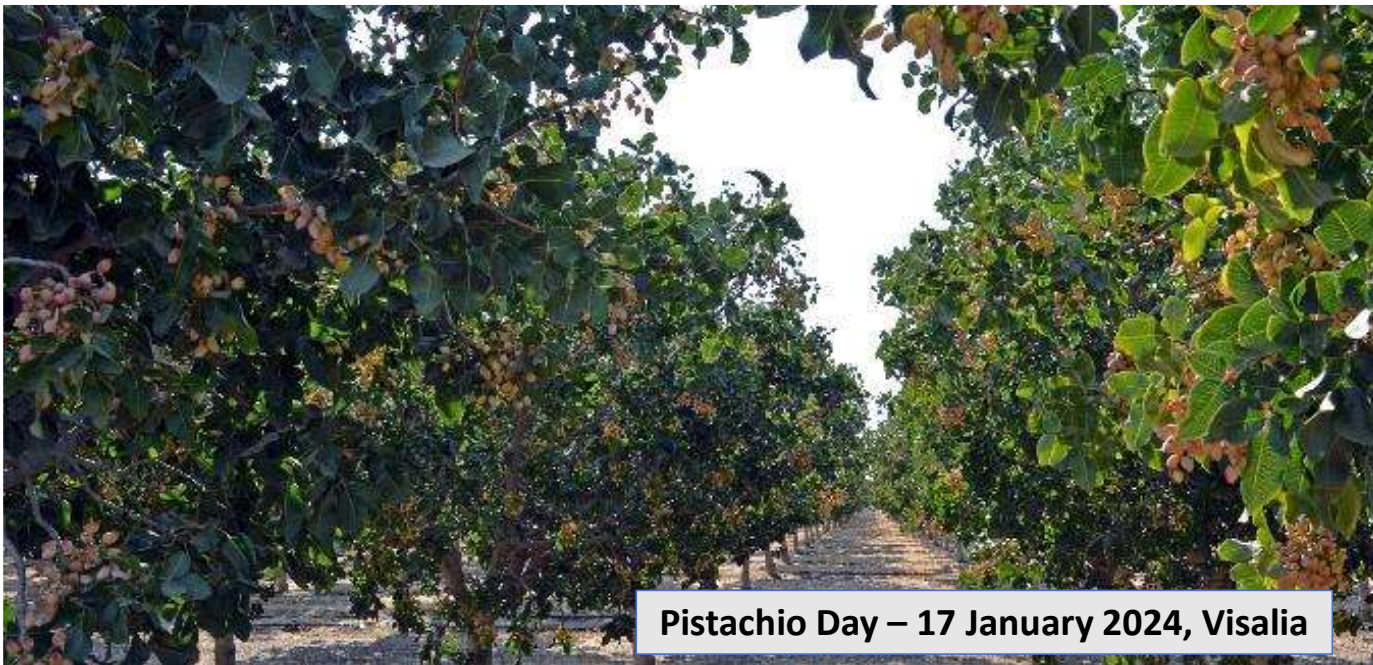


Management of Foliar Pistachio Diseases

Themis J. Michailides
University of California Davis -
Kearney Agricultural Research and
Extension Center



Pistachio Day – 17 January 2024, Visalia



The three major foliar & fruit diseases of pistachio:



1. Alternaria



2. Botryosphaeria



3. Botrytis



1. Alternaria late blight

It is caused by three species

Alternaria alternata,*** *Alternaria tenuissima*, & *Alternaria arborescens*



It causes severe defoliation



Problems during
HARVEST

It causes **shell staining** and **nut rot**



Economic losses at least **\$1000+/A**



Alternaria late blight - 2023



**Due to late rains (Hurricane Hilary):
Orchards in Westside
About 25% of nuts stayed on the trees after re-shake.**



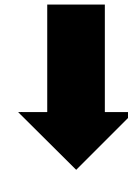
Kerman



Golden Hills

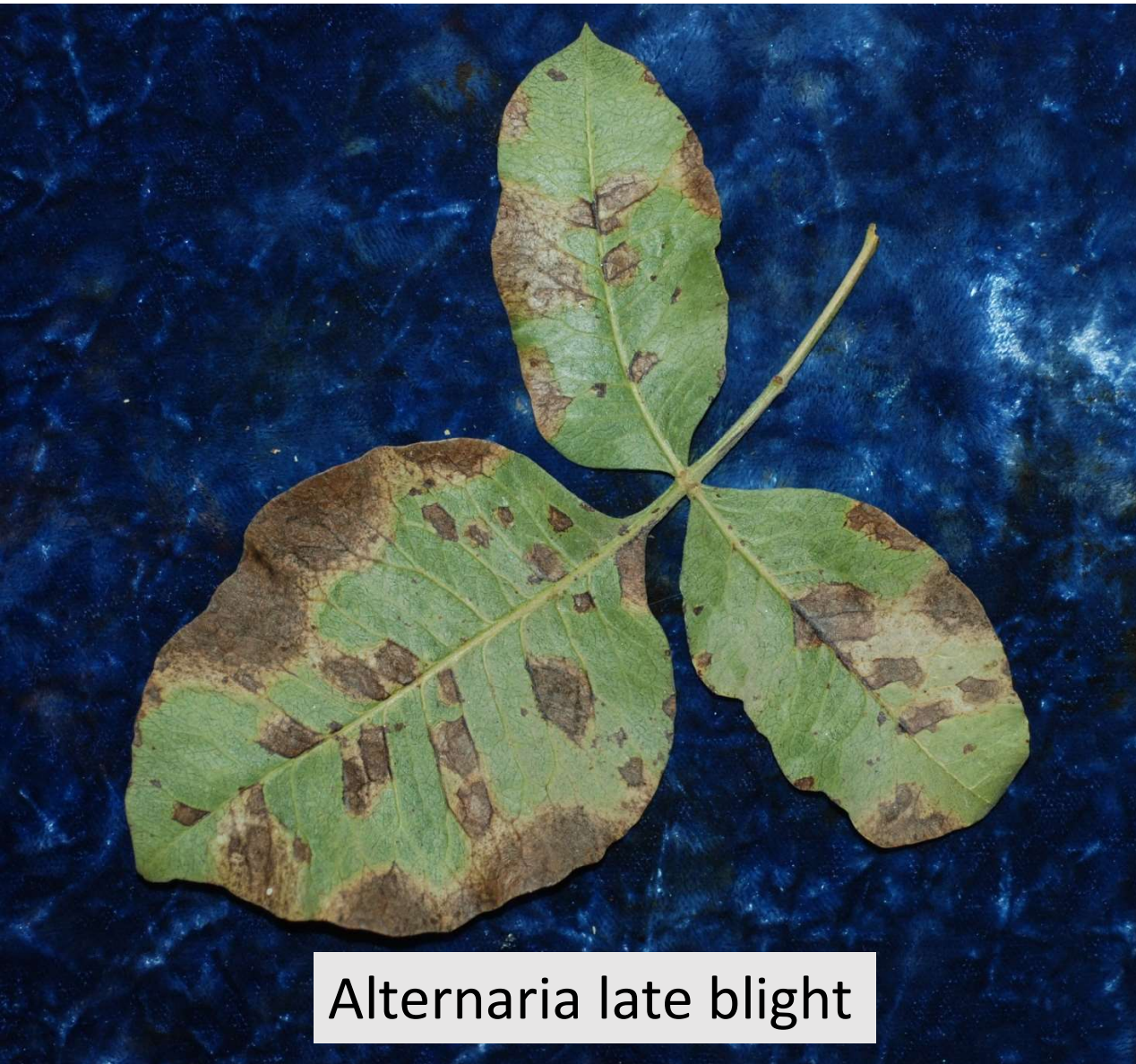


More samples brought to our laboratory



Fungicide resistance



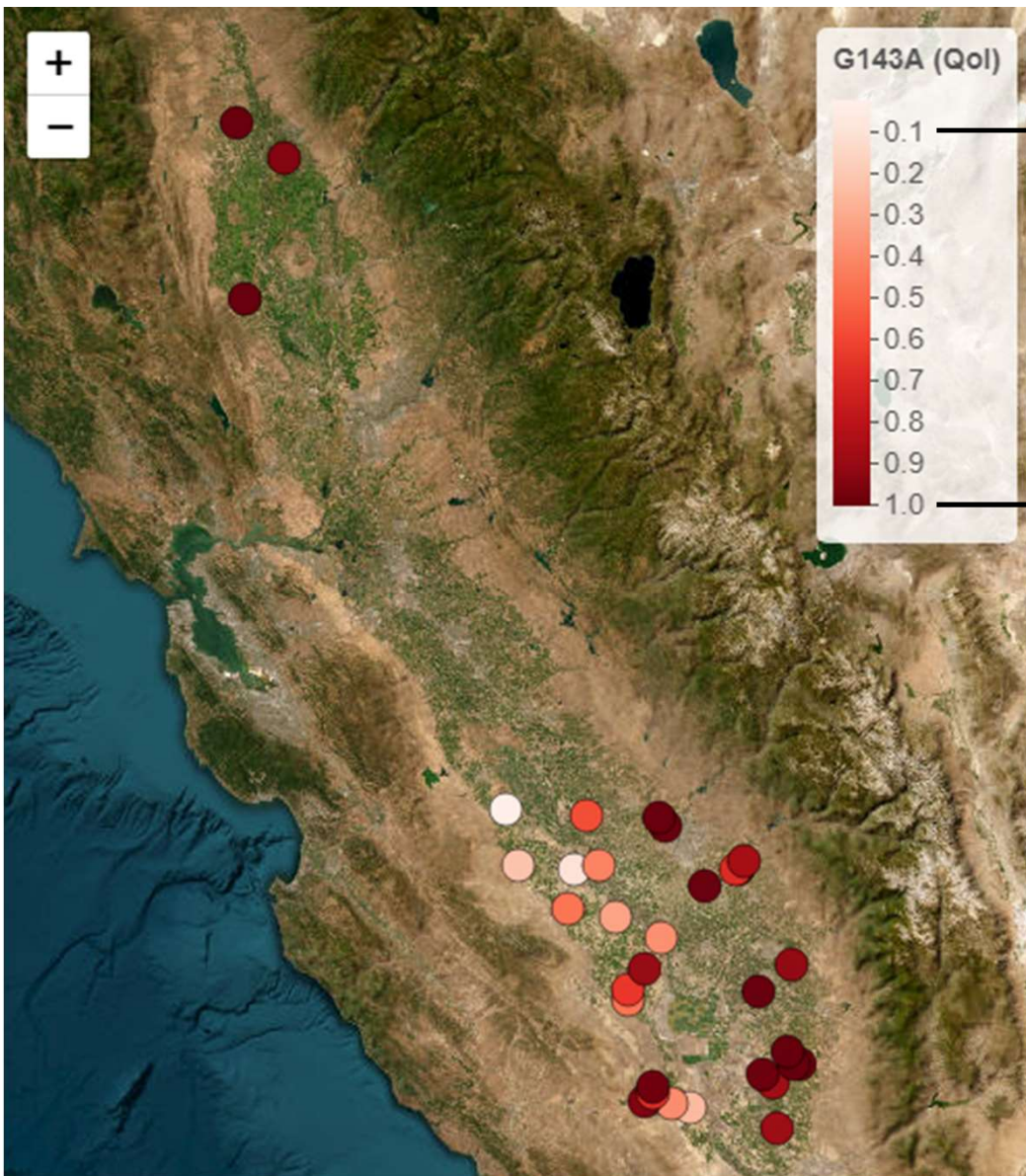


Alternaria late blight



Peters scorch





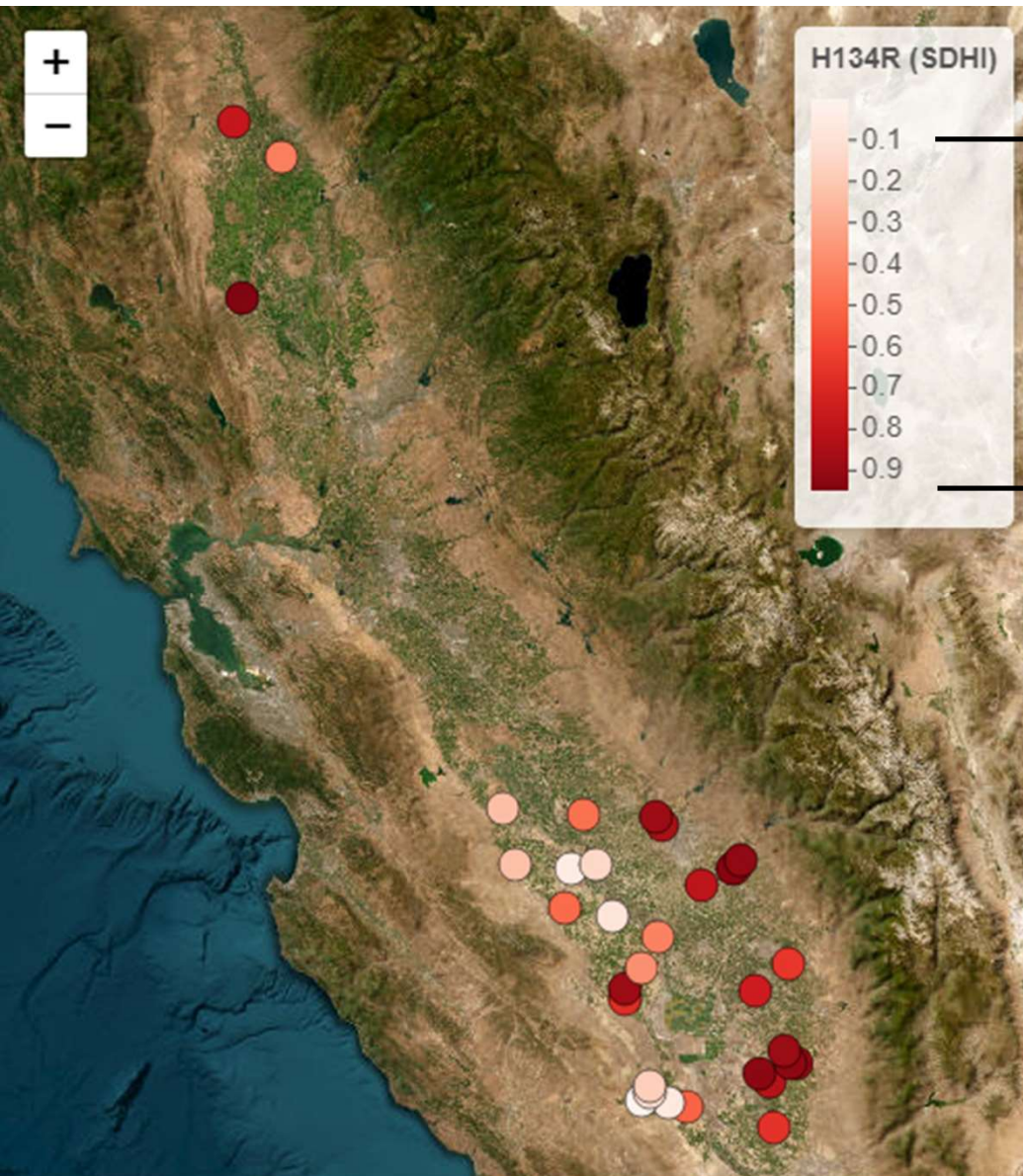
The resistance scale:

10% of isolates are resistant

100% of isolates are resistant

Resistance to Qol fungicides is widespread

Based on mutation **G143A**



The resistance scale:

