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IPM TIPS FOR KEY INSECTS AND DISEASES

Gabriele Ludwig, *Almond Board of California*

David Haviland, *UC-ANR*

Mohammad Yaghmour, *UC-ANR*

Jim Adaskaveg, *UC Riverside*

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Gabriele Ludwig, *Almond Board of California*

california almonds
Almond Board of California

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IPM TIPS FOR KEY INSECTS AND DISEASES

David Haviland, *UC-ANR*

IPM Tips for Key Insects

Navel orangeworm, mites, and stink bugs

David Haviland

Entomology Advisor, UCCE- Kern Co.

Almond Industry Conference, Dec. 2020

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Navel orangworm management

- Arch-nemesis of almond growers every year
- Requires an integrated approach
  - Sanitation
  - Monitoring
  - Insecticides
  - Early/timely harvest
  - Mating disruption
- Adage of “you have to spend money to make money” applies

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Sanitation- mummy removal

- Cornerstone of any IPM Program
- At minimum
  - Shake, blow, windrow, mow

Sanitation- mummy removal

- Cornerstone of any IPM Program
- At minimum
  - Shake, blow, windrow, mow
- Ideally
  - Poling to <2 mummies/tree
  - Reduction in moths, and sites for eggs

2 mummies per tree
X
10% infested
X
50% female, each with 85 eggs =
Within an acre, 10 females, emerging at different times, competing to lay 850 eggs in 200 nuts with no coordination, trying to each find and lay an egg on every mummy nut left in 42 trees

Sanitation- mummy removal

- Cornerstone of any IPM Program
- At minimum
  - Shake, blow, windrow, mow
- Ideally
  - Poling to <2 mummies/tree
  - Reduction in moths, and sites for eggs
- Need to balance economics
  - Sanitation is the most effective management strategy you can control
  - Good sanitation can cost more than all other practices combined

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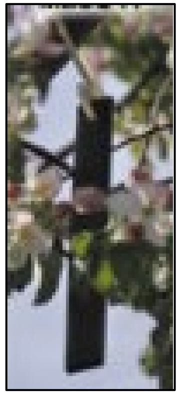
Mating disruption- a system for all inclinations

- Aerosols
  - ~1/acre, installed and removed
- Meso-emitter
  - ~20/acre, no removal necessary
- Flowable
  - Sprayed onto trees (registered but still under evaluation for efficacy)

- Four companies, same pheromone, different systems
  - Do-it-yourself products
  - Full service pay and walk-away products

Suterra	Pacific Biocontrol
Puffer NOW	Isomate NOW
semios	TRÉCÉ INCORPORATED
Semios NOW	Cidetrak NOW Meso



Optimal conditions for mating disruption

- Minimum 40 acres, ideally >100
- Square to rectangular shape
- Control of your own NOW destiny
  - Low risk of immigration of mated females
- Light breezes ideal

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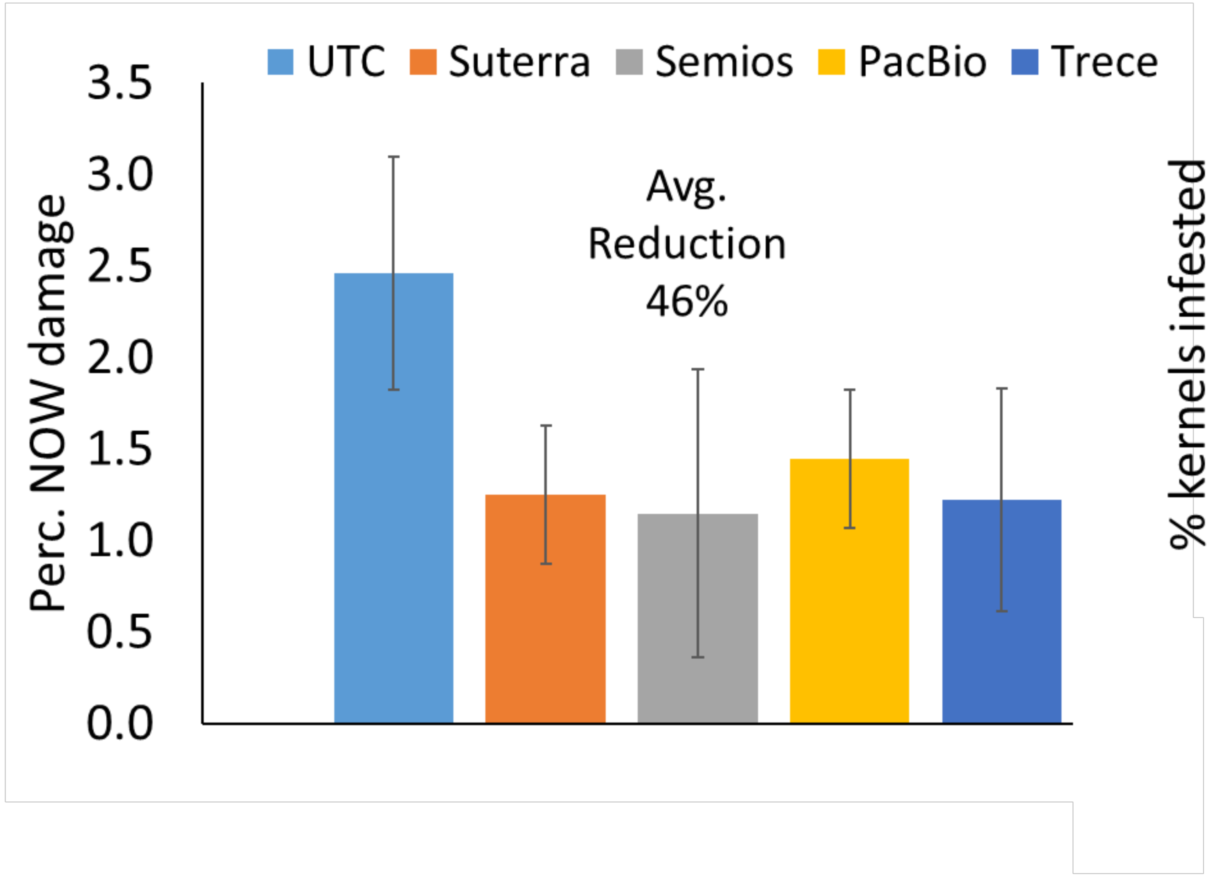
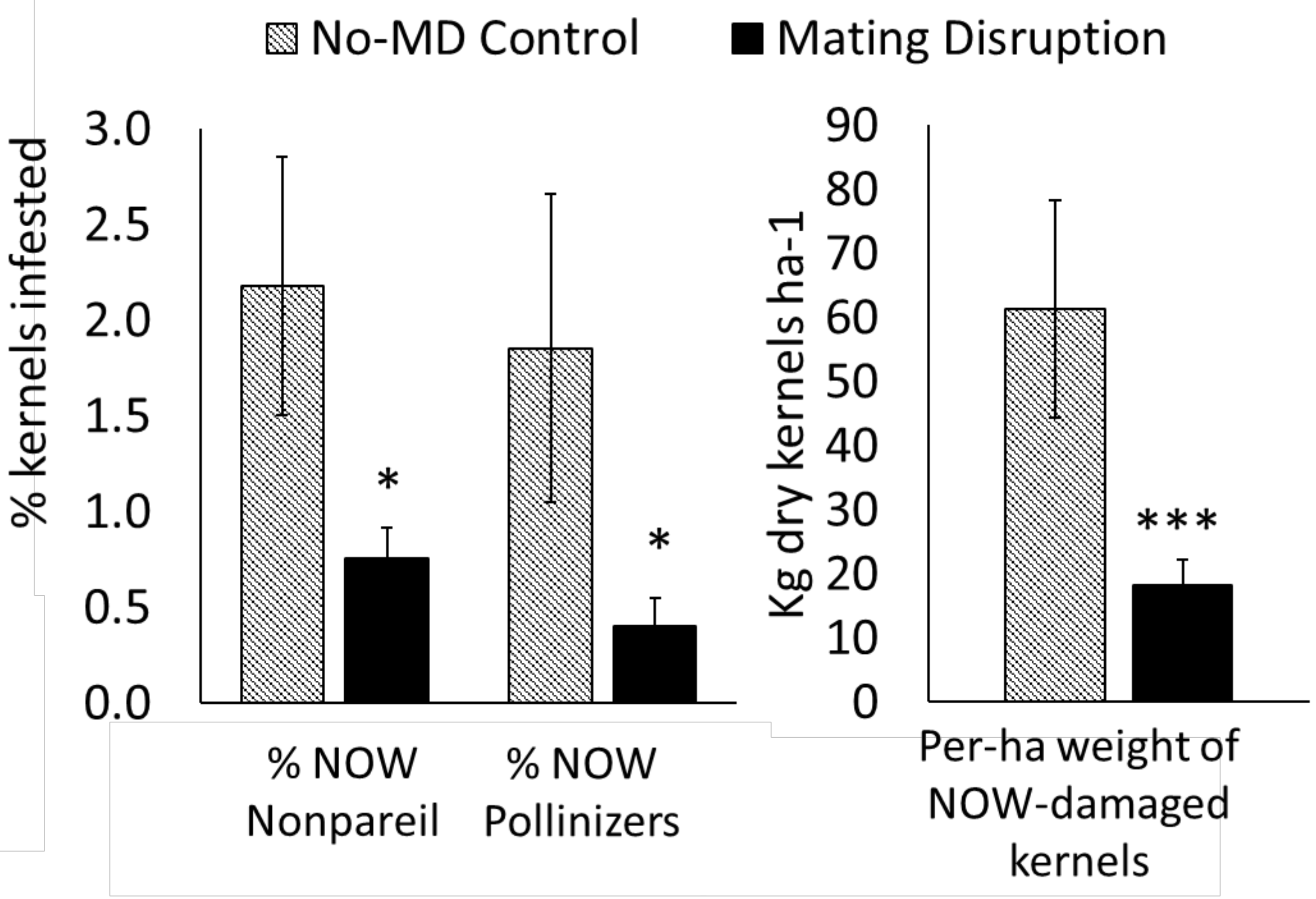
Does mating disruption work?

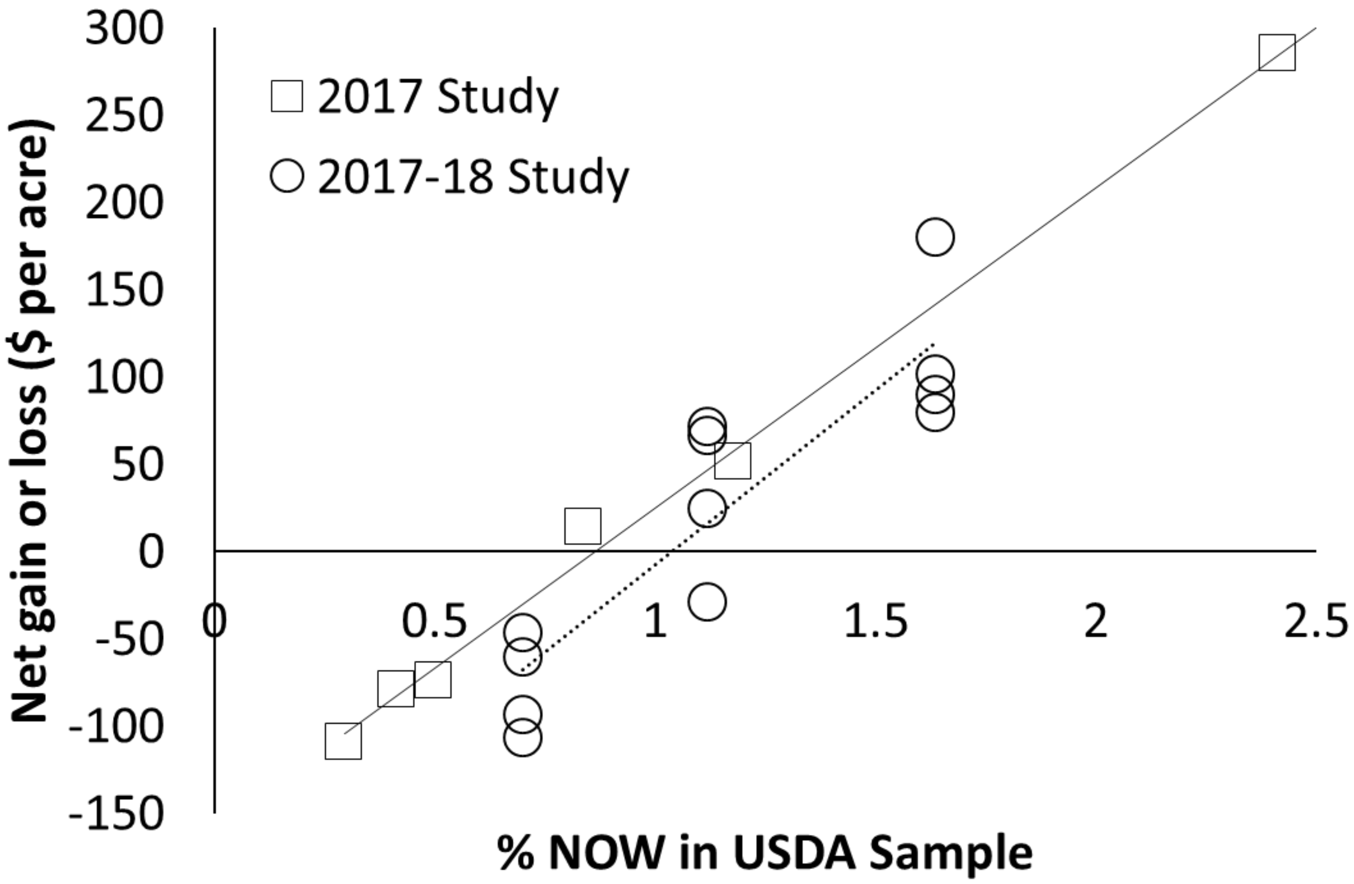
2017 Efficacy trial



2017-18 Demonstrations



Did I get a return on my mating disruption investment?



<u>Break-even points</u>

- 2017 Study- 0.83%
- 2017-18 Study- 1.06%

- *x-axis*- NOW damage with no mating disruption
- *y-axis*- Change in grower returns (increase in crop value minus cost of mating disruption)

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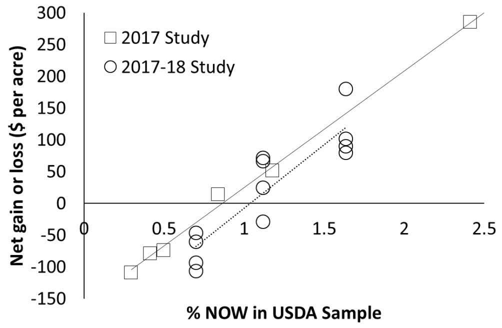
Was MD worth the money?



If you DID NOT use MD

- If you had <1% damage, investing in MD would have lost you money
- If you had 1% damage, you would have broken even
- If you had >1% damage, you would have made more money by investing in MD

If you DID use MD

- If you had <0.5% damage, your investment didn’t pay off
- If you had 0.5% damage, you broke even
- If you had >0.5% damage, investing in MD made you money

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Other factors to consider regarding MD?

