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Effects of Cured Poultry Manure, Cow Dung and Carbofuran on *Meloidogyne incognita* Race 2 at Different Stages of Development in Okra (*Abelmoschus Esculentus* (L). Moench)

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ABSTRACT
Cured poultry manure (CPM), cow dung (CCD) and carbofuran were evaluated on *Meloidogyne incognita* on okra in a screenhouse study. Two week-old okra seedlings were inoculated with 5,000 eggs of *M. incognita* per seedling. Treatments included CPM, CCD at the rate of 5 or 10 t ha^{-1}, and carbofuran 3G at the rate of 1.5 or 3.0 kg a.i ha^{-1} and the inoculated control (no amendment). The treatments were laid out in a randomised complete block design with four replications. Data were obtained on final nematode population, developmental stages and root gall-index. Adult females were observed in the roots of okra plants 18 days after inoculation (DAI) in the control plants, 22 DAI for most CPM and CCD treated plants and 30th day after egg inoculation for plants treated with carbofuran at 3.0 kg a.i / ha. Generation-time of *M. incognita* in okra plants treated with CPM and CCD at the rate of 10 t / ha and carbofuran at the rate of 3.0 kg a.i / ha was 24 days for each treatment compared to 22 days in untreated plants. The results of this study show that either CPM or CCD applied at the rate of 10 t / ha delayed the development of *M. incognita.* The results therefore suggest that the amendments possess great potentials for managing population of the nematode pest in infested fields.

Keywords: *Meloidogyne incognita*, generation time, manure, okra

INTRODUCTION

The Root-knot nematode, *Meloidogyne incognita* is an important pest of vegetable crops and its distribution in agricultural soils of Nigeria is approximately 75% among *Meloidogyne* species. It attacks almost all cultivated crops and causes significant yield losses (Adegbite, 2003). Annually, *Meloidogyne incognita,* could cause up to 80% yield losses on a wide variety of vegetable crops including okra, in heavily infested soils (Bourne *et al.,* 2004; Amulu and Adekunle, 2015). The nematode can form synergy with plant pathogenic fungi, bacteria and viruses causing greater yield losses (Rivera and Aballay, 2008). Root-knot nematodes, due to their ubiquitous nature, have high reproductive potentials and wide host ranges, and are difficult

to manage (Whitehead, 1998). The use of synthetic pesticides has been found to be effective in the management of root-knot nematode and increasing yield of agricultural products (Chaudhary and Kaul, 2013). However, the effects of pesticide overuse and misuse around the world has led to environmental pollution resulting in costly disruption of the balance of nature (Adekunle and Aderogba, 2007). The concern over indiscriminate use of chemicals in the control of pests has led to the sourcing of alternatives that are effective, ecologically safe and economical (Adekunle and Aderogba, 2007). Therefore, sourcing for alternatives to manage plant-parasitic nematodes especially *M. incognita* is very important. The use of organic amendments in nematode control has been reported to be effective in suppressing nematode pests on various crops including okra and pineapples, by various authors (Daramola *et al*., 2012; Chaudhary and Kaul, 2013; Amulu and Adekunle, 2015). This study evaluated the effect of cured poultry manure, cow dung and carbofuran on the development of *M. incognita* on okra.

MATERIALS AND METHODS

Source of Seeds and Amendments

Seeds of okra (*Abelmoschus esculentus*) cv. 47-4, which was moderately susceptible to *M. incognita* (Amulu and Adekunle, 2015), were obtained from the National Institute of Horticultural Research (NIHORT) Ibadan, Nigeria. Seeds of *Celosia* cv. TLV8 were obtained from the Department of Crop Production and Protection, Obafemi Awolowo University, Ile-Ife, Nigeria. Poultry manure and cow dung were obtained from the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife. The poultry manure and the cow dung, were separately left in a pit of 2×3 m^2 and was covered with black polythene materials for eight weeks to allow them to completely decompose. They were subsequently spread out on a concrete slab for two months before use. Carbofuran 3G was procured from a Government registered agrochemical store at Ile-Ife. The poultry manure, cow dung and steam sterilised soil used for this study were analysed for pH, total nitrogen (N), available phosphorous (P) and exchangeable potassium (K) using standard methods (Knudsen *et al.*, 1982).