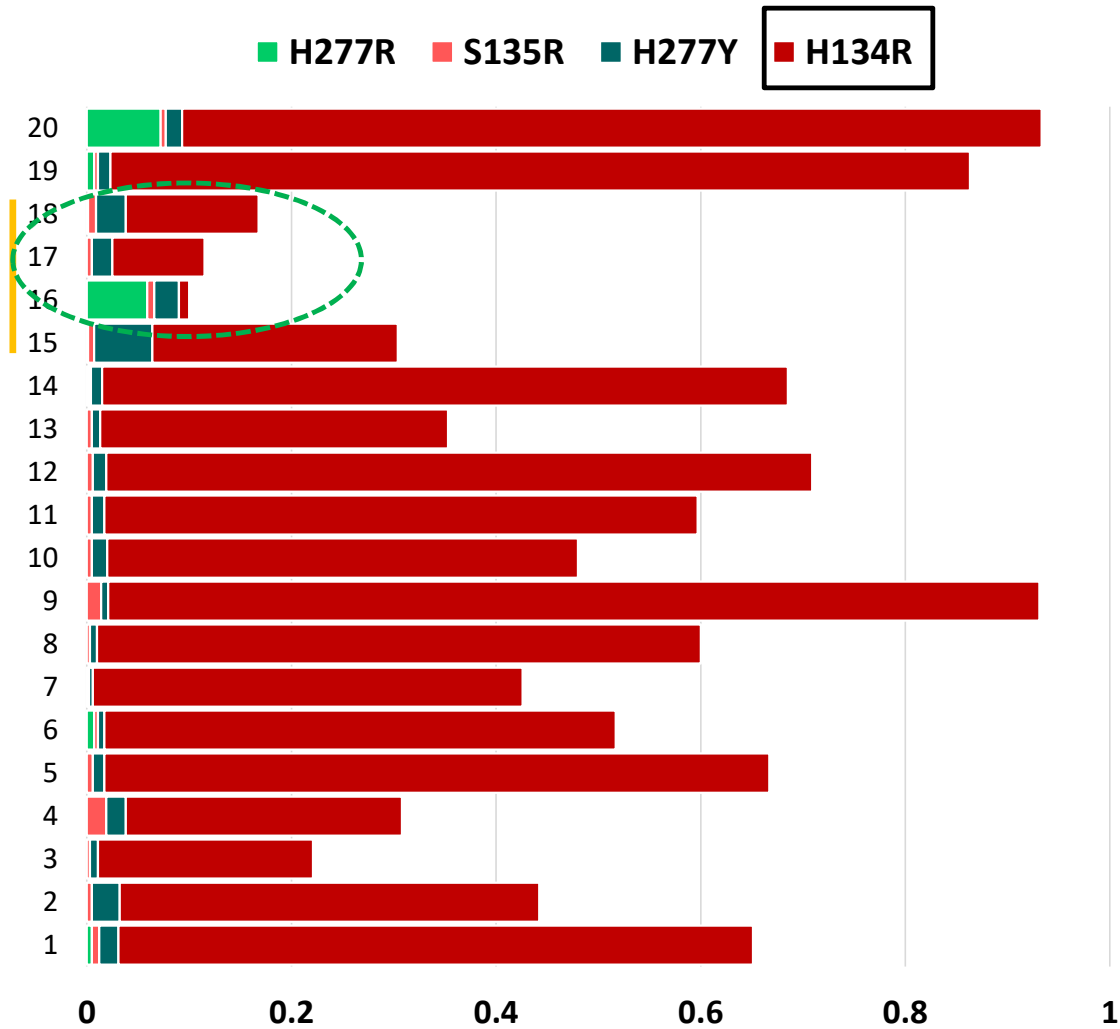
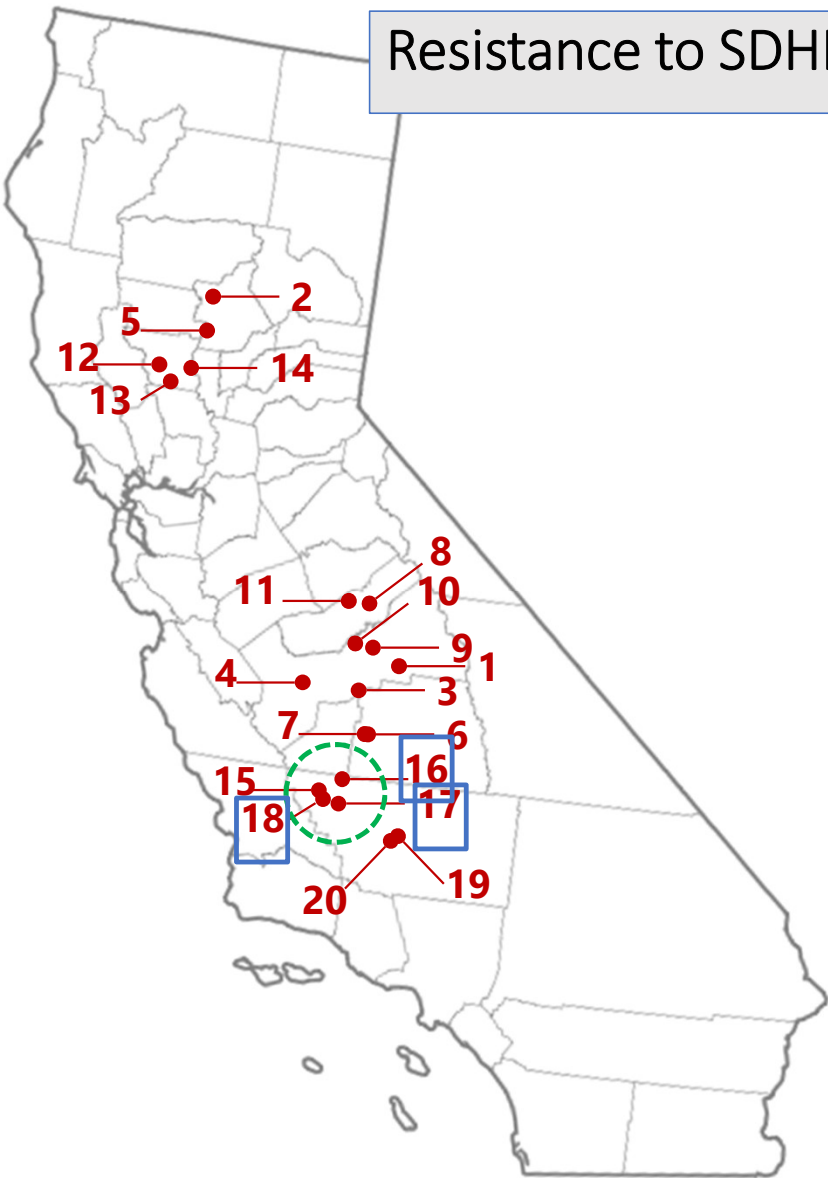
10% of isolates are resistant

100% of isolates are resistant

**Resistance to SDHI
fungicides is
widespread**

Based on mutation H134R

Resistance to SDHI fungicides is widespread in California



Best control is achieved with Integrated Disease Management

Cultural Practices

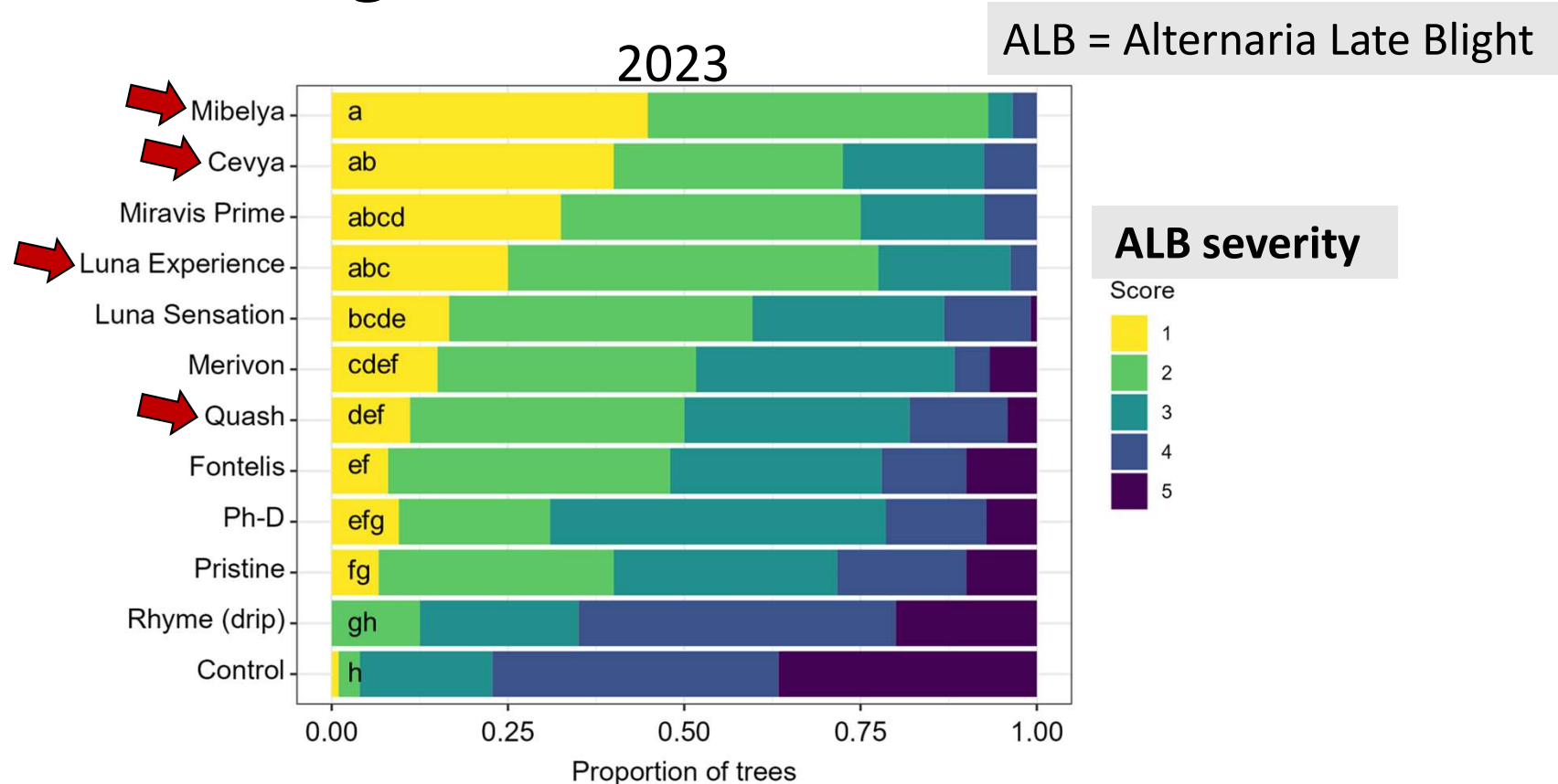
1. Drip Irrigation
2. Hedging
3. Disc soil

Chemical Control

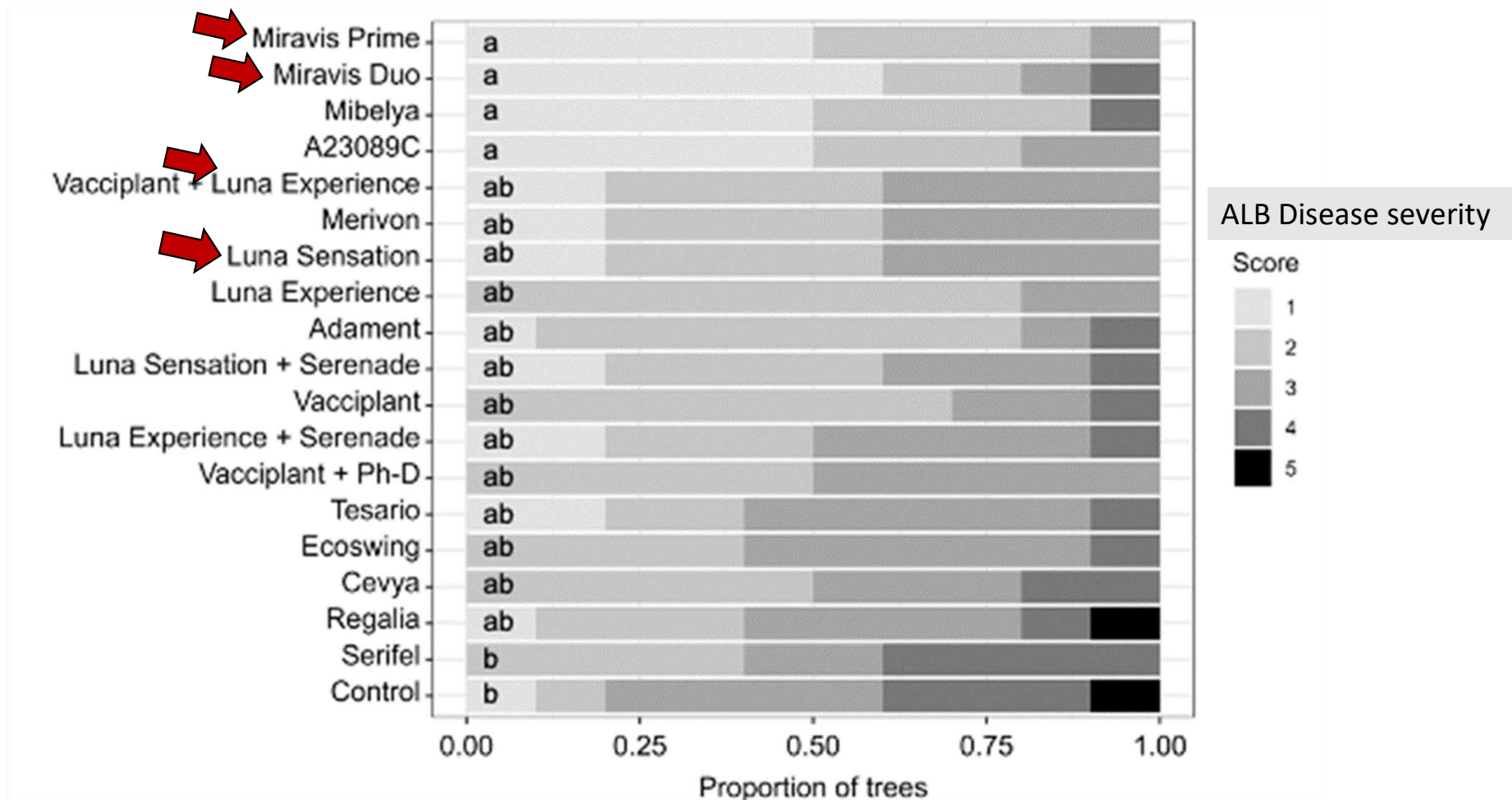
1-3 applications
Fungicide in mixtures



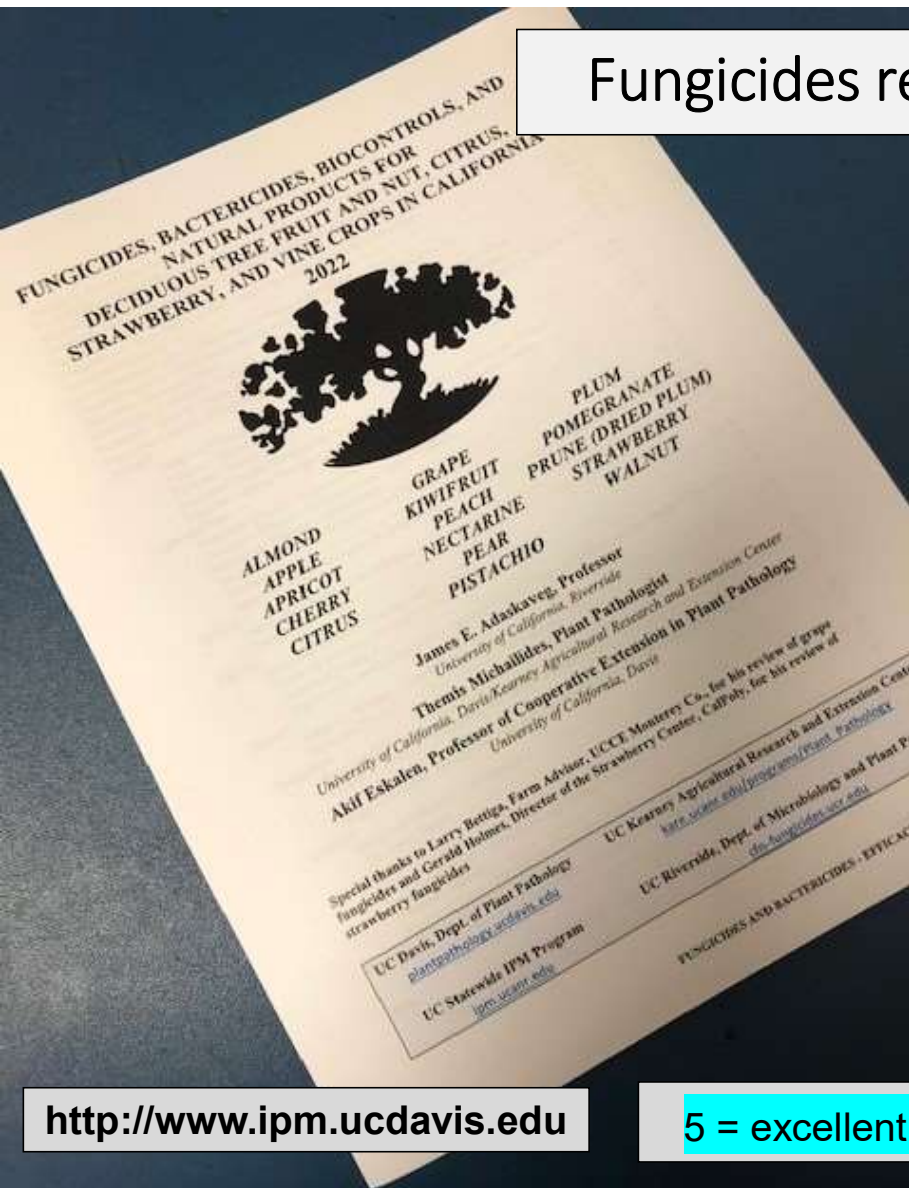
Products formulated with DMI fungicides provide ALB disease control and are recommended for reducing QoI and SDHI resistance



