SOIL DISINFESTATION WITH STEAM AND SOLARIZATION FOR FLOWER AND STRAWBERRY

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Summary. Soil solarization performance in coastal areas of California is often inconsistent due to fog and cool summer temperatures that do not allow soil to reach high temperatures required to reliably kill soil pests. Coastal California is also the principal strawberry fruit and cut flower production region, and solarization has displaced virtually no methyl bromide (MB) use in these crops. The objective of this study was to develop an economically feasible combined solarization and steam heat, soil disinfestation system for field-grown cut flowers and strawberry. Field studies were conducted at the Spence Research Farm at Salinas, CA (strawberry) and at a commercial farm (cut-flower) at Prunedale, CA in the 2007-08 seasons. For both strawberry and cut flower production, first year results show that steam treatments with and without solarization controlled weeds equal or better than methyl bromide.

Introduction. Soil disinfestation with steam has a long and proven track record for controlling soil borne weeds and pathogens in greenhouse and nursery settings. However, high energy costs and lack of appropriate steam applicators has limited the use of steam in commercial fields. Injecting steam into finished planting beds with a mobile steam generator under clear polyethylene mulch, as used for solarization, would permit steam to supplement solarization as needed. The objective of this research was to develop an economically feasible combined solarization and steam heat, soil disinfestation system for field-grown cut flowers and strawberry.

Materials and Methods. For both cut flower and strawberry production systems, raised beds were prepared as finished seed beds with starter fertilizer and drip irrigation tape installed following standard production practices. Plot beds were 52 to 72 inch wide and 20 ft long.

Prior to treatment application, pathogen (*Verticillium sp.)* and weed seed samples were installed in the planting beds. Weed species included common chickweed, common knotweed, common purslane, little mallow and yellow nutsedge. Viability of the weed propagules was determined using tetrazolium tests and enclosed in permeable nylon mesh bags. The pathogen samples were installed at the center of the bed, at 18, 12 and 6 inches depth below the soil surface (total of 3 samples per replication). Weed samples were installed at 6 and 2 inches depth from the soil surface (total of 4 samples per replication). Two of the weed samples were installed towards the edge of bed and remainder two towards bed center. After completion of treatment application, seeds and pathogens were removed from the bags and their viability determined.

The design was a randomized complete block replicated six times. Treatments included drip application of methyl bromide + chloropicrin (MBPic, 67:33) at 350 lbs/A, control (no MBPic, solarization or steam), solarization alone, steam alone, and steam + solarization. Prior to application of clear tarp for solarization, beds were irrigated to bring the soil moisture to sufficient levels for proper heat conduction and solarization. For steam + solarization treatments, beds were solarized for two weeks prior to steam application and for two weeks after application (total of four weeks). For the steam treatments, steam was injected for sufficient time to raise the temperature of the beds to 70°C for 30 min. After 30 min., steam disinfestation was discontinued. In 2007, all steam treatments were performed using a steam blanket Swartz[inc]. In the strawberry trial solarization was conducted Aug. 24 to Sept. 21, 2007 and steam was applied Sept, 6 to 11, 2007. In the flower trial solarization was conducted Aug. 28 to Sept. 27, 2007 and steam was applied Sept 12 and 13, 2007.

During solarization and steam disinfestations process, temperatures were monitored continuously using temperature probes (Hobo, Pocasset, MA) installed in beds at 2, 6, 12, and 18 inches depth. The amount of fuel, time and labor needed for treatment application were recorded.

Strawberry transplants and bulbs for cut flower were planted at the end of the 4 week treatment period. Periodically through the growing season, weed density counts in each plot were recorded. Weeds were harvested from the field, and fresh biomass recorded. Hand weeding times were monitored periodically throughout the growing season. Strawberry harvest is still in progress during Sept. 2008, and flower bulb harvest is scheduled for July 2009. Data was be subjected to analysis of variance.

