
THE ALMOND CONFERENCE
2025
WELCOME!
1
CULTIVATING A HEALTHIER
FUTURE

STAYING AHEAD OF ALMOND PEST & DISEASE THREATS

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Carpophilus Beetle

Updates on Ecology, Monitoring and Management

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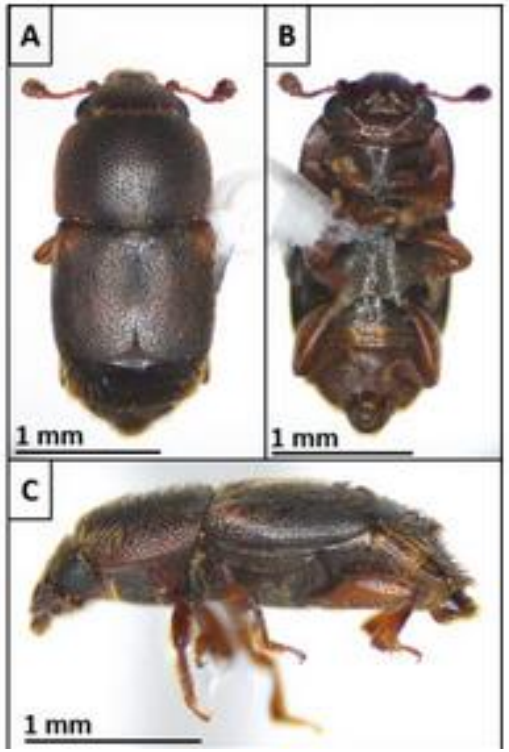
Carpophilus Beetle Background and Pest Status

Carpophilus Beetle

Origins + Arrival in CA



Species/Common Names

Order: Coleoptera

Family: Nitidulidae

Species: *Carpophilus truncatus*

Common Name: Carpophilus beetle

("car-pof-uh-lus")

Current Distribution

- Center of origin is unclear – they are globally distributed
- Originally described from collections in Madagascar
- Systematics remains unclear w/ >200 species of *Carpophilus* spp.

Recent Global Spread

- 2010s – reported on almonds in Australia
- 2020s – reported on walnuts in Argentina and Italy
- 2023 – reported on almonds/pistachios in California

scientific reports

The spread of *Carpophilus truncatus* is on the razor's edge between an outbreak and a pest invasion

Flavia de Benedetta[1,2], Simona Gargiulo[1], Fortuna Miele[1], Laura Figlioli[1], Michele Innangi[3], Paolo Audisio[4], Francesco Nugnes[1] & Umberto Bernardo[1]✉

https://www.nature.com/articles/s41598-022-23520-2

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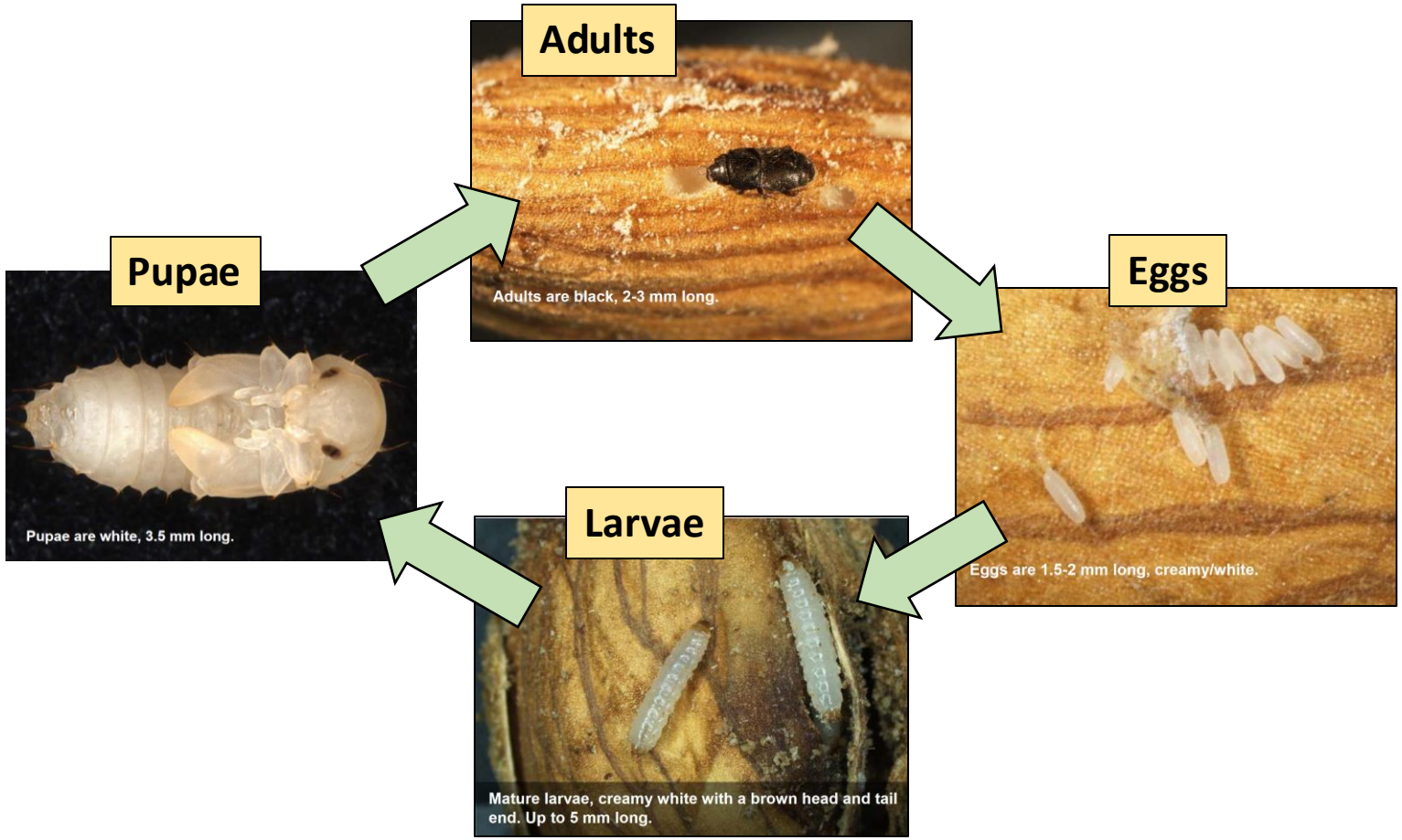
Carpophilus Beetle

Life Stages



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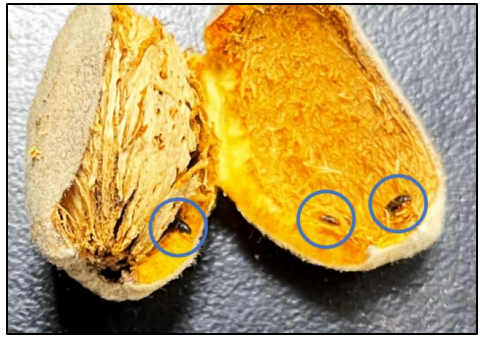
Images: Agriculture Victoria Research 2022 (Australia)

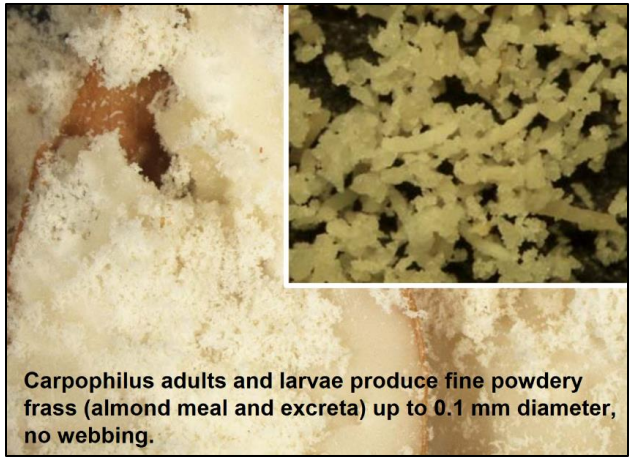
Carpophilus Beetle

Seasonal Phenology

Pest Status

- Adults chew through the shell and deposit eggs
- Larvae tunnel into the developing nuts
- Pupate in the soil





Carpophilus adults and larvae produce fine powdery frass (almond meal and excreta) up to 0.1 mm diameter, no webbing.

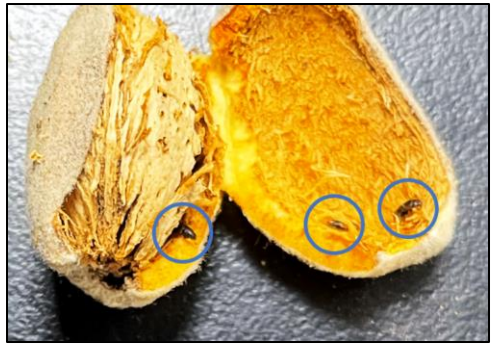
Tunnels chewed by carpophilus larvae are often flattened in cross-section.

Carpophilus Beetle

Seasonal Phenology

Overview

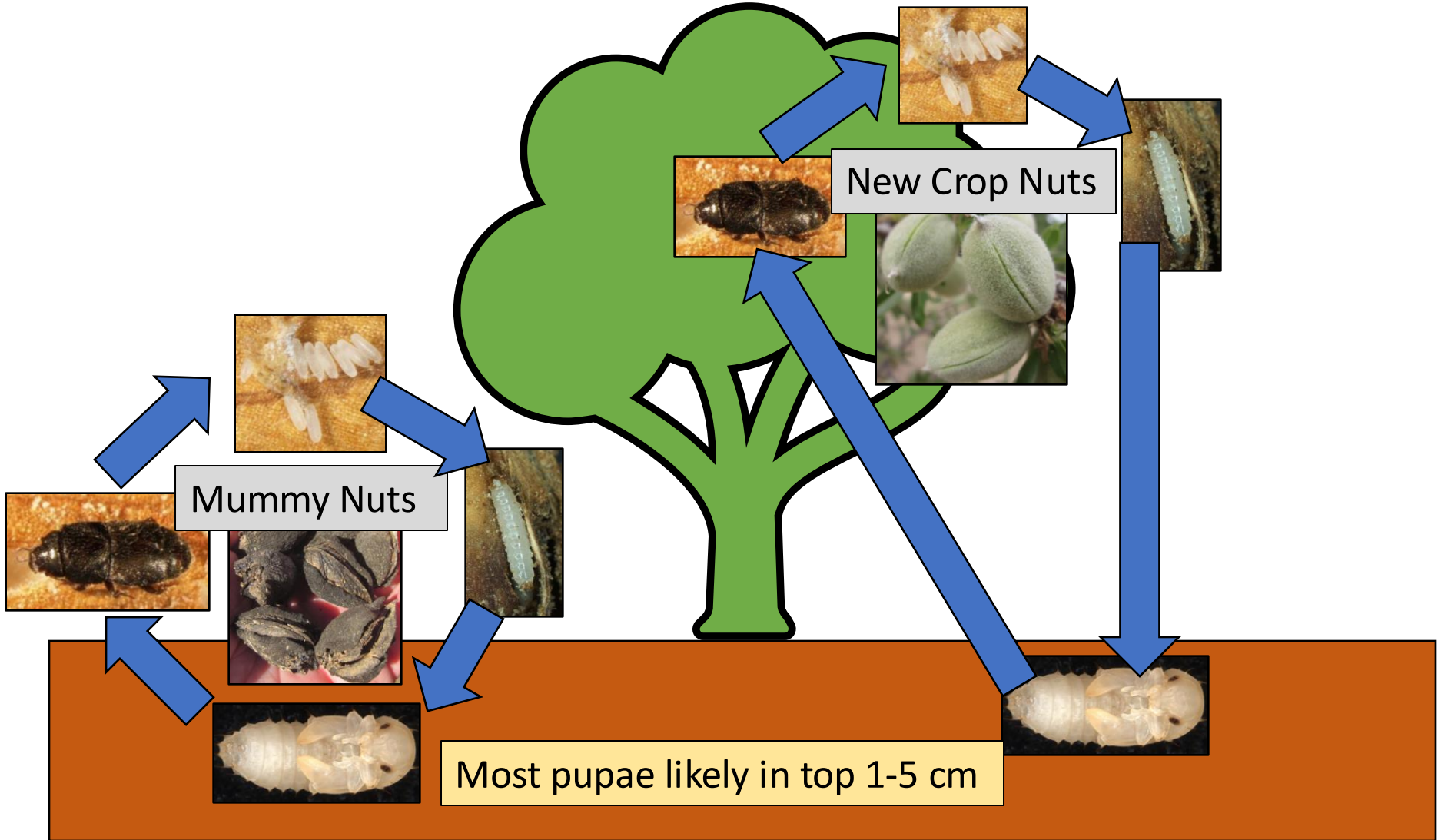
- Overwinter in remnant mummy nuts
- Beetles become active on mummies in the spring
- Infest new crop nuts at hull-split
- Adults can chew through shell, then deposit eggs
- Larvae feed on the developing nuts – leaving frass and tunnels



Carpophilus Beetle

Infest Mummy + New Crop Nuts

Pupate in the Soil



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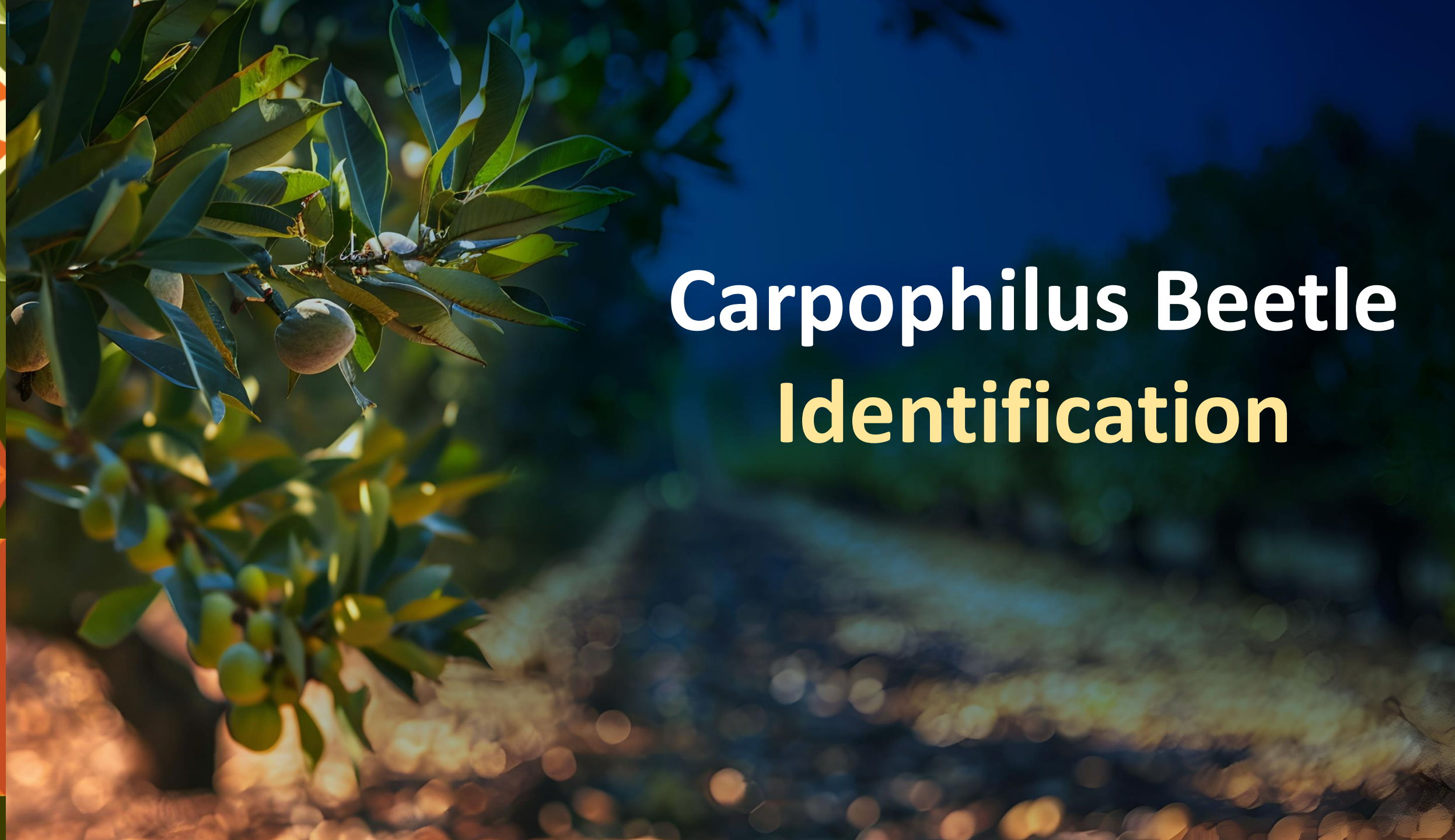


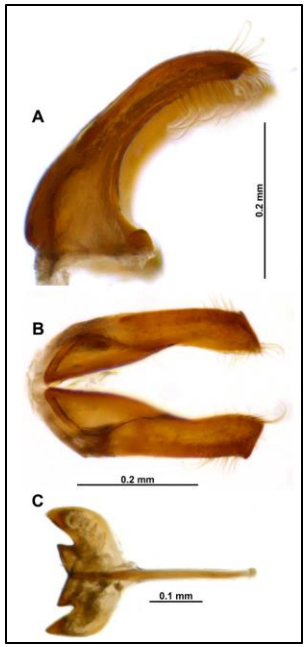
Carpophilus Beetle Identification

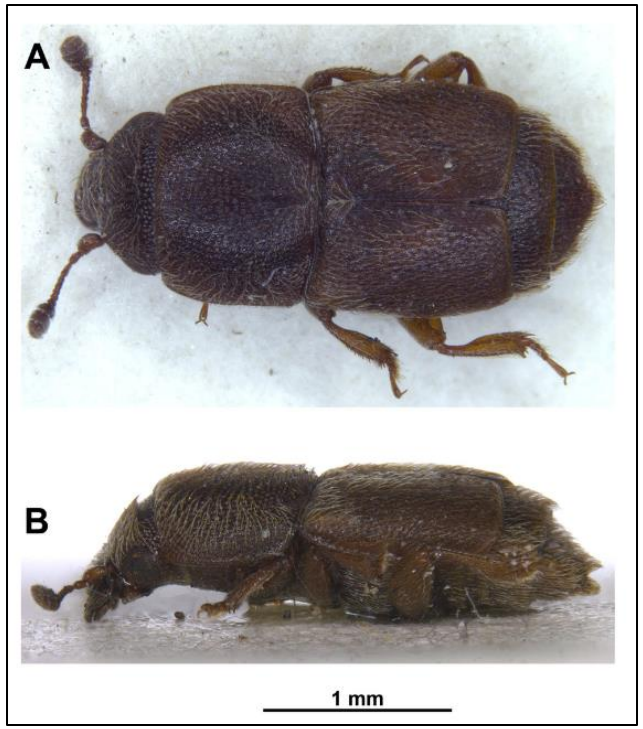
Carpophilus Beetle

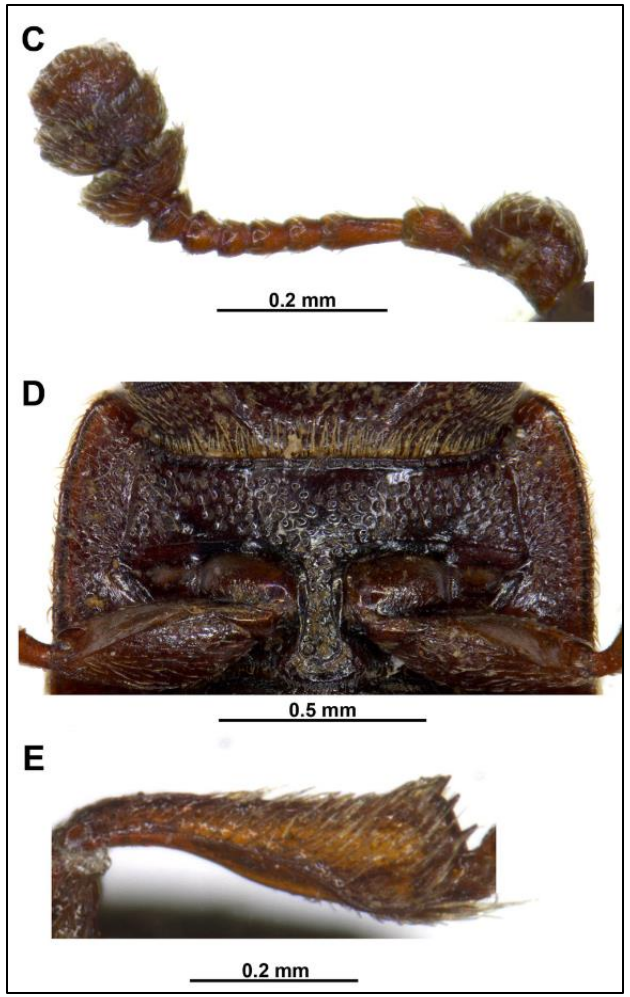
Identification is a Challenge

Adult Features

- Adult body length ranges 2.8-3.4 mm
- Morphological ID is based on very fine features / male genitalia
- Clubbed antennae (not unique to this species though)
- Pitting on bottom side of thorax
- Changes in diameter of the hind leg







Images: Semeraro et al. 2023

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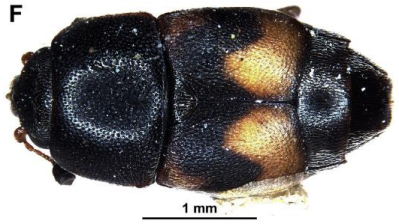
Carpophilus Beetle

Other Common Species in California Orchards

Driedfruit Beetle
Carpophilus hemipterus

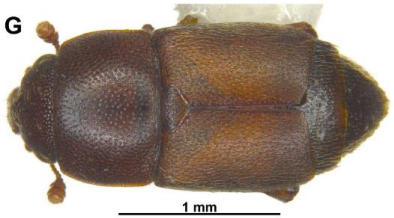


Semararo et al. 2023


UC IPM

Bugwood.org

Confused Sap Beetle
Carpophilus mutilatus



Semararo et al. 2023


U. Schmidt 2013


UC IPM

Lots of little dark beetles – *but only one of them is really a problem!*

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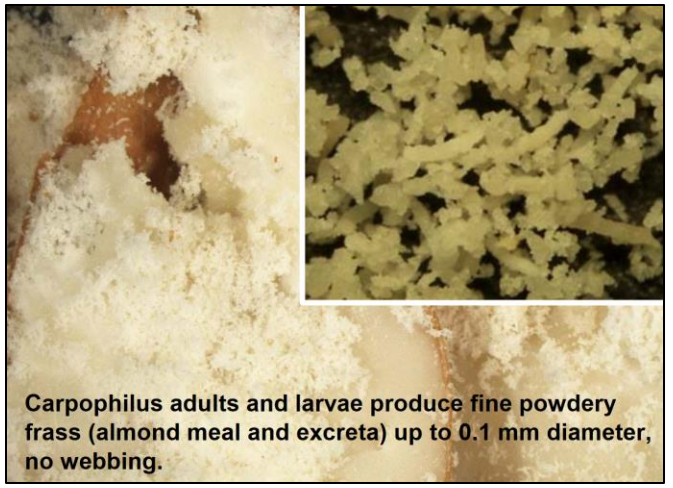
Carpophilus truncatus

Only species that feeds directly on the kernel!

Fairly distinct evidence of this damage

Produce a fine powdery frass

Carpophilus tend to consume the meat of the kernel and leave the brown skin.



Carpophilus adults and larvae produce fine powdery frass (almond meal and excreta) up to 0.1 mm diameter, no webbing.

Make oval shaped tunnels

Tunnels chewed by carpophilus larvae are often flattened in cross-section.

Entrance hole without any distinguishing external or internal features (frass, webbing, powder or insects).

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Carpophilus truncatus

Only species that feeds directly on the kernel!