Efficacy of fungicides on Alternaria late blight (ALB) disease severity in an experimental pistachio orchard in Parlier, CA (2022)



Fungicides registered for Alternaria late blight



Fungicide	Active ingredient (FRAC #)	Efficacy
Abound	azoxystrobin (11)	4
Caprio	pyraclostrobin (11)	4
Flint Extra.....	trifloxystrobin (11)	4
Inspire Super....	difenoconazole + cyprodinil (3/9)	3
Quadris Top.....	azoxystrobin+difenoconazole(3/11)	4
★ Merivon.....	fluxopyroxad+pyraclostrobin (7/11)	5
★ Pristine	boscalid + pyraclostrobin (7/11)	5
K-Phite	Polyphosphite (33)	---
★ Luna Experience	fluopyram + tebuconazole (3/7)	5
★ Luna Sensation...	fluopyram + trifloxystrobin (7/11)	5
★ Cevya	mefentrifluconazole (3)	5
★ Miravis Duo	difenoconazole + pydiflumetofen (3/7)	5
★ Miravis Prime	pydiflumetofen + fludioxonil (7/12)	5
★ Quilt Xcel	propiconazole + azoxystrobin (3/11)	5
★ Adament	tebuconazole + azoxystrobin (3/11)	5
★ Fontelis	penthiopyrad (7)	5
★ Viathon	tebuconazole + phosphite (3/33)	5

<http://www.ipm.ucdavis.edu>

5 = excellent & consistent; 4 = good & reliable; 3 = limited and/or erratic

Timing of sprays



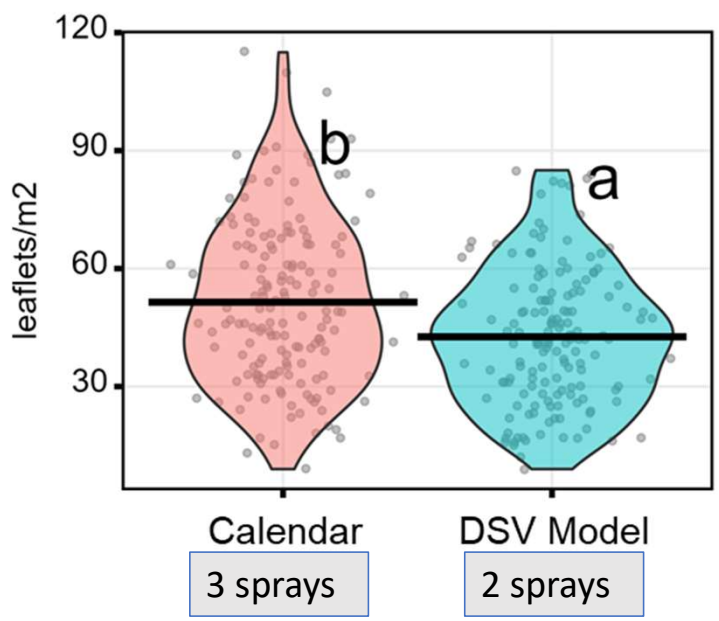
Option 1: 1 calendar spray: Early July (remember Independence Day!)

Option 2: 2 or 3 calendar sprays: Early June; late June/early July; & if high temperatures & humidity prevail, then one more spray in mid- to late-July.

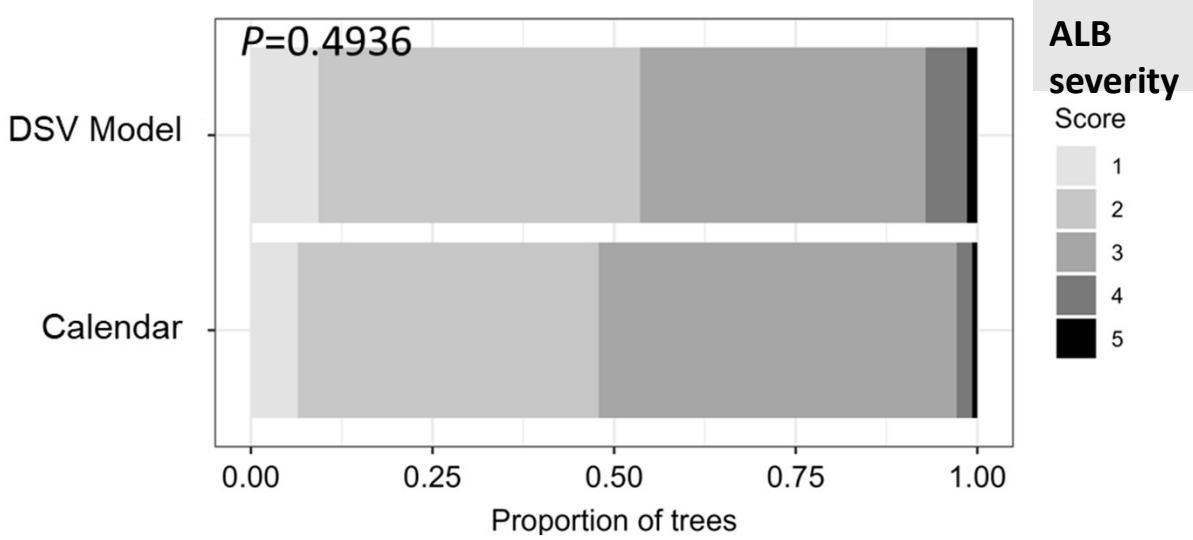
Option 3: Disease Severity Value (need to measure leaf wetness and temperature; it is temperature and leaf wetness dependent)

The Disease Severity Value model (DSV) can be used to determine the timing of fungicide sprays

Effect of two fungicide programs on defoliation



Disease severity



Take-home message

[Know the history of the orchard to diagnose the disease correctly]

- **No bloom spray(s)*****
- Start sprays in **early June and finish by end of July.**
- Sprays at bloom (**April**), in **May**, and in **August** are not effective.
- For one spray, the best time is **end June /early July.**
- Use products formulated with **DMI fungicides** to reduce QoI and SDHI resistance which are widespread in California.

***** If conditions conducive to Botrytis blight, then a bloom spray will be needed for Botrytis blight.**

Hurricane Hilary:
About 25% of
nuts stayed on
the trees after
re-shake.





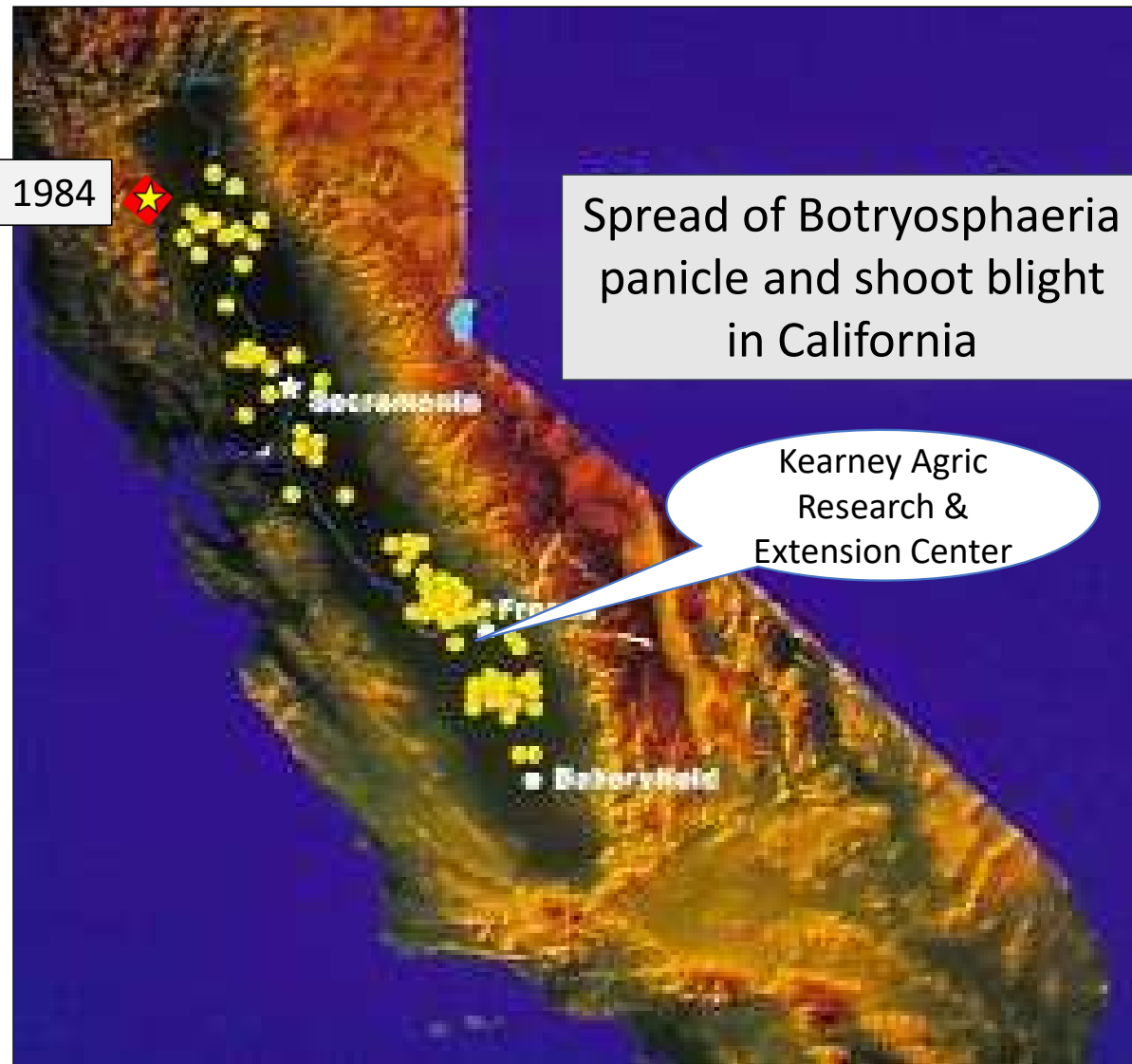
Hurricane Hilary:
About 25% of nuts stayed on the trees after re-shake.

2. Botryosphaeria panicle (cluster) and shoot blight, or BOT

Annual rainfall in inches for period 1979 to 2023 in California

Season (July 1-June 30)	Total Inches of Rainfall	Inches Above (+) Overall Season Average*
1979-1980	21.02	+ 9.16
1982-1983	25.61	+ 13.75 *** ← Discovery
1992-1993	23.66	+ 11.86
1994-1995	22.80	+ 10.99
1997-1998	31.28	+ 19.42 *** ← Epidemic
2004-2005	26.51	+ 14.65 ***
2022-2023	24.12	+ 12.26

1984 was the year when Botryosphaeria was discovered in California



Emergency situation for the pistachio industry...

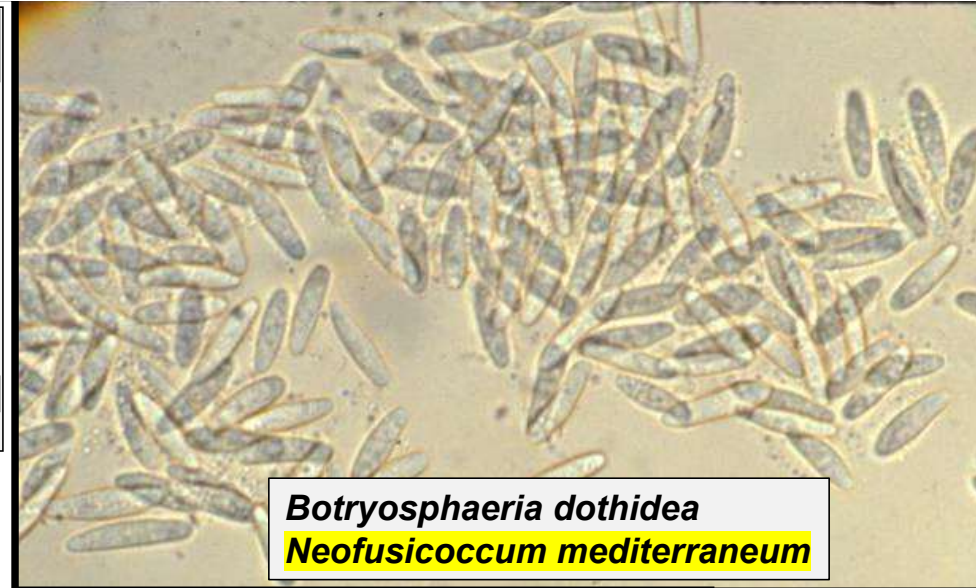
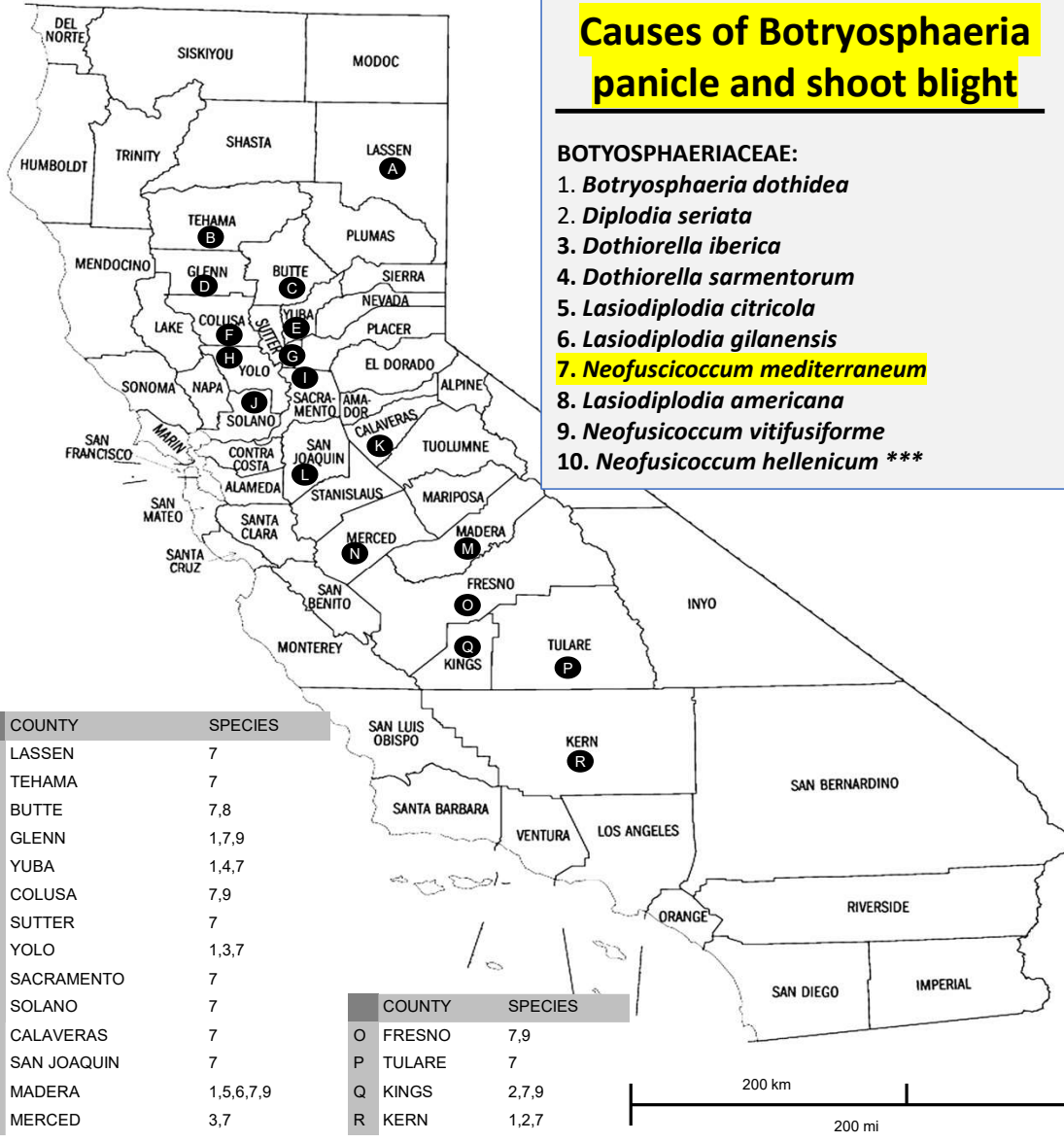
High levels in 1997 and epidemic in 1998 & 1999



