Soil Pest Management: The Latest in Regulations and Research

December 10, 2015
Speakers

Gabriele Ludwig, Almond Board (Moderator)

Randy Segawa, DPR

Suduan Gao, USDA-ARS, Parlier

Greg Browne, USDA-ARS, Davis
Regulatory Update for Soil Fumigants
Overview

• 1,3-dichloropropene (1,3-D; Telone)

• Chloropicrin

• 3 regulations in progress

• EPA registration review
1,3-D (Telone) Township Cap

- Goal: air concentration $\leq 0.14$ ppb (70-yr avg) to mitigate cancer risk

- Allocation of 90,250 lbs/yr for each township (6x6 mi), unused amount “banked”

- Max use of 180,500 lbs/yr, if bank available

- 12 townships with depleted banks (yellow), 54 with $>90,250$ lbs in 2014 (blue)

- DPR will revise cap in early 2016 after completing risk assessment
## Chloropicrin Recommended Permit Conditions

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Current Labels</th>
<th>DPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max buffer distance</td>
<td>Untarped: 1990 ft</td>
<td>Untarped: 1x – 6x of label</td>
</tr>
<tr>
<td>Min buffer distance</td>
<td>25 ft</td>
<td>Untarped: 100 ft</td>
</tr>
<tr>
<td>Buffer credits</td>
<td>11 credits</td>
<td>Only DPR-approved 60% credit tarp</td>
</tr>
<tr>
<td>Max acres</td>
<td>120–160 ac block</td>
<td>40 ac block</td>
</tr>
<tr>
<td>Overlapping buffers</td>
<td>Prohibited for 12 hrs</td>
<td>Buffer based on combined acres for 36 hrs</td>
</tr>
<tr>
<td>Tree hole limits</td>
<td>None</td>
<td>50–200 holes/ac, 40 ac max</td>
</tr>
<tr>
<td>Fumigation time limits</td>
<td>None</td>
<td>1 hr after sunrise, 3 hrs before sunset</td>
</tr>
</tbody>
</table>
Methyl Bromide and Volatile Organic Compounds (VOCs)

• Current VOC regulations require low-emission fumigation methods in San Joaquin Valley during May-Oct to reduce ozone

• Proposed regulation
  – Reconciles methyl bromide regulations with Phase 2 label revisions
  – Adds more low-emission fumigation methods for other fumigants using “totally impermeable film”

• Regulation will go into effect by May 2016
Totally Impermeable Film (TIF)

• TIF is a multi-layer tarp, usually with an ethylene vinyl alcohol (EVOH) core

• TIF tarps reduce emissions of most fumigants by 60% or more, resulting in
  – Greater fumigated acreage with same 1,3-D township cap
  – Smaller chloropicrin buffer zones
  – Lower VOC emissions
Other Field Fumigants

• Methyl isothiocyanate (MITC; Vapam, K-Pam, Sectagon) generators
  – No changes

• Allyl isothiocyanate (AITC; Dominus)
  – DPR will conduct health risk assessment as part of registration evaluation

• Dimethyl disulfide (DMDS; Paladin)
  – Registrant withdrew California application for registration
Other Regulations in Progress

• **Schools regulation**
  - Regulation will require notification and restrictions of agricultural pesticides used near schools
  - DPR plans to notice regulation for public comment by end of 2015

• **Fumigant notification regulation**
  - Regulation will require notification to residences, other sites
  - Workshops in 2016
# EPA Registration Review Schedule for All Fumigants

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Timeframe</th>
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</thead>
<tbody>
<tr>
<td>Registrant Data Call-In</td>
<td>August 2014</td>
</tr>
<tr>
<td>Data Submission</td>
<td>Summer 2016 – 2017</td>
</tr>
<tr>
<td>Risk Assessment</td>
<td>2018</td>
</tr>
<tr>
<td>Decision</td>
<td>2018 – 2019</td>
</tr>
</tbody>
</table>
Questions and Additional Information

• www.cdpr.ca.gov
  – “QUICK LINKS” tab
  – “Air” link

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Suduan Gao,
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Emission Reduction and Nematode Control from Soil Fumigation

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Research Soil Scientist
USDA, Agricultural Research Service
San Joaquin Valley Agricultural Sciences Center
Parlier, CA
Research Cooperators

