Using Insect Growth Regulators and Biopesticides in Your Orchards

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Insect Growth Regulators: Esteem and Novaluron

Esteem
• Target 2nd generation
• Post-harvest cherry border-row spray
• Females commit fat body to producing eggs out of their normal life cycle
• Low cost, no residue issues
“Biopesticides”

- Def: pesticides derived from such natural materials as animals, plants, fungi, bacteria, viruses, and certain minerals

  - Microbial
    - Bacterium, fungus, virus, protozoan
  - Biochemical
    - Naturally occurring substances that control pests by non-toxic means
      - eg. Insect sex pheromones, kaolin clay
<table>
<thead>
<tr>
<th>PEST</th>
<th>BIOPESTICIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plum Curculio</td>
<td>Entomopathogenic nematodes and fungi</td>
</tr>
<tr>
<td>Borers</td>
<td>Entomopathogenic nematodes</td>
</tr>
<tr>
<td>Codling Moth</td>
<td>Entomopathogenic nematodes and granulosis virus</td>
</tr>
</tbody>
</table>
Entomopathogens

Nematodes
- Steinernema
- Heterorhabditis

Fungi
- Beauveria bassiana
- Metarhizium anisopliae
Plum Curculio Life History

Overwintering 
Summer Generation 
Adult: Feed & Diapause

Adult Emerges in Spring, Feed, Mate & Oviposit

Winter

Egg

1st instar

2nd instar

3rd instar

4th instar

Pupa
Plum Curculio Background

• **Damage:**
  – Feeding & oviposition scars
  – Zero tolerance for larvae in processed fruit

• **Few Organic Management Tactics:**
  – Repeated kaolin clay coverage
  – Pyganic
  – Livestock
Plum Curculio Pathogen Experiment Design

- Larvae placed on surface of enclosed pots installed in 5 orchards
- Soil surface of each pot treated with a pathogen on day 0
- Counted number of adults emerging from pots
## Plum Curculio Pathogen Experiment Design

### Pathogens:
- **B. bassiana GHA** (Mycotrol-O®)  
- **H. bacteriophora** (Utah, unformulated)  
- **S. riobrave** (355 strain, Biovector®)  
- **Control** (water)

### Rates:

<table>
<thead>
<tr>
<th></th>
<th>Times:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) $5 \times 10^{13}$ conidia/ha</td>
</tr>
<tr>
<td>(2) $1 \times 10^9$ or</td>
<td>(2) $1 \times 10^9$ or $4 \times 10^9$ IJ/ha</td>
</tr>
<tr>
<td></td>
<td>(2) $1 \times 10^9$ or $4 \times 10^9$ IJ/ha</td>
</tr>
</tbody>
</table>

### Timings:
- Introduce larvae to soil -10, -5, 0, 5, 10, 15, or 20 d from pathogen application
- Hb was not tested for -10, 10, or 20 d

### Design:
- 36 treatments total
- Means comparisons made within each timing ($\alpha=0.5$)
- 8 reps per orchard, under two tree rows
Average number of adult plum curculios emerging from pathogen-treated soil. Soils were treated with the fungus *Beauveria bassiana* (Bb) or the nematodes *Heterorhabditis bacteriophora* or *Steinernema riobrave* at a low or high rate (Hb Low, Hb High, Sr Low, Sr High). Larvae were placed on soil either -10, -5, 0, 5, 10, 15, or 20 days from pathogen application. Bars with an asterisk (*) denote significantly lower means within a day-timing. Note: Hb Low and High were not included for the -10, 10, or 20 day treatments.
## Plum Curculio Pathogen Experiment Results: Orchards

<table>
<thead>
<tr>
<th></th>
<th>Percent Reduction from Control Treatment for <em>S. riobrave</em> high rate treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-10 d</td>
</tr>
<tr>
<td>All Orchards</td>
<td>25</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>48</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>45</td>
</tr>
<tr>
<td>Loam</td>
<td>14</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>33</td>
</tr>
<tr>
<td>Loam, High Org.</td>
<td>34</td>
</tr>
</tbody>
</table>
Plum Curculio Pathogen Experiment Discussion