Production of Nematode cultures

Pure cultures of *M. incognita* race 2, identified by the method outlined by Eisenback *et al*. (1981) were maintained on *Celosia argentea* cv. TLV 8 in the nematode culture plot of Obafemi Awolowo University, Ile-Ife. Eight week-old celosia plants with *M. incognita*-galled roots were uprooted and the roots were washed to remove adhering soil particles. Roots were cut into 2 cm pieces and eggs of *M. incognita* were extracted from the galled roots using sodium hypochlorite method (Southey, 1986). Extracted nematodes were counted and number of eggs per ml was adjusted to 1000 per ml.

Nematode inoculation and application of treatments

Plastic pots of 1litre capacity were filled with steam-sterilised top soil, and arranged on screenhouse benches. Seeds of okra cv. NIHORT47-4 were sown into the pots at the rate of three seeds per pot. The experiment was laid out in a randomised complete block design with seven treatments in four replicates. The treatments were cured poultry manure at 5 and 10 t/ha (2.5 g / pot and 5 g / pot), cow dung at 5 and 10 / t / ha (2.5 g / pot and 5 g / pot) carbofuran at 1.5 kg a.i / ha and 3.0 kg a.i / ha and a control. Two weeks after planting, okra

plants were inoculated with 5,000 eggs of *M. incognita* in water suspension on the roots of okra plants in each pot with the aid of a syringe. Inoculated plants were immediately amended with cured poultry manure and cow dung each at the rates equivalent to 5 and 10 t / ha (2.5 g / pot and 5 g / pot). The amendments were applied to the soil around the roots of okra seedlings and covered. Carbofuran 3G was applied at the rates of 1.5 kg a.i / ha (0.025 g / pot) and 3.0 kg a.i / ha (0.05 g/pot). The control plants were not amended. Destructive sampling was conducted for every two days for the 52 day period of the experiment in which a plant was taken per pot.

The experiment comprised 252 pots, each containing three seedlings of okra plants, 144 pots, each containing three seedlings amended with either poultry or cow dung manures at the two rates, 72 pots, each containing three seedlings of okra amended with carbofuran at the two rates and 36 pots, each containing three seedlings of okra that served as control.

Monitoring the developmental stages of Meloidogyne incognita on infected okra roots

Forty eight hours after inoculation, four okra plants were randomly and carefully uprooted per replicate per treatment and labeled. The plant roots were washed in gentle stream of water and allowed to drain between paper towels. The roots of each okra plant were then cut into approximately 4 - 5 cm pieces. The roots pieces were submerged in lactophenol cotton-blue in a beaker and warmed over waterbath at 100° C for three minutes. Thereafter, stained roots were transferred into plain lactophenol in a beaker, placed in water bath at 100° C for 15 minutes to destain the roots (McBeth *et al*., 1941). This sampling process was repeated every 48 hours for 54 days. Plant roots for each treatment per harvest time were mounted on glass slides and macerated with the aid of a picking needle. The root tissues were then examined under a compound microscope (Motic digital microscopy) to determine the stages of development of *M. incognita*. Different stages of the nematode were observed and nematodes recovered from roots were also counted. Data were collected at atmospheric temperature of the screenhouse and soil temperature of potted plants by 12 noon and 6 pm daily through the duration of the experiment.

Assessment of *Meloidogyne incognita* Damage

Thirty DAI, roots of okra plants were processed and assessed for number of egg masses before staining, the egg masses were dislodged from the roots, placed on glass slides and cut open with the aid of picking needle, and eggs were counted under a microscope. Root galls were assessed using the diagrammatic root-knot scoring chart with a scale of 1-10 (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 = fifty percent 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

Data on nematode counts were square root ($\sqrt{n+1}$) transformed before subjecting them to analysis of variance (ANOVA) using the PROC GLM procedure in statistical analysis

system (SAS) package (SAS Institute, 2002). Treatment means were separated using Fisher's Least Significant Difference (L.S.D) at 5% level of probability.

