Insect Pest Management Workshop

December 10, 2015

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ADVANTAGE
The Almond Conference

Speakers

Bob Curtis, Almond Board (Moderator)

David Haviland, UCCE Entomologist

Brad Higbee, Wonderful Orchards

Kris Tollerup, UCCE IPM Advisor

Andrea Joyce, UC Merced

Emily Symmes, UCCE IPM Advisor

Bob Curtis, Almond Board

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Continuing Education Credits

- **Continuing Education Credits** are available for many of today's symposiums. To receive CCA credit, you must sign in before and after each individual symposium at the back of the room.

David Haviland, UCCE Entomologist

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Arthropod Management

David Haviland

UC Cooperative Extension, Kern Co



Pesticides and IPM

- Resistance Management
- Role of insecticides and miticides
- Advantage and disadvantages of chemical control
- How to get the most out of a pesticide
- Ways to mitigate pesticide risks
- Options for chemical control for key groups of pests
- Learn guidelines from the University of California
- See what growers are doing

Definition of resistance

- Decreased susceptibility of a pest population to a pesticide that was previously effective at controlling the pest

- Technical Definition- A heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species

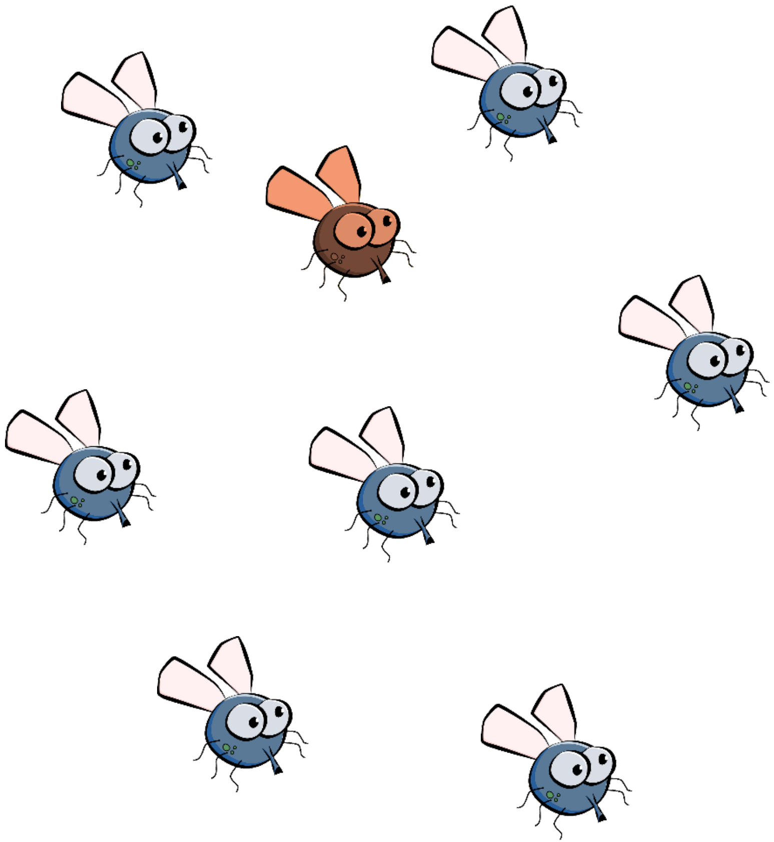
- Heritable Change Definition- A change in the genes of individuals in the present generation that is passed on to the next generation

Prevalence of resistance

- Currently more than 600 species of insect and mite pests have developed some level of resistance
- Some insects, such as spider mites, are more prone to developing resistance
- Documented cases of resistance (from G. P. Georghiou, 1990)
  - 504 Species of insects with resistance
    - 283 agricultural pests
    - 198 medical or veterinary pests
    - 23 beneficial insects
  - Resistance to most chemical classes
    - Cyclodienes- 291 species, DDT- 263
    - Organophosphates- 260
    - Carbamates- 85
    - Pyrethroids- 48
    - Fumigants- 12
    - Other (40)

How does resistance happen?

- Insects within a population have genetic diversity
  - Most insects are naturally susceptible
  - A minority have genetic traits that allow them to survive



How does resistance happen?

- Insects within a population have genetic diversity
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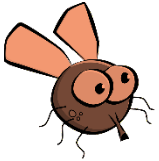
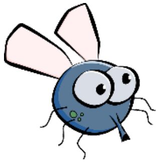
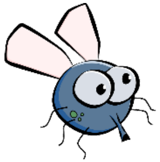
- Insecticide is sprayed
  - Susceptible insects (the majority) die
  - Resistant insects (the minority) survive
  - Survivors mate and offspring are primarily resistant
  - The surviving minority become the majority







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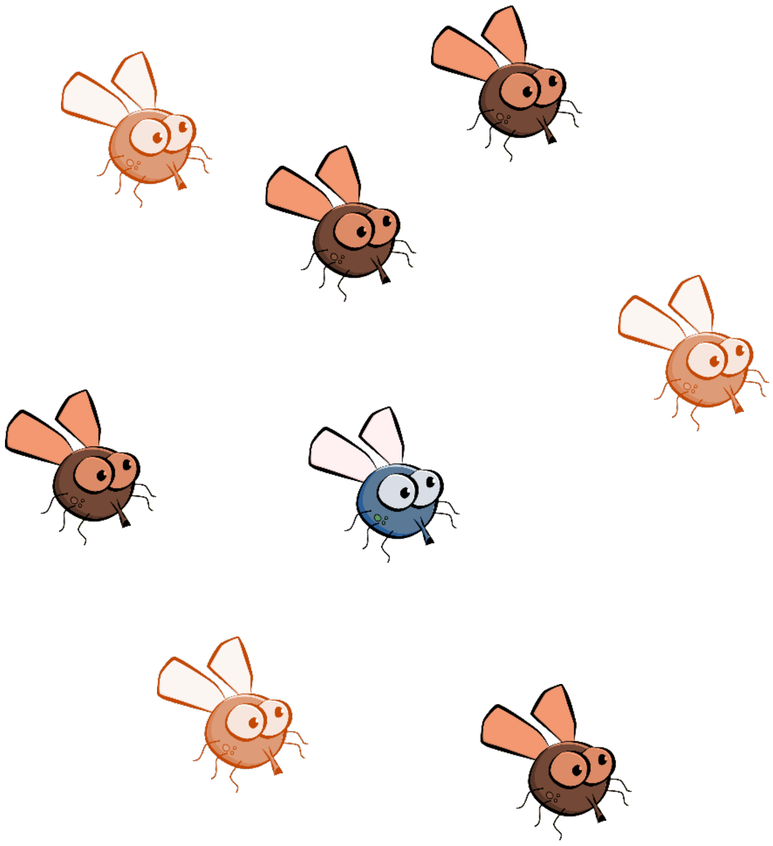

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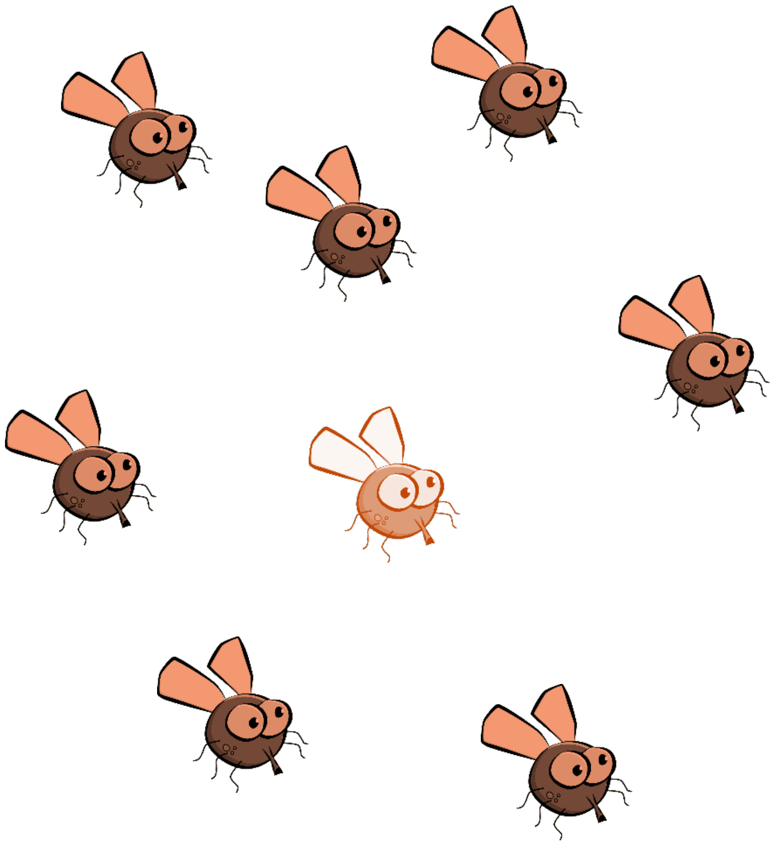
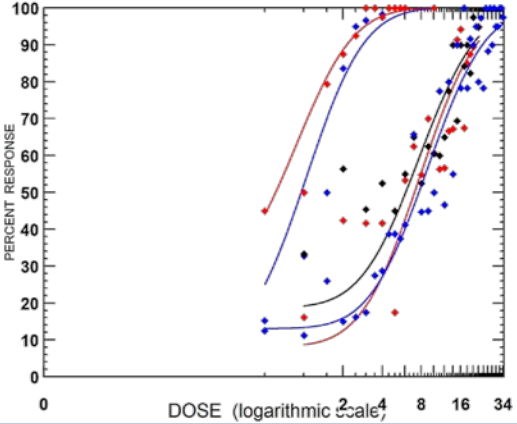
- Insecticide is sprayed again
  - Susceptible minority all die
  - Resistant majority become a unanimous majority
  - Resistant x resistant mating = resistant offspring
- Insecticide is sprayed again
  - Control failure



NOW Pyrethroid Resistance

B. Higbee, Paramount Farming Co.



RF=Resistance factor = LC_{50} of field strain/LC_{50} of USDA strain

Bifenthrin is evaluated as a surrogate for all pyrethroids (Brigade, other bifenthrin products, Danitol, Warrior II, Voliam XPress, Pounce, Ambush, other permethrins)

48 hr mortality tables

Low or no bifenthrin

	LC50		RF	
Year	**Male**	**Female**	**Male**	**Female**
2009	0.7	0.5	1.3	0.8
2010	2.1	2.1	2	2
2011	1	1.1	0.7	0.75
2012	1.8	2.35	2.4	3.5
2013	5.4/5.3	6.6/6.1	4.0/3.9	4.8/4.5
2014	6.3/7.2	6.4/7.9	6.4/7.3	7.8/9.6

High bifenthrin

	LC50		RF	
Year	**Male**	**Female**	**Male**	**Female**
2009	0.3	0.5	0.6	0.8
2010	1.35	1.8	1.3	1.65
2011	1.7	2.1	1.2	1.5
2012	2.4	2.5	3.1	3.8
2013	7.9	8.8	5.8	6.5
2014	10.6-13.8	10-13.9	10.8-14	12.1-17

RF=Resistance factor = LC_{50} of field strain/LC_{50} of USDA strain

Types of resistance

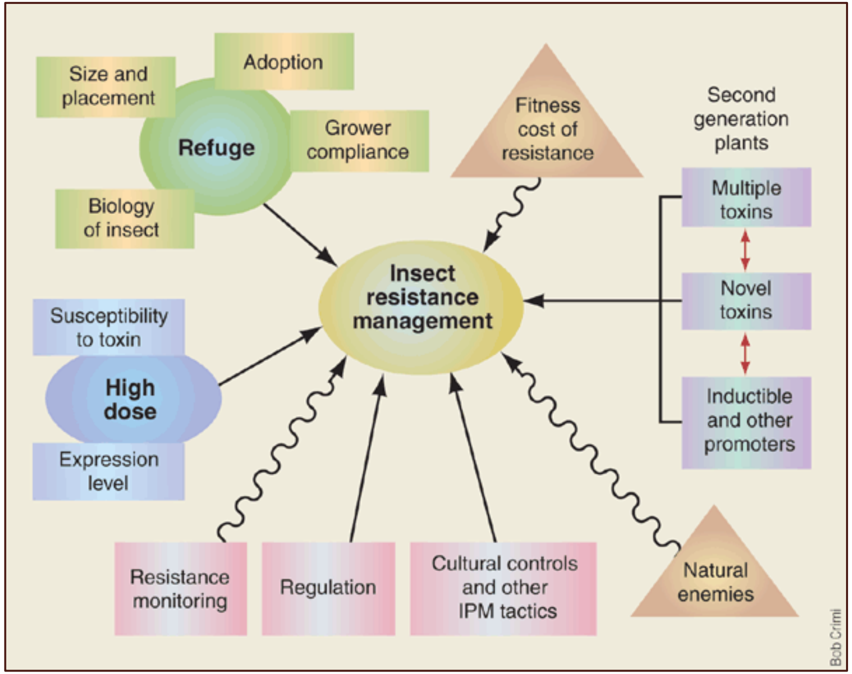
- Metabolic resistance
  - Insects can detoxify or break down the toxin by increasing the number or types of enzymes they have
  - Most common type of resistance
- Behavioral resistance
  - One portion of the population behaves differently than another portion and is selected out by the pesticide
- Altered target site resistance
  - Site where the toxin usually binds in the insect becomes modified to reduce the insecticide's effect
- Penetration resistance
    - Insects with a thicker cuticle survive because it slows the insecticide from penetrating the body

Rate of resistance development

- Types of resistance genes
  - Is there a cost to having these genes?
- How many genes are involved?
- Are resistance alleles dominant or recessive
  - If recessive- mating will result in susceptible individuals
  - If alleles are dominant, then mating will produce resistant offspring
- Generations of pest
  - More generations = more resistance
- Mobile pests
  - Higher mobility = less resistance
- Persistence of pesticide residues
  - The more you spray the more selective pressure
  - The more persistent the more selective pressure

How to manage resistance?

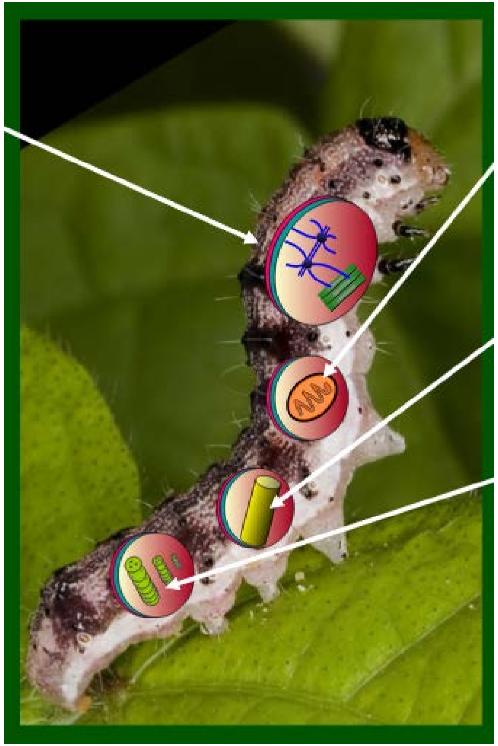
- Manage selective pressures
  - Use insecticides only when needed
    - Based on monitoring
    - Avoid ‘preventative’ management approaches
  - Use a high label rate
  - Use non-chemical controls
  - Properly time insecticide treatments (= efficacy)
  - Good coverage (= avoid escapes and low doses)
- When you use one technique to kill something, use a separate technique to kill the survivors
  - Rotate insecticide modes of action
    - Never use the same mode of action twice in a row
  - Tank mix two insecticides with different modes of action
    - This includes adding oil to an insecticide/miticide
  - Use insecticides that do not kill beneficials
    - Let biocontrol take care of the survivors



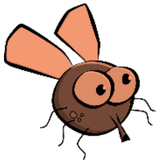
From Bates et al., 2005

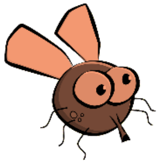
IRAC- Insecticide Resistance Action Committee- www.irac-online.org.

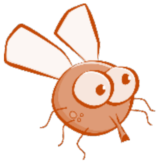
- Committee of public and private scientists
- Categorize pesticides into classes
  - Group defines the primary target site
  - Subgroup defines how the site is affected
- Insecticides/miticides organized into 28 groupings
  - Nerve and muscle
  - Respiration
  - Midgut
  - Growth and development
  - Unknown or non-specific
- Each group has a name
  - Organophosphates, carbamates, pyrethroids, etc.



Quiz- How will this affect resistance? (up, down, or stay the same?)







- A farmer uses a pesticide against an insect that has developed some resistance
  - Uses a low rate that doesn't kill susceptible insects?
  - Uses a moderate rate that only kills susceptible bugs?
  - Uses a very high rate that kills susceptible and tolerant insects?
- A farmer does sanitation to kill navel orangeworm?
- A farmer uses oil against an insect resistant to insecticides?
- A farmer sprays product 'B' on an insect resistant to product 'A'?
- A farmer sprays an insecticide for worms and it doesn't kill scale insects?

california almonds
Almond Board of California

Integrated Pest Management and Resistance Management

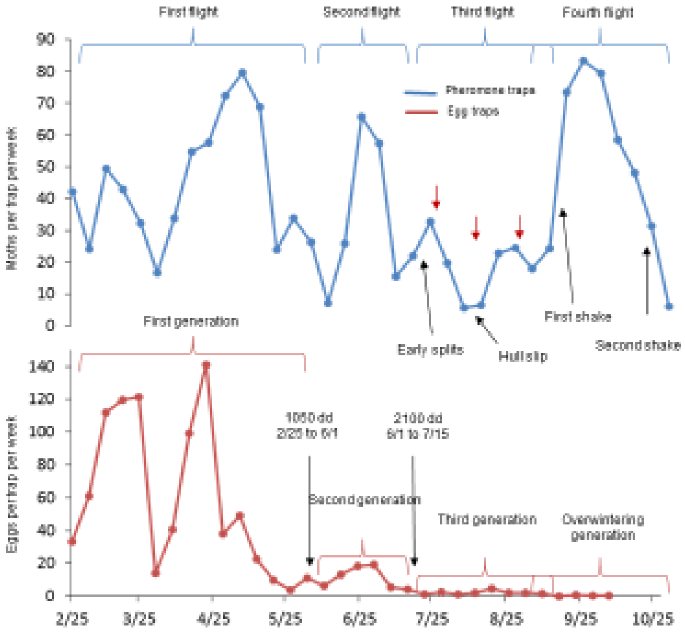
- Proper pest identification
- Monitoring
- Cultural controls
- Mechanical controls
- Biological controls
- *and when all of this is insufficient*
- Chemical controls

Why pesticides

- Farmers don't like pesticides… but they like what they can do
- Quick remediation of a problem
- Minimal labor required
- Compatible with production practices
- Surgically mitigate a problem
- Costs of pesticides significantly less than damage they prevent (economic thresholds)

Navel Orangeworm

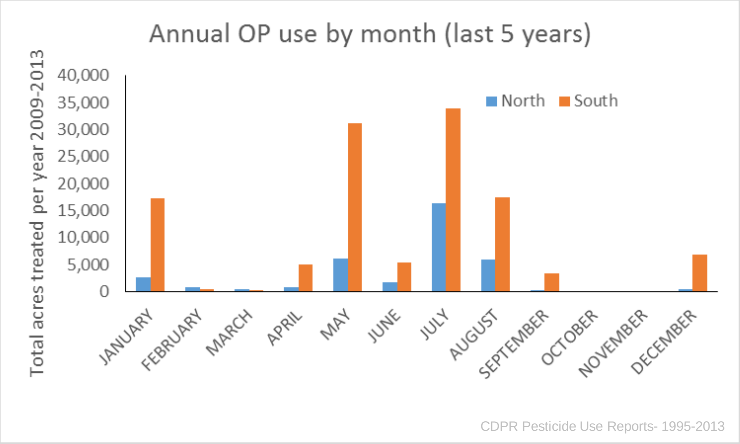
- Cultural control- Sanitation
- Monitoring
  - Egg traps (egg-laying biofix in April/May)
  - Pheromone traps (second and third flight
- Properly-timed insecticides
  - Based on degree-day models and crop phenology
- Number of treatments
  - Based on past damage, trap captures, varieties, harvest dates, residue degrada
  - One to two treatments common
    - Hull split and two weeks later
    - Adulticides and larvicides



18.5. Navel orangeworm captures in a 640-acre commercially sprayed pistachio orchard in Kern County during 2014 using A) pheromone traps and B) egg traps. Flight periods shown are approximately 2 weeks earlier than normal due to an above-normal accumulation of degree-days during 2014. Red arrows indicate insecticide applications on 27 July, 12 August and 30 August. Source: B. Higbee, Paramount Farming Company

Organophosphates (IRAC 1B)

- Nerve toxins
- Been around since the 1940s
- Most are no longer used in almonds
  - Guthion, diazinon, etc.
- Lorsban is the primary OP in CA almonds
  - Broad spectrum insecticide
  - Has a fuming activity
  - Valuable for worms, bugs, scale and ants
  - Has environmental concerns
- Functionally it is the last broad spectrum insecticide available to almond growers that is not an pyrethroid
- Imidan is also registered



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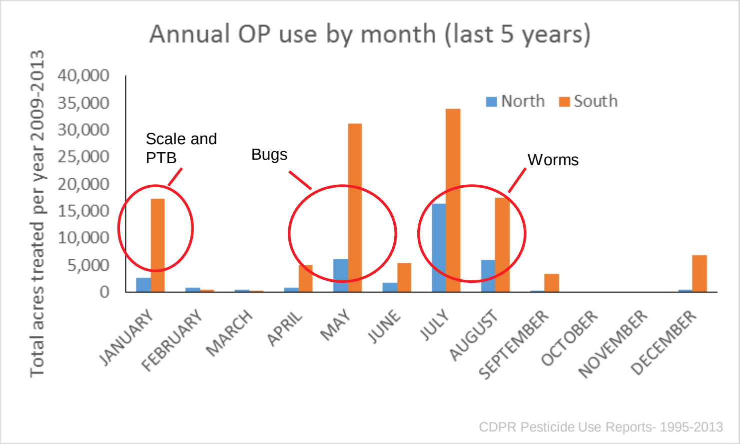
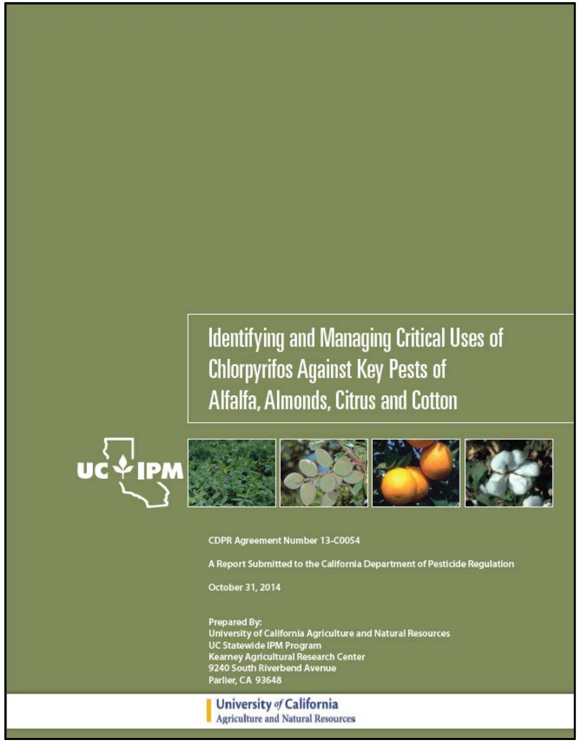


Chlorpyrifos Use in Almonds

- Environmental concerns
  - Movement into surface waters (esp. dormant treatments)
  - Movement into air (volatile organic compounds)
    - Low-VOC formulations required after May 1 in the SJV
- DPR under pressure to minimize/justify use
  - Now a restricted use insecticide
  - PCA recommendation needed (PRIA statement)
    - All other options considered yet treatment is needed
  - Chlorpyrifos must be on the permit
- Critical Uses Plan was developed
  - A joint effort of CDPR, UC, and the Almond Industry
  - Follow-up meetings beginning in January
- Registration being re-evaluated by federal EPA
  - Proposal to ban is in currently in place until EPA decides to renew, modify, or deny registrations


Identifying and Managing Critical Uses of Chlorpyrifos Against Key Pests of Alfalfa, Almonds, Citrus and Cotton

UC IPM

CDPR Agreement Number 13-C0054

A Report Submitted to the California Department of Pesticide Regulation

October 31, 2014

Prepared By:
University of California Agriculture and Natural Resources
UC Statewide IPM Program
Kearney Agricultural Research Center
9240 South Riverbend Avenue
Parlier, CA 93648

