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Efficacy of Organic Soil Amendments in the Control of *Meloidogyne incognita* and on Some Growth and Yield Parameters of Pepper *Capsicum frutenscens* in Southwestern Nigeria

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Abstract: Field trials were conducted in 2007 and 2008 planting seasons to evaluate the efficacy of different sources of organic manure in the control of *Meloidogyne incognita* infection on four varieties of pepper, *Capsicum frutenscens.* The organic manure (poultry manure, pacesetter organic fertilizer and *Chromolacna odoratum* based compost) were each incorporated 15cm deep, within the pepper plant rhizosphere, into the soil at the rates of 0, 5, 10 and 20 thaG[1]. Each of the organic manure was allowed to undergo full decomposition period of 4 months prior to application time. Untreated plots served as the control treatment. Different pepper cultivars were NHV_1A, NHV_1B, NHV_1F and "Sombo". Seedlings of four varieties of pepper raised in sterilized sandy-loam top soil were transplanted 0.5m x 0.75m apart in plots of sizes 2.50m x 1.50m. The experimental field was naturally infested with *Meloidogyne incognita*, *Pratylenchus brachyurus* and *Hoplolaimus* species. The results showed that the pepper varieties displayed varying levels of susceptibility to the nematode infection. Tolerance to the nematode attack was highest in NHV_1A while susceptibility to infection was significantly high in "Sombo" variety. Poultry manure had the most significant suppressive effect on soil and root nematode populations, number of egg mass per plant and gall index. Nematode populations in *C. odoratum* based compost amended soil were the highest. There were inverse relationships between nematode populations and rate of each organic amendment. Yield of pepper was positively correlated with increase in the rate of applied treatment. Poultry manure significantly influenced number and weight of pepper fruit with the highest yield in plots where 20t/ha poultry manure was applied. The interactive effects between manure and pepper variety, types of organic fertilizer and application rate of organic fertilizer and application rate of organic fertilizer and pepper variety on the growth and yield of pepper showed similar trends. Regardless of the pepper variety, all interactions involving 20t/ha of poultry manure recorded outstanding results on the growth and yield of pepper. These results suggest that exploitation of organic soil amendment in nematode management would be a useful control measure in organic pepper production in southwest Nigeria.

Key words: Organic manure % Meloidogyne incognita % Pepper % Nematodes % Control

INTRODUCTION

Pepper, *Capsicum* species belongs to the family Solanaceae [1]. Pepper is a short-lived herb normally grown as an annual crop or a shrubby perennial. In tropical Africa, the four main types (sweet pepper, chilli pepper, bird pepper and aromatic pepper) are grouped into two main classes namely the sweet (bell-shaped) *C. annum* and the hot (chilli) peppers, *C. frutenscens.* The genus *Capsicum* is widely cultivated in Nigeria (within latitude 7° 23°N and longitude 3° 50°E with altitude of 168m above the sea level). Nigeria ranks highest in pepper production in Africa producing about 50 percent of the total African production volume on 200,000 hectares of farmland annually. They are often grown sole or intercropped with other vegetables or in mixtures with starchy staple food crops such as Cassava (*Manihot spp),* Yam (*Discrorea* spp) etc [2]. Pepper is a shade tolerant crop and day neutral up to 45% solar radiation. It thrives well in well drained sandy-loam top

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soils with pH between 5.5 and 5.8. Nutrient requirement in pepper production is put at 130kgN, 80kgP and 110kgK while rainfall requirement for optimum growth is 600mm [2]. FAO [3] statistics showed world production estimate of pepper in 2001 as 21.3 million metric tons from 1.6million hectares with an average yield of 13.4 tons per hectare. In Nigeria, the figure stood at 695,000 metric tons obtained from an average of 77,000 hectares with average yield of 9.026 tons per hectare. Peppers are rich sources of vitamins and minerals and are veritable ingredient in the production of various spices, hot sauces, canned foods preservatives, ginger beer and some pharmaceutical formulations [2].

