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Crucifer vegetable leaf wastes as biofumigants for the management of root knot nematode (*Meloidogyne hapla* Chitwood) in celery (*Apium graveolens* L.)

B. Anita

ABSTRACT

The biocidal activity of various isothiocyanates (ITCs) released by *Brassica* tissues is well-known for its potential to suppress a range of soil-borne pests and diseases. A study was carried out to evaluate the effect of incorporating fresh crucifer residue on root knot nematode, *Meloidogyne hapla* inoculum density, root knot disease development and celery yield. The ethanol extracts of cabbage, cauliflower, radish and Chinese cabbage leaves after harvest was applied to moist soil with high nematode population and covered with low density polyethylene sheets (50 micron thickness). After 15 days the sheet was removed and celery seedlings were planted. Observation on shoot length, root length, green leaf and stalk yield and nematode population were recorded. Biofumigation with sulphur containing cruciferous vegetable waste at the rate of 1kg/5 kg soil was found to reduce significantly the root knot nematode, *M .hapla* infecting celery and enhance plant growth and yield. Among the various sources evaluated radish leaf residue was the most effective resulting in 60.6 % reduction in nematode population in soil and 41.9% increase in celery green leaf and stalk yield compared to untreated control.

Key words: Biofumigation, celery, crucifers, *Meloidogyne hapla*

INTRODUCTION

Celery (*Apium graveolens*) is popular among the world's salad vegetables and is generally considered native to the Mediterranean region. It has a relatively long production cycle, with seedlings being raised for 8–10 weeks as transplants and then for another 10–12 weeks in the field. The resultant long growing season exposes the crop to numerous pathogens (Vovlas *et al*., 2008). Root knot nematodes (*Meloidogyne* spp.) can severely damage and cause significant losses in celery (Koshy *et al*., 2005). Control strategies *viz*., use of nematicides, soil solarization, organic amendments, biological control, nematicidal plants or genetic resistance that aim to prevent nematode attack in infested celery fields are used to achieve progressive reduction of infestation level to bring down the tolerance limit of the target nematode species.

Biofumigation is an agronomic practice of using volatile chemicals (allelochemicals), released from decomposing *Brassica* tissues, to suppress soil-borne pests and pathogens (Berbegal *et al*., 2008).The potential of secondary plant products released from residues of *Brassica* spp. following their incorporation into soil to suppress pests has long been recognized in this process (Angus *et al*., 1994; Matthiessen and Kirkegaard, 2006). Mechanisms for control have been attributed partially to the chemical breakdown products of glucosinolates (GLS), the characteristic constituents of crucifer crops. GLS hydrolysis releases, among other secondary compounds, isothiocyanates (ITCs) that have fungicidal and nematicidal properties (Subbarao and Hubbard,1996; Brown and Morra,1997; Subbarao *et al*.,1999; Djian-Caporalino *et al*., 2005). Other reasons for disease suppression from crucifer residue incorporation include non host or trap crop effects, and indirect effects on the pathogen associated with changes in the populations of antagonistic organisms, as well as effects of compounds released from the tissues that may not be related to GLS or ITCs (Matthiessen and Kirkegaard, 2006). With the available traditional knowledge of achieving biofumigation, coupled with availability of a wide range of genetic variation in Brassicaceous crops commonly grown in the region (Sasi *et al*., 2011), biofumigation presents itself as an ecologically safe and economically sound option for nematode disease management to vegetable small holders in Nilgiris.With this background a preliminary study was carried out to evaluate the effect of incorporating fresh cruciferous vegetable residue on root knot nematode population, disease development and celery yield and determine if there is an additional effect of soil solarization when combined with these treatments.

MATERIALS AND METHODS

A pot culture trial was conducted to study the biofumigant properties of crucifer vegetable wastes available in plenty after harvest in Nilgiris against *M. hapla* in celery. Fresh leaf residues of cabbage, cauliflower, radish and Chinese cabbage after harvest were collected and used in the study. The leaf residue was washed free of adhering soil and one kg of the chopped leaf material was ground in 200 mL of 20% alcohol for better extraction of glucosinolates (Elseke, 2004). The green slurry was incorporated immediately to 5 kg sufficiently moist nematode infected soil in earthen pots and covered with 50 micron thick black LLDPE sheets (Jain Irrigation Systems Ltd., India) air tight. This set up was left as such in the glass house for 15 days at a temperature ranging between a maximum of 27°C and a minimum of 17°C with a relative humidity of 60%.Then the plastic sheet was removed and celery seedlings were planted.