- Impossible to predict good/bad years
  - MD is an insurance policy
  - In our trials 6/6 sites had two-yr benefit
- Value to resistance management
- More efficient processing
- Reduced aflatoxins
- Marketing value of sustainability
- Year-over-year benefits
- Potential to reduce sprays

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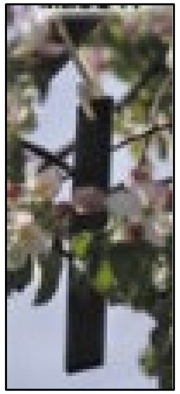
Puffer NOW

Pacific Biocontrol®
Isomate NOW

semios
Semios NOW

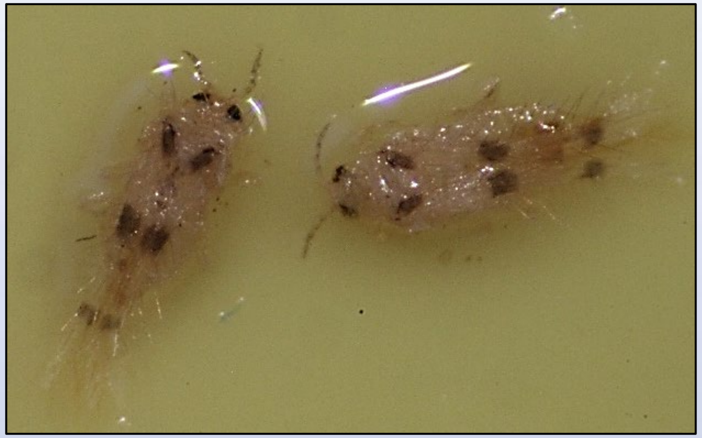
TRÉCÉ INCORPORATED
Cidetrak NOW Meso



Spider mites

Treatment thresholds and reliance on biological control



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Treatment thresholds

- Established in 1984 (Zalom/Wilson)
  - 22.0 of leaves infested with no biological control (predatory mites)
  - 43.6% of leaves infested if predatory mites are present
- Sequential sampling plan when treatments are being considered
  - 15 leaves/tree, minimum of 5 trees
  - Presence/absence of mites
  - Presence/absence of predators

UC IPM
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Almonds—Webspinning Spider Mites Sampling

Supplement to UC IPM Pest Management Guidelines: Example Form

Directions:
1. Before July 1, monitor hot spot areas where mites develop first. After July 1, monitor the whole orchard by dividing it into sampling areas that can be treated separately.
2. Within each sampling area, sample a minimum of 5 trees. Select 15 leaves from each tree, randomly picking leaves from both the inside and outside of the canopy as you walk around it.
3. Using a hand lens, examine both sides of each leaf carefully. Look for spider mites and eggs, western predatory mites and eggs, sixspotted thrips, and other predators. Look closely since there may be only 1 to 2 mites or predators on a leaf.
4. Count the number of leaves on each tree with pest mites or their eggs, and the number of leaves with predators, and record below. Do not count individual mites or predators.
5. As you move from tree to tree, keep a running total of leaves with mites on the form. Once you have sampled 5 trees, compare your total to the numbers in the "Don't Treat" and "Treat" columns below.
6. If your numbers are the **SAME OR LESS** than the "Don't Treat" column, you can stop sampling. If your numbers are **AS MUCH OR MORE** than in the "Treat" column, stop sampling and treat. If your numbers are **IN BETWEEN**, continue sampling until a decision can be reached.

Date ________________ **Grower/Orchard** ________________

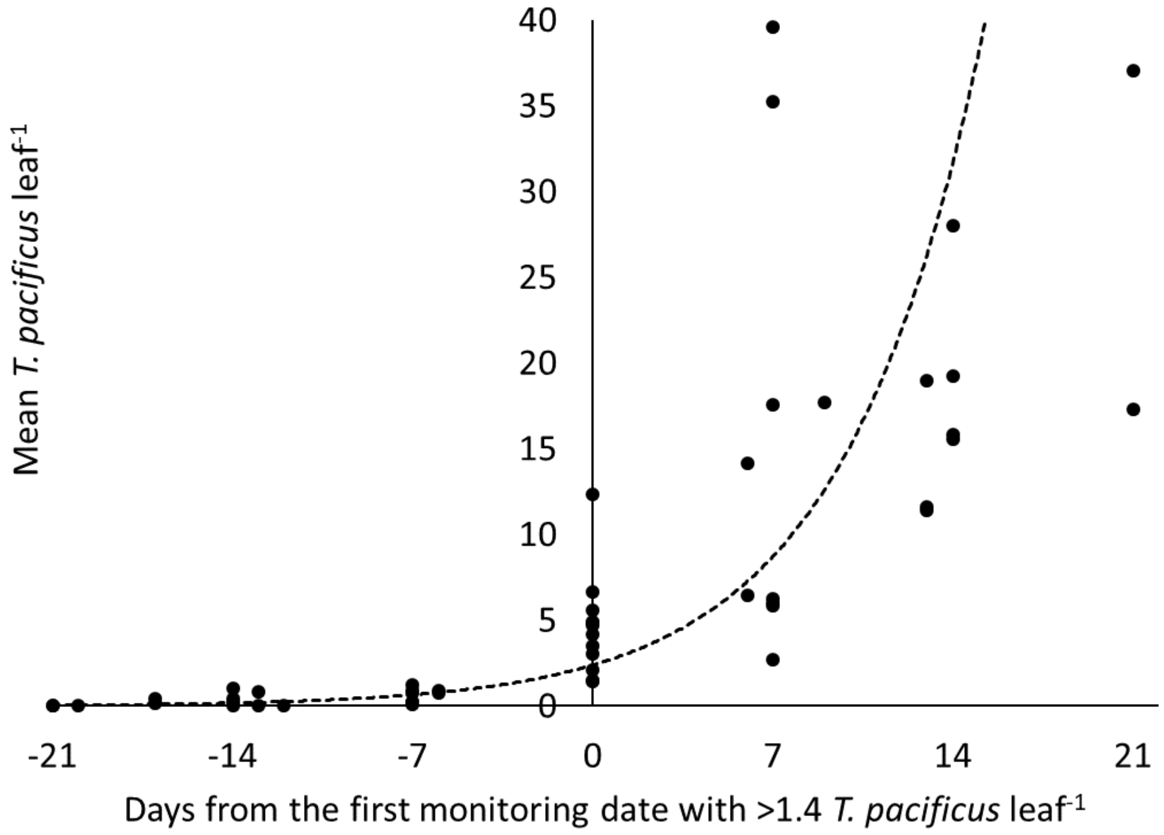
					If predators are present		*If predators are absent*	
Tree number	**Total number of leaves sampled**	**Number of leaves with mites (on each tree)**	**Total number of leaves with mites (on all trees)**	**Number of leaves with western predatory mite and/or sixspotted thrips**	**Don't treat** if total leaves with mites is:	**Treat** if total leaves with mites is:	**Don't treat** if total leaves with mites is:	**Treat** if total leaves with mites is:
1	15							
2	30							
3	45							
4	60							
5	75				≤ 27	≥ 40	≤ 12	≥ 24
6	90				≤ 33	≥ 48	≤ 15	≥ 28
7	105				≤ 39	≥ 55	≤ 18	≥ 31
8	120				≤ 45	≥ 62	≤ 21	≥ 35
9	135				≤ 51	≥ 69	≤ 23	≥ 39
10	150				≤ 57	≥ 76	≤ 26	≥ 43
11	165				≤ 63	≥ 83	≤ 29	≥ 46
12	180				≤ 70	≥ 90	≤ 32	≥ 50
13	195				≤ 76	≥ 97	≤ 35	≥ 54
14	210				≤ 82	≥ 104	≤ 38	≥ 57
15	225				≤ 88	≥ 111	≤ 41	≥ 61
16	240				≤ 94	≥ 118	≤ 45	≥ 65
17	255				≤ 101	≥ 125	≤ 48	≥ 68
18	270				≤ 107	≥ 132	≤ 51	≥ 72
19	285				≤ 113	≥ 139	≤ 54	≥ 75
20	300				≤ 119	≥ 146	≤ 57	≥ 79

(19 August 2020) Print copies of this form at ipm.ucanr.edu/FORMS/

Produced by the UC Statewide IPM Program

Thresholds revisited- 2010s

- 12 untreated orchards
- Mites tracked over time
- Synchronized by date with standardized mite density



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Thresholds revisited- 2010s

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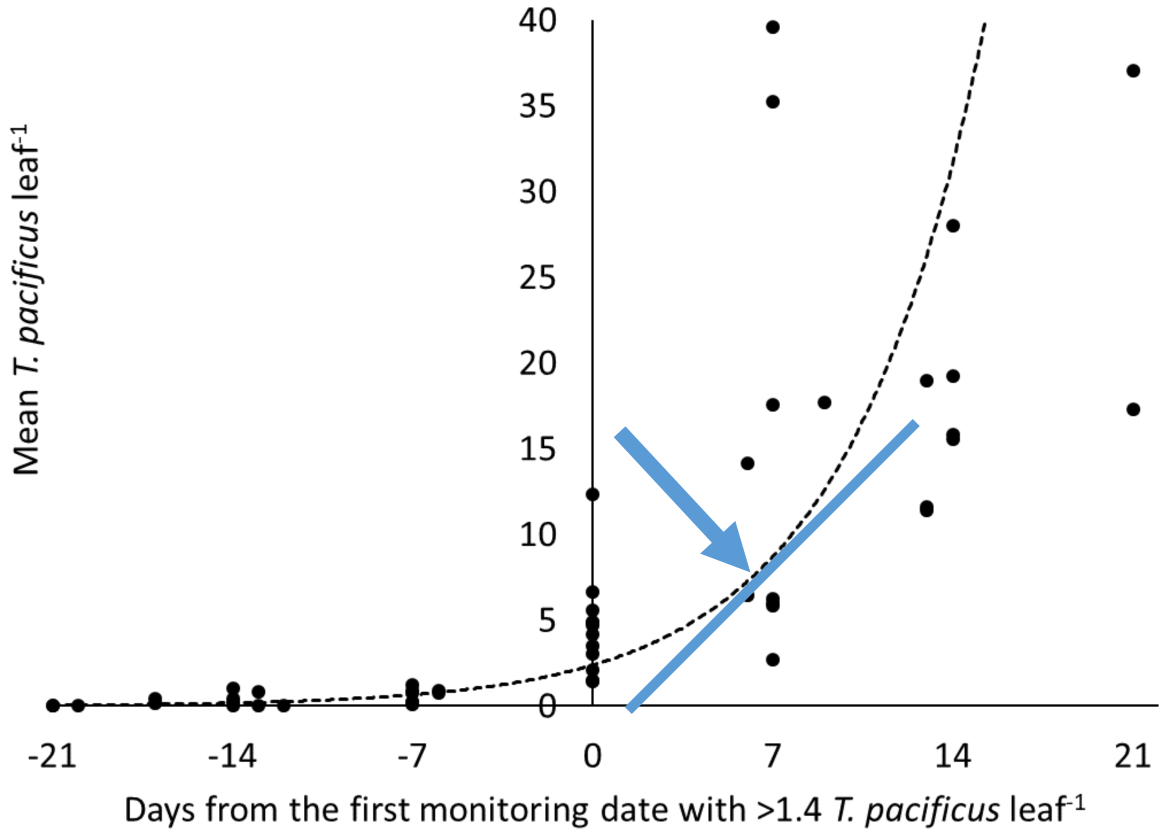
- Mites tracked over time
- Synchronized by date with standardized mite density
- Defined treatment threshold as date where regression curve has a 45% slope



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Thresholds revisited- 2010s

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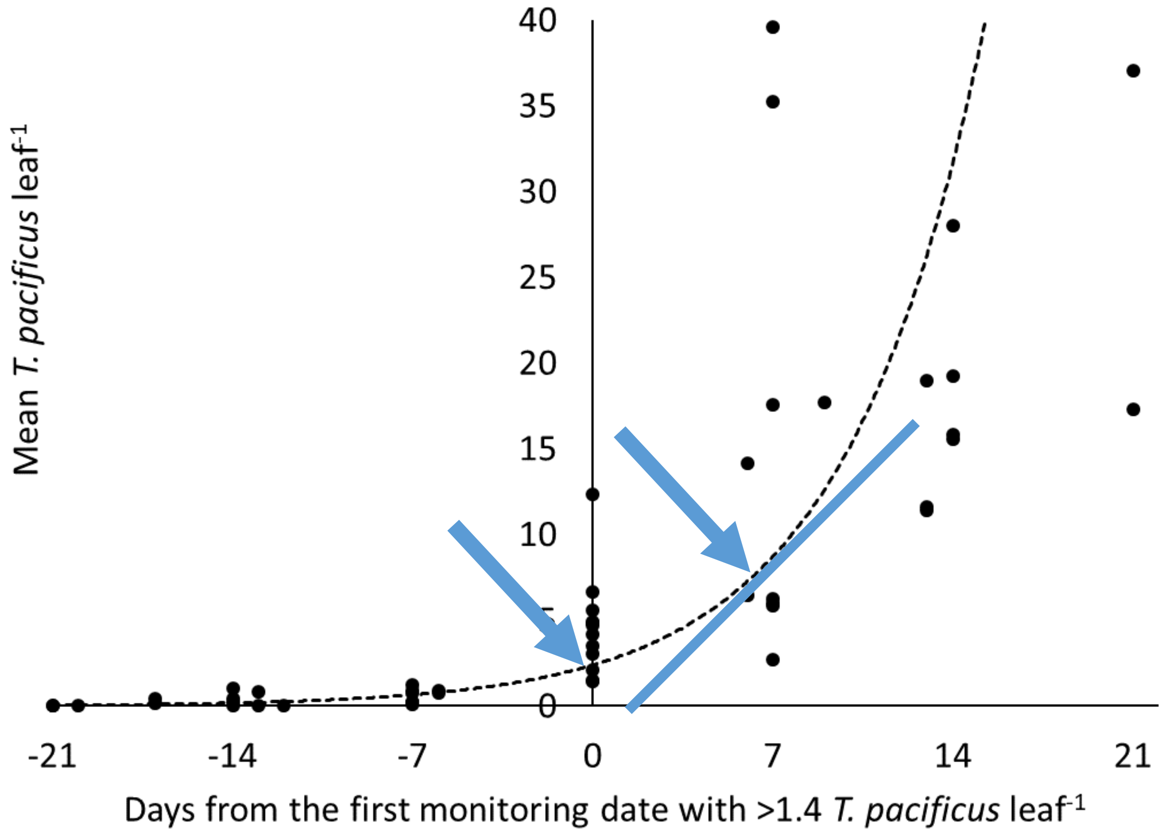
- Defined action threshold as 1 week earlier



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Thresholds revisited- 2010s

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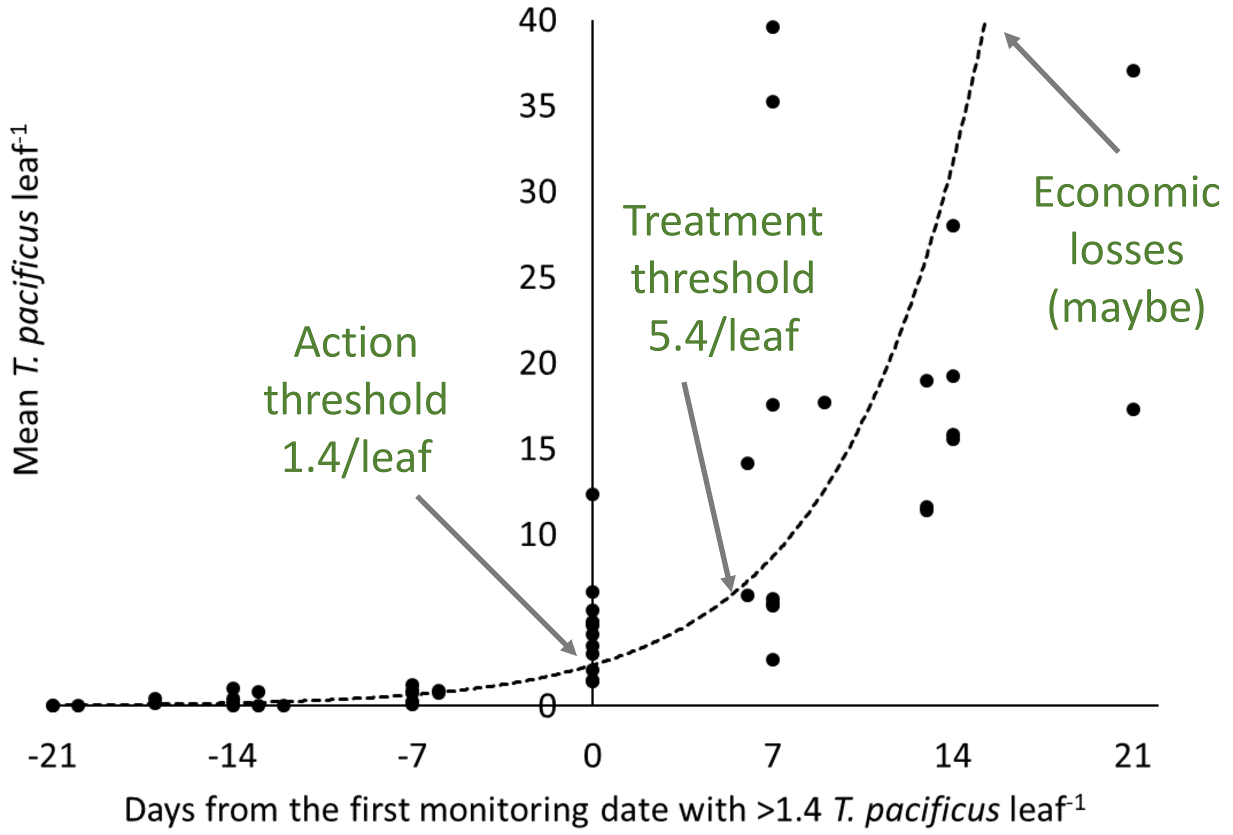

