

Evaluation of predation potency of predatory nematodes and the influence of organic amendments on nematode communities and growth of tomato

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ABSTRACT: In the experiment designed to evaluate the predation potency of predatory nematodes, *Iotonchus indicus* and *Mylonchulus minor* under laboratory condition against J₂ of *Meloidogyne incognita* (Kofoid and White) Chitwood as prey, mortality of J₂ was highest when fifteen numbers of predators were used. The mortality of *M. incognita* increased with increase in number of predators. Most effective predator was *M. minor*, when compared to *I. indicus*. Second experiment with soil amendments, showed that neem cake @ 50 g pot⁻¹ was the superior in reducing the final population of *M. incognita* (88.38%) followed by poultry manure @ 50 g pot⁻¹ (85.50%), castor cake @ 50 g pot⁻¹ (81.07%), saw dust @ 50 g pot⁻¹ (73.89%) and *Gliricidia* leaves @ 100 g pot⁻¹ (62.99%) compared to untreated. Similar trend was noticed with other plant parasitic nematodes. Neem cake was the most effective treatment in increasing the final population of *I. indicus* (333.33%), *M. minor* (278.90%) and predatory dorylaimids (125.00%) followed by poultry manure. Neem cake was the superior treatment in reducing the formation of root galls (11.25) and egg masses (7.75) in tomato plant infected with *M. incognita* followed by soil amendment with poultry manure. The shoot length (71.55cm), root length (12.93cm), shoot weight (23.15g) and root weight (6.88g) of tomato were highest when amended with neem cake followed by poultry manure. The increase in the population of predatory nematodes due to the effect of organic amendments might have reduced the population of plant parasitic nematodes and increased plant growth.

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KEY WORDS: *Mylonchulus minor*, *Iotonchus indicus*, *Meloidogyne incognita*, organic amendments, root galls, plant growth

INTRODUCTION

Tomato is an important vegetable crop grown worldwide. In India, it is cultivated in major agro ecological zone under an area of 0.846 million hectares with a production of 0.2 m t and yield of 24.0kg ha⁻¹ (Anonymous, 2023). Among the pests and diseases plant parasitic nematodes (PPN) are

important. Nair (1968) reported the occurrence of *Helicotylenchus* sp., *Hoplolaimus* sp., *Pratylenchus* sp., *Rotylenchulus reniformis*, and *Meloidogyne* sp. from the rhizosphere of tomato. Root knot nematodes (RKN) *Meloidogyne* spp. are highly pathogenic to wide array of crop plants due to their capacity to induce galls on roots. (Mekete *et al.*, 2003; Bouchtaoui *et al.*, 2025;

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Gupta *et al.*, 2025). Jain *et al.* (1994) reported yield loss due to infection of *M. incognita* (Kofoed and White) Chitwood to tomato to a tune of 71.9 per cent, whereas Chandan *et al.* (2022) reported it around 49.62 per cent.

Predatory nematodes are an important entity of the soil food web with biological control potential against plant parasitic nematodes (Bilgrami, 1997). Cobb (1917) reported the efficiency of *Mononchus* spp. as hunters and justified their use in biocontrol of PPN. Over 3126 species of dorylaimids, 432 species of mononchids and 4100 species of tylenchids were reported to occur all throughout the world. More than 200 species of PPN were reported from India. Bilgrami *et al.* (1984) studied the predation behaviour of adults and juveniles of *Mononchus aquaticus*, with *Chiloplacus symmetricus* or *Cephalobus* sp. as prey. Kulshrestha *et al.* (1993) reported that *Mylonchulus minor* feed on PPN by cutting the cuticle and shredding the prey in to pieces and the female nematodes were more vigorous predators compared to all other juvenile stages. The predator preferred to kill maximum number of J₂ of *M. incognita* compared to other nematodes. While PPNs pose considerable challenges for crop production, various nematode groups also play beneficial roles within soil ecosystems (Neher, 2001; Pires *et al.*, 2023; Semprucci *et al.*, 2025). Free-living nematodes, including bacterivores, fungivores, and omnivores contribute to soil nutrient cycling by decomposing organic matter and regulating microbial populations (Li *et al.*, 2024; Martin, 2025). Notably, predatory nematodes, such as *Mononchus* spp., have emerged as potential biological control agents against PPNs, including *Meloidogyne* juveniles (Khan and Kim, 2007; Kim, 2015; Shokoohi, 2024; Martin, 2025).