The quest for increased production is often constrained by edaphic and biotic factors. Plant parasitic nematodes constitute one of the biotic factors militating against increased pepper production in Nigeria. Increasing cropping intensity for resource maximization has encouraged high dependence on pesticides usage and chemosynthetic fertilizers.

The hazardous effect of these agrochemicals has increasingly become a major concern to environmentalists. Thus other options for the management of phytopathogenic nematodes become imperative. Incorporation of organic matter into the soil may support higher proportion of natural pests of nematodes such as fungi and bacteria, it may release toxic chemicals that are lethal to nematodes in the process of decomposition and improve the nutrient and water status of the soil to the advantage of the plant. Nwanguma and Awoderu [4] and Nwanguma and Fawole [5] respectively reported the effect of amending the soil with plant or animal wastes prior to planting susceptible tomato and okra varieties. They observed significant decline in nematodes build up with improvement in the yield of the test crops. Similar observation had been made [6] in soil amended with green manure. This cultural practice is amenable in subsistence farming since it improves the soil fertility and structure [7]. Exploitation of the dual advantage of organic soil amendment for optimum crop growth and plant health is necessary especially under subsistence and intensive production systems that are characteristic of Nigeria farmers. Apart from low dependence on pesticide usage, the calibration of other organic fertilizer sources that abounds in Nigeria for plant uptake and their lethal effects on nematode pests will eliminate health hazards arising from the consumption of such crops as opposed to similar crops produced conventionally. The study was thus aimed at determining the effect of different sources of organic fertilizers on nematode pest attacking field-grown pepper and to determine the growth and yield responses of these pepper varieties to the types and rates of organic fertilizers.

MATERIALS AND METHODS

Two consecutive field trials were conducted on the efficacy of some organic soil amendments in the control of root knot nematodes, *Meloigogyne incognita*, on four different cultivars of pepper, *Capsicum frutenscens*, at the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. Field trials were conducted in 2007 and 2008 respectively at the Vegetable Research Field of the Institute. The field was previously planted to root knot nematode susceptible okra, NHAe47-4 variety, to enhance the build-up of resident nematode population in the field. The infected roots of the okra were later ploughed into the soil prior to initial nematode sampling. Pre-plant nematode populations were assessed from 200cm^3 composite soil sample [8,9] and the resident nematode populations were identified [10,11]. The soil amendments were poultry manure, pacesetter organic fertilizer and Siam weed (*Chromolaena odoratum*) based compost. The pepper varieties (NHV_1A, NHV_1B and NHV_1F) were obtained from the gene bank of NIHORT, Ibadan, Nigeria while the 'Sombo' cultivar was procured from a local market at Ibadan. The soil amendment materials were each worked 15cm deep into the soil at the rates of 0, 5, 10 and 20t/ha and were allowed to decompose for three weeks before the pepper seedling were transplanted. Seedlings of four different pepper varieties at four-week old, earlier raised in sterilized sandy-loan soil were transplanted into prepared plots of size 2.5m x 1.5m using plant spacing of 0.5m x 0.75m between plants. Each trial was a 4 x 4 x3 factorial arrangement fitted into a randomized complete block design with four replications. Field cultural practices were maintained.

Six weeks after transplanting, three out of six guarded plants within each plot were uprooted for the assessment of soil and root nematode populations as well as the number of egg mass. Nematode populations were assessed at two-week intervals. Root nematode populations were also determined using 5g weight of root samples [8,9]. At final harvest, pepper were uprooted and the root assessed and rated for gall development [12] where: 0 = Immune; 1 = Highly resistance; 2 = Resistant; 3 = Moderately susceptible; 4 = Susceptible; 5 = Highly susceptible. The numbers of egg-masses were also assessed from 5g weight of each pepper root. Also at final harvest, plant height, number of leaves, fruit number and

fruit weight per plant were assessed. The two-year data were pooled together and subjected to analysis of variance (ANOVA) test using the SAS [13] package. The means were separated using Duncan Multiple Range Test (DMRT) where appropriate at 5% level of probability.

