Solarization Effects on Weed Populations in Warm Climates

Nancy Roe
Farming Systems Research. Inc.,
P.O. Box 741112
Boynton Beach, FL., 33474, USA

Monica Ozores-Hampton and Phillip A. Stansly
University of Florida/IFAS
Southwest Florida Research and Education Center
2686 State Road 29 North
Immokalee, FL 34142-9515, USA

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Abstract

Soil solarization is one possible alternative for methyl bromide fumigation. In several experiments in two areas of the southern United States, we observed the effects of solarization on weed populations. Clear polyethylene over raised beds (15-18 cm high) was used in all experiments, and moisture was provided during solarization by drip irrigation or subsurface seep irrigation. In sandy soil in southeast Florida, 1.2 ha blocks were solarized for 10 weeks. Control blocks were fumigated with 98 % methyl bromide: 2 % chloropicrin at 202 kg≅ha^{-1}. During growth of a cucumber (*Cucumis sativus*) crop following the initial pepper (*Capsicum annuum*) crop, mean percent weed cover in solarized blocks (59.5%) was higher than the 14.8% in controls. In a sandy loam soil in the more arid climate of central Texas, beds were solarized from 22 July to 19 Aug., 1998. Broccoli (*Brassica oleracea* var. botrytis) was planted into plots. Mean dry weight of weeds collected from solarized plots 6 weeks after solarization (9.5 g) was higher than that from non-solarized plots (2.8 g). On 14 July, 1999, during growth of a subsequent tomato (*Lycopersicon esculentum*) crop, weed coverage in solarized plots (7.8 %) was still higher than that from non-solarized plots (34.9%). On an organic farm in the same area of Texas, plots were solarized from 13 July through 26 Aug., before transplanting broccoli into plots. Although weed dry weights from non-solarized plots 6 weeks later were 2.2 times those from solarized plots, differences were not significant. In these experiments, solarization often lowered weed populations, even a year after solarization. Solarization can be an important weed management tool for warm-climate vegetable growers who cannot or choose not to use fumigation or other chemical weed control.

INTRODUCTION

Soil solarization has been suggested as a possible alternative for methyl bromide fumigation to suppress populations of nematodes, pathogens, and weeds (Chase et al.,1999; Haidar and Sidahmed, 2000; Mushobozy, et al., 1998. Ozores-Hampton et al., 2001). Like most lower impact methods, it is often more challenging to manage than conventional chemical methods. Factors such as soil texture and structure; soil moisture; solar radiation; depth of weed, nematode, and pathogen propagules; and type of polyethylene cover can affect outcomes of solarization.

Whether their production system is conventional, organic, or a combination, most vegetable growers must constantly battle weed populations, especially recalcitrant species such as the nutsedges. In areas with long growing seasons, there may be several generations of differing populations of weeds. Methyl bromide has been an effective, affordable control method used on the majority of the commercial vegetable acreage in the south. However, its loss as a soil fumigation option has many growers looking for alternatives. While most wish to find a chemical control method, some realize that each chemical alternative presents potential problems and longer term solutions would be preferable.

A prolonged warm sunny period is necessary for the solarization process to be effective. In temperate areas, it may be a problem for growers to take crop land out of production during the summer growing season. In areas with longer growing seasons, such as most of Texas and other southern states in the U.S., spring crops often finish early in the summer and there is a fallow period before fall crops are planted. The subtropical growing

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area of south Florida appears to be ideally suited to the use of solarization period, since summer is the fallow season for most cropping systems. Frequent cloudy and rainy periods may reduce the effectiveness of solarization, however, Chase et al. (1999) reported that soil at 5 mm deep under a clear polyethylene film was over 45° C for 107 hours during a 30 day summer solarization period.

Researchers have reported that effects of solarization on weeds vary with locations, solarization periods, soil moisture, and weed species. Haidar and Sidahmed (2000) reported that solarization reduced weed infestation for 180 days, but not for 230 days. Most seeds of eight weed species which tolerated temperatures of 70° C for 7 days in dry soil were killed after 3 days in moist soil (Egley, 1990). Seeds of some species were killed at 50° C while others survived to 70° C.

Our objective is to develop a long term sustainable vegetable production system for subtropical regions. These experiments were done to quantify and compare the effects of solarization on weed populations in several (relatively) warm locations.

MATERIALS AND METHODS

Clear polyethylene (low-density 1.2-mil containing UV light inhibitors, Sonoco Products Co., Orlando, FL) was used in all three experiments.

Florida: On a conventional farm in Florida, beds were constructed 20 cm high, 92 cm wide and spaced 1.7 m center to center in five 1.3 ha plots, each consisting of 10 beds, 610 m long. Fertilizer was applied to all plots at 71N-39P-44K $kg \cdot ha^{-1}$ broadcast before bedding and 283N-0P-279K $kg \cdot ha^{-1}$ banded in bed centers. Clear polyethylene was applied to 4 plots on 5 Aug., 1998. The control plot was fumigated with 98 % methyl bromide: 2 % chloropicrin at 202 kg≅ha^{-1} on 30 Aug., 1998. Beds were solarized until 19 October when the clear polyethylene was sprayed with white latex paint. >Boynton Bell= pepper (*Capsicum annuum* L.) plants were transplanted into the plots on 24 Oct., spaced 25 cm apart with 2 offset rows per beds spaced 45 cm apart. After the pepper crop was harvested, cucumbers were seeded into the beds at the same spacing as the pepper plants. Weed coverage was estimated at 28 weeks after solarization by estimating the coverage within 60 randomly chosen 0.02 m^2 areas in each plot.

