Using Irrigation and Organic Amendments to Reduce Fumigant Emissions

Project No.: **08-AIR5-Gao**

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Objectives:

The ultimate goal of the project is to develop effective, economical and environmentally sound methods to minimize fumigation emissions for *Prunus* and other perennial crop production systems that require pre-plant fumigation. The specific objective is to determine the effectiveness of irrigation and composted manure incorporation into surface soil as well as treatments in combination on reducing emissions from soil fumigation.

Interpretive Summary:

Post-fumigation irrigation and incorporation of composted manure into surface soils were tested under field conditions to reduce emission of the fumigants Telone (1,3-D) and chloropicrin (CP). Manure incorporation up to 10 tons/A (25 Mg/ha) did not reduce emissions while post-fumigation water applications with sprinklers (water seals) with or without manure incorporation reduced emissions significantly. This effect was more pronounced on emission peaks than cumulative emission loss. The results provide information for identifying effective field methods to minimize fumigation emissions.

Materials and Methods:

A field trial was conducted in November 2007 at the USDA-ARS San Joaquin Valley Agricultural Sciences Center at Parlier, California. The soil was Hanford sandy loam (coarse-loamy, mixed, superactive, nonacid, thermic Typic Xerorthents). During the trial, the daily maximum, minimum and average air temperature was in the range of 16.8–23.8, 1.8–9.6 and 8.9–14.8^{o}C, respectively. The field was cultivated to 75 cm depth and irrigated two weeks before fumigation to achieve adequate soil moisture conditions for fumigation. Soil water content determined two days before fumigation averaged 12.0% v/v (45% of field capacity) in the top 50 cm of soil.

The following treatments were applied to field plots (9 m x 3 m for manure treatment and 9 m x 9 m for irrigation treatments) with three replicates in a randomized complete block design:

1. Control
2. Manure at 12.4 Mg/ha (~5 ton/ac)
3. Manure at 24.7 Mg/ha (~10 ton/ac)
4. Manure (12.4 Mg/ha) + HDPE tarp
5. Water seals (11 mm water sprinkler applied immediately following fumigation and three subsequent applications of 4 mm water at 12, 24, and 48 h, respectively)
6. Manure (12.4 Mg/ha) + water seals (combination of treatments 2 and 5).

Telone C35 was shank applied at 553 kg/ha (493 lb/A). Emissions of 1,3-D and CP were monitored following fumigant injection for 10 days. Emission sampling was carried out using dynamic flux chambers, which trapped the fumigants on XAD sampling tubes (ORBO™ 613, XAD 4 80/40mg, Supelco, Bellefonte, PA). The samples were extracted and analyzed for the fumigants using gas chromatography techniques. In addition, fumigant concentrations in the soil-gas phase, residual fumigant in soil, soil water content and soil temperature were measured.

Results and Discussions:

Emission flux

Figure 1 shows emission flux data. The control (no manure and no post-fumigation water applications) and the two manure treatments at 12.4 and 24.7 Mg/ha gave the highest and similar emission rates for both 1, 3-D and CP for the first 4 days following fumigation. The peak emissions for these treatments were significantly higher than the other three treatments. The water seals with or without manure application resulted in the lowest emission rates for both 1, 3-D and CP within the first 4 days. The manure + HDPE tarp treatment had 1, 3-D flux values slightly higher than but not significantly different from the water seal treatments (α=0.05).

Emission rates followed diurnal temperature patterns and were highest from 1200-1500 h daily and lowest around 0300 h. After the emission peak observed the next day of fumigant application, however, emission flux decreased dramatically with time for the control and manure amendment treatments, and fell below those from the water seal treatments. For the two water seal treatments, emission flux was much lower than the control in the first few days when water was applied and remained similar throughout the whole 10 day monitoring period. At the end of the monitoring period, the emission flux from the water treatments was significantly higher than all other treatments for both 1, 3-D and CP. The manure+HDPE tarp treatment had the lowest emission flux for CP throughout the monitoring period.

Cumulative emission loss

The cumulative emission loss for 1,3-D over a 10-day monitoring period was highest for the control and the manure amendment at 12.4 Mg/ha, followed by the manure amendment at 24.7 Mg/ha (Table 1). Fumigant applied was about 33.7 g/m^2 1, 3-D and 19.4 g/m^2 CP. The emission loss of 1, 3-D for the control would be about 80% of the amount applied, which appeared much higher than those in the literature. The emission loss based on measurements using dynamic flux chambers had a tendency to overestimate emission loss. Thus, reported values here were used for comparison purposes or relative differences among treatments.

The cumulative emission losses for the two water treatments, and the manure+HDPE treatment were about half of the control; but due to large field variability, the differences were not significantly different among the treatments ($\alpha=0.05$). For CP, the cumulative emission losses from the manure+water treatment and the manure+HDPE treatment were significantly lower than the control and the two manure amendment treatments.

Water seal treatments resulted in higher surface soil water content and also higher residual fumigants in soil (data not shown) than no water application treatments. The persistence of fumigants in irrigated soils may have contributed to the relatively high emission rates observed towards end of the trial monitoring period. Generally speaking, post-fumigation water applications more efffectively reduced emission peak flux (80% reduction for 1, 3-D and >90% reduction for CP) than cumulative emission loss (~50% reduction for both 1,3-D and CP) (Figure 1).

This study suggested that manure incorporation at the rates of 12.4 and 24.7 Mg/ha (or 5 and 10 ton/ac, respectively) did not adequately reduce fumigant emissions under field conditions. Much higher manure application rates may be needed to achieve emission reductions from soil fumigation. However, it may not be economically feasible for some commodities because of the associated costs.

