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Effect of cultural practices on potato cyst nematode population dynamics and potato tuber yield

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ABSTRACT

Health concerns related to the use of pesticides are increasing the interest in alternate use of pest and disease control strategies. Accordingly, different cultural practices, *viz*., trap cropping, soil solarization and non-solanaceous crops were evaluated for the management of potato cyst nematode during summer 2013-14 and 2014-15. Among the potato cultivars used as trap crop, Kufri Jyoti attracted more PCN juveniles and recorded maximum reduction in cyst population than Kufri Swarna. In the succeeding crop Kufri Girdhari, wherein Kufri Jyoti used as trap crop recorded more yield than Kufri Swarna in both the spacings. In the soil solarisation experiment, minimum PCN reproduction factor (Rf) was recorded in soil solarisation followed by application of neem cake (@ 5 t/ha) in combination with *Trichoderma viride* (@ 5 kg/ha). The same treatment also produced significantly maximum yield during 2013-14 however, during 2014-15 the yield was found to be on par with soil solarisation + carbofuran (2 kg a.i./ha). All the non-solanaceous crops tested reduced the PCN multiplication ratio. Among different non-solanaceous crops, radish recorded 19.6-21.0% reduction in number of cysts and 12.2-16.2% reduction in number of eggs per cyst. Which was followed by garlic, it recorded 15.9-17.7% and 10.3-11.6% reduction in number of cysts and eggs respectively, during 2013-14 and 2014-15. Therefore, the above said treatments either alone or in combination can be used to manage the PCN.

Key words: Neem cake, non-solanaceous crops, potato, potato cyst mematode, soil solarization, *Trichoderma viride*.

INTRODUCTION

In India, potato is grown under different agroclimatic conditions, *viz*., high hills in north and north-eastern India, subtropical indogangetic plains, plateau as well as hilly regions of southern India. In Nilgiris, the potato crop is being taken up almost throughout the year, because of humid sub tropical weather with well distributed rains from both the monsoons. In India, Jones (6) first reported the presence of cyst nematode from the Nilgiri hills in Tamil Nadu. In order to prevent its further spread, a domestic quarantine was imposed by Tamil Nadu Government in 1971. Potato cyst nematode (PCN), *Globodera pallida* (Stone) and *G. rostochiensis* (Woll.) continue to be a major pest in potato growing areas. Once it's established, difficult to be eradicated from infested field. Despite massive chemical control measures taken up to eradicate, it remains a serious endemic pest of potato in this region due to intensive cultivation of potato and favourable climatic conditions. As per the host differential study, pathotypes Ro1 of the *G. rostochiensis* and Pa2 of *G. Pallida* are the most prevalent forms accounting for 75% of the total populations (Prasad, 8). Conventionally, an integrated approach to PCN management has relied heavily on the utility of chemicals, which is not economical and environmentally safe. Similarly, breeding for resistance has become unsuccessful because of partial resistance to one or other pathotypes. The resistant varieties (Partial) are not able to withstand for different pathotypes. The selection of a *G. rostochiensis* R_1A population on *S. tubersoum* ssp. *andigena,* resulted in a virulent population with R_3A characteristics (Seinhorst, 10). Trap crop has to produce root exudates that stimulate the hatch of PCN juveniles from their cysts. Subsequent reproduction has to be prevented by destruction of the crop before adult female development is completed and plant main crop after destruction of trap crop (Timmermans *et al.*, 11). Soil solarization relies on solar energy, has been used to suppress plant parasitic nematodes (Zasada *et al.*, 15). Growing non-host crops such as barley are grown between host crops reduce nematode population densities (Whitehead *et al.*, 14). Therefore, there is scope for other control measures like (i) Use of trap crop (Scholte and Vos, 9), (ii) Physical method like soil solarization (Candido *et al.*, 2), and (iii) Non-host crop (Wafaa and Mahmoud, 13). Accordingly, experiments were designed and conducted to derive effective management practices using potato as trap crop, soil-solarization combined with organic as well as biocontrol agent and non-solanceous crop.

