2018 | THE ALMOND CONFERENCE

SPEED TALKS: PEST MANAGEMENT

ROOM 312-313 | DECEMBER 6, 2018

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Almond Board of California

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The Almond Conference

AGENDA

- **Gabriele Ludwig**, Almond Board of California, moderator
- **Almond Board Funded Researchers**
    - Franz Niederholzer, UCCE Colusa, Yuba, Sutter
    - Ali Pourreza, UCCE UC-Davis
    - Chuck Burks, USDA-ARS, Parlier
    - Houston Wilson, UCCE, Kearney
    - Jocelyn Millar, UC Riverside
    - Houston Wilson, UCCE, Kearney
    - Themis Michailides, UCCE Kearney
    - Florent Trouillas, UCCE Kearney
    - David Rizzo & Bob Johnson, UC Davis
    - Mohammad Yaghmour, UCCE Kern
    - Rachel Vannette, UC Davis
    - Jim Adaskaveg, UC Riverside

Can Venturi Nozzles Deliver NOW Control?

Franz Niederholzer, UCCE Farm Advisor

Colusa and Sutter/Yuba Counties

@Hwy20Orchardoc

growing
ADVANTAGE
The Almond Conference

UC
CE

Ag spraying should be…

Effective

Efficient

Safe

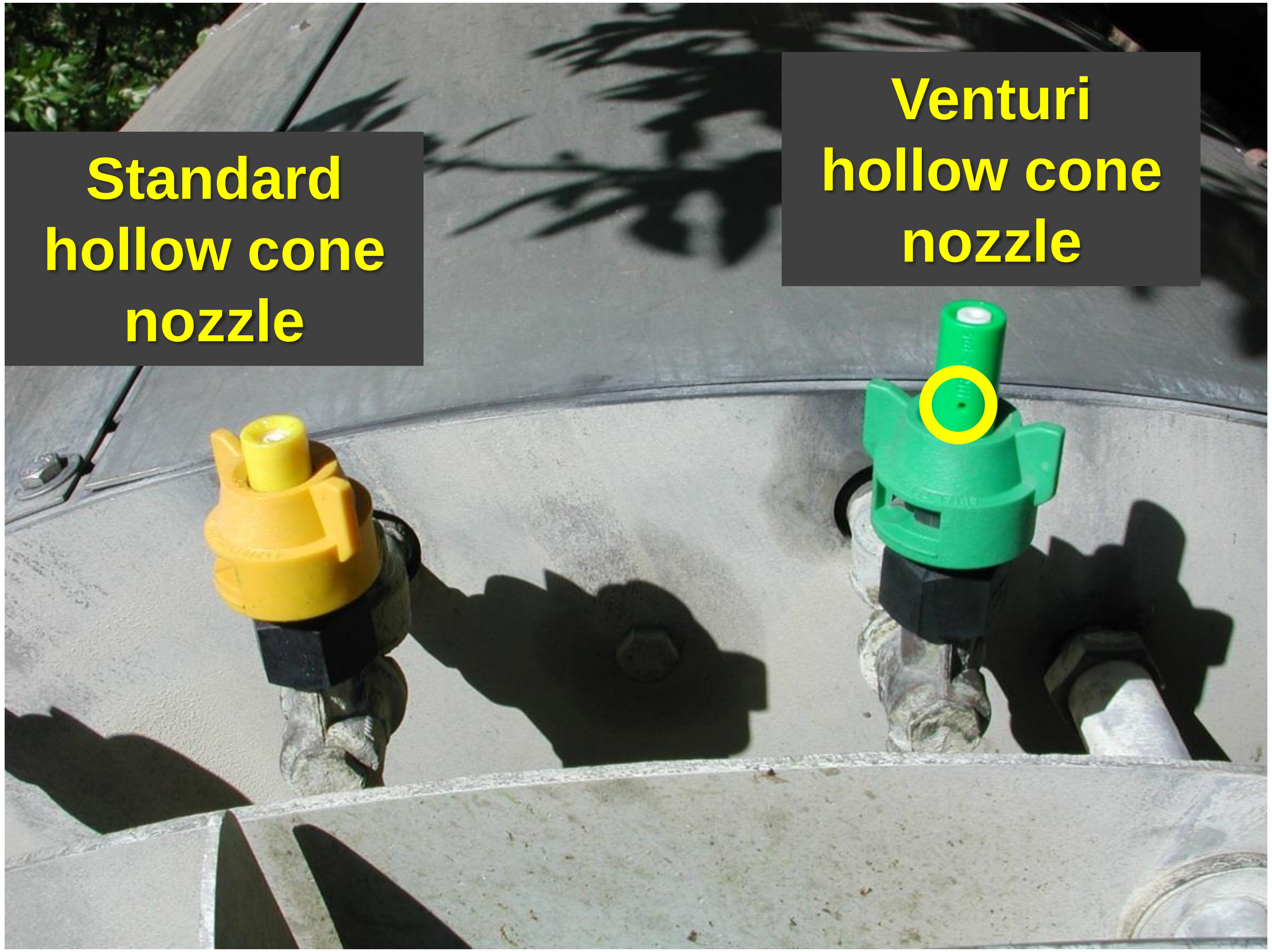
Because so much rides on each spray, your relative view of ag spraying goals might be…

What if there's a sprayer set up for hull split sprays delivering pest control and increased safety?

Droplet size is THE most important factor growers can manage regarding drift.

Nozzle size, nozzle design, and system pressure affect droplet size.

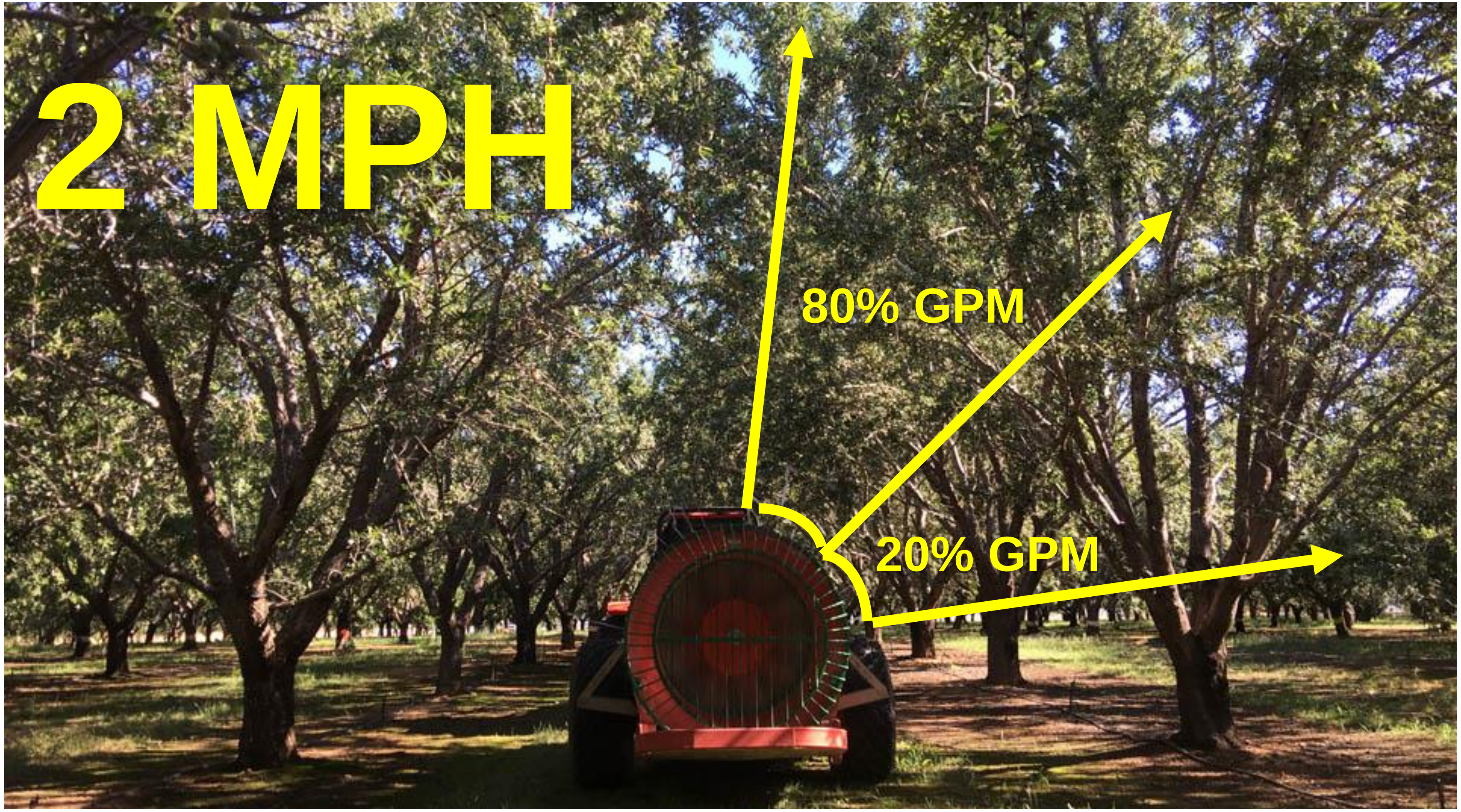
Venturi nozzles deliver more GPM as large drops (= less drift) than standard hydraulic nozzles.



2018 Field Trial

- 4.25 oz/acre Altacor® (July 8-9 & 19-20)
  - 100 gpa hollow cone (HC)
  - 200 gpa hollow cone (HC)
  - 200 gpa hollow cone Venturi
- In 2nd spray, molybdenum (Mo) micronutrient tracer added @18 oz/acre. Mo in the 200 gpa tank mix = 23 ppm vs 47 ppm Mo in 100 gpa mix.

Study orchard (20 acres), June 2018, Colusa Co.



20th leaf, Nonpareil yield history = 2,500-3,300 lb/acre

We looked at spray coverage/control in three separate ways.

1. Sample sprayed nuts, high and low in the canopy, take to the Siegel lab at USDA/ARS, Parlier. Expose each nut to 10 NOW eggs set in the suture.
2. Sample 3,000 nuts per treatment from windrows, crackout for damage.
3. Sample sprayed nuts, high and low in the canopy, analyzed the hull for Mo tracer.

Treatment	NOW mortality (5-8’)	% NOW mortality (15-20’)
100 GPA HC	90 a	73 b
200 GPA HC	80 c	74 b
200 GPA HC vent	86 b	82 a
No spray	74 d	69 c

200 GPA delivered more tracer to the target nuts high in the canopy. No difference low.

Treatment	Mo tracer (µg/nut) 15-20’ high
100 GPA HC	0.37 a
200 GPA HC	0.64 ab
200 GPA HC vent	0.89 b

In 7 replicated trials I have done in California orchards, Venturi nozzles have not failed to control pest(s) when compared to standard grower treatments.

Thank you!

More work next year….

Spray Backstop

PI: Ali Pourreza

co-PIs: Ken Giles, Franz Niederholzer, and Farzaneh Khorsandi

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Digital Ag
UCDAVIS

Problems in Almond Spray Application

- Spray Coverage
- Spray Drift

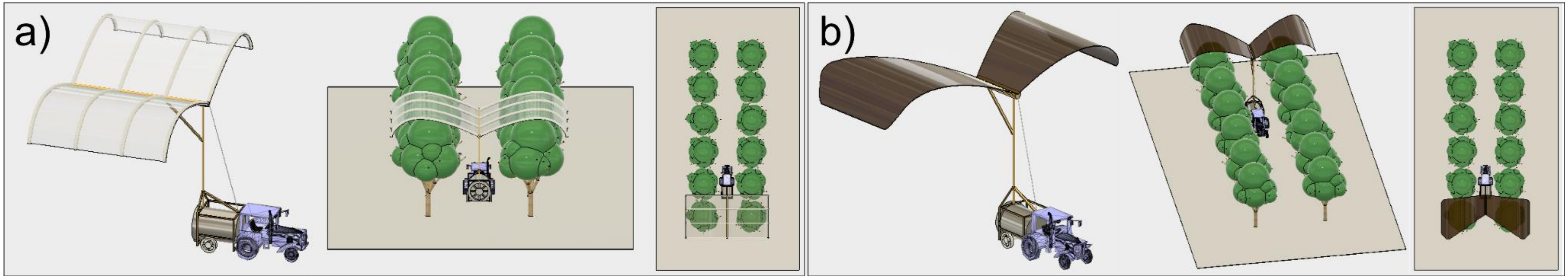
Better Coverage
Using excessive air flow

More Drift

ABC: 2015 North America AAU, US Data

Proposed Solution

- A Spray Backstop system will be developed in this project to block the spray cloud that passes the tree tops.
- This mechanism is expected to stop the droplets from escaping the orchard and becoming drift.
- Using a Spray Backstop system will allow growers to continue to adjust sprayers with more air and fine droplets that improves spray coverage in the hard-to-reach upper canopy area, while helping manage drift.

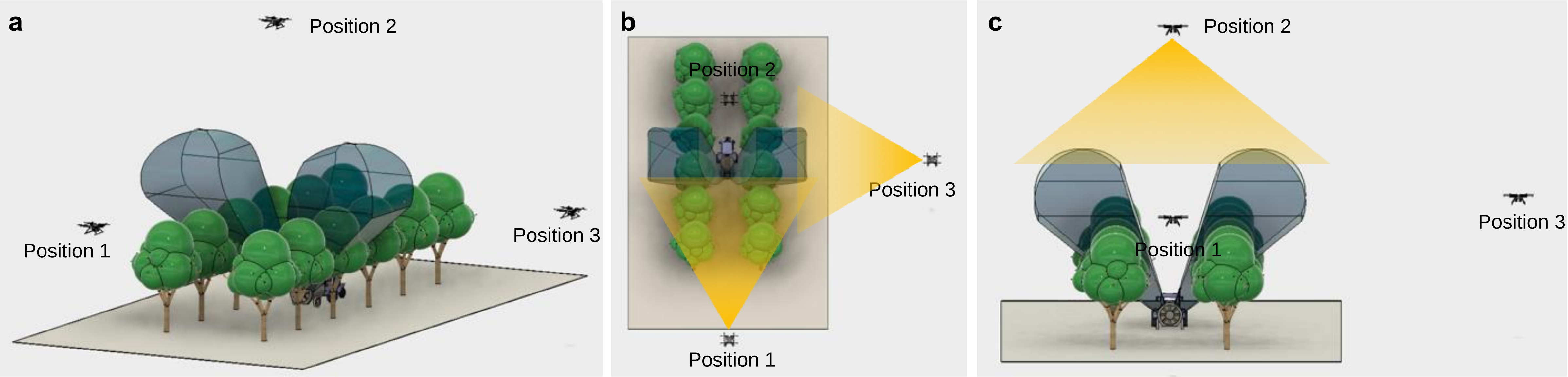


Objectives

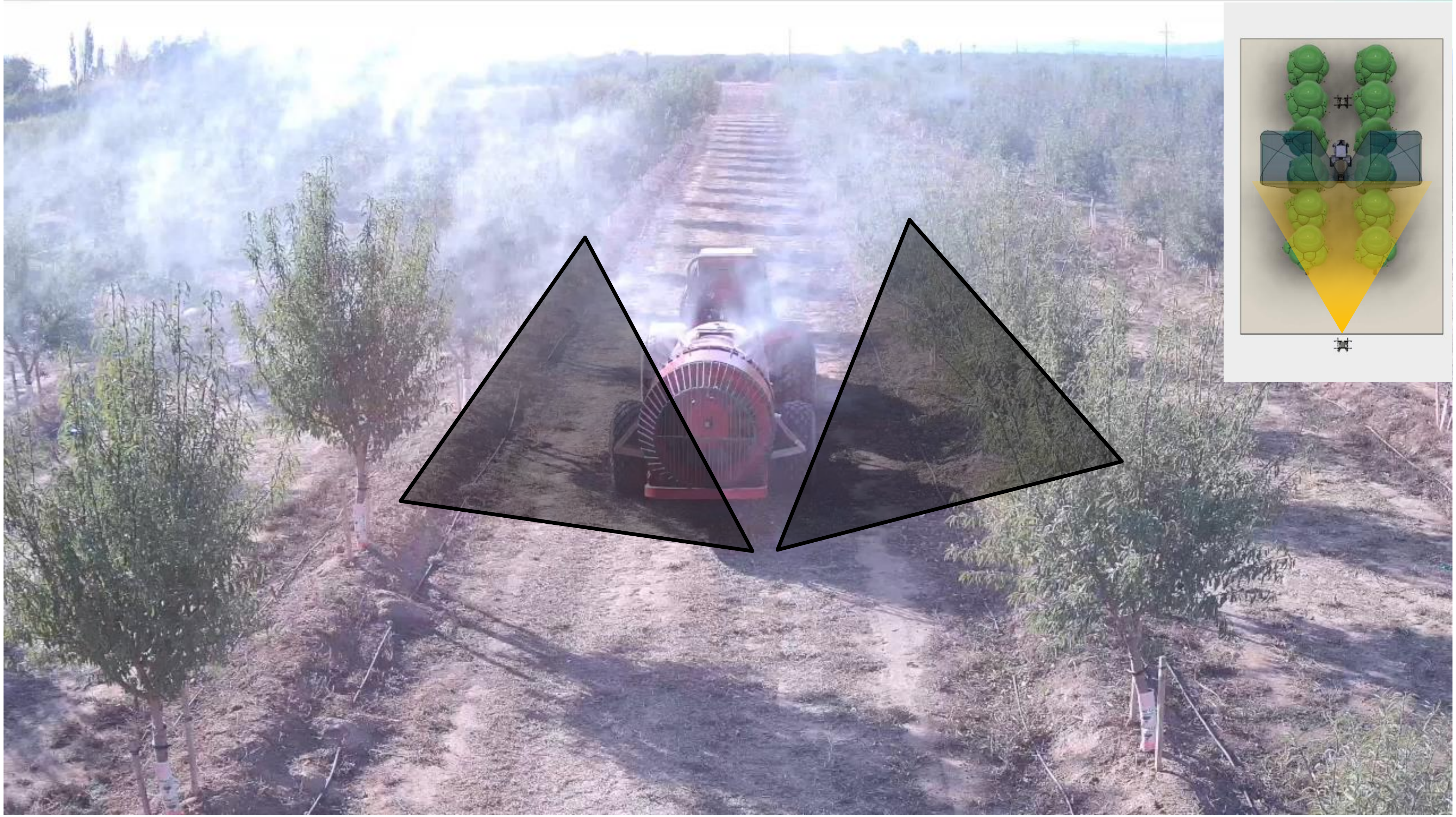
- Obj. 1 Determine the spray cloud movement with standard spray setting
- Obj. 2 Design and fabrication of the Spray Backstop mechanism
- Obj. 3 Evaluate spray drift reduction and coverage improvement using the Spray Backstop system

Objective 1

- An unmanned aerial system that carries two cameras (RGB and thermal) is used to capture images and videos of the spray cloud movement in three different positions



Position 1



Position 2

Position 3

Monitoring for NOW in the Presence of Mating Disruption & Sterile Insect Release for NOW

Chuck Burks, USDA Agric. Res. Service, Parlier, CA

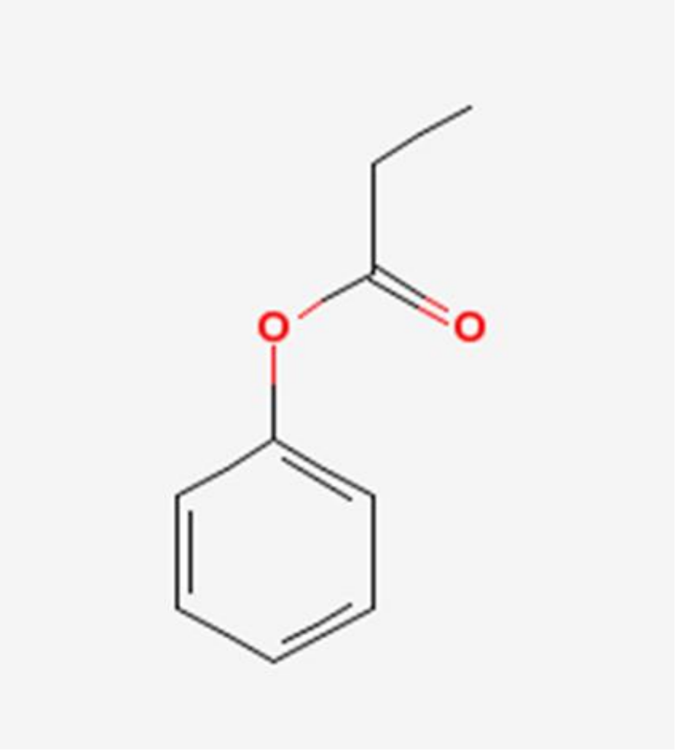
Monitoring for NOW in the Presence of Mating Disruption

The problem

- Mating disruption improves pest management but complicates monitoring
- Pheromone traps completely shut down in MD blocks
- Traps suppressed far beyond treatment blocks

Monitoring for NOW in the Presence of Mating Disruption

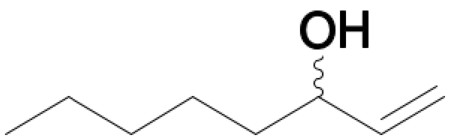
PPO (Phenyl propionate)



Monitoring for NOW in the Presence of Mating Disruption

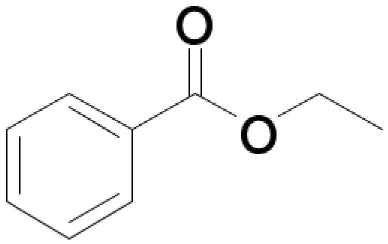
Kairomone Blend

1-octen-3-ol



12

ethyl benzoate



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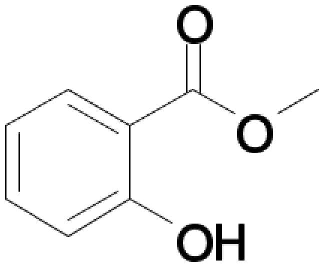
methyl salicylate



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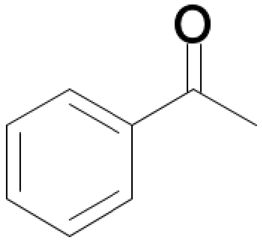
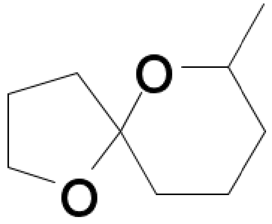
acetophenone



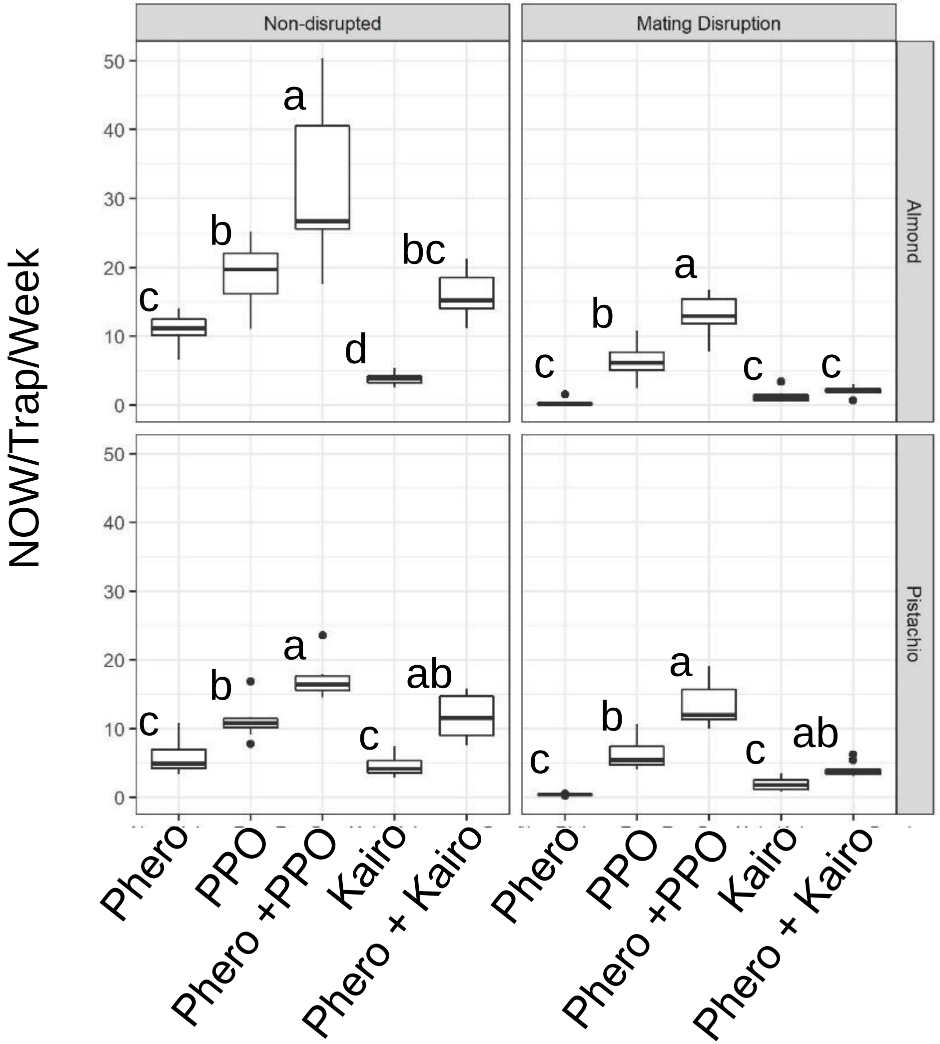
1

(E)-conophthorin



1

Monitoring for NOW in the Presence of Mating Disruption



- Pheromone enhanced capture
- PPO-combo significantly better than others
- PPO-only captured more than blend-only
- Mixture of males and females in all but pheromone

Monitoring for NOW in the Presence of Mating Disruption

Effect of trap type

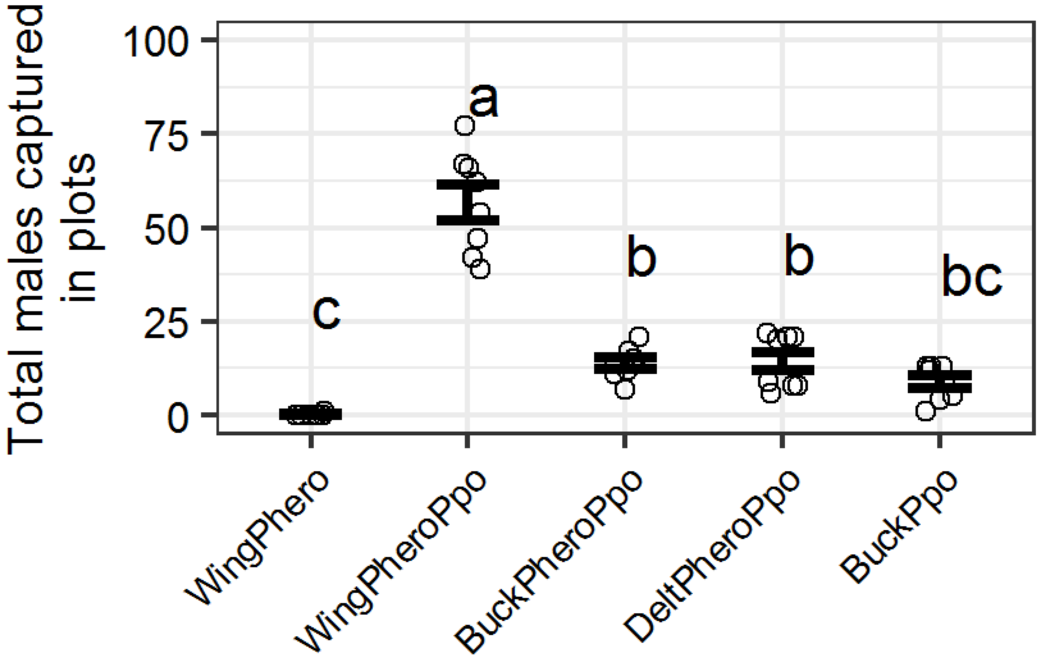
First experiment

Second experiment

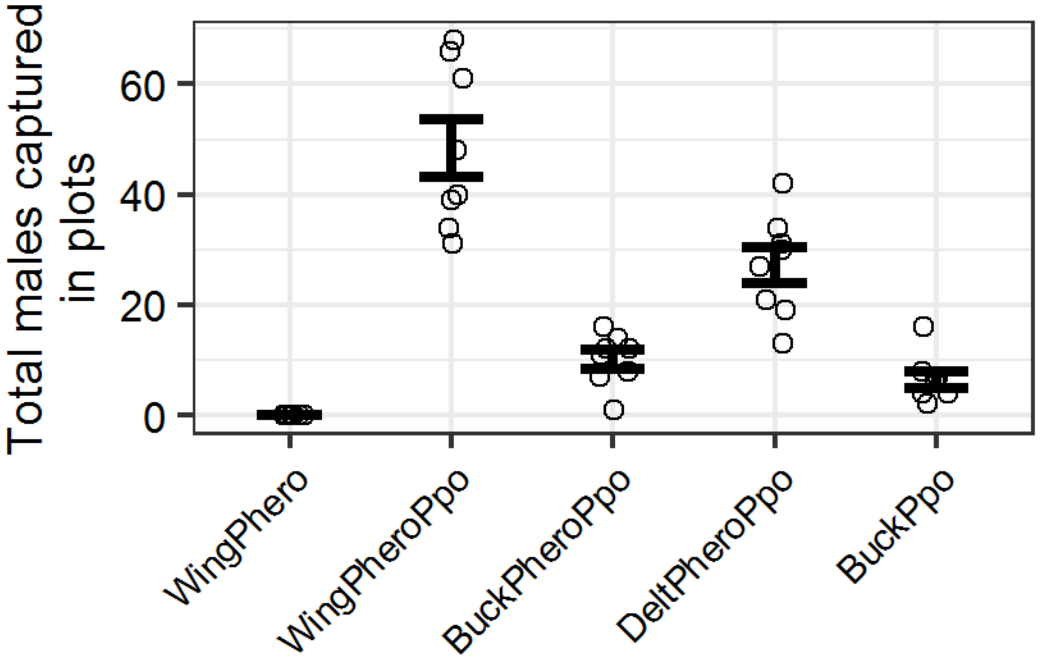
Monitoring for NOW in the Presence of Mating Disruption

Results, trap type experiments

First experiment



Second experiment

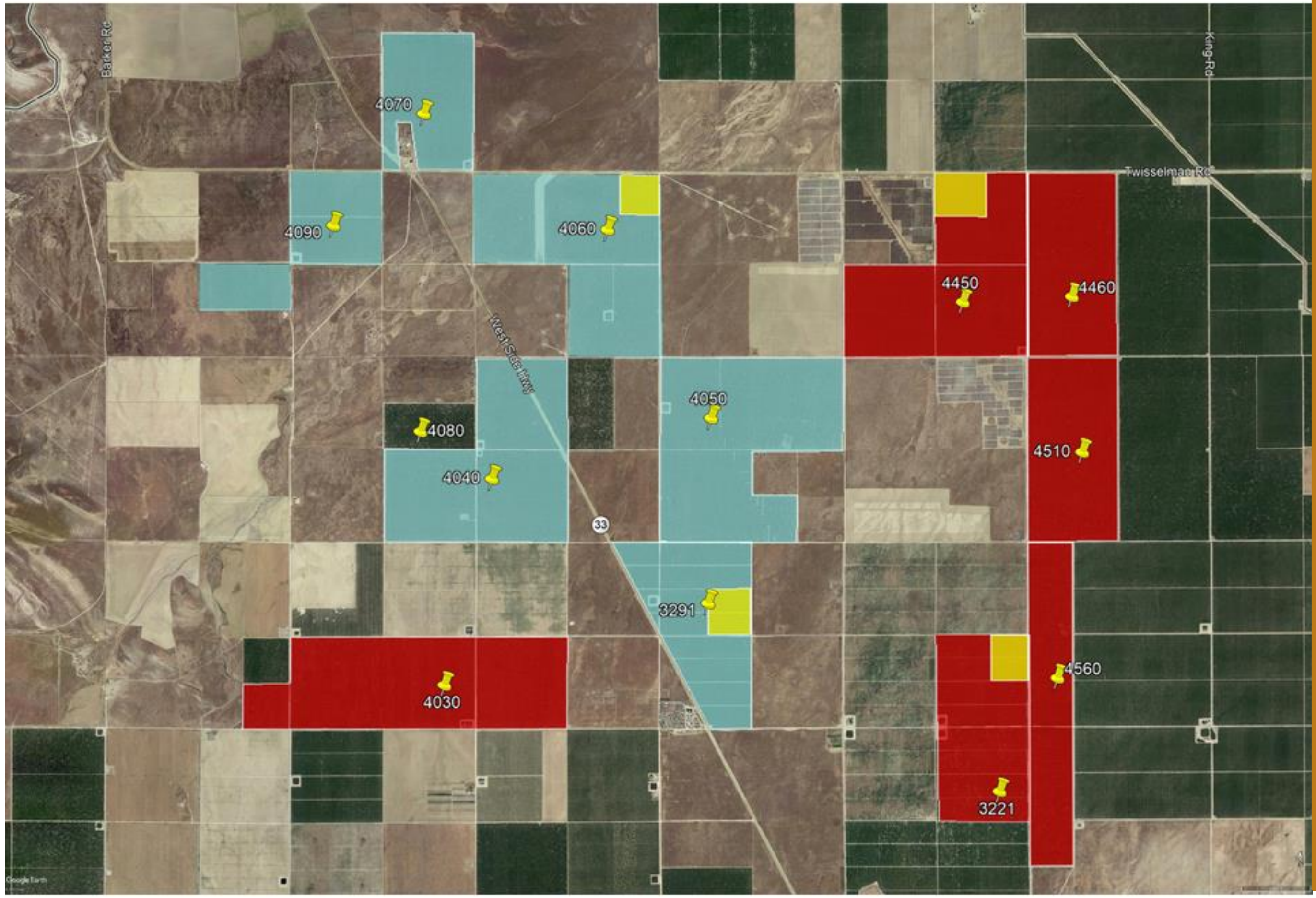


Sterile Release for NOW

- SIR experiments can enhance monitoring and mating disruption
- Mark-release-recapture experiments can enhance SIR
- Establishing quality of NOW released a necessary first step

Sterile Release for NOW

- Monitoring SIR Releases, Lost Hills, 2018
- Grids of 16 PPO-combo traps
- Monitored July 6 to October 19



SIR Release
🟦

Comparison
🟥

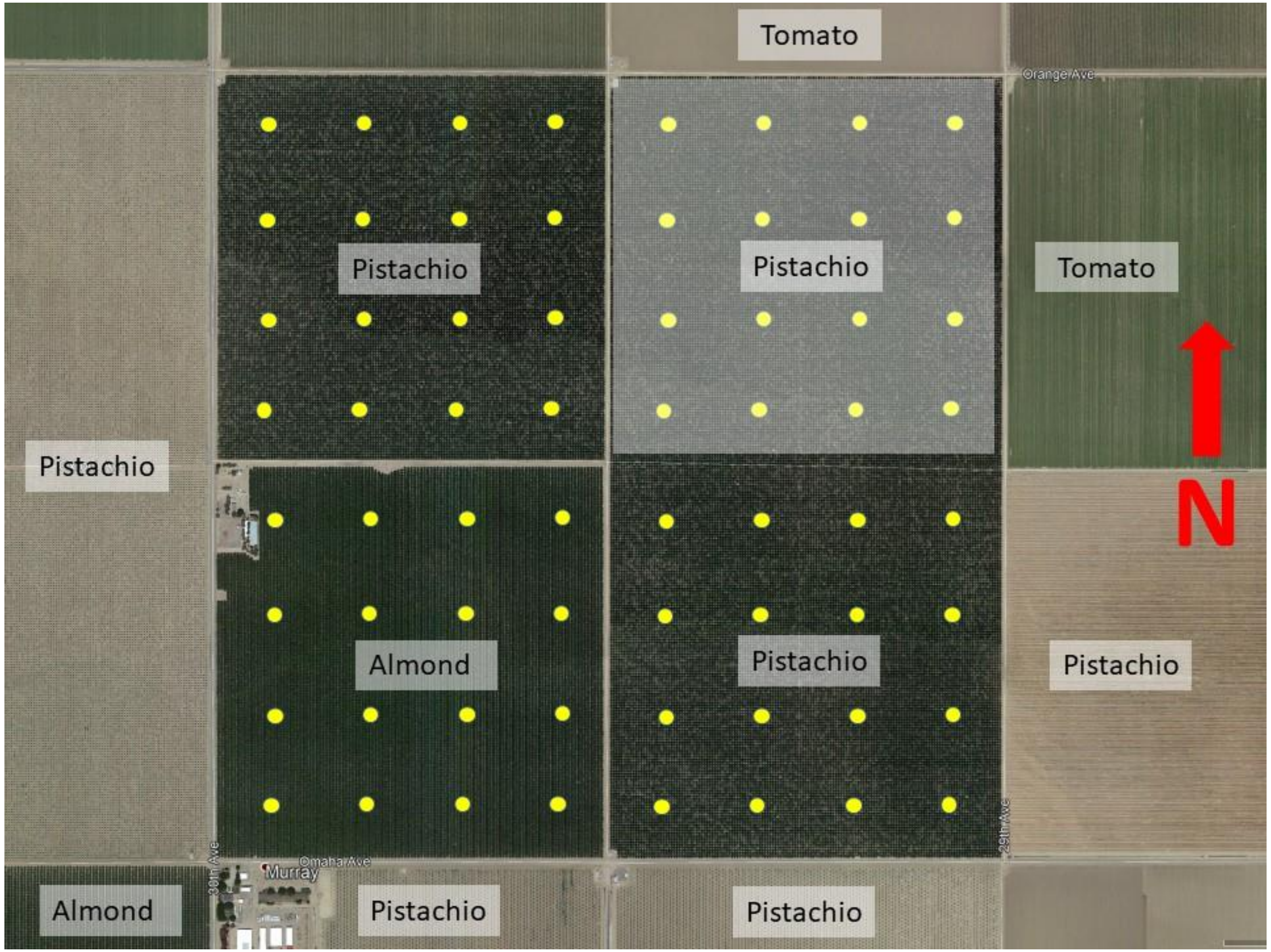
Trap grids
🟨

Sterile Release for NOW

Results, SIR NOW Recapture at Lost Hills in the Presence of Mating Disruption

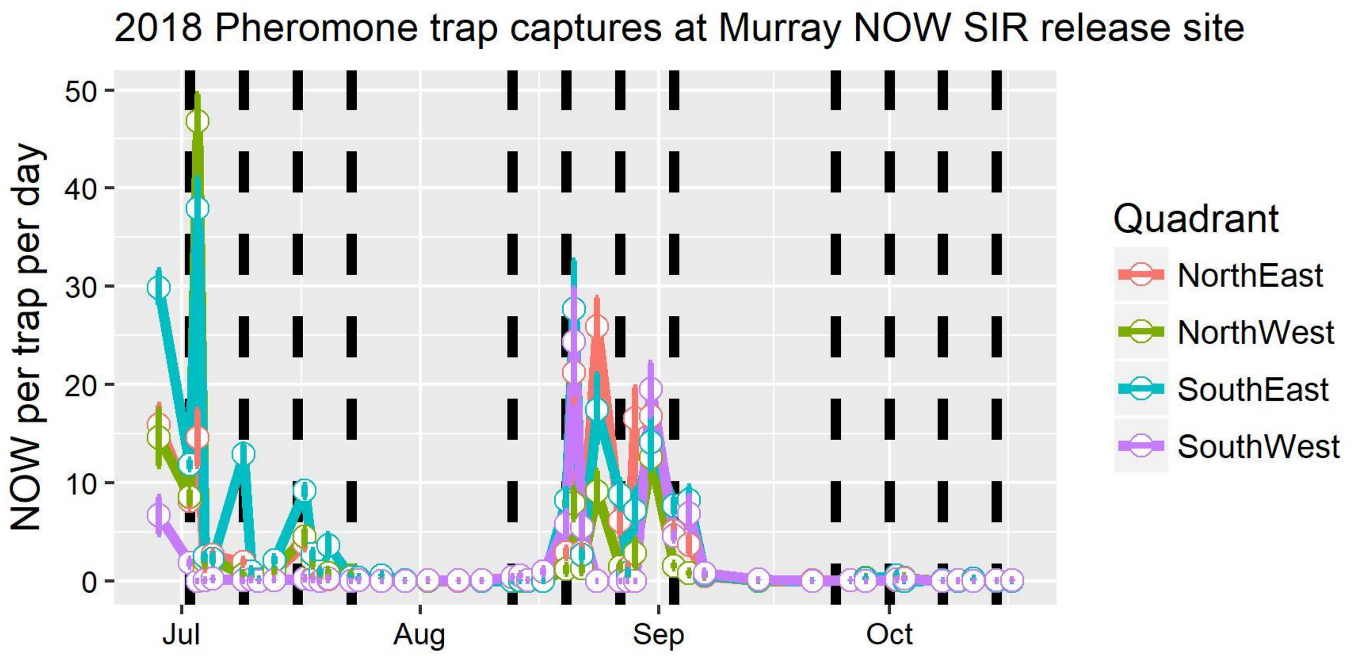
Crop	SIR Release?	Undyed NOW	Dyed NOW	Percent Dyed
Almond	Yes	412	24	5.5
	No	107	2	1.9
Pistachio	Yes	923	7	0.8
	No	724	25	3.3