RESULTS

Nematode Population in the Soil: In 2007, the resident plant parasitic nematodes were in order of *Meloidogyne incognita* (763), *Pratylenchus brachyurus* (40), *Hoplolaimus* species (13). There was an apparent increase in the population of the plant parasitic nematodes in 2008. Thus in 2008 there were 806 *Meloidogyne incognita*, 60 *Pratylenchus brachyurus* and 25 *Hoplolaimus* species (Table 1).

Effect of Nematodes on the Different Pepper Varieties: Significant suppression of the nematodes was observed in NHV_1A while NHV_1F and "sombo" cultivar indicated highest susceptibility to attack recording the highest population of nematodes in the soil, root, number of egg mass and severity of root damage (Table 2). There were significant differences in height of pepper varieties. NHV_1F recorded significantly the highest number of pepper fruits while the local cultivar produced the lowest. Fruit weights of NHV_1A and, NHV_1F were similar but were superior to the values obtained from NHV_1B and "sombo" (Table 2)

Effect of Soil Amendments on the Different Pepper Varieties: Soil and root nematode populations and number of egg mass were significantly lowest in plots amended with poultry manure; pacesetter and *C. odoratum* based compost (Table 2). Peppers that were planted in the un-amended plots (control experiment) harbored the highest root nematode populations, the number of egg mass per root system as well as the highest level of root damage. Peppers that were treated with Pacesetter and C. *odoratum* based compost had significantly lower number of fruits when compared with those treated with poultry manure.

Pepper plants in *C. odoratum* based compost amended plot recorded the significantly lowest fruit weight. The treatment effects of poultry manure and pacesetter organic manure on fruit weight were similar but superior to the corresponding fruit weight obtained in *C. odoratum* based compost amended plots (Table 2).

Effect of Rate of Application: Twenty (20) t/ha of the organic manure recorded the most significant suppression of the nematodes recording the lowest soil and root nematode populations, number of egg- mass as well as root knot index. Their effect however declined with reduction in the rates of applied manure. Un-amended plots (control) recorded the highest populations of the nematodes. In all the assessed growth parameters, response to application of manure increased significantly with the rate of applied treatment recording the highest values in plant height, number of leaves, number and weight of fruits at 20t/ha respectively. The lowest values occurred in un-amended plots (Table 2).

Interaction Effects of Variety X Organic Fertilizer: Nematode populations significantly declined in interactions involving NHV_1A and NHV_1B with other forms of manure (Table 3). Suppressive effect of these interactions on populations of root-knot nematodes and severity of root damage was significantly pronounced in interaction involving NHV_1A x poultry manure while interactions between NHV_1F x *C. odoratum* and Sombo x C. *odoratum* recorded significantly high population of nematodes in the soil (Table 3). Poultry manure x variety interaction statistically influenced all growth and yield parameters than did other interactive effects of *C. odoratum and* pacesetter organomineral. The highest number of fruit occurred in interaction involving NHV_1F x poultry manure while the heaviest fruit weight was observed in the interaction between NHV_1A and either poultry manure or pacesetter organo mineral fertilizer (Table 3)

Interaction Effects of Variety X Rate: Interactions between variety x 20t/haG^1 of manure gave statistically the lowest population of nematodes in both the soil, root, number of egg-mass as well as the lowest root damage. Severity of root damage with significantly high nematode populations in the soil and root of pepper plants occurred in variety x 0t/ha interactions (Table 4). The effect of all the variety x rate of manure interactions increased with increase in the rate of organic fertilizer application. The tallest plant was observed in NHV_1F x 20t/haG^1 interactions. NHV_1Ax20t/ha, NHV_1B x 20t/ha and NHV_1F x 20t/ha interactions recorded the highest number of fruits with corresponding heaviest fruit weight values (Table 4).