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MATERIALS AND METHODS

Field experiments on effect of trap crop, soil solarization and non-solanaceous crops on potato cyst nematode population dynamics and potato tuber yield was carried out at ICAR-Central Potato Research Station, Muthorai, Udhagamandalam located at the latitude 11°22'N and longitude 76°40' E and 2130 m above MSL during summer season (May-August) in the year 2013-14 and 2014-15. In the trap crop experiments two potato varieties *viz.*, Kufri Jyoti (Susceptible to PCN) and Kufri Swarna (Resistant to PCN) were evaluated as trap crops in two different spacing's (60 × 20 cm and 45 × 15cm) along with control (Without trap crop). Details of the treatments used in the study are T_1 = Kufri Jyoti (60 × 20 cm), T_2 = Kufri Jyoti (45 × 15 cm), T_3 = Kufri Swarna (60 × 20 cm), T_4 = Kufri Swarna (45 × 15 cm) and T_5 = Control. Each treatment was replicated four times in RBD and the plot size used was 3 × 3m. The trap crop was sown 45 days prior to sowing of main crop Kufri Girdhari and destroyed before completions of PCN life cycle i.e. 45 DAP. Observations like initial PCN population before sowing of trap crop, final PCN population after up-rooting of trap crop and yield of succeeding crop Kufri Girdhari were recorded. Second experiments on effect of soil solarization on PCN population dynamics and tuber yield of Kufri Giriraj was carried out by covering the soil with 150 m thickness transparent LDPE polythene sheet for 6 weeks before planting of summer crop. Different treatment combinations used in the study were T_1 = Soil solarization alone, T_2 = Soil solarization followed by application of neem cake (5 t/ha) + *Trichoderma viride* (5 kg/ha), T_3 = Soil solarization followed by application carbofuran (2 kg a.i./ ha), T_4 = Neem cake (5 t/ha) + *T. viride* (5 kg/ha), T_5 = Carbofuran alone (2 kg a.i./ha) and T_6 = Untreated control. Each treatment was replicated four times in RBD and the plot size used was 3 × 3m. Observations like initial PCN population before soil solarization, final PCN population after harvesting of potato crop and tuber yield were recorded. Third experiments on effect of non-host crops on PCN population dynamics was conducted with different non-solanaceous crops, *viz.*, T_1 = Cabbage, T_2 = Carrot, T_3 = Radish, T_4 = Beetroot, T_5 = Cauliflower, T_6 = Garlic, T_7 = Marigold and T_8-French beans. The crops were planted during summer season to check the effect of these crops on PCN population dynamics. The experiment was conducted in RBD with three replications. Observations on initial and final PCN population and number of eggs per cyst before and after harvesting of non-solanaceous crop were recorded. The initial (IP) and final (FP) PCN population was used for arriving reproduction factor (Rf = Pf/Pi), % reduction in cyst population [(IP-FP)/IP)*100] and % reduction in number of eggs per cyst [(No. of eggs per cyst in IP- No. of eggs per cyst in FP/ No. of eggs per cyst in IP)*100] was calculated based on the average of eggs in five cyst. As the experiment was conducted twice, potato tuber yield data were analyzed for individual year and means were separated according to the least significant differences (LSD) at 0.05 level of probability. Percentage yield increase was also calculated [(treatment yield-control yield)/control yield*100].

RESULTS AND DISCUSSION

The results of trap crop experiment revealed that PCN susceptible cv. Kufri Jyoti planted at 60 × 20 cm spacing attracted more PCN juveniles (J_2) than resistant cv. Kufri Swarna which resulted maximum reduction (30.9-53.6%) in PCN population. This may be due to enlarged root system produced by the susceptible cv. Kufri Jyoti that helped covering greater volume of soil and also production of more root diffusate which stimulated PCN hatching. Vigorous root system attracted large number of juveniles which was destroyed during uprooting of the trap crop before completion of PCN life cycle (Lane and Trudgill, 7). Our results are in confirmation with earlier reports by Whitehead *et al.* (14) they found 75% decrease in *G. pallida* population in heavily infested soil by uprooting of tolerant cv. Cara as a trap crop after six weeks of planting. PCN were effectively controlled by the potato trap crop when a highly resistant potato cultivar and moderately resistant cultivar were grown as a main crop after the trap crop, the post-harvest soil infestation was very low (Scholte and Vos, 9).

In the succeeding crop Kufri Girdhari (34.98-35.33 t/ha), wherein Kufri Jyoti (60 × 20 cm) grown as trap crop recorded 49.8-63.8% more yield as compared to control (21.8-23.4 t/ha). Whereas, it was 25.5-36.1% more wherein PCN resistant cv. Kufri Swarna used as trap crop (Table 1). This is due to more reduction of PCN population in which cv. Kufri Jyoti was grown as trap crop (Fig. 1). Tuber yield increase in potato due to significant reduction of PCN population was also reported earlier by Devrajan *et al.* (3), and Umamaheswari *et al*. (12). Previous study by Ehwaeti *et al.* (4) highlighted a negative correlation between increasing initial PCN population density and yield losses on potato plants, our results are also in agreement with earlier reports.

Soil solarization, a non-chemical technique, captures radiant energy from the sun and thereby changes soil chemical, physical and biological properties. The results revealed that treatments with

Table 1. Effect of trap crop on PCN population dynamics and yield of succeeding potato crop.