- *B. bassiana* significantly suppressed adult emergence by 48-77% in low sand sites 1/3 yr
- *S. riobrave* most effective in high sand; larvae introduced -5, 0, or 10 d from pathogen; pupae susceptible
- Physical properties of soils – top 5 cm
- Foraging strategies: “sit-and-wait”* carp vs. active* bac
- Optimal soil temp ranges: within ranges MI summer
- Formulation: gel vs. vermiculite, UV
- Fungicides
- Water activity: micro-jet sprinkler irrigation in citrus
Plum Curculio Pathogen Experiment

- Will targeting larvae reduce next summer’s damage?
  - Spring immigration of adults surviving in refuges: wild hosts, nearby fruit trees, nearby organic orchards
  - Reduce cost by concentrating oviposition – combine “push-pull” with oviposition monitoring
Plum Curculio Phenology Experiment Design

100 fruits held for larva emergence

100 fruits immediately dissected

1st instar

2nd instar

3rd instar

4th instar

egg
Plum Curculio Phenology Experiment Results

![Graph showing percent larval exit from fruit vs. degree days base 50°F. The graph includes annotations for 'Nema', 'App 1', and 'App 2'.]
### Benzie County Tart Cherry Plum Curculio Assist Chart (Revised: 11/25/2008 8:15)

#### Directions:

Locate the bloom date (date of full bloom) on the top row. Follow that column down to determine the base 50°F degree days (GDD) that have accumulated between the bloom date and the date listed at the left side of that row. Note that forward data is provided whenever available to help with planning in the near-term. Control is recommended at 375 GDD from the bloom date. Repeat for additional blooming that occurred on a different date.

#### MSU Tart Cherry Postponed Insecticide Treatment Strategy (P.I.T.S.) for Plum Curculio:

- Use date of full bloom as bloom data.
- Time control for 375 degree days (base 50°F) from the bloom date.
- This model is not recommended for growers that are not intensive scouting their orchards.

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### Table 1: Benzie County Tart Cherry Plum Curculio Assist Chart

<table>
<thead>
<tr>
<th>Day</th>
<th>Bloom Date</th>
<th>Temp Min</th>
<th>Temp Avg</th>
<th>Temp Max</th>
<th>GDD 50°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/05</td>
<td>11/18</td>
<td>17</td>
<td>22</td>
<td>26</td>
<td>100</td>
</tr>
<tr>
<td>11/06</td>
<td>11/19</td>
<td>16</td>
<td>21</td>
<td>25</td>
<td>125</td>
</tr>
<tr>
<td>11/07</td>
<td>11/20</td>
<td>15</td>
<td>20</td>
<td>24</td>
<td>150</td>
</tr>
</tbody>
</table>

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### Table 2: Benzie County Tart Cherry Plum Curculio Assist Chart

<table>
<thead>
<tr>
<th>Day</th>
<th>Bloom Date</th>
<th>Temp Min</th>
<th>Temp Avg</th>
<th>Temp Max</th>
<th>GDD 50°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/08</td>
<td>11/21</td>
<td>14</td>
<td>19</td>
<td>23</td>
<td>175</td>
</tr>
<tr>
<td>11/09</td>
<td>11/22</td>
<td>13</td>
<td>18</td>
<td>22</td>
<td>200</td>
</tr>
<tr>
<td>11/10</td>
<td>11/23</td>
<td>12</td>
<td>17</td>
<td>21</td>
<td>225</td>
</tr>
</tbody>
</table>

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### About Plum Curculio in Tart Cherries

Learn more about weather stations and station status: [www.enviroweather.msu.edu](http://www.enviroweather.msu.edu)
Ongoing Research:
Targeting Adult Plum Curculio with Fungi
Borers

