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EFFECT OF BIOFUMIGATION ON POTATO CYST NEMATODES

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ABSTRACT: Potato cyst nematodes (PCN) *Globodera rostochiensis* (Woll) and *G. pallida* (Stone) hinder the sustainable production of potato in the Nilgiri hills of Tamil Nadu. It remains as a serious endemic pest of potato in this region due to intensive cultivation of potato and favourable climatic conditions. Hence, field experiments were conducted to evaluate the efficacy of bio-fumigation by incorporating chopped residues of radish, cabbage and cauliflower in potato cv. Kufri Giriraj. One set of treatments were covered with transparent polyethylene sheets for 4 weeks before planting and another set was left uncovered. The biofumigants were compared with the chemical nematicide carbofuran @ 2 kg a.i /ha. The treatments were replicated thrice in a randomized block design. The results revealed that all the treatments significantly increased the potato yield and decreased the nematode population. Incorporation of radish leaves @ 1 kg/m^2 and covering with polyethylene sheet recorded maximum growth parameters, yield (25.97 t/ha) and minimum PCN reproduction factor (Rf) 1.21. It was on par with carbofuran treatment which yielded 25.09 t/ha and PCN reproduction factor (Rf) 1.24 and was followed by cabbage and cauliflower residues covered with polyethylene sheet.

KYEWORDS: Biofumigation, cyst nematode, cabbage, cauliflower, radish, polyethylene

INTRODUCTION

Potato is a one of the most important non-cereal horticultural food crop of India. India ranks third in potato area (1.90 million ha) and second in production (45 million tonnes) with an average yield of 22.9 t/ha (Pandey *et al*., 2014). Potato is one of the major cash crops in the Nilgiris which is bestowed with such a climatic condition that is conducive for its cultivation all round the year (Ravichandran *et al*., 2011). However, potato cyst nematodes (PCN) *Globodera rostochiensis* (Woll) and *G. pallida* (Stone) are reported from the Nilgiri and Kodaikanal hills of Tamil Nadu and adjoining hills of Kerala and Karnataka (Prasad, 1993) which is a important pests that seriously affect the sustainable production of potato in many countries worldwide. Globally, an average yield loss of nine per cent has been estimated due to this nematode alone (Evans and Rowe, 1998). To manage this, massive chemical control measures were undertaken in the 1970s (Prasad, 2001) but it was found inadequate to keep the nematode under check for longer periods besides being expensive and environmentally hazardous. This necessitated the development of alternative control measures to bring down the population to levels that permit profitable cultivation of potato in the Nilgiris. Plants from the Brassicaceae family are reported to suppress soil borne pathogens and pests including plant parasitic nematodes when used as soil amendment and the practice of incorporating brassicaceous plant material into the soil to control soil borne organisms has been termed as biofumigation (Thoden *et al*., 2011).

This bio-fumigant effect is obtained when compound like isothiocyanates (a hydrolysed form of glucosinolates present in all members of the Brassicaceae) are released during the breakdown and soil incorporation. These isothiocyanates are known to possess broad pesticidal activity against weeds, bacteria, fungi and nematodes (Ploeg, 2007; Reddy,

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2011) and are similar or relative to compounds found in commercial soil fumigants, such as metham sodium and dazomet, which release methyl isothiocyanates into the soil (Lazzeri *et al*., 2003; Westerdahl, 2011). Therefore, keeping the above fact in view biofumigation efficacy of different Brassicaceae crop residue was investigated as a cultural component for integrated management of PCN in the Nilgiris.

