The Blight Phase of Botryosphaeria Disease in Crops of California

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Decision on talking about the blight phase of diseases caused by Botryosphaeriaceae fungi

1. Botryosphaeriaceae are well known as canker pathogens by attacking shoots, branches, and trunks, and causing killing of these plant tissues.
2. Botryosphaeriaceae fungi are also known for decaying tropical and subtropical fruit (postharvest decays).
3. However, Botryosphaeria diseases are not well known in causing active fruit blight which is associated with major yield losses.

Examples for today:

a. The Botryosphaeria panicle and shoot blight of pistachio.

b. The Botryosphaeria canker and blight of walnut.

Definitions

What is a blight?

- It is the killing entire vegetative or fruiting plant tissues as a whole.
- The pathogen does not colonize all the blighted tissues.
- A blight can occur without a preceding development of a canker.
- However, a blight can result to the development of a canker.

What is a canker?

- A continuous mass of killed tissues in trunks, scaffolds, branches, and shoots of plants.
- The pathogen colonizes all the cankered tissues and beyond.
- A canker can result to the development of a blight, but a blight to occur does not need a canker.

1. Botryosphaeria panicle and shoot blight disease of pistachio

Shoot blight

Shoot blight

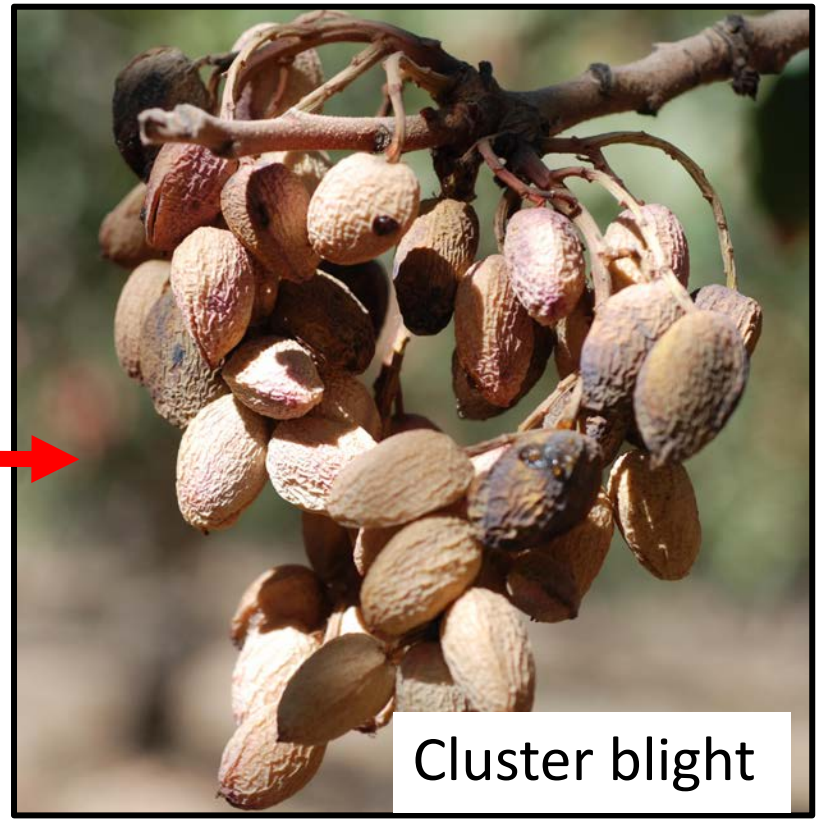
Female

Male

Spores trapped among the bud scales

Flower infection

Rachis infection at the base



Cluster blight


Leaf blight in the spring

Under normal rainfall conditions

Normal average: 10-12 inches.

Latent infections

If rains continue in the spring …

Above normal average

Quiescent infections

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 ***
1992-1993	23.66	+ 11.86
1994-1995	22.80	+ 10.99
1997-1998	31.28	+ 19.42 ***
2004-2005	26.51	+ 14.65 ***
2022-2023	24.12	+ 12.26

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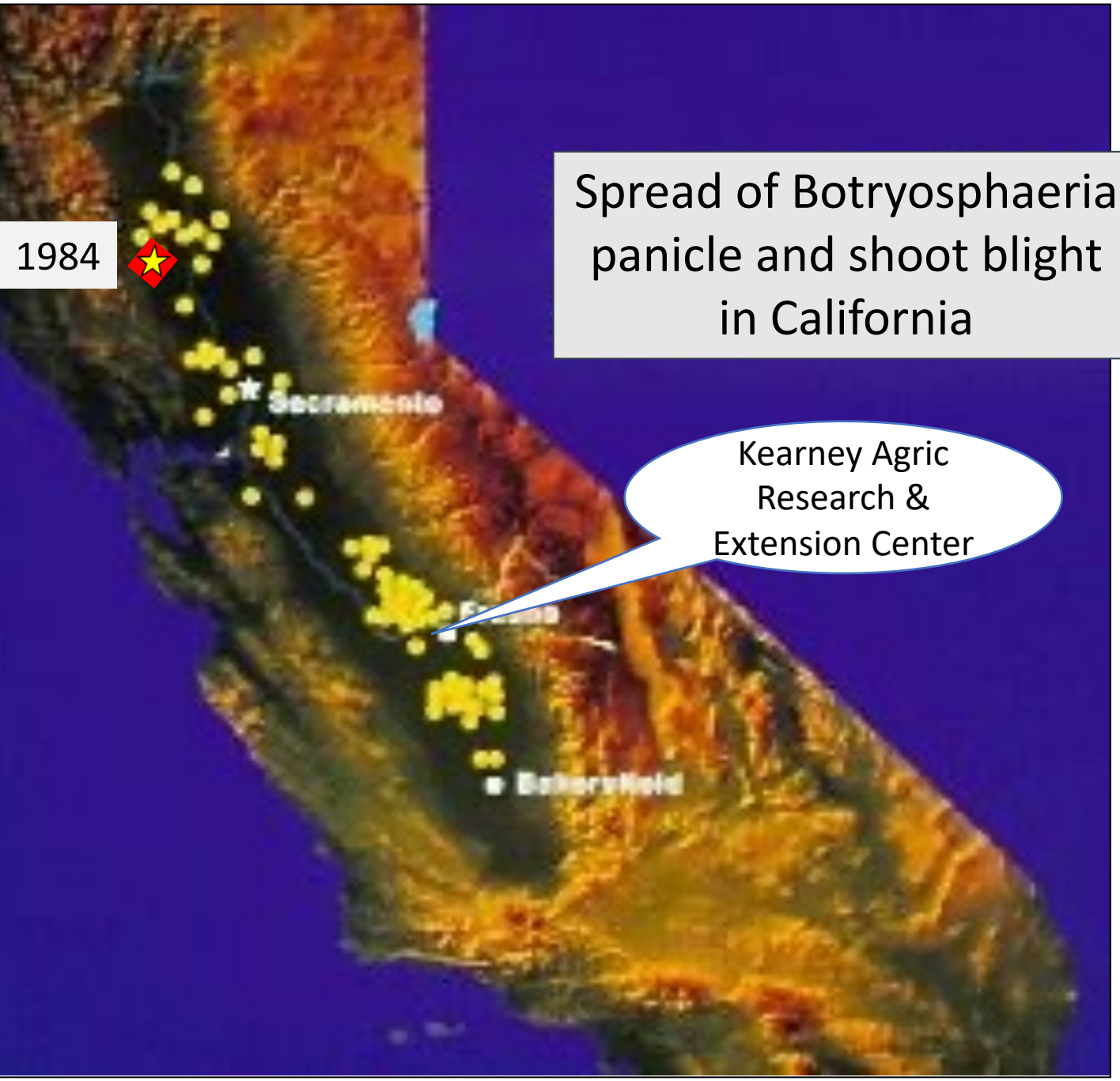
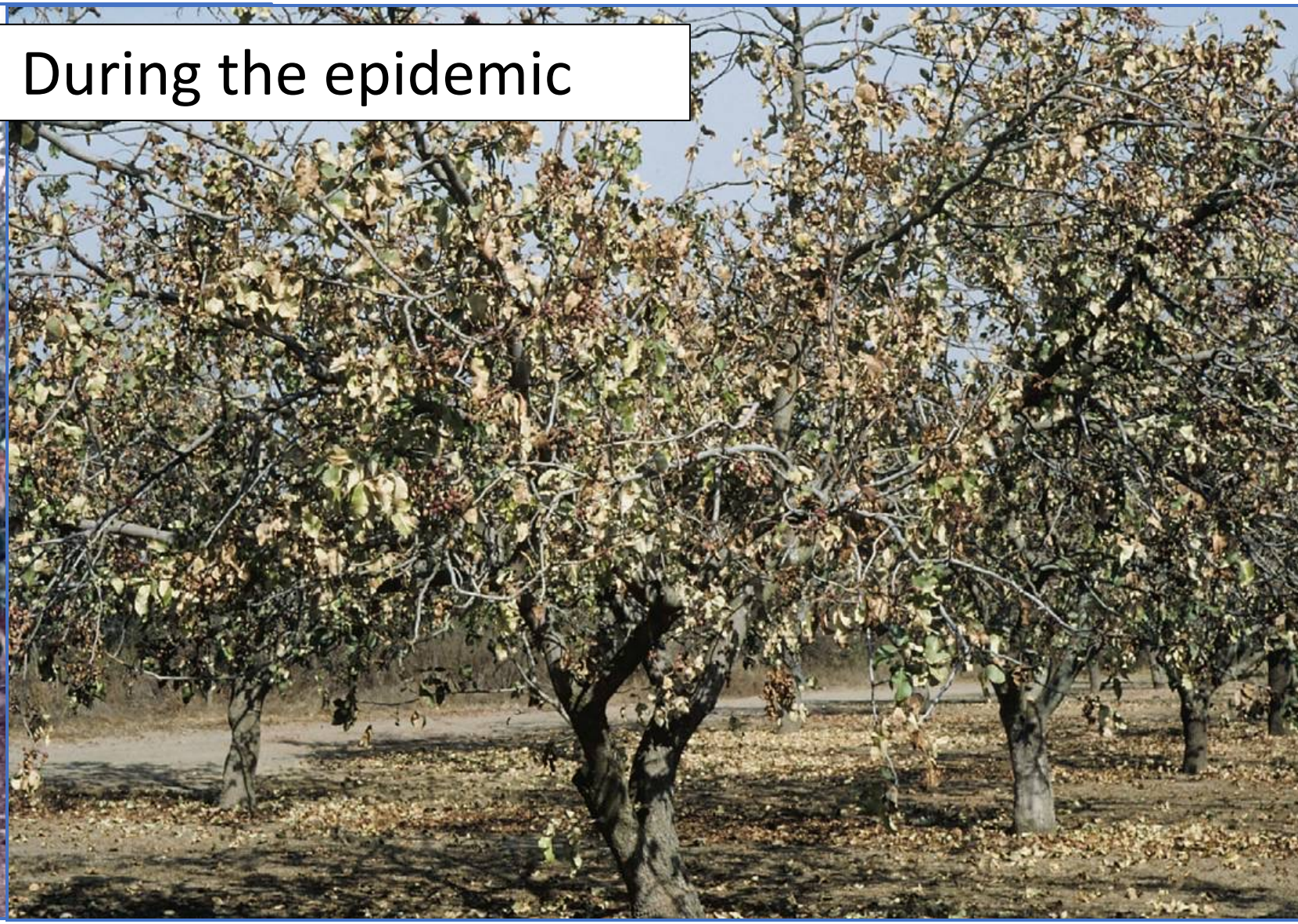


