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The effects of Brassica green manures on plant parasitic and free living nematodes used in combination with reduced rates of synthetic nematicides

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Abstract: Brassica plants once incorporated into soil as green manures have recently been shown to have biofumigant properties and have the potential of controlling plant-parasitic nematodes. In Washington State, plant-parasitic nematodes are successfully managed with synthetic nematicides. However, some of the synthetic nematicides became unavailable recently or their supply is limited leaving growers with few choices to control plant-parasitic nematodes. The objective of this project was to evaluate the effects of Brassica green manures on their own and in combination with reduced rates of synthetic nematicides on plant-parasitic nematodes and free living nematodes. In a greenhouse experiment and field trials in three seasons, Brassica green manures in combination with half the recommended rate of 1,3-dichloropropene (1,3-D, Telone) reduced root knot nematode, *Meloidogyne chitwoodi* to below detection levels, and reduced lesion nematodes, *Pratylenchus penetrans* and stubby root nematodes, *Paratrichodorus allius,* to below economic thresholds. The combination treatments did not affect the beneficial free-living nematode populations and the non-pathogenic *Pseudomonas*. The total cost of growing and soil-incorporating Brassica crops as green manures in combination with reduced rates of 1,3-D was approximately 35% lower than the present commercial costs for application for the full rate of this fumigant. Integrating conventional management practices with novel techniques fosters sustainability of production systems and can increase economic benefit to producers while reducing chemical input.
Key words: Plant parasitic nematodes, free living nematodes, Brassicaceae green manures, Telone.

Management of plant-parasitic nematodes and enhancement of beneficial free-living nematodes is essential to quality crop production and protection of the environment in the USA and worldwide. In Washington State, plant-parasitic nematodes in vegetable crops and particularly in potatoes are successfully managed with synthetic nematicides. Some of these synthetic nematicides are limited partially due to concerns about the negative impact of synthetic nematicides on the environment and health led to their re-evaluation (Mus and Huygen, 1992; Robinson et al., 1987) leaving growers with few choices to control plant parasitic nematodes. For example, aldicarb (Temik) and carbofuron (Furadon) are under review by the United States Environmental Protection Agency (EPA) because of groundwater contamination and bird toxicity, respectively (Nemaplex, 2008). In May, 2007, Bayer Crop Sciences withdrew the registration of fenamiphos (Nemacur) due to the high cost associated with additional collection of safety data requested by EPA. Also, restrictions have been placed on 1,3-dichloropropene (1,3-D, Telone) usage in some parts of California; the above restrictions are compounded by limited Telone availability (Nemaplex, 2008).

Meloidogyne chitwoodi Golden et al. is a serious pest of potato, *Solanum tuberosum* L., and is widespread in the Pacific Northwest (PNW) of the US (Santo et al., 1980). Since 1980, two host races and two pathotypes of *M. chitwoodi* have been reported in the PNW that cause challenges to potato breeding programs for nematode resistance (Mojtahedi et al., 2007). In the 1980s, *M. chitwoodi* was reported to have three generations per growing season in the PNW (Santo et al., 1980); however, 30 years later *M. chitwoodi* is able to have 5 to 7 generations per growing season in Washington State (Riga et al., Submitted). So at present, in the PNW the potato crop is attacked by higher densities of *M. chitwoodi* than before which makes its protection even more challenging. In addition to the annual generation increase, the economic threshold for *M. chitwoodi* which is 1 nematode per 250 cc soil prior to potato planting (Santo et al.,1980) increases the costs of chemical control of this nematode to > US$1235 / ha.

Glucosinolate compounds produced by the Brassicaceae family plants when broken down to various allelochemics and incorporated into soil control soil-borne pests, insects and nematodes (Hafez and Sundararaj, 2001; Lazzeri et al., 2004; McSorely et al., 1997; Riga et al., 2004). The fumigant effect of decomposing Brassicaceae plants is believed to be the result of chemical reactions that result in the formation of biologically active products (Underhill, 1980). Arugula (*Eruca sativa*) a Brassicaceae species var. Nemat is able to act as a trap crop for *M. chitwoodi, M. hapla*, and *M. incognita* in addition to its green manure properties (Riga and Collins, 2004; Riga et al., 2004; Curto et al., 2006; Melakeberhan et al., 2006). Kim and Ishii (2006) isolated six types of Glucosinolates (GSLs) from arugula plants with biological activity.

