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EFFECT OF CABBAGE (*BRASSICA OLERACEA*) LEAF RESIDUE AS A BIOFUMIGANT, ON ROOT KNOT NEMATODE, *MELOIDOGYNE INCOGNITA* INFECTING TOMATO

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Abstract: Under greenhouse conditions, crushed cabbage leaves (*Brassica oleracea*) were incorporated into the soil at different rates (2.5, 5 and 10g per pot), 10 days before transplanting tomato cv. Super Strain B. The crushed leaves were mixed in with the soil at different interval times (5 g at transplanting, and 5 and 10 days before transplanting) for managing root knot nematode, *Meloidogyne incognita*. Results indicated that adding different rates of crushed cabbage leaves significantly ($p \leq 0.05$) affected nematode criteria. The higher the rate of residue, the higher the percentage of nematode reduction. Adding a moderate rate (5 g) of crushed cabbage leaves reduced nematode criteria according to the time the leaves were added before transplanting. There was a negative correlation between the time of the addition and the percentage of nematode reduction. Also plant growth criteria improved according to the tested rates and the time the leaves were added.

Key words: cabbage leaves residue, *Meloidogyne incognita,* tomato

INTRODUCTION

Root knot nematodes (*Meloidogyne* spp.) are economically damaging nematodes on a range of crops in subtropical and tropical climates (Koenning *et al*. 1999; Stirling and Stirling 2003). For control, chemical nematicides can be used, but the range of available compounds is limited. The compounds are expensive and their uses have negative impacts on the environement and on public health. As a result, there is growing interest in alternative methods of management that are economically viable and non-polluting.

An alternative management strategy that is receiving increased interest, is fumigation. The first journal article on biofumigation was published in 1994 (Angus *et al*. 1994). Biofumigation was defined by several researchers (Halberendt 1996; Kirkegaard and Sarwar 1998) as a process that occurs when volatile compounds with pesticidal properties are released during decomposition of plant materials or animal products. Cruciferous plants belonging to *Brassica* spp. contain glucosinolate compounds. A number of toxic products (*e.g.* thiocyanate, isothiocyanate) are known to be released from these compounds during decomposition (Chew 1988; Brown *et al*. 1991). Their efficacy in suppressing nematodes and soil borne diseases has been demonstrated (Angus *et al*. 1994). Hence, the goal of this study is to compare the efficacy of cabbage leaf residue, as a biofumigant, at three rates and three times of addition to the soil. The residue is to be used for managing root knot nematode *M. incognita* infecting tomato under greenhouse conditions.

MATERIALS AND METHODS

Crushed cabbage leaves (*Brassica oleracea*) were incorporated into the soil at different rates and at different interval times. Thirty-day-old tomato (*Solanum lycopersicum*) seedlings cv. Super Strain-B were transplanted in 15-cm-diameter clay pots filled with 1 kg solarized sandy loam soil (1:1 w/w) on 22/9/2011. Treatments were applied as follows:

– as for rates, crushed cabbage leaves were added at 2.5, 5.0 and 10.0 g, 10 days before transplanting on 12/9/2011,
– as for interval times, 5 g of the leaves were added at three times: 10 days before transplanting, 5 days before transplanting, and at transplanting time.

The treated soil was covered with a plastic sheet to hold back the fumes which were the result of leaves decomposing in soil. The sheet was removed at transplanting time. After four days of transplanting, 1,000 freshly hatched juveniles/pots were added. Each treatment was replicated five times and equal numbers of non-treated replicates served as the control. Plants were uprooted on 19/1/ 2012. This was 114 days after inoculation. The nematodes in the soil were extracted by sieving and decanting methods (Barker 1985). The number of galls, egg masses, females and the developmental stages, in roots of tomato, were counted. Plant growth parameters were recorded. Chemical analysis and C:N ratio of the tested organic material according to Cottenie *et al*. (1982) is illustrated in table 1.