Emergency situation for the pistachio industry…

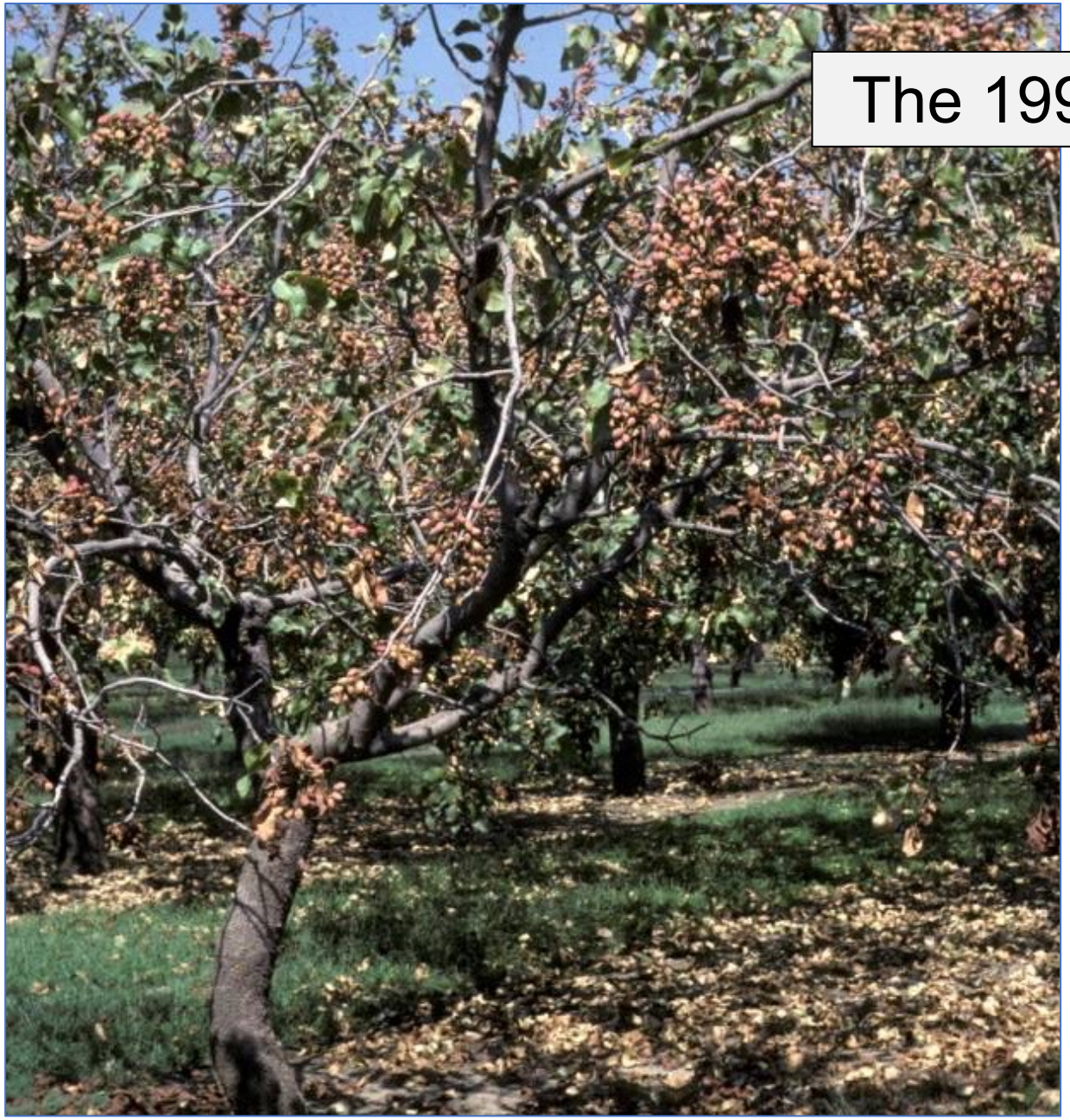
- High levels of Bot in 1997
- A major Botryosphaeria <u>epidemic</u> in 1998 & 1999

During the epidemic



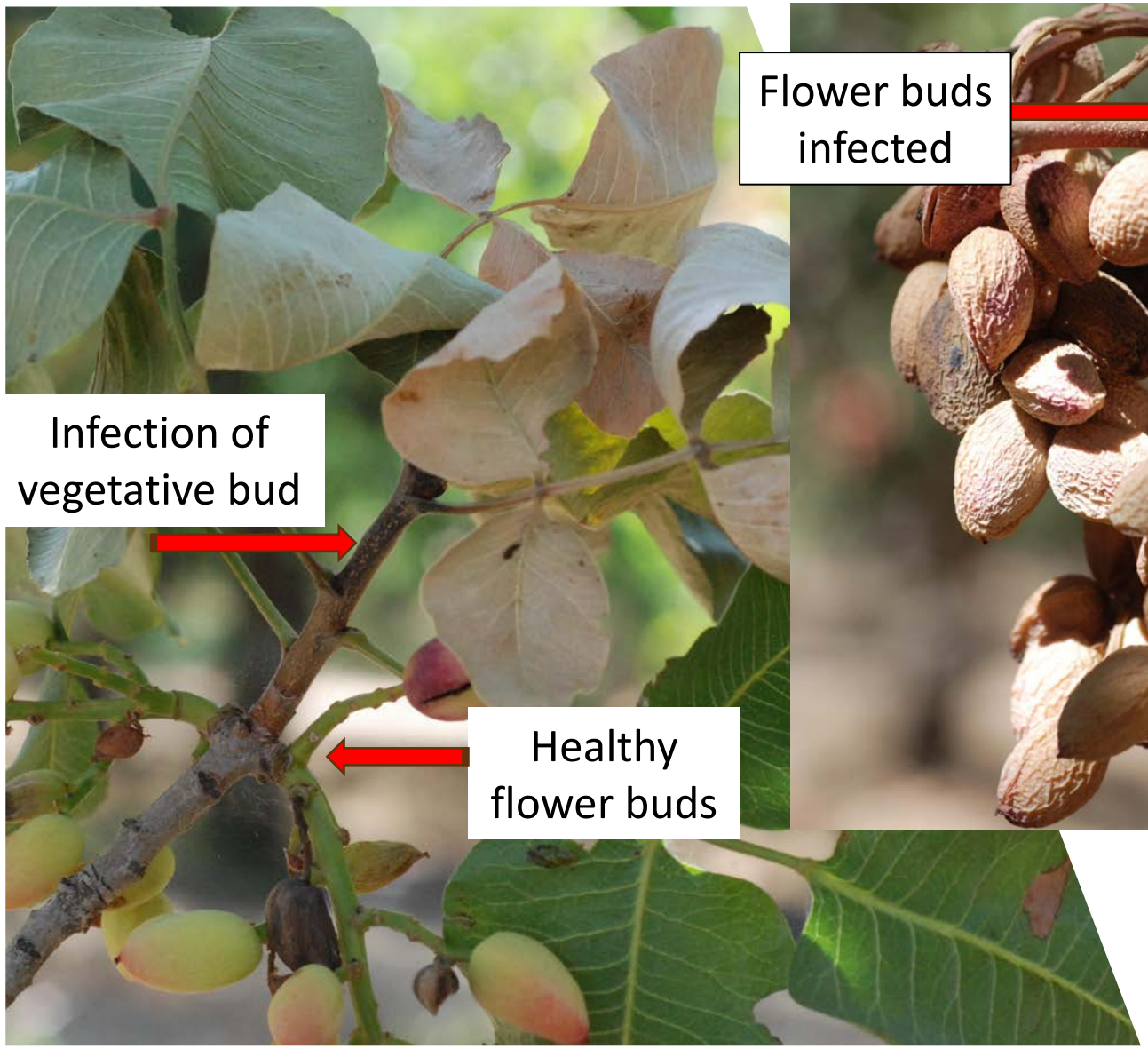
Total destruction of the crop (orchards with 100% yield loss)

