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Management of root knot nematode, *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949 on Bawchi, *Psoralea corylifolia* L.

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Abstract
An experiment entitled "Management of Root knot nematode *Meloidogyne incognita* (Kofoid and White, 1919) Chitwood, 1949 on Bawchi, *Psoralea corylifolia* L." was conducted at the All India Co-ordinated Research Project on Medicinal and Aromatic plant & Betelvine project, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist: Ahmednagar (Maharashtra) during *Kharif* 2021. During the course of study, the efficacy of different treatments for control of *M. incognita* in *Psoralea corylifolia* was studied in Randomized block design with three replications and nine treatments. Impact of different strategies on management of Root knot nematode showed that the treatment with Neem cake @ 2 Ton / ha was superior of all other treatment which is at par with *Trichoderm*a plus @ 20 kg per ha. The next promising treatment was of *Trichoderma viride* (2×10^6 cfu/g) @ 20 Kg/ha, *Paecilomyces lilacinus* ((2×10^8 cfu/g) @ 20 kg/ha and *Pseudomonas fluorescens* (1 x 10^9 cfu / ml) @ 20 kg/ha in reducing root-knot nematode population at intermediate stage. However, the next promising treatment was Karanj cake application @ 2 ton/ha followed by Intercropping of *Tagetes* spp. @ 3:1 proportion which found equally effective and at par with groundnut cake application @ 2 ton/ha.

Keywords: Bawachi, root-kont nematode, *Meloidogyne*, biopesticides, management

Introduction
Psoralea corylifolia L. (Family - Leguminosae) is a well-known traditional medicinal anuual herb plant used from ancient times for treatment of various ailments. It is widely distributed and an important part of therapeutics in Ayurveda. Interestingly, its medicinal usage is reported in Indian pharmaceutical codex, Chinese, British and the American pharmacopoeias and in different traditional system of medicines such as Ayurveda, Unani and Siddha. (Khan *et al.*, 2015) [3].

Nematodes are establishing limitation in the cultivation of many medicinal, aromatic, and spice plant. However, there is very finite information available regarding the nature and extent of nematode disease problems in Bawchi. The host range of root-knot nematodes is large and more than two thousand plant species have been reported as hosts for this nematode (Sasser, 1980) [5]. *Meloidogyne* spp. is sedentary endoparasites of roots, feeding and developing within galls. Infection can also make plants more susceptible to soil-borne, root-infecting diseases. Disease resistance can also be broken by nematodes. Chemical control approaches are now used to control plant parasitic nematodes. In the face of the dangers posed by chemical control approaches, resistant cultivars and biopesticides can be crucial components of integrated nematode management. Bio insecticides are becoming more popular because they are environmentally benign and cost effective, and they prevent nematodes from evolving into new races or biotypes.

Consequently, it has become increasingly vital to hunt for new environment friendly solutions for the management of phytonematodes. The utilization of resistant cultivars and biocontrol agents may become essential components of integrated nematode management in the face of hazards posed by chemical control methods. Biocontrol of Phytonematodes with microbial substances is becoming increasingly popular because of its environmentally favourable and economically viable approach that does not allow nematodes to evolve into new races.

Materials and Methods
The pure culture of root-knot nematode was maintained in earthen pots in glasshouse as well

as in the field of AICRP on Nematodes, Department of Agril. Entomology, M.P.K.V., Rahuri.

The Bawchi Plant was grown in such earthen pots and field to maintain and multiply the nematodes. This maintained culture was used for comparing the field populations of root- knot nematodes. The experiment on management of root-knot nematode was conducted in field during *Kharif* 2021, at research plot of AICRP on MAP & Betel vine MPKV, Rahuri. The Bawchi Plant in the field was treated with nine treatments *viz.*, T1- Neem cake @ 2 Ton / ha, T2- Ground nut cake @ 2 Ton / ha, T3- Karanj cake @ 2 Ton / ha, T4-*Trichoderma* plus @ 20 kg/ha, T5-*Pacilomysis liliacinus* @ 20 kg/ha, T6-*Trichoderma viride* @ 20 kg/ha, T7-*Pseudomonas fluorescens* @ 20 kg/ha, T8-Intercropping of *Tagetes* spp. @ 3:1 proportion, T9 -Untreated control with three replications.

