STEAM DISINFESTATION AS A METHYL BROMIDE ALTERNATIVE IN CALIFORNIA CUT FLOWER NURSERIES

C.M. Rainbolt[1,2], B.D. Hanson[2], S.A. Fennimore[2], and J.S. Gerik[3]

[1]California State University, Fresno; [2]University of California, Davis; and [3]USDA-ARS, Parlier, CA

Steam may be an effective alternative to methyl bromide in cut flower production in California. Steam has been used as a disinfestant for potting media for over a century. In fields and greenhouses, soil has been treated from the top-down using the sheet steaming technique in which steam is applied under a tarp and settles through the soil. Advantages of steam include broad spectrum pest control and a zero hour re-entry interval. The principle disadvantage of sheet steaming is cost effectiveness due to current energy prices and application efficiency. Testing and developing more efficient, bottom-up steam delivery methods may increase the viability of this non-chemical alternative to methyl bromide. To compare the effectiveness of two steam application methods to methyl bromide and an untreated control, three field trials were conducted in cut flower nurseries near Nipomo and Oxnard, CA in 2009 and 2010.

Materials and Methods

Trials were conducted in commercial nurseries in three cut flower crops, snapdragon, Asiatic lily, and sunflower/bupleurum. Treatments were applied to pre-formed beds and included an untreated control, methyl bromide, and two steam treatments. Steam was applied through three or four rows of 3-inch drain tile buried 12-in deep in each bed or through four rows of 5-in polypropylene mesh hose with 8-in steel spikes spaced 10-in apart pressed into the top of the bed (Figure 1). Individual plots were 3.5 to 4 ft wide and 50 to 100 ft long. Steam treated beds were covered with clear plastic film to increase efficiency and, in the third trial, were covered with an insulating blanket during and for one hour after application. Steam treated beds were heated to 70^{o}C for at least 30 min. The cooperating growers usually applied methyl bromide using the hot gas method to replicate plots in beds adjacent to the steam and untreated plots. Data collection included crop emergence, weed counts, crop heights, and pathogen population quantification. For each trial, data were subjected to ANOVA and means separated using Fisher's LSD ($p<0.05$).

Results and Discussion

Snapdragon Trial: The first trial was conducted in a hoop house near Oxnard, CA. Steam treatments were applied April 7-8, 2009 and methyl bromide was applied using the hot gas method on April 22, 2009. Half the trial was planted April 29, 2009 and half May 5, 2009 in several varieties of snapdragon. No significant differences in weed control or *Fusarium* spp. among treatments were found (Table 1). This may be due to the variability from the number of snapdragon varieties planted as well as the difference in planting dates. In addition, pathogen populations are naturally variable and the space provided only allowed for 3 replications.

Asiatic Lily Trial: The lily trial was conducted in a greenhouse near Nipomo, CA. Steam was applied September 28-29, 2009 and methyl bromide was applied on September 29, 2009. Reps 1 and 2 of the steam and untreated plots were planted in early October and reps 3 and 4 plus the methyl bromide plots were planted in mid-October, 2009. The steam and untreated plots were planted in 'Sorbonne' with the exception of one untreated plot planted in 'Nymph'. All methyl bromide plots were planted in 'Dynamite'. No significant differences were found among treatments for *Fusarium* spp. or *Pythium* spp. populations at 0 MAT or *Pythium* spp. at 4 MAT, weed counts at 1 or 2 MAT, crop emergence at 2 MAT, or crop heights. However, populations of *Fusarium* spp. were greater in untreated plots compared to both steam and methyl bromide treatments at the $p<0.1$ level by the conclusion of the experiment. In addition, fewer plants emerged in the untreated plots compared to other treatments at the $p<0.05$ level 1 MAT (Table 2).

Sunflower/Bupleurum Trial: The third trial was conducted in an open field near Oxnard, CA. Two steam treatments and an untreated control were replicated four times and were arranged in a randomized complete block. In this trial, insulating pads were installed on steam plots during steam application and removed approximately one hour later to reduce heat loss and increase heat uniformity across the plot. Half of the plots (two replicates) were planted in bupleurum and half seeded to sunflower approximately one month after treatment. The spike hose application method provided significantly better control of weeds compared to the control. In addition, both steam treatments provided better control of *Pythium* spp. and *Phytophthora* spp. at the $p<0.05$ level and of *Fusarium* spp. at the $p<0.1$ level. No significant differences were found for *Verticillium* spp. control (Table 3). The insulating pads used in this trial appeared to decrease the time required to reach the target temperature (70^{o}C) and may have reduced pest control variability.

In general, steam disinfestation using either spike hoses or drain tiles usually provided pest control statistically similar to hot-gas methyl bromide. However, high variability probably masked treatment differences in some cases. Although economic assessment of the treatments comparing flower yield and fuel cost estimates are still needed, steam disinfestation of soil in shallow-rooted crops like cut flowers appears to be a promising methyl bromide alternative. The spike hose and drain tile techniques used here are an improvement over sheet steaming; however, additional gains in thermal efficiency (fuel efficiency and heat retention) and a more mechanized application system is needed before steam is used on a significant portion of California's cut flower nursery acreage.

Figure 1. Steam applications in a cut flower nursery near Oxnard, CA in June 2010. Steam generated through either a propane- or diesel-fired boiler (background) is applied through buried drain tile (left) or through spike hoses inserted into bed tops (right).

Table 1. Mean *Fusarium* spp. concentration and weed density in a snapdragon trial conducted in Oxnard, California in spring and summer of 2009.

Treatment	*Fusarium* spp. propagules / g soil	Weed density no. / 0.5 m^2
Drain tile	275	16
Spike hose	1820	8
Methyl bromide	2338	15
Untreated	1327	9
Treatment P	0.148	0.553

Table 2. Mean *Fusarium* spp. and *Pythium* spp. concentrations, crop emergence, weed density, and crop height in an Asiatic lily trial conducted in Nipomo, CA in fall and winter of 2009-10.

	Fusarium spp.		*Pythium* spp.		Crop emergence		Weed density		Crop height
Treatment	0 MAT	4 MAT	0 MAT	4 MAT	1 MAT	2 MAT	1 MAT	2 MAT	3 MAT
	--------- propagules / g soil ---------				------------- no/0.5 m^2 -------------				cm
Drain tile	2097	1784 a	86	60	35 a	35	102	50	113
Spike hose	1581	1286 a	114	56	36 a	34	67	45	113
MeBr	444	1209 a	3	38	34 a	33	39	55	-
Untreated	1879	2970 b	63	106	32 b	32	112	62	112
Trt P	0.266	0.075*	0.253	0.382	0.038**	0.160	0.221	0.662	0.855

Letters indicate significant differences
*significant at the p<0.1 level
**significant at the p<0.05 level

Table 3. Mean *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., and *Verticillium* spp. concentrations and weed density in a sunflower/bupleurum trial conducted in Oxnard, CA in summer of 2010.

	Soil borne fungal populations				
	Fusarium spp.	*Phytophthora* spp.	*Pythium* spp.	*Verticillium* spp.	Weed density
Treatment	------------------ propagules / g soil ----------------				no./0.5 m^2
Drain Tile	650 a	1215 a	27 a	8	35 ab
Spike Hose	499 a	378 a	84 a	175	22 a
Untreated	1288 b	9030 b	348 b	220	64 b
Trt P	0.076*	0.001**	0.000**	0.276	0.035**

Letters indicate significant differences
*significant at the p<0.1 level
**significant at the p<0.05 level