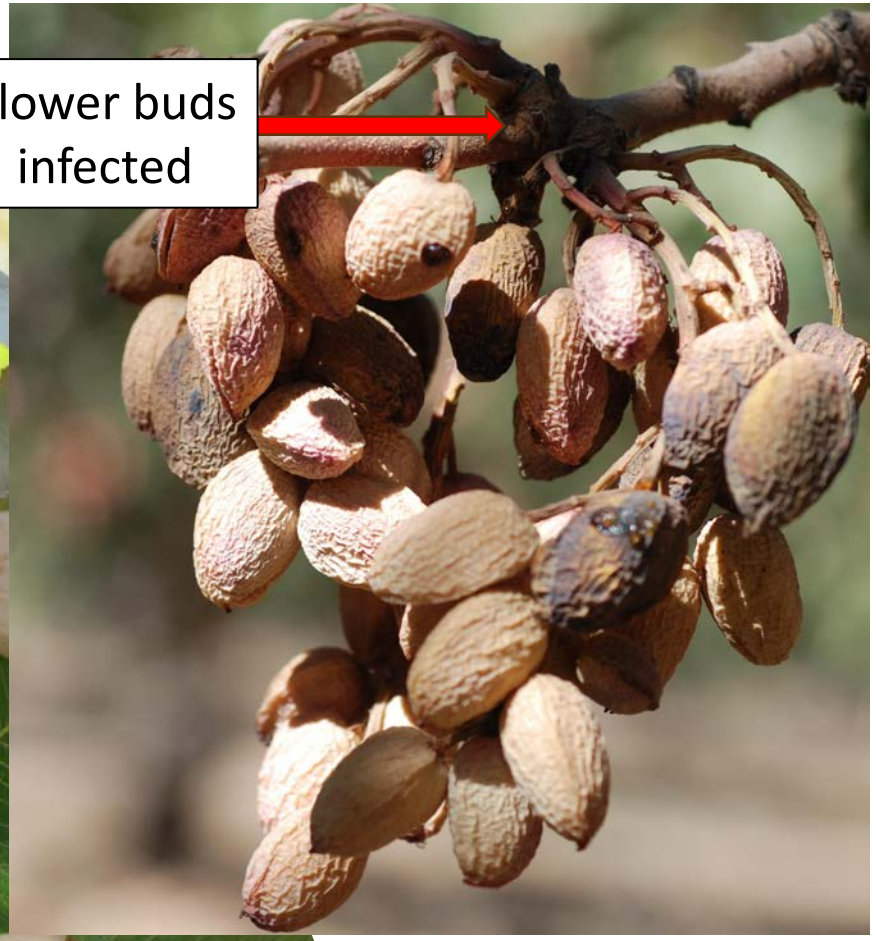
The 1998 epidemic



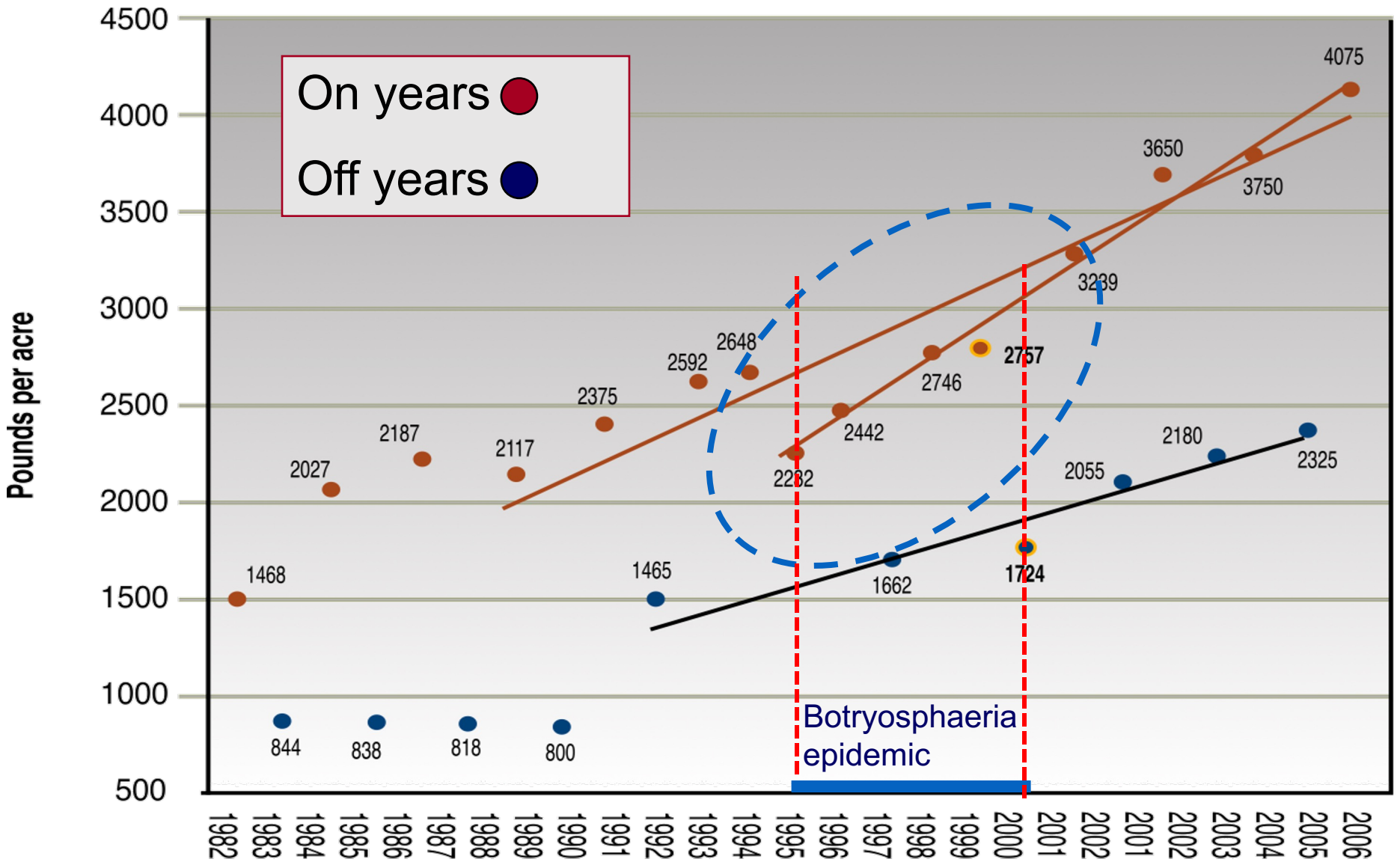
Fruit infection and leaf lesions in summer and fall

