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APPLICATION OF SOIL SOLARIZATION TO FALL PRODUCTION OF CUCURBITS AND PEPPER[1]

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Abstract. **Soil solarization, applied alone or in combination with 1,3-dichloropropene or municipal solid waste compost, was evaluated as an alternative to preplant fumigation with methyl bromide. In Palm Beach County, marketable yield of pepper was 15.3 and 16.4 tons per acre from solarized and methyl bromide treated areas, respectively, while suppression of nutsedge and density of root-knot nematodes were similar under both treatments. Following a subsequent second crop of cucumber, reductions in marketable yield and increases in the severity of root galling and density of root-knot nematodes were observed in the solarized area. In Washington County, severe root galling and high densities of root-knot nematodes were observed in untreated or solarized areas but not in an area treated with soil solarization plus 1,3-dichloropropene. In Suwannee County, suppression of yellow and purple nutsedge was similar in plots receiving soil solarization or methyl bromide while reductions in root galling and density of root-knot nematodes were greatest in plots treated with methyl bromide. Marketable yield of cucumber was greatest in methyl bromide-treated areas.**

Introduction

Methyl bromide is considered a key component in many Florida fresh market vegetable production systems (Cantliffe et al., 1995). Recently, methyl bromide has been implicated as a major ozone depleting substance, and production and sale within the United States will be eliminated after January, 2001 (Federal Registrar, 1993). In the absence of methyl bromide, production of eggplant, pepper, and tomato is projected to decline by 100%, 63%, and 69%, respectively (Spreen et al., 1995). Furthermore, yields of subsequent (double) crops of cucurbits also are expected to experience dramatic reductions. In Florida, soil solarization has been examined for its effect on soilborne pests of tomato in the Homestead, Bradenton, and Quincy production regions (Chellemi et al., 1993; 1997; McSorley and Parrado, 1986; Overman, 1985). While yields similar to those obtained after fumigation with methyl bromide were obtained, control of specific pests varied from location to location. Information regarding the potential of soil solarization for additional Florida-produced commodities is not available. The objective of this study was to examine the impact of soil solarization, performed alone or in combination with other management tactics, on soilborne pests and production of pepper, cucumber, and pumpkin.

Materials and Methods

Soil solarization was evaluated on cucumber, pepper, and pumpkin in Suwannee, Palm Beach, and Washington Counties, respectively. Crops were planted in the fall following a summer solarization period. The pepper crop was followed by a double-crop of cucumber in the spring.

Pepper. Soil solarization was performed in a plot consisting of 10 adjacent beds, 2400 ft in length (3.3 acres). The soil type was a Myakka sand. Beds were oriented north/south on 5.5 ft centers. On 16 July, compost and mineral fertilizer was broadcast over the plot. The rates used were 28 tons per acre of biosolids compost (a mixture of biosolids composted with yard

[1]The authors would like to thank Pat Byers and the Palm Beach County Solid Waste Authority for providing biosolids compost and application assistance. Mention of a trademark, warranty, proprietary product, or vendor does not constitute a guarantee by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

Table 1. Soil amendments utilized for the production of pepper and cucumber in Palm Beach county.

Treatment[z]	Soil amendment	lbs per acre (N-P-K)
Solarization	BC[y] (28 T per acre)	280-181-59
	MSW[x] (1.1 T per acre)	110-28-0
	mineral fertilizer	73-39-38
	Total	463-248-97
Methyl bromide mineral fertilizer		377-43-220

[z]Both treatments were side dressed with 30-0-7 lbs per acre of N-P-K prior to planting the double-crop of cucumber.
[y]Biosolids compost (a mixture of composted municipal solid waste and composted yard waste), Palm Beach County Solid Waste Authority.
[x]Composted municipal solid waste, Wheelabrator sludge, Queens, New York.

waste, ca. 50% moisture, Palm Beach County Solid Waste Authority), 1.1 tons per acre of dried municipal solid waste compost (Wheelabrator Sludge, Queens, New York) and 73-39-38 lbs of N-P-K per acre (Table 1). Soil solarization was initiated 17 July on 8-inch tall, 36-inch wide beds using 1.2 mil, clear, low density polyethylene (LDPE) plastic containing UV light inhibitors (AEP Industries, Hackensack, NJ).

