Codling Moth Management: Yesterday and Today

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The Good Ol’ Days: A simpler time...

- **1930s** = 6-10 lead arsenate sprays to achieve control
- Spray recommendations assume “thoroughness of application”
“Assume thoroughness of Coverage”
1937 Spray Guide

Very few reports of control failures

“Guthion doesn’t work as well as it used to!”
“Assume thoroughness of Coverage”
1937 Spray Guide

Days After Treatment

% Mortality

- Guthion 400 g/a
- Assail 400 g/a
- Guthion 100 g/a
- Assail 100 g/a

Residual control
The Good Ol’ Days: A simpler time…

• 1940s DDT replaces failing lead arsenate
• Synthetic insecticide era begins
• A succession of “silver bullets” follow
The Good Ol’ Days:
A simpler time…

• 1950s = Growers reporting DDT failures
• Organophosphates become popular
• Parathion replaces DDT
The Good Ol’ Days: A simpler time...

• **1960s** = Guthion and carbaryl replace Parathion
• The Guthion era begins
• A very long period of excellent efficacy noted
The Good Ol’ Days: A simpler time...

- **1970** “Pome Fruit Pests and Their Control”, H. Madsen and C. Morgan - Summerland Canada
- Azinphos-methyl active for 12 days
- Control of CM dependent on correct timing
  - Lure baited traps and degree-day models
- Granulosis virus has potential to control codling moth if improvements can be made
Target Multiple Life Stages with One Spray

Why Guthion appeared to work for 28 days

- CM Degree-days
- Bloom
- May
- June
- CM Adults
- CM Eggs
- CM Larvae

GUTHION

Bloom
Target Multiple Life Stages with One Spray

Why Guthion appeared to work for 28 days

CM Degree-days

Guthion

CM Adults
CM Eggs
CM Larvae

Bloom

May

June

Bloom

CM Degree-days
Target Multiple Life Stages with One Spray

Why Guthion appeared to work for 28 days

- CM Degree-days Bloom
  - Bloom
  - May 0-100
  - June 300-900

- CM Adults
- CM Eggs
- CM Larvae
Target Multiple Life Stages with One Spray

Why Guthion appeared to work for 28 days

Bloom

May

June

CM Degree-days

Guthion

CM Adults

CM Eggs

CM Larvae

CM Bloom

[Graph showing life stages and degree-days]
Target Multiple Life Stages with One Spray

Why Guthion appeared to work for 28 days

Bloom

CM Degree-days

0 100 300 500 700 900

May June

CM Adults
CM Eggs
CM Larvae

GUTHION

Bloom

CM Degree-days
Target Multiple Life Stages with One Spray

Why Guthion appeared to work for 28 days

CM Degree-days Bloom

May June

CM Adults
CM Eggs
CM Larvae

Bloom

CM Degree-days

0 100 300 500 700 900
Target Multiple Life Stages with One Spray

Why Guthion appeared to work for 28 days

CM Degree-days

Bloom

May June

0 100 300 500 700 900

CM Adults
CM Eggs
CM Larvae

GUTHION

87% Hatch

Bloom

CM Degree-days
The Good Ol’ Days: A simpler time...

- Aggressive control of 1st gen. important
- Be aware of 3rd generation in warm years
- Monitoring programs essential
  - Pheromone traps
  - Careful observations and record keeping
  - Use degree-day model
- Pheromone traps
  - Relative density
  - Validate model
  - Warning: Multiple traps necessary
- Consider 2° pests when choosing products
The Good Ol’ Days: A simpler time…

“Codling moth control is more expensive and more complicated”

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The Good Ol’ Days: A simpler time…

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<td>$172</td>
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The Good Ol’ Days: A simpler time...

