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Effect of neem, *Azadirachta indica* products and vermin-compost on root-knot nematode *Meloidogyne incognita* population build-up in tomato crop roots

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Abstract
Experiments on the effect of neem products and vermicompost on root- knot nematode *Meloidogyne incognita* population build-up in tomato was carriedout and observations on the nrmatode population on root and soil, number of galls, eggs/eggmass total nematode population and nematode multiplication factor were recorded. The observations revealed that all the parameters showed significant in root and shoot weight and reduction in the nematode population multiplication rate under pot condition in tomato crop. The highest reduction in nematode multiplication in comparison to the inoculated check was observed in carbofuran treated check (1.99) followed by the Achook @ 5% (2.19), neem cake @ 5% (2.50), neem leaf compost (2.68), neem leaf compost (2.68), vermi compost (3.14) and 3.38 in neem leaf with decomposer with the minimum reduction 4.50 observed in inoculated check respectively in ascending order. The percentage decrease in nematode multiplication factor was observed maximum (55.77) in Carbofuran treated check followed by 51.33% in Achook, 44.44% in neem cake, 40.44% in neem leaf compost, 30.22 in vermi compost and minimum 24.88% in neem leaf with organic decomposer treatment in comparison to the inoculated check. Similar trends in the observations of root weight, shoot weight and gall formation was recorded.

Keywords: *Azadirachta indica*, *Meloidogyne incognita* population, tomato crop roots

Introduction
Nematode diseases are known to be one of the most widespread diseases in the last two decades that attract the attention of researchers, especially those in the field of the plant protection. There are thousands of genus and species of plant parasitic nematodes, which cause damage in quality and quantity of the yield in varied crops; moreover, increasing the costs of production. The most famous and destructive genus around the world is the root-knot nematode, *Meloidogyne incognita,* because of its wide host range which includes more than 2000 hosts, such as vegetable, fruit trees, fiber crops, oil crops, grain crops and fodder crops. In addition to this, weeds are considered as secondary host to nematodes. Hence, the root-knot nematodes are found to be the most important and causing at least 90 per cent of all damage caused by nematode as well as plant parasitic nematodes. A total of 5.00% yield loss was reported by Hussy and Janssen; 2002 [12] globally among vegetable crops. However in India, the Avoidable yield loss between 28.30 to 47.50 in tomato, 26.5 to 50.0 in Brinjal, 19.70 to 33.30 in chili and 60.00 to 90.00 per cent in bitter gourd under Indian conditions was also reported by AICRIP (Anonymous, 1992) [8]. Although many options have been tested for the management of root-knot nematode of different crops. There is need of determining of some management options which can be ecologically safe, practically feasible and economically viable. Accordingly, the present investigation on the "Effect of neem products and vermicompost on root- knot nematode *Meloidogyne incognita* population build-up in tomato crop roots" were carried out on tomato.

Materials and Methods
Collections, identification and purification of *Nematode Inoculum*
Root-knot nematode, *Meloidogyne Spp.* infected tomato roots were collected from culture pots of departmental cage house, College of Agriculture, ANDUAT, Kumarganj, Ayodhya. The roots of collected root-knot nematode infected tomato plants were carefully washed with running water and stored at 15 ^{0}C for the isolation of root-knot nematode eggmass. Single eggmass were taken out and kept in 5 cm diameter Petri dish for a period of 72 hours at 25 ^{0}C for freshly hatched juveniles. The collected root-knot infected tomato plants were carefully washed with fresh water and surface sterilized with 0.1% mercuric chloride for 30 second.

The plant roots were again washed with fresh water and stained using Byrd et al., 1983 [9] method for staining of nematode infected plant root. The stained female of root-knot nematode were collected from roots of tomato and posterior part of the female was cut in order to get perennial pattern with the help of blade and examined under compound microscope for species identification as described by Taylor and Murant. (1955) [16]. The characteristics of root-knot nematode female perennial pattern along with other morphological parameters such as style morphology, head shape of males larval lenth and their comparison with the description given by Whitehead (1968) [17] and Eisenback (1985) [10] established the test nematode was *Meloidogyne incognita.* Root-Knot nematode species *Meloidogyne incognita* was identified on the bases of morphological characters and perennial pattern. The race identification of *Meloidogyne incognita was carried out using* host differential test reaction of the nematode population as prescribed by Hartman and Sasser (1985) [11].

Soil Preparation

Sandy loam soil was procured from departmental experimental field and sterilized in horizontal hot air oven for 30 minute at 15.5 psi. After sterilization, soil were stored on safe place & used for raising nursery for maintaining pure culture of root-knot nematode, *Meloidogyne incognita. Race*-1.

