THE POTENTIAL OF SOIL SOLARIZATION TO CONTROL *VERTICILLIUM DAHLIAE* IN OKLAHOMA

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In the late summer of 1982 clear plastic mulch was used to solarize field plots known to contain a natural infestation of *Verticillium dahliae. Soil* temperatures exceeding 37 C were achieved and maintained in the solarized plots to a depth of at least 15 cm for 9-10 hr. Post-solarization assay for microsclerotia of *Verticillium dahliae* indicated an absence or reduction of these propagules in the solarized treatments compared to pretreatment levels.

INTRODUCTION

Soilborne diseases caused by certain genera of fungi can be major limiting actors to plant productivity. Such fungi may be difficult to control owing to their production of resistant structures known as chlamydospores, or sclerotia. Crop rotation is inadequate to control such fungi, and fumigation, while it destroys the fungi, is often not economical. Recently (1-3), there has been widespread interest in utilizing solar energy and clear plastic mulch to create soil temperatures sufficient to reduce populations of these fungi.

Preliminary evaluation of solarization was done at the O.S.U. Vegetable Research Station at Bixby, OK (Conway, personal communication). Temperatures were recorded daily, between 1-2 pm, using a digital readout thermometer. In July 1982, under clear plastic mulch, maximum temperatures of 45, 42, and 36 C were recorded at soil depths of 20, 30 and 40 cm, respectively. The length of time that these temperatures were maintained under the plastic mulch could not be determined with the instrumentation available. Baker and Cook (4) illustrated that in compost, temperatures of 54-66 C held for 30-min periods controlled most damping-off organisms and plant pathogenic fungi. Pullman et al. (3) showed that at lower temperatures, longer exposures were necessary to achieve an LD_{90} for *Pythium ultimum* Trow. and *Verticillium dahliae* Kleb. Their research indicated that a temperature of at least 37 C for 18 - 28 days would be necessary to provide an effective control. However, a temperature of 50 C would reduce the time interval needed for an LD_{90} to 27 - 33 minutes. Our study was carried out to determine if soil temperatures effective in controlling *V. dahliae* could be achieved by solarization in Oklahoma.

MATERIALS AND METHODS

A field that had previously been planted to cotton for a number of years, and was known to have a high incidence of Verticillium wilt, was selected for solarization studies. The field was roto-tilled to a depth of 10 cm to loosen the soil. Six plots (3-0 X 3.8 in) were arranged in a single tier with each plot separated from the next by a 1.0-m alley. Three plots were to be covered with the plastic mulch and three would be untreated. Soil samples (to 15 cm depth) were taken randomly from each plot prior to any treatment to determine the density of *V. dahliae* microsclerotia in each plot.

On July 21, 1982, temperature probes were buried in the center of each plot at 2.5, 7.5, 15.0, and 30.0 cm below the soil surface. Soaker-type garden hoses were arranged over the three treated plots and clear 4-mil plastic was stretched over the hoses. Edges of the plastic were buried to prevent movement by the wind. Treated plots were watered twice during the experiment.

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From July 21 -August 31, soil temperatures were recorded daily between 2 - 4 p.m. using a digital readout Trendicator Model 400A (Omega Engineering, Inc., Box 4047, Stamford, Conn. 06907). On September 1, four probes from each of two solarized plots and two probes at 2.5 and 30 cm, from a nontreated plot were attached to a 10-channel continuous chart recorder. Chart speed was calibrated to give two readouts/ hr/channel. Temperature was recorded for a 48-hr period. Maxium air temperature for September 1 - 3 was 38 C.