Causes of Botryosphaeria panicle and shoot blight

BOTRYOSPHAERIACEAE:

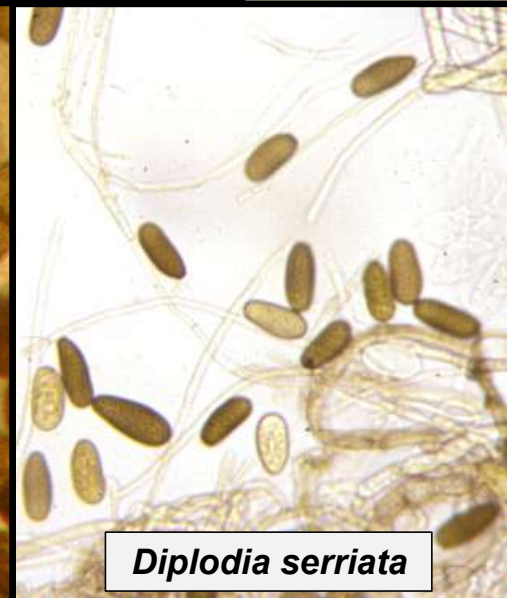
1. *Botryosphaeria dothidea*
2. *Diplodia seriata*
3. *Dothiorella iberica*
4. *Dothiorella sarmentorum*
5. *Lasiodiplodia citricola*
6. *Lasiodiplodia gilanensis*
7. *Neofusicoccum mediterraneum*
8. *Lasiodiplodia americana*
9. *Neofusicoccum vitifusiforme*
10. *Neofusicoccum hellenicum* ***



Botryosphaeria dothidea
Neofusicoccum mediterraneum



Lasiodiplodia spp.



Diplodia seriata

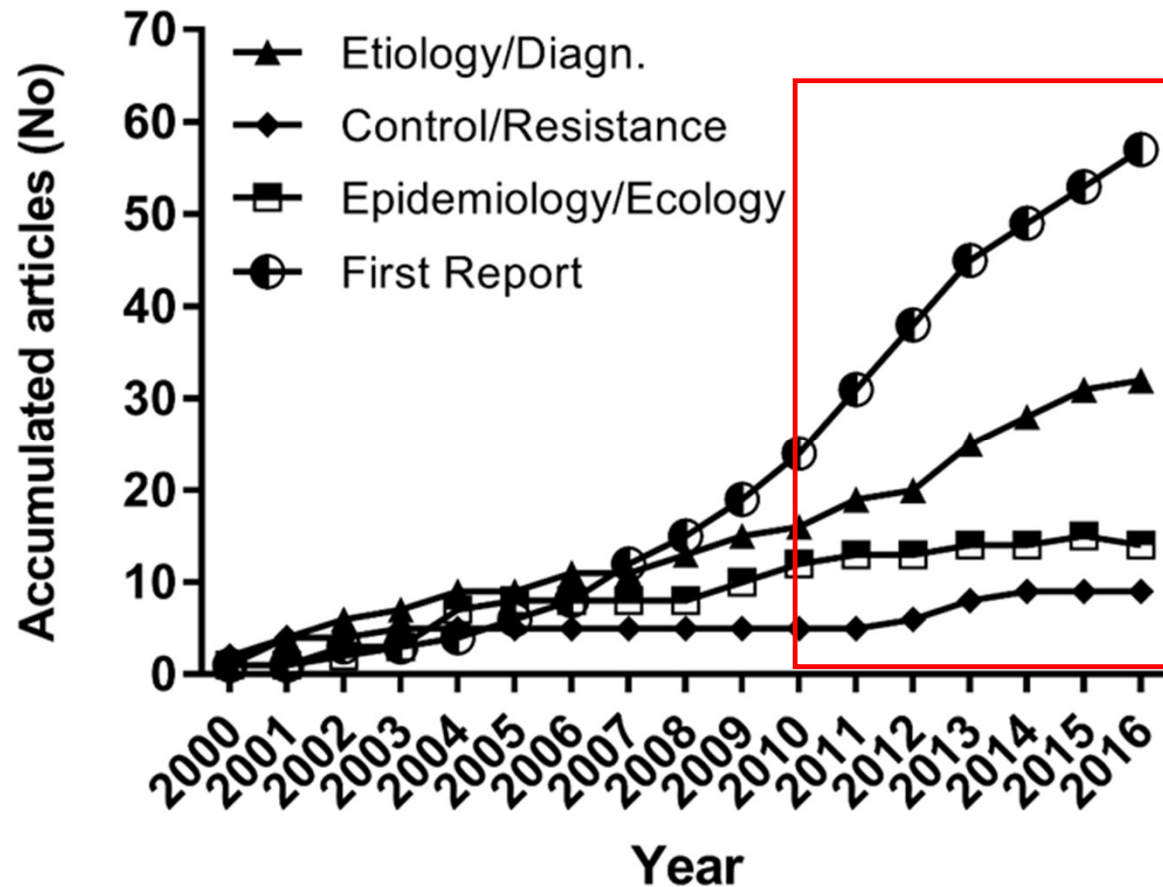
Host of Botryosphaeria in California

HOST	SCIENTIFIC NAME	FAMILY
Almond	<i>Prunus dulcis</i>	Rosaceae
Apple	<i>Malus domestica</i>	Rosaceae
Avocado	<i>Persea americana</i>	Lauraceae
Blackberry	<i>Rubus ursinus</i>	Rosaceae
Black walnut	<i>Juglans hinsii</i>	Juglandaceae
Carob seed tree	<i>Ceratonia siliqua</i>	Leguminosae
Incense cedar	<i>Cedrus libani</i>	Pinaceae
Deodar cedar	<i>Cedrus deodara</i>	Pinaceae
Chinese hackberry	<i>Celtis sinensis</i>	Ulmaceae
California redwood	<i>Sequoia sempervirens</i>	Taxodiaceae
Cotoneaster	<i>Cotoneaster frigidus</i>	Rosaceae
Cottonwood	<i>Populus deltoides</i>	Populaceae
English walnut	<i>Juglans regia</i>	Juglandaceae
Eucalyptus	<i>Eucalyptus coccifera</i>	Myrtaceae
Euonymus	<i>Euonymus fortunei</i>	Celestraceae
Silver dollar Eucalyptus	<i>Eucalyptus orbifolia</i>	Myrtaceae
Feijoa	<i>Feijoa sellowiana</i>	Myrtaceae
Fig	<i>Ficus carica</i>	Fagaceae

*The table includes fruit and nut trees, ornamentals, and forest trees and bushes

HOST	SCIENTIFIC NAME	FAMILY
Giant sequoia	<i>Sequoiadendron giganteum</i>	Rosaceae
Juniper	<i>Juniperus occidentalis</i>	Rosaceae
Jasmine	<i>Jasminum officinale</i>	Lauraceae
Lemon	<i>Citrus × limon</i>	Rosaceae
Sweet gum	<i>Liquidambar styraciflua</i>	Juglandaceae
Maple	<i>Acer sp.</i>	Leguminosae
Oak	<i>Quercus sp.</i>	Pinaceae
Olive	<i>Olea europea</i>	Pinaceae
Orange	<i>Citrus × auranteum</i>	Ulmaceae
Pistachio	<i>Pistacia vera 'Kerman'</i>	Taxodiaceae
Pear	<i>Pyrus communis</i>	Rosaceae
Pecan	<i>Carya illinoensis</i>	Populaceae
Persimmon	<i>Diospyros kaki</i>	Ebenaceae
Pine	<i>Pinus radiata</i>	Pinaceae
Prune	<i>Prunus domestica</i>	Rosaceae
Firethorn	<i>Pyracantha coccinea</i>	Rosaceae
Raymond ash	<i>Fraxinus augustifolia</i> subsp. <i>oxycarpa</i>	Oleaceae
Sycamore maple	<i>Acer pseudoplatanus</i>	Aceraceae
Wax leaf Privet	<i>Ligustrum japonicum</i>	Oleaceae
Western redbud	<i>Cedris canadensis</i>	Leguminosae
Wild rose	<i>Rosa sp.</i>	Rosaceae
White willow	<i>Salix alba</i>	Salicaceae
Arroyo willow	<i>Salix lasiolepis</i>	Salicaceae
Weeping willow	<i>Salix babylonica</i>	Salicaceae

Articles of the Botryosphaeriaceae species published in the American Phytopathological Society journals



Under normal rainfall conditions

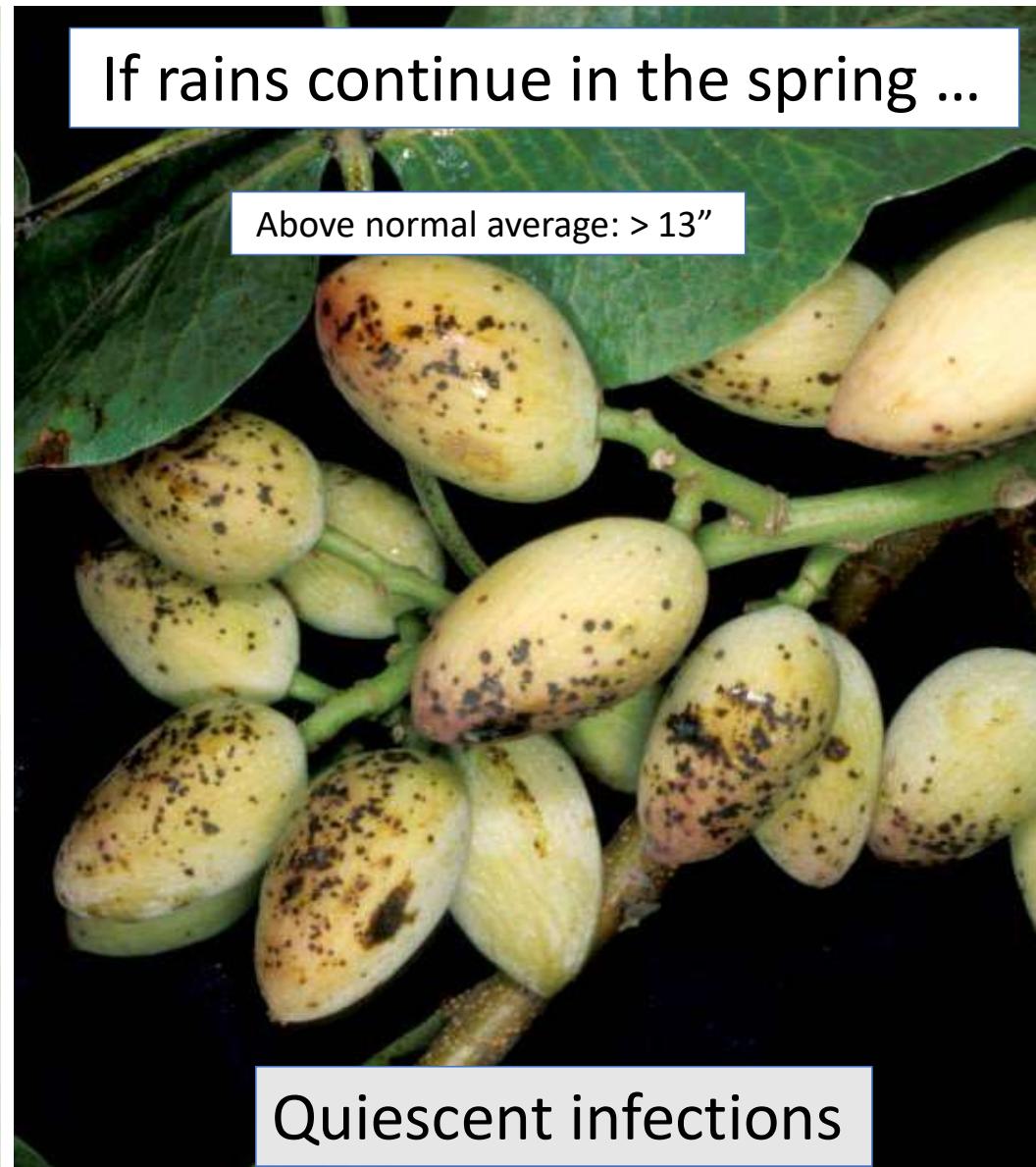
Normal average: 10-12 inches.



Latent infections

If rains continue in the spring ...