To enhance soil quality and support sustainable agriculture, soil amendments such as compost and soil organic matter incorporation are essential (Diacono and Montemurro, 2011; Matisic *et al.*, 2024). The addition of organic amendments can significantly increase soil fertility, improve soil structure, and boost microbial activity (Aytenew and Bore, 2020; Zhou *et al.*, 2025). Moreover, such practices promote the proliferation of beneficial

organisms, including predatory nematodes, which can help mitigate the effects of PPNs (Akhtar and Malik, 2000; Oka *et al.*, 2007; Thoden *et al.*, 2011; Malik *et al.*, 2025). Research shows that incorporation of compost can stimulate microbial antagonists that suppress nematode populations (Zhen *et al.*, 2014; Tothnee Bogdaanyi *et al.*, 2021; Karanastasi *et al.*, 2024). The use of nematicides was reported to be toxic to non-target soil organisms like earth worms (Wang *et al.*, 2024). Hence, the present investigation was undertaken to elucidate the predation potency of predatory nematodes distributed in Kerala on PPN and the influence of organic amendments on nematode communities in tomato.

MATERIALS AND METHODS

Potential of predatory nematodes against *M. incognita* under laboratory conditions: Culture of *M. incognita* was maintained on tomato plants in pots in net house conditions. Freshly hatched juveniles were used for the inoculation. The juveniles were counted under a stereo zoom binocular microscope, Zeiss Stemi 508, by dilution method and the required number was inoculated. Predatory nematodes *I. indicus* and *M. minor* were extracted from rhizosphere of brinjal plants (8.431147°N; 76.9906167°E) infected with *M. incognita* grown in the C block of Instructional Farm, College of Agriculture, Vellayani by Cobb's sieving and decanting technique followed Baermann's funnel technique. Sufficient numbers of the predators thus collected were surface sterilized using 0.06 per cent NaOCl. The surface sterilized nematodes were washed in sterile distilled water repeatedly for more than five times to remove the traces of NaOCl and used for further laboratory assay.

A laboratory experiment was conducted in Petri plates containing 2mm thick 1.0 per cent water agar. The predatory nematodes *I. indicus* and *M. minor* were introduced in to the surface of agar plates @ 0 (no predatory nematode - check), 5, 10 and 15. Freshly hatched 25 J₂ of *M. incognita* were introduced to the agar filled Petri plates and incubated at room temperature. Four replications of each treatment were maintained. The

observations on dead prey nematodes were recorded after 24, 48, 72, and 96 hours of exposure to the predators. The experiment was laid out in CRD design. The per cent mortality of J_2 of *M. incognita* was computed and the data was subjected to statistical analysis using ANNOVA by using RAISINS software.

Effect of organic amendments on the population of predatory nematodes and growth of tomato infected with *M. incognita*:

A pot culture experiment was conducted to evaluate the effect of organic amendments on the population of predatory nematodes and growth of tomato infected with *M. incognita* under glass house conditions of Department of Nematology, College of Agriculture, Vellayani. The pots were filled with 1 kg soil collected from nematode sick plots of vegetable ecosystem. Tomato seedlings cv. Anagha (30 days old) was planted in the pots. A total of five treatments and an untreated control (Table 2) was laid out in CRD design and replicated four times. Treatments were applied 15 days prior to planting. Initial population of nematodes including different predatory nematodes, PPN and rhabditids were estimated. Plant growth including shoot length (cm), root length (cm), shoot weight (g) and root weight (g) were recorded 45 days after transplanting. The final population of different nematodes including J_2 of *M. incognita*, predatory and rhabditids were estimated from 200 cm³ soil⁻¹ collected from different treatments and untreated control plants. The nematodes were extracted by Cobb's sieving and decanting technique followed Baermann's funnel technique. Data were subjected to analysis of variance (ANOVA) and the means were compared with critical difference. All calculations were performed with the RAISINS (R and AI Solutions in Inferential Statistics) software available online at the website of www.raisins.live (Hisham *et al.* 2025)

RESULTS AND DISCUSSION

Predation potential of predatory nematodes:

All the treatments with *I. indicus* were effective in increasing the mortality of J_2 of *M. incognita*. After 24 h of exposure @ 15 Petri plate⁻¹ showed

increasing the mortality of *M. incognita* (28.00%) followed by @ 10 Petri plate⁻¹ (14.00%) and @ 5 Petri plate⁻¹ (5.00%), with no mortality in the control. After 48 hours of exposure @ 15 Petri plate⁻¹ recorded highest mortality (76.00%), followed by @10 (31.00%) and 5 (11.00%) numbers of *I. indicus* Petri plate⁻¹. In general, after 72 h all the treatments were significantly effective in increasing the mortality compared to control; @ 15 Petri plate⁻¹ showed maximum mortality (83.00%), while the lowest was in 5 numbers Petri plate⁻¹ (17.00%), when compared to control (0.00 %). After 96 h all the treatments were statistically significant in killing the prey nematodes, @15 Petri plate⁻¹ the mortality was maximum (87.00%), followed by @10 Petri plate⁻¹ (59.00%) and the lowest @ 5 Petri plate⁻¹ (19.00 %) (Table 1).

