ALTERNATIVES TO METHYL BROMIDE FOR ROOT KNOT NEMATODE MANAGEMENT ON CUCUMBER IN LEBANON

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ABSTRACT

Abou-Jawdah, Y., K. Melki, S. L. Hafez, H. Sobh, Y. El-Masri, and P. Sundararaj. 2000. Alternatives to methyl bromide for root knot nematode management on cucumber in Lebanon. Nematropica 30:41-45.

An experiment to compare nematode management tactics was conducted in South Lebanon on cucumber in commercial greenhouses naturally infested with the root-knot nematodes *Meloidogyne incognita* and *M. javanica*. Significant increases in fruit yield and a reduction of root galling index and nematode juveniles in soil were observed in plots following soil solarization for 50 days, and in plots treated with methyl bromide. The use of "bio-rational" products containing naturally occurring agents with putative activity against nematodes (Bio-Act, Bio-Zymes and Sincocin) were ineffective in our tests, nor did these products enhance the efficacy of soil solarization.

Key words: bio-rational compounds, cultural control, *Meloidogyne incognita*, *M. javanic*a, methyl bromide alternatives, soil solarization.

RESUMEN

Abou-Jawdah, Y., K. Melki, S. L. Hafez, H. Sobh, Y. El-Masri y P. Sundararaj. 2000. Alternativas al uso del bromuro de metilo para el manejo de nematodos agalladores en el pepino en el Líbano. Nematrópica 30:41-45.

El experimento se llevó a cabo en el sur de Líbano, en el cultivo de pepino en invernaderos comerciales naturalmente infestados con los nematodos agalladores *Meloidogyne incognita* y *M. javanica*. El incremento significativo en el rendimiento de la fruta, la reducción del índice de agallamiento de la raíz y en J2/100 cm^3 de suelo, fueron observados en las parcelas con suelo solarizado y en las parcelas tratadas con bromuro de metilo. La integración de Bio-Act, Bio-Zymes y Sincocin con la solarización del suelo, no aumentó la eficacia de la solarización.

Palabras claves: alternativas al bromuro de metilo, compuestos biofavorables, control cultural, *Meloidogyne incognita*, *M. javanica*, solarización.

INTRODUCTION

In Lebanon, methyl bromide is the major fumigant used in greenhouses for the control of soil-borne pathogens. Since methyl bromide depletes the ozone layer and leads to bromine residues in soil and water, its usage will be banned in developed countries in 2005 and worldwide by 2015. Soil solarization is an effective and environmentally safe pest management option for disinfecting greenhouse soils. Solarizing soil for 30 to 60 days during the hottest months of the year selectively controlled several important fungal pathogens including *Sclerotinia sclerotiorum* (Lib.) de Bary (Phillips, 1990), and *Phytophthora nicotianae* Captan and *Rhizoctonia solani* Kuhn (*Thanatephorus cucumeris* (Frank) Donk) (Garibaldi and Tamietti, 1989). Solarization also controls several nematode pests, e.g. *Meloidogyne* sp. (Cartia *et al.*, 1989), and *Pratylenchus penetrans* and *Tylenchulus semipenetrans* (Porter and Merriman, 1983). Microbial activity in soil is affected (Stapleton, 1997) and improved nutrient status of solarized soil has also been noted (Gambiel and Katan, 1991). Stapleton and Devay (1995) have reviewed the fungi, bacteria, nematodes and weeds that are reportedly controlled by soil solarization.

Root-knot nematodes constitute one of the major problems of greenhouse crops in the Lebanese coastal area. Previous studies indicated that a significant level of control of *Meloidogyne javanica* (Treub) Chitwood and *M. incognita* (Kofoid and White) Chitwood on pepper could be achieved by solarization, with consequent yield increase (Cartia *et al.*, 1989). In Iraq, soil solarization proved to be economical and was the best of all tested disinfestation methods for management of *Meloidogyne* spp. in cucumbers that were artificially (Al-Samarria *et al.*, 1988a) or naturally (Al-Samarria *et al.*, 1988b) infested. However, other studies found soil solarization to have no effect on *M. incognita* (Overman, 1985; Chellemi *et al.*, 1997) or *M. javanica* (Chellemi *et al.*, 1997). Stapleton and Heald (1991) reported that combining biocontrol agents with solarization for the control of phytoparasitic nematodes has not been studied in depth. Although complete control of *M. incognita* may not be obtained with soil solarization alone, the efficacy of soil solarization may be enhanced by the use of a biocontrol agent. Hence, an experiment was conducted to study the effect of the integration of biological control organisms with soil solarization on *M. incognita* and *M. javanica* on greenhouse grown cucumber.

