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Integrated Management of Root-knot nematode (*Meloidogyne incognita*) in Potato (*Solanum tuberosum* L.) cv. Lady Rosetta

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Abstract

Pot experiment was conducted to find out effective management of root-knot nematode, *M. incognita* in potato cv. Lady Rosseta during November 2017 to February 2018 at department of plant nematology, C.P. College of Agriculture, S.D.A.U., Sardarkrushinagar. Pots containing 10 kg infested soil having initial nematode population of 120 J_2/100 g soil with different treatments *viz*., organic amendments (poultry manure, castor cake), bio-control agents (*Purpureocillium lilacinum* and *Pseudomonas fluorescens*) alone and in combination with the organic amendments and carbofuran 3G nematicide alone. After seventy five days of germination, recorded observations revealed that maximum increase in plant growth parameters were recorded in combined application with poultry manure (22.30 g pot^{-1}) enriched with *P. lilacinum* 10^6 cfu g^{-1} (0.022 g pot^{-1}). Among alone treatments (without combination of organic amendments and bio-agents) maximum increase in plant growth parameters was recorded in the treatment with poultry manure. Whereas, lowest root-knot index on root as well as tuber and number of galls plant^{-1} root (1 g) were observed in treatment with poultry manure enriched with *P. lilacinum* 10^6 cfu g^{-1}. Integrated management of *M. incognita* in potato revealed significant reduction in nematode population parameters in all the treatments compared to infected check. Maximum reduction in nematode population parameters was observed in treatment with poultry manure enriched with *P. lilacinum* 10^6 cfu g^{-1}. Among alone treatments (without combination of organic amendments and bio-agents), maximum reduction in nematode population parameters was recorded in the treatment with poultry manure, but in soil nematode population and total nematode population build up this treatment was statistically at par with the treatment castor cake (4.46 g pot^{-1}).

Keywords: *Meloidogyne incognita*, organic amendments, biocontrol agents, carbofuran

1. Introduction

Potato (*Solanum tuberosum* L.) is one of the most important staple food crop. Potato originated in the high hills of Peru and Bolivia of South Africa, where it was domesticated approximately 7,000 to 10,000 years ago. Presently, India rank third in area and production in the world. The area under crop during November 2017 to February 2018 was 21,76,000 ha with annual production of 49,344 mt (Anonymous, 2018). This important crop is affected by several biotic and abiotic stresses. Post harvest improvement such as fast and cheap transportation, storage and processing will help to make potato production more profitable for

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farmers by improving their access to markets, raising local value addition. But due to number of production problems that accounts for low regional as well as national yield have been identified. The growers of are also suffering up to a great extent not only due to low production, poor keeping quality of tubers but also biotic stress such as late blight, common scab, and mosaic virus (Agrawal et al., 2016). The important pathogen attacking potato crops is *Phytophthora infestans*, *Rhizoctonia, Sclerotinia* and *Alternaria solani*. Some other potato diseases include black leg, powdery mildew, powdery scab and leaf roll virus. Primarily, nematodes attacking potato crops are cyst and root knot nematode. Insects that commonly transmit potato diseases or damage the plants include the Colorado potato beetle, potato tuber moth, green peach aphid, potato aphid, beet leafhoppers, thrips and mites. Root-knot nematodes (*Meloidogyne* spp.) are one of the most important polyphagous pests in agriculture. Among the top five plant pathogens affecting world's food production, root-knot nematodes are one of the most devastating pathogen of crops. The effect of nematode infection on plant root induce typical symptoms, popularly known as 'root-knot' or 'root gall' of varying sizes depending on the species of root-knot nematode and the host. Infection of potato tubers by *Meloidogyne* spp. has been reported previously in Argentina (Chaves and Torres, 2001), Brazil (Charchar, 1997), Florida (Chitwood, 1949), Japan (Nakasono et al., 1990), Libya (Dabaj and Khan, 1981), Rhodesia (now Zimbabwe (Mitchell et al., 1971), Saudi Arabia (Al-Hazmi et al., 1993) and Turkey (Cinarli and Eterkin, 1996). The root-knot nematodes (*Meloidogyne species*) are sedentary endoparasites and most damaging agricultural nematode pest, attacking a wide range of crops. Second stage juveniles hatched from the eggs in egg masses laid by females on the infected roots initiate the penetration causing the infection (Kumar et al., 2015). Pest and disease management has played vital role in doubling food production. The indiscriminate use of chemicals has resulted in a reduction of biodiversity of natural enemies, outbreak of secondary pests, and development of resistance to pesticides and contamination of food and ecosystem. Another way is through integration of all those techniques that will make the environment less favorable for pests to develop or multiply, but which still favors crop production. Insect pest and disease management in its broadest sense includes everything that makes the life difficult for insects that kill them or prevents their increase and make it laborious for them to spread about the world (Negalur et al., 2017).