Treatment	Summer, 2013-14					Summer, 2014-15				
	Initial cyst population before trap crop	Final cyst population after trap crop	% reduction in cyst population	Yield of main crop (t/ha)	% increase in yield over control	Initial cyst population before trap crop	Final cyst population after trap crop	% reduction in cyst population	Yield of main crop (t/ha)	% increase in yield over control
Kufri Jyoti (60 × 20 cm)	392	184	53.06	34.98	49.8	232.6	160.8	30.9	35.33	61.8
Kufri Jyoti (45 × 15 cm)	341	191	43.99	31.97	36.9	242.5	175.5	27.6	32.24	47.6
Kufri Swarna (60 × 20 cm)	411	279	32.12	29.32	25.5	357.9	279.1	22.0	29.72	36.1
Kufri Swarna (45 × 15 cm)	397	313	21.16	26.85	15.0	389.2	329.2	15.4	27.37	25.3
Control	423	423	0.00	23.36	-	562.0	562.0	0.00	21.84	
$CD_{0.05}$				2.47**					1.87**	

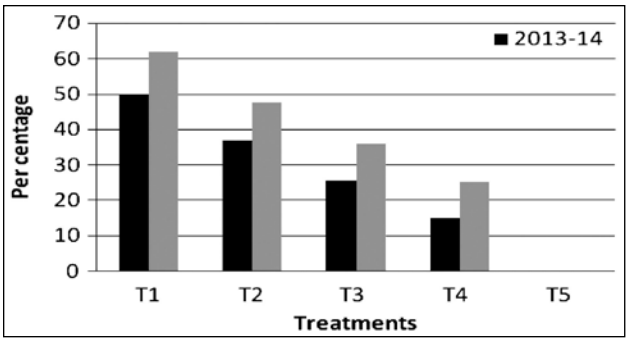

Fig 1. Effect of trap crop on per cent yield increase over control.

soil solarization reduced the PCN population and increased the tuber yield as compared to treatments without soil solarization (Table 2). Minimum (Rf-0.99 to1.02) PCN reproduction (Rf) was recorded in soil solarization followed by application of neem cake (5t/ha) and *T. viride* (5 kg/ha) at the time of planting which was followed by soil solarization and application of carbofuran (2 kg a.i. /ha) (Rf = 1.09 to 1.10) at the time of planting in both the years. This may be due to rise in temperature of soil covered with polythene sheet which killed PCN as effectively as soil fumigant. Greco *et al.* (5) also found less PCN egg survival of 6.8-17% in the soil solarization plots.Treatments receiving organic amendments in combination with *T. viride* performed relatively better than those receiving organic amendments alone (Umamaheswari *et al*., 12). Among the treatments, significantly maximum yield (31.08 t/ha) was recorded in soil solarization followed by application of neem cake (5 t/ha) and *T. viride* (5 kg/ha) at the time of planting during the year 2013-14. However, during the year 2014-15, the same treatment recoded maximum yield (31.10 t/ha) but, which was found to be on par with soil solarization followed by application of carbofuran (2 kg a.i./ha) (29.16 t/ha). In general treatments with soil solarization increased the yield to the tune of 47.75-78.30% over the control. This may be due to low PCN population in the solarization. The beneficial effect of thermal treatment on crop yield can be related not only to the suppression of potato cyst nematodes, may be also due to the release of nutrients induced by high soil temperatures and/or to the suppression of other soil pathogens as reported by Candido *et al*. (2) in tomato. 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 nematode and increased the potato yield (Devrajan *et al*., 3). Neem cake, being a nutrient rich organic material, is found

Table 2. Effect of soil solarization on PCN multiplication and yield of potato.

Treatment	Summer, 2013-14			Summer, 2014-15		
	PCN multiplication (Rf)	Yield (t/ha)	% yield increase over control	PCN multiplication (Rf)	Yield (t/ha)	% yield increase over control
Soil solarisation alone	1.18	27.83	47.75	1.12	28.27	62.10
Soil solarisation + neem cake (5 t/ha) in combination with *Trichoderma viride* (5 kg/ha)	1.02	31.08	64.99	0.99	31.10	78.30
Soil solarisation + carbofuran (2 kg a.i./ha)	1.10	29.03	54.11	1.09	29.16	67.22
Neem cake (5 t/ha) + *T. viride* (5 kg/ha)	1.23	23.71	25.85	1.20	24.43	40.08
Carbofuran alone (2 kg a.i./ha)	1.21	23.63	25.43	1.18	24.04	37.82
Untreated control	2.63	18.84	-	2.83	17.44	-
$CD_{0.05}$		1.67**			2.10**	

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 (Umamaheswari *et al*., 12).