Raising of nursery for maintaining pure culture of nematode

The sterilized sandy loam soil were filled in 12 inch earthen pots and seeded and transplanted plant of susceptible variety of tomato "SL-120" were placed carefully on the soil surface and covered with 1 cm layer of sterilized soil. The earthen pots were then irrigated carefully and kept in the cage house for its germination. The tomato seedlings when reached 3.5 leaf stages were used for transplanting for maintaining pure culture of root-knot nematode.

Preparation of root-knot nematode pure culture

Pure culture of *Meloidogyne incognita* race -1 was prepared on tomato plant var. (Pusha SL-120). 3-5 leaf stage seedlings was transplanted in 12 inch earthen pots. Single egg mass were obtained from root-knot nematode, *M. incognita* infected tomato plant roots and kept in sterilized water in Petri dish for hatching. The egg masses were incubated for 72 hours at 25^0 C in the BOD. Nematode juveniles were than inoculated in earthen pots planted with tomato var. SL-120 plant. After 30 days *M. incognita* infected plants was harvested carefully for multiplication of pure culture and isolation of nematode trapping fungi.

Effect of Neem Products and Vermi compost on *Meloidogyne incognita* management

The experiment on the efficacy of neem products and vermi compost was conducted by preparing Achook @ 5%, Neem cake @ 5%, Neem leaf compost @ 5%, Neem leaf with organic decomposer @ 5% and vermin compost @ 5% with the inoculated, uninoculated and treated check were prepared in 9 inch diameter earthen pots transplanted with three to five leaf stage tomato leaf plant in sterilized garden soil field in earthen pots. The requirement amount of Achook, neem cack, Neem leaf compost, Neem leaf with organic decomposer, vermi compost and Carbofuran was thoroughly mixed in sterilized garden soil. The plant transplanted in pots were inoculated with prissily hatched second stage juveniles of root-knot nematode in soil by poring nematode suspension @ 5 larvae per gram soil. All the plants were irrigated time to time left for the growth periods of thirty five days. observations on root and shoot weight, soil nematode population and root nematode population, galls/ plant, egg mass/ plant, eggs/ egg mass, total eggs population were recorded analyzed statistically by using CRD deigns.

Results and Discussion

Observations presented in table-1 indicate that all the treatments were significantly different over others. The maximum root weight 12.25 and shoot weight 64.35 was observed in uninoculated check where as the lowest root weight 4.70 and shoot weight 22.30 was observed in inoculated treatment followed by 5.40 in vermi compost @ 5%, 5.39 in neem leaf compost @ 5%, 7.35 in neem cack @ 5%, 9.45 in Achook @ 5% and 10.85 in treated check i.e Carbofuran @ 1.5 kg a.i/ ha in ascending order for root weight and 29.40 in vermi compost @ 5%, 34.45 in neem leaf with organic decomposer @ 5%, 36.65 in neem leaf compost @ 5%, 47.55 in neem cake @ 5%, 52.35 in Achook @ 5% and treated check with Carbofuran @ 1.5 kg a.i / ha in ascending order for shoot weight respectively. The highest percentage increase in root and shoot weight over inoculated check was observed 130.85 and 159.41treated check followed by 101.06 and 134.75 in Achook @ 5%, 56.38% in neem cake @ 5%, 26.17% in neem leaf compost @ 5%, 14.89 and 31.38 in vermi compost @ 5% and 38.29 and 54.48% in neem leaf with organic decomposer @ 5% respectively. Where as the observations on root and shoot weight in comparison to untreated check was observed in decreasing trend. It was observed 11.42 and 10.10 in Carbofuran treated check, 22.85 and 18.64 in Achook @ 5%, 40.00 and 26.10 in neem cake @ 5%, 48.40 and 43.04 in neem leaf compost @ 5%, 44.08 and 54.31 in vermi compost @ 5%, 53.06 and 46.46 in neem leaf with organic decomposer @ 5v% and 61.63 and 65.34% in inoculated check treatment respectively.

Table 1: Effect of neem products and vermin-compost on plant growth and root- knot nematode, *Meloidogyne incognita* population build-up in tomato crop. Observation is the mean of four replicates.