With *M. minor* as a predator all the treatments were significant in the mortality of *M. incognita*. After 24 h of exposure, @ 15 Petri plate⁻¹ exhibited highest mortality (45.00%) followed by @ 10 Petri plate⁻¹ (16.00 %), with least predation @ 5 Petri plate⁻¹ (5.00 %) and no predation in control (0.00 %). After 48 h 15 Petri plate⁻¹ showed highest mortality (68.00%) followed by @10 (38.00%) numbers Petri plate⁻¹ with no predation in control (0.00 %). After 72 h, all the treatments were significantly effective in increasing the mortality At 15 Petri plate⁻¹ was the superior treatment (81.00%) and the lowest mortality in @5 Petri plate⁻¹ (21.00 %). After 96 hours, all the treatments were statistically significant in killing the prey nematodes. At 15 Petri plate⁻¹ the mortality was maximum (89.00%), and the least in 5 Petri plate⁻¹ (27.00%), with no predation in control (0.00 %). Predation potentiality was more in *M. minor* than *I. indicus* (Table 1).

Similar finding was reported by Phonginsee *et al.* (2025) who found that *Mylonchulus hawaiiensis* was an active predator of J_2 of *M. enterolobii*, with an average daily consumption of 16.1 J_2 s and a cumulative total consumption of 80 J_2 s over five days. Kulshrestha *et al.* (1993) reported that *M. minor* preyed on *M. incognita* by cutting the cuticle and shredding it into pieces. Jairajpuri and Azmi (1978) reported that juveniles of *Meloidogyne* sp.

were preyed up on by *Mylonchulus dentatus*. Cohn and Mordechai (1974) reported the predation of *M. javanica* by *Mylonchulus sigmaturus*. Koohkan and Shokohi (2014) found that *M. javanica* was an excellent source of prey for mass culture of *M. sigmaturus* compared to other prey species. Mohandas and Prabhoo (1980) reported that *I. kherai* and *I. monhystera* preferred *M. incognita* and *R. reniformis*. Azmi (1983) showed that *I. monhystera* was well adapted for predacious mode of feeding of *H. dihystra*. Single *I. monhystera* devoured on an average of 74 to 81 per cent J_2 of *M. javanica* (Azmi, 1992). Wang et al. (2015) studied the predatory behavior of *Mononchus* sp. and *Neoactinolaimus* sp. by employing *M. incognita* and *R. reniformis* as prey. Cabos et al. (2013) found that *Mononchus* sp. and other predatory fauna preyed on *M. incognita*, *R. reniformis* and *Radopholus similis*. A single juvenile of *Iotonchus* sp. from rhizosphere of mango was reported to have *Helicotylenchus digonicus* in its gut (Khan and Jairajpuri, 1981).

Effect of organic amendments on the population of PPN: Neem cake @ 50 g pot⁻¹ recorded 24.25 J_2 200 cm³ soil⁻¹ and was superior in reducing the final population of J_2 of *M. incognita* (88.38%). It was followed by the poultry manure @ 50 g pot⁻¹ (with 30.25 J_2 200 cm³ soil⁻¹ and 85.5% reduction of population). Next best

treatments in the order of effectiveness in the population and in reducing the population were, castor cake @ 50 g pot⁻¹ (39.50 J_2 200 cm³ soil⁻¹; 81.07%), followed by saw dust @ 50 g pot⁻¹ (54.50 J_2 200 cm³ soil⁻¹; 73.89%). *Gliricidia* leaves @ 100 g pot⁻¹ was least effective (77.25 J_2 200 cm³ soil⁻¹; 62.99%) in decreasing the population of *M. incognita* compared to untreated control (208.75 J_2 200 cm³ soil⁻¹) (Table 2).

In general, all the organic amendments treatments were significant in the reduction of *H. dihystra*. Neem cake @ 50 g pot⁻¹ was the most effective in reducing the population of *H. dihystra* to 5.75 nematodes 200 cm³ soil⁻¹ (86.39% reduction), followed by poultry manure @ 50 g pot⁻¹ (7.75 nematodes 200 cm³ soil⁻¹, 81.65% reduction), castor (11.50 nematodes 200 cm³ soil⁻¹, 72.78% reduction, saw dust (14.75 nematodes 200 cm³ soil⁻¹, 65.08% reduction). *Gliricidia* leaves @ 100 g pot⁻¹ was least effective in the reduction of *H. dihystra* (23.00 nematodes 200 cm³ soil⁻¹; 45.56%) compared to untreated control (42.25 nematodes 200 cm³ soil⁻¹) (Table 2).

