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Management of root knot nematode, *Meloidogyne incognita* in Indian spinach, (*Basella alba* L.) through organic amendments

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Abstract
A replicated pot culture experiment was carried out in the net house condition during *Rabi*, 2017-18 to evaluate the efficacy of oilcakes (Karanja and Mustard oil cakes) as organic amendment at different doses for management of root knot nematode (*Meloidogyne incognita*) in Indian spinach. Karanja cake (*Pongamia pinnata*), mustard cake (*Brassica rapa*) each at three doses @ 0.5, 1.0 and 1.5 t/ha along with neem oilcake @1.0 t/ha as standard check and a untreated inoculated check were taken for the present study. The experiment was laid laid out in Completely Randomized Design with three replications. The result of the present investigation indicated a significant increase in plant growth parameters and decrease in nematode infectivity in all the treatments over untreated check. Among various treatments, Mustard oilcake @ 1.5 t/ha resulted highest increase of plant height (83.2%), root length (85.9%), fresh shoot weight (54.0%), fresh root weight (82.6%), dry shoot weight (90.6%), dry root weight (84.1%) with corresponding decrease in number of root galls (73.2%), number of egg masses (79.1%) and root knot nematode population (75.1%) over untreated check followed by neem oilcake @ 1.0 t/ha. Therefore, application of mustard oilcake @ 1.5 t/ha was considered the most promising management option against root knot nematode (*M. incognita*) affecting Indian spinach.

Keywords: *Meloidogyne incognita*, Indian spinach, organic amendments

1. Introduction
Indian spinach *(Basella alba* L.) is an edible perennial vine in the family Basellaceaeis one of the most popular and nutritive leafy vegetable crop grown all over the world. This leafy vegetable are widely cultivated in Orissa and other states of India. The leaves can be eaten raw or cooked. Indian spinach is not only rich source of vitamin A and C but also contains minerals like Fe, Ca. Various parts of the plant are used for treatment of the diseases as well as for different healing activities of human and animals around the world especially in India and China[1]. However, the yield of the leafy vegetable is not satisfactory because of many constraints. The crop is mostly susceptible to a number of viral, bacterial, fungal and nematode pathogens attack. Among all the leafy vegetable crops, Indian spinach is regarded as the most favorable host for root knot nematode[2]. Root knot nematode, *Meloidogyne spp.* in general and *Meloidogyne incognita* in particular remains to be the most important constraints in agriculture production world-wide [3-4]. Organic amendment is a potential alternative to the harmful chemical against plant parasitic nematodes. The use of different oil cakes as organic amendments may suppress nematodes population in important crops[5-6] including Indian spinach [7]. Amendment of soil with decomposable oil cake is known to alter the soil and root rhizospheric environment by releasing nutrients which leads to enhance the tolerance of plant towards nematode attack. So the present pot culture experiment was undertaken to evaluate the efficacy of oilcakes (Karanja and Mustard oil cakes) as organic amendment at different doses for management of root knot nematode (*Meloidogyne incognita*) in Indian spinach.

2. Materials and methods
The experiment was carried out in the net house, Department of Nematology, College of Agriculture, OUAT, Bhubaneswar during *Rabi*, 2017-18 with the objective to evaluate the efficacy of oilcakes (Karanja and Mustard oil cakes) as organic amendment at different doses for management of root knot nematode (*Meloidogyne incognita*) in Indian Spinach. The experiment comprising of 8 treatments, each replicated thrice following Complete Randomised Design (CRD) were: T_1- Soil application of Karanj oilcake @ 0.5 t /ha, T_2-Soil application of

Karanj oilcake @ 1.0 t /ha, T_3 - Soil application of Karanj oilcake @ 1.5 t /ha, T_4 - Soil application of Mustard oilcake @ 0.5 t/ha, T_5 - Soil application of Mustard oilcake @1.0 t /ha, T_6 - Soil application of Mustard oilcake @1.5 t /ha, T_7 - Soil application of Neem oilcake @1.0 t/ha as standard check, T_8 - Untreated inoculated check. Pots each of 15 cm diameter were surface sterilised in 1% formalin solution, dried under sun and filled with 1 kg autoclaved sterilised soil + sand + FYM mixture in 2:1:1 ratio. Then the pot soil was treated with oilcakes (Karanja and Mustard oil cakes) in appropriate dosage as per the treatments designed 15 days before sowing of seeds. Three to four Indian spinach (var. Moti laadan) seeds susceptible to root knot nematode, surface sterilized in 2.5% Sodium hypochlorite solution were sown in each pot. Fifteen days old plant in each replicated pot was inoculated with 1000 J_2 of *M. incognita.* Intercultural operation and watering were attended in time. The experiment was terminated 45 days after inoculation of nematodes.

2.1 Observations
The observations on growth parameters of spinach plant (Plant height, root length, fresh and dry weight of shoot & root) were taken. The number of galls and egg masses in each plant was counted. Screened the composite soil samples (200 cc) from each the treatment by cobb's sieving technique[8] followed by modified Baermann funnel technique [9] to estimated the *M. incognita* population. The population of *M. incognita* in root was estimated by Byrd method[10]. Reproductive factor (Rf = Final / Initial population of Root knot nematode) was calculated.

