EVALUATION OF WATER SEALS ON EMISSION REDUCTIONS OF 1,3-DICHLOROPROPENE AND CHLOROPICRIN

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Use of soil fumigants is heavily regulated in California to protect and improve air quality. Minimizing emissions is critical to achieve the target air-quality standard and maintain the availability of fumigants for agricultural uses. The most commonly used plastic tarp, high density polyethylene (HDPE), does not effectively control emissions of 1,3-dichloropropene (1,3-D or Telone) – one of the major alternative fumigants to methyl bromide. The cost for using standard HDPE tarp is about \$2000 ha^{-1} in the San Joaquin Valley of California compared to <\$800 ha^{-1} if 25-mm water is applied to soil by sprinklers. Use of films with low permeability [e.g., virtually impermeable film (VIF), metalized film, and semi-impermeable film (SIF)] has been or is being tested. However, technical solutions are still being sought for maintaining the permeability properties of these films in field applications. Regardless of film permeability properties, use of plastic tarps will be associated with materials disposal after use. After soil column tests demonstrated the potential of applying water to soil surface in reducing 1,3-D emissions, we conducted a field trial using small-plots and determined the effectiveness of water seal on emission reductions of 1,3-D and chloropicrin (CP) from shank-injection of Telone-C35.

Field trial: A field trial was conducted on Hanford sandy loam soil at the USDA-ARS research center near Parlier, CA. Telone-C35 (61% 1,3-D, 35% CP and 4% inert ingredient) was shank-applied to a depth of 46 cm with a spacing between shanks of 46 cm at a rate of 610 kg ha^{-1}. Small plots (9 x 9 m or 9 x 3 m depending on treatment) were used to test various surface seal treatments that included control (no tarp and no water application), HDPE tarp, VIF tarp, pre-irrigated soil (56-mm depth of water applied to soil surface 48 h prior to fumigation) + HDPE tarp, initial water application (19-mm depth of water was sprinkled to dry soil surface immediately following fumigation), and intermittent water applications (initial 19-mm depth of water sprinkled immediately following fumigation + 4.2-mm depth of water each time sprinkled to soil surface at 1st sunset [8 h], 1st sunrise [22 h], noon [28 h], 2nd sunset [32 h], and 2nd sunrise [48 h] following fumigation). Treatments were tested with three replicates in a randomized complete block design. Emissions to the atmosphere and gas-phase distribution of fumigants in soil profile were monitored for nine days.

Results: The average emission rates of 1,3-D are shown in Fig. 1. Emission rates of CP (data not shown) showed similar pattern to 1,3-D except with lower values than 1,3-D. For both the control and HDPE-tarp-dry soil treatments, 1,3-D emission rates increased rapidly within the first 12 h (up to 40 μg m^{-2} s^{-1}) and reached maximum measured peak emission by 24 h after injection. The peak emission rate for the control likely occurred during the first night when no samples were collected (indicated by the dash line in Fig. 1) and likely exceeded 80 μg m^{-2} s^{-1} for 1,3-D. The peak emission rate for the HDPE tarp over dry soil likely occurred early the second morning (about 22 h after fumigation). Initial water application immediately following fumigation delayed fumigant emission for a few hours. This delay can be important in reducing the risks to workers and bystanders during fumigation. Each water application following fumigation showed abrupt reduction of emission rates but the emission rates rebounded within 3-4 hours to approach those without water application treatment. The VIF resulted in the lowest emission rates.

Total emission losses of 1,3-D and CP as percent of applied from surface seal treatments are given in Table 1. The control was not included in the comparison because no measurements during the first night after fumigation may have resulted in significantly underestimate error because total emission loss estimate was much lower for the control than the HDPE tarp. Among the surface seal treatments, VIF and HDPE tarp resulted in the lowest and the highest total emission losses, 33% and 8% respectively. Intermittent water applications reduced 1,3-D and CP emissions significantly more than HDPE tarp alone and the initial water application only.

Overall, emission loss of CP is generally lower than 1,3-D. This is mainly due to the lower amount applied as well as it has a more rapid degradation rate than 1,3-D. Surface treatments reduced CP emissions more than 1,3-D except the initial water application treatment only. The emission loss by intermittent water seals was 30% of the HDPE tarp only for CP in comparison with 73% of HDPE tarp for 1,3-D. The pre-irrigated soil plus HDPE tarp reduced fumigant emissions effectively and also yielded the highest surface soil temperature (data not shown) that may benefit overall soil pest control. However, tarps are an expensive alternative compared to water seals alone.