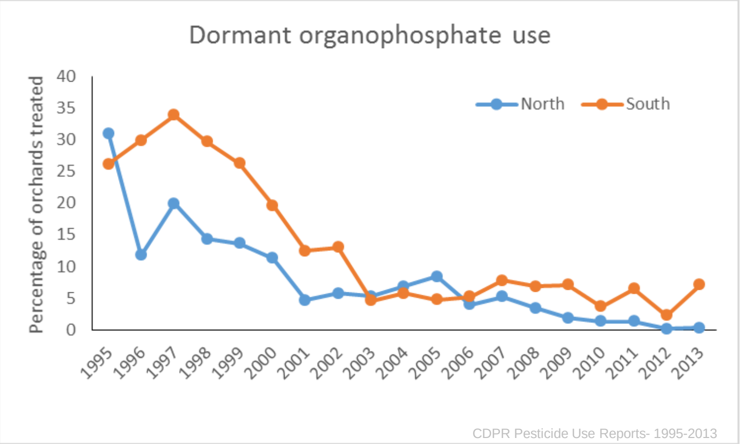
University of California
Agriculture and Natural Resources

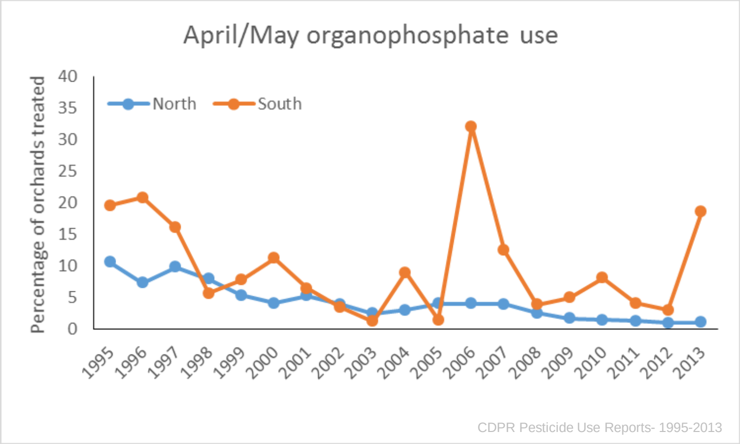
Crop Team Leaders- Bob Curtis, Gabriele Ludwig

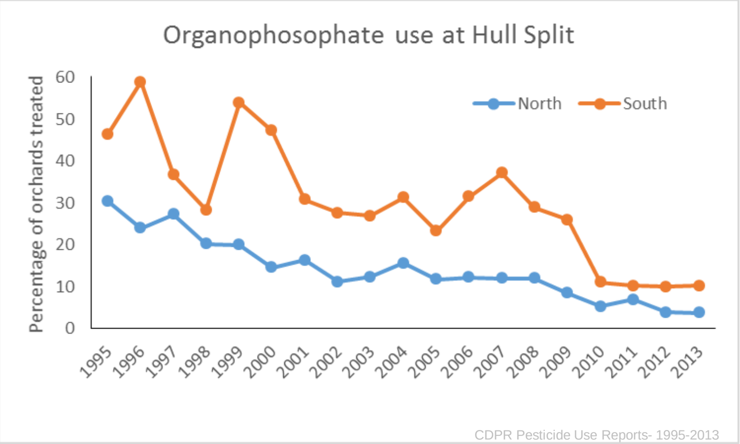
Members- Art Bowman, Mike Strmiska, David Haviland, Brad Higbee, Rob Kiss, Mel Machado, Jay Payne, Kris Tollerup, Danielle Veenstra

Organophosphates (IRAC 1B)

- Dormant (PTB) use declining
- April/May (LFB, Stink Bug) use fluctuates
- Hull split use declining

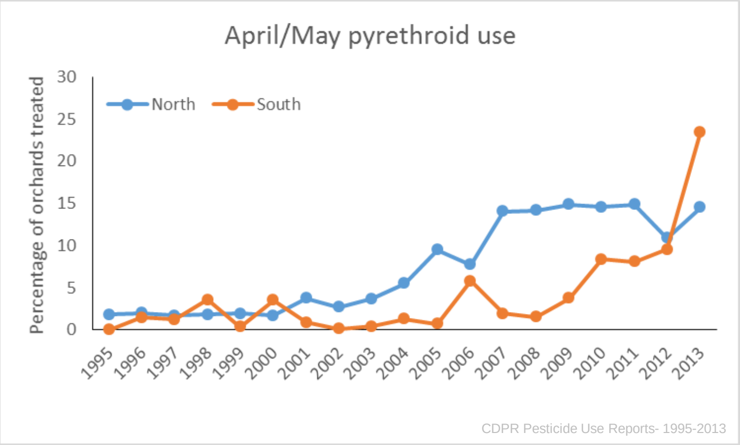


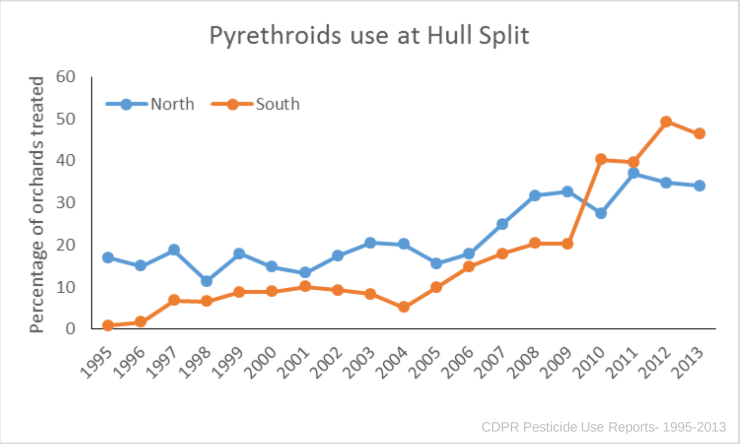




Pyrethroids (IRAC 3A)

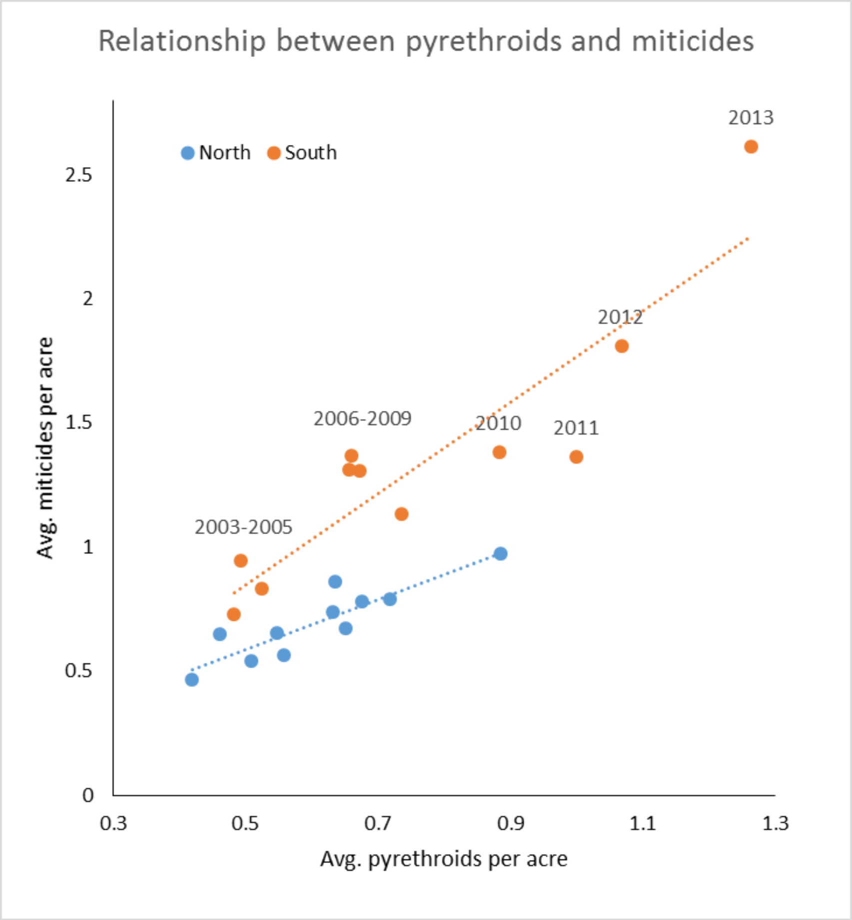
- Broad spectrum nerve toxins
- Originally with short residuals
- New products long residuals 2-4 weeks
  - Brigade, Warrior II, Danitol, Voliam Xpress, Asana
- Used for worms and bugs
- Inexpensive and effective
- Known for causing outbreaks of secondary pests
- Off-site movement into aquatic systems a concern
- Resistance documented in many crops
- Significant trends towards increased use





Pyrethroids- concerns

- Flaring secondary pests



CDPR Pesticide Use Reports- 1995-2013

Pyrethroids- concerns

- Flaring secondary pests
- Resistance

NOW susceptibility to bifenthrin

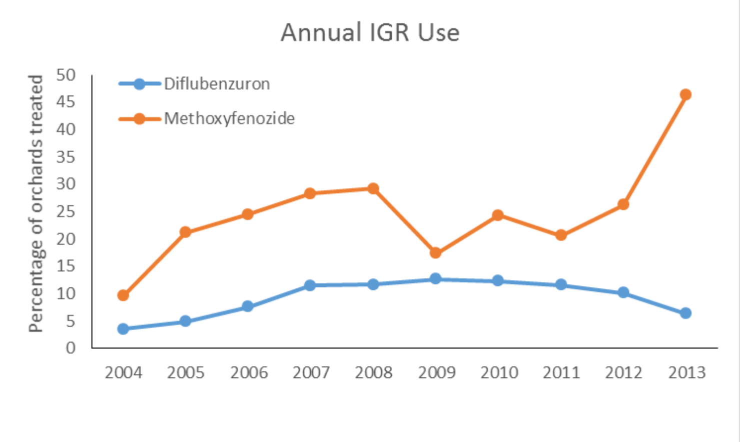
	High bifenthrin use			
	LC50		RF	
Year	Male	Female	Male	Female
2009	0.3	0.5	0.6	0.8
2010	1.4	1.8	1.3	1.7
2011	1.7	2.1	1.2	1.5
2012	2.4	2.5	3.1	3.8
2013	7.9	8.8	5.8	6.5
2014	10.6-13.8	10.0-13.9	10.8-14.0	12.1-17.0

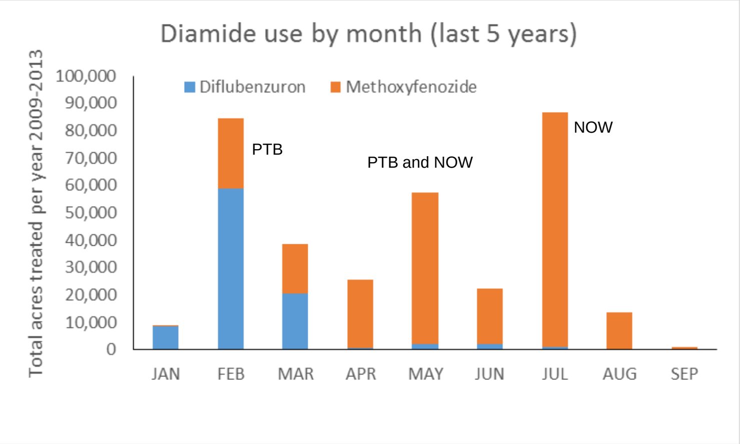
Source: B. Higbee, Wonderful Farming Co.

RF=Resistance factor
= LC_{50} of field strain/LC_{50} of USDA strain

Growth Regulators (IRAC 18)

- Ecdysone Receptor Agonists (IRAC Group 18)
  - Intrepid (methoxyfenozide)
  - Toxin is ingested
  - Larvae do not develop
  - Effective against worms
  - Spring applications for PTB and NOW
  - Hull split application for NOW
- Inhibitor of Chitin Synthesis- Benzoylureas (IRAC 15)
  - Dimilin (diflubenzuron)
  - Inhibits chitin synthesis
  - Larvae cannot molt
  - Primarily for peach twig borer
  - Historically used at bloom
    - Other timings preferred to avoid spraying at bloom

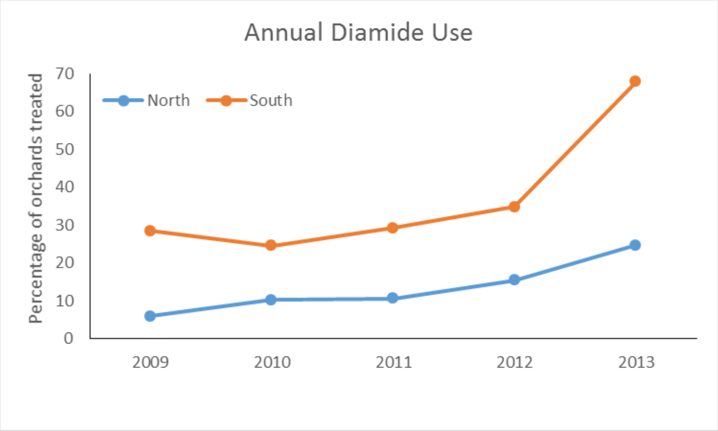


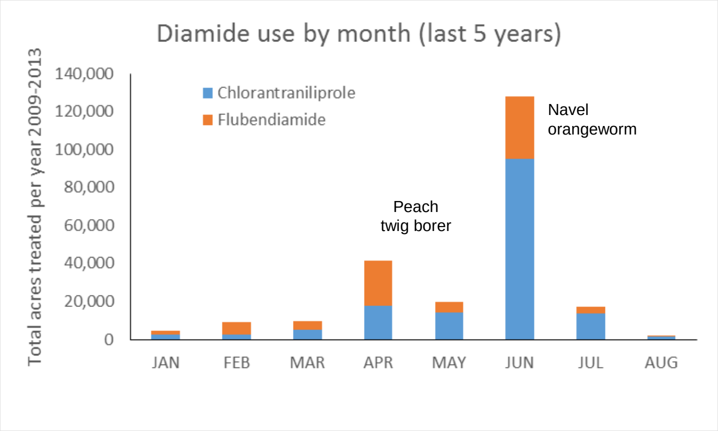


Anthranilic Diamides (IRAC 28)

- Chlorantraniliprole (=Rynaxypyr)
  - Altacor
  - Voliam Xpress
    - = Altacor + Warrior II
- Flubendiamide
  - Belt
  - Tourismo
    - = Belt + Centaur
- Cyantraniliprole (=Cyazypyr)
  - Exirel

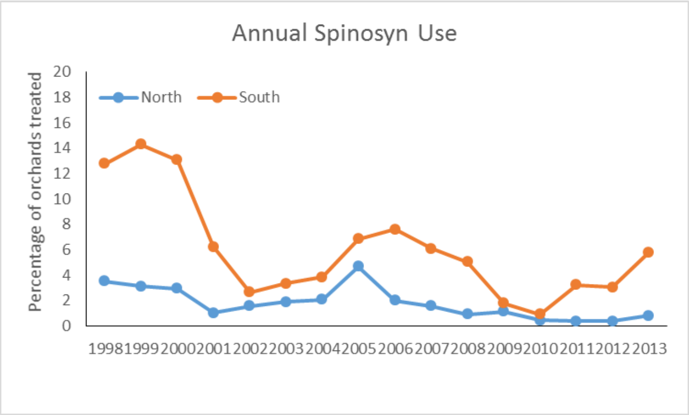
- Affect calcium channel in muscles
- Only effective on worms
- Excellent larvicides, some effect on adults
- Larvae eat it, become paralyzed, then starve
- Has to be applied before eggs are laid/hatch

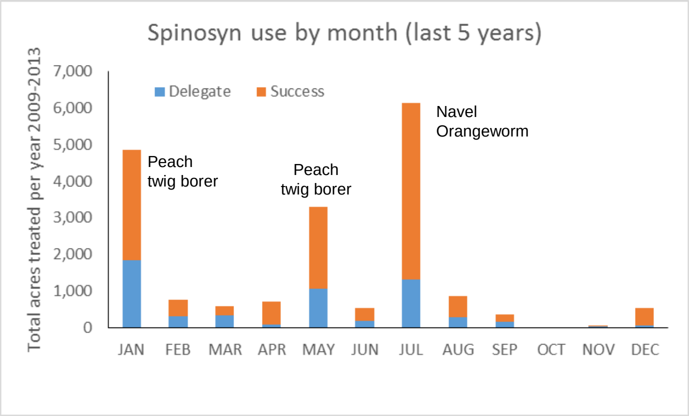




Spinosyns (IRAC 5)

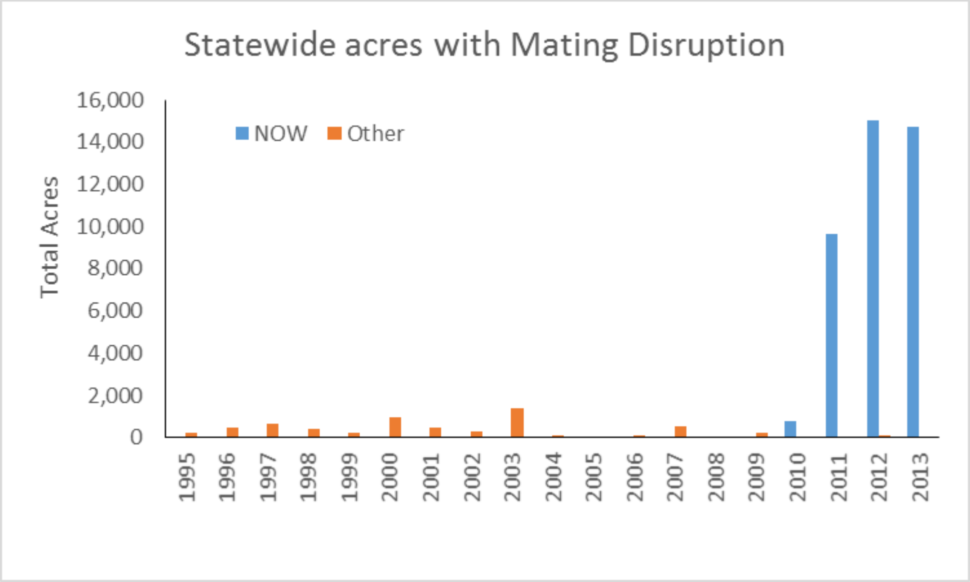
- Fungal fermentation product
- Contact and ingestion toxin
- Spinetoram- Delegate
  - Effective on all worms
  - Primarily kills larvae, but can kill adults
- Spinosad- Success, Entrust (organic)
  - Mainly used for PTB, not effective on NOW
- Toxic to parasitoids and sixspotted thrips





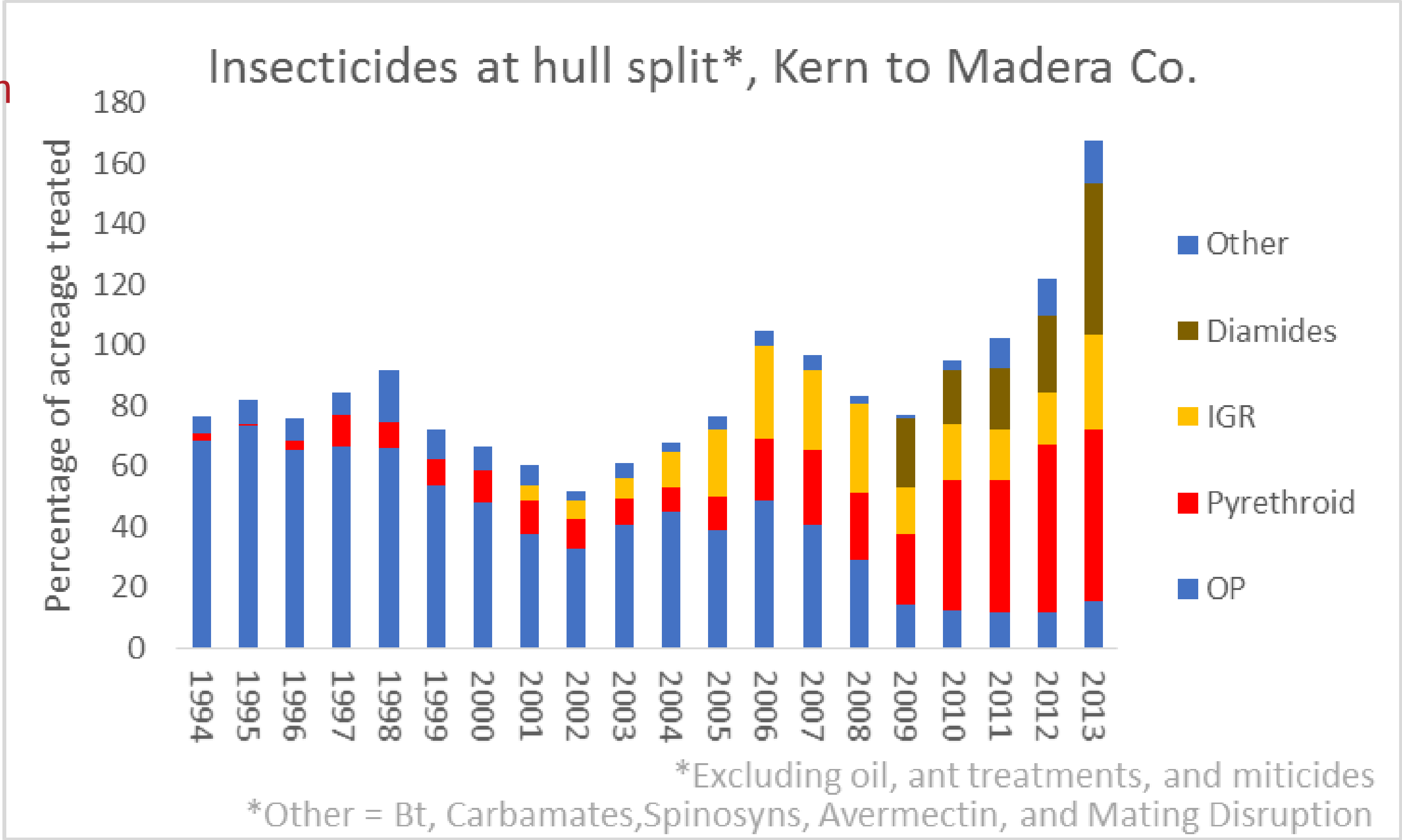
Mating Disruption (IRAC n/a)

- Mode of action
  - Disruption of mating
- Dispensers available for PTB, OFM
  - Rarely used
- Puffers available for NOW
  - New technology
  - 2 puffers per acre
  - Primarily being used in addition to insecticides in areas with high NOW pressure
  - Effective but relatively expensive



Insecticides for navel orangeworm

- Tolerance for NOW going down
- 2% no longer the goal, now an upper threshold
- Number of applications increasing
- Avg. of 1.5 sprays per orchard
- ~50% OP and Pyrethroids
- ~50% IGRs and Diamides