Infections from spring will develop



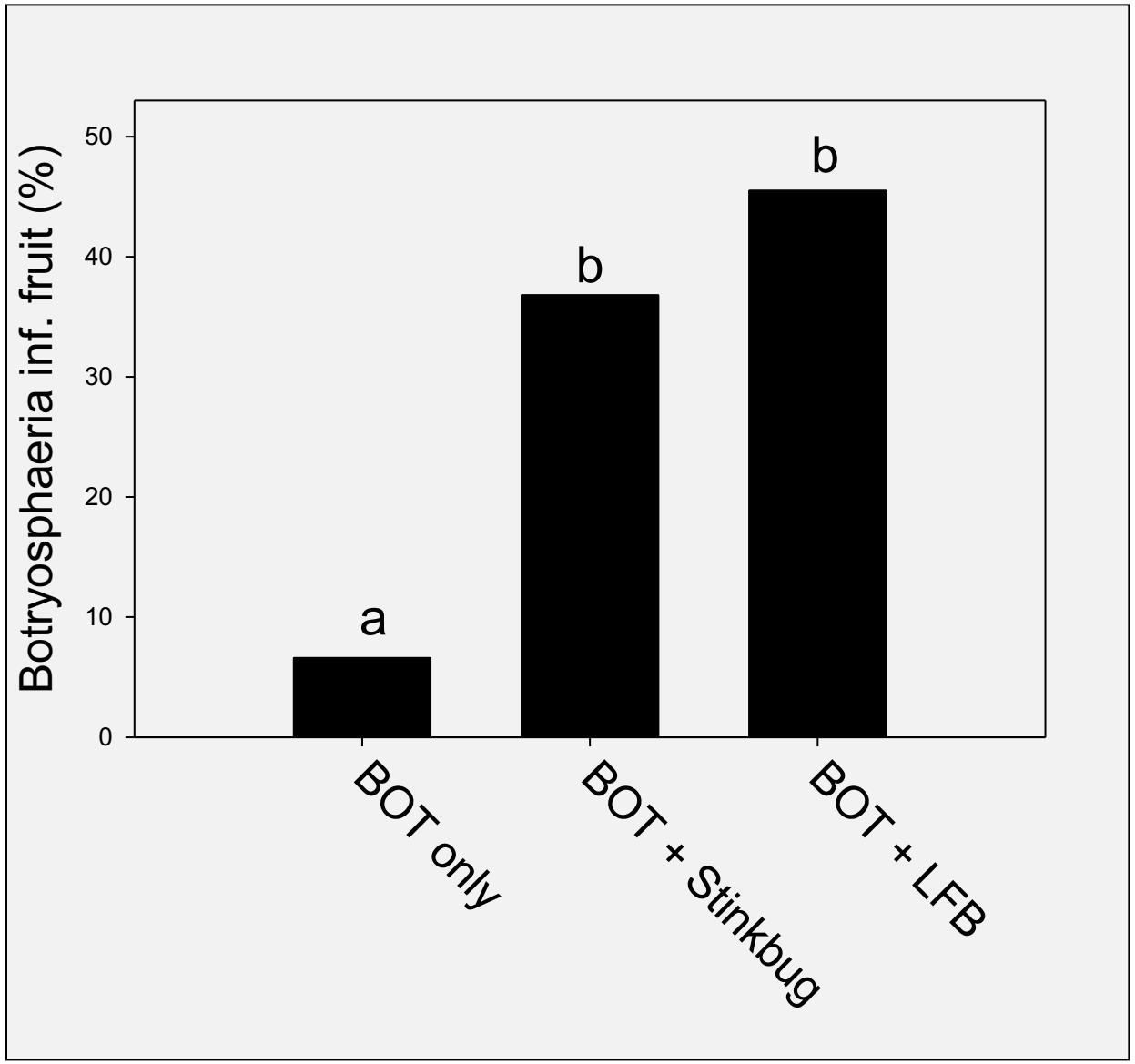


Blight of flower bud in the fall

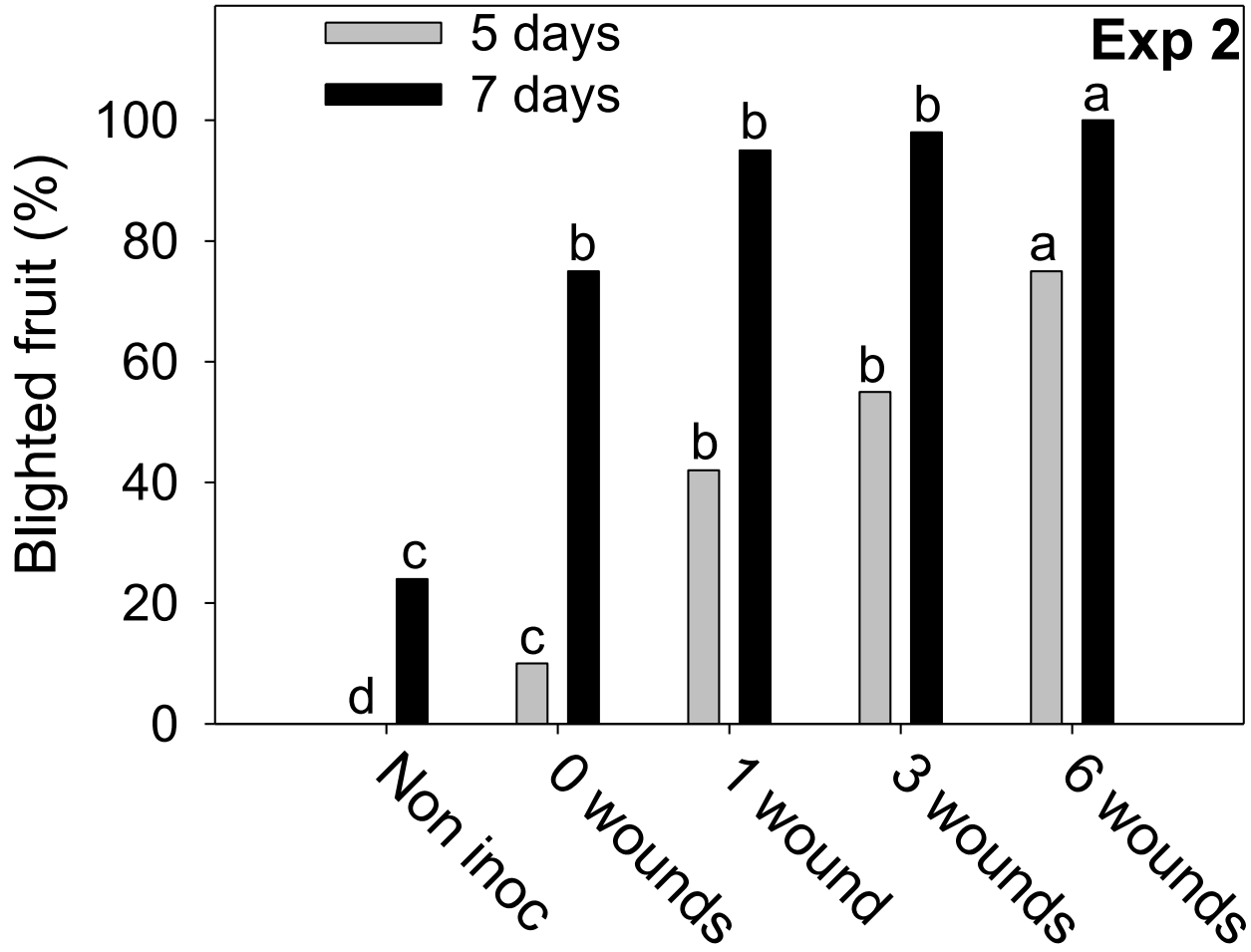


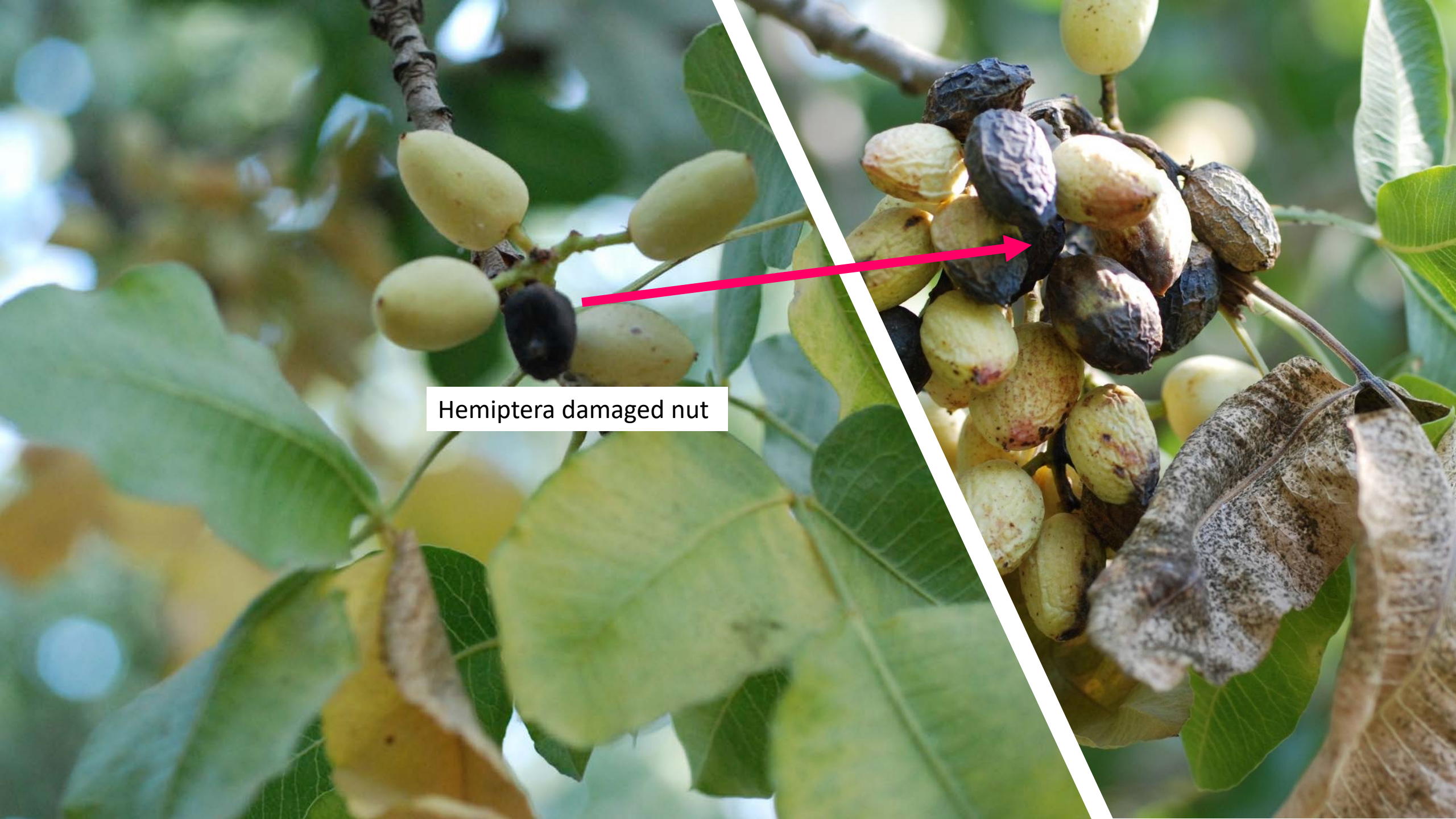
Graph prepared by Bob Klein

Leaffooted bug (*Leptoglossus zonatus / L. clypealis /L. occidentalis* (LFB) and other stinkbugs damage leads to cluster blight

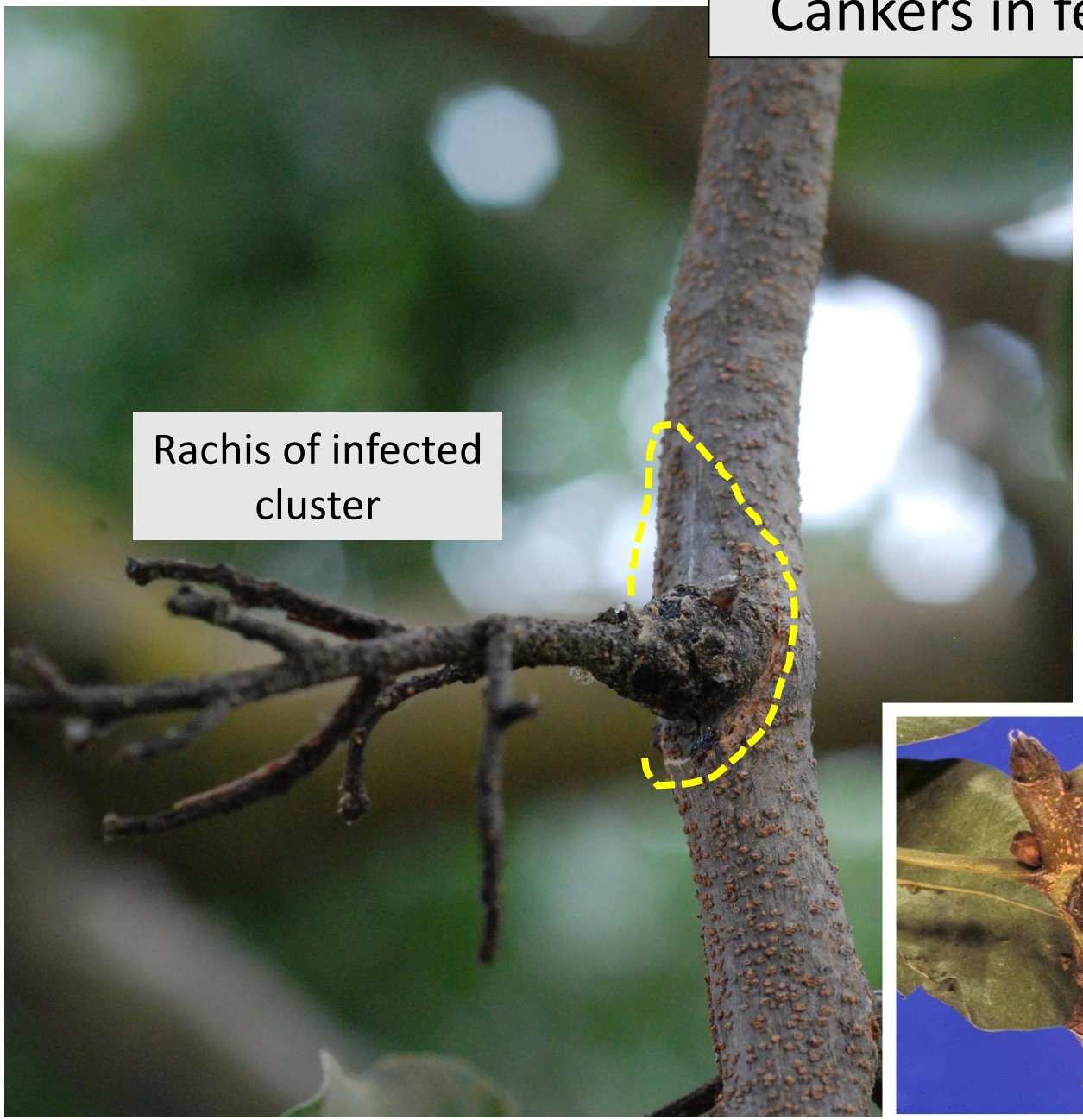


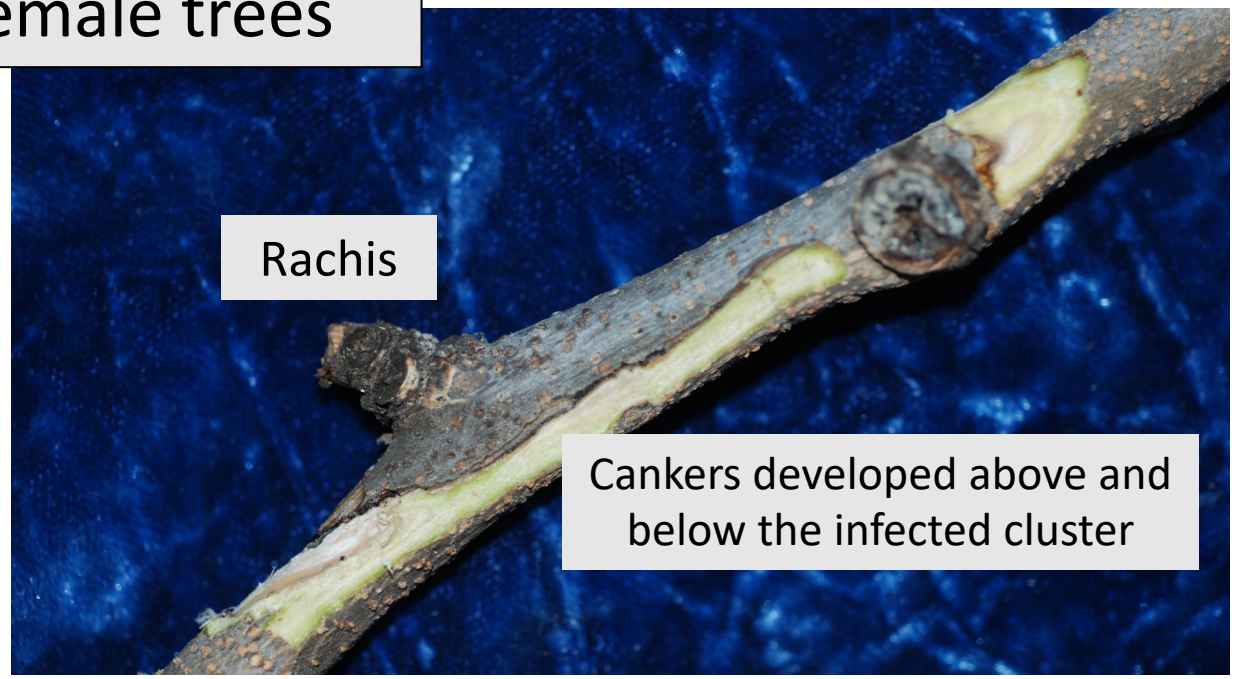
Effect of puncture wounds on the development of Botryosphaeria fruit blight

