Plum Curculio: Challenges, Changes & Management Strategies

Mark Whalon
Pesticide Alternatives Lab
Center for Integrated Plant Systems
Dept. of Entomology
Michigan State University
East Lansing, MI

Whalon Lab URL
http://whalonlab.msu.edu

- PC Problem: Policy
- PC Monitoring
- Insecticide Trials
- USDA/RAMP Study
  - Things Growers should not do...
  - Emerging Insecticide Strategies
  - Problems with Neonicotinoids
  - Possible IGR Strategy

- Novel Organic Controls

Michigan’s Agricultural & Natural Beauty

Food Quality Protection Act 1996
AZM Rate Reduction & Cancellation

<table>
<thead>
<tr>
<th>Season</th>
<th>Max Rate</th>
<th>2007-2009</th>
<th>2010-2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>ai/acre/year</td>
<td>1.5 lbs</td>
<td>0.75</td>
<td></td>
</tr>
</tbody>
</table>

- Aerial Applications Prohibited
- 60 ft Buffer Zone – Dwellings
- 60 ft Buffer – Water
- Pick Your Own – Prohibited

FDA Law – Zero Tolerance
USDA Inspection Standards
State of Michigan Law (1928)

- Impact on Growers
- Impact on Processors
- Impact on Industry

Increased Worms in Cherries
Difficult to Control a Pest Without Developing Monitoring Tools

Whalon Pyramid Trap
Pyramid Trap
Cylinder Trap
Screen Trap
Intercept Trap
Oeschlager Ramp Trap

Figure 3. Mean Total Number Plum Curculio Captured per Trap

Figure 1. Percent positive response to putative compounds in choice olfactometer. Asterisks represent treatments significantly different than 0 using Student’s t-test ($\alpha = 0.05$).

Improving kairomone blends and repellents

Objective: Test various attractants and repellants in the lab

Methods:
- PC in Olfactometer
- Observe response to chemistry

Plum Curculio Monitoring

Figure 3. Sources of plum curculio attractant odor throughout the growing season. (Top) Abundance profiles of attractive volatile components from plant structures. (Bottom) Comparative contribution of a single, constant-release lure.
New Insecticides: Problem = Weevils

Methods
- Collect and rear 1st PC-Southern and Northern Strains
- Conduct Dosage Mortality Bioassays
  - Include behavioral assays where appropriate
  - Determine sublethal reproductive effects
- Rear treated survivors & assess vertical effects
- Field trials in small plots
  - Today, very difficult to fund!
- Examine spatial & temporal residual effects
- On-farm, large acreage trials
  - State-GREEEN & Commodity funds
  - USDA: CAR, PMAP & RAMP funds

Insecticidal Activity: Plant, Insect, Chemical Interaction

Residues on/in Leaves and Fruit Coupled with Morbidity & Behavior Assays

Guthion Residue on/in Fruit

The "Standard" or a Kill Ratio = 1 (contact toxicant)

- Contact Toxicity = 84% Mortality
- Small interior residue but sufficient to be curative for many 1-3L PC in cherry
- Below LOD residues at harvest

NO Residues At harvest!

Indexacarb Kill Ratio = 0.007 (not a contact toxicant)
- Long-life surface & internal residues
- Must be ingested...mortality delayed ~100hrs post ingestion
- Must be used when PC are actively feeding
- Avoid neonicotinoid residues = antifeedant and repellent
- Loose mortality rapidly...
- Internal residues = correlation with mortality than surface residues
- Detectable residues in harvested product

5x > Likely Residues At Harvest
**Actara Residue: Fruit**

- Thiomethoxam Kill Ratio = 0.235
- ~70% mortality = leaf/fruit surface residues
- Almost immediate (4hrs) internal residues
- Repellent, anti-feedant and anti-oviposition effects
- Some mortality from internal leaf & fruit residues
- Some curative ability
- Very long internal residues = harvest residues
- Drive larvae out of fruit

Detectable Residues Almost Certain at Harvest

With RR Compounds: Pest Control Just Got Much, Much More Complex!

**Lethal Time: AZM Vs. Reduced Risk**

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Time (hours)</th>
<th>Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>Guthion</td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>Avant</td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>Actara</td>
<td>0.01</td>
<td>0.1</td>
</tr>
<tr>
<td>Calypso</td>
<td>0.01</td>
<td>0.1</td>
</tr>
</tbody>
</table>

2002 PC adult bioassay, 4hrs post-spray, TNRC (P = .05, LSD)

**Residual Activity on Plum Curculio**

- 2002 PC adult bioassay, 7 days post-spray, TNRC (P = .05, LSD)

**Curative Activity of Insecticides on Plum Curculio Larvae**

- Untreated Check
- Esteem
- Rimor
- Avant
- Calypso
- Actara
- Guthion

Mean larvae per fruit
New Damage:   
- Premature emergence  
- Larvae exiting can penetrate a 2nd or 3rd cherry; eventually escape control...  

