

Comparative Effects of Poultry Manure, Cow Dung, and Carbofuran on Yield of *Meloidogyne incognita*-Infested Okra

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ABSTRACT

The effects of poultry manure and cow dung in comparison with the nematicide, carbofuran on the yield of okra infested with root-knot nematode *Meloidogyne incognita* Race 2 were investigated. Two plots of 17×11 m, each naturally infested with the mentioned nematode, were selected for the study. Treatments were poultry manure and cow dung each at the rates of 5 and 10 t ha⁻¹, carbofuran 3G at the rates of 1.5 and 3.0 kg ai ha⁻¹, and a control. One week after application, okra seeds were sown at two seeds per hole and thinned to one plant, one week after planting. Number of pods, cumulative weight of okra pods, root gall-index, soil chemical properties, and soil nematode densities in soil were determined at the beginning and end of the study. The results showed that the highest rates of poultry manure, cow dung, and carbofuran significantly ($P \leq 0.05$) reduced root gall-index and nematode population density in soil and correspondingly increased fruit yield in comparison to those at lower rates and the control. The results of this study suggest that incorporation of poultry manure or cow dung in nematode-infested field has the potentials to suppress nematode population and reduce nematode damage on okra.

Keywords: Nematode population, Root gall-index, Root-knot nematode.

INTRODUCTION

Okra is one of the most commonly grown vegetable crops in the tropics and subtropics (Adeoluwa and Kehinde, 2011; Singh *et al.*, 2012). Its cultivation and production has been widely practiced because of its importance to the economic development of these regions and it can be found in almost every market in Africa (Opong-Sekyere, 2011). In Nigeria, okra is grown across different ecological zones because it serves as a source of income to farmers as well as a cheap source of protein, vitamins (A and B), and minerals (Ca, P, Fe and I) to many households (Adebisi *et al.*, 2007). It is a nutritious vegetable containing 86.1% water, 2.2% protein, 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (Saifullah and

Rabbani, 2009), hence, it has a vital role in human diet (Uguru, 1996).

Okra is highly susceptible to root-knot nematodes *Meloidogyne* spp. (Khan and Khan, 1994) with up to 80% yield losses reported in heavily infested soils (Bourne *et al.*, 2004; Kaskavalci, 2007). The nematodes can make plants more susceptible to damage by plant pathogenic fungi, bacteria, and viruses causing even greater yield losses (Rivera and Aballay, 2008). When plants are infected with root-knot nematodes, their feeding activities in the root tissues result in the formation of massive galls of different sizes on root system. Severely affected plants often wilt readily and may also exhibit nutrient deficiency symptoms because galled roots have limited ability to absorb and transport water and nutrients to the rest of the plant (Coyne *et al.*, 2007).

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Nematode attack on plant normally results in yield reduction. It is therefore necessary to control root-knot nematodes in order to avoid or minimize yield loss of okra.

Management of root-knot nematodes with synthetic nematicides can be very effective (Sikora and Fernandez, 2005; Adegbite and Agbaje, 2007; Dubey and Trivedi, 2011). Adegbite and Agbaje (2007) reported a significant reduction in the incidence of *Meloidogyne incognita* in three hybrid yam varieties after an application of carbofuran (3G) at 100 kg ha⁻¹. However, the soaring cost of synthetic nematicides, their hazardous effects on man, environment and non-target organisms are serious drawbacks to their usage (Idorenyin and Ugwuoke, 2010). These have resulted in increased interest in the development of alternatives to the use of synthetic nematicides for nematode control including the use of organic amendments which have been found promising (Adekunle, 2008, 2011). Unlike chemical nematicides, organic amendments have little or no adverse effects on man and the environment and they are readily available. The objective of this study was to investigate the effects of poultry manure, cow dung, and carbofuran on the yield of *M. incognita*-infested okra.

