POTENTIAL OF USING SURFACE WATER APPLICATIONS TO REDUCE FUMIGATION EMISSIONS

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Uses of methyl bromide alternative fumigants are regulated primarily based on their toxicology properties and air emissions. Minimizing emissions is critical to protecting workers, bystanders, and the environment, and to maintaining practicable use of alternative fumigants for production of high value crops. Surface seals with plastic tarps are commonly used to reduce fumigant emissions. High soil water content was found to serve as a more effective barrier to 1,3-D movement than high density polyethylene (HDPE) tarp (Gan et al 1998). Surface water application (or water seal), especially with intermittent water applications or in combination with HDPE tarp, have shown promising results in reducing fumigation emissions (Sullivan et al., 2004; Wang et al., 1997; Jin and Jury, 1995). Using water costs less comparing to plastic mulch. The **objective** of this study was to determine in soil column experiments the potential of surface water application alone and in combination with tarps in reducing 1,3-D emissions.

Study Methods. A Hanford sandy loam soil (Coarse-loamy, mixed, superactive, nonacid, thermic Typic Xerorthents) was collected from surface soils near Parlier, California. The soil was air dried, sieved and mixed. Soil columns were packed to a total depth of 61.5 cm in stainless steel columns [63.5 cm high x 15.5 cm (i.d.)] at a bulk density of 1.4 g/cm^3 throughout. Sampling ports for soil gases were installed at various depths. A flow-through gas sampling chamber (4.5 cm deep with the same diameter as the soil column) was placed on the top of the soil column for measuring emissions. After the soil column was assembled, a continuous flow rate between 100-120 mL/min through the chamber was maintained by vacuum for a 2 week study period in the laboratory (T = 22±3 ^oC). The amount of 100 µL of cis 1,3-D (122 mg) was injected into the column center at 30 cm depth. Treatments applied to the columns were: 1. Dry soil and no tarp (Control). 2. Initial water application by adding 16 mm water to the column surface just before the fumigant was injected. 3. Same as Treatment #2 followed by a second water application (2.6 mm) at 12 h after fumigant injection. 4. Same as Treatment #3 followed by a third water application of 2.6 mm water at 24 h. 5. Dry soil with HDPE tarp. 6. Initial water application (same as Treatment #2) plus HDPE tarp. 7. Dry soil with virtually impermeable film (VIF) tarp.

For emissions, ORBO™ 613, XAD 4 80/40mg tubes were connected into the outlet of the top air chambers to adsorb fumigants off the soil surface. The tubes were replaced after a certain capture time and were extracted with 5 mL of hexane in a 10 mL clear headspace vial by shaking for 2 h. 1,3-D in the extracts were analyzed using a GC-MS system with a DB-VRX capillary column. For fumigant in soil gas phase, 0.5 mL volume of soil gas was withdrawn from the sampling ports with a gas-tight syringe. The gas sample was injected into a 21-mL headspace clear vial. The vials were crimp-sealed immediately, stored in an ultra freezer at a temperature of -44 ^{o}C, and analyzed within 72 h using a GC-μECD system with a DB-VRX column.

Results. Figure 1 shows the emission fluxes of 1,3-D from the treatments. In the control, flux increased rapidly beginning 3 h after fumigant injection, peaked (~1.1 mg h^{-1} $column^{-1}$) at about 15 h, and gradually decreased thereafter. The initial 16 mm water applied just before fumigant injection reduced the peak flux to 0.7 mg h^{-1} $column^{-1}$ and also showed a lag time of 1-2 h before the flux increased. Addition of 2.6 mm water at 12 h abruptly reduced 1,3-D emission fluxes to less than 0.1 mg h^{-1} but the volatilization rates quickly rebounded to approach those without this second water application. The treatment that included two follow up water applications (2.6 mm at 12 h and 24 h) repeated this abrupt reduction at 24 h and rebound soon after. Use of HDPE tarp shows a similar degree of emission reduction as the initial surface water application. Initial water application plus HDPE tarp provided additional emission reduction over the first 48 h. The VIF tarp showed the lowest emission rates (0.01-0.03 mg h^{-1} $column^{-1}$). Although VIF had extremely low emissions under laboratory conditions, damage to the film during field application and difficulties in joining (gluing) VIF sheets together may result in greater emissions under field conditions.

Figure 2 shows the cumulative emissions from soil column treatments over 14 days. As the emission flux from the control was higher in early days than later times, all treatments showed higher emission reduction in the first few days than the total emission over the 2-week period. Surface water application treatments showed higher emission reduction initially also because of the abrupt reduction of emission flux following each surface water application. VIF, initial water plus HDPE, and the two intermittent water applications after initial water application showed emission reduced by about 92, 49 and 49%, respectively within 48 h and these values decreased to 81, 26 and 19% reductions, respectively for the full 2-week period. Emission reduction from all other treatments was between 9 and 19%. HDPE tarp alone reduced emissions about 13%.