RESULTS

The temperature of the soil and the screenhouse ranged from 29-38°C and 35-38°C respectively, for the period this study was conducted. The pH of the sterilised soil used for the study was 7.9 in water and 6.8 in $CaCl_2$. It had 0.076 % total N (Table 1). The levels of available P and K were 40.5 mg / kg and 0.46 $cmol_C$ / kg respectively. The poultry manure had pH of 8.2 in water and 8.0 in $CaCl_2$. Cow dung had pH of 8.0 and 7.6. Poultry manure had 1.85 % N, 89.80 mg / kg P and 11.03 $cmol_C$ / kg K. Cow dung had 0.91 % N, 86.37 mg / kg and 15.9 $cmol_C$ / kg.

Table 1 shows the effects of poultry manure, cow dung and carbofuran on number of second stage juveniles of *M. incognita* infecting (J_2) okra. Second-stage juveniles of *M. incognita* (J_2) were first detected in control plants (untreated plants) at day four after egg inoculation. At 4, 6 and 12 days after egg inoculation, control plants had significantly ($P \leq 0.05$) higher number of J_2 than plants treated with carbofuran, poultry manure or cow dung at rates equivalent to 5.0 t / ha and 10 t / ha. At eight days after egg inoculation, there was no significant ($P \leq 0.05$) difference in the number of J_2 in treated and control plants. However, at 10 days after egg inoculation control plants had significantly ($P \leq 0.05$) higher number of J_2 than plants treated with carbofuran and poultry manure or cow dung at the higher rates. The lowest number of J_2 (0) was recorded in plants treated with carbofuran at 3.0 kg a.i/ha at day eight.

Third-stage juveniles (J_3) were first recovered from the roots of control plants at 10 days after egg inoculation, but were later seen in the roots of treated plants from 14 days after inoculation (Table 2). At day 14, fourth-stage juvenile females were recovered from the roots of control plants, while they were first observed in the roots of treated plants from 16 days after egg inoculation. Also fourth-stage juveniles male and adult males were not found in the roots of plants treated with cow dung at the rate of 5 t / ha and roots of plants treated with poultry manure at the rate of 5 t / ha, carbofuran at the rates of 3.0 and 1.5 kg a.i / ha. Adult females were seen in the roots of control plants 18 days after egg inoculation, 22 days after egg inoculation for most treated plants and 30 days after egg inoculation for plants treated with carbofuran at 3.0 kg a.i / ha. Egg masses with eggs of *M. incognita* were found in the roots of control plants from 22 days after egg inoculation but were later seen in treated plants, 24 days after egg inoculation.

From 30 to 48 days, after egg inoculation, control plants had significantly ($P \leq 0.05$) higher number of egg masses compared to treated plants (Table 3). Also at 36, 50, and 52 days after egg inoculation, control plants had significantly higher number of egg masses than plants treated with carbofuran and poultry manure or cow dung at the higher rates. The highest number of egg masses (9) was found in control plants at 48 days after egg inoculation, while on day 40 and 44, the lowest number of egg masses (1) was seen in plants treated with carbofuran at the rate of 3.0 kg a.i / ha. This was not significantly ($P \leq 0.05$) different from number of egg masses in other treated plants. At 38, 42, 44, 46, 48, 50 and 52 days after egg inoculation, the roots of control plants had significantly ($P \leq 0.05$) higher number of eggs than treated plants, while at day 30, 32, 34, 36 and 40 after egg inoculation control plants had significantly higher number of egg than plants

Table 1: Effects of cured poultry manure, cow dung and carbofuran on number of second-stage juveniles of *Meloidogyne incognita* infecting okra cv 47-4.

Days after inoculation	Poultry manure		Cow dung		Carbofuran		Control	LSD (0.05)
	10 t/h	5 t/h	10 t/h	5 t/h	3.0 kg a.i/h	1.5 kg a.i/h		
2	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	0 .0
4	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.3 (0.8)	0.2
6	1.1 (0.3)	1.3 (0.8)	1.2 (0.5)	1.4 (1.0)	1.1 (0.3)	1.2 (0.5)	1.9 (2.5)	0.4
8	1.1 (0.3)	1.1 (0.3)	1.3 (0.8)	1.3 (0.8)	1.0 (0.0)	1.2 (0.5)	1.4 (1.0)	0.5
10	1.1 (0.3)	1.5 (1.3)	1.25 (0.8)	1.7 (1.8)	1.0 (0.0)	1.7 (2.0)	0.9 (2.5)	0.5
12	1.4 (1.0)	1.9 (2.5)	1.43 (1.3)	1.62 (1.8)	1.28 (0.8)	1.6 (1.5)	4.0 (17)	1.1

Each value is a mean of four replicates. Analysis is based on $\sqrt{n+1}$transformed data with the original means in parenthesis. DAI = Day after egg inoculation.

