# EFFICACY OF SEED CROP MEALS FOR THE MANAGEMENT OF COLUMBIA ROOT-KNOT NEMATODE *MELOIDOGYNE CHITWOODI* ON TOMATO UNDER GREENHOUSE CONDITIONS

Saad L. Hafez and P. Sundararaj

University of Idaho, Parma Research and Extension Center, 29603 U of I Lane, Parma, ID 83660, USA.

## ABSTRACT

Saad L. Hafez, and P. Sundararaj. 1999. Efficacy of seed crop meals for the management of Columbia root-knot nematode *Meloidogyne chitwoodi* on tomato under green house conditions. Nematropica 29:171-177.

Efficacy of oilcakes from soybean, cotton, sesame and rapeseed on the Columbia root-knot nematode *Meloidogyne chitwoodi* on tomato (*Lycopersicon esculentum*) was investigated under green house conditions. All crop meal amendments significantly increased foliar fresh and dry weights, compared to the unamended control. Rapeseed meal or sesame meal at all application rates and soybean meal at 4.94 tons/ha application rate produced symptoms and incidence of phytotoxicity. Application of meals at all rates consistently reduced nematode populations compared to the unamended check ($P = 0.05$), with the exception of rapeseed meal at 1.24 tons/ha. Soybean meal at 1.24 or 2.47 tons/ha resulted in the highest amount of fresh foliage and the lowest numbers of *M. chitwoodi* in soil and in root tissue compared to unamended soil and soil amended with rapeseed, cotton, or sesame meals.

*Key works:* Cultural control, *Meloidogyne chitwoodi*, soil amendments.

## RESUMEN

Saad L. Hafez, y P. Sundararaj. 1999. Eficacia de las tortas de borujo en el manejo del nematodo Columbia *Meloidogyne chitwoodi*, agallador de la raíz del tomate, en condiciones de invernadero. Nematrópica 29:171-177.

La eficacia de las tortas de borujo de frijol de soja, algodón, sésamo y colza en el nematodo Columbia agallador del tomate; *Meloidogyne chitwoodi*, fue evaluada en condiciones de invernadero. Todas las enmiendas a los cultivos, aumentaron significativamente el peso foliar seco y fresco en comparación al control sin enmienda. La aplicación de harina de colza o sésamo en todos los niveles, y la harina de frijol de soja a un nivel de aplicación de 4.94 tons/ha, mostró síntomas y ocurrencia de fitotoxicidad. Todos los niveles de aplicación de las harinas, redujeron las poblaciones del nematodo, en comparación al control sin mejoras ($P = 0.05$), con la excepción de la harina de colza a 1.24 tons/ha. La harina de frijol de soja a 1.24 ó 2.47 tons/ha rindió la mayor cantidad de foliage fresco y el menor número de *M. chitwoodi* en el suelo y en el tejido de la raíz, comparado al suelo sin mejoras o mejorado con las harinas de colza, algodón o sésamo.

*Palabras claves:* Control cultural, enmiendas del suelo, *Meloidogyne chitwoodi.*

## INTRODUCTION

In Idaho, the Columbia root-knot nematode (*Meloidogyne chitwoodi* Golden, O'Bannon, Santo and Finley, 1980) reduces potato yield and tuber quality, and decreases the ratio of grade 1 (≥8 ounces) to grade 2 (≥4 ounces and <8 ounces) tubers (Al-Rehiayani *et al.*, 1999, Hafez and Thornton, 1992). Effective management practices for the Columbia root knot nematode are critical since the entire field can be rejected by processors if more than 5% of the harvested tubers are infected (Hafez *et al.*,

1992). Currently, growers in Idaho use nematicides extensively to manage nematodes in potato. The high cost of nematicides and the continuing decline in the number of available registered chemicals increase the need for alternative nematode management options that are economically viable for growers. Organic soil amendments that have been studied for managing plant parasitic nematodes include chitin (Sarathchandra *et al.*, 1996), compost (McSorley and Gallaher, 1995), green manures (Al-rehiayani and Hafez, 1998; Johnson *et al.*, 1992; Mojtahedi *et al.*, 1991), pomace (Rodríguez-Kábana *et al.*, 1995), and oil seed crop meals (Thakar *et al.*, 1986; Walker, 1996). Oil seed crop meals, a by-product after oil extraction from oil seed crops and a livestock feed supplement, may have nematicidal properties against *Meloidogyne* species. Potential oil crop meals were tested against *Meloidogyne* spp. on tomato (Saifullah *et al.*, 1990). Walker (1996) showed that rapeseed meal, although possibly phytotoxic to tomato, reduced root symptoms induced by *Meloidogyne arenaria* in the greenhouse. The mode of action of oil seed crop meals against nematodes is uncertain. Some oil seed meals may release nematicidal compounds. Rapeseed has been implicated in releasing nematicidal isothiocyanates (Mojtahedi *et al.*, 1991). The efficacy of such crop meals against the Columbia root knot nematode and the potential for phytotoxicity requires further study.