Fairly distinct evidence of this damage

Carpophilus Damage ID Guide

Source: Rijal, J., Ghimire, M., Wilson, H., Gyawaly, S., Haviland, D. 2024. "A visual guide to identifying invasive carpophilus beetle damage in almonds: differentiating carpophilus beetle from navel orangeworm and ant damage"
http://www.sacvalleyorchards.com/wp-content/uploads/2024/08/Carpophilus-Flyer-med.pdf

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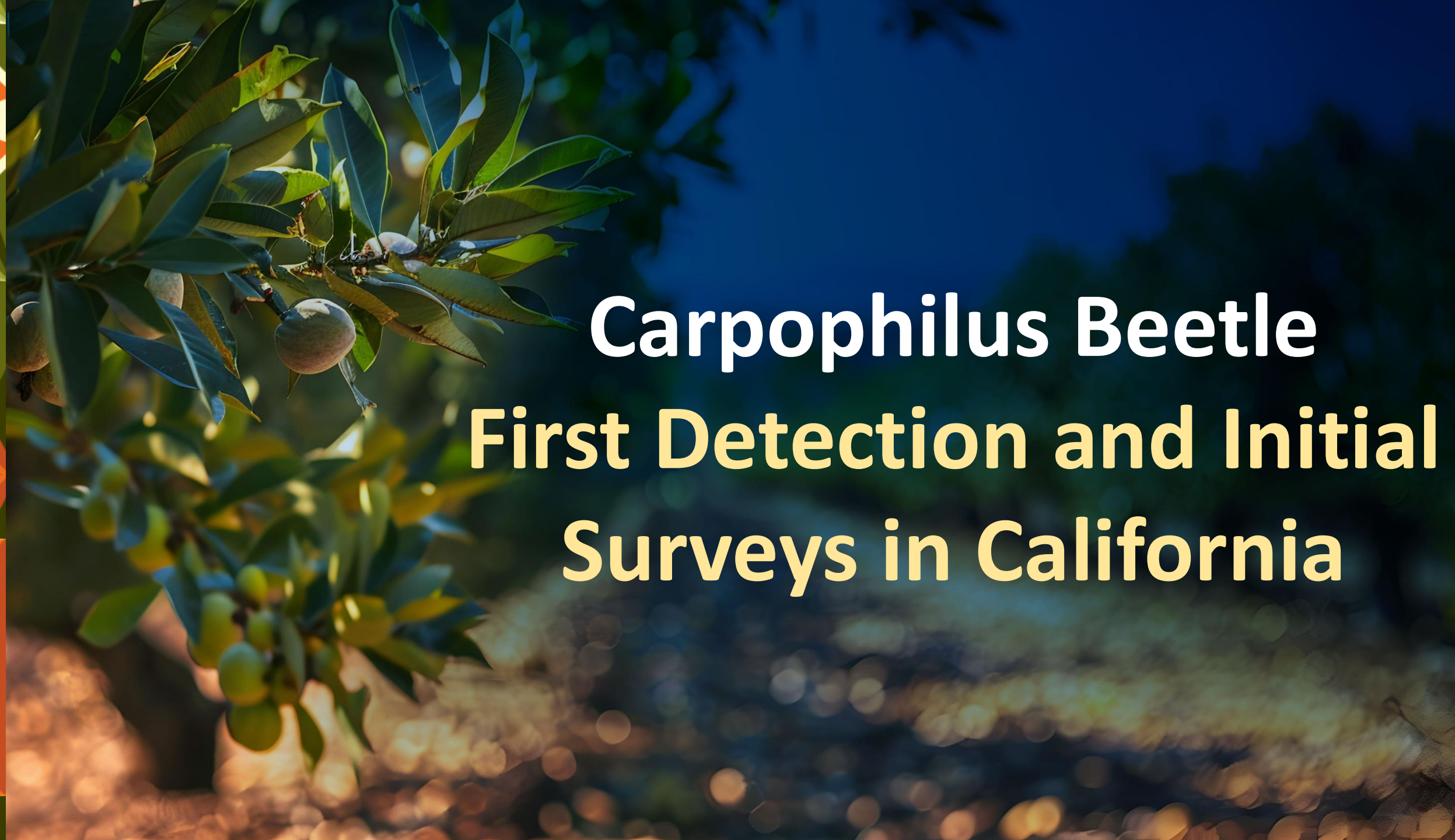

Carpophilus Beetle
First Detection and Initial
Surveys in California

Carpophilus Beetle

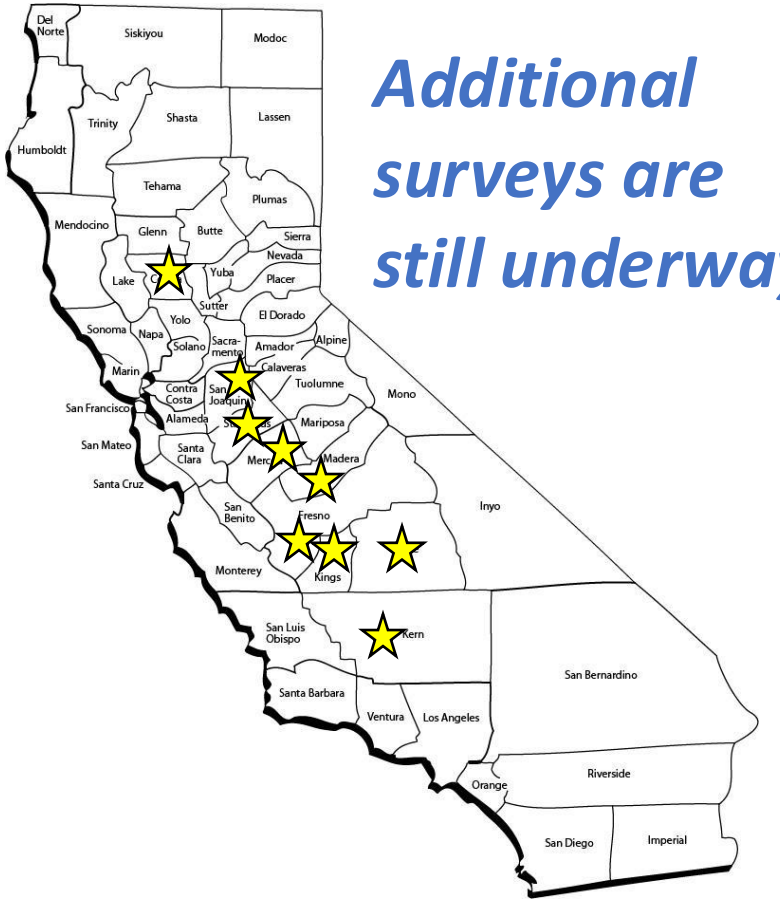
Timeline of Events in CA - 2023

[Aug/Sept] - First Confirmed Find in Madera/Kings Counties

- **Almond – Madera Co.**
- **Pistachio – Kings Co.**

[Sept/Oct] - Launched Broader Survey

- **Current Range:** San Joaquin Valley + Sacramento Valley
- **Confirmed Hosts:** Almond + Pistachio + Walnut



Additional surveys are still underway

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Carpophilus Beetle

Timeline of Events in CA - 2023

[Oct/Nov] – Connected with Australian Researchers

- **Lots of great information on ecology/mgmt**
- **Collaboration to test new pheromone lures**

[Nov/Dec] – Put Together a Game Plan for 2024

- **Extension materials**
- **Proposals to CA Pistachio Research Board and Almond Board of CA**

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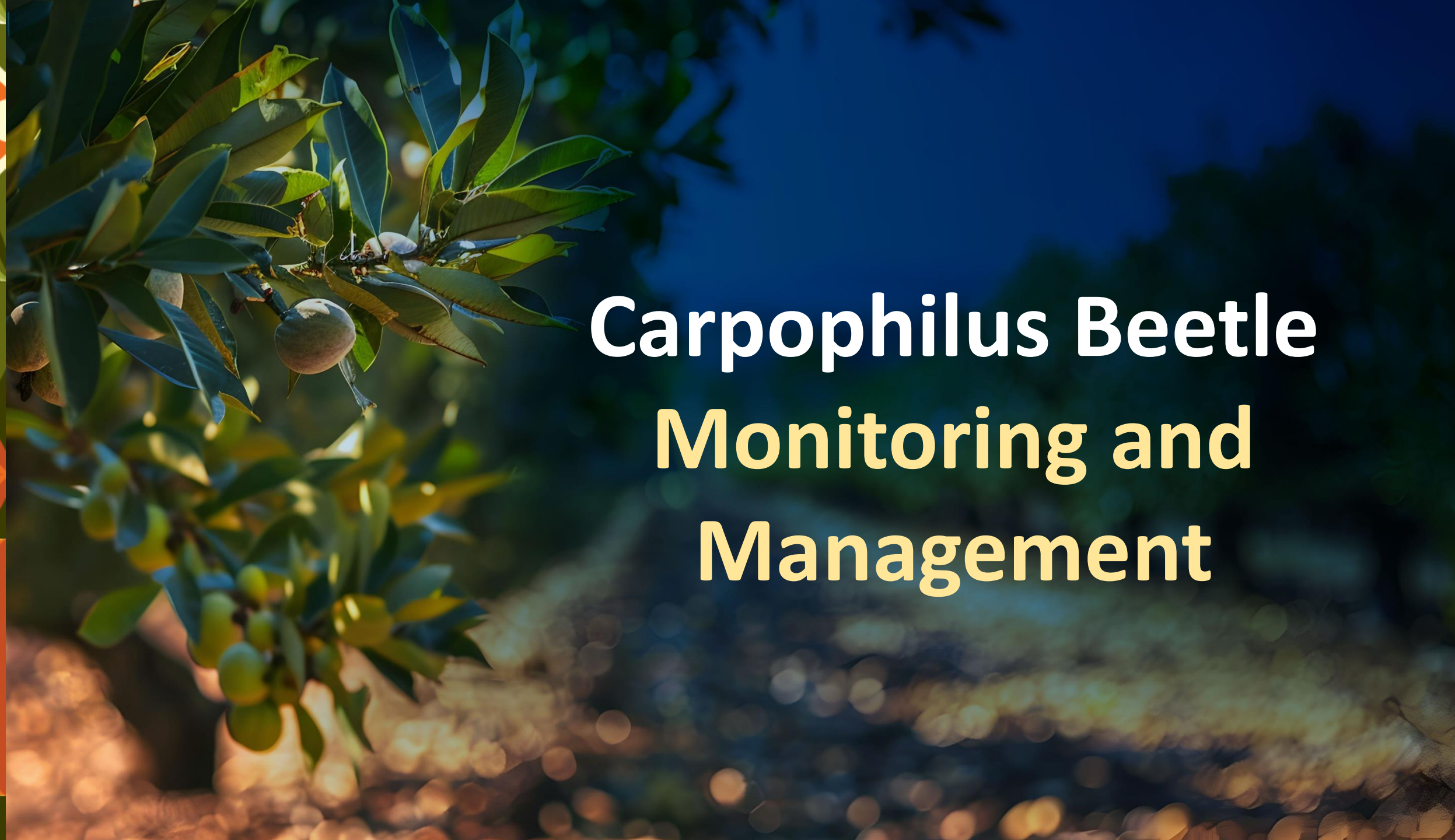
Carpophilus Beetle
Monitoring and
Management

Carpophilus Beetle

Monitoring and Management

Monitoring

- **No traps or lures available yet**
- **Directly inspect remnant and new crop nuts, especially at harvest**

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Images: Madge 2022

Carpophilus Beetle

Monitoring and Management

Monitoring

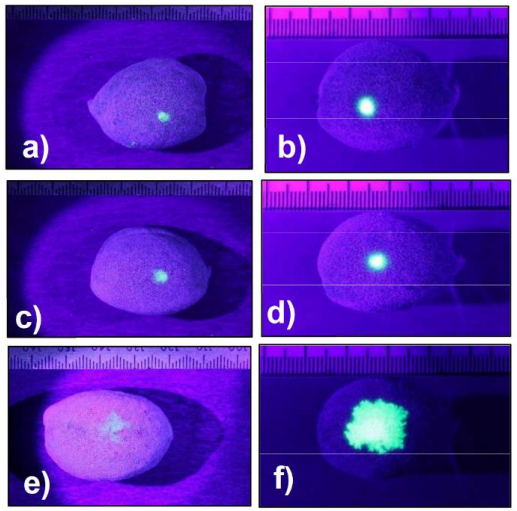
- No traps or lures available yet
- Directly inspect remnant and new crop nuts, especially at harvest

Figure 2. Nuts ready for burial at 0 cm (left) and 90 cm (right).

Adults will survive on mummies even when buried ~3 ft deep!

Management

- Biological control – very limited
- Chemical control – highly variable due to coverage issues
- CROP SANITATION – highly important!



Spray coverage is a major challenge

Crop sanitation is the key to controlling carpophilus beetle!

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Images: Madge 2022


Carpophilus Beetle
Results from Research
in 2024 – 2025

Carpophilus Beetle

Spring Emergence and Movement into Canopy

Activity Periods on Ground / in Canopy

- *Cohorts of remnant mummy nuts placed into emergence cages*
- *Cages checked weekly for carpophilus beetle activity*

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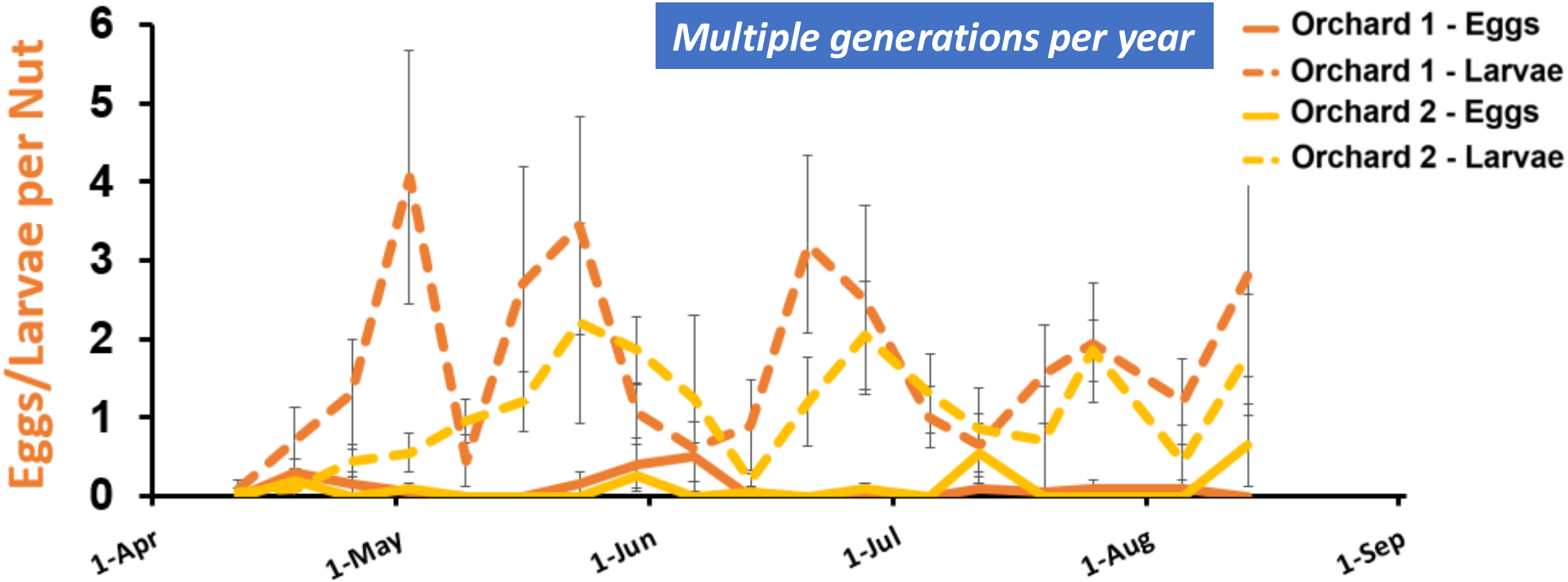
Photos: Mahesh Ghimire & Jhalendra Rijal (UC IPM)

Carpophilus Beetle

Characterize Seasonal Phenology in CA

Key Features

- Overwinter in remnant/mummy nuts
- Infest new crop nuts at hull-split
- Multiple generations per year



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Figures: Mahesh Ghimire & Jhalendra Rijal (UC IPM)

Carpophilus Beetle

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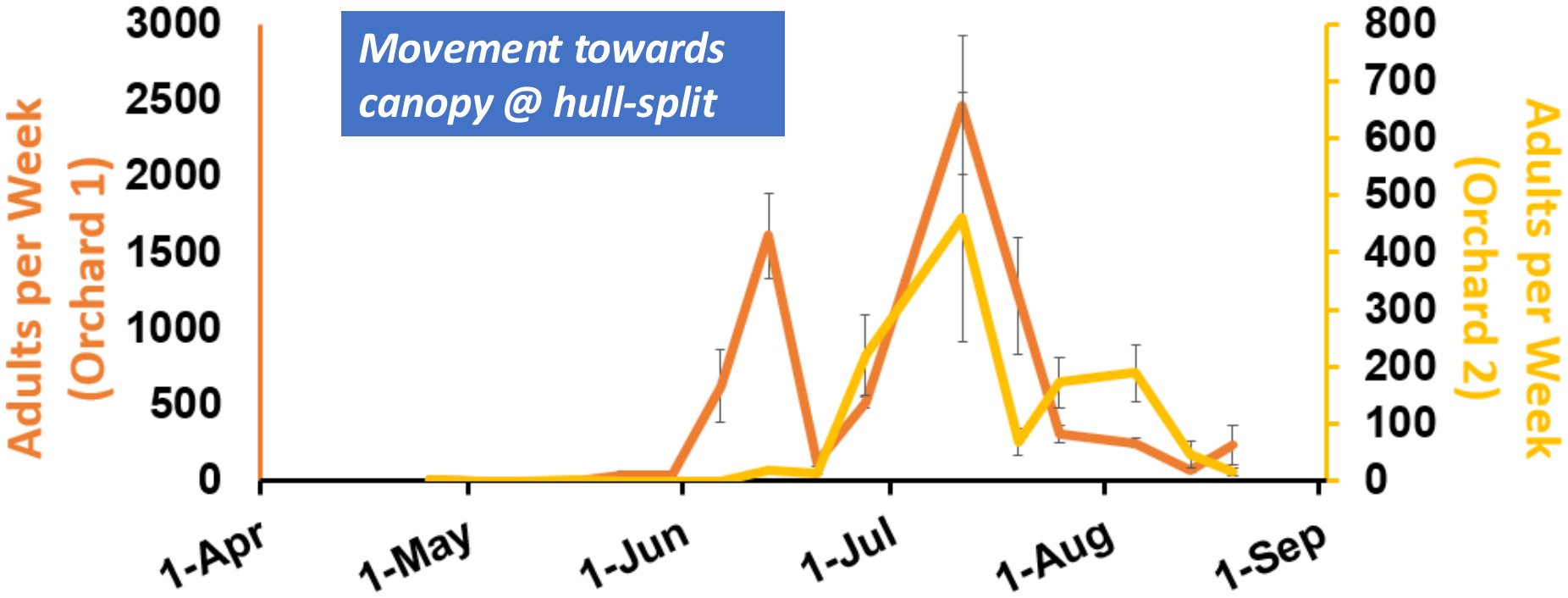

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Figures: Mahesh Ghimire & Jhalendra Rijal (UC IPM)

Carpophilus Beetle

Phenology and Temperature Models

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Carpophilus Beetle

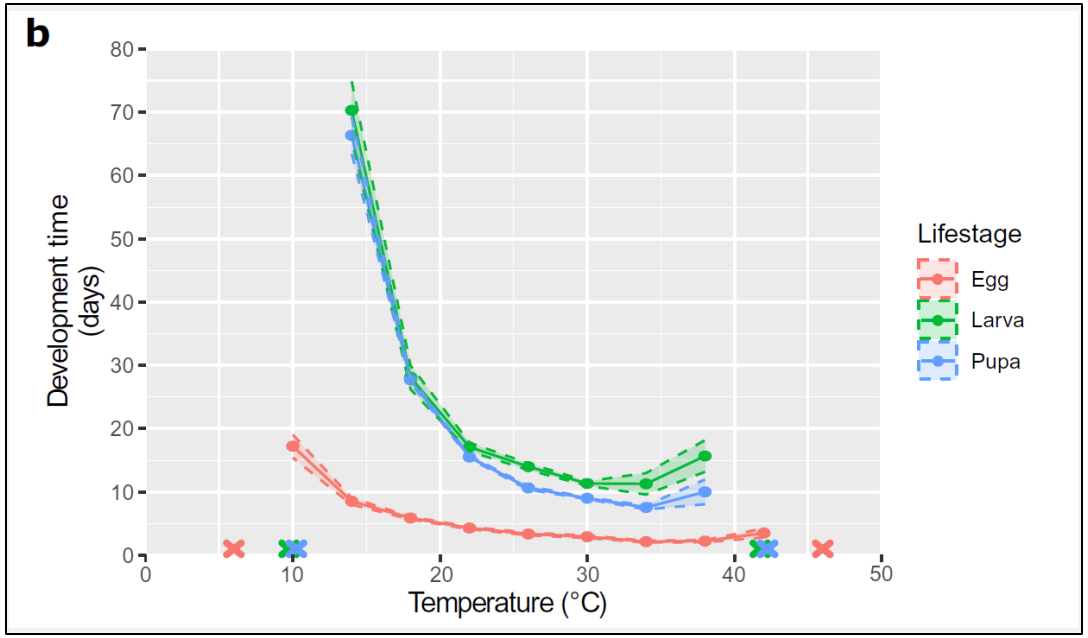
Phenology and Temperature Models

Development Thresholds

Min: 43-50°F

Max: 107-114°F

Egg to adult in ~28 days @ 86°F



Figures/Date: Tobin and Cunningham (2024) "Establishing the distribution of *Carpophilus truncatus* in Australia using an integrative approach for an emerging global pest" *Scientific Reports* 14: 19553

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Carpophilus Beetle

Phenology and Temperature Models

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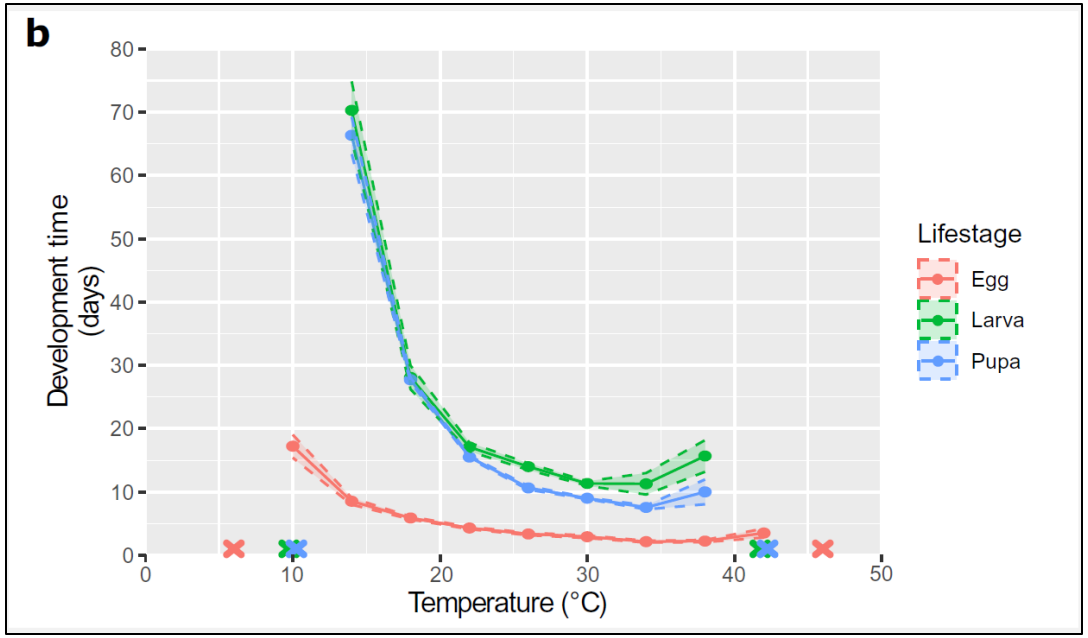


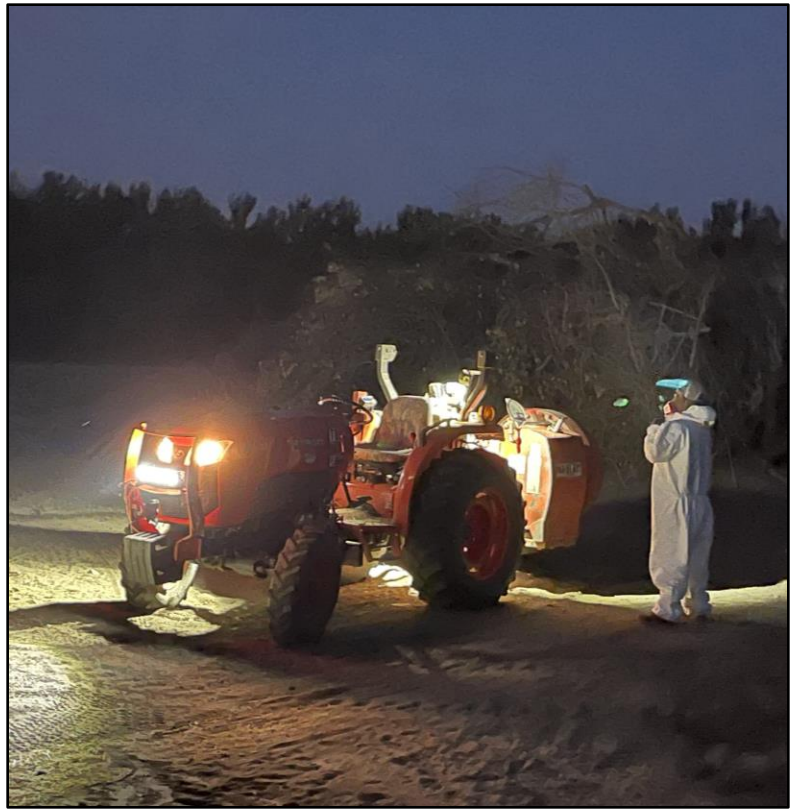
Now looking at performance on almonds, pistachios and walnuts

Figures/Date: Tobin and Cunningham (2024) "Establishing the distribution of *Carpophilus truncatus* in Australia using an integrative approach for an emerging global pest" *Scientific Reports* 14: 19553