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Table 1. Chemical analysis and C:N ratio of organic soil amendment

Treatment	Mineral carbon [%]	Organic carbon [%]	Organic matter [%]	Nitrogen [%]	C:N
cabbage (*Brassica oleracea*)	10.15	52.24	89.85	3.71	14.1:1

C:N – organic carbon:nitrogen

Statistical analysis:

The statistical analysis system (SAS 1999) analyzed the data by using the general linear model (GLM) procedure. Differences among groups were determined by Duncan's Multiple Range Test.

RESULTS

Data in table 2 indicate that adding different rates (2.5, 5 and 10 g) of crushed cabbage leaves, 10 days before transplanting to soil planted with tomato cv. Super Strain B, significantly ($p \leq 0.05$) affected nematode criteria as evident by the number of galls, egg masses, females and developmental stages in roots, and number of juveniles in soil. The higher rate revealed a greater percentage in nematode reduction. Table 2 indicated that adding a moderate rate (5 g) of crushed cabbage leaves (*Brassica oleracea*) significantly ($p \leq 0.05$) reduced nematode criteria according to the time the cabbage residue was added before transplanting. Thus, there was a negative correlation between the time of the addition of the residue and the percentage of nematode reduction. For example, the highest percentage of nematode reduction occurred when cabbage residue was added at the time of transplanting. The second highest percentage of nematode reduction occurred when cabbage residue was added 5 days after transplanting. By 10 days after transplanting, the percentage of nematode reduction was in third place.

As for plant growth, when tomato was treated by different rates of crushed cabbage leaves, the percentage increase in plant growth parameters gradually rose from a low rate, and then reached maximum at a moderate rate. There was a decrease at the high rate for all criteria except shoot fresh weight. When cabbage leaf residue was added at the rate of 5 g, 10 days before transplanting, there was a negative correlation between the time of addition and the percentages of plant growth increases. There were no increases when the residue was added at the time of transplanting (Table 3).

Table 2. Effect of crushed cabbage leaves as a biofumigant at different rates and different adding times on *Meloidogyne incognita* parameters infecting tomato plants

Treatment	Galls		Egg masses		Females		Developmental stages		Larvae/1 kg soil	
	No.	% Red.	No.	% Red.	No.	% Red.	No.	% Red.	No.	% Red.
Rates (g) added 10 days before transplanting:										
2.5	420 ab	28.2	359 abc	44.3	526 ab	28.3	173 b	68.6	1640 b	26.1
5.0	333 abc	43.1	332 abc	48.5	363 abc	50.5	160 b	71.0	1395 b	37.2
10.0	317 abc	45.8	229 bc	64.4	284 bc	61.3	69 b	87.5	1250 b	43.7
Time [days] 5g added:										
10 days before transplanting	406 ab	30.6	448 ab	30.4	454 abc	38.2	186 b	66.2	1275 b	42.6
5 days before transplanting	248 ab	57.6	265 bc	58.9	322 bc	56.1	56 b	89.8	1150 b	48.2
At transplanting	70 c	88.0	61 c	90.5	83 c	88.7	3 b	99.5	570 c	74.3
Untreated control	585 a	–	644 a	–	734 a	–	551 a	–	2220 a	–

Values are averages of 5 replicates. Figures in each column followed by the same letter(s) are not significantly ($p \leq 0.05$) different according to Duncan's Multiple Range Test

Table 3. Effect of crushed cabbage leaves as a biofumigant at different rates and different adding times on growth parameters of tomato plants infected with *Meloidogyne incognita*