- **1990s**
- The writing is on the wall, “What will we do without Ops?”
- Codling Moth Areawide Management Program (CAMP) successful
  - Mating disruption gains acceptance
  - Ability to reduce insecticides
  - Organic management may work large scale
The Good Ol’ Days: Lessons learned over time…

“Areawide Codling Moth Management”
Howard Flat, Chelan, WA
The Good Ol’ Days: A simpler time…

- **2000s** = Growers reporting Guthion failures…
- The end of an era, or an inevitable progression?
- Where do we go from here? Legalize drugs, ban insecticides???
Codling Moth Management Today

The fundamentals never change

- Monitoring for Pests
- Product Choice
- Integration of Tactics
- Timing
- Coverage (Horticulture, mechanical)
- Areawide Management Works
Monitoring Programs Essential
Madsen 1970, Brunner 1985

• Understand model predictions
• Consistent trapping program
  ▪ Measure relative densities
  ▪ Monitor adult movement
• Visual inspections
  ▪ Locate hot-spots
  ▪ Assess need for retreatment
• Keep detailed records
Codling Moth Management Today
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“Be Aggressive Against the 1st Gen”
Brunner 1985

Begin each season with an ovicide (IGR or Oil)

Date (degree-days from biofix)

Avg Cumulative % CM Injury

- Rimon 75DD
- Rimon 200DD
- Oil 200DD
- Intrepid 75DD
- Intrepid 200DD
- Esteem 75DD
- Untreated


(246) (272) (330) (415) (444) (495)
“Delay 1st Cover in Low Pressure Sites”
J. Brunner 1985

Bulk of residues at time of greatest population growth

Date (degree-days from biofix):

Avg Cumulative % CM Injury

- Rimon 75DD
- Rimon 200DD
- Oil 200DD
- Intrepid 75DD
- Intrepid 200DD
- Esteem 75DD
- Untreated

350DD+
1st cover

(246) (272) (330) (415) (444) (495)
Codling Moth Management: Egg Hatch Model Predictions

Percent Egg Hatch (1st Generation)

Cumulative CM DD
Codling Moth Management:
Egg Hatch Model Predictions

Percent Egg Hatch (1st Generation)

12% Egg Hatch

Cumulative CM DD
Codling Moth Management: Egg Hatch Model Predictions

Percent Egg Hatch (1st Generation)

- 12% Egg Hatch
- 68% Egg Hatch
Codling Moth Management: Egg Hatch Model Predictions

Percent Egg Hatch (1st Generation)

- 12% Egg Hatch
- 20% Egg Hatch
- 68% Egg Hatch

Cumulative CM DD

0 100 200 300 400 500 600 700 800 900 1000

Washington State University
World Class. Face to Face.
Codling Moth Management: Traditional Timing

Percent Egg Hatch (1st Generation)

Cumulative CM DD

1st Cover Spray

2nd Cover Spray

Weakest Residues

1st Cover Spray

2nd Cover Spray
Codling Moth Management: Ovicide Delayed Egg Hatch

Percent Egg Hatch (1st Generation)

Cumulative CM DD

1st Cover Spray

2nd Cover Spray

Ovicide

0 100 200 300 400 500 600 700 800 900 1000

0 10 20 30 40 50 60 70 80 90 100

Cumulative CM DD
Ovicidal IGRs

CM Management with Ovicides Only

Percent Reduction in CM Injured Fruit Relative to UTC

- Rimon: Significant reduction
- Intrepid: Moderate reduction
- Esteem: Lesser reduction
- Oil: Moderate reduction

Values range from 0 to 100.
Ovicidal IGRs
Opportunity for LR Control

% Reduction From Control (Range)

Intrepid
Esteem
Rimon

Control at 2nd generation
Target Multiple Life Stages with One Spray

Tank mix IGR and Neonic (350 DD cover)

- CM Adults
- CM Eggs
- CM Larvae

Bloom

May
0 100

June
300 500 700 900

CM Degree-days
Target Multiple Life Stages with One Spray

Tank mix IGR and Neonic (350 DD cover)