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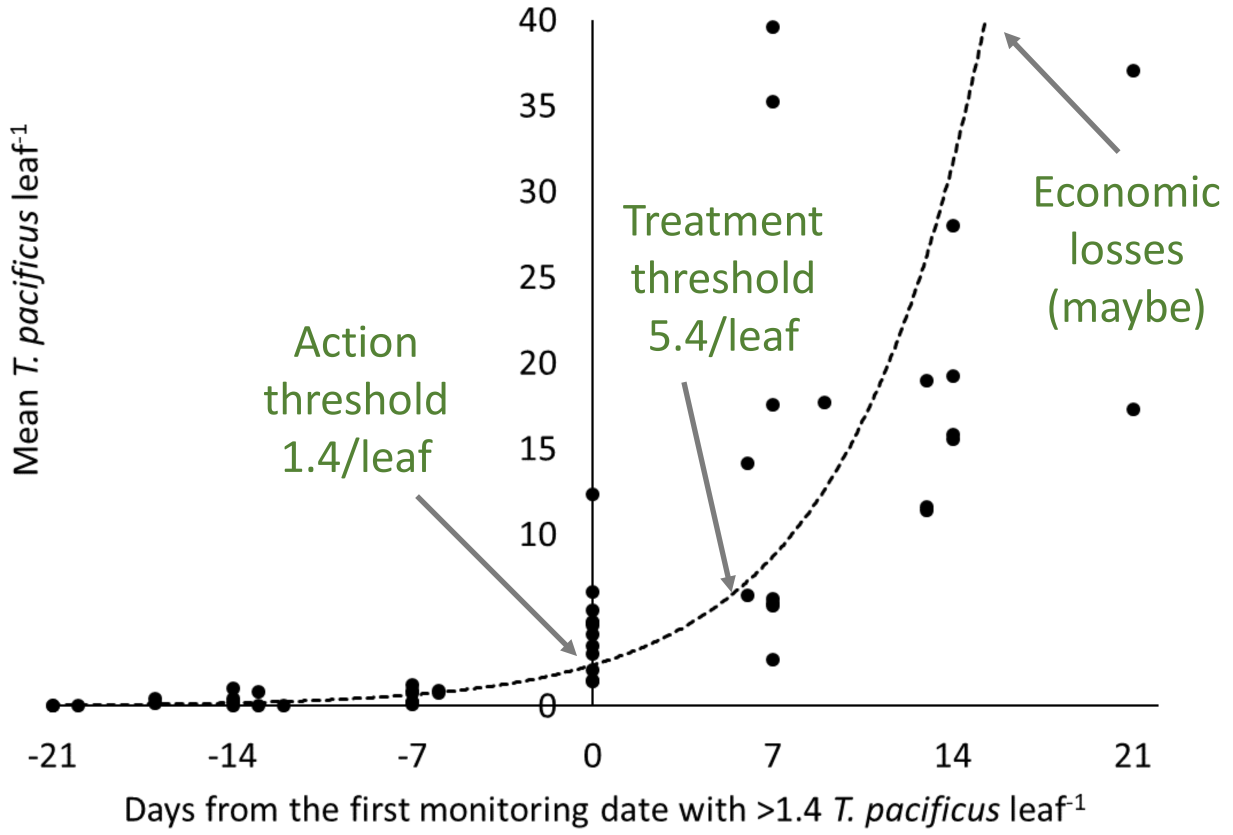
Thresholds revisited- 2010s

1.4 mites per leaf = 38% infested

Zalom 1984 threshold = 43.6% infested with biocontrol present

Average- 40% of leaves infested



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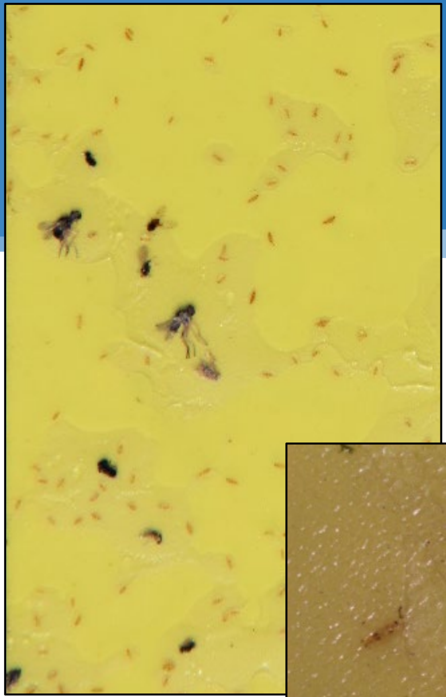
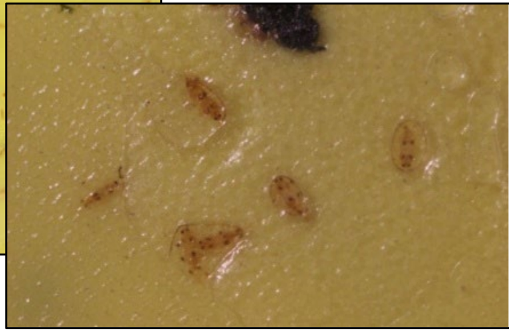
Sixspotted thrips

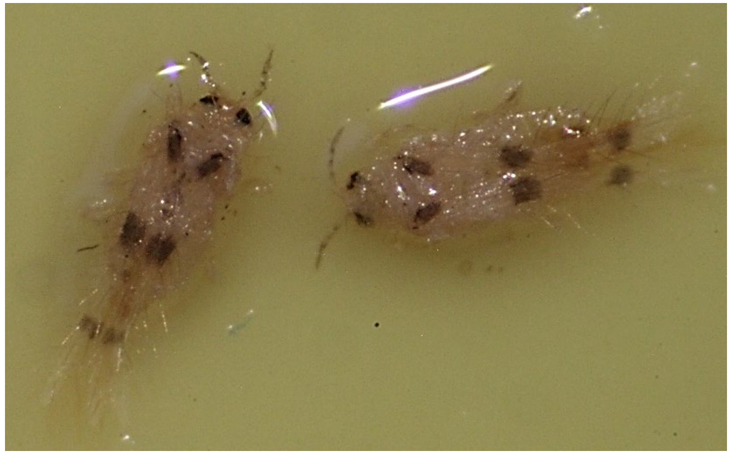
- Specialized to eat mites
- Adapted to feed within webbing
- Cannibalistic if food is scarce
- Thrive in hot, dry conditions
- ~90% females
- Can double their population every 4 days

Sixspotted thrips monitoring

- Yellow strip traps
- Predator trap- Great Lakes IPM
- Hang in orchard for one week
- Count the thrips
- Helps to track populations over time
- Can be used for thresholds







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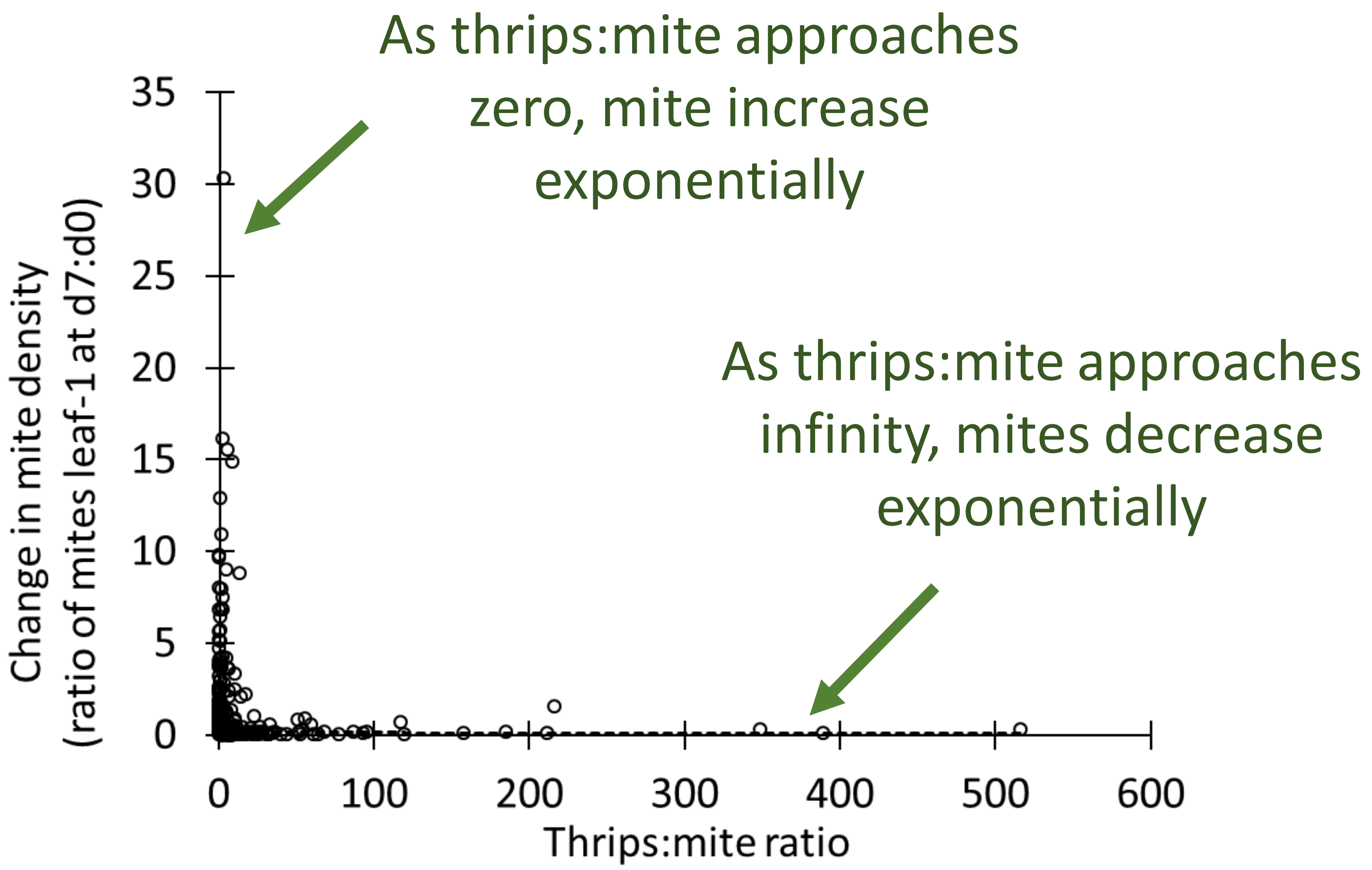
Incorporating thrips into thresholds

- Monitoring mites tells you how many mites there are
- Monitoring thrips tells you how many mites there will be



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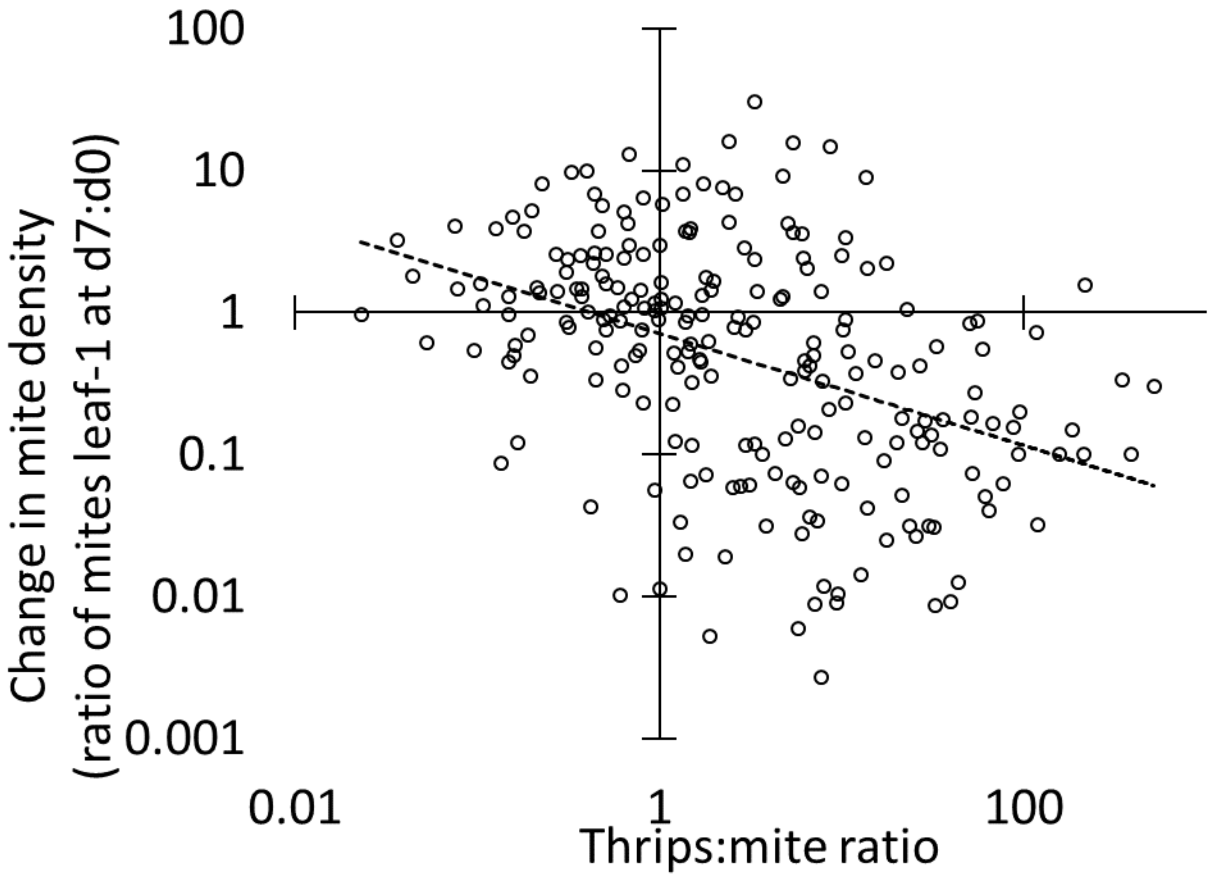
Incorporating thrips into thresholds

Mite populations remain unchanged in 7 days if there are 0.42 thrips/card/week for every 1 mite per leaf



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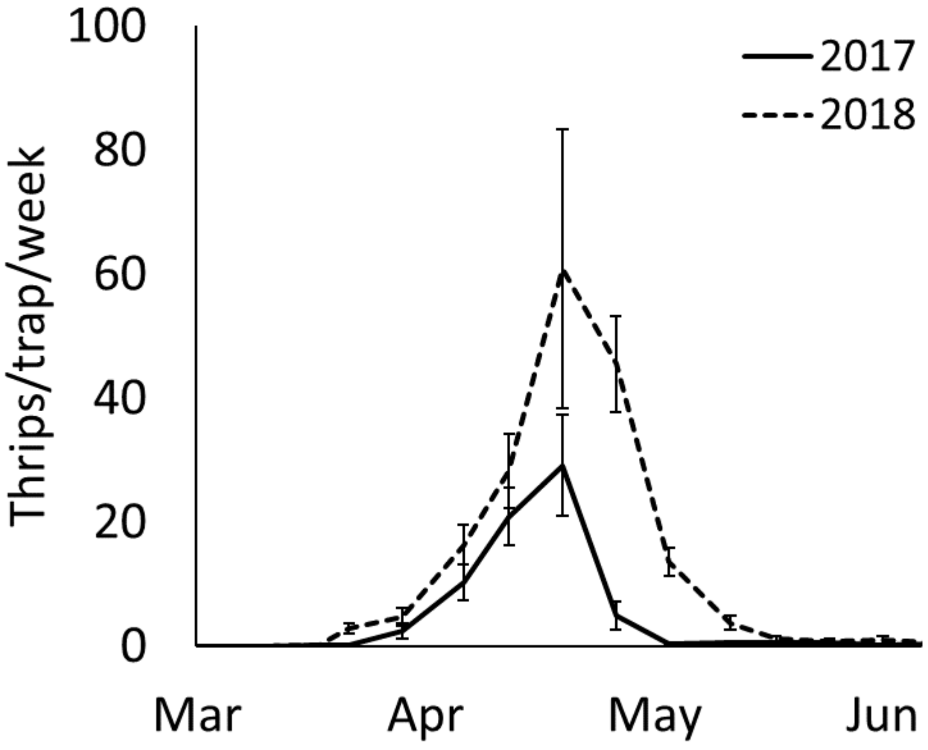
May spray decisions