In a nearby plot of the same dimensions, mineral fertilizer was applied (Table 1) and the soil was fumigated with methyl bromide plus chloropicrin (98:2) at 300 lbs per treated acre on 28 August. After fumigation, beds were immediately covered with a co-extruded, white-over-black, 0.7 mil thick, high density polyethylene plastic (Sonoco Products Co., Orlando, FL).

Solarization was terminated after 51 days (6 Sept.) by painting the plastic white using a latex based paint (Kool Grow, Gainesville, FL). Pepper (cv Boynton Bell) was transplanted on 16 Sept., two rows per bed, into the solarized and methyl bromide-treated plots. Subsurface (seepage) irrigation was used. Yield from six subplots (16 ft of row) located randomly within each main plot was assessed on 18 and 26 Nov. Marketable yield was also obtained from grower packout data on 21 Nov., 2 and 20 Dec.

Weeds protruding from the plastic or the plant hole in six 50 ft long subplots were counted on 3, 31 Oct. and 25 Nov. The incidence of *Phytophthora* root and crown rot was assessed on 27 Nov. by recording the number of diseased plants in the center four rows of each plot. The severity of root-galling by root-knot nematodes was assessed on 27 Dec. by physically removing four plants from each subplot and determining the severity of galling using a scale of 0 to 5 (Taylor and Sasser, 1978). Soil samples for nematode analysis were collected on 27 Dec. by removing and combining soil cores 1 inch in diameter and 8 inches deep from the root zone of six plants per subplot. Nematodes were extracted from 100 cm3 soil subsamples with a modified sieving and centrifugation procedure (Jenkins, 1964), and then identified and counted. Following the last pepper harvest, the plants were mowed and rows were side dressed with 250 lbs per acre of 12-0-4 N-P-K. New holes were punched into the plastic and cucumber (cv. Speedway) was planted. Cucumbers were harvested on four dates and yield was obtained using packout data. Root systems were assessed for galling and soil samples for nematode analysis were collected on 24 Mar.

Cucumber. Three treatments were arranged in a randomized complete block design with four replications per treatment. Treatments consisted of soil solarization, fumigation with methyl bromide plus chloropicrin (98:2), and an untreated control. Each plot was a single row 75 ft in length. Rows were spaced 5 ft apart on centers. Solarization was initiated on 6 June on raised beds using clear, 1.2 mil, LDPE with UV inhibitors (Polyon-Barkai, Israel). Prior to solarization, 65-20-65 lbs of N-P-K was applied to the beds. The solarization period was terminated after 65 days (10 Aug.) by painting the clear plastic white.

Methyl bromide plus chloropicrin (98:2) was applied on 1 Aug. and plots were immediately covered with a co-extruded white over black, 1.2 mil LDPE (AEP Industries). Plastic mulch was also applied to untreated control beds on 1 Aug.

Cucumber (cv. Dasher II) seeds were planted on 30 Aug. at a 12-inch spacing with two rows per bed. Weekly injections of 1 lb N + 1 lb K per acre were made beginning 1 Sept., using drip irrigation. Stand and weed count were assessed on 20 Oct. Plots were harvested on 10, 13, 16, 18, and 23 Oct. The severity of root-galling was assessed on 26 Oct. Soil samples were collected for nematode analysis on 30 Oct.

Pumpkin. Three treatments, consisting of soil solarization, solarization plus 1,3-dichloropropene (1,3-D), 8.0 gal per treated acre) and an untreated control were applied to non-replicated 10.5, 3.1, and 0.1 acre plots, respectively. The solarization and fumigation treatments were applied on 2 June to raised beds (6 by 36 in) using 1.2 mil LDPE (AEP Industries). The untreated control treatment consisted of 1.2 mil co-extruded, white over black LDPE film (Edison Plastics, Newport News, VA) and was applied on 6 June. Solarization was terminated after 34 days by painting the plastic white.

Plots were harvested on 30 Sept. Fruit within a 0.1 acre section of row were harvested and weighed for each treatment. Root gall ratings were taken on five plants in each treatment, and soil samples for nematode densities were collected from the base of five plants in each treatment.

