



Approaches for management of *Meloidogyne incognita* in pulses

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India is a major pulse growing country in the world contributing 25% of global production. However, the production of pulses is limited by several biotic and abiotic stresses including root-knot nematodes, *Meloidogyne* spp. which are responsible for the low productivity of pulses all over the world (Sikora and Fernandez, 2005, Karszen and Moens 2006). The economic losses due to root-knot nematode, *M. incognita* were reported as up to 17–23, 21 and 14–29% in blackgram (*Vigna mungo* L.), chickpea (*Cicer arietinum* L.) and mungbean [*Vigna radiata* (L.) R. Wilczek], respectively (Kumar *et al.* 2020). In Assam, yield loss due to *M. incognita* in blackgram was recorded to the tune of 13.19–23.50% (Anonymous 2011). To minimize the nematode population, many management approaches are being applied, and the use of resistant cultivars and application of bio-control agents are considered to be widely accepted. Though root-knot nematode resistant cultivars are available in a variety of crop species, including pea (*Pisum sativum* L.), it is always desirable to have new sources of resistance to increase the sources of root-knot resistance in pulses. Biological agents and their metabolites are another alternative for root-knot nematode management (Loan *et al.* 2018) which are environmentally safe, promote plant health and are cost effective. Therefore, investigations were undertaken to evaluate the germplasm of pulses for resistance against *Meloidogyne incognita* and to manage this pest using biocontrol agents in blackgram (*Vigna Mungo* L.).

A total of 64 pulse germplasm (8 chickpea germplasm, 10 pea germplasm and 46 lentil germplasm along with their respective susceptible checks) were evaluated for resistance against *Meloidogyne incognita* at the Department of Nematology, Assam Agricultural University, Jorhat, Assam under controlled conditions in net house during the winter (*rabi*) season of 2020–21. The experiment was laid out in a completely randomized design and the treatments were replicated 5 times each.

Experiment on bio-intensive management of *Meloidogyne incognita* in blackgram was conducted in Net House, Department of Nematology, AAU, Jorhat, Assam during *rabi* 2020–21 to study the effect of 7 treatments, viz. T₁, soil treatment with *Bacillus marisflavi* (AAU strain) @1 × 10⁸ cfu/ml enriched in vermicompost @20 g/m²; T₂, soil treatment with *Bacillus altitudinis* (AAU strain) @1 × 10⁸cfu/ml enriched in vermicompost @20 g/m²; T₃, soil treatment with *Bacillus subtilis* (AAU strain) @1 × 10⁸cfu/ml enriched in vermicompost @20 g/m²; T₄, soil treatment with *Trichoderma viride* (AAU strain) @1 × 10⁸ cfu/ml enriched in vermicompost @20 g/m²; T₅, soil treatment with *Verticillium lecanii* (AAU strain) @1 × 10⁸ cfu/ml enriched in vermicompost @20 g/m²; T₆, soil treatment with *Pseudomonas fluorescens* (AAU strain) @1 × 10⁸ cfu/ml enriched in vermicompost @20 g/m²; T₇, untreated control against *M. incognita* in blackgram (variety PU 31). The experiment was conducted in 1 kg capacity pots. The earthen pots were filled with autoclaved soil, thoroughly mixed with finely dried cow dung and sand at 2:1:1, respectively. Bio-agents enriched in vermicompost were applied 15 days before sowing. Sowing of seeds, thinning of seedling and inoculation of seedlings with nematodes were done as per the procedures described above. Ten days seedlings were inoculated with second stage juveniles (J₂) of *M. incognita* @ 1J₂/g of soil. Pots were labeled according to allotted treatments. All the treatments were replicated 4 times following Completely Randomized Design. Need based watering was done till the harvesting of crop. After 60 days of inoculation, the plants were uprooted and observations on plant growth parameters, viz. shoot and root length, fresh and dry weight of shoot, fresh and dry weight of root including the number of root nodules per root system; nematode reproduction, viz. number of galls per root system, number of egg masses per root system and final nematode population (200 cc of soil) were recorded. For recording the final nematode population, Cobb's modified decanting and sieving technique (Christei and Perry 1959) was used. The experimental data obtained were analyzed by using WASP 1.0 software to determine the significance of treatments.