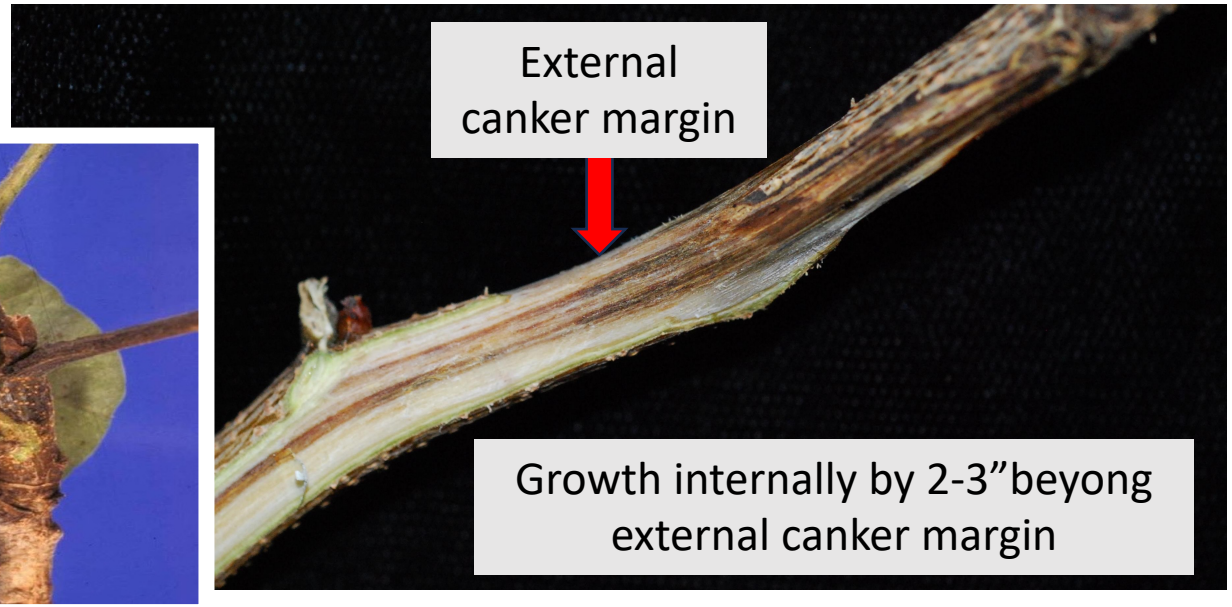



Hemiptera damaged nut

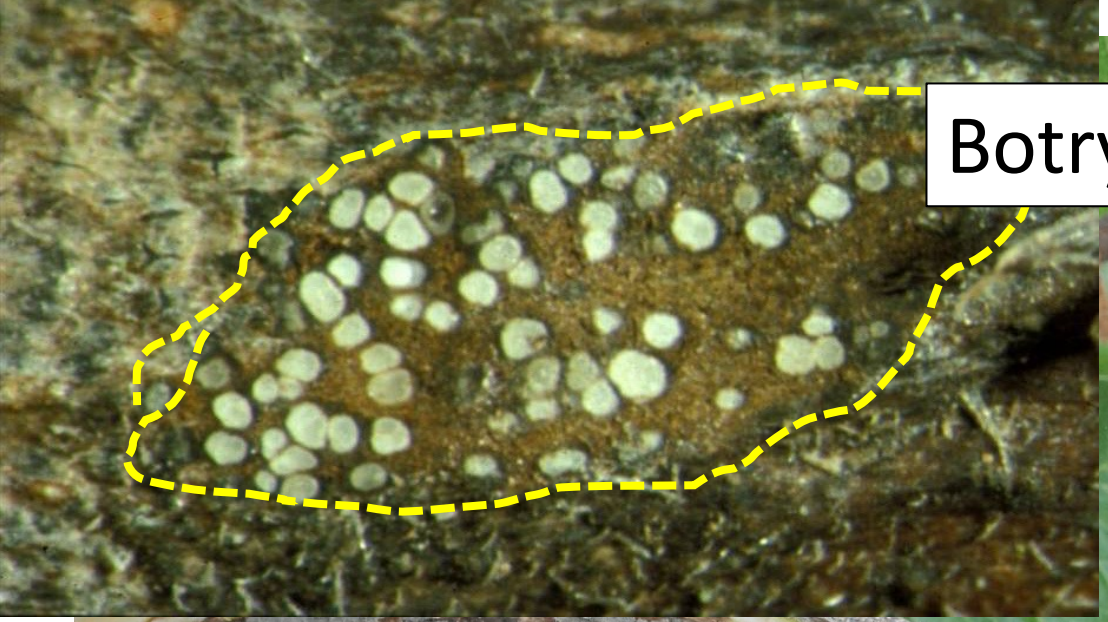
Cankers in female trees

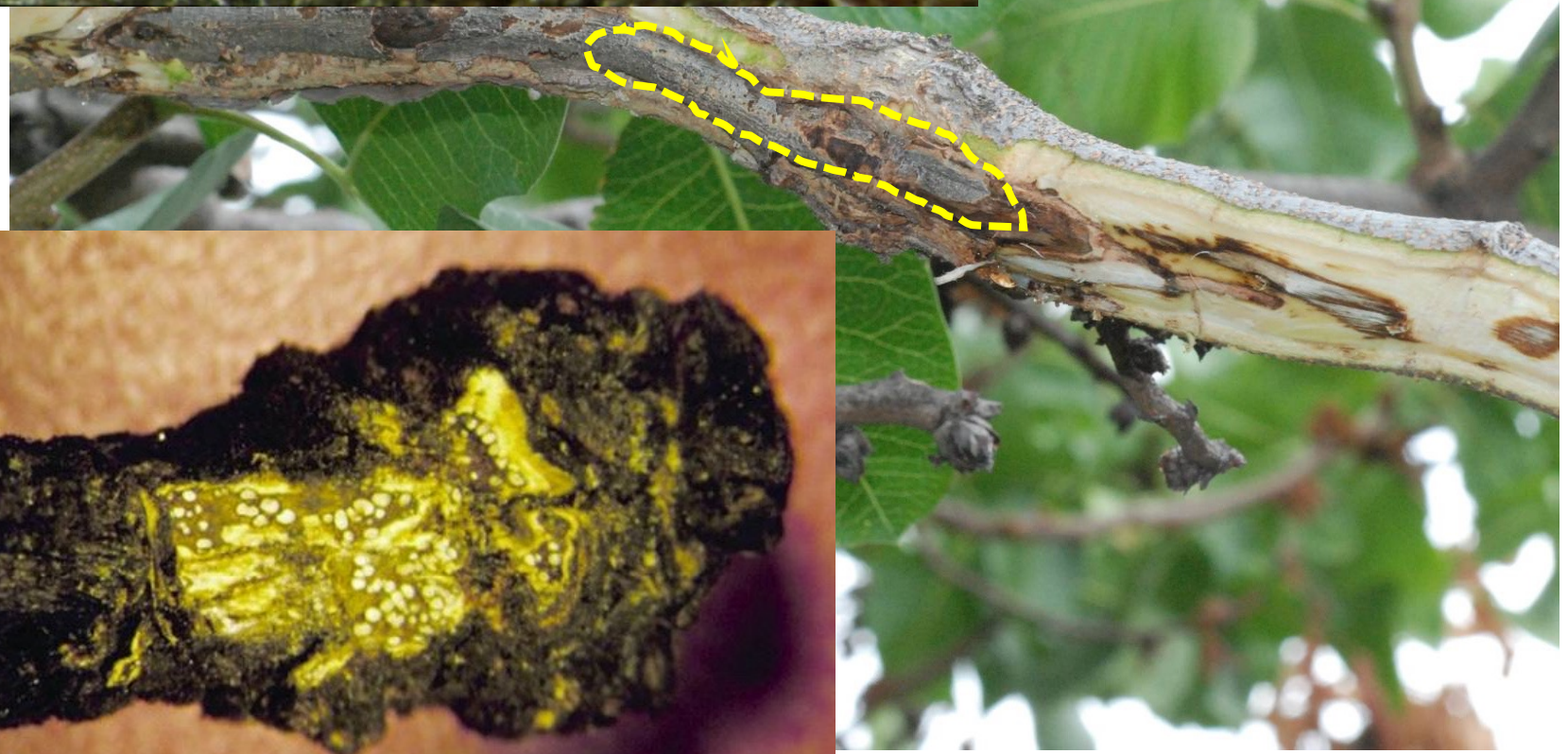




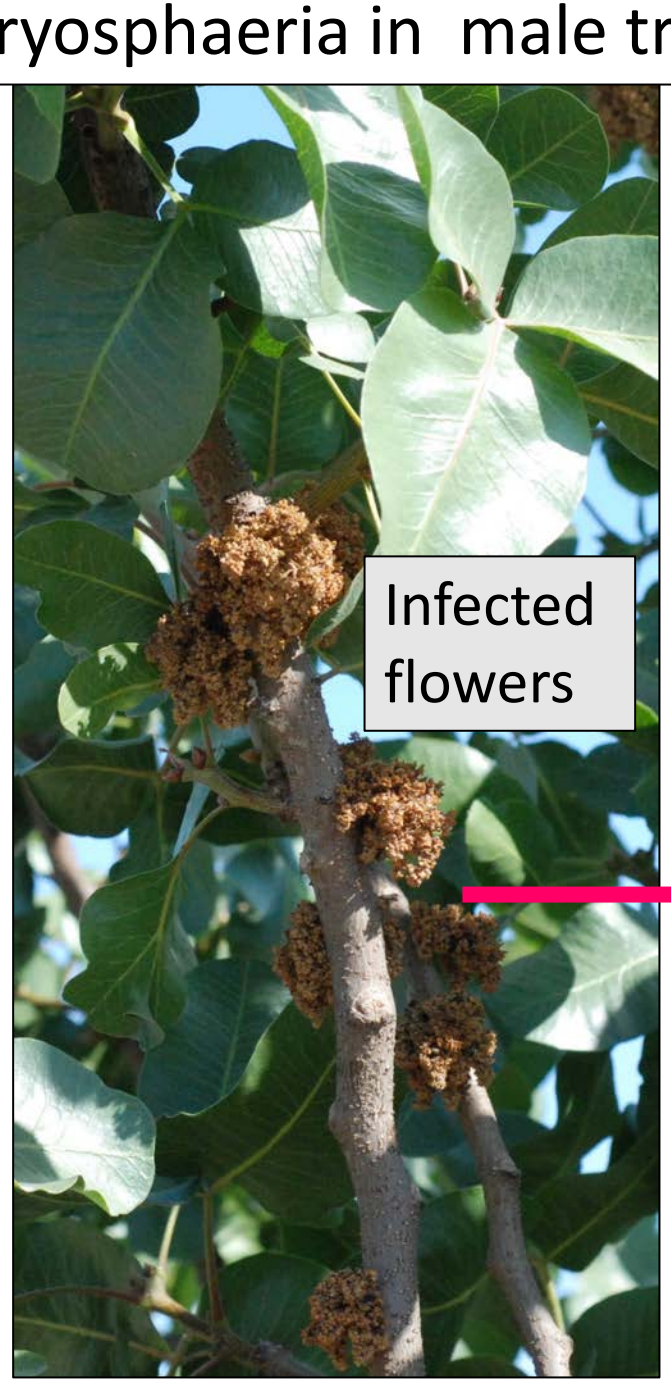


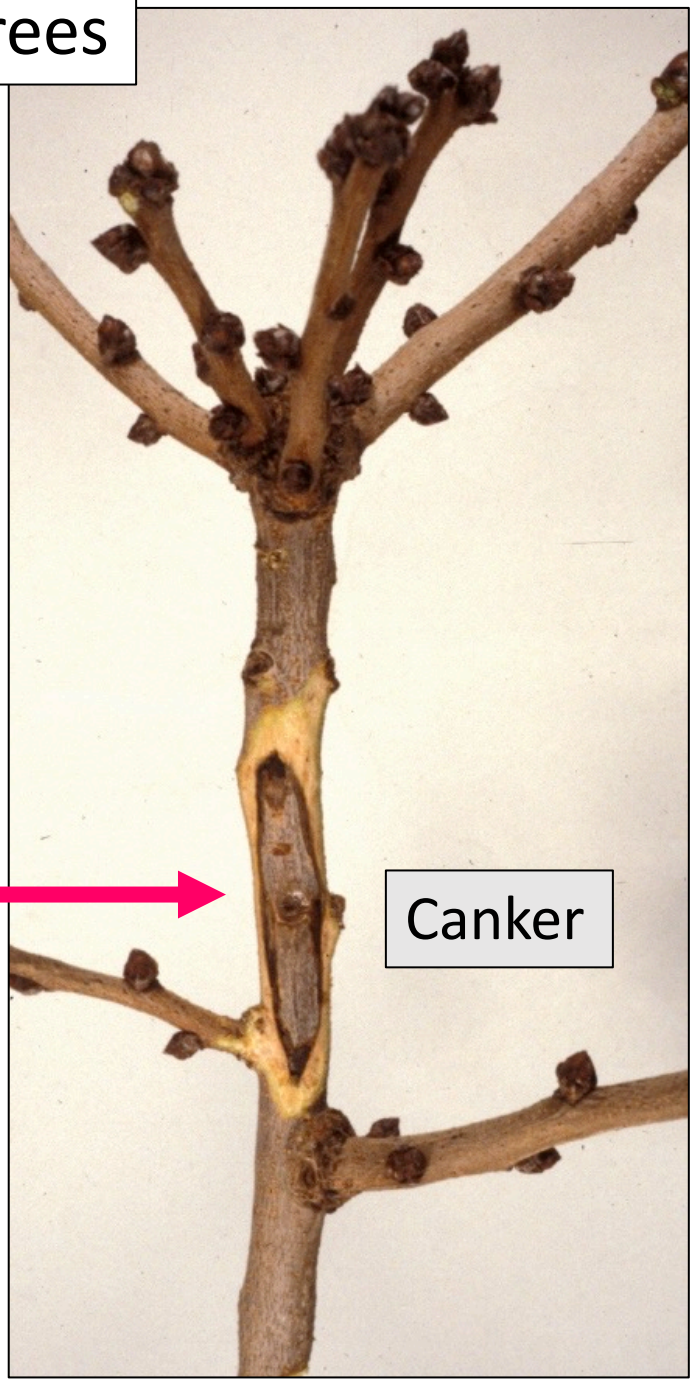
Botryosphaeria pycnidia





Cankers of Botryosphaeria in male trees



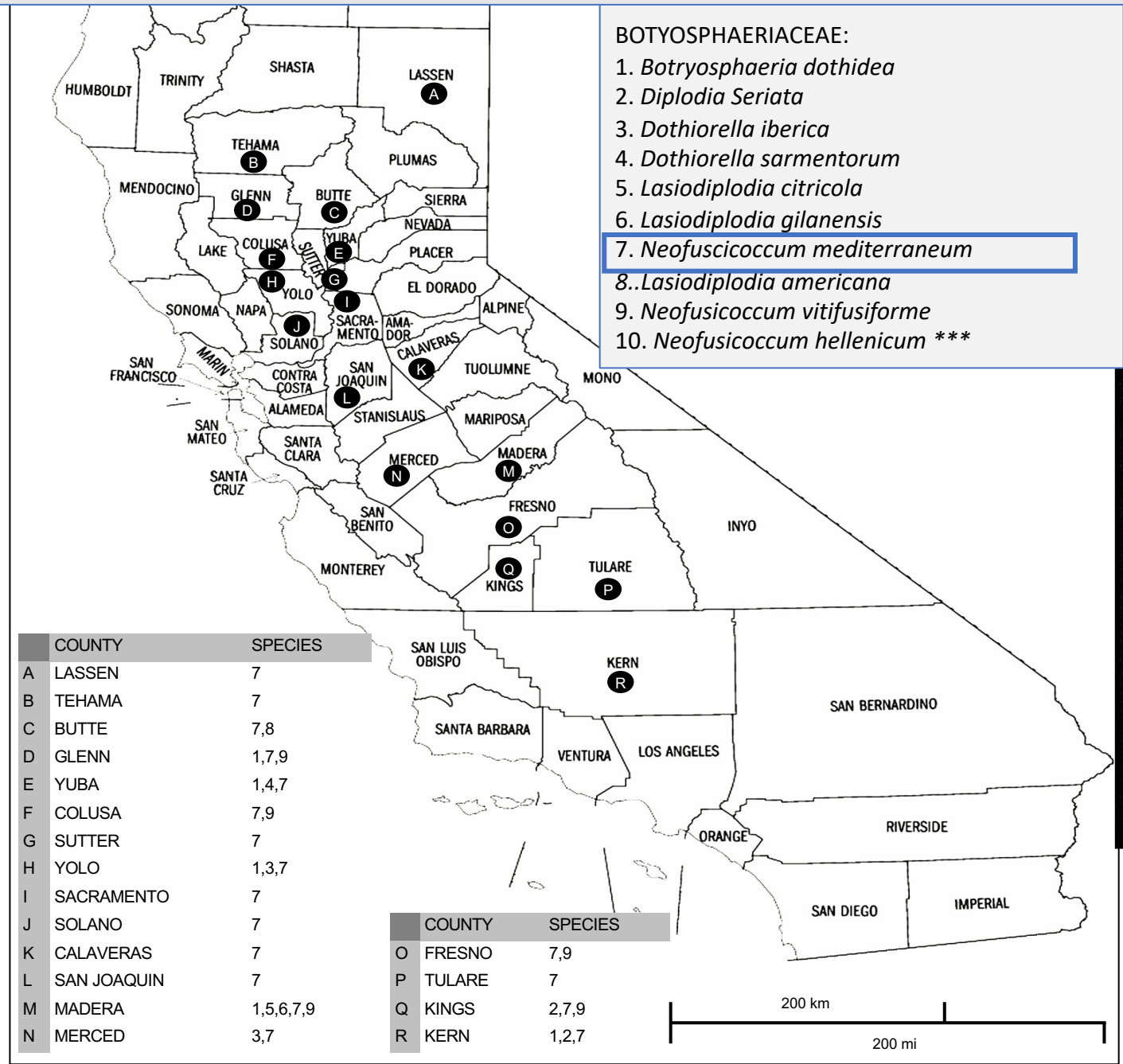


Cankers of Botrytis blossom and shoot blight disease also start from male flowers

Pathogens causing Botryosphaeria panicle and shoot blight on pistachio

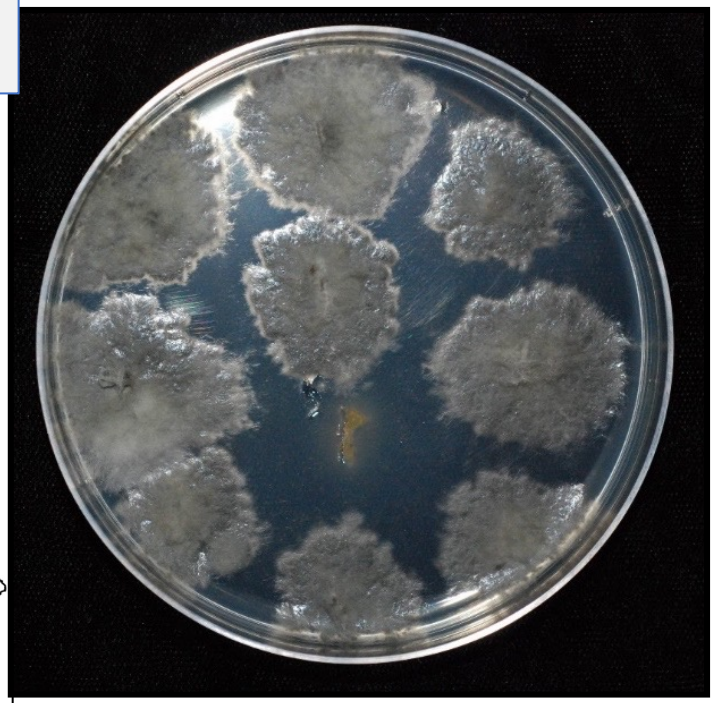
BOTYOSPHAERIACEAE:

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



	COUNTY	SPECIES
A	LASSEN	7
B	TEHAMA	7
C	BUTTE	7,8
D	GLENN	1,7,9
E	YUBA	1,4,7
F	COLUSA	7,9
G	SUTTER	7
H	YOLO	1,3,7
I	SACRAMENTO	7
J	SOLANO	7
K	CALAVERAS	7
L	SAN JOAQUIN	7
M	MADERA	1,5,6,7,9
