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Putting the sun to work

Solarization can be an effective way to kill pests, pathogens and weeds

By Jennifer Parke and Fumiaki Funahashi

Solarization is the practice of using the sun's energy to kill soilborne pathogens, insect pests and weeds without the use of chemical pesticides.

To solarize soil, it is covered with a clear plastic sheet for 2–6 weeks during the warmest time of the year. Radiant energy passes through the transparent sheet, which traps the heat and transfers it to the underlying soil. The highest soil temperatures are reached in the top 6 inches, where temperatures can reach 122–140 F (50–60 C), lethal to many disease-causing fungi, water molds, bacteria and nematodes.

Most of the research on soil solarization has been conducted in hot climates at lower latitudes such as Israel, Florida and California, where agricultural fields may be solarized prior to planting vegetable crops. However, studies by plant pathologists at the USDA Agricultural Research Service, and Washington State University, have shown that soil solarization can also be effective in reducing *Phytophthora* root rot in raspberry fields in Oregon and Washington.

With increased restrictions on the use of chemical drenches and fumigants, solarization may offer greenhouse and nursery growers an alternative way to control soilborne pests and pathogens.

Solarization is not going to solve every soilborne pathogen problem, however. The method is best suited for pathogens or pests located in the top few inches of soil, or in situations where plant roots do not penetrate deeply into the soil.

Fig. 1. Soil and gravel beds contaminated with plant debris can lead to new infections in the next crop of container plants. Solarization offers a way to disinfest these soil-gravel beds and break the disease cycle. PHOTO COURTESY OF OSU

Controlling *Phytophthora* spp.

Solarization may be especially applicable to disinfesting *Phytophthora*-contaminated soil in container nurseries. Soil becomes infested with spores from fallen diseased leaves or infected roots.

Healthy container plants commonly become infected when they are placed on these contaminated soil-gravel surfaces in can yards or in greenhouses. Spores of the pathogen swim or are splashed up onto the containerized plants where they can cause root rot, shoot dieback or leaf blight (Fig. 1).

Like most other species of *Phytophthora*, *P. ramorum* is able to persist in the soil-gravel beds from year to year, and growers have few ways to disinfest soil once it becomes contaminated with *Phytophthora* species.

Dr. Gary Chastagner and colleagues at the Washington ▶

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Fig. 2. Experimental solarization plots at the NORS-DUC site in California.
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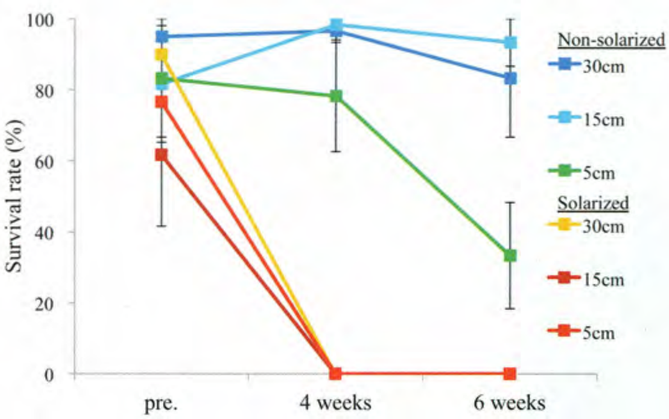

Fig. 3. Survival of *Phytophthora ramorum* at three different soil depths in plots that were solarized or not solarized.

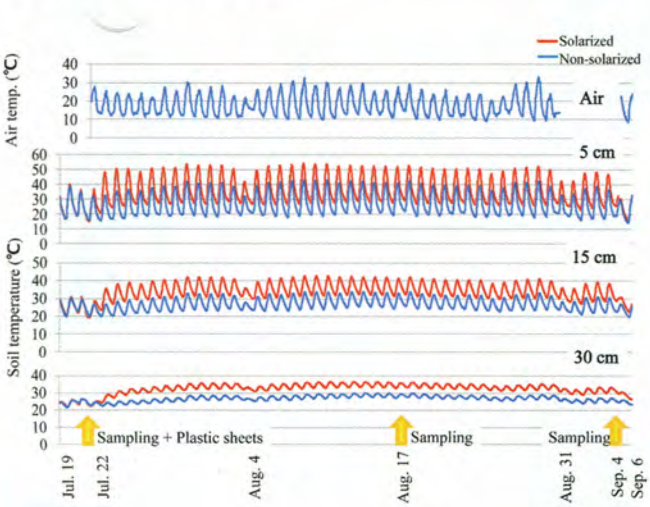

Fig. 4. Air temperature and soil temperatures in solarized and non-solarized plots at the NORS-DUC site (Trial 1).