CM Degree-days

Bloom

May

June

0 100 300 500 700 900

CM Adults

CM Eggs

CM Larvae

Bloom

CM Degree-days
Target Multiple Life Stages with One Spray

Tank mix IGR and Neonic (350 DD cover)

- CM Degree-days Bloom
- Bloom
- CM Degree-days

CM Adults
CM Eggs
CM Larvae

May
June
Bloom
CM Degree-days
Target Multiple Life Stages with One Spray

Tank mix IGR and Neonic (350 DD cover)

CM Degree-days

Bloom

May 0 100 300 500 700 900 June

CM Adults
CM Eggs
CM Larvae

Bloom

CM Degree-days
Target Multiple Life Stages with One Spray

Tank mix IGR and Neonic (350 DD cover)

Bloom

0 100 300 500 700 900

May June

CM Adults
CM Eggs
CM Larvae

Neonic + IGR

97% Hatch
Neonicotinyls

Percent Reduction in CM Injured Fruit Relative to UTC

- Guthion: 90%
- Assail: 80%
- Calypso: 75%
- Clutch: 45%
CM and LR Target Life Stages

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

Bloom

CM Degree-days

Bloom

May

June

July

Aug.

Sept.

0 100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300
Standard Insecticide-based Program

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

- May
- June
- July
- Aug.
- Sept.

Bloom

CM Degree-days

- Lorsban
- Guthion
- B.t.
- Imidan
- Success
- LR
Neonicotinyl Replacement

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

- Lorsban Bloom
- Success Bloom
- Guthion
- Neonicotin
- B.t.
- Imidan

CM Degree-days

Bloom
Increased Pressure- What’s Next?

CM Adults
CM Eggs
CM Larvae
LR Larvae

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

Bloom
CM Degree-days

May June July Aug. Sept.
Mating Disruption As Foundation

**Mating Disruption**

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

- **Guthion**
- **Neonic.**
- **Guthion**
- **Imidan**
- **B.t.**

- **Lorsban**
- **Success**

**Bloom**

**CM Degree-days**
Hand Applied Pheromone

*Release rate and longevity*

mg codlemone remaining in dispenser

- Isomate CTT
- Isomate C+
- NoMate

Age in days

2002
Mating Disruption Makes a Difference Even Under Extreme Pressure

Pattern of damage after season-long spraying
40 acre block
Mating Disruption Makes a Difference Even Under Extreme Pressure

Pattern of damage after season-long spraying 40 acre block
NoMate Fibers and Disrupt Flakes

Point Sources
Hand Applied>Fibers>Sprayable
Release Rate
Hand Applied>Fibers>Sprayable
NoMate Fibers and Disrupt Flakes
Promising ability to affect trap captures

Long vs. Short Fiber

Flake Rate Study

78% Trap Shutdown

79% Trap Shutdown
Ultra Low Volume MEC Sprayable

Point Sources
Hand Applied>Fibers>Sprayable
Release Rate
Hand Applied>Fibers>Sprayable
Ultra Low Volume MEC Sprayable
Greatest effect noted in 2nd generation

Sprayable Rate Trial

75% Trap Shutdown
Mating Disruption As Foundation

Mating Disruption

CM Adults
CM Eggs
CM Larvae
LR Larvae

Bloom

CM Degree-days

May
June
July
Aug.
Spt.

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

Guthion
Neonic.
Guthion
Imidan
B.t.

Lorsban
Success

Bloom

Eggs
Larvae

Adults
Eggs
Larvae

Neonic.
Imidan

0
t
100
t
300
t
500
t
700
t
900
t
1100
t
1300
t
1500
t
1700
t
1900
t
2100
t
2300
Mod. Pressure- Need For Ovicide

Mating Disruption

CM Adults
CM Eggs
CM Larvae
LR Larvae

Lorsban
IGR
Guthion Neonic.
Guthion
Imidan
B.t.

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

Mating Disruption

CM Adults

CM Eggs

CM Larvae

LR Larvae

IGR + IGR

Neonic.