In soil gaseous phase, VIF tarp held higher 1,3-D concentrations under the tarp compared to other treatments (Fig.3). However, there were no differences among other treatments. The results indicate that surface water applications with the amount used in this study did not affect 1,3-D concentrations in soil thus should not affect its efficacy.

Conclusions. Surface water application can reduce 1,3-D emission as effectively as or even better than using standard HDPE tarp. Fumigant concentrations in soil gas phase were not reduced with the amount of water applied in this study, which indicates that fumigation efficacy should not be affected. High frequency intermittent water application is the key to maximize reduction of 1,3-D emissions. As using water is generally much less expensive than using plastic tarp, surface water application using a sprinkler system should have a high potential to reduce fumigant emissions under field conditions.

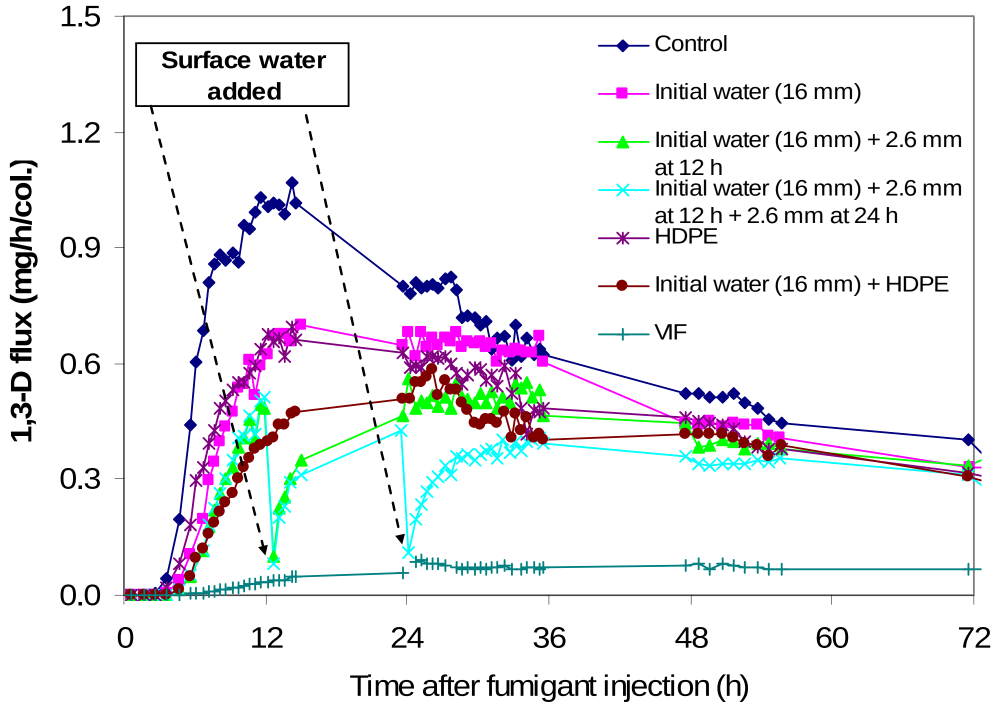

Figure 1. 1,3-D emission fluxes from soil column treatments

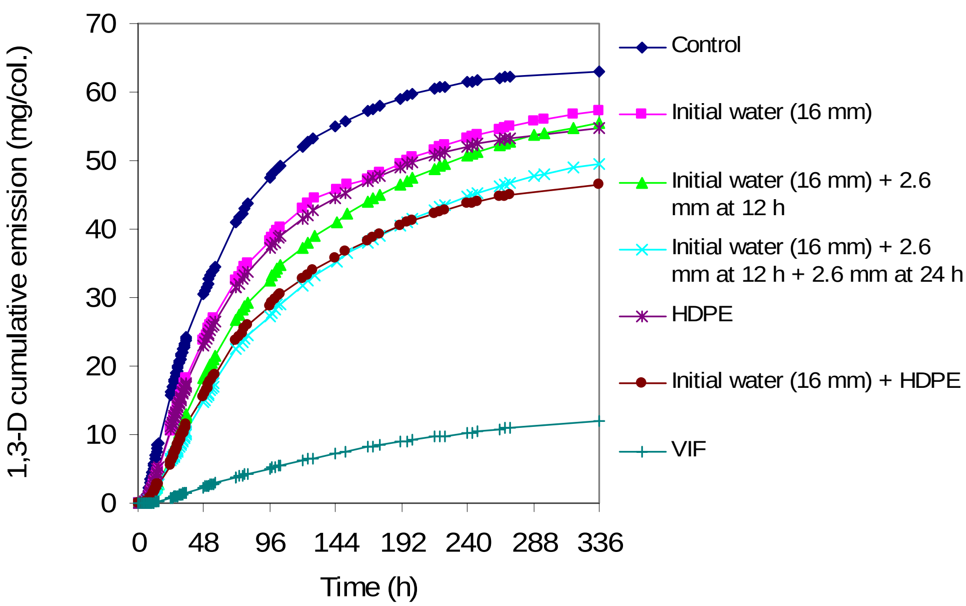

Figure 2. Cumulative 1,3-D emission loss from soil column treatments

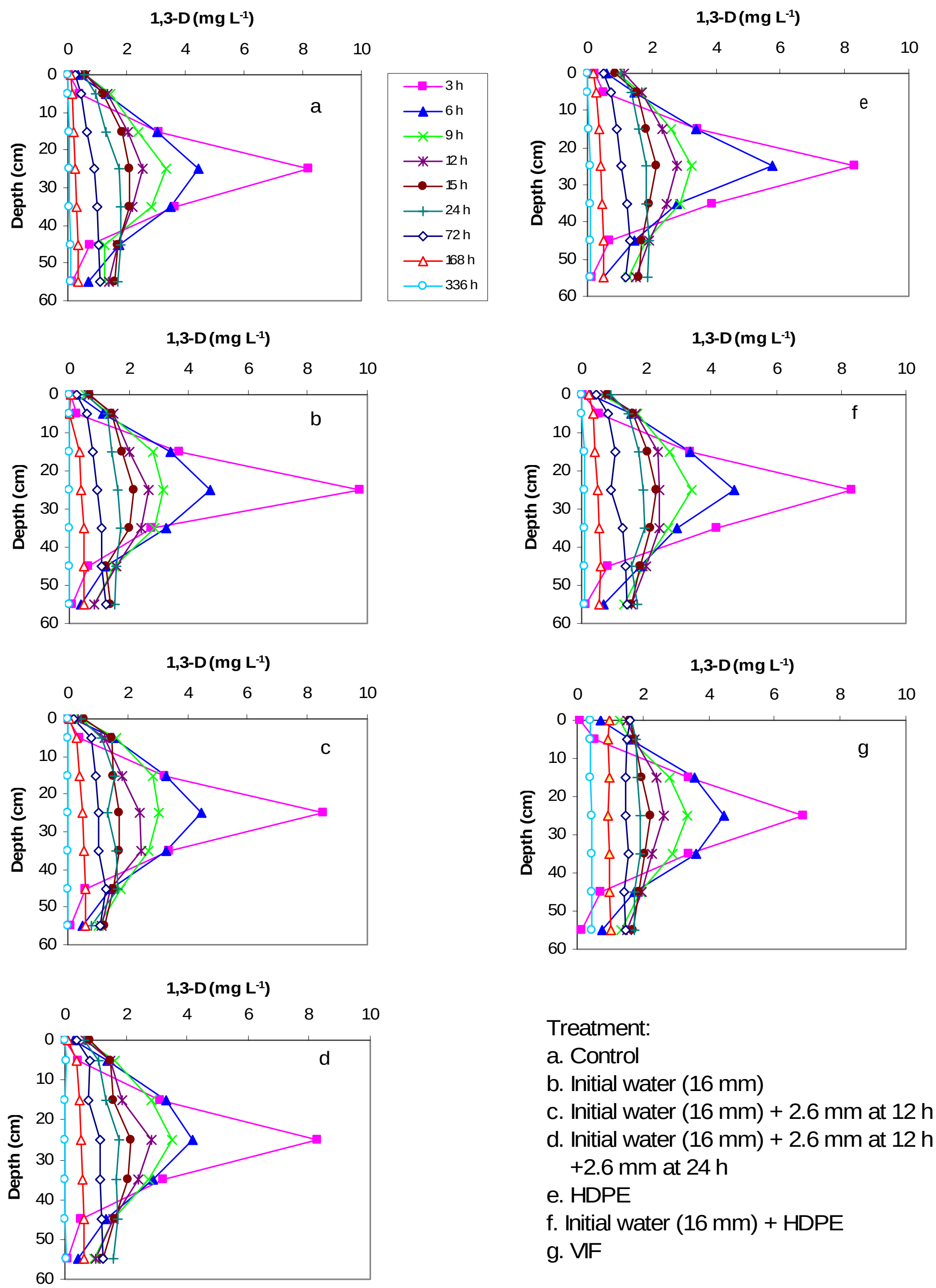

Figure 3. Distribution of 1,3-D in soil gas phase from soil column treatments.