State University Research and Extension Center in Puyallup, Wash., showed that spores and hyphae of *P. ramorum* are found only in the surface organic layer and top 10 centimeters (approximately 4 inches) of soil in infested container nurseries.

P. ramorum is also quite sensitive to elevated temperature. Dr. Robert Linderman at the USDA-ARS Horticultural Crops Laboratory in Corvallis, Ore., showed that *P. ramorum* is killed after just 30 minutes of exposure to 50 C (122 F). University of California at Davis researchers showed that it was killed by three days at 40 C (104 F).

Current research

We are conducting research to see if solarization could eliminate *P. ramorum* and other *Phytophthora* species from infested soil in container nurseries.

During the summer of 2012, we conducted two field trials on *P. ramorum* at a simulated nursery at the National Ornamentals Research Site at Dominican University of California (NORS-DUC), a quarantine facility in San Rafael, Calif. We set up a similar experiment (Trial 3) with *P. pini* at the Oregon State University Botany and Plant Pathology farm in Corvallis.

In each trial we established 12 experimental plots, each 8 feet by 8 feet. We watered them thoroughly to moisten the soil and allowed them to drain overnight.

To ensure that the pathogen was present in all the plots, we previously infested rhododendron leaves with *Phytophthora* and placed infested leaf disks in nylon mesh "sachets" filled with soil.

We buried the sachets at 5, 15 and 30 centimeters (2, 6 and 12 inches) beneath the soil-gravel surface in each plot. We then covered six of the plots in each trial with a 6-mil clear anti-condensation plastic sheet (Thermax™, AT Films, Inc., Edmonton, Alb.); the other six plots (the non-solarized treatment) were left uncovered (Fig. 2). The edges of the plastic were sealed with a layer of gravel.

We monitored soil temperature and soil moisture at each depth with a datalogger and sampled periodically to retrieve the inoculum from each plot. We determined the percentage of leaf disks from which *Phytophthora* grew and plotted survival over time at each depth (Fig. 3). Trial 1 began July 19, Trial 2 started on Aug. 17, and Trial 3 (in Corvallis) on Aug. 24.

Solarization was very effective in eliminating *P. ramorum* from the top layer of soil in all trials. In Trial 1, *P. ramorum* could not be recovered from any of the three depths by our first sampling date at 4 weeks. In Trial 2, started one month later in the summer, we sampled at two weeks and found that *P. ramorum* was eliminated from the 5-centimeter and 15-centimeter depth, but not the 30-centimeter depth.

In Trial 3 in Corvallis, our results with *P. pini* showed good effectiveness at two weeks, but only at the 5-centimeter depth. An example of the temperatures obtained during solarization is shown in Fig. 4 and summarized for all trials in the table. ▶

Table. Summary of soil temperature data for the three solarization trials.

			Temperature (°C)					
			solarized			non-solarized		
site	plot	soil depth	ave.	max.	min.	ave.	max.	min.
CA	Trial 1	5 cm	36.4	50.9	26.9	27.3	39.4	18.9
		15 cm	35.0	40.6	30.6	27.1	31.8	23.3
		30 cm	33.0	34.9	31.7	26.9	28.4	25.8
CA	Trial 2	5 cm	33.1	46.5	23.8	24.7	35.5	16.9
		15 cm	32.2	37.6	27.5	24.8	28.5	21.3
		30 cm	30.6	31.9	29.1	24.9	25.9	23.7
OR	Trial 3	5 cm	29.7	40.3	21.8	21.8	28.8	16.3
		15 cm	28.7	32.4	25.3	21.7	24.1	19.5
		30 cm	27.5	28.7	26.4	21.6	22.3	20.9

