Fumigation and alternatives update for soil-borne pests

Oleg Daugovish, Steve Koike, Tom Gordon, Krishna Subbarao, Husein Ajwa, Steve Fennimore, Joji Muramoto, Carol Shannon, Mark Bolda
Macrophomina and Fusarium

- **Fumigants** Provide protection for most of the season
- Higher rates tend to be more efficacious
- **Current UC Varieties** some tolerant to Fusarium, not to Macrophomina
Studies of fumigant and variety performance in infested fields

http://ceventura.ucdavis.edu/Com_Ag/

Vegetable and strawberry crop production

Strawberry

Recent Meetings
Fruit Yield, Ventura, 12/23/09-05/26/10

Camarosa, *M. phaseolina* isolated

<table>
<thead>
<tr>
<th></th>
<th>MB/Pic</th>
<th>Midas</th>
<th>Pic high</th>
<th>Pic low</th>
<th>Pic low + Fung</th>
<th>Pic-60</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/plot</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>-28%</td>
</tr>
</tbody>
</table>
Marketable yield, Ventura, CA

- Pic low
- Pic-60
- MB/Pic
- Pic low + Fung
- Control
- Pic high
- Midas

M. phaseolina isolated from dead plants
Bed edges:
- Less fumigant distributed?
- Dryer/greater stress?
- Root pruning aids infection?
Where did the plants die?

Mortality in bed rows, *M. phaseolina*

- Pic 60
  - A
  - A
  - B
- Untreated
  - A
  - A
  - A
Mortality in bed rows, Inline, 200 lbs /a, 

*F. oxysporum*

![Bar chart showing mortality in bed rows for Camarosa and Albion plants/plot, categorized by location (Left, Left Center, Right Center, Right)]
Inoculum buried in beds prior to fumigation
Effect of depth on fumigant efficacy

Beds fumigated with Pic-60

Spores per gram of soil

Location in bed

Center

Shoulder

Under tape

6” depth

12” depth
5 studies in Florida

• Doubling #of tapes = yield increase in all 5 studies, on average ~20%

Plant stunting from sting nematode
# Survival of *Macrophomina* after fumigation in Israel

Freeman, et al.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Crowns (%) at 30 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>60 a</td>
</tr>
<tr>
<td>MB</td>
<td>10 b</td>
</tr>
<tr>
<td>MS 44</td>
<td>5 b</td>
</tr>
<tr>
<td>MS 73</td>
<td>5 b</td>
</tr>
<tr>
<td>Chloropicrin 200</td>
<td>45 ab</td>
</tr>
<tr>
<td>Chloropicrin 400</td>
<td>30 ab</td>
</tr>
</tbody>
</table>
Anaerobic Soil Disinfestation = C-source + water + plastic mulch
## Costs of C-sources for anaerobic soil disinfection

<table>
<thead>
<tr>
<th>Organic material</th>
<th>Local price $/ton</th>
<th>Amount tons/acre</th>
<th>Cost $/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice bran (CA)*</td>
<td>$120</td>
<td>4.5 – 9.0</td>
<td>$540 - 980</td>
</tr>
<tr>
<td>Mustard cake (CA)</td>
<td>$1,600</td>
<td>1</td>
<td>$1,600</td>
</tr>
<tr>
<td>Molasses (FL)</td>
<td>$115</td>
<td>5.4</td>
<td>$617</td>
</tr>
<tr>
<td>Onion waste</td>
<td>FREE</td>
<td>Too high</td>
<td>Delivery+spread</td>
</tr>
<tr>
<td>Cover crop seeds (FL, TN)</td>
<td>~$1/lbs</td>
<td>33 - 78 lbs/acre</td>
<td>$33 - 78</td>
</tr>
<tr>
<td>MeBr/Pic fumigation</td>
<td>-</td>
<td>-</td>
<td>$2,500-3,000</td>
</tr>
</tbody>
</table>

* Approximately 75,000 tons of rice bran are available annually in CA.
Different C sources effectively reduce *V. dahliae* microsclerotia – pot studies.
ASD experiments in Ventura County
Effect of ASD on reduction rate of native *Verticillium dahliae* in soils in Ventura trial (2009). Baseline *V. dahliae* population in the soil at each treatment varied from 15 to 45 microsclerotia/gram soil.
2010-11 at Santa Paula:

- Silty clay loam soil with native *V. dahliae*: 15 microsclerotia/gram soil
- Tarps (standard black 1.5 mil, and clear 1.25 mil)
- Untreated check (UTC), UTC + water, ASD 3 weeks (8/18 – 9/09), and ASD 6 weeks (8/18 – 9/30)

- Rice bran 9 tons/acre in all ASD plots.
- **Irrigation**: 3 ac-inches except UTC plots.
Incorporation of rice bran to beds
Soil Temperatures at 15cm depth
(Vetura Trial 2010)

- Clear-ASD6wks
- Black-ASD6wks

Soil Temperatures

- 113°F
- 95°F
- 68°F
Nov 22, 2010

ASD 3WK, clear

Standard, clear
Canopy size, Nov 22, 2010

- Grower standard, no water: B
- Grower standard, water: B
- ASD 3 weeks: A +70%
- ASD 6 weeks: A

cm²
Feb 12

ASD 3WK, clear

Standard, clear
Feb 12

ASD 3WK, black

Standard, black
Significant reduction: ASDs < untreated standards
Early Marketable Yield
(Ventura, CA. Jan – Feb 2011. Mean ± SD)