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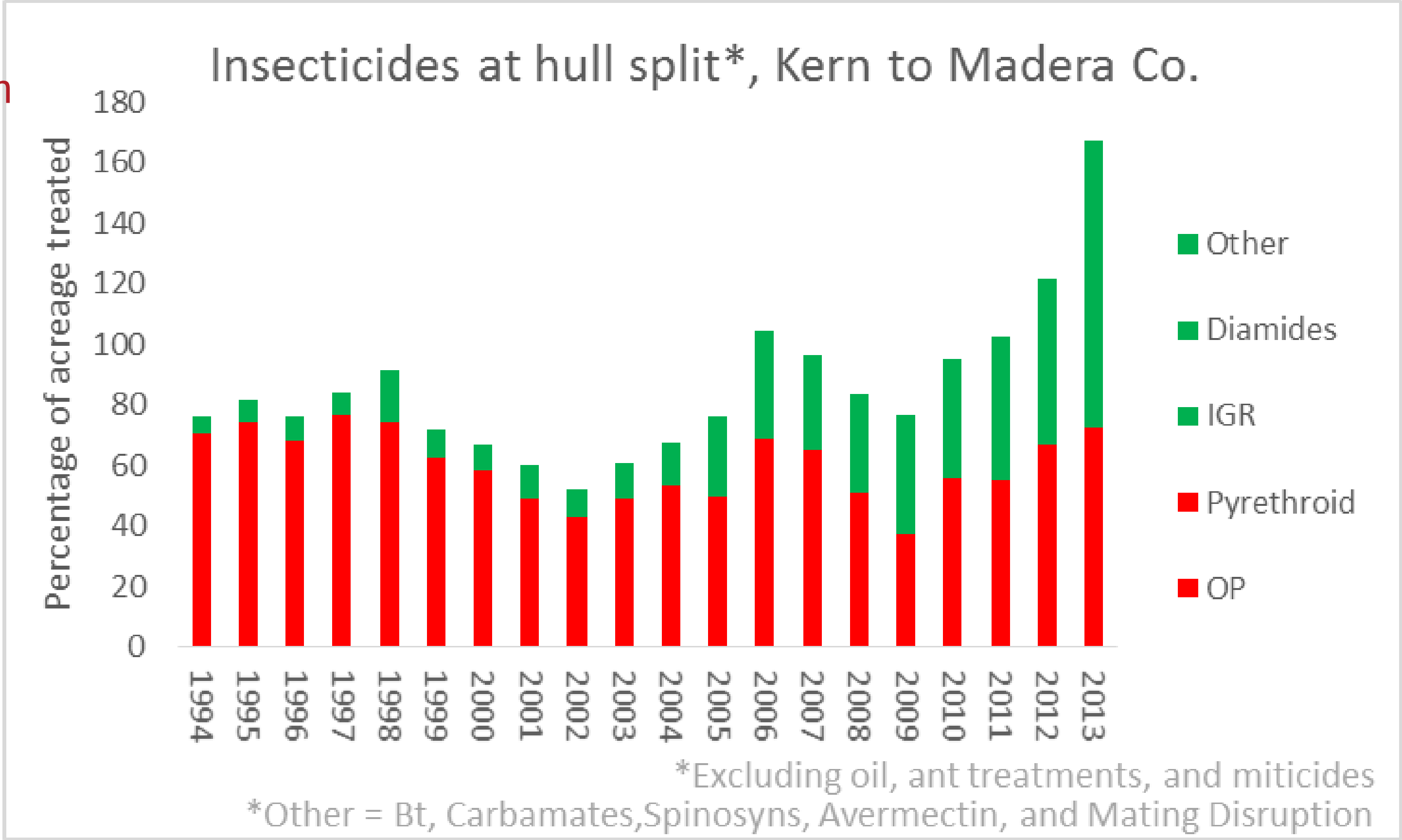
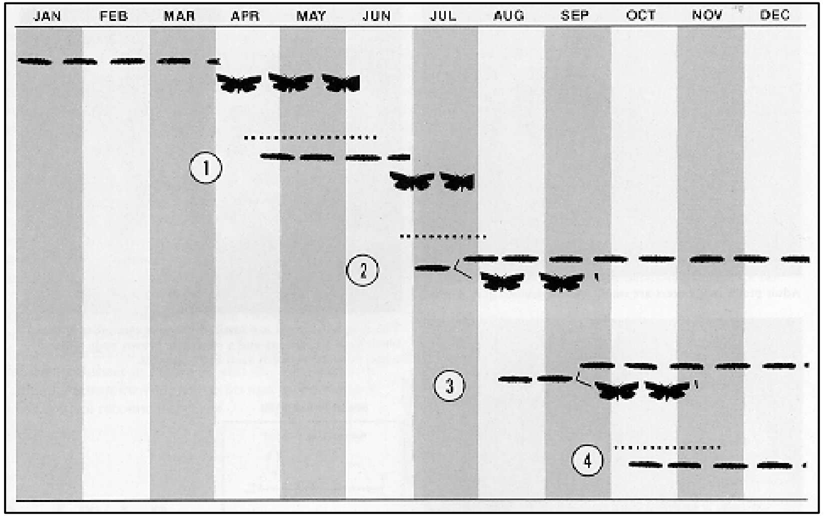


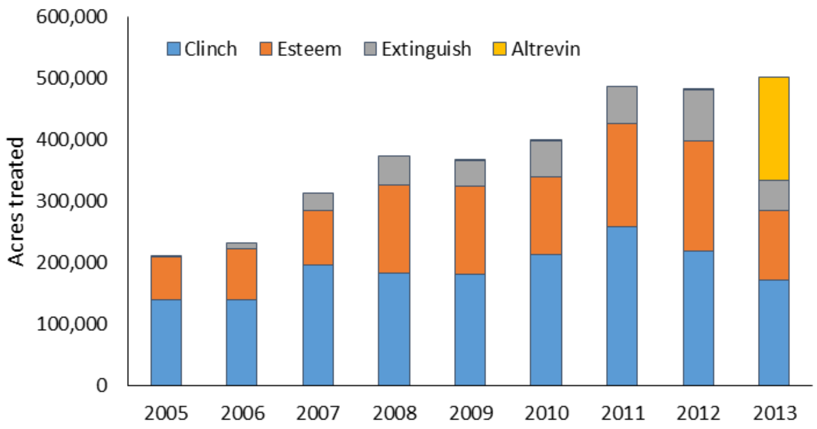
Peach Twig Borer

- Dormant treatments
  - Effective, especially with oil
  - Became unfavorable due to off-site movement of pesticides
    - e.g. diazinon and chlorpyrifos in rivers
- Bloom sprays
  - Effective, benefit from free ride
  - Common practice for many years
  - Bee issues became more prevalent
    - Original response to spray products not known to harm bees or to spray at night
    - ABC and UC now recommend avoiding all insecticides at bloom (except Bt).
      - Very conservative, precautionary recommendation due to unknowns
- May sprays
  - Effective
  - Timing based on degree-day models
  - Often coincides with May NOW flights



Southern Fire Ant

- Strategies that kill or neutralize the queen
  - Take approximately 8 weeks to work
  - Three baits, three modes of action
    - Clinch
    - Esteem
    - Extinguish
- Strategies that kill workers
  - Work within days, but not as long as traditional baits
    - Bait- Altrevin
      - Typically applied hull split to one week before harvest
    - Ground spray- Lorsban Advanced
      - Used only in emergencies

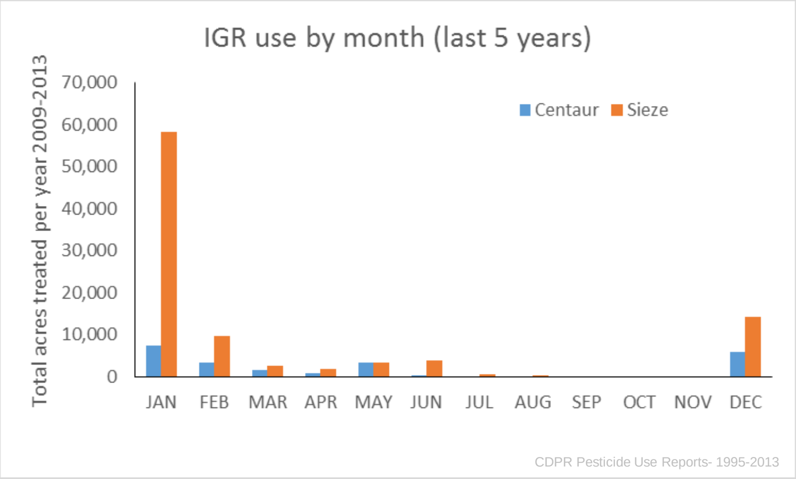


CDPR Pesticide Use Reports- 1995-2013

- General comments
  - Applications should be based on monitoring
  - Don't get baits wet
  - Remove weeds (especially spurge) that competes with baits
  - Rotate products within/between years
  - Minimize nut time on the ground

San Jose Scale

- Historically treated with dormant applications of organophosphates
- Research showed that this made things worse
  - Disruption of natural enemies (parasitoids)
- Growers now use growth regulators
  - Compatible with natural enemies
  - Typically applied every 3-5 (or more) years
  - Sieze (pyriproxifen)
    - sterilizes females, immatures don't develop
  - Centaur (buprofezin)
    - chitin inhibitor, immatures do not develop



- General comments
  - Dormant spur sampling and treatments
  - Low scale or good biocontrol
    - Don't treat
  - Moderate scale
    - Treat with oil
  - High scale
    - Treat with growth regulator and oil
  - Pheromone exists, traps also catch parasitoids

Leaffooted bug



- Migrates into orchards in the spring
- Controlled with insecticides that affect the nervous system
  - Organophosphates (Lorsban)
    - Effective on contact
    - One week of residual
  - Pyrethroids (Brigade and Warrior II)
    - Effective on contact
    - Four weeks of residual
  - Abamectin (Agri-Mek)
    - Effective on contact
    - No effects from residue
  - Other modes of action tested (some not registered)
    - Some contact activity, no residual activity
    - Beleaf, Belay, Bexar, Exirel, Sequoia, Sivanto

- General comments
  - No cultural or biological controls
  - Monitor March to June
  - Consider a treatment if you…
    - Find adult bugs
    - Find gummosis on nuts
    - Observe nut drop caused by bugs

Spider Mites

- Biological control
  - Don't starve them
    - Maintain food in the early spring
  - Don't kill them
    - Avoid broad-spectrum insecticides
    - Avoid abamectin and spinosyns if sixspotted thrips are present
- Monitoring
  - To determine the need to treat
  - Presence/Absence sampling
  - Threshold of ~30% leaves infested
- Treatments
  - Based on thresholds
  - Rotating chemistries
  - With 1% 415 oil

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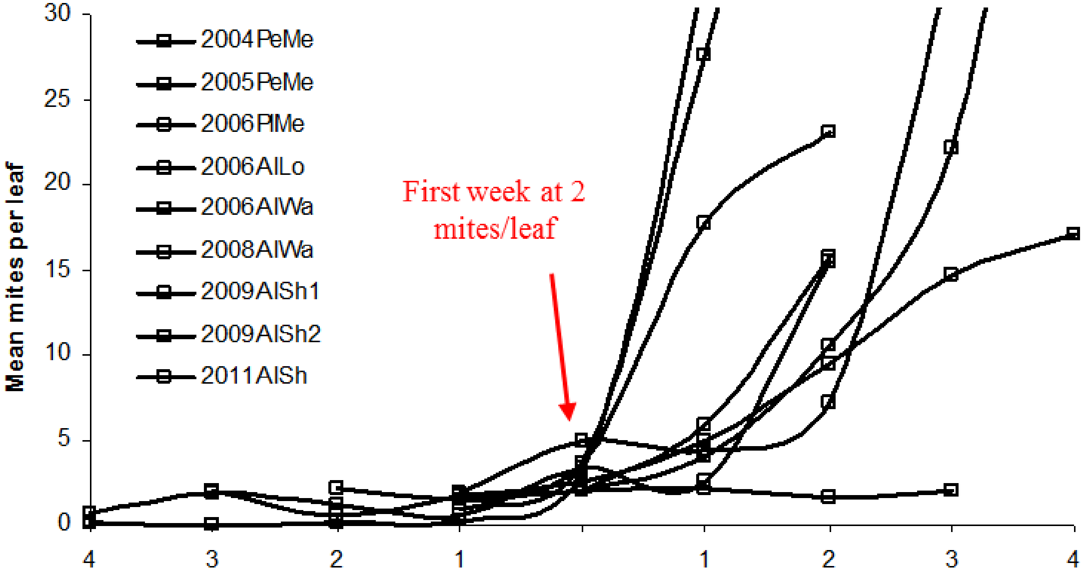

Spider Mites

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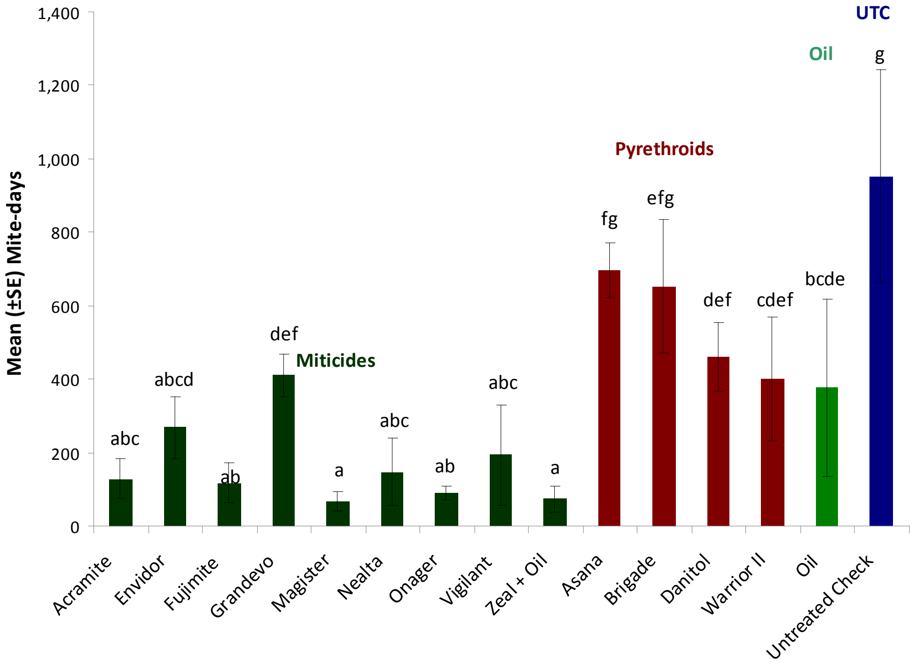
2013 Miticide Trial



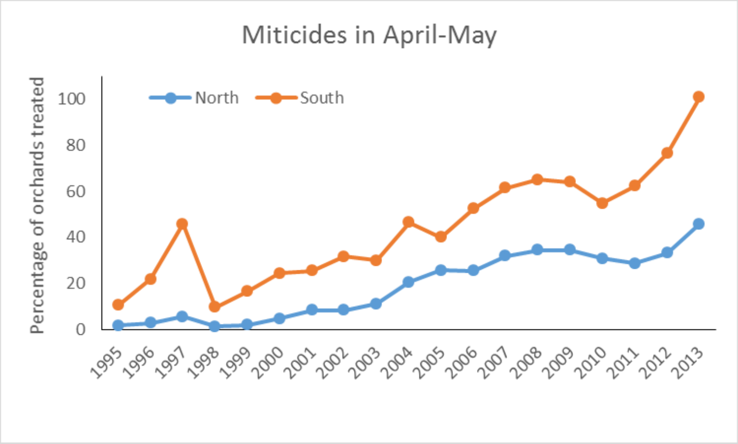
Spider Mites

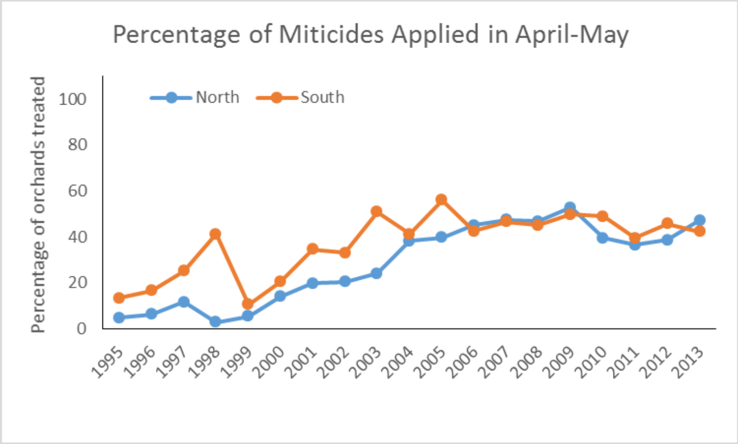
Mites[4]	6	abamectin	Agri-Mek	Avermectin – contact or ingestion toxin that paralyzes juveniles and adults; death by starvation	PM: H ; GP: L ; P:M/ H; HB: II
	10A	clofentezine hexythiazox	Apollo Onager	Growth Regulator – growth regulator of mite eggs and some nymphs, adults lay sterile eggs	PM: L; GP: L; P: L; HB: IV
	10B	etoxazole	Zeal	Growth Regulator – contact toxin on eggs; inhibits molting of juveniles; adult females produce sterile eggs	PM: -; GP: -; P: -; HB: IV
	12B	fenbutin-oxide	Vendex	Energy metabolite – contact toxin to juveniles and adults by inhibition of ATP synthesis	PM: L; GP: L; P: L; HB: IV
	12C	propargite	Omite	Energy metabolite- contact toxin to juveniles and adults by inhibition of ATP	PM: M ; GP: L ; P: L; HB: IV
	20B	acequinocyl	Kanemite	METI III – contact toxin to eggs, juveniles and adults; inhibits electron transport in the mitochondria	PM: L; GP: -; P: -; HB: IV
	20D	bifenazate	Acramite	METI III – contact toxin on all stages; inhibits electron transport in the mitochondria	PM: L; GP: L; P: L; HB: IV
	21	fenpyroximate	Fujimite	METI I – contact toxin on all stages; inhibits electron transport in the mitochondria	PM: H ; GP: L ; P: L; HB: IV
	23	spirodiclofen	Envidor	Lipid Synthesis Growth Regulator – contact on all mite stages by inhibiting lipid biosynthesis; most effective on juveniles	PM: -; GP: -; P: -; HB: I
	25A	cyflumetofen	Nealta	METI II - contact toxin on all stages; inhibits electron transport in the mitochondria	-

Spider Mites- Grower trends

- Increased adoption of preventative (prophylactic) spray programs

-Less use of thresholds
-No food in spring for predators





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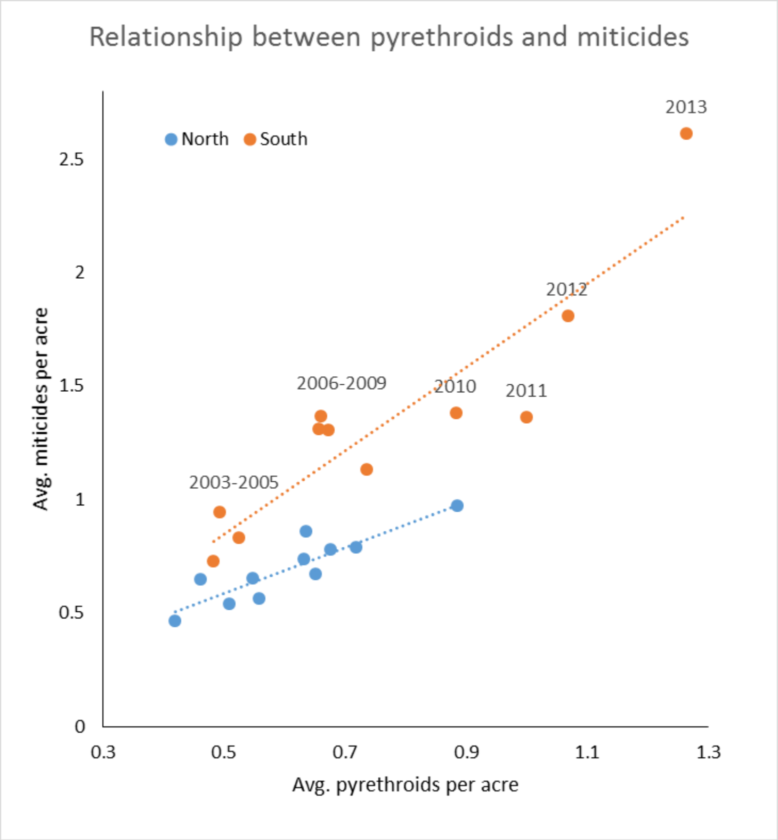
Spider Mites- Grower trends

- Increased adoption of preventative (prophylactic) spray programs
- Increased pyrethroid use

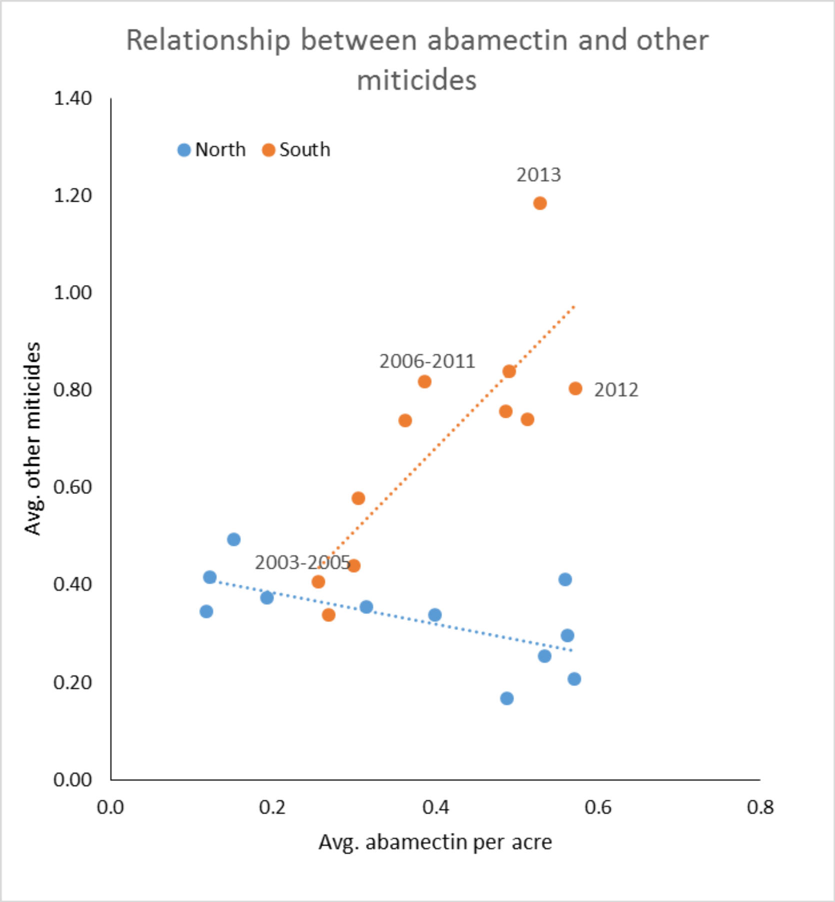
-Disruption of biological control



Spider Mites- Grower trends

- Increased adoption of preventative (prophylactic) spray programs
- Increased pyrethroid use
- Increased use of early-season abamectin that kills sixspotted thrips

-Disruption of biological control



Spider Mites- Grower trends

- Increased adoption of preventative (prophylactic) spray programs
- Increased pyrethroid use
- Increased use of early-season abamectin that kills sixspotted thrips
- Decreased use of oil that helps kill mites and prevent resistance

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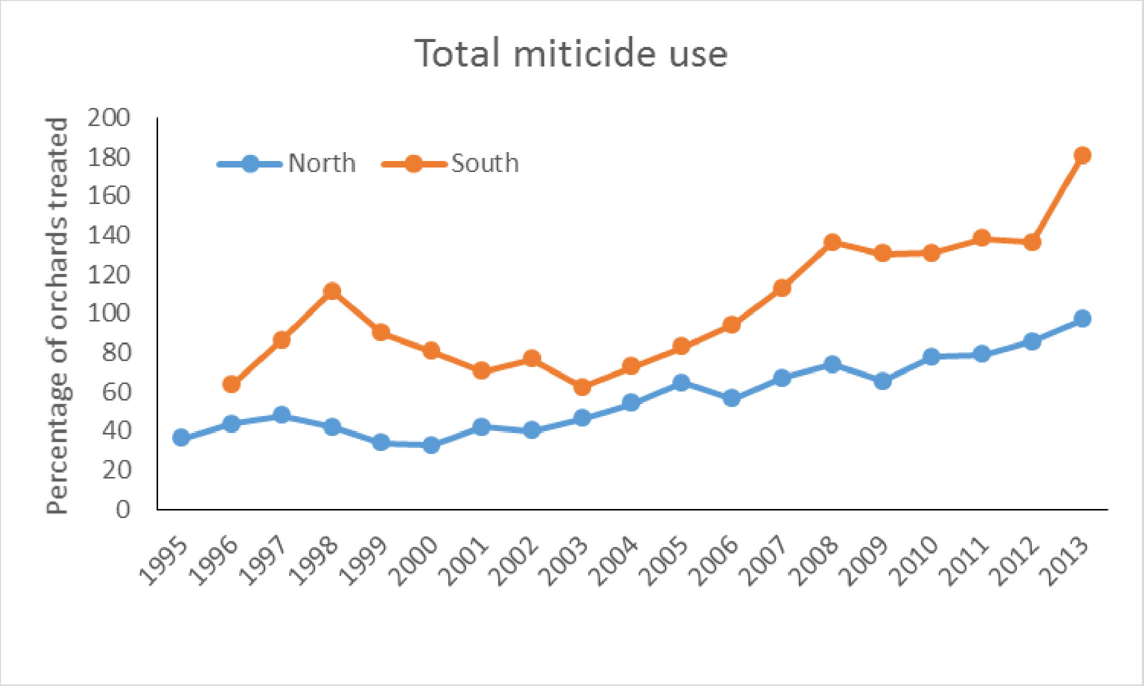
Spider Mites- Grower trends

- Increased adoption of preventative (prophylactic) spray programs
- Increased pyrethroid use
- Increased use of early-season abamectin that kills sixspotted thrips
- Decreased use of oil that helps kill mites and prevent resistance
- Overall increase in applications for spider mites
  - Despite improved miticides compared to one decade ago



