New Issues Affecting Leafroller Management

Mike Doerr
Tree Fruit Research and Extension Center
Wenatchee, WA
Important Issues

• Shift in species to OBLR
• Degree-day models
• Monitoring and sampling
• Control Options
• Insecticide Resistance
Species Shift

- PLR >>>> OBLR

% Of Adult Captures

<table>
<thead>
<tr>
<th>Year</th>
<th>PLR</th>
<th>OBLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>2002</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>2003</td>
<td>60</td>
<td>60</td>
</tr>
</tbody>
</table>
### Implications of shift to OBLR

<table>
<thead>
<tr>
<th>PLR</th>
<th>OBLR</th>
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<tbody>
<tr>
<td>Host Range</td>
<td>Broader than PLR</td>
</tr>
<tr>
<td>Complete by HIG</td>
<td>O/W emergence</td>
</tr>
<tr>
<td></td>
<td>10 d later</td>
</tr>
<tr>
<td>Top of tree</td>
<td>Location in tree</td>
</tr>
<tr>
<td></td>
<td>Distributed throughout</td>
</tr>
<tr>
<td>Insecticides</td>
<td>Less susceptible</td>
</tr>
<tr>
<td>Toxic virus</td>
<td>Biocontrol</td>
</tr>
<tr>
<td></td>
<td>More aggressive</td>
</tr>
<tr>
<td>Reproduction</td>
<td>Greater than PLR</td>
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### Implications of shift to OBLR

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<th>OBLR</th>
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<td>Host Fruge</td>
<td>Broader than PLR</td>
</tr>
<tr>
<td>Complete by HIG</td>
<td>O/W emergence</td>
</tr>
<tr>
<td></td>
<td>10-14 d later</td>
</tr>
<tr>
<td>Top of tree</td>
<td>Location in tree</td>
</tr>
<tr>
<td></td>
<td>In the trunk</td>
</tr>
<tr>
<td></td>
<td>Distributed</td>
</tr>
<tr>
<td>Toxic virus</td>
<td>Biocontrol</td>
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<td></td>
<td>More aggressive</td>
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<td>Reproduction</td>
<td>Greater than PLR</td>
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OBLR Degree-day Model

• Thresholds changed to 50-86°F
• Temps collected from Jan 1
• No Reset at Biofix
• Models for each instar being created
  ▪ Optimize sampling times
  ▪ Target pesticide applications
  ▪ Sample for biocontrol
Sampling Problem

• “Spontaneous generation” of larvae
  ▪ Sampling at the wrong time gives the impression of low population levels
  ▪ A few weeks later, the population is huge and causing damage
  ▪ Makes consultants need to be very conservative and this results in treatments that may not be warranted
“Spontaneous Generation” of OBLR

Number Collected in Summer Generation

Instar

1
2
3
4
5
6

0
200
400
600
800
1000
1200
1400
1600

OBLR
PLR
“Spontaneous Generation” of OBLR

Number Collected in Summer Generation

Instar

OBLR
PLR
Monitoring Adults

- No Biofix needed for OBLR
- Trap density not as critical as CM
- One trap per 10-20 acres
- Help to understand models
- Some relative measure of population
- Not good treatment predictor
Insecticidal control

• Mode of action
• Timing
• Control programs
• Resistance management
Pandemis Moth Flight - 1993

Delayed population development with Bt

No Bt sprays applied

Bt controls applied in spring

Moths per trap

Moths per trap
Success/Entrust (spinosad)

- *Competes with Ach on post-syn m/b, not removed*
Insect growth regulators

- Mimic insect’s natural growth hormones

Juvenile hormone-Esteem

Molting hormone-Intrepid
Insect growth regulators

- Mimic insect’s natural growth hormones

**Best time for Esteem**
Esteem Intoxication
Intrepid or Rimon Intoxication
Esteem Bioassay—new method

### Corr % mortality
- **Esteem 0.3 ppm**

### Days after start of test
- **Day 7**
- **Day 14**
- **Day 21**
- **Day 28**
- **Day 35**
- **Day 42**
- **Day 49**
- **Day 56**

