Field Application of Brassicaceous Amendments for the Control of Root Knot Nematode (*Meloidogyne incognita*) on Cucumber

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ABSTRACT

Biofumigation with brassicaceous green manures for controlling root-knot nematode (*Meloidogyne incognita*) on cucumber was evaluated under field conditions during two subsequent growing seasons. Cauliflower residues were incorporated into the soil two weeks before planting cucumber at rates of 15, 20 and 5 kg/plot (15 m^2) while both cauliflower and cabbage residues were incorporated at rates of 25 kg /plot in the second season. Cauliflower and cabbage residues at rates of 25 kg /plot significantly reduced disease severity expressed as reduction in the percentage of root galling to 15% and around 19% compared to 48% and 54% in the controls in the first and second seasons, respectively and significantly increased cucumber yield to 121 and 116 kg/plot, respectively compared to 92 kg/ plot in the control in the second season. The field application of cauliflower and cabbage green manures has effectively controlled the root-knot nematode disease and increased the yield of cucumber.

Keywords: Biofumigation, Brassica species, Cabbage, Cauliflower.

INTRODUCTION

For the past 30 years, producers have used soil fumigants to control pests such as nematodes in vegetable cropping systems. Fumigant nematocides, although effective, have negative side effects that have led to their ban or restricted use. On the other hand, the broad spectrum and commonly used methyl bromide was identified as a contributor to the depletion of the stratosphere ozone layer in 1992 and was scheduled for worldwide phase-out by 2010 (Noling, 2002; Schneider *et al.*, 2003).

Globally, researchers started to investigate the use of alternative methods to methyl bromide. Bio-fumigation is such an alternative and is identified as the suppression of soil-borne plant pests and pathogens by biocidal compounds released when crop residues are hydrolyzed (Kirkegaard *et al.*, 1998). Brassicaceae residues contain glucosinolates, which break down in the soil to produce toxic substances similar to methylisothiocyanate found in commercial soil fumigants (Vapam). They have shown to have insecticidal, herbicidal, fungicidal and nematocidal properties (Brown *et al.,* 1999). Reports showed that the reduction in disease severity is obtained with such substances through their effects on microbial antagonisms, competition and antibiosis (Papavizas and Lumsden, 1980; Johnson *et al.*,1992; Lazzeri *et al.*,

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1993; Brown and Mora, 1997; Buskov *et al.,* 2002; Zasada and Ferris, 2003). Combining plant residues and soil solarization augmented the suppression of diseases. Villapudua-Ramirez and Munneck (1988) reported that the use of solarization of soil amended with cabbage residues was more effective in controlling the wilt disease caused by the fungus *Fusarium oxysporum* than solarization without cabbage residues. Other studies showed that using lettuce as a cash crop between successive spring tomato crops in a green house and incorporating the remaining lettuce residues into the soil controlled foot and root rot diseases of tomato caused by *F. oxysporum* f.sp. *radicis lycopersici* (Javris and Thorp, 1981).

Root-knot nematodes (*Meloidogyne* spp.) cause major economic damage in agricultural production worldwide. The main options for control of phytoparasitic nematodes include chemical nematocides, crop rotation and resistant cultivars when available. The broad host spectrum of RKNs makes crop rotation difficult. Fumigant nematocides, although effective, have negative side effects that have led to their ban or restricted use (Sasser and Carter, 1985).

This paper aims at studying the effects of different application rates of crucifer amendments and evaluating two different brassicaceous amendment types on controlling root knot nematodes on cucumber under field conditions in Al-Baqa' province of Jordan.

MATERIALS AND METHODS

Two experiments were conducted in Mubas region in Al-Baqa' province of Jordan. The area had a history of tomato and cucumber plantation with moderate to heavy infestation of root knot nematodes (*M. incognita*). The soil type was silty clay loam (44.8% clay, 35.6% silt, 19.5% sand) with 1.96 organic matter content and pH 7.65. The land was prepared according to the normal cultural practices.

Effects of the Rate of Cauliflower Amendments to Control Root Knot Nematode

A field experiment was conducted during spring cucumber season (late April, 2007). The experiment consisted of five treatments: control (untreated seedlings); standard (received one application of Vydate (Oxamyl 20%) 150 ml/l); amendment with 15, 20 and 25 kg of cauliflower green manure / plot (15 m²).