2.2 Data Analysis
The recorded data of plant and nematode growth parameters were analized following Fisher's (1970) 'F' test at 5% level in a complete randomized design.

3. Results
The efficacy of organic amendments on management of root knot nematode, *M. incognita* infecting Indian spinach was estimated on the basis of the differential changes in plant and nematode growth parameters. Observed data have been compiled in a tabular form and were subjected to statistical analysis in order to test the significance of various treatments on plant growth and the nematode population.

3.1. Effect of oil cakes on Plant growth
It was evident from the tabulated data in Table-1 that, the treatment T_6 (soil application of mustard oil cake @ 1.5 t/ha) recorded the highest plant height (84.4cm) with 83.2% increase over untreated check, which was statistically differ from other treatments except the standard check (81.1 cm) followed by T_5 (76.4 cm), T_3 (74.8 cm), T4 (68.9 cm), T_2 (66.3 cm), T_1 (57.3 cm). The treatment T_6 registered highest root length (36.13 cm), which was statistically at par with the T_7 (34.0 cm) and differ from other oil cake treatments. The highest fresh shoot weight (168.5g) was recorded in the treatment having mustard oil cake @ 1.5 t/ha with 54.0% increase over check which was closely followed by T_7 (162.3 g). Observation on fresh root weight, it was noticed that T_6 recorded the highest fresh root weight (39.0 g) followed by T_7 (36.8 g), T_5 (33.7 g), T_3 (32.2 g), T_4 (30.2 g), T_2 (27.8 g) and T_1(25.5 g) in descending order. The percentage of increase in dry shoot weight over check ranged from 20.4% (T_1) to 90.6% in T_6. Highest dry shoot weight in T_6 (17.0g) was statistically at par with the neem oil cake treatment (16.4 g) and differ from othe treatments. T_6 registered highest dry root weight (6.5 g) and found statistically diferent from the rest of the treatments. The increase over untreated check was maximum in the treatment T_6 (84.1%) and minimum in T_1 (13.7%).

3.2. Effect of oil cakes on nematode growth
Host infection, in terms of number of galls and egg masses as well as final nematode population in soil and roots were modified by the introduction of different oil cakes. There was significant reduction in number of galls in different treatments over check (Table 2).The treatment T_6 (soil application of mustard oilcake @ 1.5g/kg) recorded the lowest number of galls per plant (43.0) with the highest reduction (73.24%) over untreated check and significantly different from rest of the treatments except standard check (T_7). Eggmass produced per plant reduced with the increase in dose of oil cakes in treated plants. The reduction over untreated check was highest (79.1%) in higher dose of mustard oilcake and the lowest (26.7%) in lower dose of karanja oilcake. The tabulated data showed the effect of the oilcakes towards reduction of final root knot nematode population in soil and root. Among all the treatments, the highest reduction of *M. incognita* population (75.1%) over untreated check with lowest reproductive factor of 0.4 was recorded in soil application of mustard oilcake @ 1.5 t/ ha. The lowest root knot nematode population (486.3) was observed in the treatmet T_6 followed by T_7 (678.3), T_5 (731.6), T_3 (844.6), T_4 (909.6), T_2 (1015.3) and T_1 (1108.0) in increasing order.

4. Discussion
From the results it was evident that amendment of pot soil with oilcakes such as mustard and karanja oil cakes each separately, resulted significant rise in plant growth characteristics in *Basella alba* along with reduction in root knot nematode growth in each treatment over untreated check. Increase in plant growth and decrease in nematode growth was observed in different treatment with the corresponding increase in dose of all oil cakes and these were significant at all doses as compared to untreated check. Such significant increase in plant growth along with reduction in root knot nematode population due to incorporation of different oilcakes which stimulate the microbial activity in the rhizosphere during decomposition. Amendment of soil with decomposable oil cake increase the conversion of nitrogen to nitrate [11] and available phosphorus in soil which jointly provide nutrition to poi plants promoting better growth of plant. Moreover, during decomposition process of oilcakes, toxic compound released in soil might be nematostatic/ nematicidal to root knot nematode suppressing the nematode population and other infection parameters. As a result of application of oil cakes, plant nutrients are released which accelerates root development and overall plant growth. This is in agreement with earlier reports of Sahoo and Das [7] that proved the effectiveness of oilcakes improving plant growth and reducing nematode population in *Basella alba*. This finding is corroborate with the findings of Mahalik *et. al* [12] who applied neem, mustard and karanja oil cake in okra and found significant increase in plant growth with decrease in root knot nematode population. Similar observations also recorded by Goswami and Meshram[13] in tamato by application of mustard oilcake. The population of plant parasitic nematodes including root-knot nematodes was

reduced by the release of chemical substances i.e. phenolics, ammonia, fatty acids and hydrogen sulphide, due to decomposition of oil cakes which are directly toxic to the root-knot nematode [14-16]. The host resistance against *M. incognita* also increased due to increase of phenolic compounds in host roots by absorption of water soluble fractions of the decomposed oilcakes present in the soil, [17-18]. Among different treatments, soil application of mustard oilcake @ 1.5t/ha resulted maximum increase in shoot & root length, fresh shoot & root weight, dry shoot & root weight over untreated check with least nematode nematode infection parameter.

