Demonstration and Implementation of IPM in Almonds 2016-2019

David Haviland, Jhalendra Rijal, and Emily Symmes
UCCE and UC IPM
Why IPM Demonstrations in Almonds?

• California’s #1 and fastest growing commodity
• Many new almond growers and PCAs
• Rich history of IPM research funded by the almond industry
• Underutilization of some IPM tools
• Opportunities for synergism with the California Almond Sustainability Program
• Collateral benefits to IPM programs in pistachios and walnuts
The Team

• UC Statewide IPM Program (4)
  – Statewide representation
• DPR
  – Funding, general assistance
• UCCE Farm Advisors (4)
  – Consultations, extension, guidance
• Almond Board of California
  – Funds for complimentary research
• Almond Growers and PCAs
  – Host research, guidance
• Mating Disruption Manufacturers
  – In-kind donations, guidance
PMA project sites

6 Demo Sites
Grower Standard vs Enhanced IPM

Southern San Joaquin Valley
Wasco
Maricopa
Lost Hills

Northern San Joaquin Valley
Escalon
Turlock
Ballico

3 sites Kern Co.
ABC 2025 Vision- Areas of Opportunity for increased integration

Navel orangeworm

• Winter sanitation
• Monitoring
• Mating disruption
• Early harvest
• Pesticide choice (avoid pyrethroids)
• Resistance management

Spider mites

• Monitoring
• Increased reliance on biocontrol
• Avoid prophylactic treatments
• Resistance management
<table>
<thead>
<tr>
<th>Navel orangeworm</th>
<th>Spider mites</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Winter sanitation</td>
<td>• Monitoring</td>
</tr>
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<td></td>
</tr>
<tr>
<td>• Resistance management</td>
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## Mating Disruption Products

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Manufacturer</th>
<th>Dispensers per acre</th>
<th>Type</th>
<th>Release rate</th>
<th>Other perks/costs</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puffer NOW</td>
<td>Suterra Wonderful</td>
<td>2</td>
<td>Aerosol</td>
<td>Static Nightly</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Semios NOW</td>
<td>semios</td>
<td>1</td>
<td>Aerosol</td>
<td>Variable</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Isomate NOW</td>
<td>Pacific Biocontrol</td>
<td>1</td>
<td>Aerosol</td>
<td>Static nightly</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cidetrak NOW Meso</td>
<td>TRÉCÉ</td>
<td>20 (15-28)</td>
<td>Passive</td>
<td>Static 24/7</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
How Mating Disruption Works
Data from 2018 Kern Co. PMA sites

Male/female lure and Egg traps
- 1st flight- same number of moths
  - 1st generation- 63% less eggs in MD
- 2nd flight- 47% less moths
  - 2nd generation- 35% less eggs
- 3rd flight- 56% less moths
  - 3rd generation- 87% less eggs
Pheromone trap captures - Southern SJV
Haviland Almond Board Project, 2017

Reductions in trap captures

<table>
<thead>
<tr>
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<th>ABC 2017</th>
<th>PMA 2017</th>
<th>PMA 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>89%</td>
<td>97%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>95%</td>
<td>93%</td>
<td>97%</td>
</tr>
<tr>
<td></td>
<td>91%</td>
<td>94%</td>
<td>99%</td>
</tr>
</tbody>
</table>
NOW damage at harvest - Southern SJV
Haviland Almond Board Project, 2017

All 4 MD products effective
Average damage reduction - 46%
PMA Site- Lost Hills

- One or Two sprays w/ or w/o MD

- Two-year damage ↓ 49%
- Net grower return ↑ $84/yr/acre
100ac triangle vs. 200ac square
2-3 sprays w/ or w/o MD

Two-year damage ↓ 28%
Net grower return ↑ $28/yr/acre
PMA Site- Wasco

- Low pressure
- MD replaced two sprays

- Two-year damage ↓ 58%
- Net grower return ↑ $36/yr/acre
Mating Disruption Summary

• Four commercial products, they all work
• 90+% reduction in male moth captures
• 50-70% reduction in damage
• Reduction of aflatoxins
• Two-year average benefit ($49/ac)
• Economic benefits depend on baseline damage
  – Break-even around 2.0-2.5%
  – Below 1.5%, costs can be offset by less sprays
• Larger scale = larger benefit
• Marketing benefits of being ‘sustainable’
• Improved resistance management
• Improved worker safety
• No treatment timings, PHIs, REIs or residues
Areas of Opportunity for increased integration (ABC BOD)