All the treatments were significant in the reduction in the population of *R. reniformis*. Neem cake @ 50 g pot⁻¹ was the most effective (with only 5.50 nematodes 200 cm³ soil⁻¹) in reducing the population (82.25 % over control), followed by poultry manure

Table 1 Predatory potential of *Iotonchus indicus* and *Mylonchulus minor* on J_2 of *M. incognita*

<i>I. indicus</i> (no.)	Mortality % of <i>M. incognita</i> after - hours of exposure*			
	24	48	72	96
0	0.00 ± 0.00 (0.10) ^d	0.00 ± 0.00 (0.10) ^d	0.00 ± 0.00 (0.10) ^d	0.00 ± 0.00 (0.10) ^d
5	5.00 ± 2.00 (0.25) ^c	11.00 ± 6.00 (0.35) ^c	17.00 ± 3.83 (0.44) ^c	19.00 ± 3.83 (0.46) ^c
10	14.00 ± 4.00 (0.39) ^b	31.00 ± 5.03 (0.60) ^b	45.00 ± 9.45 (0.74) ^b	59.00 ± 6.00 (0.89) ^b
15	28.00 ± 5.66 (0.57) ^a	76.00 ± 0.91 (1.10) ^a	83.00 ± 10.00 (1.17) ^a	87.00 ± 7.57 (1.23) ^a
<i>M. minor</i>				
0	0.00 ± 0.00 (0.10) ^d	0.00 ± 0.00 (0.10) ^d	0.00 ± 0.00 (0.10) ^d	0.00 ± 0.00 (0.10) ^d
5	5.00 ± 2.00 (0.25) ^c	17.00 ± 2.00 (0.44) ^c	21.00 ± 2.00 (0.49) ^c	27.00 ± 3.83 (0.56) ^c
10	16.0 ± 5.66 (0.42) ^b	38.00 ± 7.66 (0.67) ^b	62.00 ± 7.66 (0.92) ^b	77.00 ± 9.45 (1.09) ^b
15	45.00 ± 8.25 (0.74) ^a	68.00 ± 5.66 (0.42) ^a	81.00 ± 3.83 (1.13) ^a	89.00 ± 3.83 (1.25) ^a

Table 2 Effect of organic amendments on the population (200 cm³ soil⁻¹) of PPN on tomato

Treatments @ - g pot ⁻¹	J ₂ of <i>M. incognita</i>		<i>Helicotylenchus dihystra</i>		<i>Rotylenchulus reniformis</i>	
	Initial	Final	Initial	Final	Initial	Final
Neem cake @ 50	226.75±3.50 (15.06)	24.25± 3.30 (4.92) ^a	46.75± 2.22 (6.84)	5.75± 0.96 (2.39) ^a	35.25± 3.30 (5.94)	5.50± 0.58 (2.34) ^a
Castor cake @ 50	228.25±4.92 (15.11)	39.50 ± 3.42 (6.28) ^c	46.50 ± 1.73 (6.82)	11.50± 1.73 (3.38) ^c	35.00 ± 1.41 (5.92)	8.50 ± 1.29 (2.91) ^c
Saw dust @ 50	228.50±6.95 (15.11)	54.50 ± 4.20 (7.38) ^d	45.25 ± 2.22 (6.73)	14.75±1.71 (3.84) ^d	35.50 ± 2.08 (5.96)	12.00±1.41 (3.46) ^d
Poultry manure @50	228.00±3.56 (15.10)	30.25 ± 3.30 (5.49) ^b	46.25 ± 0.50 (6.80)	7.75 ± 0.96 (2.78) ^b	35.75± 1.71 (5.98)	6.50 ± 0.58 (2.55) ^b
<i>Gliricidia</i> leaves @100	227.75±4.79 (15.09)	77.25 ± 4.79 (8.79) ^c	45.75 ± 2.06 (6.76)	23.00± 0.82 (4.80) ^c	34.75± 1.26 (5.89)	16.75±1.50 (4.09) ^c
Untreated	226.75 ± 7.09 (15.06)	208.75 ± 4.86 (14.45) ^f	45.75 ± 1.71 (6.76)	42.25± 1.50 (6.50) ^f	35.25 ± 1.50 (5.94) ^f	31.00±1.63 (5.57) ^f
CD	NS	(0.41)	NS	(0.28)	NS	(0.25)

Figures in the parenthesis are square root transformed values; *Mean ± SD

In a column, mean followed by same letter (s) are not significantly different at (P=0.05) by DMRT

(6.50 nematodes 200 cm³ soil⁻¹, 79.03 % reduction over control). castor treatment recorded only 8.50 nematodes 200 cm³ soil⁻¹, showing 72.58% reduction, while saw dust treatment recorded 12.00 nematodes 200 cm³ soil⁻¹, with 61.29% reduction of population. *Gliricidia* leaves @100 g pot⁻¹ (16.75 nematodes 200 cm³ soil⁻¹) was least effective in the reduction (45.96 % reduction over control). Untreated control recorded 31.00 nematodes 200 cm³ soil⁻¹ (Table 2).