Table 2: Effects of cured poultry manure, cow dung and carbofuran on days to first appearance of J_3, J_4F, J_4M, AF, AM.

Stages of *M. incognita*	Poultry manure		Cow dung		Carbofuran		Control
	10 t h	5 t/h	10 t/h	5 t/h	3.0 kg a.i/h	1.5 kg a.i/h	
J_4F	16	16	16	16	16	16	14
J_4M	34	40	36	0.0	34	34	26
AF	22	22	22	22	30	22	18
AM	34	0.0	40	34	0.0	0.0	32
Egg mass	24	24	24	24	24	24	22

DSM = Developmental stage of *M. incognita*, J_3=Third stage juvenile; J_4F=Female fourth stage juvenile; J_4M= Male fourth stage juvenile; AM= Adult female; AM= Adult male. DAI=day after egg inoculation.

treated with carbofuran and poultry manure or cow dung at the higher rates (Table 4). The highest number of eggs (234.3) was found on day 38 after egg inoculation in control plants. At day 42, plants treated with carbofuran at the rate of 3.0 kg a.i / ha had the lowest number of eggs (9.3). This was not significantly ($P \leq 0.05$) different from number of eggs in other treated plants. Table 5. showed that at 30, 32, 34, 38, 40, 42, 44, 46, 48 and 52 days after egg inoculation, treated plants had significantly lower root gall-index than control plants. There was no significant difference among control plants and plants treated at lower rates of amendment or carbofuran on 36 and 50 days after egg inoculation. Control plants recorded the highest galling index (9.8) which was observed at day 52 after nematode egg inoculation. At day 34, plants treated with carbofuran at the rate of 3.0 kg a.i / ha recorded the lowest gall-index. This was not significantly ($P \leq 0.05$) different from the root gall-index recorded in plants treated with poultry manure and cow dung.

Table 3: Effects of cured poultry manure, cow dung and carbofuran on total number of eggs masses produced on the roots of *Meloidogyne incognita*-infected okra cv 47-4

Days after egg inoculation	Poultry manure		Cow dung		Carbofuran		Control	LSD (0.05)
	10 t/ha	5 t/ha	10 t/ha	5 t/ha	3.0 kg a.i/ha	1.5 kg a.i/ha		
30	1.7 (2.0)	2.0 (3.0)	1.8 (2.3)	2.0 (3.0)	1.6 (1.5)	1.7 (2.0)	2.5 (5.3)	0.4
32	1.9 (2.8)	1.8 (2.3)	1.7 (2.0)	1.7 (2.0)	1.3 (0.8)	1.8 (2.1)	2.5 (5.0)	0.3
34	1.8 (2.3)	2.1 (3.3)	1.7 (2.0)	2.0 (3.0)	1.5 (1.5)	2.2 (4.0)	2.7 (6.3)	0.4
36	1.6 (1.8)	2.0 (2.8)	1.9 (2.3)	1.9 (2.5)	1.5 (1.3)	1.6 (1.8)	2.3 (4.5)	0.4
38	1.8 (2.1)	1.9 (2.5)	1.7 (2.0)	1.9 (2.8)	1.3 (0.8)	1.8 (2.3)	2.7 (6.5)	0.4
40	1.7 (2.0)	1.9 (2.5)	1.7 (2.0)	2.1 (3.3)	1.4 (1.0)	1.8 (2.3)	2.5 (5.5)	0.4
42	1.5 (1.3)	1.7 (2.0)	1.5 (1.3)	1.8 (2.3)	1.4 (1.6)	1.6 (1.5)	2.6 (5.8)	0.4
44	1.5 (1.3)	2.2 (3.8)	1.8 (2.3)	1.8 (2.5)	1.4 (1.0)	1.8 (2.3)	2.8 (7.0)	0.5
46	1.8 (2.3)	2.3 (4.3)	2.2 (3.8)	2.2 (4.0)	2.0 (3.1)	2.2 (4.0)	2.8 (7.0)	0.5
48	1.9 (2.5)	2.1 (3.8)	2.1 (3.5)	2.5 (5.3)	1.9 (2.5)	2.6 (6.0)	3.2 (9.0)	0.4
50	2.5 (5.5)	2.9 (7.3)	2.1 (3.5)	2.9 (7.5)	2.0 (3.3)	2.8 (6.8)	2.7 (6.8)	0.6
52	2.6 (5.8)	2.9 (7.3)	2.6 (5.8)	3.0 (7.8)	2.5 (5.2)	3.1 (8.0)	3.1 (8.8)	0.3