### Adult emergence
- **Esteem 0.3 ppm**
- **Untreated**

### Days after start of test
- **Day 7**
- **Day 14**
- **Day 21**
- **Day 28**
- **Day 35**
- **Day 42**
- **Day 49**
- **Day 56**
Leafroller Control- *Stomach poisons*

- New chemistries must be ingested to be effective
  - Good coverage critical to good efficacy
  - Apply during periods of highest active feeding
- Intrepid and Success better alternative than Bt during cool spring conditions
  - Residual activity (Intrepid > Esteem, Success > Bt)
- Residual control less important than weather in spring
Field testing new LR products
*Treatments applied at petal fall*

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Rate/A</th>
<th># of Lv/tr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rimon</td>
<td>40 fl. oz.</td>
<td>1.0a</td>
</tr>
<tr>
<td>Success</td>
<td>6 fl. oz.</td>
<td>0.3a</td>
</tr>
<tr>
<td>Intrepid</td>
<td>16 fl. oz.</td>
<td>3.3b</td>
</tr>
<tr>
<td>Untreated</td>
<td>---</td>
<td>10.0c</td>
</tr>
</tbody>
</table>
Field testing new LR products  
*Treatments applied at petal fall*

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Rate/A</th>
<th>LR/400 shoots</th>
<th>Larvae</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>6 oz.</td>
<td></td>
<td>0.0</td>
</tr>
<tr>
<td>Intrepid</td>
<td>16 oz.</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Esteem</td>
<td>16 oz.</td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Untreated</td>
<td>---</td>
<td></td>
<td>12.9</td>
</tr>
</tbody>
</table>

Summer-July 26
**Field testing new LR products**

**Summer treatments (late June)**

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Rate/A</th>
<th>July 29</th>
<th>August 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrepid</td>
<td>16 oz.</td>
<td>3.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Intrepid</td>
<td>12 oz.</td>
<td>3.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Intrepid</td>
<td>8 oz.</td>
<td>2.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Success</td>
<td>6 oz.</td>
<td>1.1</td>
<td>1.8</td>
</tr>
<tr>
<td>Untreated</td>
<td>---</td>
<td>9.6</td>
<td>24.0</td>
</tr>
</tbody>
</table>
Standard Insecticide Program

- **CM Adults**
- **CM Eggs**
- **CM Larvae**
- **LR Larvae**

Chemicals:
- **Guthion**
- **Neonic.**
- **B.t.**
- **Imidan**
- **Lorsban**
- **Success**

Timeline:
- May: Bloom
- June: Guthion, Neonic.
- July: Guthion, B.t., Imidan
- Aug.: Lorsban, Success
- Sept.: Bloom

CM Degree-days:
- 0 to 100
- 100 to 300
- 300 to 500
- 500 to 700
- 700 to 900
- 900 to 1100
- 1100 to 1300
- 1300 to 1500
- 1500 to 1700
- 1700 to 1900
- 1900 to 2100
- 2100 to 2300
- 2300
Increased Pressure- What’s Next?

- CM Adults
- CM Eggs
- CM Larvae
- LR Larvae

- Lorsban
- Success
- Guthion
- Neonic.
- B.t.
- Asana
- Imidan
- Neonic.
- Lorsban
- Success

Bloom

CM Degree-days

May 0 100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300
June
July
Aug.
Sept.
Mating Disruption As Foundation

CM Degree-days

May

June

July

Aug.

Sept.

Bloom

Lorsban

Success

Guthion

Neonic.

Guthion

Imidan

B.t.

LR Larvae

CM Adults

CM Eggs

CM Larvae

LR Larvae

Bloom
Mod. Pressure- Need For Ovicide

Mating Disruption

CM Adults
CM Eggs
CM Larvae
LR Larvae

IGR
Guthion Neonic.
Guthion
Imidan
B.t.
Lorsban

May
June
July
Aug.
Sept.