Carpophilus Beetle

Evaluation of Chemical Controls @ Hull-Split

Almonds



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Photos: Mahesh Ghimire & Jhalendra Rijal (UC IPM)

Carpophilus Beetle

Evaluation of Chemical Controls @ Hull-Split

No measurable impacts in first attempt

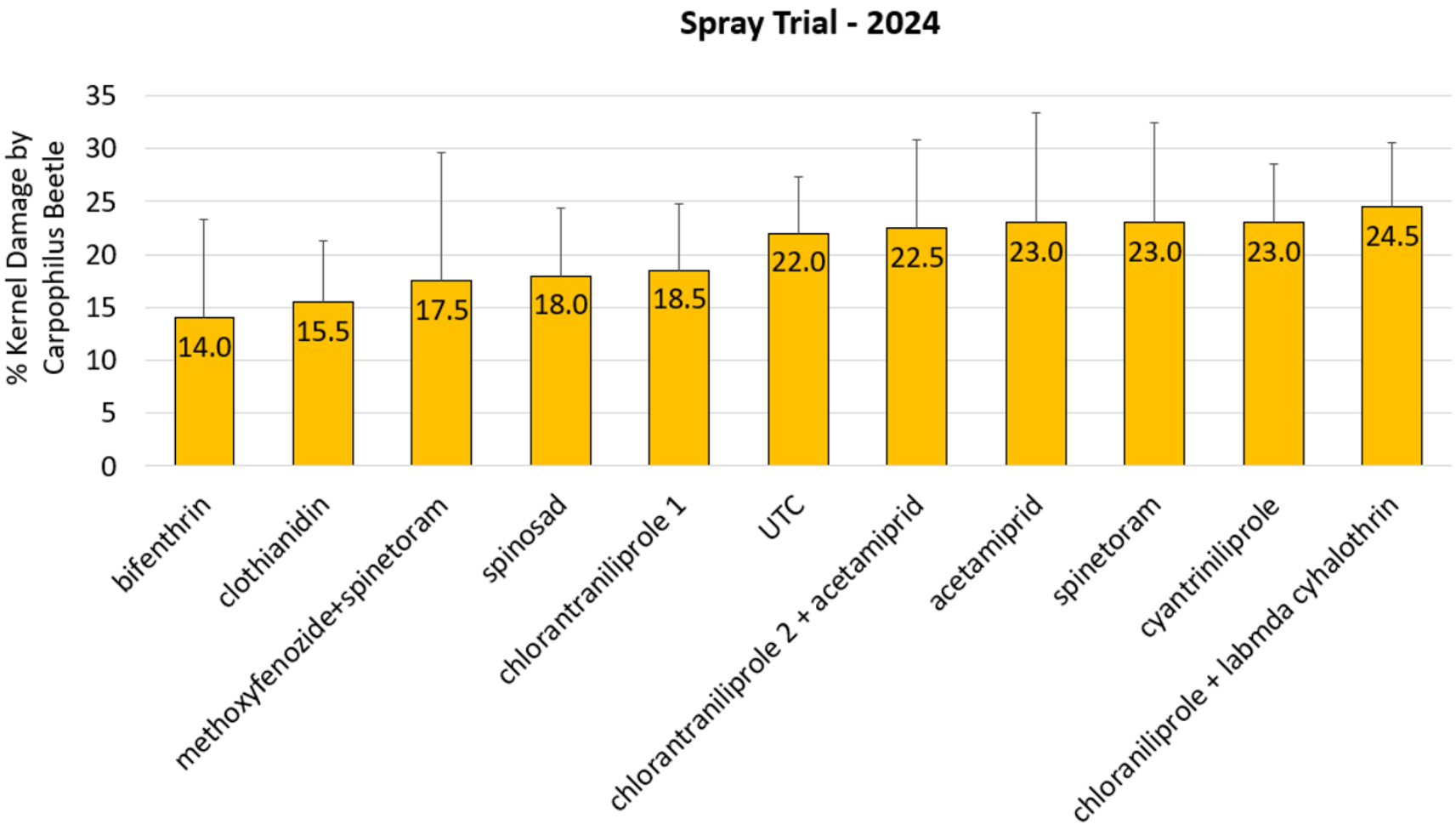

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Figure: Mahesh Ghimire & Jhalendra Rijal (UC IPM)

Carpophilus Beetle

Evaluation of Chemical Controls @ Hull-Split

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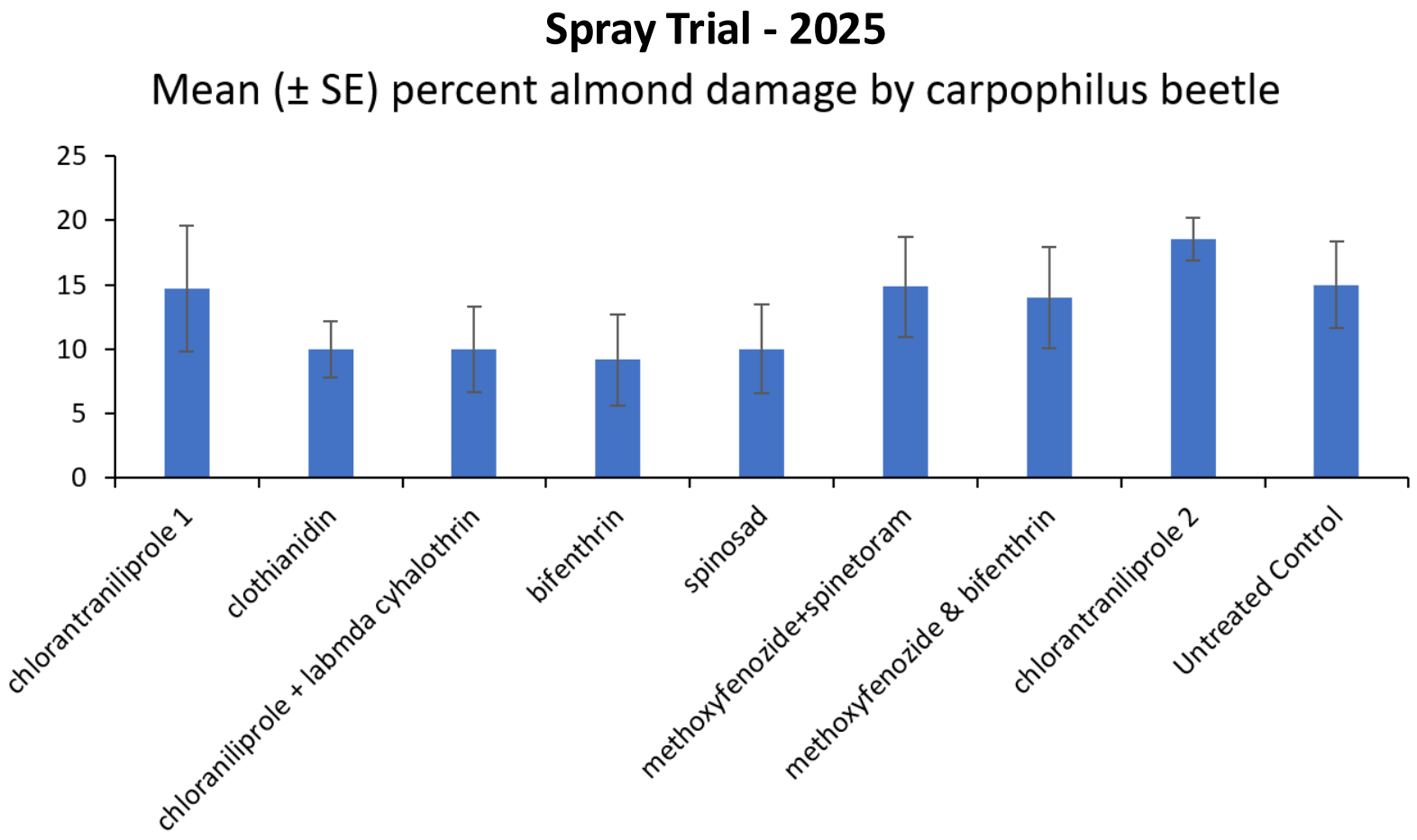

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Figure: Mahesh Ghimire & Jhalendra Rijal (UC IPM)

Carpophilus Beetle

Measured Infest in Tree Canopy

Tends to be Higher in the Lower Canopy

Reva Scheibner (Wilson Lab) collecting nuts from the upper, middle and lower canopy

Carpophilus Beetle

Evaluating New Pheromone Lures

- **Pheromone compounds have been identified and synthesized by the Australians**
- **We're helping them to refine the lure composition/use**
- **No lures are commercially available…yet**

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Carpophilus Beetle

Evaluating New Pheromone Lures

So Far – They Attract A LOT of Carpophilus Beetles

Bucket trap placed at ground level with pheromone and co-attractant

1,000s of carpophilus beetles captured

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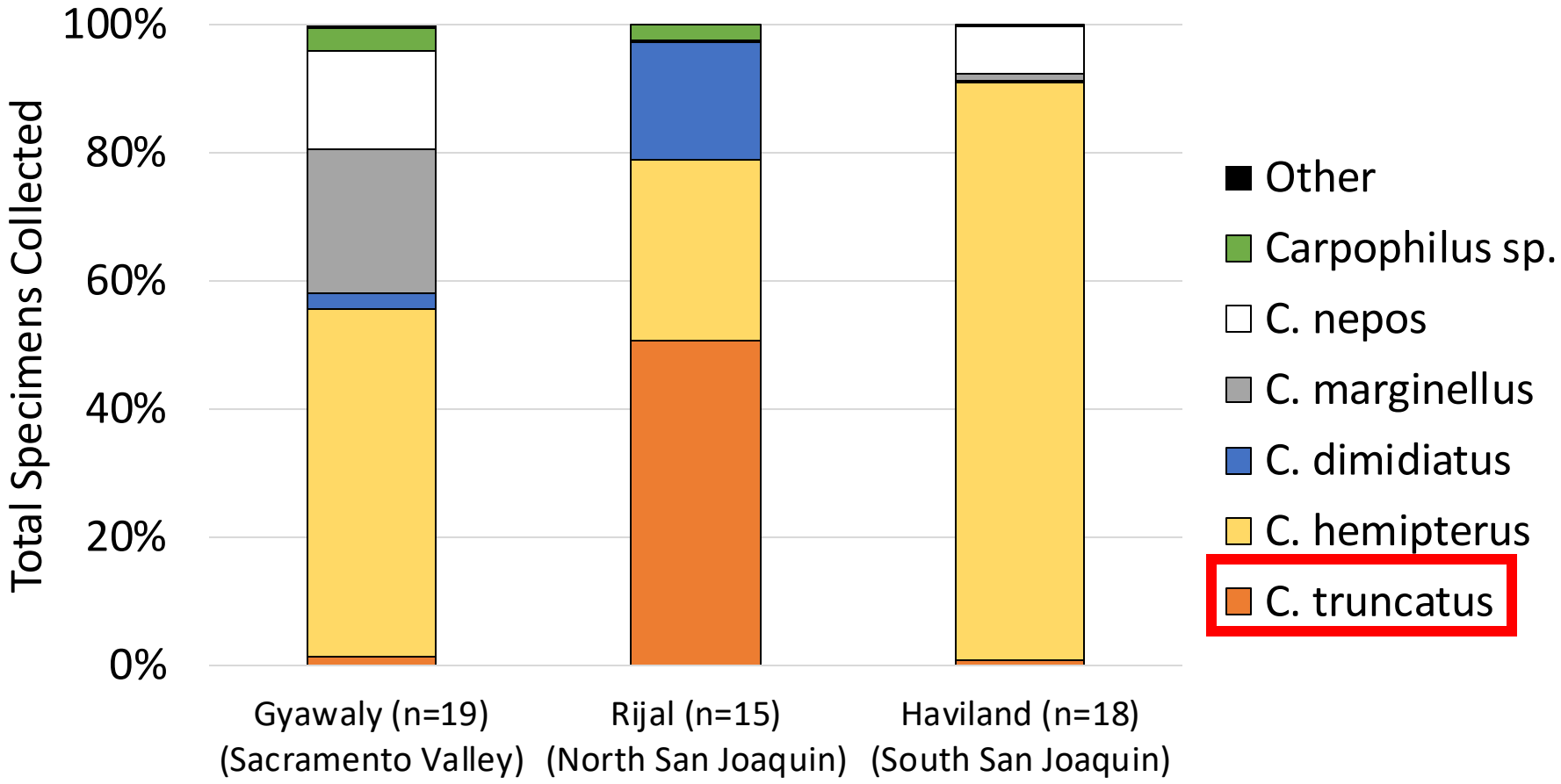
Carpophilus Beetle

Regional Distribution of *Carpophilus truncatus*

Higher Populations in Northern San Joaquin Valley

Carpophilus Species Composition – Findings to Date



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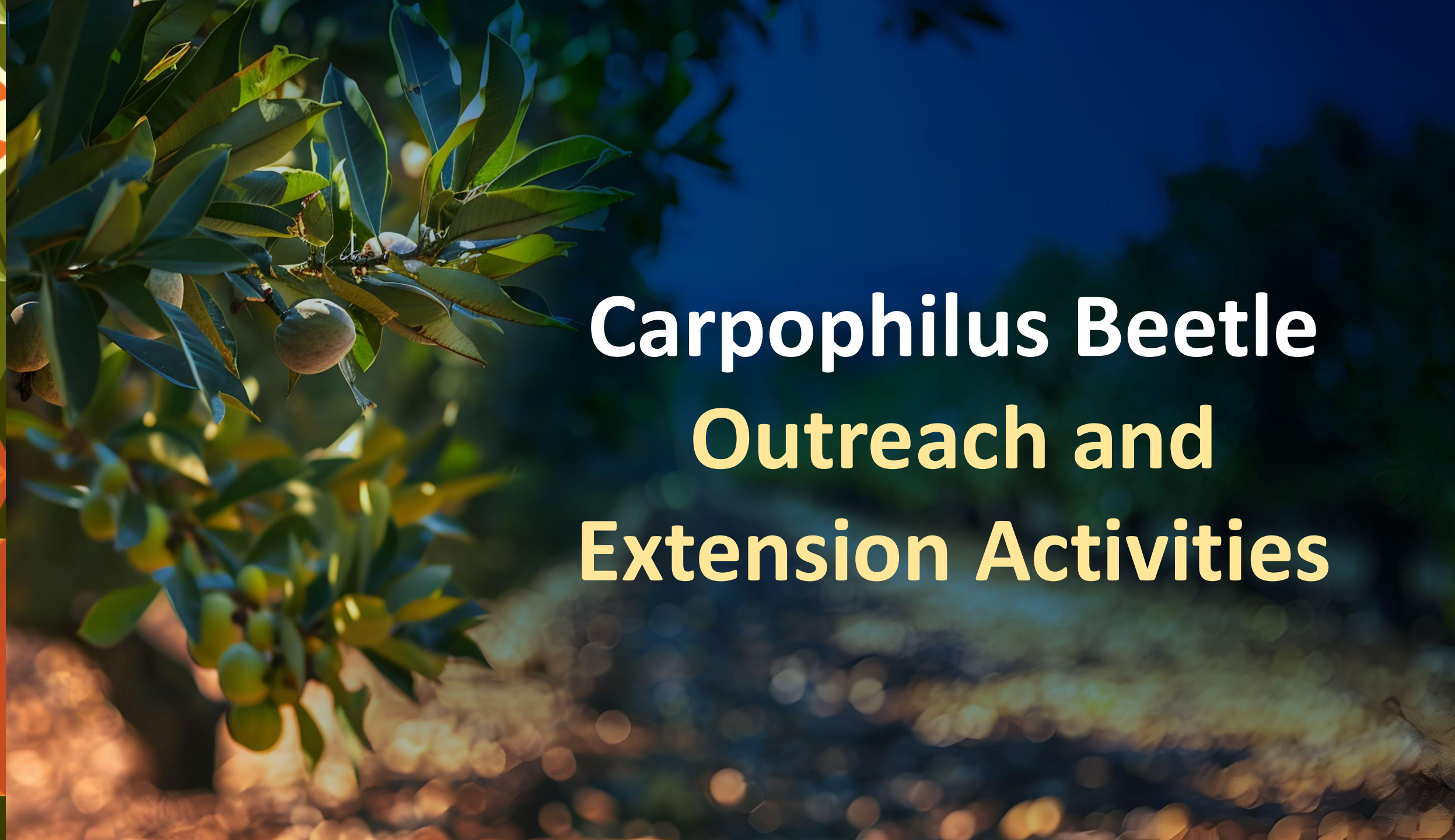
Carpophilus Beetle
Outreach and
Extension Activities

Carpophilus Beetle

Outreach and Education Activities

Articles in Trade Journals

Dozens of Talks Across the State

New Pest ID Guide

http://www.sacvalleyorchards.com/wp-content/uploads/2024/08/Carpophilus-Flyer-med.pdf

Webinar with Research and Industry in Australia

https://youtu.be/Ybduf-jm3mQ

Carpophilus Webinar with Growers and Researchers in Australia

All Available Online

https://treecrops.ucr.edu/

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Carpophilus Beetle
Conclusions and Next Steps

Carpophilus Beetle

Key Take-Aways

Life-Cycle

- Overwinter in remnant mummy nuts, active in the spring
- Reproduce on mummies all year, attack new crop nuts at hull-split

Monitoring

- Visually inspect nuts (crack out)
- Pheromone trap in development – insect ID a challenge

Control Strategies

- Biological control is limited
- Chemical controls face major coverage challenges
- CROP SANITATION IS KEY TO CONTROL!

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Carpophilus Beetle

Next Steps…

Continued Funding

- Almond Board of California | CA Pistachio Research Board
- USDA APHIS Plant Protection Act 7721

Monitoring

- Continue to Characterize Phenology in CA
- Clarify Regional Intensity of Infestations
- Refine the Use of Pheromone Lures

Control Strategies

- Evaluate New Sanitation Equipment
- Screen More Pesticides
- Understand Impact of Soil Conditions on Pupation Success
- Mass-trapping?

Images: Agriculture Victoria Research 2022

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Thank You! Questions?

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Acknowledgements:

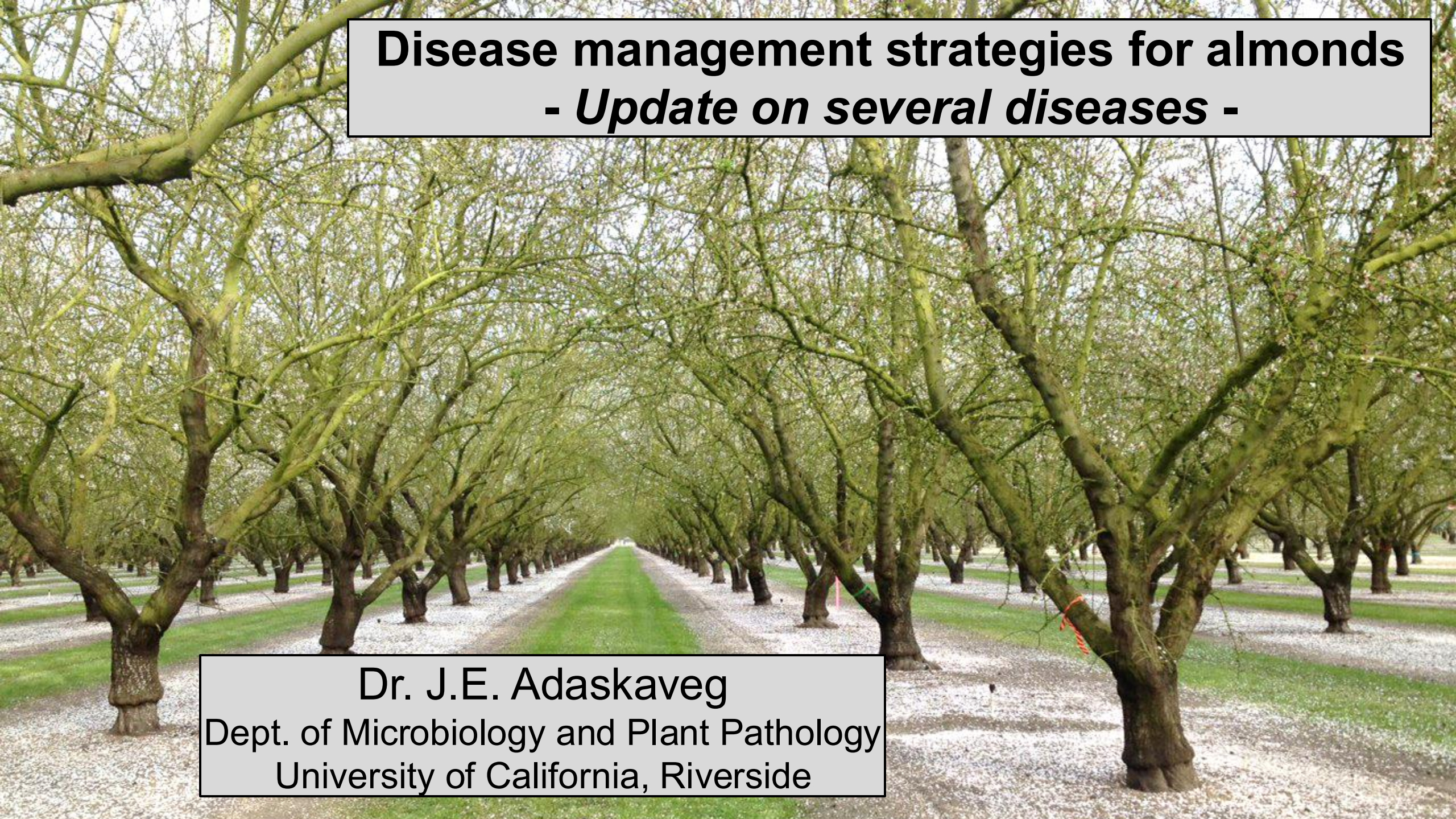
[Lab Assistants] Sarah Meierotto, Nathalie Baena-Bejarano, Victoria Morelos, German Camacho, Reva Scheibner, Marina Mendiola, Juan Alonso

[Cooperators] Idong Mokwunye (UC IPM)

[Funding] The Almond Board of California, California Pistachio Research Board and USDA APHIS Plant Protection Act 7721

Numerous growers and pest control advisors (PCAs) who helped us collect samples and identify infested field sites.

Disease management strategies for almonds
- *Update on several diseases* -



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

Flower, foliar, fruit, and root/crown diseases of almond

Bacterial, Fungal, Oomycota, etc…..