2. Materials and Methods

Pot experiment was conducted to find out effective management practices of root-knot nematode in potato crop cv. Lady Rosetta during November 2017 to February 2018 at department of plant nematology, C.P. College of Agriculture, S.D.A.U., Sardarkrushinagar. The experiment was arranged in completely randomised design with three replications and eleven treatments *i.e.,* T_1=Poultry manure @ 5.0 t ha^{-1} (22.30 g pot^{-1}), T_2=Castor cake @ 1.0 t ha^{-1} (4.46 g pot^{-1}), T_3=*Paecilomyces lilacinus* 10^6 cfu g^{-1} @ 5.0 kg ha^{-1} (0.0022 g pot^{-1}), T_4=*Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5.0 kg ha^{-1} (0.0022 g pot^{-1}), T_5=Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}), T_6=Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}), T_7=Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}), T_8=Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}), T_9=Carbofuran 3G @ 2 kg a.i. ha^{-1} (0.29 g pot^{-1}), T_{10}=Control (sterilized soil) and T_{11}=Control (infested soil). Plastic pots having 24 cm diameter were sterilized with 4% formaldehyde (formalin 40 EC) and filled with 10 kg of *M. incognita* infested soil with initial nematode population of 120 J_2/100 g soil. Before sowing the crop, all the soil amendments (*viz*., castor cake and poultry manure) in treatments (T_5, T_6, T_7 and T_8) were enriched with respective bio-agents. All the treatments were applied as per treatments (an enriched soil amendment was made 15 days prior to application of treatments) and mixed with the soil. Then nematode free potato tubers (weight ranging from 91-95 g) of cv. Lady Rosetta were sown with one tuber pot^{-1}. After seventy five days of germination observations were recorded on the plant growth parameters *viz.,* plant height (cm); fresh shoot and root weight (g); dry shoot and root weight (g), number of tuber, root-knot index and nematode population parameters *viz.,* number of galls root^{-1} (1 g), different stages of embedded females and eggmasses plant^{-1} root (1 g), soil nematode population pot^{-1}, total nematode population build-up and reproduction rate (pf/pi) and also recorded market value of tubers. Finally, the data were statistically analysed using Duncan's New Multiple Range Test (DNMRT).

3. Results and Discussion

Significant differences were recorded in plant height between control (uninfected check and infected check) and all treatments. Among alone treatment (without combination of organic amendments and bio-agents), maximum plant height was observed in treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}), which was statistically at par with T_2 and T_3 compared to infected check (Table 1).

Significant increase in tuber weight was observed in all the treated pots compared to infected check. maximum tuber weight (g) was recorded with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @ 5 kg ha^{-1}(0.022 g pot^{-1}) followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) (Table 1).

Maximum fresh shoot weight and root weight were recorded in treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @ 5 kg ha^{-1}

Table 1: Effect of different management practices on root-knot nematode (*Meloidogyne incognita*) and plant growth parameters of potato crop cv. Lady Rosetta