MATERIALS AND METHODS

Source of Seeds and Amendments

Seeds of okra (*Abelmoschus esculentus*) cv. 47-4, which is susceptible to *M. incognita*, were obtained from the National Institute of Horticultural Research (NIHORT) Ibadan, Nigeria. Celosia seeds cv. TLV8 were obtained from the Department of Crop Production and Protection, Obafemi Awolowo University, Ile-Ife. The poultry manure was obtained from the battery cage system of poultry production unit of the Teaching and Research farm of Obafemi Awolowo University, Ile Ife. The poultry pen is usually cleaned approximately once a

month. The primary constituent of the poultry manure was chicken excrement. The cow dung was collected from the

paddock of the same institution. The paddock is usually cleaned daily. The poultry manure and the cow dung were left on a concrete slab for about two months before they were used. Carbofuran was procured from a Government registered agrochemical store at Ile-Ife.

Experimental Site

Two field trials were carried out simultaneously at the Teaching and Research farm of Obafemi Awolowo University Ile-Ife, Nigeria. Two plots of land each 17×11m, naturally infested with

M. incognita, were selected at the experimental site located on latitude 07° 28'N, and longitude 043° 33'E at 244 m above sea level, in the tropical rainforest zone of Nigeria. To increase the population of *M. incognita* on the sites, celosia was sown in the early rainy season (April) of 2012. Also, roots of *M. incognita*-infested celosia harvested from nematode culture plot were cut into 2-cm pieces and distributed over the two sites. The plots were ploughed and harrowed after four weeks. Soil in each plot was divided into four blocks, 17 m by 2 m. Each block was divided into seven plots of 2 m by 2 m. There was a space of 1m between blocks and 0.5 m between plots. The organic amendments and carbofuran were added to the plots one week before planting and there were seven treatments in four replicates arranged in a randomized complete block design (RCBD). The treatments were poultry manure and cow dung each at the rates of 5 and 10 t ha⁻¹ and carbofuran at the rates of 1.5 and 3.0 kg ai ha⁻¹, and a control (untreated plot).

Planting Operations

Seeds of okra cv. 47-4 were sown in rows into the *M. incognita*-infested soil at the rate

of two seeds per hole and at spacing of 30 cm within and 60 cm between rows, one week after treating the soil. The seedlings were thinned to one plant per stand at seven days after planting. There were 22 plants per plot or 352 plants per block. The plants were rain fed and manual weeding was carried out at weekly intervals. Insect pests were controlled by spraying the okra plants with cypermethrine at the rate of 60 mL/10 L of water before flowering. Inorganic fertilizer was not applied in the experimental field. The two trials were terminated hundred days after planting.

Soil and Nematode Analyses

Soil samples for nematode analysis were collected from each experimental plot prior to planting, and at harvest. Twenty-eight core samples of soil collected with a soil auger to the depth of 30 and 25 cm apart from the base of the okra plants, were taken from each plot for bulking thorough mixing. Nematodes were extracted from sub-samples of an aliquot of 200 mL from the bulk, using the modified Baermann tray extraction method of Whitehead and Hemming (1965). The nematode species was *M. incognita* (Race 2). This was identified by perineal pattern of the structure of the adult females as described by Eisenback *et al.* (1981).

Soil samples and cow dung and poultry manure were analyzed for pH, total nitrogen (N), available phosphorus (P) and exchangeable potassium (K) using standard methods (Knudsen *et al.*, 1982).

Assessment of Crop Yield

Okra pods were harvested from each plot beginning from 52 days after flowering, and every four days thereafter until fruiting ceased. The pods were weighed and counted. Cumulative weights of pods per treatment were calculated from the periodic data.

Assessment of *Meloidogyne incognita* Damage

At the termination of the study, okra plants were carefully uprooted in each plot and the roots of okra were assessed for galling according to the diagrammatic rating scale of Bridge and Page (1980) where 0= No knots on roots; 1= Few small knots, difficult to find; 2= Small knots only

but clearly visible, main roots clean; 3= Some larger knots visible, main roots clean; 4= Larger knots predominate but main roots clean; 5= 50% of roots affected, knotting on some main roots with reduced root system; 6= Knotting on main roots; 7= Majority of main roots knotted; 8= All main roots including tap root, knotted with few clean roots visible; 9= All roots severely knotted, and 10= All roots severely knotted, no root system, plant usually dead.