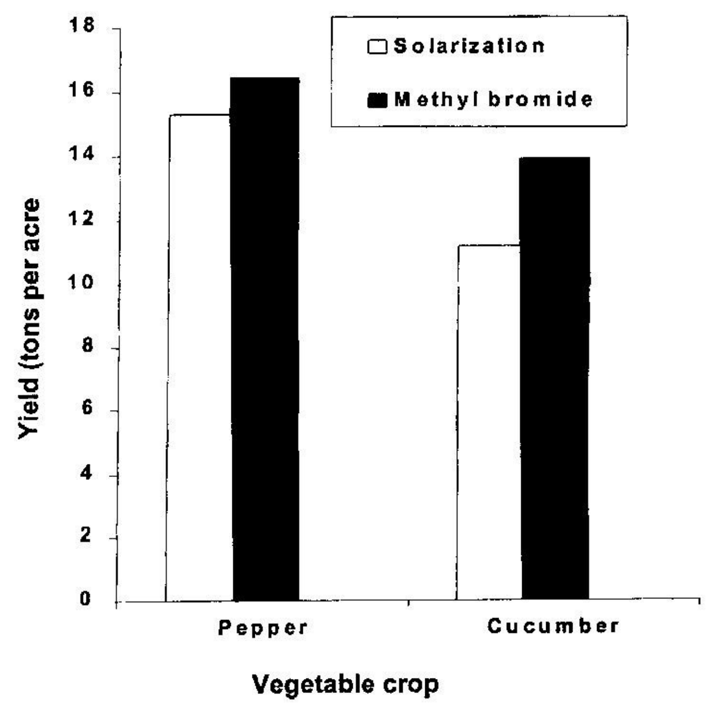

Figure 1. Marketable yield of pepper and a double-crop of cucumber from solarized and methyl bromide-treated plots in Palm Beach County.

(282)

Table 2. Effect of solarization and compost on soil-borne pests of pepper and cucumber in Palm Beach County.

Treatment	*Phytophthora* blight[z]	*Meloidogyne incognita*[y]	Root gall ratings[x]	Weed density[w]
	Pepper			
Solar + MSW[v]	2.5%	1.6	0	0.22
Methyl bromide	2.3%	0	0	0.04
	Cucumber			
Solar + MSW	—	1,682	1.04	—
Methyl bromide	—	0	0.04	—

[z]Disease incidence.
[y]Density of nematodes per 100 cm3 of soil.
[x]Estimates of the number of galls per root system using a scale of 0 to 5 in which 0 = no galls and 5 = > 100 galls (Taylor and Sasser, 1978).
[w]Number of weeds emerging through the plastic per ft of row.
[v]Municipal solid waste compost.

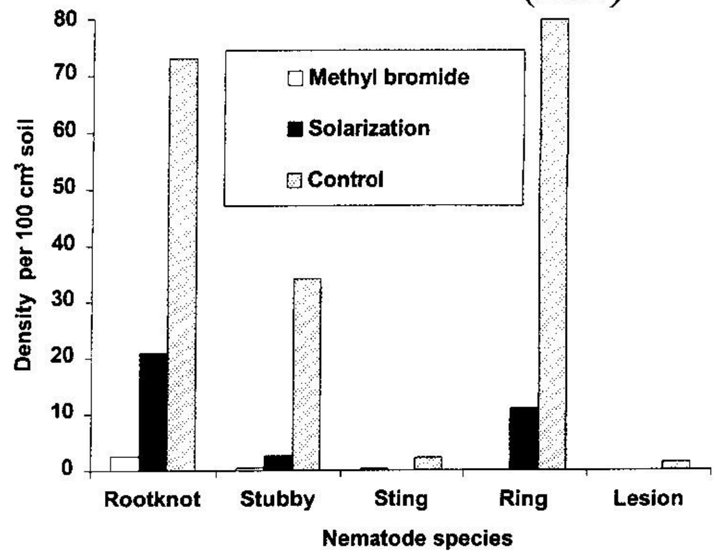

Figure 3. Density of plant parasitic nematodes following production of cucumber in Suwannee County.

Results and Discussion

Marketable yields of pepper were 1.1 ton per acre greater with methyl bromide than with solarization (Fig. 1). Pest levels were low in both treatments (Table 2). In the double-crop of cucumber, marketable yields were 2.7 ton per acre higher with methyl bromide (Fig. 1). There was a large increase in root galling and density of root-knot nematodes with solarization. *Meloidogyne incognita* was subsequently identified from those soil samples.