Each value is a mean of four replicates. Values are $\sqrt{n+1}$ transformed with real means in parenthesis. DAI = day after egg inoculation.

Table 4: Total number of eggs from roots of *Meloidogyne incognita*-infected okra cv 47-4 treated with cured poultry manure, cow dung and carbofuran

Days after egg inoculation	Poultry manure		Cow dung		Carbofuran		Control	LSD (0.05)
	10 t/ha	5 t/ha	10 t/ha	5 t/ha	3.0 kg a.i/ha	1.5 kg a.i/ha		
30	2.6 (6.8)	4.4 (18.5)	3.5 (13.5)	4.0 (15.5)	3.2 (11.5)	5.2 (27)	5.6 (34.3)	2.2
32	4.8 (23.8)	5.6 (31.8)	4.6 (22.0)	5.2 (26.3)	4.6 (21.5)	5.8 (37)	7.4 (54.8)	2.30
34	5.5 (32.5)	7.8 (59.5)	5.40 (29.5)	6.3 (41.0)	4.8 (23.3)	6.4 (40.5)	7.9 (62.0)	1.48
36	5.1 (25)	5.9 (34.5)	5.3 (27.0)	6.6 (44.8)	5.1 (25.5)	6.0 (35.8)	7.9 (64.0)	1.6
38	6.8 (50.5)	5.7 (35.8)	4.8 (22.5)	5.6 (30.0)	3.3 (12.8)	6.9 (49)	14.7 (234.3)	4.1
40	7.9 (76.0)	9.1 (81.5)	6.4 (40.8)	6.3 (48.0)	5.6 (30.5)	6.8 (51.5)	10.1 (102.5)	3.7
42	4 (20.8)	6 (42.3)	4.6 (24.0)	6.5 (48.3)	2.8 (9.3)	3.6 (19)	13.2 (173.3)	3.5
44	3.7 (16.0)	6.1 (42.8)	4.3 (17.5)	5.6 (37.0)	5.4 (17.5)	4.8 (24)	12.3 (151.3)	3.1
46	5.0 (24.5)	5.6 (31)	6.3 (43)	7.2 (52.5)	5.4 (30.0)	5.8 (32.8)	12.5 (161.3)	2.1
48	6.4 (40.3)	7.3 (52.5)	7.2 (51.5)	9.4 (88.3)	6 (35.3)	6.7 (45)	11.8 (140.0)	1.5
50	6.8 (45.3)	7.6 (57.5)	7.5 (56.5)	9.7 (93.3)	6.4 (40.3)	7.3 (52.3)	12 (145.0)	1.4
52	7.2 (51.3)	8 (63.5)	7.3 (52.5)	9.8 (94.8)	6.9 (46.3)	7.9 (61.8)	12.3 (151.0)	1.2

Each value is a mean of four replicates. Analysis of variance is based on square root $\sqrt{n+1}$ transformed data. DAI = day after egg inoculation. The raw data is in parenthesis

Table 5: Effects of weathered poultry manure, cow dung and carbofuran on root gall of *Meloidogyne incognita*-infected okra cv. 47-4