Table 1: Plant parasitic nematodes populations in soil during the two consecutives years of field experimentation

	Nematode populations	
Plant parasitic nematodes	2007	2008
Meloidogyne incognita Pratylenchus brachyurus Hoplolaimus species	7634013	8066025

Table 2: Effect of variety, organic sources of manure and rates on some growth and yield parameters, soil and root nematodes populations, number of egg mass and root knot index in Meloidogyne incognita infested soil

Treatment	Ht (cm)	No. of leaf	No. of fruit	Fruit. Wt.(g)	Soil nem. Pop./200cm^3 soil	Root nem. Pop./5g root	No of eggmass /5groot	Root knot index (1-5)
Effect of variety								
NHV1A	24.99a*	83.17a	20.06c	92.63a	400d	9d	1b	2.0c
NHV1B	23.49a	80.11a	21.61b	76.95b	661c	12c	2b	3.3b
NHV1F	24.15a	70.86a	23.97a	96.39a	1060b	18b	8a	4.33a
L. Sombo	23.69a	70.83a	18.78c	72.96b	2300a	26a	10a	4.50a
Effect of orga. man.								
PM	24.30a	86.73a	23.38a	97.73a	250b	8b	2b	1.25b
PS	24.69a	73.77b	19.85b	87.87a	539a	11a	5a	1.7a
Co	23.25a	68.23b	20.08b	69.06b	539a	12a	7a	2.0a
Effect of Rate(t/ha)								
20	29.28a	109.06a	30.22a	124.11a	210d	6c	1c	1.2c
10	26.07b	86.83b	21.92b	99.01b	262c	11b	5b	1.3c
5	23.63c	68.89c	18.69c	72.09c	621b	14ab	9a	3.3b
0	17.35d	40.19d	13.58d	44.36d	1586a	17a	12a	4.3[a]

Means followed by the same letter are not significantly different at 5% LSD

PM= poultry manure, PS= pacesetter, Co= Chromolaena odoratum

Table 3: Effect of variety and organic sources interaction on some growth parameters of pepper and their effect on root-knot nematodes populations in infested soil

Variety x Org.Fert.	Ht (cm)	No of leaf	Fruit Number	Fruit Wt (g)	Soil nem pop	Root nem. Pop	No of Eggmass / 5g root	Root knot index (1-5)
A x C	22.03a	77.25b	16.33c	55.13c	2.3c	5de	7a	2.0b
A x M	25.55a	94.66a	23.91b	117.62a	169c	4e	3c	1.25c
A x P	27.38a	77.58b	19.91c	105.13ab	193c	6cd	4c	1.70bc
B x C	23.56a	68.25b	23.00b	68.88c	576b	7c	8b	3.3b
B x M	25.28a	93.00a	23.91b	98.48b	198c	6cd	3c	2.15b
B x P	21.63a	79.08b	17.91c	72.23c	481b	8bc	5bc	3.4b
F x C	25.44a	79.33b	23.33b	92.45b	1333a	12a	8a	4.31a
F x M	22.71a	71.91a	27.00a	97.80b	268c	6cd	6bc	2.79b
F x P	24.31a	61.33b	21.58b	98.73b	573b	7c	6bc	3.65b
L x C	21.99a	48.08c	17.66c	59.78c	1789a	13a	11a	4.7a
L x M	23.66a	87.33a	18.66c	83.70b	387c	9b	6bc	2.42b
L x P	25.40a	77.08b	20.00b	75.40bc	694b	10b	7b	3.82ab

Means followed by the same letter are not significantly different at 5% DMRT

A=NHV1A, B=NHV1B, F=NHV1F, L=Local M = poultry manure, P = pacesetter, C = Chromolaena odoratum

Table 4: Effect of variety x rate interaction on some growth parameters of pepper and their effect on root-knot nematodes populations in Meloidogyne incognita infested soil