Sterile Release for NOW

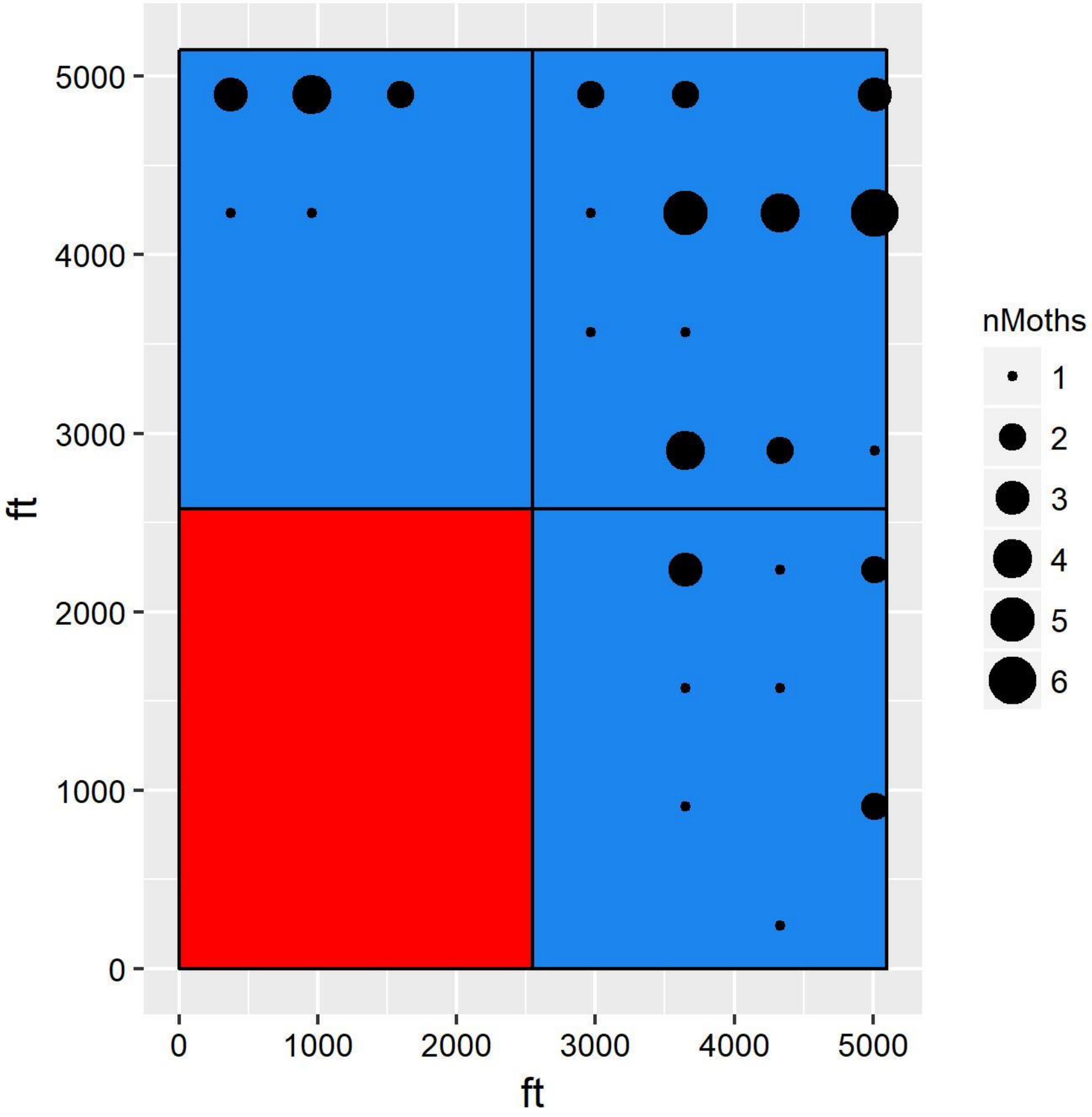


- SIR NOW Released over northeast 160 acres
- Entire 640 acre planting trapped
- No mating disruption, pheromone traps used

Sterile Release for NOW



Cumulative capture of dyed moths



Bottom Line:

- 15,493 males trapped
- 0.35% dyed

Sterile Release of NOW

Houston Wilson | Dept. Entomology, UC Riverside

Chuck Burks | USDA-ARS, San Joaquin Valley Ag. Sci. Center

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Overview of NOW-SIT Program in 2018

Geography of Releases and Research

Parlier (UC Kearney Ag. Center)

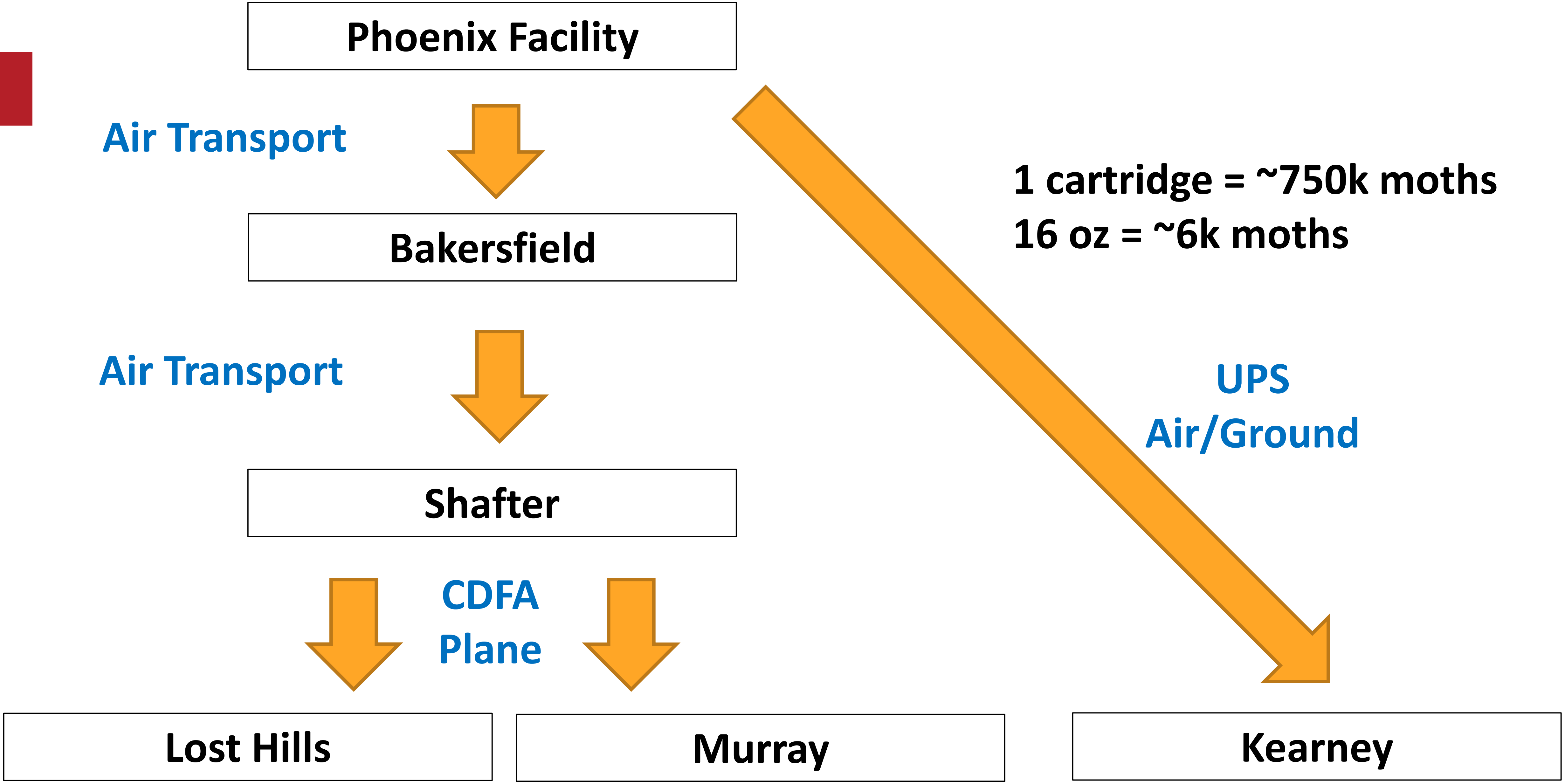
- 2 ac. pistachios – no sanitation, no sprays, no mating disruption
- Weekly ground releases (Jun 11 – Oct 15), ~6,000 moths/week (3,000/acre)

Murray / Kettleman City (commercial orchard)

- 480 ac. pistachios, 160 ac. almonds – conventional, no mating disruption
- Weekly aerial release (July 1 – Oct 15), ~750,000 moths/week (4,687/acre)

Lost Hills (commercial orchard)

- 1,800 ac. total, mostly pistachios, some almonds – conventional with disruption
- Aerial release 5-6x/week (April 1 – Nov 1), ~4,500,000 moths/week (2,500/acre)



Phoenix Facility

Air Transport

Bakersfield

Air Transport

Shafter

CDFA
Plane

Lost Hills

1 cartridge, 5-6x/week

Murray

1 cartridge, 1x/week

UPS
Air/Ground

Kearney

16 oz, 1x/week

1 cartridge = ~750k moths
16 oz = ~6k moths

Field Experiments in 2018

Kearney Ag. Center

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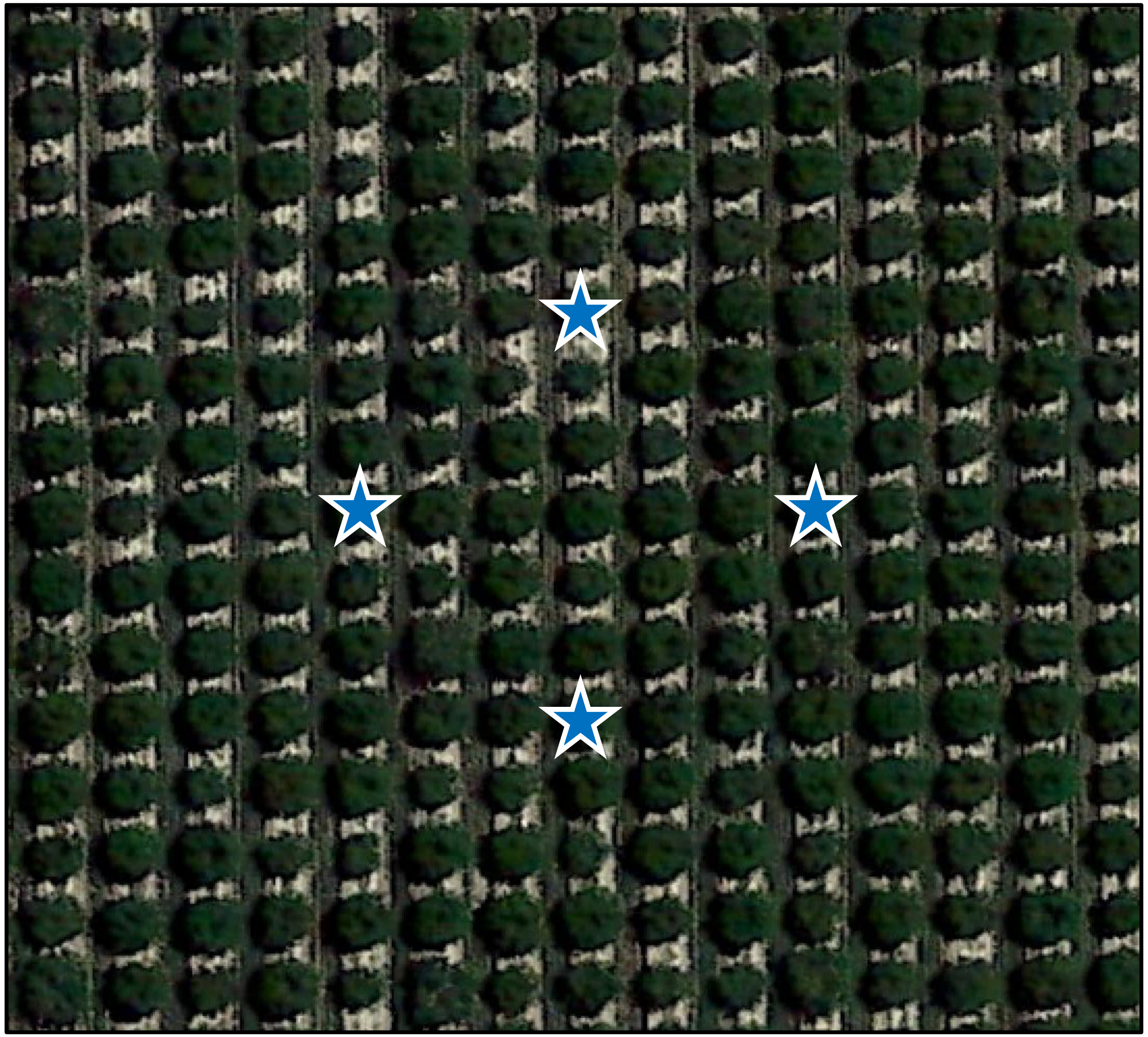
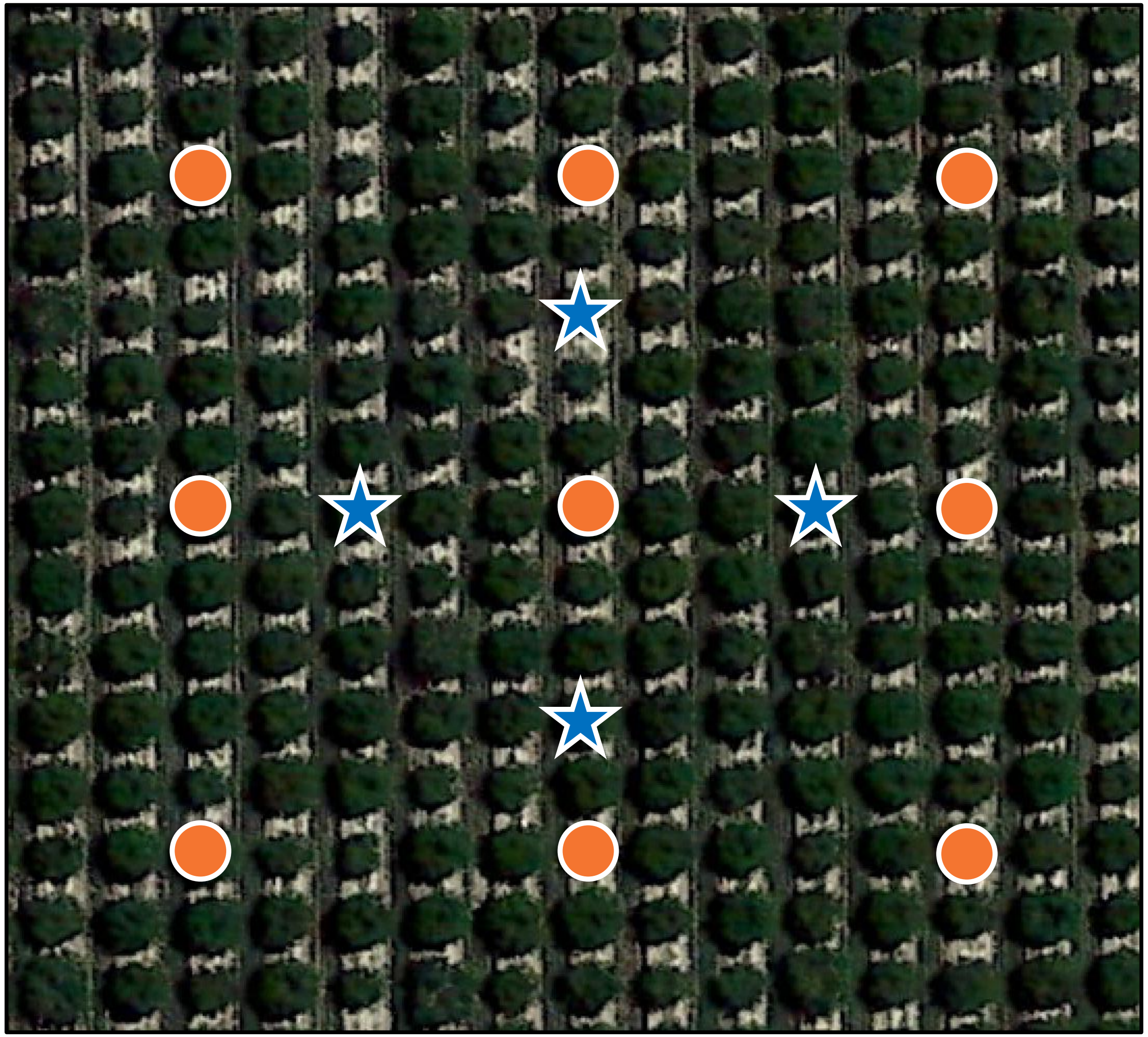
Flight Traps and Mating Tables



★ Wing-trap + Biolure

Flight Traps and Mating Tables



● **Mating Table**

Flight Traps and Mating Tables

How Mating Tables Work

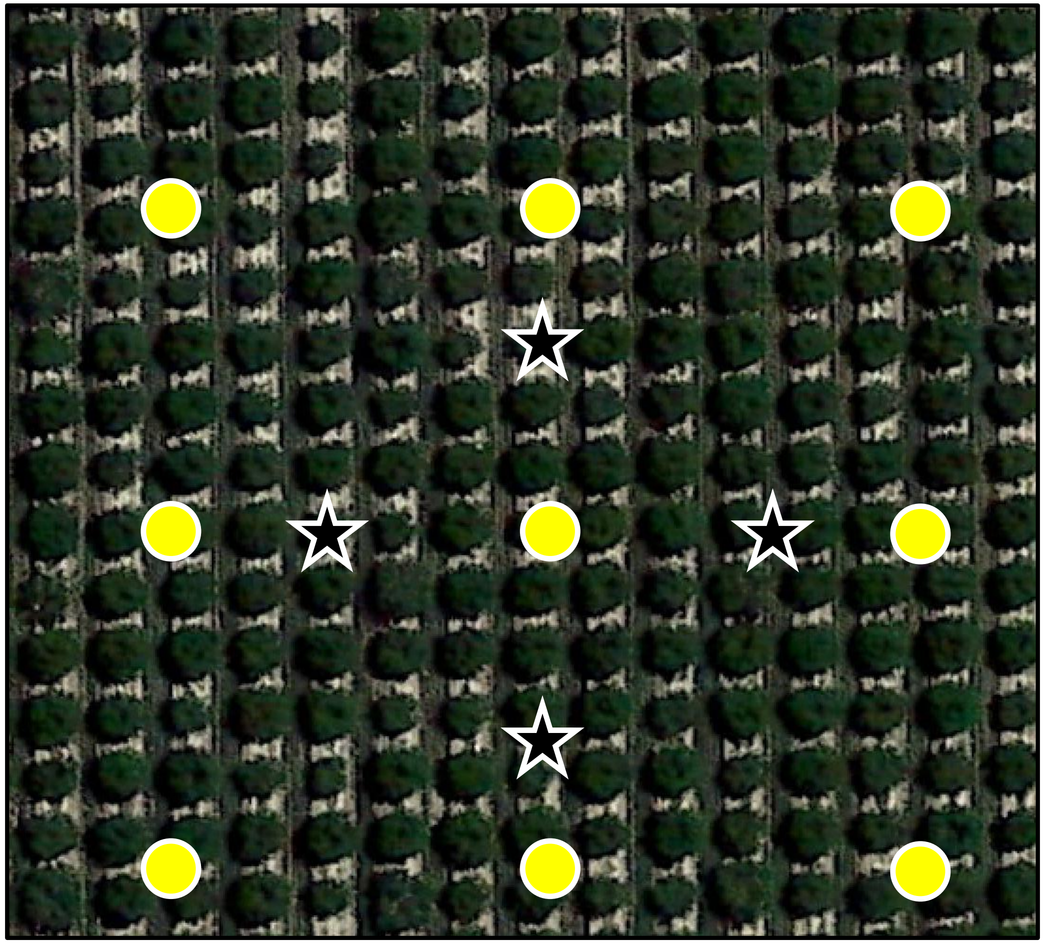
“Mendota Strain” = Unirradiated Control

Release of Irradiated Moths

First release June 11
16 oz = 6,000 moths
50:50 male:female

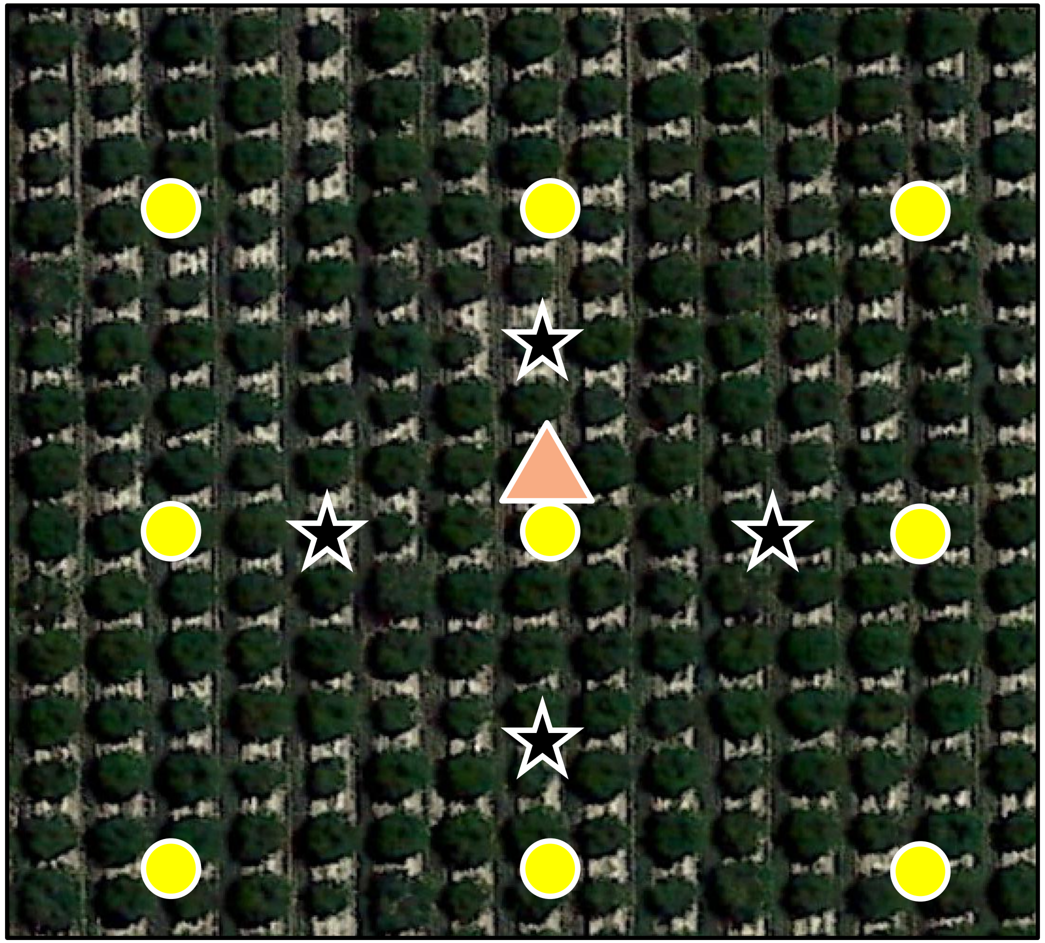
Release of Irradiated Moths

Center Point Release



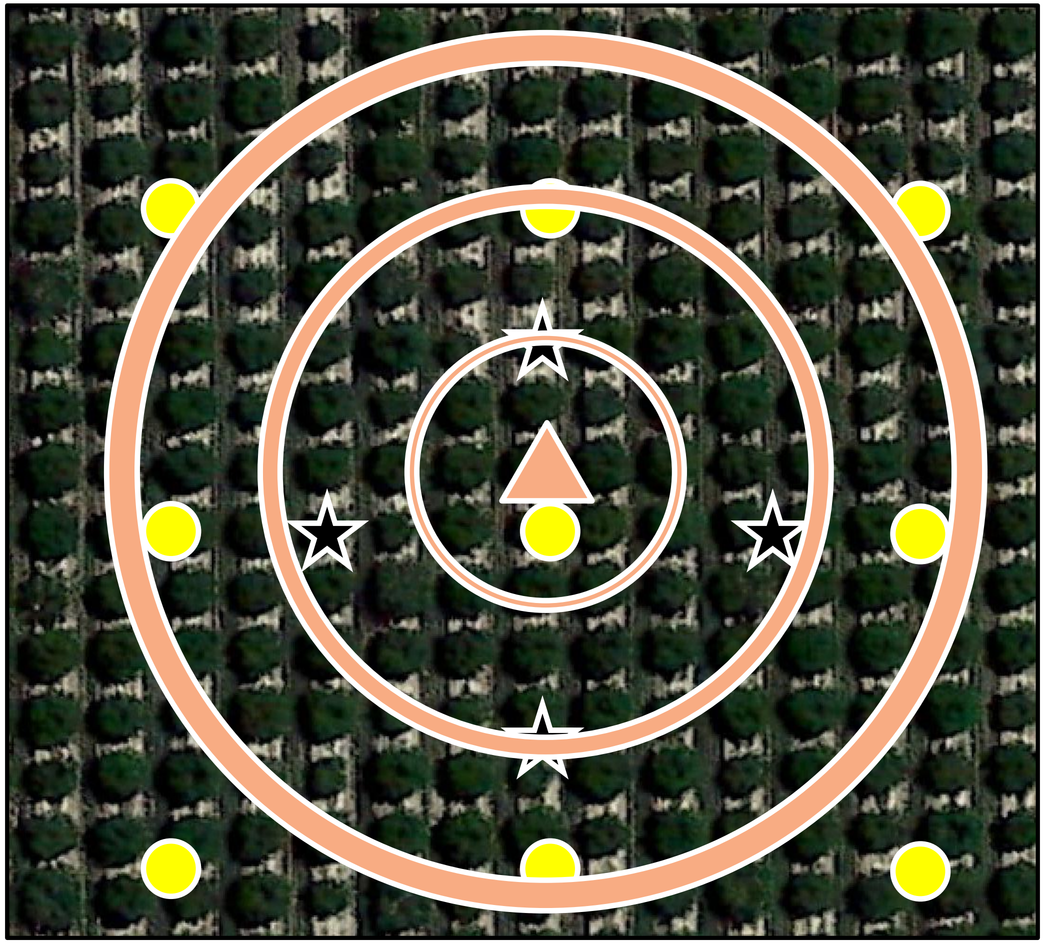
Release of Irradiated Moths

Center Point Release



Release of Irradiated Moths

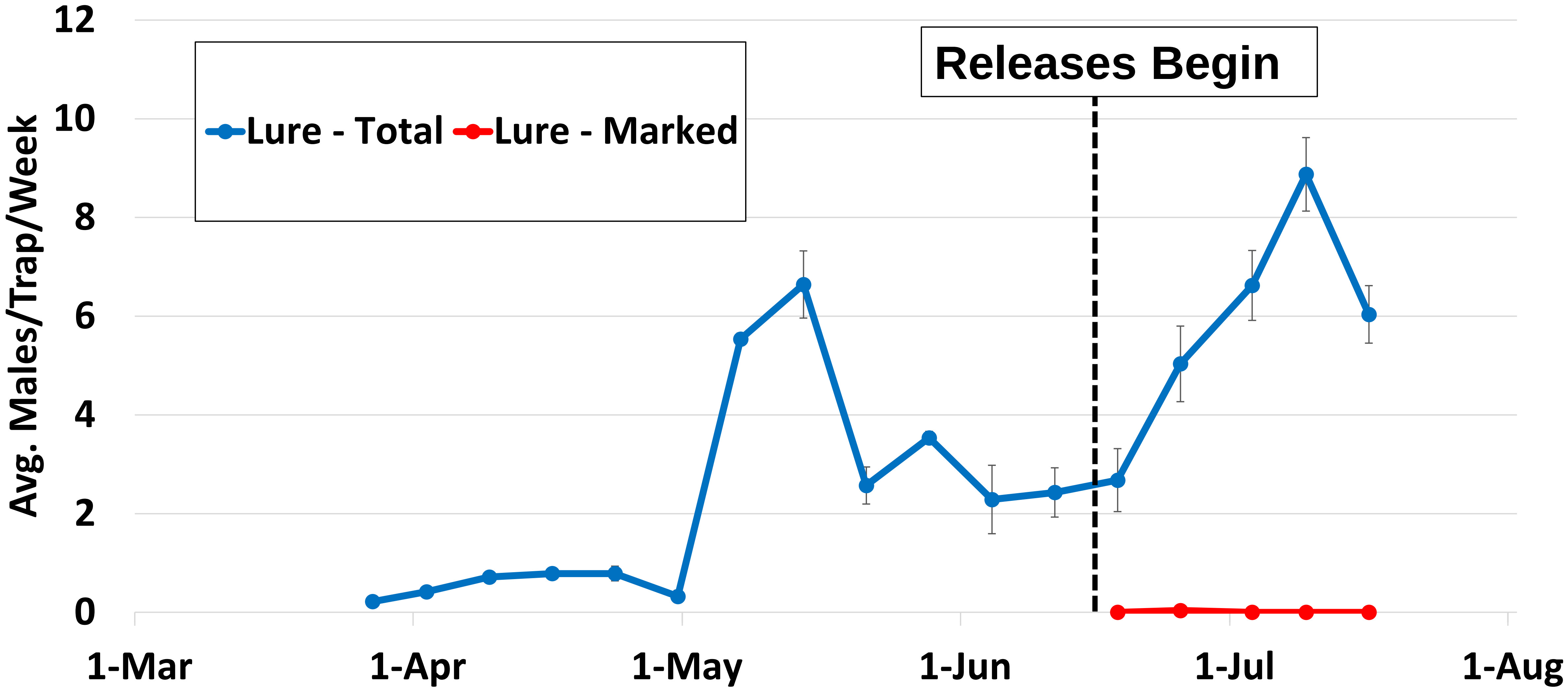
Center Point Release



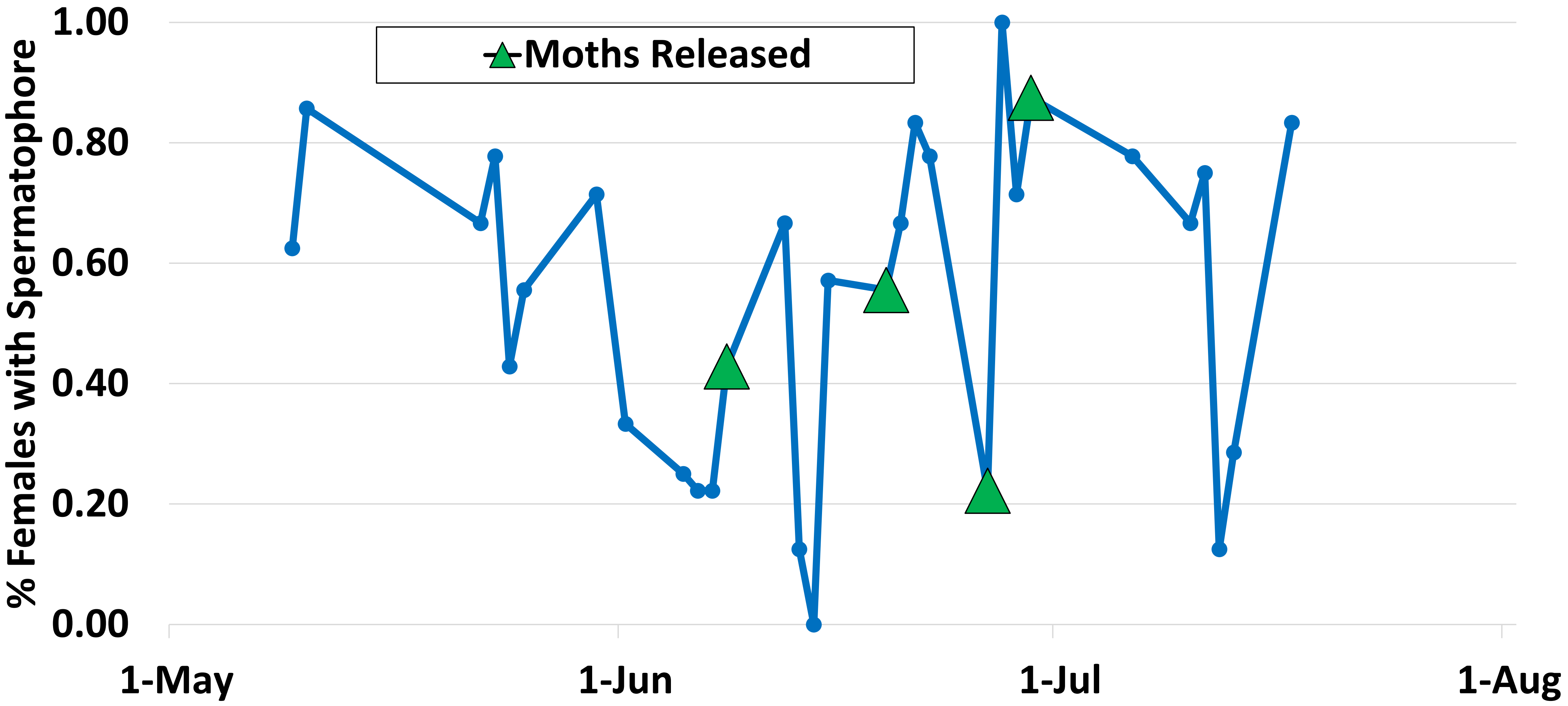
Release of Irradiated Moths

Moths Marked Internally

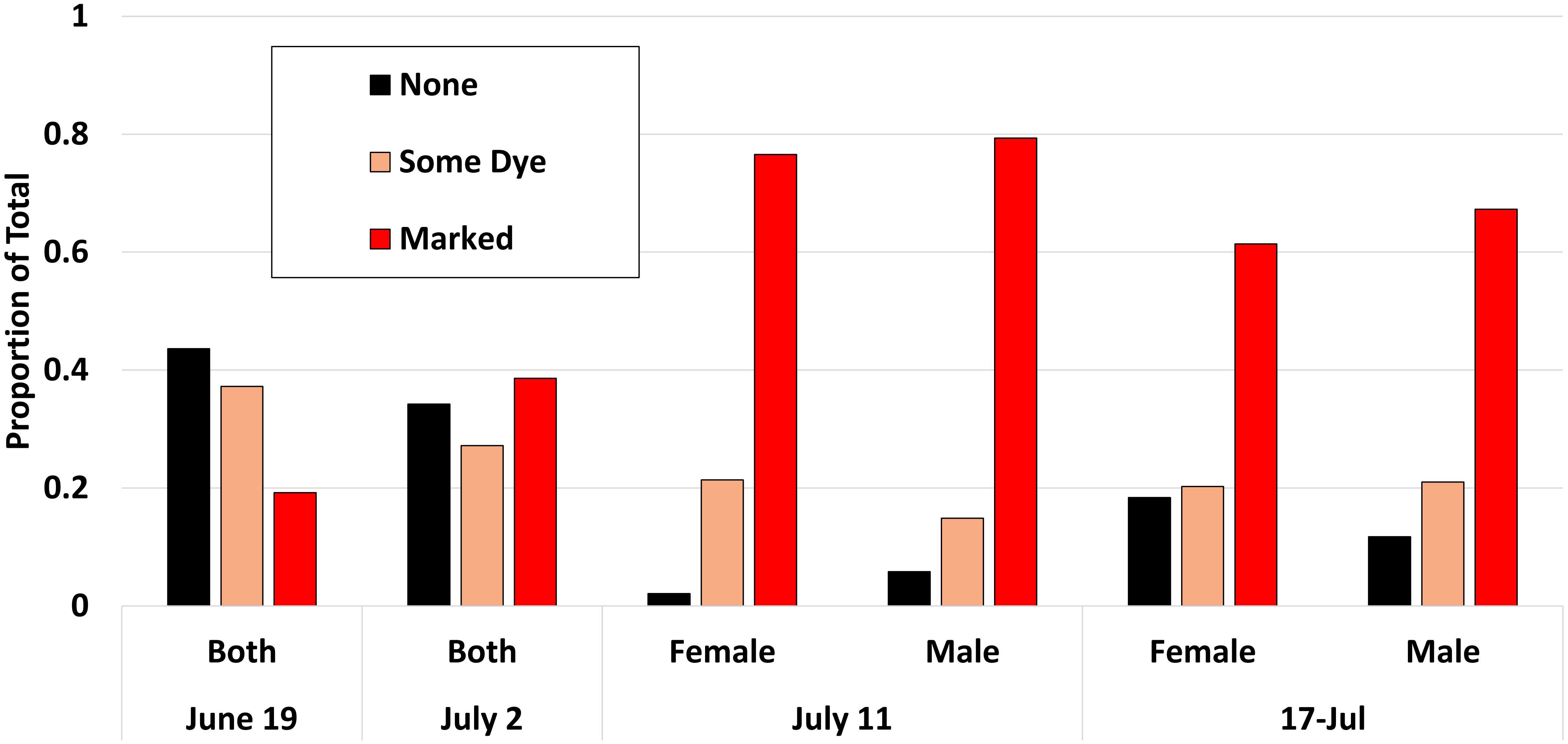
Flight Traps at Kearney



Mating Tables – Proportion Mated



Sterile Moth Marking



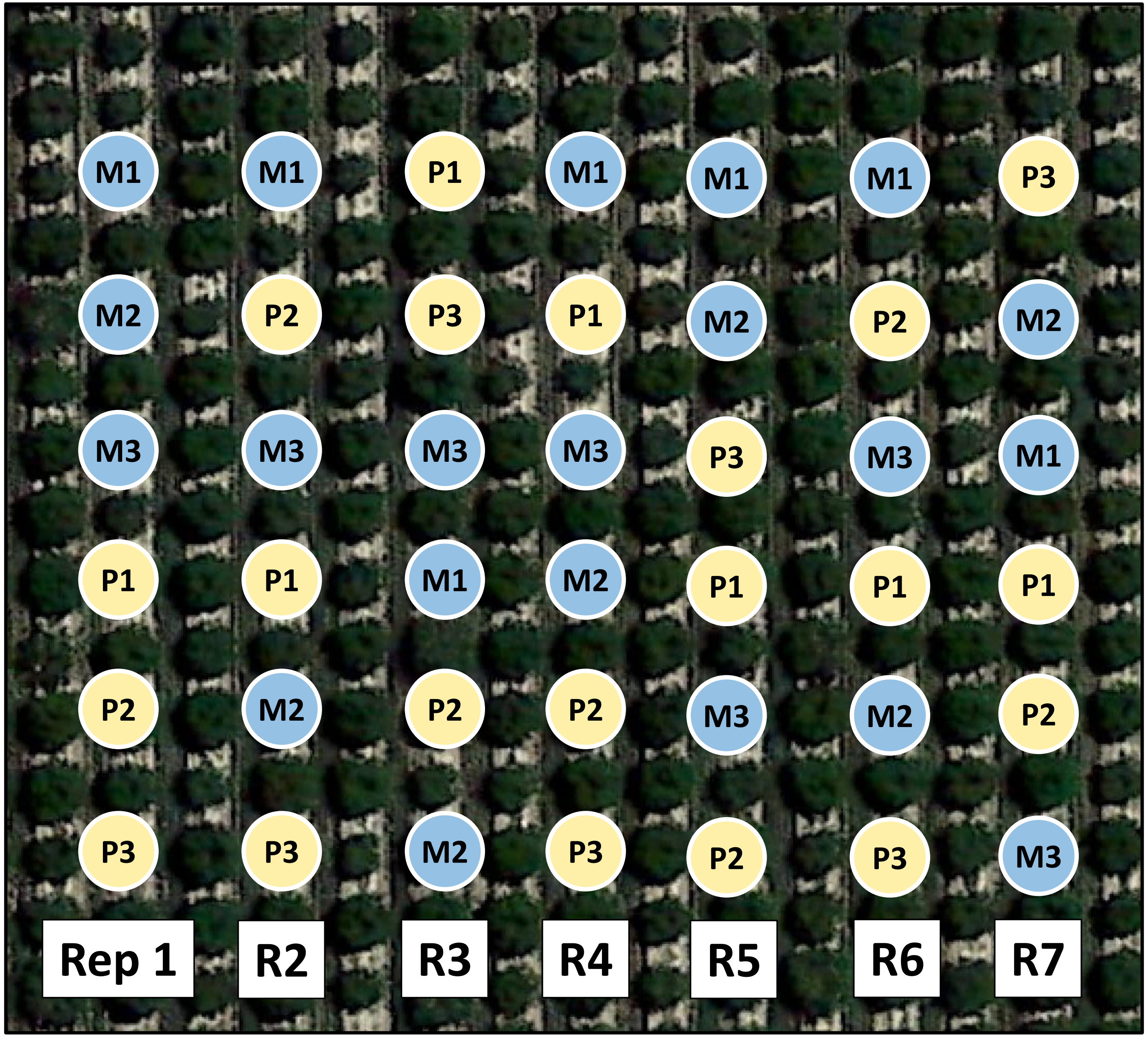
Key Point

- Irradiated males rarely showing up in the pheromone traps and never in the mating tables

