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Steam as a Preplant Soil Disinfestant Tool in California Cut-flower Production

Christine M. Rainbolt[1], Jayesh B. Samtani[2], Steven A. Fennimore[3], Celeste A. Gilbert[3], Krishna V. Subbarao[4], James S. Gerik[5], Anil Shrestha[1], and Bradley D. Hanson[6,7]

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SUMMARY. **Methyl bromide (MB) has been widely used in California cut-flower production for effective control of a broad range of soil pests, including plant pathogens and weeds. However, MB is an ozone-depleting substance, and its availability to growers is limited according to the Montreal Protocol guidelines. Steam has been suggested as a nonchemical option for preplant soil disinfestation. Five trials were conducted in protected greenhouse structure or open-field cut-flower nurseries in Monterey, San Luis Obispo, and Ventura counties to evaluate the effect of steam application, alone or in combination with solarization, on soilborne plant pathogen populations, weed densities, and crop growth. Several steam application methods were used including steam blanket, spike-hose, buried drip irrigation lines, or drain tile, and these varied among trials. Calla lily (*Zantedeschia aethiopica*) nursery trials initiated in 2007 and 2008 showed that steam alone or with solarization was similar to or more effective than MB:chloropicrin (MBPic), applied via drip lines, in controlling weeds and *Verticillium dahliae* at 6-inch depth. Trials conducted in Spring and Fall 2009 in an oriental hybrid lily (*Lilium* sp.) nursery showed that, 112 days after steam treatment (DAT) in the spring, the steam (spike-hose) treatment had fewer *Fusarium oxysporum* propagules than the MB treatment. Lily plant growth in the steam-treated plots was similar to MB-treated plots and taller than in control plots. In the fall trial, fewer lily plants emerged by 44 DAT in the untreated control than in steam- and MB-treated plots and steam was not as effective as MB in reducing *Pythium* populations. In the 2010 sunflower (*Helianthus annuus*) and bupleurum (*Bupleurum griffithii*) trial, all steam treatments reduced *Pythium* and *Phytophthora cactorum* survival compared with the untreated control plots, whereas weed densities were reduced only in the spike-hose steam-treated plots. These trial studies showed that steam appeared as effective as MB in suppressing pathogens and weeds and improving crop growth in cut-flower nurseries. However, additional information on fuel consumption, treatment time efficiency, and long-term effects of steam treatment on soil health are needed before steam can be recommended as a viable alternative to MB in California cut-flower nurseries.**

Cut-flower production systems are often complex, with growers continually planting small areas with a range of species and cultivars to ensure year-round availability of the highly perishable crop while also targeting key market windows. The intensity, diversity, and high capital costs inherent in this cropping system have led to a reliance on MB fumigation for preplant control of a broad range of soilborne pathogens, weeds, and nematodes. MB was classified as a Class I stratospheric ozone-depleting substance and became subject to the provisions of the Montreal Protocol in 1993. This international treaty called for elimination of MB use in developed countries by 2005 and in developing counties by 2015 (Ristaino and Thomas, 1997); however, critical use exemptions for MB are considered when alternatives are ineffective or not economically feasible (Duniway, 2002; Martin, 2003). In California cut flowers, currently registered chemical alternatives to MB include 1,3-dichloropropene, chloropicrin (Pic), dazomet, metam potassium, and metam sodium. Because of various efficacy and regulatory concerns, it is unlikely that any of these products alone can replace all MB uses (Gerik and Hanson, 2011). Importantly, few of the currently registered MB alternatives are labeled in California for use in protected greenhouse structures, a production system that accounts for ≈11% of the cut-flower acreage in the state [U.S. Department of Agriculture (USDA), 2009].

Soil solarization was proven to effectively control plant pathogens and weeds in vegetable and cut-flower production in Turkey and Portugal during the hot summer months when greenhouses were not in production (Ozturk et al., 2002; Reis, 2002). However, fog and cooler soil temperatures make solarization a less optimal tool for pest control in coastal California, where most cut flowers are produced (Elmore et al., 2007). In addition, Stapleton and DeVay (1986) suggest that even under favorable conditions, 4 to 8 weeks is ideal for effective solarization treatment, a substantial reduction in production time in a high-value crop such as cut flowers.

Steam has been used as a soil and substrate disinfestant since the late 1800s and has been suggested as an effective MB alternative (Newhall, 1955; Pizano, 2006). In the Netherlands, ≈50% of the cut-flower acreage is steam treated for soil disinfestation, and it is also used in Australia, Colombia, Brazil, and Italy (Pizano, 2006). High temperatures can control a wide range of pests, although selectivity and efficacy depend on the temperature and exposure duration (Bollen, 1969; Pullman et al., 1981; van Loenen et al., 2003).

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
102.7902	acre-inch(es)	m^3	0.0097
29,574	fl oz	μL	3.3814×10^{-5}
29.5735	fl oz	mL	0.0338
0.3048	ft	m	3.2808
0.0929	ft^2	m^2	10.7639
2.54	inch(es)	cm	0.3937
0.4536	lb	kg	2.2046
1.1209	lb/acre	$kg \cdot ha^{-1}$	0.8922
1	micron	μm	1
0.0254	mil	mm	39.3701
28.3495	oz	g	0.0353
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32