0 100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300

Bloom

CM Degree-days
Highest Pressure - Need For Ovicide

CM Degree-days

Mating Disruption

CM Adults
CM Eggs
CM Larvae
LR Larvae

Bloom

May June July Aug. Sept.

0 100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300

Bloom

Guthion + IGR
Neonic.
Guthion
Imidan
B.t.

IGR

Guthion
Neonic.

Guthion + IGR

Mating Disruption
Highest Pressure- Need For Ovicide

Mating Disruption

CM Adults
CM Eggs
CM Larvae
LR Larvae

IGR + IGR
Neonic.
Guthion + IGR
Imidan

Bloom
May June July Aug. Sept.

0 100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300

Bloom CM Degree-days
Stable CM and LR Control- AWII

Reduced rates (250 d/a)

CM Adults
CM Eggs
CM Larvae
LR Larvae

IGR
Neonic. or IGR
Neonic. or IGR

Bloom
CM Degree-days

May  June  July  Aug.  Sept.

0 100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300
Leafroller Mating Disruption

Hand applied

- Isomate 250 mg dispenser - season long
- Effectiveness seen over time
  - Average reduction in population around 50%
- Must be used in an intensive monitoring program

New Technologies

- Sprayables, fibers, flakes, attract and kill
- Promising, but research must continue
Insecticide Resistance

• Survey every 3 years
• Cross resistance before insecticide is registered
• Development of resistance to new chemistry
Dose-mortality curves for OBLR

- Compare LC$_{50}$ from field collected populations to **susceptible laboratory colony** to determine level of resistance (Resistance Ratio)
Dose-mortality curves for OBLR

- Compare LC$_{50}$ from field collected populations to susceptible laboratory colony to determine level of resistance (Resistance Ratio)
Dose-mortality curves for OBLR

- Compare LC$_{50}$ from field collected populations to **susceptible laboratory colony** to determine level of resistance (Resistance Ratio)

![Graph showing dose-mortality curves for OBLR with LC$_{50}$ at 4 ppm and 40 ppm.]
Dose-mortality curves for OBLR

- Compare LC\(_{50}\) from field collected populations to susceptible laboratory colony to determine level of resistance (Resistance Ratio)
Guthion bioassay data - 2001 and 2004

$RR_{2004} = 3.9-30.0$

Dose (ppm)

Probit value

Percent mortality

High-2001

300 ppm

High-2004
Guthion resistance ratios: 1995-2004

Resistence ratio (based on 6.2 ppm)
Resistance Reversion

Generations in Colony

Resistance Ratio

Guthion

F1 | F3 | F5 | F9
Intrepid bioassay data - 2001 and 2004

Intrepid resistance ratios: 1997-2004

Resistance ratio (based on 1.54 ppm)

- MA
- MF
- AR
- BR1
- MA4
- MF4
- SN
- MF1
- MF4
- MF3
- Q2
- Q1

Registered 2001

1997
2003
2004

ns
Success bioassay data - 2004

LC$_{50}$ = 0.3

Concentration (ppm)

Probit value

Percent mortality

Manson

Colony-2004

Colony-2001

MF

Dilute field rate

0.8 ppm

30 ppm

90

50

100

10

3.0

3.5

4.0

4.5

5.0

5.5

6.0

6.5

7.0

0.01

0.1

1.0

10

100
Success resistance ratios: 1997-2004

Resistance ratio (based on 0.3 ppm)

Registered 1998

1997

2001

2004

MA1, MF2, AR, MA2, MA4, MF4, SN, TF1, M2, MF1, MF4, MF5, MF3, Q3, Q2, TF1
Conclusions

• All field populations resistant to Guthion
• Reversion may take place over 5-9 generations
• Evidence for cross-resistance to Intrepid
• Success probably not cross-resistant to Guthion
  ▪ Tolerance may be changing after 5 years of use