Treatment	Lengths [cm]				Fresh weights [g]				Dry weights [g]			
	root	[%] Inc.	shoot	[%] Inc.	root	[%] Inc.	shoot	[%] Inc.	root	[%] Inc.	shoot	[%] Inc.
Rates [g] added 10 days before transplanting:												
2.5	24.60 a	–	74.00 a	04.2	6.27 ab	37.5	28.52ab	12.0	0.68 a	19.3	4.18 ab	06.6
5.0	29.60 a	19.4	85.80 a	20.9	6.76 ab	48.3	36.58a	43.6	0.74 a	29.8	6.45 a	64.5
10.0	24.80 a	–	79.00 a	11.3	6.33 ab	38.8	37.84a	48.6	0.70 a	22.8	6.10 a	55.6
Time [days] 5g added:												
10 days before transplanting	31.80 a	28.2	88.20 a	24.2	8.29 a	81.8	37.14 a	45.8	0.82 a	43.9	6.22 a	58.7
5 days before transplanting	28.50 a	14.9	83.67 a	17.9	7.41 ab	62.5	35.44 a	39.1	0.81 a	42.1	6.10 a	55.6
At transplanting	22.00 a	–	60.25 a	–	2.56 b	–	18.57 b	–	0.16 a	–	2.75 b	–
Untreated control	24.80 a	–	71.00 a	–	4.56 ab	–	25.47ab	–	0.57 a		3.92 ab	–

Values are averages of 5 replicates. Figures in each column followed by the same letter(s) are not significantly ($p \leq 0.05$) different according to Duncan's Multiple Range Test; Inc. – Increase

DISCUSSION

Amending soil with crushed cabbage leaves significantly ($p \leq 0.05$) reduced *M. incognita* criteria and enhanced plant growth criteria of tomato cv. Super Strain B. These results agree with those obtained by Motjahedi *et al*. (1993), Lazzeri *et al*. (1993) and Lopez-Perez *et al*. (2005). In this study, there was a positive correlation between the rates of cabbage leaf residue and the percentage of nematode reduction. This result was in agreement with that of Kwerepe and Labuschagne (2003) who found that low rates of cruciferous residues (2 kg/m^2 or 20 kg/ha) were ineffective in reducing the galling of *M. incognita*, but higher rates (6 kg/m^2 or 60 kg/ha) caused a higher reduction. Thus, the high rate of 10 g added at 10 days before transplanting, in the present study, was effective in reducing nematode parameters, but it tended to be phytotoxic. This was the case with most chemical pesticides at high rates. Effective nematode control is, therefore, dependent on amendment at a rate which is below the threshold of phytotoxicity, but still in effective use. Also, the addition of cabbage residue (5 g) at transplanting time, caused the highest percentage nematode reduction, compared to the other times. However, no increases occurred in plant growth criteria at this time, which may explain the phytotoxic effect that occurred at this time. Thus, when the time after the addition was prolonged, there was less of an effect on nematode and less phytotoxicity occurred. As a result, maximum plant growth increases with less effect on nematode caused by cabbage residue added 10 days before transplanting. This may be because of the quick decomposition of the tested residue in soil. Rapid evaporation and partial loss of the volatile compounds occurred after removing the plastic sheet during the transplanting process and before nematode inoculation. Roubtsova *et al*. (2007) showed that for the nematicidal activity of biofumigation to be effective, a thorough, even distribution of biofumigants through the soil profile where the target nematodes are, is required. In addition, it is possible that nematicidal activity, at least by nitrogenous by-products, should be most evident when the C:N ratio of the amendment is less than 20:1 (Stirling 1991). Cabbage residue used in this study, had a C:N ratio which equals to 14.1:1, so more of an effect of the toxic by-products on the nematode population could be expected. Other factors shown to greatly enhance the pest-suppressive activity of biofumigation include a very thorough disruption of the plant tissue prior to soil incorporation and sufficient soil moisture at the time of tissue incorporation (Morra and Kirhegaard 2002). Also, soil temperature at the time of incorporation appears to determine, to a large extent, the level of control and the time needed to achieve control (Ploeg and Stapelton 2001; Lopez-Perez *et al*. 2005).

CONCLUSION

Although biofumigation often results in satisfactory levels of nematode control, the underlying mechanisms responsible for control are still largely unknown. In spite of this, biofumigation appears to be a very promising technique that could easily be integrated with other pest control measures. In addition, it may offer alternative uses for some agricultural by-products.

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