Treatment		Root Weight (g/Plant)	% Increase over Inoculated Check	Shoot Weight (g/Plant)	% Increase over Inoculated Check
T_1	Carbofuran @ 1.50 kg a.i/ha	10.85	+130.85	57.85	159.41
T_2	Achook @ 5.00%	9.45	+101.06	52.35	+134.75
T_3	Neem Cack @ 5.00%	7.35	+56.38	47.55	-113.22
T_4	Neem Leaf Compost @ 5.00%	5.93	+26.17	36.65	+64.34
T_5	Vermicompost @ 5.00%	5.40	+14.89	29.40	+31.83
T_6	Neem leaf with Organic Decomposer @ 5%	6.50	+38.29	34.45	+54.48
T_7	Inoculated	4.70	-	22.30	-
T_8	Uninoculated	12.25	+160	64.35	+188.56
CD. Value at 5%		0.83	-	1.93	-

Nematode Population on Roots

The data as presented in table- 2 on nematode population on roots indicate significant different in observations among all treatments. The maximum nematode population on root was observed in inoculated check (86.96) followed by 8.50 in vermi compost @ 5%, 78.29 in neem leaf compost, 76.50 in neem leaf with organic decomposer @ 5%, 63.86 in neem cake @ 5%, 56.34 in Achook @ 5% with the maximum nematode population observed in Carbofuran treated check @ 1.5 kg a. i/ha in descending order respectively. The percentage decrease in nematode population on root was observed maximum 44.05% in Carbofuran treated check @ 1.5 kg a. I /ha followed by 35.21% in Achook treatment, 26.53 in neem cake, 12.02% in neem leaf with organic decomposer, 9.97% in leaf compost and 7.42% in vermi compost @ 5% treatment respectively in descending order.

Nematode population (J2) in soil

The observations presented in table- 2 on J2 population in soil indicate that all the treatments were significantly different from each other. The maximum number of soil J2 3830.07 was recorded in inoculated check which is followed by neem leaf with organic decomposer (3418.00), vermi compost @ 5% (3138.00), neem leaf compost (2784.96), neem cake @ 5% (2616.32), Achook @ 5% (2430.14) with minimum in treated check (2081.32) second stage juveniles respectively in descending order. The percentage decrease in J2 was observed maximum (45.66) in Carbofuran treated check followed by 36.55% in Achook, 31.45% in neem cake, 27.28% in neem leaf compost, 18.06% in vermi compost with the minimum decrease 10.78% in neem leaf with organic decomposer treatment in descending order respectively.

Table 2: Effect of neem products and vermin-compost on root- knot nematode, *Meloidogyne incognita* population build-up in tomato crop. Observation is the mean of four replicates.

Treatment		Nematode Population		Galls/ Plant	Egg / Egg mass	Egg mass/ Plant	Eggs Population (In thousands)	Total Nematode population	M/F*
		Root	Soil						
T_1	Carbofuran @ 1.50 kg a.i/ha	48.65(44.05)	2081.32(45.56)	38.50(44.86)	312.25(16.29)	144.25(58.36)	7.80(58.24)	2178.62(43.39)	1.99
T_2	Achook @ 5.00%	56.34(35.21)	2430.14(36.55)	33.25(52.38)	358.75(33.61)	199.50(42.42)	8.48(54.60)	2486.48(35.39)	2.19
T_3	Neem Cack @ 5.00%	63.86(26.53)	2616.32(31.69)	43.50(37.70)	396.50(47.67)	219.25(36.72)	9.86(47.21)	2680.18(30.31)	2.50
T_4	Neem Leaf Compost @ 5.00%	78.29(9.97)	2784.96(27.28)	36.58(47.61)	412.25(53.53)	189.52(45.30)	10.56(423.46)	2863.25(25.60)	2.68
T_5	Vermicompost @ 5.00%	80.50(7.42)	3138.00(18.06)	47.50(31.97)	468.50(74.48)	236.75(31.67)	12.52(32.97)	3218.50(16.37)	3.14
T_6	Neem leaf with Organic Decomposer @ 5%	76.50(12.02)	3418.00(10.78)	22.00(68.49)	412.75(53.72)	155.63(55.08)	13.45 (27.99)	3494.50(9.20)	3.38
T_7	Inoculated	86.96	3830.07	69.83	268.50	346.50	18.68	3848.75	4.50
T_8	Uninoculated	-	-	-	-	-	-	-	-
CD. Value at 5%		1.56	41.10	1.94	7.56	14.35	1.89	23.36	-

Note: Data in Parenthesis are the percentage reduction in respective parameter

Number of galls

The observations presented in table- 2 on number of galls per plant revealed that all the treatments were significantly different from each other. The maximum number of soil galls 69.83 was recorded in inoculated check which was followed by vermi compost @ 5% (47.50), neem cake @ 5% (43.50), Neem leaf with decomposer (38.50), Neem leaf compost (36.58), Achook (33.25) with minimum in treated check (22.00) respectively in descending order. The percentage decrease in galls/plant was observed maximum (68.49%) in Carbofuran treated check followed by 52.38% in Achook, 47.61% in neem leaf compost, 44.86% in vermi compost with decomposer, 37.70% in neem cake with the minimum decrease 31.97% in vermi compost treatment in descending order respectively.

