Alternative Fumigants and Emissions Reduction

Husein Ajwa
University of California-Davis, Salinas, CA
FUMIGATION
+ Reliable; No Residues in Crop; Variable Costs

• Methyl Bromide, Chloropicrin, MITC Generators, 1,3-D,
• DMDS in Cal/EPA registration process

Conventional Fumigation
(Acres, California 2007):

- Methyl Bromide/Chloropicrin: 40,000
- Telone/Chloropicrin: 17,000
- Telone II: 37,000
- Chloropicrin alone: 6,000
- Metam sodium: 77,000

TOTAL: ~ 180,000 acres annually

Significant Regulatory Pressure:

- Buffer zones
- VOCs regulations
- Application rates

Resulted in development of new film (tarp) technology:

- “Virtually impermeable (VIF)”
- “Totally impermeable (TIF)”
Agricultural Film (tarp) Types

“Standard” polyethylene tarp (HDPE or LDPE)

“Semi-impermeable” Tri-extruded LDPE

“Virtually impermeable (VIF)” LDPE + Nylon barrier

“Totally impermeable (TIF)” 5-layer EVOH resin barrier
Fumigant concentration under tarp

- **1,3-D**
  - PE
  - TIF

- **CP**

Concentration (µg cm\(^{-3}\)) vs. Time (h)
Concentration-time (CT) exposure index (µg cm\(^{-3}\cdot h\)) of 1,3-D and CP in 2009 Oxnard fumigation trial

<table>
<thead>
<tr>
<th>Soil depth (cm)</th>
<th>PE field</th>
<th>TIF field</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,3-D</td>
<td>CP</td>
</tr>
<tr>
<td>0</td>
<td>88</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>97</td>
<td>14</td>
</tr>
<tr>
<td>15</td>
<td>131</td>
<td>28</td>
</tr>
<tr>
<td>25</td>
<td>211</td>
<td>83</td>
</tr>
<tr>
<td>35</td>
<td>332</td>
<td>243</td>
</tr>
<tr>
<td>45</td>
<td>197</td>
<td>122</td>
</tr>
<tr>
<td>55</td>
<td>105</td>
<td>54</td>
</tr>
<tr>
<td>70</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Pests controlled with fumigants

• Soil borne diseases
  – Pythium
  – Phytophthora
  – Verticillium
  – Others (Macrophomina, Fusarium, Rhizoctonia, Colletotrichum coccodes,.....)

• Nematodes
• Insects
• Weeds
  – Volunteer crops
  – Annual & perennial weeds
*Macrophomina* problems are increasing on fields treated consecutively via drip fumigation (or low application rates of alternative fumigants). Growers need to fumigate with methyl bromide or methyl iodide to keep these fields viable for crop production.
Fusarium wilt control requires methyl bromide
Alternative Fumigants

Summary of Previous Research:

Fumigant application rates required to control soil-borne fungal pathogens
Methyl Bromide + chloropicrin (57%MeBr + 43%Pic)

- For control of *Verticillium dahliae*: 300 to 400 lb/a
- Excellent control of *Phytophthora cactorum*, *Pythium* sp., and citrus nematode)

- Excellent control of *Macrophomina* and *Fusarium*
Telone C35 or Inline (62% 13-D + 33% Pic)

- For control of *Verticillium dahliae*: 425 lb/a
- For *P. cactorum*, *Pythium* spp., and citrus nematode: 300 to 400 lb/a)

- *Control of Macrophomina and Fusarium*: >400 lb/a under retentive film (VIF/TIF)
Chloropicrin (Pic)

- For control of *Verticillium dahliae*: 200 to 300 lb/a
- For control of *P. cactorum, Pythium* sp., and citrus nematode: 300 to 400 lb/a

- *Control of Macrophomina* and *Fusarium*: 300 lb/a under VIF/TIF
Pic-Clor 60 (60% chloropicrin + 40% 1,3-D)

- For control of *Verticillium dahliae*: 300 to 350 lb/a
- For control of *P. cactorum*, *Pythium* sp., and citrus nematode: 250 to 350 lb/a

- *Control of Macrophomina and Fusarium*: 350 lb/a under VIF/TIF
MITC Generators
(metam sodium & metam potassium)

➢ For control of *Verticillium dahliae*: >300 lb ai/a
➢ For *P. cactorum*, *Pythium* spp., and citrus nematode: 200 to 300 lb ai/a

➢ Can provide enhanced efficacy of pest control when used in conjunction with other fumigants

➢ Control of *Macrophomina* and *Fusarium*: ???
Summary

Allyl isothiocyanate

IRF135

April 2013

- Product Performance Update
- Region: USA

ISAGRO USA

Mike Allan
IRF 135 Product Overview

- IRF135 is a pre-plant soil treatment that is patented and licensed to ISAGRO USA for worldwide development and commercialization along with its parent company, ISAGRO SpA located in Milan, Italy.

- IRF135 is a synthetically produced biopesticide having the active ingredient Allyl Isothiocyanate (AITC), with its origins in a naturally occurring plant defense chemical from the plant family, brassicaceae.