Anti-feedant Results in More Injury

**Plum Curculio Control in Processor-Bound Cherries**

**Goal:**  
- OP-Alt  
- Reduced Risk Management

**FQPA Ushered Changes Yields New Insight!**

**Acute vs Chronic Effects of Various RR Insecticides**

- **AZM Orchard Ecosystem**
  - Deep Impact & Recovery Time
  - Shallow & Long Disruption

**Neonicotinoid or IGR Orchard Ecosystem**

- Deep & Short Disruption
- Shallow & Long Disruption

Figure 1. An illustration of the chronic ecological effects of different insecticides upon an orchard ecosystem.

**IGR's Present a New Set of Ecological Challenges**

**Subtle Endocrine-Like Effects & Vertical Transmission**

- Esteem (pyriproxyfen): will brake diapause  
- Esteem treated females produced eggs = create a two generation pest in apples & mortality in cherries ...>>> complexity!  
- Esteem treatment caused reduced fat reserves = winter mortality...  
- Novaluron (Rimon): vertical transmission ; to offspring...  
- If they do ...What about Natural Enemies Effects?

**Emerging Neonicotinoid (RR) Issue...**

- Premature emergence  
- Larvae exit post treatment  
- New Damage:  
  - Larvae exiting can penetrate a 2nd or 3rd cherry; eventually escape control...  

Anti-feedant Results in More Injury  
At Harvest

**AZM Insecticide Alternative's in Cherry**

- New Research  
- GFW, LR, PC, CFF  
- New Tool's  
  - Indoxacarb (2007*)  
  - Acetamiprid (2008)  
  - Thiamethoxam (2006)  
  - Imidacloprid (2004)  

- MRL's  
- Economically Sustainable?  
- Time to Adapt...
PC Ovary Development with Esteem™
Obligate Diapause Broken

Viable Egg Production & Rapid Utilization of Fat Body

Ventral Thorax Application

Mean Ovary Stage ± SE

Cumulative Degree days base 50°F

Plum Curculio Control in Processor-Bound Cherries

New Window for Control
- Low rate Esteem
- Post Harvest tmt
- Break diapause
- PC Can’t Overwinter

Plum Curculio Developmental Stages: Conventional Cherry
Zero Tolerance @ harvest!

Organic Production
Phenology & Emerging Control of Plum Curculio?

Plum Curculio Activity Window

Trap Out & Push / Pull

Plum Curculio Management

Apple Organic Pest Management & Spray Program
• Surround (Kaolin Clay)
• Pyganic for PC & LFRL
• Neem (azadirachtin)
• Oil
• Monitoring, Timing, Thresholds
• Attract & Kill (Push/Pull)
• Predator Prey Ratios
• Biopesticides

Ground cover, surrounding habitat, biodiversity plantings, post harvest strategies & neighbors

Mark Whalon
whalon@msu.edu
Push/Pull Strategy

- Pull PC to the Orchard Borders
- Kill PC by Trap Out and Border prays
- Push PC out of the Interior Rows

Clarksville ‘O’ Orchard: PC Distribution

- PC Damage much higher in check
- Border trapping pulled PC out of interior
- Spraying border reduced damage

Surround & Trap Out: Reduces Larval Damage & Oviposition Scars

- Reduces Oviposition Scars
- 2004, 05 & 06 Difference in PC Damage at Harvest

Beauveria bassiana (Bb)

- Insect pathogenic fungus
- Registered on over 100 crops
  - Sensitive to UV light, low rH, temperature extremes
- Strain variance: adapted to different hosts

Important Fungal Pathogens of plum curculio

Novel Population Suppression Strategies

- Trap Out, Attractants & Border Sprays
- Phenology Models To Time Activity
- Kaolin Clay (Push)
- Drop Control
- Summer Generation Control Nemas
Strategy: Colonizing grain with fungus (build over time)

- Seed Bb, Ma &/or Nemas into drip line of trees
- Grow on cheap grain castings in the barn or surrogate hosts
- Colonized grain is dried and stored
- Application methods -
  - Disc fertilizer spreader (2007)
  - No-till drill
  - Hand Gun or Spray By hand applicator
- Irrigation helps activity and longevity

Experimental Methods

- Large Treatments:
  - Replicated 3x in 4 orchards
  - 2 cherry & 2 apple blocks
- Micro-plots within blocks
  - Replicated 4x per block
  - 5 treatments per micro-plot
  - Control
  - Spray (weed sprayer)
  - Low, med & hi rates

Methods: Plot Setup

Five treatments:
- Untreated Control (Water)
- Boom Sprayer
  - 3 applications at high rate
  - Low density rice
    - 2*10^5 spores/cm^2
  - Medium density rice
    - 2*10^6 spores/cm^2
  - High density rice
    - 2*10^7 spores/cm^2

10 PC larvae per cup