Minimizing Emissions and Improving Efficacy in Soil Fumigation with TIF Tarp

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Study Background

Pre-plant soil fumigation is still one of the most effective tools to control soil-borne pests and diseases for establishing productive and healthy trees in almond replanting orchards. With the environmental constraints on fumigant use, fumigation methods for high pest control efficiency and low emissions are needed greatly. This project is to develop strategies for increasing fumigation efficiency with reduced rates and lower emissions by using a low permeability tarp, such as the totally impermeable film (TIF).

Objectives

- Demonstrate that the use of TIF can improve fumigant distribution in soil and increase fumigant concentration-time exposure index values for better pest control than standard polyethylene (PE) tarp in field fumigation.
- Evaluate pest control efficacy (nematodes, pathogens, and/or weeds) under TIF and reduced fumigation rates.
- Monitor almond tree vigor and growth from different fumigation treatments in fumigated growers' fields.
- Determine the effective field fumigation rates under TIF with regards to soil-borne pest control and almond tree performance.

Tree Response to Fumigation Treatment in 2012 Merced Trial

A fumigation field trial was conducted in an almond orchard in late November 2012 at Braden's Farm in Merced County, CA. Fumigation treatments included various rates of Telone® C-35 injected at 45 cm (18 inch) soil depth, and three surface sealing methods (bare, standard PE tarp, and TIF) with six replicates in a randomized complete block design. Tree growth has been monitored since planted in February 2013. **Table 1** shows the tree growth measurements.

Table 1. Tree diameter measurement following tree planting after fumigation treatments at Braden's Farm, Merced, CA.

Treatment (Telone® C35 rate & tarp)	Tree diameter[a] (mm)			
	3/8/2013	12/15/2013	5/9/2014	11/14/2014
100% No Tarp	11.4	46.3 a	57.6 a	87.2 a
100% PE	10.6	46.2 a	57.1 a	86.4 a
100% TIF	10.8	45.6 a	56.2 ab	85.1 a
66% No Tarp	11.2	44.1 ab	55.5 ab	87.0 a
66% PE	11.0	45.5 a	53.8 ab	87.0 a
66% TIF	11.6	45.7 a	54.9 ab	85.9 a
33% No Tarp	11.1	43.2 abc	55.0 ab	82.8 ab
33% PE	11.1	43.8 ab	55.4 ab	84.4 a
33% TIF	11.4	43.1 abc	53.7 ab	82.8 ab
0% No Tarp	10.8	37.6 d	47.7 b	73.9 c
0% PE	11.0	39.3 bcd	50.0 ab	75.9 bc
0% TIF	10.4	38.2 dc	48.9 ab	74.5 c

[a] Different letters in the same column indicate significance at P<0.05.

- There were no significant differences in tree diameter following tree planting (3/8/2013).
- Ten months after planting (12/15/2013), all fumigated treatments at 100% and 66% rates under tarp had significantly larger tree diameters than the non-fumigated controls. These differences were reduced on 5/9/2014. By 11/14/2014, the trees from all 100% and 66% rates again showed significantly larger than the controls.

Nematode control. High population of resident nematodes in soil were detected prior to fumigation in the 2012 Merced field trial. Nematode survival from the fumigation treatments are shown in **Fig. 1.**

Soil sampling for nematode survival determination

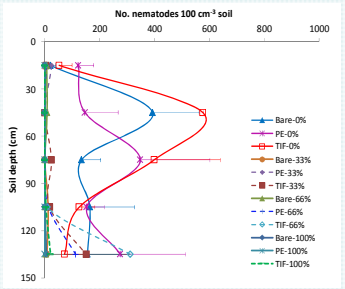

Fig. 1. Survival of residential nematodes (sum of pin, ring, and spiral) in soil after fumigation.

- All fumigated treatments at ≥66% rate provided effective control in soil depths above 1 m (~3 ft), but not in soil below.
- Below 1 m depth, fumigant concentrations were extremely low indicating the need to deliver more fumigants in order to control plant-parasitic nematodes.