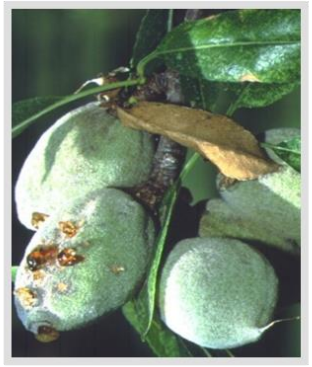

Brown rot blossom blight


Green fruit rot/Jacket rot


Shot hole


Bacterial spot


Bacterial blast


Anthracnose


Scab


Alternaria leaf spot

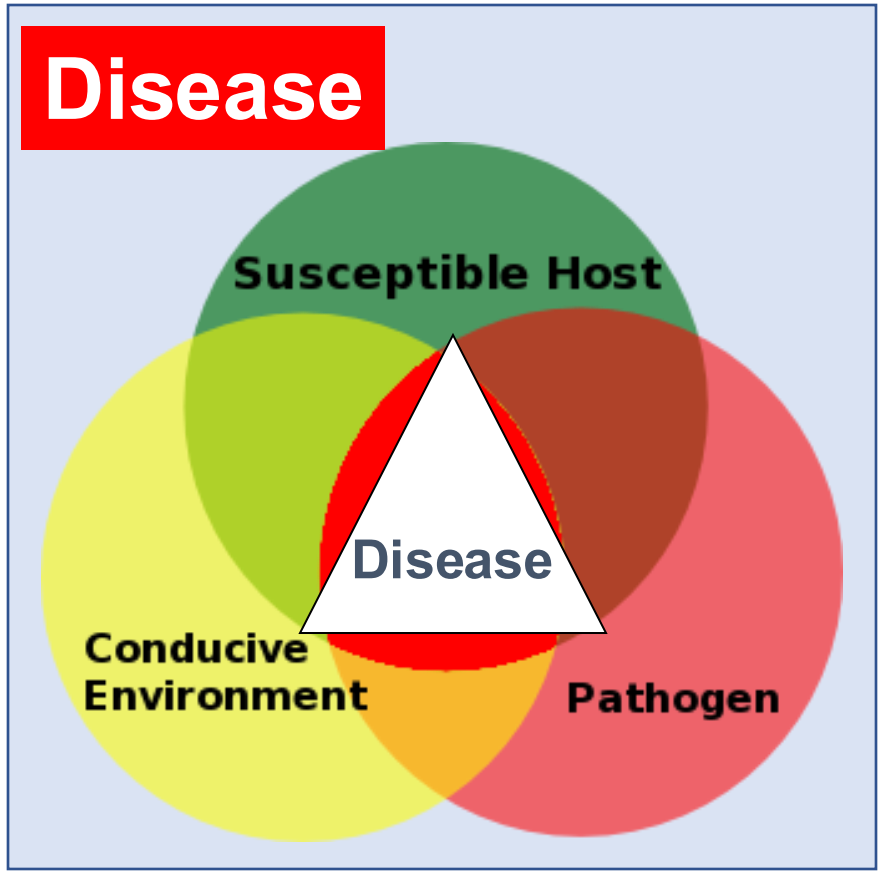

Rust

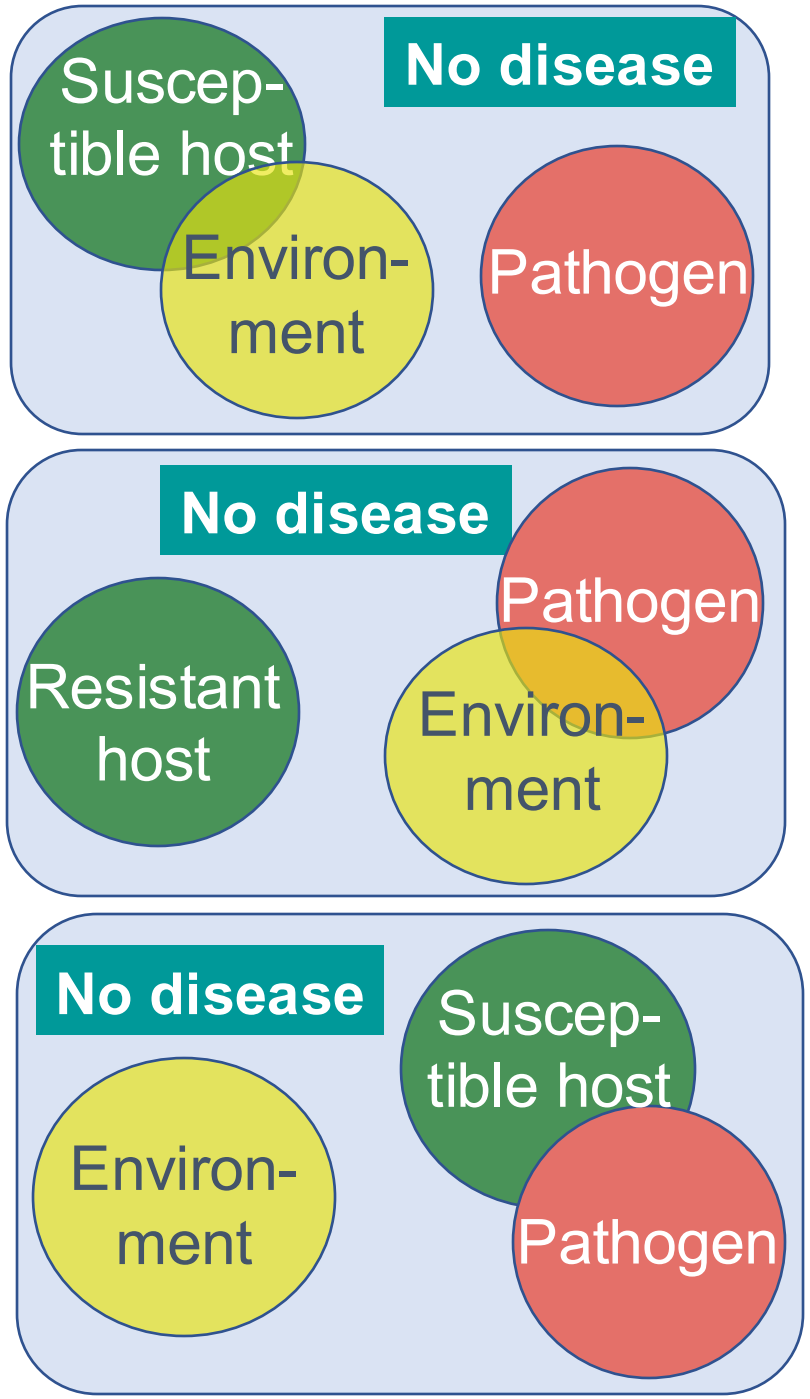

Hull rot


Phytophthora root and crown rot

- Although the almond crop can be affected by numerous diseases caused by fungi, fungal-like organisms and bacteria, climatic conditions of California generally limit severe disease outbreaks.
- Fungicide/bactericide applications have the potential to be minimized.

The foundation of Plant Pathology: *The Disease Triangle*





The impact of the components of the disease triangle can be modified:

- We can modify the **orchard environment** and **host susceptibility** to reduce disease pressure.
- We can monitor for the presence of the **pathogen** and look at disease history
- We can forecast **regional environments** and adjust management practices

Presentation overview

Updates on ….

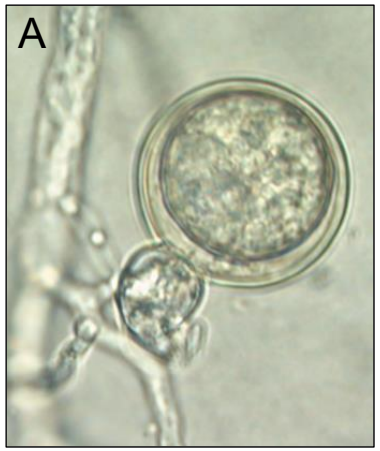
- **Phytophthora disease management**
- Bacterial blast – Section 18
- Hull rot
- Disease forecasting

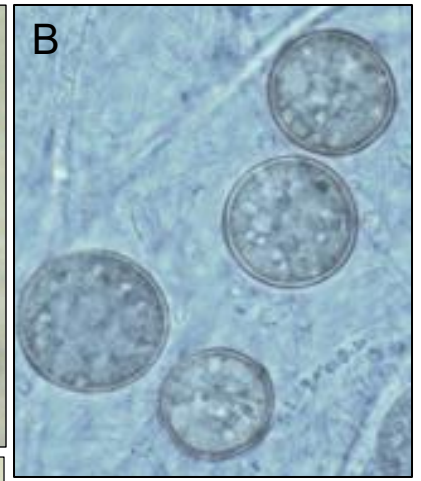
Phytophthora diseases of almond and morphological features of *Phytophthora* species

Phytophthora crown and trunk cankers (currently most common)

Trunk cankers

Root rot less common





Aerial and Perennial ('Crotch') Phytophthora cankers

Tree death

A) Oospore of *P. cactorum*. B) Chlamydospores of *P. parasitica*. C,D) Sporangia of *P. cactorum* releasing zoospores in Fig. D.

Phytophthora diseases on almond

Disease	Pathogens	Canker type	Remarks
Root Rots, Crown and Lower Trunk Cankers	*P. cactorum*** *P. megasperma*** *P. niederhauserii**** *P. mediterranea****	Lower trunk cankers typically originate at the tree crown, active year-round (depending on the species), generally lethal to trees	*P. niederhauserii* and *P. mediterranea* are most virulent *(P. med.* is resistant to PO_3).
Aerial Phytophthora = Phytophthora Pruning Wound Canker (PPWC)	*P. syringae**	Non-persistent, nonlethal, associated with pruning wounds or young shoots. Cankers can be confused with Ceratocystis canker or band canker that are caused by true fungi.	Susceptible cultivars: Nonpareil, Shasta, Aldrich, Monterey, Bennett-Hickman.
Perennial Phytophthora Canker	*P. cactorum*** *P. citricola***	Cankers active year-round, lethal to trees, associated with water holding pockets and cracks at the tree crotch	

Fungicides for Phytophthora diseases of almond

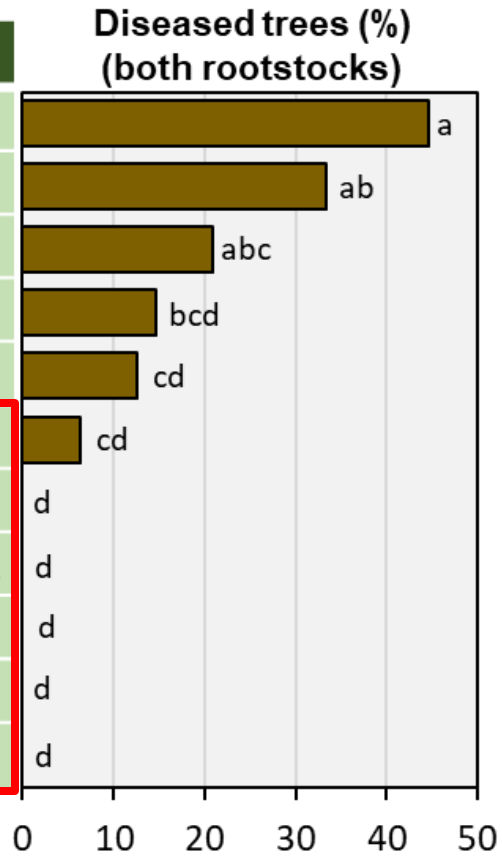
- Ethaboxam, fluopicolide, mandipropamid, and oxathiapiprolin and represent three new modes of action and have EC_{50} values equal to or lower than those of mefenoxam.
- Oxathiapiprolin is 10X to 1000X more active than other fungicides allowing low field rates.

	Common name	Trade name	FRAC
Older	Metalaxyl, mefenoxam	Ridomil Gold, others	4
	Fosetyl-Al, K-phosphite	Various	P07 (33)
New	Oxathiapiprolin	Orondis	49
	Ethaboxam	Elumin	22
	Fluopicolide	Presidio	43
	Mandipropamid	Revus	40

Host	*Phytophthora* spp.	No. isolates	EC_{50} values for mycelial growth (µg/ml)			
			Ethaboxam	Fluopicolide	Mandipropamid	Oxathiapiprolin
Almond	*P. cactorum*	9	0.013 - 0.079	0.111 - 0.275	0.004 - 0.009	0.0005 - 0.0007
	P. citricola complex	11	0.046 - 0.158	0.046 - 0.069	0.005 - 0.007	0.0003 - 0.0005
	P. niederhauserii	31	0.031 - 0.105	0.041 - 0.070	0.003 - 0.009	0.0001 - 0.0004
	P. syringae	19	0.017 - 0.190	0.021 - 0.318	0.001 - 0.006	0.0002 - 0.0004
	P. mediterranea	23	0.006 - 0.036	0.034 - 0.078	0.002 - 0.007	0.0001 - 0.0004
	P. megasperma	4	0.040 - 0.079	0.082 - 0.240	0.002 - 0.005	0.0003 - 0.0005

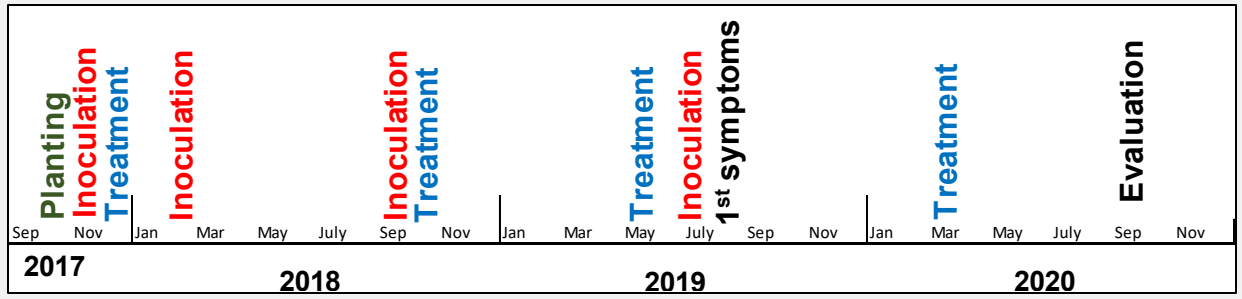
Evaluation of new fungicides for management of Phytophthora crown rot of Nonpareil almond on Hansen or Nemaguard rootstocks at UC Davis

Treatment	Rate(/A)
Control	---
Ridomil Gold 480SL	16 fl oz
Elumin	10 fl oz
Revus 250SC	8 fl oz
Orondis - 200 OD	2.4 fl oz
Presidio + Elumin	6 + 10 fl oz
Prophyt	64 fl oz
Prophyt + Ridomil Gold	64 + 16 fl oz
Presidio	6 fl oz
Orondis - 200 OD	4.8 fl oz
Orondis - 200 OD	9.6 fl oz



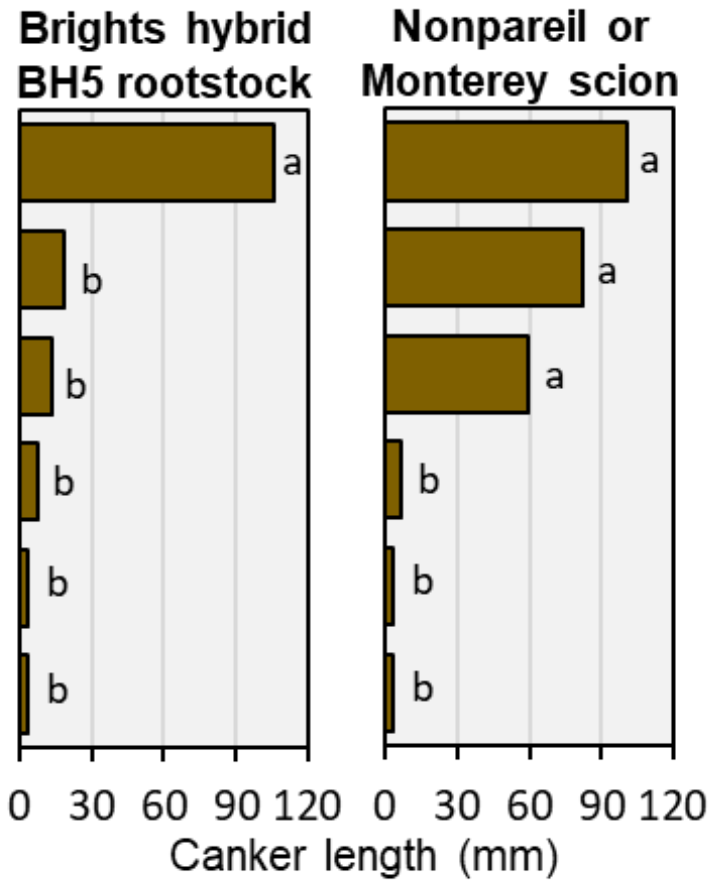
Trees developed severe crown rot and trunk cankers. Re-isolations determined that symptoms were caused by *P. cactorum*.

Experimental schedule



Systemic uptake of Phytophthora fungicides after soil application

Treatment	Rate(/A)
Control	---
Elumin	10 fl oz
Revus	8 fl oz
Presidio	4 fl oz
Orondis 200	9.6 fl oz
Ridomil Gold SL	4 fl oz



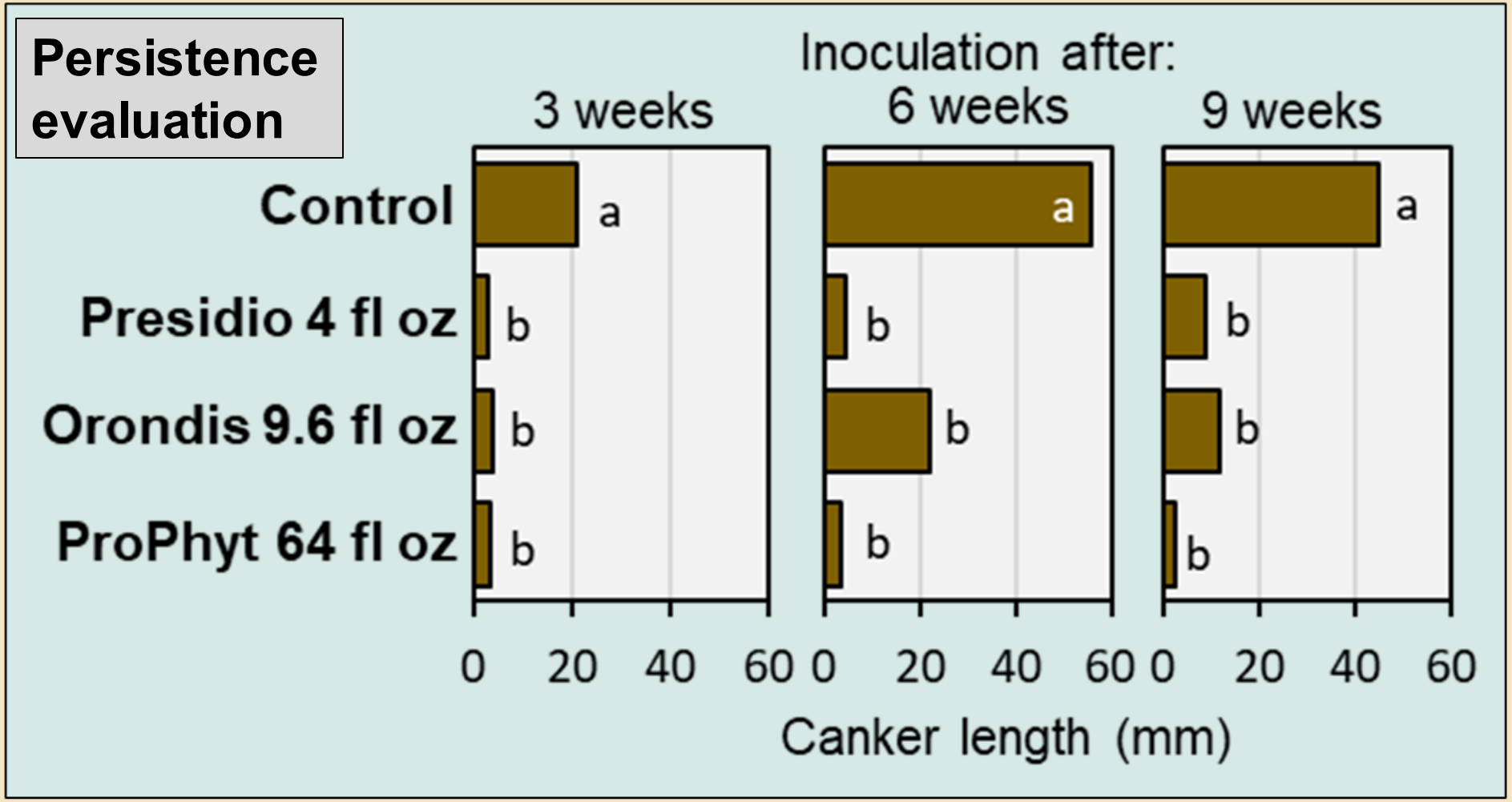
Greenhouse studies: Scions and rootstocks wound-inoculated with *P. cactorum* 2 wk after soil treatment. Canker length measured after 3 wk.

Control **Orondis**

- Orondis, Presidio, and Ridomil Gold were the most systemic and reduced canker formation on rootstock and Monterey scions.
- Elumin and Revus only protected the rootstock from infection – no significant movement into scions.

Protection of rootstocks after soil application - Systemic uptake

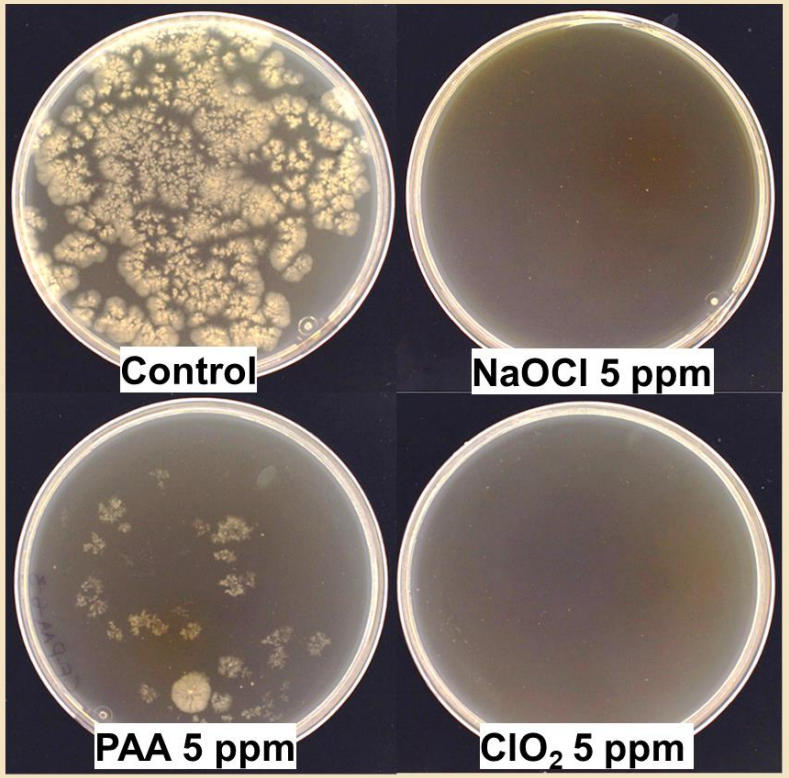
Persistence evaluation



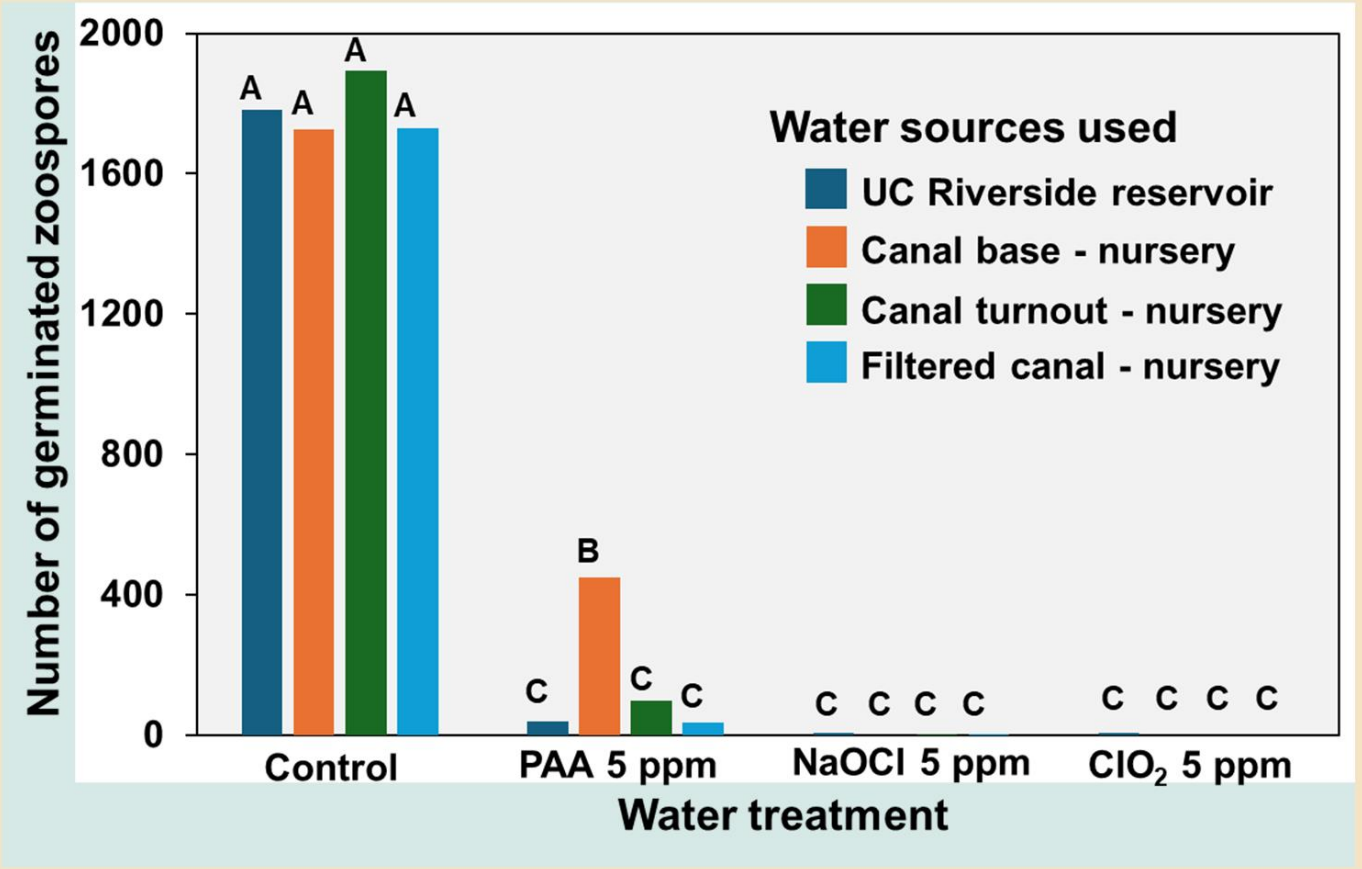
- Soil treatments to first-leaf Nonpareil almond on Nemaguard rootstock.
- After 3, 6, and 9 weeks, rootstocks were wound-inoculated with *P. cactorum*.
- Canker length was determined after another 3 to 4 weeks.

New sanitation treatments for irrigation

Efficacy of PAA, sodium hypochlorite (NaOCl), and chlorine doxide (ClO_2) in nursery irrigation water sources



Using various water sources, 2-min exposures to 5 ppm NaOCl or ClO_2 completely inactivated zoospores.



- Irrigation water was spiked with zoospores of *P. citrophthora*
- PAA, NaOCl, or ClO2 was added to irrigation water
- The mixture was incubated for 2 min and then spread onto an agar medium. *Phytophthora* colonies were counted after 48 h.