Texas REC: At the Texas A&M Research and Extension Center in Stephenville, soil was tilled, beds were constructed 20 cm high, 77 cm wide and spaced 1.5 m center to center, drip tape was placed 10 cm deep, and clear polyethylene was applied to solarization plots by machine on 22 July, 1998. Mean air temperature during the solarization period was 29°C. On 19 Aug., black polyethylene mulch was applied over all plots (including over the clear polyethylene in the solarized plots) >Packman= broccoli was transplanted into all plots (two rows/bed) on 25 Aug. Plants were fertilized through the drip system with N-P-K at 0.55-0.24-0.45 kg≅ha^{-1} /day. On 28 Sept., weed tops and roots were pulled from all plots, and dried at 160°C for 96 hrs. Weight of dried tissue was recorded. After broccoli harvest, beds were left standing over the winter. On 8 Mar., 1999, all plots were sprayed with glyphosate (2%) to kill weeds growing at the time. >Summer Flavor XLT= tomato plants were transplanted into the plots on 31 Mar. Plants were fertilized through the drip system with N-P-K at 1.1- 0.48-0.91 kg≅ha^{-1}/day and sprayed for diseases and insects as needed. Percentage of weed coverage was estimated by 4 people on 14 July and estimates were averaged.

Texas organic: At an organic farm in Texas, beds were constructed 1.8 m apart on 13 July, 1998. Drip tape was placed about 10 cm deep. Plots were 15 m long and one bed wide. Fish emulsion was the only fertilizer used. On 26 Aug., all plots were covered with a black polyethylene mulch. >Packman= broccoli was transplanted into all plots (two rows/bed) on 27 Aug. On 13 Oct., all weeds in each plot were cut off at the soil line and dried at 160°C for 96 hrs. Weight of dried tissue was recorded.

Data from all experiments were subjected to analysis of variance (ANOVA) and mean separation according to Duncan=s Multiple Range Test.

RESULTS

At the end of the cucumber crop, solarized treatments in Florida had higher percentage weed cover, compared with the fumigated plots (Table 1) Locascio et al., (1999) reported nutsedge control similar to methyl bromide fumigation at one location but, at another location, the researchers noted that the solarization was not as effective, probably because it was done too late in the summer. Although solarization sometimes controls weeds as well as methyl bromide fumigation, growers who plan to use solarization should not expect the same level of control.

After the first crop at the REC in Texas, weight of weeds was higher in solarized plots than in plots with no weed control method. This may have been related to the vigor of the species of weeds in the various treatments; solarization, like the use of herbicides, tends to select for certain species. Ozores-Hampton et al. (2001) reported that solarized treatments contained more perennial than annual weeds, compared with methyl-bromide fumigated plots. Since our data at the first Texas REC collection date was by weed weight, we could have actually had fewer, but larger, weed plants in the solarization plots. The most interesting and obvious difference in these experiments was the difference in weed coverage at the Texas REC on the second observation date (Table 1). These plots had been covered with black polyethylene all winter and 11 months after solarization ended, it was easy to identify the solarized plots by the low number of weeds in them, compared with unsolarized plots. Of course, if we had compared solarization with a methyl bromide fumigation, it may not have been so effective. However, for growers in a climate such as this who may not wish to fumigate or may not have access to the technology or money for it, solarization does appear to be a viable alternative.

Although the weights of weeds collected from plots at the organic farm appear to be different, the differences were not significant, due to problems with the watering system causing high variability within the field.

Our results are similar to those of other authors who have reported that, under favorable conditions, solarization generally results in effective weed control. Mushobozy et al. (1998) reported that solarization controlled weeds of 16 species. Only a mean of 3 plants/plot of purple nutsedge (*Cyperus rotundus*) survived, compared with 123 in the unsolarized plots.

In our experiments, solarization was less effective in controlling weeds than methyl bromide fumigation, but generally more effective than not using any weed control method. In one case, it provided significant control even a year after solarization. Solarization can be a helpful weed control tool for growers who cannot or do not wish to use methyl bromide fumigation.

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Tables

Table 1. Weed coverage in solarized and control plots in three experiments.

Experiment	weed cover in solarized plots (% or g/plot)	weed cover in control plots (% or g/plot)	Significance (Pr>F)
Florida	59.5%	14.8 %	*
Texas REC (first crop)	9.5 g	2.8 g	* (0.0195)
Texas REC (second crop)	7.8 %	34.9 %	* (0.0233)
Texas: organic farm	27.9 g	63.8 g	NS (0.0618)