Como manejar la palomilla de la manzana cuando nada parece funcionar

X SIMPOSIO INTERNACIONAL SOBRE EL MANZANO Y FRUTALES DE CLIMA TEMPLADO.

Patrick W. Weddle, BCE

Pacific Biocontrol Corporation
Subjects to Be Covered in Presentation

- Biology and Identification
- *Tactics* for effective and economical control
- Most effective *strategy* for deploying tactics
- Economics of multi-tactic strategy
- What can growers and their advisors do to always succeed in CM control
Origins of Codling Moth

CM Range Followed *Malus silvestris*; Europe, Caucasus, SW & mountains of Asia

Origin of Other Hosts Overlap; Pear - Caucasus, s. Europe; Walnut - Caucasus
Damage
Life Stages

- Eggs
- Neonate
- Adults
- Pupating larvae
- Egg

Images are sourced from the UC Statewide IPM Project, © 2000 Regents, University of California.
Cydia pomonella

Ciclo Vital

Adulto

Huevo
(hojas y frutos)

Pupa
(tronco)

Larva
5 instares
(frutos)
Codling Moth Life History
Biology and Behavior

Overwintering

Adult Activity (0 DD)

Larval Activity (250 DD)

2nd Gen begins (1250 DD)

Diapause Induction

Source: Brunner, WSU
CM Overwintering Mortality

Most larvae dead below -25 deg.C

Newcomer and Whitcomb 1924
Codling Moth Fecundity

Egg Mortality Can Be High (12 to 60%) Depending on Conditions
CM Numbers Game

- Spring
  - Females: 1,000
  - Number of Eggs Laid: 25,000
  - Post Egg Mortality: 12,500
  - Post Larval Mortality: 6,250
- Summer
  - Females: 1,000
  - Number of Eggs Laid: 50,000
  - Post Egg Mortality: 37,500
  - Post Larval Mortality: 28,125

1 becomes 6+ in Spring
1 becomes 28+ in Summer
What are the Most Effective Tactics?

- Systematically applying as many different tactics as available and economically practical to annihilate codling moth populations. AKA

The “Multi-tactic” IPM Approach
“Umbrella Tactic”

Mating Disruption
Commercially Available Delivery Systems

1. Hand Applied Dispensers

2. Aerosol Dispensers

3. Sprayable Formulations
Most Widely Used CMMD Formulations

Isomate C+ (C TT)
Pacific Biocontrol

102,000 ac. Apples & Pears in Western US

WA
84,000 ac

OR
2000 ac

CA
16,000 ac.
Estimated Pome Fruit & CM MD Treated Acreage in WA, 1996-2004

Pome Fruit Acres

CM MD Treated Acres

USDA – NASS Census of Agriculture
MECHANISMS OF MATING DISRUPTION

FALSE TRAIL FOLLOWING
ADAPTATION/HABITUATION

MASKING OF ODOUR TRAILS?

200 - 400 Dispensers/Ac
Moderate to High Release Rate/Dispenser
The Cost of Delaying Mating in the Lab for Codling Moth

A 2 night delay reduced the number of viable eggs by 45%.

Source: Dr. Alan Knight
Location, Location, Location

Worst

Better

Best

(Best on >5 Ha)
Supplemental controls may be required in moderate pressure orchards

Percent CM inj. previous year

0.1  0.5  2.0

Low  Moderate  High

1  2  4

Possible no. of cover sprays
What CMMD Can Do

- Reduce CM Populations
- Enhance efficiency of pesticide use
- Reduce use of “high risk” pesticides
- Reduce pesticide residues on fruit
- Resistance management
- Reduce input costs
- Reduce CM losses
Michigan Apples

3 Year Conclusions:

1. Relative cost of MD declined each year

2. MD was a viable means of economizing while reducing reliance on OPs

3. Overall economics was more attractive the greater fresh fruit sales and higher yields

4. The economics of Isomate C+ was particularly favorable due to reduced fruit damage relative to no MD
Strategies for Success with MD

• Location, location, location!
  – Size, shape and past pressure

• Product selection
  – Release rate, point sources

• Monitoring
  – Trap design, placement, management
  – Lure selection (Longevity, release rate)

• Supplemental treatments
  – Follow trapping thresholds
  – Focus on border controls
Monitoring is the “Cornerstone Tactic”
Monitor Daily Temperatures