PCN prefer solanaceous crops (potato, tomato, brinjal) for feeding and multiplication. Growing of non-solacaneous crops in crop rotation will bring down the cyst population and increase the yield of potato crop. The results of our study revealed that in general all the non-solanaceous crops reduced the PCN multiplication rate from 0.78-0.95 as compared to potato (1.07-1.28). Among the non-solanaceous crops tested, radish recorded maximum (19.6-21.0%) reduction in number of cysts and number of eggs (12.2-16.2%) per cyst (Table 3). This may be due to effect of root-exudates that suppress the hatching of nematode cysts and also they might have killed PCN larvae that spontaneously hatched due to the presence of potato root exudates in the soil. Growing non-host crop like radish, garlic, beet root, french bean, cruciferous vegetables, turnip or green manure crops bring down the cyst population by more than and 50% (Aires *et al*., 1). Non-solanaceous crop garlic also recorded 15.9-17.7 and 10.3-11.6% reduction in number of cysts and eggs respectively, during 2013-14 and 2014-15 (Fig. 2). Botanical extracts of garlic clove and castor significantly reduced the root-knot nematode galls and egg masses on roots of tomato and number of juveniles in roots and soil, compared to nematicide and non-treated plants (Wafaa and Mahmoud, 13).

Extensive use of chemical nematicides is not only expensive but also causes serious impact on the environment and human health. Therefore, for the management of PCN different cultural practices, *viz*., trap cropping, soil solarization and non-solanaceous crops is being advocated in the Nilgiris to bring down the PCN population to the levels that permit profitable cultivation of potato. The results of the present study proved that the trap crop can be an alternative to chemical soil disinfection. But the stage of destroying/ lifting of trap crop is important to ensure optimum control. Soil solarisation during summer for four weeks followed by application of neem cake (@ 5 t/ha) in combination with *Trichoderma viride* (@ 5 kg/ha) also minimized the PCN population

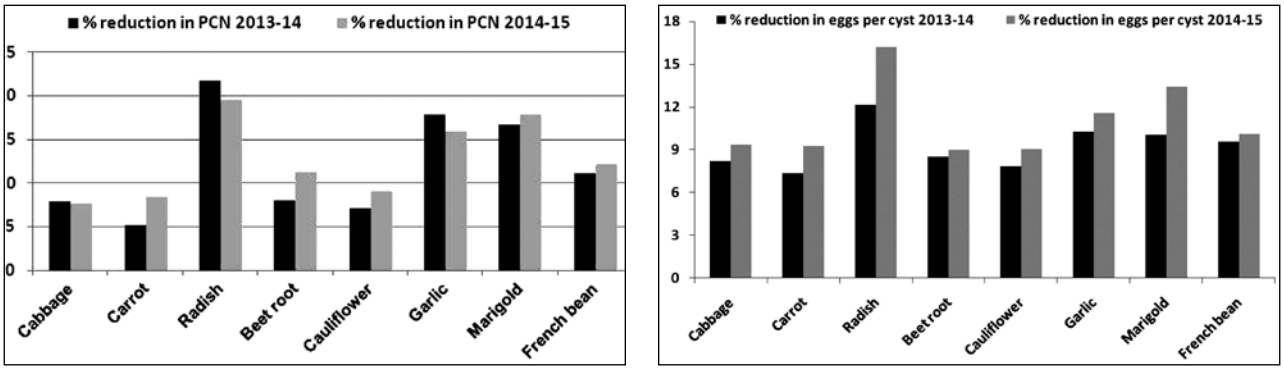

Fig. 2. Effect of non-solanaceous crops on per cent reduction of PCN population over control and number of eggs per cyst.

Table 3. Evaluation of non-host crops on PCN dynamics.

Non-solanaceous crop	Summer, 2013-14					Summer, 2014-15				
	Before the crop		After the crop		PCN multiplication (Rf)	Before the crop		After the crop		PCN multiplication (Rf)
	Cyst population	Eggs per cyst	Cyst population	Eggs per cyst		Cyst population	Eggs per cyst	Cyst population	Eggs per cyst	
Cabbage	248	195	228	179	0.92	228	179	213	162	0.93
Carrot	410	230	389	213	0.95	389	213	369	196	0.95
Radish	356	189	279	166	0.78	279	166	224	142	0.80
Beet root	394	269	36	246	0.92	362	246	317	223	0.88
Cauliflower	395	217	366	200	0.93	366	200	335	183	0.92
Garlic	225	224	185	201	0.82	185	201	152	176	0.83
Marigold	247	209	206	188	0.83	206	188	174	166	0.84
French beans	254	198	226	179	0.89	226	178	198	159	0.88

and increased the potato yield. Non-solanaceous crops, *viz.,* radish and garlic were effective to reduce the PCN multiplication hence, this can be used as either intercrop or as rotational crop. Therefore, the above said technologies can be recommended as eco-friendly component in the IPM package for the management of PCN in The Nilgiris.

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