The objectives of this study were to assess the impact of four oil seed crop meals (cotton, *Gossypium hirsutum* L.; rapeseed, *Brassica napus* L.; sesame, *Sesamum indicum* L.; and soybean, *Glycine max* (L.) Merr.) on Columbia root knot nematode population density and phytotoxicity on tomato grown in the greenhouse, and to determine suitable application rates of crop meals.

## MATERIALS AND METHODS

*General:* Tomato (*Lycopersicon esculentum*) variety 'Payette' was used for all experiments. Meals for all experiments were obtained from either Western Stockman Inc. (sesame, soybean, cotton) or the University of Idaho, Moscow (rapeseed).

At the termination of each experiment, nematodes were collected from root tissue using a modified Baermann funnel method with intermittent mist (Lownsbery and Serr, 1963) and from soil using the wet-sieve sucrose-gradient method (Cobb, 1918). Shoot and root fresh and dry weights were collected at the end of each experiment.

*Experiment 1:* The experiment was conducted in a completely randomized block design, under green house conditions with four treatments (meals of cotton, rapeseed, soybean, and an unamended control) of 10 replications each. Soil naturally infested with *M. chitwoodi* (4.2 nematodes per $cm^3$ soil) was collected from a farm near the University of Idaho, Parma Research and Extension Center, Parma, Idaho. Infested soil was mixed in a plastic bag with each meal alone at a rate of 4.94 tons/ha (10.4 g/1500-$cm^3$ pot) and placed in 1500 $cm^3$ plastic pots. Pots filled with unamended infested soil (no meal) or with steam sterilized soil served as control treatments. Additional second-stage juvenile nematodes from a culture maintained on tomato plants (J2) were added to all treatments except the sterilized soil to bring the initial nematode population to 7.2 nematodes per $cm^3$ soil. One, three-week old tomato seedling was transplanted to each pot. Plants were fertilized at weekly intervals with 1% solution of 20-20-20 soluble fertilizer for nine weeks and the crop was harvested.

*Experiment 2:* Field soil was collected and inoculated with J2 *M. chitwoodi* to establish an initial nematode population

density of 6 nematodes/cm$^3$ soil. Inoculated soil was mixed with one of four meal amendments (cotton, rapeseed, sesame, or soybean) at a rate equivalent to 4.94 tons/ha, or left unamended. Plastic pots of 700 cm$^3$ capacity were filled with amended or unamended soil and one three-week-old tomato seedling was transplanted to each pot. The experiment was arranged in a completely randomized design with 5 replications (pots). Seven days after transplantation, seedlings were visually assessed for the presence of phytotoxicity symptoms (chlorosis). Pots were fertilized bi-weekly with a 1% solution of 20-20-20 soluble fertilizer and the experiment was terminated after 11 weeks.

*Experiment 3:* Field soil was collected and inoculated with J2 *M. chitwoodi* to establish an initial nematode population density of 5 nematodes/ cm$^3$ soil. Inoculated soil was mixed with one of four meal amendments (sesame, rapeseed, cotton, or soybean) at three rates (equivalent to 1.24, 2.47, or 4.94 tons/ha), or left unamended. Amended and unamended soil was placed in 1400 cm$^3$ plastic pots, and two days later, one three-week old tomato seedling was transplanted to each pot. The experiment was arranged in a completely randomized design with 5 replications (pots). Phytotoxicity assessments including number of plants displaying symptoms of burning along leaf margins, stunting, or chlorosis were recorded. Pots were fertilized bi-weekly with a 1% solution of 20-20-20 soluble fertilizer. The experiment was harvested after 11 weeks (November 17).

*Data analysis:* Data for fresh and dry foliar and root weights, final nematode numbers per 500 cm$^3$ soil, and final nematode numbers per gram dry root were subjected to analysis of variance (ANOVA) using the general linearized model procedure in SAS (Statistical Analysis Software, SAS Institute, Cary, North Carolina). Means were separated at $P \leq 0.05$ with Fisher's least significant difference test (LSD, alpha = 0.05).

## RESULTS

*Effect of crop meals on plant growth:* Phytotoxicity was not assessed in the first experiment. In the second experiment, slight chlorosis of the lower leaves was observed on tomato seedlings in pots containing soil amended with sesame meal, rapeseed meal, cotton meal, and soybean meal (data not shown). Tomato seedlings grown in the unamended control displayed no chlorosis or other phytotoxicity symptoms.

