Strawberry Production With and Without fumigants

Steve Fennimore, Extension Specialist
U.C. Davis, at Salinas, CA
Collaborators

- Tom Miller
- Krishna Subbarao
- Rachael Goodhue
- Oleg Daugovish
- Joji Muramoto
- Carol Shennan
- Frank Martin
- Nathan Dorn, Reiter Affiliated Cos.
- Ian Greene, Ramco Norcal
- Jenny Broome, DSA
- Clint Miller
- Myra Miller-Spahn
- Marty Madesko, DSA
- Jose Garcia
Financial support

- USDA NIFA Methyl Bromide Transitions
  - 2010-51102-21648,
  - 2013-51102-21524
- California Strawberry Commission
- Propane Education and Research Council
- In-kind support from Reiter Affiliated Companies, Driscoll’s, NorCal Ramco
Introduction

- Role of steam – what it does & why needed?
- Results from 2012-13 work
- Business role for steam
- New steam generator technology
- New herbicides
- Summary
Why We Need Non-fumigant Alternatives

- For soil disinfestation in:
  - Buffer-zones
  - Organic fields
  - Prepare for future
AUTOMATIC STEAM APPLICATION

McFadden Rd.
Salinas, CA
9/27/13
Trial Setup

- Target temperature/dwell - 70°C for 20 min.
- Treatments were replicated 4 times RCBD
- Economic analysis included material costs, labor and machine costs
- 2012-13 trials included ASD (anaerobic soil disinfestation).
<table>
<thead>
<tr>
<th>Treatments Ranch 1</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Steam - Clayton steam applicator</td>
<td>158°F for 20 min</td>
</tr>
<tr>
<td>2. Steam + mustard seed meal</td>
<td>158°F for 20 min + 1.5 tons/A</td>
</tr>
<tr>
<td>3. ASD + rice bran</td>
<td>9 tons/A rice bran</td>
</tr>
<tr>
<td>4. Untreated Control</td>
<td></td>
</tr>
</tbody>
</table>

Note: ASD was not successful in this test
Soil Temperature by Depth Ranch 1, Watsonville, Sept. 2012

- 2 inches
- 6 inches
- 10 inches
# Weed Densities & Hand Weeding Times 2012-13

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Watsonville-Ranch 1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weeds (no./Acre)</td>
<td>Time (hr./Acre)</td>
<td></td>
</tr>
<tr>
<td>Steam + mustard</td>
<td>6,071 b</td>
<td>21 b</td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>2,024 b</td>
<td>12 b</td>
<td></td>
</tr>
<tr>
<td>ASD + rice</td>
<td>130,313 a</td>
<td>196 a</td>
<td></td>
</tr>
<tr>
<td>Non-treated</td>
<td>101,175 a</td>
<td>167 a</td>
<td></td>
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</tbody>
</table>

Mean separation using Fisher’s Protected LSD P = 0.05
Pythium Control Ranch 1 2012

- non-treated
- steam
- steam+MSM
- ASD-rice

Pythium parts per gram soil

pre post

non-treated
steam
steam+MSM
ASD-rice

AB
B
B
A
Albion: % Plants With *Macrophomina p.* at Season End

![Bar chart showing infected plants (%).](chart.png)

- **Non-treated**
- **Steam**
- **Steam+MSM**
- **ASD-rice**

Infection levels:
- **non-treated** ~ 35%
- **steam** ~ 5%
- **steam+MSM** ~ 10%
- **ASD-rice** ~ 45%

Significance:
- **a** indicates no significant difference.
- **b** indicates a significant difference.
Seasonal Fruit Yields Ranch 1

Albion

Fruit Yield lbs. Acre

27M171

Fruit Yield lbs. Acre
Seasonal Fruit Yields Ranches 1 & 2

**123Q191**

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<thead>
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<td></td>
</tr>
<tr>
<td>steam</td>
<td></td>
</tr>
<tr>
<td>steam + MSM</td>
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</tr>
<tr>
<td>ASD rice</td>
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**49C129**

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<td>steam+MSM</td>
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</tr>
<tr>
<td>ASD rice</td>
<td></td>
</tr>
<tr>
<td>ASD molasses</td>
<td></td>
</tr>
</tbody>
</table>

Legend:
- b
- a
- ab
2010-2012 Findings

- Steam controls soil pests such as *Verticillium dahliae*, *Macrophomina phaseolina*, *Pythium* spp. and weeds.
- Strawberry yields in steam treated soils are comparable to yields in fumigated soils.

