SOIL SOLARIZATION: A PERSPECTIVE FROM A NORTHERN TEMPERATE REGION.

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Soil solarization has proven to be an effective means to control damage caused by soilborne pests and plant pathogens. Solarization depends on solar energy to heat the soil to temperatures which are lethal to these organisms. This is accomplished by covering moist soil with a clear plastic film or mulch during a 2 to 8 week period with plentiful solar radiation. Most soilborne pests and plant pathogens are mesophilic and are killed at temperatures between 40 and 60 C. At these elevated temperature, disfunction of membranes and increased respiration are responsible for death. However, death depends on the thermal dose, a product of temperature and exposure time.   Exposure to long periods of sublethal temperatures may effectively control diseases by reducing the ability of propagules to geminate, increasing the susceptibility to biological control organisms, and decreasing the ability to infect the host. High soil moisture also is critical because organism with resting stages or structures may become metabolically active and less tolerant of the elevated temperature, and because water increases the conductivity of heat in the soil.

In the future, the use of pesticides will become more restrictive. In addition to the loss of methyl bromide, provisions of the Food Quality Protection Act will limit the use of many effective pesticides, particularly on minor crops. In this scenario, soil solarization may become an economically viable component in integrated pest management. The broad spectrum of plant pathogenic fungi, phytonematodes, and weeds which have been controlled by solarization also make it a good tool in IPM. Reduced rates of soil fumigants in combination with solarization have been reported to be effective, as have certain green manures in combination with solarization. Following solarization soils have been observed to become suppressive to plant diseases. Solarization has been shown to shift the structure of microbial communities in the soil with increased population densities of *Bacillus* spp., fluorescent pseudomonads, and actinomyctes following solarization. Members of these groups are known to be biocontrol agents and to produce an increased plant growth response (IGR). Solarization can be an "environmentally friendly" technique for reducing the use of pesticides and to develop sustainable crop production practices. However, climatic and economic factors most likely will limit the areas where solarization will be practical.

Among the areas that solarization has been successfully used are hot, arid regions (Israel, California) and the subtropics (Florida).   Less data are available on the efficacy of solarization in the northern temperate regions. Climatic conditions in the Pacific northwest are favorable for solarization. Daily maximum temperatures in the summer range from 30 to 40 C, relative humidity is low, and cloud cover is rare. In addition, the returns from high value crops, such as small fruits and nursery, grown on small acreage in the region, may justify the cost of solarization. Over the last 4 years, we evaluated solarization in field plots artificially and naturally infested with soilborne pathogens and subsequently planted with susceptible nursery or small fruit crops.

Field experiments were conducted on a silty-clay loam in Corvallis, OR during the summers of 1995 and 1996 to study the effects of green manure cover crops (Sudangrass, rape, and barley), soil solarization, soil fumigation, and combinations of these treatments

on artificially introduced populations *Verticillium dahliae*, *Phytophthora cinnamomi*, *Pratylenchus penetrans*, **and** *Agrobacterium tumefaciens*. **Soil solarization was performed mid July to mid September using a 0.6 mil clear polyethylene film. Maximum soil temperatures recorded at depths 5, 10, 20, and 30 cm were 52, 47, 39, and 33 C in solarized soil, respectively; these temperatures were 8-16 C higher than in corresponding nonsolarized plots. Soil samples were collected before, during, and after solarization to quantify the pathogens at these four depths. Soil solarization, cover crops plus solarization, or fumigation with methyl bromide (800 L/ha) or metam sodium (920 L/ha) resulted in a significant decrease ($P \leq 0.05$) in density of *P. cinnamomi* populations at all 4 depths (Table 1) and *V. dahliae* at 5 and 10 cm (Table 2), while green manures alone were not effective. The soil also was assayed by planting snapdragons (for *P. cinnamomi*) or eggplants (for *V. dahliae*) in the sampled soil in the greenhouse and by planting maple or cherry trees in the field plots. The disease severity data of assay plants correspond with the densities of pathogens isolated from the soil. After one year the incidence of galls on cherry roots was reduced in solarized compared to nonsolarized plots. Because of the high initial densities of *V. dahliae* in the soil and the extreme susceptibility of Norway maples, solarization did not significantly reduce the severity of wilt.**

In 1997, a second experiment was established in a strawberry planting in decline from red stele, caused by *Phytophthora fragariae*, and black root rot, caused by a complex of fungi. Plots were solarized from mid July to mid September and soil samples were collected before and after solarization. Maximum soil temperatures recorded at depths 10 and 20 cm were 48 and 36 C in solarized soil, respectively; these temperatures were 17-10 C higher than in corresponding nonsolarized plots. Totem strawberry plants were transplanted into sampled soil, grown at 15 C for 6 weeks in saturated soil to promote infection, and then harvested to determine the effects of treatment on plant growth and root health using a root necrosis rating scale. Solarization significantly ($p \leq .01$) reduced strawberry root necrosis (Table 3) and root infection by *P. fragariae*, *Pythium*, *Rhizoctonia*, and *Cylindrocarpon* spp. in bait plants. Solarization also significantly increased plant dry weight in comparison to plants grown in non-solarized soils. Prior to planting strawberries in the field plots in spring 1998, soil samples again were collected and assayed. The incidence of root rot was significantly lower on plants grown in the solarized soil. Plants from the field plots will be evaluated for root infection symptoms in spring 1999.

