Weed Control with Methyl Bromide Alternatives

Husein Ajwa, Milt Haar, Steve Fennimore, and Mark Bolda
University of California-Davis

Possible alternative fumigants to methyl bromide (MB) include 1,3-dichloropropene (1,3-D), chloropicrin (Pic), methyl isothiocyanate (MITC), iodomethane (IM), and propargyl bromide (PrBr). Application of these fumigants through drip irrigation systems may provide a more uniform distribution of chemicals in soil (Ajwa et al. 2002) and greater weed control than shank injection (Fennimore et al., 2003). Our studies found that higher amounts of irrigation water would result in greater fumigant concentration in the gas phase across the soil profile. Factors affecting water distribution around a drip line include soil hydraulics, water application rate, drip system specification (emitter spacing and distance between the drip lines), and soil bed configuration (Ajwa et al., 2003). The objective of this research was to evaluate the weed control efficacy of alternative fumigants applied through drip irrigation systems in strawberry fruiting fields in California.

Methods

Several studies were established to evaluate weed control by fumigants applied through the drip irrigation systems. Soil gas concentrations of Pic, 1,3-D, MITC, IM, and PrBr (applied as Pic EC, InLine, metam sodium, IM/Pic mixture, and PrBr/toluene) in the soil profile were monitored following drip fumigation for 7 days. The effects of fumigants on weed seed viability were determined by burying weed seed samples at 5 cm deep in each plot prior to fumigation. Weed species tested were common chickweed (*Stellaria media*), common purslane (*Portulaca oleracea*), little mallow (*Malva parviflora*), and prostrate knotweed (*Polygonum aviculare*). About 7 days after fumigation, weed seeds were removed and viability was tested in the lab using tetrazolium. Native weed biomass (fresh weight) in all plots was determined at least twice during the crop growing season.

Results

Fumigant (1,3-D, Pic, and MITC) movement and distribution in soil depends largely on the amount of irrigation water used to deliver the fumigant. Figure 1 shows 1,3-D distribution in a Watsonville sandy loam soil approximately 24 hours following drip fumigation with InLine (393 L ha^{-1} or 476 kg ha^{-1}) using three amounts of irrigation water (26, 43, and 61 mm). These figures show that the concentration of 1,3-D in the soil air space was highest when applied with the largest amount (61 mm) of irrigation water, even though the concentration of 1,3-D in the applied water was the least (450 mg L^{-1}). The highest concentrations of fumigants in the soil air with large amounts of application water suggest that water reduces fumigant volatilization losses, possibly by reducing the total air space in soil and/or by forming a water seal. Our studies indicated that a minimum of 40 mm of water is needed to move the fumigant horizontally 30 cm in a sandy loam soil beds.

Application of these fumigants through the drip irrigation systems provided equal or better weed control than equivalent rates applied by shank injection (Table 1). InLine and Pic efficacy on little mallow or prostrate knotweed seed buried at the center of the bed did not differ from MB:Pic (Table 2). However, the percentage of weed seed survival at the edge of the bed was often higher in the shank treatments than in the drip-applied treatments, possibly due to the close proximity of the shank-injected fumigant to the edge of the bed. Weed seed sensitivity was in the order: Common purslane > prostrate knotweed > little mallow. Seed coat hardness thought to be responsible for differences. Drip applied InLine was often more active on weeds than shank applied Telone C35. Metam sodium was less effective than MB:Pic on the native weed population or on buried weed seeds.

References

Ajwa, H.A., T. Trout, J. Mueller, S. Wilhelm, S.D. Nelson, R. Soppe, and D. Shatley. 2002. Application of Alternative Fumigants Through Drip Irrigation Systems. Phytopathology 92: 1349-1355.

Ajwa, H.A., T. Trout, S. Fennimore, C. Winterbottom, F. Martin, J. Duniway, G. Browne, B. Westerdahl, R. Goodhue, and L. Guerrero. 2002. Strawberry production with alternative fumigants applied through drip irrigation systems. Proceedings 14. *In*: Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions. Orlando, FL.

Fennimore, S.A., M.J. Haar and H.A. Ajwa. 2003. Weed control in strawberry provided by shank- and drip-applied methyl bromide alternative fumigants. HortScience. 38 (In press).

Table 1. Effect of MB:Pic and alternative fumigants on weed fresh weight. Total mean weed fresh weight $g \cdot m^{-2}$ of shank-applied MB:CP was compared to Pic, Inline, Telone C35 or metam sodium applied through the drip irrigation system or by shank injection at Salinas and Watsonville.

Treatment	Rate ha^{-1}	Application method	*Salinas 1999*	*Watsonville 2000*
			---------------- $g \cdot m^{-2}$ -------------------	
MB:Pic standard	425 kg	shank	39.0	20.3
Telone C35	374 L	shank	48.3 (0.81)[a]	50.0 (0.17)[a]
Inline (60%)	236 L	drip	25.5 (0.98)	14.9 (0.80)
Inline (100%)	393 L	drip	17.3 (0.55)	7.1 (0.44)
Pic EC	130 L	drip	31.3 (0.78)	10.8 (0.65)
Metam sodium (60%)	420 L	drip	98.9 (<0.01)	15.6 (0.82)
Metam sodium (100%)	700 L	drip	89.2 (<0.01)	4.8 (0.40)
Untreated	0	--	516.6 (<0.01)	186.7 (<0.01)

[a] P values of single degree of freedom contrasts comparing weed biomass with MB:Pic treatment.

Table 2. Efficacy of Pic, Inline, Telone C35 and metam sodium on prostrate knotweed seed viability compared to MB:Pic at Watsonville in 2000. The data are percentage viable seed buried
in the center and edge of a 1 m bed.

Treatment	Rate ha^{-1}	Application method	Prostrate knotweed		
			Center	Edge	
			---------- % viable ----------		*P* value
MB:Pic standard	425 kg	shank	0.13	1.77	0.73
Telone C35	374 L	shank	0.25 (0.92)[a]	26.82 (0.26)[a]	0.08
Inline (60%)	236 L	drip	0.06 (0.95)	88.63 (<0.01)	<0.01
Inline (100%)	393 L	drip	0.07 (0.95)	49.38 (0.04)	<0.01
Pic EC	130 L	drip	1.83 (0.52)	89.27 (0.03)	<0.01
Metam sodium (60%)	420 L	drip	5.45 (0.20)	91.70 (<0.01)	<0.01
Metam sodium (100%)	700 L	drip	3.17 (0.29)	90.48 (<0.01)	<0.01
Untreated	0	--	98.3 (<0.01)	79.80 (<0.01)	0.28

[a] P values of single degree of freedom contrasts comparing weed biomass with MB:Pic treatment

Figure 1. The concentration of 1,3-dichloropropene (μg 1,3-D L^{-1} air) in the gaseous phase of a Watsonville sandy loam soil 24 h after drip application of InLine at 393 L ha^{-1} (58% 1,3-D) in three amounts of irrigation water.