<table>
<thead>
<tr>
<th>Timing</th>
<th>Event</th>
<th>Management action</th>
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<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; generation</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; generation</td>
<td>Start of flight</td>
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<tr>
<td>0 DD°</td>
<td>1060 DD°</td>
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<td>250 DD°</td>
<td>1250-1300 DD°</td>
<td>First egg hatch</td>
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<tr>
<td>350 DD°</td>
<td>1350-1400 DD°</td>
<td>20% egg hatch</td>
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<td>Still under threshold</td>
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<tr>
<td>10-21 days after treatment</td>
<td>Loss of residual</td>
<td>Over threshold</td>
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<td>Under threshold</td>
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<tr>
<td>10-21 days after treatment</td>
<td>Loss of residual</td>
<td>TREAT if over threshold and model indicates continued egg hatch</td>
</tr>
<tr>
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<tr>
<td>1000 DD°</td>
<td>2100 DD°</td>
<td>End of flight</td>
</tr>
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</table>
Monitor Adult Moths

Note: Delta traps maintain integrity and are easier to service. Keep clean bottoms in trap.
• Trap Height
• Trap Type
• Lure Type (10X vs. 1X)
• Trap Location
• Consistency!
Monitor Fruit Damage at Each Generation and Harvest
Codling Moth Resistance to OPs

• Azinphosmethyl Used for Almost 40 Years

• Resistance First Documented in 1989
  – California, Washington, South Africa, others
  – Low levels Give Control Difficulties

• Cross-Resistance to Many Classes
  – Ops, Carbamates, Pyrethroids, IGRs
  – Chlorinated hydrocarbons

• Negatively-Correlated Cross-Resistance
  – Chlorpyrifos: 6-12 fold
  – Methyl parathion: 2-4 fold

John Dunley, WSU
## Larvicides to Control CM

**Expected % Control**

<table>
<thead>
<tr>
<th>Insecticide</th>
<th># tests</th>
<th>Ave. % control</th>
<th>$/ac.</th>
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<tbody>
<tr>
<td>Guthion</td>
<td>16</td>
<td>96.3%</td>
<td>20</td>
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<tr>
<td>Imidan</td>
<td>2</td>
<td>92.3%</td>
<td>35</td>
</tr>
<tr>
<td>Warrior</td>
<td>2</td>
<td>91.1%</td>
<td>9</td>
</tr>
<tr>
<td>Assail</td>
<td>21</td>
<td>87.3%</td>
<td>45</td>
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<tr>
<td>Calypso</td>
<td>16</td>
<td>83.4%</td>
<td>36</td>
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<tr>
<td>Success</td>
<td>10</td>
<td>82.9%</td>
<td>30</td>
</tr>
<tr>
<td>Entrust</td>
<td>2</td>
<td>75.1%</td>
<td>48</td>
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<tr>
<td>Avaunt</td>
<td>10</td>
<td>66.5%</td>
<td>35</td>
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<tr>
<td>CpGv</td>
<td>4</td>
<td>50.0%</td>
<td>30</td>
</tr>
</tbody>
</table>

Mike Doerr, WSU

- Stand alone
- Supplement
Coverage is Critical!

- Ops, carbamates & pyrethroids, required *good* coverage
- IGRs, chloronicotinyls, microbials, particle films require *excellent* coverage
- Sprayers must be carefully calibrated for use with new insecticides
- Higher volumes of water improve control
- Be careful with tractor speed
- “Trim” row ends and borders with extra spray
Mating Disruption

- Monitoring
- Granulosis Virus
- Horticultural Oil
- Insect Growth Regulators
- Organophosphates
- New Chemistries
Horticultural oil

- Orchex 796 safe for multiple apps
- MOA- Smother eggs
- Trees must not be stressed by heat or dryness
- Coverage, concentration, rates
- Reduce potential for resistance
Oil Improves Control

• Smothers codling moth eggs
• Improves control with IGRs and chloronicotinyls (Van Steenwyk)
• Provides suppression of scale insects
• Provides suppression of mites
• Helps to prevent resistance to other pesticides
Granulo Virus
Origins & History

CpGV Isolated from Larvae in Mexico, 1963
First Field Tested by University of California, 1965 to 1972
Sandoz Produced the First Commercial Formulation (SAN 406)
Granulo Virus
Mode of Action

Introduction to Host

- Granules Must Be Ingested by the Larvae
  - Uptake from the Surface of Leaves and Fruit
- Granules Dissolve in the Alkaline Gut
- Virus Infects the Gut Cells & Replicates
- Virus Moves to the Fat Body and Replicates
Mating Disruption & Virus to Control CM