Similarly, Akhtar (1998) reported that treatment involving neem cake was the most effective treatment in reducing the population of *H. dihystra*, *R. reniformis* and *M. incognita* infected chick pea. In contrast, treatment of neem leaf powder in the rhizosphere of chick pea increased the populations of predatory nematode, *Dorylaimus elongatus* and other free-living nematodes. Khan *et al.* (1974) reported that neem cake and castor cake significantly reduced the population of *R. reniformis* in brinjal. Phenolic contents of neem cake and castor cake were toxic to *R. reniformis* (Alam, *et al.* 1981). Water soluble fractions of oil cakes extracted from neem, mahua, groundnut and castor were toxic to nematodes like *Hoplolaimus indicus*, *R. reniformis* and *Tylenchorynchus*

brassicae and *M. incognita* (Khan *et al.* 1974). Aqueous extracts of neem seed and neem cake used as root dip treatments were reported to be superior treatments in the mitigation of *M. incognita* infection in tomato (Vijayalakshmi, 2000).

Effect of organic amendments on the population of predatory nematodes: All the treatments were significant in enhancing the population of *I. indicus*. However, soil treatment with neem cake @ 50 g pot⁻¹ (19.50 nematodes 200 cm³ soil⁻¹) was the most effective in increasing the final population of *I. indicus* (333.33% increase over the untreated control), followed by poultry manure @ 50 g pot⁻¹ (14.00 nematodes 200 cm³ soil⁻¹, 211.10 per cent increase over the untreated control). castor treatment showed 150.00 per cent increase over the untreated control, while saw dust treatment recorded 77.7 per cent increase over the untreated control. Lowest population of *I. indicus* was recorded in *Gliricidia* leaves treatment (6.50 nematodes 200 cm³ soil⁻¹, 44.40% increase over the untreated control).

In the case of *M. minor* (Table 3) also amendment with neem cake @ 50 g pot⁻¹ (18.00 nematodes 200 cm³ soil⁻¹) was the most effective treatment in

Table 3 Effect of organic amendments on the population (200 cm³ soil⁻¹)* of predatory nematodes on tomato

Treatments @ - g pot ⁻¹	<i>Iotonchus indicus</i>		<i>Mylonchulus minor</i>		<i>Dorylaimid</i>		<i>Rhabditids</i>	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Neem cake @50	7.50± 0.58 (2.74)	19.50 ± 0.58 (4.42) ^a	6.75± 0.96 (2.59)	18.00 ± 0.82 (4.24) ^a	11.25 ± 2.63 (3.34)	24.75±0.96 (4.97) ^a	70.75±5.80 (8.67)	95.25±5.05 (9.75) ^b
Castor cake @50	8.00 ± 0.82 (2.83)	11.25 ± 0.96 (3.35) ^c	8.25 ± 1.26 (2.87)	12.25 ± 0.96 (3.50) ^c	11.00 ± 1.83 (3.31)	21.00±1.41 (4.58) ^c	55.00±4.96 (8.40)	96.25±2.63 (9.81) ^b
Saw dust @50	7.50 ± 1.29 (2.73)	8.00 ±0.82 (2.38) ^d	7.00 ± 0.82 (2.64)	7.50 ± 1.29 (2.73) ^d	10.50 ± 1.29 (3.24)	14.25±0.96 (3.77) ^d	60.25±4.78 (8.38)	69.00±3.36 (8.30) ^d
Poultry manure @50	8.00 ± 0.82 (2.83)	14.00± 1.15 (3.74) ^b	7.00 ± 0.82 (2.64)	15.25 ± 0.96 (3.90) ^b	10.75 ± 0.96 (3.28)	22.75±0.96 (4.77) ^b	70.25±4.78 (7.75)	105.25±6.23 (10.25) ^a
<i>Gliricidia</i> leaves @100	6.50 ± 1.00 (2.54)	6.50 ± 0.58 (2.55) ^e	6.50 ± 0.58 (2.55)	7.00 ± 0.82 (2.64) ^d	10.25 ± 0.50 (3.20)	12.25±3.50 (7.05) ^e	75.25±6.07 (7.41)	85.25±5.56 (9.23) ^c
Untreated	7.50 ± 0.58 (2.74)	4.50 ± 0.58 (2.12) ^f	7.75 ± 0.50 (2.78)	4.75 ± 0.50 (2.18) ^e	12.00 ± 2.83 (3.45)	11.00±3.50 (5.94) ^f	23.75±2.63 (4.86)	29.75±4.03 (5.44) ^e
CD	NS	(0.19)	NS	(0.22)	NS	(0.17)	NS	(0.40)

Figures in the parenthesis are square root transformed values; *Mean ± SD of four replications;

In a column, mean followed by same letter (s) are not significantly different at (P=0.05) by DMRT

increasing (278.9%) the population of *M. minor*. It was followed by poultry manure (15.25 nematodes 200 cm³ soil⁻¹, with increase of 221.05%). Castor treatment recorded 157.89 per cent increase over control, while in the case of saw dust it was 57.89 per cent. Lowest population of *M. minor* was recorded in *Gliricidia* treatment (7.00 nematodes 200 cm³ soil⁻¹, with only 47.36% increase). Untreated control recorded only 4.75 nematodes 200 cm³ soil⁻¹. However, the treatments saw dust and *Gliricidia* leaves were on par.

