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ECO-FRIENDLY MANAGEMENT OF POTATO CYST NEMATODES IN THE NILGIRIS OF TAMIL NADU

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ABSTRACT: Potato cyst nematodes (PCN) *viz.*, *Globodera rostochiensis* and *G. pallida* are one of the most destructive pests of quarantine significance hindering the potato production in the Nilgiris region of Tamil Nadu. Hence two different field experiments were conducted from 2007 to 2009 to study the effect of organic amendments and biocontrol agents on PCN multiplication and potato yield. Organic amendments *viz.*, eucalyptus de-oiled leaves, spent mushroom compost and neem cake individually and in combination with *Trichoderma viride* and biocontrol agents *viz.*, *Paecilomyces lilacinus*, *Pochonia chlamydospora*, *Trichoderma viride*, *Pseudomonas fluorescens* Pf1 strain and *Pseudomonas* sp. were evaluated. Among the organic amendments, neem cake in combination with *T. viride* recorded significantly higher plant growth parameters and tuber yield (18.44 t/ha) and was on par with carbofuran (17.16 t/ha). However, the PCN population in soil and roots and PCN multiplication were significantly lower in carbofuran treatment and was on par with neem cake in combination with *T. viride*. Among the biocontrol agents, *P. fluorescens* Pf1 recorded significantly higher growth parameters and yield (16.03 t/ha) coupled with lower PCN population in soil and roots and nematode multiplication (Rf - 1.38). However, carbofuran treatment performed better than all the biocontrol agents tested (Rf - 0.88).

KEYWORDS: potato cyst nematodes, biocontrol agents, organic amendments, carbofuran, eco-friendly management

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important cash crops in the Nilgiri hills of Tamil Nadu. The major limiting factors in potato cultivation in this region are the potato cyst nematodes (PCN), *Globodera rostochiensis* and *G. pallida* (Howard *et al.,* 1977) and the farmers go for basal application of carbofuran at planting against these nematode pests. In spite of the chemical measures taken up to control potato cyst nematodes in Nilgiris, the nematode is well established and has become an endemic pest due to intensive cultivation of potato and favorable climatic conditions (Prasad, 1989; Prasad, 2001).

Earlier reports on successful use of the nematophagous fungi, *Pochonia chlamydosporia* and *Paecilomyces lilacinus*; the plant growth promoting rhizobacteria, *Pseudomonas fluorescens* and soil amendment with neem cake indicated their potential as a part of integrated pest management strategy against PCN under field conditions (Jacobs *et al.*, 2003; Devrajan *et al.,* 2004; Tobin *et al.,* 2008). Therefore, investigations are being carried out at Central Potato Research Station, Ootacamund to develop an integrated nematode management package with judicious use of various biological, cultural and chemical management options for PCN in Nilgiris.

Two different field experiments were conducted to evaluate the effect of biocontrol agents *viz., Pochonia chlamydosporia, Paecilomyces lilacinus, Pseudomonas fluorescens* and *Trichoderma viride* and some locally available low cost organic amendments *viz.,* eucalyptus deoiled leaves, spent mushroom compost and neem cake individually and in combination with *T. viride* to manage the PCN and to develop an effective ecofriendly technology for The Nilgiris region.

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MATERIALS AND METHODS

Field experiments were conducted for three consecutive years from 2007 to 2009 at Central Potato Research Station, Muthorai, Ootacamund in summer season (May to August) in potato cv. Kufri Giriraj, under rainfed conditions. The data from the experiments were pooled and statistically analysed (Panse and Sukhatme, 1985).

The experiments were conducted in RBD in plots of 3 × 3 m having three replications for each treatment. The biocontrol agents were procured from Tamil Nadu Agricultural University, Coimbatore. The treatments were given at the time of planting as per the schedule furnished below.