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) using SAS (1985) statistical package. Treatment means were separated using New Duncan Multiple Range Test (NDMRT) at $P \leq 0.05$.

RESULTS

Table 1 shows the average daily precipitation, relative humidity, solar radiation, and temperature at Obafemi Awolowo University, Ile-Ife, between the months of January to October 2012. The pH of poultry manure and cow dung used in this study ranged from 7.6 to 8.2. Poultry manure had 1.85% total N. The available P and exchangeable K were 89.8 mg kg⁻¹ and 11.03 cmol kg⁻¹, respectively (Table 2). Cow dung had 0.91% total N. The available P and exchangeable K were 86.4 mg kg⁻¹ and 15.2 cmol_c kg⁻¹, respectively. The numbers of juveniles of root-knot nematodes extracted in both treatments and the control plots ranged from 1,050 to 1,220 J₂/200 mL soil

**Table 1.** Average daily precipitation, relative humidity, solar radiation and temperature at Obafemi Awolowo University, Ile-Ife, between January and October 2012.^a

Months	TR Fall ^b (mm)	Av. RH ^c (%)	Av. ^d SRD ^e (wm ⁻²)	Average Temperature (°C)	
				Min	Max
January	3.0	51.3	251.5	30.6	26.1
February	38.7	58.3	250.2	30.8	26.3
March	434.1	81.4	215.5	30.5	27.6
April	140.3	89.0	196.8	26.7	24.7
May	227.9	89.8	178.5	26.4	24.4
June	176.5	88.2	196.7	26.9	24.8
July	302.1	90.9	159.9	25.7	23.8
August	246.8	90.5	174.2	25.7	23.7
September	171.9	88.2	194.6	26.3	23.6
October	206.1	89.2	191.9	26.0	23.9

^a Source: Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile-Ife.

^b Total Rainfall; ^c Relative Humidity; ^d Average, ^e Solar radiation.

Table 2. Chemical properties of organic amendments used for the experiments.

Sample	N ^a (%)	P ^b (mg kg ⁻¹)	K ^c (cmol _c kg ⁻¹)	pH (Water)	pH (CaCl ₂)
Poultry Manure	1.9	89.8	11.0	8.2	8.0
Cow dung	0.9	86.4	15.2	8.0	7.6

^a Total Nitrogen ; ^b Available phosphorous, ^c Exchangeable potassium.

before planting okra, which were high enough to infest susceptible plants (okra). The nematode species was *M. incognita* (Race 2). There were no significant differences in NPK levels among the plots at planting in both trials (Table 3). The levels of total N, available P, and exchangeable K were significantly ($P < 0.05$) higher in treated plots in comparison with the control plots at harvest in both trials (Table 4). Plots treated

with poultry manure had the highest level of total N in both trials. In both trials 1 and 2, the control plants had the highest significant ($P \leq 0.05$) gall-indices (9.25 and 9.45) compared to the tested treatments (Table 5). In trial 1, the control plot and plots treated with carbofuran, poultry manure or cow dung at lower rates had significantly ($P \leq 0.05$) higher nematode population than plots treated with those at higher rates (Table 6).

Table 3. Soil NPK levels at the beginning of field trials.^a

Treatments	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
	N	N	P	P	K	K
	(%)	(%)	(mg kg ⁻¹)	(mg kg ⁻¹)	(cmol _c kg ⁻¹)	(cmol _c kg ⁻¹)
Poultry manure (5 t ha ⁻¹)	0.06ab	0.08a	15.68a	14.45a	0.15e	0.18a
Poultry manure (10 t ha ⁻¹)	0.07ab	0.07a	15.46a	14.45a	0.15d	0.16ab
Cow dung (5 t ha ⁻¹)	0.07ab	0.11a	15.25a	17.38a	0.18a	0.14bc
Cow dung (10 t ha ⁻¹)	0.05b	0.3a	15.34a	17.91a	0.24b	0.14c
Carbofuran (1.5 kg ai ha ⁻¹)	0.07ab	0.08a	14.43b	17.12b	0.19d	0.11c
Carbofuran (3.0 kg ai ha ⁻¹)	0.08ab	0.07a	15.13a	17.12a	0.19c	0.19a
Control	0.08ab	0.07a	15.45a	16.93a	0.19c	0.16ab

^a Each value is a mean of four replicates. Each value is a mean of four replicates. Means followed by the same letter (s) along the same column are not statistically different at $P \leq 0.05$.

