Determine Emission Reduction Using Totally Impermeable Film (TIF) and Waiting Period for Tarp Cutting in a Large Field Fumigation Trial

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Objectives:

The main goal of this project is determine the efficiency of TIF to reduce emissions from soil and to collect soil concentration data that will help estimate the dose and predict the waiting period for tarp cutting. The specific objectives are:

1) Determine the best tarp cutting time for fields fumigated with 1,3-dichloropropene and chloropicrin under TIF. This objective will generate comparative emission data from three large broadcast shank application scenarios in Ventura County.
2) Determine fumigant concentration change and distribution in soil profiles down to 1 m depth under the TIF.
3) Generate data on the fumigant emissions using dynamic flux chambers and measure under-tarp fumigant concentration changes overtime.
4) Determine residual fumigants upon tarp-cutting.
5) Generate data on the permeability of the plastic film (VaporSafe^{TM}) used in this study.

Interpretive Summary:

This project collected field data to address issues associated with totally impermeable film (TIF) and to help regulatory agencies make decisions on adoption TIF technology in soil fumigation in ozone non-attainment areas (San Joaquin Valley and Ventura

County). Large field trials were conducted to determine the efficiency of TIF to reduce fumigant emission rates and total mass loss from soil and to determine fumigant concentration changes and distribution in soil. Three large fields with TIF tarp for different covering times were established near Lost Hills in Kern County. Emission rates were measured by the off-field method as well as dynamic flux chamber method. Soil gas distribution and fumigant concentration under the tarp were monitored and were used to predict the proper waiting period for the tarp cutting. The results of this study demonstrated that emissions of 1,3-dichloropropene and chloropicrin under TIF tarp are significantly lower when tarp splitting is extended from five to ten days. For 1,3-dichloropropene, flux peak was eliminated when tarp splitting is extended to 15 days from the date of application. This project provided policy makers and regulatory agencies with the information for the safe use of TIF for chloropicrin and 1,3-dichloropropene soil fumigants.

Introduction

Pre-plant soil fumigation remains critical to profitable crop production for strawberry and perennials in California. The phase-out of methyl bromide (MeBr) has shifted to the greater use of alternatives, particularly Telone (1,3-dichloropropene or 1,3-D) and Chloropicrin (Pic) co-formulated products for these commodities. These alternatives, however, are strongly affected by environmental regulations due to potential exposure risks and their contribution to the deterioration of air quality through VOC emissions. Buffer zones, township caps, and the requirement for low emission application methods are the measures taken to control emissions. Both federal and the state regulatory agencies continue to develop more stringent regulations on fumigants or amend those already in place. To increase the likelihood of fumigant availability for agricultural use, reducing emissions continues to be a critical factor. Management strategies that minimize emissions and improve pest control efficacy at the same time offer the best hope for maintaining the availability of fumigants to commodities in the prospective short and intermediate term future. Low permeable tarp technology has shown promising results to meet these requirements. A number of field trials were conducted in the last few years and evaluated various surface sealing or treatments to reduce emissions from soil fumigation. The most promising and dependable emission reduction technique is the use of totally impermeable film (TIF). The USDA-ARS and commodity groups are generating field emission data in collaboration with the California Department of Pesticide Regulations to mitigate fumigant emissions from agricultural fields in the Non-Attainment Areas (NAA). Although several studies demonstrated that TIF can significantly reduce early emissions rates of both 1,3-dichloropropene and chloropicrin, the time of tarp splitting that would result in the least emissions is unclear. This project was designed to accurately determine the waiting time before splitting and removing TIF from fumigated soils.

Materials and Methods:

This project was conducted in Kern County, part of the San Joaquin Valley f, a NAA, where air quality improvement is needed. The results obtained from this study will be applicable to other NAA such as Ventura County, as well as more general application to other regions.

This study was conducted on three fields using a commercial formulation of a mixture of Pic and 1,3-D (Pic-Clor 60; USEPA Reg. No. 8536-8; 62% 1,3-D and 35% 1,3-D). All fields were covered with TIF ("VaporSafeTM"; Raven Industries, Inc., Sioux Falls, SD). The target application rate was 588 lbs/acre (broadcast). This application rate would give 350 lbs Pic/acre and 238 lbs 1,3-D/ac. The fumigants were applied using a Noble Plow application rig at a depth of approximately 10 to 12 inches. The Noble Plow is a plow that consists of horizontal v-shaped blades mounted by vertical arms on the tool bar that injects 1,3-D and chloropicrin laterally (away from the shank trace) to a depth between approximately 10 and 15 inches beneath the soil surface. The Noble Plow has two 32-inch wide plows on spacing that does not exceed 48 inches.