- David Doll, Pomology Farm Advisor, UCCE Merced County
- Brad Hanson, CE Specialist, UC Davis
- Ruijun Qin, Research Project Specialist, UC Davis
- Sadikshya Dangi, Postdoctoral Research Associate, UC Davis
- J. Alfonso Cabrera, Research Scientist, Bayer CropScience, Fresno
- James Gerik, Research Pathologist, USDA-ARS, Parlier
- Greg Browne, Research Pathologist, USDA-ARS, UC Davis
- Dong Wang, Research Soil Scientist, USDA-ARS, Parlier
Soil fumigation for perennial specialty crops:

Pre-plant soil fumigation to control

• parasitic nematodes
• replanting disease
Regulatory issues on fumigant emissions

• **Exposure risk**: buffer zones; township cap for Telone®

• **Volatile organic compounds (VOCs)**: low-emission fumigation methods during May-Oct in NAAs
Processes affecting the fate of fumigant in Soil

Phase distribution: Soil air/water/solid (OM)

Degradation, sorption

Volatilization

Leaching
Goals of soil fumigation

• Minimize emission
• Maximize efficacy
• Reduce fumigation costs
• Maximize yield
Emission reduction methods:

• Application Methods:
  – Deep injection (shank design)
  – Drip vs. shank
  – Target area treatment (strip shank; spot drip)

• Surface Treatment:
  – Plastic tarp
    • (standard PE; low permeability – VIF, TIF)
  – Irrigation (water seals; pre-irrigation)
  – Organic amendment (manure)
  – Chemical Treatment (e.g., thiosulfate)
2011-15 Research Objectives:

Demonstrate the ability of TIF to reduce emission and improve efficacy as well as the potential of using reduced rates in soil fumigation for perennials

 Conducted three large field trials:
1. Oct 2011 Parlier trial (USDA-ARS)
2. Nov 2012 Merced trial (Bluff Ranch)
3. Dec 2014 Ballico trial (Littlejohn’s Farm)
Low permeability tarp reduce emissions

From shank injection of Telone® C35 (407 kg/ha); Hanford sandy loam ripped down to 3 ft depth

Cumulative loss (% of applied)

<table>
<thead>
<tr>
<th>Surface seal</th>
<th>1,3-D</th>
<th>Chloropicrin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare</td>
<td>53.5</td>
<td>0.5</td>
</tr>
<tr>
<td>PE</td>
<td>38.3</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>TIF</td>
<td>1.9</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Off TIF tarp in bare soil*</td>
<td>0.6</td>
<td>&lt; 0.5</td>
</tr>
</tbody>
</table>

* Assuming the same application rate was applied.
Fumigant concentration under tarp
(2012 Merced trial; Snelling sandy loam)
Fumigant distribution in soil profile
(2012 Merced trial)

- 1,3-D and chloropicrin do not move as well as methyl bromide
- Soil (Snelling sandy loam) was not cultivated well
Deep injection to deliver fumigants
(2014 Ballico trial; Delhi Sand)

1,3-D concentration (µg cm⁻³)

Soil depth (cm)

a. Full-bare

1 d
4 d
9 d
14 d
28 d

1,3-D concentration (µg cm⁻³)

Soil depth (cm)

b. Full-bare-deep

1 d
4 d
9 d
14 d
28 d
Nematode survival after fumigation
(2011 Parlier trial; Hanford Sandy loam; data from Alfonso Cabrera)

Plotted are sum of Citrus, Root-knot, Pin, Dagger, and Ring nematodes found in different treatments after fumigation
Nematode survival after fumigation
(2012 Merced Trial; Snelling sandy loam)

Before fumigation
# Nematode survival after fumigation

(2014 Ballico Trial; Delhi Sand)

<table>
<thead>
<tr>
<th>Soil depth</th>
<th>Alive Ave (stdv)</th>
<th>Dead Ave (stdv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 ft</td>
<td>10 (11)</td>
<td>22 (25)</td>
</tr>
<tr>
<td>1-2 ft</td>
<td>8 (17)</td>
<td>1 (17)</td>
</tr>
<tr>
<td>2-3 ft</td>
<td>4 (4)</td>
<td>10 (7)</td>
</tr>
<tr>
<td>3-4 ft</td>
<td>5 (12)</td>
<td>4 (7)</td>
</tr>
<tr>
<td>4-5 ft</td>
<td>3 (5)</td>
<td>8 (14)</td>
</tr>
</tbody>
</table>

* All fumigation treatments provided 100% kill except 1 sample (0-1 ft depth; PE tarped full rate) with live root-knot nematode (out of 135 samples)*
Almond tree growth and yield  (planted Feb. 2013, Merced trial; from David Doll)