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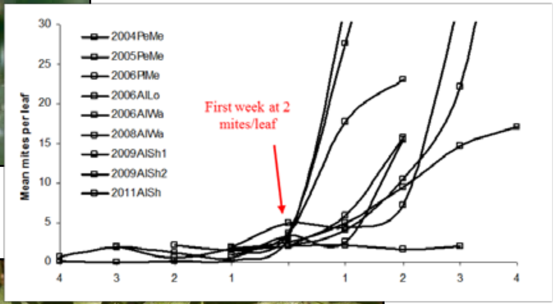
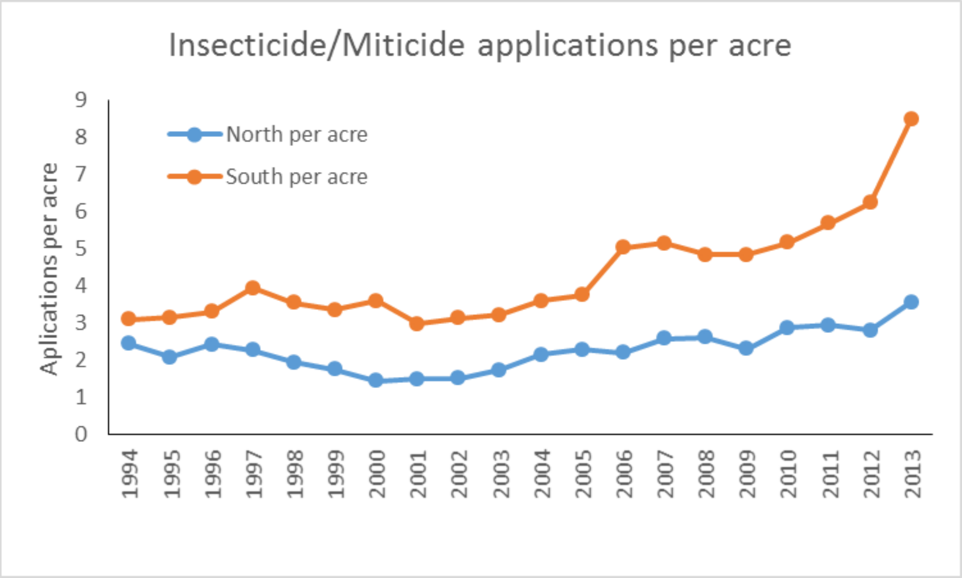


Insecticide/Miticide Use Summary

- Almond growers are becoming one of the largest users of insecticides and miticides
  - Due to increases in acreage
  - Due to per-acre increases
- Industrywide improvements are being made
  - OP use going down
  - Reduced-risk insecticides being adopted
  - Ant management
  - San Jose scale management
- Industrywide improvements needed
  - Pyrethroid use going up
  - Miticide use going up
  - Management of NOW and Leafooted bug



UC Statewide IPM Program

- http://ucipm.ucanr.edu or Search for "UCIPM"
- Clearinghouse for pest management information
- No research papers, no data, no statistics
- Distillation of 'what it all means'
- Major revision every 5 years
- Minor revisions (especially to insecticides) every year
- Contents
  - Pest Management Guidelines
  - Year-Round IPM Program
  - Photo Galleries
  - Degree-day models
  - Susceptibility/toxicity charts

UC Statewide IPM Program

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- HOME
- SEARCH
- ON THIS SITE
- What is IPM?
- Home & landscape pests
- Agricultural pests
- Natural environment pests
- Exotic & invasive pests
- Weed gallery
- Natural enemies gallery
- Weather, models & degree-days
- Pesticide information
- Research
- Publications
- Events & training
- Links
- Glossary
- About us
- Contact us

How to Manage Pests

Almonds

All crops

Emerging Pests in California

- Bacterial Spot

Year-Round IPM Program

Tells you what you should be doing throughout the year in an overall IPM program. Includes Year-Round IPM Program Annual Checklist.

Using the almond year-round IPM program | Forms and supplemental pages

Year-Round IPM Program for Almonds (3/09)

- Dormant to delayed-dormant
- Bloom to postbloom
- Fruit development
- Harvest
- Postharvest

UC IPM Pest Management Guidelines

University of California's official guidelines for pest monitoring techniques, pesticides, and nonpesticide alternatives for managing pests in agriculture, floriculture, and commercial turf. More

Authors & credits | All crops | Download PDF | Recent updates

General Information

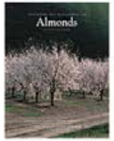
- Dormant Spur Sampling and Treatment Guidelines (11/12)
  - Pests monitored
  - How to monitor
- Relative Toxicities of Pesticides used in Almonds to Natural Enemies and Honey Bees (7/14)
- General Properties of Fungicides Used in Almonds (11/12)
- Fungicide Efficacy for Almonds Diseases (10/13)
- Treatment Timings for Key Disease (10/13)
- Fungicide Resistance Management (11/12)

Diseases

- Almond Brownline and Decline (3/09)

Insects and Mites

- Ants (9/15)
- Brown Mite (3/09)
- European Fruit Lecanium (9/15)
- European Red Mite (3/09)
- Forest Tent Caterpillar (3/09)
- Leaffooted Bug (9/15)
- Leafrollers (9/15)
- Navel Orangeworm (9/15)
- Oriental Fruit Moth (9/15)
- Peach Silver Mite (11/12)
- Peach Twig Borer (9/15)



More information

- 2013 Efficacy and Timing of Fungicides, Bactericides, and Biologicals for Deciduous Tree Fruit, Nut, Strawberry, and Vine Crops (PDF)
- Seasonal Guide to Environmentally Responsible Pest Management Practices in Almonds (PDF)
- Almond Production in California: A Study of Pest Management Practices, Issues, and Concerns
- Mitigating pesticide hazards
- Chlorpyrifos decision-support tool
- Herbicide resistance: Glyphosate
- Research projects related to almonds

PDF: To display a PDF document, you may need to use a PDF reader.

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- HOME
- SEARCH

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- What is IPM?
- Home & landscape pests
- Agricultural pests
- Natural environment pests
- Exotic & invasive pests
- Weed gallery
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- Pesticide information
- Research
- Publications
- Events & training
- Links
- Glossary
- About us
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How to Manage Pests

UC Pest Management Guidelines

| All almond pests | All crops | About guidelines |

Almond

Relative Toxicities of Pesticides used in Almonds to Natural Enemies and Honey Bees

(Reviewed 3/09, updated 7/14, pesticides updated 9/15)

In this Guideline:

- Publication
- Glossary

Common name (Example trade name)	Mode of Action[1]	Selectivity[2] (affected groups)	Predatory Mites[3]	General Predators[4]	Parasites[4]	Honey Bees[5]	Duration of impact to natural enemies[6]
abamectin (Agri-Mek)	6	moderate (mites, leafminers)	H	L	M/H	II	long to predatory mites and affected insects
acequinocyl (Kanemite)	20B	narrow (mites)	L	—	—	IV	—
Bacillus thuringiensis ssp. kurstaki	11A	narrow (caterpillars)	L	L	L	IV	short
bifenazate (Acramite)	un	narrow (mites)	L	L	L	IV	short
bifenthrin (Brigade)	3A	broad (insects, mites)	H	H	H	I–III[7]	long
buprofezin (Centaur)	16	narrow (sucking insects, beetles)	L	H[8]	L	IV	long
carbaryl (Sevin XLR Plus)	1A	broad (insects, mites)	L/H	H	H	I	long
chlorantraniliprole (Altacor)	28	narrow (primarily caterpillars)	L	L	L/M	IV	short
chloropyridazin/sulfur (Desperado)	—	—	H	—	—	—	—
chlorpyrifos (Lorsban)-dormant	1B	broad (insects, mites)	L	L/M	L	I[9]	moderate
chlorpyrifos (Lorsban)-in season	1B	broad (insects, mites)	M	H	H	I[9]	moderate
clofentezine (Apollo)	10A	narrow (mites)	L	L	L	IV	short
cyfluthrin (Baythroid)	3A	broad (insects, mites)	H	H	H	I	moderate
diazinon	1B	broad (insects, mites)	L	H	H	I	moderate to long
diflubenzuron (Dimilin)	15	—	L	H[10]	L	IV	—
emamectin benzoate (Proclaim)	6	narrow (caterpillars)	—	—	—	III	—
esfenvalerate (Asana)	3A	broad (insects, mites)	H	M	H	I	moderate

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What is IPM?
Home & landscape pests
Agricultural pests
Natural environment pests
Exotic & invasive pests
Weed gallery
Natural enemies gallery
Weather, models & degree-days
Pesticide information
Research
Publications
Events & workshops
Online training
Links
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UC IPM offers interactive tools and models that can help you make pest management decisions based on conditions at your site.
California weather data | Pest and plant models | Additional tools | Degree-day calculator
California weather data
Current daily and hourly data from stations throughout California, plus long-term data for climate stations. PestCast research networks provide hourly and daily values from selected locations.
Station news | About the database | Western Regional Climate Center | CIMIS
Select from:
stations in (County) County Map
stations in (Networks) Networks Map
station: Enter all or part of a name. List
Active stations only
Submit
Clear
Pest and plant models (including UC-recommended degree-day models)
Videos: Using degree-days to time insecticide applications
Beet armyworm (TABLE)
California red scale (TABLE)
Codling moth (TABLE)
Consperse stink bug (TABLE)
Cotton (TABLE)
Elm leaf beetle (TABLE)
Fire blight risk for apple and pear
Obliquebanded leafroller (TABLE)
Omnivorous leafroller (TABLE)
Orange tortrix (TABLE)
Oriental fruit moth (TABLE)
Peach twig borer (TABLE)
Pink bollworm (TABLE)
ADDITIONAL TOOLS
Cotton planting forecast (March and April)
Chilling accumulations (November through March)
Sunset temperatures (February through May 15)
Model descriptions
More interactive tools
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HOME

LIST NATURAL ENEMIES

- By order and family name
- By scientific name
- By pest

ON THIS PAGE

- Predators
- Insect parasites

ON THIS SITE

- What is IPM?
- Home & landscape pests
- Agricultural pests
- Natural environment pests
- Exotic & invasive pests
- Weed gallery
- Natural enemies gallery
- Weather, models & degree-days
- Pesticide information
- Research
- Publications

Natural enemies gallery

Natural enemies are organisms that kill, decrease the reproductive potential of, or otherwise reduce the numbers of another organism. Natural enemies that limit pests are key components of integrated pest management programs. Important natural enemies of insect and mite pests include predators, parasites, and pathogens.

The UC IPM Natural Enemies Gallery includes natural enemy species commonly found on California farms and in landscapes. Additional species will be added over time.

For more information about natural enemies, purchase the Natural Enemies Handbook.

Predators | Parasites | List by order and family name | List by scientific name | List by pest

Additional resources

- Biological Control and Natural Enemies of Invertebrates Pest Note
- Video Narrated presentation on biological control (24 minutes)
- Poster: Meet the Beneficials: Natural Enemies of Garden Pests
- More biological control resources

Predators

A predator is an organism that attacks, kills, and feeds on several to many other individuals (its prey) in its lifetime.

Common name	Scientific name
Assassin bugs	Reduviidae family
Bigeyed bugs	*Geocoris* spp.
Brown lacewings	*Hemerobius* spp.
Convergent lady beetle	*Hippodamia convergens*

How to Manage Pests:

Pest Management and Identification

| More natural e

Sixspotted thrips

Scientific name: ***Scolothrips sexmaculatus***

Phylum: Arthropoda
Class: Insecta
Order: Thysanoptera
Family: Thripidae

Common prey: Predaceous on phytophagous mites

Commercially available: No

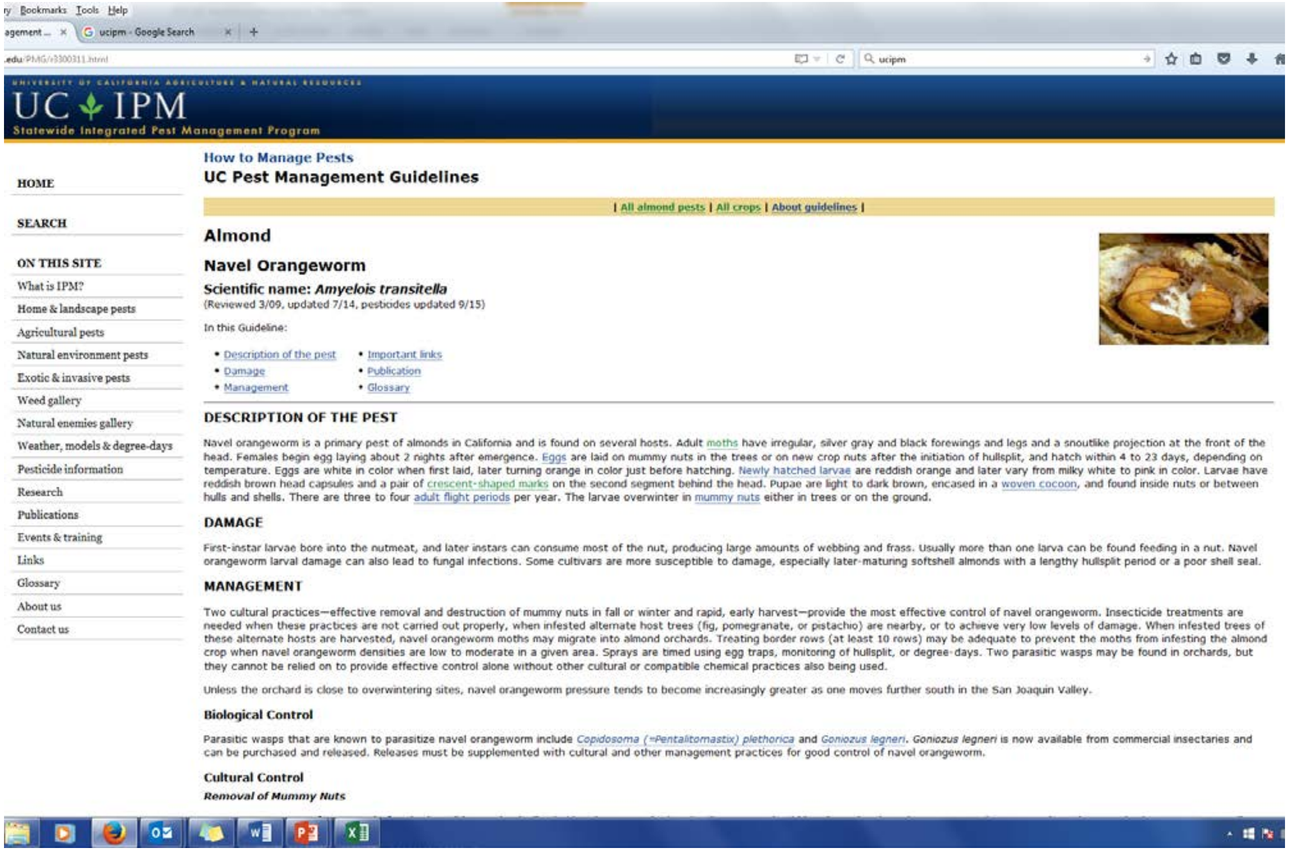
Click on image to enlarge

DESCRIPTION

Thrips are tiny, 2-3 mm (less than 1/8 inch) in length, slender insects with long fringes on the margins of th be phytophagous or predaceous. Sixspotted thrips adults can be distinguished from other species by the th to yellow and difficult to discern from other thrips species. Adults and larvae are entirely predaceous, feedir spider mites. Sixspotted thrips can rapidly reduce high mite populations, but often don't become numerous u

Pest Management Guidelines

- Identification
- Damage
- Management
  - Biological control
  - Cultural Control
  - Monitoring
  - Treatment guidelines
  - Insecticides
- Water Toxicity
- Air Quality
- Decision Support Tool



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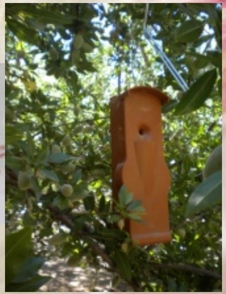
Brad Higbee,
Wonderful Orchards

growing
ADVANTAGE
The Almond Conference

Mating Disruption: A Tool for Control of Navel Orangeworm

Bradley S. Higbee
Director, Entomology Research
Wonderful Orchards
Bakersfield, CA
bradh@paramountfarming.com



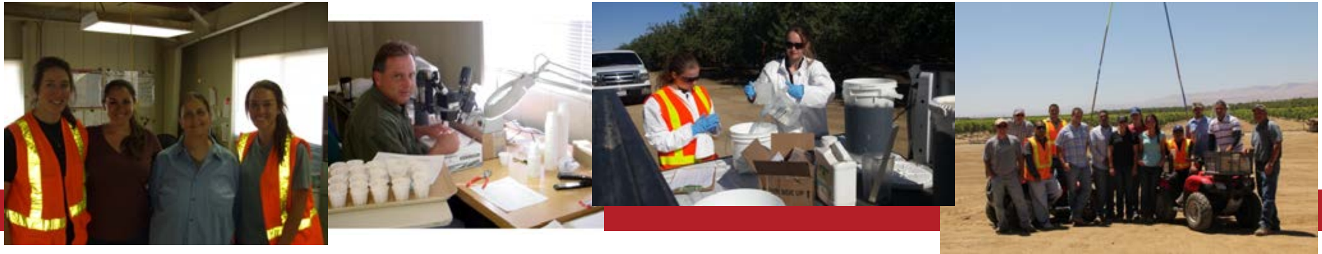
Wonderful orchards™

Entomology Research Program (est 2002)

PARAMOUNT FARMING → Wonderful orchards™

2015

- Mission: To develop sustainable pest management and monitoring programs in almonds, pistachios and pomegranates that integrate the most efficient and cost effective strategies.
- Primarily focused on Navel Orangeworm (60-75% of effort), we also work on ants, mites, ALS, Plant bugs, other moth pests, aphids, whiteflies
- Biology – Phenology, Dispersal/movement, development
- Chemical Ecology – Attractants, Semiochemicals
- Management / Control – Sanitation, Insecticides, Mating Disruption



NOW Control

- Past – heavy reliance on OPs , then pyrethroids
- Current – pyrethroid resistance developing
- Transition to: diamides, IGRs, MD??
  - Primarily ovi-larvicides
  - Adequate coverage difficult to achieve

Brad Higbee, Wonderful Orchards

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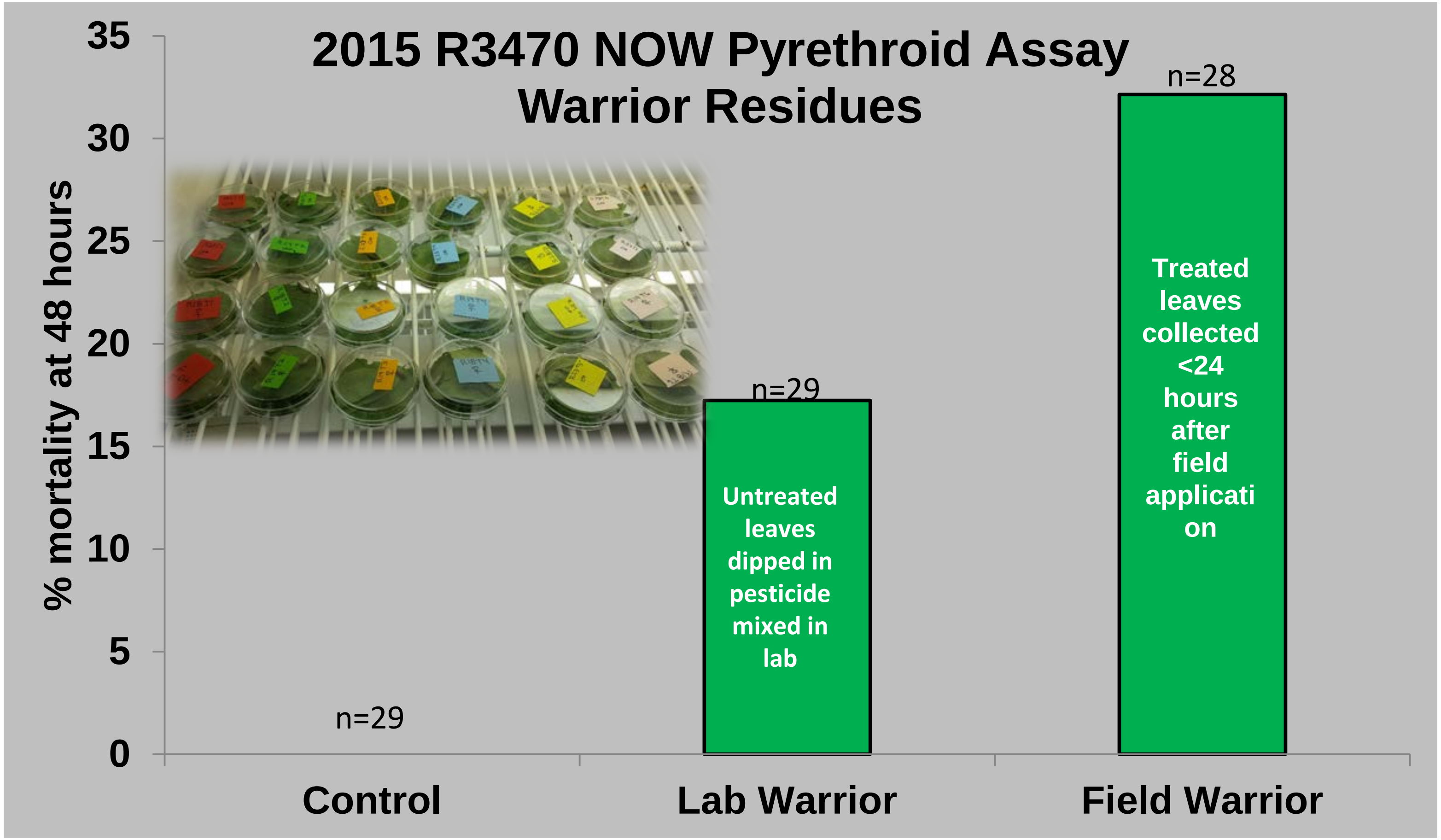
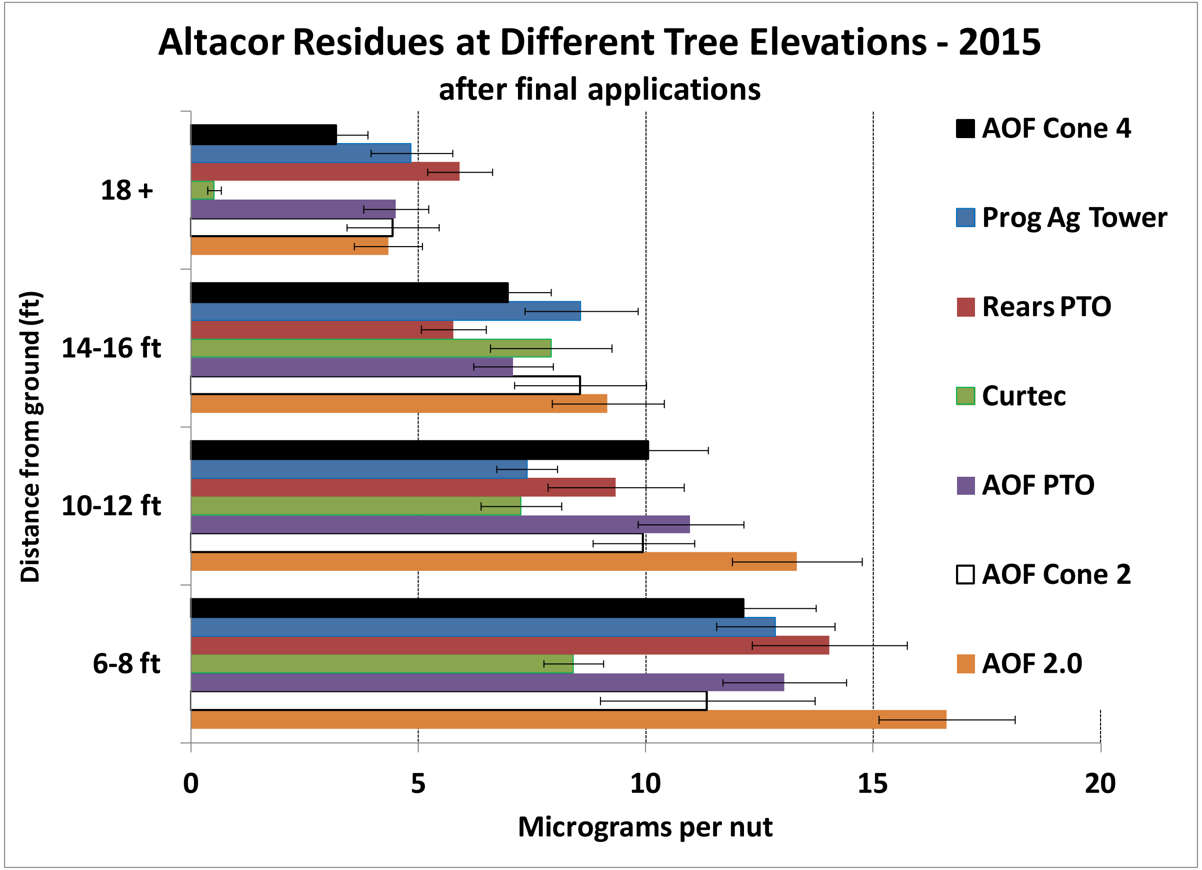

