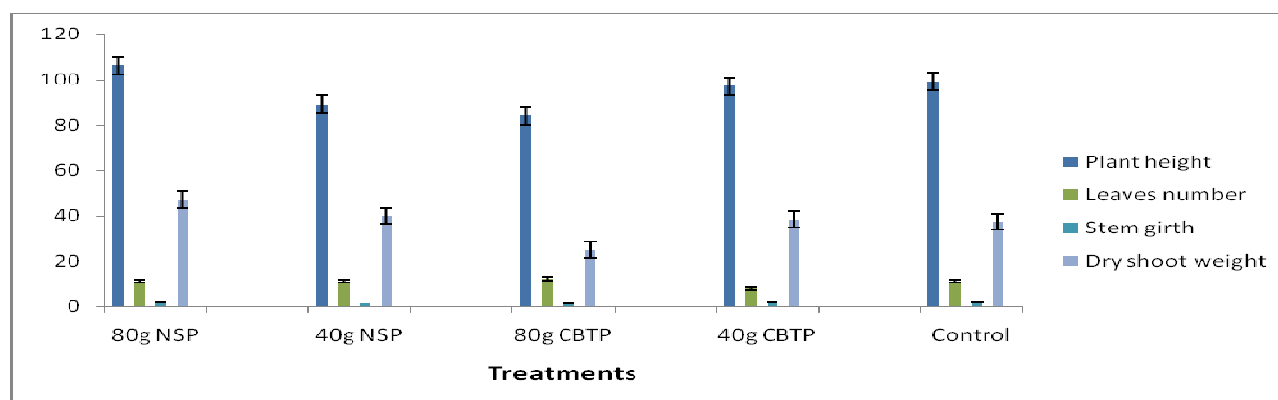


Fig. 3. Morphological parameters recorded in the minor season

Various products prepared from the leaves and seeds of neem plants have been reported as effective protectants against nematode pests (Akhtar, 2000). In this work, the control (unamended plot) recorded high population densities of *Meloidogyne* species, *Rotylenchulus reniformis* and *Helicotylenchus multicinctus* in final rhizosphere soils. These population densities were significantly ($P=0.05$) different from that of the amended plots (Table 2).

Control effect on *Pratylenchus coffeae* population density was significant ($P=0.05$). It was 71%, 67%, 71% and 52% over the 80g NSP, 40g NSP, 80g CBTP and 40g CBTP amended plots respectively. Treatments effect on population densities on the amended plot was not different except the 40g CBTP which significantly suppressed *Meloidogyne* species, *Pratylenchus coffeae* and *Rotylenchulus reniformis* in rhizosphere soils.

Table 2. Nematodes densities/100 cm³ soil at final harvest

Treatment	<i>Meloidogyne</i> species	<i>Pratylenchus coffeae</i>	<i>Rotylenchulus reniformis</i>	<i>Helicotylenchus multicinctus</i>
80g NSP	24 (5)* a	37 (6) a	561 (20) a	25 (5) a

40g NSP	69 (8) abd	50 (7) a	757 (23) a	24 (5) a
80g CBTP	59 (7) ad	35 (6) a	579 (18) a	23 (5) a
40g CBTP	158 (11) b	103 (10) b	1752 (42) b	25 (5) a
Control 	535 (23) c	455 (21) c	5536 (74) c	165 (13) b
LSD 5%	(3.3)	(1.2)	(10.8)	(1.1)

*Square root transformed ($\sqrt{1+0.5}$) data used in analysis in brackets. Means followed by the same letter (s) are not significantly different at 5%.

When soils are amended with organic matter some plant pathogens may be hindered in their development or their antagonists increase in number. Nematotoxic compounds of neem plants, especially azadirachtins are released through volatilization, exudation, leaching and decomposition [12; 13]. Neem leaf amended soil recorded a significant reduction of *Meloidogyne* spp. over the untreated control plot in okra under field conditions [14]. *Meloidogyne* spp. and *Pratylenchus coffeae* were recorded from roots and their densities on the control plot were higher. Eighty (80)g NSP amended plot recorded the least in *Meloidogyne* spp. population density per 5g root weight but was not different from that of the 40g NSP and 80g CBTP amended plots. *Pratylenchus coffeae* recovered from 40g CBTP amended plot was the least in population density per 5g root weight which was 98.5% lesser than that of the control plot (Table 3).

Table 3. Nematodes population densities/5 g root weight

Treatments	<i>Meloidogyne</i> species	<i>Pratylenchus coffeae</i>
80g NSP	3 (2)* a	25 (5) b

40g NSP	19 (4) b	50 (7) cd
80g CBTP	22 (5) b	42 (6) bd
40g CBTP	72 (8) cd	4 (2)ed a
Control	3629 (59) de	166 (133) d
LSD 5%	(1.2)	(1.3)

135 *Square root transformed ($\sqrt{1+0.5}$) data used in analysis in brackets. Means followed by the
 136 same letter (s) are not significantly different at 5%.