Table 1: Effect of oil cakes on growth of *Basella alba* L. infected by Root knot nematode (*M. incognita*)

Treatments	Plant height (cm)	Increase over check (%)	Root length (cm)	Increase over check (%)	Fresh shoot weight (g)	Increase over check (%)	Fresh root weight (g)	Increase over check (%)	Dry shoot weight (g)	Increase over check (%)	Dry root weight (g)	Increase over check (%)
T_1	57.3	24.4	23.5	21.2	135.5	23.8	25.5	19.5	10.7	20.4	4.0	13.7
T_2	66.3	43.9	24.0	23.8	138.8	26.8	27.8	30.0	11.4	27.7	4.4	24.3
T_3	74.8	62.4	29.4	51.4	151.3	38.2	32.2	50.7	13.6	52.5	4.9	38.2
T_4	68.9	49.6	27.1	39.8	143.4	31.0	30.2	41.4	12.6	41.4	4.6	30.6
T_5	76.4	65.8	31.8	63.6	155.8	42.3	33.7	57.9	14.7	64.9	5.5	53.8
T_6	84.4	83.2	36.1	85.9	168.5	54.0	39.0	82.6	17.0	90.6	6.5	84.1
T_7	81.1	76.1	34.0	74.9	162.3	48.2	36.8	72.1	16.4	84.3	6.0	67.8
T_8	46.0		19.4		109.4		21.3		8.9		3.5	
SE(m) ±	2.6		0.7		2.7		0.9		0.6		0.15	
CD(0.05)	7.9		2.3		8.3		2.8		1.7		0.4	

T_1- Soil application of Karanj oilcake @ 0.5 t /ha, T_2-Soil application of Karanj oilcake @ 1.0 t /ha, T_3 - Soil application of Karanj oilcake @ 1.5 t /ha, T_4 - Soil application of Mustard oilcake @ 0.5 t/ha, T_5 - Soil application of Mustard oilcake @1.0 t /ha, T_6 - Soil application of Mustard oilcake @1.5 t /ha, T_7 - Soil application of Neem oilcake @1.0 t/ha as standard check, T_8 - Untreated inoculated check.

Table 2: Effect of oil cakes on Root knot nematode (*M. incognita*) growth in *Basella alba*

Treatments	Galls / plant (number)	Decrease over check (%)	Egg masses /plant (number)	Decrease over check (%)	Nematode population / kg soil (number)	Decrease over check (%)	Reproductive factor
T_1	117.6 (10.8)*	26.7	108.6 (10.4)*	26.7	1108.0 (3.0)**	43.2	1.1
T_2	96.0 (9.7)	40.2	85.3 (9.2)	42.4	1015.3 (3.0)	48.0	1.0
T_3	73.0 (8.5)	54.5	62.0 (7.8)	58.2	844.6 (2.9)	56.7	0.8
T_4	82.0 (9.0)	48.9	70.3 (8.3)	52.5	909.6 (2.9)	53.4	0.9
T_5	65.3 (8.0)	59.3	52.0 (7.1)	64.9	731.6 (2.8)	62.5	0.7
T_6	43.0 (6.5)	73.2	31.0 (5.5)	79.1	486.3 (2.6)	75.1	0.4
T_7	56.0 (7.4)	65.1	42.6 (6.5)	71.2	678.3 (2.8)	65.2	0.6
T_8	160.6 (12.6)		148.3 (12.1)		1953.3 (3.2)		1.9
SE(m) ±	(0.4)		(0.4)		(0.02)		
CD(0.05)	(1.2)		(1.3)		(0.05)		

* Parenthesis are square root transformed value

** Parenthesis are log transformed value

(T_1- Soil application of Karanj oilcake @ 0.5 t /ha, T_2-Soil application of Karanj oilcake @ 1.0 t /ha, T_3 - Soil application of Karanj oilcake @ 1.5 t /ha, T_4 - Soil application of Mustard oilcake @ 0.5 t/ha, T_5 - Soil application of Mustard oilcake @1.0 t /ha, T_6 - Soil application of Mustard oilcake @1.5 t /ha, T_7 - Soil application of Neem oilcake @1.0 t/ha as standard check, T_8 - Untreated inoculated check.)

5. Conclusions

From the experimental findings it was evident that barring the untreated check, all other seven treatments significantly increased the plant growth parameters and reduced the root knot nematode infection parameters and its population. However, among various treatments, the soil application of mustard oilcake @ 1.5 t/ha performing better than others in respect of increasing the plant growth and reducing the nematode growth and was at par with the standard check. Therefore, the application of mustard oilcake @1.5t/ha may be recommended for ecofriendly management of root knot nematode (*M. incognita*) in Indian spinach.

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