Shank and Drip Applied Soil Fumigants as Potential Alternative to Methyl Bromide in California-Grown Cut Flowers

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Producers of cut flowers and ornamental bulbs are highly dependent on pre-plant soil fumigation with methyl bromide/chloropicrin (MB/Pic) for profitable production. The impending loss of MB will require growers to use alternative fumigants in the future. Fumigant pesticide combinations or pesticide sequences with a high potential to replace the standard 2/1 mixture of MB/Pic for management of a multi-pest complex were tested as preplant treatments, applied as either shank injection or drip fumigation treatments under two different plastic mulch types in two commercial cut flower systems (Calla lily and *Ranunculus* systems) in California. Shank applied fumigant treatments were MB/Pic (67/33) and Midas (iodomethane/Pic, 50/50) at 350 and 300 lbs/ac, respectively. Drip applied fumigant treatments were Midas (33/67), Pic, MB/Pic (67/33) at 200 lbs/ac, and InLine at 300 lbs/ac. Metam sodium (Vapam) was sequentially applied to ½ of the drip treatments and untreated plots at 50 gal/ac. The efficacy of alternative shank and drip fumigant treatments for management of key pests in each cropping system was evaluated relative to the MB/Pic shank standard at 350 lbs/ac and an untreated control. Plant growth parameters, flower stems counts were evaluated for *Ranunculus*, bulb yield, circumference and quality parameters will be determined for *Ranunculus* and Calla lilies after bulb harvest and grading in July and September 2007, respectively. Findings from these studies suggest that shank applied Midas at 300 lbs/ac was equally effective in providing weed and pathogen management in *Ranunculus* production systems, while drip applied alternative fumigants at 200 lbs/ac (300 lbs/ac for InLine) were not consistently effective as the MB/Pic shank standard at 350 lbs/ac. For Calla lily production systems, drip applied Midas at 200 lbs/ac and InLine at 300 lbs/ac are currently the best alternative treatments for control of a multi-pest complex in the absence of methyl bromide.

Materials and Methods

Field studies were initiated in Moss Landing on May 25 and June 8, 2006; and in Carlsbad on October 26, 2006. Shank-applied fumigant treatments were MB/Pic (67/33), Pic, Telone C35, and Midas (iodomethane/Pic, 50/50) at 350, 300, 400, and 300 lb/A for Moss Landing, and MB/Pic (67/33), and Midas (50/50) at 350 and 300 lb/A for Carlsbad. In another experiment at Moss Landing and Carlsbad, the fumigants MB/Pic (67/33), Pic, InLine (1,3-dichloropropene (1,3-D)/ Pic, 62/35), and Midas (33/67) were applied at 200, 200, 300 and 200 lb/A though the drip irrigation system. Metam sodium and metam potassium was applied sequentially at 37.5 and 50 gal/ac to ½ of the drip-applied treatments and the untreated control 6 days past the first fumigant application in Moss

Landing and Carlsbad, respectively. One half of the length of each plot was covered with high density polyethylene film (HDPE) (Moss Landing trial) or cross polymer PE (Carlsbad trial) and virtually impermeable film (VIF) covered the other half. Nylon bags with common weed seeds (*Polygonum arenastrum, Stellaria media, Portulaca oleracea, Malva parviflora, Kochia scoparia,* and *Cyperus esculentus*) and selected flower bulbs (Calla lilies, Gladiolas, Irises, Ranuncula), and soil with known populations of *Pythium* spp., *Rhizoctonia*, *Verticillium dahliae*, *Fusarium oxysporum, Phytophthora cactorum*, and citrus nematodes (*Tylenchulus semipenetrans*) were installed in research plots at 2" soil depth before fumigation. Inoculum pouches were retrieved 8 days past the last fumigation and analyzed for survival of weed seeds, flower bulbs, and soil-borne pathogens following standard procedures.

Calla lily (*Zantedeschia* sp.), and *Ranunculus* sp. were direct seeded at the entire plot area 3 to 4 weeks after fumigation at Moss Landing and Carlsbad, respectively. Conventional production practices and pest management for the areas were followed. Crop stand densities were evaluated 6 to 8 weeks after planting. Densities of native weed populations were evaluated prior to each weed removal practice. Plant growth and yield parameters were evaluated at regular intervals during the season. *Ranunculus* flowers were harvested by hand, and total stem numbers per plot were determined. Bulbs will be harvested, counted, graded according to size (circumference) and weight, and subjected to quality evaluation. *Ranunculus* bulbs were harvest in July 2007 at Carlsbad. Harvest of Calla lily bulbs at Moss Landing is scheduled for September 2007.

Results

***Ranunculus* systems:**

There were significantly lower numbers of little mallow (*Malva parviflora*) in soils shank fumigated with 300 lbs/ac Midas compared to soils fumigated with 350 lbs/ac of the MB/Pic standard mixture (Tab. 1). However, these differences in weed control are most likely related to spatial variations of weeds within the plot area than to a treatment effect, because there was also no difference between Midas treatments and the untreated control. There were no statistical differences between shank treatments and the untreated control for numbers of native clover species (mainly California bur clover, *Medicago polymorpha*). These results are not surprising, because both, little mallow and bur clover are difficult to control by soil fumigation. Midas (300 lbs/ac) resulted in a lower weed cover than 350 lbs/ac MB/Pic standard mixture. Soil cover by resident weeds ranged from 10 to 13% in Midas, and from 15-18% in MB/Pic fumigated soils.