Variety x Rate	Ht (cm)	No. of Leaf	Fruit Number	Fruit wt. (g)	Soil nem. pop./200cm^3 soil	/Root nem. pop/5g wt	No of Eggmass / 5g root	Rootknot index (1-5)	No of Eggs / 5g root
A x 0	18.34c	42.00e	13.67d	47.88d	1791a	18ab	10a	4.6a	10a
A x 5	24.67b	69.11c	17.33c	88.91c	311b	11b	6c	1.9c	6c
A x 10	27.10a	97.44b	20.22b	108.61b	291b	9c	4cd	1.7c	4cd
A x 20	29.84a	124.11a	29.00a	125.10ab	206c	8c	1,5d	1.3c	1,5d
B x 0	16.86c	44.67e	13.00d	42.01d	1997a	19a	11a	5.0a5.0a	11a
B x 5	24.31b	74.67c	19.44c	59.61d	1937a	19a	7bc	2.19b	7bc
B x 10	24.70b	93.22b	21.77b	88.57c	425b	12bc	4.4cd	1.98bc	4.4cd

Table 4: Continue

Variety x Rate	Ht (cm)	No. of Leaf	Fruit Number	Fruit wt. (g)	Soil nem. pop./200cm^3 soil	/Root nem. pop/5g wt	No of Eggmass / 5g root	Rootknot index (1-5)	No of Eggs / 5g root
B x 20	28.11a	107.89a	32.22a	129.24a	389b	11c	2.3d	5.0a	2.3d
F x 0	16.31c	39.11e	15.00c	50.18d	1783a	22a	9b	5.0a	9b
F x 5	23.08b	65.11d	22.22b	83.20c	1802a	20a	8b	2.79b	8b
F x 10	27.17a	76.67c	25.11b	113.34b	496b	13b	6c	2.58b	6c
F x 20	30.06a	102.56a	33.56a	138.58a	476b	13b	6c	5.0a	6c
L x 0	17.90c	35.00e	12.67d	37.36e	1796a	23a	12a	5.0a	12a
L x 5	22.43b	66.67c	15.77c	59.06d	1799a	22a	8b	2.92b	8b
L x 10	25.31b	80.00c	20.56b	85.51c	524b	14b	7bc	2.70b	7bc
L x 20	29.11a	101.67b	26.11b	109.91b	501b	14b	6.5c		6.5c

Means followed by the same letter are not significantly different at 5% DMRT

Note: A=NHV1A, B=NHV1B, F=NHV1F, L=Sombo

Table 5: Effect of organic sources and rate interaction on some growth parameters of pepper and their effect on root knot nematode populations in Meloidogyne incognita infested soils

Fert. x Rate	Height (cm)	Number of leaf	Number of fruit	Fruit Wt (g)	Soil nem. pop. /200cm^3 soil	Root nem. pop. / 5g root	No of Eggmass / 5g root	Root knot index (1-5)
C x 0	18.10c	12.41f	13.25e	37.08f	1978a	20[a]	13[a]	4.6a
C x 5	22.74b	62.33d	17.58d	59.13e	794b	16b	8b	3.6b
C x 10	24.75b	78.50c	22.00c	80.12d	446b	10c	6bc	1.6c
C x 20	27.44a	99.67b	27.50b	99.91c	227c	10c	4.5c	1.4c
M x 0	16.61c	40.67e	15.00d	43.04f	2067a	22a	12a	5.0a
M x 5	23.77b	72.42c	19.92c	81.64d	249c	10c	8b	2.18bc
M x 10	26.09b	101.92b	24.42bc	119.48b	376c	5d	4d	0.84d
M x 20	30.75a	131.92a	34.17a	153.43a	134d	3d	1.3e	0.77d
P x 0	17.35c	47.50e	12.50e	52.95f	2285a	21a	12a	5.0a
P x 5	24.36b	71.92c	18.58d	77.31d	698b	17b	9b	2.8b
P x 10	27.38a	80.08c	19.33cd	97.43c	324c	12c	5c	1.15
P x 20	29.65a	95.58b	29.00b	123.78b	309c	11c	3d	1.07c