Experiment	Treatments
Evaluation of organic amendments	T_1-Eucalyptus cake at 10 t/ha
	T_2-Spent mushroom compost at 10 t/ha
	T_3-Neem cake at 5 t/ha
	T_4-T_1 + *Trichoderma viride* at 0.5 kg/ha (containing 1.5×10^9 cfu/g of talc)
	T_5-T_2 + *T. viride* at 0.5 kg/ha
	T_6-T_3 + *T. viride* at 0.5 kg/ha
	T_7–carbofuran at 2 kg a.i/ha
	T_8–untreated control
Evaluation of biocontrol agents	T_1- *Paecilomyces lilacinus* at 20 kg/ha (containing 7×10^8 colony forming units (cfu)/g of talc)
	T_2- *Pochonia chlamydosporia* at 20 kg/ha (containing 2.5×10^9 cfu/g of talc)
	T_3-*T. viride* at 20 kg/ha (containing 1.8×10^9 cfu/g of talc)
	T_4-*Pseudomonas fluorescens* Pf1 strain at 10 kg/ha (containing 1.5×10^9 cfu/g of talc)
	T_5-*Pseudomonas* sp. – a native strain at 10 kg/ha (containing 1.5×10^9 cfu/g of talc)
	T_6–carbofuran at 2 kg a.i/ha
	T_7–untreated control

Observations were recorded on plant height, number of stems and number of leaves at 75 days after planting. At the time of harvest, data on tuber yield were recorded on number and weight basis. The initial cyst population (Pi) before planting and final cyst population (Pf) after harvest was recorded from each plot. The cysts were extracted from 100 ml soil by Fenwick can method (Fenwick, 1940) and the nematode reproduction factor (Rf) was estimated as the ratio of final and initial nematode population. Egg population density was estimated by crushing 25 cysts collected at random from each plot and expressing the results as numbers/g soil (Brown, 1969). The number of females per 2.5 cm root was also recorded.

RESULTS AND DISCUSSION

Evaluation of organic amendments

Treatments receiving organic amendments in combination with *T. viride* performed relatively better than those receiving organic amendments alone. Among the treatments, neem cake in combination with *T. viride* recorded significantly higher plant growth parameters (plant height, number of stems and number of leaves) and yield parameters (number of tubers and tuber weight) and was on par with carbofuran. It was followed by treatments with spent mushroom compost and eucalyptus deoiled leaves which were on par with each other. However, PCN population in soil and roots and nematode multiplication (Rf) were significantly lower in carbofuran treatment and was on par with neem cake + *T. viride* (**Table 1**).

Earlier reports on integrated management of PCN indicated that combined application of neem cake and *P. fluorescens* coupled with mustard intercropping significantly reduced potato cyst nematodes and increased the potato yield (Devrajan *et al.*, 2004). Neem cake, being a nutrient rich organic material, is found to be an excellent organic fertilizer by itself and many workers worldwide have proved its efficacy on major plant parasitic nematodes and boosting the yield of various crops (Abbasi *et al.*, 2005; Javed *et al.*, 2007; Tiyagi *et al.*, 2011).

Besides being a decomposing agent, *T. viride* is found to be a promising biocontrol agent against many pathogenic fungi and plant parasitic nematodes. Several native *Trichoderma* isolates from potato ecosystem showed positive reactions for chitinase activity, antibiotic production, egg hatching inhibition and egg parasitization of *G. rostochiensis* and *G. pallida* in The Nilgiri hills (Devrajan *et al.*, 2011). In green gram, *T. viride* induced the plant growth and also the systemic resistance in plants against *Meloidogyne incognita* by enhancing the activity of the defense enzymes *viz.*, peroxidase, polyphenoloxidase and catalase. Moreover, it also altered the root exudates and reduced the hatching of eggs of root knot nematode (Umamaheswari *et al.*, 2004). Since the potato root exudates is the key factor for hatching of PCN, alteration of root exudates might have played a vital role in the reduction of PCN population. Thus the present study proved the successful compatibility of the neem cake and *T. viride* and their combined nematicidal action on PCN.

Evaluation of biocontrol agents

It is evident from the results that all the biocontrol agents recorded significantly higher growth parameters and yield and lower PCN population (**Table 2**). However, treatment with carbofuran performed better than all biocontrol agents tested in recording the maximum increase in potato yield (38.20%) and decrease in PCN multiplication (59.82%) (**Fig. 1**).