Mating Tables – Mendota vs. Phoenix

- **Mendota**
  - 1 night – **M1**
  - 2 nights – **M2**
  - 3 nights – **M3**
- **Phoenix**
  - 1 night – **P1**
  - 2 nights – **P2**
  - 3 nights – **P3**


M1
M2
M3
P1
P2
P3
Rep 1


M1
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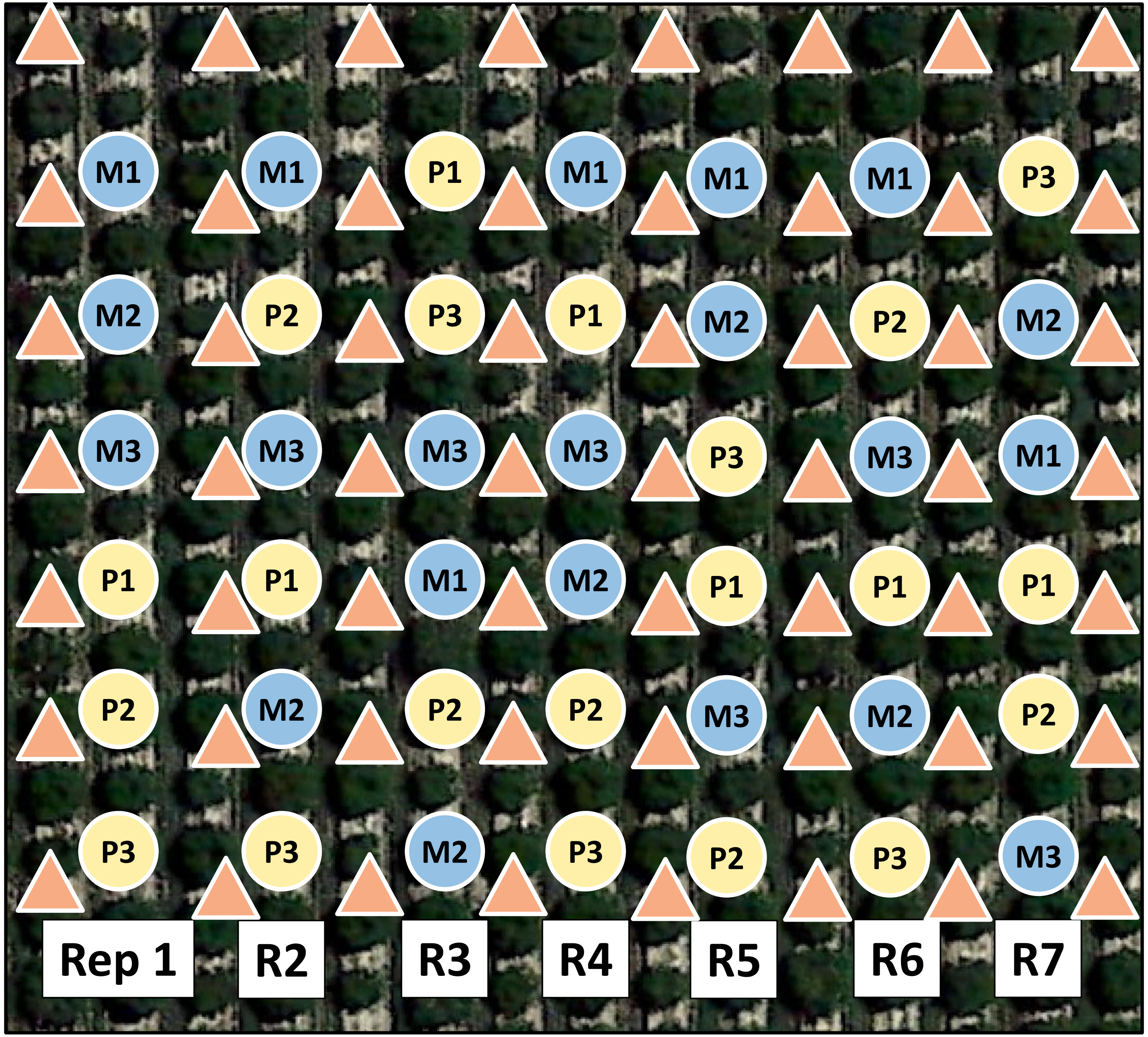
M3
Rep 1
R2
R3
R4
R5
R6
R7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Rep 1
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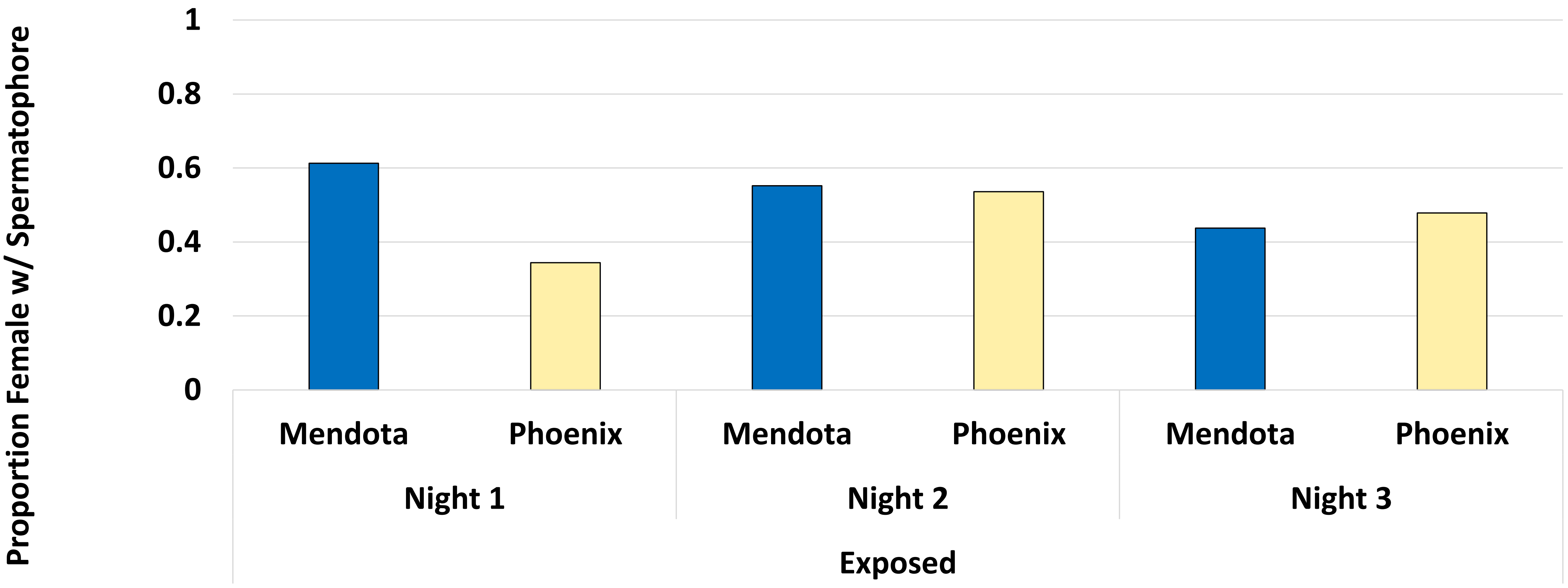
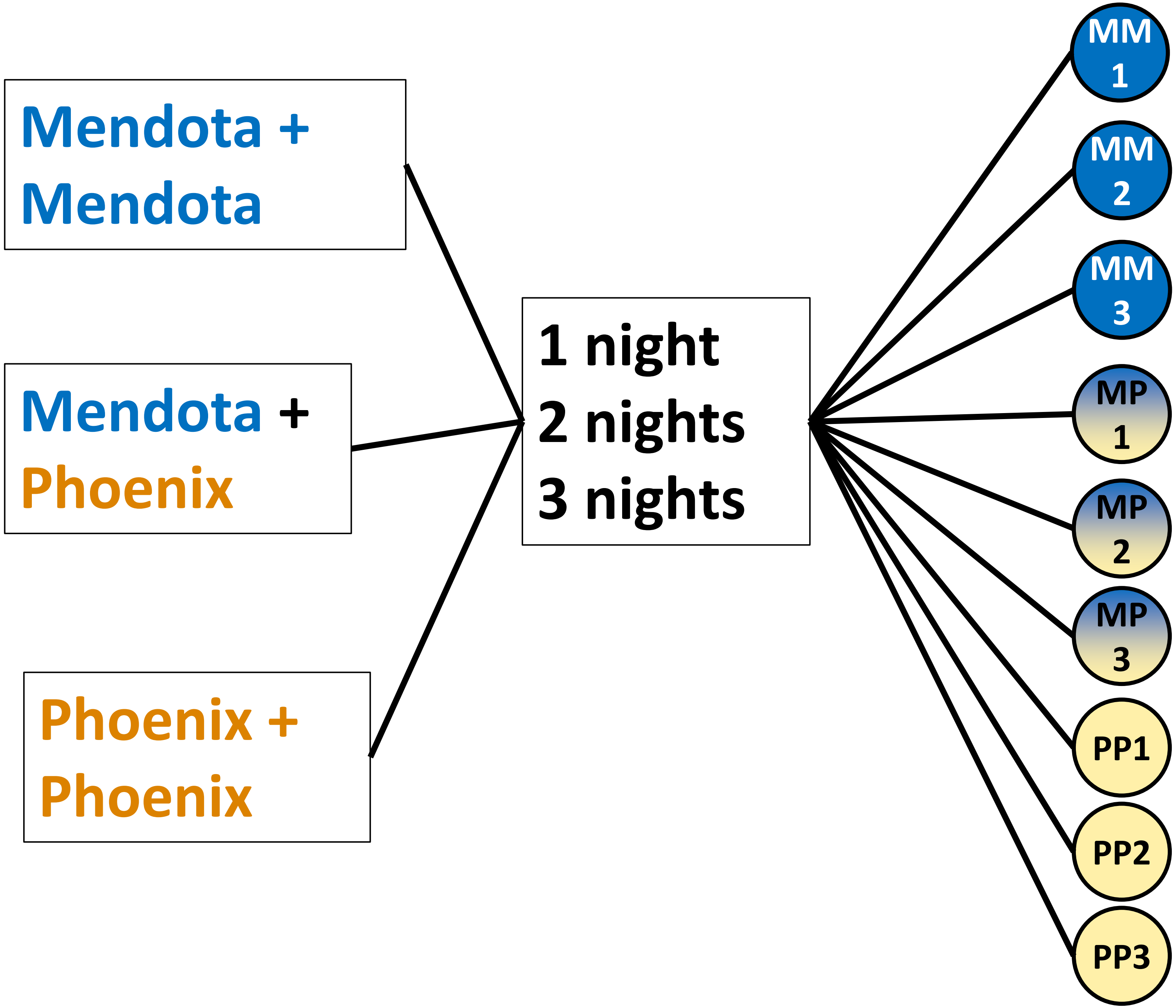
R3
R4
R5
R6
R7

Mating Success – Mendota vs. Phoenix





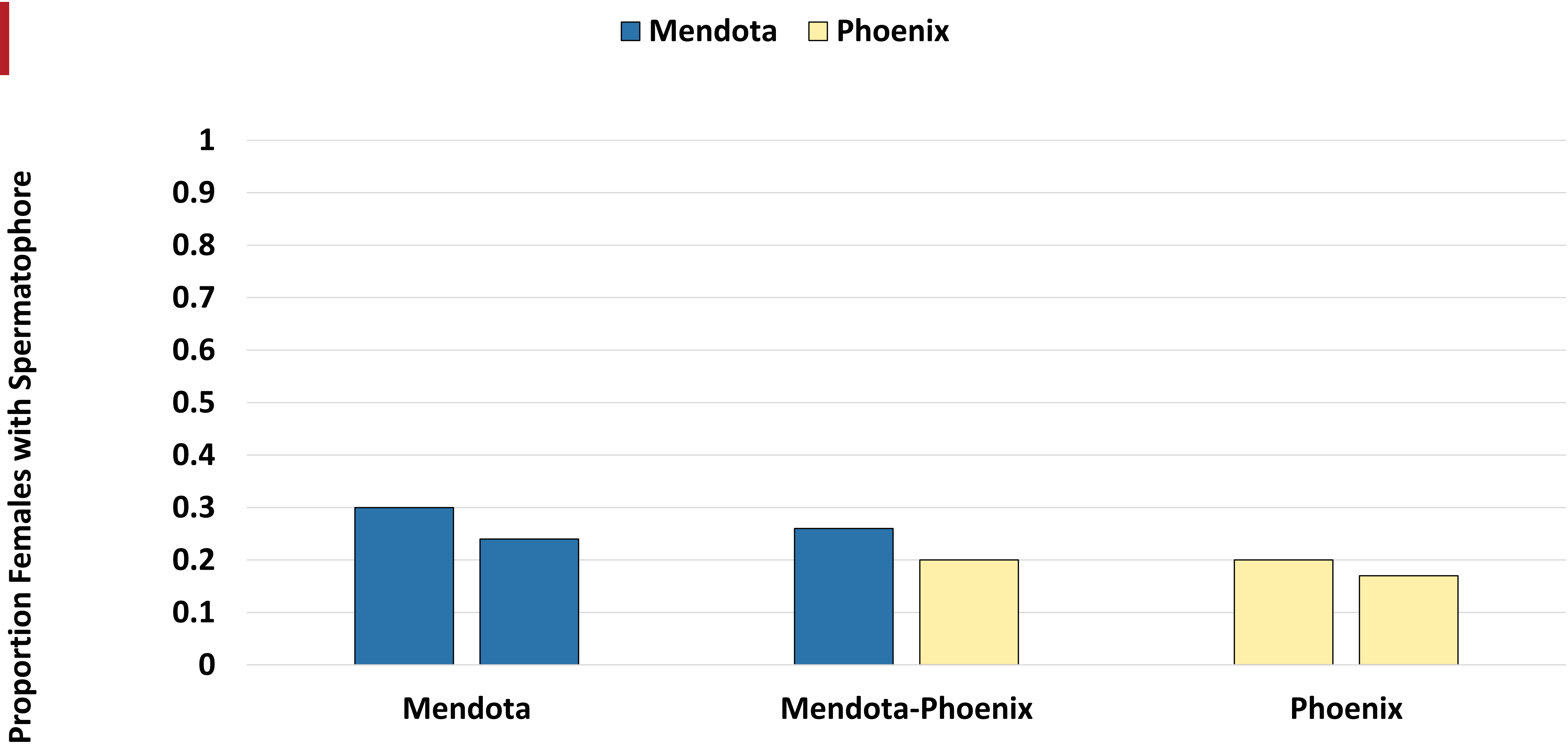
Mendota + Mendota

Mendota + Phoenix

Phoenix + Phoenix

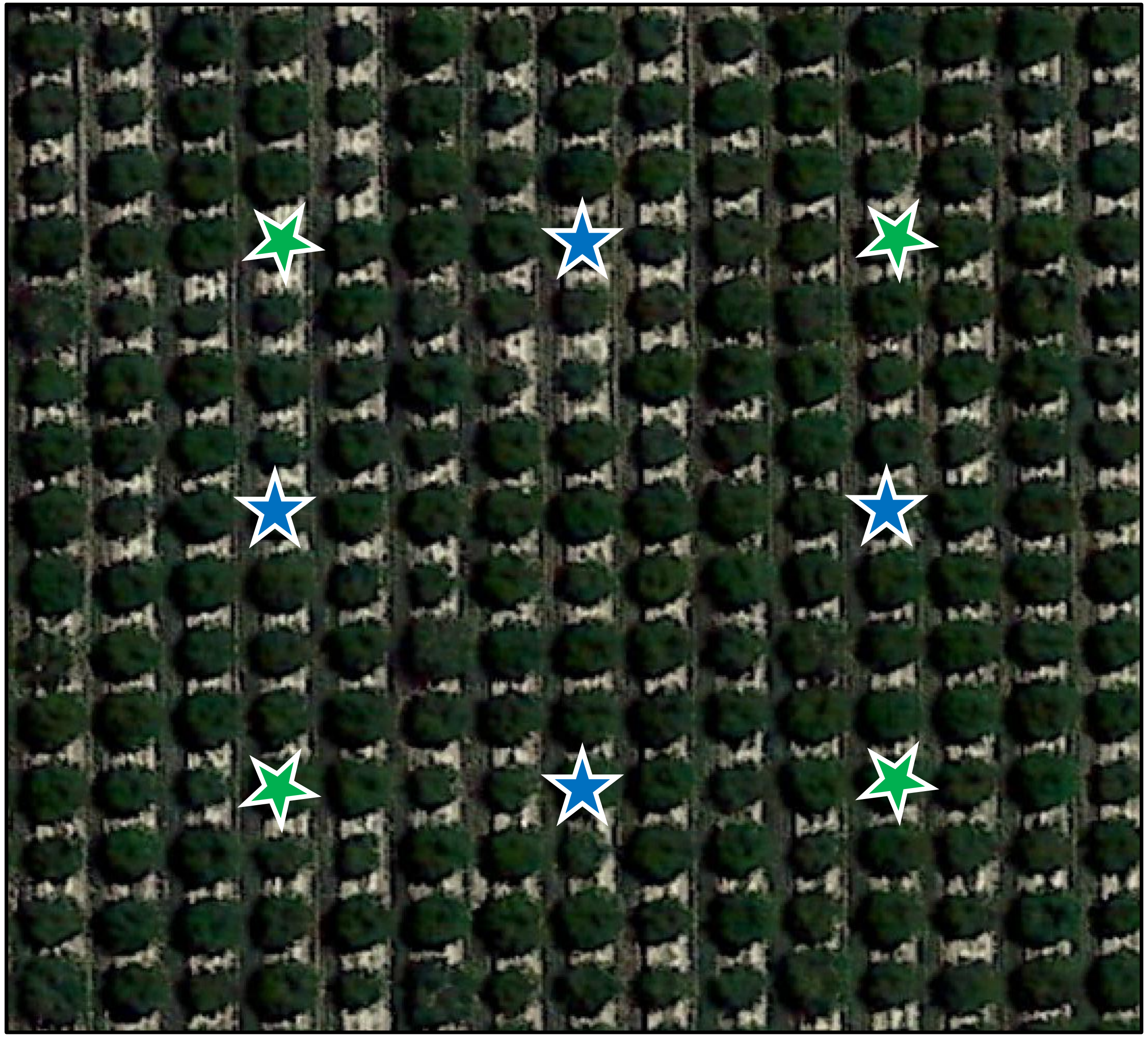
1 night
2 nights
3 nights

Mendota + Phoenix Paired Together



Key Points

- **Irradiated females do attract wild males**
- **Not as attractive on the 1st night, but perform equivalent on 2nd and 3rd nights**
- **Difference on 1st night is likely related to shipping/photoperiod**
- **Pairing Mendota + Phoenix did not effect mating success**



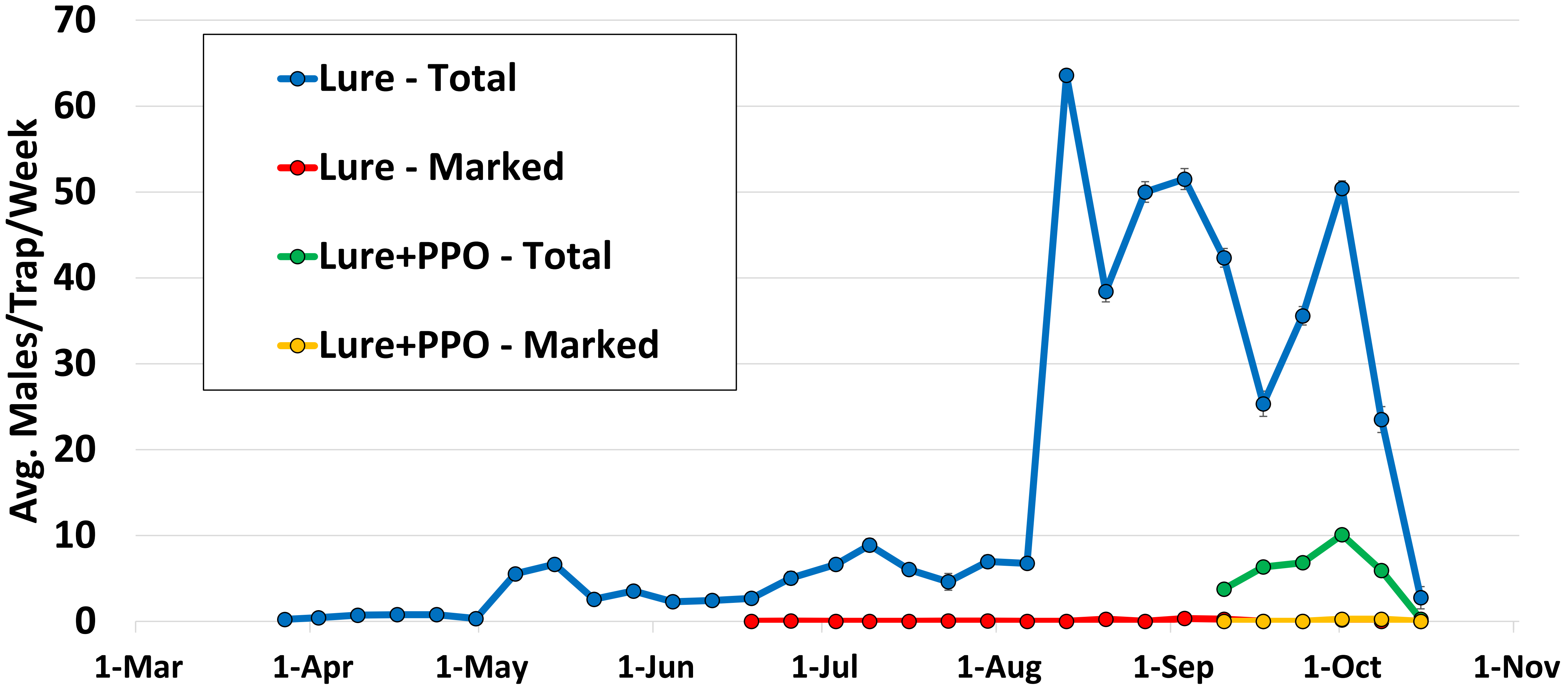
Wing-trap + Biolure

★ Weekly (3/26 – 8/7)
Daily (8/7 – 10/15)

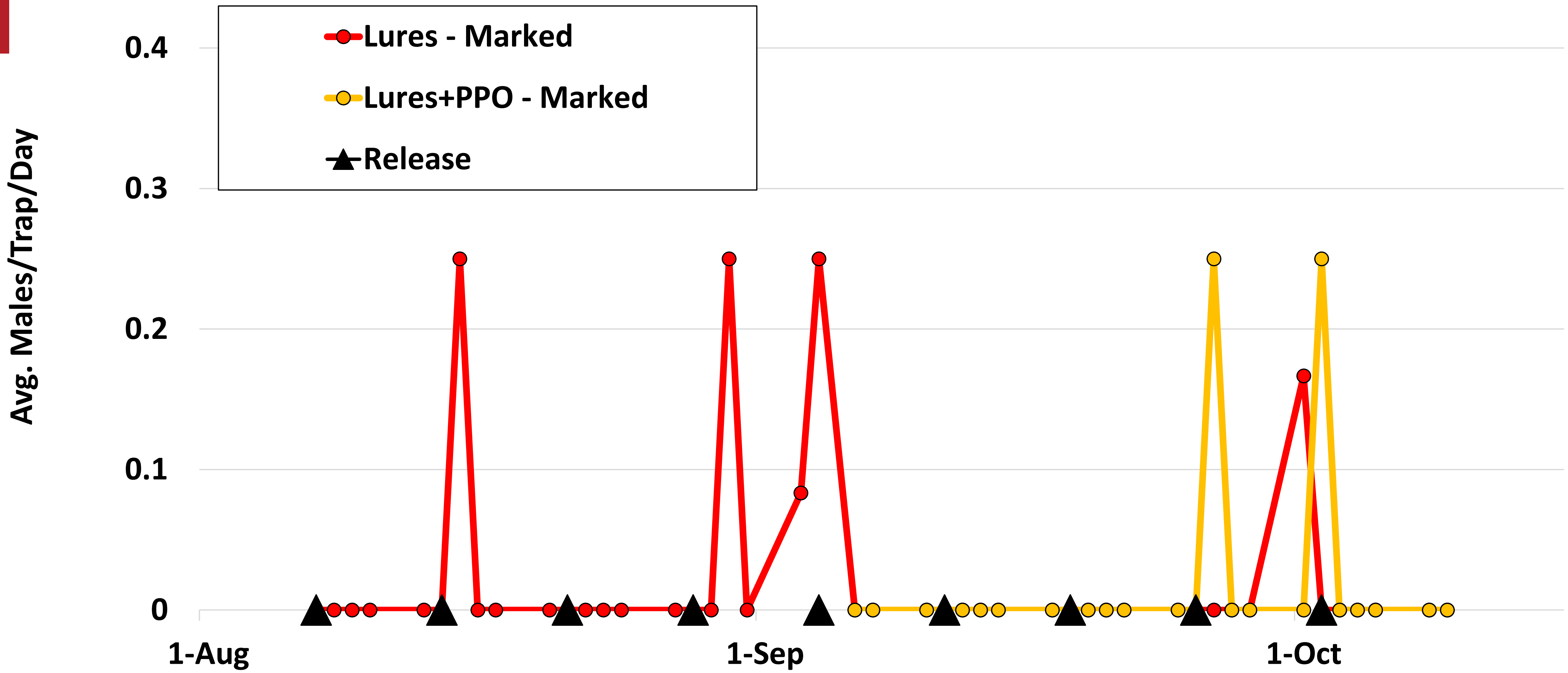
Wing-trap + Biolure + PPO

★ Daily (9/6 - 10/15)

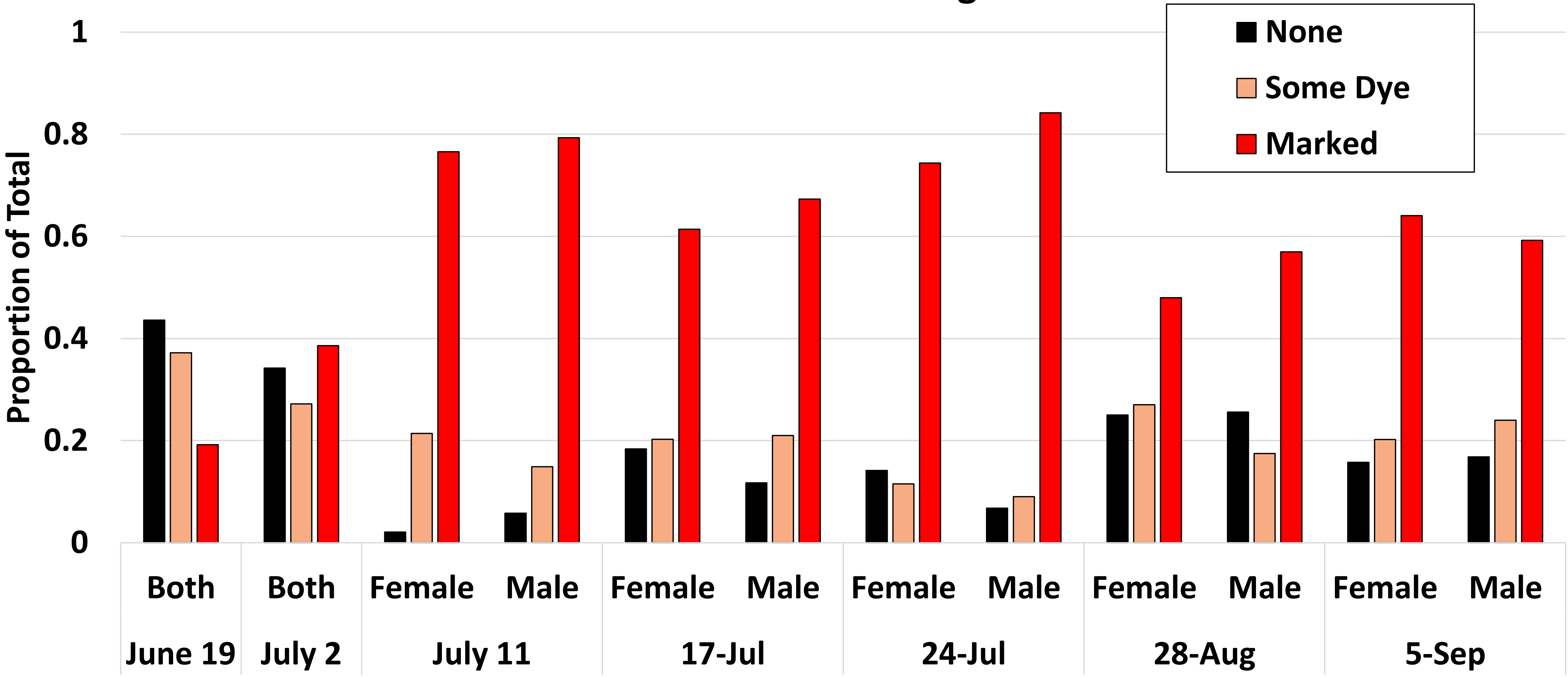
Flight Traps at Kearney



Flight Traps at Kearney - During Release Period



Irradiated NOW Marking



Key Points:

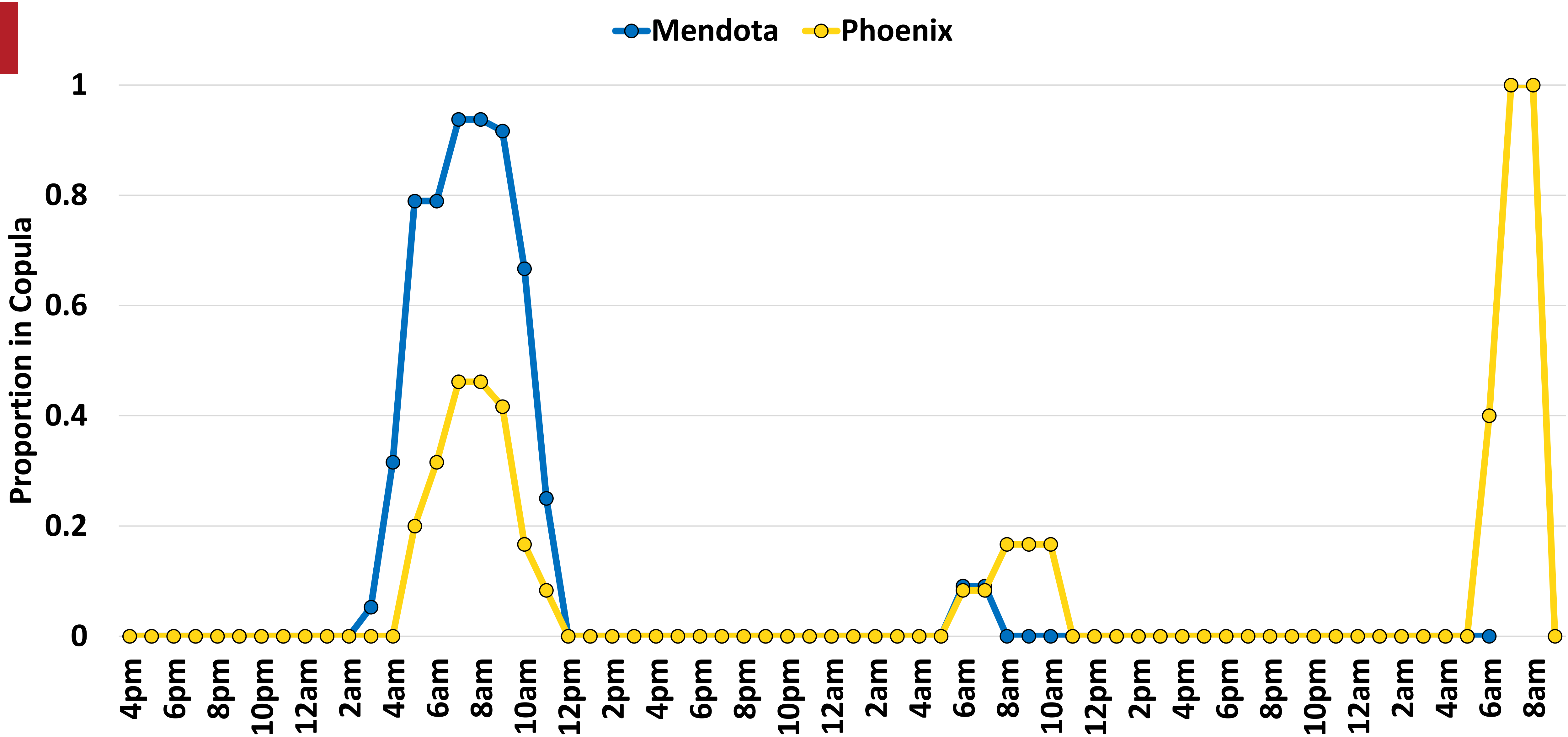
- Irradiated moths not showing up in PPO traps either

Timing of Copulation

- **Compared exposed Mendota vs. Phoenix moths**

- **Checked mating tables 1x/hour over 3-day period**

Proportion In Copula Every Hour



Key Points

- Irradiated females call and mate at approximately the same time as Mendota strain

Kearney Ag. Center – Summary and Conclusions

- **Released ~114,000 irradiated NOW into a 2 ac. block**
  - **Released by hand, on the ground**
  - **Practically unmanaged trees**
  - **Flight traps and mating tables function well**

Kearney Ag. Center – Summary and Conclusions

- **Irradiated males were rarely recovered in flight traps and never in mating tables**
    - Traps collected 4,455 moths, only 11 were marked (0.24%)

- **Marking sometimes low, generally ~80%**
    - Could be improved
    - Not bad enough to explain the lack of recaptured marked moths

Kearney Ag. Center – Summary and Conclusions

- **Irradiated females do attract wild males**
  - **Not as successful on 1st night – shipping/photoperiod issue**
  - **Equivalent with Mendota on 2nd and 3rd nights**
  - **Both groups appear to call at approx. the same time**

Research in 2019 – Future Directions

Key Immediate Issues

- Moths not flying and/or males not following plumes
- Shipping impacts photoperiod and activity after release

Research Questions for 2019

- What is influencing moth performance?
  - Strain
  - Rearing conditions
  - Radiation dose
  - Shipping conditions/photoperiod
  - Release method and timing

Long Term Research Plan

1. Produce a moth that is equivalent/competitive with wild moths
    - Strain, production system, radiation dose, shipping and release
2. Develop release methodology
    - Aerial/ground, plane/UAV, time of day
3. Determine overflooding ratios
    - Lab and field cage studies; Seasonal timing of releases
4. Run larger-scale field trials
    - Paired plots with and without releases; Dispersal studies
5. Integrate with Area-wide IPM
    - Determine best situations for use of irradiated moths

Long Term Research Plan

**SIT is not stand-alone,
exact role TBD by many other factors.**

THANK YOU!

Contact

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Acknowledgements

Chuck Burks (USDA-ARS, Parlier)
Greg Simmons (USDA-APHIS, Salinas)
Eoin Davis, Earl Andress, John Claus (USDA-APHIS, Phoenix)
Jessica Maccaro (UC Riverside, Kearney Ag. Center)

Funding

CA Pistachio Research Board

Collaborating Growers/PCAs

Jerred Berba, Stone Land Co.