Tarp Type

Marketable fruit yield grams/plot

ASD Treatments

Marketable fruit yield grams/plot

UTC
UTC + water
ASD 3 weeks
ASD 6 weeks

Early Marketable Yield
(Ventura, CA. Jan – Feb 2011. Mean ± SD)

Tarp Type

Marketable fruit yield grams/plot

ASD Treatments

Marketable fruit yield grams/plot

UTC
UTC + water
ASD 3 weeks
ASD 6 weeks
Marketable yield, total

Marketable fruit yield lbs/plant

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Black</th>
<th>Black</th>
<th>Black</th>
<th>Black</th>
<th>Clear</th>
<th>Clear</th>
<th>Clear</th>
<th>Clear</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTC</td>
<td></td>
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<tr>
<td>UTC + water</td>
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<td></td>
</tr>
<tr>
<td>ASD 3 wks</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASD 6 wks</td>
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<tr>
<td>+70%</td>
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+87%
Marketable yield, clear mulch
Marketable yield, black mulch
April 19, 2011

ASD 3 wks/clear

Untreated/clear
Plants with *V. dahliae* symptoms, Apr 1. 2011

<table>
<thead>
<tr>
<th></th>
<th>Untreated/black</th>
<th>Untreated/clear</th>
<th>Untreated + water/black</th>
<th>Untreated + water/clear</th>
<th>ASD 3 wk/black</th>
<th>ASD 3 wk/clear</th>
<th>ASD 6 wk/black</th>
<th>ASD 6 wk/clear</th>
</tr>
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<tbody>
<tr>
<td>#/16 plants per plot</td>
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</tr>
</tbody>
</table>

- Untreated/black: 6
- Untreated/clear: 16
- Untreated + water/black: 4
- Untreated + water/clear: 8
- ASD 3 wk/black: 6
- ASD 3 wk/clear: 2
- ASD 6 wk/black: 2
- ASD 6 wk/clear: 4
For effective ASD

- Need C-source uniformly mixed
- Standard LDPE mulch – sufficient
- Black mulch as good as clear
- 3 inches of water - sufficient
- 3 weeks duration in summer
Applying non-fumigant combinations to a buffer zone
Fusarium oxysporum
NON-FUMIGANT COMBINATIONS

• Mustard + Solar
• Mustard + Steam
• Steam + Solar
Mustard seed meal 2,000 lbs /a
140°F/60°C at 12”
Soil temperature at 6” under clear mulch (solarization effect)
15 cm
PLANT CANOPY AREA (size), Nov. 29, 2011

- Untreated: -35%
- Solar+steam: a
- Mustard +steam: a
- Solar+ mustard: a

cm²
Macrophomina phaseolina

The bar graph shows the number of colonies (per 5 g of soil) for different treatments and soil depths.

- **Untreated**
- **Solar+ mustard**
- **Solar+steam**
- **Mustard +steam**

### Soil Depths
- **0-6"**
- **6-12"**

### Comparison:
- The untreated samples have the highest number of colonies across both soil depths.
- Solar+ mustard treatment shows a moderate decrease in colony numbers compared to untreated.
- Solar+steam and Mustard +steam treatments show the least number of colonies, indicating efficacy in reducing Macrophomina phaseolina.
Early marketable fruit yield (Jan-Feb. 2011)

42% < rest

g/20 plants

Untreated | Solar+ mustard | Solar+steam | Mustard +steam

Untreated: 600 g/20 plants
Solar+ mustard: 1200 g/20 plants
Solar+steam: 1600 g/20 plants
Mustard +steam: 1600 g/20 plants

All treatments with 'a' are significantly different from the untreated group.
Total marketable fruit yield (Jan- June 2011)

- Untreated
- Solar+ mustard
- Solar+ steam
- Mustard + steam

38% < rest

3000 g/20 plants for Untreated, 4000 g/20 plants for Solar+ mustard, 6000 g/20 plants for Solar+ steam, and 5000 g/20 plants for Mustard + steam.
Marketable fruit yield

- Solar + Steam
- Steam + Mustard
- Untreated
- Solar + Mustard

g/20 plants
Steam + Solar

Steam + Mustard

19 April 2011
Mortality

Number of life plants

plants/45 ft of bed

- Untreated (black)
- Solar + Steam
- Steam + Mustard
- Solar + Mustard (black)

10/24/2010
11/7/2010
11/21/2010
12/5/2010
12/19/2010
1/2/2011
1/16/2011
1/30/2011
2/13/2011
2/27/2011
3/13/2011
3/27/2011
4/10/2011
4/24/2011
5/8/2011
5/22/2011
End of the season mortality images

June 2, 2011
Untreated / black
Solar + Steam
Solar + Mustard
Steam + Mustard
Fumigated / ‘Skunk’
Non–fumigant combinations

- Did not eliminate fungal pathogens but may reduce their abundance in soil
- Improve plant vigor and productivity
- Economics?

Clear mulch: Earlier and greater
- yield
- disease development and severity
Acknowledgements

• Terry Farms
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• UC Hansen