Above normal average: > 13"



Quiescent infections

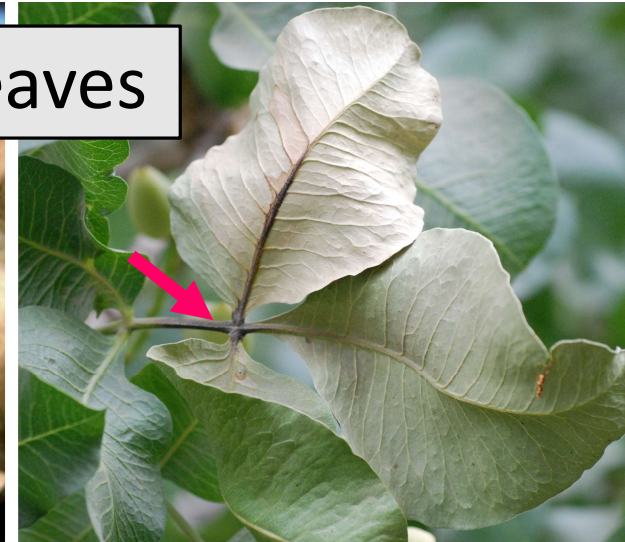
Infection of green tissues by invading stomates & lenticels



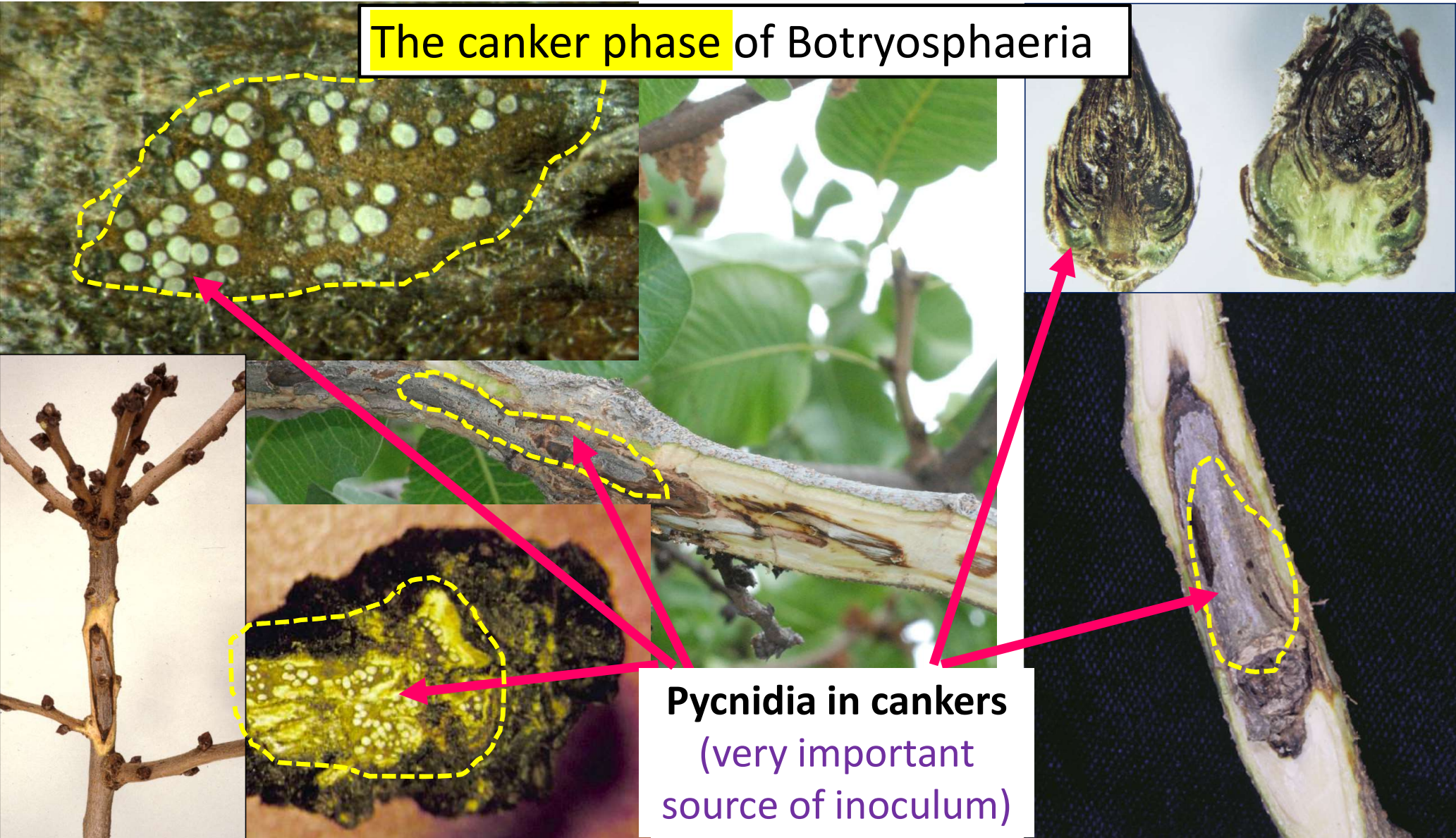
Blighted clusters, shoots, and leaves



The blight phase




The canker phase of Botryosphaeria



Pycnidia in cankers
(very important source of inoculum)



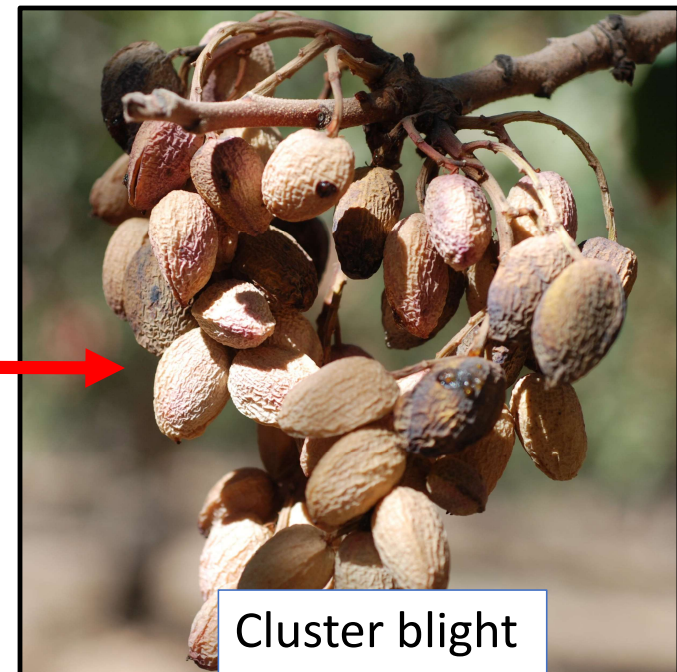
 Spores trapped among the bud scales



Flower infection



Rachis infection at the base

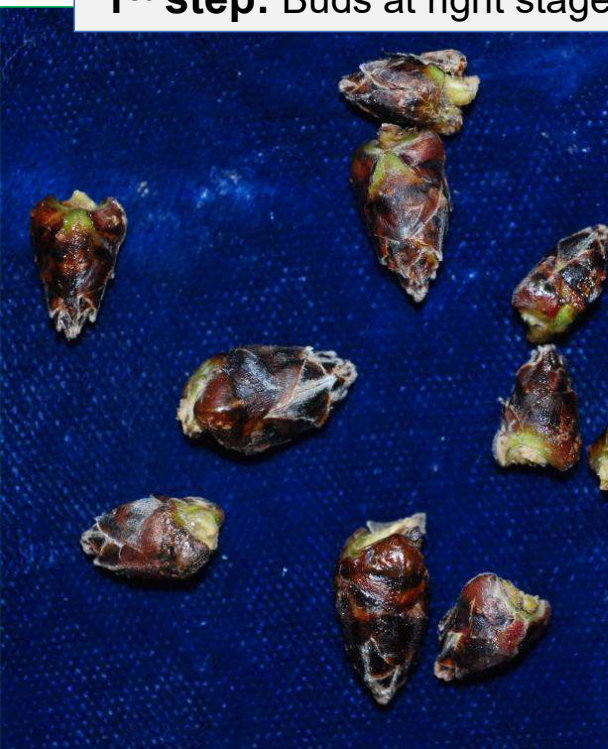


Cluster blight

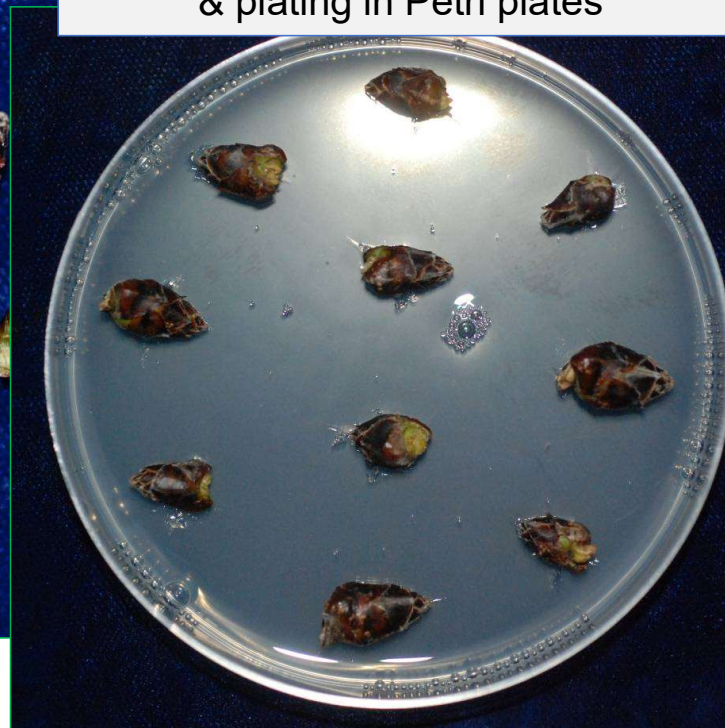
BUD MONitoring (BUDMON) Technique to detect and predict disease pressure in pistachio orchards

Collection of buds in late Feb – late March

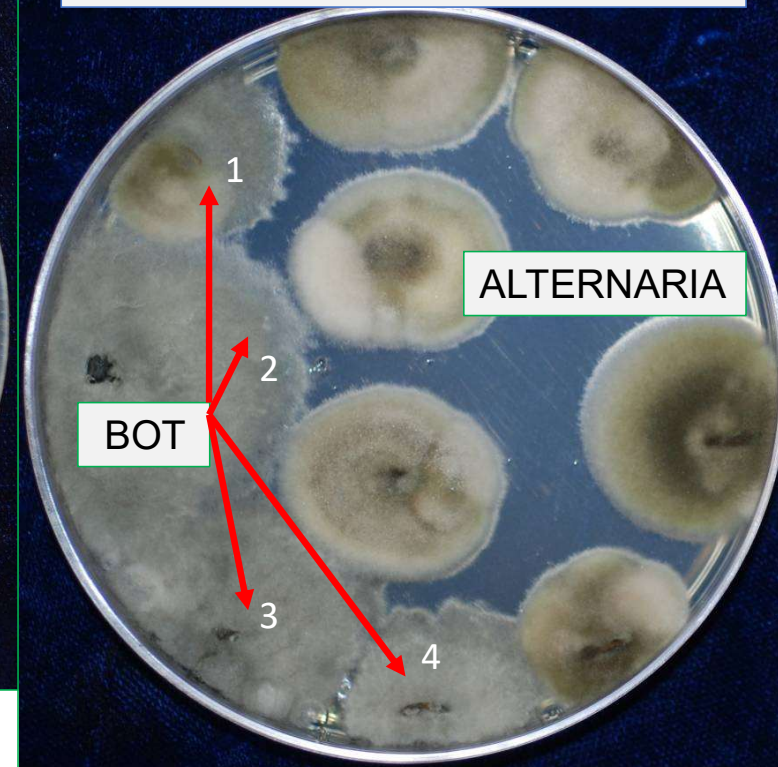
1st step: Buds at right stage



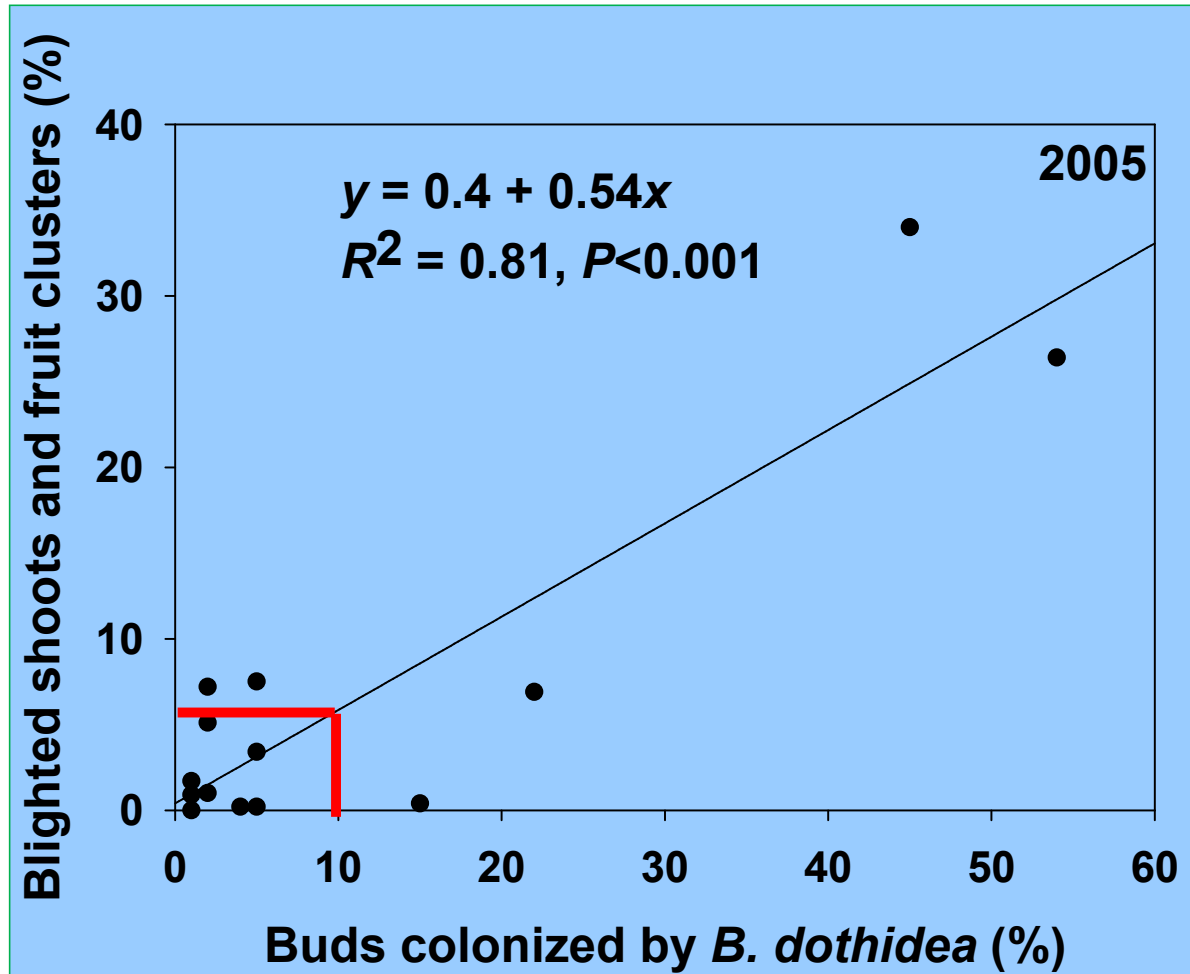
2nd step: After surface sterilization & plating in Petri plates