There were no statistical differences in total weed biomass between all shank treatments and plastic mulch types and the untreated soil tested at this location and year, although weed biomass seems reduced by up to 40% in MB/Pic and Midas fumigated soils under VIF if compared to cross polymer PE mulch.

There were no statistical differences in numbers of little mallow (*M. parviflora*) and native clover species (mainly California bur clover, *M. polymorpha*) between all drip treatments and plastic types tested at this location and year (data not shown). There were also no differences in control of these two major weed species between shank-fumigated and drip-fumigated MB/Pic and Midas treatments. There were no statistical differences in soil weed cover between all tested drip-fumigant treatments if applied under cross

polymer PE, but a significantly lower weed cover under Midas + Kpam if applied under VIF. Soil cover by resident weeds ranged from 28 to 35% in drip-fumigated soils under cross polymer PE, and from 26 to 43% under VIF. Untreated soils had generally higher weed covers than fumigated soils, although differences were not significant. There were no statistical differences in total weed biomass between all drip treatments and plastic mulch types tested at this location and year. Weed biomass in untreated soils under cross polymer PE was between 55 and 75% higher than in fumigated soils. Sequential application of Kpam to Pic and InLine reduced weed biomass only slightly compared to single application of fumigants. Higher weed biomass was measured in plots were Kpam followed MB/Pic and Midas.

Total numbers of general soil fungi were significantly reduced in MB/Pic and Midas (iodomethane/chloropicrin) shank fumigated soils compared to untreated soils (Tab. 2). Total fungi numbers were, on average, 7 to 14 fold lower in MB/Pic (350 lbs/ac) and Midas (300 lbs/ac) fumigated soils than in untreated soils. These results suggest that Midas is a stronger fungicide than MB/Pic. There were no statistical differences between treatments on *Pythium* control in soils collected at this year and location, suggesting that neither MB/Pic nor Midas provided a good control for this soil-borne pathogen if shank-applied at 8" soil depth. Also, no statistical differences were found in general fungi numbers and *Pythium* control between STD film and VIF.

Total numbers of general soil fungi were significantly reduced in soils fumigated with drip-applied alternative fumigants compared to MB/Pic fumigated and untreated soils (Tab. 3). There were no statistical differences in total fungi numbers between cross polymer PE film and VIF. Although not statistically significant, sequential application of Kpam seems to improve control of general soil fungi in all treatments, including the untreated control. There were no statistical differences between drip-applied treatments on *Pythium* control in soils collected in April 2005 at this location, suggesting that none of the tested fumigants provided a good control of this soil-borne pathogen if drip-applied at 2" soil depth.

Results for the effect of shank and drip applied MB alternatives on pest management and flower bulb yield and quality parameters for Calla lily and *Ranunculus* production systems will be presented.

Table 1. Presence of resident weeds in shank-fumigated soils in March 2005, Carlsbad, CA (VIF, virtually imperable film; STD, standard high density polyethylene film).

Treatment	**Rate lbs/ac**	**Plastic type**	**Weed density (No./acre)**				**Cover %**	**Weed biomass (g/acre)***
			Malva	Clover	Fescue	Swinecress		
MB/Pic (67/33)	350	STD	4,901 a	170,701	0	0	18	4,525
		VIF	6,534 a	130,727	4,901	0	15	2,581
Midas (50/50)	300	STD	817 b	164,984	0	0	10	5,018
		VIF	0 b	151,916	0	0	13	3,734
Untreated Control	0	none	817 b	178,052	0	1,634	13	4,515

* Weed biomass in g dry weight/acre.

Table 2. Presence of general soil fungi and *Pythium* spp. in shank-fumigated soils in April 2005, Carlsbad, CA (VIF, virtually imperable film; STD, standard high density polyethylene film).

Treatment	Rate lbs/ac	Plastic type	General soil fungi* CFU/g soil	*Pythium* CFU/g soil
MB/Pic (67/33)	350	STD	2065 a	37
		VIF	1148 a	51
Midas (50/50)	300	STD	699 a	44
		VIF	402 a	29
Untreated Control	0	none	11,126 b	55

* Means followed by the same letter in the same column are not significantly different (P<0.05).

Table 3. Presence of general soil fungi and *Pythium* spp. in drip-fumigated soils, in April 2005, Carlsbad, CA (VIF, virtually imperable film, PE, cross-polymer polyethylene film).

Treatment	Rate lbs + gal/ac	Plastic type	General soil fungi* CFU/g soil	*Pythium* CFU/g soil
MB/Pic (67/33)	200	VIF	7,164 a	40
MB/Pic + Kpam	200 + 37.5		11,258 ab	31
Pic	200		3,745 b	39
Pic + Kpam	200 + 37.5		2,938 b	40
InLine	300		5,260 b	46
InLine + Kpam	300 + 37.5		3,472 b	29
Midas	200		5,094 b	30
Midas + Kpam	200 + 37.5		1,485 b	38
Untreated Control	0		9,341 a	46
Untreated Control + Kpam	0 + 37.5		2,974 b	34
MB/Pic (67/33)	200	PE	4,024 b	25
MB/Pic + Kpam	200 + 37.5		2,289 b	37
Pic	200		1,973 b	35
Pic + Kpam	200 + 37.5		1,888 b	38
InLine	300		2,945 b	26
InLine + Kpam	300 + 37.5		2,839 b	34
Midas	200		4,178 b	31
Midas + Kpam	200 + 37.5		80 c	29
Untreated Control	0		15,123 a	46
Untreated Control + Kpam	0 + 37.5		7,126 ab	27

* Means followed by the same letter in the same column are not significantly different (P<0.05).