FIELD TESTS ON EMISSION REDUCTION METHODS FROM TELONE C35 APPLICATION

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Telone or 1,3-dichloropropene (1,3-D) and chloropicrin (CP) are primary alternative soil fumigants to methyl bromide and, as volatile organic compounds (VOCs), emission reductions are required to meet air-quality standards in California. Research has identified various methods including plastic tarp, irrigation, and soil amendment with organic materials or chemicals to reduce fumigant emissions. Effective and economically feasible field methods, however, are not clearly defined. Some emission reduction methods have a tendency to reduce fumigant concentrations, especially near soil surface, and simultaneous studies on emission reductions and efficacy are necessary. The objective of this study was to determine the effectiveness of several surface seals and treatment methods including pre-irrigation, post-fumigation water seals with or without chemical amendment such as potassium thiosulfate (KTS), and tarp over soil amendment with either KTS or composted manure on emissions and pest control. This paper reports results only on emissions.

Field trial: A field trial was conducted in October 2006 at the USDA-ARS San Joaquin Valley Agricultural Sciences Center, Parlier, CA. The soil is a Hanford sandy loam (coarse-loamy, mixed, superactive, nonacid, thermic Typic Xerorthents). A field strip (150 m x 9 m) was prepared for the trial, was cultivated to 76 cm depth, and irrigated to moisten dry surface soils. Half of the strip area was fumigated by shank injection of Telone C35 at a depth of 45 cm below soil surface and a rate of 499 kg ha^{-1} (445 lb ac^{-1}). The other half was not fumigated and served as a comparison to the fumigated area for efficacy studies. The fumigation was applied using a commercial Telone rig with 51 cm spacing shanks. Immediately following fumigation, the field surface, including non-fumigated area, was cultivated by a spring tooth harrow followed by a ring roller to close shank traces and pack the soil surface. The effects of six surface seal treatments on fumigant emissions were tested on the fumigated plots and data were analyzed as a randomized complete block with three replicates

1. Control
2. Manure + HDPE (composted steer manure incorporated into the soil surface at 12,350 kg/ha (5 ton/ac), then covered by High Density Polyethylene (HDPE) tarp)
3. KTS + HDPE (2:1 KTS/fumigant ratio, sprayed onto the soil surface in 1 mm of water, then covered by HDPE tarp)
4. Pre-irrigation (applied 34 mm water with sprinklers 4 days prior to fumigation)
5. Intermittent water seals (applied 13 mm water with sprinklers immediately following fumigation, plus an additional 4 mm at 12 h, 24 h, and 48 h)
6. Intermittent KTS applications (applied 2:1 KTS/fumigant ratio immediately following fumigation, and 1:1 KTS at 12, 24, and 48 h using the same amount of water as Treatment #5).

Fumigant emissions and concentrations in the soil-gas phase were determined for two weeks. Residual fumigants and soil moisture were determined at the end of the trial.

Results: Figure 1 shows emission rates (flux) for both 1,3-D and CP. The control gave the earliest high emissions. The manure + HDPE tarp resulted in surprisingly high emission rates (up to 34 µg m^{-2} s^{-1} for 1,3-D and 15 µg m^{-2} s^{-1} for CP in the day time). This contradicts earlier findings that manure application to soil effectively reduced emissions, indicating that soil or application conditions need to be better understood to achieve consistent emission reductions. The KTS application plus HDPE tarp substantially reduced emission peaks (11 and < 2 µg m^{-2} s^{-1} for 1,3-D and CP, respectively). The pre-irrigation had similar emission peaks for 1,3-D as the KTS + HDPE tarp but a higher CP emission peak (5 µg m^{-2} s^{-1}). The intermittent water seals after fumigation gave low emissions for the first 48 h when water seals were applied but high emissions after 48 h. The intermittent water seals with KTS addition resulted in very low emissions for 1,3-D for the first 4 days and for CP through the whole monitoring period. The results showed that KTS more effectively reduced emissions for CP than 1,3-D, as was also observed in the KTS + HDPE treatment.

The cumulative emission losses of 1,3-D and CP correspond to the flux data (Figure 2). Although the control resulted in the earliest and highest 1,3-D emission losses in the first few days, later emissions of 1,3-D was exceeded by the manure + HDPE tarp, which gave the highest 1,3-D total emission loss (32% of applied), although the CP total loss (17%) was slightly lower than the control (20%). The KTS + HDPE tarp, gave much lower cumulative emissions of 1,3-D and extremely low emissions of CP. The intermittent water seals did not reduce 1,3-D total emissions. The intermittent KTS applications resulted in the lowest total emissions for both 1,3-D and CP. The pre-irrigation treatment resulted in lower emissions for both 1,3-D and CP than other treatments except those with KTS. The pre-irrigation has an advantage over post fumigation treatments because of reduced exposure risks to workers. The pre-irrigation did not result in lower fumigant concentrations in soil-air (data not shown).