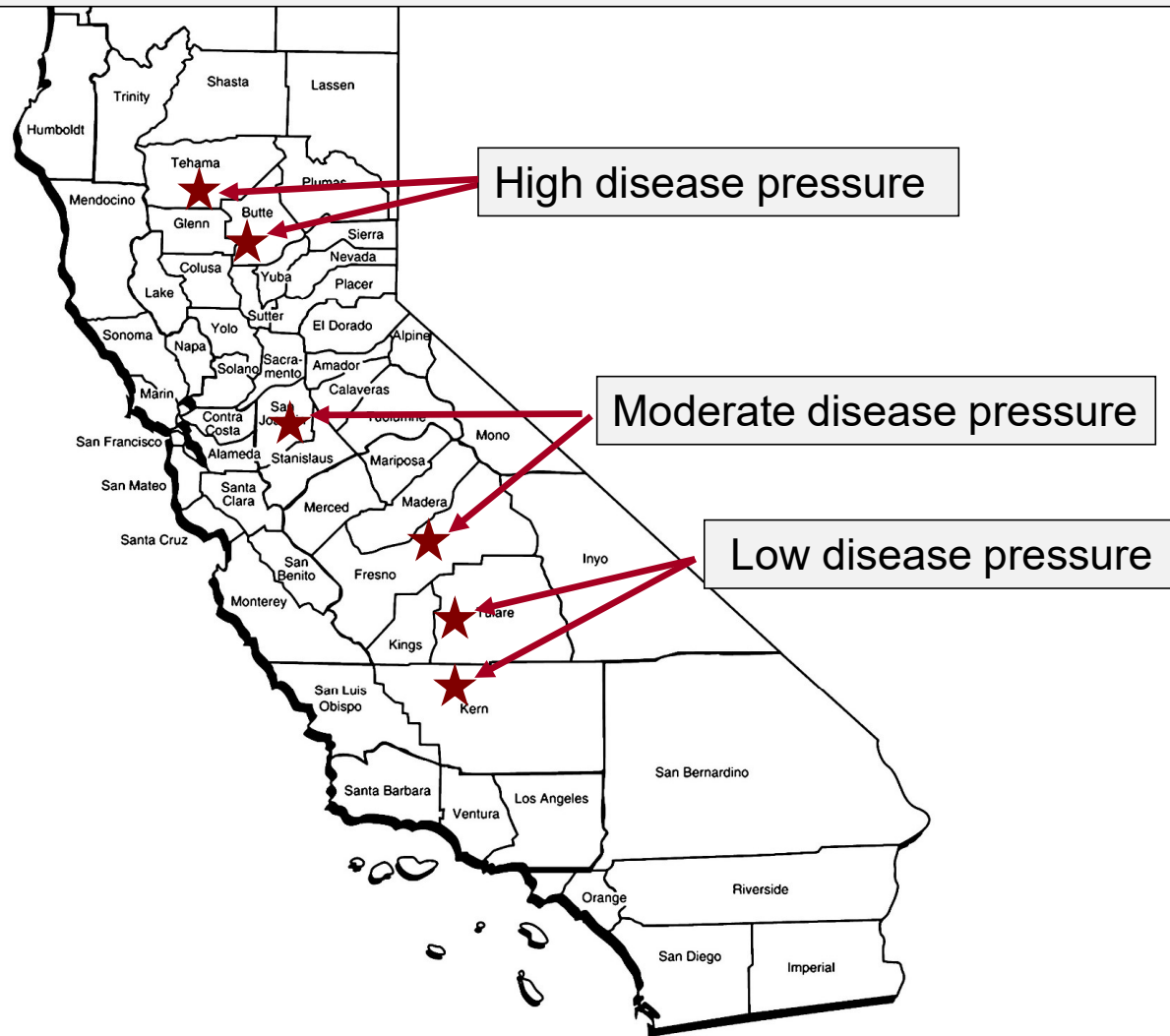
3rd step: After incubation for 5 days



Correlation of BUDMON with disease at harvest



BOT Risk Throughout Pistachio Growing Regions

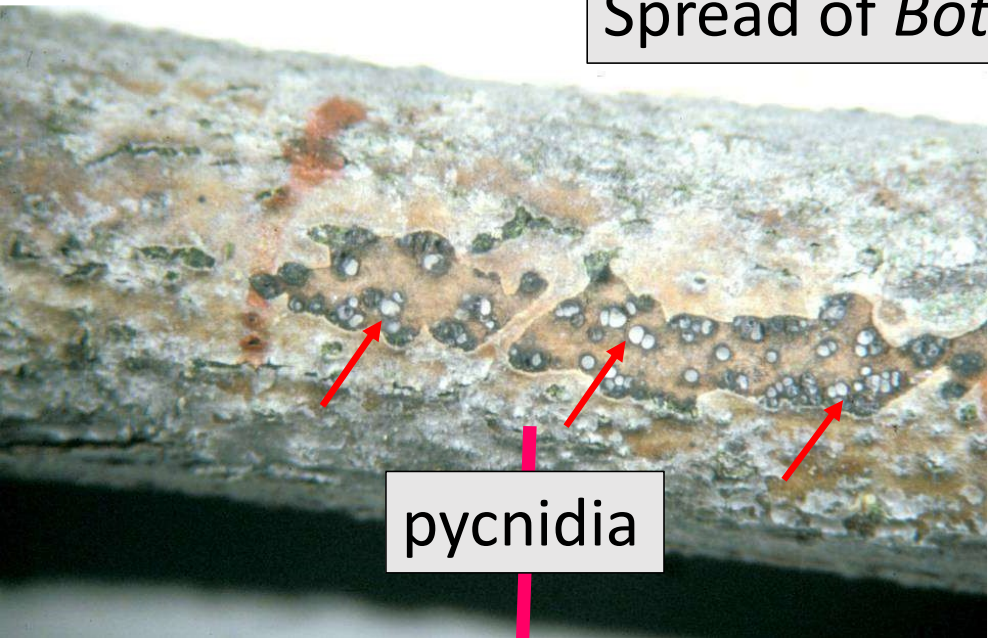


Empirical Table

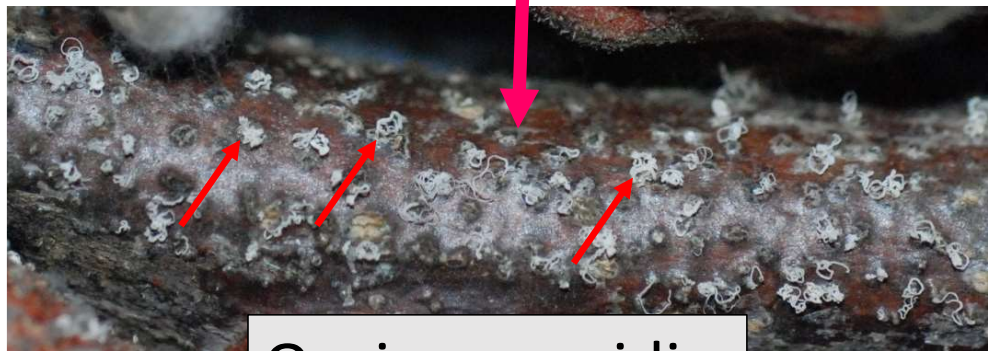
Levels of bud infection, disease risk, and suggested spray program:

Bot in buds	Disease risk	# of sprays
0% :	no risk.....	No sprays
1 to 3% :	low risk.....	1 spray
4 to 8% :	moderate risk.....	2-3 sprays
≥ 9% :	high risk.....	3+ sprays

Spread of *Botryosphaeria* fungi



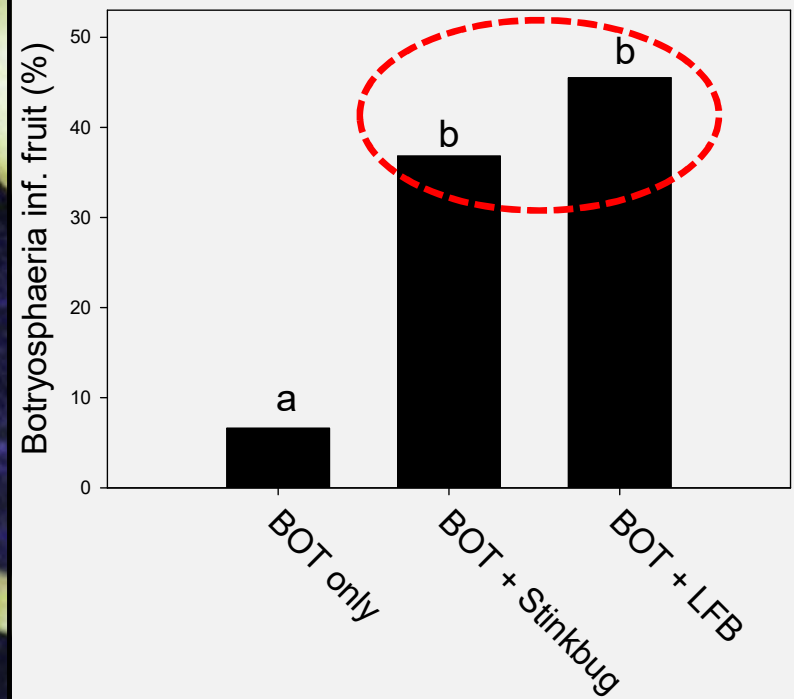
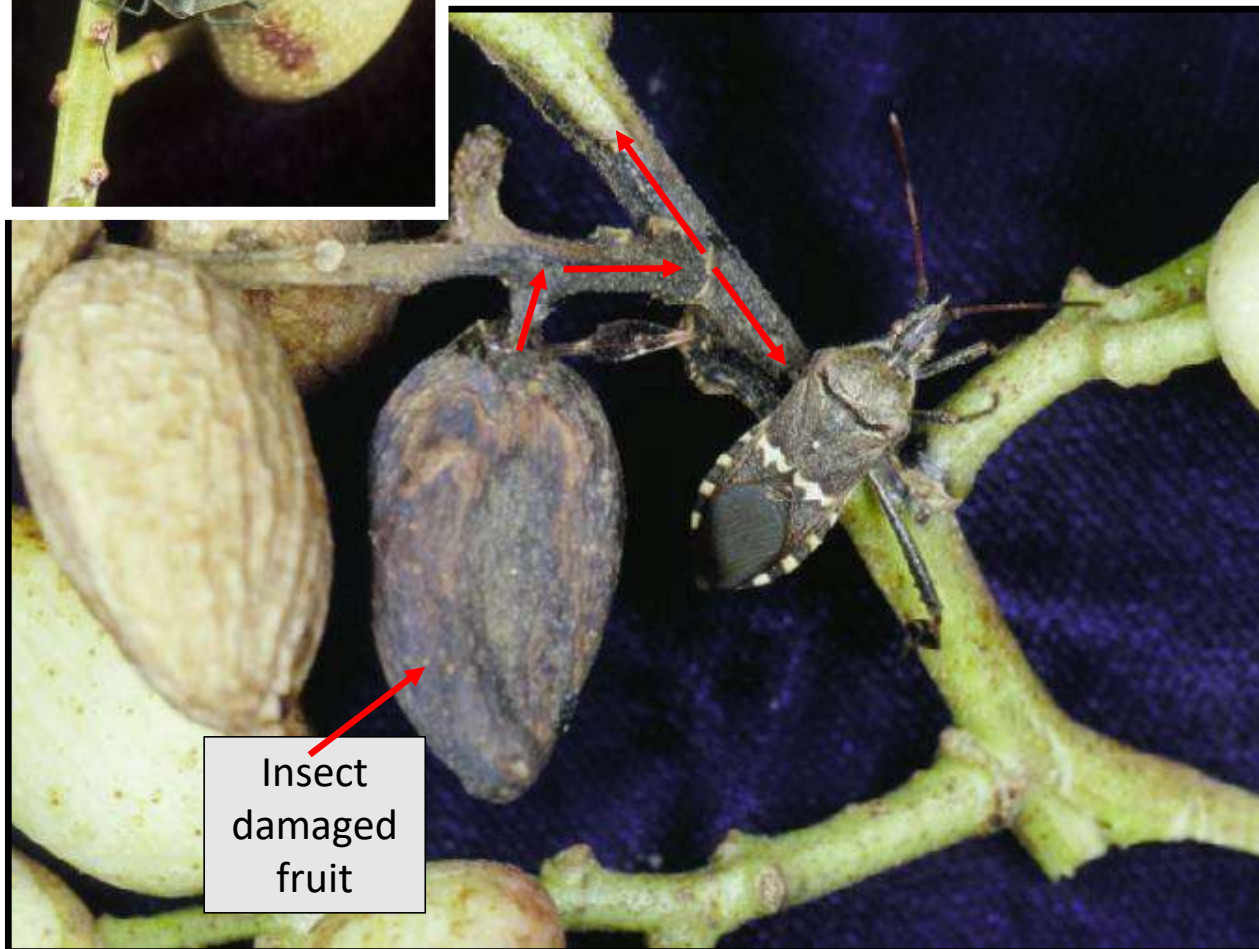
pycnidia

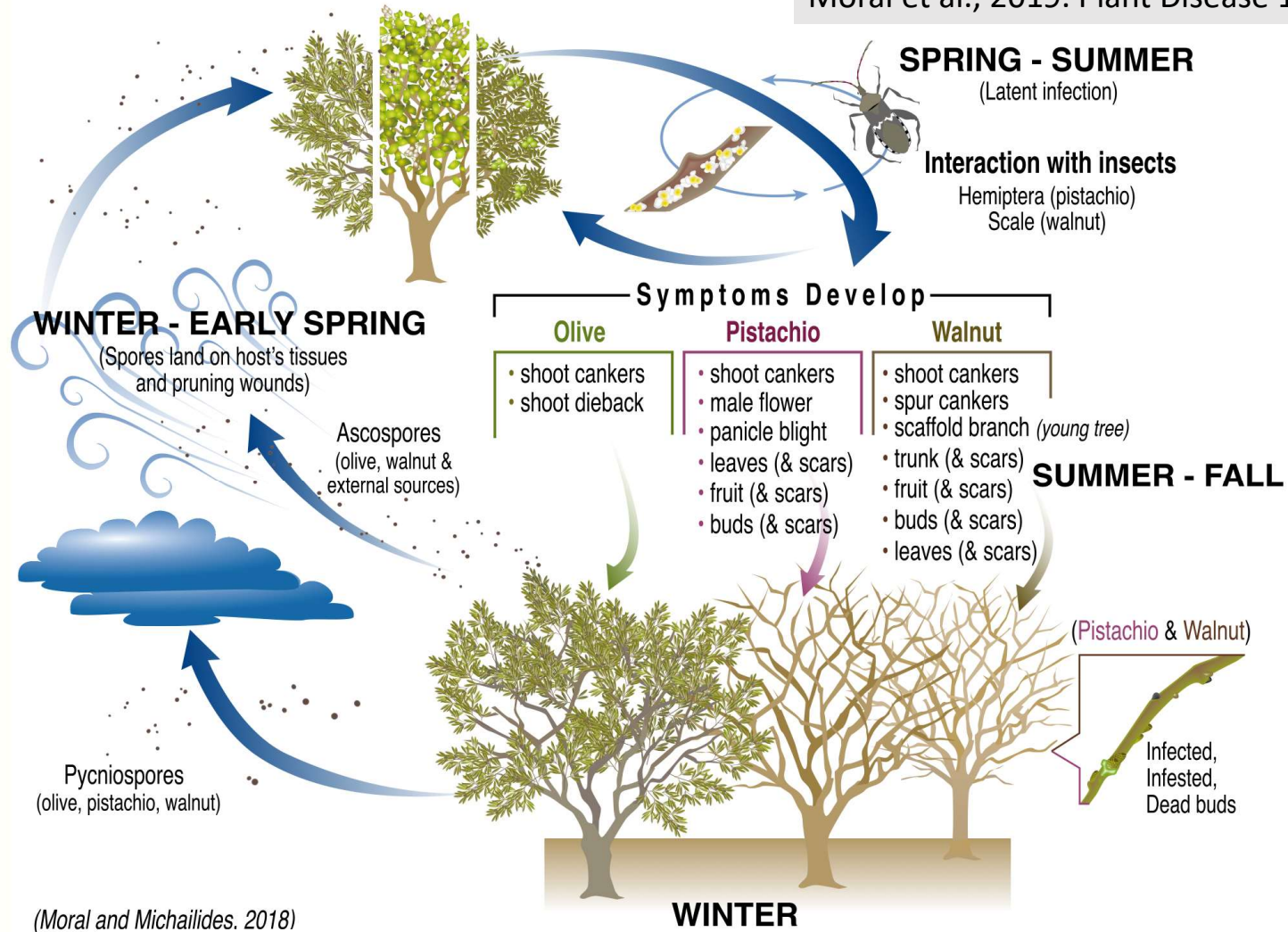


Oozing pycnidia



Spread by leaffooted bug (LFB, *Leptoglossus zonatus*) and other stinkbugs



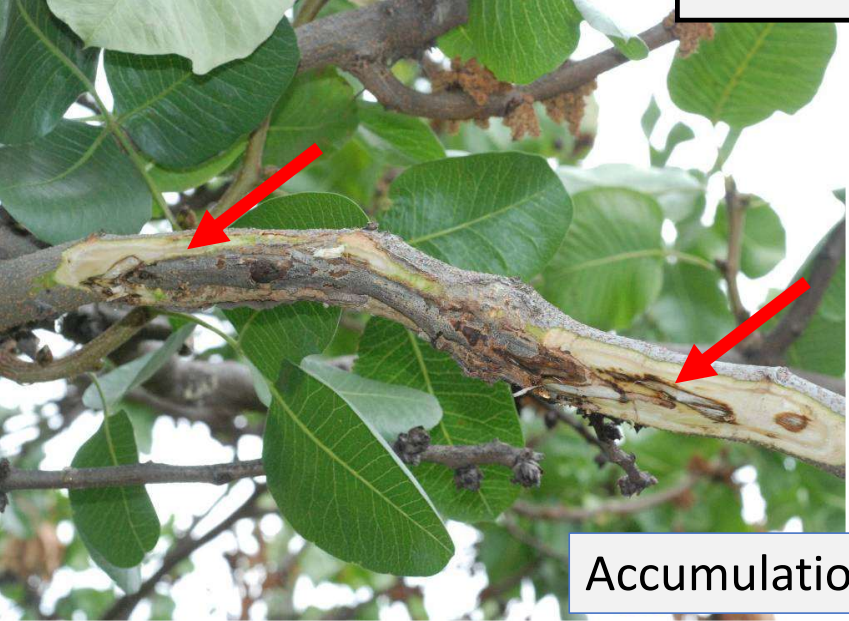


(Moral and Michailides. 2018)