The cauliflower residues were added two weeks before planting into the plots grounded, watered and covered with black plastic mulch. Cucumber cultivar Sultana type seedlings were transplanted. The plots within the experiments were arranged in a randomized complete block design (RCBD) with four replicates. Yield was assessed by calculating the sum of 18 harvests. Disease severity assessment was determined at the end of the season by estimating the % of root galling of five plants per replicate. Analysis of variance (ANOVA) was performed and means were separated using least significant difference (LSD).

Evaluation of Cabbage and Cauliflower Residues to Control Root Knot Nematode

Another field experiment was conducted during the subsequent season (August, 2007). The experiment consisted of four treatments: control (untreated); standard (received one application of Vydate (Oxamyl 20%)150 ml/l); amendment with 25 kg of cabbage green manure/plot (15 m²); amendment with 25 kg cauliflower green manure / plot (15 m²).

The Brassica residues were added two weeks before planting cucumber into the plots grounded, watered and covered with black plastic mulch. The plots within the experiments were arranged in an RCBD with four replicates. Analysis of variance was performed and means were separated using LSD test. Disease severity expressed as % of galled roots was assessed twice at the

harvesting date of each season by examining five plants per replicate. Yield was assessed for the second season by the summation of multiple harvest dates.

RESULTS

Effects of the Rate of Cauliflower Amendments to Control Root Knot Nematode

The results indicated that using cauliflower residues at the rate of 25 kg/ plot significantly reduced the root galling compared with the control (Table 1). Results also showed a significant increase in the yield when the rate of 25 kg of residues was used. On the other hand, there were no significant differences between the effect of this rate and that of the commercial synthetic nematocide, Vydate .

Table 1. The effect of cauliflower residues on the severity of root knot disease on cucumber and its yield under field conditions.

Treatment	Yield / plot (kg)	Disease severity %
15 kg	101.1* AB	32.5 * AB
20 kg	103.21 AB	29.75 AB
25 kg	108.5 A	24.75 B
Vydate	105.9 AB	25.5 AB
Control	79.5 B	38.5 A*

* Values are the means of four replicates. Means in a column followed by the same letter do not differ significantly according to LSD ($P \leq 0.05$).

Using 15 and 20 kg /plot did not exhibit a significant reduction in the severity of infestation or a significant increase in yield compared with the control or Vydate treatment (Table 1).

Evaluation of Cabbage and Cauliflower Residues to Control Root Knot Nematode

The results indicated that using cabbage and cauliflower residues at the rate of 25 kg/plot significantly reduced the nematode galling compared with the control in the two subsequent seasons (Table 2); while there was no significant reduction in root galling between Vydate treatment and the untreated control (Table 2). The galling index was significantly reduced to 15% and around 19% when cabbage and cauliflower green manures were used compared with 48% and around 55% for the untreated control.

Table 2. The effect of cabbage and cauliflower residues on the severity of root knot disease on cucumber.

Treatment	Disease severity (1st season)	Disease severity (2nd season)
Control	48* A	54.8 B*
Cabbage residues (25kg/ plot)	15 B	18.6 A
Cauliflower residues (25kg/ plot)	15 B	18.8 A
Vydate	20 AB	19.6 A

*Values are the means of four replicates. Means in a column followed by the same letter do not differ significantly according to LSD ($P \leq 0.05$).

Cauliflower and cabbage green manures were similar and as effective as vydate in reducing nematode infection in the fall season (Table 2). The results showed that using cabbage and cauliflower residues increased the yield significantly up to 121 and 116 kg/plot compared to 92 kg and 103 kg/plot with the control and Vydate, respectively (Table 3) . Although using (Table 2) Vydate resulted in increasing the yield this increase was not significantly different from that of the untreated control.

Table 3. The effect of cabbage and cauliflower residues on the severity of root knot disease and the yield of cucumber.

Treatment	Yield (kg) / 15m^2 2nd season
Control	92 * B
Cabbage residues	116 A
cauliflower resides	121 A
Vydate	103 B

* Values are the means of four replicates. Means in a column followed by the same letter do not differ significantly according to LSD ($P \leq 0.05$)

DISCUSSION

Biofumigation is based on incorporating soil amendment (fresh plant mass, manure) into the soil, which will release several substances, known as isothiocyanates and able to suppress soil borne pests. In addition, this method is a soil heater to enhance biological activities. Plants from the cruciferous family (cabbage, radish, cauliflower… etc.) release large amounts of these toxic substances in the soil and are considered the best material for biofumigation (Brown *et al*., 1999).