2015 R3470 NOW Pyrethroid Assay
Warrior Residues
% mortality at 48 hours
35
30
25
20
15
10
5
0
n=29
n=29
n=28
Untreated leaves dipped in pesticide mixed in lab
Treated leaves collected <24 hours after field applicati on
Control
Lab Warrior
Field Warrior

Spray coverage



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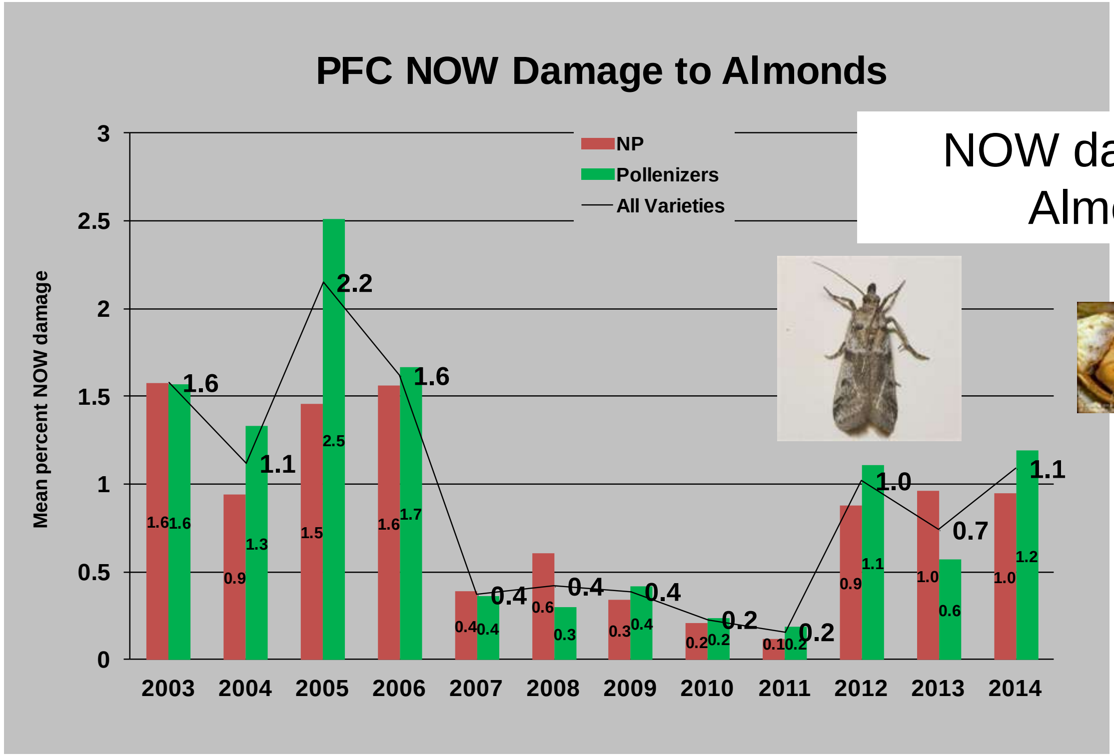
Navel Orangeworm – Public Enemy #1 for Almond and Pistachio

Factors that influence NOW "Thresholds" - Alfatoxin risk, Processor sorting expense, Direct yield impact



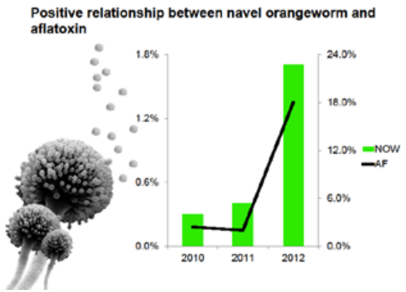
NOW damage to Almonds

$0.88/lb >> $4+/lb

Organophosphates → Pyrethroids → MD/New chems

Factors that Matter
Alfatoxin risk, Processor sorting expense, Direct yield impact

- 2002: Almonds $0.88/lb ⟹ 2014: ≈ $3–4+/lb
- For 2500 lb/ac: 1% dmg = $22 vs $75-100
- Aflatoxin



- Processor incentives for low damage

Cost/ac of:
Pyrethroid appl ≈ $5-10
New chemistries ≈ $40-50
MD ≈ $120/ac

Why Mating Disruption?

- It is effective when used properly
  - Typically increases performance of insecticide programs
- Loss of pyrethroids leaves only ovi-larvicides in the toolbox
  - Effectiveness limited by coverage
- Unlikely to develop resistance
  - MD works regardless of insecticidal resistance status of NOW
- Economics have become favorable
- Worker safety
- Environmental stewardship
  - Eco-friendly marketing and promotion of almonds

Concerns with Mating Disruption

- Not a silver bullet
- Immigration of mated females (border effects)
  - Context is important
  - Occur in both MD and non-MD orchards
- Topography
- Influenced by air movement at night
- May require additional monitoring/sampling
- Cost

What is a pheromone?

Intraspecific Action

PHEROMONE

releaser

- Alarm
- Sexual
- Aggregation
- Territorial
- Oviposition
- Trail
- Recruitment
- Kin-recognition
- Propaganda
- Nest-building etc.

primer

- Sexual maturation
- Development
- Physiological state

Interspecific Action

(benefits receiver)

KAIROMONE

Pheromones,
allomones,
toxins,
metabolites etc.;
used in host/prey
location.
Floral scents.

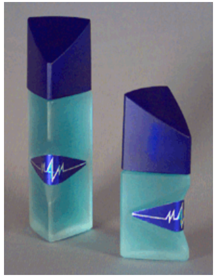
(benefits sender)

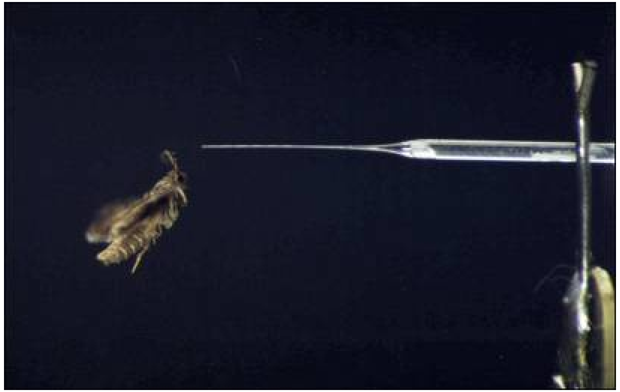
ALLOMONE

Defense secretions,
repellents,
floral scents etc.

Chemical communication within a species:

Sex Pheromones





M4M cologne: classically simple, yet intoxicatingly complex.....

Bradley S. Higbee, Wonderful Orchards

Practical Application of Pheromones

Monitoring/Surveillance purposes

- Attractant lures in traps to monitor the distribution (spatial, temporal, density) of pests.
- Use information to direct either eradication or management efforts.
- Provides information on presence/absence and pop dynamics that can assist in efforts to time insecticide sprays and verify need.

Practical Application of Pheromones

Control purposes – Mating Disruption (MD)

- As the name suggests, interfering with the ability of males and females to locate each other for the purpose of mating.
- For the Navel Orangeworm, the female emits a sex pheromone blend, which the male uses to locate and mate with female moths.

Practical Application of Pheromones

Control purposes – Mating Disruption (MD)

- Broadcast application of formulated, synthetic pheromone.
- Interferes with normal mate-finding behavior
- Multiple types of release platforms

Sprayable microcaps 10-100k/ac

Hand-applied Passive 100-200/ac

Puffers Metered, timed 1-2/ac

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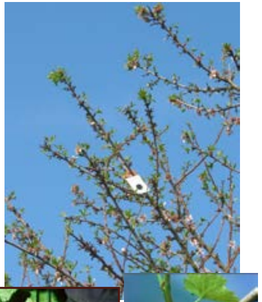
Practical Application of Pheromones

Rates of pheromone emission

• **Calling female**	**0.3 ng/min**
• **Hollow, open-ended fiber**	**1 ng/min**
• **Rubber septum (4 mg load)**	**17 ng/min**
• **Sealed rope**	**300 ng/min**
• **Puffer**	**1-2 g/day**

1 ng = 1ppb



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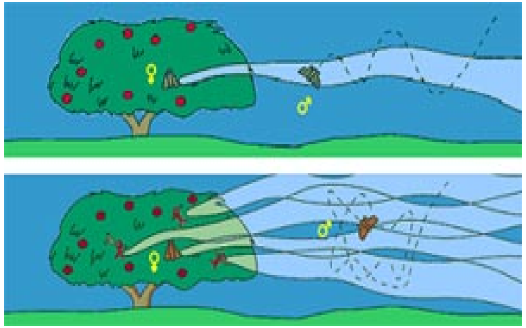
Mechanisms of Mating Disruption

Neurological and Behavioral

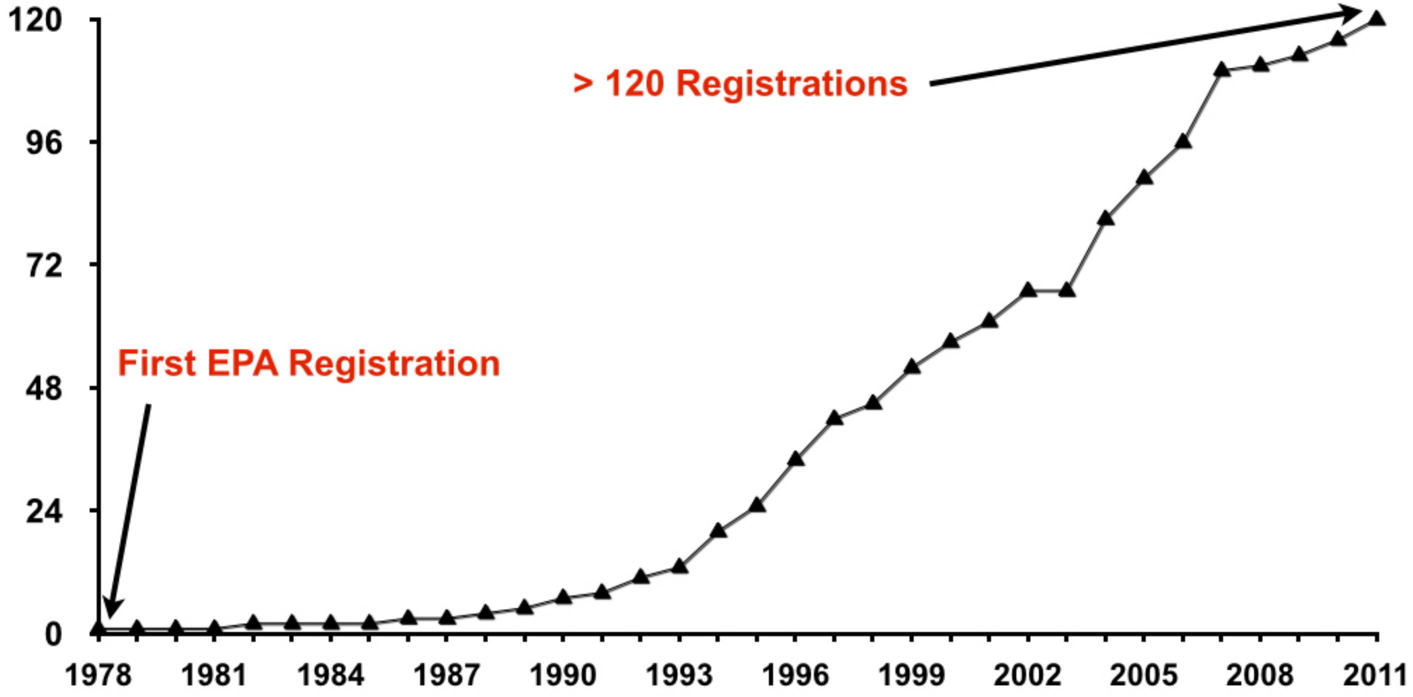
- Sensory Adaptation – (desensitization or sensory fatigue)
  – Short and long-term peripheral adaptation
- Habituation – central nervous system
- Camouflage
- False Trail Following (Competitive Attraction)



- Not mutually exclusive
- Dose and release mechanism dictate
- May work together

Adapted from Carde et al. 1998

US EPA Pheromone Registrations



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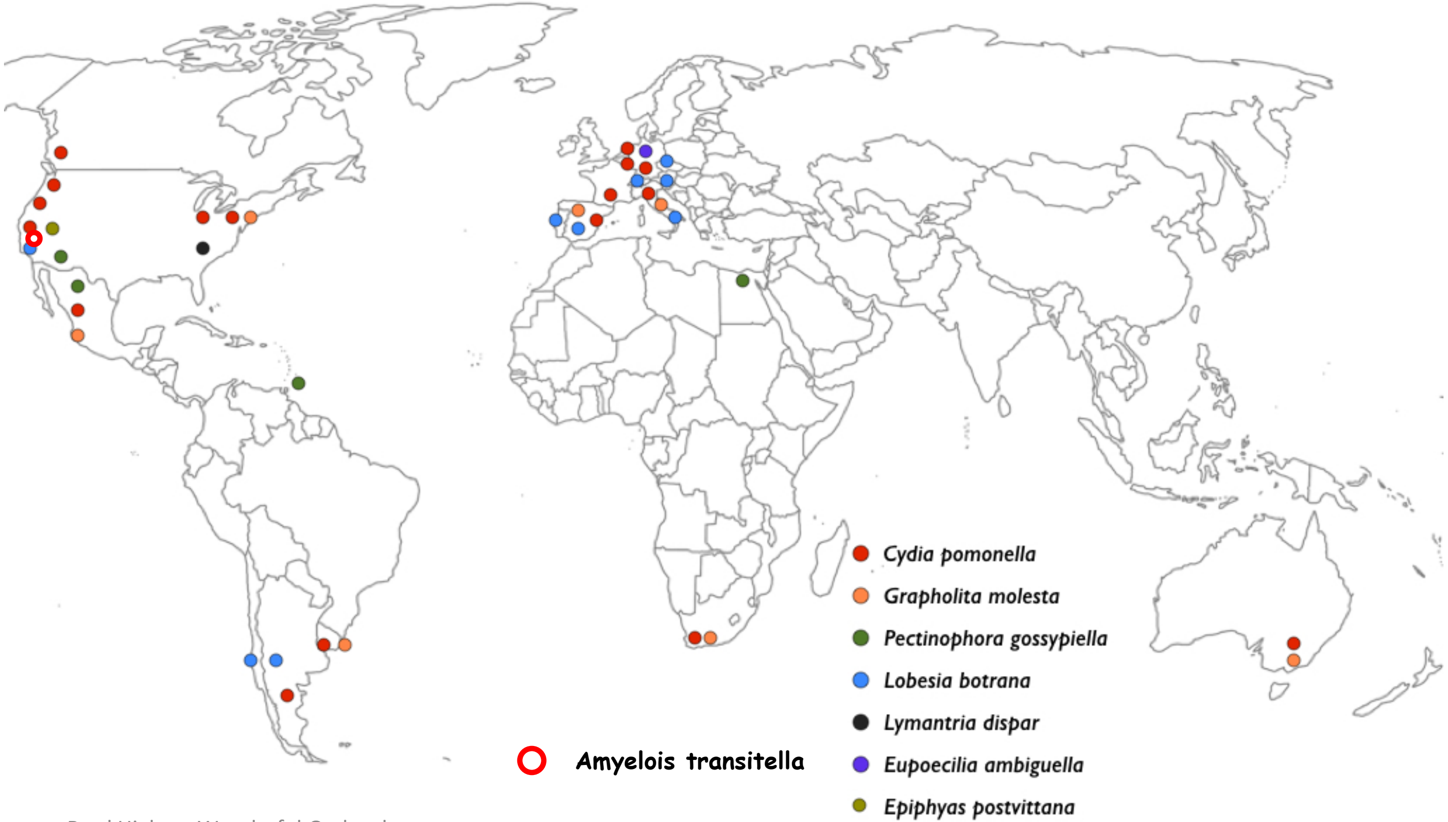
Large-area Mating Disruption Projects



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NOW MD Development

1980's – Landolt, Curtis, et al. Trap suppression and limited damage reduction with various dispensers

1990's – Shorey showed trap shut-down with puffers in 40 ac perimeters

2002 – 2007

Demonstrated impact on damage reduction in 20 and 40 ac almond plots – Puffers in grids most effective, Higbee, B. S., and C. S. Burks. 2008. J. Econ. Entomol. 101(5):1633-1642

2005 - Commercial product available

2008 -2012 - USDA NOW Areawide Project

2013 – 32k ac under NOW MD

2014 – 60k ac under MD

2015 – Est 120k ac

2016 - ??

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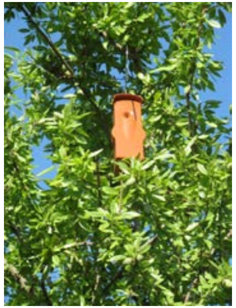
Mating Disruption for NOW

- Aerosol formulation
- Pheromone component used is not attractive
- Amount used is 10 to 15% that used for other species
- Material is much more expensive
- 2 puffers/ac is recommended rate



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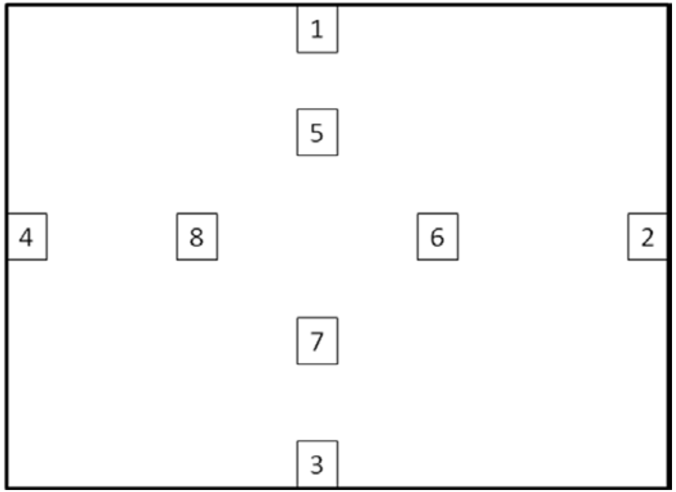
Mating Disruption for NOW

- What is your objective?
  1. Eliminate insecticides
     - Not possible in all situations
     - Context is critical
  2. Decrease insecticide use
     - More intensive monitoring required
  3. Current program not achieving desired results
     - Add MD to current program
     - Monitor normally

Implementing MD in Almonds

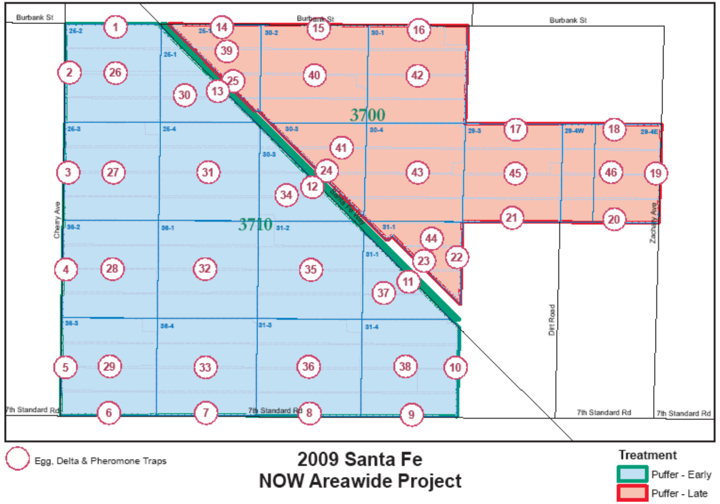
- 1st step: Site evaluation
  - What are the historical damage and NOW pops levels within your orchard
- What is the context
  - What crops/land use are immediately outside the borders of your orchard?
  - What is the regional cropping pattern and NOW pressure?
- Design a monitoring program

Monitoring Site approach



1 site per 25-160 ac

1. Pheromone trap
2. Egg or oviposition attractant trap
3. Pre-harvest or early split examinations
4. Harvest sample evaluations
5. Kairomone lure?



Monitoring Site approach

Information that can inform action

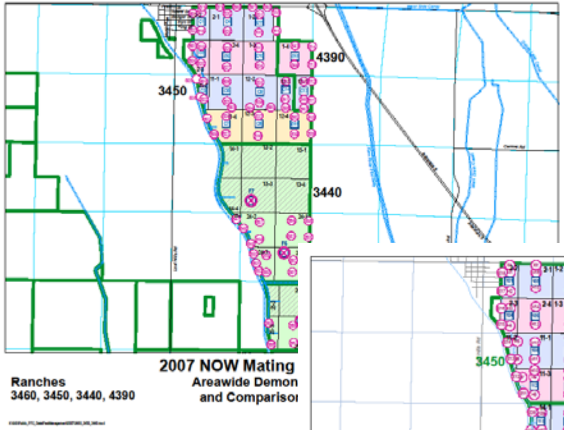
- Relative
  - Are there areas with elevated counts?
  - Do metrics agree?
- Precision
  - What areas are at the highest risk?
  - Is a treatment needed?
- Confidence builds with experience

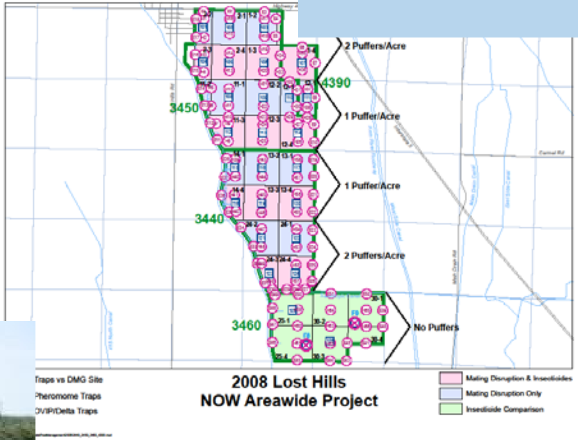
Areawide MD for NOW compared to :