Pheromonal and Related Attractants for Leaffooted Bug

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Sean Halloran[1], and Kent Daane[2]

[1] Dept. of Entomology, University of California, Riverside, CA 92521
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Known and suspected chemical signals used by LFB:

1. Alarm & defensive secretions (both sexes)

2. Summer-form, long-range aggregation pheromones (male only?)

3. Overwintering aggregation pheromones (both sexes?)

http://www.westernfarmpress.com/tree-nuts/almond-growers-urged-watch-leaffooted-bug

Summary of work to 2017:

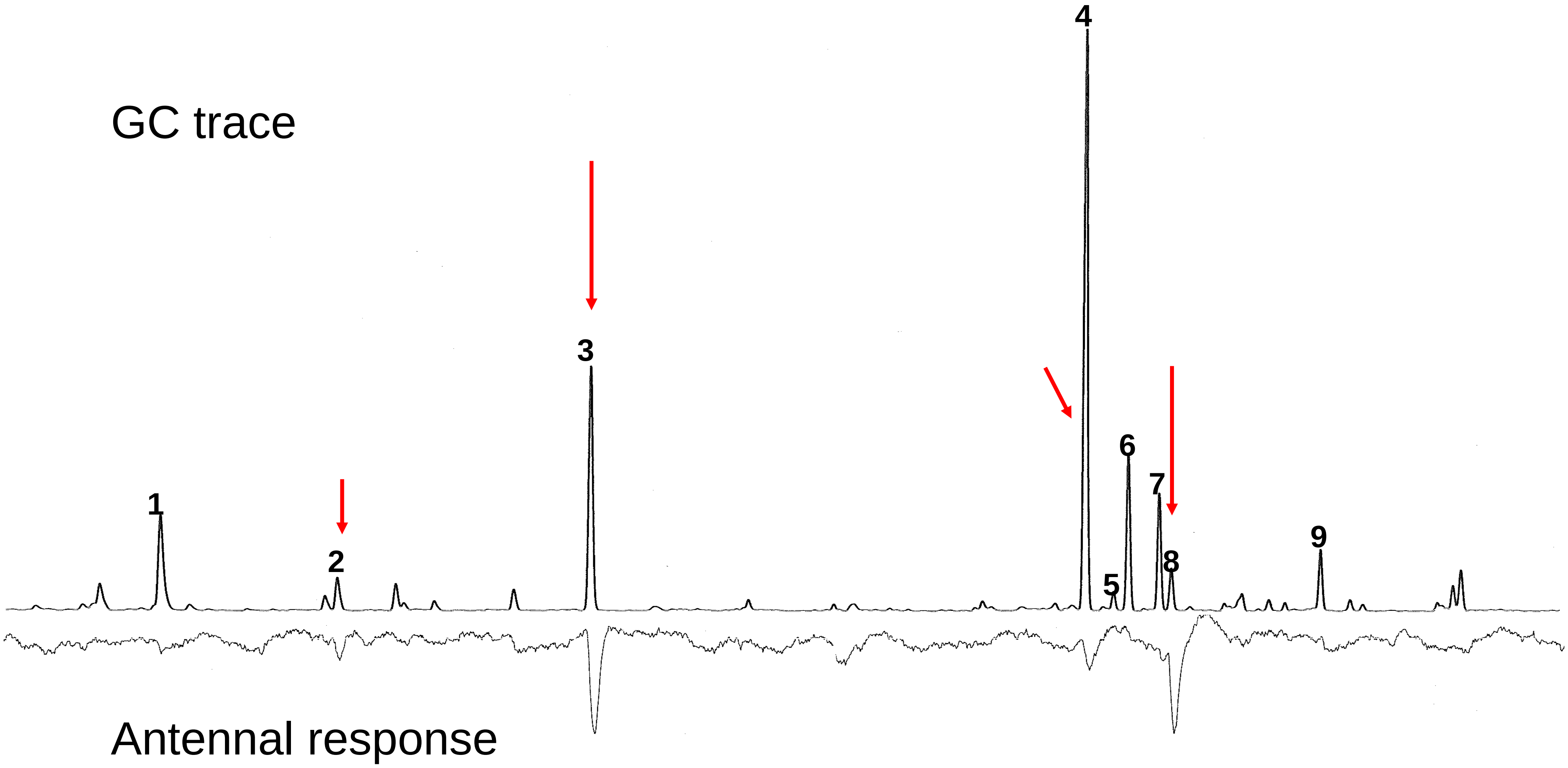
- Summerform LFB males attract, then court females.
- Summerform males produce sex-specific chemicals.
  - Sesquiterpene hydrocarbons, other compounds.
  - Some obtained from commercial sources, two synthesized.
- Field trials: indications of attraction to reconstructed blends.
- Hanging cross-vane panel traps identified as most effective traps.
- Trapping efficiency greatly improved by painting traps with Fluon®.
- Summer- and winterform adults have different profiles of cuticular hydrocarbons.
  - Winterform profiles may help to hold winter aggregations together.

Collection of *Leptoglossus zonatus* volatiles

- Collect odors from:
    - Male or Female
    - Sexually immature
    - Sexually mature unmated
    - Sexually mature mated
    - Individuals or groups

- Collect for 24 hours, then change collector

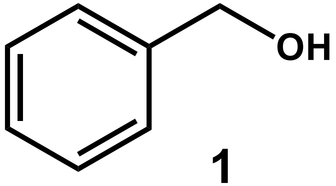
Coupled gas chromatography-electroantennography analysis of extract of summerform males, with female antenna



Compounds from summerform males:

- Only produced by summerform, sexually mature males.
- Produced by both mated and unmated males.
- Produced by single males and males in groups.

Chemicals identified in *L. zonatus* extracts



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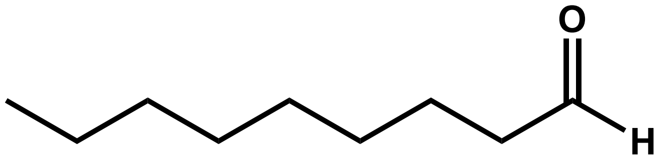

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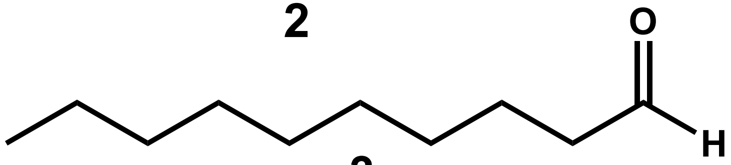

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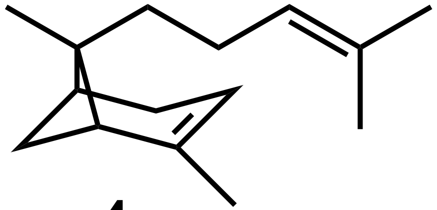

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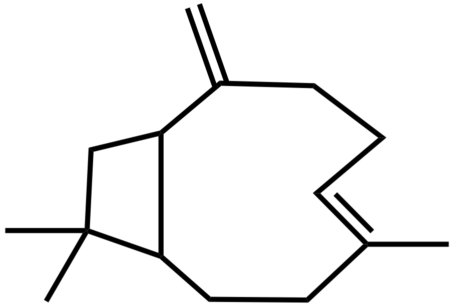

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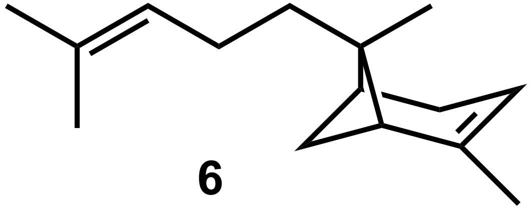

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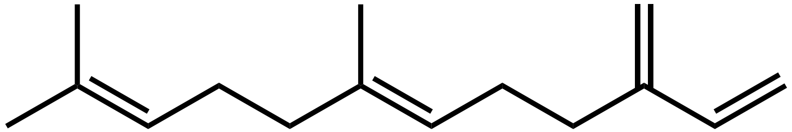
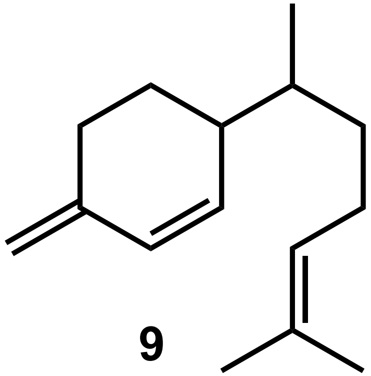


7

Compound 8
?



9

Work to isolate and identify active compound 8

- Combine 54 samples of volatiles collected from groups of summerform males over ~6 months
  - Fractionate by liquid chromatography
  - Isolate a few micrograms of compound 8 by preparative gas chromatography
    - Structure has three double bonds, two connected ring structures
  - Microbore NMR analyses
    - Narrow down to 6 possible structures
    - Synthesis of highest priority structure is in progress

Work with *L. clypealis*:

- Finally able to start small colony of *L. clypealis*.
- Preliminary results: Sexually mature summerform males produce similar blend of compounds as *L. zonatus*.
  - Both species have bioactive compound 8.

Field studies in 2018:

- Next talk by Houston Wilson

Ongoing work:

- Finish identification, synthesis, and bioassays of all male-specific compounds for *L. zonatus* and *L. clypealis*
  - Stockpiling volatiles from *L. zonatus* males for another isolation attempt.
  - More material = more and better spectra
- Field tests of possible host-related attractants
- Studies of LFB biology and ecology (Houston Wilson and Kent Daane)
- Testing of cuticular hydrocarbons of summerform and winterform adults.

Acknowledgements:

california almonds®

Almonds.com

ADMINISTRATIVE COMMITTEE *for* PISTACHIOS

LFB Pheromones and Related Attractants

Houston Wilson | Dept. Entomology, UC Riverside

Kent Daane | Dept. Enviro. Sci. Policy Management, UC Berkeley

Jocelyn Millar | Dept. Entomology, UC Riverside

california almonds®
Almond Board of California

LFB Pheromonal and Attractants Project

Project Goals and Objectives

Goals

- Develop a trap/lure system for LFB

Objectives

- Characterize + synthesize compounds
- Find a trap that works
- Evaluate compounds in field setting
- Work out trap density and arrangement
- Relate trap catch to populations/damage/timing etc.

Field Experiments in 2017

Finding a Trap that Works

Field Experiments – 2017

Comparing Trap Types

Pyramid
4-ft

Pyramid
2-ft

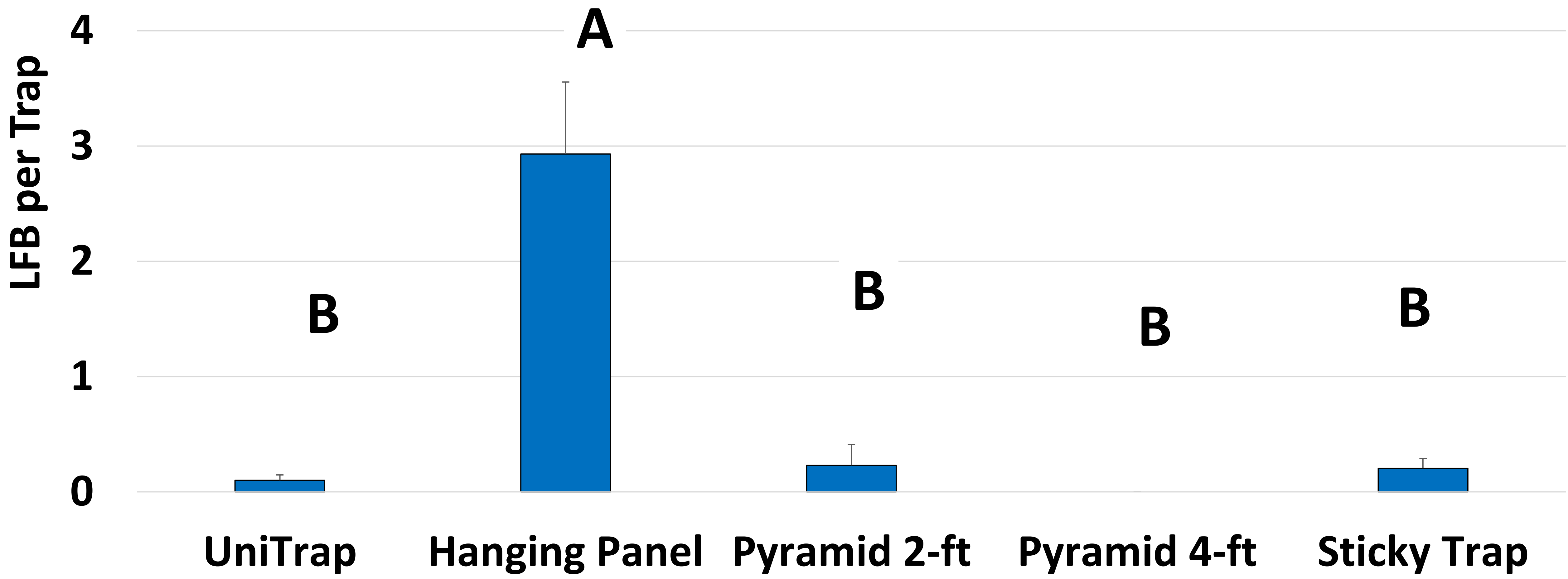
Sticky

Hanging
Panel

UniTrap

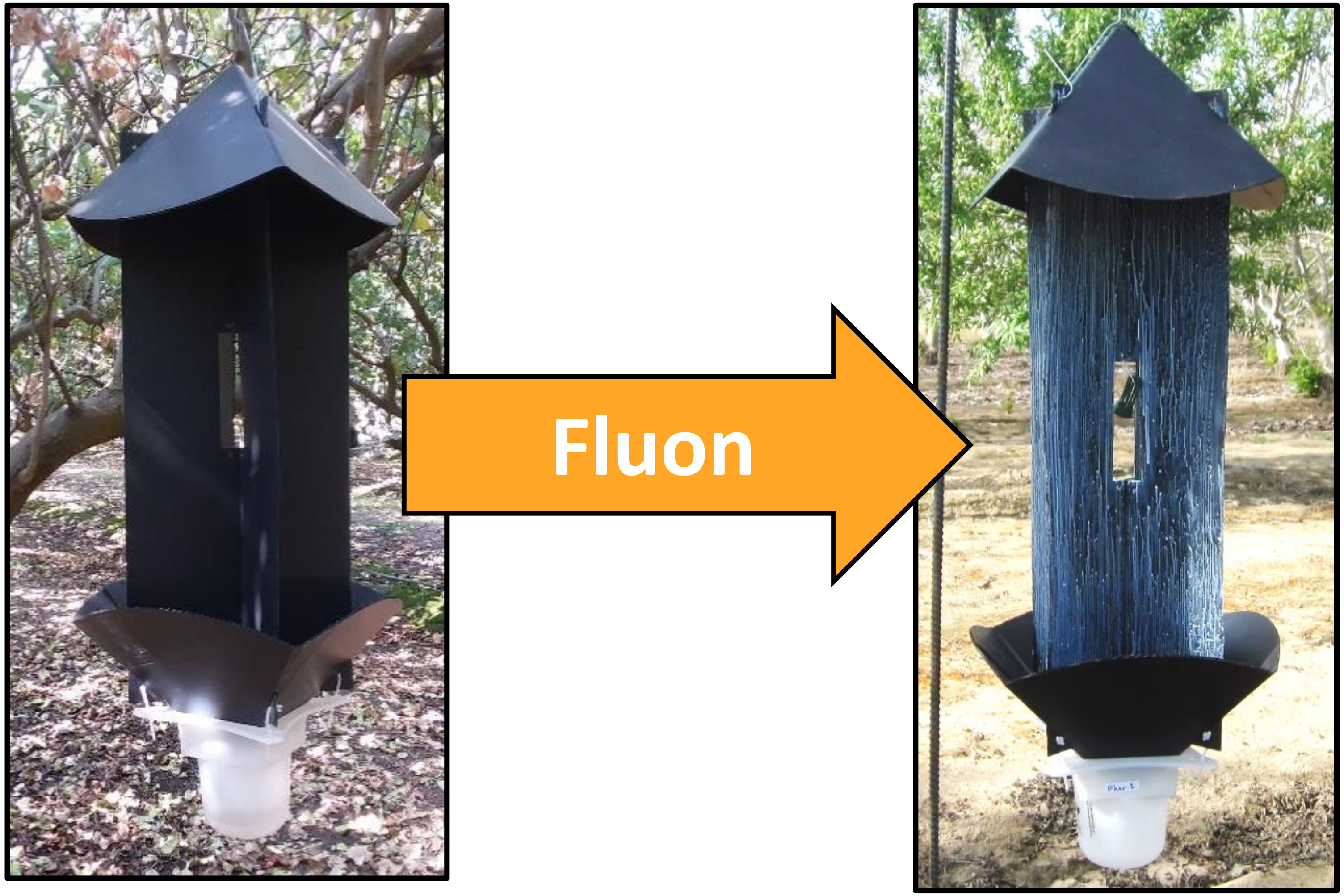
Field Experiments – 2017

Comparing Trap Types



Field Experiments – 2017

Fluon to Improve Trap Catch

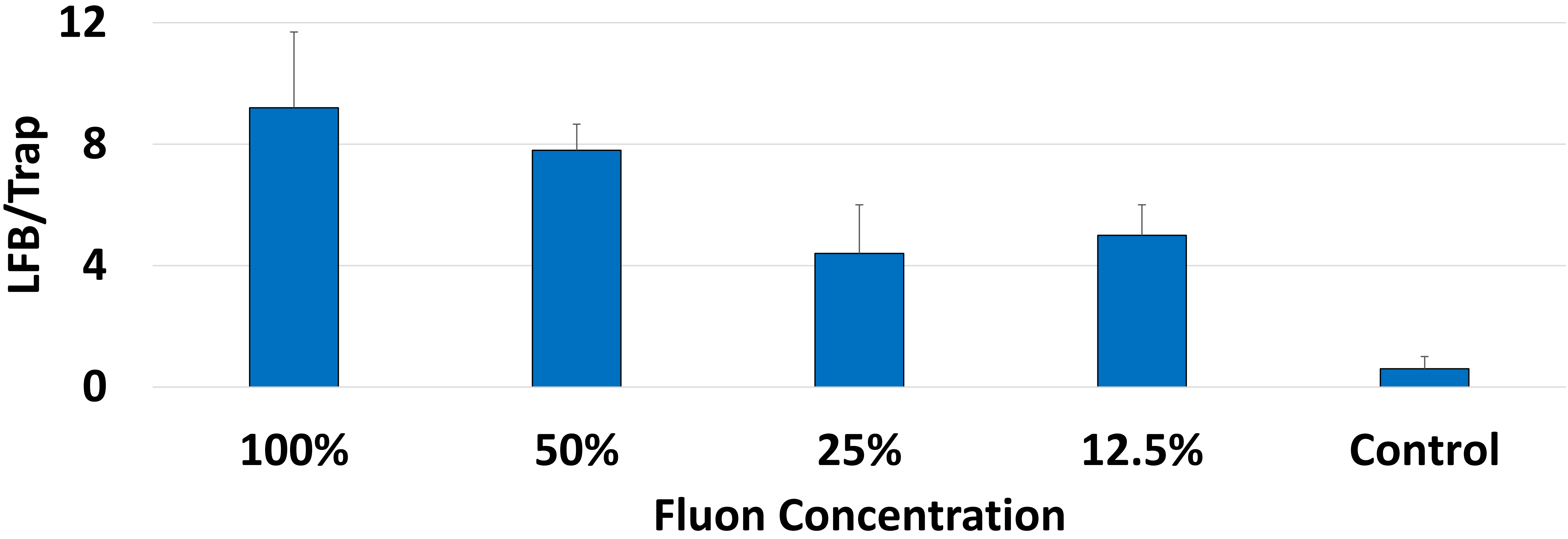


Setup:

- 1 site
- 4 dilutions x 5 reps
- Trap check 2x/month
- Nov. 13 – Dec. 4

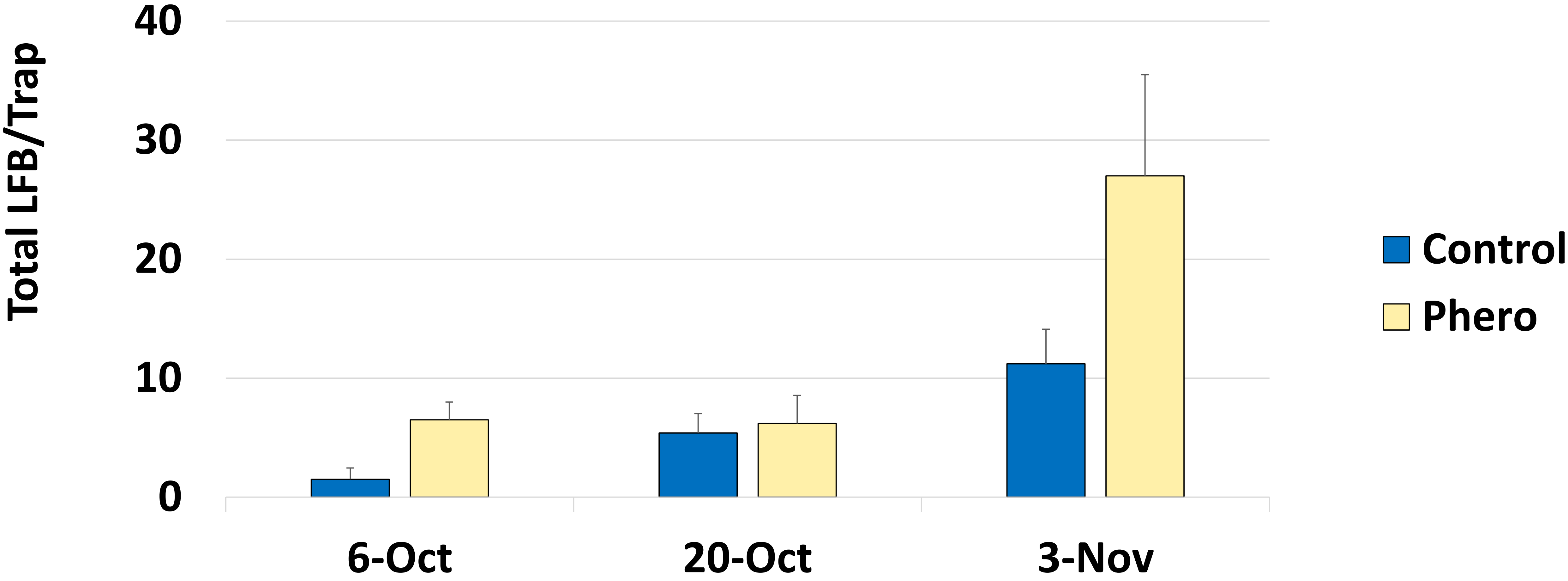
Field Experiments – 2017

Fluon to Improve Trap Catch



Field Experiments – 2017

Pheromone Evaluation



Field Experiments in 2018

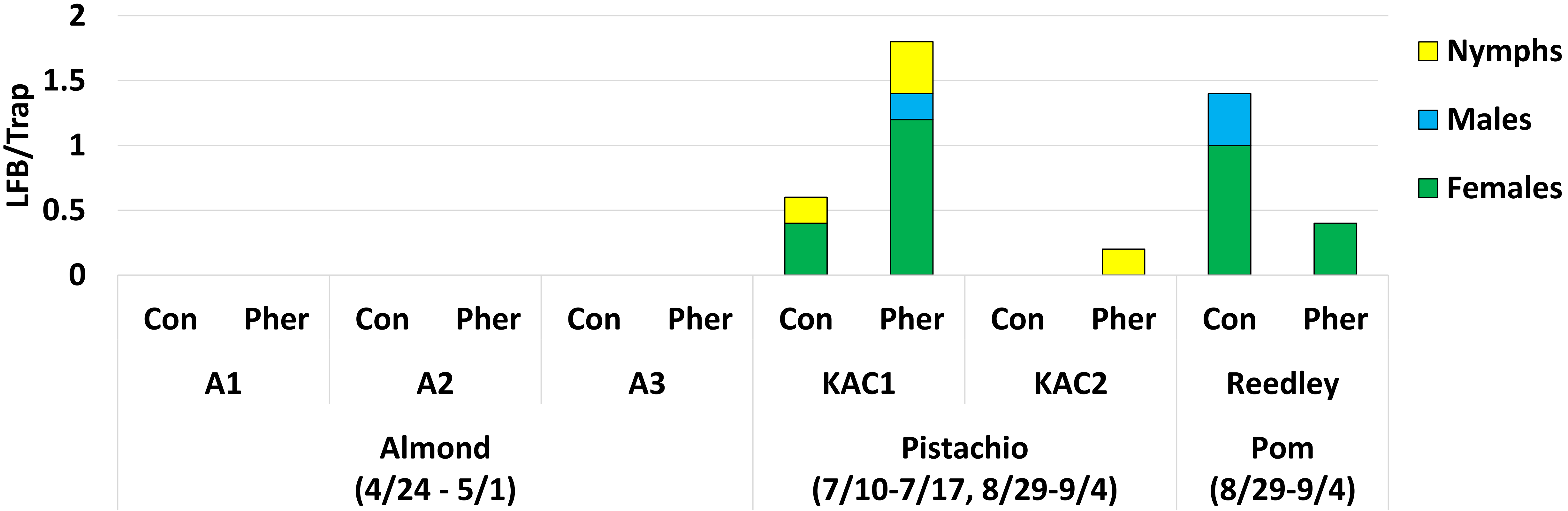
Finding a Lure for the Trap

Field Experiments – 2018

Summer-form Pheromones

Field Experiments – 2018

Summer-form Pheromones

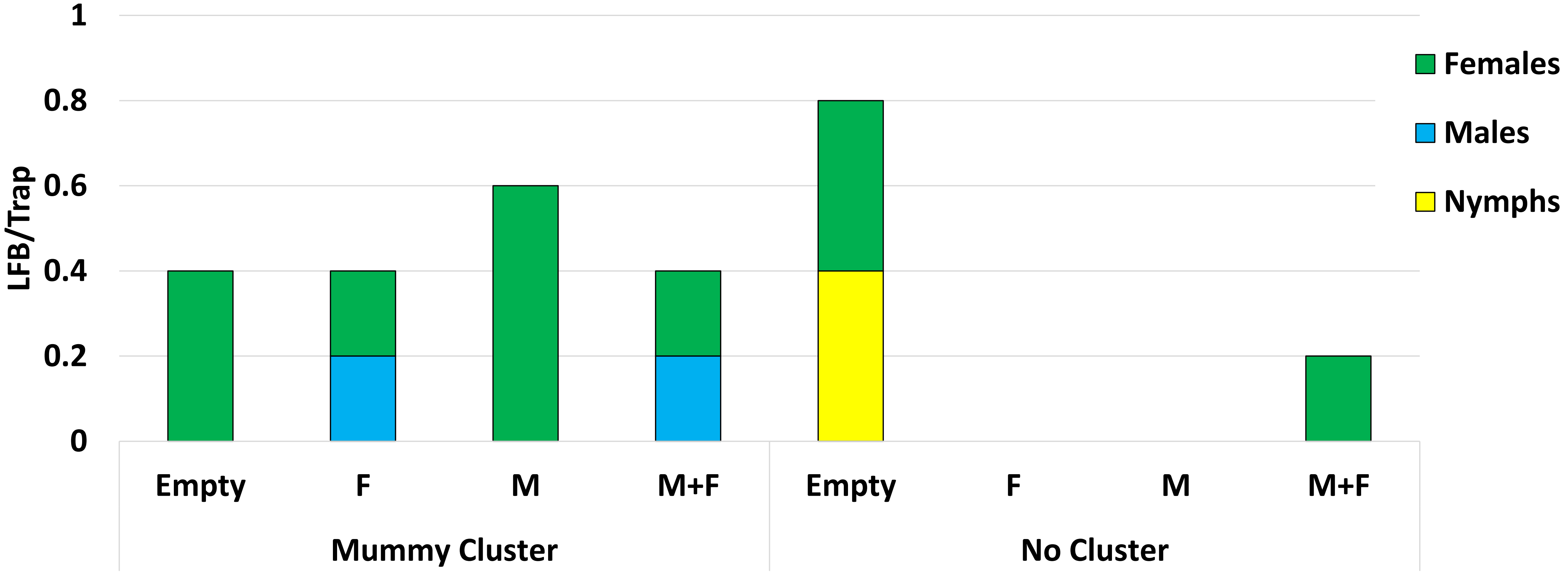


Field Experiments – 2018

Aggregations on Mummy Pistachio Clusters

Field Experiments – 2018

Attraction to Aggregations on Mummy Clusters



Field Experiments – 2018

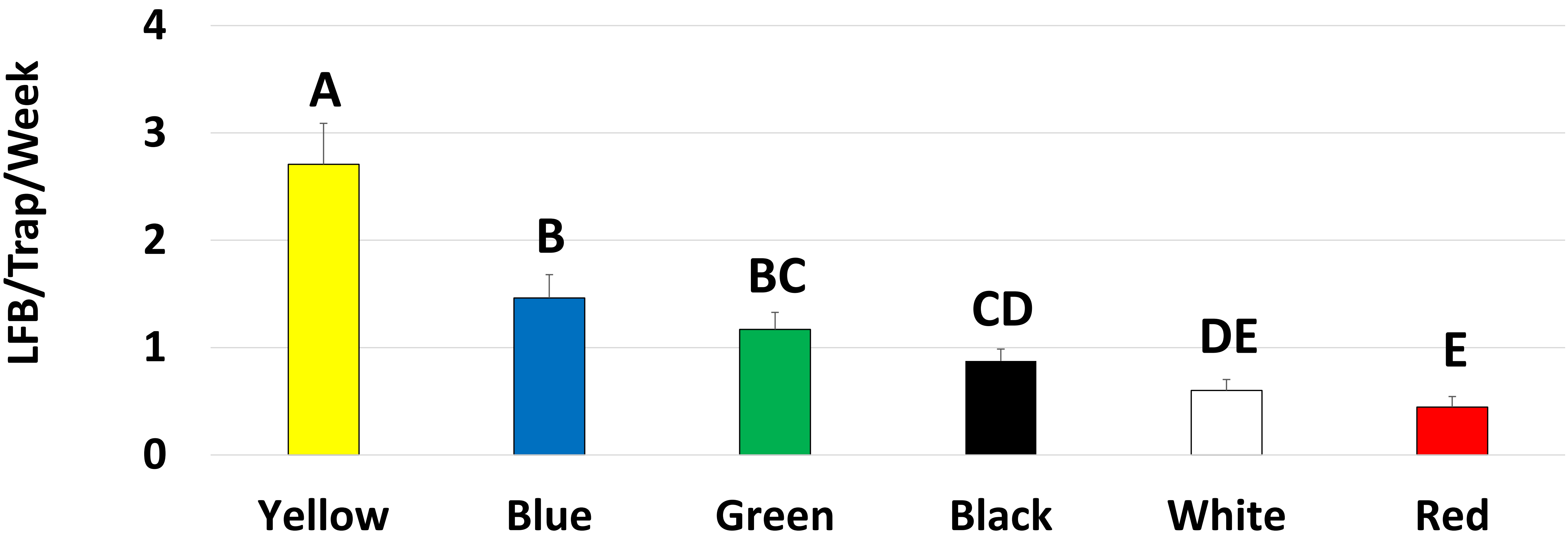
Trap Color

Setup

- Replicated completed block design – 5 replicates
- Pomegranates
- Aug. 22 – Nov. 20

Field Experiments – 2018

Trap Color



Field Experiments – 2018

Summary

Pheromones + Host-Plant Volatiles

- Some interesting finds, but overall mixed results

Trap Type

- Hanging panel-trap works
- Fluon improves catch
- Yellow was more attractive

2019?

Future Directions

Research in 2019

Synthesis of male summer-form pheromones

- Additional components to isolate and synthesize
- Explore alternate synthesis methods for known compounds

Field Bioassays

- Improve trap efficiency
- Evaluate novel or promising compounds

LFB Seasonal Ecology

- Overwintering site selection
- Dispersal between orchards

THANK YOU!

Contact

Houston Wilson – Houston.Wilson@UCR.edu

Acknowledgements

Jocelyn Millar (UC Riverside), Kent Daane (UC Berkeley),
Sean Halloran (UC Riverside),
Jessica Maccaro (UC Riverside, Kearney Ag. Center)

Funding

Almond Board CA
CA Pistachio Research Board

Collaborating Growers/PCAs

Matt Chase, Craig Wylie, Jerred Berba

UC RIVERSIDE
UNIVERSITY OF CALIFORNIA

Best Timing of Application and Efficacy of AF36 Prevail to Control Aflatoxin Contamination in Almond

Themis J. Michailides[1]

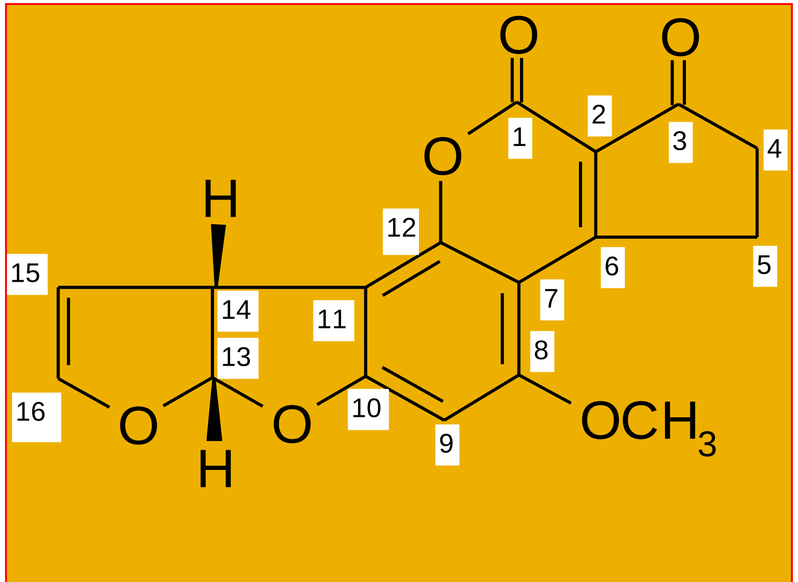
R. Jaime[1], J. Moral[2], T. Garcia-Lopez[2], D. Felts[1], and R. Puckett[1]

[1] Dept. of Plant Pathology, University of California Davis/ Kearney Agricultural Research & Extension Center;

[2] Universidad de Cordoba, Spain

Aspergillus flavus and *A. parasiticus* produce:

Aflatoxins B_1, B_2, G_1, G_2,



Aflatoxin B_1

B1 aflatoxin is the most potent & can cause liver cancer

***A. flavus* L-strain**

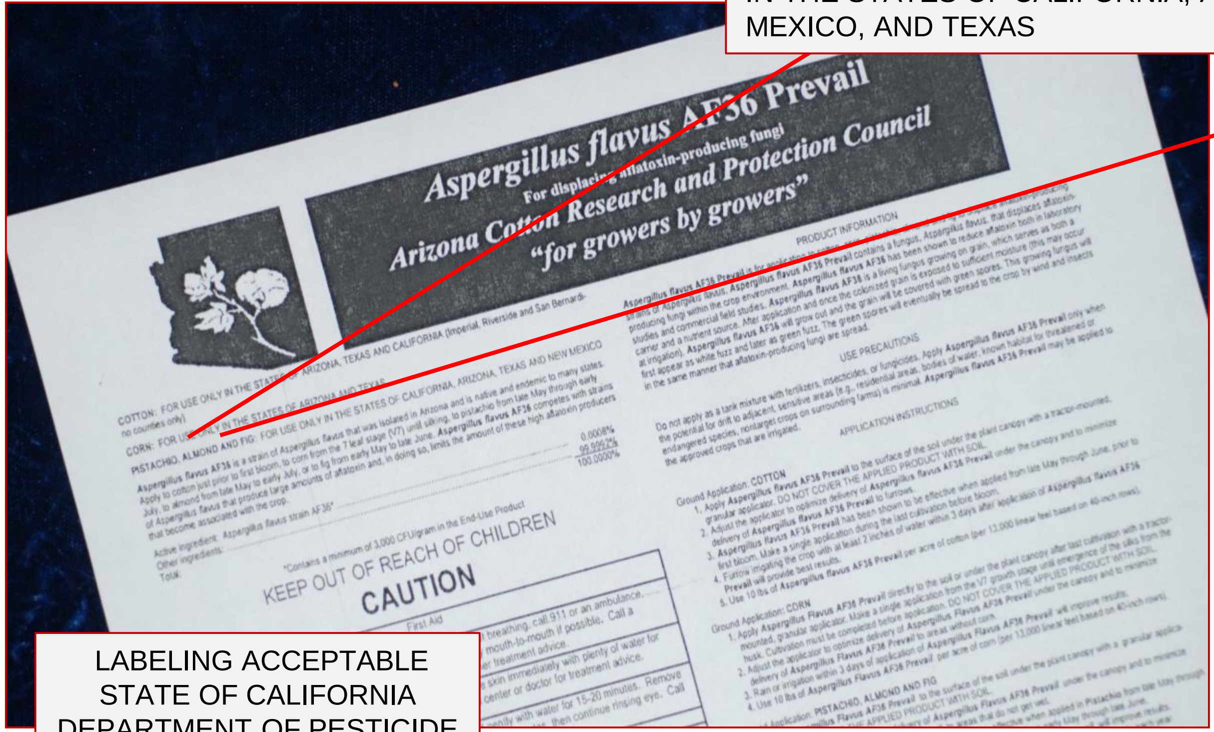
The almond industry has taken extensive measures and supports pre- and post-harvest research to control aflatoxins and to assure compliance with aflatoxin regulations.