Table 4. Soil NPK levels at the end of field trials.^a

Treatments	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
	N	N	P	P	K	K
	(%)	(%)	(mg kg ⁻¹)	(mg kg ⁻¹)	(cmol _c kg ⁻¹)	(cmol _c Kg ⁻¹)
Poultry manure (5 t ha ⁻¹)	0.09d	0.04c	21.2bc	26.3bc	0.4b	0.4c
Poultry manure (10 t ha ⁻¹)	0.14a	0.13a	28.7a	32.5a	0.5a	0.5a
Cow dung (5 t ha ⁻¹)	0.09d	0.04c	19.5bc	26.3bc	0.4bc	0.4c
Cow dung (10 t ha ⁻¹)	0.11c	0.07b	28.7ab	31.1ab	0.5a	0.5b
Carbofuran (1.5 kg ai ha ⁻¹)	0.09d	0.03c	19.2c	25.3c	0.4bc	0.4c
Carbofuran (3.0 kg ai ha ⁻¹)	0.13b	0.04b	21.2bc	26.5bc	0.4bc	0.4c
Control	0.09d	0.03c	16.8c	25c	0.3c	0.4c

^a Each value is a mean of four replicates. Means followed by the same letter (s) along the same column are not statistically different at $P \leq 0.05$.

Table 5. Effects of poultry manure, cow dung and carbofuran on root gall-index of okra cv 47-4 infested with *M. incognita*.^a

Treatments	Trial 1	Trial 2
	Root gall-index	Root gall-index
Poultry manure (5 t ha ⁻¹)	4.75 (2.4)b	5.50 (2.6)b
Poultry manure (10 t ha ⁻¹)	3.00 (2.0)c	3.25 (2.1)cd
Cow dung (5 t ha ⁻¹)	4.75 (2.4)b	6.00 (2.6)b
Cow dung (10 t ha ⁻¹)	3.50(2.1)c	4.00 (2.2)c
Carbofuran (1.5 kg ai ha ⁻¹)	4.75(2.4)b	6.25 (2.7)b
Carbofuran (3.0 kg ai ha ⁻¹)	3.25 (2.1)c	2.75 (1.9)d
Control	9.25 (3.2)a	9.45 (3.2)a

^a Each value is a mean of four replicates. Means followed by the same letter (s) along the same column are not statistically different at $P = 0.05$. Analysis of variance is based on $\sqrt{n+1}$ transformed data. Figures in parenthesis are means of transformed values. Rating scale: 0= No knots on roots; 1= Few small knots, difficult to find; 2= Small knots only but clearly visible, main roots clean; 3= Some larger knots visible, main roots clean; 4= Larger knots predominate but main roots clean; 5= 50% of roots affected. Knotting on some main roots. Reduced root system; 6= Knotting on main roots; 7= Majority of main roots knotted; 8= All main roots, including tap root, knotted, few clean roots visible; 9= All roots severely knotted. Plant usually dying, and 10= All roots severely knotted. No root system. Plant usually dead (Bridge and Page, 1980). Initial population density (P_i)= 1050-1220 $J_2/200$ ml soil.

Table 6. Effects of poultry manure, cow dung and carbofuran on nematode population in soil infested with *M. incognita*.