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Evaluation of germplasm of pulses for resistance against Meloidogyne incognita: It was revealed that none of the chickpea germplasm tested was found to be either resistant or moderately resistant and was in agreement with Siddiqui and Hussain (1992). Borah *et al.* (2020) evaluated 25 chickpea germplasm, of which Vijay and ICC 313 were recorded to be moderately resistant while, the rest of the germplasm was found to be either susceptible or highly susceptible to *M. incognita*. Out of 10 pea germplasms, 2 germplasms, viz. IPFD 99-13 and IPFD 12-2 were found to be resistant, 2 germplasms were found to be moderately resistant and the rest were either susceptible or highly susceptible (Table 1). The present investigation is in accordance with Anwar *et al.* (2017) and Bhagawati *et al.* (2018). Among 46 lentil germplasm screened, only 1 germplasm (IPL 81) was found to be resistant, 7 germplasm were found to be moderately resistant, while the rest of 39 germplasms were found to be either susceptible or highly susceptible to *M. incognita* (Table 1). Similar findings were obtained by Chakraborty *et al.* (2016) and Khan *et al.* (2017).

Bio-intensive management of Meloidogyne incognita in blackgram: The result revealed that all the 6 bio-agents, viz. *Bacillus marisflavi*, *Bacillus altitudinis*, *Bacillus subtilis*, *Trichoderma viride*, *Verticillium lecanii* and *Pseudomonas fluorescens* positively influenced plant growth parameters including nodule formation with the corresponding decrease in the number of galls and egg masses per root system, and root-knot nematode population in the soil as compared to untreated control (Table 2). However, the maximum shoot and root length, fresh and dry weight of shoot, fresh and

dry weight of root and number of nodules were recorded in treatment with soil application of *Pseudomonas fluorescens* @ 1×10^8 cfu/ml enriched in vermicompost @20 g/m² (T₆), followed by soil application of *Bacillus marisflavi* @ 1×10^8 cfu/ml enriched in vermicompost @20 g/m² (T₁). The minimum plant growth parameters and number of nodules were recorded in the untreated control (T₇). Positive effect of *P. fluorescens* on plant growth characters and nodule formation was reported by Khan *et al.* (2016) and Abd-El-Khair *et al.* (2019). The minimum number of galls per root system, egg masses per root system and final root-knot population in soil were recorded in the treatment with soil application of *Pseudomonas fluorescens* @ 1×10^8 cfu/ml enriched in vermicompost @20 g/m² (T₆), followed by soil application of *Bacillus marisflavi* @ 1×10^8 cfu/ml enriched in vermicompost @20 g/m² (T₁). Dash *et al.* (2015) and Nyodu and Das (2020) reported the nematocidal behaviour of *P. fluorescens*.

The use of resistant varieties is thought to be the most cost-effective, remunerative, and environmentally benign strategy for phytonematode management. Reaction of eight chickpea germplasms, 10 pea germplasms and 46 lentil germplasms along with their respective susceptible checks for resistance against *Meloidogyne incognita* was evaluated in controlled conditions. All 8 germplasms of chickpea screened were found to be either susceptible or highly susceptible to *M. incognita*; while in pea 2 out of 10, viz. IPFD 99-13 and IPFD 12-2 were found to be resistant, two germplasm, viz. IPFD 14-2 and IPF 99-25 were found to be moderately resistant. Out of 46 lentil germplasms screened,

Table 1 Reaction of pulse germplasms against *Meloidogyne incognita* (Mean of 5 replications)

Crop	Germplasms	Root knot index	Reproductive factor	Reaction
Chickpea	IPC 2006-77, IPC 2004-1, IPC 11-112, IPC 05-62	3.6-4.0	1.44-1.76	Susceptible
	IPC 2004-98, IPCK 2-29, IPCK 04-29, DCP 92-3, JG16 (SC*)	4.8-5.0	2.34-2.79	Highly susceptible
Field pea	IPFD-12-2, IPFD-99-13	2.0	0.53- 0.59	Resistant
	IPF-99-25, IPFD-14-2	2.8-3.0	0.76-0.79	Moderately resistant
	IPFD-9-2, IPFD-1-10, IPFD-10-12, IPF-5-19	4.0	1.59-1.78	Susceptible
	IPFD-6-3, IPFD-11-5, Bonvielle (SC*)	4.6- 5.0	2.15 - 2.54	Highly susceptible
Lentil	IPL 81	2.0	0.55	Resistant
	LNEMO 20-1, LNEMO 20-4, LNEMO 20-10, LNEMO 20-6, LNEMO 20-7, LNEMO 20-8, IPL 406, IPL 220, IPL 315, IPL 316, IPL 321, IPL 526, IPL 534, DPL-15, DPL-62, LNEMO 20-2, LNEMO 20-3, LNEMO 20-5, LNEMO 20-9, LNEMO 20-11, LNEMO 20-12, LNEMO 20-13, LNEMO 20-14, LNEMO 20-15, LNEMO 20-16, LNEMO 20-17, LNEMO 20-18, LNEMO 20-19, LNEMO 20-20, LNEMO 20-21, LNEMO 20-22, LNEMO 20-23, LNEMO 20-24, LNEMO 20-25, LNEMO 20-26, LNEMO 20-27, LNEMO 20-28, LNEMO 20-30, LNEMO 20-31, LNEMO 20-32, LNEMO 20-33,	2.6-3.0	0.71-0.86	Moderately resistant
	LNEMO 20-29, LNEMO 20-34, LNEMO 20-35, LNEMO 20-36, PL-406 (SC*)	3.2 - 4.0	1.07-1.78	Susceptible
		4.6-5.0	2.11-2.80	Highly susceptible

SC, Susceptible check.

