Bed fumigation and other ways to live with the New EPA rules on soil fumigation
**Washington**
- Deep shank injected
- Telone C-35, C-17, PC 60. Metam
- Non-tarped.
- Planting life 5-10 years

**California**
- Applied noble plow
- MB:pic, Telone C-35, PC 60
- Tarped, sometimes TIF
- Planting life 1.5-5 years
Phase 2 fumigant labels

In effect now
Label requirements are very complex!!!

- Fumigation management plans
- Responder/community outreach
- Applicator training
- No applications near sensitive areas
- Buffers and buffer credits
- Posting
- Emergency preparedness
22 Acre Raspberry field (yellow block) fumigated with Telone C-35, 39 gallons/A, no tarp

Broadcast fumigated,
625 ft buffer

Bed fumigated with VIF tarp,
25 ft buffer
Grower Trials of Bed Fumigation

Five trials established in raspberry fields:
• Lynden 1, non-replicated, substantial *P. rubi* and *P. penetrans*
• Lynden 2, replicated, low *P. penetrans* and *P. rubi*; Also trialing non-tarped bed
• Lynden 3, replicated, substantial *P. penetrans*
• Burlington, replicated, high *P. penetrans* and *P. rubi*; Also trialing middle row management
• Mount Vernon, replicated, high *P. penetrans*

Treatments applied Sept 2010, raspberries planted April 2011
Treatment and evaluation timeline

• Soil fumigated: Sept 2010 (Lynden and Burlington trials), 2011 (Mt Vernon trial)
• Raspberries planted April-May 2011
• Primocane growth measurements, December 2011
• Yield evaluations, July 2012
• Soil bioassay for *P. rubi*, October 2011 (and annually thereafter)
• *P. penetrans* extraction from soil and from roots, April and October of each year
Plants in bed-fumigated plots generally grew as well as those in broadcast-fumigated plots.
# 2012 Harvested fruit weight, bed fumigated plots: percent of fruit weight from broadcast-fumigated plots

<table>
<thead>
<tr>
<th>Location</th>
<th>Harvested fruit weight from bed fumigated plots as percent of fruit weight from broadcast-fumigated plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burlington (non-fumigated control)</td>
<td><img src="image" alt="Burlington (non-fumigated control)" /></td>
</tr>
<tr>
<td>Burlington (plus cover crop)</td>
<td><img src="image" alt="Burlington (plus cover crop)" /></td>
</tr>
<tr>
<td>Burlington</td>
<td><img src="image" alt="Burlington" /></td>
</tr>
<tr>
<td>Lynden 3</td>
<td><img src="image" alt="Lynden 3" /></td>
</tr>
<tr>
<td>Lynden 2</td>
<td><img src="image" alt="Lynden 2" /></td>
</tr>
<tr>
<td>Lynden 1</td>
<td><img src="image" alt="Lynden 1" /></td>
</tr>
</tbody>
</table>

*Bed-fumigated plots were as productive as broadcast-fumigated plots, sometimes much more productive.*
**P. rubi** bioassay, 2011

Root rot control in bed-fumigated plots has been as good as in broadcast treated plots so far

<table>
<thead>
<tr>
<th>Root rot severity</th>
<th>Burlington</th>
<th>Lynden 1</th>
<th>Lynden 2</th>
<th>Lynden 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>beds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-fumigated</td>
<td>5.5</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bed fumigated, tarp</td>
<td>5.8</td>
<td>6.0</td>
<td>4.0</td>
<td>2.3 a</td>
</tr>
<tr>
<td>Bed fumigated, tarp+cover crop</td>
<td>4.3</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Broadcast fumigated</td>
<td>4.8</td>
<td>7.0</td>
<td>3.8</td>
<td>5.3 b</td>
</tr>
<tr>
<td>(P)-value</td>
<td>0.68</td>
<td>n/a</td>
<td>0.70</td>
<td>0.05</td>
</tr>
<tr>
<td>alleyways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-fumigated</td>
<td>6.3</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bed fumigated, tarp</td>
<td>6.0</td>
<td>7.0</td>
<td>3.8</td>
<td>6.7 b</td>
</tr>
<tr>
<td>Bed fumigated, tarp+cover crop</td>
<td>6.0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Broadcast fumigated</td>
<td>6.5</td>
<td>6.0</td>
<td>4.3</td>
<td>4.0 a</td>
</tr>
<tr>
<td>(P)-value</td>
<td>0.90</td>
<td>n/a</td>
<td>0.80</td>
<td>0.01</td>
</tr>
</tbody>
</table>
In some trials, less root rot in alleyways than in beds. No treatment differences.