The test fields (**Table 1**) were located on a commercial carrot production farm in Kern County, California. The test fields were chosen to reflect the following application parameters: a non-attainment area, a typical season of application, a typical soil type, and typical application equipment. The test fields consisted of two 2-acre fields and one 8-acre field. For field #1 (8 acres), the tarp cutting took take place on Day 16 following the application. For field #2 (2 acres), the tarp cutting took take place on Day 10 following the application. For field #3 (2 acres), the tarp cutting took take place on Day 5 following the application. The off-field monitoring method was used to back-calculate emissions from each field using eight sampling stations for each of the 2 acre fields and 16 stations for the 8 acre field. **Figures 1** and **2** shows the GPS locations of the monitoring stations around the 8 acre and 2 acre fields.

Table 1. Experimental Specifications

Field #	Fumigant Product	Field size (acres)	Soil Sealing Method	Tarp cutting Time/Date
1	Pic-Clor 50	8.16	VaporSafe TIF	6/20/2011 07:40-08:30 am PST
2	Pic-Clor 50	1.97	VaporSafe TIF	6/14/2011 07:43-08:07 am PST
3	Pic-Clor 50	2.03	VaporSafe TIF	6/9/2011 08:20-08:52 am PST

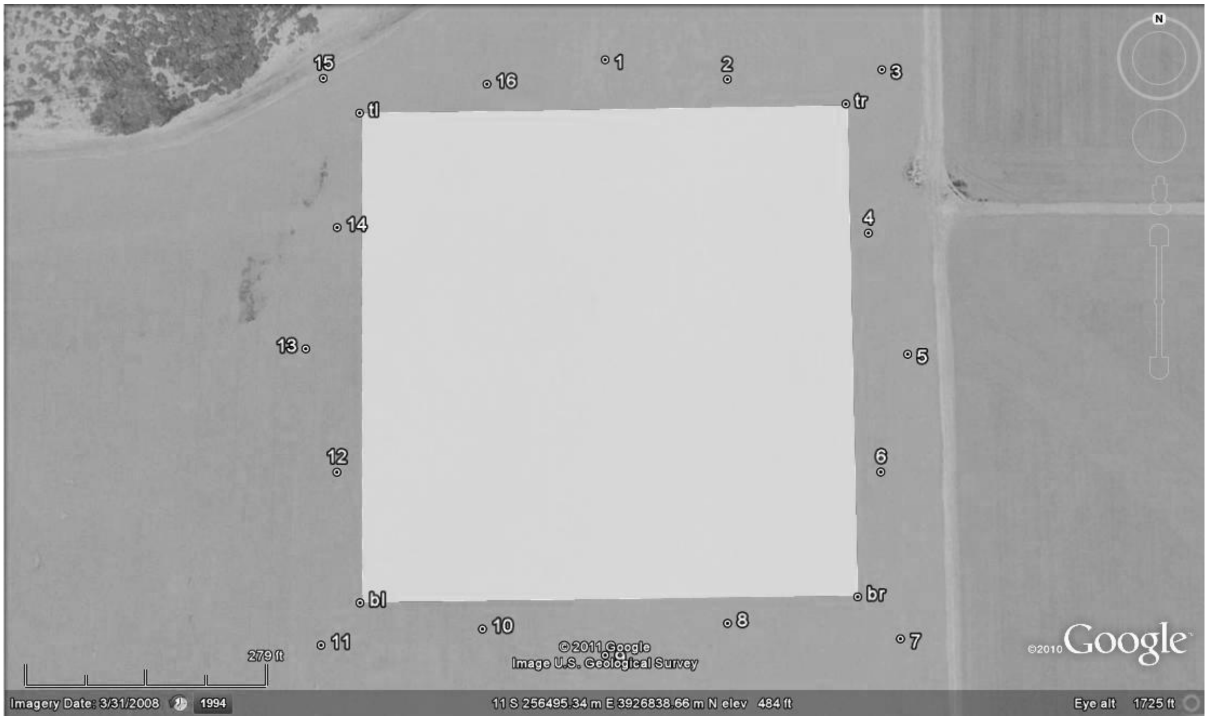

Figure 1. Location of the 16 air sampling stations around Field #1 (8 acres).