All crop meal amendments in the first and second experiments, except sesame meal in the second experiment, significantly increased foliar fresh and dry weights compared to unamended controls (Table 1). Plant weight from the soybean meal-amended soil in the first experiment was lower than either the rapeseed meal- or cotton meal-amended treatments ($P \leq 0.05$). In the second experiment, foliar weight of the sesame meal-amended treatment was lower ($P \leq 0.05$) than soybean meal- or rapeseed meal-amended treatments.

In Experiment 3, plants in soil amended with all application rates of rapeseed and sesame meal or soybean meal (4.94 tons/ha application rate) displayed symptoms and incidences of phytotoxicity (Table 2). Burned leaf margins were observed on all tomato plants in soil amended with rapeseed meal at all rates, and chlorotic leaves were observed on most plants in sesame-meal amended soil at all application rates. Severe stunting, necrosis, and plant death were observed for tomato grown in soil amended with 4.94 tons/ha rate of soybean meal, and by time of harvest, both root and foliage tissue from this treatment had decayed

Table 1. Effects of amending soil with various crop meals on tomato growth and nematode population densities.

| Meal | Foliar weight (g) | | Root weight (g) | | Number of larvae | |
|---|---|---|---|---|---|---|
| | Fresh | Dry | Fresh | Dry | per 500 $cm^3$ soil | per g dry root |
| | 1994 (after 9 weeks) | | | | | |
| Rapeseed | 82.4 a[z] | 11.6 a | 24.2 a | 3.1 a | 41 b | 70.3 b |
| Soybean | 63.0 b | 7.7 b | 15.3 bc | 1.8 b | 88 b | 0.5 b |
| Cotton | 83.3 a | 10.9 a | 21.7 a | 2.6 a | 104 b | 21.9 b |
| Unamended | 29.9 d | 4.1 d | 12.4 c | 1.6 b | 186 a | 561.0 a |
| Sterile | 43.3 c | 6.5 c | 18.0 b | 2.9 a | 0 c | 0 c |
| | 1996 (after 11 weeks) | | | | | |
| Rapeseed | 32.8 a | 4.5 a | 4.7 a | 6.2 NS | 5206 a | 8639 b |
| Sesame | 25.8 bc | 3.4 b | 4.2 ab | 6.9 | 7404 a | 11730 b |
| Soybean | 35.1 a | 4.5 a | 4.9 a | 7.2 | 278 b | 1035 c |
| Cotton | 31.1 ab | 4.3 a | 4.7 a | 5.6 | 494 b | 2696 c |
| Unamended | 22.9 c | 2.7 b | 3.7 b | 4.4 | 9576 a | 19850 a |

[z]Values within columns (and within years) followed by the same letter are not significantly different according to Fisher's LSD (alpha = 0.05). NS indicates that no significant differences among treatments were found ($P > 0.05$) according to ANOVA.

beyond recovery. However, among treatments at the low application rate (1.24 tons/ha), soybean meal-amended soil was the only treatment that increased ($P$ = 0.001) the foliar fresh weight compared to the unamended control (Table 3). Fresh foliar weights of plants grown in cotton or rapeseed meal applied at the higher rates (2.47 tons/ha and 4.94 tons/ha) were higher ($P$ = 0.001) than the unamended control. In contrast, fresh foliar weights for sesame meal-amended soil at 2.47 or 4.94 tons/ha were lower ($P$ = 0.001) than the unamended control.

*Effects of crop meals on M. chitwoodi:* Soybean meal-amended treatments consistently reduced the number of *M. chitwoodi* juveniles in soil and root tissue (Tables 1 and 3), providing a positive effect on plant growth, except when applied at a rate of 4.9 T/ha in 1997.

All meal treatments at all application rates consistently reduced nematode populations compared to the unamended check, with the exception of rapeseed meal at 1.24 tons/ha (Table 3). Application of soybean meal at 1.24 or 2.47 tons/ha resulted in the highest amount of fresh foliage and the lowest number of *M. chitwoodi* in soil and in root tissue compared to unamended soil and soil amended with rapeseed, cotton, or sesame meals. At 4.94 tons/ha, cotton meal and rapeseed meal amended treatments resulted in the highest fresh foliar weight and the lowest number of J2 in soil or in roots (Table 3).