Residual 1,3-D and CP extracted from soil samples taken at the end of the field trial showed that the highest 1,3-D concentration was from the manure + HDPE treatment near the soil surface (up to 6 mg kg^{-1}), indicating that with manure amendment, the soil retention capacity for fumigants might have increased. The high temperature under HDPE tarp resulted in its increased permeability and fumigants may be subject to desorption which could contribute to emissions.

Figure 3 shows soil water content for the control and pre-irrigation treatments during the field trial. The control had a uniform soil water distribution the day before fumigation (8%, v/v, ~30% of the FC (26%). The pre-irrigated soil had much higher soil water content at surface the day before fumigation (21% v/v or 80% of FC), which was reduced to ~50% of FC 4 days later. To achieve low emissions, fumigation may need to be done within a few days following an irrigation.

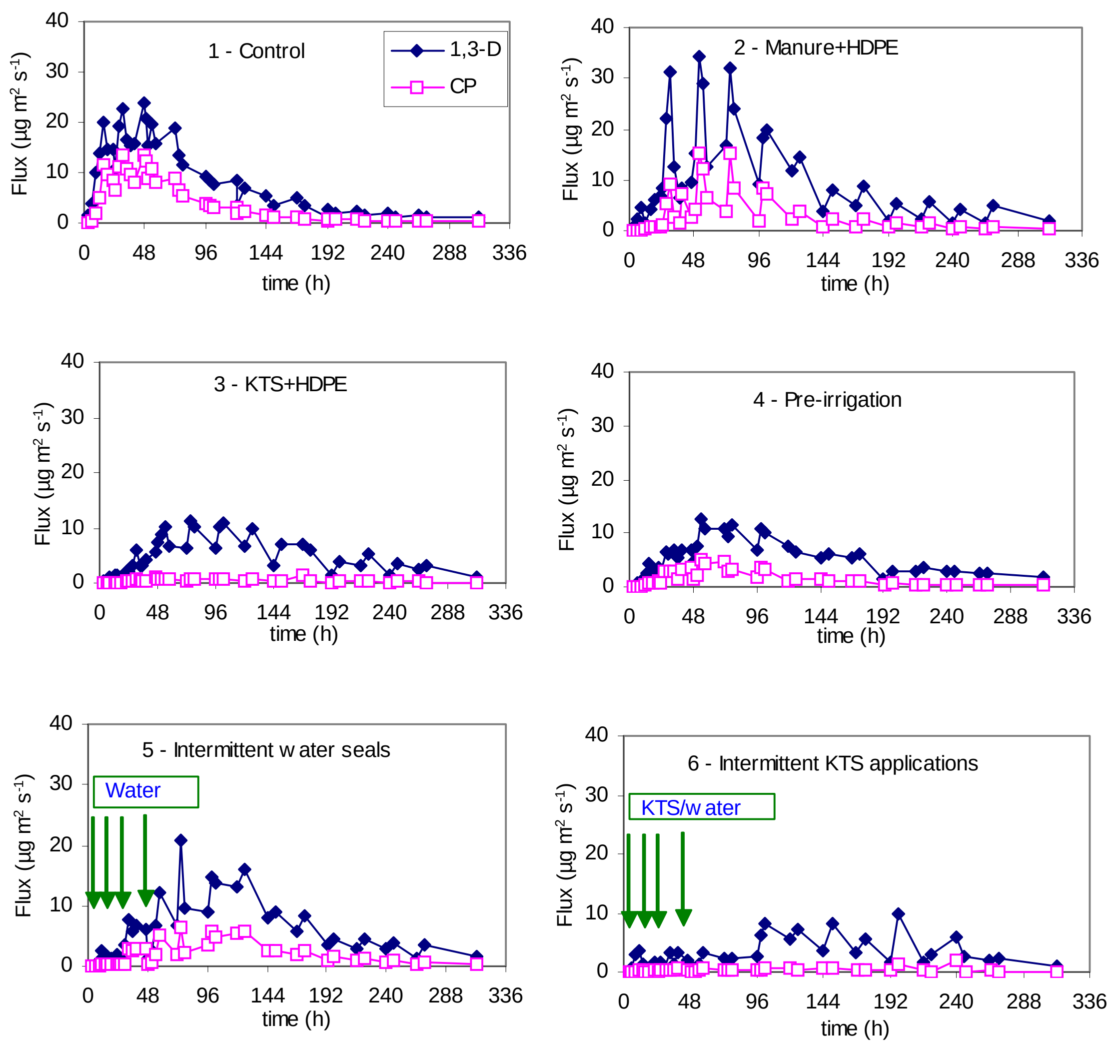

Figure 1. Effects of surface seal and soil treatments on emission flux of 1,3-dichloropropene (1,3-D) and chloropicrin (CP) from shank-injection of Telone C35. Plotted are averages of three replicates. Manure, composted steer manure; KTS, potassium thiosulfate.

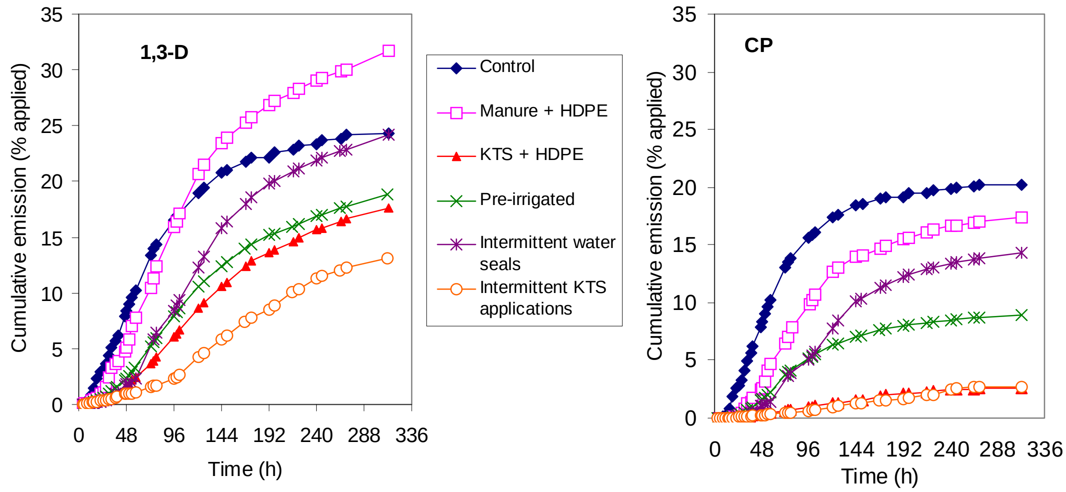

Figure 2. Cumulative emission losses of 1,3-dichloropropene (1,3-D) and chloropicrin (CP) from surface seal and soil treatments. Plotted data are averages of three replicates. Manure, composted steer manure; KTS, potassium thiosulfate.

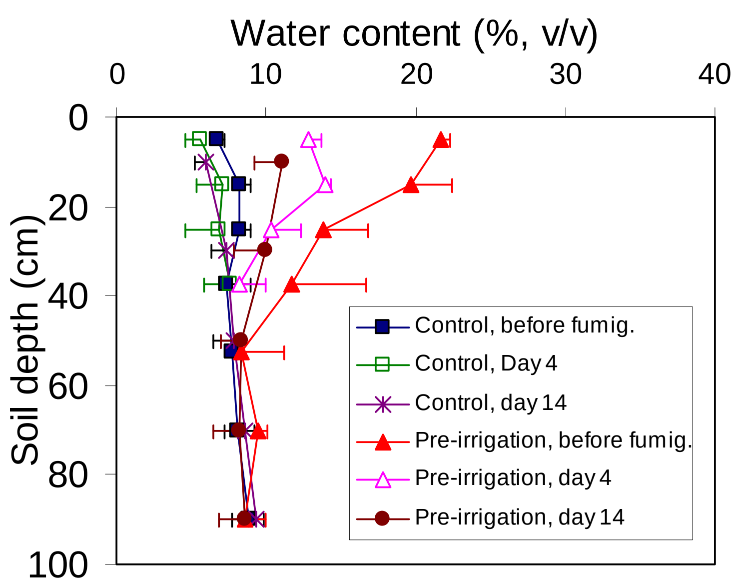

Figure 3. Soil water content measured the day before fumigation and 4 and 14 days after fumigation under various surface treatments. Horizontal bars are the standard deviations of the mean (n=3).