For predatory dorylaimids soil treatment with neem cake (24.75 nematodes 200 cm³ soil⁻¹) was the superior in increasing the population of dorylaimids (125.00% increase over control), followed by poultry manure (22.75 nematodes 200 cm³ soil⁻¹, 106.81% increase over control). Castor cake treatment recorded 90.90 per cent increase of dorylaimids over control, while in the case of saw dust it was only 29.54 per cent. Dorylaimids population was low in *Gliricidia* leaves treatment (12.25 nematodes 200 cm³ soil⁻¹, 11.36% increase over control). Untreated control recorded 11.00 nematodes 200 cm³ soil⁻¹ (Table 3). Application of castor cake and *Gliricidia* leaves supported more

density of *M. minor* (157.89 and 47.36% respectively) than *I. indicus* (150.00 and 44.40% respectively). This is in accordance with Choudhury and Sivakumar (1997) findings that neem cake, castor cake, mahua cake and groundnut cakes @ 5 g pot⁻¹ encouraged the multiplication of *M. minor* and mitigated the density of *H. dihystra* on tomato. Nisha and Nimisha (2017) found that soil incorporation of *G. maculata* @ 5kg pit⁻¹ at planting of banana reduced the population of *M. incognita* and *P. coffeae* and increased the population of predatory nematode, *Eudorylaimus* sp.

Organic amendments have enhanced the population of predatory nematodes (neem cake 207.40%; poultry manure 156.79%; castor cake 119.75%; saw dust 46.91%; *Gliricidia* leaves 27.16%). However, it reduced the population of PPN (neem cake 87.50%; poultry manure 84.21%; castor cake 78.90%; saw dust 71.18%; *Gliricidia* leaves 58.51%) (Fig. 1).

Poultry manure @ 50 g pot⁻¹ was the superior in enhancing the population of rhabditids (105.25 nematodes 200 cm³ soil⁻¹), followed by castor cake

@ 50 g pot⁻¹, neem cake @ 50 g pot⁻¹, *Gliricidia* leaves @ 100 g pot⁻¹ and saw dust @ 50 g pot⁻¹ compared to untreated control. However, the application of castor cake and neem cake were statistically on par. In the case of bacterivorous rhabditids, application of poultry manure @ 50 g pot⁻¹ increased the population to a tune of 253.78 per cent, followed by castor cake (223.52%), neem cake (220.16%), *Gliricidia* leaves (186.55 %) and saw dust (131.93%) compared to control (Table 3). Hunt *et al.* (1973) found that population of cephalobids and rhabditids were highest in the soil receiving 32 t ha⁻¹ of compost in oats and sorghum grown in Florida. Organic amendments not only create better habitats for nematodes and facilitate their movement through soil pore water, but also improve the ability of nematodes to capture abundant food resources (bacteria) due to the increased soil organic matter (Liu *et al.*, 2016; Jiang *et al.*, 2018). The higher values of enrichment index (EI), structure index (SI), and maturity index (MI) indicated a more mature and stable food web structure, while the low value of channel index indicated dominant bacterial decomposition pathways under organic material amendments (Shi *et al.*, 2023).

Effect of organic amendments on number of galls and egg masses: Neem cake @ 50 g pot⁻¹ (11.25) was the superior treatment in reducing the formation of root galls in tomato plant infected with *M. incognita*, followed by soil amendment with poultry manure @ 50 g pot⁻¹ (14.0). Treatment with *Gliricidia* leaves @ 100 g pot⁻¹ (26.50) was least effective, compared to untreated control (58.50). Gall index was low in all treatments (index 2). The gall index was three in untreated control. Neem cake @ 50 g pot⁻¹ was the superior in reducing the egg masses of *M. incognita* (7.75), followed by poultry manure @ 50 g pot⁻¹ (9.25). Lowest reduction was noticed in *Gliricidia* leaves (19.50) when compared to untreated control (40.75) (Table 4). Even though treatment involving mulching of *Gliricidia* leaves @ 100 g pot⁻¹ was the least effective in reducing the population of plant parasitic nematodes and enhancing the population of predatory forms, this treatment was significantly effective compared to untreated control.

Pakeerathan *et al.* (2009) recorded that the number of galls produced by *M. incognita* was lowest (35.87) in *G. maculata* @ 25 t ha⁻¹ treated tomato crop compared to control. Nimisha and Nisha (2019) reported that mulching with green leaves of *G. maculata* @ 5 kg pit⁻¹ was equally effective in reducing the population of plant parasitic nematodes. Incorporation of organic amendments and green leaves in soil resulted in an increase in organic matter, water holding capacity and nutrient status of soil which resulted in increased yield of banana. Nisha and Sheela (2002) reported the anthelmintic property of *G. maculata*.

