Mating disruption: A selective tool for fruit pest management

Larry Gut

"Hold it right there, young lady! Before you go out, you take off some of that makeup and wash off that gallon of pheromones!"
Moth Sex 101: “how males find females”

- Females release pheromone from specialized glands

Wind

Pheromone plume

- Antennal hairs sift pheromone molecules from the air
- Odorant stimulates receptor cells within antenna
How males normally find females

gentle wind

female
female

gentle wind
female

gentle wind
gentle wind

eggs
How does it work?

Mating disruption is intended to stop this!!
• Identify and synthesize pheromone
• Load in release device
• Deploy in field

Monitoring

ca 0.010 micrograms per female gland

Direct control
(e.g., mating disruption)

ca. 0.1 micrograms per dispenser / hour

10x

ca. 5 micrograms per dispenser / hour

50x
Principal models (explanations) for mating disruption:

Competition (False-plume-following) – males are diverted from orienting to authentic females due to competing attraction to nearby false plumes from pheromone dispensers.
Principal models (explanations) for mating disruption:

Non-competitive, (e.g., Desensitization) – males cannot find calling females because pre-exposure to pheromone causes loss of sensitivity in antennae or brain.
In practice, mating disruption entails:

- Dispensing a large amount of sex pheromone within the crop
- Disturbing the normal behavior of male insects
- Interfering with mating
- And hence reducing the incidence of larvae
40 years of trial-and-error

**Operational factors**

- Technological
  - pheromone delivery strategies,
  - application parameters
  - characteristics of the site

- Management considerations

- Economics
  - costs relative to other control options,
  - compatible with current IPM programs,
  - easy to use

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Deliver the appropriate amount and blend of pheromone in a cost-effective manner
Worldwide use of MD

- GM: 200,000 ha
- EGVM: 150,000 ha
- VM: 60,000 ha
- GM: 220,000 ha
- OFM: 60,000 ha

Total: 756,000 ha
LARRY'S MOST EXCELLENT ADVENTURE WITH PHEROMONES

Full-blown resistance has developed

On top of the world as a bachelor in Wenatchee

End of 1st year pheromone research

The lonely disrupted years

Tolerance to pheromones occurs

91 92-93 94 95
…… pheromone traps are the primary means of assessing disruption treatments

Males can’t locate “calling females”

Trap serves as false female, thus males can’t locate standard trap

More robust measures
Monitoring in disrupted orchards

- For most species, use standard lure; catches should be near 0
- For CM, use standard and “high-load” or CM/DA lures
- Place traps in areas with history of pest pressure
- Position traps at mid-canopy or high (CM) in the canopy

*CM/DA Improves Monitoring of seasonal flight*

![Graph showing mean moths per trap over time for L2 and CM/DA lures.]

- **CM/DA** Improves Monitoring of seasonal flight
Bottom line

- Select a trap/lure combination that works best in your system - stick with it!
- With monitoring more is better
- Biggest mistake people make is not have enough traps to “see” problems coming.
- Trapping results are not fool proof but can provide valuable information - back up with visual assessments
- Cost of monitoring is small compared to:
  - Crop loses due to failing to apply controls
  - Cost of over spraying
Many pests are potential targets for pheromone-based control in tree fruit crops

**Peach pests**

**Apple pests**

**Grape pest**

**Small fruit pests**
Species vary in sensitivity to disruption

- Achievable with various formulations
- Dosage required is less
- Trap shutdown is greater
- Fruit or tree protection is easier to achieve
**Borders can be problematic**

- Loss of pheromone
- Immigration of mated females

**GBM and wild grape**
Michigan Codling Moth
Whole-farm Management

- 800 ac in 2004
- 2000 ac in 2005
- 3000 ac in 2007

Included monitoring two other programs:

- No pheromone control
- MD, single orchard
Over the course of 4 years:

- Reduction in fruit injury
Reservoir formulations

Need to know:
- Longevity
- Product performance
- Placement requirements
- Application rate

Require hand application
Residual pheromone analysis for CM dispensers

Product A released 60% of pheromone - rate ~ 1.0-1.2 mg/day
Product B released 70-80% of pheromone, rate ~ 0.7 mg/day
Product C released 70-80% of pheromone - rate 0.8 mg/day
Product D released only ~25% of pheromone over 140 days - rate ~ 0.5-0.6 mg/day.
Product E released only ~38% of pheromone, over 140 days - low release rate ~ 0.4-0.5 mg/day.