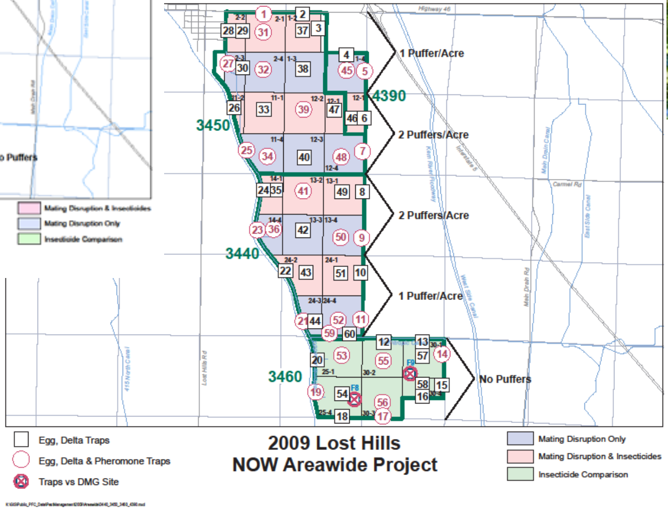
3000 ac

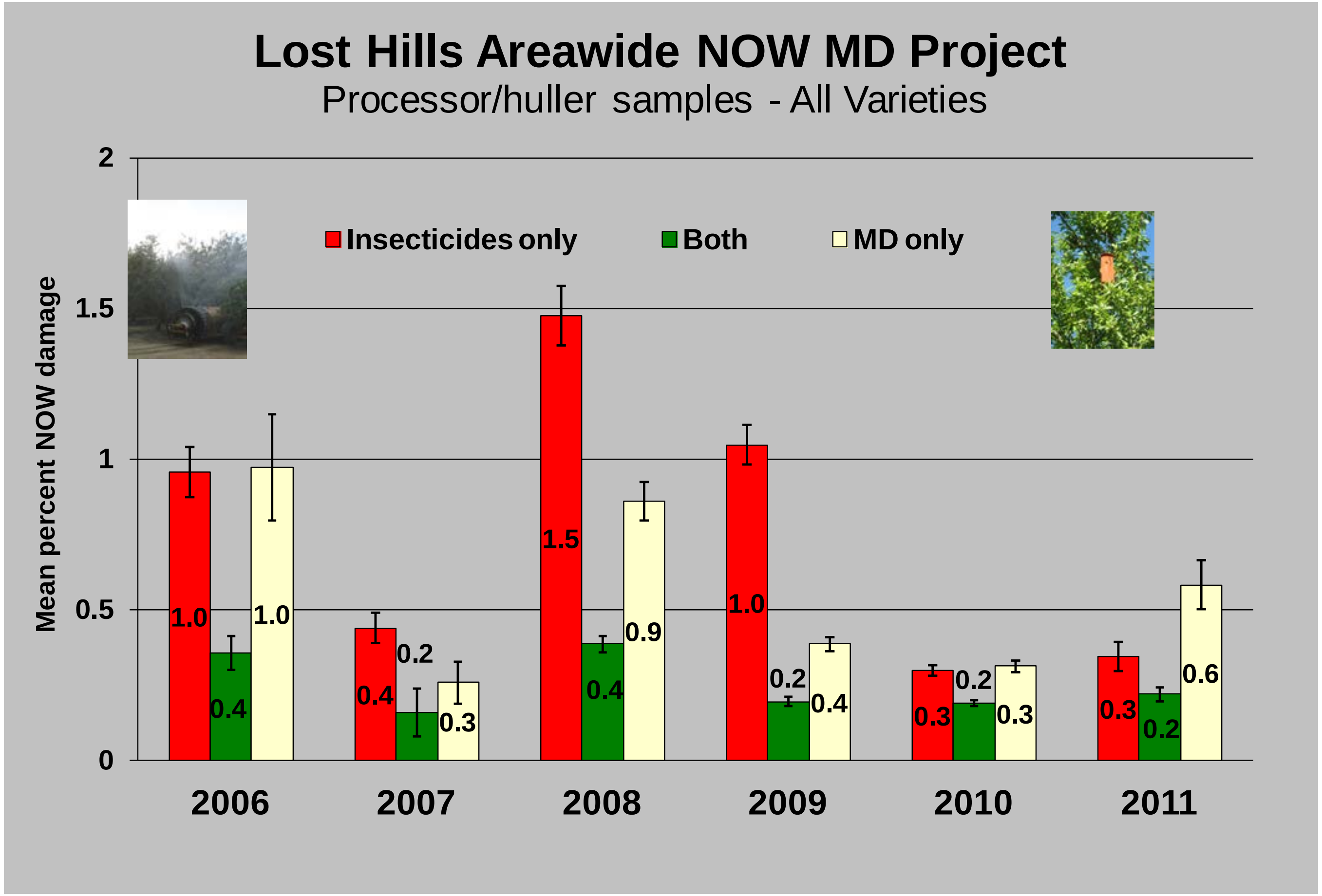
Conventional Insecticide program

Combination









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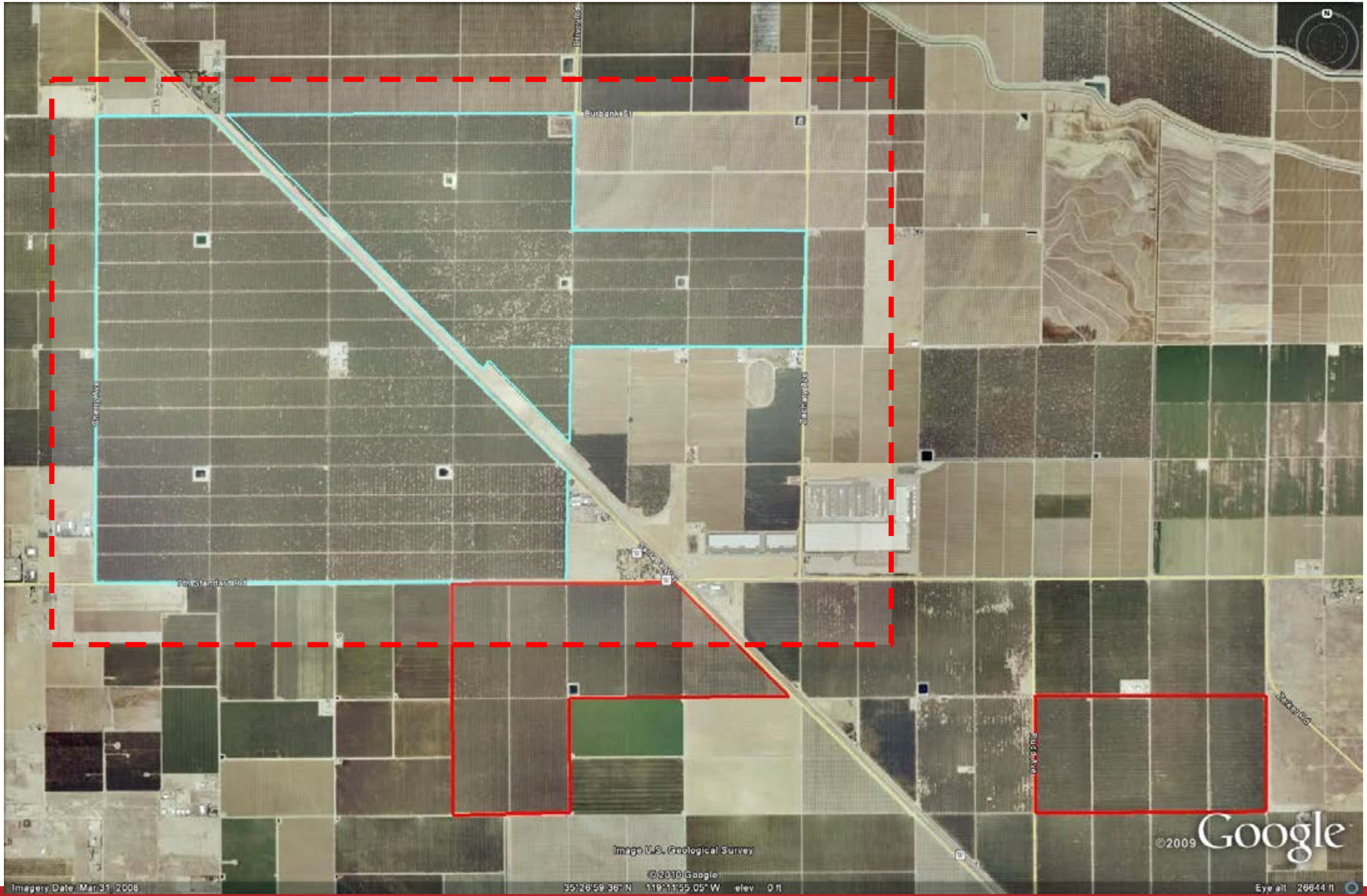
Santa Fe Areawide Demonstration



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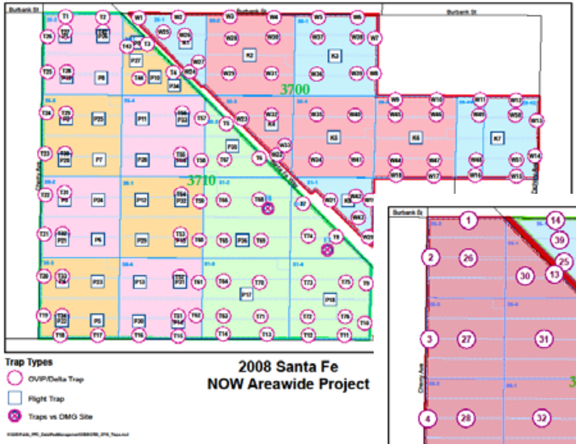
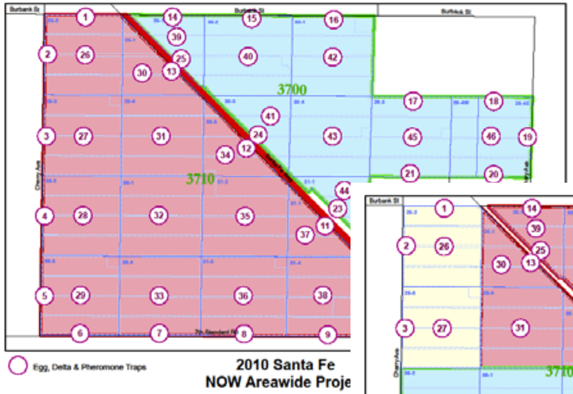
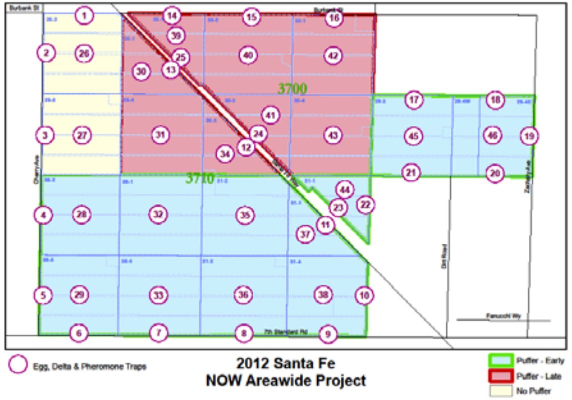
Santa Fe Areawide Project - 2500 acres 2007-2012

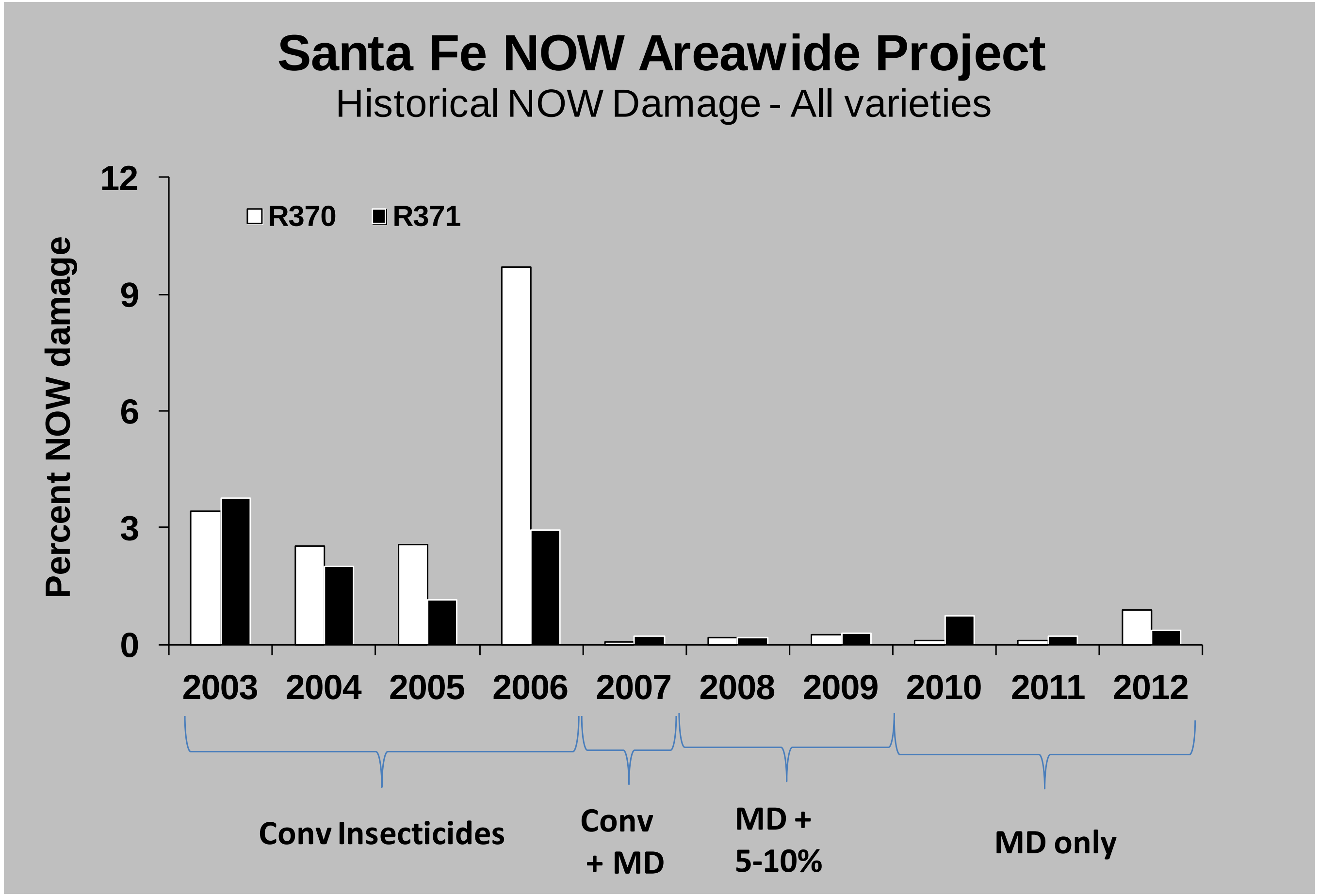




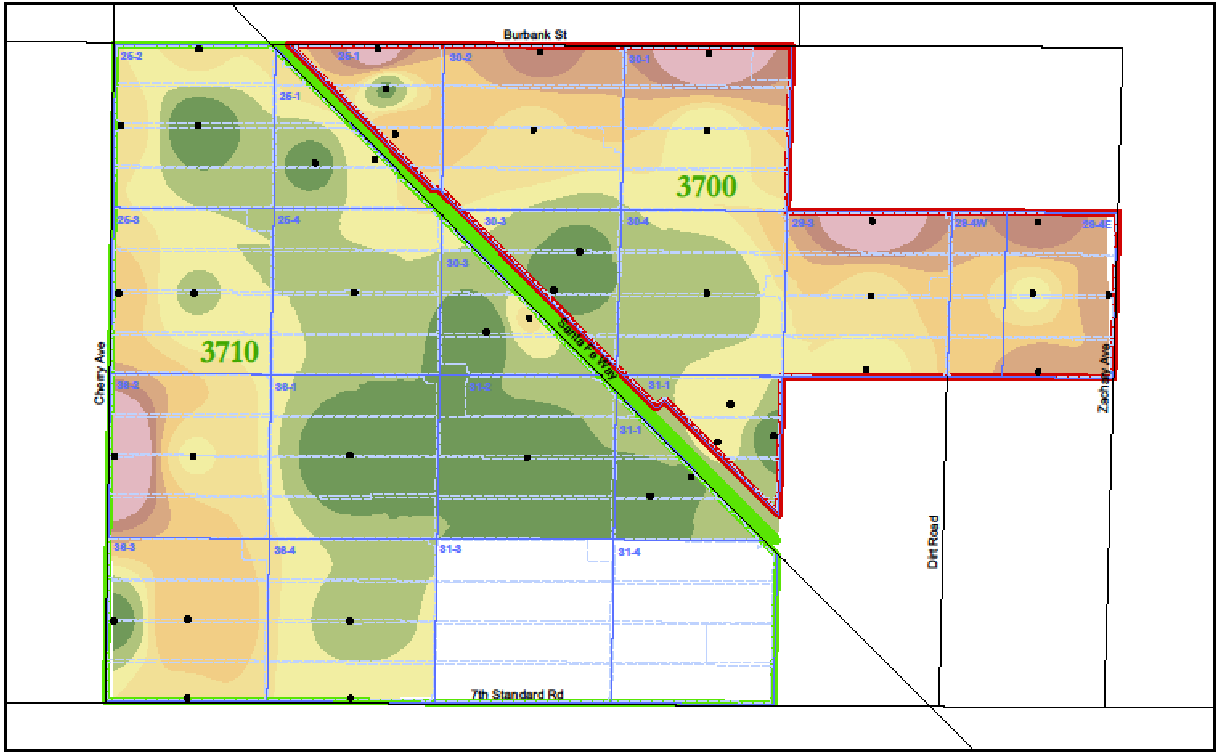


"Puffer"
Mating Disruption
2 puffers/ac

Development of Monitoring System
46 monitoring sites, 1 per 54 ac



**** After 2007: 75-100% reduction in insecticide applications for NOW**



Percent Infested
- 0.1% - 0.5%
- 0.51% - 1%
- 1.1% - 1.5%
- 1.51% - 2%
- 2.1% - 3%
- 3.1% - 4%
- 4.1% - 5%
- 5.1% - 8%
- 8.1% - 10%

2009 Santa Fe
NOW Areawide Project
NOW Infested NP Distribution

Treatment
- Puffer - Early
- Puffer - Late

NOW MD Summary

- Can stand alone in specific situations
- Generally 50% damage reduction
- Reduction of insecticide inputs possible: Context and scale of MD are critical
- Greatest impact in higher pressure settings
- 2 puffers per acre are recommended
- Movement to MD may require a transition period
- Requires sanitation program and maintenance of OFM/PTB programs
- Requires sampling program (traps and early splits) for no spray decisions

Future

- Damage thresholds have decreased as global quality demands have increased (aflatoxin a driver).
- Prices for nut crops have increased
- The impending development of resistance to pyrethroids and less than ideal coverage that limits the potential of existing Insecticides.
- My vision: Sanitation and MD serve as the foundation, then monitor and supplement with insecticides/ other technologies as necessary.
- Lure and Kill, SIT, RNAi?, GMO?

Bradley S. Higbee,

Questions

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The Almond Conference

Kris Tollerup,
UCCE IPM Advisor

growing ADVANTAGE The Almond Conference

Leaffooted Bug, Early-Season Monitoring and Management

K. Tollerup, UC Cooperative Extension Advisor, IPM

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Hemipteran, Leaffooted Bug

- Leaffooted bugs identified in San Joaquin Valley
  - *Leptoglossus clypealis.*
  - *Leptogolssus zonatus.*
  - *Leptoglossus occidentalis*?

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Hemipteran, Others

- Stink bugs
  - Species
    - Green, *Chinavia hilaris* (Say), syn. *Acrosternum hilare*
    - Southern, *Nezara viridula*
    - Red shouldered, *Thyanta pallidovirens*
    - Uhler's, *Chlorochroa uhleri*

Hemipteran, Others

- Stink bugs
  - Species
    - Say's, *Chlorochroa sayi*
    - Consperse, *Euschistus consperse*
    - Rough-shouldered, *Brochymena sulcate*
      - Commonly believed to be a predator, however it is primarily an herbivore.
  - Green stink bug overwinters in orchard, other species are migratory

Hemipteran, Others

- Stink bugs
  - Two generations per year, adults present most of the year.
  - Five instar stages, vary in color making ID difficult.
  - Eggs laid in groups and barrel-shaped.

LFB, Biology

- True bug, Coreidae
- Native to Southwest US
- Agriculture hosts
  - Citrus
  - Corn
  - Pomegranate
  - Almond
  - Pistachio
  - Tomato

Biology

- Leaffooted bug
  - **Long lived, 60 d**, with 3 overlapping generations per year, partial 4th
- Five instar stages
- Eggs laid in a tube-shaped group
  - After mating, ~ 30 days before egg-laying begins.

Biology

- Overwinters in aggregations from five to 500 individuals.
  - Appears that only adults are able to overwinter
    - Nymphs extremely cold sensitive.
- Leave aggregations in early-spring

Damage

- March to mid-April, most vulnerable
  - Aborted nuts with gummosis
- After mid-April
  - Damaged nut likely will not drop
    - Kernel necrosis

Monitoring Tools

- Beat samples for large bugs.
  - Species in canopy, simple, quick response.
- Tapping with pole.
- Damage on nuts.
  - Presence/absence and % damage.
  - Critical sampling period: March to June.

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Monitoring Tools

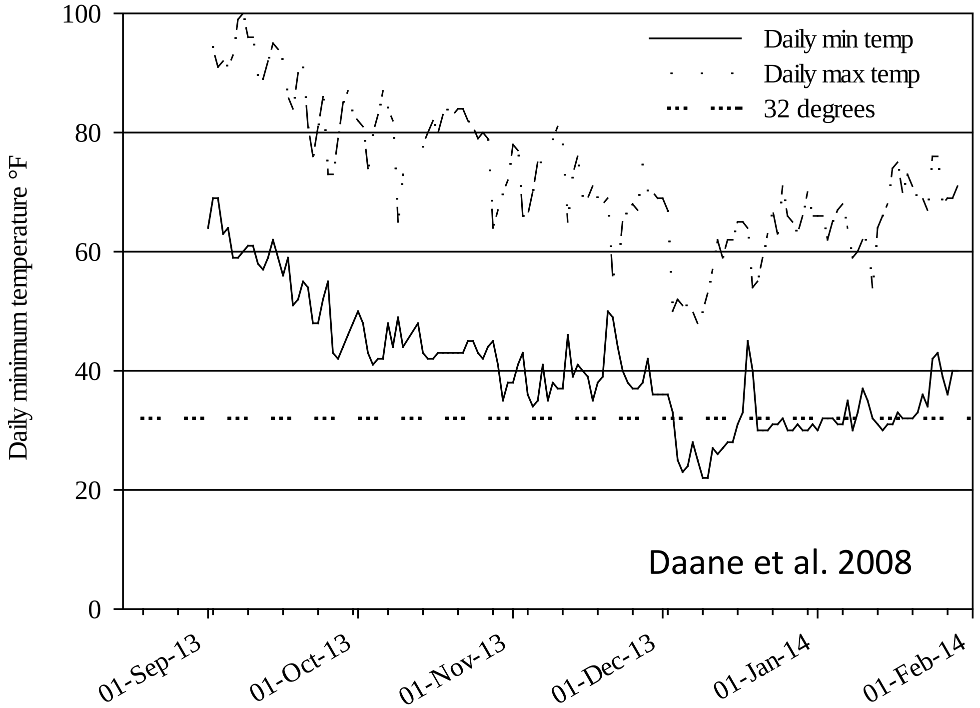
- Possible tools for monitoring during the early season
  - Pheromone, likely involved in aggregation.
  - Color traps: red, yellow, green, white, and clear.
  - Plant volatile compounds.

Monitoring Tools

Monitoring Tools

- Tested various oils
  - Almond
  - Avocado
  - Coconut
  - Olive
  - Peanut
  - Walnut

Leaffooted Bug, Cold Threshold



Leaffooted Bug, Cold Threshold

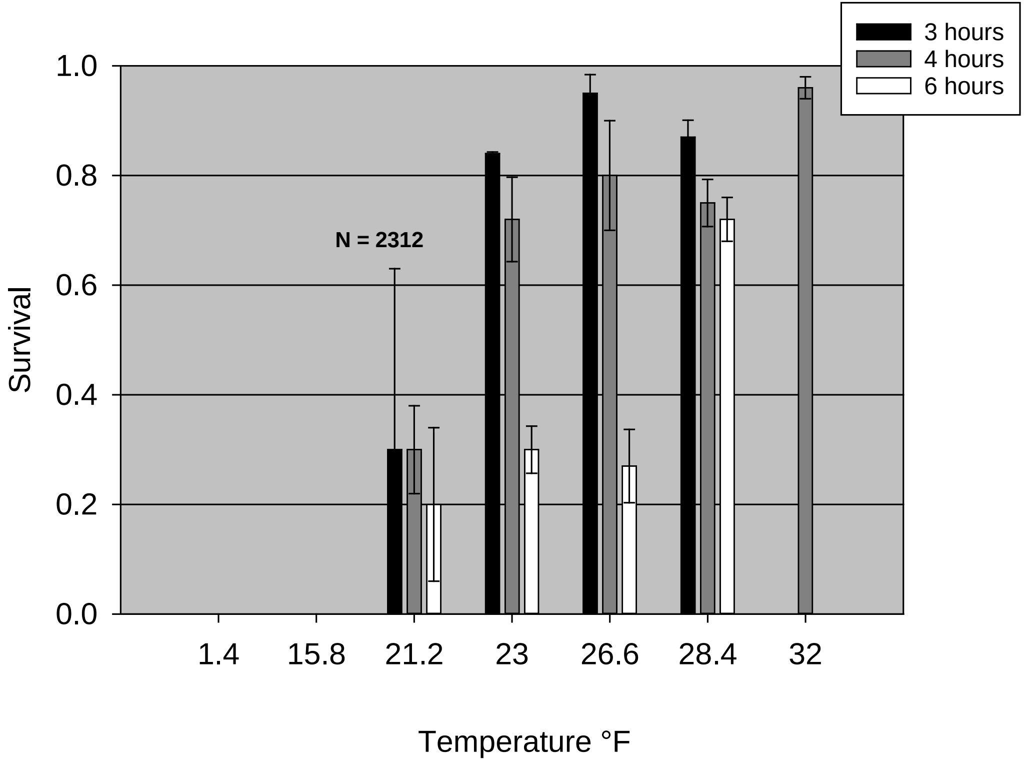


Table 1. Treatment list.