MATERIALS AND METHODS

A field experiment was conducted in South Lebanon at two commercial greenhouse production farms infested with the root knot nematodes *M. incognita* and *M. javanica.* Two greenhouses with similar cropping histories and sandy clay loam soil (pH value of 7.6) were selected at Ghazieh. The soil was flood irrigated, fertilized (2 kg cow manure/m^2) plowed, and roto-tilled. The soil was then solarized for 50 days, from July 10 to August 30, 1998. The soil was irrigated initially to about 80% field capacity and covered with polyethylene sheeting of 50 µm thickness and received supplemental irrigation twice on August 5 and 21 through drip irrigation. Methyl bromide was applied on August 22, to additional plots at a rate of 100 gm/m^2.

Before the transplanting of cucumber seedlings, the planting holes were treated with 200 ml of solutions or suspensions of Sincocin, Bio-Act or Bio-Zymes at a rate of 1.68 L, 14.6 kg and 5.4 L/ha respectively (i.e., 84 µl, 0.73 g or 0.27 ml/plant). Sincocin is an organic plant extract blended with 0.53% (a.i.) fatty acids (Appropriate Technologies Ltd.). Bio-Act, manufactured by BIOACT Corporation, USA, contains 10^9 spores of *Paecilomyces* sp./g. Bio-Zymes, manufactured by Agrotex, USA, is a complex culture of living microorganisms (fungi, bacteria, and yeasts) with nematode-trapping imperfect fungi. A second application of Biozymes, was done by soil drenching one month after transplanting. Cucumber seedlings (cv. Ghena) at the stage of first to second leaf, were transplanted on September 8, into greenhouse soil at a spacing of 1 m between rows and 50 cm within rows. Plot sizes were 6 × 4.7 m and 6 × 4.25 m in the first and second greenhouse, respectively. The experimental design was a randomized complete block design with nine treatments (untreated control, soil solarization, methyl bromide, Sincocin, Bio-Act, and Bio-Zymes, and soil solarization combined with the latter three treatments). Each greenhouse contained two blocks for a total of four replications of each treatment. Normal horticultural practices were conducted throughout the growing seasons.

Plants were uprooted on November 9th (5 plants/replicate) and at the end of the trial (10 plants/replicate). The root-knot index was evaluated using a scale of 0-10, with 0 indicating no symptoms and 10 indicating that roots were completely covered with galls, with some disintegrating (Zeck 1971). A composite soil sample of 10 subsamples was taken from each plot and the J2 stage of *Meloidogyne* was extracted by using a modified Baermann funnel method. Cucumber fruits were harvested every other day from 10 plants / replicate and weighed.

Statistical analyses: Statistical analyses were conducted using MSTATC for all parameters in all tests. Mean separation was accomplished using Duncan's Multiple Range Test and all tests of significance were conducted at $P \leq 0.05$.

Table 1. Soil temperatures recorded at Ghazieh from July 11 to August 30, 1998.