Data courtesy of Jay Brunner, WSU-TFREC, Washington
Proper application heights

CM - place in upper canopy only

OFM - place at mid-canopy in most blocks: place equal numbers in mid and upper canopy if trees > 12 ft tall

Borer’s - place in lower canopy

LR - not determined - but generally combined with CM pheromone, thus place in upper canopy
### Application rate of reservoir dispensers

<table>
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<tr>
<th>Pest</th>
<th>Dispensers per acre</th>
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CM mating disruption technologies continue to be driven by:
Desire to reduce the need for labor and the overall cost.

- Aerosol emitters
- Sprayable
- Micro emitters
Desire to reduce application rate

1.2% fruit injury

High pest density
Low pest density

Data courtesy of Brunner et al., WSU
Desire for ease of application: The Tangler
**Similar inhibition of male activity**

![Graph showing mean moths/trap/season](image)

- **Means with different letters are significantly different at p < 0.05.**

- **5x faster to apply**

![Graph showing minutes per acre for different application methods](image)
Sprayable pheromone

Low Rate Frequent Application (LRFA) is a GOOD approach

Weekly applications of 2-4 oz/ac

45 gm ai/acre per season
20 gm ai/acre per season
MEC sprayable formulations for CM

Low volume approach is the most efficacious

Airblast unsatisfactory

Even then, we consistently achieve: only ca. 70% disruption for 2-3 weeks
Machine-applied formulations

Deposition & Adhesion needs to be improved
• only 10-20% application efficiency
• with high percentage of those dislodged over time

Successful for gypsy moth

Problematic for fruit pests

Level of disruption variable:
• Pest density
• Number of dispensers actually on tree
Aerosol emitters as an option

- Each unit releases huge quantities
- Every 15 min over a 12 hr cycle
- Deployed at 1 unit /ac
Aerosol emitters field performance

Mean # Male CM / L2 Trap

- **SIR**
- **Wild**

- **MIST**
- **CM Rope**
- **No MD**
Aerosol emitters: Edges are especially problematic

Mean CM captures/trap

- Exposed traps
- Sandwiched traps

Control | Hand-applied | Puffer | Microsprayer

\[
\begin{align*}
\text{Control} & : b \\
\text{Hand-applied} & : a \\
\text{Puffer} & : b \\
\text{Microsprayer} & : b \\
\end{align*}
\]
Dispenser density has yet to be critically examined:

- Is 1 unit / 1 ac sufficient?

Current use pattern based on:

- Keeping the cost below some maximum
- Extrapolation based on limited plume studies

Figure courtesy of S. Welter, UC
Emitter Density Impacts Performance

Mean Catch/trap

Targeting 90% suppression

0 0.25 0.5 1 2 3 6

90%
Increasing Worldwide use of MD

![Graph showing hectares treated across different years and regions.](image)
Comparison of ability to prevent crop damage using:

**Insecticides**

- dramatically reduce pest density
- effective during short life-span on crop
- limit potential for biological control

**Mating disruption**

- do not kill; thus no direct reduction in pest density
- remain active for long periods
- compatible with biological control
LUKASZ IS DOSED WITH PHEROMONE
Resistance is documented!

2009

In love with fruit flies
...... and Kirsten

2004-07

2001

2002-03

A happy man

Early years of pheromone research

2009

Evidence for mating disruption?

2004-07

2001

2002-03

20 publications, no babies
Thanks to the many who have contributed to these efforts

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