Reduced rates of pheromone applications for control of codling moth (*Cydia pomonella*) in pear and walnut orchards

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Two approaches

- Reducing the number of point sources per acre to reduce labor costs (meso dispensers)
- Reducing the amount of pheromone required per acre to reduce material costs (meso and puffer trials) – D. Casado
• Goal: To optimize pheromone mating disruption for codling moth for lower overall costs and lower labor requirements
  • Design a device that provides comparable control to current pheromone MD standard programs (CTT, Checkmate in US) using hand-applied dispensers

• 2009-10 field trial focus – Large block testing of “best” mesos from 2007 and 2008
  • Meso-emitter rate trials (walnuts only)
  • Meso-emitter large plot efficacy trials (walnuts and pears)
Conclusions – Starting at the End

• Meso emitters appear to provide control equal to the standard pheromone programs IF the same levels of pheromone per acre are used (20 Suterra Mesos and 40 Rings)

• At lower densities of codling moth, lower levels of pheromone should also work

• If verified with damage data, the amount of pheromone per acre in puffers can be reduced by 50% or more

• Reductions in labor (meso dispensers) and overall program costs (amount of pheromone) appear possible
Pheromone “Meso-emitter”

- Hand applied dispenser unit
- Reduced point sources: 18-20 units per acre vs >160 per acre
- Higher emission rate per unit (vs Checkmate or Isomate)
- Initially keeping the amount of pheromone constant per acre
Current Meso-emitter Products
(Differ in Expected Total Pheromone per Acre)

Isomate “Ring” (2008)

* 2009 “ring” is a 5-C TT unit that separates to form a ring of 10 single tubes. Deployed at 20-40 rings per acre.

Suterra membrane type dispensers. G037 deployed at 18 units per acre.

CM XL1000 (for comparison)
2007 Walnuts: Point Source Manipulation
Total Codling Moth Damage at Harvest

Selected **20 units** per acre as starting point from replicated 5 acre plot trial
2010 Meso-emitter Efficacy Trials

Large plot meso plots in orchards expected to have high codling moth densities (1 Sacramento, 3 in Lake County)

Treatments:
- Meso Treatment (Suterra Meso or Pacific Biocontrol Rings)
- Standard pheromone (Checkmate or CTT)
- Controls (Untreated (3))

Assessments: Fruit Damage and Trap Suppression
Suterra Meso-emitter Efficacy 2009

Combined commodity data (n=8)

• Damage was significantly suppressed by meso program compared to control
• No statistical difference between meso and standard pheromone programs
• Control plots were as follows
  • Pears – untreated controls
  • Walnuts - may have included insecticide treatments applied by the grower uniformly to both control and pheromone plots.
• Plots sizes varied, but ranged from 10-20 acres for meso plots

Blocks with 0% damage in all treatments excluded

Pear and Walnut Combined Codling Moth Damage at Harvest 2009

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent Codling Moth Damage ±SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (GS)</td>
<td>3%</td>
</tr>
<tr>
<td>XL1000 + GS</td>
<td>1%</td>
</tr>
<tr>
<td>G037 + GS</td>
<td>0%</td>
</tr>
</tbody>
</table>

P = 0.03 *
2009-2010 Isomate Ring and Suterra Meso Trials
Codling Moth Damage at Harvest

Suterra Meso + GS

Pheromone Standard + GS

Grower Standard (GS)

Isomate Ring + GS

Pheromone Standard + GS

Grower Standard (GS)

Percent CM Damage ± SE
0% 2% 4% 6% 8% 10%

Suterra Meso
n = 12
P = 0.001

Isomate Ring
n = 5
P = ns
For each lure type higher numbers collected in untreated controls

Lack of independence between plots indicated by low 1x counts in untreated controls

No significance between plot treatments

Even with large blocks, there is pheromone intrusion

Meso treated plots will catch more moths (ca. 10-20%)
2010 Pears: Modified Dispenser Efficacy Trials
Season Total Trap Capture

Number of Codling Moth per Trap

Lure Type
- 1x
- combo

Lakeport
- Pheromone Std
- Suterra Meso
- Grower Std (no MD)

Upper Lake
- Pheromone Std
- Isomate Ring
- Grower Std (no MD)

Walnut Grove
- Pheromone Std
- Isomate Ring

Season Total Trap Capture:
- (98%)
- (100%)
- (95%)
- (90%)
Trap Suppression in Walnuts

High pressure orchard in Gustine, CA

Whereas combo lure baited traps >1300 moths / season, 1X baited traps were suppressed 100%
2010 Isomate Ring Efficacy Trials at 50% of Full Rate
Codling Moth Damage at Harvest

Crop / Site

- WALNUTS
  - Glenn
  - Winters Halley

- PEARS
  - Walnut Grove
  - Upper Lake

- Isomate Ring+GS
- Pheromone Standard +GS
- Grower Standard (GS)

Percent Damage

Note: Only 50% AI per acre at 20 units per acre
## 2010 Walnuts and Pears: Isomate Ring Dispenser Trials
### Season Total Trap Capture per Trap and 1x-Trap Suppression