Sl. No.	Treatments	Plant height (cm)	Tuber weight (g)	Fresh weight (g)		Dry weight (g)	
				Shoot	Root	Shoot	Root
T_1	Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1})	33.33^{bc}	82.73^{d}	111.44^{c}	17.71^{cd}	9.76^{cde}	1.06^{bc}
T_2	Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1})	31.00^{cd}	78.45^{de}	110.10^{cd}	16.10^{de}	9.38^{cde}	1.04^{bc}
T_3	*Purpureocillium lilacinum* 10^{6} cfu g^{-1} (0.022 g pot^{-1}) @ 5 kg ha^{-1}	30.67^{cde}	76.86^{de}	104.73^{de}	14.38^{ef}	8.66^{def}	0.98^{cd}
T_4	*Pseudomonas fluorescens* 10^{6} cfu g^{-1} (0.022 g pot^{-1}) @ 5 kg ha^{-1}	27.50^{ef}	75.59^{de}	102.58^{e}	14.13^{f}	8.53^{ef}	0.95^{cd}
T_5	Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1})+ *Purpureocillium lilacinum* 106 cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}	38.33^{a}	129.71^{a}	126.27^{a}	20.18^{b}	12.52^{b}	1.17^{b}
T_6	Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1})+ *Pseudomonas fluorescens* 106 cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}	34.50^{b}	118.37^{b}	120.04^{b}	18.29^{bc}	10.47^{c}	1.00^{c}
T_7	Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1})+ *Purpureocillium lilacinum* 106 cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}	30.17^{cde}	98.41^{c}	105.52^{cde}	16.13^{de}	10.21^{cd}	0.99^{cd}
T_8	Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1})+*Pseudomonas fluorescens* 10^{6} cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}	29.50^{de}	96.86^{c}	104.23^{de}	15.50^{ef}	9.84^{cde}	0.97^{cd}
T_9	Carbofuran 3G @ 2 kg a.i. ha^{-1} (0.29 g pot^{-1})	24.50^{fg}	76.59^{de}	104.97^{de}	15.25^{ef}	7.79^{f}	0.85^{de}
T_{10}	Control (Steam sterilized soil only)	38.50^{a}	121.49^{ab}	128.21^{a}	22.30^{a}	14.21^{a}	1.63^{a}
T_{11}	Control (Infested soil only)	23.17^{g}	69.21^{e}	102.51^{e}	12.23^{g}	7.30^{f}	0.77^{e}
SEm±		0.98	2.89	1.82	0.57	0.48	0.04

Figures indicating common alphabets in superscript do not differ significantly at 5% level of significance according to DNMRT

(0.022 g pot^{-1}) followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}); both the treatments were statistically at par with each other (Table 1).

Significant differences were recorded in dry shoot and root weight in all the treatments compared to infected check. Highest dry shoot weight and root weight were recorded in the treatment with poultry manure @ 5 t ha^{-1} (6.70 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) (Table 1).

Minimum root-knot index (RKI) of 0.97 and 0.30 respectively, were observed on root as well as tuber in treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^{6} cfu g^{-1} @ 5 kg ha^{-1}, which was followed by the treatment poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) (Table 2).

Data presented in Table 2 showed significant reduction in the number of root galls/plant root (1 g) in all the treated pots compared to infected check. Maximum reduction in number of galls was recorded in the treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}).

Significant reduction in root nematode population *viz.*, different stages of embedded females and egg masses/plant root (1 g) in all treated pots compared to infected check. Maximum reduction in different stages of embedded females were recorded in the treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}). Maximum reduction in egg masses/plant root (1 g) was observed in treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum*10^{6} cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^{6} cfu g^{-1} @

Table 2: Effect of different management practices on population of root-knot nematode (*Meloidogyne incognita*) in potato (*Solanum tuberosum* L.) crop cv. Lady Rosetta

Treatments	Root-knot index (0-5)*		Nematode population root^{-1} (1 g)			Soil nematode population pot^{-1}	Total nematode population buildup	Reproduction rate (Pf/Pi)
	Root	Tuber	No. of root galls	Females	Egg masses			
T_1	1.6	1.17	3.72^{cd} (13.84)	3.39^{d} (11.49)	3.24^{d} (10.50)	148.30^{c} (19684.09)	149.54^{c} (22362.21)	1.86
T_2	1.93	1.43	3.98^{c} (15.84)	3.76^{c} (14.14)	3.63^{c} (13.18)	150.55^{c} (22665.30)	151.950^{c} (23088.80)	1.92
T_3	2.07	1.20	4.34^{b} (18.84)	4.10^{b} (16.81)	3.94^{b} (15.52)	158.09^{b} (24992.45)	159.51^{b} (25443.44)	2.12
T_4	2.33	1.87	4.45^{b} (19.80)	4.22^{b} (17.81)	4.06^{b} (16.48)	159.12^{b} (25319.17)	160.59^{b} (25789.15)	2.15
T_5	0.97	0.30	2.48^{f} (6.15)	2.34^{e} (5.48)	2.11^{f} (4.45)	113.96^{f} (12986.88)	115.06^{f} (13238.80)	1.10
T_6	1.13	0.47	3.13^{e} (9.80)	3.13^{d} (9.80)	2.73^{e} (7.45)	122.43^{e} (14989.10)	123.65^{e} (15289.32)	1.27
T_7	1.63	1.13	3.49^{d} (12.18)	3.19^{d} (10.18)	2.97^{e} (8.82)	127.79^{de} (16330.28)	129.07^{de} (16659.06)	1.39
T_8	1.93	1.20	3.67^{d} (13.47)	3.39^{d} (11.49)	3.24^{d} (10.50)	134.13^{d} (17990.85)	135.49^{d} (18357.54)	1.53
T_9	2.00	1.20	3.98^{c} (15.84)	3.67^{c} (13.47)	3.63^{c} (13.18)	163.26^{ab} (26653.83)	164.45^{ab} (27043.80)	2.25
T_{10}	0.00	0.00	0.71^{g} (0.00)	0.71^{f} (0.00)	0.71^{g} (0.00)	0.71^{g} (0.00)	0.71^{g} (0.00)	0.00
T_{11}	3.57	2.50	5.85^{a} (34.22)	5.73^{a} (32.83)	5.64^{a} (31.81)	167.36^{a} (28009.37)	169.62^{a} (28770.94)	2.40
SEm±	-	-	0.08	0.08	0.08	2.01	2.01	-