The initial, intermediate and termination observations on population of *M. incognita* per 200 cm3 soil, root galls and egg masses/5 g roots were obtained prior to starting of an experiment. 200 g of soil and root composite samples were taken from every treatment while recording observation. Cobb's sieving and decanting method was used to process sampled soil in the laboratory, followed by a modified Baermann's funnel method. In a plastic beaker, the residues from the 200 mesh and 350 mesh sieves were obtained and by adding tap water, the volume of the plastic beaker was increased to 200 ml. For the nematode count, 10 counts of 1 ml solution were recorded which was multiplied by 200 ml of solution. A per cent decrease in nematode population was calculated based on this observation. After observing infestation by root knot nematode, out of six plants in each field plot, five plants will be selected and uprooted at the time of termination of the experiment and washed under clean tap water to remove the adhering soil particles to the roots. It will be washed properly under clean tap water. The plants then cut at the base and observations like number of root galls and egg masses on roots will be counted. The number of egg masses recorded by observing each plant and counted visually for the numbers of galls. To remove soil particles that had attached to the roots, the 5 g roots obtained at each observation was rinsed under clean tap water. The root knots and egg mass on the roots was counted. Based on these observations, the per cent decrease in root knots and egg mass compared to control was computed. Galled roots were dyed for simple counting of egg mass by immersing them for 5 minutes in a 1.0% solution of trypan blue solution. The roots were thoroughly cleansed with water after dipping to remove any excess stain. The bawchi seed yield obtained from each treatment's individual plant from field at each picking from start to finish, expressed in quintals per hectare. The yield increase over an untreated control was calculated based on these observations. Number of root galls and egg masses on roots per plant was recorded with gall indices 1 to 5 scale by considering the number of root galls and egg masses per plant. On the basis of gall index infestation categorized in different reaction.

Results and Discussion

It is revealed from the pooled data (Table -1-4), that all the treatments were found significantly superior over untreated control for control of root knot nematode on bawchi.

1. Effect of Various Treatments on Population of *M. incognita* Infesting Bawchi

The results from the Table 1 revealed that all treatments were comparatively superior over control in reducing *M. incognita* population at intermediate and termination stage. The treatment of Neem cake application (standard check) was observed most effective treatment in reducing *M. incognita* population (57.14%) and found equally effective and at par with *Trichoderma* plus (2×10^6 cfu/g) @ 20 Kg/ ha in reducing the *M. incognita* population (54.55%) at intermediate stage. The next promising treatment was of *Trichoderma viride* (2×10^6 cfu/g) @ 20 Kg/ha, *Paecilomyces lilacinus* ((2×10^8 cfu/g) @ 20 kg/ha and *Pseudomonas fluorescens* (1 x 10^9 cfu/ml) @ 20 kg/ha in reducing 47.00, 31.57 and 43.42% root-knot nematode population at intermediate stage, respectively. At termination stage, treatment of Neem cake @ 2 Ton/ha was most effective which were found at par with *Trichoderma* plus (2×106 cfu/g) @ 20 Kg/ha which reducing *M. incognita* population 55.36 and 49.76%, respectively

The present experiment results are in agreement with Kerakalamatti *et al*. (2020) [2] research findings. Among the oil cakes, neem cake was found significantly superior over all other nematicides as it recorded least number of juveniles emerged in fields of pomegranate were infested by root knot nematode caused by *Meloidogyne incognita*.

2. Effect of Various Treatments on Root Galls of *M. incognita* Infesting Bawchi

In Table 2 we can see that, at intermediate stage, the treatment of Neem cake @ 2 Ton/ha and *Trichoderma* plus (2×10^6 cfu/g) @ 20 Kg/ ha were found to be most significant and at par with each other in reducing the root-galls/5 g of roots by 39.01 and 35.12%, respectively. The next superior treatments was *Trichoderma viride* (2×10^6 cfu/g) @ 20 Kg/ha which is at par with *Paecilomyces lilacinus* (2×10^8 cfu /g) @ 20 kg/ha and *Pseudomonas fluorescens* (1 x 10^9 cfu/ml) @ 20 kg/ha in reducing root galls 31.57, 28.41, 23.97%, respectively. At termination stage, treatment of Neem cake @ 2 Ton/ha also found superior of all treatment which observed at par with *Trichoderma* plus (2×10^6 cfu/g) @ 20 Kg/ha by reducing the root knots/5 g roots from 30.00 and 22.34%, respectively. However, treatment with Groundnut cake @ 2 Ton/ ha was observed to be the least effective in reducing root galls (5.05%).

3. Effect of Various Treatments on Gall Index of *M. incognita* Infesting Bawchi

It could be observed from the data form Table 3 that Neem cake application @ 2 Ton /ha was found to be most effective in reducing in gall index per plant to 20.00% which was equally effective with *Trichoderma* plus (2×10^6 cfu/g) @ 20 Kg/ha. The next effective treatment *Pseudmonas fluorescens* (1 x 10^9 cfu/ml) @ 20 kg/ha was equally effective with *Trichoderma viride* (2×10^6 cfu/g) @ 20 Kg/ha and *Paecilomyces lilacinus* (2×10^8 cfu/g) @ 20 kg/ha recording 13.33% reduction in gall index per plant.