<table>
<thead>
<tr>
<th>Site/Treatment</th>
<th>PEARs</th>
<th>WALNUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1x combo</td>
<td>100%</td>
<td>98%</td>
</tr>
<tr>
<td>combo</td>
<td>95%</td>
<td>100%</td>
</tr>
<tr>
<td>Pheromone Std</td>
<td>n/a</td>
<td>94%</td>
</tr>
<tr>
<td>Isomate Ring</td>
<td>n/a</td>
<td>91%</td>
</tr>
<tr>
<td>Grower Std (no MD)</td>
<td>n/a</td>
<td>98%</td>
</tr>
</tbody>
</table>

### Chart Details:
- **PEARS**
  - Upper Lake: 100%
  - Walnut Grove: 95%
  - Grower Std (no MD): n/a
- **WALNUTS**
  - Winters 1: 94%
  - Winters 2: 91%
  - Grower Std (no MD): 98%

### Site/Treatment
- Upper Lake
- Walnut Grove
- Winters 1
- Winters 2

### Chart Notes:
- "1x combo" and "combo" represent trap suppression rates.
- "n/a" indicates not applicable.
Trap Suppression in Pears using rings at 50% of Full Rate

Consistent “breakthrough” in rings at 50% of full rate, but also in standard CTT

Very high pressure observed in combos
Aerosol Delivery of Pheromones: Suterra “Puffers”

- Mechanical automatic devices
- Emit puffs of aerosol pheromone every 15 minutes for 12 hours a day
- High emission rate
- Low density (0.5-1 units/ac)
- Ease of application
- Unfarmed (3 years) pear orchard
- 17 acres (7 ha) approx.
- Heavily infested by codling moth (20.4 ± 1.6 males/trap & night in early-June)
Lures
- Pheromone: 1 mg commercial lures
- Females:
  - 1 virgin female (< 24 h)
  - kept in a 4 x 4 x 4 cm$^3$ aluminum cages
  - sugar water supplied daily

Data recorded
- Number of males/night
- Time to first capture (nights)
- Effectiveness (nights with captures/total nights)
-2 complete replicates in 2009, 2-4 reps in 2010
No puffer

- Captures in absence of puffer were reasonably uniform across the orchard (despite some hot-spots)

With puffer

- In presence of the puffer a gradient of captures, perpendicular to the wind direction, was very apparent. Captures were totally suppressed up to 900 ft downwind.

- Smaller values without puffer due to timing of the control (late in season)
Plume cutting a swath through codling moth flight

pheromone lures, July 23rd to 31st (captures/night)
Rate Effects on Plume Size and Shape on Wild CM Males in Pears

1% 10%

No clear plume observed with 1% ai per puff

Smaller, more narrow plume with 10% ai per puff

50% 100%

50% and 100% rates with roughly similar plume size and shapes
Effects of Rates on Sterile CM Males in Walnuts

Relatively small plume with 1% ai per puff with little clear distinction between 10 and 50% plume
Paired Rate Contrasts

50 vs 100%

10 vs 100%
Passive Versus Active Release

Puffer with 50% ai pheromone load compared to aggregated 10-unit “Pacific Biocontrol Ring” dispenser that were estimated to release at the same overall rate per day

Contrasts the effect of delivery mechanism (intermittent aerosol bursts versus continuous diffusion from reservoir system)
SECONDARY EMISSION OF PHEROMONE FROM PUFFER-EXPOSED LEAVES

Objective: test attraction of codling moth males to leaves exposed to a puffer plume

Pheromones have been shown to bind to surfaces (e.g. glass, leaves,...)

For other insects, Lobesia, LBAM, pea moth, pheromones bind and are released later

Residual plume images for codling moth suggested secondary release

Do puffers impregnate the orchard such that the orchard becomes the emitter
Approach

• CM puffer run at standard settings in walnut and pear orchards

• Leaves collected after one week at different horizontal distances downwind from puffer and frozen
  – Distances of collection: <1, 17, 50, 100, 135 and 170 m

• In walnuts only, a vertical transect run at multiple distances from dispenser

• Replicates of 15 to 20 codling moth males were exposed to leaf samples in the wind tunnel

• Males were flown one-by-one, allowed a 3 minute response time
- Unfarmed (3 years) pear orchard
- 17 acres (7 ha) approx.
- Heavily infested by codling moth (20.4 ± 1.6 males/trap & night in early-June)

- Pheromone puffer
- Pheromone-baited trap (53)
- Female-baited trap (40)
Moth Flight Wind Tunnel

- Room air is filtered as it is pulled into the tunnel.
- Odor source placed at “upwind” position in tunnel.
- Moths placed at downwind end of tunnel.
Secondary Release from Pear Foliage Relative to Distance from Puffer

Beginning of Oriented Flight

Oriented (sustained) flight up to more than one half of the wind tunnel

Close-in approach to the leaflets

Contact
Meso Dispensers at full rates appear to be viable alternatives for control of codling moth in larger mature walnut and pear tree canopies.

Opportunities for reducing the amount of pheromone per puff exist.
2010 Walnuts: Suterra Meso Trial
Codling Moth Damage at Harvest

Same general pattern observed in 2010, but not statistically different

Pressures were quite good in a lot of the orchards

*sites with less than 0.5% damage in Grower Standard were excluded from analysis