Samtani et al. 2012; Fennimore et al. 2013
Steam business model

- The assumption is that fumigants would continue to be used where possible.
- Steam would be used where fumigants cannot.
- Crop management is the same across fumigated and steamed blocks.
An 80 acre field impacted by sensitive sites
An 80 acre field impacted by sensitive sites

White = steam 7 acres
Red = fumigate 65 acres
A business role for steam

- An 80 acre farm with 72 acres farmable
- 65 acres can be fumigated, 7 acres cannot
- Fumigant cost $1,900/A or $123,500; steam costs $5,000/A or $35,000 for total treatment cost of $158,500.
- Net returns above operating costs for 7 acres $25,399 based on Albion yields

Daugovish et al. 2011.
New Steam Generation Technology

- Downhole steam generator – oil field technology.

- Advantages
  - No steam boiler
  - Does not require softened water
    - Small size
Steam Generator input/output

Proof of Concept, steam works, just requires more energy output and smaller footprint

2.5 MM Btu/hr. Clayton Steam Generator

10 MM Btu/hr. PCI Steam Generator

6.4 Gallons Water to Propane

10.4 Gallons Water to Propane
Steam Costs

- Estimated costs with the Clayton Steam prototype was $5,400 to $5,700 /A
- Target rate is 8 hours/A
- We are proposing to build a commercial-scale unit and cost estimates for operation are $3,182 to $3,832/A.
Summary - Steam

- Steam kills soil pathogens and weeds in field soils.
- Strawberry yields are similar in fumigated and steamed soils.
- Steam can be used as a component in a multi-tactic soil disinfestation program.
FOR USE IN SELECTED CROPS

Active Ingredient*: pendimethalin: N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine .... 38.7%
Other Ingredients: .......................................................... 61.3%
Total: .......................................................... 100.0%

*1 gallon contains 3.8 pounds of pendimethalin formulated as an aqueous capsule suspension.

EPA Reg. No. 241-418
EPA Est. No.
Prowl H₂O

- Can be applied pre-transplant
- Can be applied post-transplant but not if new leaves are present
- Can apply to row middles if applied at least 35 days before harvest
- Can apply no more than 3 pints/A per application and no more than 6 pints/A per season.
Prowl H₂O: rates by soil texture

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Broadcast Rate (pts/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>1.5</td>
</tr>
<tr>
<td>Medium</td>
<td>2.0 to 2.5</td>
</tr>
<tr>
<td>Fine</td>
<td>2.5 to 3.0</td>
</tr>
<tr>
<td>Treat.</td>
<td>Rate</td>
</tr>
<tr>
<td>--------</td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Prowl</td>
<td>2.1 pts</td>
</tr>
<tr>
<td>Prowl</td>
<td>2.1 pts</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
</tr>
</tbody>
</table>
Prowl H₂O 2.1 pints/A at Salinas
Prowl H$_2$O

- A new tool for strawberry weed management
- Has a very flexible label
- Very effective on annual grasses
- Very safe to strawberry applied pre-transplant
- Reentry interval is 24 hours
Mode of Action / Use Pattern

- Active Ingredient = sulfentrazone
- Mode of Action = PPO Inhibitor
- WSSA Group 14
- HRAC Group E
- Primarily a soil applied herbicide
- Entry through root and shoot uptake
Zeus weed control at Salinas 2012-13

![Bar chart showing densities of Burclover control and various treatments, with letters indicating significant differences.]

- a
- cd
- bcd
- cd
- d
- d
- cd
- ab
Zeus fruit yield at Salinas 2012-13

no significant differences
Zeus

- Appears to be safe on strawberry
- Slightly less effective on burclover than Chateau
- Zeus’ niche might be for nutsedge control