In the present findings (Fig. 11), all the treatments significantly reduced number of root galls formed and egg masses of *M. incognita*. Neem cake @ 50 g pot⁻¹ was the superior treatment in reducing the formation of root galls (80.76%) followed by soil amendment with poultry manure @ 50 g pot⁻¹ (76.06%), castor cake (70.51%), saw dust (62.82%) and *Gliricidia* leaves (54.70%). Similar trend was noticed with number of egg masses. Neem cake was the best treatment in reducing the number of egg masses of *M. incognita* (80.98%) followed by poultry manure (77.33%), castor cake (69.32%), saw dust (60.12%) and *Gliricidia* leaves (52.14%). Similarly, Sidhu and Kanwar (2020) reported that all the treatments including neem cake, poultry manure and the predatory nematode *Fictor composticola* were significantly effective in reducing the gall formation in roots compared to untreated control. The same work also highlighted that minimum egg masses were recorded in case of treatment with *F. composticola* (400 individuals kg soil⁻¹) + poultry manure 5.0 g pot⁻¹ + neem cake 5.0 g pot⁻¹ + neem leaves 5.0 g pot⁻¹ when added to rhizosphere of cucumber infected with *M. incognita*. It was also reported that chemicals like ammonia (Khan *et al.*, 1974) and fatty acids (Sitaramaiah and Singh, 1978) liberated during the decomposition of neem cake could be one of the factors involved in nematode control. Application of poultry manure @ 4t ha⁻¹ significantly reduced both root galling and final nematode population of root knot nematode and significantly increased yield and growth of carrot (Kankam *et al.*, 2015). Prakash and Singh (2014) reported that minimum

Table 4 Effect of predatory nematodes on number of galls, egg masses in tomato infected with *M. incognita* treated with organic amendments

Treatments@ - g pot ^l	No. of galls(5g plant ⁻¹)*	Gall index	No. of egg masses(5g plant ⁻¹)*
Neem cake @50	11.25 ± 1.50 (3.35) ^a	1.00	7.75 ± 1.26 (2.78) ^a
Castor cake @50	17.25 ± 1.50 (4.15) ^c	1.00	12.50 ± 1.29 (3.53) ^c
Saw dust @50	21.75 ± 1.71 (4.66) ^d	1.00	16.25 ± 0.96 (4.03) ^d
Poultry manure@50	14.00 ± 0.82 (3.74) ^b	1.00	9.25 ± 0.96 (3.04) ^b
<i>Gliricidia</i> leaves@100	26.50 ± 1.29 (5.15) ^e	2.00	19.50 ± 1.29 (4.41) ^e
Untreated	58.50 ± 2.52 (7.65) ^f	3.00	40.75 ± 2.50 (6.38) ^f
CD	(0.25)	-	(0.26)

Figures in parenthesis are square root transformed values; *Mean ± SD of four replications;

In a column, mean followed by same letter (s) are not significantly different at (P=0.05) by DMRT

Table 5 Effect of predatory nematodes on the growth parameters of tomato infected with plant parasitic nematodes treated with organic amendments

Treatments @ - g pot ^l	Shoot length (cm)*	Root length (cm)*	Shoot weight (g)*	Root weight (g)*
Neem cake @50	71.55 ± 4.00 ^a	12.93 ± 0.91 ^a	23.15 ± 1.71 ^a	6.88 ± 0.10 ^a
Castor cake@50	54.38± 3.49 ^c	11.35 ± 0.19 ^{bc}	18.79 ± 0.25 ^{bc}	6.46 ± 0.04 ^b
Saw dust @50	51.67 ± 4.24 ^c	10.80 ± 0.18 ^c	17.36 ± 0.23 ^c	6.17 ± 0.02 ^c
Poultry manure@50	64.38 ± 3.27 ^b	11.88 ± 0.17 ^a	19.63 ± 0.33 ^b	6.50 ± 0.05 ^b
<i>Gliricidia</i> leaves@100	50.27 ± 3.55 ^c	9.60 ± 0.18 ^d	15.61 ± 0.13 ^d	4.61 ± 0.04 ^d
Untreated	42.98 ± 3.62 ^c	6.78 ± 0.42 ^c	11.18 ± 1.72 ^c	2.45 ± 0.33 ^c
CD	(0.35)	(0.37)	(1.14)	(0.21)

Figures in the parenthesis are square root transformed values; *Mean ± SD of four replications;

In a column, mean followed by same letter (s) are not significantly different at (P=0.05) by DMRT

number of galls in tomato infected with *M. javanica*, when saw dust was amended in. Sidhu and Kanwar (2024) found that combined application of castor cake @ 15.0 g kg soil⁻¹ + *F. composticola* (400 individuals kg soil⁻¹) was significantly effective in reducing the number of galls and egg masses of *M. incognita* in cucumber plants. This is in accordance with the present findings where castor cake @ 50 g pot⁻¹ was effective in reducing galls and egg masses on tomato plants infected with *M. incognita*. Castor cake contains a lectin (ricin) which inhibits the mobility of *M. incognita* at relatively high concentrations (Rich *et al.*, 1989).