N	MERCED	3,7

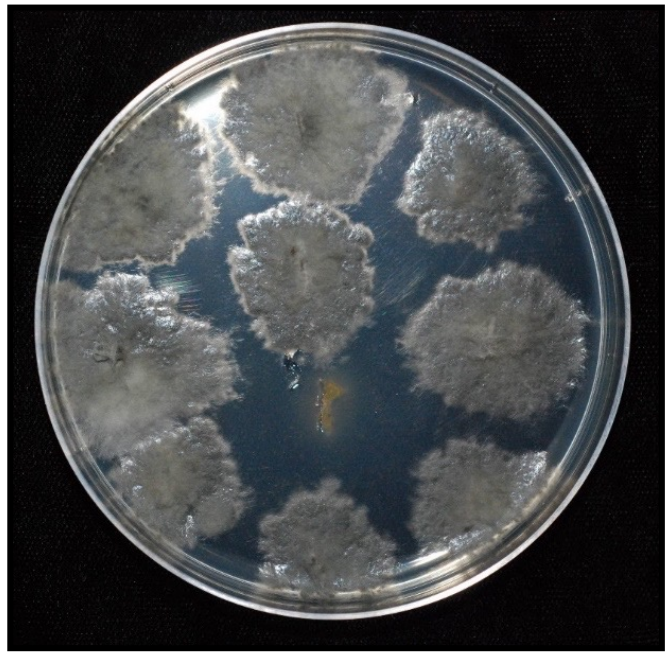
	COUNTY	SPECIES
O	FRESNO	7,9
P	TULARE	7
Q	KINGS	2,7,9
R	KERN	1,2,7



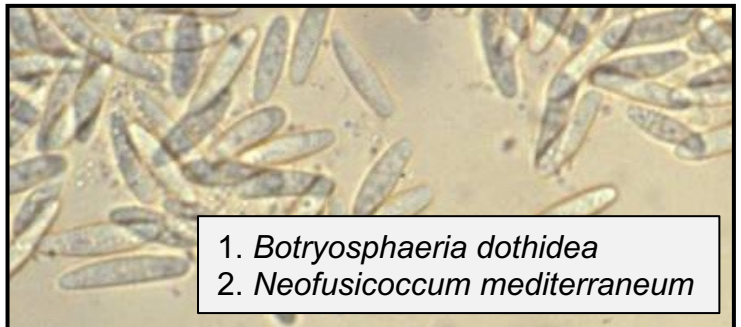
Neofusicoccum mediterraneum

Causes: Summary of Botryosphaeriaceae in nut crops – California

Fungal species	Walnut	Pistachio	Almond
Botryosphaeria dothidea	+	+	+
Neofusicoccum parvum	+	+	+
Neofusicoccum mediterraneum	+	+	+
Diplodia mutila	+	*Diplodia serriata*	---
Neofusicoccum nonquaesitum	+	*Lasio. americana*	+
Neofusicoccum vitifusiforme	+	+	---
Diplodia seriata	+	+	+
Dothiorella iberica	+	+	+
Lasiodiplodia citricola	+	+	+
Neoscytalidium dimitiatum (=*Hendersonula toruloidea*)	+	+	+



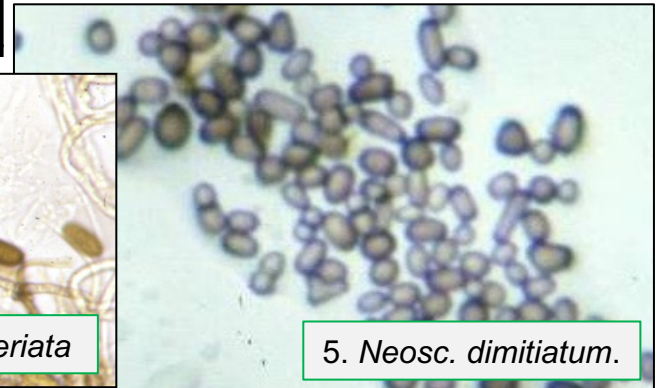
Neofusicoccum mediterraneum



1. *Botryosphaeria dothidea*
2. *Neofusicoccum mediterraneum*

3. *Lasiodiplodia* spp.