MATERIALS AND METHODS

Field experiments were conducted in summer seasons in the same plot during 2012-13 and 2013-14 at ICAR-Central Potato Research Station, Muthorai, Udhagamandalm having mixed population of *Globodera rostochiensis* and *Globodera pallida* (1:1) to evaluate the efficacy of biofumigation by incorporating chopped residues of radish cv. Nilgiri red, cabbage cv. Takila and cauliflower cv. Ooty-1 @ 1 kg/m^2. The fresh crop residues left unused in the field after harvest were chopped and used in the experiment. One set of treatments were covered with transparent polyethylene sheets (150 µ) after residue incorporation for 4 weeks and another set was left uncovered. After four weeks the plots were planted with cv. Kufri Giriraj. The effect of bio-fumigants were compared with chemical nematicide carbofuran @ 2 kg *a.i.*/ha applied at the time of planting. The treatments were given 4 weeks before planting as per the schedule: T_1: Cabbage leaves @ 1 kg/m^2, T_2: Cabbage leaves @ 1 kg/m^2 + polyethylene covering, T_3: Radish leaves @ 1 kg/m^2, T_4: Radish leaves @ 1 kg/m^2 + polyethylene covering, T_5: Cauliflower leaves @ 1 kg/m^2, T_6: Cauliflower leaves @ 1 kg/m^2 + polyethylene covering and T_7: Carbofuran @ 2 kg a.i/ ha and T_8: Untreated control. The treatments were replicated thrice in plots of 3 x 1.8 m in a randomized block design. Observations were recorded on the plant growth parameters *viz.,* plant height, number of stems and number of leaves at 75 days after planting. At the time of harvest, yield parameters *viz.,* number of tubers and tuber weight was recorded. 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. Per cent reduction in nematode reproduction was calculated for treatments compared to control by using the formula [(C–T)/ T] X 100 wherein C-Nematode reproduction factor in Control, T-Nematode reproduction factor in Treatment. 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. The results of the two years' experiments were pooled and statistically analyzed (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

The results revealed that all the biofumigation treatments significantly increased the potato yield and decreased the nematode population. In general, covering of plots with polyethylene sheet after incorporation of crop residues was more effective than those left uncovered.

Among all the treatments, incorporation of chopped radish leaves @ 1 kg/m^2 with polyethylene covering recorded maximum growth parameters in terms of plant height, number of stems, number of leaves and yield parameters in terms of number of tubers and tuber weight. It was coupled with minimum number of eggs and larvae per gram soil and nematode reproduction **(Table 1 and 2)**. It recorded 66.67% increase in yield

Table 1. Effect of biofumigation on growth parameters (75 DAP) and yield of potato (120 DAP).

Treatments	Plant height (cm)	No. of stems/plant	No. of leaves/plant	No. of tubers ('000/ha)	Yield (t/ha)
T_1	48.33	3.33	38.67	599.89	18.82
T_2	54.13	4.00	43.00	655.56	20.36
T_3	57.67	4.33	44.33	693.18	22.69
T_4	64.33	5.67	54.67	772.77	25.97
T_5	42.67	2.67	35.00	561.85	18.59
T_6	51.23	3.67	41.67	623.32	19.89
T_7	62.00	5.33	50.67	750.27	25.09
T_8	34.67	1.67	24.33	451.48	15.58
CD (0.05)	4.16	1.11	10.24	43.13	2.05

Table 2. Effect of biofumigation on PCN population.

Treatments	No. of females/ 2.5 cm root	Initial cyst population (Pi)/ 100 ml soil	Final cyst population (Pf)/ 100 ml soil	No. of eggs and larvae/g soil	PCN multiplication (Rf)*
T_1	7.47	180.95	291.33	92.67	1.61
T_2	6.80	178.72	252.00	82.33	1.41
T_3	5.23	170.87	230.67	76.33	1.35
T_4	4.07	138.29	167.33	52.33	1.21
T_5	7.80	170.97	304.33	89.00	1.78
T_6	7.10	185.14	274.00	97.33	1.48
T_7	4.63	138.71	172.00	58.33	1.24
T_8	11.33	161.61	501.00	181.00	3.10
CD (0.05)	1.13		28.42	19.8	

*Rf = nematode reproduction factor (Pf/Pi).

and 60.97% decrease in PCN population, with high nematicidal action under polyethylene covering as compared to untreated control **(Fig. 1)**.