Guthion

Imidan

B.t.

Bloom

May  June  July  Aug.  Sept.

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

CM Degree-days

Bloom
Highest Pressure - Need For Ovicide

CM Adults
CM Eggs
CM Larvae
LR Larvae

Mating Disruption

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

CM Degree-days

Bloom
Stable CM and LR Control - AWII

Reduced rates (250 d/a)

CM Adults
CM Eggs
CM Larvae
LR Larvae

IGR ± IGR

May June July Aug. Sept.

Bloom

CM Degree-days
“Granulosis virus shows promise”
H. Madsen 1970

2-yr side by side demonstration
(both treatment plots with MD and oil)

Untreated

House

Entrust (x4)
+ Virus (x6)

Virus (x8)
“Granulosis virus shows promise”
H. Madsen 1970

Year 0 Harvest
% Fruit Damage

- Entrust + Virus
- Virus
- Untreated
“Granulosis virus shows promise”
H. Madsen 1970

Year 1 First Generation
% Fruit Damage

Entrust + Virus: 2.3%
Virus: 13.9%
Untreated: 60.0%
"Granulosis virus shows promise"
H. Madsen 1970

Year 1 Second Generation
% Fruit Damage

- Entrust + Virus: 8.3
- Virus: 33.5
- Untreated: 96.0
“Granulosis virus shows promise”
H. Madsen 1970

2-yr side by side demonstration
(2nd-year received no Entrust)

Untreated

House

Virus (x11)  Virus (x11)
“Granulosis virus shows promise”
H. Madsen 1970

Year 2 First Generation
% Fruit Damage
“Granulosis virus shows promise”
H. Madsen 1970

Year 2 Second Generation
% Fruit Damage

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<th>Virus</th>
<th>Virus</th>
<th>Untreated</th>
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<tr>
<td>0%</td>
<td>26.0</td>
<td>26.0</td>
<td>96.0</td>
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<tr>
<td>80%</td>
<td>37.0</td>
<td>37.0</td>
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<tr>
<td>100%</td>
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“Granulosis virus shows promise”
H. Madsen 1970

2004 2nd Generation
(16.3 moths/trap)

2005 2nd Generation
(9.0 moths/trap)
Organic CM - Best chance for success

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

Bloom

May: 0-100
June: 300-700
July: 900-1100
Aug.: 1100-1300
Sept.: 1300-1500

CM Degree-days

Bloom

0 100 300 500 700 900 1100 1300 1500 1700 1900 2100 2300
Organic CM - Best chance for success

Mating Disruption

CM Adults
CM Eggs
CM Larvae
LR Larvae

Bloom
CM Degree-days

May June July Aug. Sept.
Organic CM - Best chance for success

Mating Disruption

CM Adults

CM Eggs

CM Larvae

LR Larvae

Oil

Oil+

Entrust

Oil

Oil+

Entrust

Oil

Oil+

Entrust

Bt

May

June

July

Aug.

Sept.

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

Bloom

CM Degree-days
Organic CM - Best chance for success

Mating Disruption

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

Bloom

May June July Aug. Sept.

CM Degree-days

Bloom

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

- Virus
- Oil
- Oil+ Entrust
- Bt
- Virus
- Oil
- Oil+ Entrust
- Virus
- Oil
- Oil+ Entrust
- Virus
- Oil
- Oil+ Entrust
- Virus
- Oil
- Oil+ Entrust

Oil

Entrust

Oil+

Virus

Virus

Virus

Virus
Best Chance for Success

• Be creative, don’t keep doing the same thing if it is not working!
• Establish a consistent monitoring program
• Use mating disruption as a base to your CM control program
Lessons learned from AWII

- Cost of CM control increases with softer programs
  - Less toxic, shorter residual = more apps
- Overall cost and control of soft and conventional programs are equal
  - IGRs, chloronicotinyls control multiple pests
  - Biocontrol likely reducing need for some sprays
- Use oil whenever possible (CM control)