- Don't treat unless you have 40% of leaves infested (1.4/leaf)
- At this density, mite density will not change if there are 0.6 thrips/card
- 'No need to treat' decision is confirmed if you find 1 thrips/card
- In our studies, thrips/card was >1 in 100% of >20 orchards monitored
- May sprays are only needed if…
  - 40% of leaves are infested and you capture no thrips
  - If you plan on killing the thrips



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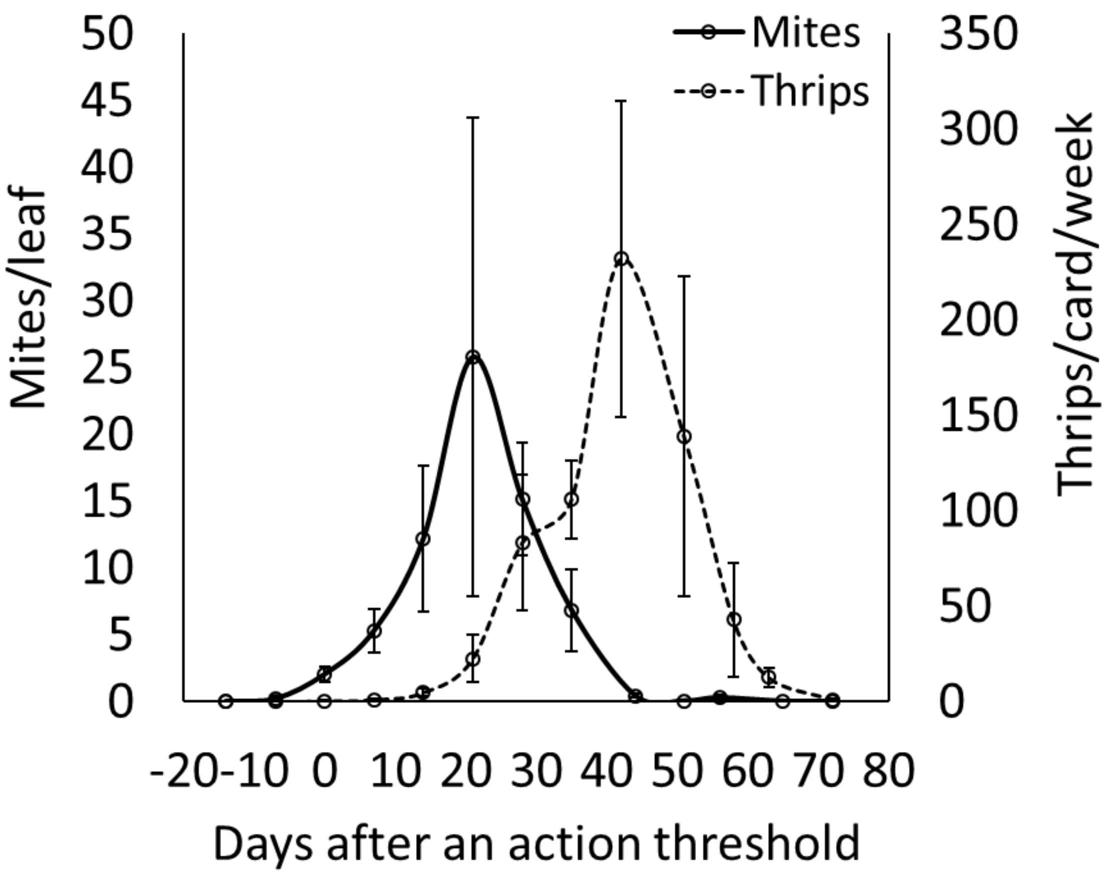
Hull split spray decisions

- Threshold of 40% of leaves infested is still applicable
- But logistics (free rides, PHIs, harvest) can be problematic
- Thrips respond 2 weeks after mites increase (lag time)
- Thrips density doubles every 4 days
- Probabilities show
  - At 3 thrips/card, no change in mite density in 14 days
  - At 3/card, mites lower in 77% of orchards in 14 days



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Stink bugs

Becoming primary pests

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Stink Bugs

- Watch out for them
- Reduced-risk NOW/PTB/SJS programs no longer controlling stink bugs secondarily
- Very camouflaged/cryptic
- Often in the tops of trees
- Can migrate into orchards (corn/tomato harvests)
- Can cause damage into June (black spots)
- External damage (gummosis) not always evident
- Follow-up on causes for inedibles at huller
- Controlled with pyrethroids and Belay
- Work is also underway on BMSB

Thank you

This research was made possible through long-term funding by the Almond Board of California and a Pest Management Alliance grant from DPR

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IPM TIPS FOR KEY INSECTS AND DISEASES

Mohammad Yaghmour, *UC-ANR*

california almonds

Almond Board of California

IPM Tools to Manage Hull Rot

Mohammad Yaghmour, PhD
UCCE Kern County

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Signs and Symptoms of Hull Rot

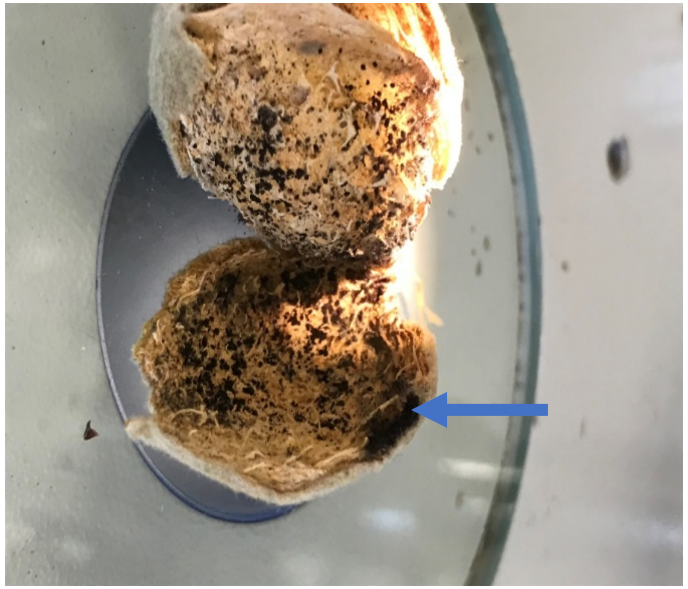
When the hull is infected and disease progresses, leaves near the infected fruit starts to dry and shrivel.

Signs and Symptoms of Hull Rot

Monilinia spp.

Rhizopus stolonifer

Aspergillus niger



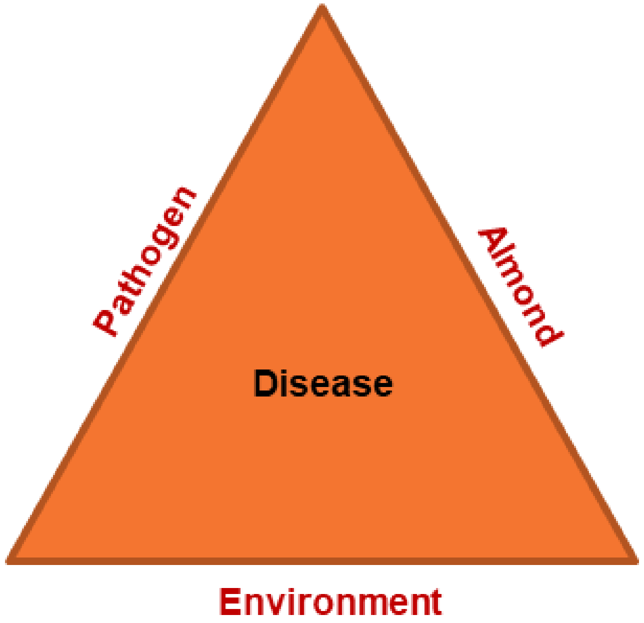
Strategies Used in IPM

What is Integrated Pest Management?

It is the combination of different strategies to manage and combat plant diseases (Hull Rot).

- Avoidance: Mainly dealing with the environment component
- Exclusion: Focusing on keeping the pathogen out of production areas, state, or country
- Eradication: Focusing on eliminating and removal of the primary inoculum (pathogen)

➔Protection



Protection

- Cultural Practices
  - Managing Plant Nutrition:
    - Nitrogen management for hull rot
  - Water Management:
    - Important in soil borne diseases
  - Planting on Berms:
    - Phytophthora root rot and Crown rot
  - Row Orientation:
    - Alternaria leaf blight
  - Proper Scaffold Selection:
    - Canker diseases
- Chemical Control
  - Fungicides, Chemicals, etc.
- Host Resistance
  - Use of Resistant Rootstocks
    - Soil borne disease, managing nematodes
  - Varietal Susceptibility and Resistance
- Biological Control

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Sources of Inoculum

- *Monilinia* spp.:
  - Causes Brown Rot on stone fruits

- Sources of Inoculum:
  - Infected almonds
  - Stone fruit twigs
  - Fruits
  - Mummies
  - Etc.

Monilinia spp.

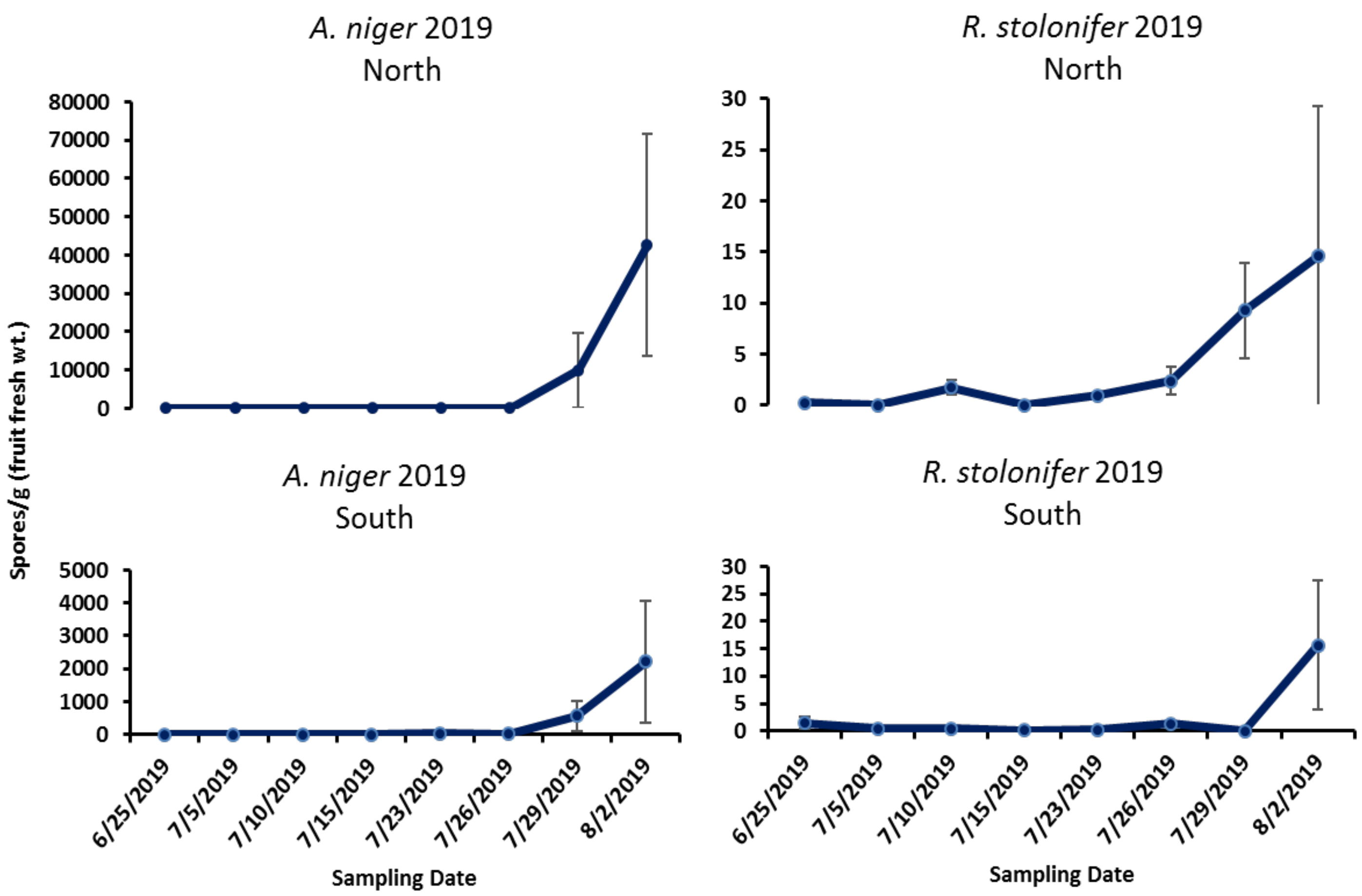
Sources of Inoculum

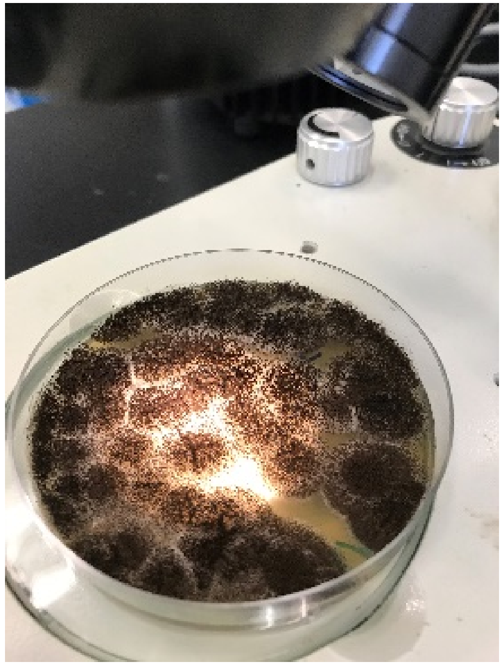
Rhizopus stolonifer

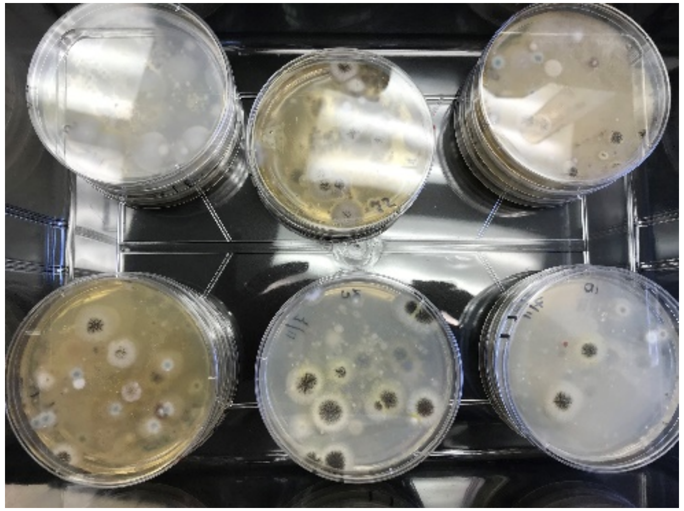
Aspergillus niger

Main source of spores and primary inoculum is the soil.