In Suwannee County, the highest yields of fancy, number 1 and number 2 cucumbers were obtained from the methyl bromide- treated plots (Fig. 2). Yields were 3.1 tons per acre higher than yields in solarized plots and 8.1 tons per acre higher than the untreated control plots. Density of root-knot nematodes reached 73 per 100 cm3 of soil in the nontreated soil as compared with 21 in the solarized plots and 2.5 in the methyl bromide-treated plots (Fig. 3). Both solarization and methyl bromide appeared to control stubby-root (*Trichodorus* spp.) and ring (*Criconemoides* spp.) nematodes. Densities of sting (*Belonolaimus* spp.) and lesion (*Pratylenchus* spp.) nematodes were low with all three treatments. Root gall indices were 0.7, 1.6, and 3.1 in the methyl bromide, solarized, and control plots, respectively. Late-season stand counts for cucumber were 100%, 100%, and 40% for the methyl bromide, solarized, and untreated plots, respectively.

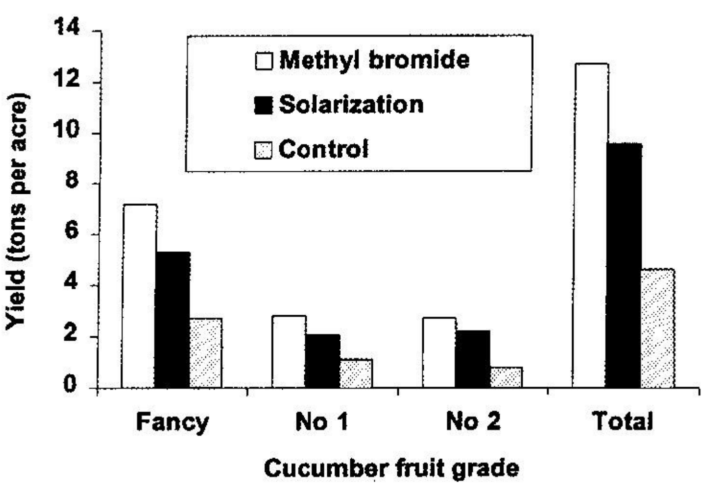

Figure 2. Marketable yield of cucumber from solarized, methyl bromide and untreated plots in Suwannee County.

Highest yields of pumpkin were obtained with the nontreated control, followed by solarization plus 1,3-D, and solarization (Table 3). The differences in yield may be due to uneven pollination in the field as a greater number of fruit was observed in the nontreated area of the field. High densities of *Meloidogyne* spp. and severe root galling were observed in the control and solarization treatments. Combining solarization plus 1,3-DCP eliminated root galling and the high density of *Meloidogyne* spp. Weed densities were similar in both solarized treatments and were well below the untreated control.

Soil solarization is a hydrothermal process which utilizes clear plastic stretched over moistened soil to trap solar energy and heat the soil (Stapleton and DeVay, 1995). When extended over a 4 to 8 week period of time, this procedure has been shown to control many of the soilborne pests which threaten the Florida fresh market vegetable production industry (Chellemi et al., 1997; Heald and Robinson, 1987; Ristaino et al., 1991, 1996). In this study, solarization did not control root-knot nematodes on cucurbit crops, especially in the cucumber crop that followed pepper. Combining solarization with 1,3-D provided control of nematodes, as was observed in

Table 3. Effect of solarization and 1,3-dichloropropene on yield of pumpkin and the incidence of soilborne pests.

Soil	treatment	Fruit T per acre	*Meloidogyne* spp.[z]	Root gall ratings[y]	Weed density[x]
Clear	—	4.4	1,468	4	0.10
Clear	1,3-DCP[w]	5.3	0	0	0.00
White[v]	—	6.0	933	3	2.53

[z]Density of nematodes per 100 cm³ of soil.
[y]Estimates of the number of galls per root system using a scale of 0 to 5 in which 0 = no galls and 5 = > 100 galls (Taylor and Sasser, 1978).
[x]Number of weeds emerging through the plastic per ft of row.
[w]1,3-dichloropropene applied at 8 gal per broadcast acre.
[v]Untreated control.

other studies (Cartia et al., 1989; Chellemi et al., 1997). Soil samples measured for nematode density did not contain root-knot species for any of three locations prior to planting. Thus, it is advisable to include treatments for the management of root-knot nematodes when utilizing solarization for cucurbit production.

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