SOIL DISINFESTATION IN STRAWBERRY WITH STEAM

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Summary. Steam is an effective nonfumigant tool for soil disinfestation. Techniques such as physically blending steam with soil increase the speed and efficiency of steam application. Combining steam with exothermic compounds or with biofumigants may be a method to improve the performance of steam at lower energy cost. Steam application in field buffer zones where fumigants cannot be applied and fumigant use in less restricted areas is a strategy that may allow more complete land utilization especially near urban areas. Steam may also be used to disinfest field soil prior to blending with substrates, as well as, to treat recycled substrates used in two or more production cycles.

Use of steam in strawberry production. Traditional steam application strategies are very slow and energy intensive. However, there are several strategies to partially overcome these obstacles. Strategies for use of steam in strawberry production are outlined below.

1. Steam kills soil pests. Steam injected into the soil in sufficient quantities to raise the temperature to 158°F for 20 minutes kills most soil pathogens and weed propagules. We have been working on steam application methods for the past several years and find that it kills weed seeds and pathogens; and strawberry plants grown in steam-treated soils produce fruit yields comparable to methyl bromide (Tables 1, 2 & 3).

2. The need for steam. Steam kills soil pests as effectively as soil fumigants and is likely the most effective nonfumigant treatments for killing soil pests. Steam for soil disinfestation is compatible with current strawberry production systems and does not require retooling of the industry as would other practices.

3. How steam kills soil pests. Steam is injected into soil to raise the temperature to 70°C for at least 20 minutes. Steam kills nematodes, pathogens and weed seeds by denaturing and coagulating cell proteins in pest tissues. Steam is very different from fumigants because it disperses very slowly in soil by convection and conduction. Traditionally steam has been applied by sheet steaming where steam is applied under a tarp at the soil surface. Sheet steaming is very effective, but it is slow and expensive due to high energy consumption. This method of steam application is inefficient because steam is applied top down, and the heat at the soil surface requires several hours to be conducted to deeper soil layers and in the process the surface soil layers receive excessive steam application. Because steam dispersal is so slow in soil we are evaluating machinery to physically mix steam with soil to speed the

process of bringing soil to critical temperature. Physical mixing of soil decreases the distance steam must travel from the orifice to the target soil particles.

4. Practices for improving steam use efficiency. Researchers in Italy reported that use of exothermic compounds such as calcium oxide (CaO) or potassium hydroxide (KOH) in combination with steam improved kill of soil pests compared with steam alone. Exothermic compounds or biofumigant compounds appear to be very effective treatments with steam. Another idea for improving steam use efficiency is to limit the volume of soil treated to the absolute minimum required. An example is to steam soil/substrate blends and limit contact of the steam disinfested material from field soil using a landscape fabric barrier.

5. How steam can be used commercially. Steam soil disinfestation is needed most where fumigants cannot be used such as in buffer zones, near sensitive sites and in organic fields. In a location with buffer zones that cannot be fumigated, a “hybrid system” can be used. For example the buffer zones can be treated with steam and the remainder of the field treated with fumigants. Substrates can be blended with steamed field soil to reduce the amount of substrate needed, and steam can be used to disinfest recycled substrate to allow several crop cycles to be produced on the same substrate.

6. Summary. Steam is an effective non-fumigant alternative for soil disinfestation. The often cited limits to steam use such as high fuel costs and slow speed can be partially overcome by innovative use of this very valuable tool. The ability to use this technology in both conventional and organic production systems is an added benefit.

Literature cited

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Table 1. Effect of treatment on weed seed and yellow nutsedge viability at Salinas, CA, in 2008-09.

Treatment	Common chickweed	Common knotweed	Common purslane	Little mallow	Yellow nutsedge
			Viability (%)		
Control	50.2 a [z]	82.0 a	38.3 a	80.7 a	31.9 a
MBPic	4.3 c	11.5 c	0.8 b	40.3 b	4.4 b
Solarization	32.5 b	61.7 b	51.7 a	42.3 b	30.0 a
Steam	0.0 c	0.0 c	0.0 b	1.8 d	1.3 b
Treatment P	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[z] Means with the same letter within a column are not significantly different using least significant difference at $P \leq 0.05$.

Table 2. Effect of treatments on survival of *Verticillium dahliae* microsclerotia at 15, 30 and 45 cm depth at Salinas, CA, in 2008-2009.

	Depth		
	15 cm	30 cm	45 cm
Treatment		(% viability)[z]	
Control	53.9 a[y]	82.8 a	50.8 a
MBPic	0.4 c	4.3 c	14.2 b
Solarization	53.5 a	81.0 a	67.3 a
Steam	10.8 bc	47.6 ab	55.8 a
Treatment P	0.0001	0.0001	0.0008

[z] Percent control calculated as percent of internal control

[y]Means with the same letter within a column are not significantly different using least significant difference at $P \leq 0.05$.

Table 3. Cumulative strawberry yields in 2007-08 and 2008-09 growing seasons at Salinas, CA.

	Yield	
	2007-08	2008-09
Treatment	(g/plant)	
Control	264.7	610.4 c [z]
MBPic	348.6	857.9 ab
Solarization	291.9	720.0 bc
Steam	353.2	970.9 a
Treatment P	0.0936	0.0033

[z] Means with the same letter within a column are not significantly different from each other using least significance difference at $P \leq 0.05$.