Summary – Phytophthora diseases of almond

Causal agents:

- **Cool to moderate temperature species (winter and spring):**
  P. cactorum and *P. megasperma* (root, crown, & lower trunk), *P. citricola* and *P. syringae* (scion, aerial).
- **Warm to high temperature species (late spring and summer):**
  P. niederhauserii and *P. mediterranea* (formerly *P. cinnamomi*) (crown & lower trunk)

Epidemiology:

1. **Endemic**: infested soil (root and crown infections in water-saturated soils).
2. **Introduction of inoculum**:
   a) Transplants from nursery (bare root or potted trees)
   b) Irrigation water (surface water vs. well water)
   c) Aerial Phytophthora occurs when spores are deposited on limbs or in tree crotches through dust, rain splash, or flooding, followed by wet conditions (e.g., rain).

Summary – Phytophthora diseases of almond *continued*

Management:

Root and Crown rots:

Cultural – Plant on berms, remove tree cartons after the first year, move water lines away from crown
Resistant rootstocks - RootPacR, Marianna 2624, Krymsk-86; Mod. Resistant – Nemaguard and Lovell; Highly susceptible – Peach almond hybrids

Fungicides - Soil applications of Mefenoxam, Potassium phosphite, Oxathiapiprolin (other products pending registration - Presidio, Elumin)

Aerial Phytophthora:

Foliar applications of potassium phosphite (fall and/or early to mid-March). Susceptible cvs. - Nonpareil, Shasta, Aldrich, Monterey and Bennett-Hickman

Sanitation treatments for irrigation water

- Low concentrations of **PAA** were very effective, and rates of >5 ppm completely inactivated zoospores.
- **NaOCl and chlorine dioxide at 5 ppm were highly effective** in 2-min exposures to different irrigation water sources. NaOCl is a salt that may be harmful to plants. ClO_2 is applied as a liquid and volatizes off.
- **A new formulation of chlorine dioxide** is nearly odorless and much less corrosive than chlorine.

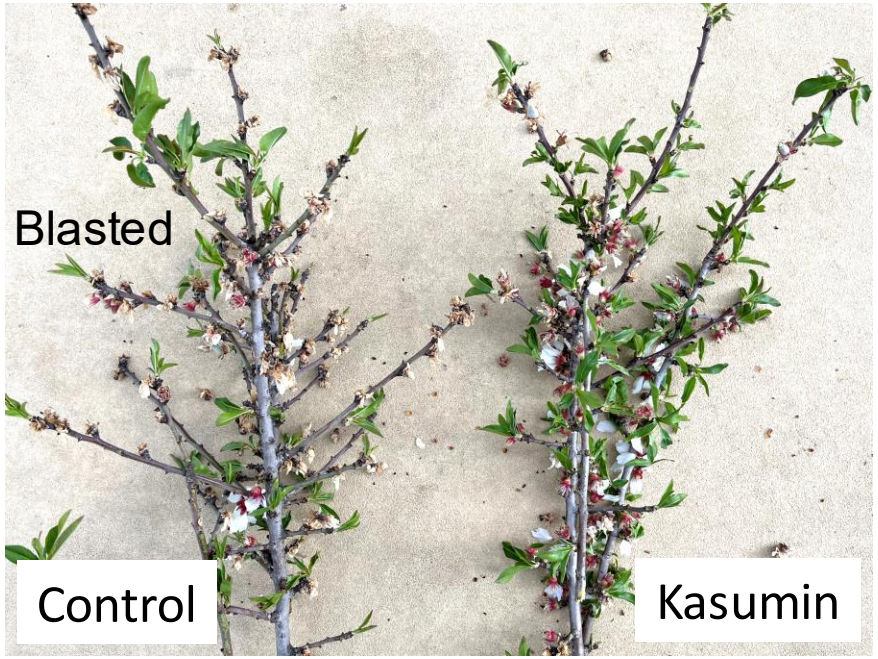
Presentation overview

Updates on ….

- Phytophthora disease management
- **Bacterial blast – Section 18**
- Hull rot
- Disease forecasting

Update on bacterial blast and Section 18 for Kasumin

- Blast occurred at high severity at some locations with low temperatures during bloom in the spring of 2025 on **Independence, Aldrich, Wood Colony**.
- Kasumin treatments applied with Section 18 approval were highly effective.
- A Section 18 for Kasumin was again submitted for spring of **2026** – full registration is still pending.



Presentation overview

Updates on ….

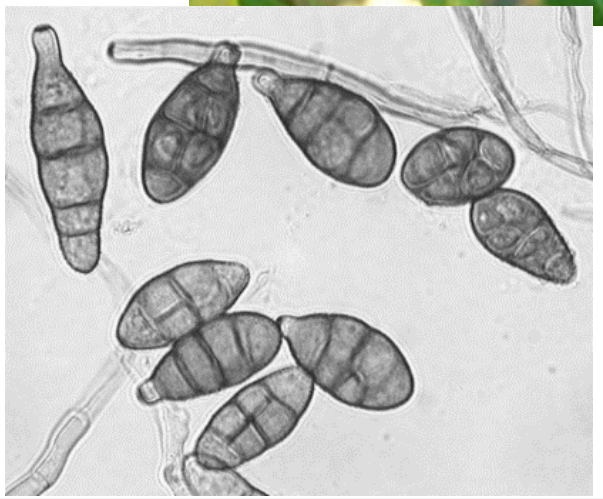
- Phytophthora disease management
- Bacterial blast – Section 18
- **Hull rot and Alternaria leaf spot**
- Disease forecasting

Alternaria Leaf Spot of Almond

Alternaria alternata and *A. arborescens*

Early symptoms

Late symptoms



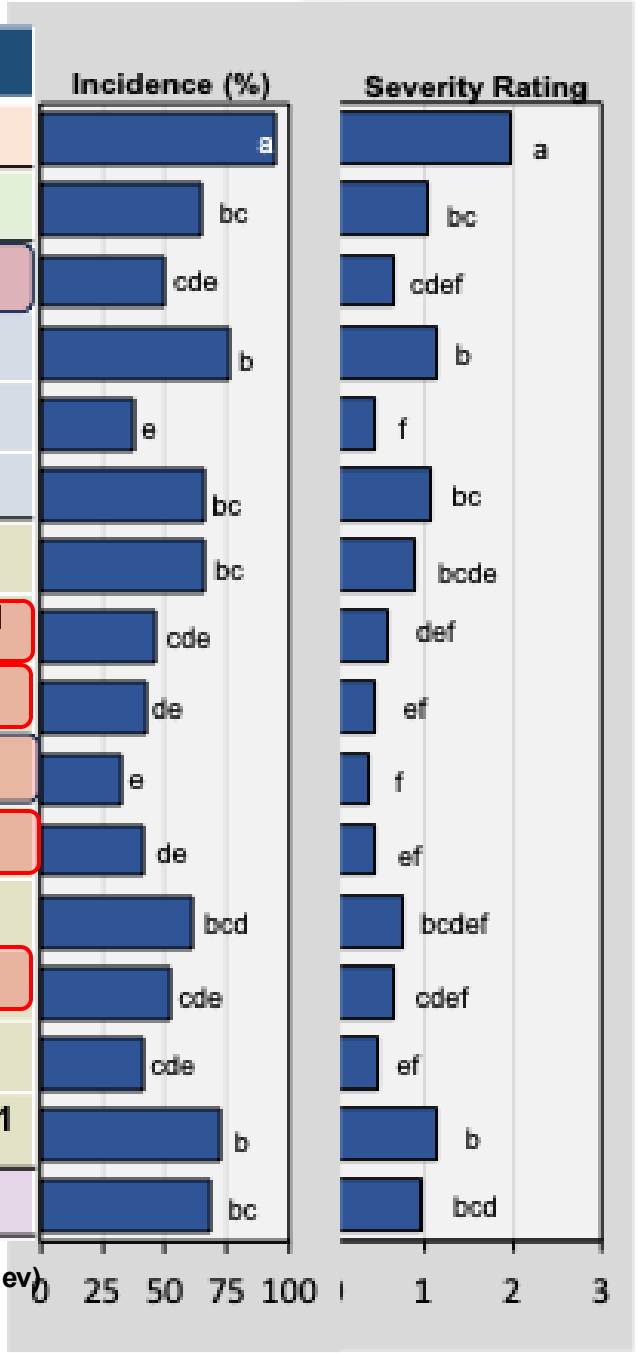
Conidia of *Alternaria* species

Tree defoliation

Leaf drop

Efficacy of fungicides for managing Alternaria leaf spot of almond 2025

	Treatment	FRAC	Incidence (%)	Severity Rating
	Control	---	a	a
Biol.	SA-0650120 41 fl oz	BM 01	bc	bc
Single ai's	Cevya 5 fl oz	3	cde	cdef
	Fontelis 20 fl oz	7	b	b
	Fluazinam 24 fl oz	29	e	f
	Axios 14.4 fl oz	52	bc	bc
Mixtures and Premixtures	Fontelis + Aproach 20 + 12 fl oz	7+11	bc	bcde
	Regev 7 fl oz	3/BM 01	cde	def
	Miravis Duo 13.6 fl oz	3/7	de	ef
	Elysis (Mibelya) 6 fl oz	3/7	e	f
	Scala DFO 23.9 fl oz	3/9	de	ef
	Absolute Maxx 7.32 fl oz	3/11	bcd	bcdef
	Miravis Prime 9.1 fl oz	7/12	cde	cdef
	V6M-5-14 22.8 fl oz	7/21	cde	ef
	SA-0650130 18 fl oz	11/BM 01	b	b
Soil	Velum-1 6.84 fl oz	7	bc	bcd



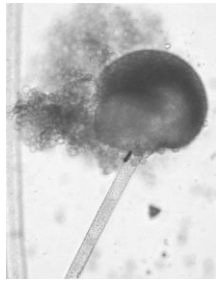
Applications: 4-30, 5-21, and 6-11-25. All (except Regev) with DyneAmic. Velum-1 was a soil application.

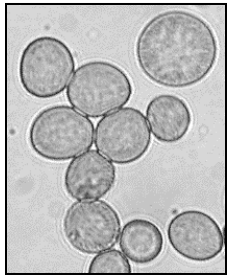
Evaluation on 7-16-25. Severity rating from 0 = healthy to 3 = > 5 lesions/leaf.

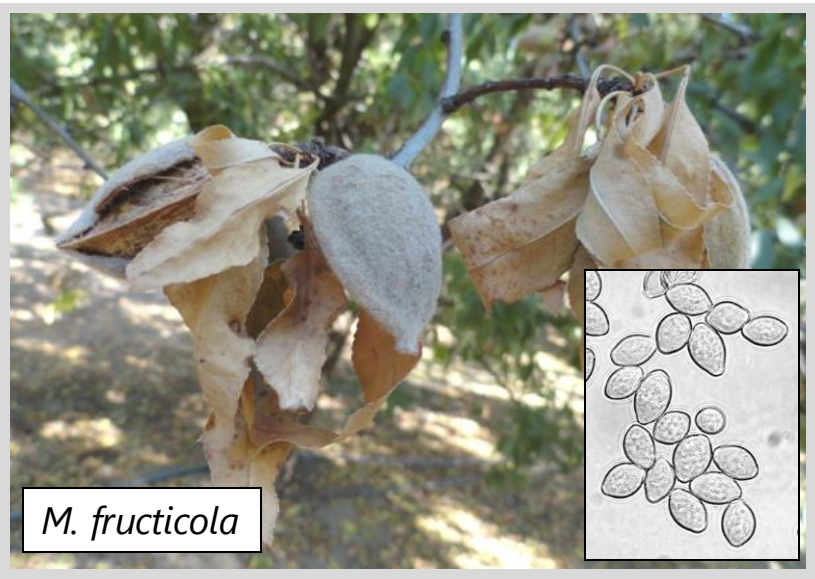
Almond Hull Rot

Major pathogens: *Rhizopus stolonifer* and *Monilinia fructicola*

- Both major pathogens infect fruit and cause dieback
- *Aspergillus niger* and *Botrytis cinerea* can occasionally cause hull rot







Aspergillus hull rot

In surveys of twelve orchards in Butte, Colusa, Sutter, San Joaquin, and Stanislaus Co., *R. stolonifer* was found to be the predominant cause of hull rot in eleven; whereas *A. niger* was found in one orchard in Stanislaus Co. at a low incidence.

Efficacy of fungicides for managing hull rot of almond

	Treatment*	FRAC	Plot 1 Applications 7-9	Plot 1 Applications 7-23	Plot 1 Strikes/tree** No.	Plot 1 Strikes/tree** LSD	Plot 2 Applications 7-16	Plot 2 Applications 7-23	Plot 2 Strikes/tree No.	Plot 2 Strikes/tree LSD	% Reduction
	Control	---	---	---	29.0	a	---	---	49.3	a	
Biologicals	SeaBest 64 fl oz	0-19-19	---	---	---	---	@	@	27.8	bc	43.6
	Vectorite CR-7 342 mg	BM 02	@	@	13.3	b	---	---	---	---	
	Instill + ProBlad Verde 68+40 fl oz	M1+BM 01	@	@	15.0	b	@	@	17.5	bc	
Fertilizer	Banx 60 oz	Fert.	@	@	12.0	b	@	@	22.3	bc	
Single	Cevya 5 fl oz	3	@	@	14.3	b	@	@	26.8	bc	
	Axios 14.4 fl oz	52	@	@	20.8	ab	@	@	17.0	bc	
Pre-mixtures	Regev 7 fl oz	3/BM 01	@	@	14.5	b	@	@	11.8	c	76.1
	Miravis Duo 13.6 fl oz	3/7	@	@	11.8	b	@	@	21.5	bc	
	Elysis (Mibelya) 8.5 fl oz	3/7	@	@	13.8	b	@	@	36.3	bc	
	Scala DFO 23.9 fl oz	3/9	@	@	13.0	b	@	@	17.0	bc	64.5
	Absolute Maxx 8 fl oz	3/11	@	@	13.0	b	@	@	23.5	bc	
	Miravis Prime 9.1 fl oz	7/12	@	@	14.0	b	@	@	26.0	bc	
	V6M-5-14 22.8 fl oz	7/21	@	@	11.3	b	@	@	19.8	bc	

* - Treatments were applied using an airblast sprayer at 100 gal/A. DyneAmic was used at 8 fl oz/A for all except for Regev. The first application was at 5% hull split, the second one at 60% split.

**- Disease was evaluated on 8-12-25, and the number of hull rot strikes was counted on each tree for 1 min.

Phytotoxocity was observed after Instill + ProBlad Verde treatments: trees partially defoliated.

New fungicides perform well against Alternaria leaf spot and hull rot in our trials for the last three years

			Efficacy	
Fungicide	**FRAC**	**Active ingredient**	**Alternaria leaf spot**	**Hull rot**
Cevya	3	mefentrifluconazole	4	4
Elisys	3/7	mefentrifluconazole + fluxapyroxad	5	4
Miravis Prime	7/12	pydiflumetofen + fludioxonil	5	4
Miravis Duo	3/7	difenoconazole + pydiflumetofen	5	4
Regev	3/BM 01	difenoconazole + tea tree oil	5	4
Scala DFO	3/9	difenoconazole + pyrimethanil	5	4

- Applications of fungicides are timed with hull split NOW treatments which are compatible as tank mixtures.
- Hull rot stick tights lead to more NOW overwintering sites so adding a fungicide makes sense for managing both disease and pest.

Presentation overview

Updates on ….

- Phytophthora disease management
- Bacterial blast – Section 18
- Hull rot
- **Disease forecasting**

Disease management

Orchard …..

Location:

- Low or high elevation
- Near riparian areas

Design:

- Number of trees per acre (density)
- Planting design (square, diamond)
- Irrigation system (drip, microsprinkler)
- Cultivar selection

Age:

- New vs. established plantings

Disease risk:

- Historical records of diseases (by year)
- Presence of fungicide resistance
- Monitor for disease
- Use of disease forecasts for **Anthracnose, Brown rot, Shot hole, Alternaria leaf spot, Scab, Bacterial blast, and Bacterial Spot**

Models for foliar diseases of almond that allow forecasting

Blossom blight

Bloom stage	Inoculum potential	Temperature (°C)	Wetness duration (h) 4	8	12	16	20	24
popcorn to full bloom	low[x]	10						
		15						
		20						
		25						
	high	10						
		15						
		20						
		25						
late full bloom to petal fall	low	10						
		15						
		20						
		25						
	high	10						
		15						
		20						
		25						

no risk | low risk | moderate risk | high risk

Luo, Y., D. P. Morgan, and T. J. Michailides. 2001. Phytopathology 91:759-768

Favorable conditions: Precipitation during bloom, temperatures >14C

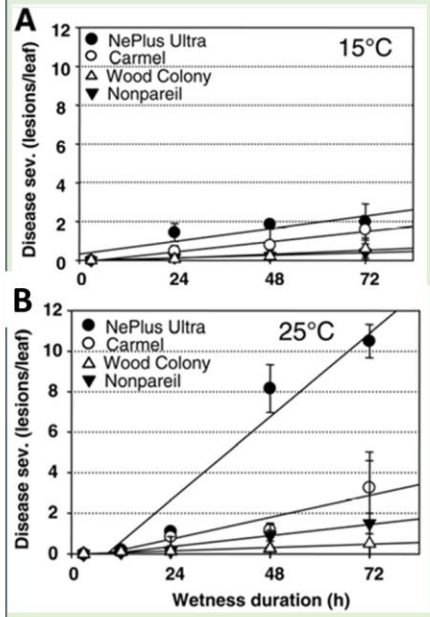
Green fruit rot

Favorable conditions: Rain during early fruit development, cool temperatures. High fruit set can cause retention of dying flower parts.

Bacterial spot

Favorable: Precipitation during bloom and early fruit development, temperatures >18C

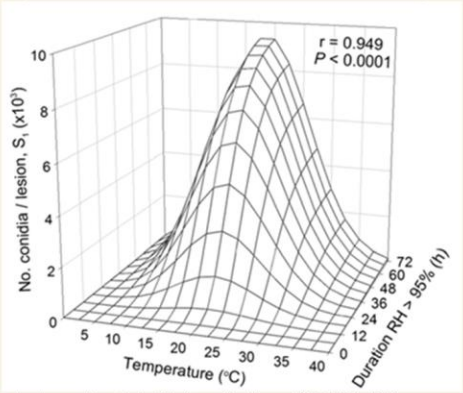
Anthracnose



Favorable conditions: Rain during bloom and early fruit development, temperatures >18C

Dieguez-Uribeondo et al. 2011 Phytopathology 1013-1020

Scab



Lalancette et al. Phytopathology 102:421-428

Favorable conditions for sporulation: temp. 10-35C, humidity >95% for >12h

Bacterial blast

WEATHER NEWS

UPDATE: Frost advisory affecting Northern California until Wednesday morning

By CA Weather Bot

Friday, Feb. 6, 2025, 6:05 AM

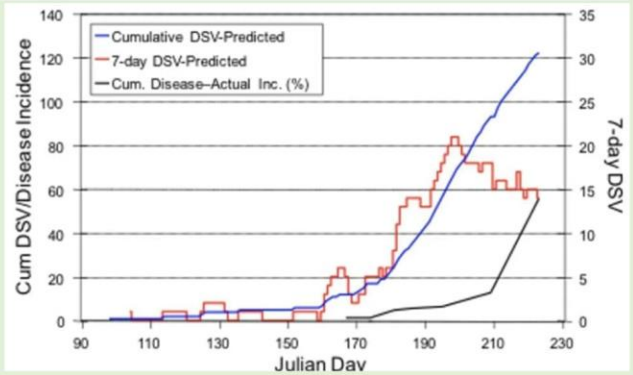
Favorable conditions: Freezing temperatures during bloom

Alternaria leaf spot

Favorable conditions: Leaf wetness duration, and temperatures of 15-29C

Madden L, Pennypacker SP, Mac Nab AA (1978) Phytopathology 68:1354–1358 (as modified for ALS in CA by Adaskaveg).

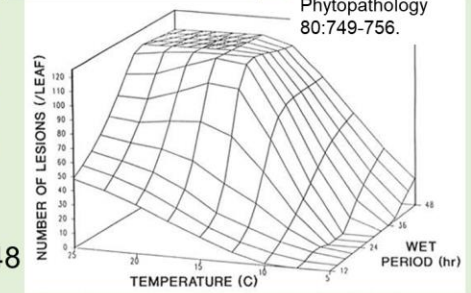
Mean temperature (C) during wetness	Leaf wetness duration (Hours)				
15-17	0-6	7-15	16-20	21	-
17.1-20	0-3	4-8	9-15	16-22	23+
20.1-25	0-2	3-5	6-12	13-20	21+
25.1-20	0-3	4-8	9-15	16-20	23+
DSV	0	1	2	3	4



Shot hole

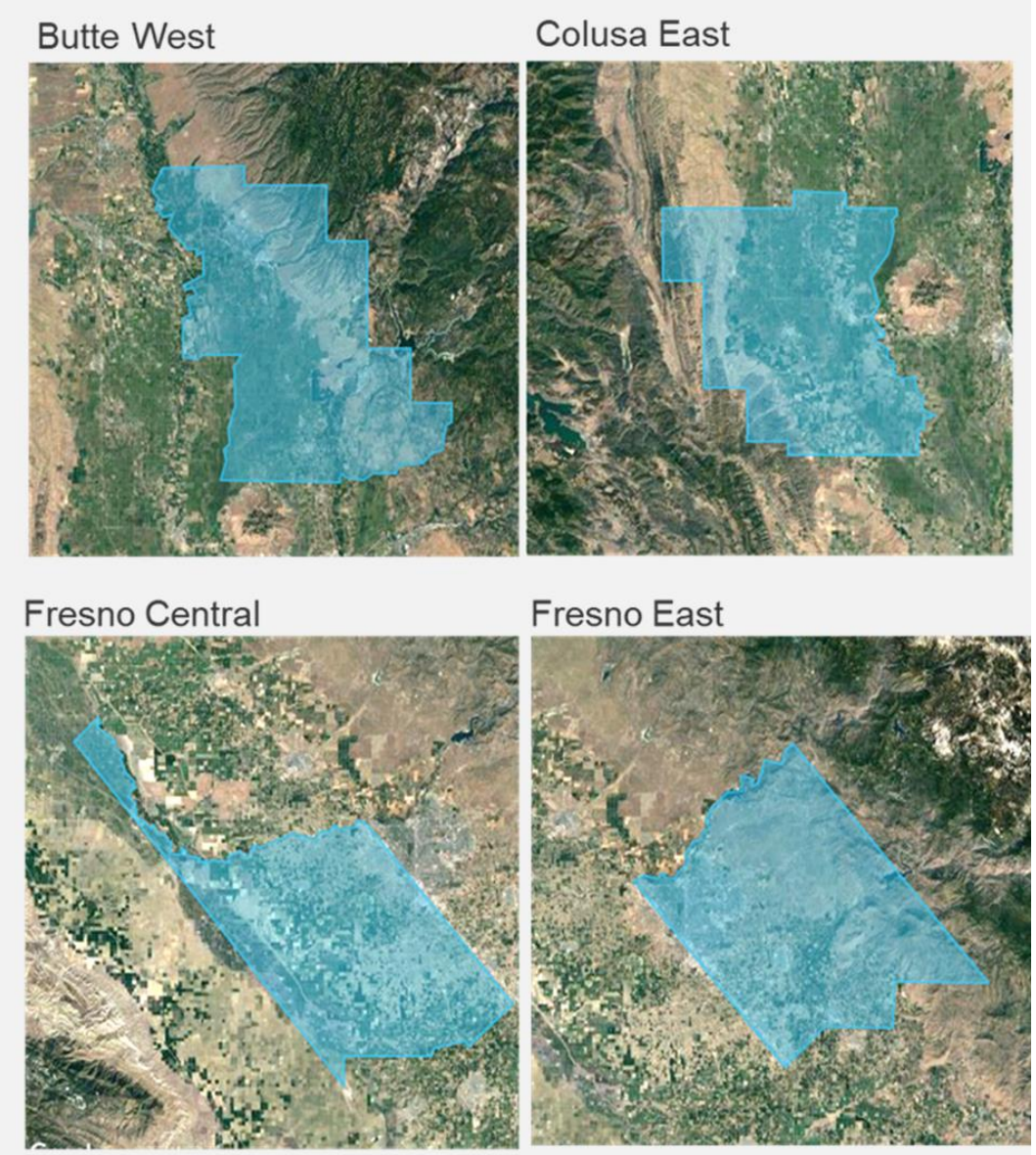
Favorable: Wetness from dew for 12 to 48 h at 5 to 25 C.

Shaw et al. 1990. Phytopathology 80:749-756.



Almond Board of California

- Disease Forecasts in cooperation with the University of California -



california almonds

Why Almonds Almond Industry Tools & Resources

Regionalized Disease Forecasts – A pilot program

Disease risk forecasts for **7 regions** based on regional in-orchard/near-orchard weather data and disease modeling. Powered by Semios(R) precision farming platform, the data is logged and then summarized by UC Riverside

- From 2022 to 2024, forecasts were posted on the Almond Board of California and Semios websites.
- In 2025, Semios merged with AgWorld as Almanac and converted to audible forecasts with artificial intelligence (AI).
- An agreement for postings on the ABC website could **not** be reached.