Aspergillus flavus L strains: toxigenic and atoxigenic

A. *flavus* L-strain

One L-strain, the AF36 atoxigenic strain was selected and registered for use in almond (2017)

PISTACHIO, ALMOND, AND FIG: FOR USE ONLY IN THE STATES OF CALIFORNIA, ARIZONA, NEW MEXICO, AND TEXAS



Aspergillus flavus AF36 Prevail

For displacing aflatoxin-producing fungi

Arizona Cotton Research and Protection Council

“for growers by growers”

PRODUCT INFORMATION

USE PRECAUTIONS

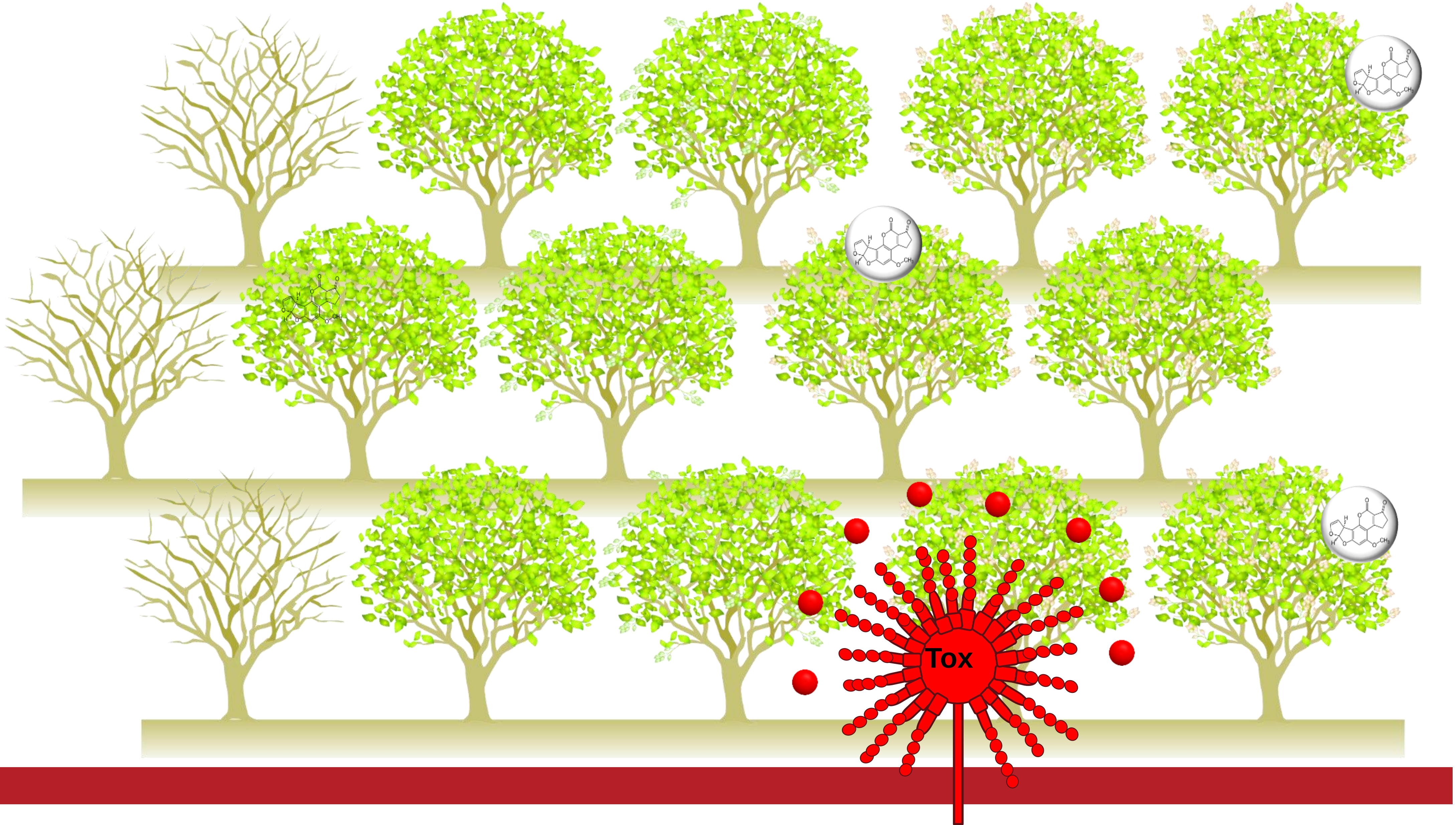
APPLICATION INSTRUCTIONS

KEEP OUT OF REACH OF CHILDREN

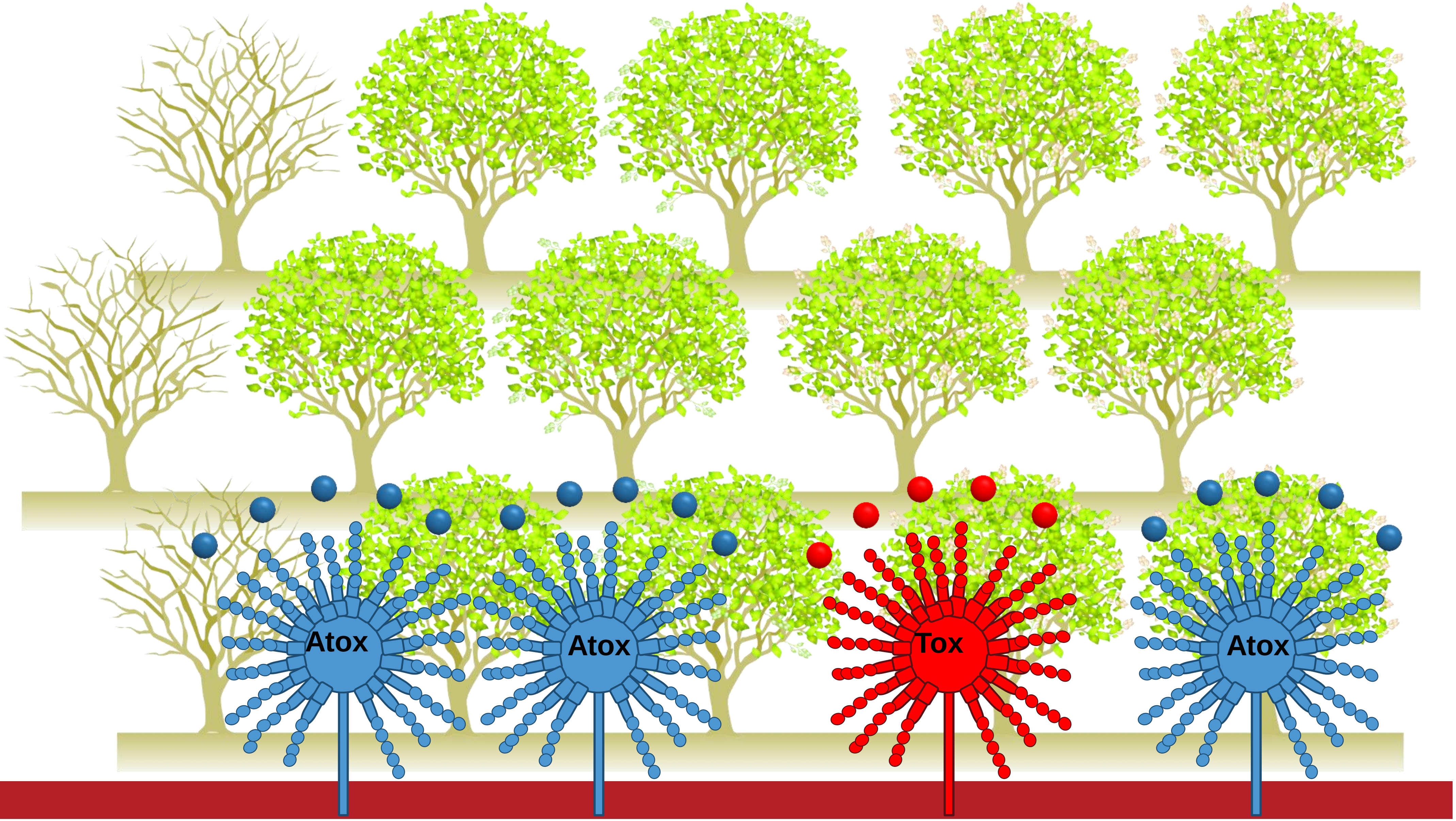
CAUTION

LABELING ACCEPTABLE
STATE OF CALIFORNIA
DEPARTMENT OF PESTICIDE REGULATION
Date: **08/07/2017**
Reg. No. 71693-2-AA

Not treated orchard



Treated Orchard with AF36 Prevail



Objectives:

- **We focused in four objectives in 2018:**
  1. To determine the optimal time for applying the AF36 Prevail biopesticide in the almond orchards.
  2. To study the risk of infection of almond fruit by *A. flavus* while on the ground (during drying).
  3. Efficacy of AF36 Prevail in commercial almond orchards (in progress)
  4. To monitor AF36 strain in almond orchards using a qPCR technique.

Objective 1: Timing of application in a commercial orchard (2018):

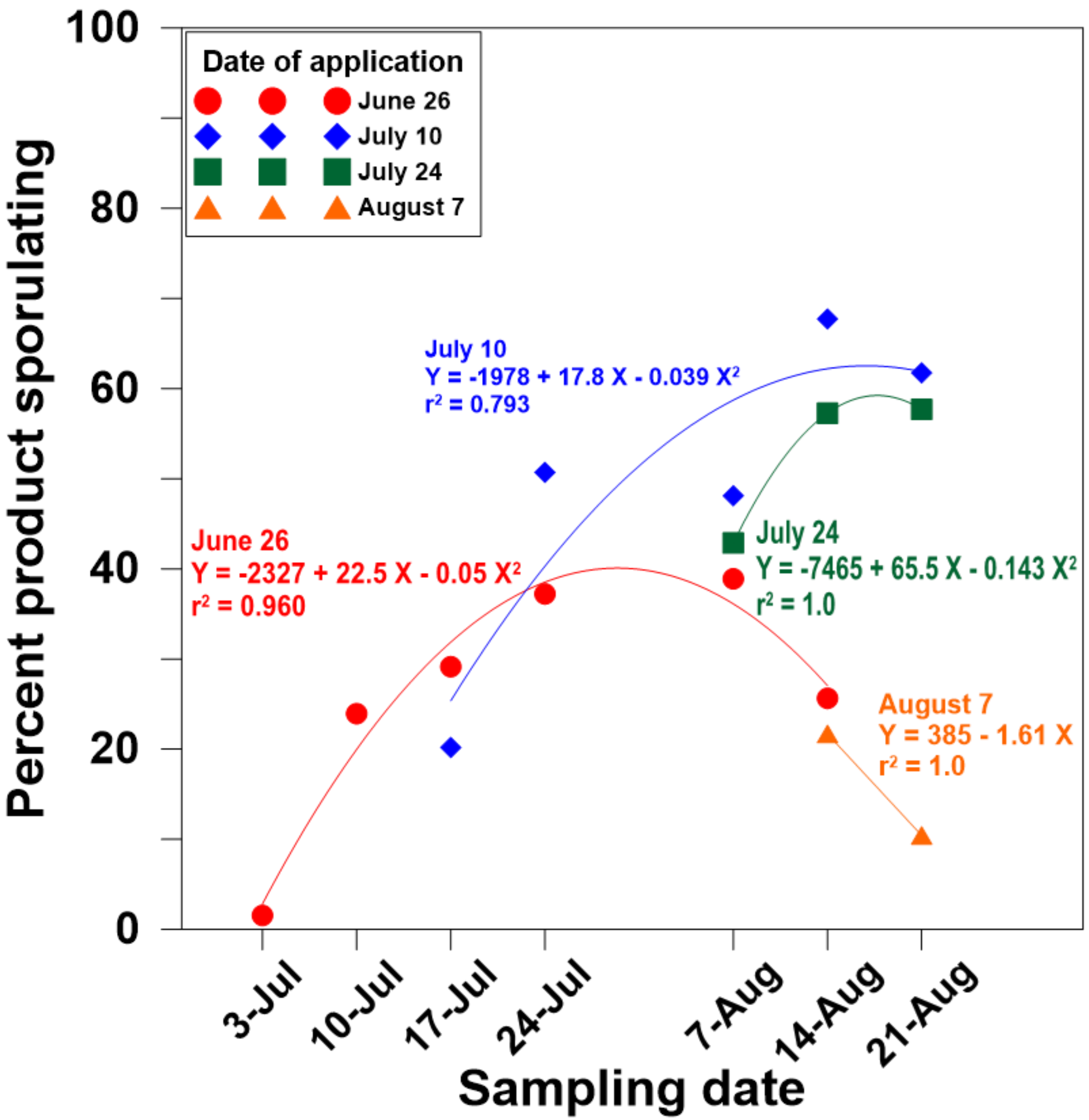
AF36 Prevail at different times of application in Almond

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Dates of application of
AF36 Prevail in Almond

1: 26 June
2: 10 July
3: 24 July
4: 7 August
5: --- (None)

Results of experiment for the best application time:



- **Conclusion:** The most sporulation occurred with the **application on 10 July**.

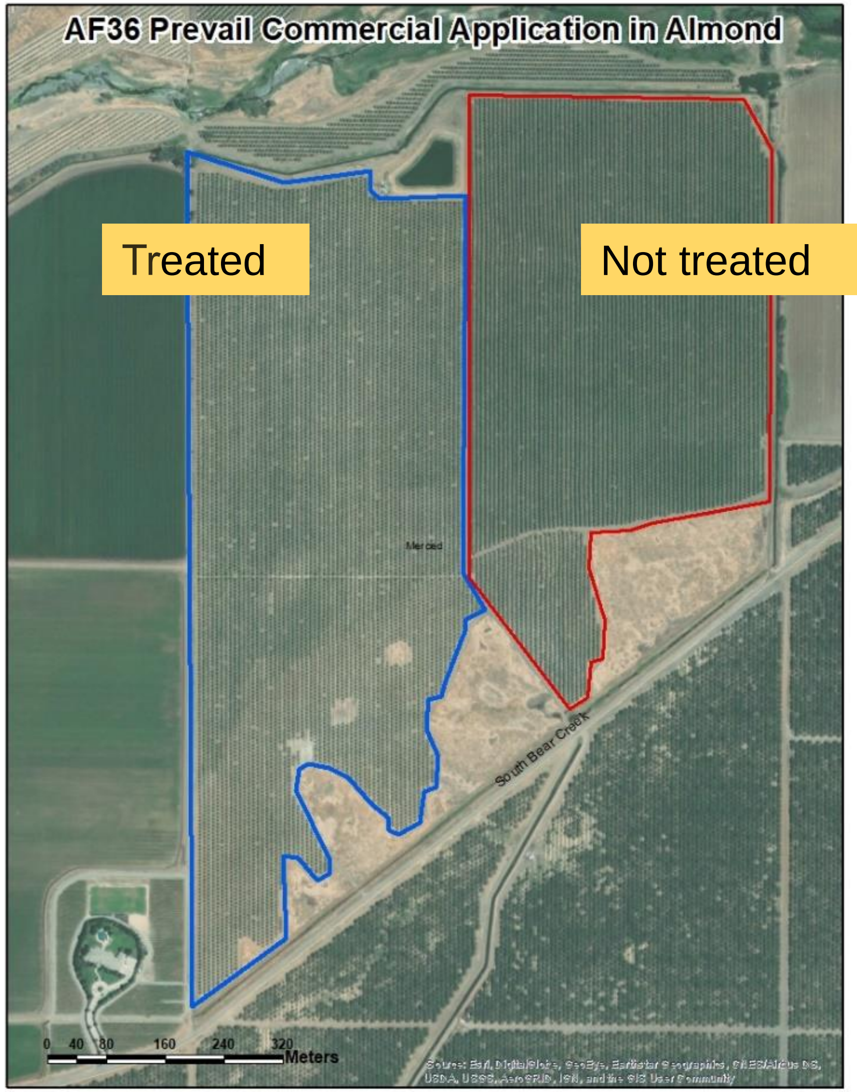
Objective 2: Infection of almond fruit by *A. flavus* while on the ground (during drying).

Samples contaminated with B_1 aflatoxins (%)

Treatment	Wet	Dry	Mean
Non inoculated	70.6	37.5	54.6
Inoculated	47.5	25.0	34.4
	B_1 > 10 ppb		
Non-inoculated	29.4	18.7	24.2
Inoculated	6.2	0.0	3.1

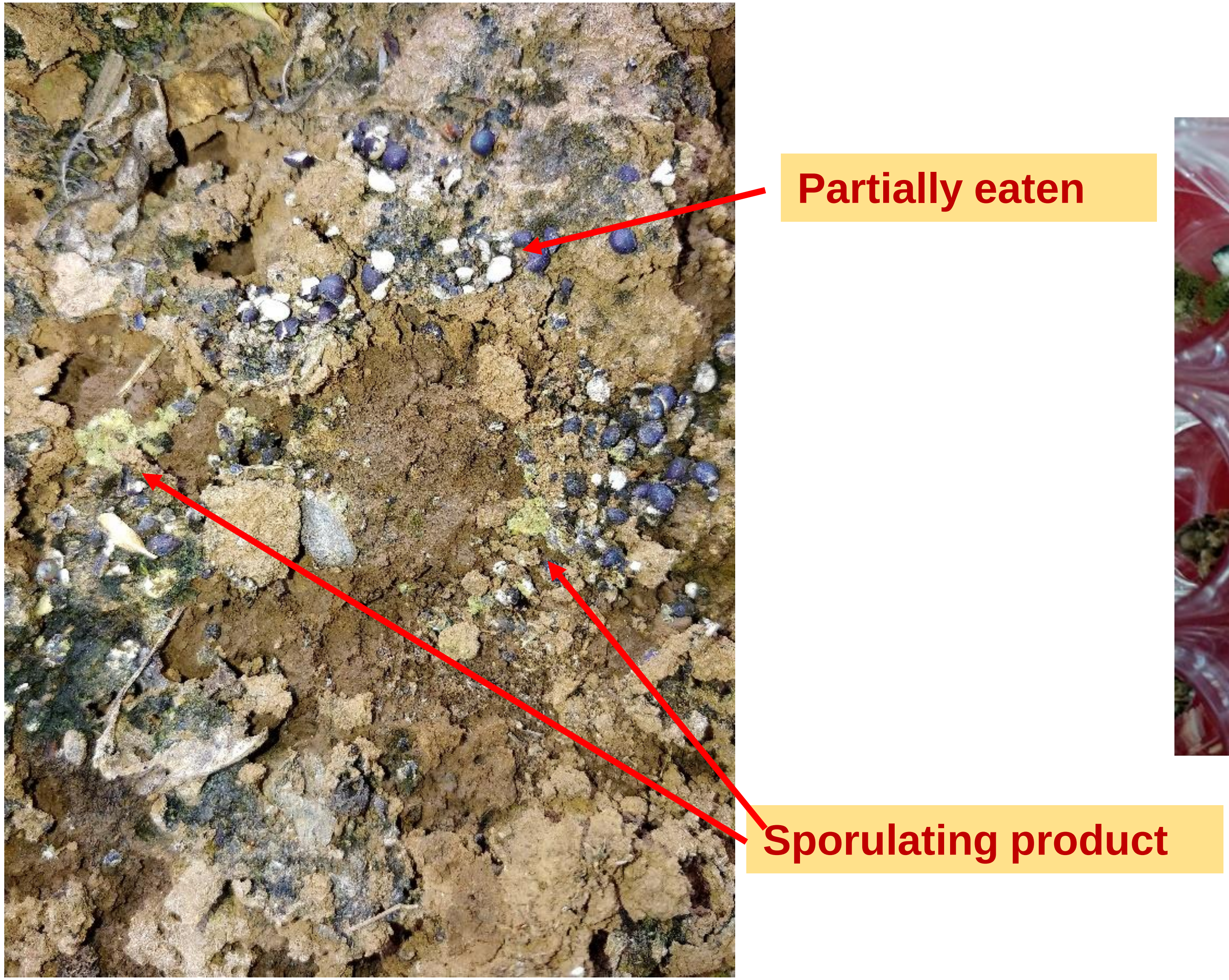
Conclusion: Even after inoculation with a highly-toxigenic *Aspergillus flavus,* the incidence of infection did not increase.

Objective 3: Efficacy of AF36 Prevail in a commercial almond orchard (Merced Co.) – In progress



Rate of biopesticide:
10 lbs/acre

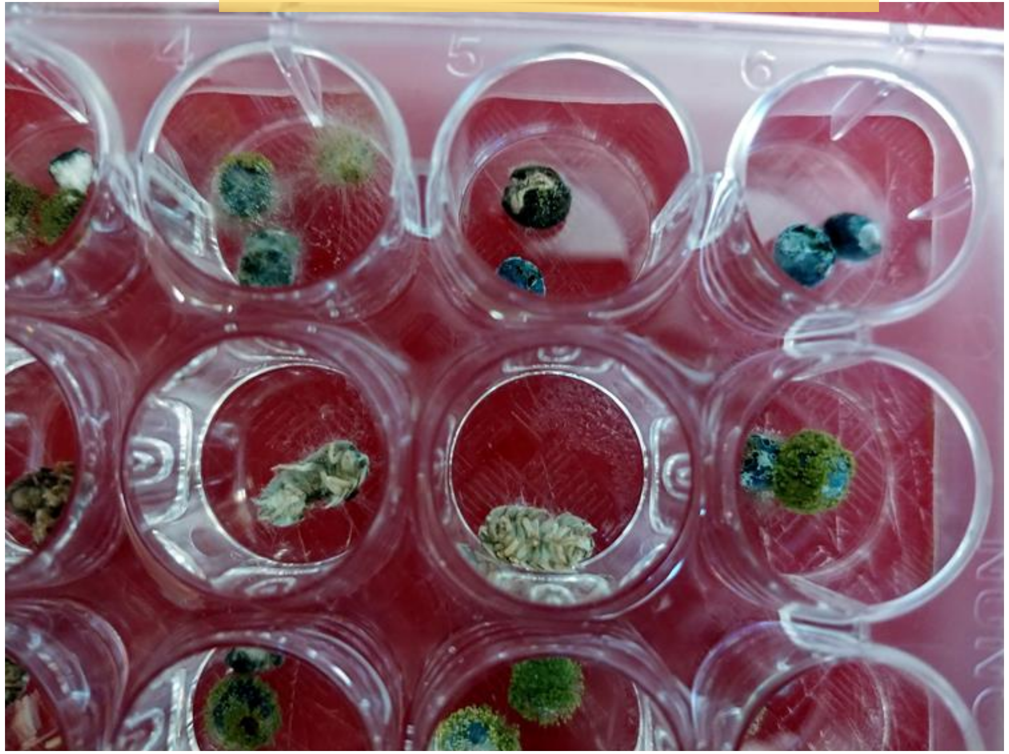
Sporulation of AF36 Prevail and challenges in a commercial orchard



Partially eaten

Sporulating product

Partially eaten product after 4 days of incubation



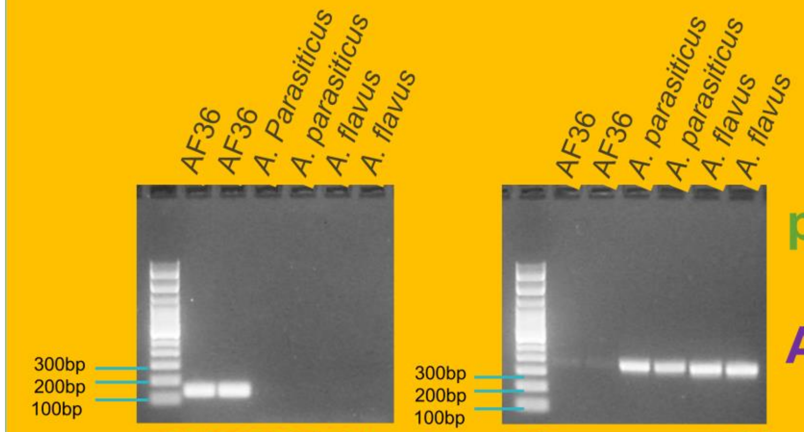
Samples were collected and will be analyzed for aflatoxins.

Objective 4: To monitor the atoxigenic AF36 strain in almond orchards where the AF36 product will be applied using a quick & efficient assay

SNP – qPCR Assay

1. Primer design

Differential amplification of PCR products of *A. flavus* AF36, and *A. flavus* or *A. parasiticus*



SNP36 Sh2/ SNP36 Cb

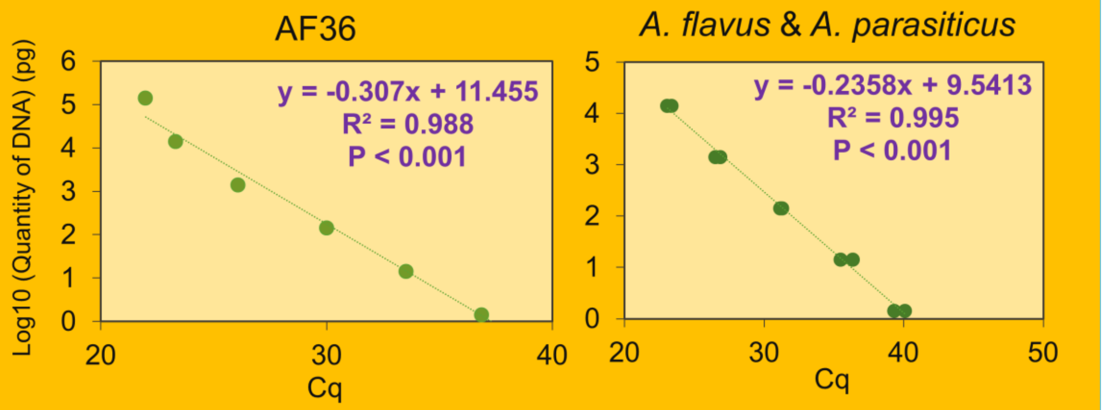
3-Fw-no mut B/ 8-Rv-no mut-267

Single nucleotide polymorphism

Aflatoxin gene cluster

2. Calibration

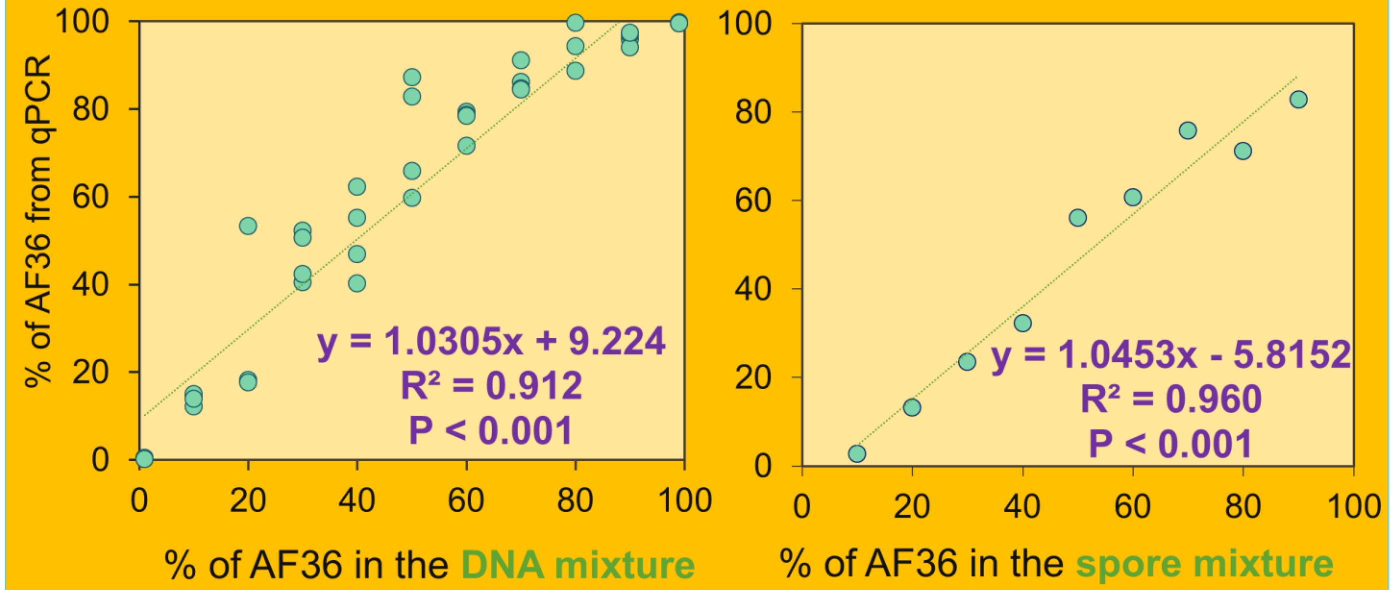
Standard Curves



Quantifying DNA from *A. flavus* AF36 vs DNA from both toxigenic or atoxigenic *A. flavus* or *A. parasiticus* to calculate the ratio *A. flavus* AF36/*A. flavus* + *A. parasiticus*

Objective 4: To monitor the atoxigenic AF36 strain in almond orchards where the AF36 product will be applied using a quick & efficient assay

3. Verification



Relationship between known proportions of AF36 from both mixed DNA and mixed spores and proportions obtained by qPCR

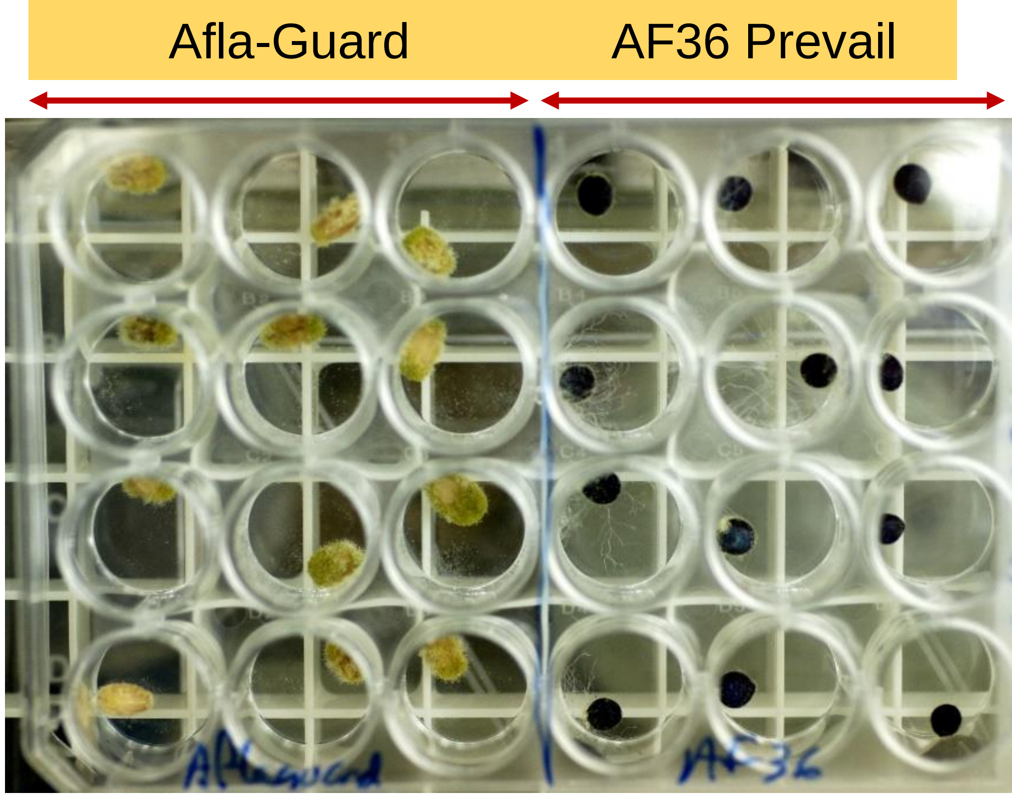
SNP – qPCR Assay

Conclusion: We now have a reliable technique which will cut time and costs in quantifying *A. flavus* AF36 in orchard samples.

Conclusions and Future Studies

- We verified that the optimum time for the best sporulation by the AF36 Prevail is in mid-July.
- Almond nuts on the orchard floor are not at risk for increased aflatoxin contamination.
- This SNP-qPCR assay is being validated and be used to efficiently and less costly quantify AF36 in commercial orchards after application of AF36 Prevail.

Prospects:
A new product is being tested: **Afla-Guard** (a.i. *Aspergillus flavus* NRRL21882 strain).



For details, please visit Poster #37 (**18.AFLA1 Michailides**)

Etiology and Management of Almond Trunk and Scaffold Canker Diseases

Leslie Holland and Florent Trouillas

Fruit & Nut Crop Pathology
UC Davis - Department of Plant Pathology
Kearney Agricultural Research and Extension Center

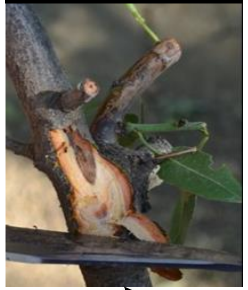
california almonds
Almond Board of California

What are canker diseases?

What is the incidence of almond canker diseases in CA?

Eutypa canker

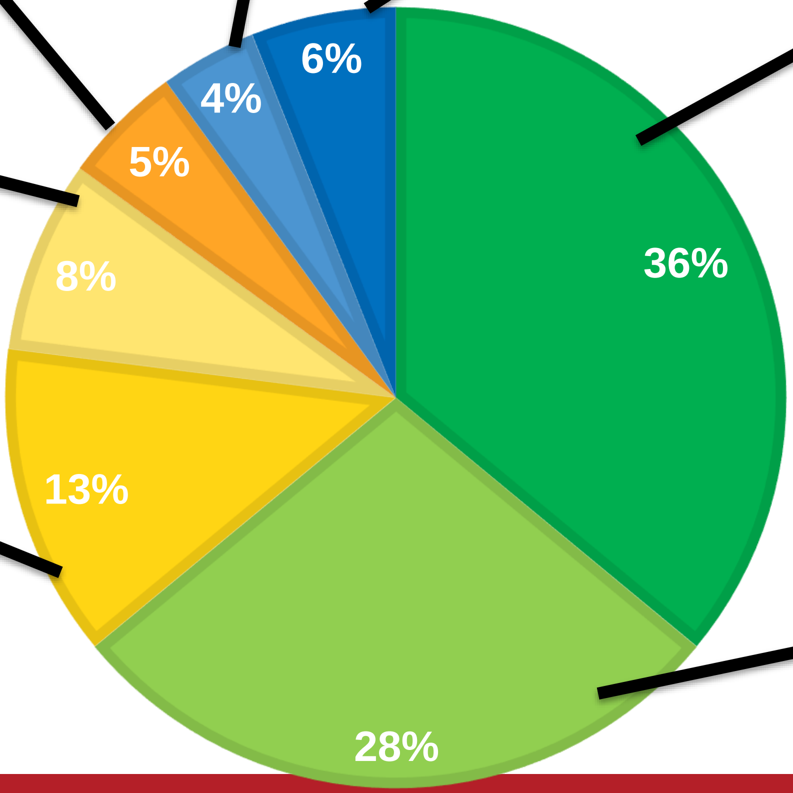
Diaporthe



Collophorina

Phytophthora

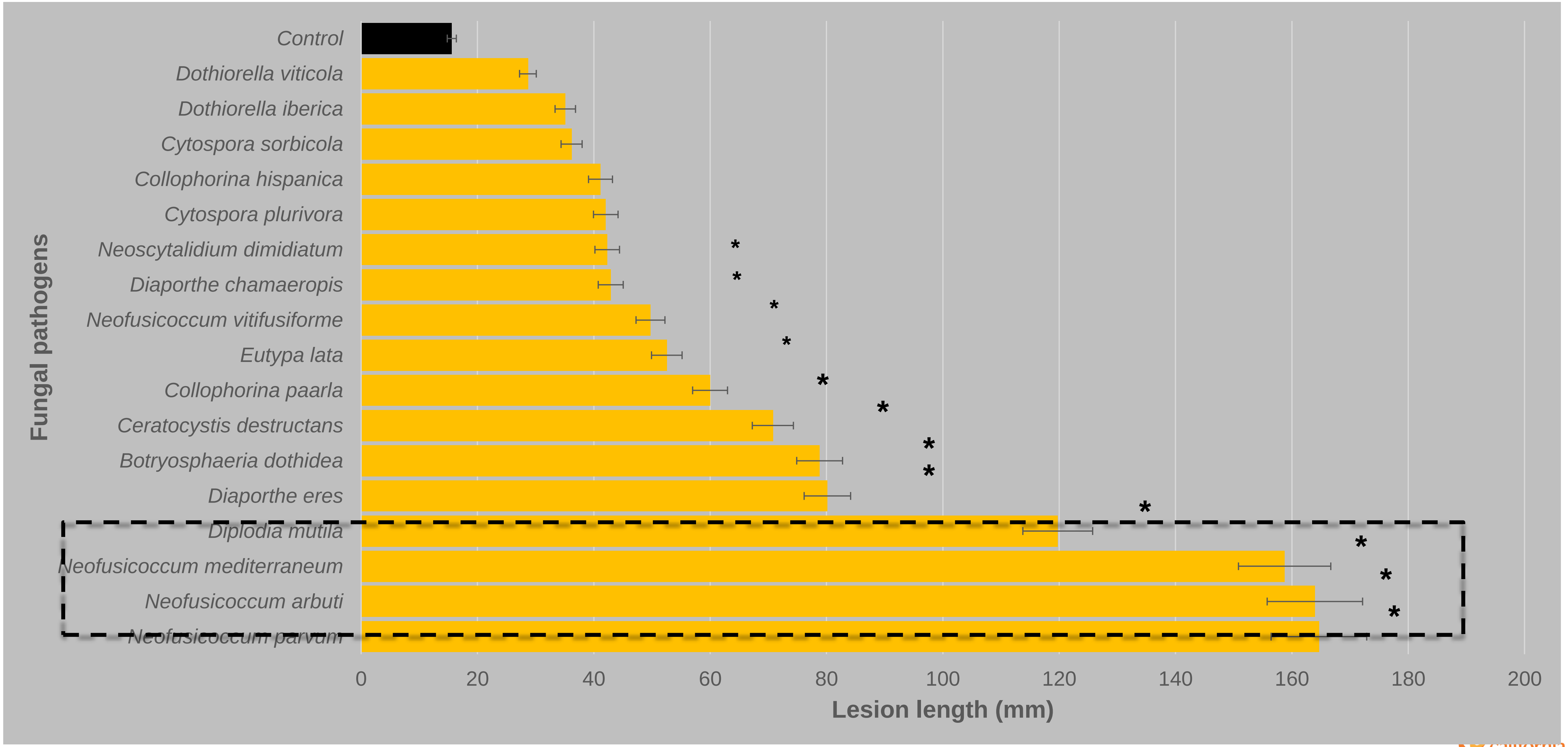
Botryosphaeria 'band' canker



Cytospora canker

Ceratocystis canker

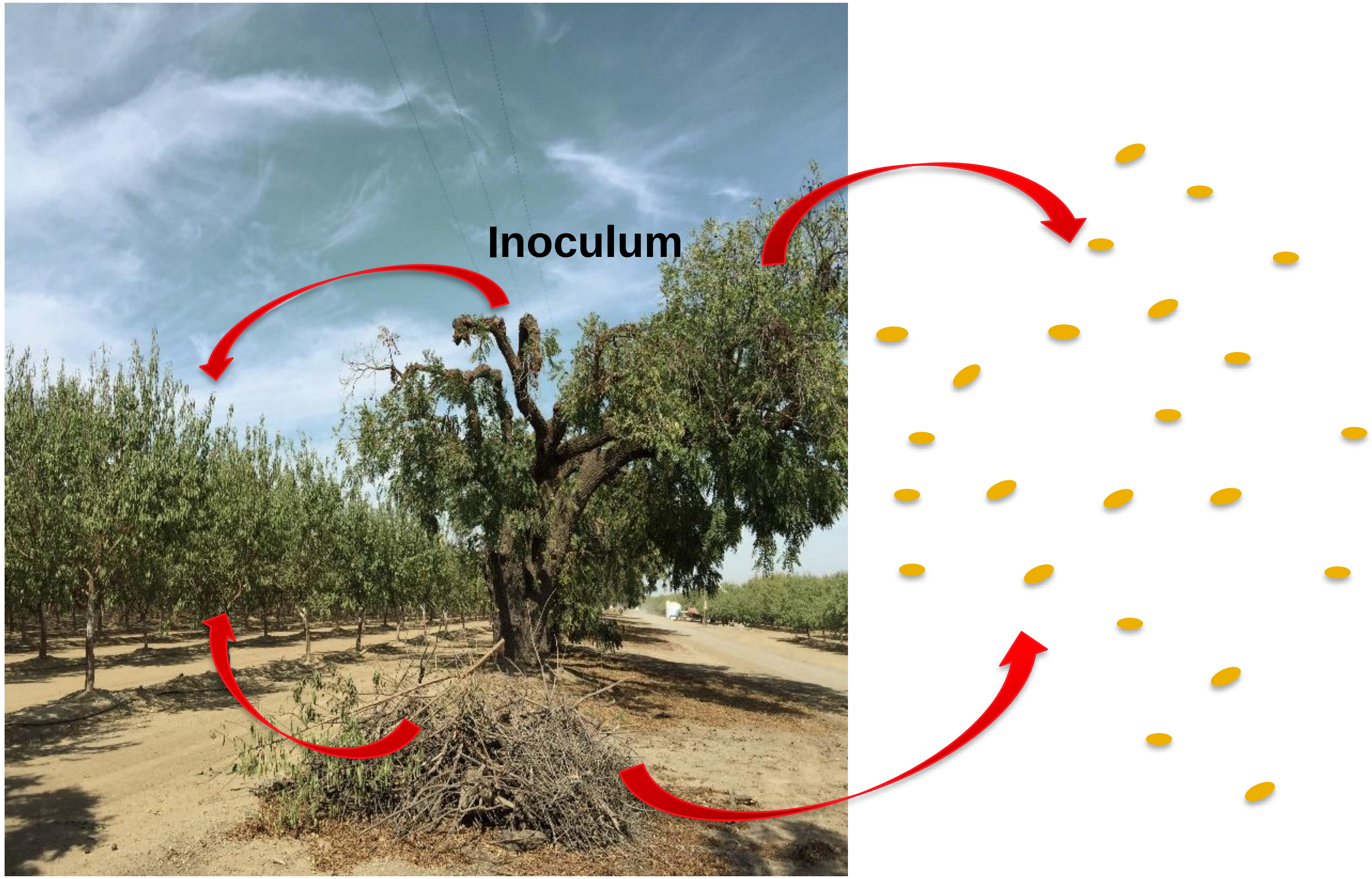
What pathogens should we be most concerned about?