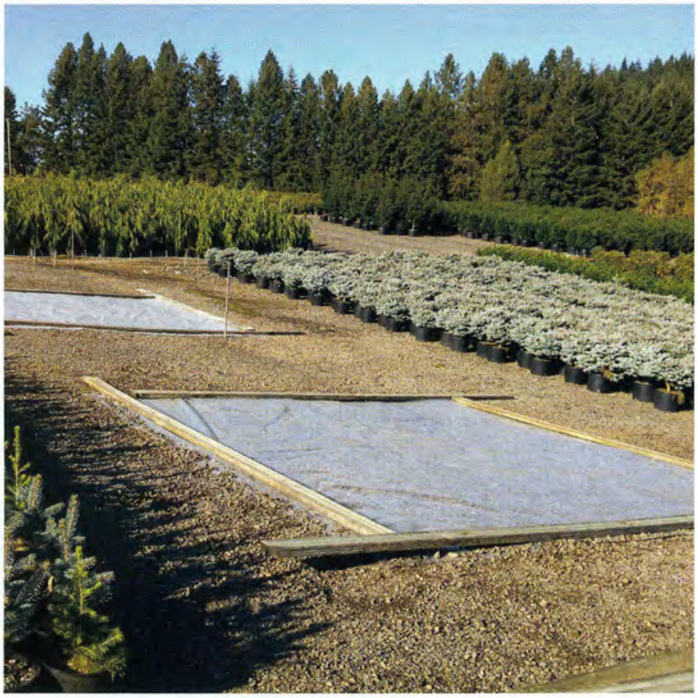

Fig. 5. A solarization trial at a commercial nursery in Oregon. PHOTO COURTESY OF OSU

For more information

To learn more about soil solarization, see these links:

http://edis.ifas.ufl.edu/in856
Introduction to Soil Solarization by R. McSorley and H. K. Gill. 2010. University of Florida Institute of Food and Agricultural Sciences Publication ENY 062

http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn74145.html
Soil Solarization for Gardens and Landscapes by J. J. Stapleton et al. 2008. University of California Agriculture and Natural Resources Pest Notes Publication 74145.

Tests at commercial nurseries

We also conducted a preliminary experiment in two commercial nursery sites in Oregon in September 2012 (Fig. 5). Container yards in these nurseries were naturally infested with *Phytophthora* spp.

We sampled soil before and after solarization, and baited for *Phytophthora* with rhododendron leaf disks in lab tests to determine effects on the *Phytophthora* population. We compared two types of plastic sheets: the 6-mil clear anti-condensation plastic that we used previously, and a slightly opaque plastic which was intended to retain more heat at night than the clear plastic. We also sampled and baited an adjacent non-solarized plot.

One of the nursery sites was on a poorly drained area, and water accumulated on top of the plastic and prevented optimal soil heating. In the other nursery site, water did not pool, and solarization was successful. *Phytophthora* was no longer detected after solarization. Also, the clear plastic was more effective than the opaque plastic.

We also investigated solarization as a way to disinfest used containers and infested media. We placed sachets containing *P. pini*, *Pythium irregulare* and *Rhizoctonia solani* in media and in used pots stacked on pallets. The pallets were covered with Thermax™ and either placed outdoors or inside closed, non-ventilated greenhouses for two weeks during the summer.

None of the pathogens survived greenhouse solarization, where temperatures exceeded 150 F, but outdoor solarization resulted in uneven heating and incomplete kill of the pathogens. The pathogens survived in pots stacked in the bottom and middle of the pallet loads stored outside.

Further studies to come

Experiments planned for 2013 include soil solarization trials in multiple nursery locations on a variety of soil types and surfaces (including bare soil and gravel or rock at different thicknesses) to generate soil temperature data for diverse nursery conditions.

We will determine the relationship between exposure time and temperature as a first step in developing a model for predicting where and when soil solarization would be most effective in nurseries.

Biocontrol amendments may also be applied after solarization. If you would like to participate in future solarization research, please contact us.

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