Almond Board of California
<industry@almondboard.com>

3 of 12 Growing regions in California planned for disease forecasts

7-day risk assessment disease forecasts

Colusa West

Stanislaus Central

Kern East

7-day risk assessment disease forecasts – mid-season

No.	County	Region	Anthracnose (value, date, color code)^	Bacterial spot (value, date, color code)^	Alternaria leaf spot (value, date, color code)^	Almond scab sporulation level (date, LW value, Precip.)^
1	Butte	West	0	0	0	0
2	Colusa	East	0	0	0	0
3	Fresno	Central	0.28 (4/13)	0.7 (4/13)	0	low (4/13, 15, 6.7 mm)
4	Fresno	East	0.25 (4/13)	0.59 (4/13-4/14)	0	low (4/13, 18, 9.1 mm)
5	Fresno	West	0	0	0	low (4/13, 13, 6.8 mm)
6	Kern	Central	0.36 (4/13)	0.9 (4/13)	0	low (4/13, 10, 5.7 mm)
7	Kern	East	0.51 (4/13-4/14)	0.11-1.13 (4/13-4/14)	0	0
8	Kern	West	0.3-0.4 (4/13-4/14)	0.81-0.92 (4/13-4/14)	0	0
9	Madera	Central	0.24 (4/13)	0.47 (4/13)	0	0
10	Merced	Central	0	0	0	0
11	Stanislaus	Central	0	0	0	low (4/13, 13, 10.4 mm)
12	Stanislaus	East	0	0	0	low (4/13, 15, 13.6 mm)
13	Stanislaus	West	0	0	0	low (4/13, 14, 9.6 mm)

^ - Numerical risk is scaled as follows: 0 = no risk, 1 = action threshold (Note: values may exceed 1 due to hourly accumulations). Color code risk: yellow = low, orange = moderate, red = high.

Overall planned forecasts and future directions

- **Forecast temperature and leaf wetness by dew or rain prediction.** Critical parameters for forecasting any foliar disease.
- **Fungal and bacterial pathogens require wetness to grow and multiply as they assimilate**; temperature determines if the organism will grow and the speed of growth.
- **By using previously developed epidemiological models,** we plan to use virtual weather stations to make regional forecasts referencing site-level data incorporated into the WSU AgWeatherNet.
- Ultimately, **AI could be used to automate the system** that currently depends on individual models that are interpreted weekly with planned posting at the Almond Board website.
- The "**Regional Almond Disease Risk Prediction System**" is a system to increase awareness of the risk for disease and improve management including timing of fungicide and bactericide treatments for the almond production regions of the state.

Biology and Control of Red Leaf Blotch:

a new and invasive disease of almond in California

Florent P. Trouillas
Professor of Cooperative Extension
University of California, Davis

ALMOND BOARD OF CALIFORNIA

Red leaf blotch

- Caused by the fungal pathogen ***Polystigma amygdalinum***
- First described in **1843 in France** from almond leaves
- One of the most important almond diseases in the **Mediterranean basin**, particularly in **Spain**, and regions of the Middle East
- **First detected May 29, 2024, in Merced County**
- A new, **invasive** disease of almond for California
- It only affects **leaves** of almond

Early symptoms

- Merced County, May 1st, 2025

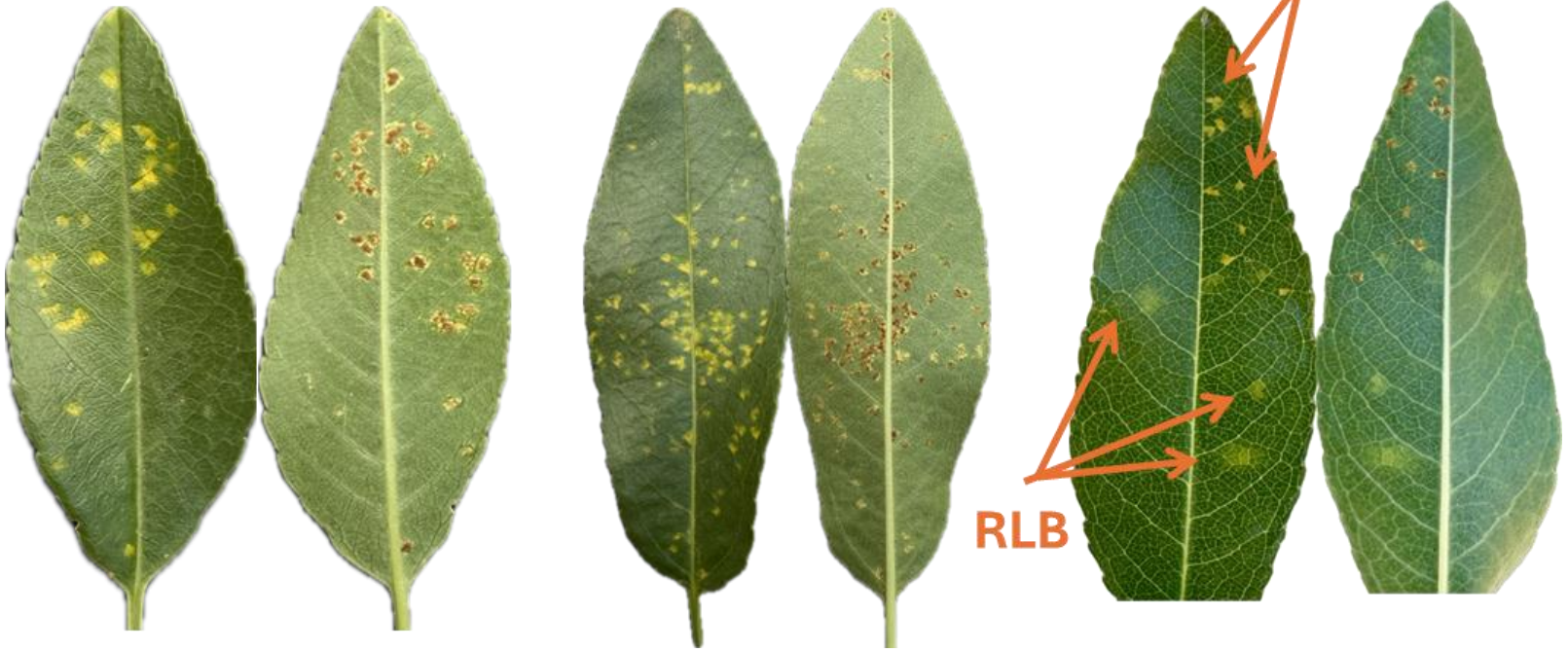
Early symptoms

(Early May)

Early symptoms

- **Symptoms are quite unique** and easily distinguishable from other spring leaf diseases

Rust caused by *Tranzschelia discolor*



Bacterial blast caused by *Pseudomonas syringae*

Advanced symptoms

(June – July)









Symptoms during summer in an unsprayed orchard

Trees defoliate by the end of August

- **Early defoliation has high energy costs for trees** which might prompt the production of new leaves before fall
- **Leaves on the ground (leaf litter) will serve as inoculum** for next growing season

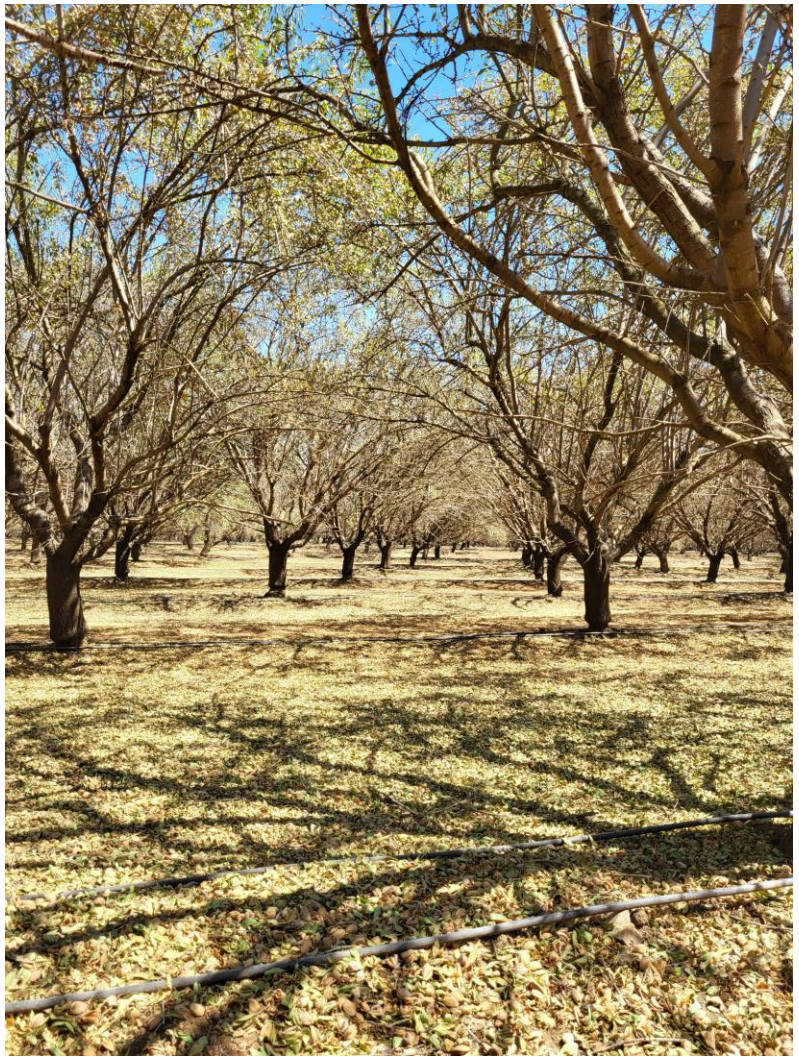
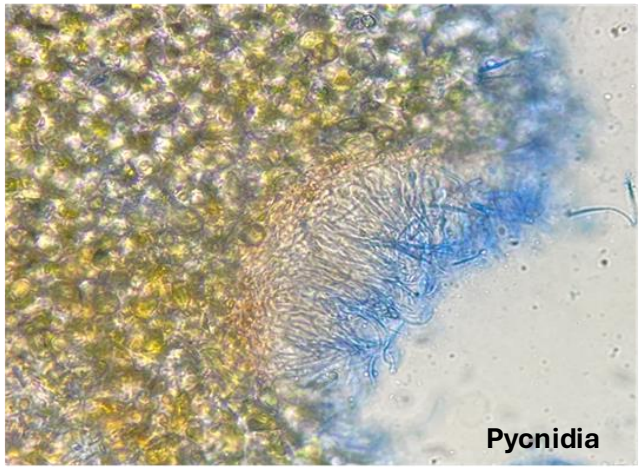


Photo credits Cameron Zuber

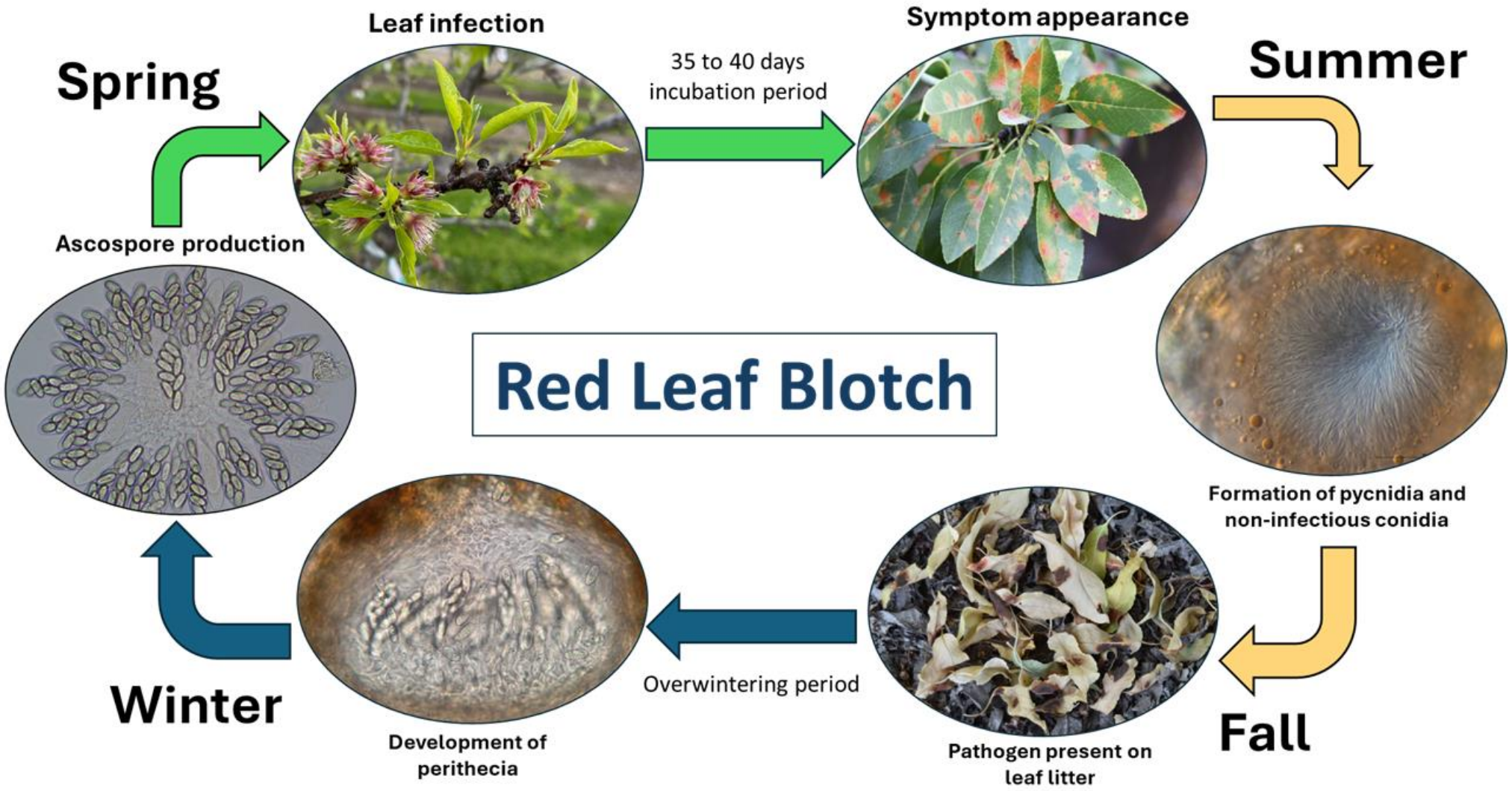
The pathogen: *Polystigma amygdalinum*

- *P. amygdalinum* (Ascomycota) is an **obligate biotrophic** fungal pathogen, and is dependent on living plant tissue for growth, reproduction, and feeding and cannot be grown on culture medium.



Disease cycle

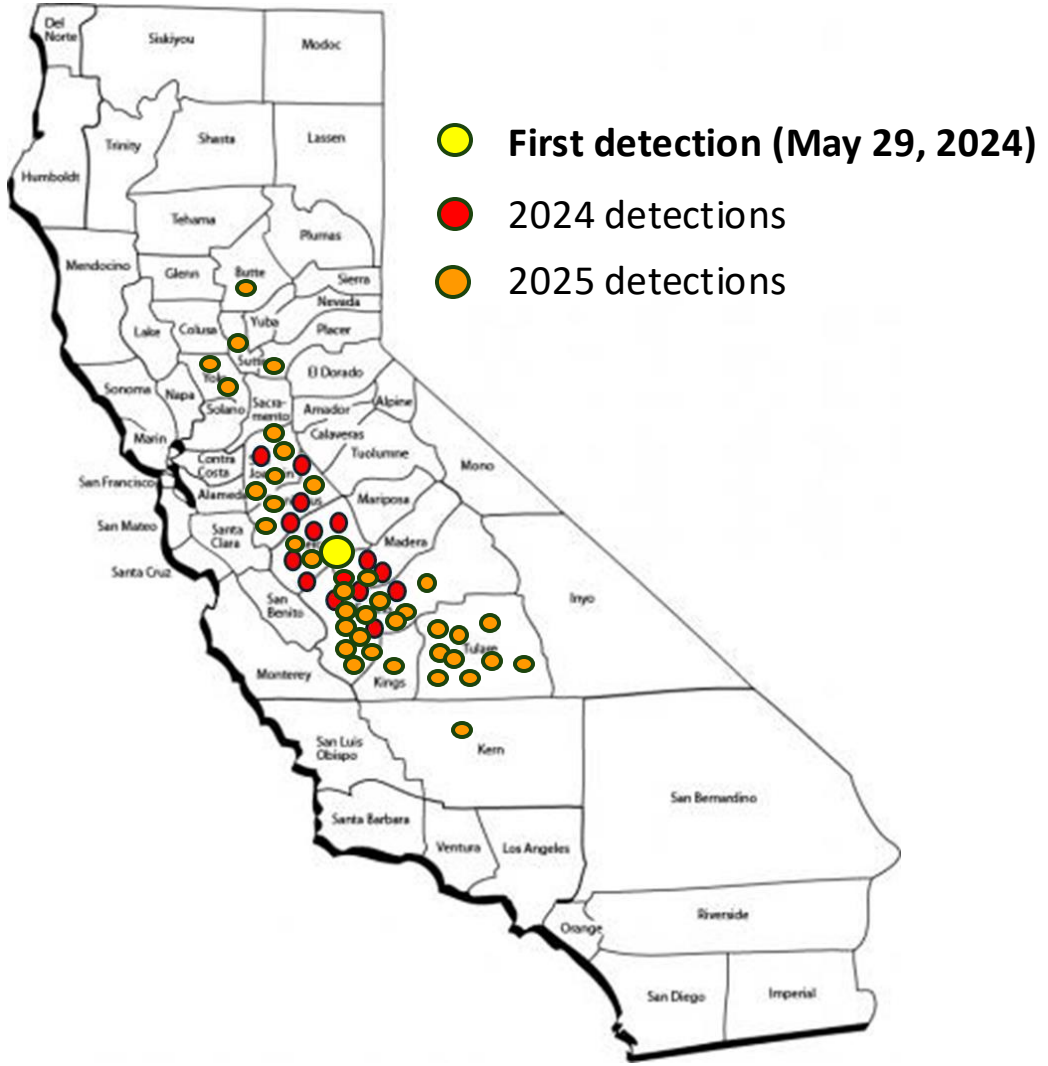
The disease is monocyclic, with only one primary infection cycle



Current disease distribution

Epidemic – Disease outbreak

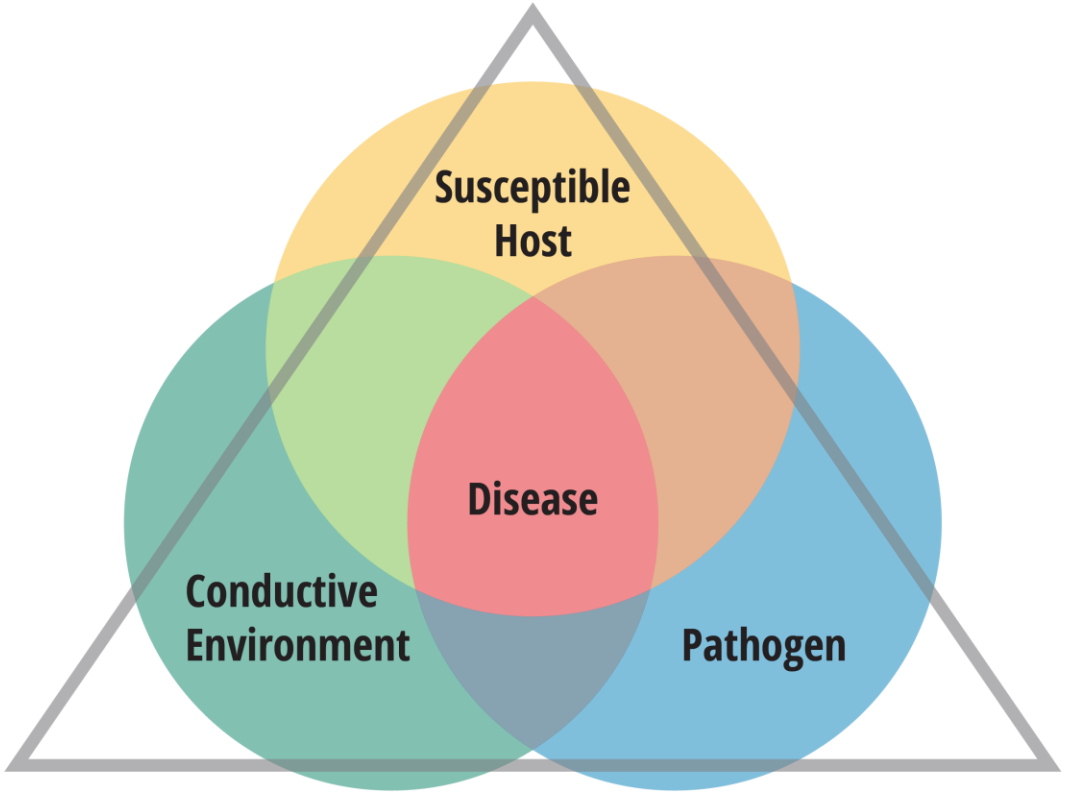
- First detection in May 2024 in Merced Co (CE advisor Cameron Zuber)
- Now detected in Butte, Kern, Kings, Madera, Merced, Fresno, San Joaquin, and Stanislaus, Sutter, Tulare and Yolo counties
- Cultivars affected included Aldrich, Butte, Carmel, Fritz, Independence, Monterey, Nonpareil, Padre, Shasta, and Wood Colony



Plant Disease Triangle

Plant disease outbreaks result when three factors are in place:

- **Host - A susceptible host plant is available**
- **Pathogen - A pathogen is present**
- **Environment - Environmental conditions that favor the host and pathogen to allow disease development**



Disease emergence

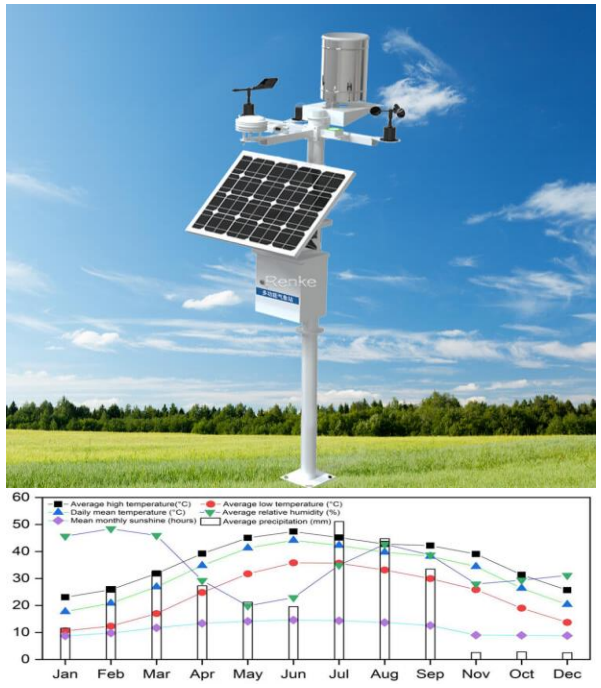
- Intensification of agricultural practices
- Global warming and climate change, atmospheric rivers
- Expanded geographical distribution of the host
- Reduced fungicide applications in orchards
- **Movement of plant material into California**
- **Pathogen introduction**

Current Research in the Trouillas Lab

Disease Epidemiology

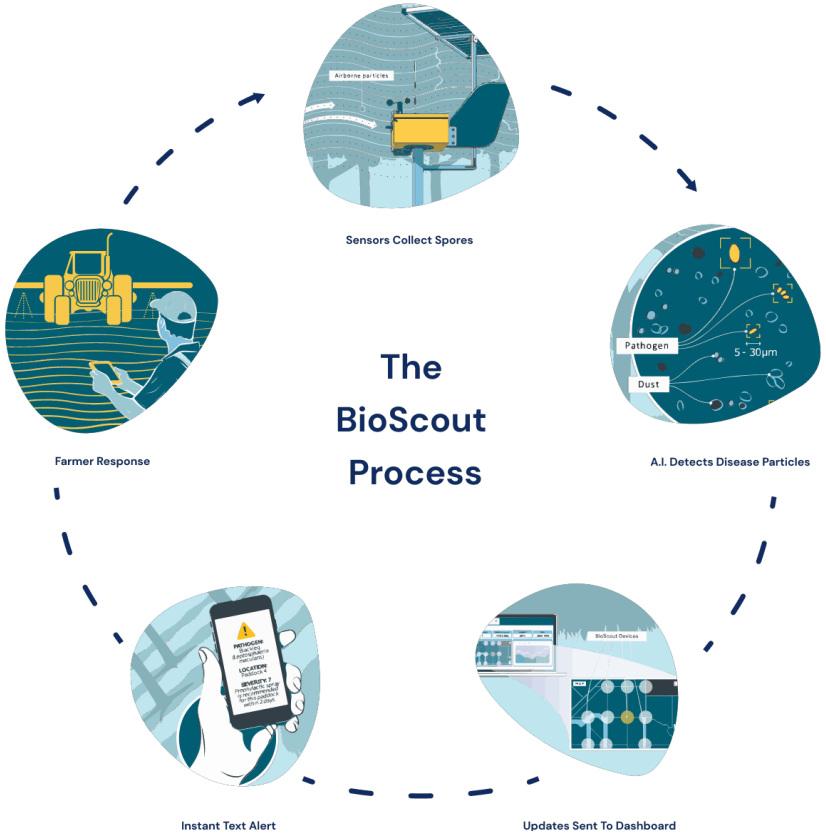
Spore Trapping Study

Studying the seasonal spore dispersal dynamic → To determine when spore inoculum is present in almond orchards → Using microscope slides covered with Vaseline and collected weekly to bi-weekly → Spore are counted under the microscope → Spore counts are superimposed with weather data