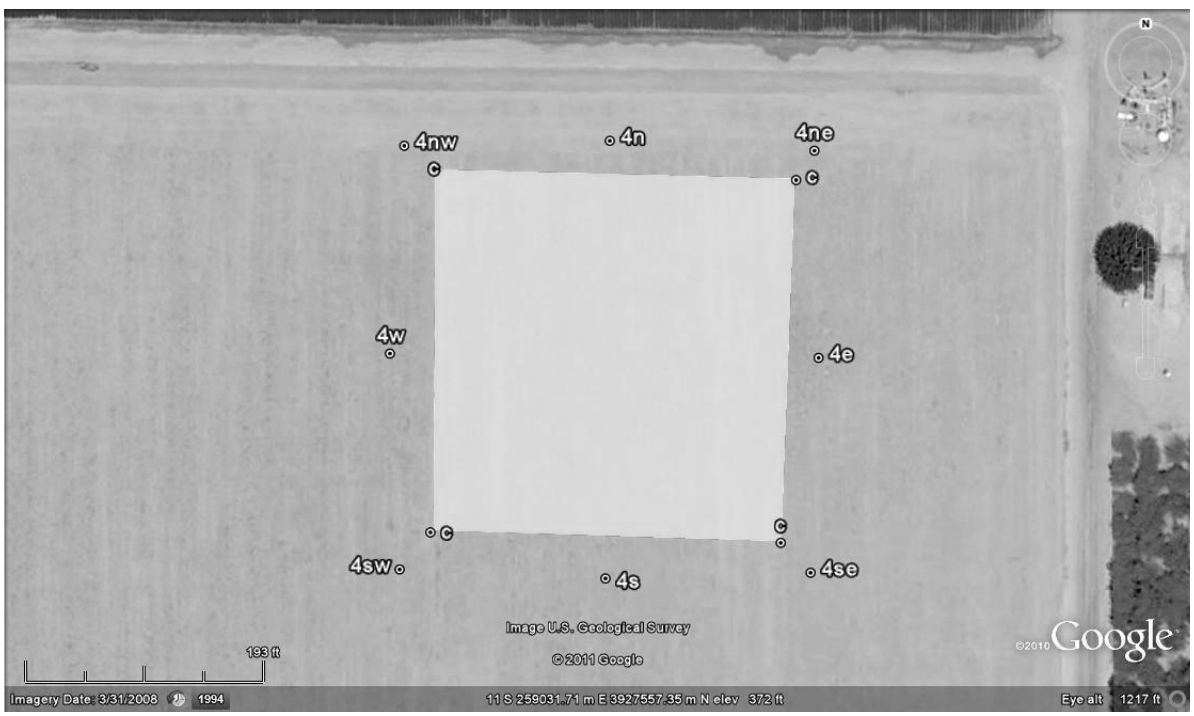

Figure 2. Location of the 8 air sampling stations around Field #2 (Field #3 had a similar setup**).**

The fields were reasonably flat and free of obstacles around the edges, such as tree rows and other obstacles. For the 2 acre fields, the off-site air sampling pumps were established in eight directions surrounding each field at approximately 40 feet from the sides of each field (4 stations) and approximately 80 feet from the corners of each field (4 stations). For the 8 acres field, 16 air sampling pumps were used. Four pumps were placed approximately 80 feet from the corners and 3 pumps were placed at 40 feet on each side of the field. The spacing between the three pumps on the sides was approximately 148 feet each other and from the field corners. The sample point was approximately 5 feet (1.5 m) above ground level. Within 24 hours prior to application, background ambient air sampling occurred for approximately 12 hours at two off-site sample locations per field.   Three two-dimensional sonic meteorological systems (measurement resolution: 0.01 m/s) were installed adjacent to fields at 1, 3 and 4 at 10 feet anemometer height above ground level within 20 feet of the field edge. Two three-dimensional anemometers also were used.

Chloropicrin and 1,3-dichloropropene air sampling was conducted using XAD-4 and coconut charcoal sorbent tubes, respectively, supplied by SKC Company (PA, USA). The original protocols for chloropicrin and 1,3-dichloropropene were developed or validated by the California Department of Food and Agriculture for chloropicrin (CDFA Method #: EM16.0; CDFA) and 1,3-dichloropropene (CDFA method EM59.6). Air under the TIF (above soil surface) and at various depths in the soil were collected over the entire monitoring period (9, 24, 48, 72 h followed by 3-day intervals after application) using XAD-4 sorbent tubes.