Treatments	Trial 1	Trial 2
	Total Nematode Population in soil	Total Nematode Population in soil
Poultry manure (5 t ha ⁻¹)	1329a	1287ab
Poultry manure (10 t ha ⁻¹)	1141b	1177b
Cow dung (5 t ha ⁻¹)	1340a	1292ab
Cow dung (10 t ha ⁻¹)	1187b	1175b
Carbofuran (1.5 kg ai ha ⁻¹)	1283a	1266ab
Carbofuran (3.0 kg ai ha ⁻¹)	1137b	1191b
Control	1355a	1388a

^a Each value is a mean of four replicates. Means followed by the same letter (s) along the same column are not statistically different at $P \leq 0.05$.



The result of the trial 2 followed similar trend, except that plants treated with organic amendments or carbofuran at lower rates were not significantly different from those treated at higher rates. In both trials, plants treated with carbofuran, poultry manure, and cow dung at the highest rates produced significantly ($P \leq 0.05$) higher number of fruits than the control plants (Table 7). The total number of fruits produced by plants treated with carbofuran and organic amendments at lower rates were not significantly higher than that produced by control plants. In both field trials, plants treated with carbofuran at both rates and poultry manure and cow dung at 10 t ha^{-1} produced significantly ($P \leq 0.05$) higher fruit yield than plants treated with those at 5 t ha^{-1} and the control plants (Table 8). Fruit yield of plants treated with poultry manure, or cow dung at lower rate, was not significantly different from that produced by the control plants.

DISCUSSION

Incorporation of poultry manure, cow dung, and carbofuran in *M. incognita*-infested soil sown to okra reduced the population density of *M. incognita* and increased fruit yield of okra. Higher fruit yield recorded in plots amended with poultry manure or cow dung might be due to an improvement in soil fertility associated with organic amendments as well as the nematode-toxic substances released by the organic amendments on decomposition (Riegel and Noe, 2000; Oka, 2010). These toxins may have killed the juveniles of *M. incognita* in the soil. Organic manures have been shown to be rich in nitrogen and phenolic compounds (Agyarko *et al.*, 2006; Renco and Kováčik, 2012). On decomposition, nitrogen is converted to ammonia (Lazarovits *et al.*, 2001; Adetiloye

Table 7. Effects of poultry manure, cow dung and carbofuran on number of fruits per plant in *Meloidogyne incognita*-infested okra, cv. 47-4.

Treatments	Trial 1	Trial 2
	Number of fruits	Number of fruits
Poultry manure (5 t ha^{-1})	55.5ab	43.0ab
Poultry manure (10 t ha^{-1})	59.5a	60.8a
Cow dung (5 t ha^{-1})	44.8bc	45.3ab
Cow dung (10 t ha^{-1})	63.5a	45.5ab
Carbofuran ($1.5 \text{ kg ai ha}^{-1}$)	43.5bc	44.8ab
Carbofuran ($3.0 \text{ kg ai ha}^{-1}$)	68.3a	60.3a
Control	29.0c	37.5b

^a Each value is a mean of four replicates. Means followed by the same letter (s) along the same column are not statistically different at $P \leq 0.05$.

Table 8. Effects of poultry manure, cow dung and carbofuran on cumulative fruit yield of *Meloidogyne incognita*-infested okra cv. 47-4.

Treatments	Trial 1	Trial 2
	Fruit yield (t ha^{-1})	Fruit yield (t ha^{-1})
Poultry manure (5 t ha^{-1})	2.14bc	2.13b
Poultry manure (10 t ha^{-1})	3.42a	3.47a
Cow dung (5 t ha^{-1})	2.03bc	1.94b
Cow dung (10 t ha^{-1})	3.18a	3.23a
Carbofuran ($1.5 \text{ kg ai ha}^{-1}$)	2.19ab	2.25ab
Carbofuran ($3.0 \text{ kg ai ha}^{-1}$)	3.74a	3.53a
Control	1.38c	1.53b

^a Each value is a mean of four replicates. Means followed by the same letter (s) along the same column are not statistically different at $P \leq 0.05$.