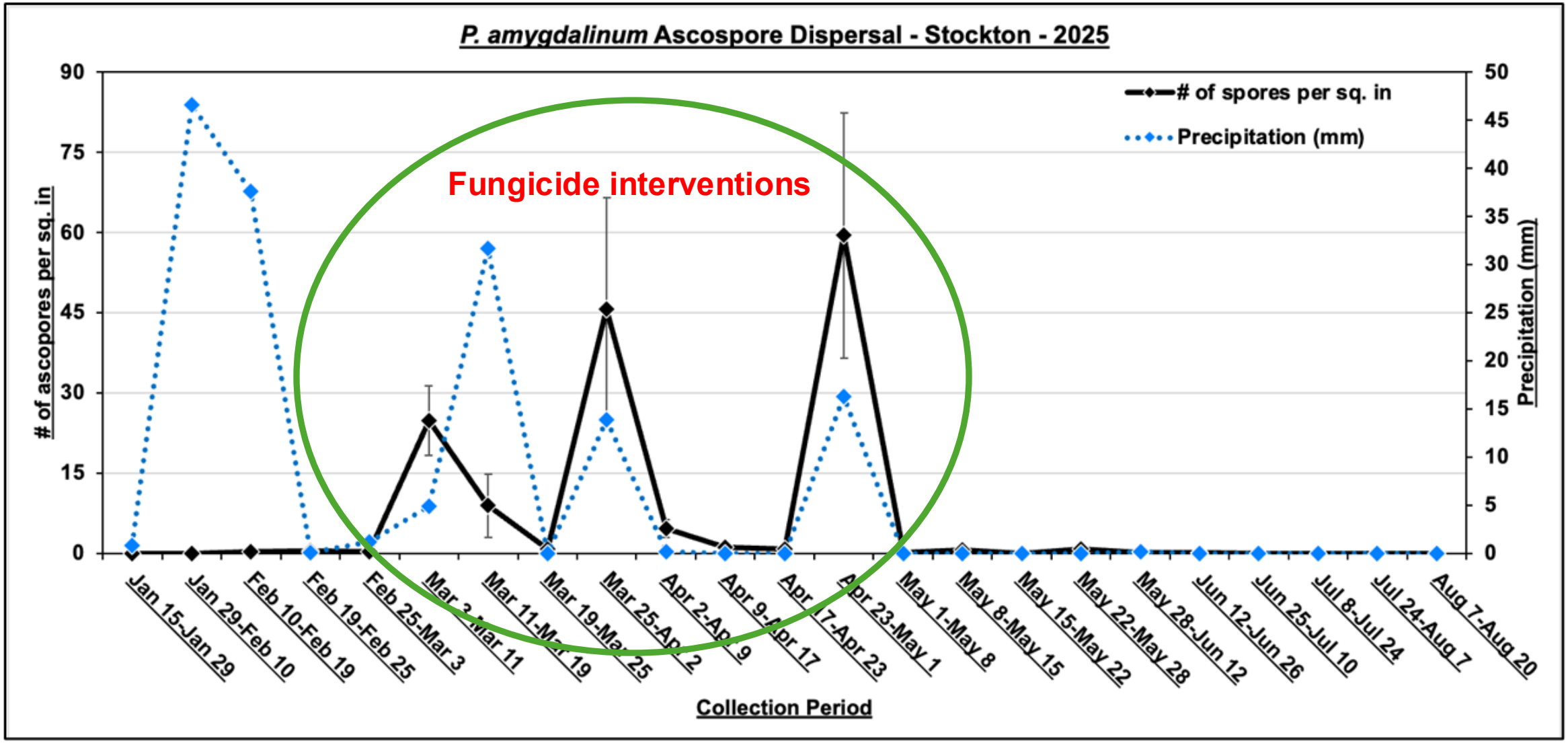
New technologies

- ❑ Current initiative of ABC (Trouillas Lab)
- ❑ Advanced spore trapping technologies
- ❑ Realtime detection of plant pathogens in orchards



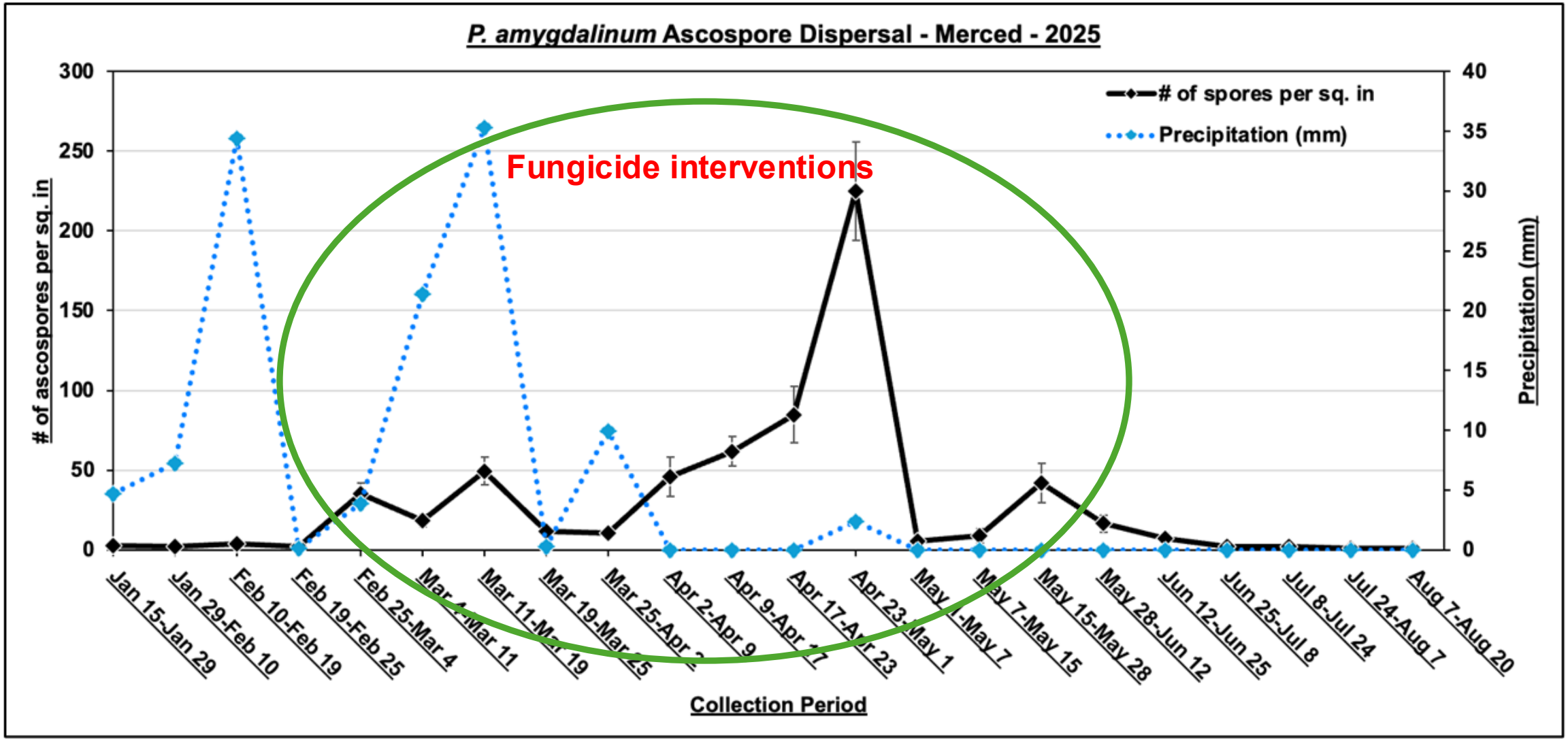
Disease Epidemiology

Dynamic of spore inoculum (Stockton, California, 2025)



Disease biology

Dynamic of spore inoculum (Merced, California, 2025)



Chemical control

Timing of fungicide applications

- **Fungicides applied during bloom and after symptoms are visible are NOT effective**

Disease	Dormant	Bloom			Spring[1]		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Red leaf blotch	----	----	----	+++	+++	++	----	----
Anthracnose[2]	----	++	+++	+++	+++	+++	+++	++
Bacterial spot	+	----	++	+++	+++	++	+	----
Brown rot	----	++	+++	+	----	----	----	----
Green fruit rot	----	----	+++	++	----	----	----	----
Hull rot[7]	----	----	----	----	----	----	----	+++
Leaf blight	----	----	+++	++	+	----	----	----
Rust	----	----	----	----	----	+++	+++	+[6]
Scab[3]	++	---	---	++	+++	+++	+	---
Shot hole[4]	+[5]	+	++	+++	+++	++	----	----

Rating: +++ = most effective, ++ = moderately effective, + = least effective, and ---- = ineffective

Adaskaveg et al. 2017

Integrated Disease Management

Best timing of fungicide applications and best products

- Mixed fungicides (**FRAC groups 3+7; 3+11; 7+11; 7+12) and FRAC 3-triazoles** are most effective (Trouillas Lab, 2025 trials)
- Integrated approach of managing multiple diseases at the same time

Disease	Dormant	Bloom			Spring		Summer	
		Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	May	June
Rust	----	----	----	----	----	3, 3/7, 3/11 3/33, 7, 7/11, 11, 19 M3	3, 3/7, 3/11 3/33, 7, 7/11, 11, 19	3, 3/7, 3/11 3/33, 7, 7/11, 11, 19
Scab[4]	M1+oil, M2[3], M5+oil	----	----	1[2], 3/7, 3/9, 3/11, 3/33, 7, 7/11[2] 11[2] M3 M4, M5	1[2], 3/7, 3/9, 3/11, 3/33, 7, 7/11[2] 11[2] M3 M4, M5	3, 3/7, 3/9, 3/11 3/33, 7, 7/11[2], 11[2] M2[3] M3, M4	M2[3] M4	----
Shot hole	M1	2 3, 3/7, 3/9, 3/11, 7, 9, 11	2 3, 3/7, 3/9, 3/11 7, 7/11 9, 11, 19	2 3, 3/7, 3/9, 3/11 7, 7/11 9 11, 19	7, 7/11 11, 19 M3 M4 M5	7, 7/11 11, 19 M3 M4 M5	----	----

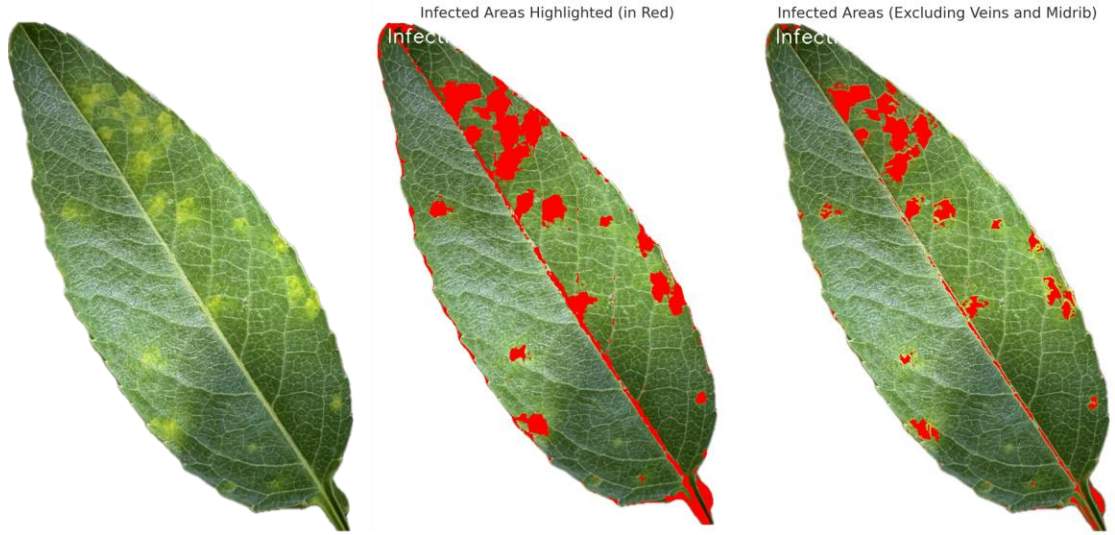
Adaskaveg et al. 2022

Chemical control

Trouillas Lab – 2025 Fungicide Trial

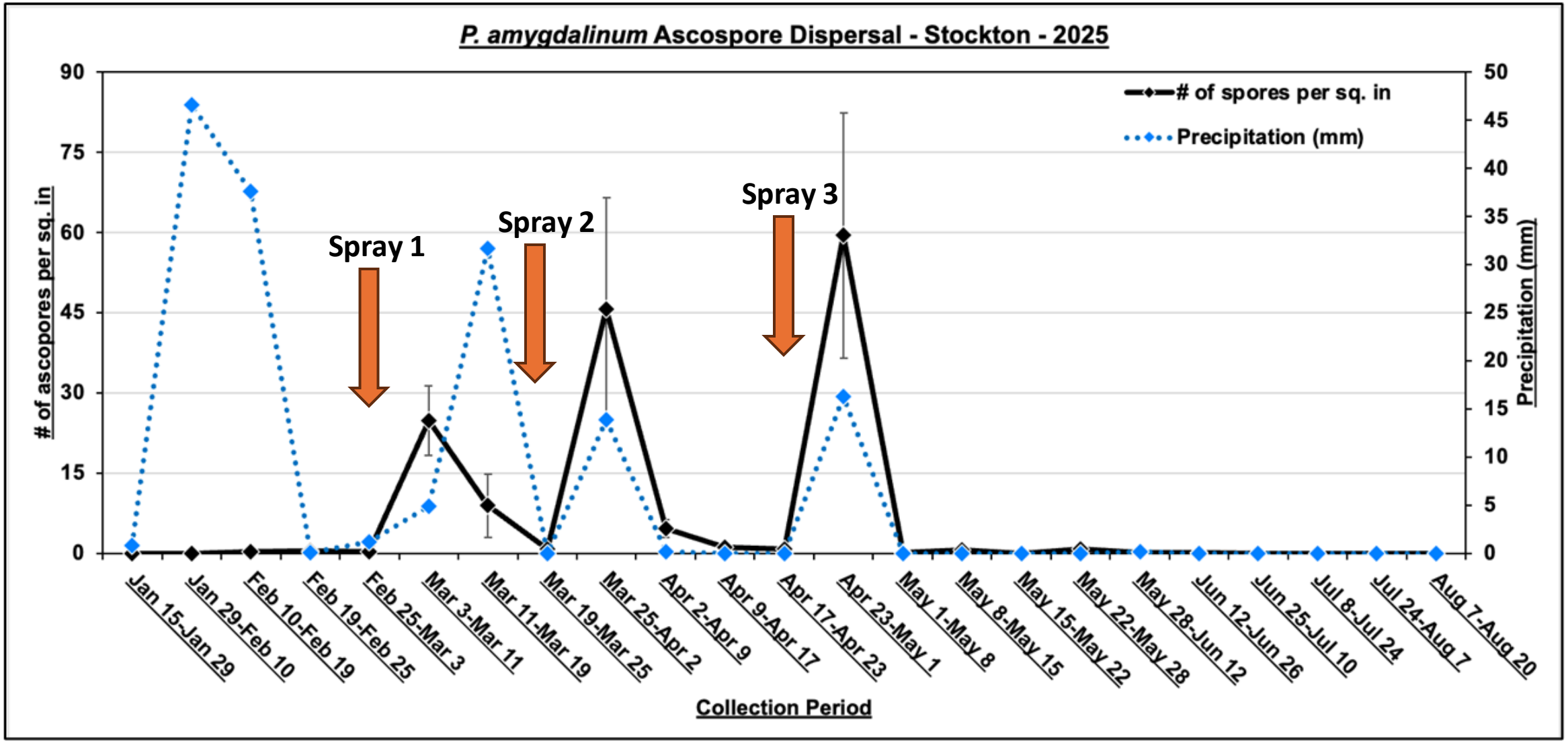
Brand	Product	FRAC Groups	A.I.	Rate/A	Color
	Water		Water		White
Bayer	**Luna Sensation (2 applications)**	FRAC 7 + 11	Fluopyram + Tryfloxystrobin	7.6 fl oz	Green/black stripes
	Scala + DFO	FRAC 9 + 3	Pyrimethanil + Difenoconazole	23.84 fl oz	White/red stripes
	Adament (liquid formulation)	FRAC 3 + 11	Tebucnonazole + Tryfloxystrobin	7.3 fl oz	Blue/black dots
	Serenade	BM02	Bacillus subtilis strain QST 713	4 qt	Yellow/black stripes
BASF	**Merivon**	FRAC 7 + 11	Fluxapyroxad + Pyraclostrobin	6.5 fl oz	Orange/black stripes
	Elisys	FRAC 3 + 7	Mefentrifluconazole + Fluxapyroxad	8.5 fl oz	Yellow/white stripes
	Pristine	FRAC 7 + 11	Pyraclostrobin + Boscalid	14.5 oz	Light blue
Corteva	**Fontelis**	FRAC 7	Penthiopyrad	20 fl oz	Pink/black stripes
Syngenta	**Miravis Duo**	FRAC 3 + 7	Difenoconazole + Pydiflumetofen	13.6 fl oz	Orange
	Miravis Prime	FRAC 7 + 12	Adepidyn + Fludioxonil	9.1 fl oz	White/blue dots
	Quadris Top	FRAC 3 + 11	Difenoconazole + Azoxystrobin	14 fl oz	Red/black stripes
FMC	**Rhyme**	FRAC 3	Flutriafol	7 fl oz	Dark blue
Heritage Crop Science	**Gleam**	P-unspecified	Chitosan 10% Vinegar 90%	20 fl oz	Blue/black Checkered
	Romeo	BM02	Cerevisane	0.5 lbs	Purple
UPL	**AXIOS™ 20 SC**	FRAC 52	Ipflufenoquin	5 fl oz	Red
Valent	**Quash**	FRAC 3	Metconazole	3.5 oz	White/yellow checkered
	Excalia	FRAC 7	Inpyrfluxam	4 fl oz	Neon yellow
	Intuity	FRAC 11	Mandestrobin	6 fl oz	White/blue stripes
Gowan	**Ecoswing**	BM01	Extract of Swinglea glutinosa	32 fl oz	White/orange dots
SAN Agrow	**Gargoil**	BM01	Cinnamon oil + Garlic	1% v/v	White/orange stripes
	Botector	NC	*Aureobasidium pullulans* strain DSM 14940 + *Aureobasidium pullulans* strain DSM 14941	10 oz	Green/black dots

- ❑ **Trial 1:** Stockton, Nonpareil (20 products) – backpack sprayer
- ❑ **Trial 2:** Stockton, Monterey (20 products) – backpack sprayer
- ❑ **Trial 3:** Merced, Lombardy Ave, Carmel (22 products) – spray bottle
- ❑ **Trial 4:** Merced, Childs Ave, Nonpareil (22 products) – spray bottle
- ❑ **Trial 5:** Merced, Lombardy Ave, Carmel (22 products) – single application



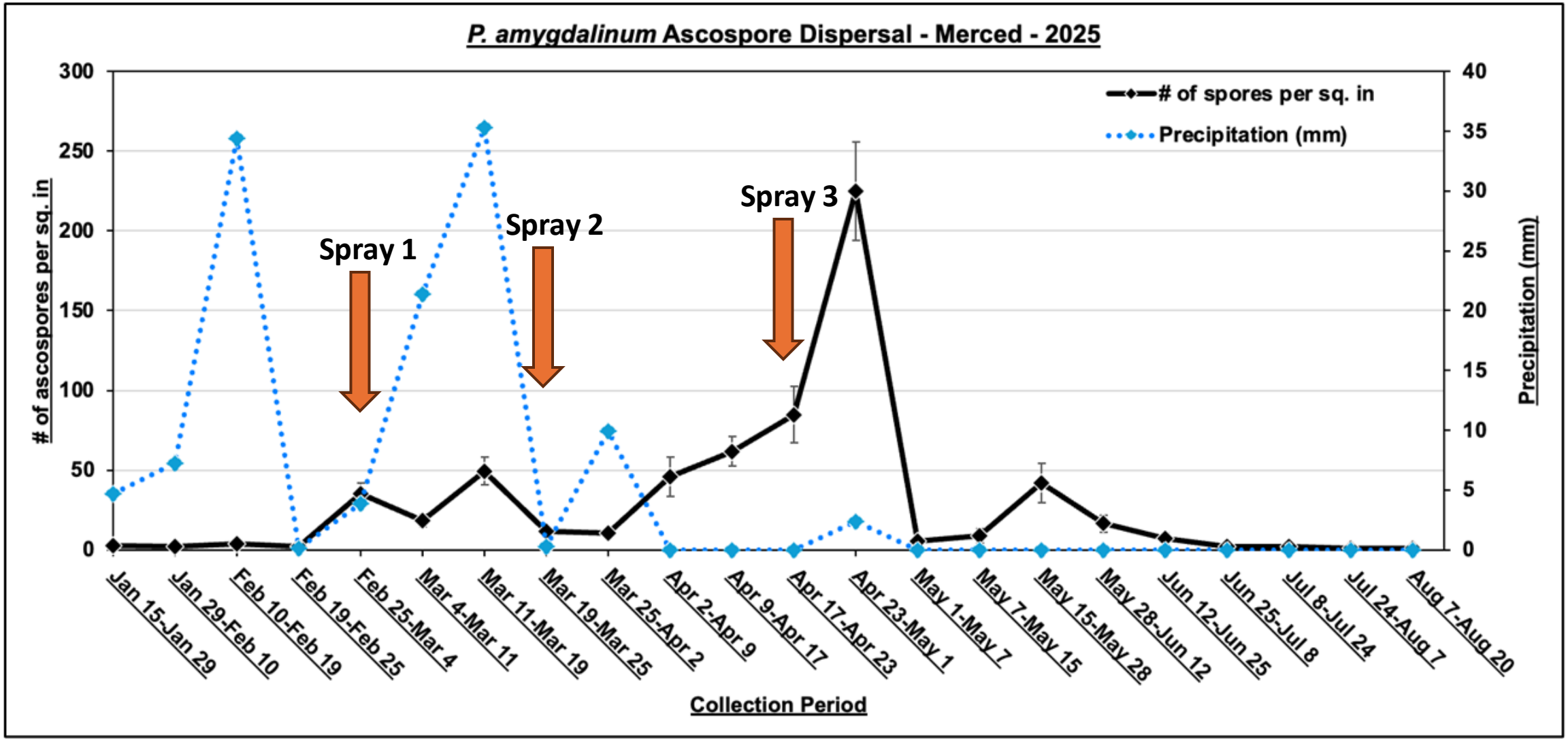
Timing of fungicide applications

Dynamic of spore inoculum (Stockton, California, 2025)



Timing of fungicide applications

Dynamic of spore inoculum (Merced, California, 2025)