Sources of Inoculum







Fruit Susceptibility to Hull Rot Pathogen *R. stolonifer*

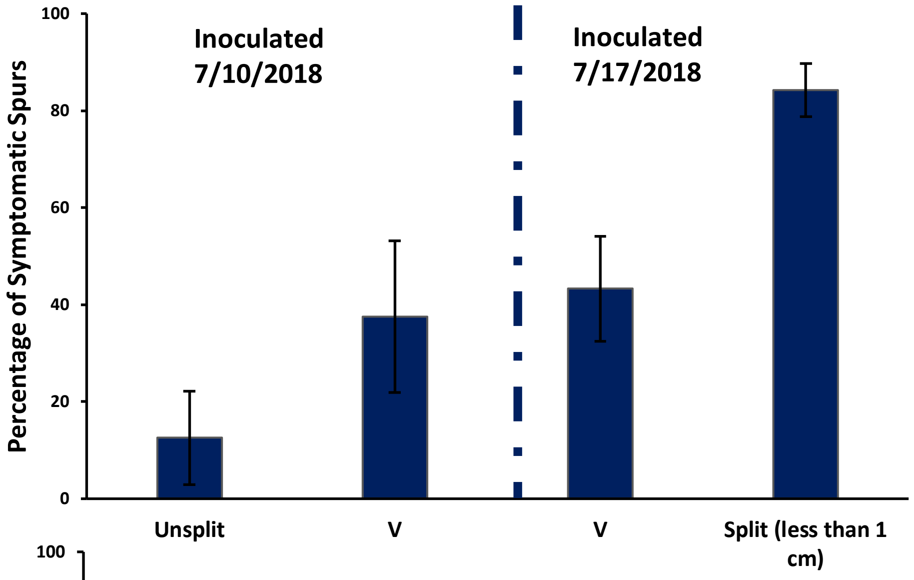
(b1) Initial separation – 50% or more of a thin separation line visible

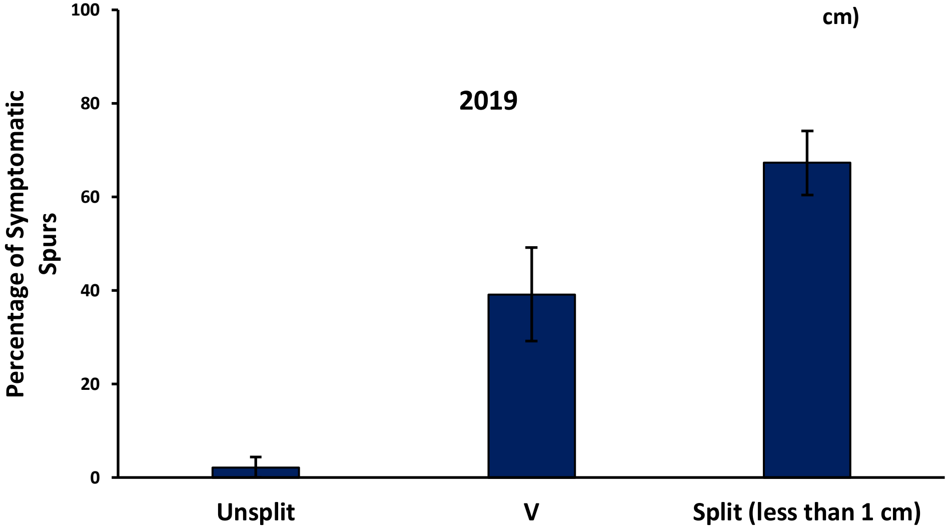
(b2) Deep V – is the most susceptible stage (source: Adaskaveg. 2010. Almond Board of California Research Proceedings # 09-PATH4-Adaskaveg)

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

(c) Split, less than 3/8 inch

Field Fruit Inoculation at Different Fruit Development Stages and Fruit Susceptibility with *A. niger*





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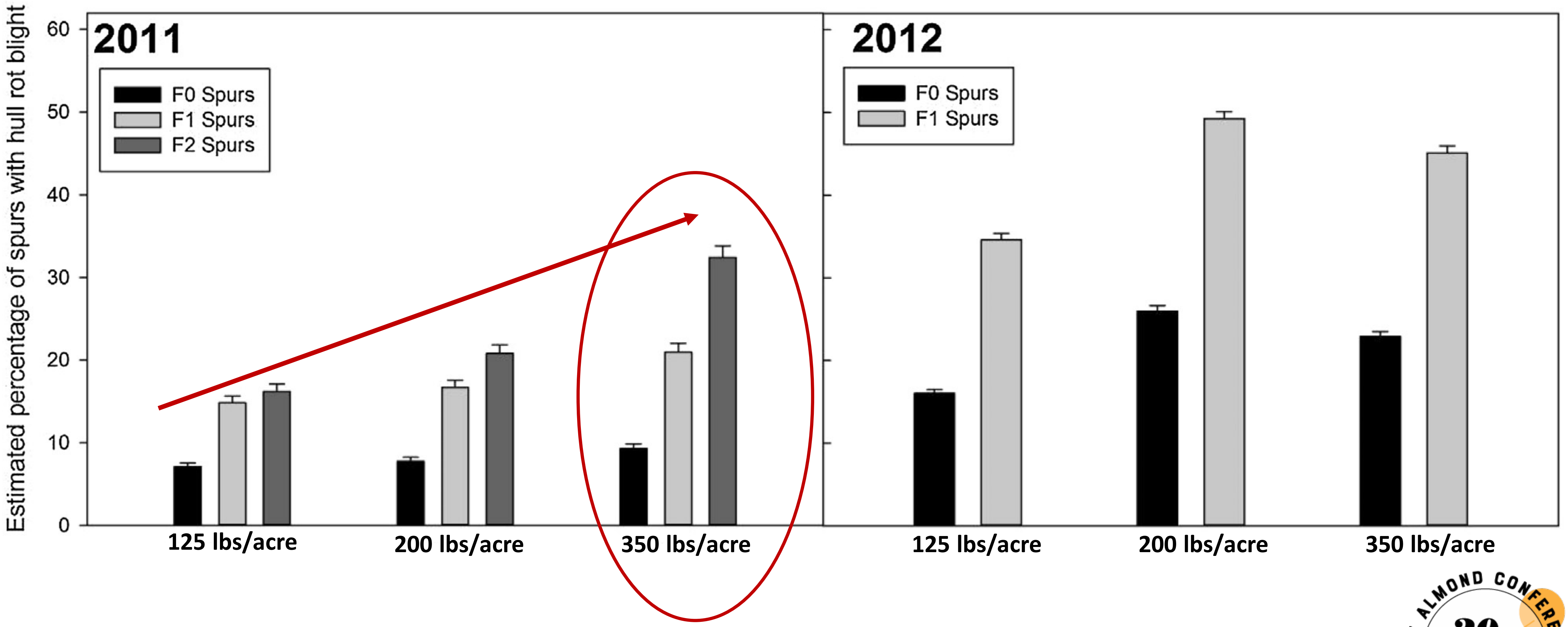
Varietal Differences

Variety	Strikes / tree	Susceptibility
Nonpareil	>500	Very high
Butte	>200	High
Winters	>200	High
Price	100-200	Medium
Sonora	100-200	Medium
Aldrich	10-100	Low
Wood Colony	10-100	Low
Mission	10-100	Low
Ruby	10-100	Low
Livingston	10-100	Low
Padre	10-100	Low
Fritz	0-10	Very Low
Carmel	0-10	Very Low
Montrey	0-10	Very Low

Source: Doll and Holtz. 2013. Almond Hull Rot – Cultural and Chemical Management

Nitrogen and Hull Rot Development



Source: Saa et al. 2016. Nitrogen increases hull rot and interferes with the hull split phenology in almond (Prunus dulcis)

Integrated Hull Rot Management

- Cultural:
  - Irrigation management using Strategic Deficit Irrigation (SDI)
  - Nitrogen Management
- Chemical:
  - Use of fungicides
  - Use of other chemical such as alkaline fertilizers

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Irrigation Management and Hull Rot

Deficit irrigation decreased incidence of hull rot, and regulated deficit irrigation was more effective than sustained deficit irrigation

Table 2. Effects of deficit irrigation on natural incidence of hull rot disease caused by *Rhizopus stolonifer* in almond trees cultivar Nonpareil, Kern County, CA

	Dead leaf clusters[y] (no. per tree)		Dead wood[y] (cm per tree)		Infected hulls[y] (%)	
Irrigation treatment[x]	**1994**	**1995**	**1994**	**1995**	**1994**	**1995**
100 (control)	20.1	23.1	28.4	49.2	26.5	24.2
85 sustained	18.0	35.2	32.8	66.6	35.0	24.5
85 regulated	6.1	13.5	8.2	22.1	24.2	14.5
70 sustained	7.1	15.5	8.4	17.2	21.5	14.2
70 regulated	4.7	5.4	2.2	2.2	35.8	18.8
Significance of F, P = [z]	0.032	0.001	0.001	0.002	0.010	0.036
Orthogonal contrasts						
100 versus deficits	0.005	0.022	0.006	0.068	NS	0.063
100 versus 85 sustained	NS	NS	NS	NS	0.072	NS
85 versus 70	0.030	0.007	0.003	0.003	NS	NS
Sustained versus regulated	0.027	0.002	0.003	0.009	NS	NS

[x] Irrigation deficits of 70 and 85% of potential evapotranspiration (ETc) were imposed at every irrigation (70 and 85 sustained) or by one preharvest reduction to 50% of ETc from 1 June to 31 July (70 regulated) or 1 to 15 July (85 regulated).

[y] Average of 12 trees per replication. Dead wood consisted of spurs, twigs, and small branches and was visually estimated. Data collected 11 and 18 August 1994 and 1995, respectively, 2 days after trees were shaken for harvest.

[z] Irrigation treatments were replicated six times and arranged in a randomized complete block design. NS = not significant, $P > 0.1000$. Means were separated by orthogonal contrasts.

Source: Teviotdale et al. 2001. Effects of deficit irrigation on hull rot disease of almond trees caused by *Monilinia fructicola* and *Rhizopus stolonifer.* Plant Dis. 85:399-403

Deficit Irrigation and Hull Rot

- Moderate stress at the onset of hull split will:
  - Increase hull split uniformity
  - Reduce hull rot
- Start water reduction by 10-20%
  - Maintain irrigation frequency
- When trees are 2 – 3 bars below baseline, resume normal irrigation
- When hull split starts ~1% (-14 to -18 bars)
- Maintain deficit irrigation for 2 weeks and then return to normal irrigation (full ET) until harvest dry-down

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Nitrogen Management

- Follow nitrogen management plan based on yield
  - Excessive nitrogen will increase susceptibility to hull rot.
- Manage N fertilization to keep mid-summer leaf nitrogen percentage within the critical value 2.2 – 2.5%.
- Before harvest, N should not be applied after the completion of kernel development and fill.

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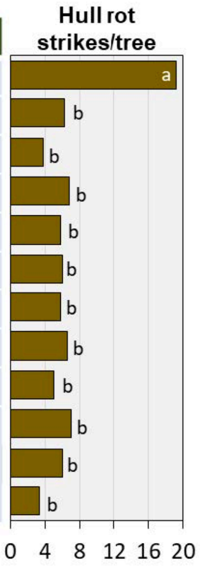
Chemical Control of Hull Rot

- Dr. Adaskaveg worked extensively on chemical control.
- Several FRAC group fungicides 3, 11, and 19 have a “good and reliable” control of hull rot.
- Use of alkaline fertilizers were as effective in controlling hull rot.
- Timing:
  - R. stolonifer can be managed by a single application at hull split (1-5% hull split)
  - *Monilinia* spp. is best managed with fungicide applications 3 to 4 weeks before hull split (early June).

Treatment	Rate(/A)	7-18	8-3
Control	---	---	---
di-K-PO4	48 oz	---	@
di-K-PO4	48 oz	@	@
di-K-PO4 + Ca(OH)2	48+ 320 oz	---	@
di-K-PO4 + Ca(OH)2	48 + 320 oz	@	@
Ca(OH)2	320 oz	---	@
Cinetis	24 fl oz	@	@
Cinetis	24 fl oz	---	@
Fontelis + Tebucon	20 fl oz + 8 oz	---	@
Fontelis + Inspire	20 + 7 fl oz	---	@
Fontelis + Abound	20 + 15.5 fl oz	---	@
Fontelis + Ph-D	20 fl oz + 6.2 oz	---	@



7-18-17: early suture opening, 8-3-17: 5% hull split.

ALMOND: FUNGICIDE EFFICACY

Fungicide	Resistance risk (FRAC)[1]	Brown rot	Jacket rot	Anthrac -nose	Shot hole	Scab[3]	Rust[3]	Leaf blight	Alternaria leaf spot [3]	PM-like[5]	Hull rot[16]
Bumper,Tilt,Propicure, Propiconazole[4]	high (3)	++++	+/-	++++	++	++	+++	ND	++	+++	++
Fontelis[4]	high (7)	++++	++++	++	++++	+++	+++	ND	+++	ND	----
Kenja[4]	high (7)	++++	++++	++	++++	+++	+++	ND	+++	ND	----
Indar	high (3)	++++	+/-	+++	++	++	NL	ND	+	ND	----
Inspire	high (3)	++++	+	+++	++	+++	+++	ND	+++	ND	+++
Inspire Super[4]	medium (3/9)	++++	++++	ND	+++	+++	+++	ND	+++	ND	+++
Luna Experience[3]	medium (3/7)	++++	+++	++++	+++	++++	++++	ND	++++	+++	+++
Luna Sensation[3,7]	medium (7/11)	++++	++++	++++	++++	++++	++++	ND	++++	+++	+++
Merivon[3,7]	medium (7/11)	++++	++++	++++	++++	++++	+++	ND	++++	++++	+++
Pristine[3,7]	medium (7/11)	++++	++++	++++	++++	++++	+++	ND	+++	+++	+++
Quadris Top[3]	medium (3/11)	++++	NL	++++	+++	++++	++++	ND	+++	+++	+++
Quilt Xcel,Avaris 2XS[3]	medium (3/11)	++++	+++	++++	+++	++++	++++	ND	+++	+++	+++
Quash[4]	high (3)	++++	++	++++	+++	+++	++++	ND	++++	+++	+++
Rovral + oil[8, 9]	low (2)	++++	++++	----	+++	+/-	++	ND	+++	ND	----
Scala[3, 7]	high (9)	++++	++++	ND	++	----	ND	ND	+	----	----
Tebucon,Toledo (Elite**,Tebuzol**)	high (3)	++++	+/-	+++	++	++	+++	ND	+	ND	++
Topsin-M,T-Methyl, Incognito,Cercobin[2,6,7,8]	high (1)	++++	++++	----	----	+++	+	+++	----	++	----
Vangard[3, 7,9]	high (9)	++++	++++	ND	++	----	ND	ND	+	----	----
Viathon	medium (3/33)	++++	+/-	+++	++	++	+++	ND	+	ND	++
Abound[3,4,7,10]	high (11)	+++	----	++++	+++	++++	++++	+++	+++	+++	+++
CaptEvate*	low (M4/17)	+++	+++	+++	+++	+++	----	+++	+	----	----
Elevate[7]	high (17)	+++	++++	----	+	ND	ND	ND	ND	ND	----
Gem[3,4, 7, 10]	high (11)	+++	----	++++	+++	++++	++++	+++	+++	+++	+++
Laredo	high (3)	+++	----	++	++	----	+	+++	----	+++	----
Luna Privilege	high (7)	+++	++	++	++	+++	+++	ND	+++	++	++
Rovral,Iprodione, Nevado[9]	low (2)	+++	+++	----	+++	----	----	ND	++	----	----
Rally[13]	high (3)	+++	----	++	+/-	----	+	+++	----	+++	----
Rhyme	high (3)	+++	+/-	ND	+	++	ND	ND	++	ND	ND
Bravo,Chloro-thalonil,Echo,Equus[11, 12, 15]	low (M5)	++	NL	+++	+++	+++	++++	NL	NL	----	----
Captan[4, 6, 12]	low (M4)	++	++	+++	+++	++	----	+++	+	----	----
Fracture	low	++	+	----	----	----	----	----	----	----	----
Mancozeb	low (M3)	++	++	+++	+++	++	+++	+++	+	----	----
Ph-D	medium (19)	++	+++	----	++	+++	+++	ND	++++	ND	+++
Ziram	low (M3)	++	+	+++	+++	+++	----	++	+	----	----
Syllit	medium (U12)	+	----	ND	+++	++++	ND	ND	+	ND	----
Copper[14,15]	low (M1)	+/-	+/-	----	+	+	----	----	ND	----	----
Lime sulfur[12,15]	low (M2)	+/-	NL	----	+/-	++	++	NL	NL	----	----
Sulfur[4,12]	low (M2)	+/-	+/-	----	----	++	++	----	----	+++	----
PlantShield[17]	low	----	----	----	----	----	----	----	----	----	----
Copper + oil[14,15]	low (M1)	ND	ND	----	+	+++	----	----	ND	----	----