Means followed by the same letter are not significantly different at 5% DMRT M = Poultry manure, P = Pacesetter, C = Chromolaena odoratum

Interaction Effects of Variety X Rate: Interactions between variety x 20t/haG[1] of manure gave statistically the lowest population of nematodes in both the soil, root, number of egg-mass as well as the lowest root damage. Severity of root damage with significantly high nematode populations in the soil and root of pepper plants occurred in variety x 0t/ha interactions (Table 4). The effect of all the variety x rate of manure interactions increased with increase in the rate of organic fertilizer application. The tallest plant was observed in NHV_1F x 20t/haG[1] interactions. NHV_1Ax20t/ha, NHV_1B x 20t/ha and NHV_1F x 20t/ha interactions recorded the highest number of fruits with corresponding heaviest fruit weight values (Table 4).

Interaction Effects of Organic Sources X Rate: Poultry manure x 20t/ha interaction exhibited the highest suppressive effect on soil and root nematode populations' number of egg mass as well as root damage of pepper plants. Conversely, all interactions with 0t/ha of manure (control) recorded the highest level of root damage, soil and root nematode populations as well as number of egg mass (Table 5). Regardless of the manure type, the effect of all the interactions on the assessed growth and yield parameters increased with the rate of each applied organic manure. Interaction involving 0t/ha of manure (control) recorded the least values (Table 5).

DISCUSSION

The results obtained from this study underscore the need to exploit the potential of various organic sources for plant nutrients to enhance the soil fertility, promote plant health and increase crop productivity especially under intensive cropping that is characteristic of the Nigerian farmer. The varied nematode control tendencies of each organic source of manure as were expressed by their individual effect on the populations of the nematode pests possibly reflected qualitative expression of their nematicidal properties. Nwanguma *et al*. [14] have observed differential susceptibility of these varieties to nematode infection in soils heavily infested with

Meloidogyne incognita. Thus, the virulence of the nematodes on NHV_1F and the tolerance displayed by NHV_1A and NHV_1B apparently were indications of their respective host efficiencies. The inverse relationship between nematode populations and increasing rate of manure implies that efficacy of each manure in nematode control is quantity dependent.

Babatola [15] attributed decline of nematode populations in amended soils to increased hydrogen ion concentration (pH) and induced hypertonic solution in the manure. Similar observations were reported by soil amendment materials. Nwanguma and Awoderu [4] similarly observed that animal droppings such as pig droppings enhanced vegetative and reproductive growth of plants with significant suppressive effect on nematode pest populations. Berkelaar [16] reported that plants grown in neem, *Azadirachta indica* or chinaberry leaves amended soil showed growth comparable to that in non-infested soil. They noted that their effectiveness in nematode control however depended on the level of application since they have the unique ability to improve plant growth in soil containing nematodes. Similarities in height of the pepper plants regardless of the variety may reflect similarities in their respective genetic constitution.

The size of fruits of NHV_1A may have compensated for the differences in higher number of fruits in NHV_1F, which probably resulted in the insignificant weights of the two varieties of pepper. The significant plant responses to poultry manure when compared with pacesetter and *C. odoratum* suggests a reflection of their nutrient content for plant growth and development. Grubben and El Tahir [2] and Babatola [15] reported that increasing level of poultry manure application to solanaceous vegetable crops translated into enhanced growth and improved yield. Pacesetter organic fertilizer is a product constituted from animal wastes, urban wastes and farm residues. Thus the superior effect of this fertilizer as compared with *C. odoratum* was expected apparently due to the efficient mineralization of raw materials used for its formulation. Significant interactive effects of manure x varieties, manure x rate as well as rate x variety in the control of these pest suggests that the control of the pest and crop performance depends on the quality and quantity of amendment materials. The overall results thus suggest that exploitation of the dual advantages of this integrated approach in the improvement of soil fertility status and structure as well as containment of invasive nematode pests on susceptible pepper varieties may be a useful tool in organic pepper production in Nigeria.

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