The overall mean initial population level of *M. hapla* before treating was estimated. Soil samples (100 g each) were processed and active nematode juveniles extracted by combining Cobb's sieving and decanting method with the Baermann technique (Schindler, 1961). *Meloidogyne hapla* juveniles per ml of aqueous suspension were counted with a microscope. The number of the nematodes per 100 g soil from all the 5 replicates was pooled and the mean value for each treatment was calculated. The shoot length, root length, green leaf and stalk yield were measured in the celery crop in treated and untreated pots. Root-gall index (on a 1-5 scale, according to Heald *et al.*, 1989) and nematode population levels in root (Byrd *et al.*, 1983) and soil (Trudgill *et al.*, 1972) were recorded in each pot. The experiment was conducted in a completely randomized block design and the treatments were replicated five times. Data collected were subjected to analysis of variance and significance assessed by means of a modified Duncan's multiple range tests (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Biofumigation with sulfur containing cruciferous vegetable waste was found to significantly reduce the root knot nematode, *M. hapla* infecting celery and enhance plant growth and yield. Among the various sources tried *viz.*, cabbage, cauliflower, Chinese cabbage and radish for their biofumigant properties against nematodes, radish leaf residue was the most effective. The ethanol extract of fresh radish leaf residue reduced the root knot nematode population in soil by 60.6 % compared to untreated control. The root gall index was 2 in this treatment compared to 5 in untreated control. As a result there was a 42% increase in celery green leaf and stalk yield. Cabbage leaf residue was the next best treatment in reducing the root knot nematode population in soil and roots. There was a significant reduction in the population of *M. hapla* in soil and root in the biofumigated soil with 36.9% increase in the green leaf and stalk yield of celery.

A lot of investigations have been made about root-knot nematodes *Meloidogyne* spp. and they indicate that the use of different plant materials can be efficient for controlling these pests. Fresh tissues (2, 5 % w/w) of *B. napus*, *B. rapa*, *B. juncea*, *B. carinata*, *Raphanus sativus* and *Crambe abyssinica* incorporated in soil infested with *M. incognita* significantly suppressed nematode multiplication on the roots, compared to the untreated control (Auger and Thibout, 2005).

Table 1. Effect of crucifer vegetable leaf residue on plant growth and yield of celery (n = 5)

Treatment	Shoot length (cm)	Root length (cm)	Green Leaf and stalk yield/plant(g)
Cabbage leaf waste @1 kg/5kg soil	52.5^{b}	15.7^{a}	339.8^{b}
Cauliflower leaf waste @1 kg/5kg soil	43.6^{d}	13.8^{c}	321.8^{c}
Radish leaf waste @1 kg/5kg soil	54.9^{a}	16.4^{a}	369.6^{a}
Chinese cabbage leaf waste @1 kg/5kg soil	45.5^{c}	14.2^{c}	298.5^{d}
Untreated control	39.6^{e}	6.4^{d}	214.5^{e}
S. Ed. ±	0.91	0.86	1.31
CD(P=0.05)	1.5	0.92	3.52

Table 2. Effect of crucifer vegetable leaf residue on root knot disease and population of *M.hapla* (n=5)

Treatment	Root gall index	Nematode population per 100g soil	Number of females per g root
Cabbage leaf waste @1 kg/5kg soil	3	166.3[b]	16.5[b]
Cauliflower leaf waste @1 kg/5kg soil	3	194.8[c]	18.9[c]
Radish leaf waste @1 kg/5kg soil	2	142.9[a]	12.6[a]
Chinese cabbage leaf waste @1 kg/5kg soil	3	210.5[d]	29.3[d]
Untreated control	5	362.6[e]	39.5[e]
S.Ed. ±		1.09	0.36
CD(P=0.05)	-	4.56	1.4

Results from different studies have demonstrated the effectiveness of crucifer residue incorporation in the reduction of both *V.dahliae* microsclerotia in soil and the incidence of Verticillium wilt in Artichoke (Berbegal *et al.*, 2008). One plant based bio-fumigant containing mustard and chilli pepper extracts (Dazitol) was found to reduce the population of potato cyst nematodes in soil (Martin *et al.*, 2007).

In the present study it was observed that covering with polyethylene sheets enhanced the efficacy of the crucifer leaf residue in reducing the root knot nematode population. According to various other studies, the strategy of covering the field with plastics to retain volatile compounds in soil released by crucifer crop residues is known to increase their effect on the incidence of various diseases (Gamliel and Stapleton, 1993; Block *et al.*, 2000). Mechanisms of nematode control when crucifer amendments are incorporated into soil are varied and often unknown. However, it has been widely assumed that they are based on the release of toxic volatile compounds (Wiggins and Kinkel, 2005). These mechanisms need to be further investigated specifically with the aim to develop bio-pesticides, which could be effective against various soil borne nematodes as well as root pathogens without deteriorating the soil environment.

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B. Anita
Department of Nematology, Tamil Nadu Agricultural University, Coimbatore - 641003. India. Phone: + 91 763912 3531; E-mail: anitabellie@gmail.com.

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