Botryosphaeria blight on pistachio, walnut and olive



Disease Management



Accumulation of inoculum on the trees

Disease management

A. Cultural control



a) Winter pruning



b) Summer pruning

B. Chemical control

Strobilurins (FRAC 11)

Abound (azoxystrobin)
Gem (trifloxystrobin)
Cabrio (pyraclostrobin)

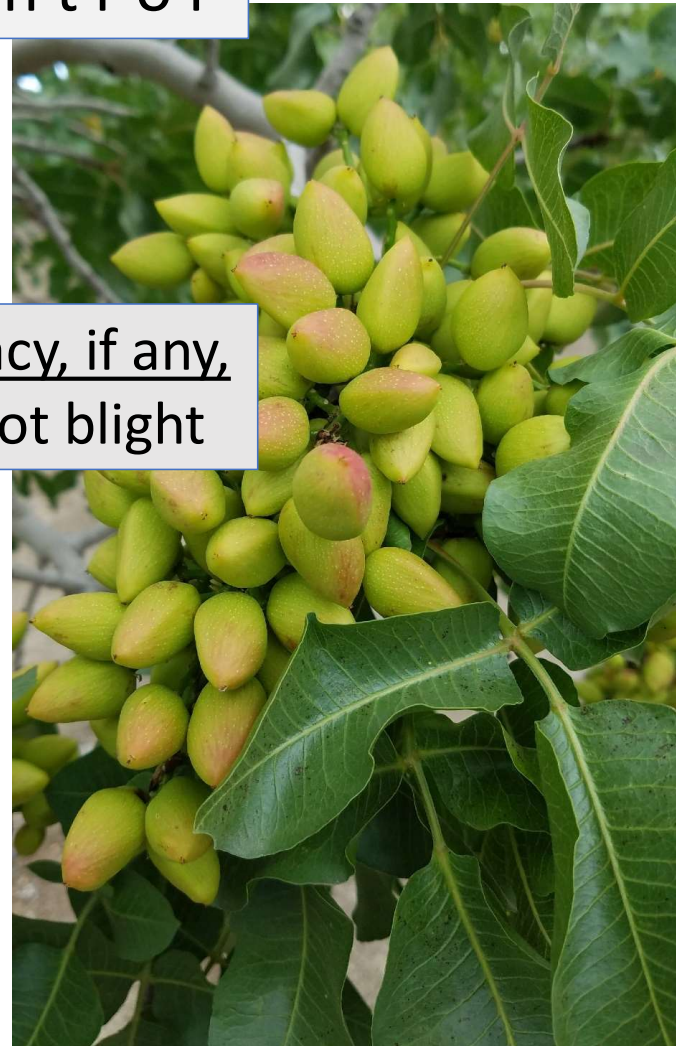
Biologicals show low efficacy, if any,
against Bot panicle & shoot blight

SDHI (FRAC 7)

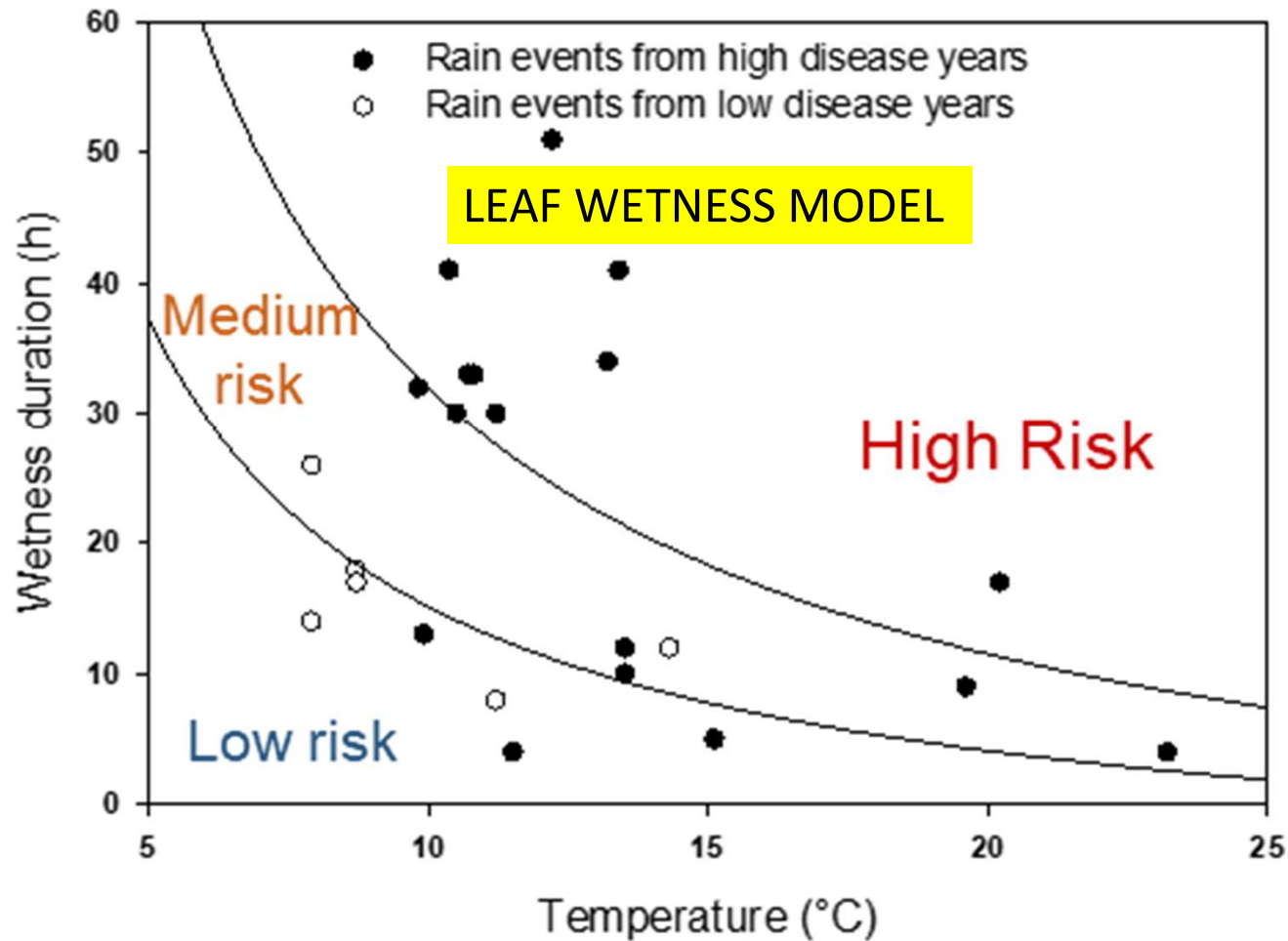
Endura (boscalid)
Luna Privilege (fluopyram)
Fontelis (penthioopyrad)

Premixtures (7/11, 3/11, 3/7, & 3/9)

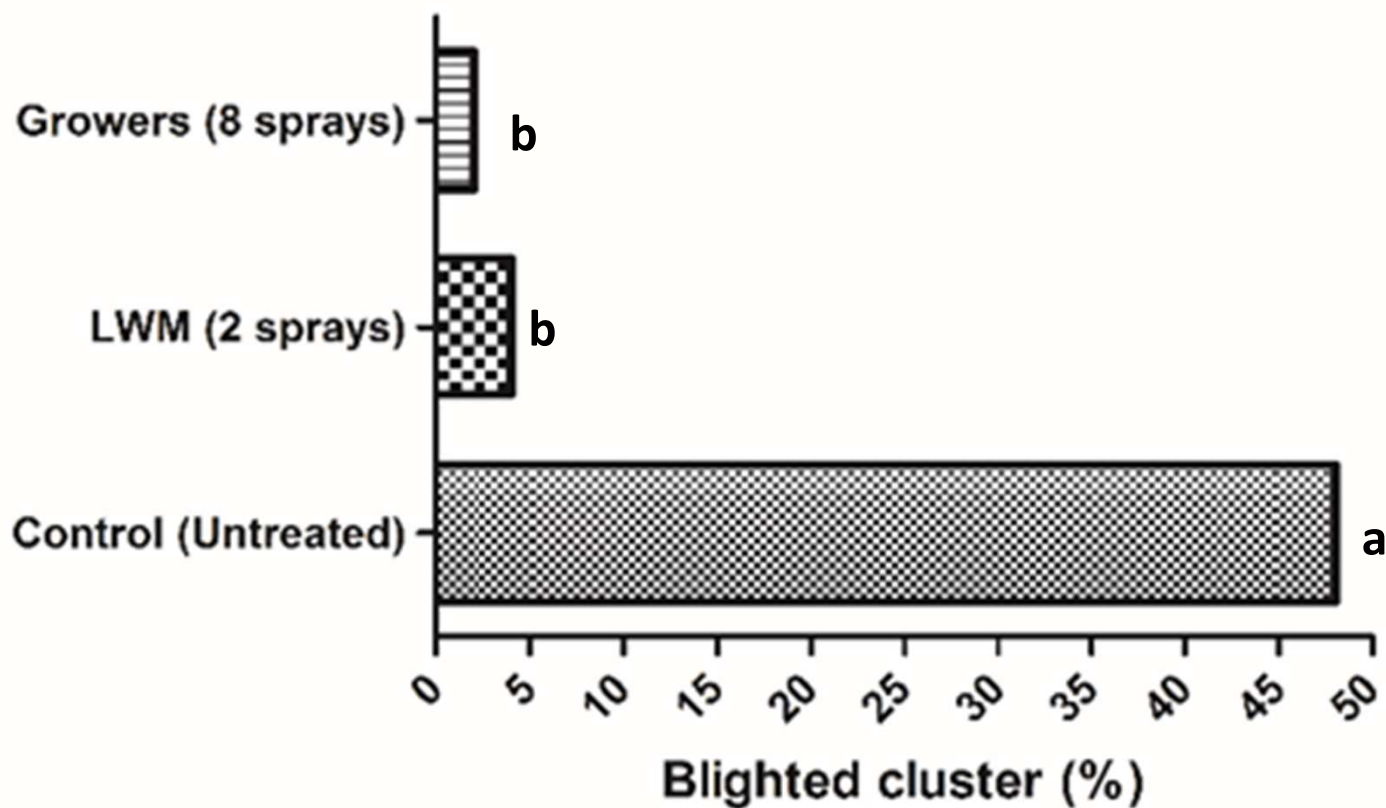
Pristine [SDHI (7)/QoI (11)]
Merivon [SDHI (7)/QoI (11)]
Luna Sensation [SDHI (7)/QoI (11)]
Luna Experience [DMI-triazole (3)/SDHI (7)]
Inspire Super [DMI-triazole (3)/AP (9)]
Quilt-Xcel [DMI-triazole (3)/QoI (11)]



Relative risk of infection of pistachio fruit by *Neofusicoccum mediterraneum* as determined by the wetness period (W) and Temperature (T)



Blighted clusters (%) of pistachio caused by *Neofusicoccum mediterraneum* as affected by the grower's calendar sprays (8) or the leaf wetness model (LWM, 2 sprays)



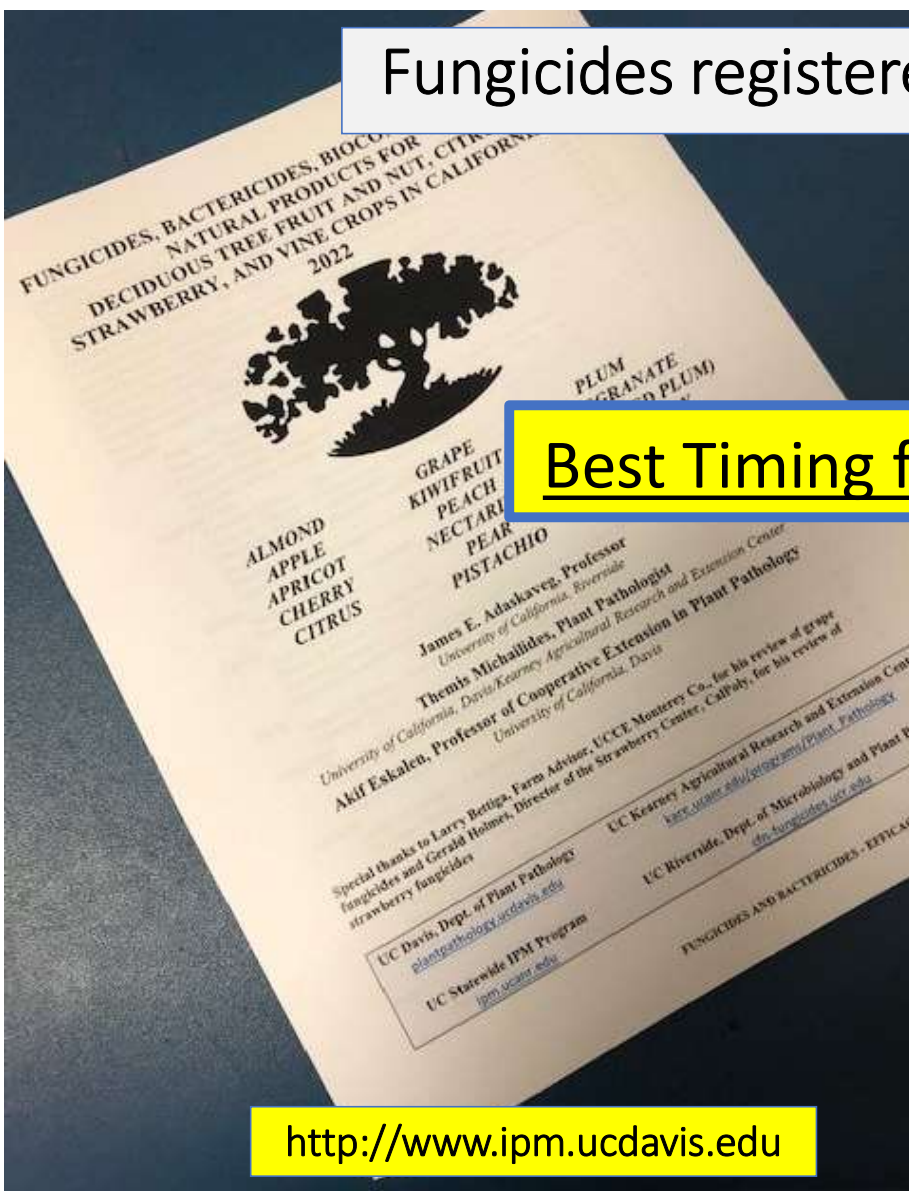
Fungicides registered for Bot panicle & shoot blight

Best Timing for one spray: early June

Fungicide	Active ingredient (FRAC)	Efficacy
Abound	azoxystrobin (11)	4
.....	4
.....	4
.....	cyprodinil (3/9)	4/5
Quadris Top.....	azoxystrobin+difenoconazole(3/11)	4/5
Merivon.....	fluxopyroxad+pyraclostrobin (7/11)	5
Pristine	boscalid + pyraclostrobin (7/11)	5
K-Phite	Polyphosphite (33)	4/5
Luna Experience	fluopyram + tebuconazole (3/7)	5
Luna Sensation...	fluopyram + trifloxystrobin (7/11)	5
Cevya	mefentrifluconazole (3)	5
Miravis Duo	difenoconazole + pydiflumetofen (3/7)	5
Miravis Prime	pydiflumetofen + fludioxonil (7/12)	5
Quilt Xcel	propiconazole + azoxystrobin (3/11)	4/5
Adament	tebuconazole + azoxystrobin (3/11)	4/5
Fontelis	penthiopyrad (7)	4/5
Viathon	tebuconazole + phosphite (3/33)	5

5 = excellent & consistent; 4 = good & reliable

<http://www.ipm.ucdavis.edu>



Take-home message

[Know the history of the orchard to diagnose the disease early and correctly]

- Start at 4th – 5th leaf to monitor for any occasional cluster and shoot blights.
- If not found, continue monitoring the following year(s).
- If found, immediately prune blighted shoots/clusters.
- Spray before or (2-3 days) after rain events [April (bloom), May, & June, July]
[rains cause infection events (at least 1/4 inch rain and > 50 °F temperature)].
- No resistance to fungicides!!!
- Lots of registered effective fungicides; BOT is now an easy to control disease.

