The Practice of IRM in Eastern Fruit Crops

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Primary Insect Pests of Apples

CM

OFM

PC

AM

OBLR
Secondary Insect Pests of Apples

- WALH
- STLM
- RAA
- PLH
- SJS
- WAA
Primary Drivers of Apple IPM Programs in Michigan

- Control of key direct pest: Codling moth.
- Control other direct pests (OBLR, OFM, PC, AM).
- Manage secondary pests when needed.
- Develop programs that are economically sustainable.
- Optimize strategies for resistance management
Rejected loads: 2000 - 2004
CM Susceptibility to Azinphosmethyl in MI, 2001

- Ridge: 10.7 x
- Ridge: 10.5 x
- Ridge: 8 x
- Belding: 7.8 x
- West Central: 4.4 x
- Lowell / Belding: 1 x
- Lowell / Belding: 1 x
- TNRC: 0.1 x

LC50 (µg/moth)
Awareness of Cross Resistance

Criteria for Successful IRM Programs

• Select high performance tools for CM control.
• Rotate insecticide MOA between generations.
• Select complementary partners within a given CM generation:
  – Optimize CM control
  – Cover secondary pests
# Codling Moth Control Options

<table>
<thead>
<tr>
<th>1&lt;sup&gt;st&lt;/sup&gt; Generation</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Generation</th>
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</thead>
<tbody>
<tr>
<td>- Rimon</td>
<td>- Rimon</td>
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<tr>
<td>- Calypso/Assail/Clutch</td>
<td>- Calypso/Assail</td>
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<tr>
<td>- CM virus</td>
<td>- Delegate</td>
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<tr>
<td>- Delegate</td>
<td>- Delegate</td>
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<tr>
<td>- Altacor/Belt</td>
<td>- Altacor/Belt</td>
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<tr>
<td>- Organophosphates</td>
<td>- Organophosphates</td>
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<tr>
<td>- Pyrethroids</td>
<td>- Voliam flexi</td>
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<td>- Voliam flexi</td>
<td>- Voliam flexi</td>
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<tr>
<td>- Tourismo</td>
<td>- Tourismo</td>
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<tr>
<td>- Leverage</td>
<td>- Leverage</td>
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<tr>
<td>Insecticide</td>
<td>CM</td>
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<td>-------------</td>
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<tr>
<td>Avaunt</td>
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<td>Intrepid</td>
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<td>Movento</td>
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<td>Esteem</td>
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<tr>
<td>Rimon</td>
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<tr>
<td>Assail</td>
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<tr>
<td>Calypso</td>
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<tr>
<td>Delegate</td>
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<tr>
<td>Proclaim</td>
<td>**</td>
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<tr>
<td>Altacor</td>
<td>***</td>
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<tr>
<td>Belt</td>
<td>***</td>
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Partnering for Broad Spectrum Control

**Spring:**

<table>
<thead>
<tr>
<th>CM + PC + aphids</th>
<th>OBLR + CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Neonics/CM virus</td>
<td>• Rimon / Delegate</td>
</tr>
<tr>
<td>• Neonics /Altacor</td>
<td>• Rimon / Belt</td>
</tr>
<tr>
<td>• Voliam Flexi</td>
<td>• Proclaim / Neonics</td>
</tr>
</tbody>
</table>

**Summer:**

<table>
<thead>
<tr>
<th>CM/OFM + AM + STLM</th>
<th>CM/OFM + SJS</th>
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</thead>
<tbody>
<tr>
<td>• Voliam flexi / Altacor</td>
<td>• /Assail</td>
</tr>
<tr>
<td>• Neonics/ Delegate</td>
<td>• Belt/Tourismo</td>
</tr>
<tr>
<td>• Neonics / Belt</td>
<td>• Leverage/Warrior</td>
</tr>
</tbody>
</table>
Seasonal Program Under Resistance Management

Seasonal Program Under Resistance Management

Apr May Jun Jul Aug

Delegate Delegate Altacor Altacor

Bloom

PF
egg laying
hatch

0 100 250 500 1000

Codling Moth Degree-days (base 50 F° post-biofix)
Seasonal Program Under Resistance Management (with OBLR, PC, and aphids present)

- Rimon Neonic Belt
- Belt

Bloom
- PF
- egg laying
- hatch

Codling Moth Degree-days (base 50 F° post-biofix)
Seasonal Program Under Resistance Management
(with OBLR and apple maggot, SJS present)

- **Rimon Delegate Neonics**
  - Neonics o
  - Neonics P
  - Neonics F
  - Neonics P0
  - Neonics 100
  - Neonics 250
  - Neonics 500
  - Neonics 1000

- **Codling Moth Degree-days (base 50 F° post-biofix)**
Seasonal Program Under Resistance Management

Voliam flexi Altacor

Diamide or Neonic

Bloom

PF

 Adults

Egg laying

Hatch

Codling Moth Degree-days (base 50 F° post-biofix)
Seasonal Program Under Resistance Management

- **Apr** - **May** - **Jun**
  - **Neonics Tourismo**
    - Adults
    - Egg laying
    - Hatch

- **Jul** - **Aug**
  - **Diamide or Neonic**

**Bloom**

**PF**

**Codling Moth Degree-days (base 50 F° post-biofix)**
Resistance Shortens Residual Activity of Insecticides

Fig 2. Mean and SE of codling moth larval entries in fruit exposed to infestation of the Fennville and Calderwood populations after a spray of azinphos methyl (Guthion 50 WP, 1.12 kg AI / ha).

Monitoring for Resistance

Ridge Belding Resistance

SW

NW

WC

SE

TNRC Kalamazoo

Percent corrected mortality

0 10 20 30 40 50 60 70 80 90 100
IRM Concerns

• All’s Quiet on the “secondary pest” front?
• Compounds targeting secondary pests may contribute to Codling Moth selection pressure?
• Differences in life-stage susceptibility and expression of resistance.
• Mechanisms responsible for cross-resistance and field tolerance?