Navel orangeworm

• Winter sanitation
• Monitoring
• Mating disruption
• Early harvest
• Pesticide choice (avoid pyrethroids)
• Resistance management

Spider mites

• Monitoring
• Increased reliance on biocontrol
• Avoid prophylactic treatments
• Resistance management
PMA Demonstration Battle Plan

• Monitor weekly for mites (presence/absence)
• Don’t treat unless you have
  – 33% leaves with mites (predators)
  – 25% leaves with mites (no predators)
• Monitor for sixspotted thrips
  – Use yellow panel traps
  – Watch for thrips mid-April to mid-May
  – Watch for thrips in response to mites
• Treat (if needed) with a miticide that doesn’t kill thrips
Spider mites- monitoring and thresholds

Treat too early
= Starve predators

Treat too late
= Risk of defoliation

- 2004PeMe
- 2005PeMe
- 2006PMe
- 2006ALo
- 2006A/Wh
- 2008A/Wh
- 2009A/Wh1
- 2009A/Wh2
- 2011A/Wh

Mean mites per leaf

Treatment threshold (40% infested)
Action threshold (30% infested)
Sixspotted thrips

- Feed almost exclusively on spider mites
- Thrive in hot dry climates
- Have replaced predatory mites as the dominant natural enemy of spider mites
- Can eat 50 eggs per day at 86°F
- Population can quadruple in one week
- Thigmotaxic (not afraid of tight spaces, thrives in mite webbing)
Monitoring - sixspotted thrips

- Yellow strip trap
- 3” x 5”
- Great Lakes IPM
- Case of 1000 for $260

- Hang from tree using binder clip and large uncoiled paper clip
- Place near NOW or PTB traps
Thrips:mite ratios can predict change in mite density

- As thrips approach zero, mites increase exponentially
- As thrips approach infinity, mites decrease exponentially
Thrips:mite ratios can predict change in mite density

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Thrips: mite ratios can predict change in mite density

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2.6 thrips/card/week for every 1 mite/leaf equals no change in mites 7 days later
  - Spring implication - If 1 mite per 3 leaves, 1 thrips on a card is all you need
Thrips: Mite ratios can predict change in mite density

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- 2.6 thrips/card/week for every 1 mite/leaf equals no change in mites 7 days later
  - Spring implication- If 1 mite per 3 leaves, 1 thrips on a card is all you need

- Simplified version for mid-season to hull split
  - 3 thrips/trap/week = break even
    - 50% chance mites will be the same or lower in 14 days
  - 6 thrips/trap week = walk away
    - 72.7% chance mites will decrease in 7d, 96.6% chance mites will decrease in 14d

\[ y = 10.036x^{0.785} \]
\[ R^2 = 0.4295 \]
Avoid prophylactic treatments

- May sprays for mites becoming obsolete
- Nine orchards (9/9) miticides not justified
- Predatory thrips above thresholds in all cases
- Miticides should never be used in May without monitoring for spider mites and thrips
- If a treatment is justified, avoid products that kill thrips

Sixspotted thrips/card/week

Wasco

Maricopa

Buttowillow
Maximizing biocontrol

- Mites flare up
- Appx. 2-week delay
- Thrips respond
- Thrips overtake mites
- Mites crash
- 9 case studies
### Population Doubling Time

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Pacific Spider Mite</th>
<th>Sixspotted thrips</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Shafter</td>
<td>15.9</td>
<td>4.2</td>
</tr>
<tr>
<td>2016</td>
<td>McFarland</td>
<td>6.0</td>
<td>4.2</td>
</tr>
<tr>
<td>2017</td>
<td>Shafter</td>
<td>3.8</td>
<td>2.3</td>
</tr>
<tr>
<td>2017</td>
<td>Maricopa</td>
<td>9.3</td>
<td>2.7</td>
</tr>
<tr>
<td>2007</td>
<td>Buttonwillow</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>7.6</td>
<td>3.4</td>
</tr>
</tbody>
</table>
Take-home messages

**Spider mites**
- Weekly monitoring
- Use thresholds
  - 25% to 33% presence/absence
- Avoid prophylactic sprays
- Maximize biocontrol
  - Sticky traps to thrips
  - Consider thrips populations in treatment decisions
PMA Project 2018 update: Navel Orangeworm and Mites (North San Joaquin Valley Perspective)

Jhalendra Rijal, Ph.D.
IPM Advisor, Northern San Joaquin Valley
UC Cooperative Extension & UC Statewide IPM Program
PMA Project Sites

(Northern San Joaquin Valley)

3 sites

3 sites Kern Co.