Almond Board of California

How do the pathogens spread and infect trees?

Infections occur at wounds caused by cultural practices



Rainy season coincides with pruning of almond during dormancy

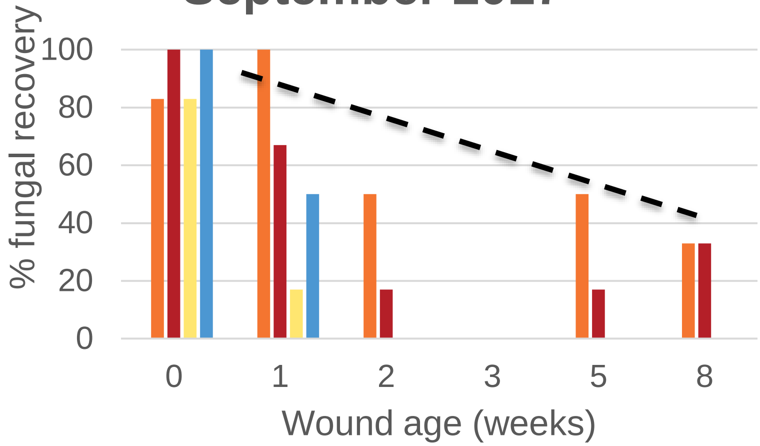
Scaffold selection

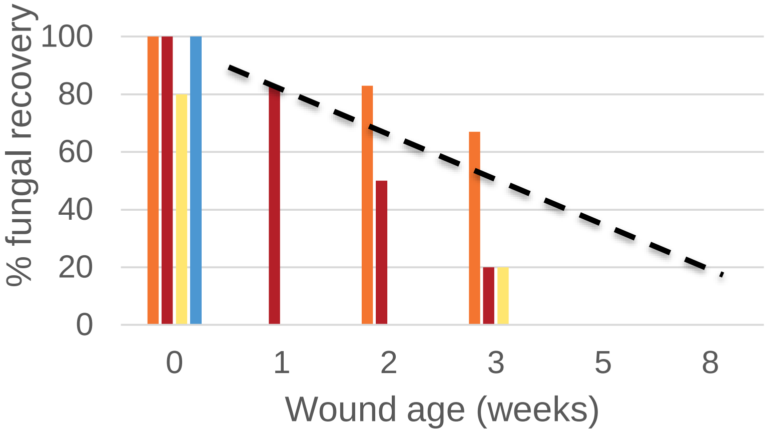
Mechanical harvest

Maintenance pruning

When is the best time to prune to avoid infection?

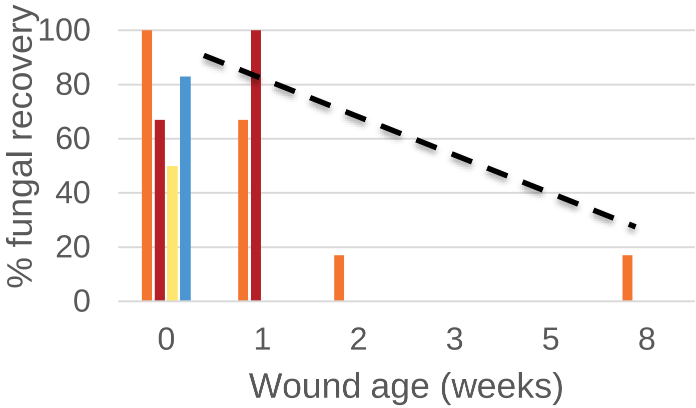
Year 1, Trial 1

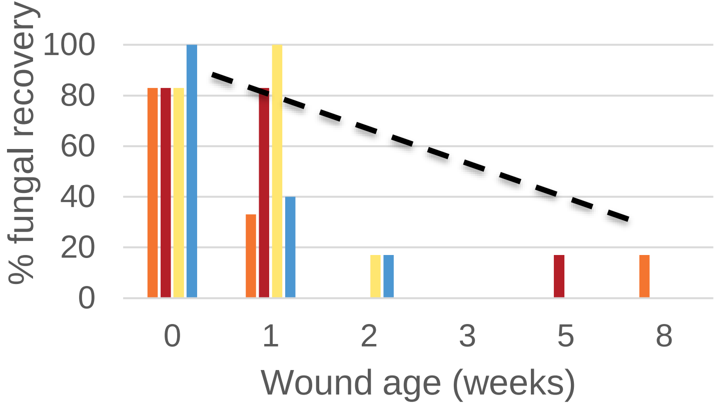

September 2017

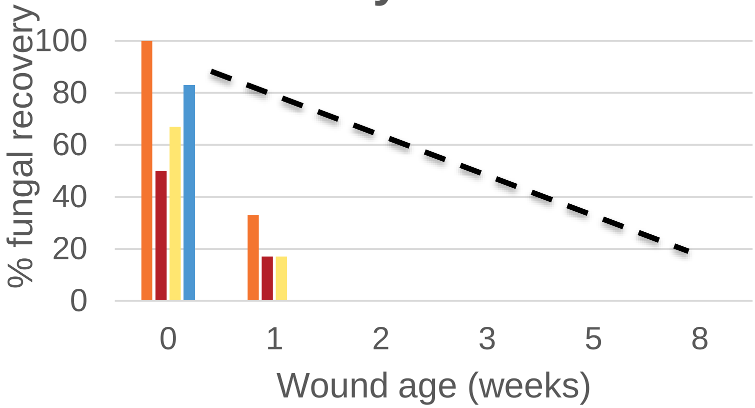

October 2017

Key:

- 🟧 *Eutypa*
- 🟥 *Neof. parvum*
- 🟨 *Bot. dothidea*
- 🟦 *Neoscytalidium*


November 2017


December 2017


January 2018

How do we protect pruning wounds?

Year 2, Trial 2

	Eutypa	*Cytospora*	*B. dothidea*	*N. parvum*	Avg. recovery (%)
Control (water)	67	83	100	67	**79**
Topsin M	17	**0**	17	17	**13**
Rally	67	67	**0**	**0**	**34**
Quadris Top	50	83	**0**	**0**	**33**
Inspire Super	67	67	**0**	50	**46**
Quilt Xcel	33	17	**0**	**0**	**13**
Luna Experience	67	50	**0**	**0**	**29**
Merivon	**0**	33	**0**	17	**13**
Quash	33	50	**0**	**0**	**21**
Luna Sensation	100	17	**0**	20	**34**
***Trichoderma* spp.**	17	**0**	**0**	17	**9**
***Trichoderma* sp. (0.5 g/L)**	**0**	**0**	**0**	**0**	**0**
***Trichoderma* sp. (5.0 g/L)**	**0**	**0**	**0**	**0**	**0**
***Trichoderma* sp. (50 g/L)**	**0**	**0**	**0**	**0**	**0**
Acrylic paint	50	67	**0**	**0**	**29**
Sealant (polymer)	100	83	50	100	**83**

Product performance

- ⬛ High
- ▦ Good
- ░ Moderate
- ☐ Limited

✓ Topsin M , *Trichoderma sp.*, Quilt Xcel, Merivon

The take home…….

Who? Where? When? What?

Bottom line

- ✓ As pruning wound age increased susceptibility to canker pathogens decreased – 2 weeks!!
- ✓ Fresh pruning wounds are most susceptible to infection
- ✓ Variation among the different fungal pathogens
- ✓ *Trichoderma* biocontrol products provided excellent pruning wound protection
- ✓ Top-performing fungicides included: **Topsin M**, **Quilt Xcel**, and **Merivon**
- ✓ Acrylic paint provided a physical barrier against some pathogens, but needs further investigation

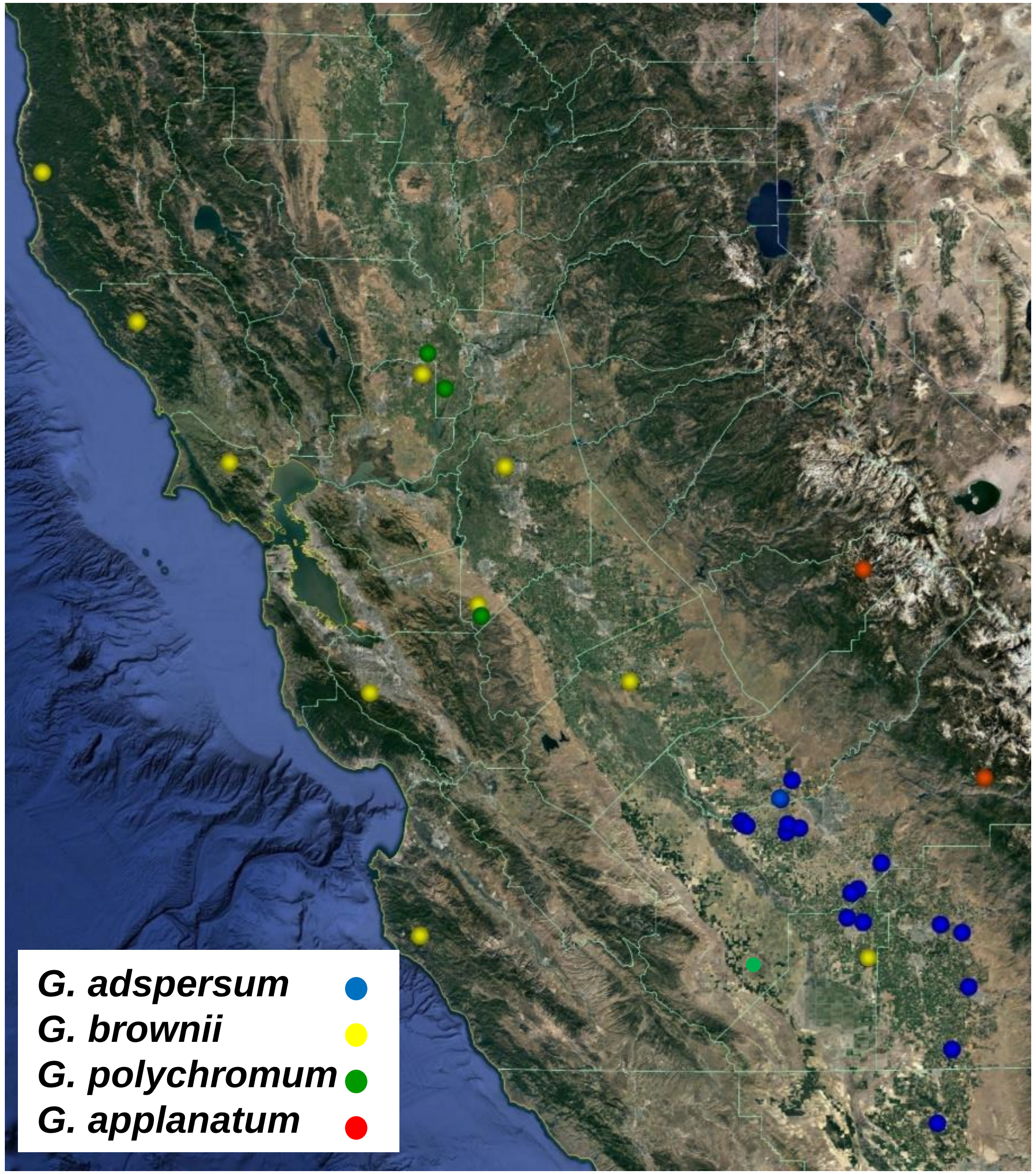
Ganoderma Root and Butt Rot

Bob Johnson and Dave Rizzo

Almond Board of California

What We Know

- Three *Ganoderma* species identified in almond orchards
- *Ganoderma adspersum* can half the lifespan of an orchard
- *Ganoderma* infections require wounding
- Decay is most significant below the soil line
- Nemaguard rootstock most affected
- Wood decay rates varied between *Ganoderma* species and rootstock variety
- Spores are the main source of inoculum
- Potential to survive on course woody debris



What We Know

- Three *Ganoderma* species identified in almond orchards
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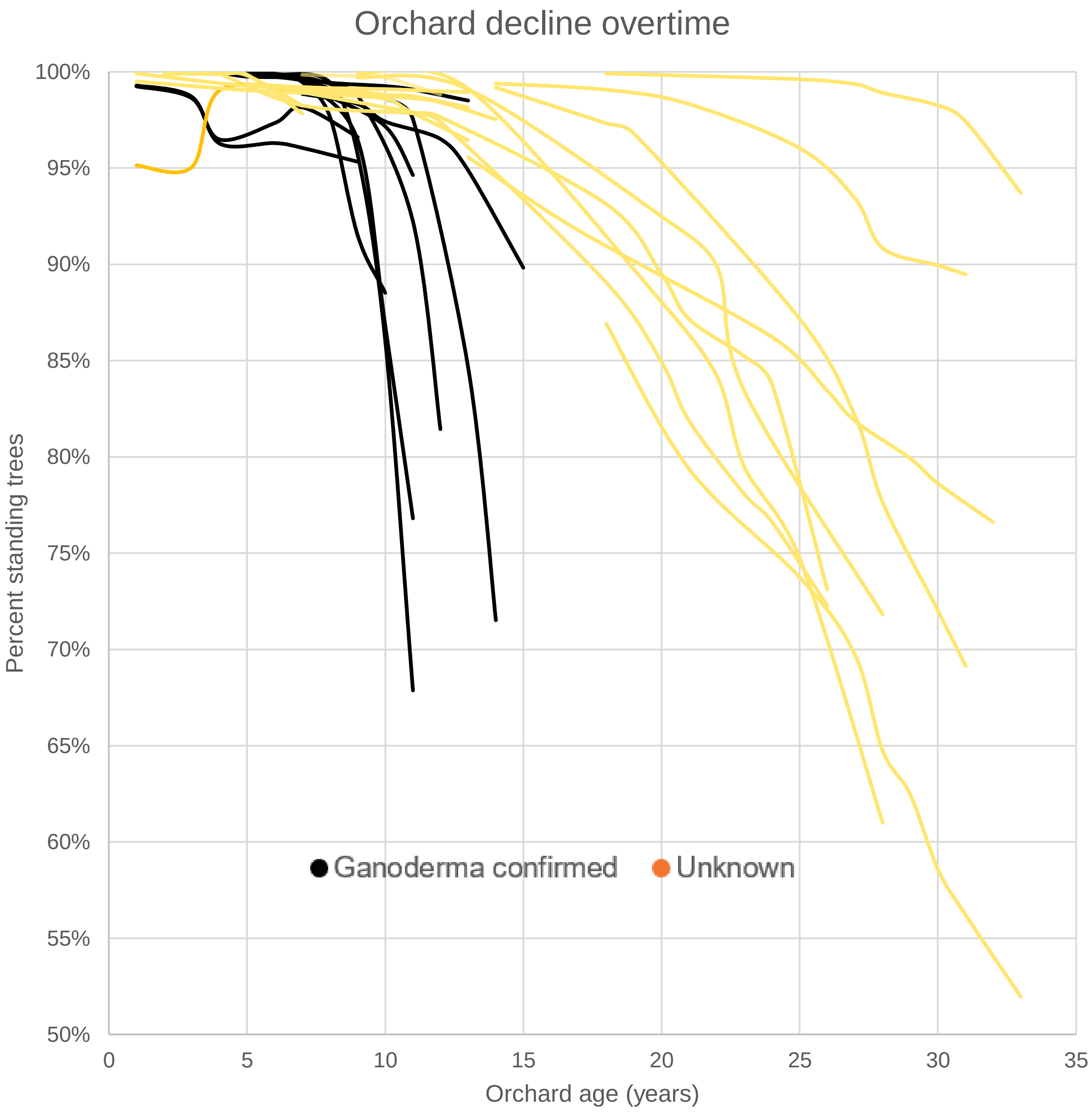
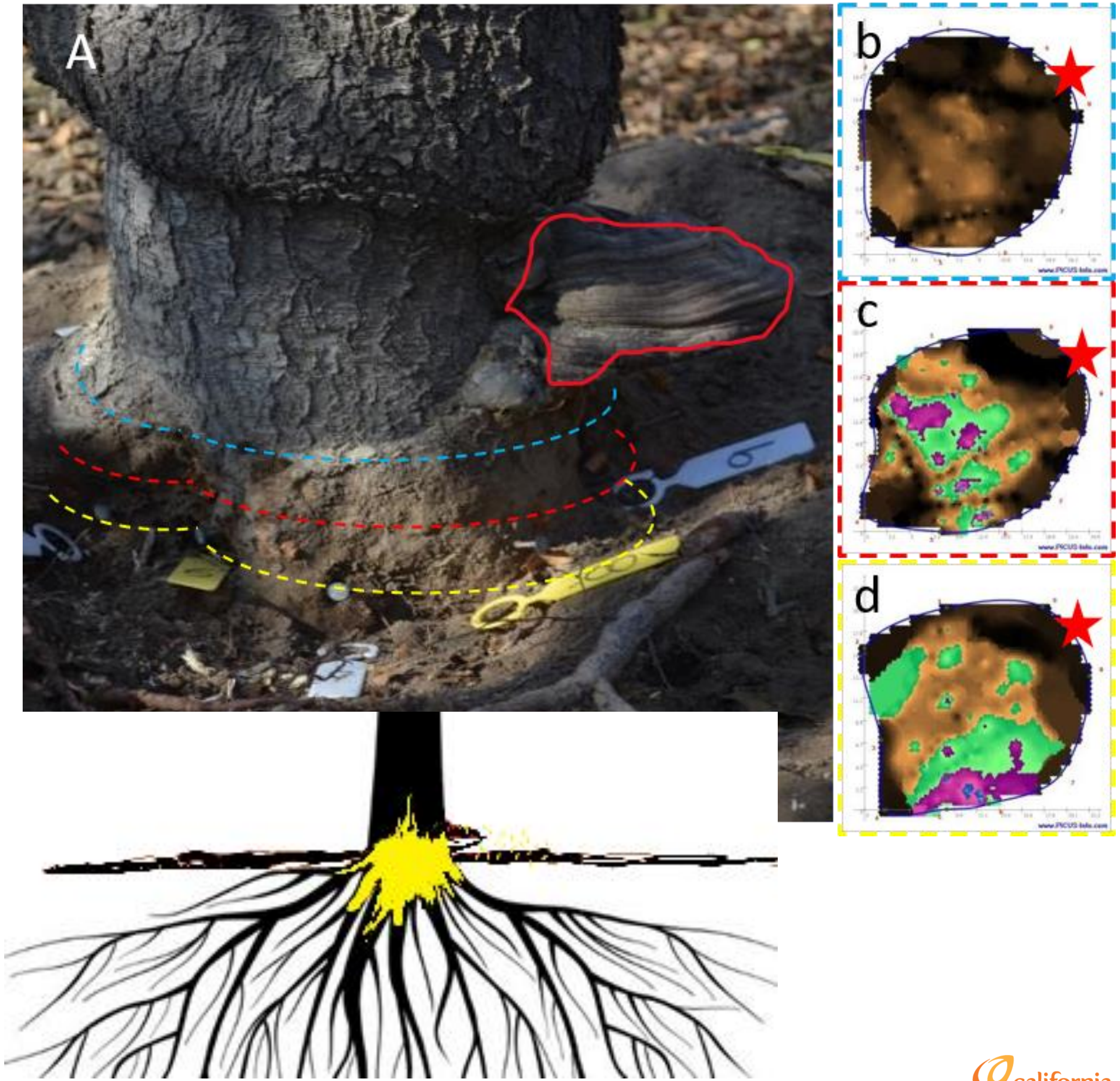


What We Know

- Three *Ganoderma* species identified in almond orchards
- *Ganoderma adspersum* can half the lifespan of an orchard
- *Ganoderma* infections require wounding
- Decay is most significant below the soil line
- Nemaguard rootstock most affected
- Wood decay rates varied between *Ganoderma* species and rootstock variety
- Spores are the main source of inoculum
- Potential to survive on course woody debris



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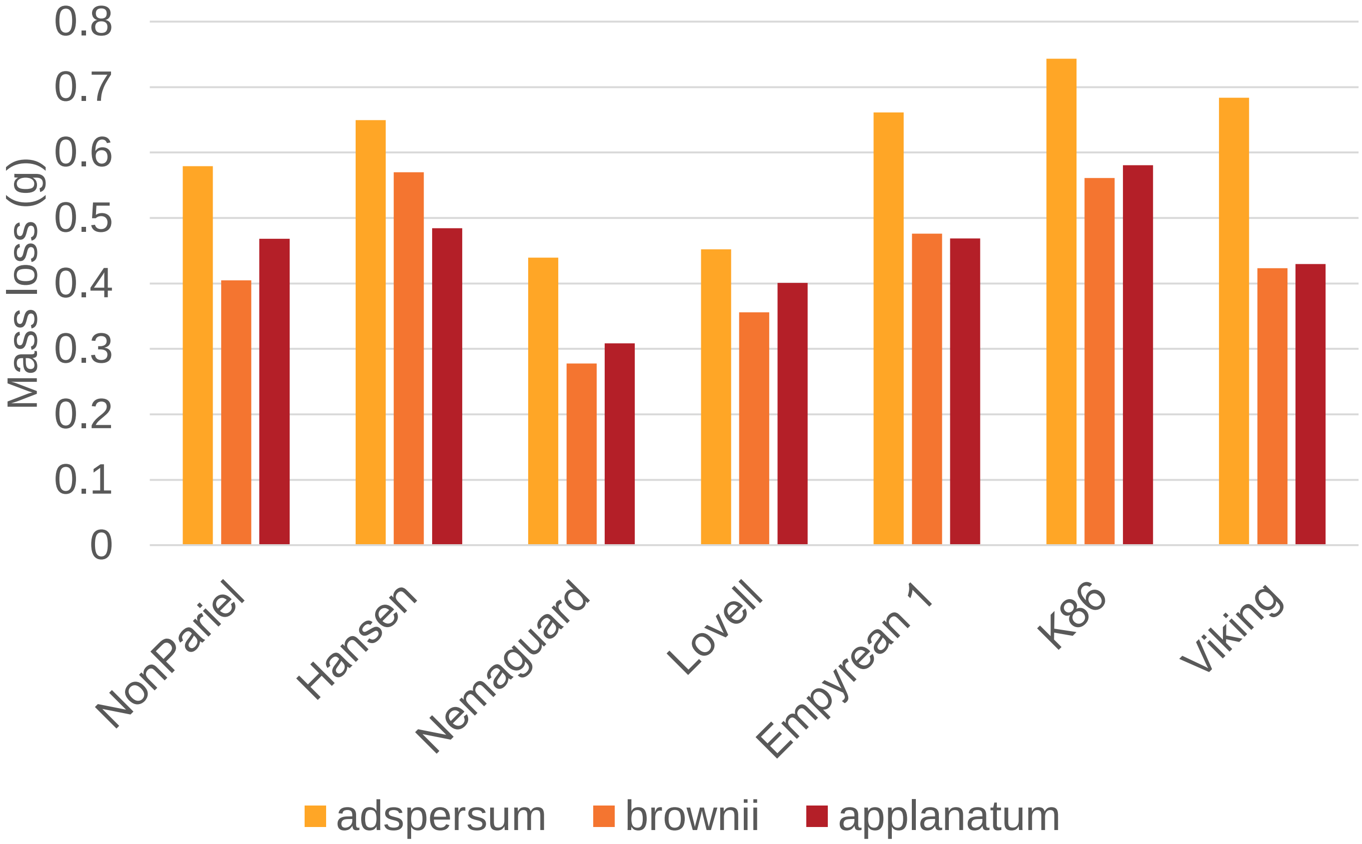

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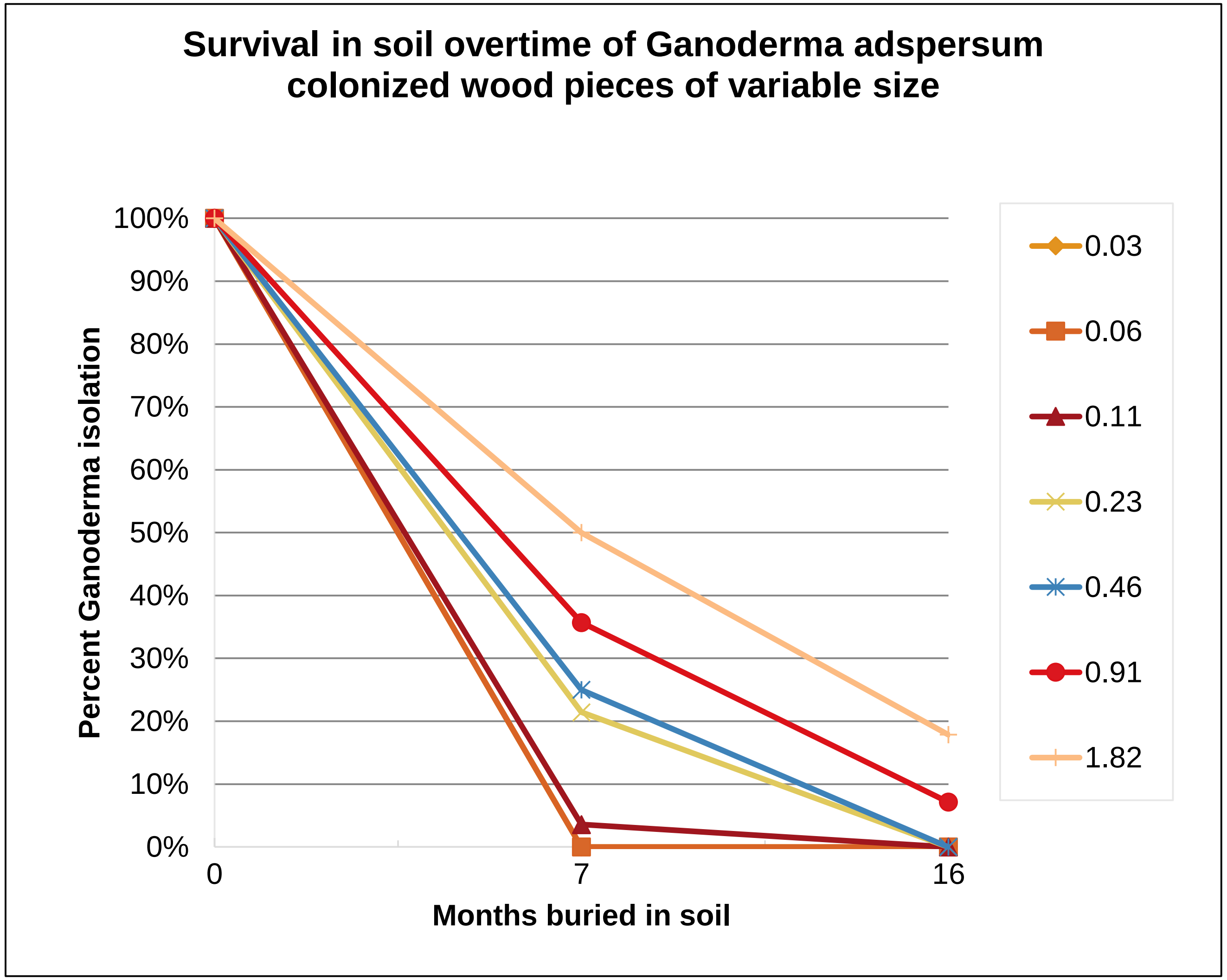


Harvest drives infection and spread

Shaking

- Wounds to lower trunk and roots at or below soil line

Sweeping Pickup

- Spore dispersal

Irrigation

- Spore percolation into soil
- Spore germination

What We Still Don’t Know

- How does shaking influence infections?
- Is there a seasonality to spore release?
- How do decay rates vary between rootstocks in live trees?
- Do rootstock physical characteristics (flexibility, bark thickness, etc.) influence infection?
- What percentage of orchards are infected?
- What possible control strategies are there?

Continued Research

- Continued rootstock screening
- Develop spore based inoculation protocol
- Spore monitoring technology
- Preliminary screening of biological control agents

Thanks:

Almond Board of California

California Dried Plum Board

UCCE Farm advisors

Cooperating growers/PCAs

Rizzo lab

Investigation of *Aspergillus niger* Causing Hull Rot, and Conditions Conducive to Disease Development in Kern County

Mohammad Yaghmour and Themis Michailides

Causal Agents and Sources of Inoculum

Monilinia spp.

Infected almond and stone fruit twigs, fruits, mummies, etc

Rhizopus stolonifer

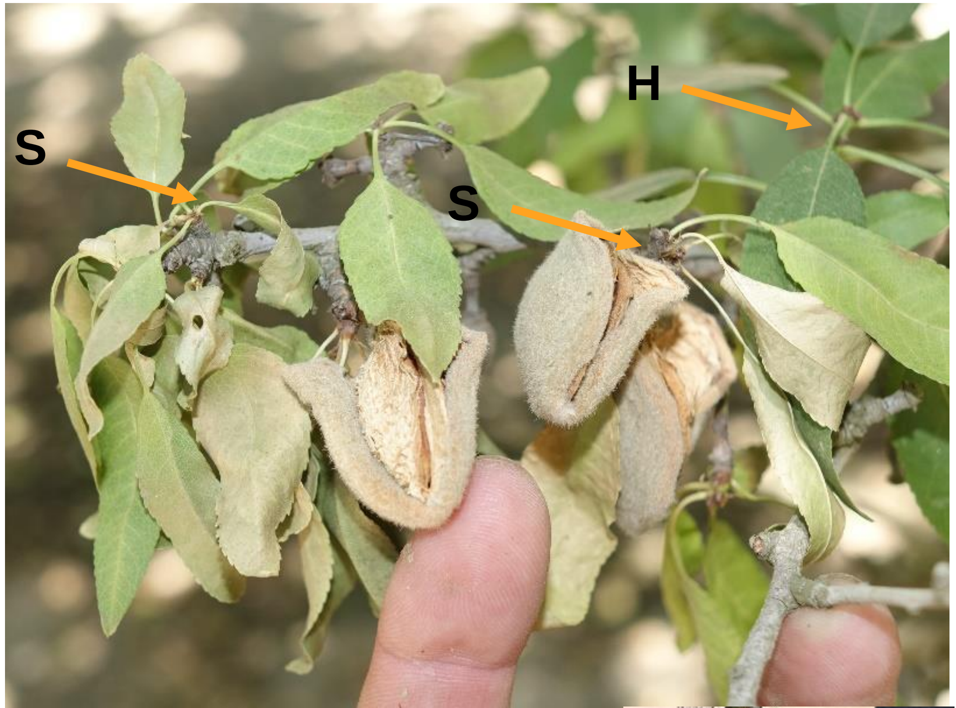
Soil

Aspergillus niger Association with Hull Rot in Southern San Joaquin Valley

- In past years, Hull Rot infections observed in almond orchards with flat jet-black spores identified as *Aspergillus niger*

Symptoms and Signs of Hull Rot

- When the hull is infected and disease progress, leaves near the infected fruit starts to dry and shrivel
- *Monilinia*: Infected hull has a brown area on the outside and either tan fungal growth in the brown area on the inside or outside of the hull
- *Rhizopus*: Black fungal growth on the inside of the hull between the hull and the shell.
- *Aspergillus niger*: Flat jet-black spores between the hull and the shell



Fruit Susceptibility to Hull Rot Pathogen *Rhizopus stolonifer*

(b1) Initial separation-50% or more of a thin separation line visible

(b2) Deep V, is the most susceptible stage (source: Adaskaveg. 2010. Almond Board of California Research Proceedings # 09-PATH4-Adaskaveg)

(b3) Deep V, split-a deep "V" in the suture, which is not yet visibly separated, but which can be squeezed open by pressing both ends of the hull

(c) Split, less than 3/8 inch

Objectives

Studying disease biology and factors contribute to disease development

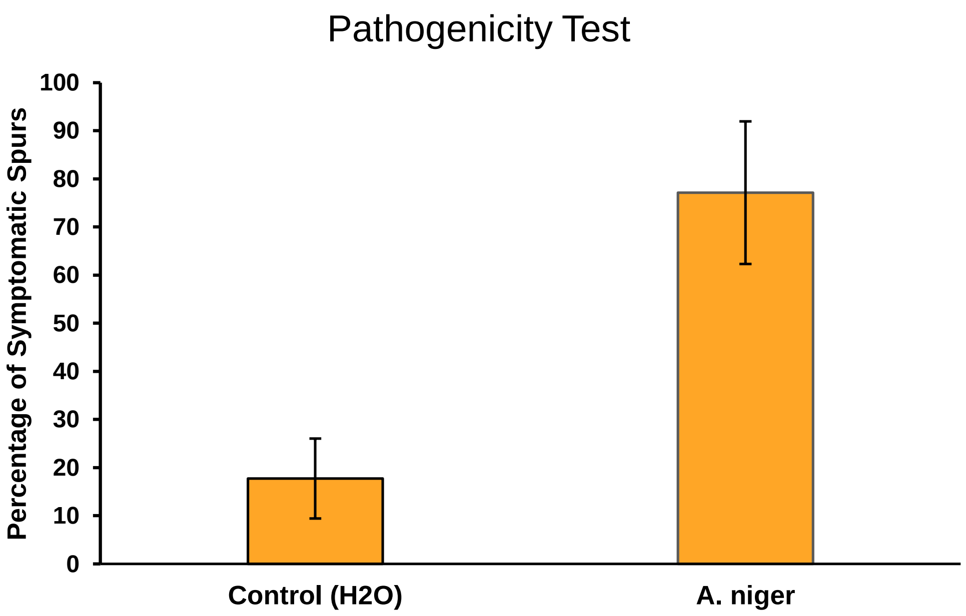
- **To complete *Aspergillus niger* pathogenicity tests and study almond fruit susceptibility.**
- **To assess disease incidence and monitor inoculum dispersal in the orchard.**
- **Effect of tree water and nitrogen status on disease development.**

Experimental Site

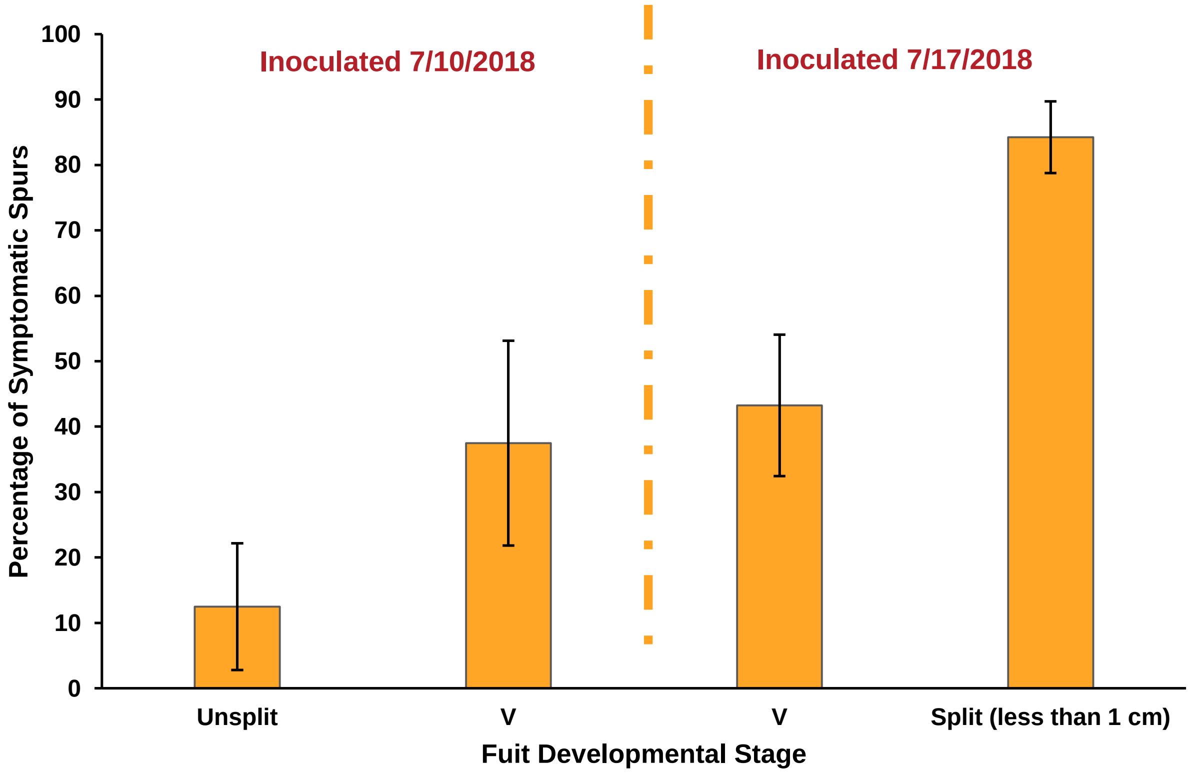
- Planted in 2011 in Arvin, CA with 50% Nonpareil, 25% Sonora, and 25% Monterey
- Planted 22’×20’ and irrigated with microsprinklers
- Five replicates in each main plot established on the NP row.