4. *Diplodia seriata*

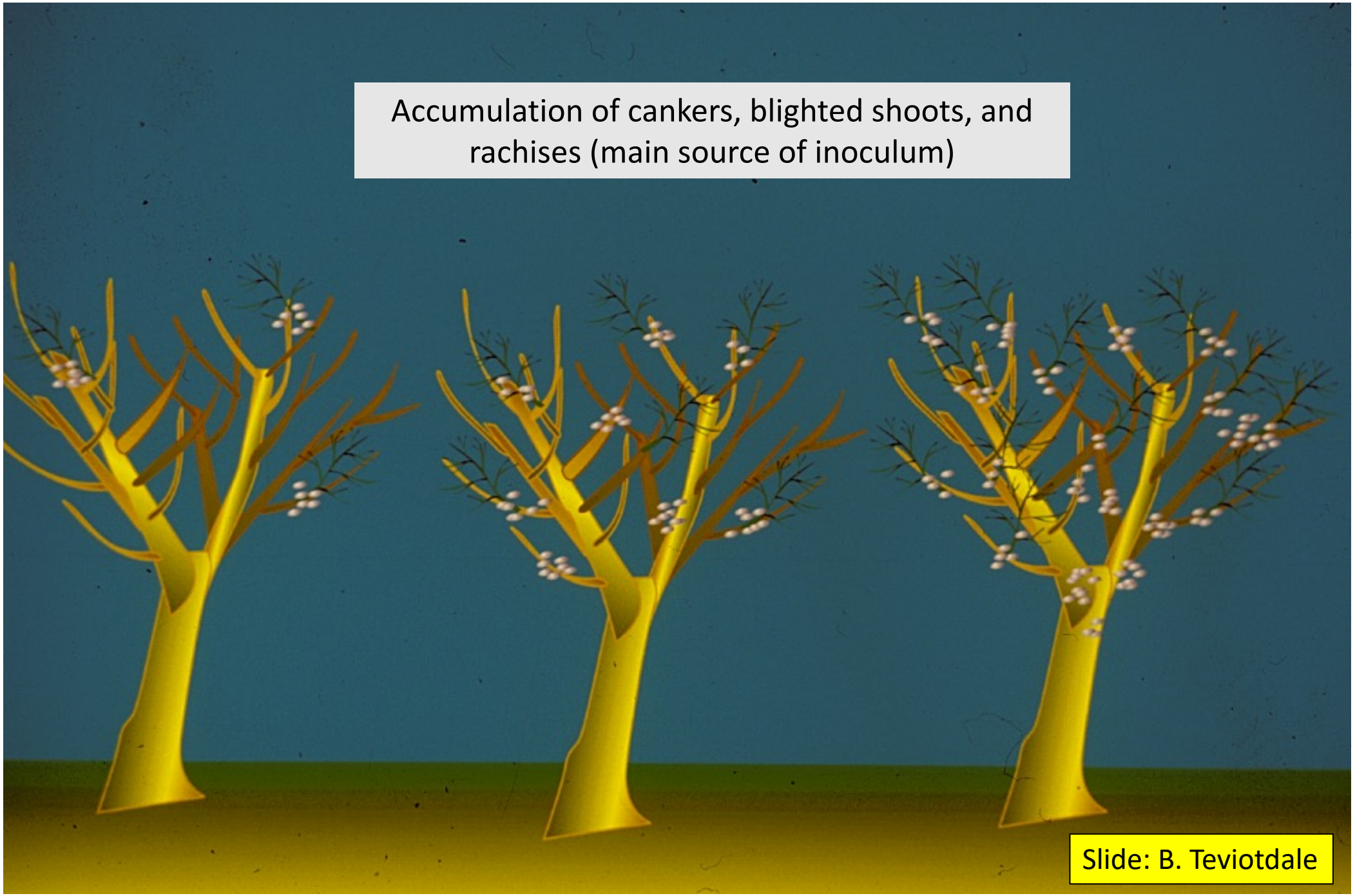


5. *Neosc. dimitiatum.*

Host of Botryosphaeria in California

HOST	SCIENTIFIC NAME	FAMILY
Almond	*Prunus dulcis*	Rosaceae
Apple	*Malus domestica*	Rosaceae
Avocado	*Persea americana*	Lauraceae
Blackberry	*Rubus ursinus*	Rosaceae
Black walnut	*Junglans hinsii*	Juglandaceae
Carob seed tree	*Ceratonia siliqua*	Leguminosae
Incense cedar	*Cedrus libani*	Pinaceae
Deodar cedar	*Cedrus deodara*	Pinaceae
Chinese hackberry	*Celtis sinensis*	Ulmaceae
California redwood	*Sequoia sempervirens*	Taxodiaceae
Cotoneaster	*Cotoneaster frigidus*	Rosaceae
Cottonwood	*Populus deltoides*	Populaceae
English walnut	*Juglans regia*	Juglandaceae
Eucalyptus	*Eucalyptus coccifera*	Myrtaceae
Euonymus	*Euonymus fortunei*	Celestraceae
Silver dollar Eucalyptus	*Eucalyptus orbifolia*	Myrtaceae
Feijoa	*Feijoa sellowiana*	Myrtaceae
Fig	*Ficus carica*	Fagaceae
Giant sequoia	Sequoiadendron giganteum	Rosaceae
Juniper	*Juniperus occidentalis*	Rosaceae
Jasmine	*Jasminum officinale*	Lauraceae
Lemon	*Citrus × limon*	Rosaceae
Sweet gum	*Liquidambar styraciflua*	Juglandaceae
Maple	*Acer sp.*	Leguminosae
Oak	*Quercus sp.*	Pinaceae
Olive	*Olea europea*	Pinaceae
Orange	*Citrus × auranteum*	Ulmaceae
Pistachio	*Pistacia vera 'Kerman'*	Taxodiaceae
Pear	*Pyrus communis*	Rosaceae
Pecan	*Carya illinoensis*	Populaceae
Persimmon	*Diospyros kaki*	Ebenaceae
Pine	*Pinus radiata*	Pinaceae
Prune	*Prunus domestica*	Rosaceae
Firethorn	*Pyracantha coccinea*	Rosaceae
Raymond ash	*Fraxinus augustifolia* subsp. *oxycarpa*	Oleaceae
Sycamore maple	*Acer pseudoplatanus*	Aceraceae
Wax leaf Privet	*Ligustrum japonicum*	Oleaceae
Western redbud	*Cedris canadensis*	Leguminosae
Wild rose	*Rosa sp.*	Rosaceae
White willow	*Salix alba*	Salicaceae
Arroyo willow	*Salix lasiolepis*	Salicaceae
Weeping willow	*Salix babylonica*	Salicaceae

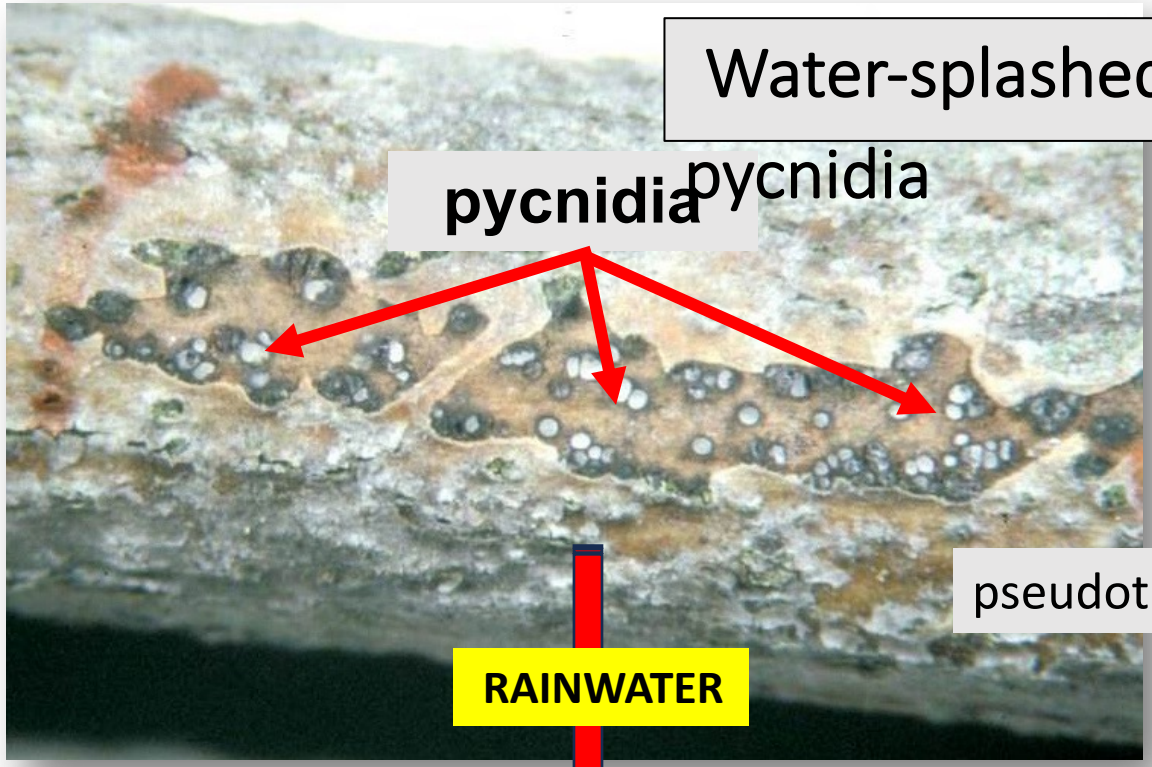
*The table includes fruit and nut trees, ornamentals, and forest trees and bushes