Among the biocontrol agents tested, *P. fluorescens* Pf1 recorded significantly higher plant height, number of stems and number of leaves and yield on number and weight basis (28.02% increase over control). It also recorded lower PCN population in soil, roots, number of eggs and larvae per g of soil and nematode multiplication (36.99% decrease over control). It was followed by treatments with *P. lilacinus*, *P. chlamydosporia* and *T. viride* which were on par with each other (**Table 2; Fig. 1**).

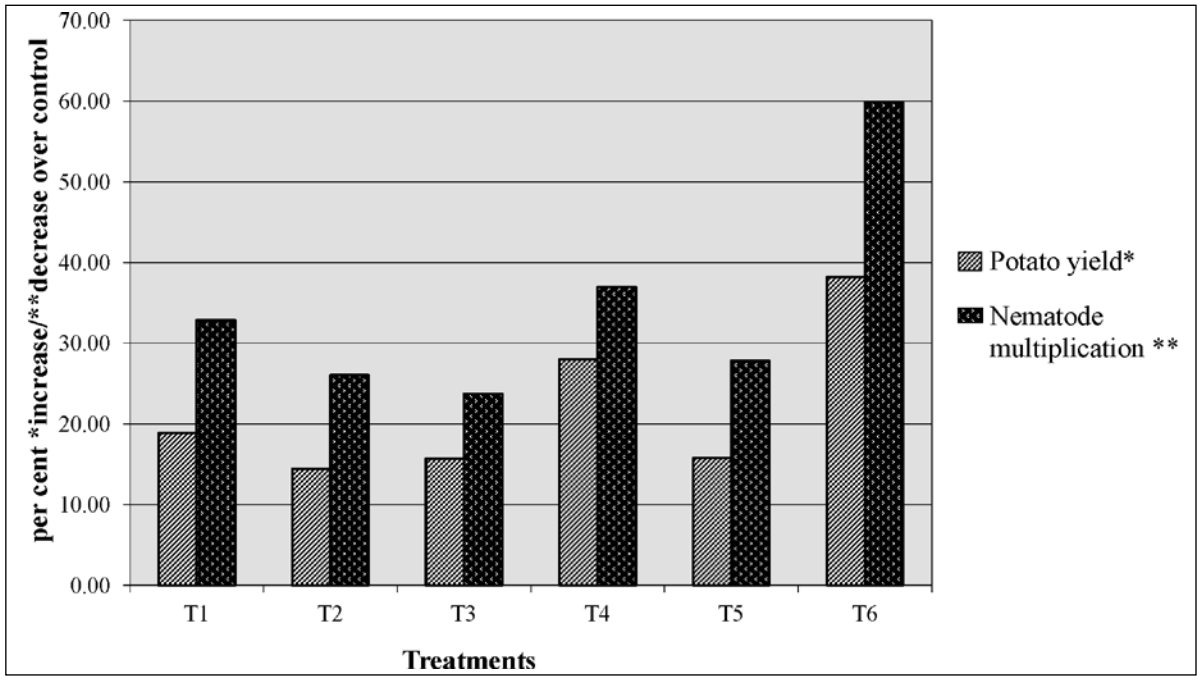

Fig. 1. Effect of biocontrol agents on potato yield and PCN multiplication.

Table 1. Effect of organic amendments on potato growth, yield and PCN population.

