EFFECTS OF SOIL SOLARIZATION AND FUMIGATION ON INDIGENOUS ARBUSCULAR MYCORRHIZAL FUNGI.

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Soil solarization, the process of heating soil by covering fields with clear plastic, is a promising method to reduce populations of soilborne pests and weeds without the use of pesticides. The destruction of beneficial organisms such as arbuscular mycorrhizal (AM) fungi also may occur, thereby reducing positive effects of solarization. We tested the effects of solarization and fumigation (metam sodium and methyl bromide) on the survival of indigenous AM fungi in soil. Field plots (2 × 2 m) on a silty-clay loam soil at the Oregon State University, Botany Research Farm were utilized. Solarization or fumigation with metam sodium at 2 rates (230 or 930 L ha^{-1} -see footnote C in Table 2) were compared in year 1. Fumigation with methyl bromide at 800 kg ha^{-1} under a tarp was added to our experiment in the second year. Each treatment plot was replicated 4 times in year 1 and 5 times in year 2 in a randomized complete block design. Soil samples were collected from 0-30 cm depth immediately before and after the solarization period (July 20 and September 19, 1995 and July 25 and September 18 1996) and again 8 months after treatment (over winter). Infective propagules of mycorrhizal fungi were monitored using a greenhouse bioassay or a field bioassay with *Sorghum bicolor* L.

The effects of solarization on soil temperatures at three depths are shown in Table 1. Solarization increased the average daily soil temperature 6-10 °C and the maximum daily temperature 10-16 °C at 5-20 cm depth. An estimate of the thermal dose that occurred in solarized plots is shown as the cumulative hours of temperatures above 35, 40 and 45 °C (Table 1).

Solarization or fumigation with metam sodium had consistent effects on mycorrhizal fungi for both years of our study. Solarization did not reduce propagules of AM fungi immediately after the solarization period in either year, as determined by the greenhouse bioassay (Table 2 & 3). Mycorrhizal fungi were greatly reduced, however, 8 months after treatment in solarized plots. Fumigation with metam sodium at the high rate reduced mycorrhizal fungi in both years just after the solarization period or the following spring (Table 2 & 3). Metam sodium applied at the low rate reduced AM fungi in 1996 only. Differences between the low and high rate of metam sodium were not statistically significant in either year. Methyl bromide completely eliminated AM-fungus propagules to our sampling depth of 30 cm (Table 3).

A distinctive checkerboard pattern could be seen in our experimental plots the spring following treatment because of the dramatic effect on weed populations. In

the 1996 trial, weed densities measured in plots 8 months after solarization showed the strong suppression of weeds that occurred in solarized soil over the winter (Table 3). Weeds were nearly eliminated from solarized plots and those treated with methyl bromide. Plots treated with metam sodium at the low rate had similar weed densities as the control. No significant differences in the diversity of weeds present in different treatments were found (data not shown). Solarization was just as effective as methyl bromide and metam sodium at 930 L ha^{-1} in controlling winter annual weeds.

We suspected that the decline in mycorrhizal infectivity in our soil was due to the suppression of weeds in solarized plots. Weed populations were reduced to roughly one-tenth of the control level in our solarized plots. Thus, it seems that solarization may have indirectly reduced AM-fungus propagules by suppressing weeds that maintained AM fungi over the winter. Positive effects of winter cover crops on mycorrhizal fungi and growth of subsequent crops are well known from other studies. In our case, because no cover crops were included, the maintenance of mycorrhizal fungi over the winter was dependent on weeds. Solarization apparently reduced mycorrhizal fungi indirectly by suppressing weeds over the winter.

Solarizing soil during the summer may not be economical for vegetable growers in the Willamette Valley of Oregon, because of the loss of income during the growing season. Solarization during the summer is feasible for a number of horticultural and nursery crops, however, because fall or spring planting is often preceded by a summer fallow period. Our study showed that soil solarization per se did not reduce propagules of AM fungi in our soil, but rather reduced weeds that maintained mycorrhizal fungi over the long-term. Solarization may not impede mycorrhiza formation as long as crops are quickly planted into solarized soils. Otherwise, a mycorrhizal cover crop should be used after solarizing soil to maintain infective propagules of mycorrhizal fungi.

Table 1. Soil temperatures at three depths in solarized and non-solarized field plots during the solarization period in 1995 and 1996.

		Soil temperature (°C)[a]						
		Nonsolarized plots		Solarized plots		Cumulative hours in solarized plots		
Solarization period	Depth (cm)	Mean	Maximum	Mean	Maximum	>35	>40	>45
21 July-19Sept. 95	5	23.2	34.5	31.7	49.3	399	195	53
	10	23.4	31.2	33.1	45.9	445	160	9
	20	22.8	27.4	31.0	37.4	75	0	0
26July-18Sept. 96	5	22.9	37.0	29.3	52.6	309	169	66
	10	23.6	32.7	31.7	47.6	390	152	17
	20	22.4	28.0	29.9	39.1	101	0	0

[a] Temperatures were recorded hourly by a datalogger.

Table 2. Effects of solarization and fumigation in 1995 on arbuscular mycorrhiza formation in *Sorghum bicolor*.

	Percentage Root Colonization by AM Fungi		
	Greenhouse assay[a]		Field assay[b]
Treatment	July 1995	Sept. 1995	June 1996
Control, nonsolarized	2.48 (0.63)	2.73 (0.88) **a**	12.9 (1.16) **a**
Solarized		2.25 (0.59) **a**	2.8 (0.80) **b**
Metam sodium[c] - low		1.17 (0.34) **ab**	8.8 (1.20) **ab**
Metam sodium[c] - high		0.51 (0.18) **b**	6.9 (1.83) **b**
ANOVA sig. level (p)		0.032	<0.001

[a] Root colonization in greenhouse plants grown for 21d in diluted field soil (1:10) collected on July 20, 1995 prior to solarization or September 19, 1995 after solarization. (2 samples per field block, n=8). Values represent mean (se).

[b] Root colonization in field plants grown for 56d from May 10-June 22, 1996 (4 samples per field block, n=16) Values represent mean (se).

[c] Metam sodium was applied to the soil surface at 230 or 930 L per hectare, tilled to a depth of 20 cm and surface sealed by rolling.

Means within a column followed by the same letter are not significantly different by LSD ($p \leq 0.05$).

Table 3. Effects of solarization and fumigation in 1996 on arbuscular mycorrhiza formation in *Sorghum bicolor* and on weed densities in field plots.

	Percentage Root Colonization by AM fungi[a]			Weeds m^{-2}
Treatment	July 1996	Sept. 1996	May 1997	May 1997
Control, nonsolarized	1.69 (0.37)	1.97 (0.61) **a**	3.66 (0.65) **a**	357 (48) **a**
Solarized		1.74 (0.36) **a**	0.10 (0.06) **b**	36 (7) **b**
Metam sodium - low		0.83 (0.43) **b**	0.78 (0.38) **b**	352 (75) **a**
Metam sodium - high		0.08 (0.09) **b**	0.06 (0.08) **b**	107 (20) **b**
Methyl bromide		0 (0)	0 (0)	38 (9) **b**
ANOVA sig. level (p)		0.004	<0.001	<0.001

[a]Root colonization in greenhouse plants grown for 21d in diluted field soil (1:10) collected on July 25, 1996 prior to solarization, September 18, 1996 immediatley after solarization or May 12, 1997 eight months after solarization (2 samples per field block, n=10). Values represent means (se).

Means within a column followed by the same letter are not significantly different by LSD ($p \leq 0.05$).