Greater Peachtree Borer
Lesser Peachtree Borer
American Plum Borer
Dogwood Borer
## Borers: Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Crop</th>
<th>Location</th>
<th>Treated</th>
<th>Control</th>
<th>Destructive</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Peach</td>
<td>SW</td>
<td>32</td>
<td>32</td>
<td>2-Oct</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Tart cherry</td>
<td>SW</td>
<td>28</td>
<td>28</td>
<td>4-Nov</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tart cherry</td>
<td>NW</td>
<td>32</td>
<td>32</td>
<td></td>
<td>summer 2009</td>
</tr>
<tr>
<td>4</td>
<td>Tart cherry</td>
<td>NW</td>
<td>32</td>
<td>32</td>
<td>16-Oct</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sweet cherry</td>
<td>NW</td>
<td>32</td>
<td>32</td>
<td>16-Oct</td>
<td>summer 2009</td>
</tr>
<tr>
<td>6</td>
<td>Apple</td>
<td>CENTRAL</td>
<td>32</td>
<td>32</td>
<td></td>
<td>summer 2009</td>
</tr>
<tr>
<td>7</td>
<td>Apple</td>
<td>CENTRAL</td>
<td>32</td>
<td>32</td>
<td>15-Oct</td>
<td></td>
</tr>
</tbody>
</table>
Borers: Applications

Backpack sprayer application of nematode 
*S. carpocapsae* (BionemC, organic formulation)
Rate: 300,000 Infective Juveniles (IJ's) 
in 2 cups water applied to tree trunks and 300,000 IJ's in 2 cups water applied under trees to a radius of 0.5 m from the trunk

At one site: 
Wet 1 hr (30 gallons/acre/hr) with microjet sprinklers before nematode application
Wet 1 hr/day three days post-treatment
Borers: Timing

Dates and Degree Days Base 50°F
(from MAWN: Fennville site 2007 / 2006 values)

- American Plum Borer
- Lesser Peachtree Borer
- Greater Peachtree Borer
- Dogwood Borer
- Nematode Application
Borers: Evaluations
Borers: Early Results

Modifying Environment Key to Performance
Solid State Delivery System
Codling Moth
Larry Gut & Dave Epstein

Same organic formulation of *S. carpocapsae* (BionemC)
-70% reduction of live larvae

Adult CM captures in pheromone-baited traps for organic farm two showed significant declines following the mid-season EPN application.
**Codling Moth *Granulosis* Virus**

- First collected in Mexico and tested in 1960’s (Tanada, 1964)
- Highly lethal baculovirus protected by protein coat
- Must be ingested by neonate larvae for mortality to occur (Lacey and Shapiro-Ilan)
- Effectiveness in the field has been inconsistent (Charmillot 1993, Huber and Dickler 1977) - High incidence of stings

Slow acting
Disease progresses over 5 - 10 days
Short residual activity
Determine the efficacy and optimum patterns of use of CpGV

Summary of results:

- Targeting 1st generation protects fruit, lowers CM population density
- Use CpGV frequently at low rates

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean entries (%)</th>
<th>Proportion attributed to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shallow</td>
<td>Deep</td>
</tr>
<tr>
<td>Untreated</td>
<td>4.0</td>
<td>53.6a</td>
</tr>
<tr>
<td>Virus (4.4 oz)</td>
<td>8.0</td>
<td>8.6b</td>
</tr>
<tr>
<td>Virus (8.8 oz)</td>
<td>8.0</td>
<td>13.0bc</td>
</tr>
<tr>
<td>Virus (13.2 oz)</td>
<td>10.0</td>
<td>20.6c</td>
</tr>
</tbody>
</table>

Mean followed by the same letter are not significantly different at p = 0.05.
Codling Moth Summary

• Multiple Targets:
  – Egg with oil
  – Larva with granulosis virus* & nematodes
    *granulosis virus Low Rate Frequent Applications
  – Adult with mating disruption
Acknowledgements

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Thanks to Larry Gut Lab and Dave Epstein for Codling Moth trials.