**Root rot severity**

<table>
<thead>
<tr>
<th>Sampling location</th>
<th>Burlington</th>
<th>Lynden 1</th>
<th>Lynden 2</th>
<th>Lynden 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>alleyways</td>
<td>5.6 a</td>
<td>5.8</td>
<td>4.1</td>
<td>2.7 a</td>
</tr>
<tr>
<td>beds</td>
<td>6.8 b</td>
<td>6.0</td>
<td>3.8</td>
<td>7.0 b</td>
</tr>
</tbody>
</table>

**Fumigation treatment (all sampled from beds)**

- Non-fumigated: 6.3
- Bed fumigated, tarp: 7.3
- Bed fumigated, tarp+cover crop: 6.8
- Broadcast fumigated: 7.0
Nematode recolonization in bed- and broadcast-fumigated plots

**From Soil**

Lynden 2

Lynden 3

**From Roots**

Spring '11 | Fall '11 | Spring '12 | Fall '12 | Spring '13
---|---|---|---|---
Bed fume-tarped | Bed fume-nontarped | Broadcast fume

Bed fume-tarped | Bed fume - tarp | Broadcast fume

P. penetrans/100 g dry soil

P. penetrans/g root
Challenges:

• The shaper we used (an adjustable unit for vegetables) can only make beds up to about 8” high. You’d need a different shaper to make larger beds.

• You’ll need GPS or some other way to assure that beds are made in the correct location.

• It takes more time to fumigate a field this way; we usually travel at about 3 mph when fumigating and laying tarp. (Broadcast rig travels about 5-6 mph.)
Yield - California trial, fall 2011

UTC yields lower than Telone, MB-treated plots
Phytophthora bioassay - California trial, Spring 2012

No significant differences between treatments
Yield and Plant Height - California trial, fall 2013

Mean(Plant height (ft)) & Mean(Yield per plot, July–Nov) vs. Fume treatment

- No significant differences in yield
- Plant height of UTC is significantly lower than fumed plots
No significant differences between treatments
Another option - metam (Vapam)

- Telone C-35, deep shank injected
- 35 gal/A
- 20 A field
- 20% credit for 2-3% organic material
- 460 ft buffer

- Vapam HL, applied with rotary spader
- 75 gal/A
- 20 A field
- 20% credit for 2-3% organic material
- 96 ft buffer
- ?Less volatile?
Applying Vapam with a rotary spader
Applying Vapam with a rotary spader

About 75% of the fumigant is injected in these sweeps near the front of the spader
Applying Vapam with a rotary spader

Spader blades rotate slowly, mixing soil and Vapam
Applying Vapam with a rotary spader

Remaining 25% of Vapam is injected ahead of this shallow power harrow
Applying Vapam* with a rotary spader

Seal generated by power roller

*Relax. They are just applying water in this demonstration.
Other options?

• Paladin (Dimethyl Disulfide)
  – Effective, strong smell
  – Must be applied under VIF or TIF tarp
  – 25 ft buffer for bed applications

• Mustard meals
  – Effective in greenhouse tests, less encouraging in field
  – Incorporate with rotary spader?
  – Mustard variety matters
Thanks!!

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