Results of previous studies showed that Brassica species when incorporated as green manure have a good level of nematocidal effect (Bello *et al*., 2000). However, the level of nematode control from Brassica was found to be dependent on the rate of application. Results showed that the use of Brassica green manure at the rate of 15 and 20 kg/ plot was less effective against root knot nematode compared to that of 25 kg/ plot. Labrada and Fornasari (2001) reported that in order to achieve high efficiency of biofumigation using Brassica residues a total of 5 kg of Brassica residues /m^2 area should be used. The level of nematode control using Brassica amendments was found to be inconsistent between and within Brassica species (Morra and Kirkegaard, 2002; Zasada *et al*., 2003; Hartz *et al*., 2005). This does not agree with the present study that found similar effects for cabbage and cauliflower green manures in controlling root knot nematode. Bello *et al*. (2000) reported that gases released from the biofumigant, that are produced in the biodegradation of the organic matter should be retained in the area of root zone for at least 2 weeks, since their effect in the majority of cases is not biocidal, but rather biostatic. Therefore, it is necessary to prolong their action on pathogens throughout the biofumigation process. This study allowed for a broad examination of the potential effects of some Brassica species against *M. incognita* and on cucumber yield under open field conditions. The study confirms the use of either cabbage or cauliflower green manures as a biological control option in vegetable production in Jordan. Therefore, to achieve the maximum benefit from utilizing Brassica species as a green manure for the control of soil borne pathogens, a producer will need to choose a Brassica species with a high potential of glucosinolate production and also one that produces large quantities of biomass in the selected geographic location or environment (Kirkegaard and Sarwar, 1998; Morra and Kirkegaard, 2002; Zasada *et al*., 2003). Further research is needed to determine which Brassica species are more effective as biological control options and to determine the level of susceptibility of the various Brassica species to *M. incognita* under the Jordanian conditions. In this study, both cauliflower and

cabbage residues were incorporated into soil two weeks before planting cucumber. Therefore, there is also a need for more studies to examine the nematocidal effects of Brassica green manures at different incorporation times. Furthermore, there is a need to evaluate the level of control for nematodes achieved with the incorporation of selected Brassica amendments in combinations with varying rates of commercially available nematocides

In conclusion, the use of either cauliflower or cabbage green manure at higher incorporation rates (e.g. 25kg/ plot) could be effective in controlling RKN (*M. incognita*) in Jordan.

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استخدام مخلفات العائلة الصليبية تحت الظروف الحقلية لمكافحة نيماتودا تعقد الجذور *Meloidogyne incognita* على الخيار

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ملخـص

تم تقييم استخدام مخلفات العائلة الصليبية الخضراء في التعقيم الحيوي لمكافحة نيماتودا تعقد الجذور على الخيار تحت الظروف الحقلية خلال موسمين متتاليين لإنتاج الخيار. تمت إضافة مخلفات القرنبيط في التربة قبل اسبوعين من زراعة الخيار بمعدل 15، 20 و 25 كغم / مقطع (15 م2) ، في حين أن كلا من مخلفات القرنيط و الملفوف تمت إضافتها للتربة بمعدل 25 كغم / مقطع في الموسم الثاني. أدى استخدام مخلفات الزهرة و الملفوف بمعدل 25 كغم / مقطع إلى إنقاص معنوي في شدة المرض تم التعبير عنها كتخفيض في نسبة تعقد الجذور إلى 15% و حوالي 19% مقارنة مع 48% و 54% مع الشاهد في الموسم الأول و الموسم الثاني على التوالي، وزيادة كبيرة و معنوية في محصول الخيار إلى 121 و 116 كغم / مقطع ، على التوالي مقارنة مع 92 كغم / مقطع في الشاهد في الموسم الثاني. إن استخدام مخلفات القرنبيط و الملفوف الخضراء في الحقل أدى إلى مكافحة فعالة لنيماتودا تعقد الجذور على الخيار وزيادة في الإنتاج.

الكلمات الدالة: التعقيم الحيوي، أنواع العائلة الصليبية، الملفوف، القرنبيط.

المركز الوطني للبحوث الزراعية والإرشاد.

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