Incorporation of radish residues with polyethylene covering was on par with carbofuran treatment which resulted in 61.0% increase in yield and 60.0% decrease in nematode reproduction. It was followed by other treatments with cabbage and cauliflower where covering with polyethylene sheets was more effective than those left uncovered and recorded 30.65 and 27.66% increase in yield and 54.52 and 52.26% decrease in PCN reproduction, respectively, over untreated control treatment. Plots incorporated with radish, cabbage and cauliflower left uncovered recorded 45.60, 20.76 and 19.31% increase in yield and 56.45, 48.07 and 42.58% decrease in PCN reproduction, respectively, over untreated control. If the trend of the two years' experiment was analyzed, it could be observed that there was an increasing trend in the yield and decreasing trend in PCN population over the two years because of bio-fumigation treatments in the plots **(Fig. 1)**.

The results of the present investigation are in line with **e**arlier reports by Lord *et al.* (2011) wherein twelve of the 22 brassica accessions screened *in vitro* against *G. pallida* significantly inhibited the motility of *G. pallida* juveniles and the most potent were radish (*Raphanus sativus* cv. Weedcheck), cress (*Nasturtium officinale*) and Indian mustard (*Brassica juncea*

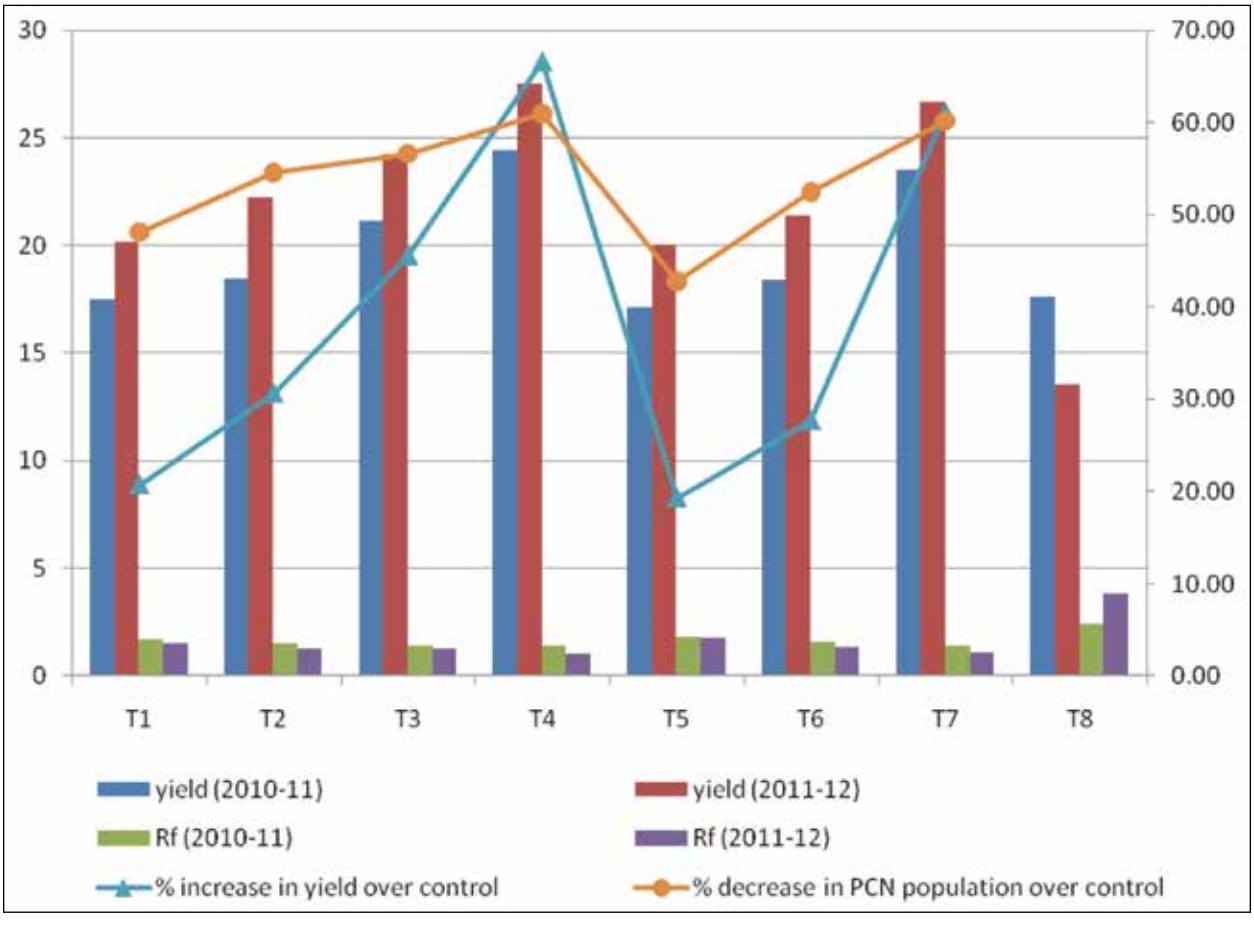

Fig. 1. Effect of biofumigation on potato yield and PCN population.

cv. Nemfix) which caused 97, 93 and 89% inhibition in juvenile motility, respectively. Aires *et al.* (2009) reported that biofumigation by amending plant parts of Brassicaceae recorded lower numbers of cysts from potato roots that received extracts of watercress, cauliflower and *Brassica rapa.* Reproduction factor (Rf) was minimum for water cress followed by cauliflower and *Brassica rapa,* based on the high levels of 2-phenthyl and 2-propenyl glucosinolates in these plants.

Glucosinolates, secondary metabolites sequestered within the plant tissues are regarded as a natural chemical defense to protect the plant against diseases and pests (Hopkins *et al.*, 2009). When brassica plants are chopped and incorporated immediately in the soil, the plant tissues get ruptured or lysed and release a flush of toxic and volatile isothiocyanates in sufficient concentrations to affect plant parasitic nematode populations (Ploeg, 2008). In addition to glucosinolate hydrolysis products, decomposing brassica residues are reported to produce other volatile sulfur containing toxins including methyl sulfide, dimethyl sulfide, dimethyl disulfide, carbon disulfide and methanethiol which may play a role in biofumigation (Wang *et al.*, 2009) and dimethyl disulfide and carbon disulfide are particularly toxic to nematodes (Gu *et al.*, 2007; Rosskopf *et al.*, 2006).