Ballico

Escalon

Turlock
PMA Project Sites-North SJV

Variety: NP/Carmel/Monterey
Age: 12 yrs.

Variety: NP/Monterey/Fritz
Age: 6 yrs.

Variety: NP/Aldrich/Wood Colony
Age: 6 yrs.
Turlock Site, Navel Orangeworm

Male NOW captures in pheromone traps

Reduction in trap capture

2018: 99.6%

2017: 94.7%
% NOW damage (Turlock)

- **Nonpareil**: 34% reduction
- **Carmel**: 38% reduction
- **Monterey**: 67% reduction

**Overall damage reduction**

2018: 46.3%
2017: 57.3%
Male NOW captures in pheromone traps

Reduction in trap capture

2018: 97.6%
2017: 97.1%
Escalon Site, Navel Orangeworm

% NOW damage (Escalon)

Overall damage reduction

2018: 73%
2017: 70%
Ballico Site, Navel Orangeworm

Male NOW captures in pheromone traps

Reduction in trap capture

2018: 96.6%
2017: 83.2%
Ballico site, Navel Orangeworm

% NOW damage (Ballico)

Overall damage reduction
2018: 53%
All Sites Combined, Navel Orangeworm

% NOW damage in 3 PMA sites in 2017 and 2018

Reduction in damage

2017: 71.9 %

2018: 63.3 %

Combined: ~68%
Prevalence of Spider Mites and Predators in NSJV

Spider Mite Infestation

Mite Predators

Stethorus Beetle

Sixspotted Thrips
Stethorus population
North San Joaquin Valley

Turlock site: Stethorus/card

C Avg.  M Avg
Stethorus population
North San Joaquin Valley

Ballico: Stethorus/card

- **C Avg.**
- **M Avg**
Conclusion: NOW and Mites

Navel Orangeworm
- Mating disruption (an excellent candidate for IPM)
- >65% damage reduction by using MD based on 2-yr demo trials in the northern San Joaquin Valley (along with regular insecticide program)
- Areawide MD approach should be the next step for comprehensive NOW management

Spider Mites:
- Strong evidence of mite predators (Stethorus, sixspotted thrips) presence in almond orchards in NSJV
- Monitor mites and predator population with leaf and yellow sticky card sampling
- Avoid broad-spectrum insecticides and prophylactic miticide application to conserve NEs
2018 Research Update:
Brown Marmorated Stink Bug (BMSB)

Jhalendra Rijal, Ph.D.
IPM Advisor, Northern San Joaquin Valley
UC Cooperative Extension & UC Statewide IPM Program
Brown Marmorated Stink Bug

- Invasive stink bug, *Halyomorpha halys* (Stal)
- First detection in PA around late-1990s
- In 2010, significant economic loss in Mid-Atlantic States ( $37 million only in apple)
- >170 host crops

Photo: Doug Pfeiffer, Virginia Tech

~5/8 inch long, marble brown

www.pestworld.org
Established in 16 Counties

Modesto
First detection
2015 July 2015

Severe nuisance problem since Fall 2013
2017-BMSB in almond orchard (First Report)

Rijal and Gyawaly 2018, Insects, 9(4):126
2018-BMSB infestation in 6 almond orchards in NSJV

Substantial nut drop
BMSB phenology

Weekly BMSB adults/trap in an almond orchard

- sticky
- pyramid
2018-Temporal Feeding Study in Almonds
(in collaboration with Dr. Zalom Lab, UCD)

- 2 varieties: Nonpareil and Monterey
- Fabric cages placed at early fruit set covering 7-15 nuts/cage
- 9 cages/variety infested with 3 BMSB adults/cage weekly
- Last wk. of March (Wk. 1) to the last wk. of July (Wk. 18)
- Nut size, nut development stage, drop nuts, shell hardness, injury categories: hull, shell, kernel.
BMSB feeding study in almonds

% nut drop after 21 days of BMSB infestation

(var. Nonpareil)

Infested vs Control

(var. Monterey)

27 March (Wk 1) → 9 May (Wk 9)
BMSB feeding injury to almonds (April 11, Wk 3 infestation)
BMSB damage at harvest
BMSB damage at harvest