Treatment	Plant height (cm)	No. of stems/ plant	No. of leaves/ plant	Total No. of tubers ('000/ ha)	Yield (t/ha)	No. of females/ 2.5 cm root	Final cyst population/ 100 ml soil	No. of eggs and larvae/ g soil	PCN multiplication (Rf)
T_1	43.00	3.03	35.10	539.26	13.96	7.83	290.67	104.23	1.70
T_2	44.13	3.47	38.87	552.59	14.20	6.90	262.67	93.57	1.51
T_3	50.00	4.23	44.40	575.93	14.98	6.13	225.00	65.87	1.31
T_4	48.43	3.77	43.30	541.48	14.53	6.80	241.33	86.10	1.36
T_5	48.90	3.57	42.43	560.00	14.56	6.40	245.33	77.33	1.31
T_6	63.67	5.43	54.97	680.74	18.44	4.67	164.67	54.63	1.07
T_7	59.77	5.33	50.67	634.44	17.16	4.07	120.67	32.47	0.80
T_8	32.00	1.43	21.77	400.37	10.76	10.33	415.33	172.70	2.06
CD (0.05)	5.81	1.04	9.91	84.26	3.19	0.78	99.44	23.83	-
SE(d)	2.71	0.48	4.62	39.28	1.49	0.36	46.36	11.11	-

Table 2. Effect of biocontrol agents on potato growth, yield and nematode population.

Treatment	Plant height (cm)	No. of stems/ plant	No. of leaves/ plant	No. of tubers ('000/ha)	Yield (t/ha)	No. of females/2.5 cm root	Final cyst population/ 100 ml soil	No. of eggs and larvae/ g soil	PCN multiplication (Rf)
T_1	47.10	3.73	39.00	590.74	14.88	7.47	252.00	80.40	1.47
T_2	43.33	3.57	37.53	561.85	14.49	7.60	316.33	92.33	1.62
T_3	43.00	3.30	37.27	555.56	14.33	7.73	293.33	93.70	1.67
T_4	52.80	4.83	45.43	683.70	16.03	5.97	212.33	69.97	1.38
T_5	44.33	3.53	37.74	566.30	14.49	7.50	264.00	81.57	1.58
T_6	60.20	6.27	51.43	763.70	17.30	4.30	164.33	51.67	0.88
T_7	36.43	1.97	27.67	451.48	12.52	12.07	480.00	182.03	2.19
CD (0.05)	4.54	1.08	4.97	64.93	1.05	0.44	37.69	9.97	-
SE(d)	2.08	0.5	2.28	29.8	0.48	0.2	17.3	4.58	-

In earlier studies against cyst nematodes, the biocontrol agents *P. fluorescens* and *P. lilacinus* were found equally effective in reducing the PCN population and increasing potato yield (Seenivasan *et al.,* 2007). *P. fluorescens* is found to be surviving in and colonizing the rhizosphere of several field crops and is reported to promote plant growth (Oyekanmi *et al.,* 2008).

The suppression of phytonematodes by the application of *P. fluorescens* has been attributed to several mechanisms, such as competition for nutrients, production of siderophores and alteration of specific root exudates such as polysaccharides and aminoacids, which modify the nematode behaviour and their host finding mechanisms (Kavitha *et al.*, 2007; Negi *et al.,* 2011). The antibiotic 2,4-diacetyl phloroglucinol, produced by *P. fluorescens* was found inhibitory to root knot and cyst nematodes (Siqqiqui and Shaukat, 2003; Cronin *et al.,* 1997). Soil application of *P. fluorescens* induced the systemic resistance in tomato against *Meloidogyne incognita* by enhancing the activity of defense enzymes like peroxidase, polyphenol oxidase, catalase, chitinase and phenylalanine ammonia lyase (Anita *et al.,* 2004). These mechanisms were involved in the successful control of PCN by *P. fluorescens* which was proved in the present study and hence *P. fluorescens* application and organic amendment with neem cake + *T. viride* can be incorporated as promising components in the IPM strategy for PCN in The Nilgiris region.

CONCLUSIONS

Extensive use of chemical nematicides is not only expensive but also causes serious impact on the environment and human health. Hence, an integrated nematode management (INM) package incorporating judicious blend of various management options such as host resistance, chemical, biological and cultural methods is being advocated in the Nilgiris to bring down the PCN population to levels that permit profitable cultivation of potato. The results of the present study proved the bio-efficacy of organic amendment, neem cake + *T. viride*, and biocontrol agent, *P. fluorescens* by increasing the potato yield as well as minimizing the PCN population. Hence these can be recommended as successful eco-friendly components in the IPM package for the potato farmers of the Nilgiris region.

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