T_1: Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}); T_2: Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1}); T_3: *Purpureocillium lilacinum* 10^6 cfu g^{-1} (0.022 g pot^{-1}) @ 5 kg ha^{-1}; T_4: *Pseudomonas fluorescens* 10^6 cfu g^{-1} (0.022 g pot^{-1}) @ 5 kg ha^{-1}; T_5: Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1})+*Purpureocillium lilacinum* 10^6 cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}; T_6: Poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1})+*Pseudomonas fluorescens* 10^6 cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}; T_7: Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1})+*Purpureocillium lilacinu*m 106 cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}; T_8: Castor cake @ 1 t ha^{-1} (4.46 g pot^{-1})+*Pseudomonas fluorescens* 10^6 cfu g^{-1} (0.022 g pot^{-1}) enriched @ 5 kg ha^{-1}; T_9: Carbofuran 3G @ 2 kg a.i. ha^{-1} (0.29 g pot^{-1}); T_{10}: Control (Steam sterilized soil only); T_{11}: Control (Infested soil only); Figures indicating common alphabets in superscript do not differ significantly at 5% level of significance according to DNMRT; *0 = Free; 5 = Maximum disease intensity. Figures in parentheses are re-transformed values (square-root transformation)

5 kg ha^{-1} (0.022 g pot^{-1}) (Table 2).

Significant reduction in soil nematode population/pot was observed in all the treatments compared to infected check. Highest reduction in soil nematode population/pot was recorded in the treatment with combined application of poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @5 kg ha^{-1} (0.022 g pot^{-1}) followed by treatment poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) (Table 2).

Total nematode build-up was significantly less in all the treatments as compared to infected check. Total nematode build-up and reproduction rate (Pf/Pi) were recorded least in the treatment poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot) followed by treatment poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) (Table 2). The treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}) produced more healthy and bigger size tuber.