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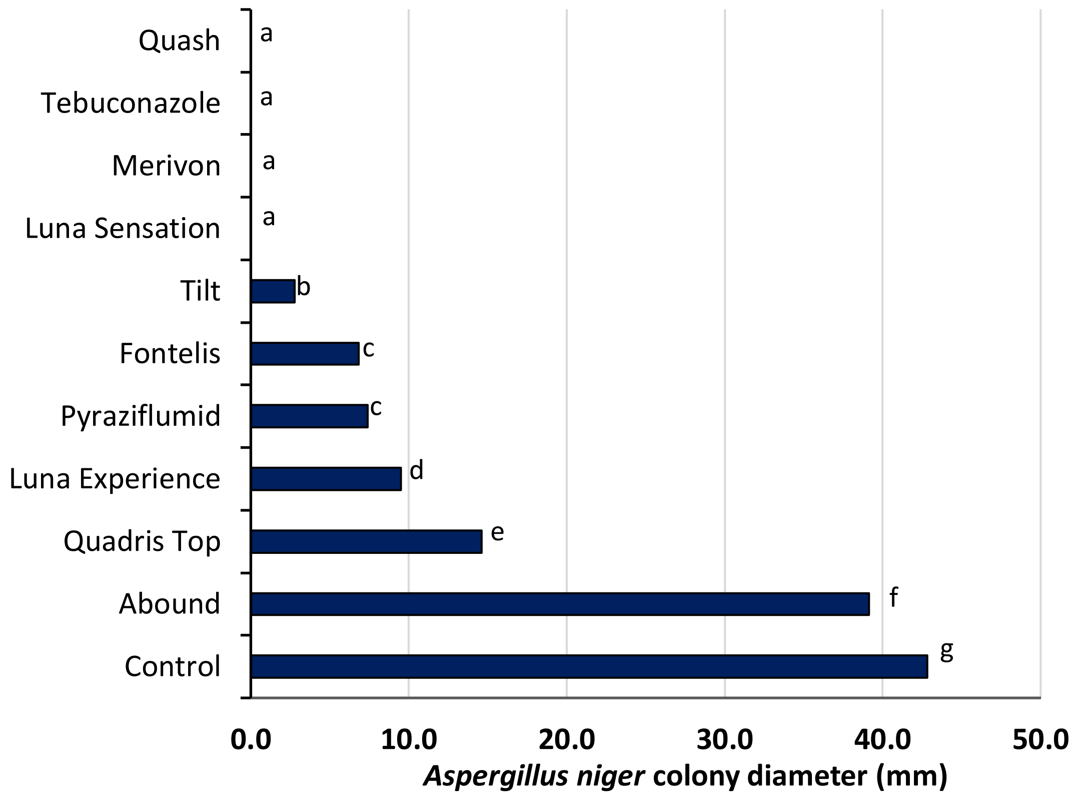
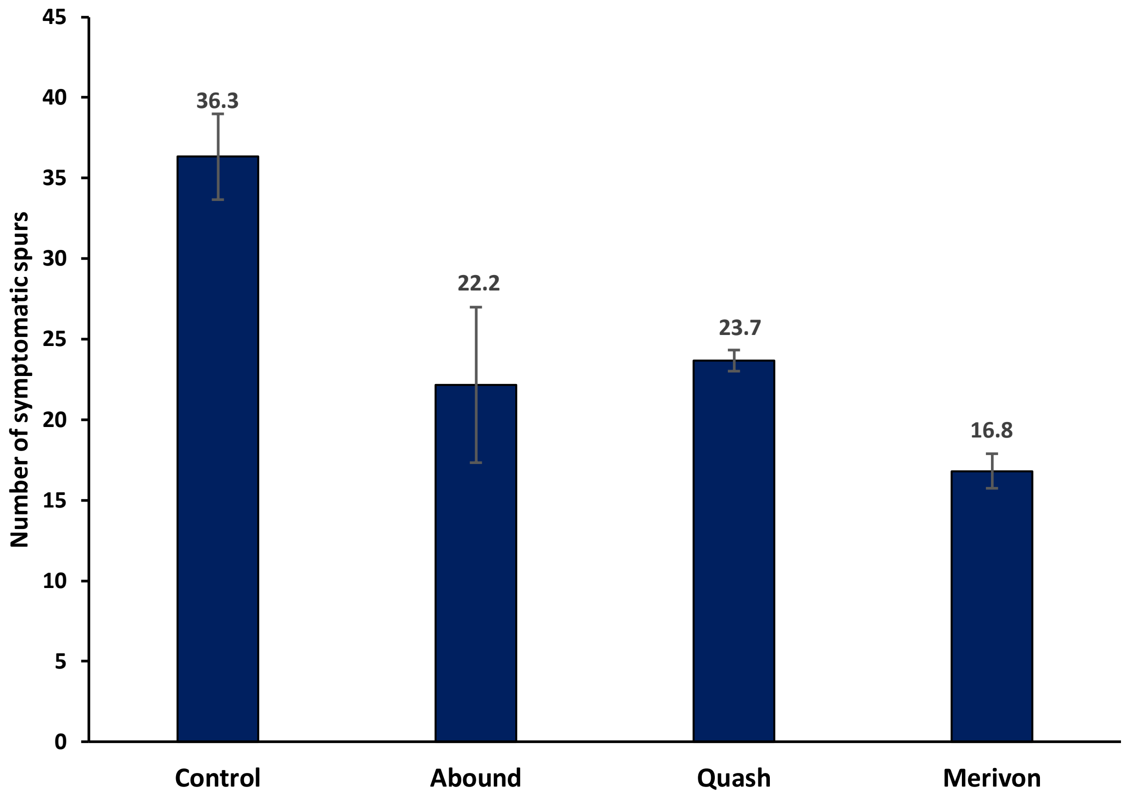
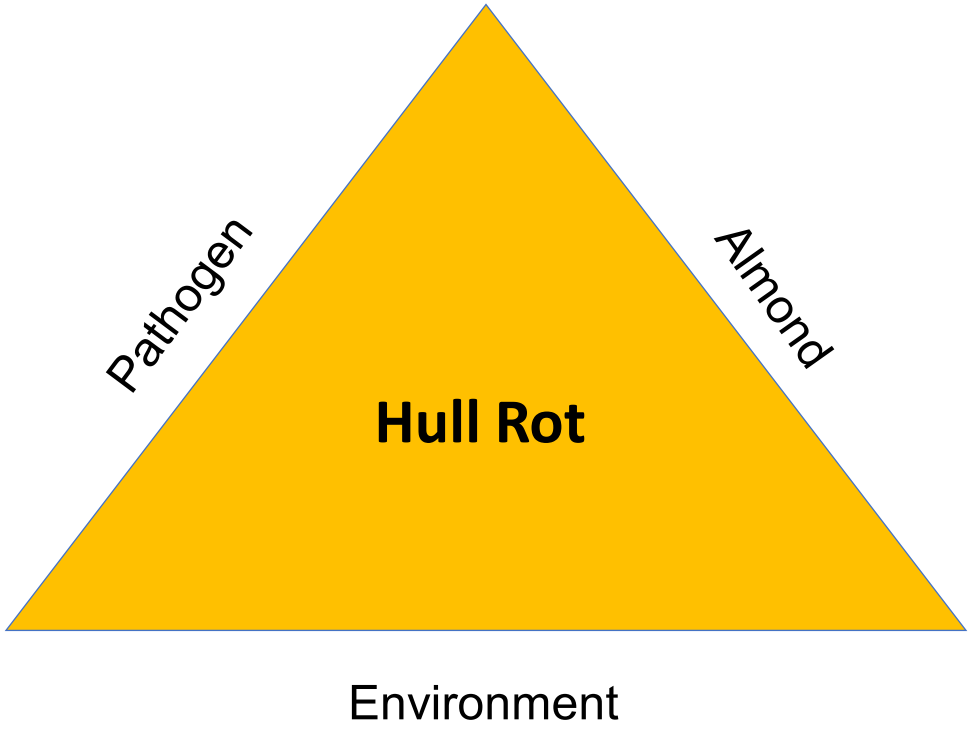
Chemical Control of Hull Rot





The Whole Picture

- Causal agent
- Chemical control
- Dust management



- Varietal difference
- Nitrogen management
- Irrigation management

Thank You!

Mohammad Yaghmour, Ph.D.
mayaghmour@ucanr.edu
661-868-6211

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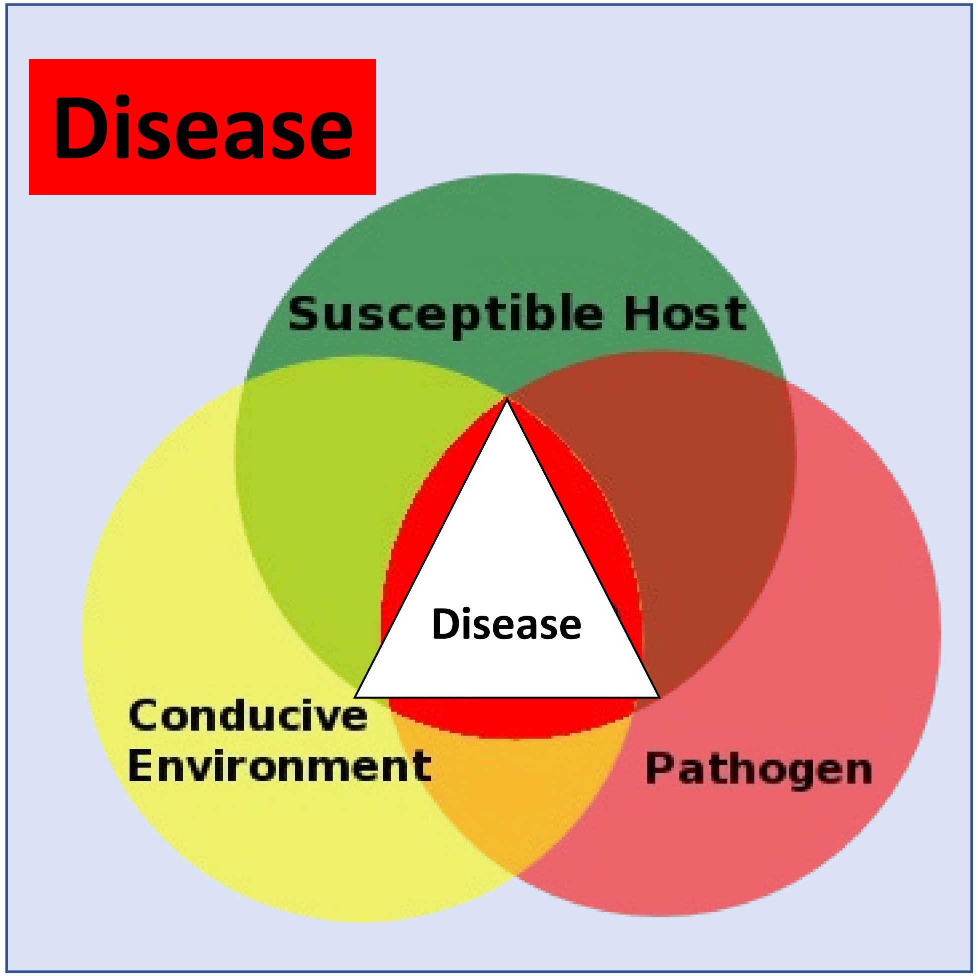
IPM TIPS FOR KEY INSECTS AND DISEASES

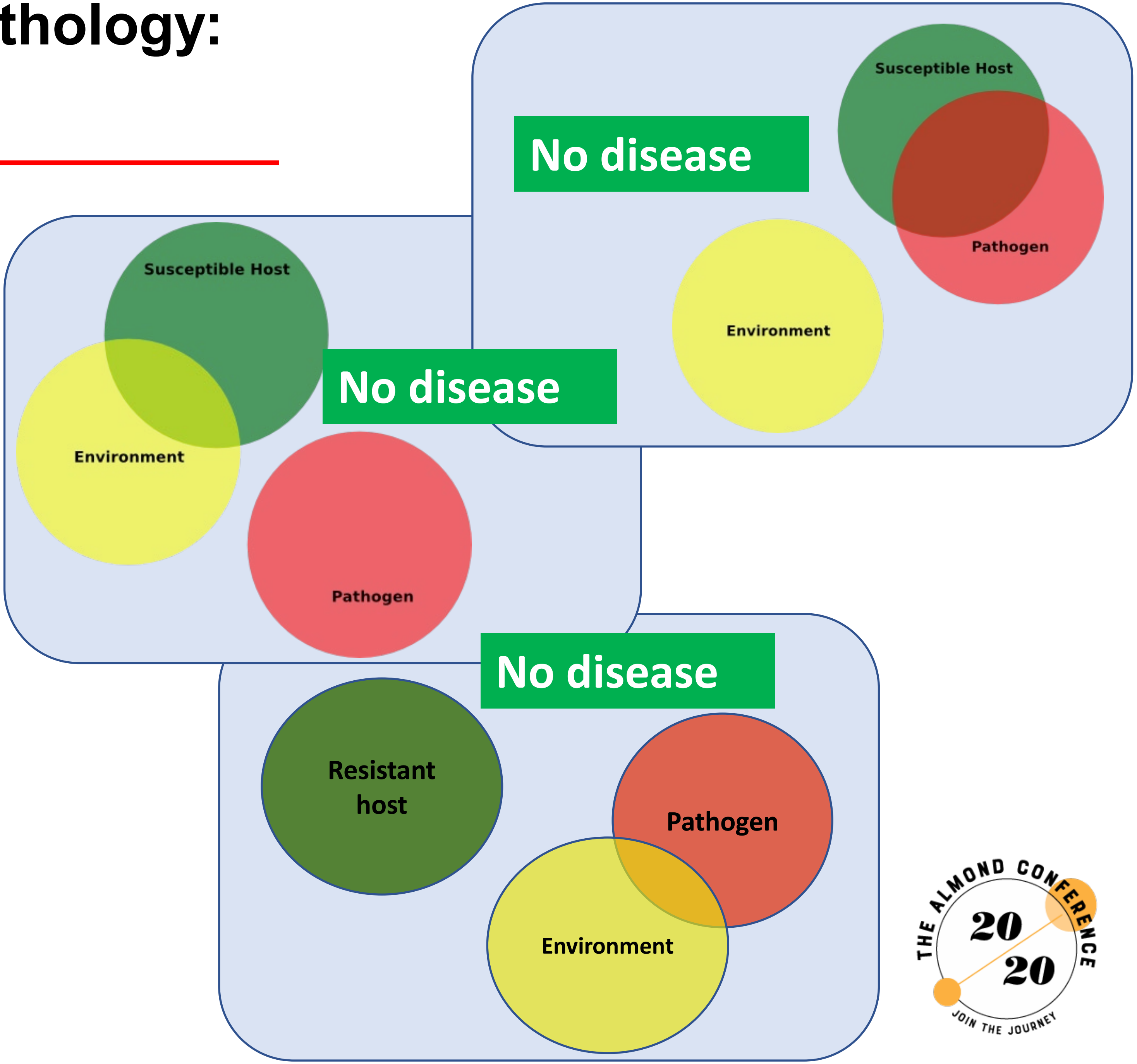
Jim Adaskaveg, *UC Riverside*

Predicting Alternaria leaf spot (ALS) of almond using the DSV model
&
Integrated cultural practices and fungicide programs for managing ALS