et al., 2006; Oka, 2010; Thoden *et al.*, 2011) and this has been reported to kill several nematode spp. in the soil (Lazarovits *et al.*, 2001). Phenolic compounds have also been reported to be lethal to plant-parasitic nematodes (Nwaguma and Fawole, 2004). It could also be due to increased activities of other microbes facilitated by the organic amendments. Many of which are antagonistic to *M. incognita*. Antagonistic fungi have been isolated from juveniles and egg masses of nematodes in organic soils in New York (Viaene and Abawi, 1995). Increase in microbial organisms following the incorporation of organic compounds has been reported by many earlier workers (Sikora, 1992; Jaffee *et al.*, 1994; Riegel and Noe, 2000). The perceived increase in soil fertility in this study was confirmed by the observed elevated levels of total nitrogen, available phosphorous, and exchangeable potassium observed at the termination of the study in plots amended with poultry manure, cow dung, and carbofuran compared to the control plots. A number of studies using animal manures or organic residues as soil amendments also demonstrated beneficial effects on yields in a variety of crops and reductions in plant-parasitic-nematode (Orisajo *et al.*, 2008; Pakeerathan *et al.*, 2009; Iqbal *et al.*, 2011; Nwaguma *et al.*, 2011; Renco and Kováčik, 2012; Chaudhary and Kaul, 2013). In the current study, okra plants treated with poultry manure and cow dung at lower rates were not consistently significantly better than the control plants in yield, root gall-index, and nematode population in soil. This is different from the findings of Chindo and Khan (1990) who reported that poultry manure at the rates of 4 and 8 t ha⁻¹ significantly reduced the nematode population and increased tomato fruit yield compared to those treated with 0 and 2 t ha⁻¹. The heavily galled roots and reduced yield of okra observed in this experiment is an indication that the okra cv. 47-4 used in this study was highly susceptible to *M. incognita*. This finding is also different from that of Afolami and Adigbo (1999) who reported that the heavily

galled roots on okra species *A. caillei* (A. Chev) Stevels by *M. incognita* did not negatively correlate with the yield, this is because the wild okra species was able to confer tolerance to the nematode attack (Afolami and Adigbo, 1999).

The results of this study suggest that the application of poultry manure or cow dung at the rate of 10 t ha⁻¹ for controlling root-knot nematode could effectively control the population of the pest.

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مقایسه اثر کود مرغی، کود دامی، و کاربوفوران روی عملکرد بامیه آلوده به نماتد

گره ریشه *Meloidogyne incognita*

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چکیده

در این پژوهش، اثر کود مرغی، کود دامی، و کاربوفوران روی عملکرد بامیه آلوده به نماتد گره ریشه *Meloidogyne incognita* Race 2 بررسی شد. به این منظور، دو کرت $17\text{ m} \times 11\text{ m}$ که هر کدام به طور طبیعی آلوده به نماتد مزبور بودند برای این بررسی انتخاب شد. تیمارها عبارت بودند از کود مرغی و کود دامی هر کدام به مقادیر ۵ و ۱۰ تن د رهکتار و کاربوفوران 3G به مقادیر $\text{kg a.i} / \text{ha}$ ۱.۵ و $\text{kg a.i} / \text{ha}$ 3.0 یک شاهد. یک هفته بعد از مصرف این مواد، بذر بامیه به مقدار ۲ بذر در یک حفره کاشته شد و یک هفته بعد به یک بوته کاهش یافت. در ابتدا و انتهای دوره آزمایش، تعداد نیام ها، وزن تجمعی نیام ها، نمایه گال های ریشه، ویژگی های شیمیایی خاک، و چگالی نماتدهای خاک تعیین شد. نتایج نشان داد که مقادیر حد اکثر کود مرغی، کود دامی و کاربوفوران مقدار نمایه



گال ها و چگالی جمعیت نماتد ها را به طور معنی داری ($P \leq 0.05$) در خاک کاهش داد و در نتیجه مقدار عملکرد میوه را در مقایسه با مقادیر کمتر این مواد و نیز در قیاس با شاهد افزایش داد. بر پایه نتایج این پژوهش می توان گفت که در مزارع آلوده به نماتد، کار برد کود مرغی و کود دامی در خاک مستعدا می تواند جمعیت نماتد را محدود کرده و صدمه نماتد به بامیه را کم کند.