These findings were in accordance with Kankam et al. (2014) observed effect of poultry manure on the growth, yield and root-knot nematode *(Meloidogyne* spp.) infestation of carrot. Ramakrishnan et al. (2014) who evaluated poultry manure against root-knot nematodes in FCV tobacco nursery for three years. Results revealed that, there was no adverse effect of poultry manure on tobacco seed germination. At 60 DAS, poultry manure @ 200 g m^{-2} was at par with poultry manure @ 250 g m^{-2} and recorded reduced root-knot index (RKI) of 1.36 and 1.34 respectively and was also at par with neem cake+soil solarization (1.40) and dazomet @ 30 g m^{-2} (1.22). Similarly, application of poultry manure @ 200 g m^{-2} in FCV tobacco nursery beds resulted in 40% reduction in number of rootgalls g^{-1} root, 34% reduction in number of root-knot nematode adult females g^{-1} root, 43% reduction in number of root-knot nematode egg masses g^{-1} root and 36.9 % reduction in root-knot nematode soil population/100 g soil compared to untreated check. Singh et al. (2014) examined the integrated management of root-knot disease of okra caused by root-knot nematode (*Meloidogyne incognita*) by using egg parasitic fungus (fungal bioagent), *Purpureocillium lilacinum* (*Paecilomyces lilacinus*) and plant growth promoting rhizobacteria (*Pseudomonas fluorescence*) were applied as seed treatment (10.0 g kg^{-1} seed) as well as soil application (10.0 kg ha^{-1}) with 1.5 t ha^{-1} FYM and reported that integration of all management components caused better recovery of plant height (20.0%) and enhanced marketable fruit yield (71.0%) compared to individual treatments and/or control(s). Also, the best protection from root-knot disease of okra, in terms of reduction of root-knot gall-index (1.0) and reproductive factor (Pf/Pi (R)=0.4) was achieved through integration of seed treatment and soil application of both bio-agents, *P. lilacinus* and *P. fluorescens* and FYM, which gave best result recorded next to the tested chemical nematicide (cabofuran 3 G). Joshi et al. (2012a) carried out a pot experiment under glasshouse condition for management of *M. incognita* infecting tomato by using fungal bio-agents namely *Pochonia chlamydosporia, Paecilomyces lilacinus* and *Trichoderma harzianum* (@ 1 and 2 g kg^{-1}) as soil application along with chemical (Carbofuran 3G @ 1 kg a.i. ha^{-1}) and untreated control. Results showed that the all fungal treatments were found more effective in improvement of plant growth and in reduction of nematode as compared to untreated check. Among fugal bio-agents, *Paecilomyces lilacinus* @ 2 g kg^{-1} soil was the best treatment in increasing plant growth and in reducing nematode reproduction over other fungal bio-agents. Sharma and Trivedi (2012) studied effects of ovi-parasitic fungus, *Paecilomyces lilacinus* to control root-knot nematode infecting *Vigna radiata*. They found that *P. lilacinus* could control the nematode population but increase in initial population of nematode also increased the percentage of egg masses. Treatment of *P. lilacinus* (wheat bran+*Paecilomyces lilacinus* 5, 10, 15 and 20 g) showed significantly higher yield as compared to control and best results were achieved in wheat bran+*Paecilomyces lilacinus* (20 g). Our finding agrees with those of Goswami et al. (2006) and Prakob et al. (2009) that *P. lilacinus* enhanced growth of tomato and lettuce infected by *M. incognita* and *Meloidogyne* spp. Das and Sinha (2005) who evaluated that maximum increase in growth parameters of okra *viz*., plant height, root length, fresh and dry weight of shoot and root including yield and decrease in number of galls, egg masses per root system and final nematode population in soil was observed in the combined treatment with *P. lilacinus* @ 4.0 g kg^{-1} soil, carbosulfan 25 EC @ 0.2%, poultry manure @ 2.5 t ha^{-1} and FYM @ 2.5 t ha^{-1}. Efficacy of neem cake (NC), mustard cake (MC) and castor cake (CC) was also reported by Ravindra et al. (2001), Patel et al. (2004) and Raveendra et al. (2011). All the treatments were significantly different from the control in increasing growth parameters and reducing nematode population in soil. Similar reduction in root-knot disease incidence in terms of RKI and final soil nematode population and subsequent improvement in okra pod yield due to application of organic amendments was earlier reported by Ramakrishnan et al. (1997). Rao et al., 1997 revealed that management of *Meloidogyne incognita* on okra by castor cake suspension and *Paecilomyces lilacinus.*

From the above results, it is clear that, in general combined application of organic amendments and bio-agents lead to significant reduction in nematode population parameters and significant increase in plant growth parameters compared to alone treatments. It may be attributed to high multiplication of bio-control agents in organic amendments, nutrients stimulation to plant root by decomposition of organic amendments and release of toxic gases, which may be lethal to the nematodes. So, it can be concluded that integration of organic amendments with bio-control agents support decent plant growth and decrease nematode population in better way compared to alone treatments.

4. Conclusion

Integrated management of root-knot nematode in potato cv. Lady Rosseta revealed significant reduction in nematode population parameters in all the treatments compared to infected check. Maximum healthy tuber and reduction in nematode population parameters were observed in treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Purpureocillium lilacinum* 10^6 cfu g^{-1} @ 5 kg ha^{-1} followed by treatment with poultry manure @ 5 t ha^{-1} (22.30 g pot^{-1}) enriched with *Pseudomonas fluorescens* 10^6 cfu g^{-1} @ 5 kg ha^{-1} (0.022 g pot^{-1}).

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