This field trial was conducted during hot days. The maximum and minimum air temperature ranged from 37–41°C and 21–24°C, respectively, during the field trial. Water application to soil surface illustrated the immediate effect on reducing emission rates but the intermittent water applications (five sprinkler applications after fumigation) did not significantly reduce more 1,3-D emissions (24%) compared to the initial water application immediately following fumigation (27%).

Conclusions: Water seals can be more effective in emission reductions of 1,3-D and CP than HDPE tarp and offer a great opportunity in field applications. Water applications can clearly reduce emission peaks and delay emissions thus providing a benefit for reducing the risks to workers and by-standers during fumigation. Using water costs much less than HDPE tarp and is also environmentally friendly (no material disposal involved). Further research is needed to determine the relationship between water content and fumigant distribution for different types of soils. Integrated research is needed to clearly define the optimum soil water content for minimizing emissions as well as achieving adequate pest control.

Table 1. Total emission loss of 1,3-dichloropropene (1,3-D) and chloropicrin (CP) for surface seal treatments measured over 9 d after fumigation in summer 2005 field trial on a Hanford sandy loam soil.

Treatment	Total loss (% applied)[a]	
	1,3-D	CP
High density polyethylene (HDPE)	33.0 (a)	9.2 (a)
Virtually impermeable film (VIF)	7.5 (c)	1.2 (c)
Pre-irrigated soil + HDPE	22.1 (b)	2.8 (b, c)
Initial water application	26.5 (a, b)	8.0 (a, b)
Intermittent water applications	24.2 (b)	3.2 (b, c)

[a] Within a column, means (n=3) with the same letter in parentheses are not significantly different (α=0.05).

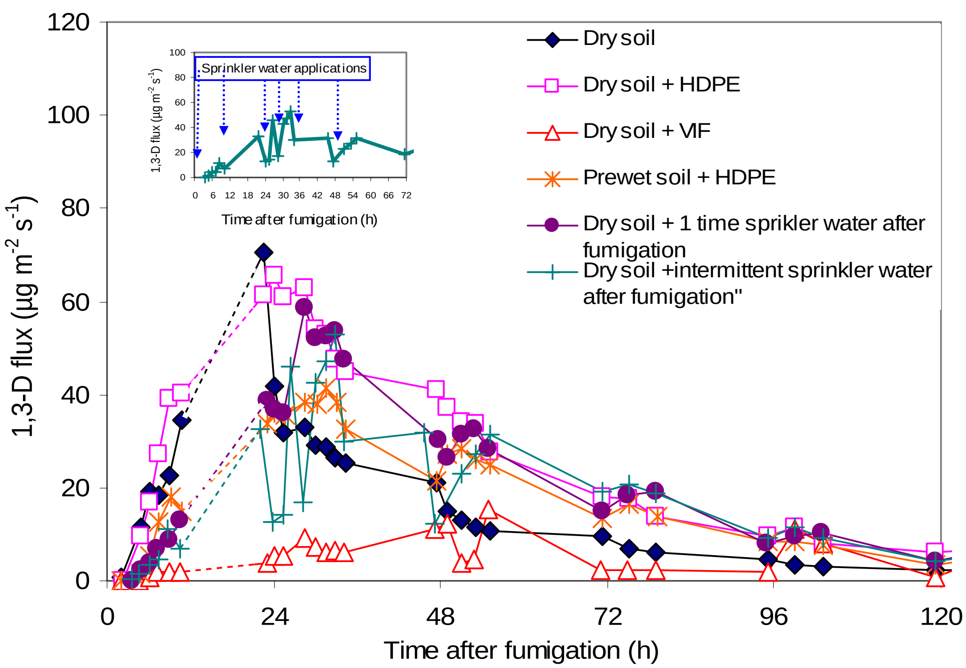

Figure 1. Effects of surface seal treatment on emission flux of 1,3-dichloropropene (1,3-D) after shank injection of Telone C35 in a field trial on a Hanford loam soil. Plotted data points are the means of three replicates. Dashed lines indicate that no measurements during this period of time resulted in some uncertainties. The effects of intermittent water application events on emission rates are shown in the sub-figure.