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

Foundation of Plant Pathology: The Disease Triangle



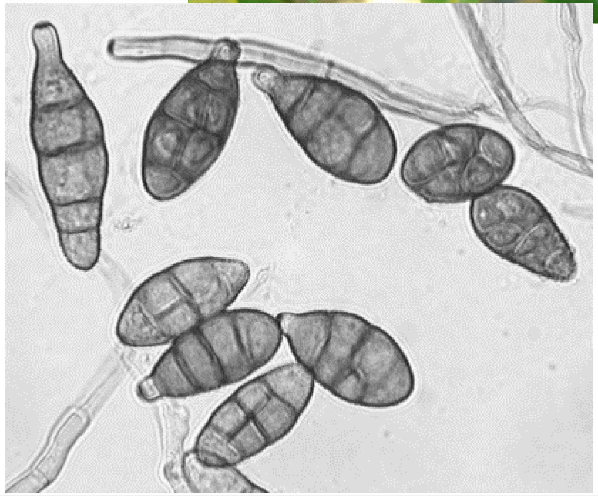


Alternaria Leaf Spot of Almond

Alternaria alternata and *A. arborescens*

Early symptoms

Late symptoms



Conidia of *Alternaria* species

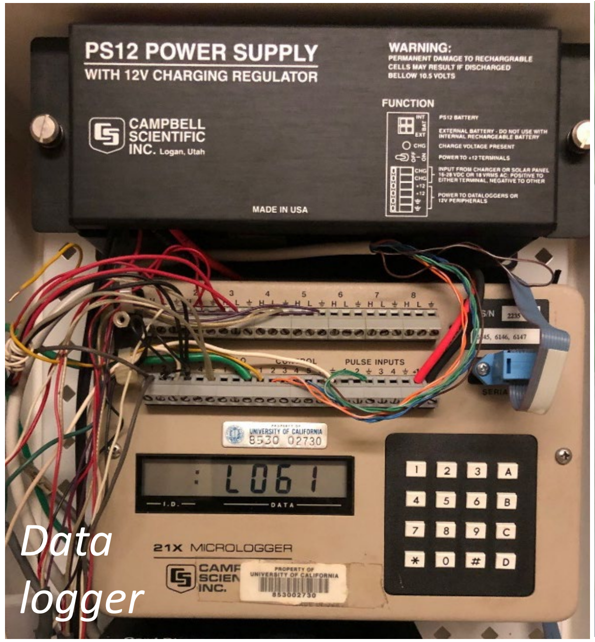
Tree defoliation

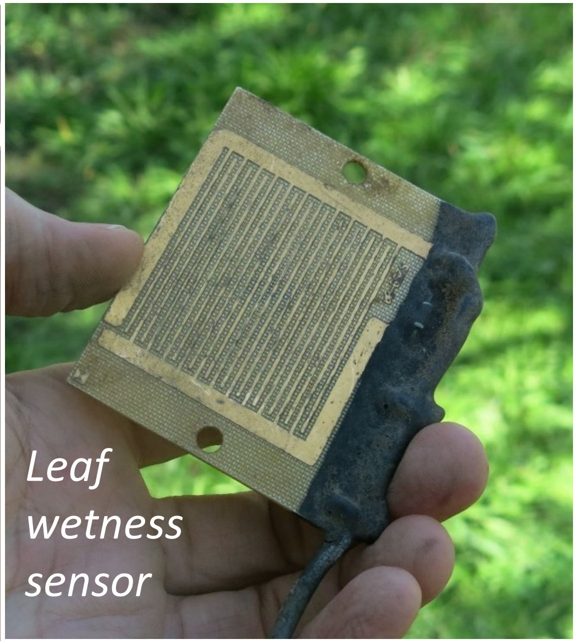
Leaf drop

Alternaria Leaf Spot of Almond
- *Biology and Epidemiology of the Pathogen* -

- **A ubiquitous fungus in nature**
- **The leaf phase of the disease affects several crops from almonds to pistachios** (Fruit are also affected on many crops – citrus, stone fruit, pomegranates, pome fruit)
- Conducive conditions:
  - ✓ **Leaf phase – warm temperatures, high humidity, and frequent dews**
  - ✓ Fruit phase – injuries, cavities, rain, fruit ripening, (possibly insects and mites)

✓ **Disease develops on the shoulders of the tree** where dew settles and develops up- and downward





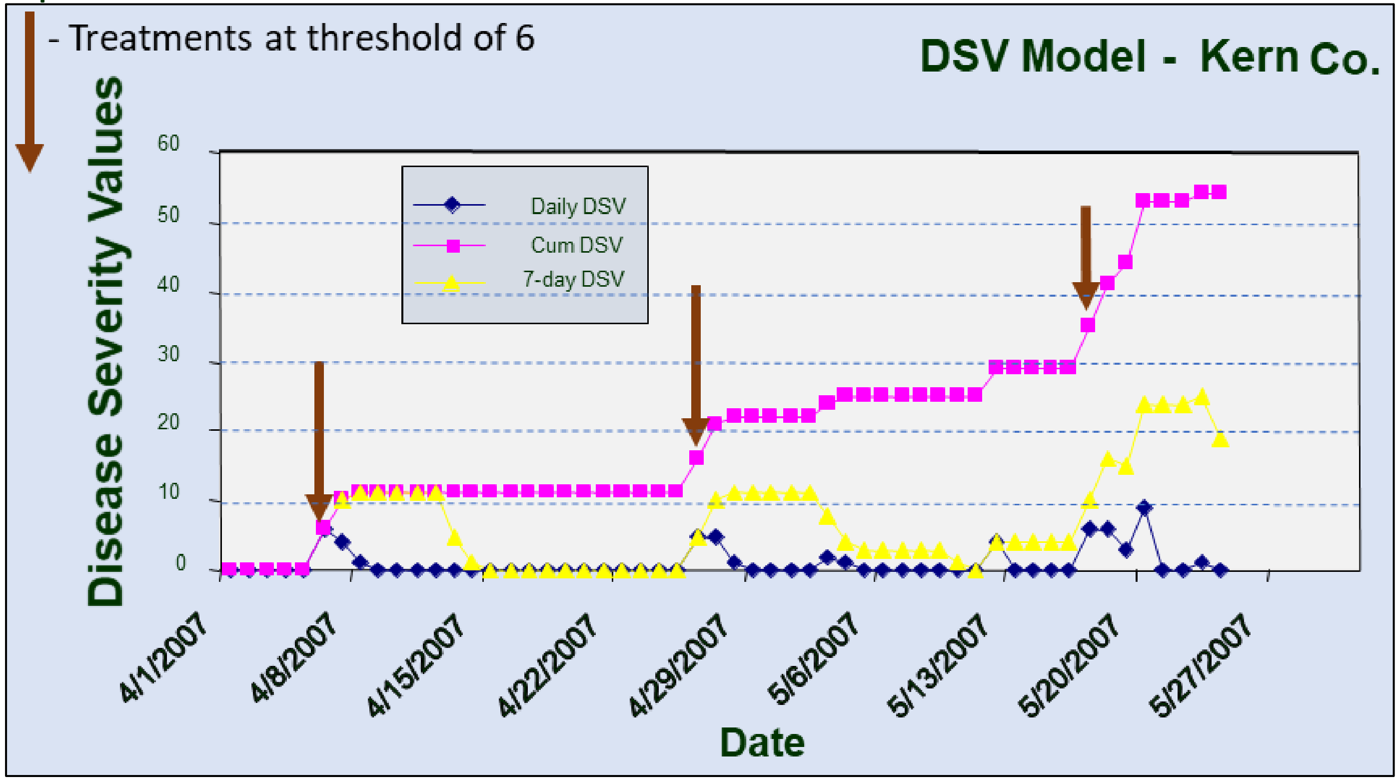
Identifying Alternaria leaf spot infection periods and optimizing timing of fungicide treatments

- Inoculum is omnipresent in orchards.
- Alternaria leaf spot is greatly influenced by microclimatic conditions within orchards.
- The DSV (Disease Severity Value) Model was originally developed for forecasting black mold of tomato caused by *A. alternata.*
- We evaluated the model for forecasting on almond and adapted the temperature parameters.

The modified DSV model

Mean temperature during wetness (C)	(F)	Leaf wetness duration (hr)				
15 - 17	59 - 63	0 – 6	7 - 15	16 - 20	21	---
17.1 - 20	63.1 - 68	0 - 3	4 - 8	9 - 15	16 - 22	23+
20.1 - 25	68.1 - 77	0 - 2	3 - 5	6 - 12	13 - 20	21+
25.1 - 29	77.1 – 85	0 - 3	4 – 8	9 - 15	16 - 20	23+
	DSV	0	1	2	3	4

Disease severity values (DSV) as a function of leaf wetness duration and average air temperature during the wetness period. Fungicides are applied and persist for 3 weeks when only dews are recorded. With rainfall, persistence is 7-14 days. Threshold values are selected based on the intensity of the control program (higher threshold for a less intense program).



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Fungicides for Managing Almond Diseases

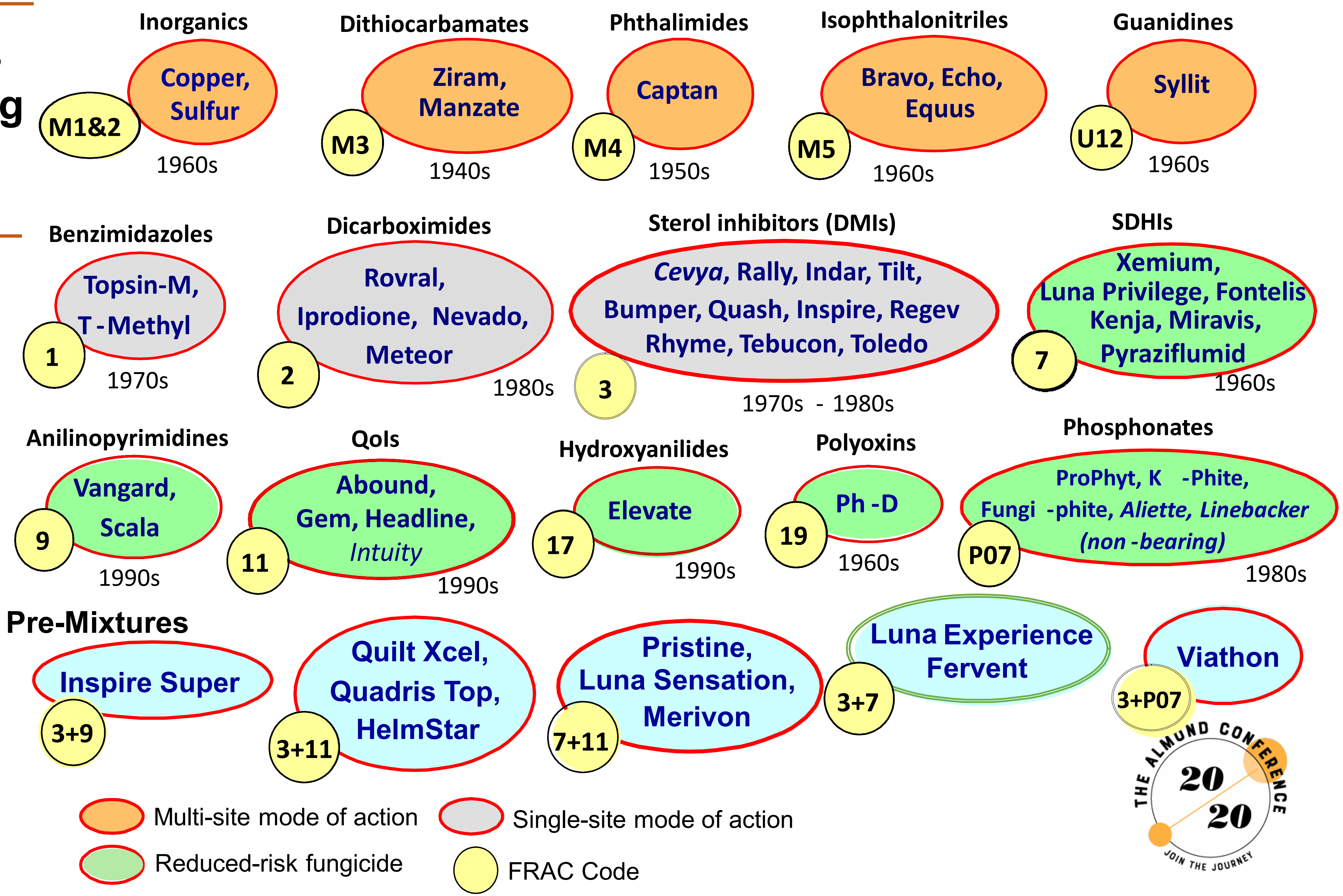
Inorganics and Conventional Synthetics

***New*:**

Helmstar (2018)
Fervent (2018)
Cevya (2020)
Regev (2020)
Miravis Top (2021)

Ongoing:

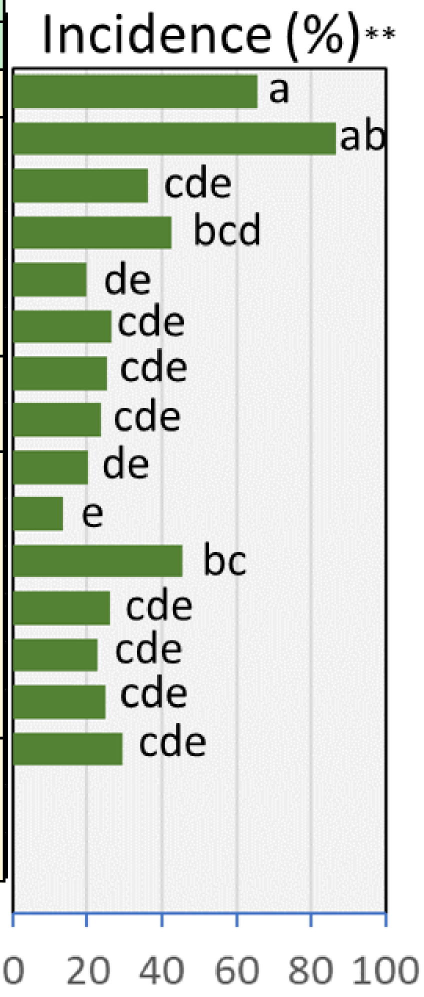
Miravis Prime, Pyraziflumid, UC-2, F4406, others

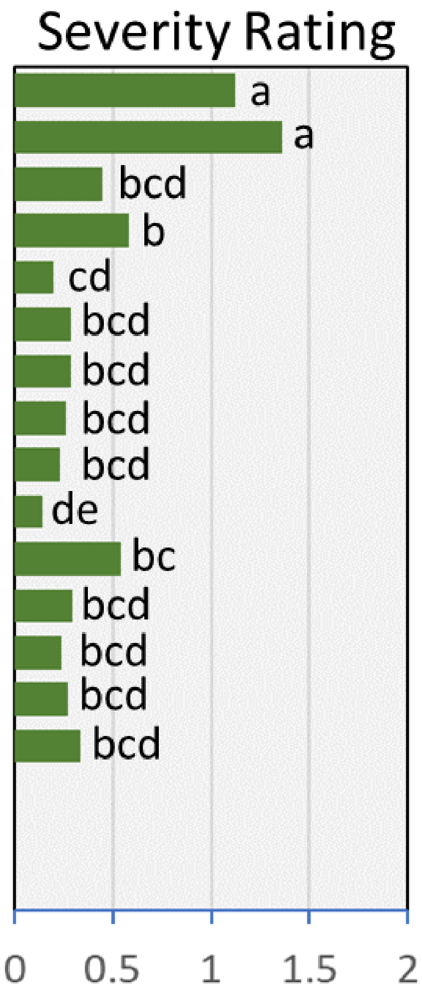


Adaskaveg et al. 2020

Fungicide programs for management of Alternaria leaf spot of cv. Carmel almond - Colusa Co. 2018

No.	Program	Treatment*	Rate (/A)	Applications		
				5-16	6-14	8-21
1	---	Control	---	---	---	---
2	Single	Rhyme***	7 fl oz	@	@	@
3		Pyraziflumid	4.7 fl oz	@	@	@
4		Fontelis	20 fl oz	@	@	@
5		Ph-D	6.2 oz	@	@	@
6		UC-1	5 fl oz	@	@	@
7	Mixtures	Quash + Intuity	2 oz + 2 fl oz	@	@	@
8		Fontelis + Teb	20 fl oz + 8 oz	@	@	@
9	Pre-mixtures	Luna Experience	8 fl oz	@	@	@
10		Quadris Top	14 fl oz	@	@	@
11		Merivon	6.5 fl oz	@	@	@
12		UC-2	7 fl oz	@	@	@
13		EXP-AD	14 fl oz	@	@	@
14		EXP-AF	7 fl oz	@	@	@
15	Rotation	Fontelis + Teb	20 fl oz + 8 oz	@	---	---
		Quash	2 oz	---	@	---
		Ph-D	6.2 oz	---	---	@





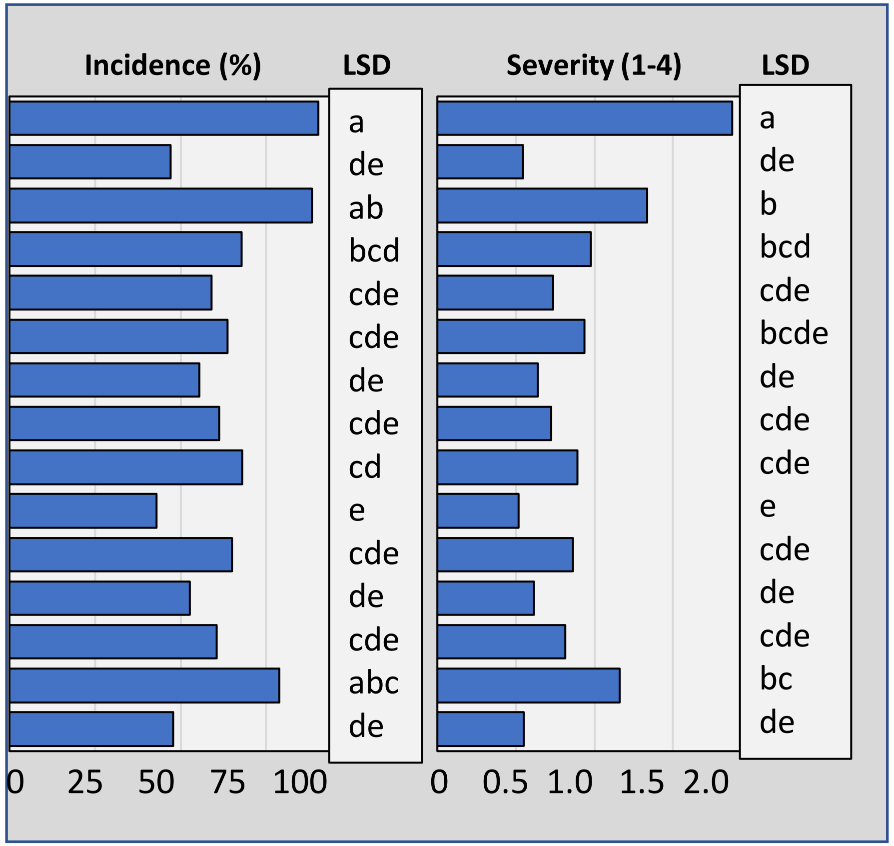
Disease was evaluated in early Sept.

