Management of Organophosphate Resistant Codling Moth

In the Field

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Background

- Codling moth has increased as a problem in the past several years

- Possible explanations for problems...
  - Evolution of resistance to mating disruption
    - no
  - Evolution of resistance to Guthion
    - maybe
  - Inadequate control tactics
    - ? hmmmm

- New materials are available
  - Assail, Calypso, Diamond, Avaunt
    - More expensive
    - More applications
Resistance in CM

- Cross-resistance with OP-
- resistance is very broad
  - X-R possible with just about everything

Summary of Resistance Ratios

- Diazinon
- Azinphosmethyl
- Carbaryl
- DDT
- Esfenvalerate
- Fenpropatrin
- Fenoxycarb
- Chloryrifos
- Methyl Parathion

LC50 Resist / LC50 Susc.
Guthion bioassays – Statewide survey
Washington 2003

• First generation
  ▪ Susceptible generally around 0.6 to 0.1 \( \mu g / \text{moth} \)
  ▪ Moderate resistance to 0.3 \( \mu g / \text{moth} \)
  ▪ High resistance > 0.4 \( \mu g / \text{moth} \)

• Variable in resistance
  ▪ Low to moderate
First Generation - Resistance Ratios

- Some variation
  - But no significant differences
Guthion bioassays

- Second generation
  - More variation
  - Location with high resistance
Second Generation - Resistance Ratios

- **Guthion resistance** - mostly low levels

- **Codling moth resistance** low to moderate
  - But one location was significantly high

![Resistance Ratio Chart]

- **High R**
- **Mod. R**
- **Susc.**

Dunley - WOPDMC 2005
Lorsban bioassays

- Limited information for Lorsban
  - Negative cross-resistance may be there
    - Not statistically significant, however

<table>
<thead>
<tr>
<th>Location</th>
<th>LC50 (µg ai / moth)</th>
<th>Resistance Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosser</td>
<td>0.028</td>
<td>-1.8</td>
</tr>
<tr>
<td>Grandview</td>
<td>0.03</td>
<td>-1.7</td>
</tr>
<tr>
<td>WSU-TFREC</td>
<td>0.05</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Asana bioassays

- Limited information for Asana
  - No differences

<table>
<thead>
<tr>
<th>Location</th>
<th>LC50 (µg ai / moth)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Prosser</td>
<td>0.06</td>
<td>1.2</td>
</tr>
<tr>
<td>Grandview</td>
<td>0.03</td>
<td>0.6</td>
</tr>
<tr>
<td>WSU-TFREC</td>
<td>0.05</td>
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</tbody>
</table>
Assail bioassays

• Assail results not statistically robust
  ▪ Cross-resistance appears likely, though

<table>
<thead>
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<th>Resistance Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosser</td>
<td>0.32&lt;sup&gt;1&lt;/sup&gt;</td>
<td>na</td>
</tr>
<tr>
<td>Grandview</td>
<td>0.11</td>
<td>1.0</td>
</tr>
<tr>
<td>WSU-TFREC</td>
<td>0.11</td>
<td>--</td>
</tr>
<tr>
<td>Manson-1</td>
<td>0.76&lt;sup&gt;1&lt;/sup&gt;</td>
<td>6.9&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Manson-2</td>
<td>0.27&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2.5&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup> estimates - probit lines are not statistically significant
Conclusions about resistance

• Pressure related performance
  ▪ Increased resistance / tolerance led to decreased Guthion performance
  ▪ Reduce management tactics compounded problems
  ▪ High pressure led to reduced performance
    • Portion attributable to Guthion resistance
Codling moth resistance

• Worry about OP resistance in CM
  ▪ High levels rare
  ▪ Many areas have low to moderate levels

• Worry about cross-resistance
  ▪ Guthion resistance gives some level of resistance to almost everything
  ▪ Assail / Calypso?
Bioassays in 2004

- In OP-Resistant apple orchard

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<tr>
<th>Location</th>
<th>LC50 (µg ai / moth)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Guthion</td>
<td>0.39</td>
<td>3.6</td>
</tr>
<tr>
<td>Assail</td>
<td>0.80</td>
<td>6.1</td>
</tr>
<tr>
<td>Asana</td>
<td>0.10</td>
<td>2.0</td>
</tr>
<tr>
<td>Lorsban</td>
<td>0.03</td>
<td>-1.7</td>
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</tbody>
</table>
2004 Field Trials

• In OP-R orchard

• Large plots

• Standard and ‘new’ season long programs

• Each generation assessed separately

• Same program on each experimental unit for 1st and 2nd generation
### Field trials in 2004 -- % damage

- In OP-Resistant population in apple

<table>
<thead>
<tr>
<th>Tmt</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; gen</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; gen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calypso 6 oz (2 covers / gen)</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Assail 3.4 oz (2 covers / gen)</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Guthion 3 lb (2 covers / gen)</td>
<td>0.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Diamond 40 oz, Assail 3.4 oz (1 combination cover / gen)</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Success 6 oz (2 apps 1&lt;sup&gt;st&lt;/sup&gt; gen, 3 apps 2&lt;sup&gt;nd&lt;/sup&gt;)</td>
<td>1.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Lorsban 2 lb (2 covers / gen)</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Asana 14.5 oz (2 covers / gen)</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Conclusions

• All of the programs were effective
• OP resistance can be managed
• Cross-resistance with neonicotinyls is likely
• But it doesn’t appear to affect field performance at field rates