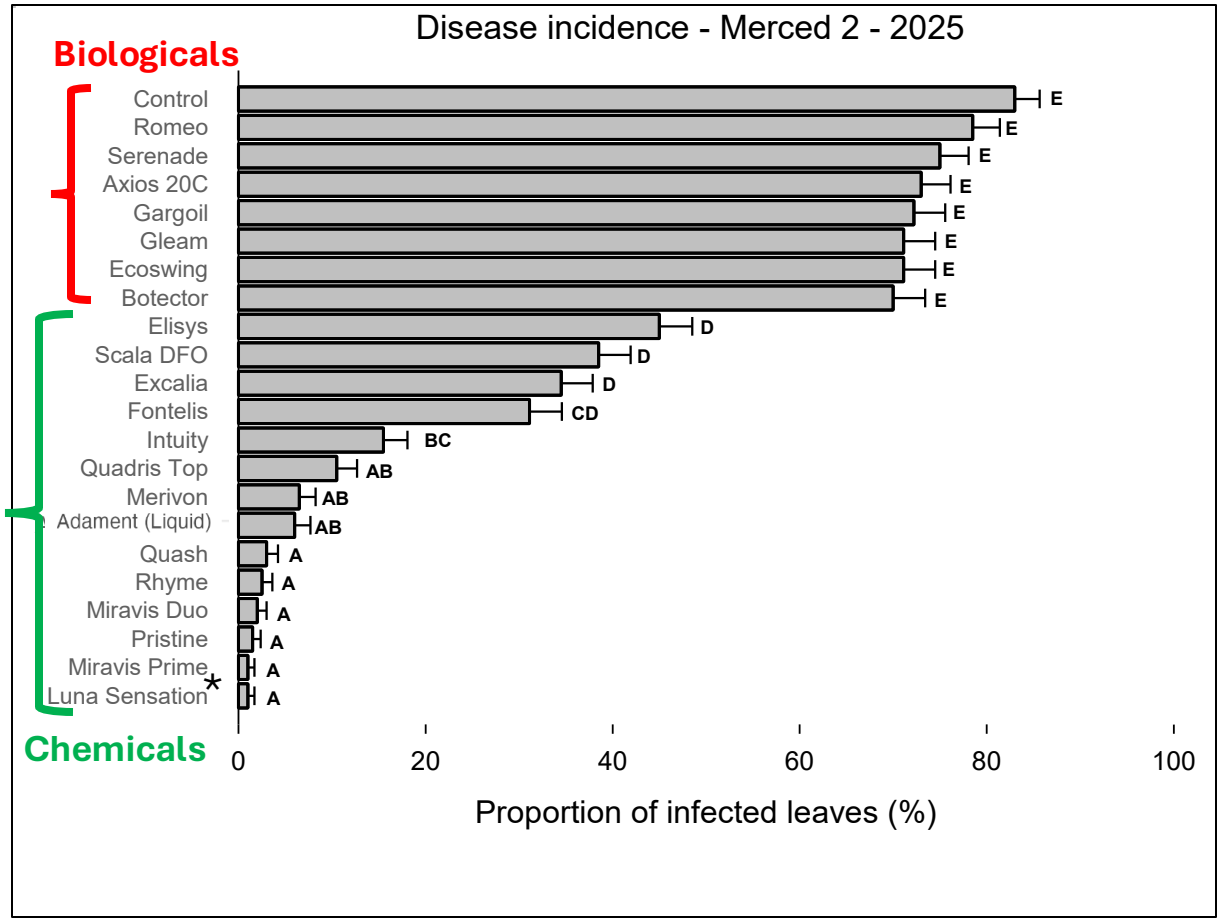


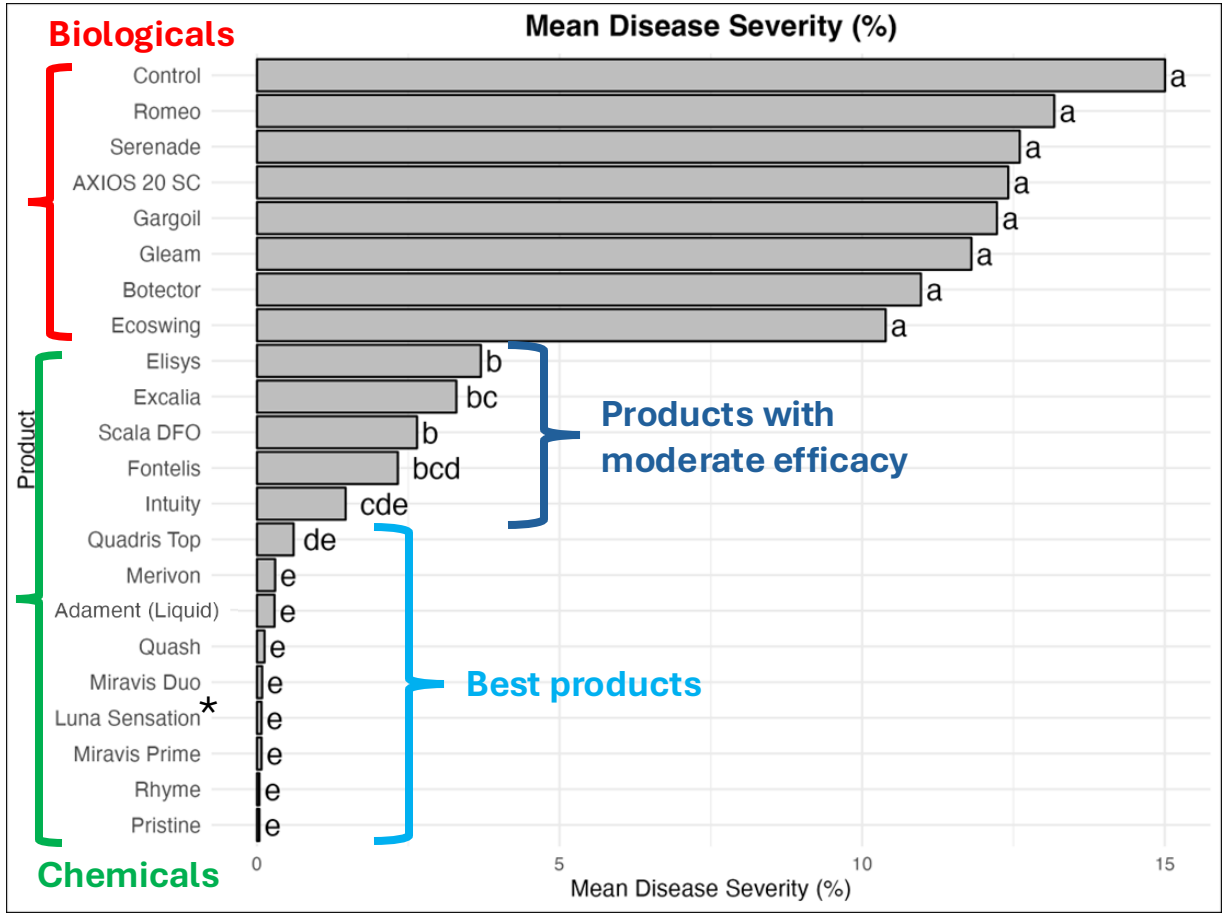
Chemical control

<u>Trouillas Lab</u> – 2025 Fungicide Trial - Childs Ave, Merced Co, Nonpareil

Application timings: @3/3/25, @3/19/25, @4/23/25

*Luna Sensation: @3/3/25, @3/19/25 only





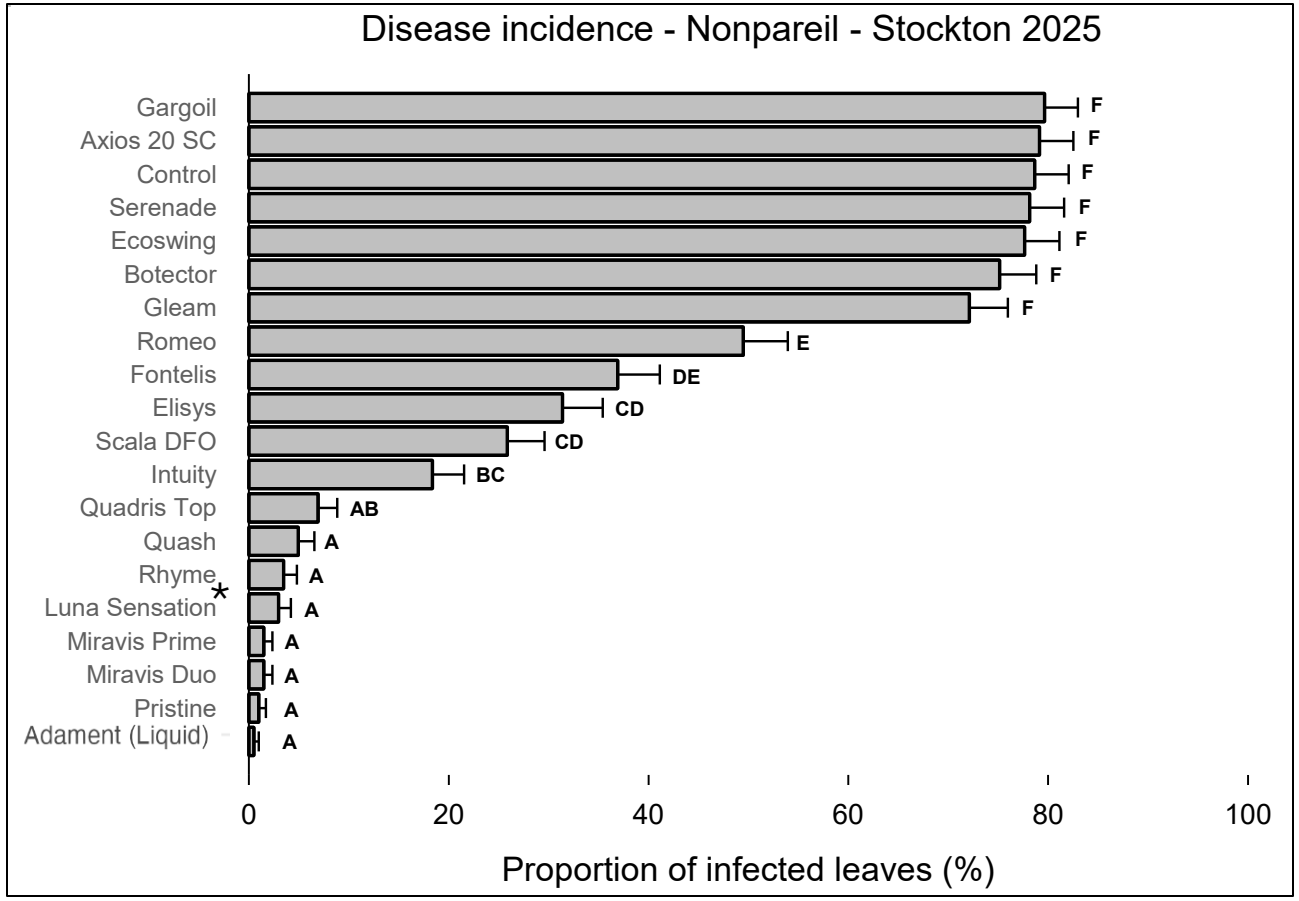
Chemical control

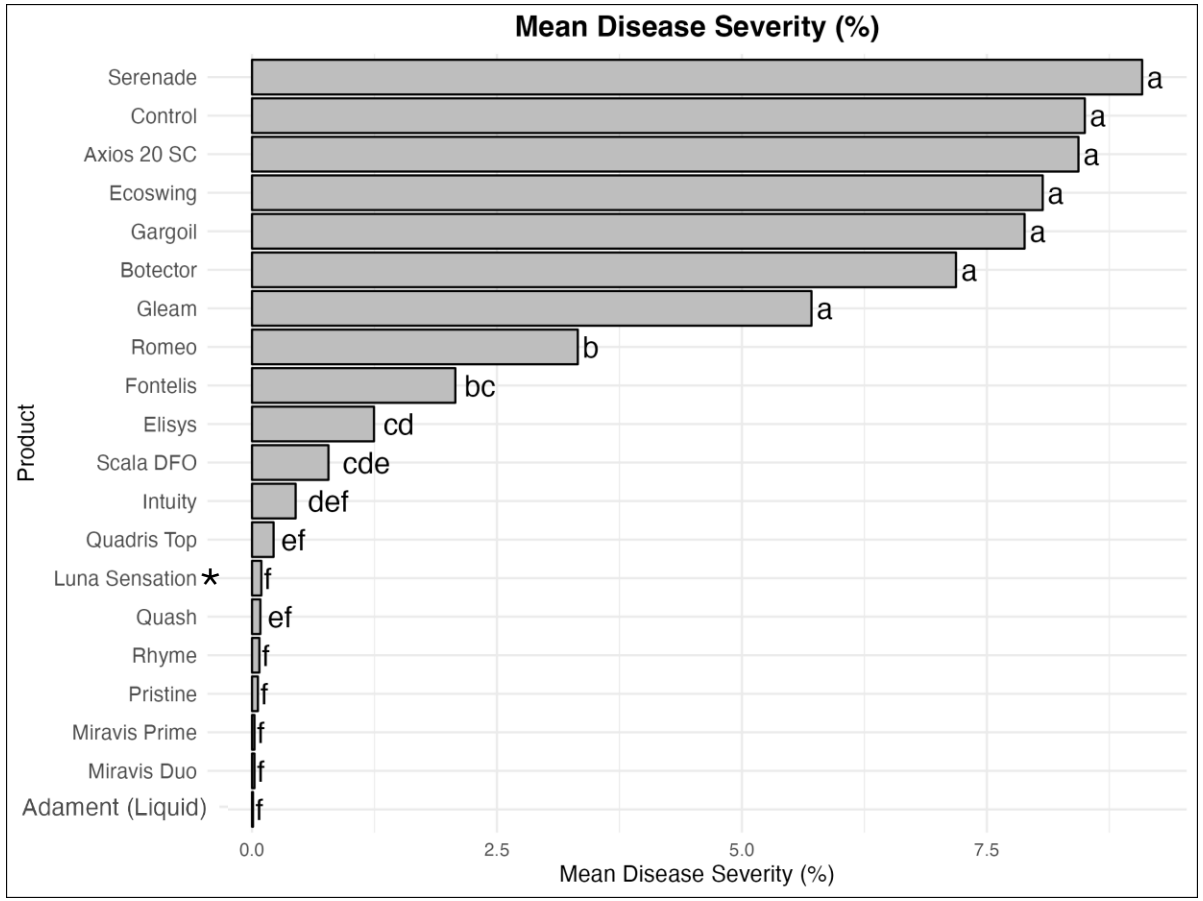
<u>Trouillas Lab</u> – 2025 Fungicide Trial - Stockton, Nonpareil

Application timings: @ 3/3/25, @3/19/25, @4/23/25

*Luna Sensation: @ 3/3/25, @3/19/25 only

(Nu-Film-P was added to biocontrol products)

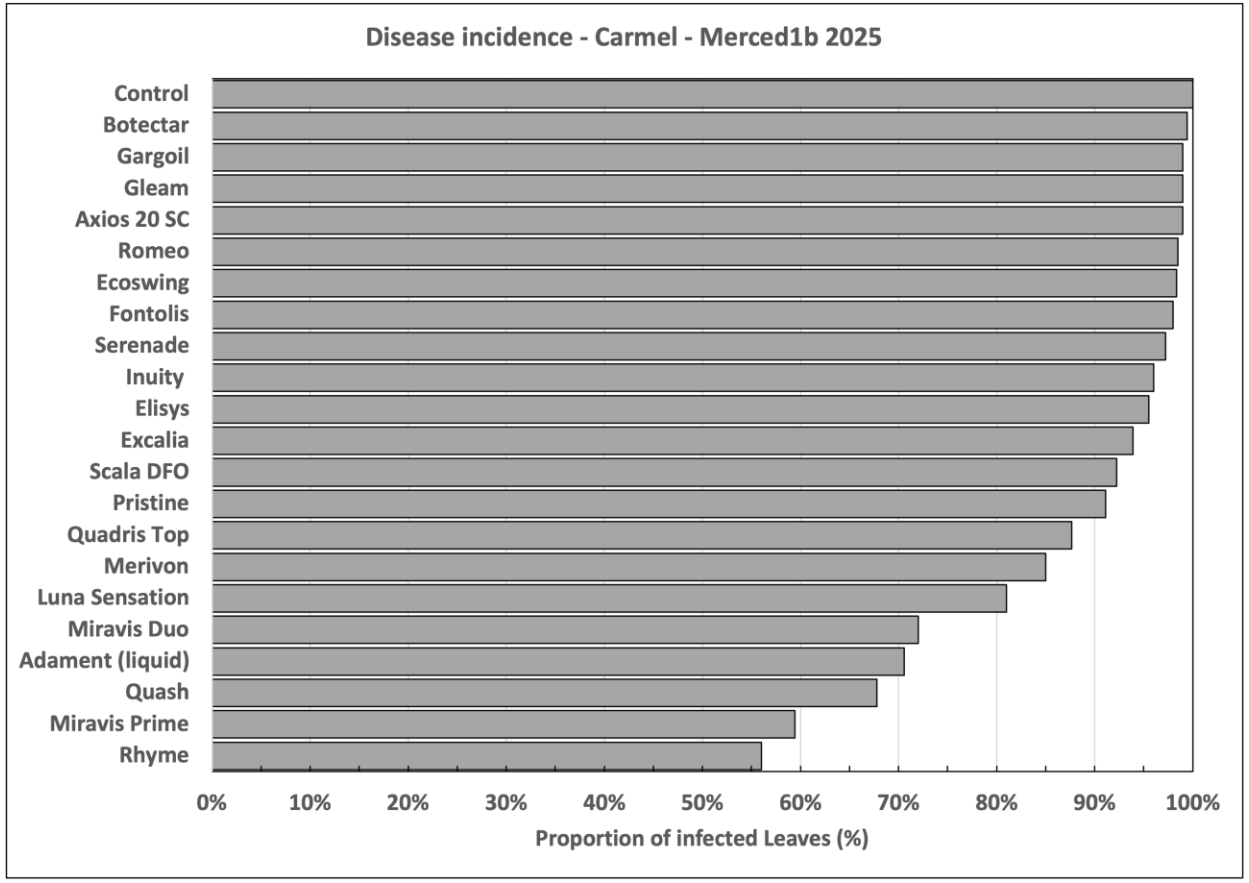




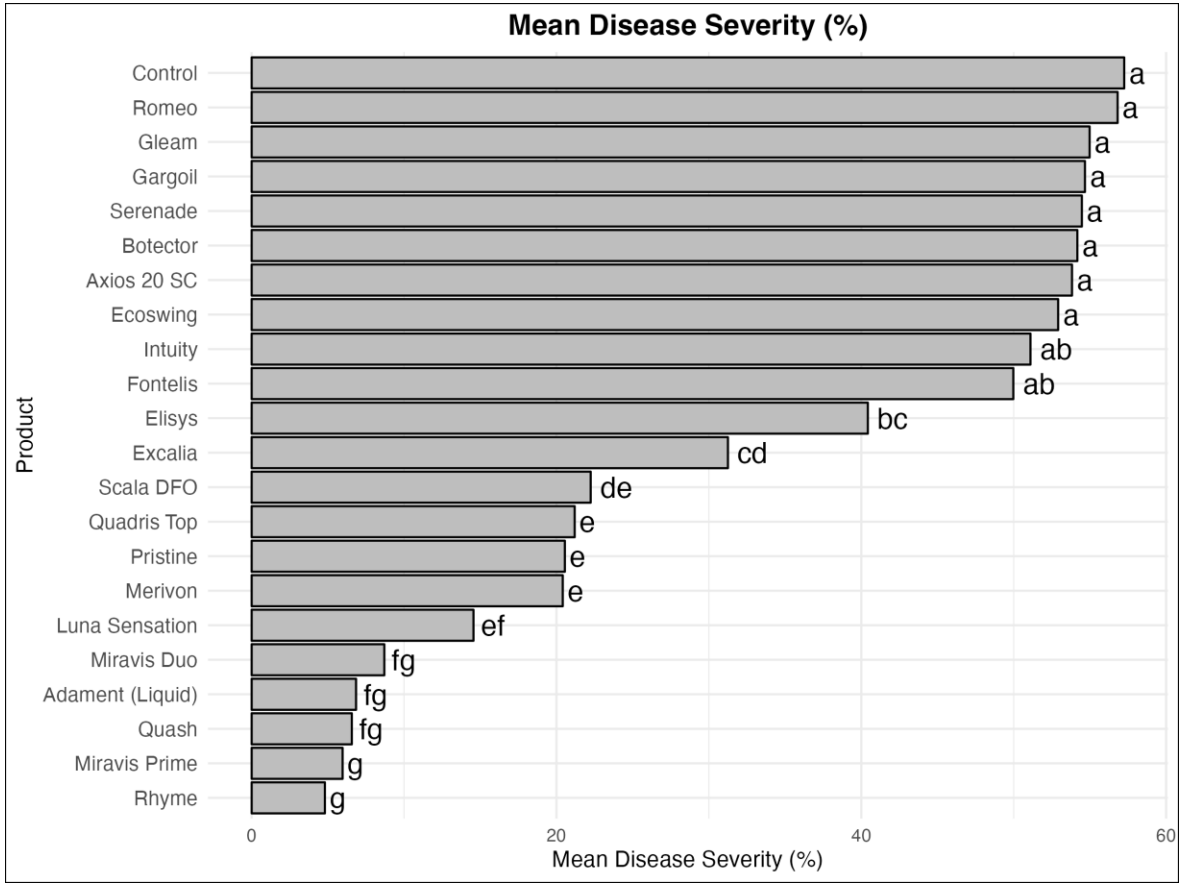
Single application

<u>Trouillas Lab</u> – 2025 Fungicide Trial – Merced 1b (Carmel)

Application timings: @ 3/18/25

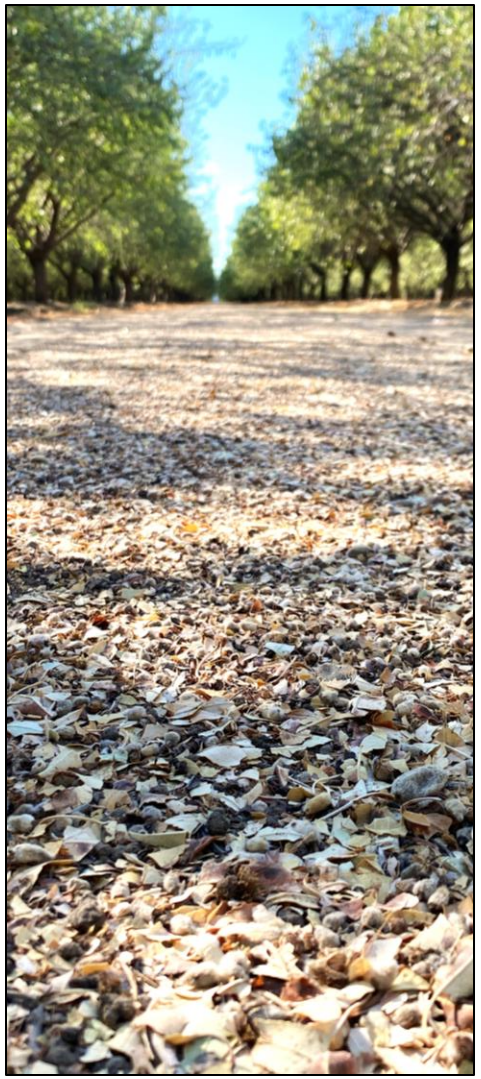


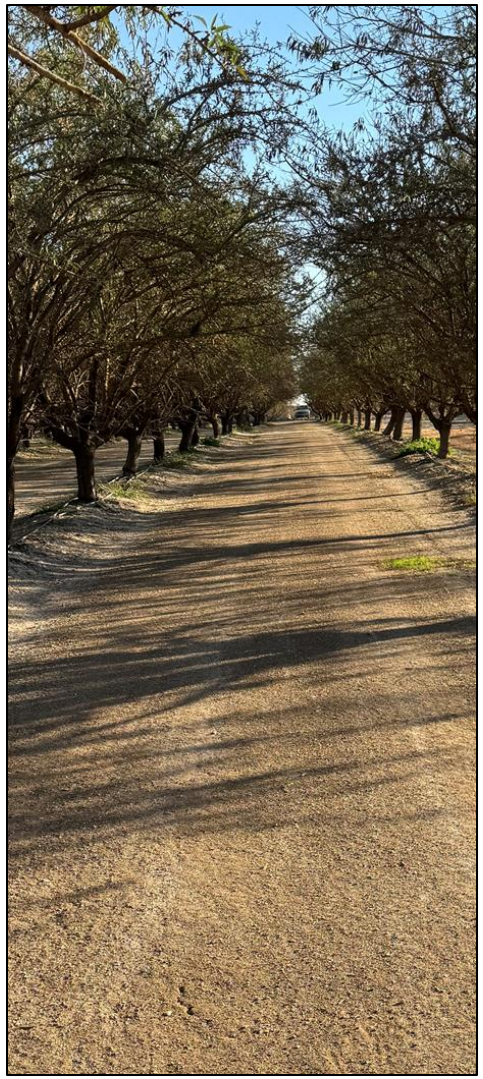
Carmel



Cultural practices

- ❑ Cultural practices focused on **eliminating the primary inoculum of infected fallen leaves** can help mitigate the disease
- ❑ **Zinc sulfate** to hasten leaf fall
- ❑ **Removing leaf litter**
- ❑ Applying **urea** or **lime sulfur** to accelerate leaf decomposition
- ❑ **Bio-sanitation** using beneficial microbes
- ❑ However, such strategies are only effective **when applied over a wide area**
- ❑ **Cleaning harvest and spray equipment** between orchards





Conclusion

- ❑ **New and serious disease outbreak** in California due to Red Leaf Blotch (RLB)
- ❑ It is here to stay – widespread now in CA
- ❑ **Paradigm shift in IPM strategies**, RLB will likely become the main focus in almond disease management strategies
- ❑ Integrate RLB management with management of rust, scab and shot hole
- ❑ Mixed fungicides (**FRAC groups 3+7; 3+11; 7+11; 7+12**) and **FRAC 3-triazoles** are most effective at controlling RLB
- ❑ Use them smartly, **alternate active ingredients** to avoid development of fungicide resistance
- ❑ Research is on-going to determine the optimal number of fungicide applications, but at least **2 to 3 applications will be required between petal fall (early to mid-March) and 5-weeks post petal fall (mid- to late April) for effective management**
- ❑ Fungicides applied during bloom and after symptoms are visible are NOT effective









Thank you!

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Trouillas Lab - UC Davis

Fruit & Nut Crop Pathology

Funding: Almond Board of California, Project Duration: **April 01, 2025 - July 31, 2028**

Cooperating personnel:

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Erin Shipley, Laboratory Assistant, KARE-UC Davis
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Growers, farm advisors and PCA cooperators

THANK YOU!

2025 THE ALMOND CONFERENCE

CULTIVATING A HEALTHIER FUTURE