Results and Discussion:

Flux rates:

Emission rates of 1,3-D and Pic are shown in **Figures 3** and **4**, respectively. Total mass loss relative to the amount applied for 1,3-D and Pic are shown in **Figures 5** and **6**, respectively.   In all fileds, emission rates of both fumigants were very small (<10 ug/m^2/sec) for the first 5 days (until tarp cutting). Cutting the tarp after 5 days resulted relatively large flux values (spikes) of 1,3-D (47 ug/m^2/sec) and Pic (42 ug/m^2/sec). Cutting the tarp after 10 days resulted small flux values of 1,3-D (<11 ug/m^2/sec) and very small flux values of Pic (3 ug/m^2/sec). Cutting the tarp after 16 days resulted in very small flux values of both chemicals. These results indicate TIF can be cut after 10 days for Pic fumigation and 14 days for 1,3-D fumigation.

Total mass loss relative to the amount applied increased sharply when the tarp was cut after 5 days. Approximately 8% of the applied chloropicrin and 15% of the applied 1,3-D volatilized after tarp cutting (day 5 and day 6). However, monitoring of this field (Field #3) ceased after 6 days. The total mass loss of chloropicrin did not significantly change when the tarp was cut after 10 days (the change was <1%). However, the mass loss of 1,3-D changed from ~5% to 9% the day after tarp cutting.

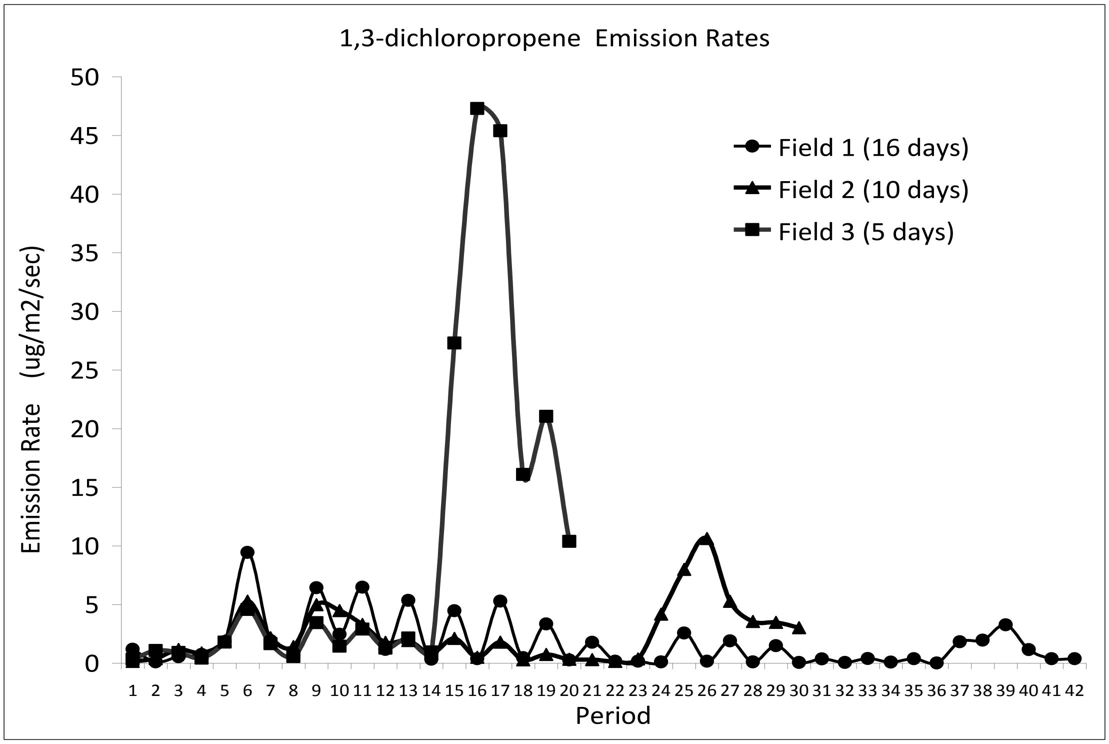

Figure 3. 1,3-Dichloropropene emission rates after tarp cutting (5, 10, and 16 days).