2013 Parlier Trial - Carbonation on Fumigant Movement

A field trial was conducted during May 16-June 19, 2013 at Parlier, CA. With the challenge to deliver fumigants to below 1 m soil depth, this trial evaluated the potential of carbonated fumigants (dissolving carbon dioxide into fumigant at 1.5%) to improve fumigant movement. The TIF has been shown to significantly reduce emissions but it is uncertain if off-tarp edge emissions were high. This trial determined that TIF tarp extensions (additional 60 cm tarp distance at the 66% rate) can control the off- tarp edge emissions. Efficacy was not determined in this trial because the soil did not have indigenous nematodes.

Emissions (Fig. 2).

- The 2/3 rate plots with 60 cm tarp extension showed much lower 1,3-D emission flux than the full rate without no tarp extension.
- Estimated total emission loss from regular tarp-edge at 100% full rate was 2.17% of applied 1,3-D and 0.03% of applied CP to the plot over the 15 d monitoring period. At the 2/3 rate with 60 cm tarp extension, the total emission loss from the tarp edges was 0.44% and 0.02% of total applied 1,3-D and CP, respectively.

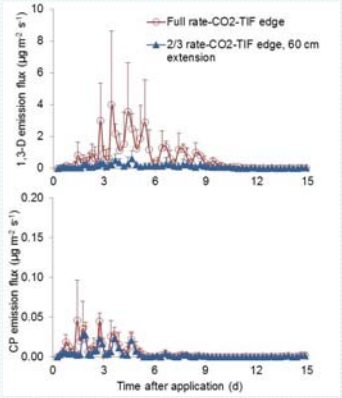

Fig. 2. Emission flux of 1,3-D and chloropicrin in Parlier trial, 2013.

Air under tarp (Fig. 3). TIF has been proven to retain much higher fumigant concentrations compared to standard PE tarp.

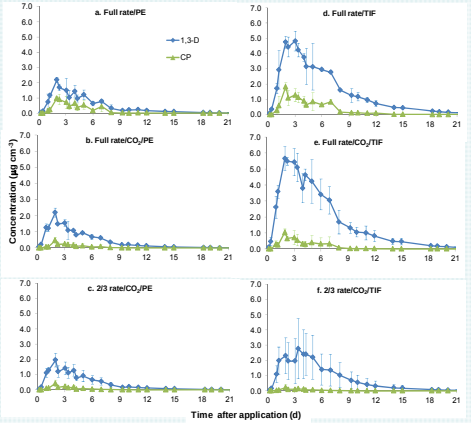

Fig. 3. 1,3-D and chloropicrin (CP) concentration under tarp.

1,3-D distribution profile in soil-gas phase (Fig. 4). The carbonated fumigant under the studied conditions (1.5% CO_2 in fumigants and 45 cm injection depth) did not increase fumigant concentration or movement to deeper soils. Either higher CO_2 concentration or deeper injection is needed to deliver fumigants to soil below 1 m depth.

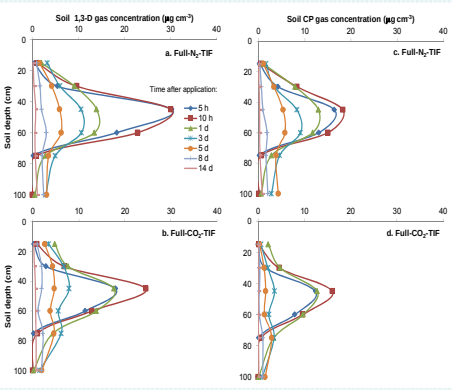

Fig. 4. 1,3-D and chloropicrin (CP) distribution in soil.

On-going work. A new fumigation trial will be conducted in early December to test if deeper injection would facilitate fumigant movement to soil below 1 m depth and confirm the effectiveness of reduced (66%) fumigation rate under TIF on pest control and orchard performance. Nematode control, fumigant movement, and tree growth data will be collected from this trial.

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