The objective of our long term project was to evaluate the effects of Brassicaceae plants used as green manures on their own or in combination with reduced rates of synthetic nematicides on plant parasitic nematodes and free living nematodes of potatoes in Washington State. Here, we report only results from the use of arugula as a green manure and Telone as a synthetic fumigant, but we have used several species from the Brassicaceae

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family as green manures on their own and in combination with synthetic fumigants and non-fumigants (Riga et al., unpublished).

In our studies, a green manure crop of arugula on its own has not been able to control *M. chitwoodi* in the field where long season potatoes, i.e. Russet Burbank have been planted for over 6 months under the pressure of >5 nematode generations. However, in greenhouse studies when only one generation of *M. chitwoodi* was allowed to develop after an arugula green manure, the nematode population densities were reduced from 100 nematodes / 100 g soil to 0.1 nematode / 100 g soil. In addition, arugula reduced *M. hapla* and *P. allius* to non-detectable levels. Based on the limited control of *M. chitwoodi* by arugula used as green manure under field conditions, we decided to combine green manures with half the recommended rate of synthetic nematicides to produce marketable tubers and high yield. At different field sites in a 3-year study, the treatments of arugula seeded at 7.85 kg / ha, Telone applied at full rate of 187.1 l / ha, arugula 7.85 kg / ha, followed by Telone at 93.55 l / ha, and untreated control were applied in a randomized complete block design with five replications. In the third year, application of half rate of Telone at 93.55 l / ha was used as an additional control. Arugula was seeded in the beginning of September, grown for 4 to 5 weeks and then chopped with a flail chopper and incorporated to a depth of 15 to 20 cm, at soil temperature of 15 to 20 ^{0}C; the field was watered prior to the incorporation and compacted with a roller following incorporation to avoid loss of biofumigants. At the end of October, Telone was applied to the respective rates and plots. Potato seed pieces 'Russet Burbank' were planted in the following spring (April) and grown for at least 6 months. Soil was sampled prior to treatments i.e. in the beginning of September, prior to potato planting at the beginning of April (the following spring) and at harvest (the following September). Plant-parasitic nematodes were identified to species level while free-living nematodes were enumerated as one group. In addition to nematodes, the effect of the treatments was evaluated on culturable non-pathogenic *Pseudomonas* populations, *Verticillium dahliae* and *Rhizoctonia solani*. Potato yield, was collected in addition to tuber rating, % culls (% tubers with six or more infection sites by root knot nematode) and infection index (0 = no nematode infection; 1 =1-3; 2 =4-5; 3 =6-9; 4 =10+; 5 =50+; and 6 =100+ infection sites) for all three years.

Arugula in combination with the half-rate of Telone significantly reduced *M. chitwoodi* in comparison to all the other treatments and the control with the exception of Telone at full rate. Arugula on its own and in combination with half rate of Telone had significantly fewer lesion and stubby nematodes than all other treatments with the exception of Telone at full rate. Arugula on its own or in combination with Telone did not significantly reduce the beneficial free-living nematode populations or the non-pathogenic *Pseudomonas* populations. Both *V. dahliae* and *R.solani* levels were reduced numerically by arugula in combination with half rate of Telone but the reduction was not statistically significant. Yield and tuber quality was significantly higher in the arugula combination with half rate of Telone treatment in comparison to all the other treatments with the exception of Telone at full rate. Telone on its own, applied at half rate, did not provide significant nematode control (Riga et. al., unpublished).

In conclusion, the brassica green manure treatment in our study did not by itself provide control of *M. chitwoodi* throughout the whole growing season. However, arugula green manure could be used in combination with reduced rates of 1,3-D to make the treatment affordable and less environmentally taxing. Brassica green manures could be effective nematode control treatments on their own if used against nematode species that are less fecund than *M. chitwoodi* and/or in short season crops. We estimated that the cost of growing and incorporating arugula as green manure in combination with half-rate of 1,3-D was 35% lower than the present commercial cost of this fumigant.