Pathogenicity Test (2018)

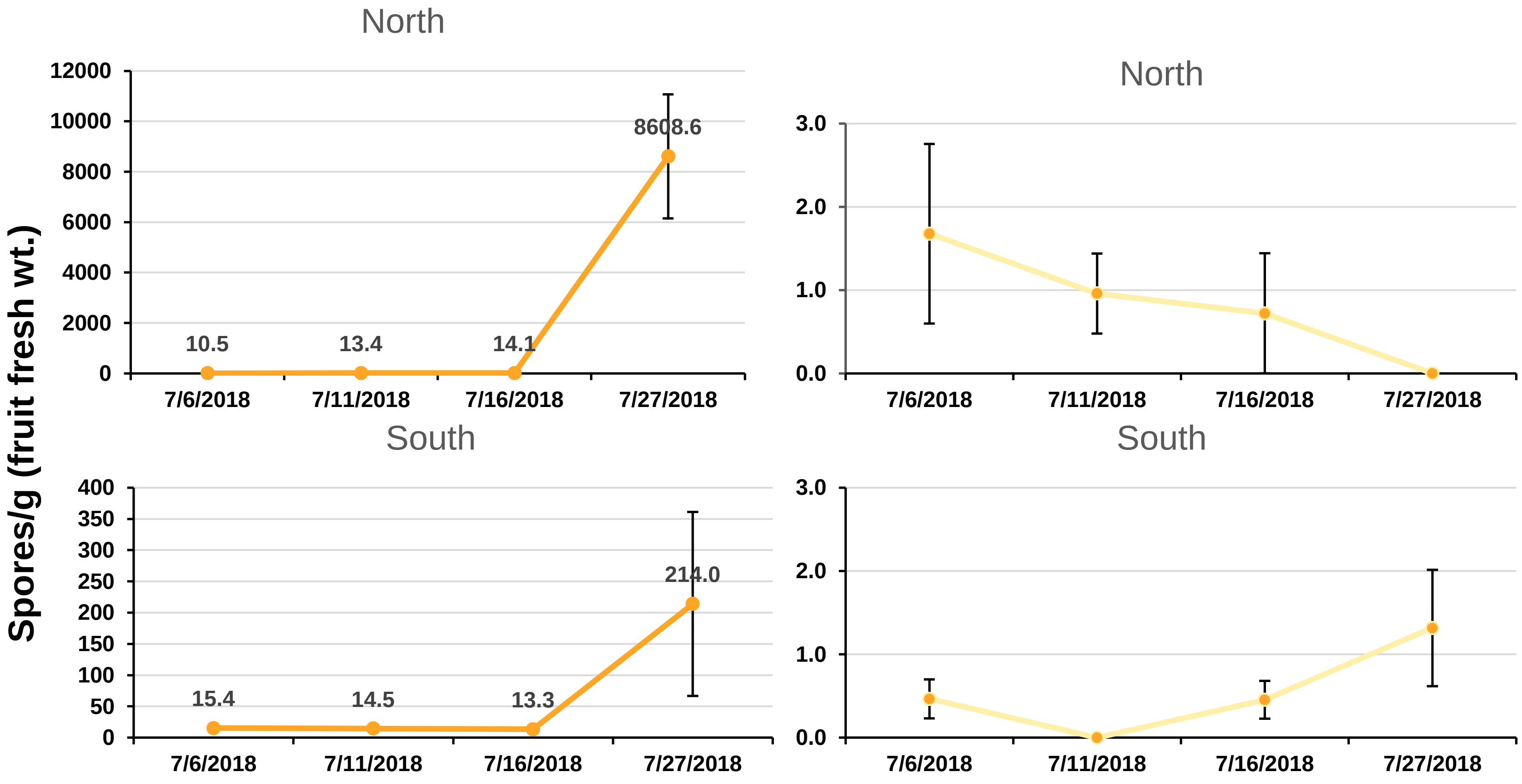
- Almond fruits (cv. Nonpareil) was inoculated with 10 µl of *A. niger* of 1×10^6 spore suspension (10,000 spores)
- Fruits inoculated with sterile water served as a control



Field Fruit inoculation at different fruit development stages and fruit susceptibility

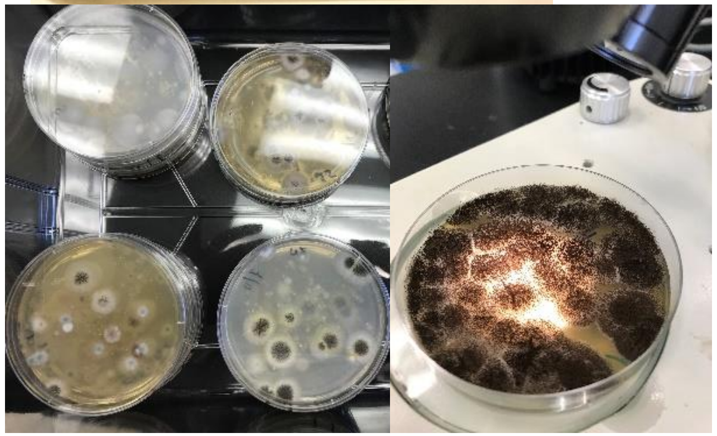


Aspergillus niger and Rhizopus stolonifer spore population on almond fruit



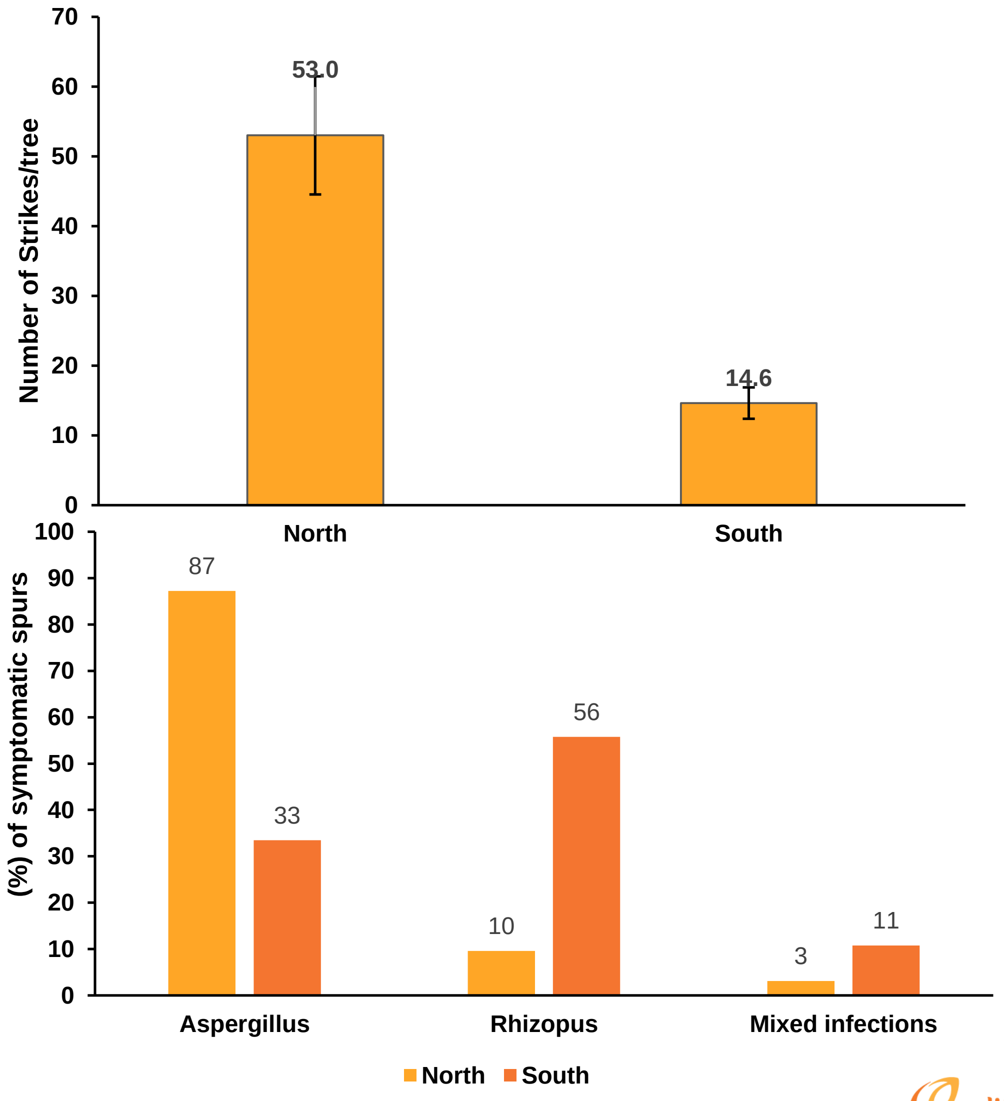
A. niger

R. stolonifer



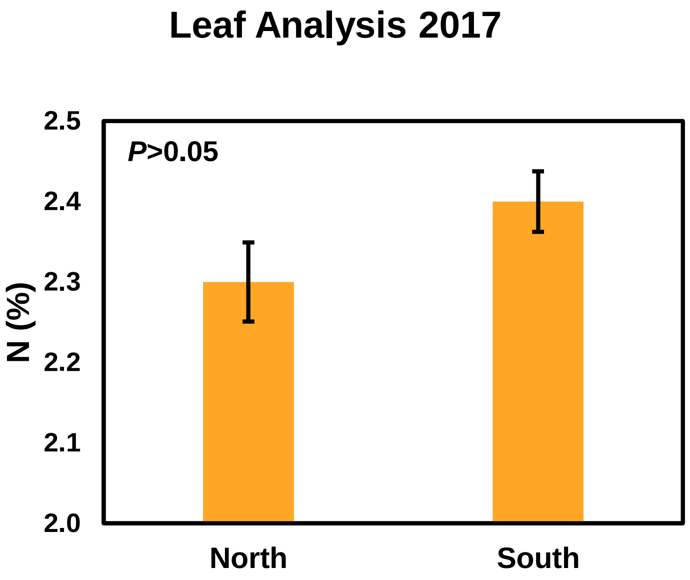
Percentage of Fruit Associated with Hull Rot that has *Aspergillus niger* or *Rhizopus stolonifer*

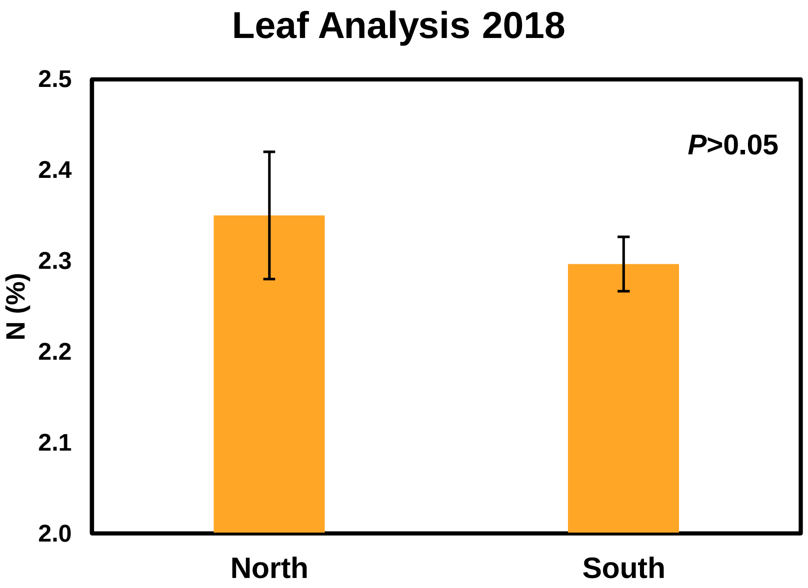
- For the second year, the Northern plot had significantly higher natural incidence of hull rot
- Symptomatic spurs with hull rot symptoms were collected and fruit were evaluated for *A. niger, R. stolonifera,* and mixed infections
- When looking at each block within the orchard, the northern plot had higher percentage of spurs with fruit infected with *A. niger* while the southern plot had higher *R. stolonifer* infections compared to the northern plot



Leaf Analysis

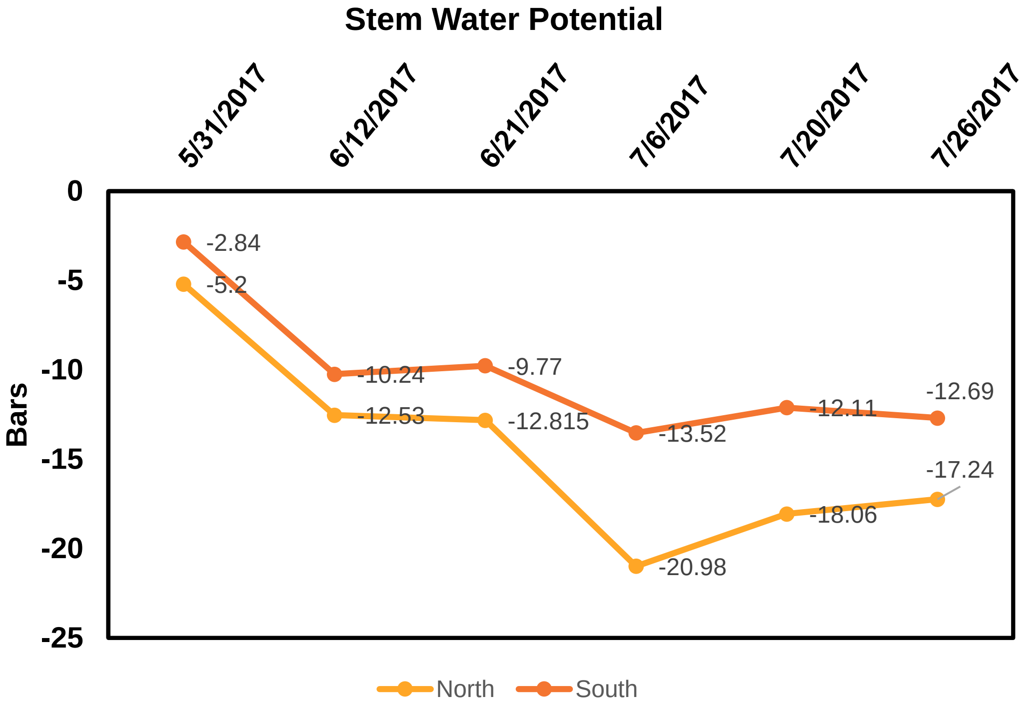
- In 2018, July Leaf Nitrogen content was within the normal Nitrogen content for both plots
- Nitrogen levels was not significantly different between the two major plots for two years in a row

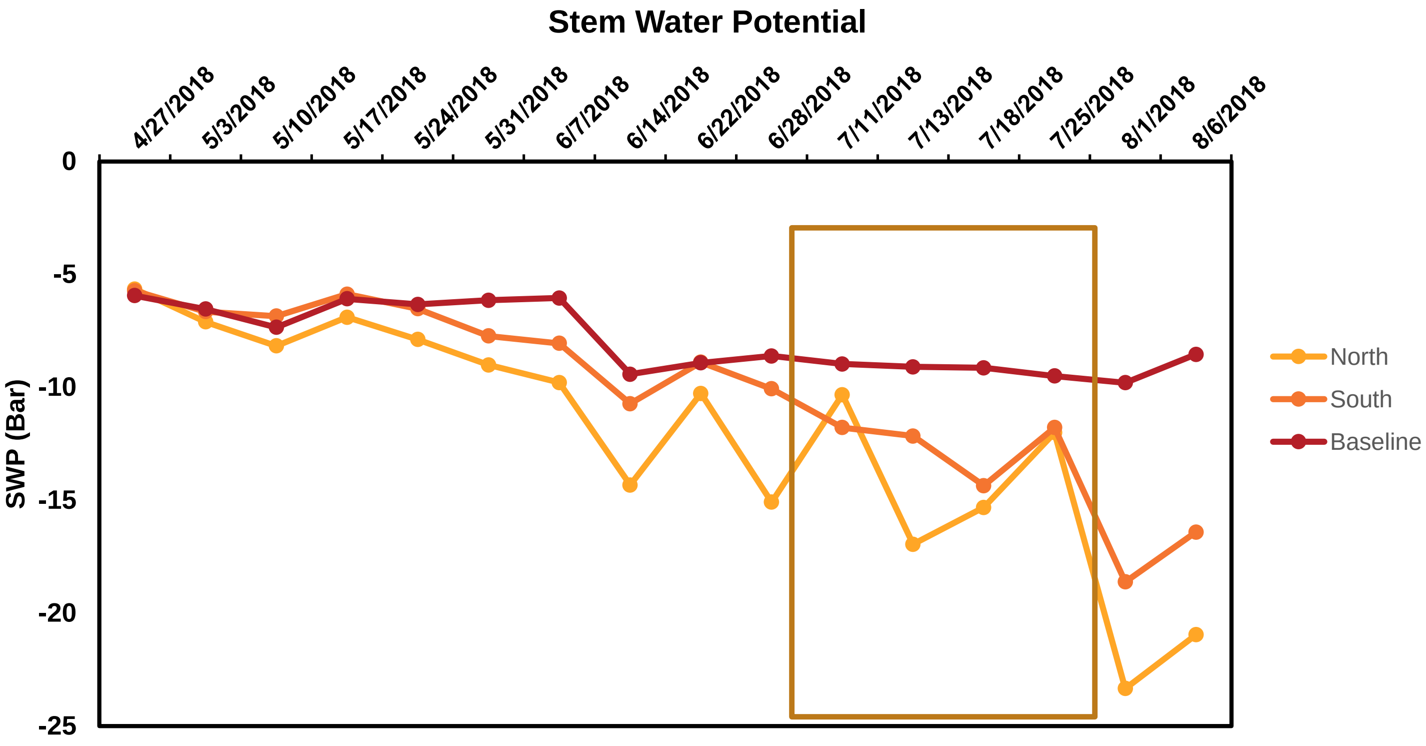




Stem Water Potential

- Trees in the Northern plot was more stressed compared to the trees in the Southern plot in both years

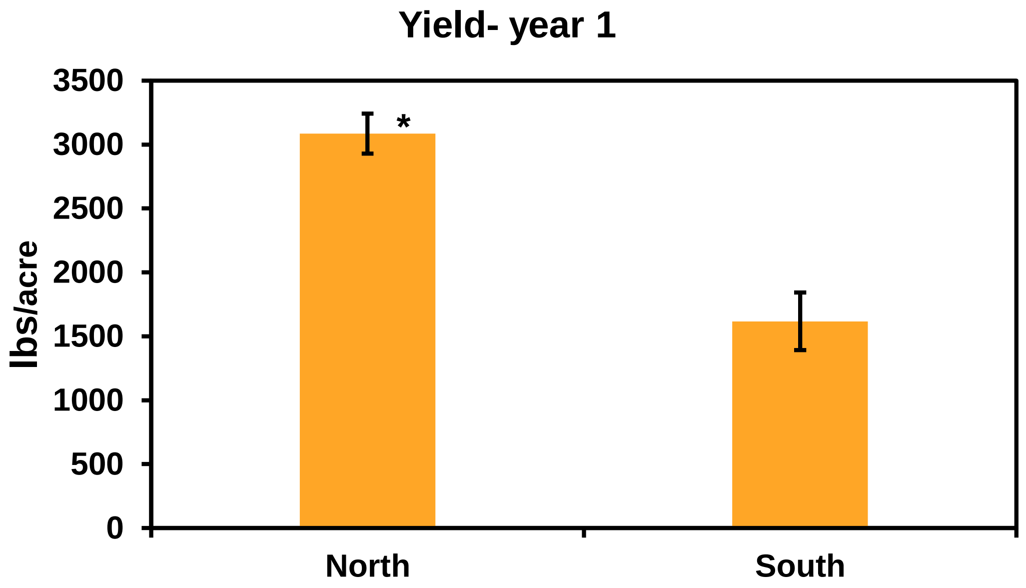




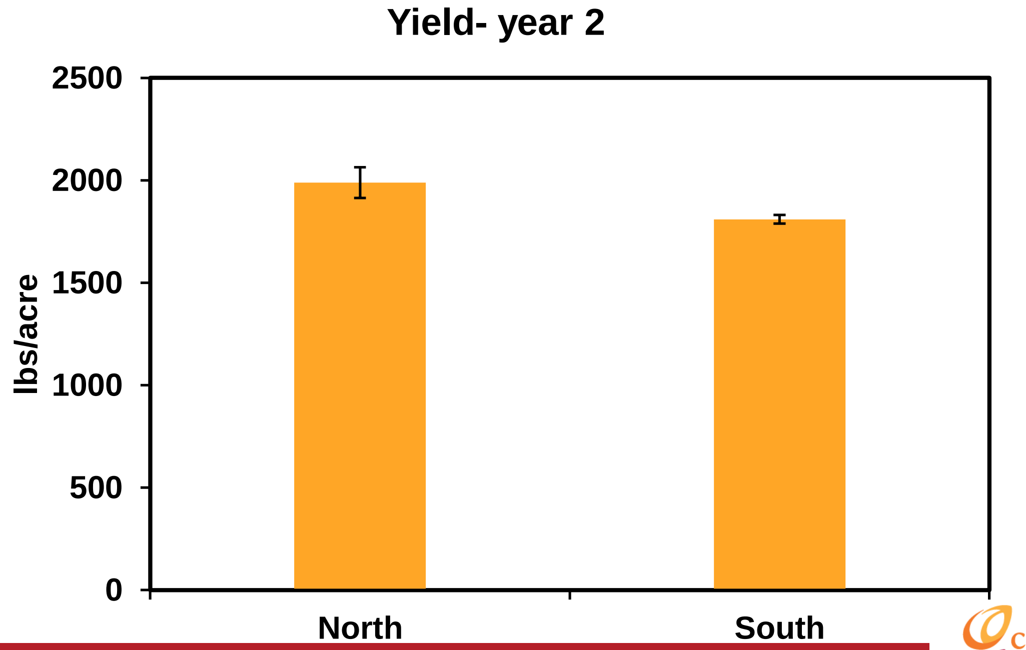
Yield

Yield trend in the 2nd season is still similar to year 1 despite the fact that they are not statistically different

We will monitor yield to document the effect of disease on yield in this orchard



Yield- year 1



Yield- year 2

Findings

- *Aspergillus niger* has been associated with hull rot in Kern County and main almond producing counties in the SJV and was isolated from the cankers from samples sent to Dr. Michailides' lab.
- *A. niger* reproduced hull rot symptoms in field inoculations.
- The highest spore population on fruit was observed later in the season with fruits corresponding to fruits with hull split less than 3/8 inch (stage C)
- In first year fruit susceptibility study, inoculated fruit at stage (c) with hull split less than 3/8 of an inch had the highest percentage of spurs producing disease symptoms.

Thank You!

Sustainable Microbial Biocontrol of Brown Rot Blossom Blight

Rachel L. Vannette, Robert N. Schaeffer,
Elina L. Niño, and Florent P. Trouillas
University of California, Davis

Brown rot blossom blight IPM

- Brown rot blossom blight (*Monilinia* spp.) is a significant threat to orchard sustainability

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- Flowers harbor a diverse microbial community

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- Fungicides are an important component of effective IPM
  - Costs include evolved resistance and pollination
- Flowers harbor a diverse microbial community
- **Can we leverage microbes for biocontrol?**

Objectives

- Identify candidate microbial biocontrol agents

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- Evaluate effects of microbial biocontrol agents on floral attractiveness and pollination

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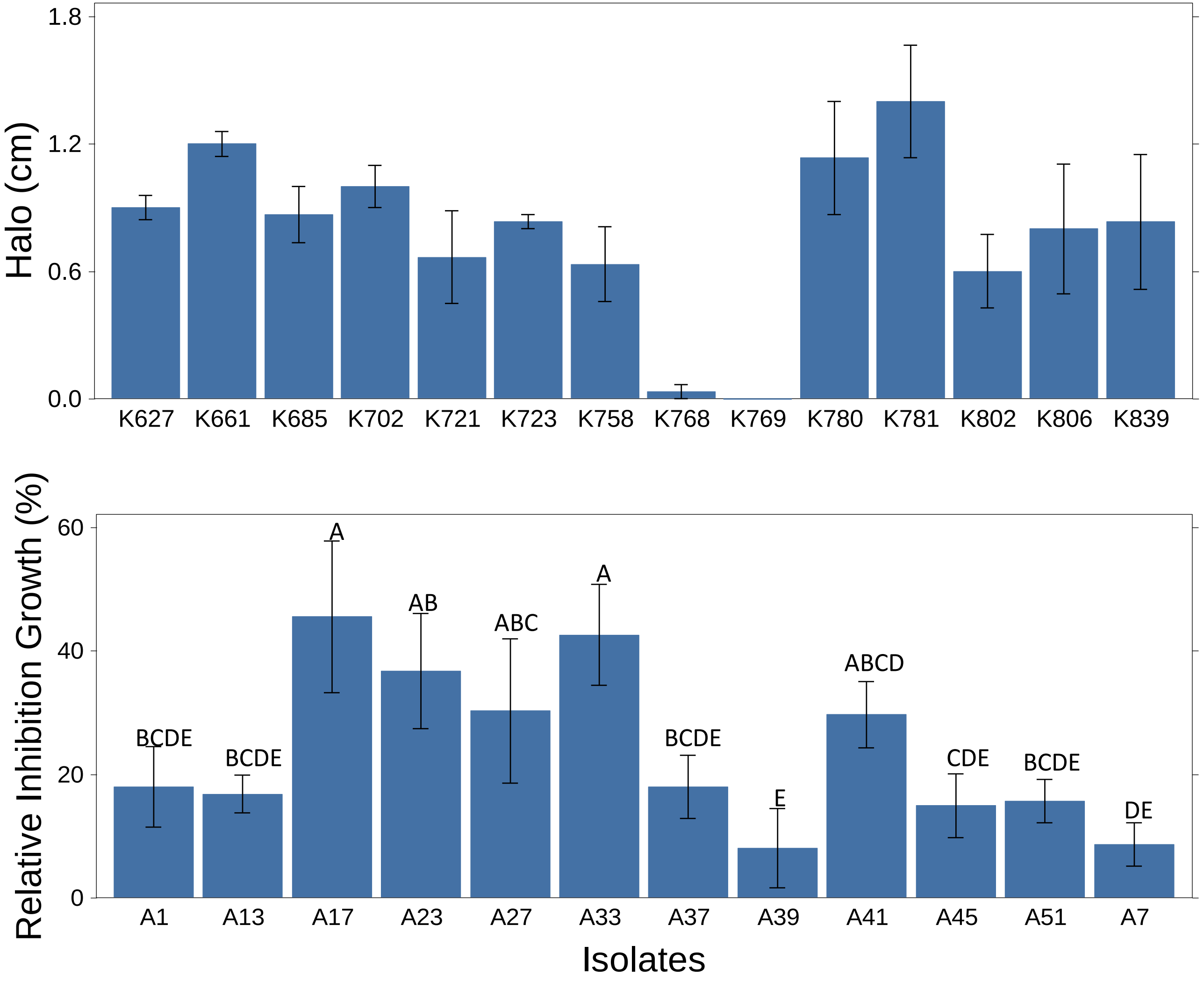
- Determine safety of microbial biocontrol agents for honey bee brood and adults

Screening microbial isolates for *Monilinia* control

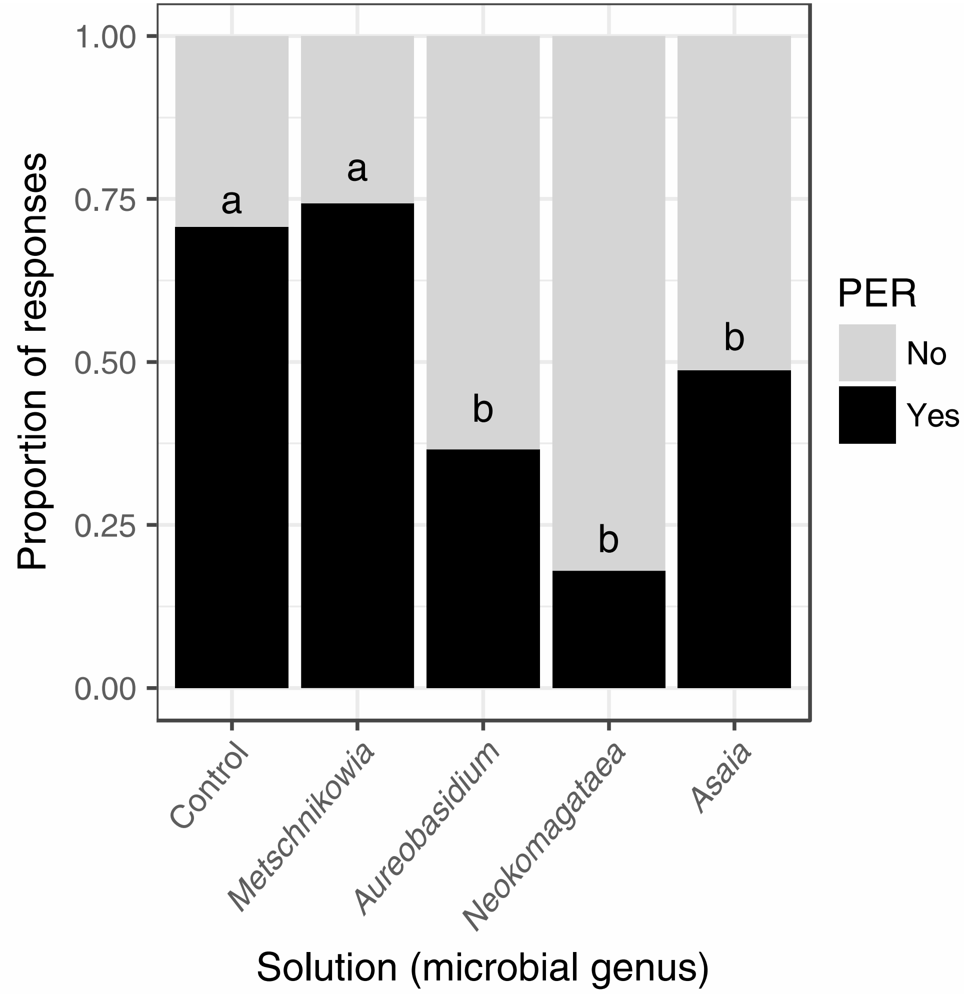


Epicoccum nigrum

Aureobasidium pullulans

Honey bees are sensitive to flower microbes

Proboscis extension reflex (PER)



Ongoing Work & Conclusion

- Continued screening of isolates to identify an effective candidate for field trials

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Acknowledgments

Funding

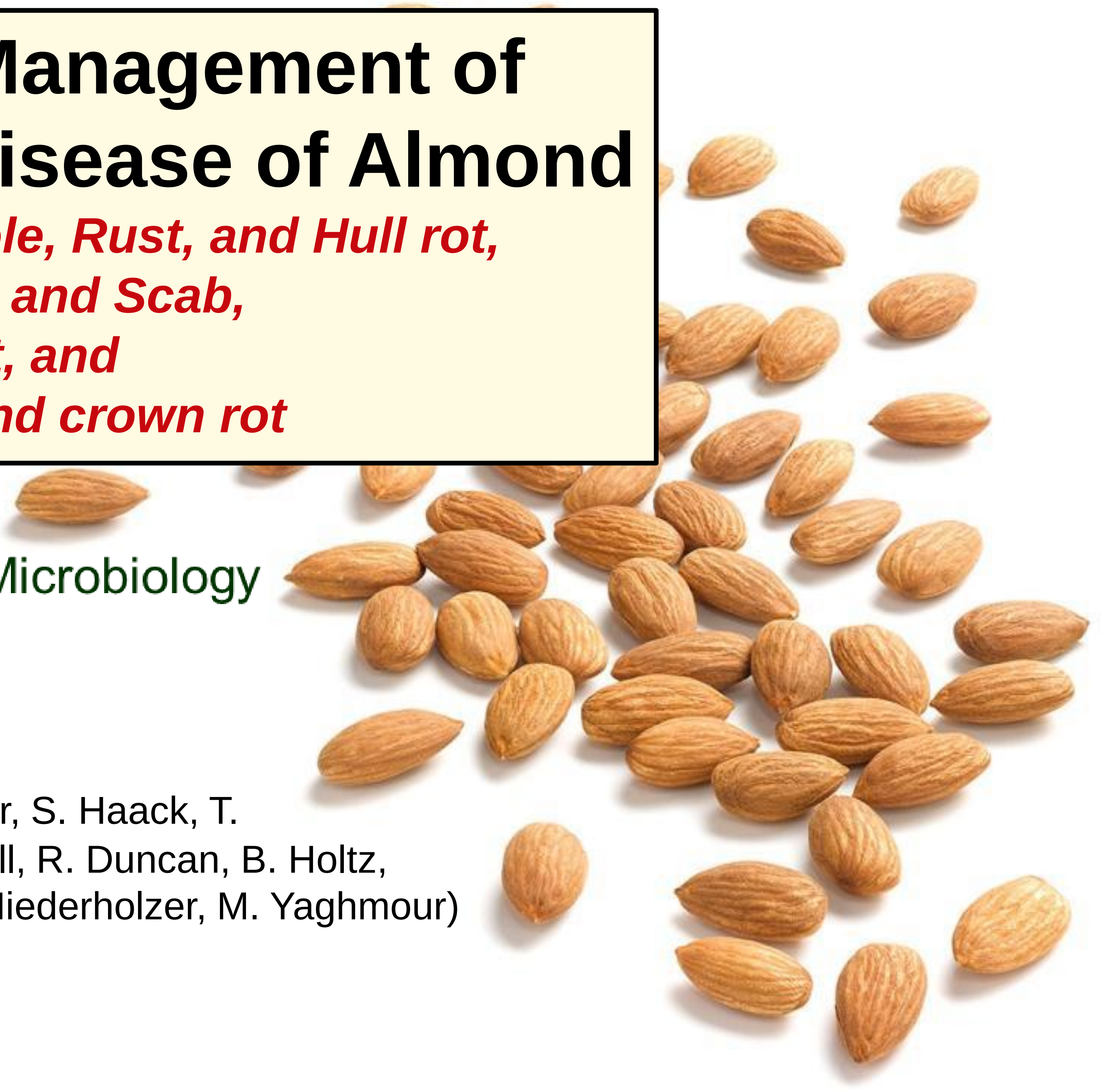
Almond Board of California

University of California, Davis

USDA

Epidemiology and Management of Fungal and Bacterial Disease of Almond

Brown rot, Jacket rot, Shot hole, Rust, and Hull rot,
Alternaria leaf spot and Scab,
Bacterial spot, and
Phytophthora root and crown rot



Dr. J. E. Adaskaveg
Department of Plant Pathology and Microbiology
University of California, Riverside

In cooperation D. Thompson, D. Cary, H. Förster, S. Haack, T. Gradziel, F. Trouillas, and Farm Advisors (D. Doll, R. Duncan, B. Holtz, C. Kallsen, L. Milliron, F. Niederholzer, M. Yaghmour)

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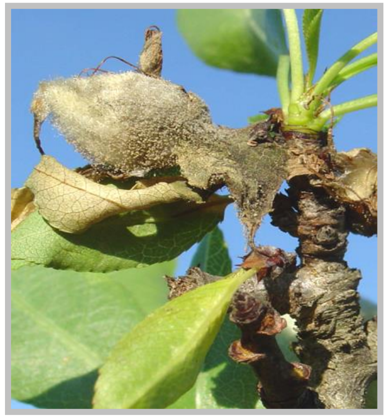
Flower, Foliar, Fruit, and Root/Crown Diseases of Almond

Brown rot blossom blight



Green fruit rot/Jacket rot

Shot hole

Bacterial spot

Anthracnose

Scab

Alternaria leaf spot

Rust

Hull rot

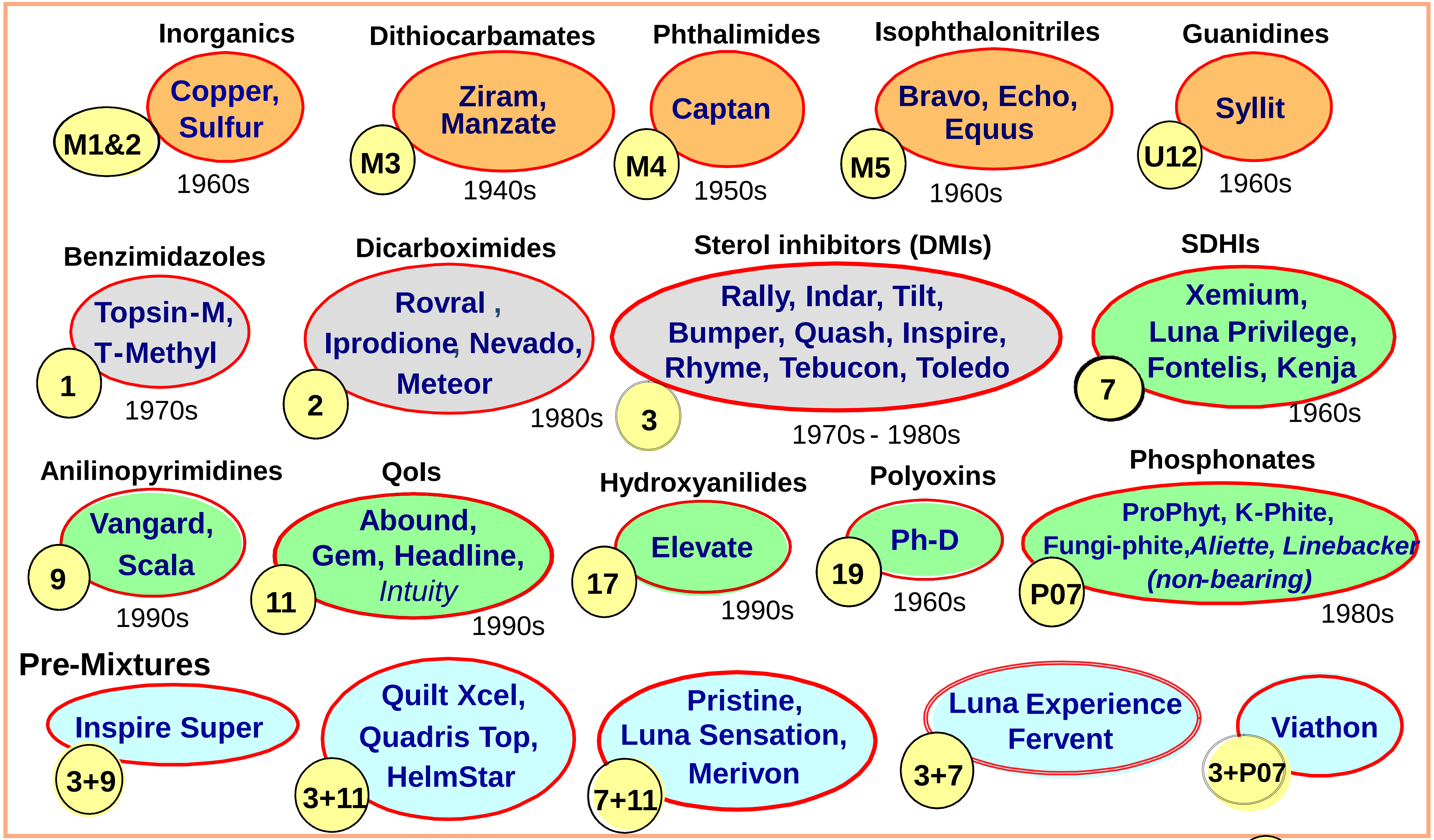
Phytophthora root and crown rot

Fungicides for Managing Almond Diseases

Inorganics and Conventional Synthetics

New:
Helmstar (2018)
Fervent (2018)

Ongoing:
Pydiflumetofen,
Pyraziflumid,
EXP-AD, -AF,
UC-1, UC-2,
F4406



Inorganics	M1&2	**Copper, Sulfur**	1960s
Dithiocarbamates	M3	**Ziram, Manzate**	1940s
Phthalimides	M4	**Captan**	1950s
Isophthalonitriles	M5	**Bravo, Echo, Equus**	1960s
Guanidines	U12	**Syllit**	1960s
Benzimidazoles	1	**Topsin-M, T-Methyl**	1970s
Dicarboximides	2	**Rovral , Iprodione, Nevado, Meteor**	1980s
Sterol inhibitors (DMIs)	3	**Rally, Indar, Tilt, Bumper, Quash, Inspire, Rhyme, Tebucon, Toledo**	1970s - 1980s
SDHIs	7	**Xemium, Luna Privilege, Fontelis, Kenja**	1960s
Anilinopyrimidines	9	**Vangard, Scala**	1990s
QoIs	11	**Abound, Gem, Headline, *Intuity***	1990s
Hydroxyanilides	17	**Elevate**	1990s
Polyoxins	19	**Ph-D**	1960s
Phosphonates	P07	**ProPhyt, K-Phite, Fungi-phite,*Aliette, Linebacker (non-bearing)***	1980s

Pre-Mixtures

3+9	**Inspire Super**
3+11	**Quilt Xcel, Quadris Top, HelmStar**
7+11	**Pristine, Luna Sensation, Merivon**
3+7	**Luna Experience Fervent**
3+P07	**Viathon**

🟧 Multi-site mode of action
⬜ Single-site mode of action
🟩 Reduced-risk fungicide
🟡 FRAC Code

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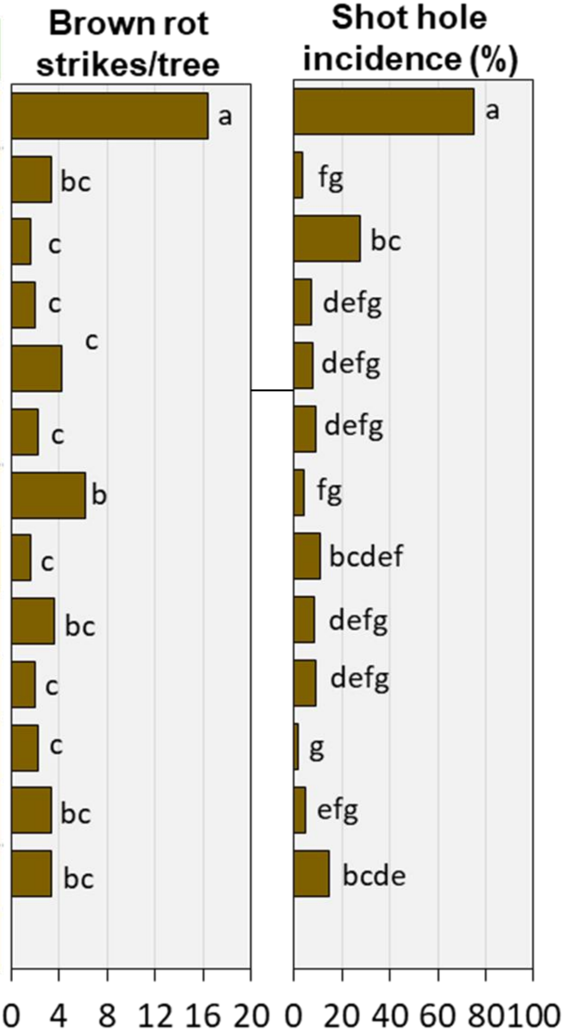
Almond Board of California

Brown Rot Blossom Blight And Shot Hole - 2018

	Treatment	Rate(/A)	FB	3 WAPF
	Control	---	---	---
Single	Rhyme	7 fl oz	@	@
	Pyraziflumid	4.7 fl oz	@	@
	F4406-3	5 fl oz	@	@
	UC-1	4 fl oz	@	@
	GWN 10320	24 fl oz	@	@
Pre-mixtures	Merivon	5.5 fl oz	@	@
	Luna Sensation	7.8 fl oz	@	@
	Luna Experience	8 fl oz	@	@
	Helmstar	14.5 fl oz	@	@
	UC-2	7 fl oz	@	@
	EXP-AD	13.7 fl oz	@	@
Rotation	Vangard + Tilt	5 oz + 4 fl oz	@	---
	Quadris Top	14 fl oz	---	@



Applications on 2-13, 3-9-18
cv. Drake, high disease pressure

Brown rot

Single: FRAC (1), 2, 3, 7, 9.