Based on our experience Oregon, climatic conditions were adequate for solarization. Solarization resulted in a significant reduction in population densities of several important pathogens and the plant diseases which they cause. However, solarization must be done during the summer, precluding a crop and income from the land for one cropping year. Unlike more southern regions, cropping from fall through the early spring is not an option. Most growers are reluctant to lose the income, at least while fumigants and pesticides are effective and available. However, there are several cases where solarization may be economical. In nursery crop production when plants are dug in the spring, the field can solarized during the summer, and then replanted in fall or the following spring. The same is be true of strawberries and raspberries. After the berries are harvested in the spring, the field can be solarized and replanted the following spring.

References

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Table 1. Recovery of *Phytophthora cinnamomi* **from artificially infested soil after 2 months in solarized, fumigated, and cover cropped field plots in Corvallis, OR**.

	Mean *Phytophthora cinnamomi* baiting efficacy %						
Treatment	1995			1996			
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	30 cm
Control - Solar	0 c	0 c	16.7 cd	0 d	0 d	11.7 cde	31.7 c
Control - Nonsolar	87.5 a	93.8 a	100 a	88.3 a	100 a	100 a	100 a
Barley - Solar	0 c	0 c	4.2 d	0 d	0 d	20 cd	48.3 bc
Barley - Nonsolar	20.8 c	58.3 b	83.3 ab	30 c	73.3 b	83.3 b	95 a
Rape - Solar	0 c	0 c	0 d	0 d	0 d	11.7 cde	36.7 bc
Rape - Nonsolar	18.8 c	58.3 b	75 b	6.7 d	43.3 c	81.7 b	96.7 a
Sudan - Solar	0 c	0 c	0 d	0 d	0 d	21.7 c	53.3 b
Sundan - Nonsolar	58.3 b	75 b	87.5 ab	43.3 c	70 b	86.7 ab	93.3 a
Metam 230[y] - Solar	0 c	0 c	29.2 c	0 d	0 d	0 e	3.3 d
Metam 230[y] - Nonsolar	0 c	0 c	10.4 cd	0 d	0 d	6.7 de	11.7 d
Metam 930[y] - Nonsolar	0 c	0 c	0 d	0 d	0 d	0 e	0 d
Methyl bromide	NA	NA	NA	0 d	0 d	0 e	0 d
Initial inoculum density	100	100	100	100	100	100	100

Table 2. Population densities of *Verticillium dahliae* **in artificially infested soil after 2 months in solarized, fumigated, and cover cropped field plots in Corvallis, OR.**

	V. dahliae counts (cfu $^{-g}$ dry soil)						
Treatment	1995			1996			
	5 cm	10 cm	20 cm	5 cm	10 cm	20 cm	30 cm
Control - Solar	4.5 d	22.5 de	57.0 b	1.2 c	12.8 de	42. 0de	75.2 bcd
Control - Nonsolar	101.5 a	115.3 a	170.8 a	162.6 a	189.2 a	203.2 a	204.4 a
Barley - Solar	2.8 d	5.0 fg	27 e	0 c	6.4 efg	25.2 e	47.6 e
Barley - Nonsolar	50.3 c	35.8 c	22.5 ef	12.6 b	23.0 cd	38.8 de	48.2 e
Rape - Solar	0 d	2.5 g	30.8 de	0 c	1.8 efg	43.8 de	57.4 de
Rape - Nonsolar	75.5 b	49.5 b	40.3 cd	19.6 b	41.4 b	65.6 bc	91.4 b
Sudan - Solar	0.5 d	4.8 fg	42. 0 c	1.2 c	11.2 ef	46.8 cd	62.6 cde
Sundan - Nonsolar	58.0 c	31.3 cd	12.5 fg	19.4 b	33.6 bc	78.8 b	87.0 bc
Metam 230[z] - Solar	2.8 d	14.8 ef	47.3 bc	0.6 c	3.0 efg	30.0 de	71.4 bcde
Metam 230[y] - Nonsolar	0.5 d	9.0 fg	46.8 bd	1.8 c	10.4 efg	39.4 de	69.0 bcde
Metam 930[y] - Nonsolar	1.8 d	2.3 g	7.3 fg	0 c	1.2 fg	3.8 f	5.0 f
Methyl bromide	NA[z]	NA	NA	0 c	0 g	0.6 f	1.2 f
Initial inoculum density	302	302	302	234	234	234	234

TABLE 3. Mean Root Rot rating[y] of strawberry bait plants

	Treatment		
	Solarized	Nonsolarized	Control[z]
Pre solarization	1.95 a	1.53 a	0.03 b
Post solarization	0.17 b	1.15 a	0.01 b

[y] Root rot rating of 0 indicating no root rot and 5 indicating 100% of the roots were rotted.
[z] PasTueurized field soil