Results. Solarization alone did not control weeds; hold down weeding times or kill weed propagules as consistently as MBPic (Tables 1, 2, 3, 4). However steam with or without solarization resulted in weed control similar to MBPic. Temperature highs of 42 to 44°C in the solarization treatments did not control weeds as thoroughly as MBPic (Table 5). However, peak temperatures of >78°C in the steam treatments did kill weeds as well as MBPic.

Table 1. Weed control in strawberry beds at Salinas, CA.

Treatment	------------Weed Biomass------------			Hand weed time
	Oct. 18.07	Jan. 24.08	Apr. 22.08	Apr. 22.08
	-----------------------grams/43.2 ft^2-------------------------			min./43.2 ft^2
1. MB/Pic	0.4 c	337.9 b	1097.9	1.54 c
2. Control	639.2 a	1115.4 a	734.2	4.09 a
3. Solarization	375.0 b	280.0 b	1256.3	2.91 b
4. Steam alone	86.7 c	119.6 b	1487.5	1.21 c
5. Steam + solarization	0.0 c	229.6 b	540.8	1.33 c
LSD (P=.05)	190.5	249.7	1360.7	0.59
Treatment P	0.0001	0.0001	0.6040	0.0001

Table 2. Weed densities and hand weeding times in flower beds at Prunedale, CA.

Treatment	Weed densities		Hand weed time	
	Feb. 4, 2008	Mar. 21, 2008	Feb. 4, 2008	Mar. 21, 2008
	----------- number (80 ft^2) -------------		------------- time (min. 80 ft^2) ----------	
1. MB/Pic	16.8 ab	25.7 b	2.2 abc	2.9 bc
2. Control	24.0 a	92.0 a	3.4 a	6.7 a
3. Solarization	18.8 a	29.0 b	2.9 ab	3.6 b
4. Steam alone	8.8 bc	14.0 b	1.8 bc	2.0 c
5. Steam + solarization	6.0 c	13.8 b	1.5 c	1.8 c
LSD	8.6	33.2	1.2	1.5
Treatment P	0.0018	0.0004	0.0168	0.0001

Table 3. Weed propagule survival in strawberry beds at Salinas, CA.

Treatment	Common purslane	Little mallow	Common chickweed	Yellow nutsedge [1]
	-------------------------------- Viability (%) -----------------------------			
1. MB/Pic	9.0 b	37.3 b	0 c	8.3 c
2. Control	85.7 a	70.7 a	60.5 a	37.0 b
3. Solarization	82.0 a	39.5 b	49.2 b	55.0 a
4. Steam alone	0 b	3.8 c	0 c	11.7 c
5. Steam + solarization	2.8 b	6.2 c	0 c	0.0 c
Treatment P	<0.0001	<0.0001	<0.0001	<0.0001

[1] Viability of tuber samples buried 2-inches deep in the bed center

Table 4. Weed propagule survival in flower beds at Prunedale, CA.

Treatment	Common purslane	Little mallow	Common chickweed
	---------------------------------- Viability (%) ----------------------------------		
1. MB/Pic	0.2 c	29.0 b	0 c
2. Control	82.6 a	69.8 a	49.4 a
3. Solarization	58.8 a	31.8 b	34.6 b
4. Steam alone	7.3 c	35.0 b	8.3 c
5. Steam + solarization	11.2 c	11.5 c	7.7 c
Treatment Pr.	<0.0001	<0.0001	<0.0001

Table 5. Treatment effects on 2 inch soil temperatures over a 4 week period.

Treatment	High temp. [a]		Average temp.		Time > 40 °C	
	strawberry	flower	strawberry	flower	strawberry	flower
	------------------------ temperature (°C) -------------------				------------ hours -----------	
Control	38.4	36	21.4	18.5	0.2	0.1
Solarization	42.4	44.6	28.3	27.3	33.0	27.0
Steam [a]	99.7	98.7	35.9	34.1	50.0	28.0
Steam + solarization	85.8	78.3	31.5	27.7	14.0	8.0

[a]Steam temperatures taken over 24hr.