Adaskaveg et al. 2018

*- Induce was included at 6 fl oz/A. The model with a threshold setting of 6 called for the first application on May 16, and subsequent applications were called for on 6-14 and 8-21 based on a three-week level of fungicide persistence.

Fungicide programs for management of Alternaria leaf spot of cv. Carmel almond - Colusa Co. 2019

No.	Program	Treatment*	Rate (/A)	Applications		
				5-23	6-12	7-3
1	---	Control	---	---	---	---
2	Single	Ph-D	6.2 oz	@	@	@
3		Rhyme	5 fl oz	@	@	@
4		Quash	3 oz	@	@	@
5		V-10424	3 fl oz	@	@	@
6		Cevya	4 fl oz	@	@	@
7	Mixture	Fontelis + Teb	20 fl oz + 8 oz	@	@	@
8	Pre-mixtures	Luna Experience	8 fl oz	@	@	@
9		Quadris Top	14 fl oz	@	@	@
10		Fervent	15 fl oz	@	@	@
11		Miravis Duo	13.7 fl oz	@	@	@
12		Miravis Prime	9.1 fl oz	@	@	@
13		UC-2	7 fl oz	@	@	@
14		F 4406-3	6 fl oz	@	@	@
15	Rotation	Cevya	4 fl oz	@	---	---
		Merivon	6.5 fl oz	---	@	---
		Ph-D	6.2 oz	---	---	@



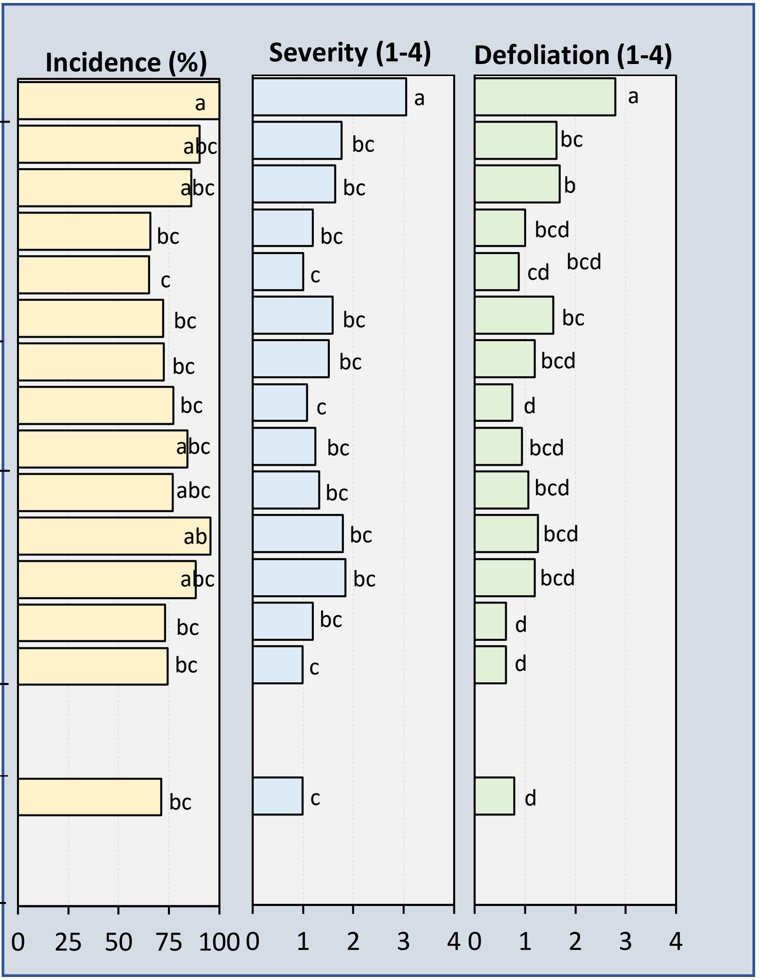
Disease was evaluated in August.

*- Induce was included at 6 fl oz/A. The model with a threshold setting of 6 called for the first application on May 23, and subsequent applications were called for on 6-12 and 7-3 based on a three-week level of fungicide persistence.

Adaskaveg et al. 2019

Efficacy of fungicide treatments for management of Alternaria leaf spot of cv. Monterey almond - Yolo Co. 2020

	Treatment	Rate/A	Application dates 5-13	6-3	6-24
	Control	---	---	---	---
Single	Serifel	8 oz	@	@	@
Single	Fontelis	20 fl oz	@	@	@
Single	Quash liquid	3 fl oz	@	@	@
Single	Cevya	5 fl oz	@	@	@
Single	GWN 10570	10 fl oz	@	@	@
Mixtures	Merivon + Serifel	6.5 fl oz + 8 oz	@	@	@
Mixtures	Quash + V-20	3 + 6 fl oz	@	@	@
Mixtures	Fontelis + Teb	20 fl oz + 8 oz	@	@	@
Pre-mixtures	Luna Experience	8 fl oz	@	@	@
Pre-mixtures	Luna Sensation	8 fl oz	@	@	@
Pre-mixtures	Merivon	6.5 fl oz	@	@	@
Pre-mixtures	UC-2	7 fl oz	@	@	@
Pre-mixtures	Cevya	5 fl oz	@	---	---
Rotations	Merivon	6.5 fl oz	---	@	
Rotations	Ph-D	6.2 oz	---	---	@
Rotations	Fontelis	10 fl oz	@	---	---
Rotations	Quash liquid	3 fl oz	---	@	
Rotations	Ph-D	6.2 oz	---	---	@



Disease was evaluated in early Sept.

*- Applications were done using an airblast sprayer at 100 gal/A. The model with a threshold setting of 6 called for the first application on May 13, and subsequent applications were called for on 6-3 and 6-24 based on a three-week level of fungicide persistence.

Fungicides (FRAC codes) and Timing for Managing Alternaria Leaf Spot

		Bloom			Spring		Summer	
Disease	Dormant	Pink bud	Full bloom	Petal fall	2 weeks	5 weeks	April/ May	June
Alternaria leaf spot	----	----	----	----	----	2 (SSJ)*	3, 7, 3/9, 3/7, 3/11, 7/11 11,19	3, 7, 3/7, 3/9, 3/11, 7/11 11, 19

*-SSJ = Southern San Joaquin Valley

- Timing is based on history of disease, preventative treatments in advance of symptoms using the modified DSV model.
- Fungicides generally have a 14- to 21-day residual from April through May due to low rainfall. If rain occurs the interval is 7-14 days depending rainfall amounts.

FRAC Code	Fungi-cide*	Top active Ingredients
2	Dicarbox -imide	Iprodione
3	DMI	Triazole – difeno- propicon-, metriflucon-, tebucon- azole
7	SDHI**	Fluopyram, Isofetamid, pydifumetofen
9	AP	Cyprodinil, pyrimethanil
11	QoI**	Azoxy-, pyraclo-, trifloxy-strobin
19	Polyoxin	Polyoxin-D

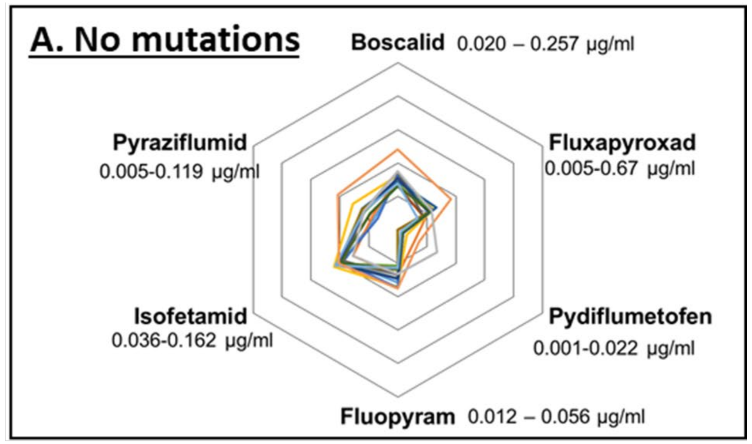
*- Used in rotation programs
**-Should always be used in mixtures, resistant sub-populations detected.

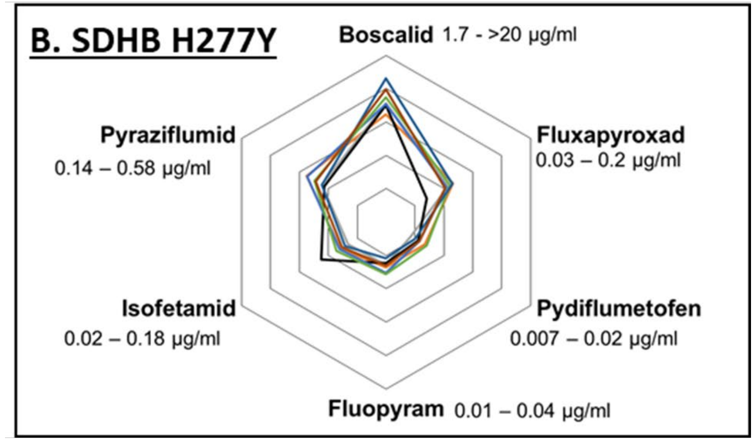
Cross-resistance in *Alternaria* spp. isolates to six SDHI sub-groups

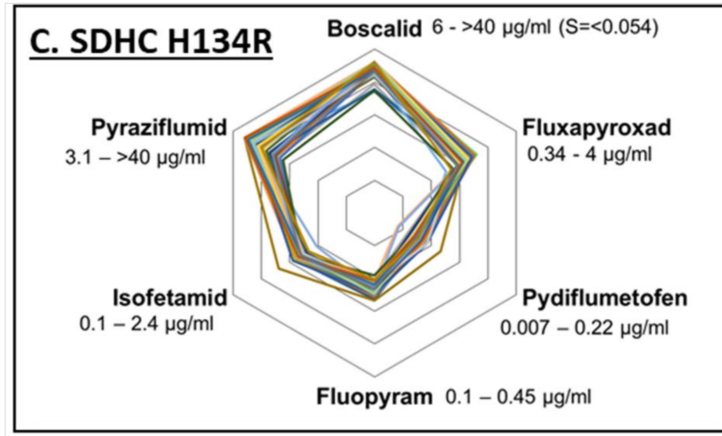
Mutations were identified in subunits B, and C of the target SDH gene that correspond with resistance to selected SDHI fungicides.

Sensitivity phenotypes with no mutation (**Fig. A)**, mutation at H277Y in SDHB (**Fig. B)**, and mutation at H134R in SDHC (**Fig. C)**. EC_{50} values for each fungicide are on a $\log_{10}$ scale with 50 µg/ml at the edge of each diagram. The range of EC_{50} values for isolates with each mutation is indicated.

Highest incidence of resistance: boscalid, fluxapyroxad, penthiopyrad, pyraziflumid. Cross-resistance present. In contrast no resistance with isofetamid, fluopyram, and pydiflumetofen.







Integrated management of Alternaria leaf spot of almond

- **Orchard design and cultivation**
  - Improve air movement – wider rows and pruning/hedging (every 3rd row every 3 yrs)
  - Row orientation with prevailing winds
  - Clean cultivation to reduce humidity
- **Fertilization**
  - Nitrogen use on replacement schedule only to reduce excess growth
  - Last spring/summer application early May and after harvest
- **Irrigation**
  - Shorter irrigation periods with moderate to high volume (24-36 hr)
  - Improve water penetration (Gypsum), pre-plant ripping of soil
- **Fungicide use**
  - Timing with infection periods using **DSV model** set for thresholds
  - Rotations of FRAC Codes 3, 7, 9, 11, 19 or 3/7, 3/9, 3/11
  - Among FRAC Code 7 fungicides: isofetamid, fluopyram, and pydiflumetofen have currently the lowest levels of resistance in *Alternaria* populations.

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IPM TIPS FOR KEY INSECTS AND DISEASES

Gabriele Ludwig, *Almond Board of California*

David Haviland, *UC-ANR*

Mohammad Yaghmour, *UC-ANR*

Jim Adaskaveg, *UC Riverside*

california almonds

Almond Board of California

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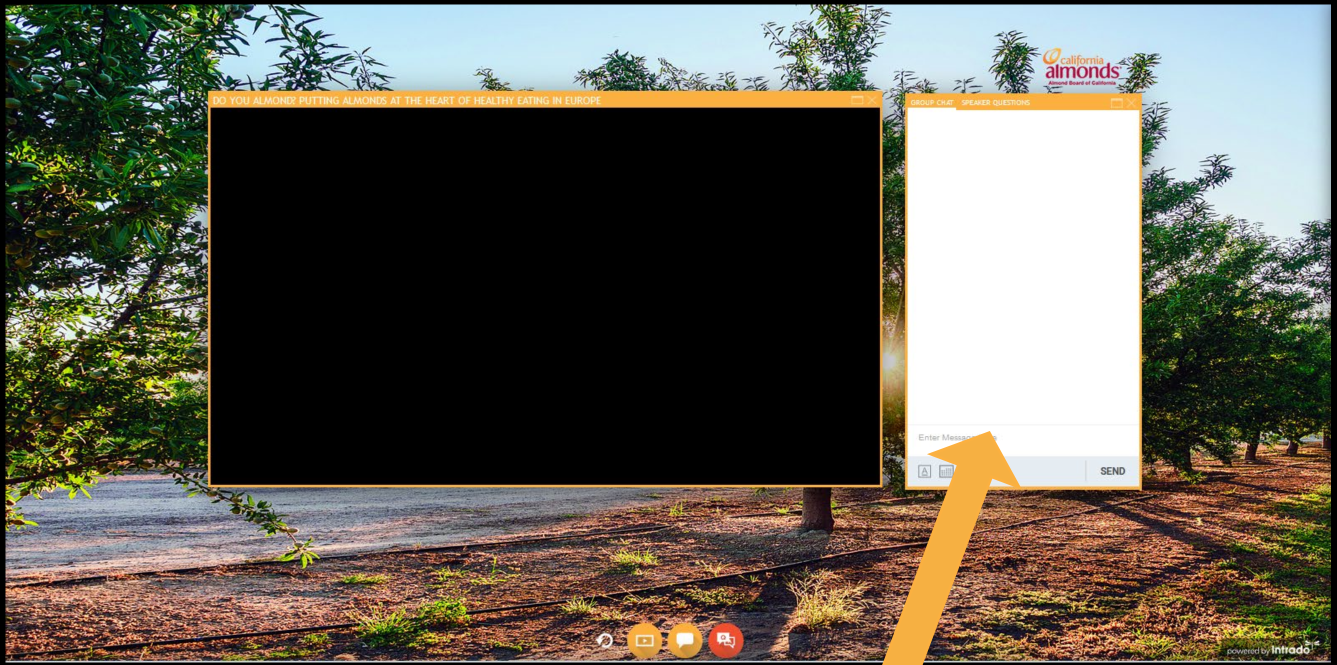

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