Soil treatment	Soil Depth (cm)	Temp. Range (°C)	Temp. Mean (°C)
Control	5	39.0-49.0	44.8
	15	33.0-48.0	41.2
	25	30.0-42.0	36.4
Solarized	5	43.0-56.0	50.1
	15	41.0-50.0	46.7
	25	33.0-51.0	43.5

RESULTS AND DISCUSSION

In solarized soils, the highest soil temperatures recorded at depths of 5, 15 and 25 cm were 56, 50 and 51°C and the highest mean temperatures were 50.1, 46.7 and 43.5°C, respectively. The mean sustained temperatures in solarized soils were 5.3 to 7.1°C higher than those of nonsolarized soils (Table 1). An increase in soil temperatures due to solarization was reported by Martyn and Hartz (1986), Tjamos and Paplomatas (1988), Said and Abu-Gharbieh (1998) and Alexander (1990). However, the mean maximum temperature recorded at 5 cm in the current study is higher than those reported previously (Abdel-Rahim *et al.*, 1988; Lopez-Herrera *et al.*, 1994; Katan *et al.*, 1976; and Gonzalez-Torres *et al.*, 1993).

A significant reduction in root-gall index was observed with plants grown in soil treated either by solarization or with methyl bromide alone when compared to control plants (Table 2). These results are in agreement with those of Said and Abu-Gharbieh (1998) in Jordan who reported significant control of *M. javanica* by soil solarization. Solarization alone significantly increased the yield of cucumber as did methyl bromide alone. One of the contributing factors for the increased yield of cucumber seemed to be the phenomenon of increased growth response (IGR), as observed by Gruenzweig *et al.* (1993). Kyrou (1973) reported that, under greenhouse conditions, application of methyl bromide (56.7 g/m^2) significantly reduced population of *M. incognita* and increased cucumber yield. However, treatments either with Sincocin, Bio-Act, or Bio-Zymes were not effective in reducing the root-gall index or in increasing the total yield. Moreover, the combination of these treatments with soil solarization did not significantly improve the results obtained with solarization alone.

During the experiment, it was observed that the border rows of the greenhouse were more severely infested by nematodes than the inner rows. Data from border rows were also collected and analyzed separately. The average root-gall indices in bor-

Table 2. Effect of different soil treatments in greenhouses in Lebanon on root-gall index, yield of cucumbers, and root-knot nematode population densities during summer and fall 1998.

Treatment	Root-gall index[y] (0-10) 9 Nov.	Root-gall index[y] (0-10) 20 Nov.	Yield (kg/10 plants)	No. of J_2 per 100 g of soil
Control	4.32 a[z]	4.02 a	2.10 bc	415 a
Bio-Zymes	4.42 a	4.17 a	1.90 c	116 a
Bio-Act	5.32 a	4.90 a	2.10 bc	511 a
Sincocin	4.40 a	4.77 a	1.90 c	152 a
Methyl bromide	0.60 b	0.00 b	2.60 ab	4 b
Soil solarization	0.35 b	0.27 b	2.80 a	3 b
Soil solarization + Bio-Zymes	0.42 b	0.70 b	3.00 a	2 b
Soil Solarization + Bio-Act	0.27 b	0.27 b	2.50 abc	1 b
Soil Solarization + Sincocin	0.30 b	0.45 b	3.00 a	3 b

[y]The root gall index indicates the extent of root galling: 0 = healthy, 10 = maximum gall development.
[z]Means within each column, followed by the same letter, are not significantly different according to Duncan Multiple Range Test ($P = 0.05$).

der rows for 8 treatments ranged between 4.2 and 6.4 and were not significantly different. Methyl bromide alone was more effective than the other treatments in reducing the galling with a significantly lower galling index of 1.25. Therefore, it is important to conduct further studies on the integration of soil solarization with a suitable treatment to improve the efficacy of soil solarization on border rows. An integrated treatment would also be beneficial in cases when time is limited or where environmental conditions for solarization may be marginal.

The results of these studies indicate that soil solarization for 44-50 days is a promising alternative to the use of methyl bromide in Lebanon. In addition to effectively controlling root knot nematodes, it can also control the fungi *Sclerotinia* sp. and *Verticillium* sp. in Lebanon (Sobh and Abou-Jawdah, 1998) and most annual weeds throughout the growing season (data not presented). A long solarization period is not a constraint to most greenhouse farmers, because they usually do not grow crops between the end of June to mid August or early September. None of the biological control organisms tested gave a significant level of protection against *Meloidogyne* sp. This may be partially attributable to the high pH of Lebanon soils or to problems in formulation or in maintaining viability of biocontrol agents during shipment.

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