- IRF135 is a broad spectrum soil treatment alternative having efficacy against many soil borne pathogens, nematodes, weeds and insects that negatively impact yields in high value crops such as strawberries, tomatoes, peppers, ornamentals, turf, trees and vines.
Summary

**Summary Disease Control**

<table>
<thead>
<tr>
<th>Target Diseases:</th>
<th>Fusarium sp.</th>
<th>Phytophthora sp</th>
<th>Macrophomina sp</th>
<th>Verticillium sp.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>IRF135 @15 gpa</th>
<th>IRF135 @20 gpa</th>
<th>IRF135 @30 gpa</th>
<th>IRF135 @40 gpa</th>
<th>Standard</th>
</tr>
</thead>
</table>
Dimethyl disulfide (DMDS)

- EPA Registration was granted in 2010 (Arkema)
  *Applied only under VIF/TIF*

- Used as a flavoring for an onion or garlic taste in some processed cheese and meat (0.02-10 ppm)

- Efficacy?? (Rates: 400 – 650 lb/a)
ODOR

DMDS (PALADIN®) has a strong, objectionable odor which can be detected at concentrations significantly below the levels that can potentially cause harm. The odor is a garlic-like or natural gas and may be confused with the odor of or propane leak.

Minimum tarp removal on the label is 14 days. With VIF/TIF tarps and for odor mitigation, minimum tarp removal will be based on soil temp and the plant back chart.
### Laboratory dose-response studies

**80% inhibitory concentration (MIC$_{80}$)**

<table>
<thead>
<tr>
<th>Soil fumigant</th>
<th>Application rate to control 80% of pathogens population (lbs/.ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusarium Oxysporum</td>
<td>Pythium ultimum</td>
</tr>
<tr>
<td>DMDS:Pic (79:21)</td>
<td>288</td>
</tr>
<tr>
<td>MBr:Pic (50:50)</td>
<td>150</td>
</tr>
</tbody>
</table>
## Paladin research, 2012

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Lbs product/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td></td>
</tr>
<tr>
<td>MeBr (57:43) + Standard Film</td>
<td>350 lbs</td>
</tr>
<tr>
<td>Pic + TIF</td>
<td>200 lbs</td>
</tr>
<tr>
<td>Paladin 70:30</td>
<td>280 lbs</td>
</tr>
<tr>
<td>Paladin 70:30</td>
<td>315 lbs</td>
</tr>
<tr>
<td>Paladin 70:30</td>
<td>350 lbs</td>
</tr>
<tr>
<td>Paladin 65:35</td>
<td>260 lbs</td>
</tr>
<tr>
<td>Paladin 65:35</td>
<td>383 lbs</td>
</tr>
<tr>
<td>Paladin 79:21</td>
<td>378 lbs</td>
</tr>
<tr>
<td>Paladin 79:21</td>
<td>500 lbs</td>
</tr>
<tr>
<td>Paladin 60:40</td>
<td>450 lbs</td>
</tr>
<tr>
<td>Paladin 50:50</td>
<td>400 lbs</td>
</tr>
</tbody>
</table>
Paladin Shank Treatments
 Marketable yield to date, Salinas 2012

- Untreated
- MeBr (57:43) + Standard Film
- Pic + TIF 200 lbs
- Paladin 70:30 280 lbs
- Paladin 70:30 315 lbs
- Paladin 70:30 350 lbs
- Paladin 65:35 260 lbs
- Paladin 65:35 383 lbs
- Paladin 79:21 378 lbs
- Paladin 79:21 500 lbs
- Paladin 60:40 450 lbs
- Paladin 50:50 400 lbs

Total and Marketable Yield (g/plant)
Summary

- No phytotoxicity or plant mortality was observed in any of the Paladin treatments.

- Maximum yields were obtained with Paladin 50/50 @400 lbs/ac, Paladin 60/40 @450 lbs/ac, and Paladin 79/21 @500 lbs/ac.

- Undergoing research on shank and drip applications of IRF135 (allyl isothiocyanate).
**Emission Reduction Research**

**2011 Flux Research: TIF Cutting Time**

- To determine the best tarp cutting time, studies were conducted on 3 separate fields (2 or 8 acres) in Lost Hills near Bakersfield in June, 2011.

- Pic-Clor 60 soil fumigant (60% chloropicrin and 40% 1,3-D) was applied by shank injection under TIF at 12 inches deep.

- Target application rate was 588 lbs/ac of Pic-Clor60 (350 lbs of chloropicrin plus 238 lbs of 1,3-D).
Tarp cutting time
Shank applications, 2 to 8 acres each field
Tarp cutting was done after 5, 10, and 16 days
Field layout showing locations of the monitoring stations
1,3-dichloropropene Emission Rates

Lost Hills Flux Study, 2011

Emission Rate (ug/m²/sec)

Period

Field 1 (16 days)
Field 2 (10 days)
Field 3 (5 days)
Chloropicrin Emission Rates

Lost Hills Flux Study, 2011

- Field 1 (16 days)
- Field 2 (10 days)
- Field 3 (5 days)
Cumulative Mass loss of 1,3-dichloropropene

Lost Hills Flux Study, 2011

- Field 1 (16 days)
- Field 2 (10 days)
- Field 3 (5 days)

Percent Mass Lost (%) vs. Period

Period: 1 to 42
Summary

✓ For chloropicrin, a tarping period of 7 days should be sufficient for application rates of less than 200 lbs/acre. 10 days of tarping might be needed for application rates >300 lbs/acre.

✓ For 1,3-D, a tarping period of 10 days should be sufficient for application rates of less than 200 lbs/acre. 14 days of tarping might be needed for application rates >250 lbs/acre.
Summary

- TIF significantly reduced total emissions of chloropicrin and 1,3-D. Relative to other flux studies with standard PE tarp, TIF reduced total emissions by 4 to 5 times.

- The use of TIF may allow for smaller buffer zones and/or large fumigant application rates in heavily infested soils.
Thank you very much

Husein Ajwa
CE Specialist, UC Davis
1636 East Alisal St., Salinas, CA 93905
Phone (831) 970-8621
haajwa@ucdavis.edu