Number of Egg mass/Plant

The observations presented in table- 2 on egg mass per plant indicate that all the treatments were significantly different from each other. The maximum number of egg mass/plant 166.50 was recorded in inoculated check which was followed by vermi compost (146.75), neem leaf with decomposer (135.63), neem leaf compost (129.52), neem cake @ 5% (119.25), Achook @ 5% (99.50) with minimum in treated check (44.25) eggs per egg mass respectively in descending order. The percentage decrease in egg per egg mass was observed maximum (73.42) in Carbofuran treated check followed by 40.25% in Achook, 28.37% in neem cake, 22.21% in neem leaf compost, 18.54% in neem leaf with organic decomposer with the minimum decrease 11.86% in vermi compost treatment in descending order respectively.

Number of Eggs/ Egg mass

The observations presented in table- 2 on eggs/ egg mass indicate that all the treatments were significantly different from each other. The maximum number of egg/egg mass 268.50 was recorded in inoculated check which was followed by vermi compost (250.25), neem leaf with decomposer (205.75), neem leaf compost (186.25), neem cake @ 5% (180.25), Achook @ 5% (168.50) with minimum in treated check (65.75) eggs per egg mass respectively in descending order. The percentage decrease in egg per egg mass was observed maximum (75.51) in Carbofuran treated check followed by 37.24% in Achook, 32.86% in neem cake, 30.63% in neem leaf compost, 23.37% in neem leaf with organic decomposer with the minimum decrease 6.79% in vermi compost treatment in descending order respectively.

Number of Eggs/Plant

The observations presented in table- 2 on egg per plant indicate that all the treatments were significantly different from each other. The maximum number of eggs/plant 18.08 was recorded in inoculated check which was followed by neem leaf with decomposer (13.45), vermi compost (12.52), neem leaf compost (10.56), neem cake @ 5% (9.86), Achook @ 5% (8.48) with minimum in treated check (7.80) eggs per eggs respectively in descending order. The percentage decrease in egg per plant was observed maximum (56.85) in Carbofuran treated check followed by 50.99% in Achook, 28.37% in neem cake, 45.46% in neem leaf compost, 41.59% in neem leaf with organic decomposer with the minimum decrease 25.60% in vermi compost treatment in descending order respectively.

Total Nematode population

The observations presented in table- 2 on total nematode population indicate that all the treatments were significantly different from each other. The maximum total nematode population 3848.75 was recorded in inoculated check which was followed by neem leaf with decomposer (3494.50), vermi compost (3218.50), neem leaf compost (2863.25), neem cake @ 5% (2680.18), Achook @ 5% (2486.48) with minimum in treated check (2178.62) eggs per eggs respectively in descending order. The percentage decrease in egg per plant was observed maximum (43.39) in Carbofuran treated check followed by 35.39% in Achook, 30.31% in neem cake, 25.60% in neem leaf compost, 16.37 in vermi compost and minimum 9.20% in neem leaf with organic decomposer treatment in descending order respectively.

Nematode population Multiplication Factor

The observations presented in table- 2 on nematode multiplication factor indicate that nematode multiplication was recorded in all the treatments. The maximum total nematode multiplication factor 4.50 was recorded in inoculated check which was followed by neem leaf with decomposer (3.38), vermi compost (3.14), neem leaf compost (2.68), neem cake @ 5% (2.50), Achook @ 5% (2.19) with minimum in treated check (1.99) nematode multiplication factor respectively in descending order. The percentage decrease in nematode multiplication factor was observed maximum (55.77) in Carbofuran treated check followed by 51.33% in Achook, 44.44% in neem cake, 40.44% in neem leaf compost, 30.22 in vermi compost and minimum 24.88% in neem leaf with organic decomposer treatment in descending order respectively.

The observations recorded on the plant growth and nematode multiplication showed significant increase in root and shoot weight and reduction in the nematode population multiplication rate under pot condition in tomato crop in treatments where neem leaf, neem leaf compost and other neem products are used may be due to the various phytochemicals present in various neem plant parts like Azadirachtin, Nimbidin, Nimbin, Nimbinin and Vepinin who have shown their nematicidal properties in research carried out by various scientists (Abid et al., 1995; Acharya and Padhi, 1988; Addabbo, 1995; Ahmed *et.al.*,1972; Akhtar, 1998; Akhtar, 1999b; Abbas *et.al*., 2020; Sivakumar *et.al*, 2018; Sidhu *et.al*., 2017; Resha and Rani, 2015) [2, 3, 4, 5, 6, 7, 1, 15, 14, 13]. Similarly reduction in nematode population and improvement in the plant growth in the treatment where vermicompost is used may be attributed to the improvement in the plant tolerance level after good supply of the plant nutrients which is well known fact that vermicompost supply most of the plant nutrients after proper decomposition in the soil and henceforth improve the plant growth and the disease tolerance level of the crop (Abbas *et.al*., 2020) [1].

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