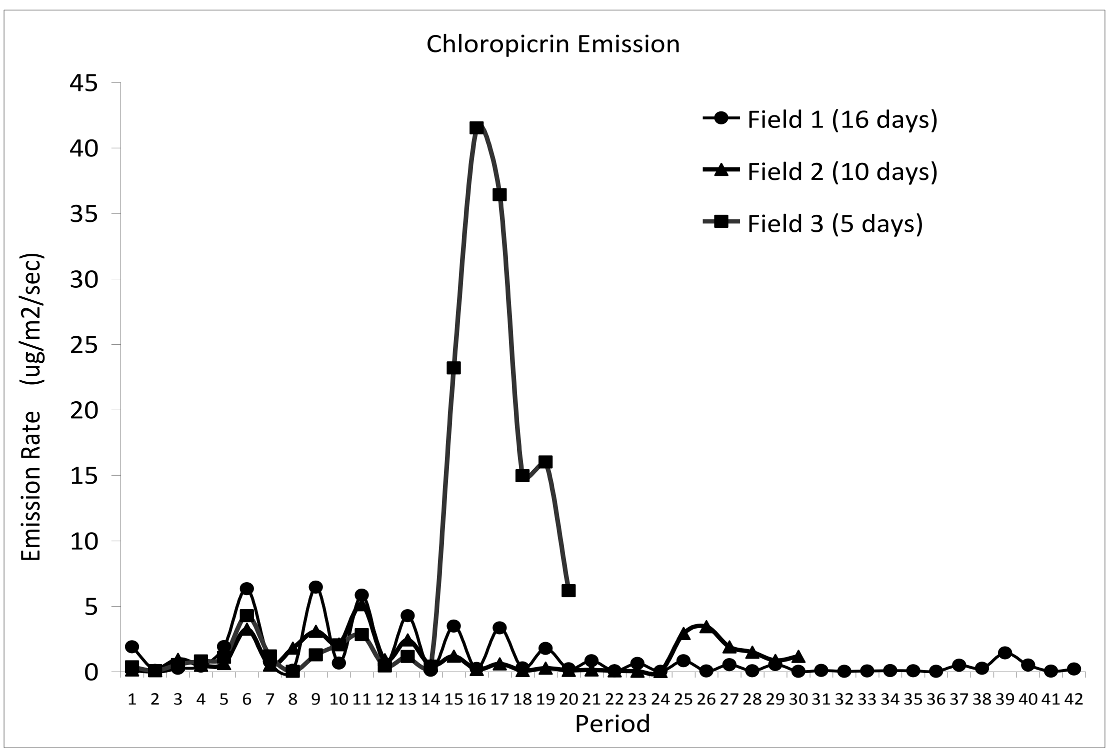

Figure 4. Chloropicrin emission rates after tarp cutting (5, 10, and 16 days).