Effect of organic amendments on the growth of tomato infected with nematodes: There was significant variation among treatments on biometric characters of tomato plants at harvest (Table 5). The shoot length of tomato infected with nematodes, was maximum in neem cake treatment (71.55cm) and was statistically superior to other treatments. Poultry manure (64.38cm) was the next best treatment. Treatment with *Gliricidia* leaves (50.27cm) was the least effective compared to untreated control (42.98cm). However, the treatments like castor cake, sawdust and *Gliricidia* leaves treatments were on par in their effect.

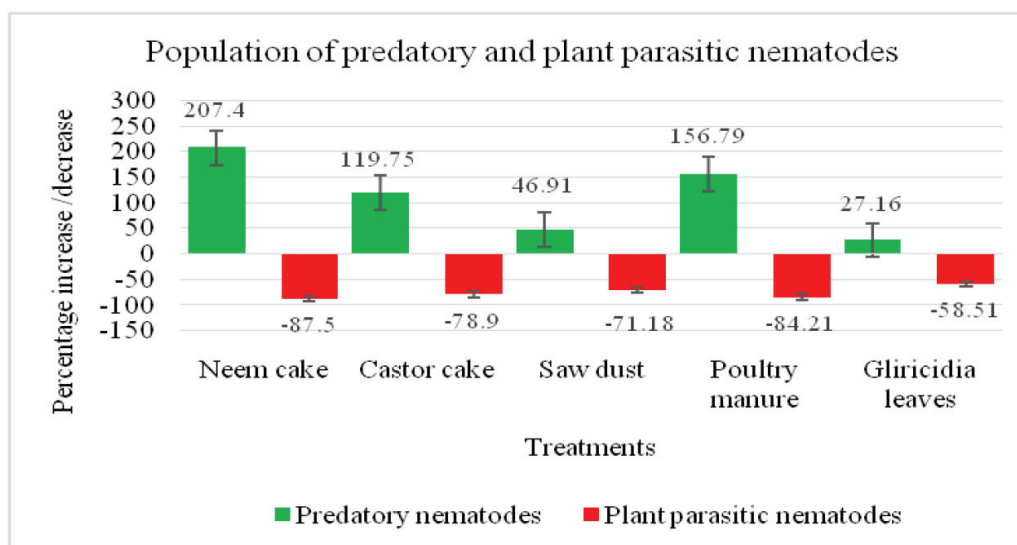


Fig. 1 Influence of organic amendments on nematode communities

The root length of tomato in neem cake treatment was maximum (12.93cm), followed by the poultry manure (11.88cm). Both the treatments were statistically on par. Soil amended with *Gliricidia* leaves (9.60cm) exhibited the lowest root length compared to the untreated control (6.78cm). Perusal of the data on the shoot weight of tomato plants revealed that neem cake (23.15g) was the most effective, followed by the poultry manure (19.63 g). However, application of poultry manure and castor cake was on par. *Gliricidia* leaves showed the lowest shoot weight (15.61g) compared to the untreated control (11.18 g). Neem cake @ 50 g pot⁻¹ (6.88g) was the best treatment in increasing the shoot weight of tomato plants infected with nematodes followed by the treatment with poultry manure @ 50 g pot⁻¹ (6.50 g). The treatments, poultry manure @ 50 g pot⁻¹ and castor cake @ 50 g pot⁻¹ were on par. Soil amended with *Gliricidia* leaves @ 100 g pot⁻¹ (4.61g) showed the lowest root weight compared to the untreated control (2.45g).

Among the treatments, neem cake was the most effective, resulting in an increase in shoot length (66.47%), in root length (90.70%), in shoot weight (107.06%), and in root weight (180.80%), followed by poultry manure (shoot length 49.79%, root length 59.29%, shoot weight 55.27%, root weight 165.30%), castor cake (shoot length 26.52%, root

length 40.26%, shoot weight 112.24%, root weight 163.60%), sawdust (shoot length 20.21%, root length 67.40%, shoot weight 68.06%, root weight 151.00%). *Gliricidia* leaves recorded relatively lower increase (shoot length 16.96%, root length 41.59%, shoot weight 39.62%, root weight 88.16%). These findings are in agreement with the observation of Sidhu and Kanwar (2024) who reported that combined application of *F. composticola* @ 400 individual kg soil⁻¹+ neem cake @ 15g kg soil⁻¹ enhanced plant height (21.63cm), shoot weight (14.91g) and root weight (3.79g) of cucumber infected with *M. incognita* compared to untreated (8.07cm) followed by the treatment with chicken manure @ 15g kg soil⁻¹. Similarly, Akhtar (1998) reported that treatment with neem oil cake significantly improved the dry weight, plant height and number of pods on chickpea plants infected with nematodes.

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