Days after egg inoculation	Poultry manure		Cow dung		Carbofuran		Control	LSD (0.05)
	10 t/ha	5 t/ha	10 t/ha	5 t/ha	3.0 kg a.i/ha	1.5 kg a.i/ha		
30	2.3	2.5	2.3	3.0	2.0	2.4	5.3	1.6
32	1.8	2.3	2.0	2.0	1.0	2.1	5.0	1.5
34	1.2	2.8	1.3	2.5	0.5	6.3	8.8	2.3
36	1.5	2.3	2.0	2.3	1.5	2.5	4.3	2.1
38	2.3	3.0	2.3	3.2	1.5	2.6	6.3	2.3
40	2.3	2.5	2.0	3.3	1.5	2.6	5.3	1.16
42	1.3	2.3	2.0	3.0	0.5	2.3	6.0	1.8
44	1.3	2.8	1.8	2.3	1.3	2.5	6.8	1.5
46	1.8	5.5	2.8	4.3	2.3	3.3	7.0	1.4
48	2.5	4.8	3.3	4.5	2.4	5.5	9.0	2.0
50	5.8	6.0	5.12	7.8	5.8	6.5	9.5	2.1
52	7.0	7.3	6.5	6.5	6.5	7.5	9.8	1.5

Each value is a mean of four replicates. DAI = day after inoculation. Galling was on a1-9 scale, 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. 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. 10 – all roots severely knotted. no root system. Plant usually dead.

DISCUSSION

Poultry manure and cow dung applied at the rates of 10 t / ha each, reduced penetration and slowed down the development of second stage juveniles in okra plants compared to plants amended at the lower rate and control plants. The J_3 and adult females were first observed in untreated plants indicating that the amendments might have prevented or reduced the rate at which some eggs hatched or might have killed some J_2 that hatched. This observation might be due to the release of nematicidal compounds from the decomposing poultry manure and cow dung (Oka, 2010; Thoden *et al*., 2011). Organic wastes such as poultry manure and cow dung are known to release nitrogenous compounds, organic acids, phenolic compounds and these have been found to be toxic to plant-parasitic nematodes (Akhtar and Malik, 2000; Maina *et al*., 2012). The findings from this study agree with those of Adekunle and Fawole (2003) who reported that the application of water extracts of neem leaves, siam weed leaves and roots at 20,000 mg / kg and 40,000 mg / kg or carbofuran at 1.5 kg a.i / ha and 2.5 kg a.i / ha to potted tomato plants inoculated with *M. incognita* eggs, delayed development of *M. incognita* by four days in comparison with control plants. They further stated that the cohort of females in treated plants might not have been mature as those in control plants. Also, Adekunle and Akinlua (2007) reported that treatment of nematode-infected okra plants with *Leucaena leucocephala* and *Gliricidia*

sepium extracts resulted in reduced nematode population, reduced gall-index and reduced nematode reproduction rate in comparison with control treatment. Similarly, Osei *et al*. (2011) evaluated the effects of five organic waste extracts for their hatching inhibitory potential to *M. incognita* eggs. They reported that at the highest concentration of 10% of cocoa bean testa compost, citrus waste, palm bunch waste and poultry manure had hatched eggs of 7.0, 18.0, 5.0, 34.0 and 20.0, respectively, out of a total of 100 eggs, while the distilled water (control), recorded 73 hatched eggs. All the amendments were found to be effective in inhibiting hatching of eggs of the nematode.

The application of cured poultry manure, cow dung and carbofuran resulted in a delayed development of *M. incognita* in okra plants by two days. It is known that the population build up and development of nematodes is affected by a variety of factors including biotic and abiotic factors (Ravichandra, 2013). This can either increase or reduce the rate of reproduction in plants. Increased rate of penetration and reproduction by nematode in plant can consequently lead to rapid build-up of the pest and might in turn affect the growth and productivity of plant. Damage by root-knot nematode on plants depends on the number of nematode that penetrate the root of infected plant and the reproductive fitness of the nematodes. Higher nematode population and increased rate of reproduction in root of plants have been reported to cause significant damage in okra and tomato plants (Adekunle and Fawole, 2003; Amulu and Adekunle, 2015).

The development pattern and life cycle of *M. incognita* as observed in this study are consistent with the description given for *Meloidogyne* spp., in similar studies on other crops (Nwauzor and Fawole, 1992; Adekunle and Fawole, 2003). All the stages of development were observed as they differentiate from one form to another including the adult male, which is usually rare. The J_2 were first seen at the second day after inoculation, J_3 and adult female were first seen at 10 and 18 days after inoculation respectively, while the nematode completed its life cycle at 18 DAI in control plants, 22 DAI in plants amended with the manures and 30 DAI in plants amended with carbofuran. The results of this study suggest that the application of poultry manure or cow dung at the rate of 10 t / ha to root-knot nematode infested fields could effectively manage population of the pest.

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