## DISCUSSION

All meal amendments reduced population densities of *M. chitwoodi* on tomato under greenhouse conditions. These pre-

Table 2. Number of plants (out of five) displaying various phytotoxicity symptoms with respect to meal application rate and time.

| | Necrotic leaf margins | | | Stunting | | | Chlorosis or paling | | |
|---|---|---|---|---|---|---|---|---|---|
| Meal | 1.24 T/ha | 2.47 T/ha | 4.94 T/ha | 1.24 T/ha | 2.47 T/ha | 4.94 T/ha | 1.24 T/ha | 2.47 T/ha | 4.94 T/ha |
| | 3 September 1997 | | | | | | | | |
| Rapeseed | 0 | 0 | 2 | | | | | | |
| Sesame | 0 | 0 | 0 | | No symptoms | | | No symptoms | |
| Soybean | 0 | 0 | 0 | | | | | | |
| Cotton | 0 | 0 | 0 | | | | | | |
| Unamended | 0 | 0 | 0 | | | | | | |
| | 16 September 1997 | | | | | | | | |
| Rapeseed | 3 | 5 | 5 | | | | 0 | 0 | 0 |
| Sesame | 0 | 0 | 0 | | | | 1 | 4 | 5 |
| Soybean | 0 | 0 | 0 | | No symptoms | | 0 | 0 | 0 |
| Cotton | 0 | 0 | 0 | | | | 0 | 0 | 0 |
| Unamended | 0 | 0 | 0 | | | | 0 | 0 | 0 |
| | 8 October 1997 | | | | | | | | |
| Rapeseed | 5 | 5 | 5 | 0 | 0 | 3 | 0 | 1 | 0 |
| Sesame | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 5 |
| Soybean | 0 | 0 | 0 | 0 | 0 | 5[z] | 0 | 0 | 0 |
| Cotton | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Unamended | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[z]All plants in soil amended with soybean meal at the 2.0 ton/acre rate were dead by October 8, 1997.

liminary experiments suggest that rapeseed, soybean, cotton, and sesame meals may be useful as soil amendments against *M. chitwoodi* on potato in Idaho. Our results complement those of Mojtahedi *et al.* (1991) in which rapeseed, when grown as green manure, effectively reduces *M. chitwoodi* populations.

Although sesame meal reduced the population density of *M. chitwoodi*, it did not perform as well as other meals in this study in terms of the magnitude of nematode reduction and plant biomass increase. However, sesame meal may provide sufficient nematode management, particularly since sesame may emit isothiocyanates during breakdown, particularly methyl isothiocyanate, which are nematicidal (Lear, 1956).

Phytotoxicity is a limiting factor in the use of oil seed crop meals against root knot nematodes. In this study, phytotoxicity from soybean meal applied at a rate equivalent to 4.94 tons/ha caused tomato plant death. Walker (1996) showed that certain meals, including rapeseed, can be

Table. 3. Effects of amending soil with various crop meals on tomato growth and numbers of *M. chitwoodi* at three different meal application rates in 1997.

| Meal | Fresh foliar weight | Number of larvae per 500 $cm^3$ soil | Number of larvae per g dry root |
|---|---|---|---|
| | 1.24 Tons/ha | | |
| Soybean | 52.4 a[z] | 238 c | 1152 b |
| Rapeseed | 38.1 b | 1202 b | 4728 ab |
| Cotton | 42.3 b | 920 bc | 4121 b |
| Sesame | 33.7 b | 458 bc | 1430 b |
| Unamended | 34.3 b | 2416 a | 12967 a |
| | 2.47 Tons/ha | | |
| Soybean | 58.1 a | 24 b | 1038 b |
| Rapeseed | 52.0 b | 358 b | 1411 b |
| Cotton | 56.8 ab | 380 b | 1981 b |
| Sesame | 24.0 d | 174 b | 2382 b |
| Unamended | 34.3 c | 2416 a | 12967 a |
| | 4.94 Tons/ha | | |
| Soybean | 0 d | 0 b | 0 b |
| Rapeseed | 59.4 a | 34 b | 281 b |
| Cotton | 66.1 a | 28 b | 272 b |
| Sesame | 11.4 c | 134 b | 2289 b |
| Unamended | 34.3 b | 2416 a | 12967 a |

[z]Values within columns and within application rate followed by the same letter are not significantly different according to Fisher's SLD (alpha = 0.05).

phytotoxic to tomatoes. However, a possible benefit of phytotoxicity might be weed control, particularly if the crop meal is applied one to two weeks prior to planting. Furthermore, phytotoxicity of these meals on potato has not yet been evaluated.

Use of oil seed crop meals as soil amendments for the management root knot nematodes is a promising technique for growers in the northern United States for several reasons. The trend toward shorter growing seasons may limit the utility of green manure crops against nematodes, making the use of meal amendments to manage nematodes more attractive. Crop meals high in glucosinolates and consequently unsuitable as livestock feed amendments, and otherwise considered waste, would have a new application in agriculture and nematode management; and costly chemical nematicide use would decline. Further work evaluating the effect of these meals on nematode populations and potato growth in microplot and field experiments are ongoing to verify the potential benefits of oil seed crop meals as soil amendments.

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