137
 138 Differences in fruit yield in both seasons were not different. It implied that, the treatments did
 139 not have any significant ($P=0.05$) effect on fruit yield. In the major season 80g NSP and 80g
 140 CBTP amended plots recorded the highest (1.37 t/ha) and least (0.67 t/ha) respectively. In the
 141 minor season however, 40g CBTP amended plot recorded the highest (1.58 t/ha) in fruit yield
 142 whilst 80g CBTP repeated the least (1.11 t/ha). The control plots yielded 0.90 and 1.42 t/ha over
 143 the two seasons respectively (Table 4).

144 **Table 4. Yield of okra (t/ha)**

Treatment	Major season	Relative yield	Minor season	Relative yield
80g NSP	1.37	2.04	1.49	1.34
40g NSP	0.80	1.19	1.28	1.15
80g CBTP	0.67	1.00	1.11	1.00
40g CBTP	0.89	1.32	1.58	1.42

Control	0.90	1.34	1.42	1.27
LSD 5%	(0.21)		(0.37)	

145 Relative yield = ratio of a particular treatment on the least yielding treatment.

146 Okra fruit yield was generally higher in the minor season than the major. This could be attributed
 147 to the cumulative beneficial effects of the treatments. Lower fruit yield realized was partly due to
 148 the wider planting distance used which resulted in a lower plant population density. This is
 149 because higher plant population density could lead to an increased yield under optimum climatic
 150 and management conditions due to a greater number of smaller fruits or pods per unit area.

151 Organic soil amendments have nematicidal effect on plant parasitic nematodes. Plant parasitic
 152 nematode population levels may change due to toxic metabolites release from organic
 153 amendments breakdown [15]. Evaluating the potential of cocoa bean testa powder to control
 154 plant parasitic nematodes in *Dioscorea rotundata*, nematodes population densities were
 155 suppressed in rhizosphere soils and yam tubers but there were no differences in tuber yield [16].
 156 In this work there was significant treatments effect on plant parasitic nematodes population
 157 densities but no differences in fruit yield were observed.

158 4. CONCLUSION

159 The organic soil amendments evaluated suppressed population densities of plant parasitic
 160 nematodes in rhizosphere soils and roots but did not significantly improve okra fruit
 161 yield, plant height, number of leaves, dry shoot weight and stem girth.

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163 REFERENCES

1. GEPC. Ghana export promotion council. Export performance report. 2002.
2. SRID-MOFA. Statistical Research and Information Directorate, Ministry of Food and Agriculture (Ghana). Production figures. 2007; 56-57.
3. Ploeg AT. The relationship between pre-plant levels of root-knot nematodes, *Meloidogyne incognita* and melon growth. Department of Nematology, California University, Riverside. 2001; Available on <http://cekern.ucdavis.edu/newsletterfiles/kern-vegetable2751.pdf> (Accessed April, 2007).
4. Sikora RA, Fernandez E. Nematode parasites of vegetables. *In*: Plant parasitic nematodes in sub-tropical and tropical agriculture. CAB International, Wallingford, 2005; 319-390.
5. Mabbeth T. Feed your crops and fight the pest: African farming, March/April. 2007; 19-20.
6. Ofosu-Budu GK, Quaye AK, Danso SKA. Effect of compost-amendment rate on growth, yield and quality of cabbage in Ghana. Ghana Journal of Horticulture. 2005; 4: 28–36.
7. Dedzoe CD, Dwomo O, Adjei-Gyapong T, Senayah JK, Tetteh FM, Adjei S. Land suitability assessment for cashew varietal evaluation in selected agro-ecologies in Ghana. Detailed soil characterization in the Ejura-Sekyedumasi District, Forest-savannah transitional agro-ecological zone. *SRI Technical Report*. 2004; 243.
8. Whitehead AG, Hemming JR. A comparison of some quantitative methods of extracting small vermiform nematodes from soil. *Ann. App. Biology*. 1965; 55: 5.
9. Hussey RS, Barker KR. A comparison of methods for collecting inocula for *Meloidogyne* species, including a new technique. *Plant Disease Reporter*. 1973; 57: 1025-1028.
10. Rodriguez-Kabana R, Pope MH. A simple incubation method for the extraction of nematodes from soil. *Nematropica*. 1981; 11: 175-185.
11. Doncaster CC. Counting dish for nematodes. *Nematologica*. 1962; 7: 334-336.
12. Akhtar M. Nematicidal potential of the neem tree. *Integrated pest management review*. 2000; 5: 57-66.
13. Neem Foundation. Neem for fertilizer management. 1997. Available on www.neemfoundation.org/fert.htm. (Accessed December, 2003).
14. Agyarko K, Asiedu EK, Adomako WJ. Effect of leaves and poultry manure soil amendments on growth and yield of tomato and okra. Ghana Journal of Horticulture. 2007; 6: 89–94.

- 197 15. Luc M, Sikora RA, Bridge J. Plant parasitic nematodes in sub tropical agriculture.
198 CAB International Publishing, London. 2005; 319–390.
- 199 16. Osei K, Otoo E, Danso Y, Adomako A, Agyeman A, Sackey-Asante J. Organic soil
200 amendments in nematode management in yam production. *Nematropica*. 2013; 43(1): 79-
201 81.
- 202