LITERATURE CITED

Curto, G., Lazzeri, L., Dallavalle, E., Santi, R. and Malaguti, L. 2006. Effectiveness of crop rotation with Brassicaceae species for the management of the southern root-knot nematode *Meloidogyne incognita*. Second International Biofumigation Symposium p. 51, June 25-29, Moscow, ID.

Hafez, S. L. and Sundararaj, P. 2001. Life cycle of duration of *Meloidogyne incognita* and host status of Brassicaceae and Capparaceae selected for glucosinolate content. Nematology 7:203–212.

Kim, S.-J. and Ishii, G. 2006. Glucosinolates profiles in the seeds, leaves and roots of rocket salad (*Eruca sativa* Mill.) and anti-oxidative activities of intact plant powder and purified 4-methoxyglucobrassicin. Soil Science and Plant Nutrition 52:394–400.

Lazzeri, L., Curto, G., Leoni, O. and Dallavalle, E. 2004. Effects of glucosinolates and their enzymatic hydrolysis products via myrosinase on the root-knot nematode *Meloidogyne incognita* (Kofold et White) Chitw. Journal of Agricultural and Food Chemistry 52:6703–6707.

McSorley, R., Stansly, P. A., Noling, J. W., Obreza, T. A. and Conner, J. M. 1997. Impact of organic soil amendments and fumigation on plant-parasitic nematodes in Southwest Florida vegetable fields. Nematropica 27:181–189.

Melakeberhan, H., Xu, A., Kravchenko, A., Mennan, S., and Riga, E. 2006. Potential use of arugula (*Eruca sativa* L.) as a trap crop for *Meloidogyne hapla*. Nematology 8:793–799.

Mojtahedi, H., Brown, C. R., Riga, E., and Zhang, L. H. 2007. A new pathotype of *Meloidogyne chitwoodi* Race 1 from Washington State. Plant Disease 91:1051.

Mus, A. and Huygen, C. 1992. Methyl Bromide. The Dutch Environmental Situation and Policy. TNO. Institute of Environmental Sciences. Order No. 50554. 13pp.

Nemaplex (2008) Chemical methods of nematode management. Online, <http://plpnemweb.ucdavis.edu/NEMAPLEX/Mangmnt/Chemical.htm#Fumigant%20Nematicides> Accessed on April 29, 2010.

Riga, E., Perry, M., Collins, H., Wilson, J., and Pierce, F. Submitted. Population dynamics and spatial and temporal distribution of plant parasitic and free-living nematodes under potato rotation. Journal of Nematology .

Riga, E., and Collins, H. 2004. Green manure effects on *Meloidogyne chitwoodi* and *Paratrichodorus allius*, economically important nematodes of potatoes in the Pacific Northwest of the USA. Agroindustria 3:321–322.

Riga, E., Mojtahedi, H., Ingham, R., and McGuire, A. M. 2004. Green manure amendments and management of root knot nematodes on potato in the Pacific Northwest of USA. Pp. 151–158 *in* R. C., Cook and D. J. Hunt eds. Nematology Monographs and Perspectives. Proceedings of the Fourth International Congress of Nematology. 2nd edition, Leiden, The Netherlands. Brill Academic Publishers, Inc.

Robinson, M. P., Atkinson, H. J. and Perry, R. N. 1987. The influence of soil moisture and storage time on the motility, infectivity and lipid utilization of second stage juveniles of the potato cyst nematodes *Globodera rostochiensis* and *G. pallida*. Revue de Nematologie 10:343–348.

Santo, G. S. 1994. Biology and management of root-knot nematodes in the Pacific Northwest. Pp. 193–201 *in* G. W. Zehnder, M. L. Powelson, R. K. Jansson, and K. V. Raman eds. Advances in Potato Pest Biology and Management. APS Press, St. Paul, Minnesota.

Underhill, E. W. 1980. Glucosinolates. Pp. 493–511 *in* Bell, E.A. and Charlwood, B. V. eds. Secondary plant products. Encyclopedia of Plant Physiology. New Series 8: Berlin, Germany Springer-Verlag.