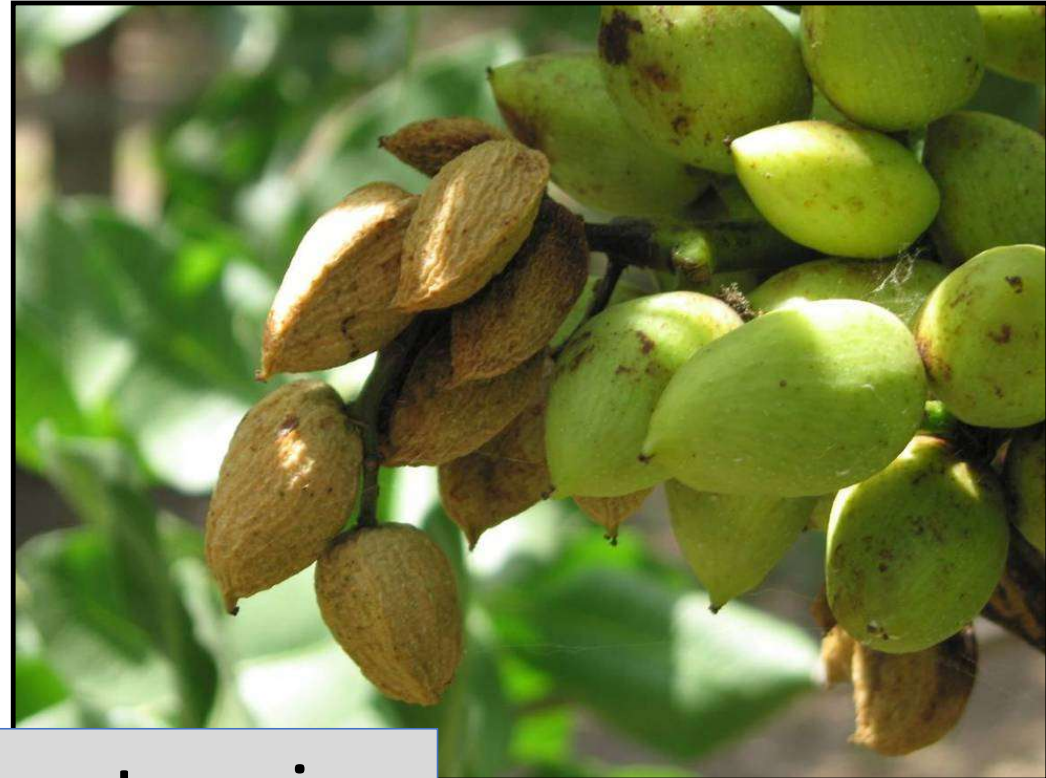
Hurricane Hilary – August 2023



Botryosphaeria panicle and shoot blight following the **Hurricane Hilary** – August 2023

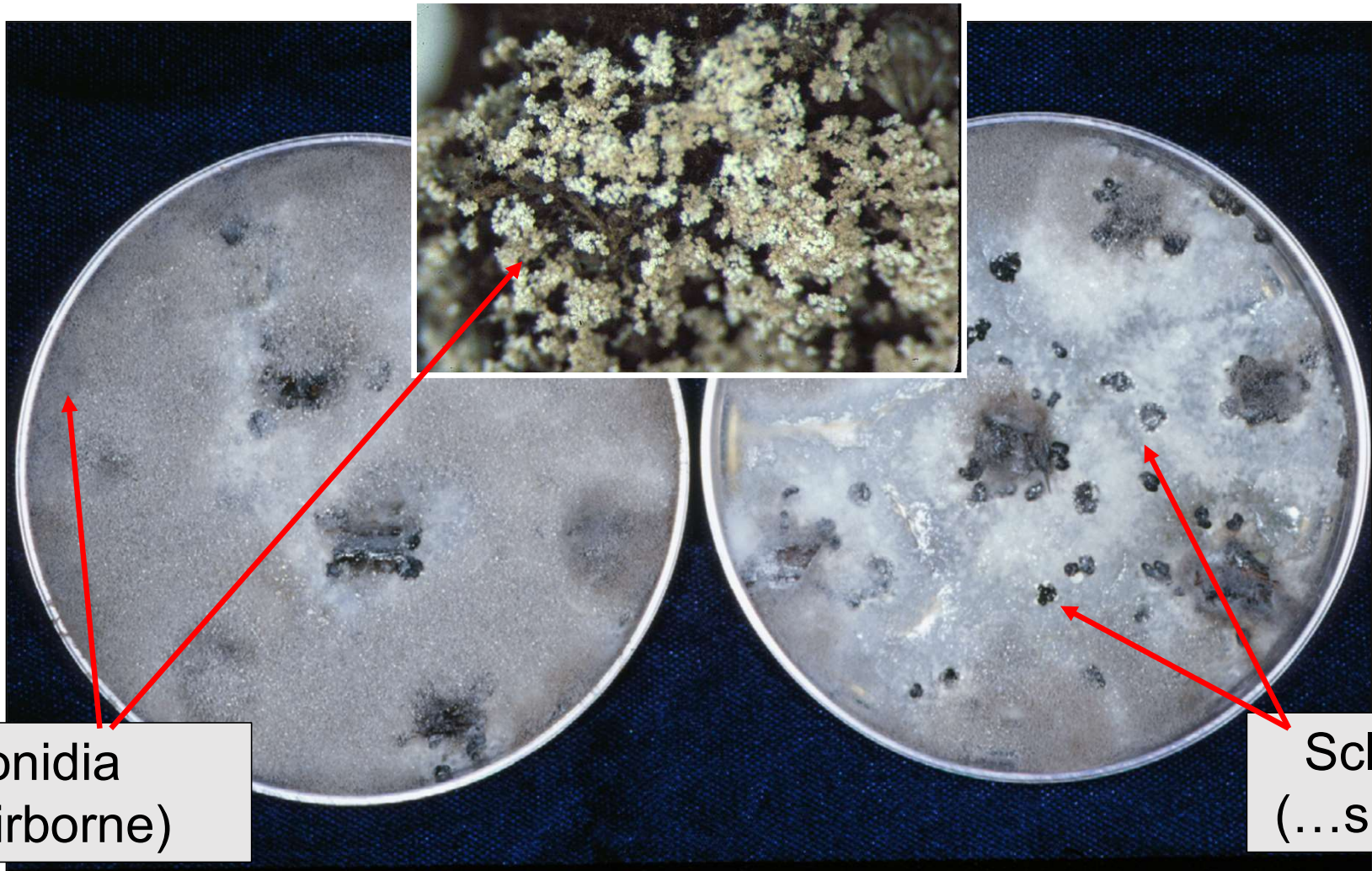


3. Botrytis blossom, shoot, and fruit blight



Cool and wet spring

Pathogen: *Botrytis cinerea*



Conidia
(...airborne)

Sclerotia
(...survival)

Infection by *Botrytis cinerea*



Early infections start in bud scales



Infection moves into the base of tender shoot

Symptoms of Botrytis in the summer = **shepherd's hook**



Peters

Selections 02-16 & 02-18



Cankers start from male flowers



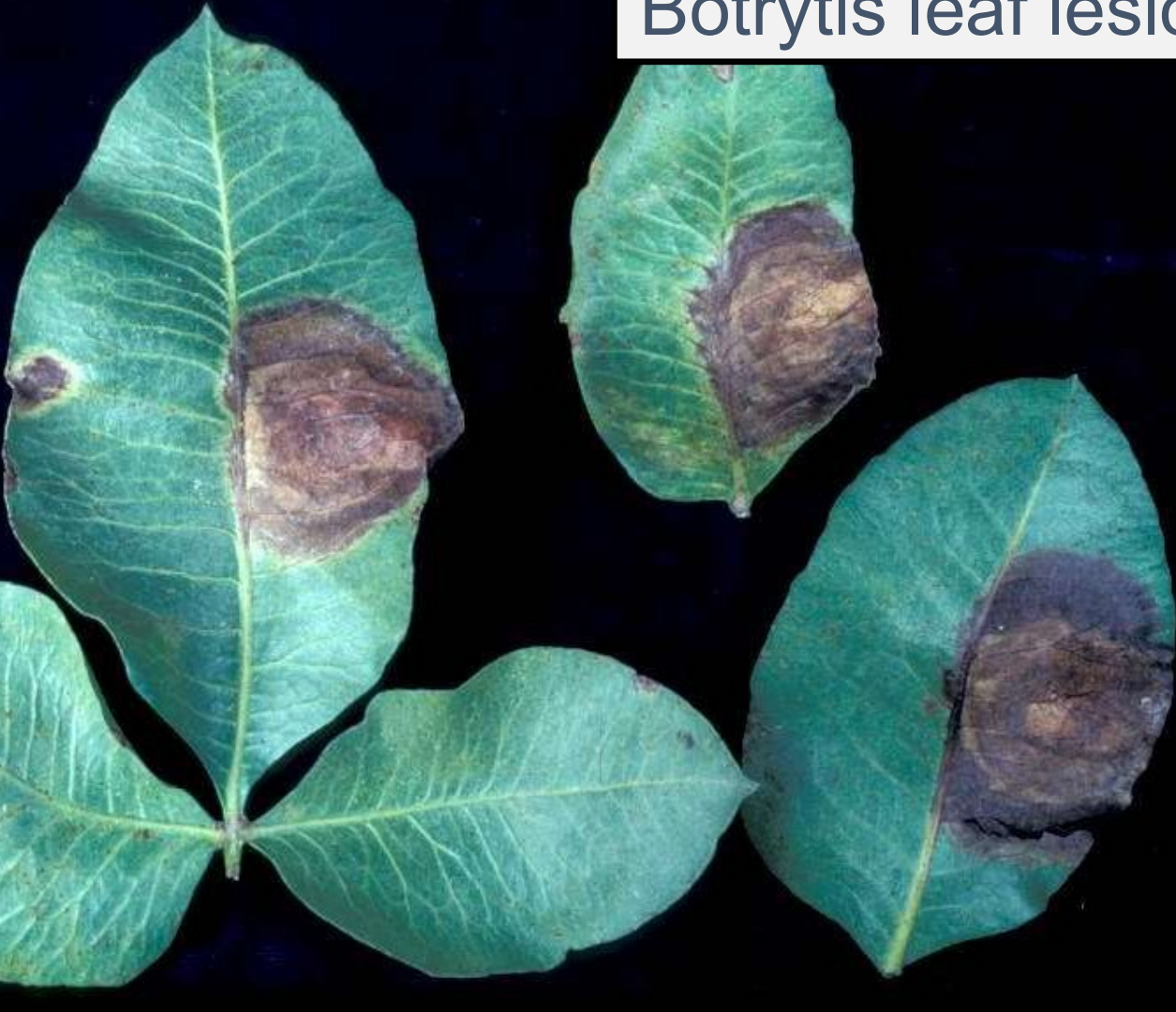
Severe Botrytis blossom and shoot blight in ♂ trees

When a cool rain in May/early June  Botrytis fruit blight

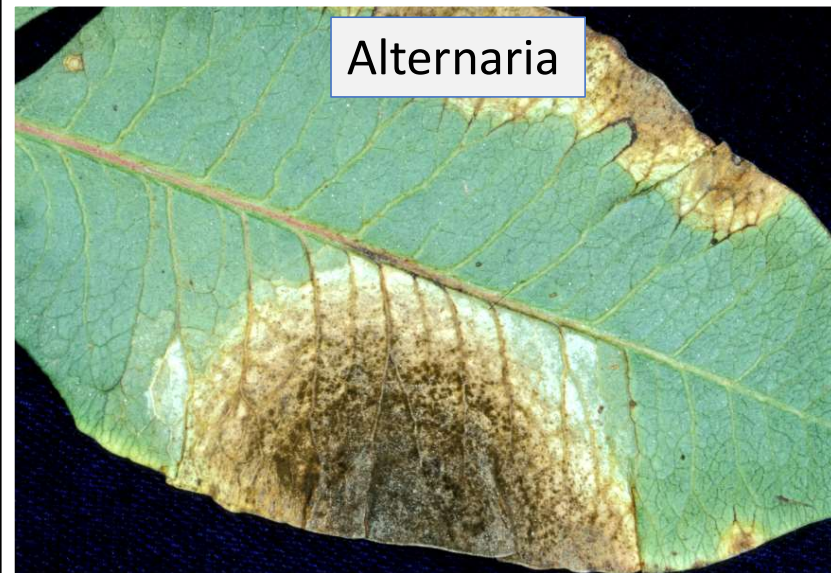


Partial cluster blight

Botrytis leaf lesions



Alternaria



Fungicides registered for Botrytis blight

Fungicide	Active ingredient	Efficacy
Adament.....	trifloxystrobin+tebuconazole	3
Fontelis	penthiopyrad	5
Bravo.....	chlorothalonil	
Bumper.....		
Cabrio.....	pyraclostrobin	
Elevate.....	fenhexamid	5
Quash.....	metconazole	4
Inspire Super...	difenoconazole + cyprodinil	4
Pristine	boscalid+pyraclostrobin	5
Quilt-Xcel.....	azoxystrobin+propiconazole	3
Scala.....	pyrimethanil	4
Switch.....	cyprodinil+fludioxonil	4
Tebuzol.....	tebuconazole	2
Topsin-M.....	thiophanate-methyl	4
Merivon.....	fluxapyroxad+pyraclostrobin	5
Luna Experience	fluopyram+tebuconazole	5
Luna Sensation	fluopyram+trifloxystrobin	5

Timing: 1 to 2 sprays in the spring

5= Excellent control
0 = No control

Thank you



Grower cooperators: Jimmy Nichols; Ryan Kaplan; Dan Huftless; & Wonderful Orchards.

PCAs: Todd Fukuda; Joe Coehlo, Brandon Koch; Tony Rabo; & Ryan Kaplan.