% damage

- Gumming
- Dark spot(s)
- Depression/dimples

2 per. Mov. Avg. (Gumming)
2 per. Mov. Avg. (Dark spot(s))
2 per. Mov. Avg. (Depression/dimples)
Conclusion and recommendation for BMSB monitoring

- BMSB is spreading to agricultural areas and causing damage in commercial orchards
- BMSB seems to cause damage in almonds throughout the season
- Conduct visual inspections for the bug and damaged fruits (beginning March)
- Use sticky panel traps with BMSB lure early in the season to detect BMSB presence in the orchard
Acknowledgements

Many Thanks to:

• MD Product Support: Pacific Biocontrol, Semios, Suterra, Trece
• Cooperator Growers,
• Pest Control Advisers
• UC Farm Advisors and Faculties

Help from: Daniel Green, Daniel Rivers, Raquel Gomez, Emily Buerer, Adriana Medina

Dr. Joanna Fisher, UCD

Pls. visit BMSB Poster # 18.ENTO23.Rijal
2018 Research Update: Sacramento Valley

Emily Symmes
IPM Advisor, Northern San Joaquin Valley
UC Cooperative Extension & UC Statewide IPM Program
### Treatment Options for NOW IPM Demo 2018 – Sacramento Valley

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Description</th>
<th>Plot Size</th>
<th>Application Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>GS*</td>
<td>Grower Standard (3 insecticide applications)</td>
<td>55 acres</td>
<td>May 8, July 14, July 31</td>
</tr>
<tr>
<td>MT</td>
<td>Mass Trapping, Peterson Trap Co.</td>
<td>70 acres</td>
<td>April 19 – August 9</td>
</tr>
<tr>
<td>PBC</td>
<td>Pacific Biocontrol ISOMATE® NOW Mist (aerosol)</td>
<td>70 acres</td>
<td>April 9</td>
</tr>
<tr>
<td>MESO</td>
<td>Trécé Cidetrak® NOW MESO (passive)</td>
<td>70 acres</td>
<td>April 9</td>
</tr>
<tr>
<td>MESO+FLOW</td>
<td>Trécé Cidetrak® NOW MESO (passive) + sprayable NOW pheromone (experimental formulation)</td>
<td>70 acres</td>
<td>April 9 (MESO) July 14, July 31 (FLOW)</td>
</tr>
<tr>
<td>FLOW</td>
<td>Trécé sprayable NOW pheromone (experimental formulation)</td>
<td>70 acres</td>
<td>July 14, July 31 (FLOW)</td>
</tr>
</tbody>
</table>
NOW IPM Demo 2018 – Sacramento Valley

Glenn County, CA. Nonpareil, Winters, Monterey
NOW IPM Demo 2018 – Sacramento Valley

% Reduction Relative to GS

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>MT*</td>
<td>NA (+1.4%)</td>
</tr>
<tr>
<td>PBC</td>
<td>98.7%</td>
</tr>
<tr>
<td>MESO</td>
<td>99.3%</td>
</tr>
<tr>
<td>MESO+FLOW</td>
<td>99.3%</td>
</tr>
<tr>
<td><em>Flowable applications</em></td>
<td>*Cum. 8 wks post appls. (7/17-9/12)</td>
</tr>
<tr>
<td>FLOW*</td>
<td>98.0%</td>
</tr>
</tbody>
</table>
NOW IPM Demo 2018 – Sacramento Valley

**Harvest Samples**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date Collected</th>
<th>No. Evaluated/Plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonpareil</td>
<td>9/5-9/8</td>
<td>4,000 (20 X 200)</td>
</tr>
<tr>
<td>Monterey</td>
<td>9/26</td>
<td>2,000 (10 X 200)</td>
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</table>

*Mass trapping removed prior to Nonpareil harvest*
Female mating status evaluation underway
Sixspotted Thrips – Sacramento Valley

Great Lakes IPM Yellow Sticky Strips

Small 5-in X 3-in

Large 10-in X 6-in
Sixspotted Thrips – Sacramento Valley
Sixspotted Thrips – Sacramento Valley

2018 Sixspotted Thrips

![Graph showing sixspotted thrips data for 2018 in Sacramento Valley, with two lines representing Small YSC and Large YSC, and dates from April 2 to October 29.](image-url)
Funding was provided by a California Department of Pesticide Regulation Pest Management Alliance Grant and the Almond Board of California.

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Thank you!