Table 1. Emission peak and cumulative emission loss of 1, 3-dichloropropene (1, 3-D) and chloropicrin (CP) monitored over 10 d following fumigation

Treatment†	Maximum Emission flux‡ ($\mu g\ m^{-2}\ s^{-1}$)		Cumulative Emissions§ ($g\ m^{-2}$)	
	1, 3-D	CP	1, 3-D	CP
Control	98.0 (a)	38.8 (a)	26.0(a)	7.4 (a)
Manure 12.4 Mg ha^{-1}	104.9 (a)	36.3 (a)	26.3 (a)	6.2 (a)
Manure 24.7 Mg ha^{-1}	72.8 (a)	30.7 (a)	21.5 (a)	6.9 (a)
Manure 12.4 Mg ha^{-1} + HDPE	33.3 (b)	3.3 (b)	13.0 (a)	1.2(b)
Water seals	16.7 (b)	3.4 (b)	16.5 (a)	4.3(a, b)
Manure 12.4 Mg ha^{-1} + water seal	20.0 (b)	3.4 (b)	14.4 (a)	2.7 (b)

† Manure, composted manure; HDPE, high density polyethylene.

‡ Within a column, means (n=3) with the same letter in parentheses are not significantly different according to Tukey's HSD test ($\alpha=0.05$).

§ Emission loss calculated from dynamic flux chamber measurement.

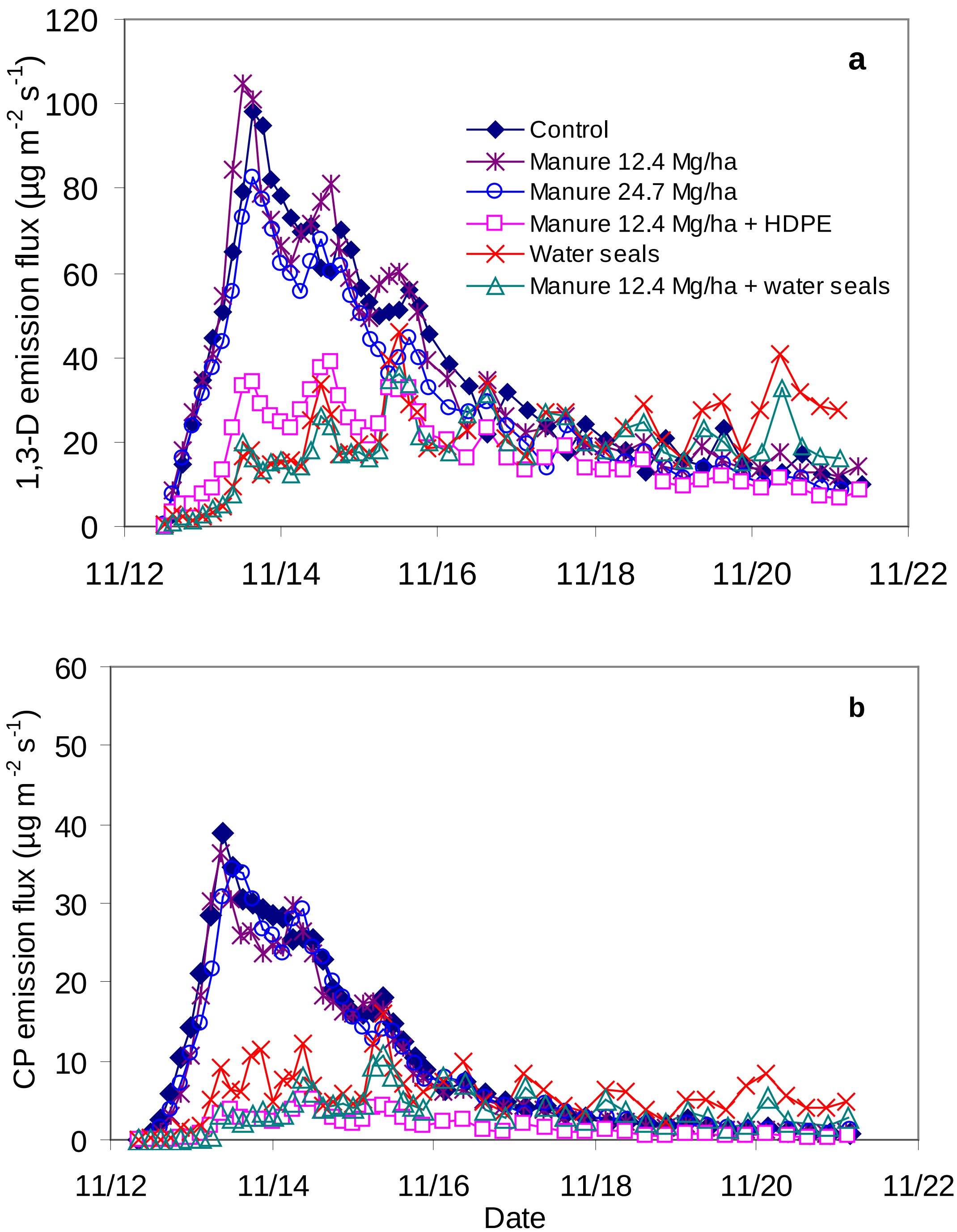

Figure 1. Effects of manure and water applications on emission flux of (a) 1, 3-dichloropropene (1,3-D) and (b) chloropicrin (CP). Plotted data are averages of three replicates. Error bars are not given for the legibility of the figure (significance of the differences between treatments is indicated in Table 1). Manure = composted manure; HDPE = high density polyethylene tarp.