<table>
<thead>
<tr>
<th>Treatment (Telone® C-35 rate &amp; tarp type)</th>
<th>Tree diameter* (mm)</th>
<th>Yieldb (field wt, lb/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% no tarp</td>
<td>11.4</td>
<td>46.3 a</td>
</tr>
<tr>
<td>100% PE</td>
<td>10.6</td>
<td>46.2 a</td>
</tr>
<tr>
<td>100% TIF</td>
<td>10.8</td>
<td>45.6 a</td>
</tr>
<tr>
<td>66% no tarp</td>
<td>11.2</td>
<td>44.1 ab</td>
</tr>
<tr>
<td>66% PE</td>
<td>11.0</td>
<td>45.5 a</td>
</tr>
<tr>
<td>66% TIF</td>
<td>11.6</td>
<td>45.7 a</td>
</tr>
<tr>
<td>33% no tarp</td>
<td>11.1</td>
<td>43.2 abc</td>
</tr>
<tr>
<td>33% PE</td>
<td>11.1</td>
<td>43.8 ab</td>
</tr>
<tr>
<td>33% TIF</td>
<td>11.4</td>
<td>43.1 abc</td>
</tr>
<tr>
<td>0% no tarp</td>
<td>10.8</td>
<td>37.6 d</td>
</tr>
<tr>
<td>0% PE</td>
<td>11.0</td>
<td>39.3 bcd</td>
</tr>
<tr>
<td>0% TIF</td>
<td>10.4</td>
<td>38.2 dc</td>
</tr>
</tbody>
</table>

aDifferent letters in the same column indicate significance at P<0.05; bThe weight includes the hull, kernel and shell
Key points

• Almond tree growth and yield show positive response to fumigation.

• Minimizing emissions with low permeability tarp not only satisfy regulatory requirement but also increase fumigation efficiency.

• There is no difference between full rate (540 lb/ac) and 2/3 rate of Telone® C35 when injected to 18” soil depth. Fumigant distribution is the key to nematode control.

• Cultivate the soil for the best possible soil fumigation: 1,3-D and chloropicrin do not move well in soil. Deep injection shows some improvement on fumigant delivery to soil below 3 ft depth.

• Research continues addressing improvement of fumigant delivery and/or distribution in soil profile in perennial fields (ARS-UCD-UCANR collaborative project supported by CDFA-SCBGP 2015-2018)
Acknowledgements

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- California Department of Food and Agriculture - Specialty Crop Block Grants Program (CDFA-SCBGP) (10/2011-6/2014)
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- Almond Board of California (2005-present)

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- TriCal Inc.
- Growers – Bluff Ranch, Little John’s Farm, Sierra Gold Nursery; Bright’s Nursery, Jost/Thiesen Orchard
Thanks to the dedicated research staff
Greg Browne, USDA-ARS, Davis
Potential for Managing Replant Problems Without Soil Fumigants

Greg Browne
Natalia Blackburn
Hossein Gouran
Gurreet Brar
Brent Holtz
David Doll
Andreas Westphal
Amelie Gaudin
Potential for Reducing Fumigation Use for Replant Disease

1. Predictive assays, diagnostics

2. “Spot” fumigation, rate reduction

3. Tolerant / resistant rootstocks

Relative impact of PRD on different almond and stone fruit rootstocks

- Stem dia. increase in NF soil as proportion of that in F soil

- 2011-12 trial

- Non-fumigated soil
- Fumigated soil
## KAC Trials: Potential for Replacing Fumigant Use

### Non-fumigant soil remediation potential, KAC Parlier, 2013-15

Preplant treatments included:

- Control
- Early removal / fallow or Sudan rotation
- Deep soil ripping
- Anaerobic soil disinestation (ASD)
- Early and late season fumigation

**KAC Trials**

- **Non-fumigant soil remediation potential**
  - KAC Parlier, 2013-15

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Non-fumigant soil remediation potential, KAC Parlier, 2013-15

<table>
<thead>
<tr>
<th>Preplant treatments included:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
</tr>
<tr>
<td>Early removal / fallow</td>
</tr>
<tr>
<td>or Sudan rotation</td>
</tr>
<tr>
<td>Deep soil ripping</td>
</tr>
<tr>
<td>Anaerobic soil disinestation</td>
</tr>
<tr>
<td>(ASD)</td>
</tr>
<tr>
<td>Early and late season fumigation</td>
</tr>
</tbody>
</table>
Anaerobic Soil Disinfestation (ASD)

- Developed in Japan and Netherlands, being tested in CA strawberries

- Initiated by adding readily available carbon substrate to soil, covering with clear tarp, keeping soil moisture near field capacity for several weeks; heat facilitates

