EVALUATION OF AN AUTOMATIC STEAM APPLICATOR IN STRAWBERRY

S. Fennimore, T. Miller, R. Goodhue and K. Subbarao

University of California, Davis, Salinas, CA 93905

Summary. Steam is an effective nonfumigant tool for soil disinfestation. Steam kills pathogens and weed propagules in the soil. Physically blending steam with soil increases the speed and efficiency of steam application. Combining steam with exothermic compounds or with biofumigants such as mustard meal 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 to allow more complete land utilization especially near urban areas. Steam may also be used to disinfest field soil prior to blending with substrates such as peat or coir, 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 tested for soil disinfestation with steam for strawberry production are outlined below.

1. Steam kills soil pests. Steam injected into the soil in sufficient quantities to raise the temperature to 70°C for 20 minutes kills most soil pathogens and weed propagules.

   Two tests of an automatic steam applicator were done in October 2011, one at Salinas, CA Oct. 12, 13, 2011 and the second at Watsonville, CA Oct. 25, 2011. At both locations the soil temperature reached >70˚C for >20min. At Watsonville weed seed bags were installed in the strawberry beds as soon as the steam applicator passed. At both sites Pic-Clor 60 was included as a fumigant standard (at 350 and 250 lb/acre in Watsonville and Salinas, respectively). The trials were arranged in a randomized complete block design with five reps at Salinas and four reps at Watsonville.

   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 fumigated soils (Tables 1, 2 & 3). Operation costs for the prototype single bed automatic steam applicator were determined to be approximately $5,500 per acre including fuel, labor and machine costs.

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 conventional and organic

strawberry production systems and does not require retooling of the industry as would other practices such as soilless strawberry production.

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. 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 source to the target pests within the soil.

4. Improvements in steam application 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. Commercial uses of steam. 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.

   Another application for steam will be the production of strawberry in soilless substrates. Soilless material can be blended with steamed field soil to reduce the amount of material 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 now with technology already available. The ability to use this technology in both conventional and organic production systems is an added benefit.

Literature cited

Baker, K.F., and Roistacher, C.N. (1957): Heat treatment of soil, ed. The UC System for producing healthy container-grown plants. University of California, Division of Agricultural Sciences, Oakland, CA

Barberi, P; Moonen, A.C.; Perruzzi, A; Fontanelli, M.; Raffaelli, M. 2010. Weed suppression by soil steaming in combination with activating compounds. Weed Research. 49:55-56.

Rao. S. Sterilization and Disinfection. http://www.microrao.com/micronotes/sterilization.pdf

Soil Steam Sterilization. http://en.wikipedia.org/wiki/Soil_steam_sterilization

Table 1. Evaluation of a prototype steam applicator at Salinas, CA in strawberry during the 2011-12 season. Shown are hand weeding times and fruit yields.

Treatment	Cumulative weeding time[1]	Fruit yield[2]
	hr/acre	(g/plant)
Steam	32.5 b	446 a
Pic Clor 60	39.4 b	471 a
Non-treated	88.9 a	360 b
Least significant difference	22.1	34

[1] Hours/acre, evaluated on 1/11, 2/2. 3/6, and 4/4/12
[2] Cumulative marketable yield 3/28 – 8/10/12

Table 2. Evaluation of a prototype steam applicator at Watsonville, CA in strawberry during the 2011-12 season. Shown are hand weeding times and fruit yields.

Treatment	Cumulative weeding time[1]	Fruit yield[2]
	hr/acre	(g/plant)
Steam	18 b	664
Pic Clor 60	13 c	542
Non-treated	32 a	503
Least significant difference	1.3	211

[1] Hours/acre, evaluated on 1/17, 3/8, and 4/24/12
[2] Cumulative marketable yield 4/24-8/9/12

Table 3. Weed seed and nutsedge tuber viability at Watsonville, CA following treatment with the automatic steam applicator or Pic Clor 60

Treatment	Bluegrass	Chickweed	Knotweed	Mallow	Nutsedge
	Viability (%)				
Steam	1 b	2 b	6 b	72 b	0 b
Pic Clor 60	86 a	4 b	0 b	63 b	0 b
Non-treated	66 a	69 a	96 a	95 a	45 a