Insecticide		Active ingredient	Rate
1.	Untreated control		
2.	Cyfluthrin	Baythroid	@ 2.4 fl oz/A
3.	Indoxycarb	Avaunt	@ 6 fl oz/A
4.	Cyantraniliprole	Exirel	@ 20 fl oz/A
5.	Clothianidin	Belay	@ 4 fl oz/A
6.	Tolfenpyrad	Bexar	@ 27 oz/A
7.	Flupyradifurone	Sivanto	@ 12 oz/A
8.	Flonicamid	Beleaf	@ 2.8 fl oz/A
9.	Flubendiamide	Belt	@ 4 fl oz/A

Table 2. Toxicity of various insecticides against adult leaffooted bug.

Treatment		LFB caged on *in situ* pistachio clusters at five times after treatment. Mean survival ± SEM (N = 14, n = 4)						Spray applied on LFB in laboratory. Mean survival ± SEM (N = 40, n = 4)
		24 h	7 d	14 d	21 d	28 d		24 h
Untreated control		94 ± 6.3	88 ± 13	100	100	100		88 ± 5
Brigade		0	0	0	6 ± 6.3	25 ± 5		
Warrior		44 ± 25	69 ± 16	75 ± 2.5	88 ± 13	75 ± 35		
Belay		94 ± 6.3	94 ± 6.3					5 ± 3
Beleaf		94 ± 6.3	94 ± 6.3	100	100			93 ± 3
Bexar		88 ± 7.2	69 ± 19		100			3 ± 3
Closer		94 ± 6.3	88 ± 6.3					
Exirel		100	81 ± 12	88 ± 7.2				0
Sivanto		88 ± 7.2	100					

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Brigade		0	0	0	6 ± 6.3	25 ± 5		
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Beleaf		94 ± 6.3	94 ± 6.3	100	100			93 ± 3
Bexar		88 ± 7.2	69 ± 19		100			3 ± 3
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Untreated control		94 ± 6.3	88 ± 13	100	100	100		88 ± 5
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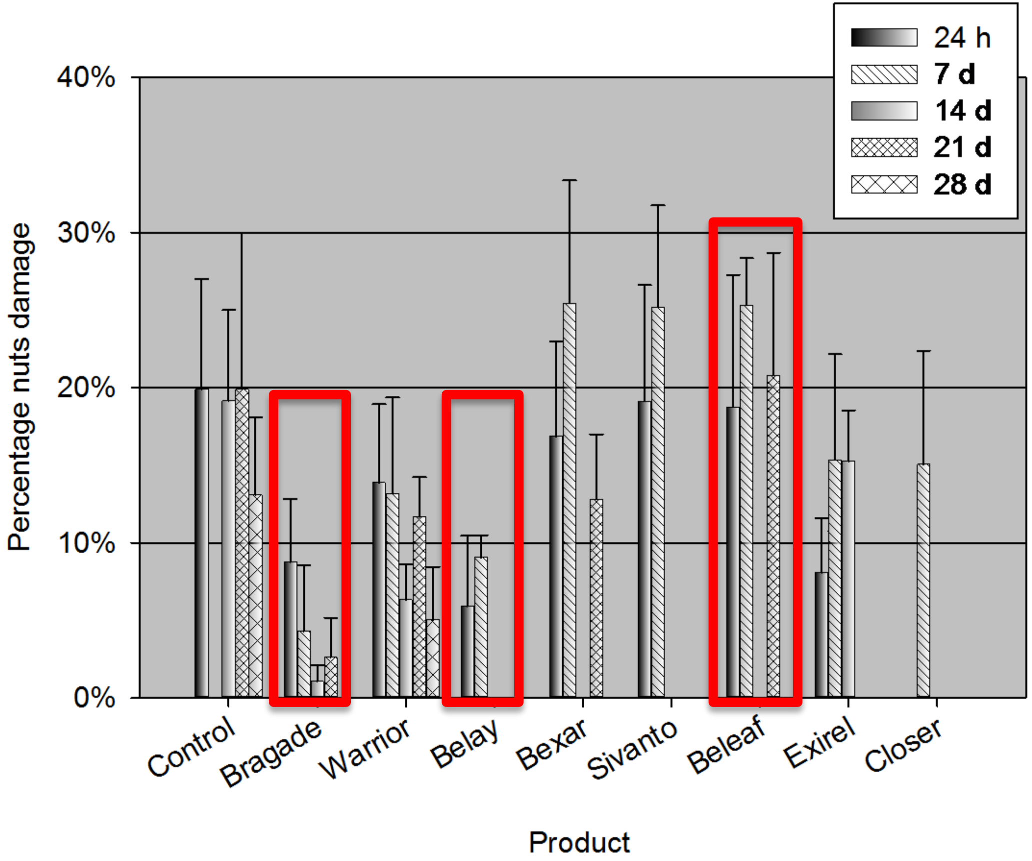
Belay		94 ± 6.3	94 ± 6.3					5 ± 3
Beleaf		94 ± 6.3	94 ± 6.3	100	100			93 ± 3
Bexar		88 ± 7.2	69 ± 19		100			3 ± 3
Closer		94 ± 6.3	88 ± 6.3					
Exirel		100	81 ± 12	88 ± 7.2				0
Sivanto		88 ± 7.2	100					

Leaffooted Bug Feeding Damage on Pistachio



What We Know

- LFB is a beast
  - Potentially a pest on several SJV crops.
- Overwinters on citrus, pomegranate, Cyprus in aggregations
  - Monitor aggregations for spring movement.
  - Treat overwintering aggregations may be an option; however limited available materials on pomegranate.

What We Need to Know

- How to monitoring in the early season.
  - Initiation of egg-laying.
    - Do female overwinter as mated?
  - Pheromone.
  - Plant volatile.
- When do aggregations begin to disperse?
- Can treating overwintering aggregations protect neighboring host crops?
- Best uses for reduced-risk insecticides.

Thank you

Questions

Andrea Joyce,
University of California, Merced

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The Almond Conference

Leaffooted Plant Bugs:
Field-cage Study to Assess Damage

Andrea Joyce, University of California Merced

IPM Session, Dec. 10, 2015 Almond Conference

Leaffooted Plant Bugs:
Field-cage Study to Assess Damage

Andrea Joyce, University of California Merced

IPM Session, Dec. 10, 2015 Almond Conference

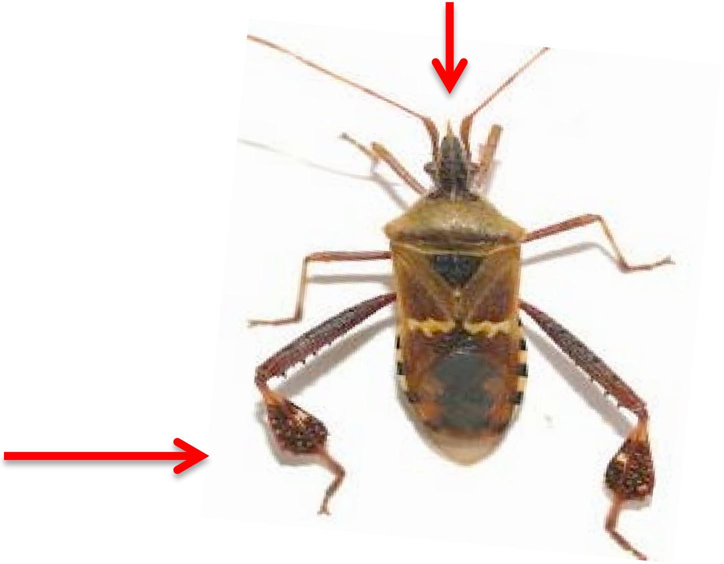
Introduction

Leaffooted Plant Bugs (*Leptoglossus* spp.)

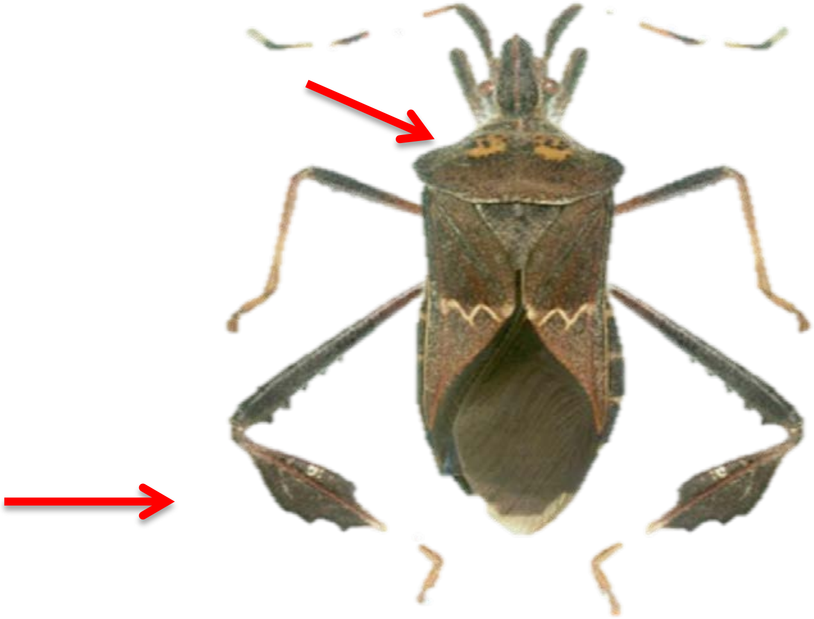
Large, seed-feeding insects that move from native host plants into crops including almonds and pistachios. Their long mouthparts pierce through almonds, feeding on developing kernels.

Leaffooted Plant Bugs

L. clypealis



L. zonatus



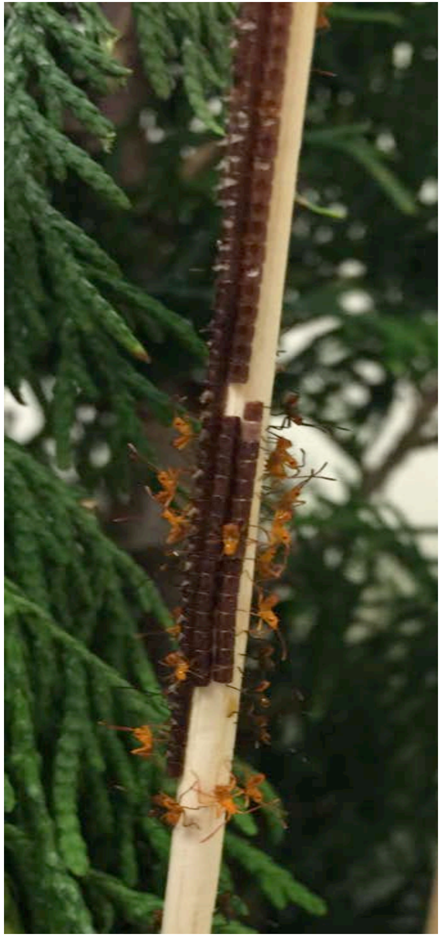
Long-Term Goal

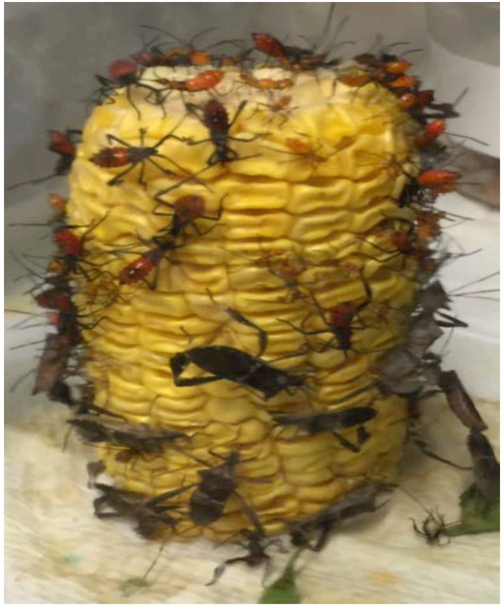
Monitoring or detection of LFPBs before observing gummosis and almond drop. Traps for monitoring might use bug pheromones or aggregation behavior for early detection or trapping.

Objectives:

- Establish a colony of Leaffooted bugs for field and lab work
- Examine species of leaffooted bugs and stinkbugs on almonds, pistachios, and pomegranates
- Conduct a field-cage study with two LFPB species feeding on almonds to determine when almonds are most susceptible to feeding damage

Maintaining LFPB Colonies





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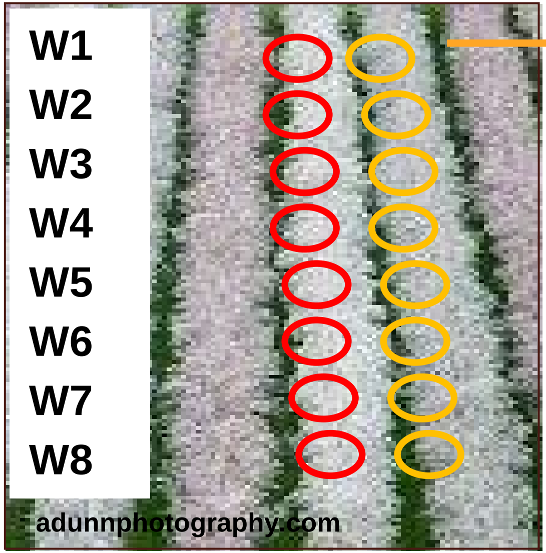
Field-cage Study of LFPB Feeding Damage

Part 1: Assess almond drop and damage by feeding Leaffooted bugs during the growing season as almonds develop

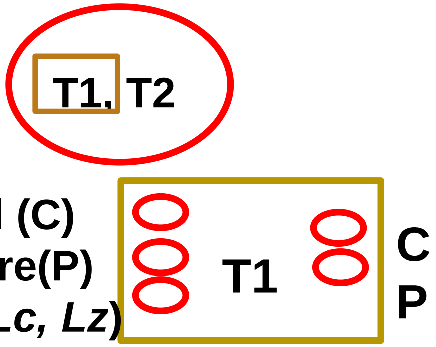
Part 2: Conduct a final assessment of almond kernel damage at harvest

Research Sites Overview

Merced

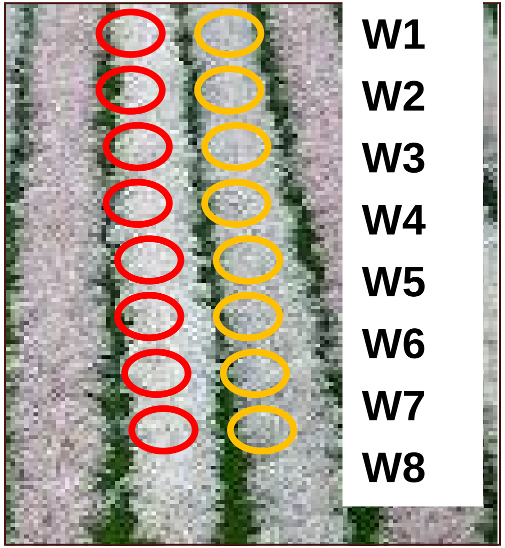


Monterey, Carmel



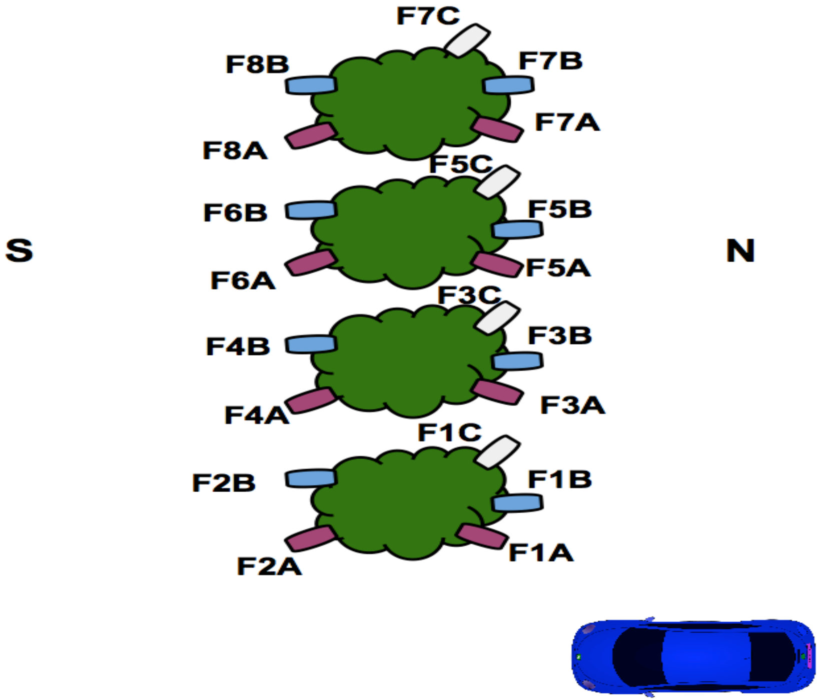
Control (C)
Puncture(P)
(Bugs-*Lc, Lz*)

Winton



Nonpareil, Fritz

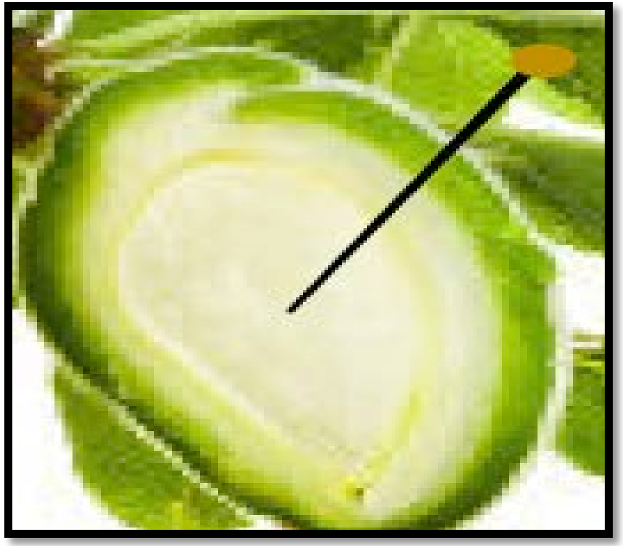
Field Cage Set Up



Controls (A)

almonds enclosed in field cages to observe natural almond drop

Punctured (B)



Bug Fed (C)

5 bugs caged for a week, then removed.
Cage remained until harvest and final damage assessment.

Gummosis and Sap Response

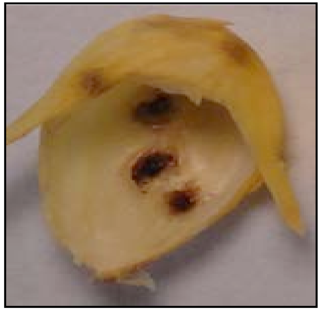
Part 2: Final Assessment at Harvest

Strike on the Hull

A blemish inside the hull, a black or brown dot or bruise.

Strike on the Nut

Blemishes or bruises on the nut, usually accompanied by a strike on the hull.



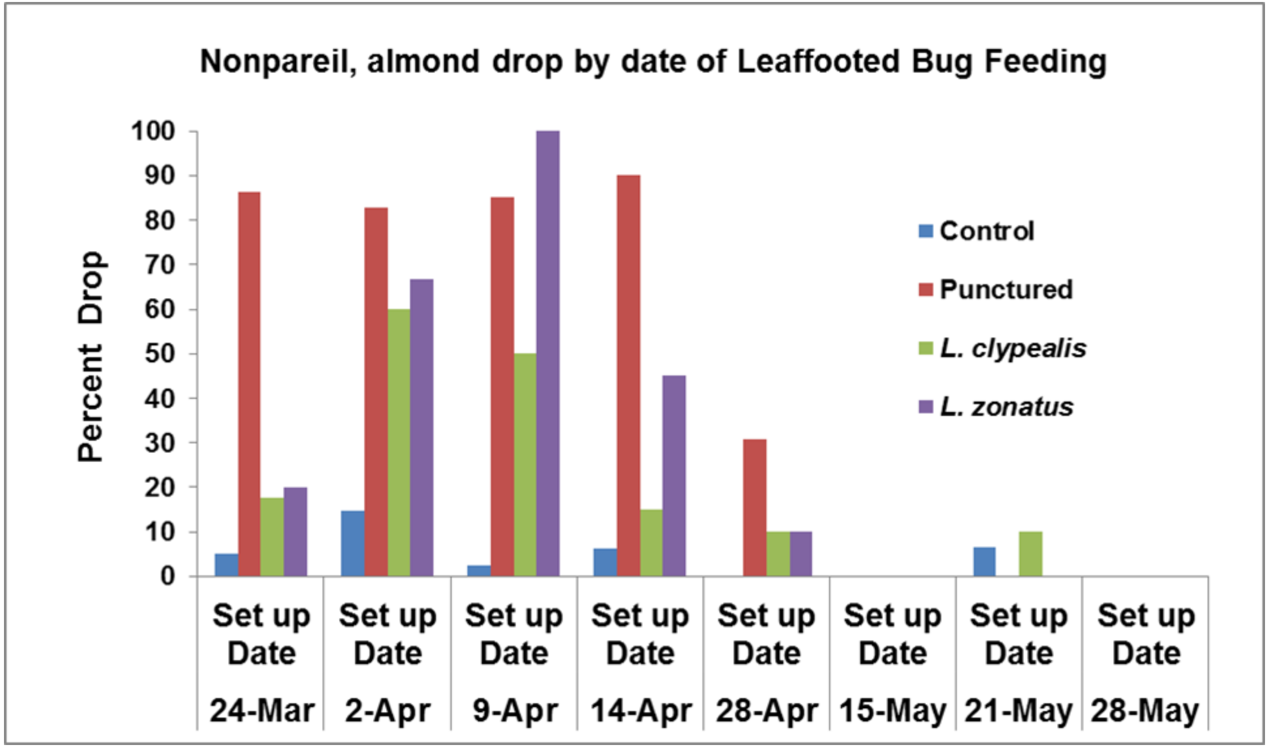
Nut Damage

Apparent indentations from nut strikes, slimy, rot or may be deemed “unsellable.”

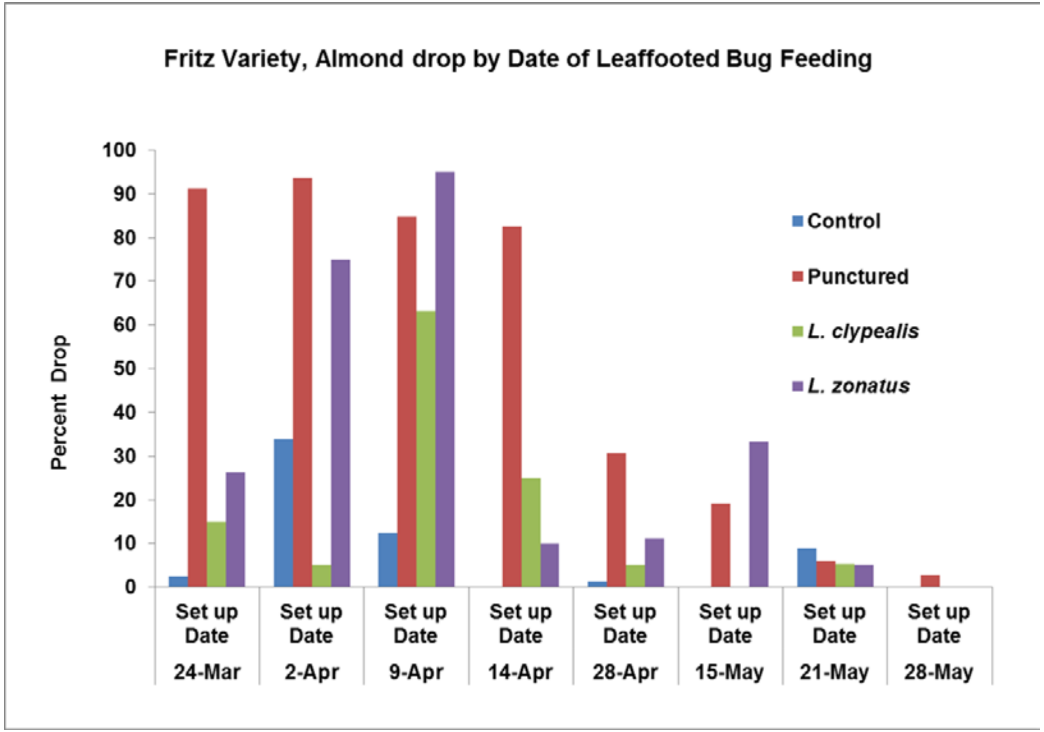
Almond Shriveled

Very obvious discoloration and shrunken/hardened kernel.