- Mechanism incompletely understood, but ASD is lethal and/or suppressive to many pathogens
ASD Treatments at Kearney Ag Center (KAC), Parlier
Details of ASD Trial Treatments and Methods in 2014-15 Report to Almond Board of California

- 2 experiments started in 2014
- 2 experiments started in 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Expt.</th>
<th>Trt. no.</th>
<th>Treatment name</th>
<th>Month of old orchard tree removal</th>
<th>Month of sudan rotation</th>
<th>Fall/winter soil disinfestation treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>1</td>
<td>1</td>
<td>Control, no sudan</td>
<td>Sep</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>Control, with sudan</td>
<td>May</td>
<td>May-Oct</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3</td>
<td>ASD, high bran rate, wide strip, with sudan</td>
<td>May</td>
<td>May-Oct</td>
<td>ASD, 20 metric tons/treated ha, 3.0-m-wide strips</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>Fumigation in Oct, no sudan</td>
<td>Sep</td>
<td>No</td>
<td>Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>5</td>
<td>Fumigation in Oct, with sudan</td>
<td>May</td>
<td>May-Oct</td>
<td>Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>6</td>
<td>Fumigation in Dec, no sudan</td>
<td>Sep</td>
<td>None</td>
<td>Telone C35, 600 kg/treated ha in Dec, 3.4-m-wide strips</td>
</tr>
</tbody>
</table>

| 2014 | 1     | 1        | Control, no sudan | May | None | None |
|      | 2     | 2        | ASD, high bran rate, wide strip, no sudan | May | None | ASD, 20 metric tons/treated ha, 3.0-m-wide strips |
|      | 3     | 3        | Fumigation in Oct, no sudan | May | None | Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips |
|      | 4     | 4        | ASD, low bran rate, narrow strip, no sudan | Sep | None | ASD, 12 metric tons/treated ha, 1.8-m-wide strips |
|      | 5     | 5        | Fumigation in Oct, no sudan | Sep | None | Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips |
|      | 6     | 6        | Fumigation in Oct, with sudan | May | May-Oct | Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips |
|      | 7     | 7        | Fumigation in Oct, no sudan | Sep | None | Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips |

### Details:
- 2 experiments started in 2014
- 2 experiments started in 2015

### Treatments:
- **Control, no sudan**
- **Control, with sudan**
- **ASD, high bran rate, wide strip, with sudan**
- **Fumigation in Oct, no sudan**
- **Fumigation in Oct, with sudan**
- **Fumigation in Dec, no sudan**
Included in all four KAC experiments with ASD:

The standard…
Telone C35, 11-ft strip, no tarp
Impacts of ASD on Soil Reduction Potential and Temperature

Treatment period was late Sep through Nov
Assessing Impacts of ASD

Growing season 1

Bioassays:
Pre-plant fumigation and ASD both eradicated bioassay inoculum of Pythium ultimum

Tree growth:

Microbial sampling
Assessing Impacts of ASD

Growing Season 2
Experiments 1 and 2 with ASD

Response 1<sup>st</sup> growing season

Response 2<sup>nd</sup> growing season

Ex. 1, October 28, 2014; first growing season
Experiments 3 and 4 with ASD

Response 1st growing season

- Trunk circ. increase (cm)

- 22 July 2015
- 12 Nov 2015

- Control, no sudan
- Control, with sudan
- ASD, high, wide, w/ sudan
- ASD, high, narr., no sudan
- ASD, low, narr., no sudan
- Fumig. in Oct, no sudan
- Fumig. in Oct, w/ sudan

- Trunk circ. increase (cm)

- 22 July 2015
- 12 Nov 2015

- Control, no sudan
- Control, with sudan
- ASD, high, wide, w/ sudan
- ASD, high, narr., no sudan
- ASD, low, narr., no sudan
- Fumig. in Oct, no sudan
- Fumig. in Oct, w/ sudan

- Experiments 3 and 4 with ASD
- Response 1st growing season
Conclusions ASD:
ASD works for PRD control in SJV sandy loam but is logistically challenging & expensive; optimization and expanded testing needed.

Estimated cost of full rate rice-bran based ASD: $2439 / acre
(50% strips; all materials, application);

Estimated cost of Telone C35: $1143 / acre
(50% strips; all materials and application, no tarp)

2015 results suggest can reduce ASD costs by up to 40% with low rates, narrow strips
The Promise of Alternative, Less-expensive Carbon Substrates...
A Valuable Opportunity ?
Thank You!

Acknowledgements:
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