Rehman *et al.* (2014) findings are in consonance with present findings. Among various treatments the Neem cake @ 100g/pot was found most effective in limiting root gall index and enhancing plant growth parameters in blackgram. Root knot nematode, *Meloidogyne incognita* reduces all plant growth characters of untreated inoculated control plants as compared to all other treated or uninoculated control plants.

4. Effect of Various Treatments on Yield of Bawchi seeds

It is revealed from data shown in Table 4 and Fig. 4.3 that all

the treatments added significant effect on increase in yield of Bawchi plant. Among all treatments, Neem cake application @ 2 Ton/ha was found to be significantly superior in recording highest yield of 18.19 q/ha with 61.41% yield over untreated control which was at par with treatment of *Trichoderma* plus @ 20 Kg/ha recorded 13.83 q/ha with 49.24% increase in yield over untreated control. Rao *et al*. (2008) [6] are in present experiment on effectiveness of neem cake treatment was at par with the bio-agents in decreasing the root and soil population densities of the nematode until 6 months after the third application, but it did not decrease significantly the nematode populations thereafter when compared with the bio-agents for the management of the root-knot nematode *Meloidogyne* spp. on acid lime are in agreement with present findings. However, Next superior treatment were *Trichoderma viride* (2×106 cfu/g) @ 20 Kg/ha followed by *Paecilomyces lilacinus* @ 20 kg/ha and *Pseudomonas fluorescens* @ 20 kg/ha which recorded 11.95, 11.60, 11.53 q/ha yield, respectively with 41.26, 39.48, 39.12 percent yield over untreated control. However, the lowest yield obtained from intercropping with *Tagetes* spp. which was 7.53 q/ha over untreated plot which recorded 7.02 q/ha. Table 4.10 shows the increased yield above the untreated control as well as the net profits (Rs./ha) of the various treatments. Table 4.10 states that the treatment of Neem cake @ 2 Ton/ha recorded highest additional returns of Rs.1, 11,700 per hectare with an ICBR of 1:4.20. The next treatment from which economical returns were obtained are of Trichoderma plus @ 20 Kg/ha which gave net profit of Rs.62, 150 with an ICBR of 1:10.44.

These results are in consonance with Jagdev and Mhase (2020) [1] who reported that at termination stage, the treatment of Phule Trichoderma plus at 20 kg/ha was found to be effective in reducing the root-knot nematode population (40.36%), number of root galls (37.08%) and egg masses (41.02%) and increasing the fruit yield of fig (13.54%) with 1:11.20 ICBR. This was followed by the treatments with rest of the bioagents. The reduction in root-knot nematode population, number of root galls and egg masses and increase in fruit yield at termination recorded in *Trichoderma viride* treatments ranged from 32.03, 29.71, 32.26% and 10.05 q/ha respectively with 1:7.66 ICBR.

Table 1: Effect of various treatment on population of *M. incognita* infesting *Psoralea corylifolia*

Sr. No.	Treatments	Root-knot nematode population/200 cm3 of soil			Decline in nematode population at termination (%) *	
		Initial	Intermediate	Initial	Intermediate	Initial
1	Neem cake @ 2 Ton / ha.	560.00	240.00	560.00	57.14 (49.11)	55.36 (48.08)
2	Groundnut cake @ 2 Ton/ ha	543.33	430.00	543.33	20.86 (27.18)	16.20 (23.73)
3	Karanj cake @ 2 Ton / ha.	570.00	350.00	570.00	38.60 (38.41)	34.15 (35.76)
4	*Trichoderma* plus @ 20 kg/ha.	550.00	250.00	550.00	54.55 (47.61)	49.76 (44.86)
5	*Paecilomyces lilacinus* @ 20 kg/ha.	553.67	323.33	553.67	41.60 (40.17)	38.59 (38.41)
6	*Trichoderma viride* @ 20 kg/ha.	566.67	300.33	566.67	47.00 (43.28)	41.18 (39.92)
7	*Pseudomonas fluorescens* @ 20 kg/ha.	540.67	330.33	540.67	38.90 (38.59)	35.88 (36.80)
8	Intercropping of *Tagetes* spp.@ 3:1 proportion	562.67	400.00	562.67	28.91 (32.53)	24.17 (29.45)
9	Untreated control	601.33	610.00	601.33	0.00 (0.00)	0.00 (0.00)
	SE	13.56	12.50	11.74	1.33	1.93
	C. D. at 5%	NS	37.47	35.18	3.98	5.80

*Figures presented in parentheses are arc sin transformed values

Table 2: Effect of various treatment on root galls of *M. incognita* infesting *Psoralea corylifolia*

