# Minimize Emissions and Improve Efficacy with Low Permeability Tarp and Deep Injection in Soil Fumigation

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## Study Background

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 increasing regulations on fumigant use, fumigation methods for high pest control efficiency and low emissions are being sought. This project is to develop strategies for increasing fumigation efficiency with reduced rates and lower emissions by using a low permeability tarp (TIF). Previous field tests indicate poor efficacy because of difficulties in delivering fumigants to deeper soil. The research this year evaluated the potential of using deep injection.

## Objectives

- Demonstrate the benefit of using totally impermeable film (TIF) to reduce emission, improve fumigation efficacy by increasing exposure index values for pest control, and reduce fumigant rates.
- Determine the potential of deeper injection to improve fumigant delivery to deeper soils to improve pest control.
- Determine tree response to fumigation treatments by monitoring almond tree growth and yield from different fumigation treatments in fumigated growers' fields.

## 2014-15 Ballico Fumigation Trial with Deeper injection and TIF

A fumigation trial was conducted from Dec 9, 2014 through Jan 6, 2015 at Littlejohn's Farm, Ballico, Merced County. The soil was Delhi sand (Mixed, thermic Typic Xerosamments). Previous field trials demonstrated the challenge of delivering fumigants to below 1 m soil depth, In this trial treatments included two injection depths: regular 18 in (~46 cm) injection depth and a deeper injection depth at 28 in (~71 cm) at full rate and 66% rates of Telone® C35 at regular injection depth and non-fumigated controls with three surface sealing methods (no tarp, standard PE tarp, and TIF).



### Emissions (Fig.1)

- TIF tarped plots gave consistently lowest emissions.
- The highest emission rates were from PE tarped plots (both regular and deep injection depths).
- Lower emission rates from the bare soil were due to rain received during the trial illustrating a water seal effect.
- Chloropicrin emissions are generally lower than 1,3D from Telone® C35 application. After applying to soil, chloropicrin dissipates much faster than 1,3-D.

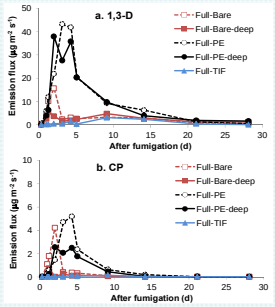


**Fig. 1.** Emission flux of 1,3-D and chloropicrin in Ballico trial, 2014-15.

### Air under tarp (Fig. 2)

- TIF at full or 2/3 rate retains much higher concentrations than full rate standard PE tarped plots.
- The lower fumigant concentration under PE was due to the high emissions through the tarp (Fig. 1).
- Fumigant concentrations under TIF were lower from the deeper injection than the regular depth indicating facilitated fumigant movement in soil profile.

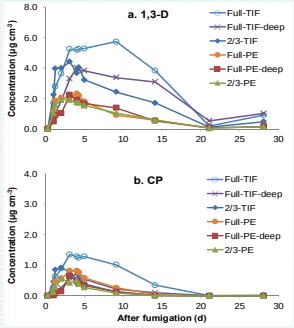


**Fig. 2.** 1,3-D and chloropicrin concentration under tarp.

### 1,3-D distribution profile in soil-gas phase (Fig. 3)

- Deeper injection resulted in the maximum concentration near 60 cm depth compared to the 45 cm soil depth from regular injection depth.
- The deeper injection resulted in higher concentrations at 100 or 125 cm depths under bare and PE tarp.
- The better movement of fumigants in this soil could be due to its coarse texture.
- Chloropicrin (not shown) showed similar distribution pattern as 1,3-D except at lower concentration levels.

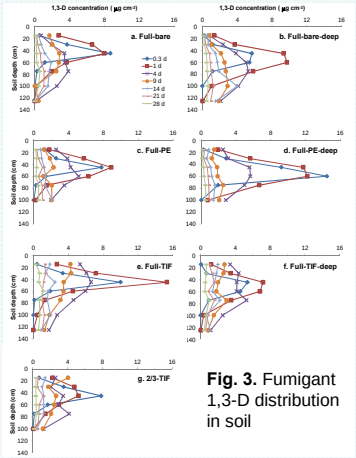


**Fig. 3.** Fumigant 1,3-D distribution in soil

### Nematode control

Ring, Lesion, Root-knot, Pin, and Stubby nematodes were found in nonfumigated plots at all depths (Table 1).