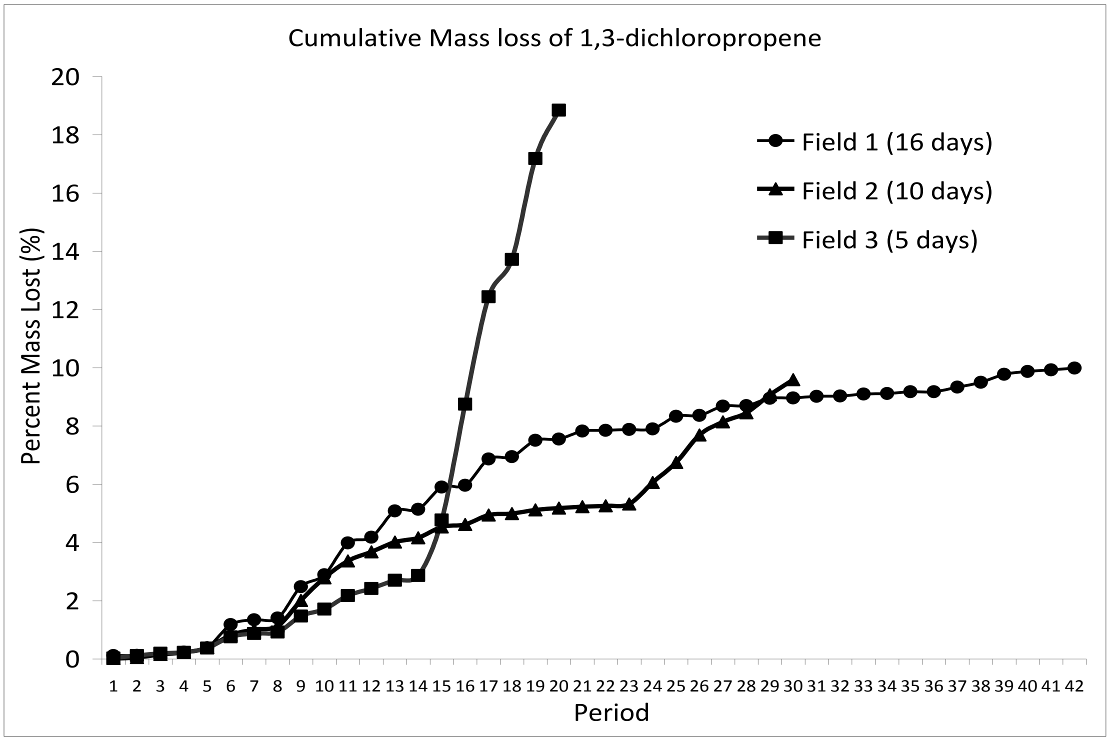

Figure 5. 1,3-Dichloropropene mass loss relative to the amount applied.

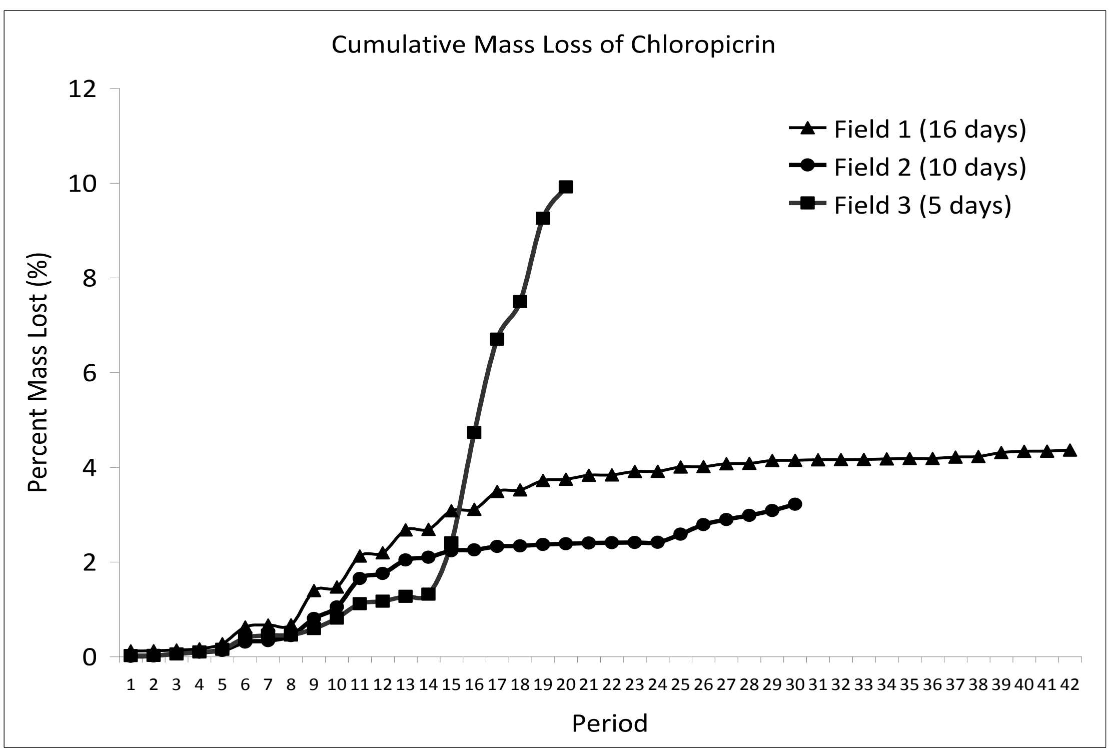

Figure 6. Chloropicrin mass loss relative to the amount applied.