Sr. No.	Treatments	Root galls/ 5 g of roots			Per cent decline in root galls (%) *	
		Initial	Intermediate	Termination	Intermediate	Termination
1	Neem cake @ 2 Ton / ha.	33.33	20.33	23.33	39.01 (38.65)	30.00 (33.21)
2	Groundnut cake @ 2 Ton/ ha	33.00	28.00	31.33	15.15 (22.91)	5.05 (12.99)
3	Karanj cake @ 2 Ton / ha.	31.67	24.67	29.33	22.09 (28.04)	7.37 (15.75)
4	*Trichoderma* plus @ 20 kg/ha.	31.33	20.33	24.33	35.12 (36.34)	22.34 (28.21)
5	*Paecilomyces lilacinus* @ 20 kg/ha	31.67	22.67	26.67	28.41 (32.21)	15.79 (23.41)
6	*Trichoderma viride* @ 20 kg/ha.	31.67	21.67	26.33	31.57 (34.18)	16.84 (24.23)
7	*Pseudomonas fluorescens* @ 20 kg/ha.	32.00	24.33	27.00	23.97 (29.31)	15.63 (23.28)
8	Intercropping of *Tagetes* spp. @ 3:1 proportion	32.67	26.67	31.00	18.36 (25.37)	5.10 (13.05)
9	Untreated control	34.00	35.00	36.00	0.00 (0.00)	0.00 (0.00)
	S. E. (±)	0.84	0.37	0.43	1.48	2.43
	C. D. at 5%	NS	1.10	1.28	4.44	7.29

*Figures presented in parentheses are arc sin transformed values

Table 3: Effect of different treatments on gall index of root-knot nematode infesting *Psoralea corylifolia*

Sr. No.	Treatment	Average gallindex/plant	Decline in gall index at Termination (%) *
1.	Neem cake @ 2 Ton / ha.	4.00	20.00 (26.57)
2.	Ground nut cake @ 2 Ton / ha.	4.67	6.67 (14.96)
3.	Karanj cake @ 2 Ton / ha.	4.33	13.33 (21.42)
4.	*Trichoderma* plus @ 20 kg/ha.	4.00	20.00 (26.57)
5.	*Paecilomyces lilacinus* @ 20 kg/ha.	4.33	13.33 (21.42)
6.	*Trichoderma viride* @ 20 kg/ha.	4.33	13.33 (21.42)
7.	*Pseudomonas fluorescens* @ 20 kg/ha.	4.33	13.33 (21.42)
8.	Intercropping of *Tagetes* spp. @ 3:1 proportion	4.67	6.67 (14.96)

9.	Untreated control	5.00	0.00 (0.00)
	S.E. ±	0.11	2.43
	CD at 5%	0.33	7.29

*Figures presented in parentheses are arc sin transformed values

Table 4: Effect of different treatment on ICBR of *Psoralea corylifolia*

Sr. No.	Treatments	Yield (q/ha)	Per cent increase in yield over untreated control	Additional yield over untreated control (q/ha)	Gross profit (Rs/ha)	Additional Profit (Rs/ha)	Cost of treatment and Labour (Rs/ha)	Net profit (Rs/ha)	ICBR
1	Neem cake @ 2 Ton / ha.	18.19	61.41	11.17	181900	111700	21500	90200	1: 4.20
2	Ground nut cake @ 2 Ton / ha.	7.91	3.13	0.17	79100	1700	65500	63800	1: 0.97
3	Karanj cake @ 2 Ton / ha.	10.63	33.96	3.61	106300	36100	55500	19400	1: 0.35
4	*Trichoderma* plus @ 20 kg/ha.	13.83	49.24	6.81	138300	68100	5950	62150	1: 10.44
5	*Paecilomyces lilacinus*@ 20 kg/ha.	11.60	39.48	4.58	116000	45800	5950	39850	1: 6.70
6	*Trichoderma viride* @ 20 kg/ha.	11.95	41.26	4.93	119500	49300	5950	43350	1: 7.29
7	*Pseudomonas fluorescens* @ 20 kg/ha.	11.53	39.12	4.51	115300	45100	5950	39150	1: 6.58
8	Intercropping of *Tagetes* spp. @ 3:1 proportion	7.53	6.77	0.51	75300	5100	1700	3400	1: 2.0
9	Untreated control	7.02	0	0	0	0	0	0	0

Market rates: 1. neem cake @Rs 10000/Ton 2. *Pseudomonas fluorescens* @ Rs. 200/kg 3. *Trichoderma viride* @ Rs. 200/kg 4. *Paecilomyces lilacinus* @ Rs. 200/kg 5. Groundnut cake @Rs.32/Kg 6. Karanj cake @ Rs. 27/Kg 7. *Trichoderma* plus @ Rs. 200/Kg 8. Labour (5 units/ha)-Rs.300/unit/Day 9. Marigold seeds -Rs.200 10. FYM /Kg- Rs. 450.

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