**Table 1.** Total population of nematode (no/100 cc) in non-fumigated plots

| Soil depth | Alive Ave (stdv) | Dead Ave (stdv) |
|---|---|---|
| 0-1 ft | 10 (11) | 22 (25) |
| 1-2 ft | 8 (17) | 1 (17) |
| 2-3 ft | 4 (4) | 10 (7) |
| 3-4 ft | 5 (12) | 4 (7) |
| 4-5 ft | 3 (5) | 8 (14) |


* All fumigation treatments provided 100% kill except 1 sample out of 135. The sample was from 0-1 ft depth; PE tarped full rate and 12 live root-knot nematodes were detected.

### Residual fumigants (Fig. 4)

- All 2/3 rates showed lower 1,3-D concentrations than the full rates at the deepest (125 cm) depth.
- Downward movement (note from the full rates) in soil needs to be avoided to reduce potential leaching.
- Fumigation in winter (rain season) increases the risk of fumigant leaching; using reduced rate can minimize the risk.

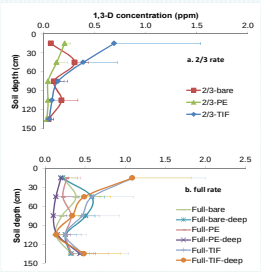


**Fig. 4.** Soil residual fumigant concentrations after fumigation.

## Tree Growth and Yield in a 2012 fumigated Almond Orchard at Bluff Ranch

Tree response to fumigation treatment was monitored in an almond orchard fumigated Nov 2012 at Bluff Ranch, Merced. Treatments included various rates of Telone® C-35 and three surface sealing methods (bare, PE tarp, and TIF). Table 2 shows the tree growth over time and yield measurement ~3 years after fumigation.

**Table 2.** Tree diameter measurement and yield after fumigation treatments at Bluff Ranch, Merced, CA.

| Treatment (Telone® C35 rate & tarp) | Tree diameter[a] (mm) | | | | Yield (field wt, lbs/tree) |
|---|---|---|---|---|---|
| | 3/8/13 | 12/15/13 | 5/9/14 | 11/14/14 | 8/7/15 |
| 100% No Tarp | 11.4 | 46.3 a | 57.6 a | 87.2 a | 38.2 a |
| 100% PE | 10.6 | 46.2 a | 57.1 a | 86.4 a | 37.3 a |
| 100% TIF | 10.8 | 45.6 a | 56.2 ab | 85.1 a | 36.3 a |
| 66% No Tarp | 11.2 | 44.1 ab | 55.5 ab | 87.0 a | 38.2 a |
| 66% PE | 11.0 | 45.5 a | 53.8 ab | 87.0 a | 34.4 a |
| 66% TIF | 11.6 | 45.7 a | 54.9 ab | 85.9 a | 35.1 a |
| 33% No Tarp | 11.1 | 43.2 abc | 55.0 ab | 82.8 ab | 31.2 ab |
| 33% PE | 11.1 | 43.8 ab | 55.4 ab | 84.4 a | 31.9 ab |
| 33% TIF | 11.4 | 43.1 abc | 53.7 ab | 82.8 ab | 30.4 ab |
| 0% No Tarp | 10.8 | 37.6 d | 47.7 b | 73.9 c | 19.0 c |
| 0% PE | 11.0 | 39.3 bcd | 50.0 ab | 75.9 bc | 21.5 bc |
| 0% TIF | 10.4 | 38.2 dc | 48.9 ab | 74.5 c | 22.1 bc |

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

## Conclusions

- TIF reduces emissions in the field under any conditions.
- At 66% Telone® C-35 rate, tree growth and yield are comparable to that at the full rate. Three field trials indicated similar effect on nematode control indicating the reduced rate can be used.
- Fumigant distribution in soil plays the key in pest control. Improving fumigant movement in sandy loam soil is still a challenge.

## Acknowledgements

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