Plastic was removed from the solarized plots on September 7 and post-treatment soil samples (0 - 15 cm depth) were taken randomly from each of the six plots. Densities of *V. dahliae* microsclerotia were determined for each plot (pre- and posttreatment) according to the procedure of Martin, et al. (5) except that ethanol-agar-streptomycin medium was used (6). Bulk soil samples from each plot were thoroughly mixed and air dried. Three 10-g soil samples were taken from each treatment. Each- 10-g sample from each treatment was washed through nested sieves with 125-µm and 37-µm openings. The residue on the 37-µm sieve was surface-sterilized for 10 sec in 0.5% NaOCI, rinsed, and washed into a 50-ml beaker to give a volume of 15-20 ml. This suspension was distributed onto the surface of ten petri dishes containing the selected medium. The alcohol-agar was prepared by first autoclaving 10 g agar in 1000 m*l* water. When the agar had cooled to 45 C the following ingredients were added; 0.3 g streptomycin sulfate, 0.03 g tetracycline hydrochloride and 6 ml 95% ethyl alcohol. The cultures were incubated in dark at room temperature for 10 - 14 days, after which time soil was washed from the surface of the medium. Each colony of *V. dahliae* in the agar was presumed to have originated from a single microsclerotium. The numbers of colonies were totaled from the ten petri dish cultures and this equalled the number of microsclerotia in the original 10-g soil sample (5).

RESULTS AND DISCUSSION

Daily temperature recordings showed that temperatures under the plastic were usually 6 - 10 C higher than in the nontreated plots. These recordings gave only relative temperature differentials and did not indicate either maximums or the time at which maximum temperatures occurred at each soil depth. Temperature recordings from September 1 - 3 showed diurnal fluctuations with maximum soil temperatures occurring at 3 - 4 p.m., 3 - 5 p.m., 5 - 9 p.m., and 6 p.m. - 4 a.m. at 2.5, 7.5, 15.0 and 30.0 cm respectively for the solarized plots. Max-

TABLE 1. *Maximum temperature and hours above 37 C for solarized and nonsolarized soil at various depths, Stillwater, OK 1 Sept - 3 Sept, 1982*

	Solarized		Non-Solarized	
Depth (cm)	Maximum C.	Hr>37 C	Maximum C.	Hr>37 C
2.5	53	10-13	46	6-8
7.5	50	10-13	—[a]	—
15.0	41	9-10	—	—
30.0	37	0	33	0

[a]denotes no temperature recorded at these depths.

TABLE 2. *Soil solarization: number*[a] *of* Verticillium dahliae *colonies isolated from 10 grams of air-dried soil.*

Treatment	Pre-solarization	Post-solarization	Change, %
Clear Plastic Mulch			
Plot 1	6.0	0	−100.0
2	9.3	0	−100.0
3	3.0	1.3	−56.7
Nontreated			
Plot 1	3.0	2.7	−10.0
2	4.0	5.7	+42.5
3	5.0	1.7	−66.0

[a]Average from three replications of 10 g each.

imum temperatures were approximately 7 C and 4 C higher at 2.5 cm and 30.0 cm. respectively, in solarized compared to nontreated plots. Table I shows the number of hours that a temperature of 37 C was maintained at the various levels. Although maximum soil temperature under the plastic was lower at 15.0 cm than at 2.5 cm in the nontreated plot, the number of hours at 37 C or above was greater in solarized plots at 15.0 cm than at 2.5 cm in the non-treated plot. Threshold temperature of 37 C was maintained almost twice as long as the 2.5-cm depth in the solarized plots as in the nontreated plots.

Average densities of viable *V. dahliae* microsclerotia prior to solarization from three 10-g soil samples were 3, 4, and 5 microsclerotia/10 g of soil in nontreated plots and 6, 9.3, and 3 microsclerotia/10 g of soil in plots to be solarized (Table 2). Number of microsclerotia/10 g of soil recovered from the postsolarization assays were reduced 100% in two solarized plots and 56.7% in the third. Number of microsclerotia/10 g of soil decreased 10% and 66% in 2 nontreated plots and increased 42.5% in the third.

Although solarization using plastic mulch appears to have more utility for small garden areas, it has been used in California to commercially treat 4 - 8 X 10^3 acres of young pistachio orchards to control Verticillium wilt (7). Other researchers (1) are using soil solarization in integrated control programs to reduce the economic losses caused by soilborne diseases.

Results from this experiment are preliminary; however, there are good indications that solarization of field soil with clear plastic mulch can be successfully used in Oklahoma to control *V. dahliae*. In addition, the maintenance of 37 C temperatures to depths of at least 15 cm (September I - 3) indicates that solarization has application during several months under Oklahoma conditions.

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