Fumigant concentration under TIF in in the soil air:

Figure 7 shows the under tarp (above soil) concentrations of 1,3-D and Pic for the entire study (Field #1). The maximum concentrations were detected 24 hours following fumigation and were 8.3 µg/cm^3 for CP and 6.9 µg/cm^3 for 1,3-D. High concentrations also measured in the first 3 days around noon time. The concentration of both fumigants sharply decreased after four days. 1,3-D concentrations under the tarp were below 1, 0.25 and 0.10 µg/cm^3 on Day 10, 13, and 15, respectively. The Pic concentrations were half the 1,3-D concentrations after five days follwing the application and were negligiable (<0.5 µg/cm^3) after 8 days.

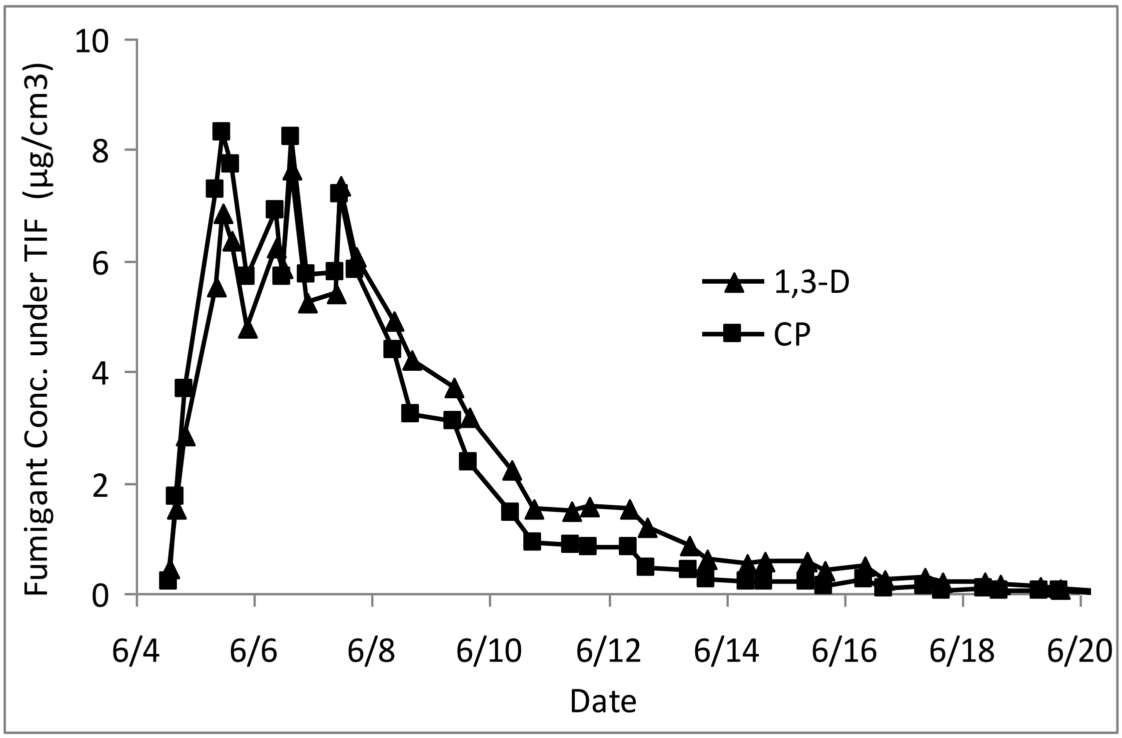

Figure 7. 1,3-Dichloropropene and chloropicrin concentrations under TIF**.**

The concentrations of 1,3-D and Pic in the soil gaseous phase to a depth of 100 cm are shown in **Figure 8**. The maximum concentrations were detected between the shanks within 26 hours after application. The highest concentrations were between shanks because the Nobel plow does not inject chemicals below the shank traces and the injection points are located at the plow wings below the soil surface. However, 1,3-D and Pic concentrations in the soil gaseous phase became negligiable after 217 hours (~9 days).