Charmillot and Pasquier 2002

No Controls

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<tr>
<td>Sirene CP 5/10</td>
<td>Fenoxyccarb 5/27</td>
<td>Isomate C Plus</td>
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<td>Sirene CP 6/12</td>
<td>Dimilin 6/26</td>
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<tr>
<td>Phosalone 7/2</td>
<td>Phosmet 8/2</td>
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<tr>
<td>Granulosis Virus</td>
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<tr>
<td>Phosalone 7/28</td>
<td>Lorsban 8/14</td>
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</tr>
</tbody>
</table>

- **Sirene CP**: 5/10, 6/12
- **Fenoxyccarb**: 5/27
- **Dimilin**: 6/12, 6/26
- **Phosalone**: 7/2
- **Phosmet**: 8/2
- **Granulosis Virus**: 8 X 100 ml, 3 X 100 ml, 1 X 100 ml, 1 X 100 ml
- **Dimilin**: 7/28
- **Lorsban**: 8/14

**Note:** The table represents different treatments and their application rates for controlling caterpillar damage.
Insect Growth Regulators

Mating Disruption

Organophosphates

Horticultural Oil

Granulosis Virus

Monitoring

Orchard Sanitation

Physical Controls

New Chemistries

Organophosphates

Orchard Sanitation

Physical Controls
Sanitation & Physical Controls

• Remove infested fruit from orchard
• Bin piles and orchard props house CM
• Don’t dump cull apples in or near the orchard
• Beware of infestations near lighted areas
• Beware of border infestations
• Know your orchard, know your neighbor
Predicting problem areas, hot spots

- Abandoned or untreated trees
- Abandoned or Untreated orchards
- Bin piles
What is the Key to Sustainable Multi-tactic IPM Programs?

Use Control Tactics Against All Life Stages

- **Adults**
  - Mating Disruption

- **Eggs**
  - Intrepid, Esteem, oil

- **Larvae**
  - Ops, Assail, Success, Intrepid, CpGV
Key Information Resources for Apple IPM in USA


• [http://www.tfrec.wsu.edu/](http://www.tfrec.wsu.edu/)

• [http://www.ipm.msu.edu/](http://www.ipm.msu.edu/)
Key Information Resources for Apple IPM in USA

http://www.agcenter.org/progpest.html
What is the Most Effective Strategy?

- Cooperative programs focused on collective efforts to economically annihilate codling moth populations in a targeted geographical area, AKA “Area-wide Programs”
Codling Moths Areawide Management sites (CAMP)

The original 5 CAMP sites were funded as part of a USDA pilot implementation project for areawide management of pests in a cropping system.
CAMP Statistics

- 5 year program 1995-99
- 6 western US states
- USDA, WSU, OSU, UCB
- 1064 Ha in 1995 – 8400 Ha in 1999
- 66 growers initially - 400+ in 1999
- Today approx. 60,000 Ha of CMMD applied

Howard Flat CAMP Site
Chelan, Washington


- Average number of moths per trap
- Average percent fruit injury
- Average number of sprays per acre
Summary
What Have We Learned?

• Ideally, CM must be controlled to “extinction” levels to be economically manageable
• “Conventional” control methods are at risk
  – Resistance
  – Regulation
• Alternative tactics and strategies are more complex
• The $ costs of chemicals are increasing
Summary: Economic Realities

- **Efficacy** is the #1 criteria for selection of a CM management strategy.

- The **cost to manage** CM can be very expensive. The **cost of damage** is always more expensive.

- The lower the CM population the lower the cost to manage.
Summary
It is a Simple Equation

- Soft Pesticides + CMMD = Better Survival of Natural Enemies

- Soft Pesticides + Natural Enemies + CMMD = CM Population Reduction

- Reduced CM Populations = Reduced Damage + Reduced Costs
Please Remember

- **MD based IPM requires:**
  1. Initial (year 1) investment
  2. Multiple year use to be effective
  3. Increased management (i.e. *orchard monitoring*)

- **MD based IPM provides:**
  1. Favorable economics especially after first year
  2. Reduced OP & pyrethroid reliance
  3. Reduced target and overall pest damage
Area-wide MD based multi-tactic IPM
Is your best strategy for success

Insect Growth Regulators
Organophosphates
Granulosis Virus
Horticultural Oil
Monitoring
Orchard Sanitation
Physical Controls
New Chemistries
Orchard Sanitation
Physical Controls