Table 2 Effect of different treatments on the plant growth parameters of blackgram and infestation and multiplication of *M. incognita* (Mean of 4 replications)

Treatment*	Shoot length (cm)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Root length (cm)	Fresh weight of root (g)	Dry weight of root (g)	No. of nodule	No. of galls/root system	No. of egg masses/root system	Final root-knot population (200 cc) soil
T ₁	39.20 ^b	5.00 ^b	1.41 ^{ab}	9.62 ^b	1.83 ^b	0.83 ^b	27.75 ^b	26.00 (5.09) ^d	11.50 (3.38) ^d	555.50 (23.55) ^d
T ₂	31.75 ^d	3.25 ^d	1.17 ^c	6.75 ^d	1.35 ^d	0.61 ^d	23.50 ^d	47.75 (6.90) ^b	23.75 (4.85) ^b	899.00 (29.98) ^b
T ₃	34.57 ^c	3.87 ^c	1.31 ^b	8.75 ^{bc}	1.52 ^c	0.72 ^c	25.25 ^{cd}	34.25 (5.84) ^c	17.00 (4.10) ^c	794.50 (28.18) ^c
T ₄	37.87 ^b	4.75 ^b	1.32 ^b	9.50 ^b	1.76 ^b	0.82 ^b	27.25 ^{bc}	26.25 (5.10) ^d	12.75 (3.55) ^d	581.50 (24.11) ^d
T ₅	32.50 ^{cd}	3.54 ^{cd}	1.19 ^c	7.25 ^{cd}	1.41 ^d	0.65 ^{cd}	24.50 ^d	46.50 (6.80) ^b	23.00 (4.79) ^b	866.25 (29.43) ^b
T ₆	45.75 ^a	6.65 ^a	1.45 ^a	11.62 ^a	2.10 ^a	1.06 ^a	34.50 ^a	9.75 (3.10) ^e	6.25 (2.48) ^e	403.25 (20.07) ^e
T ₇	26.00 ^e	2.15 ^e	0.80 ^d	4.87 ^e	1.12 ^e	0.47 ^e	12.00 ^e	60.25 (7.76) ^a	32.00 (5.65) ^a	1382.25 (37.17) ^a
SEd±	1.09	0.18	0.05	0.75	0.04	0.04	1.14	2.98	1.88	15.30
CD (P=0.05)	2.28	0.38	0.12	1.56	0.096	0.08	2.38	6.02	3.92	31.83

Mean followed by the same letter in the superscript(s) are statistically at par. Values of the number of galls, egg masses and final nematode population within in parentheses are square root($\sqrt{x + 0.5}$) transformed data. Mean followed by the same letter in the superscript(s) are statistically at par.

only one germplasm (IPL 81) was found to be resistant, 7 germplasms were found to be moderately resistant. The germplasm regarded as resistant or moderately resistant can be evaluated for its field performance in terms of yield and other characteristics.

SUMMARY

Meloidogyne incognita can be effectively managed through biological control agents. The present study on the bio-intensive management of *M. incognita* on blackgram with bio-agents, viz. *Bacillus marisflavi*, *Bacillus altitudinis*, *Bacillus subtilis*, *Trichoderma viride*, *Verticillium lecanii* and *Pseudomonas fluorescens* as soil application was carried out under net house conditions at the Department of Nematology, Assam Agricultural University, Jorhat, Assam under controlled conditions during the winter (*rabi*) season of 2020–21. Treatment with soil application of *Pseudomonas fluorescens* @ 1×10^8 cfu/ml enriched in vermicompost @ 20 g/m² was found to be the most effective in enhancing plant growth parameters, number of nodules per root system and reducing the number of galls per root system, egg masses per root system and final root-knot nematode population in the soil. Given the importance of pulses in maintaining national food and nutritional security, as well as the importance of root-knot nematode as a limiting factor in pulse production, biological agents for nematode control are a viable alternative to pesticides. Biocontrol agents studied help in attaining favourable plant growth and health, therefore considered a more promising management practice against root-knot nematode.

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