In the present study, covering soil with polyethylene sheet after incorporation of residues performed better than those left

uncovered. Similar trend was also reported in earlier studies by Lord *et al*. (2011) wherein incorporation of three *Brassica juncea* lines (Nemfix, Fumus and ISC 199) containing high concentrations of 2-propenyl glucosinolate were the most effective in causing 95% mortality of encysted eggs of *G. pallida* in polyethylene covered soil and the toxic effects of bio-fumigants were more in polyethylene covered soil than in open soil. This may prevent rapid emission of volatile nematicidal compounds from the soil to the atmosphere and increase the soil temperature via soil solarisation effect when performed in hot seasons (Ploeg and Stapleton, 2001). Combination of biofumigation by *Brassica juncea* and soil solarization by covering with transparent polyethylene mulch was the most effective in increasing tomato yields and decreasing densities of *Pyrenochaeta lycopersici* (corky root rot) and *Meloidogyne incognita* (root knot nematode) (Iapichino *et al*., 2008.). This proves our present investigation wherein plots covered with polyethylene sheet after residue incorporation resulted in increased potato yield and decreased nematode densities. Hence in the present study, increased potato yield was recorded due to biofumigation effect of the brassicaceous crops coupled with nematode control.

CONCLUSION

Potato is one of the major cash crops in the Nilgiris which is bestowed with such a climatic condition that is conducive for its cultivation all round the year. Because of it, the potato cyst nematodes have emerged as the serious endemic pest of this area. Extensive use of chemical nematicides for control of PCN is not only expensive but also hazardous to environment and human health. Hence, an integrated nematode management package incorporating judicious combination of various management options such as host resistance, chemical, biological and cultural methods is being advocated for PCN decline. The results of the present study prove that bio-fumigation also has the potential to contribute as a successful eco-friendly component in the integrated nematode management package for the potato farmers of the Nilgiri region.

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