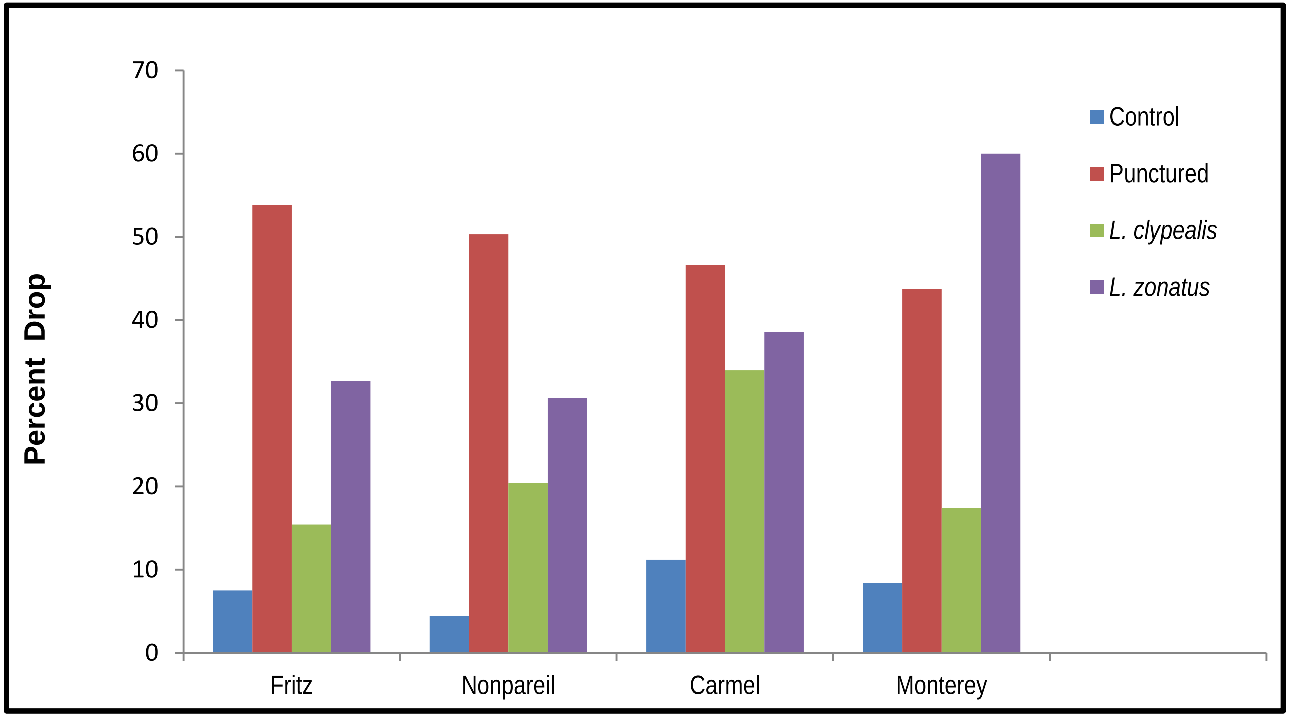
Results: Date in Orchard & Almond Drop-Nonpareil



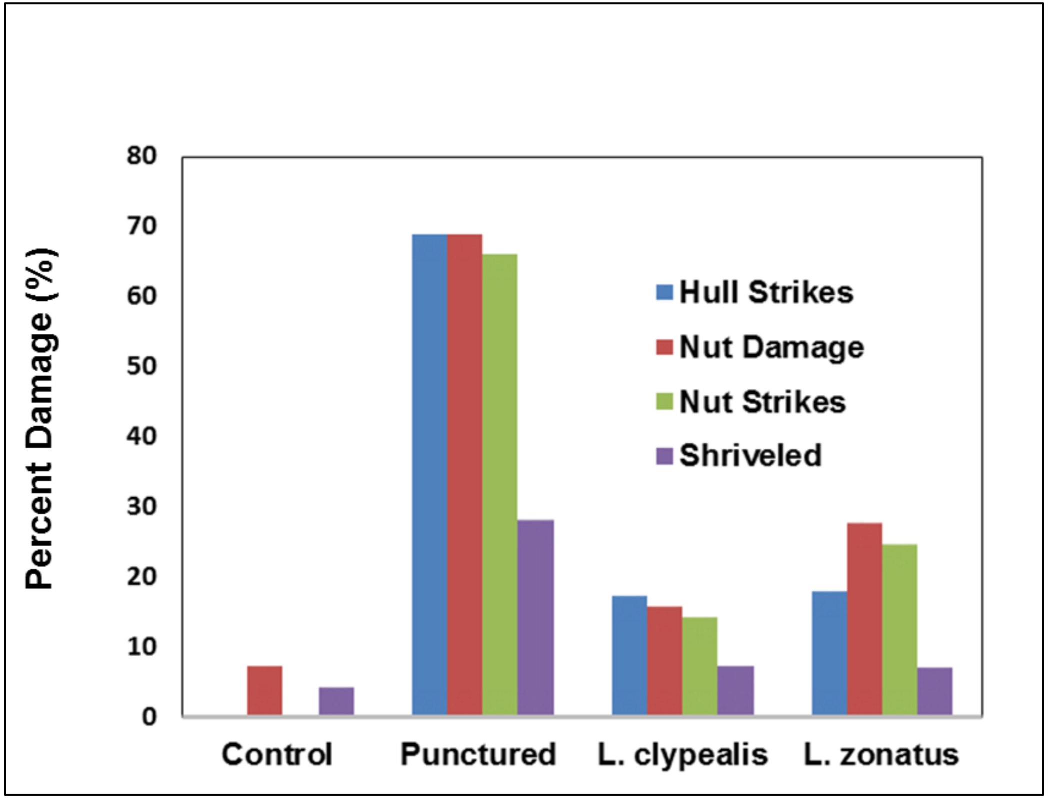
Results: Date in Orchard & Almond Drop-Fritz

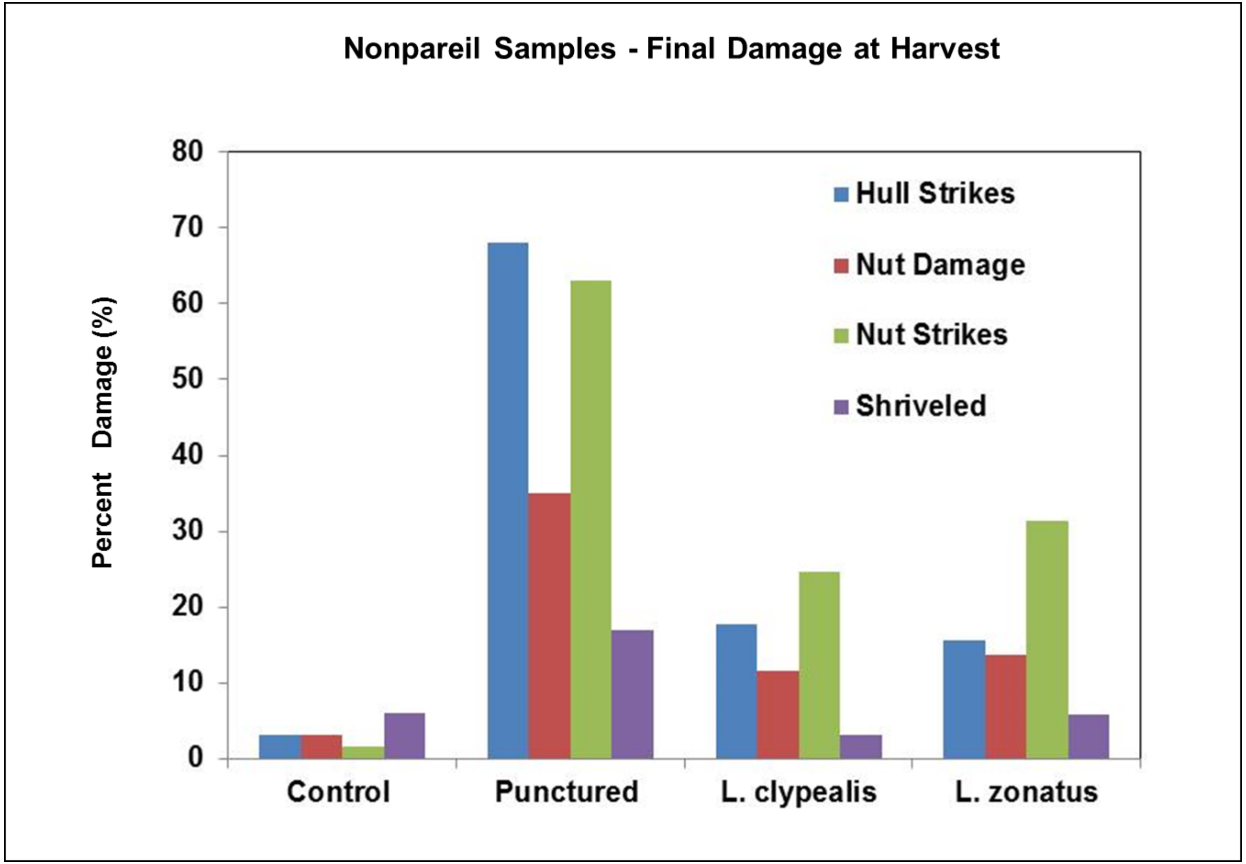


Overall Percent Almond Drop by Variety



Final Damage at Harvest-Fritz




Nonpareil Samples - Final Damage at Harvest
Percent Damage (%)
80
70
60
50
40
30
20
10
0
Hull Strikes
Nut Damage
Nut Strikes
Shriveled
Control
Punctured
L. clypealis
L. zonatus

Conclusions

1) 2014-2015, *L. zonatus* was the dominant LFPB observed in almonds

2) Late March through mid-April, almonds were most susceptible to drop from LFPBs

3) Most almonds drop 2 weeks after bug feeding occurs

4) Both almond drop and damage at harvest are higher from *Leptoglossus zonatus*

5) LFPBs were seen at almond harvest and pistachio harvest

6) Aggregation behavior in *L. zonatus* might be used for monitoring or trapping

Data will contribute to an IPM program for these insects

Acknowledgements

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UCCE Collaborators: Roger Duncan, David Doll, David Haviland, Kris Tollerup, Joe Connell; Wonderful Orchards-Brad Higbee; Clendenin and Arnold Families, Merced County; Mel Machado, Blue Diamond; Steve Boone, Wilbur-Ellis; Matt Thompson, Tracy Miller, Mid-Valley Agricultural Services; Brad Robson, Buchanan Hollow Nut Co., Le Grand; Juan Holguin, Monarch Bio Systems; Cal-Poly SLO students-Kylie McMillan, Lindsay Robson. UC Merced Student Assistants Etienne Melese, Amanda Khoo, Maria Martinez, Rebecca Quinte; Ashley Valley, Andrew Loera, Karen Cedano, Eunis Hernandez, Ryan Torres. Many more!

Questions

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Emily Symmes,
UCCE IPM Advisor

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Effective Communication Between Growers & PCAs

Emily J. Symmes

University of California Area IPM Advisor, Sacramento Valley

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Year-Round IPM Program

UNIVERSITY OF CALIFORNIA AGRICULTURE & NATURAL RESOURCES

UC IPM

Statewide Integrated Pest Management Program

HOME

SEARCH

ON THIS SITE

- What is IPM?
- Home & landscape pests
- Agricultural pests
- Natural environment pests
- Exotic & invasive pests
- Weed gallery
- Natural enemies gallery
- Weather, models & degree-days
- Pesticide information
- Research

Almond

Year-Round IPM Program

(Reviewed 3/09, updated 3/09)

These practices are recommended for a monitoring-based IPM program that enhances pest control and reduces environmental quality problems related to pesticide use.

Water quality becomes impaired when pesticides and sediments move off-site and into water. Air quality becomes impaired when volatile organic compounds (VOCs) move into the atmosphere. Each time a pesticide application is considered, review the Pesticide application checklist at the bottom of this page for information on how to minimize water and air quality problems.

This year-round IPM program covers the major pests of almond. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the Almond Pest Management Guidelines. Track your progress through the year with the annual checklist form.

| **Print annual IPM checklist** (PDF) | **Almond Pest Management Guidelines** | **Forms and Photo ID pages** |

- Dormancy to delayed dormancy
- Bloom to postbloom
- Fruit development
- Harvest
- Postharvest
- Pesticide application checklist

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✓ Done	**Dormant/delayed dormant season activities** Mitigate pesticide usage to minimize air and water contamination.
	Count mummy nuts in orchard. • If more than 2 nuts per tree remain, knock off and destroy mummy nuts to reduce navel orangeworm and brown rot before February 1.
	Manage orchard floor vegetation: • After harvest, assess weeds present and identify those that were not controlled by a fall preemergent treatment (if applied). • Keep records. In January, consider applying postemergent herbicides in tree row strips alone or in combination with preemergents.
	Take a dormant spur sample for scale and mite eggs mid-November to mid-January. • Record results. • Treat if needed according to PMG.
	Examine trees for peach twig borer hibernacula in the crotches of one-year-old wood. Consider treatment for peach twig borer with environmentally sound material or delay treatment until bloom.
	In orchards with varieties that retain leaves, monitor rust for possible spring treatment.
	Other pests you may see: • Armillaria root rot (oak root fungus): mushrooms emerge during wet periods. • Pocket gophers (mound-building activity).

✓ Done	**Bloom to postbloom period activities** Mitigate pesticide usage to minimize air and water contamination.

	Manage navel orangeworm:
	• Be sure mummies are off trees by February 1.
	• Disc or flail mow mummies by March 15.
	• Put out egg traps:
	  ▪ *Central and southern San Joaquin Valley* by March 15
	  ▪ *Northern San Joaquin and Sacramento valleys* by April 1

	Monitor peach twig borer: • Put up pheromone traps by March 20 and check according to PMG. • Record results.
	When rainy conditions promote disease, time fungicide treatment according to PMG for: • Anthracnose • Brown rot • Jacket rot • Leaf blight • Rust (if overwintered lesions on retained leaves) • Scab
	Monitor for shot hole fruiting structures in leaf lesions as long as weather is wet. • Treat if needed according to PMG.
	Monitor San Jose scale: • Put up pheromone traps by March 1 and check according to PMG. • Record results.
	Start to monitor for spider mites when mites are first seen in the lower center tree canopy. • Treat if needed according to PMG.
	Monitor for vertebrates and manage as necessary. • Gophers • Ground squirrels • Voles
	Other pests you may see: • Bacterial canker • Brown mite • European red mite • Forest tent caterpillar • Fruittree leafroller (possible nut drop) • Leaffooted plant bug (possible nut drop) • Obliquebanded leafroller
	Manage orchard floor vegetation: • Mow ground cover before bloom for frost protection and to remove competing bloom.

✓ Done	**Fruit development period activities (late April to start of shaking)** Mitigate pesticide usage to minimize air and water contamination.
	Monitor shoot strikes for peach twig borer and Oriental fruit moth, examining strike to properly identify species. • Treat if needed according to PMG.
	Monitor San Jose scale: • Pheromone traps are useful for detecting male scales and parasites.
	Monitor navel orangeworm egg traps: • Keep records. • Treat if needed according to PMG.
	Monitor ant mounds (once during April-May) • Keep records. • Treat if needed according to PMG.
	Monitor spider mites: • Keep records. • Treat if needed according to PMG.
	Take leaf samples in July to make sure that nitrogen levels do not favor hull rot.
	Monitor for and treat if needed according to PMGs: • Alternaria • Rust • Scab
	Assess weeds in late spring: • Identify uncontrolled weeds to plan future management strategies. • Keep records of monitoring. • Continue to maintain ground cover short.
	Other pests you may see: • Armillaria root rot (dying trees) • Band canker (2nd to 6th leaf trees) • Brown mite • Ceratocystis canker • European red mite • Leaffooted bugs • Obliquebanded leafroller • Peach silver mite • Peachtree borer • Silver leaf • Stink bugs • Tenlined June beetle (where soils are very sandy)
	Identify beginning of hull split; regulate irrigation during hull split to manage hull rot.

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✓ Done	Harvest
	Harvest early to avoid third generation navel orangeworm eggs and to minimize hull rot.
	Assess trunk damage to evaluate shaker/harvest operation for bark injury.
	Pick up nuts promptly to avoid ant damage.
	Take harvest sample to determine pest damage. • Store sample in freezer until nuts are cracked open for observation.

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✓ Done	Postharvest
	Look for nuts or leaves stuck on trees well after harvest, indicating hull rot or San Jose scale.
	Monitor for rust lesions. Manage according to PMG.
	After fall rain begins, monitor for shot hole leaf lesions with fruiting structures. • Manage according to PMG.
	If use of preemergent herbicide** in rows is planned, time it properly.
	Survey weeds: • Record results. • If use of preemergent herbicide in rows is planned, time it properly.
	Don't bother to seed a cover crop unless you have sparse resident vegetation.

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Communications

- Is a spray necessary?

- Is it the right time to spray?

- What material should be applied?

Communications

- Is a spray necessary?
  - What is this decision based on?
    - Trap counts
    - Thresholds
    - Orchard history
    - Environmental conditions
    - Crop stage
  - Where should we spray?
    - Everywhere
    - Hot spots
    - Start in a certain block or area
    - Full application or not (e.g., every other row)

- Is it the right time to spray?
  - How do we know?
    - Trap counts
    - Pest biology/phenology
    - Pest life stage
    - Crop stage

Communications

- What material should be applied?
  - Is it effective?
  - Is it cost-effective?
  - Will it impact non-targets?
  - Will it cause other pest outbreaks or situations?
  - Are we rotating modes of action?
  - Are we mitigating resistance risk?
  - Understand the mode of action & base post-application expectations accordingly
  - Is the material targeting the right pest life stage?
  - How should we apply (ground, air, etc.) for best results?
  - What time of day should we spray?
    - Non-target considerations, coverage, efficacy, drift

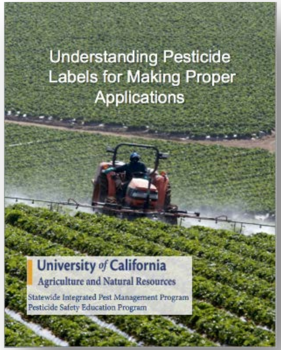
Communications

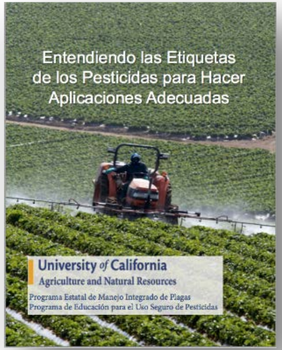
- Follow up
  - Did it work?
  - How do we know?
  - Was it worth it?
  - Did it cause other problems that we needed to add additional inputs for?
  - Do we need to make adjustments in the future?

- Records
  - Site-specific data set – orchard history
  - Picture is worth 1,000 words
    - Graphs relating to orchard history (damage), pest dynamics, spray timings, etc.

Pesticide Application Checklist

- Impact on natural enemies & pollinators
- Potential for water quality problems
- Air quality & VOCs
- Chemistry & mode of action
  - Efficacy, resistance management, secondary pest outbreaks
- Environmental & human health impacts
  - Worker safety
- Maintenance & proper calibration of spray equipment
  - Optimal rate, coverage key
- Apply only when environmental conditions minimize risk
- Keep records
- Follow up after application





Understanding pesticide labels for making proper applications – FREE printable card deck
English:
http://www.ipm.ucdavis.edu/PDF/TRAINING/Pesticide_labels_English.pdf
Spanish:
http://www.ipm.ucdavis.edu/PDF/TRAINING/Pesticide_labels_Spanish.pdf

Additional Resources

- UC IPM webpage for almonds
  - http://www.ipm.ucdavis.edu/PMG/selectnewpest.almonds.html
  - New decision support module available for key pests

- IRAC Mode of Action Table
  - http://www.irac-online.org/documents/moa-classification/


IRAC

IRAC Mode of Action Classification Scheme

Prepared by: IRAC International MoA Working Group

Approved by: IRAC Executive

CropLife

Honey Bee BMPs

Emily J. Symmes

University of California Area IPM Advisor, Sacramento Valley

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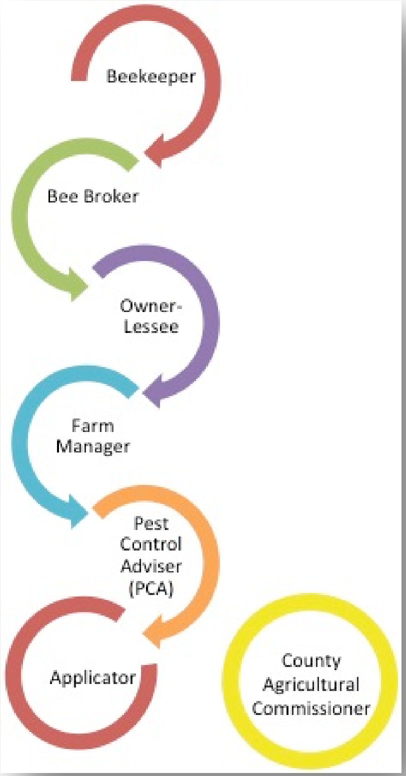
Communication is the key

- Communication Chain



Communication is the key

- Communication should occur between all pollination stakeholders along the communication chain about pest control decisions during bloom
- Agreements/contracts should include a pesticide plan that outlines which pest control materials may be used
- If treatment is deemed necessary, growers/PCAs/applicators should contact county ag commissioners so that beekeepers with nearby managed hives are notified 48 hours in advance
- Beekeepers should register hives and request optional notification from ag commissioners
- Report suspected pesticide related incidences to county ag commissioners. Bee health concerns cannot be addressed without data from potential incidents
- Maintain communication with neighbors after hive removal

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General Guidelines

- Provide adequate clean water for bees
- Never spray hives directly
- Turn off spray rig nozzles near hives
- Avoid hitting flying bees with any application
- Avoid application or drift onto blooming weeds in or adjacent to orchard
- Avoid applying systemic pesticides or those with residual toxicities prior to bloom

General Guidelines

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- Never spray hives directly
- Turn off spray rig nozzles near hives
- Avoid hitting flying bees with any application
- Avoid application or drift onto blooming weeds in or adjacent to orchard
- Avoid applying systemic pesticides or those with residual toxicities prior to bloom
- Agree on proper hive removal timing
- Continue communicating with neighbors that may still have bees foraging nearby

If treatments are necessary during bloom

- Explore alternate timing options
  - Dormant
  - Delayed-dormant
  - Post-bloom

- Be aware of presence of bees in the areas outside of your orchard

- Use IPM – only apply as needed based on sound monitoring, thresholds, decision support guidelines

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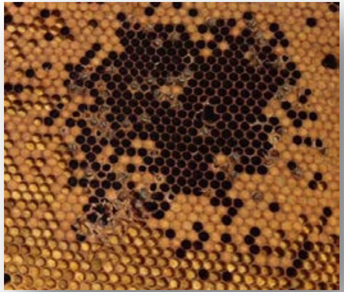
Insecticide recommendations

- Do not spray insecticides at bloom
- One exception – *Bacillus thuringiensis* (Bt)
- Remember that most labels only note honey bee cautionary statements based on acute toxicity to adult bees, not impacts on developing brood

Newly emerged, wingless bees pulled from the combs by other bees



Empty cells of brood that failed in their attempts to emerge as adults

Fungicide recommendations

- Disease protection during bloom is critical
- Fungicide applications need to be made at certain times
  - Late afternoon, evening
  - Bees & pollen not present
  - Ensure adequate drying time before bees begin foraging the following day
- Addition of adjuvants may be detrimental – proceed with caution until more is known

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Fungicide recommendations

Bee kill resulting from spraying a tank mix of an herbicide, spray oil, and foliar nutrient

- Disease protection during bloom is critical
- Fungicide applications need to be made at certain times
  - Late afternoon, evening
  - Bees & pollen not present
  - Ensure adequate drying time before bees begin foraging the following day
- Addition of adjuvants may be detrimental – proceed with caution until more is known
- Avoid tank mixes – synergistic impacts not well understood

Signs of Bee Injury

- Excessive numbers of dead or dying adult honey bees in front of hives
- Dead newly-emerged workers or brood at the hive entrance
- Lack of foraging bees on a normally attractive blooming crop
- Adult bees exhibiting stupefaction; paralysis; jerky, wobbly, or rapid movements; spinning on the back
- Disorientation and reduced efficiency of foraging bees
- Immobile or lethargic bees unable to leave flowers
- Bees unable to fly and crawling slowly as if chilled
- Queenless hives

More Information & Additional Resources

- Honey Bee Best Management Practices for Almonds (CA Almond Board)
  - www.Almonds.com/BeeBMPs
  - Supplemental quick guide – general
  - Supplemental quick guide – applicator/driver (English and Spanish)
- http://www.almonds.com/growers/pollination#honey-bee-protection

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