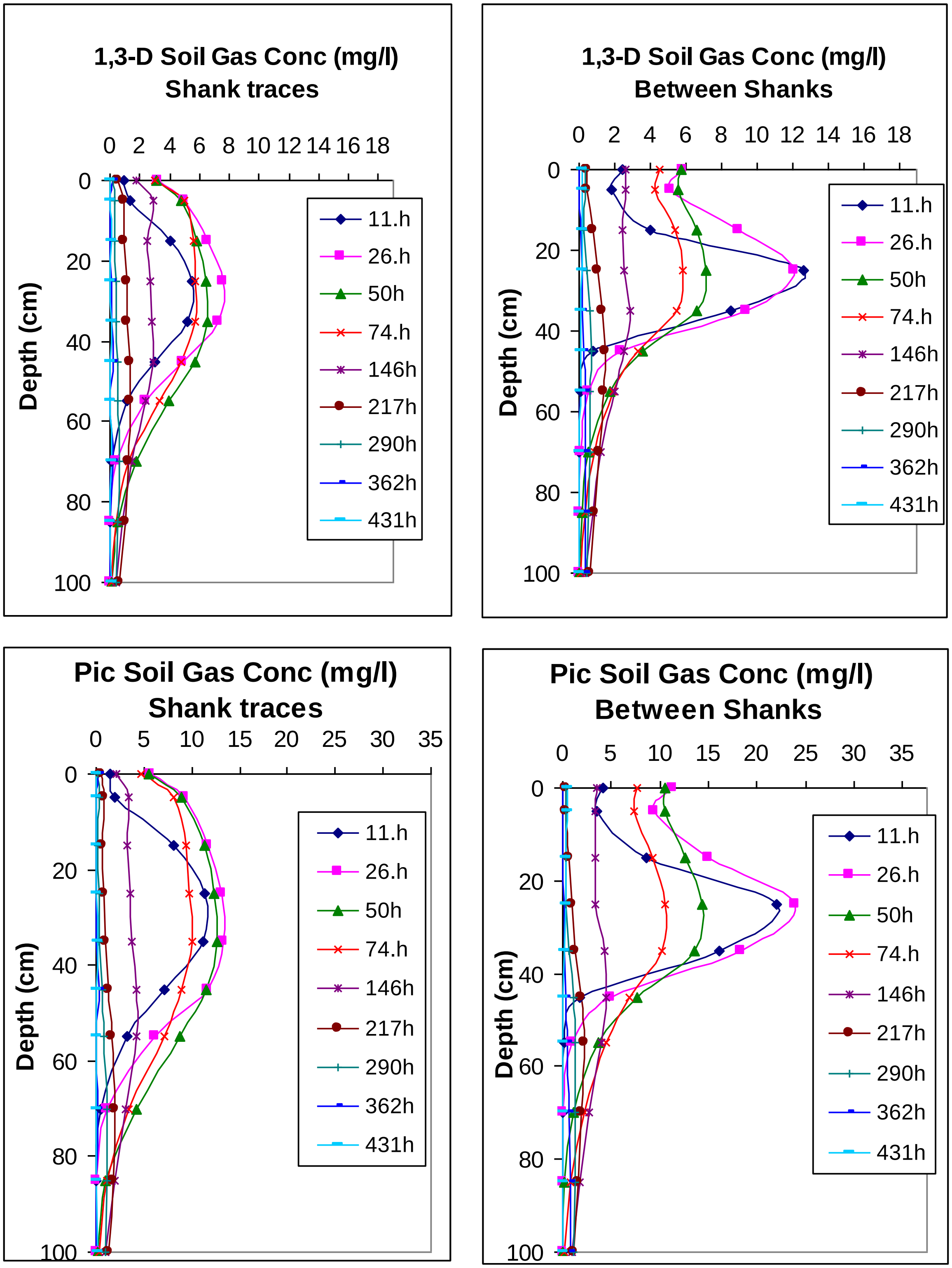

Figure 8. 1,3-Dichloropropene and chloropicrin concentrations in the soil profile to a depth of 100 cm.

Conclusion

1) TIF effectively reduced fumigant emissions by retaining fumigants in the soil. Early emission rates of both fumigants were very small (<10 ug/m^2/sec).
2) Early tarp cutting (after 5 days) resulted in unacceptable emissions (spike) when applied at a maximum chloropicrin rate.
3) Tarp cutting can be done after 10 days for Pic alone application and after two weeks for 1,3-D applications with a minimum potential exposure to workers and bystandards.
4) TIF greatly reduced total emissions and can be used to reduce atmospheric VOCs from fumigated soils. Relative to previous flux studies with standard PE tarp, TIF reduced total emissions by more than 5X when the tarp is cut after 10 days (for Pic) or 14 days (for 1,3-D).

Acknowledgements:

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Research Effort Recent Publications:

The project was completed in October, 2011. Publications are in progress.