New: Pydiflumetofen, Pyraziflumid, Helmstar, UC-1, UC-2, EXP-AD, F4406-3, GWN 10320.

Pre-mixtures: FRAC 3+7, 3+9, 3+11, 7+11. Highest efficacy, consistency, resistance management.

Biologicals: Botector, Fracture, MBI compounds (intermediate efficacy).

Shot hole

Single: M3-M5, FRAC 3,11,19

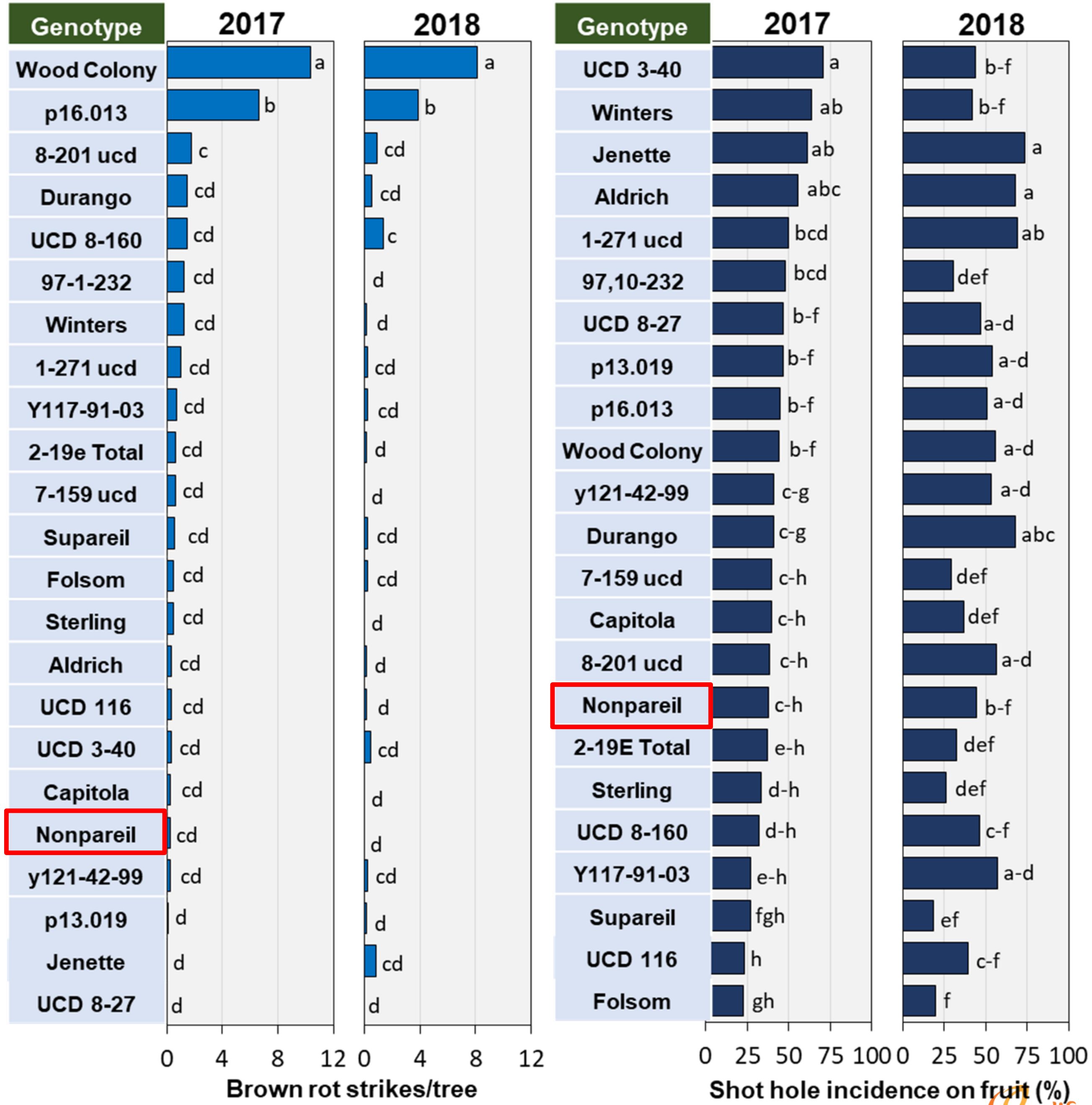
Pre-mixtures and mixtures: FRAC 3+7, 3+9, 3+11, 7+11, U12+3, 3+19.

2017-18 Natural Host Susceptibility to Brown Rot and Shot Hole Among 24 Cultivars and Genotypes in the UCD Variety Block

Some new cultivars such as Capitola and Jenette showed low susceptibility to brown rot, similar to Nonpareil.

Folsom, Supareil, Sterling, and Kester (2-19E) showed reduced susceptibility to shot hole on fruit.

Trees were planted in 2014. Scions were grafted to Nemaguard and Krymsk rootstocks.



Almond Hull Rot

- Caused by *Rhizopus stolonifer* or by *Monilinia fructicola*
- Both pathogens infect fruit and cause dieback
- *Aspergillus niger* can also cause hull rot (occasionally found together with other fungi)

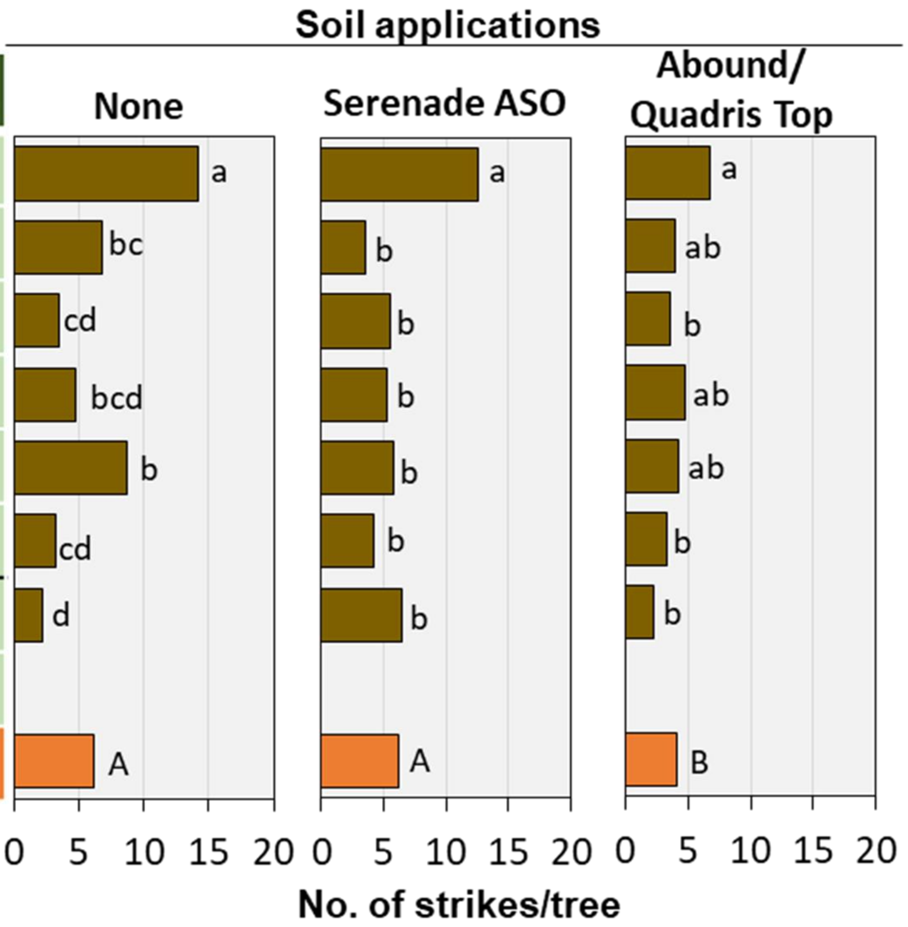
Rhizopus stolonifer (left), *Monilinia fructicola* (right)

- For dieback of Rhizopus hull rot, fumaric acid production of the pathogen may be involved.
- The pathogens require different management strategies.

Almond Hull Rot – Alkalizers, biologicals, nutrient optimizers, and fungicides as foliar and soil treatments

Foliar applications

Treatment	Rate (/A)	7/5	7/18
Control	---	---	---
Cinetis (GA142)	24 fl oz	@	@
DiKPO4	48 oz	@	@
Aluminum sulfate	125 oz	---	@
Serenade ASO	96 fl oz	---	@
Quash + Ph-D	3 + 6.2 oz	---	@
DiKPO4	48 oz	@	---
GA142 + DiKPO4	24 + 48 fl oz	---	@
		Mean	



Rhizopus hull rot 2018

Alkaline fertilizers were effective, possibly neutralize fumaric acid that is released by *R. stolonifer* into host tissues

Cinetis: Optimizes utilization of nitrogen and other nutrients.

Fungicides: All were similarly effective, reduction of disease up to 80%.

Soil treatments: Abound/Quadris Top had significantly less disease than the no-soil or Serenade soil treatments.

- Serenade ASO applied 6-21 and 7-12 at 1 gal/50 gal/A.
- Abound (12 fl oz/A) applied 6-25, followed by Quadris Top (14 fl oz/A) on 7-17-18.
- Soil treatments were watered in. Foliar treatments were done in combination with DynAmic (8 fl oz/A).

Almond Hull Rot - Integrated management

- **Water management** - Reduce watering starting at hull split (i.e., modified deficit irrigation).
- **Nitrogen fertilization** – restrict amount of nitrogen (apply based on replacement and do not apply close (40-60 days) before hull split.
- **Dust control**
- **Different pathogens** are present at varying frequencies among locations and years.
- **Fungicides can reduce the incidence of disease, different timings are needed :**
  Monilinia hull rot: late spring (late May/June).
  Rhizopus hull rot/(Aspergillus?): early hull split (with NOW application).
- **Effective treatments**: FG **3, 11**, 19, 3+7, 3+9, 7+11, 3+11, 3+19.
- **New** optimizer of nutrient utilization including nitrogen: **Cinetis**
- **Alkalizing treatments: Di-K-PO$_4$** - neutralizes fumaric acid that is released into host tissues and causes dieback.

Almond Scab

Pathogen: *Fusicladium carpophilum*

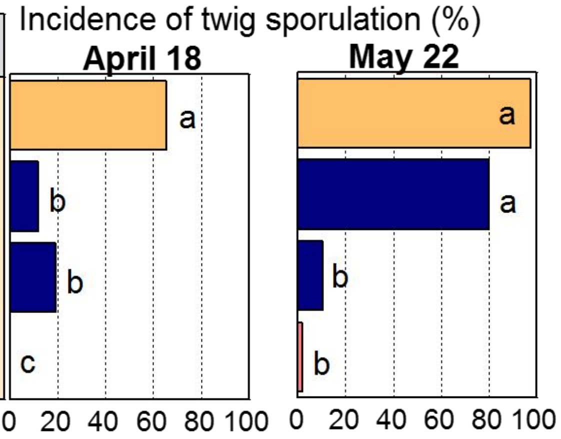
Phylogeny: Different from other scab fungi on *Prunus* spp.

Biology: No evidence of sexual reproduction

- An effective 3-spray program includes a dormant and two applications after twig-infection sporulation
- First in-season scab application at the beginning of twig-lesion sporulation.
- **Multi-site fungicides** (e.g., chlorothalonil, captan, ziram) at petal fall. Rotations of captan with single-site and pre-mixtures.
- In 2018, scab sporulation on twigs and disease incidence were low in our trial plot where aerial applications of chlorothalonil/oil were done. No data was obtained.

- Previously, we established that chlorothalonil-oil is highly effective in delaying sporulation of twig lesions into late spring.
- Timing: Mid-December to mid-January.
- Copper-oil is also effective

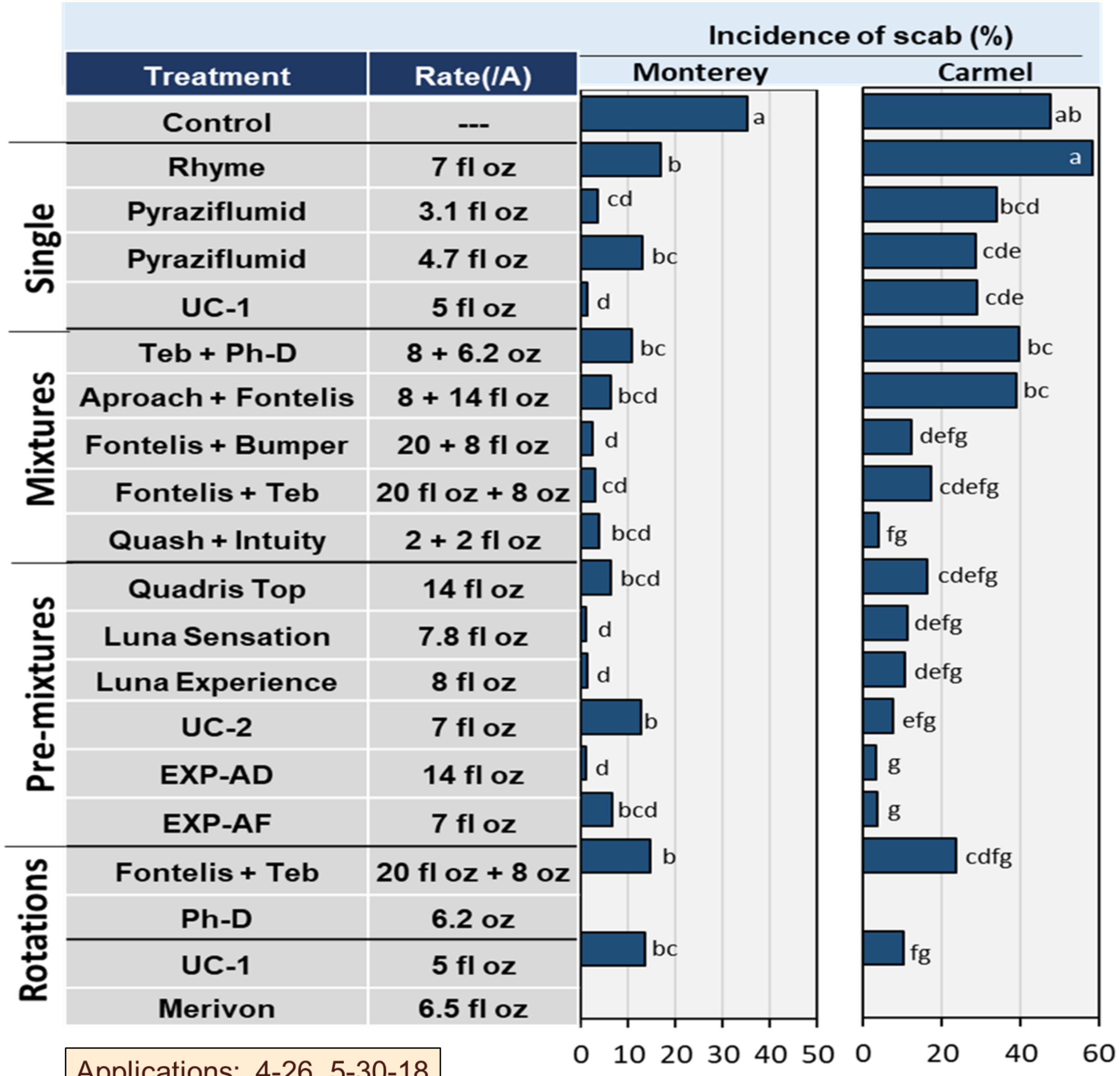
Fungicide	Oil
Control	-
Kocide 3000 5 lb	+
Bravo WeatherStick 4 pts	+
Bravo WeatherStick 6 pts	+



cv. Carmel, Butte Co.

Application: Delayed dormant - January.

Efficacy of In-season Scab Treatments - 2018



	Treatment	Rate(/A)	Incidence of scab (%) Monterey	Incidence of scab (%) Carmel
	Control	---	a	ab
Single	Rhyme	7 fl oz	b	a
	Pyraziflumid	3.1 fl oz	cd	bcd
	Pyraziflumid	4.7 fl oz	bc	cde
	UC-1	5 fl oz	d	cde
Mixtures	Teb + Ph-D	8 + 6.2 oz	bc	bc
	Aproach + Fontelis	8 + 14 fl oz	bcd	bc
	Fontelis + Bumper	20 + 8 fl oz	d	defg
	Fontelis + Teb	20 fl oz + 8 oz	cd	cdefg
	Quash + Intuity	2 + 2 fl oz	bcd	fg
Pre-mixtures	Quadris Top	14 fl oz	bcd	cdefg
	Luna Sensation	7.8 fl oz	d	defg
	Luna Experience	8 fl oz	d	defg
	UC-2	7 fl oz	b	efg
	EXP-AD	14 fl oz	d	g
	EXP-AF	7 fl oz	bcd	g
Rotations	Fontelis + Teb	20 fl oz + 8 oz	b	cdfg
	Ph-D	6.2 oz		
	UC-1	5 fl oz	bc	fg
	Merivon	6.5 fl oz		

Applications:. 4-26, 5-30-18

Most effective in-season:

- **Single:** FGs 3, 7, 19, U12

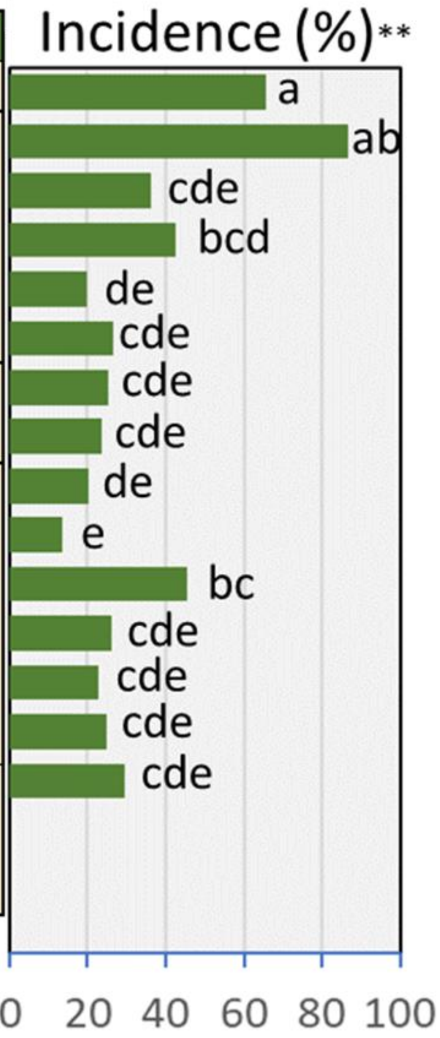
  New: Pyraziflumid, UC-1
- **Pre-mixtures:** FG 3/9, 3/11, 7/11
  New: EXP-AD, -AF, UC-2, Fervent

Resistance management:

- Use single-site fungicides in rotations and/or mixtures.
- Do not apply single-site fungicides once disease is developing.
- ***No reports of new resistance*** *but QoI and SDHI resistance in some areas.*

Efficacy of In-season Alternaria Treatments - 2018

Program	Treatment*	Rate (/A)
—	Control	—
Single	Rhyme***	7 fl oz
	Pyraziflumid	4.7 fl oz
	Fontelis	20 fl oz
	Ph-D	6.2 oz
	UC-1	5 fl oz
Mixtures	Quash + Intuity	2 oz + 2 fl oz
	Fontelis + Teb	20 fl oz + 8 oz
Pre-mixtures	Luna Experience	8 fl oz
	Quadris Top	14 fl oz
	Merivon	6.5 fl oz
	UC-2	7 fl oz
	EXP-AD	14 fl oz
	EXP-AF	7 fl oz
Rotation	Fontelis + Teb	20 fl oz + 8 oz
	Quash	2 oz
	Ph-D	6.2 oz



cv. Monterey, Colusa Co.

*- Treatment applications 5-16, 6-14, 7-21-18

Most effective in-season:

- **Single:** Some FRAC 3, 7, 19, U12

  New: Pyraziflumid, UC-1
- **Pre-mixtures:** FRAC 3/9, 3/11, 7/11

  New: EXP-AD, -AF, UC-2, Fervent

Resistance management:

- Use single-site fungicides in rotations and/or mixtures.
- Do not apply single-site fungicides once disease is developing.
- ***No reports of new resistance*** but QoI and SDHI resistance in some areas.

See poster for the latest on resistance among SDHI sub-groups.

Epidemiology of Bacterial Spot

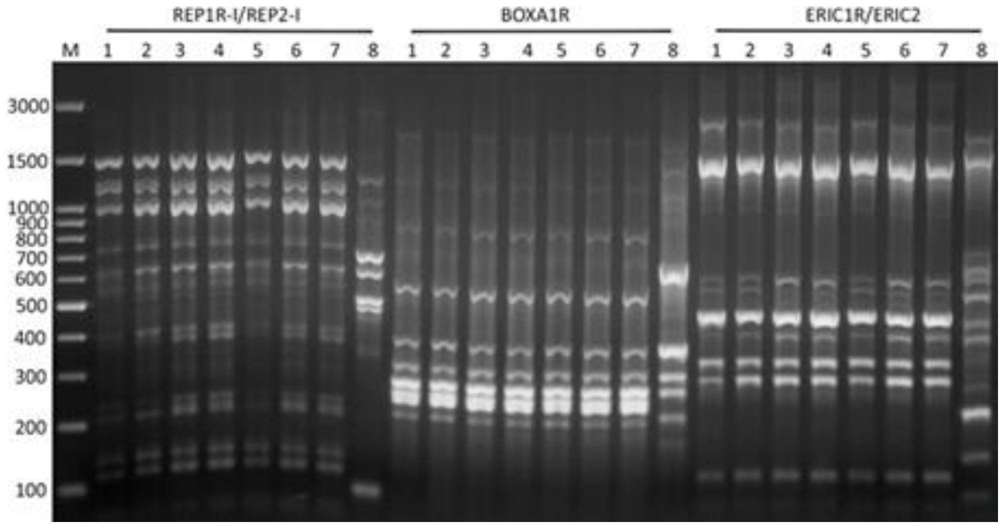
- The pathogen *Xanthomonas arboricola* pv. *pruni* overwinters in fruit mummies and attached peduncles on the tree.
- Healthy flower buds and leaves in close proximity to mummies also yielded the pathogen. No twig cankers were found.
- Isolates evaluated to date were all copper-sensitive.

Structure/tissue	Years collected	% recovery
Symptomatic mummy	2013 - 2018	40
Asymptomatic mummy	2015, 2016	0
Spur of a symptomatic mummy	2017, 2018	51.4
Asymptomatic dormant buds	2016, 2018	0
Asymptomatic flowers	2016, 2018	0
Flowers (<20 cm of a mummy)	2017, 2018	19.4
New leaves (<20 cm of a mummy)	2016, 2017	3.4

Between 30 and 200 samples were evaluated for each tissue type.

Survival:

The pathogen was detected in overwintering symptomatic fruit mummies and attached peduncles (spurs), but also in healthy flower buds and emerging leaves that were in **close proximity** to mummies in the tree.



The pathogen was found to be genetically homogeneous.

Management of Bacterial Spot

Efficacy if copper and mancozeb applied at different phenological stages on natural incidence of bacterial spot on cv. Fritz almond

Phenological stage	Date	Incid. of diseased fruit (%)	LSD^
Control	--	23.3	A
Full bloom	2/13/18	7	B
Petal fall	2/28/2018	5.4	BC
3 weeks after petal fall	3/15/2018	3.5	BC
Full bloom + petal fall	2/13 + 2/28	2.4	C
3 + 5 weeks after petal fall	3/15 + 3/26	2.8	BC

In-season treatments with Badge 3.3 lb/A + Manzate 4 lb/A at full bloom, petal fall, or 3-5 weeks after petal fall with copper-mancozeb reduced the disease to very low levels.

Timing: Full bloom and **Petal Fall**

Summary -

Management in high-disease years:

Delayed dormant treatments with copper, copper-mancozeb.

One (two) in-season treatment at full bloom/**petal fall** timed around rain events and before temperatures start to rise.

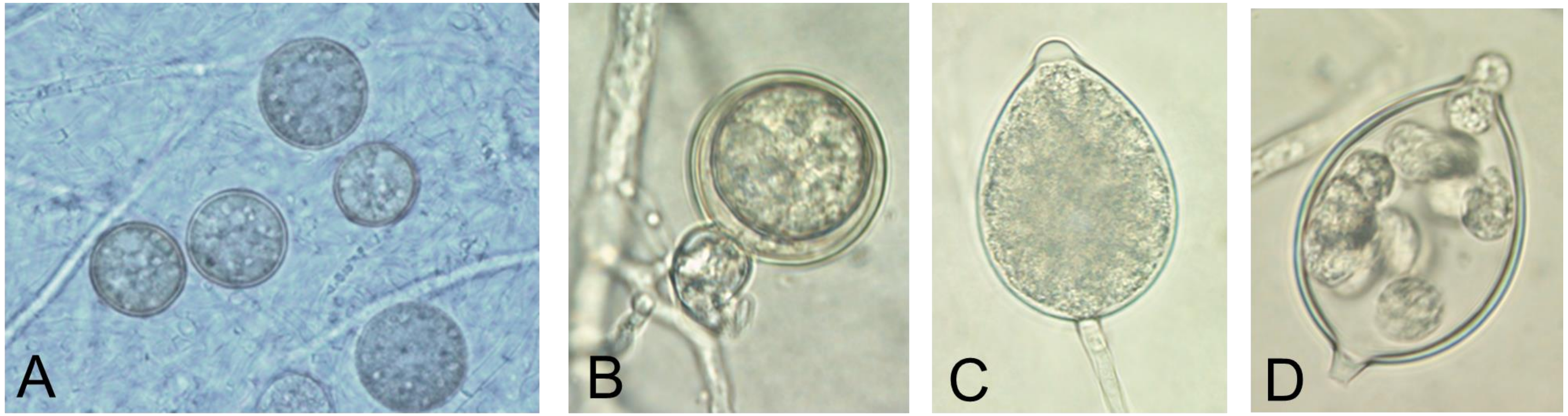
See Poster

Biologicals: OMRI-approved biologicals (e.g., Serenade+sugar, Blossom Protect) were also effective.

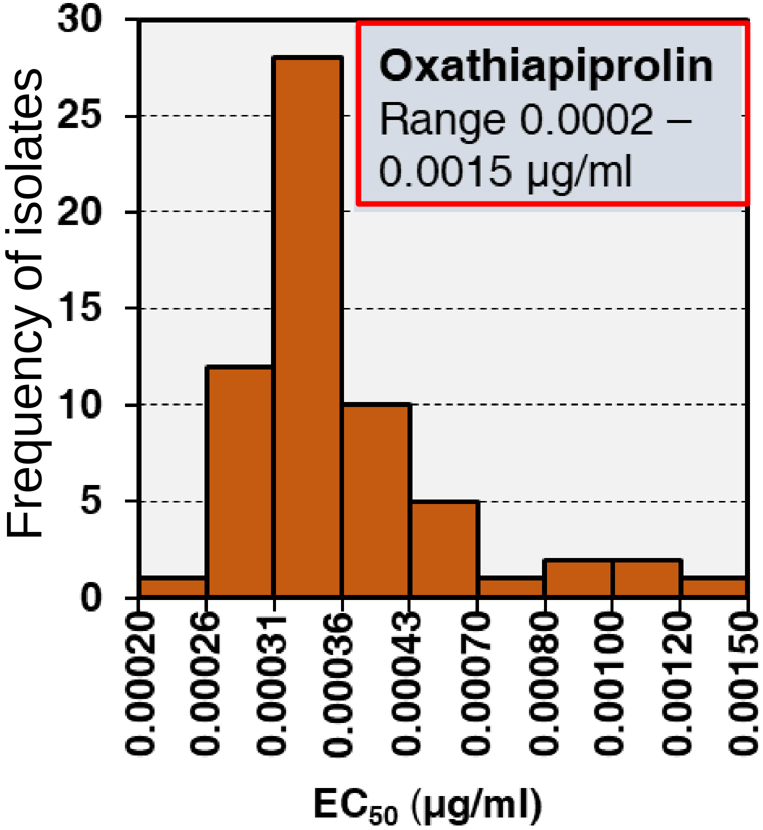
Experimentals: Kasumin was submitted to EPA for registration through IR-4. Kasumin was also effective against blast.

New antimicrobials (nisin, poly-L-lysine) approved for food use by FDA are exciting new approaches.

Epidemiology and Management of Phytophthora Root and Crown Rot of Almond



A) Chlamydospores of *P. parasitica*. B) Oospore of *P. cactorum*. C) Sporangium of *P. cactorum*. D) Sporangium of *P. cactorum* releasing zoospores.

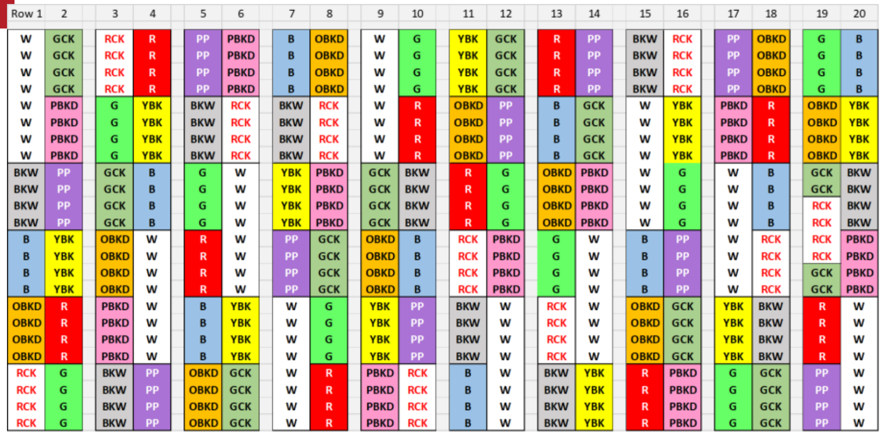


Frequency histogram of EC_{50} values to inhibit mycelial growth of 62 isolates of *Phytophthora citrophthora*. Similar data obtained for 11 *Phytophthora* spp. on almond and other tree crops.

Currently registered and new fungicides for managing Phytophthora Root and Crown Rot diseases

Common Name	Trade Name	Class	FRAC
metalaxyl, mefenoxam	Ridomil Gold	Phenylamides	4
fosetyl-Al, phosphorous acid	Various	Phosphonates	33
mandipropamid	Revus	CAAs	40
fluopicolide	Presidio	Benzamides	43
ethaboxam	Intego	Thiazole carboxamide	U5
oxathiapiprolin	Orondis	Piperidinyl thiazole isoxazolines	49

Field trial on the management of Phytophthora root and crown rot of almond



Row 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
W	GCK	RCK	R	PP	PBKD	B	OBKD	W	G	YBK	GCK	R	PP	BKW	RCK	PP	OBKD	G	B
W	GCK	RCK	R	PP	PBKD	B	OBKD	W	G	YBK	GCK	R	PP	BKW	RCK	PP	OBKD	G	B
W	GCK	RCK	R	PP	PBKD	B	OBKD	W	G	YBK	GCK	R	PP	BKW	RCK	PP	OBKD	G	B
W	GCK	RCK	R	PP	PBKD	B	OBKD	W	G	YBK	GCK	R	PP	BKW	RCK	PP	OBKD	G	B
W	PBKD	G	YBK	BKW	RCK	BKW	RCK	W	R	OBKD	PP	B	GCK	W	YBK	PBKD	R	OBKD	YBK
W	PBKD	G	YBK	BKW	RCK	BKW	RCK	W	R	OBKD	PP	B	GCK	W	YBK	PBKD	R	OBKD	YBK
W	PBKD	G	YBK	BKW	RCK	BKW	RCK	W	R	OBKD	PP	B	GCK	W	YBK	PBKD	R	OBKD	YBK
W	PBKD	G	YBK	BKW	RCK	BKW	RCK	W	R	OBKD	PP	B	GCK	W	YBK	PBKD	R	OBKD	YBK
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BKW	PP	GCK	B	G	W	YBK	PBKD	GCK	BKW	R	G	OBKD	PBKD	W	G	W	B	RCK	BKW
BKW	PP	GCK	B	G	W	YBK	PBKD	GCK	BKW	R	G	OBKD	PBKD	W	G	W	B	RCK	BKW
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OBKD	R	PBKD	W	B	YBK	W	G	YBK	PP	BKW	W	RCK	W	OBKD	GCK	YBK	BKW	R	W
OBKD	R	PBKD	W	B	YBK	W	G	YBK	PP	BKW	W	RCK	W	OBKD	GCK	YBK	BKW	R	W
OBKD	R	PBKD	W	B	YBK	W	G	YBK	PP	BKW	W	RCK	W	OBKD	GCK	YBK	BKW	R	W
OBKD	R	PBKD	W	B	YBK	W	G	YBK	PP	BKW	W	RCK	W	OBKD	GCK	YBK	BKW	R	W
RCK	G	BKW	PP	OBKD	GCK	W	R	PBKD	RCK	B	W	BKW	YBK	R	PBKD	G	GCK	PP	W
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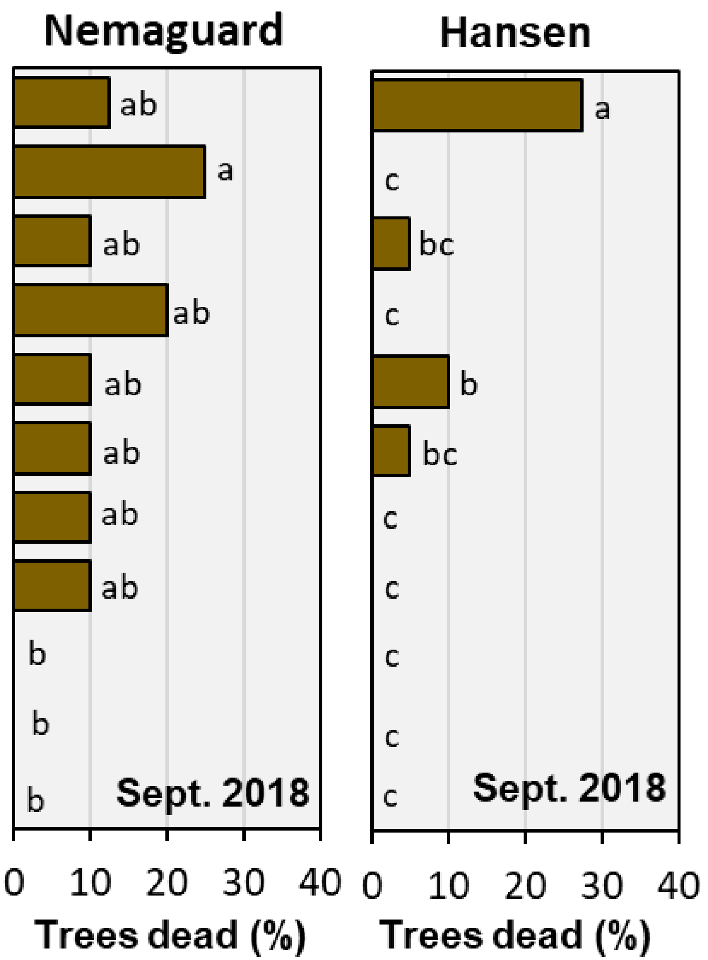
RCK	G	BKW	PP	OBKD	GCK	W	R	PBKD	RCK	B	W	BKW	YBK	R	PBKD	G	GCK	PP	W
RCK	G	BKW	PP	OBKD	GCK	W	R	PBKD	RCK	B	W	BKW	YBK	R	PBKD	G	GCK	PP	W

Plot map

Treatment	Rate(/A)
Control	---
Ridomil Gold 480SL	1 pt
Intego	10 fl oz
Prophyt	64 fl oz
Presidio	6 fl oz
Presidio + Intego	6 + 10 fl oz
Prophyt + Ridomil Gold	64 + 16 fl oz
Revus 250SC	8 fl oz
Orondis 100 OD	4.8 fl oz
Orondis 100 OD	9.6 fl oz
Orondis 100 OD	19.2 fl oz

P. cactorum was isolated



Orondis was highly effective on both rootstocks, whereas, Revus, Presidio, and Intego also were very effective on Hansen against Phytophthora root rot.

Thank you
Danke
Gracias
Merci
Cheers
谢谢
ありがとう
धन्यवाद
спасибо
شكرا

Happy holidays!

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University of California, Riverside

california almonds
Almond Board of California