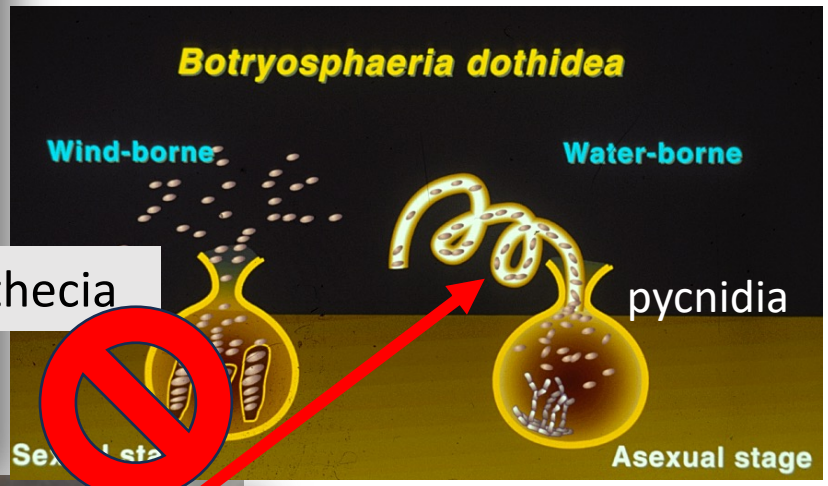

Accumulation of cankers, blighted shoots, and rachises (main source of inoculum)
Slide: B. Teviotdale

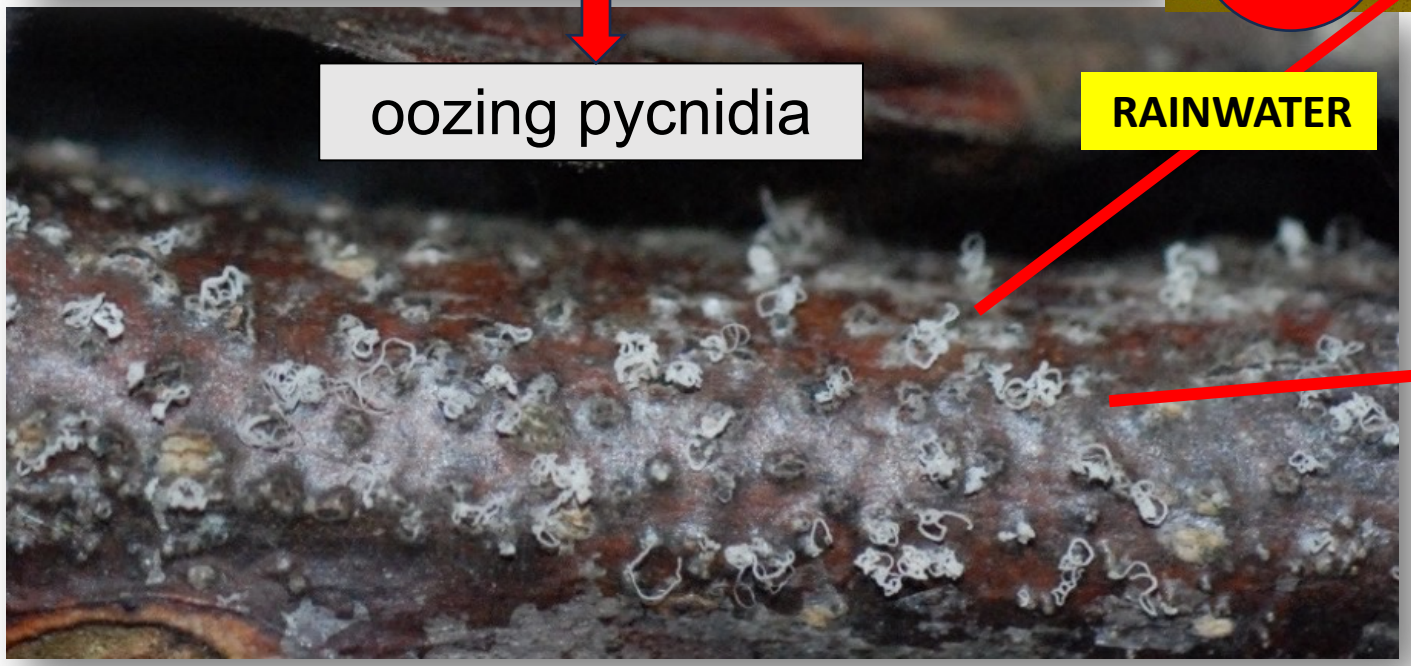
Rains during fall and winter

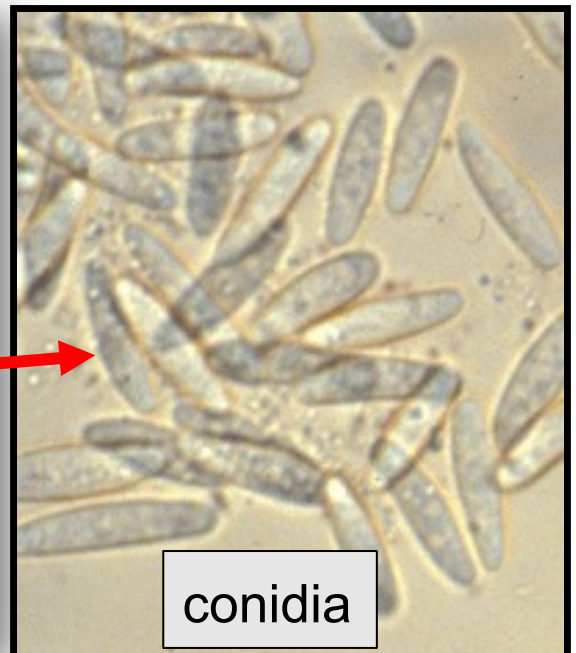
Rains during spring

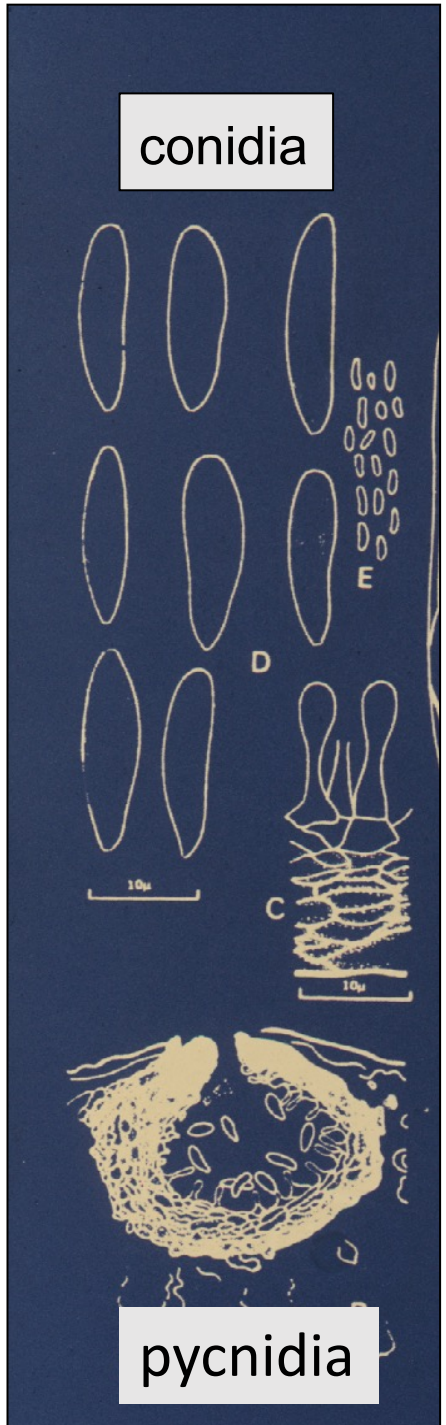
Water-splashed inoculum from pycnidia





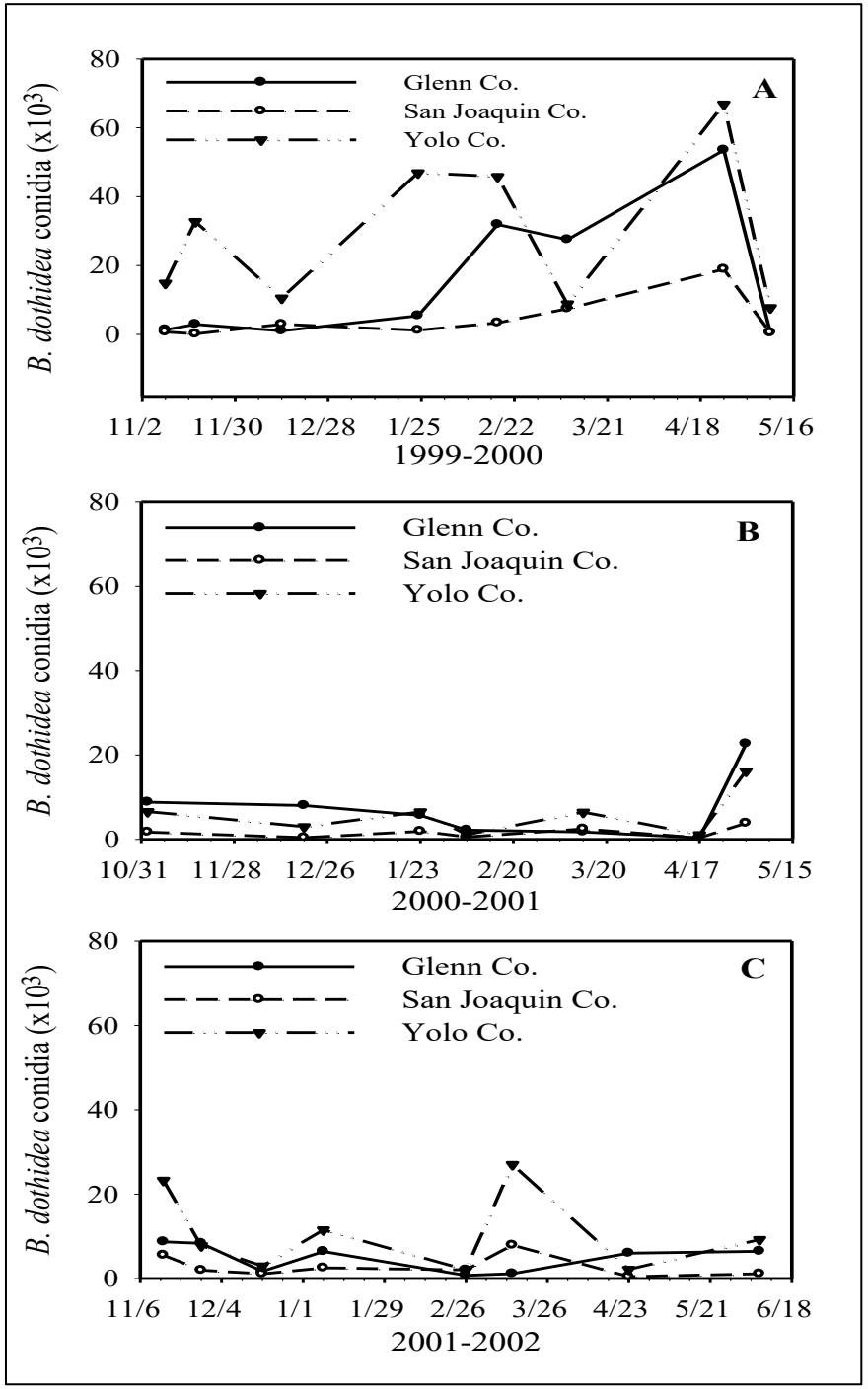






Spread of Botryosphaeria spores with rainwater

Levels of Botryosphaeria conidia collected under the canopy of pistachio trees during rain events



The orchards have higher risk for disease in 2000.

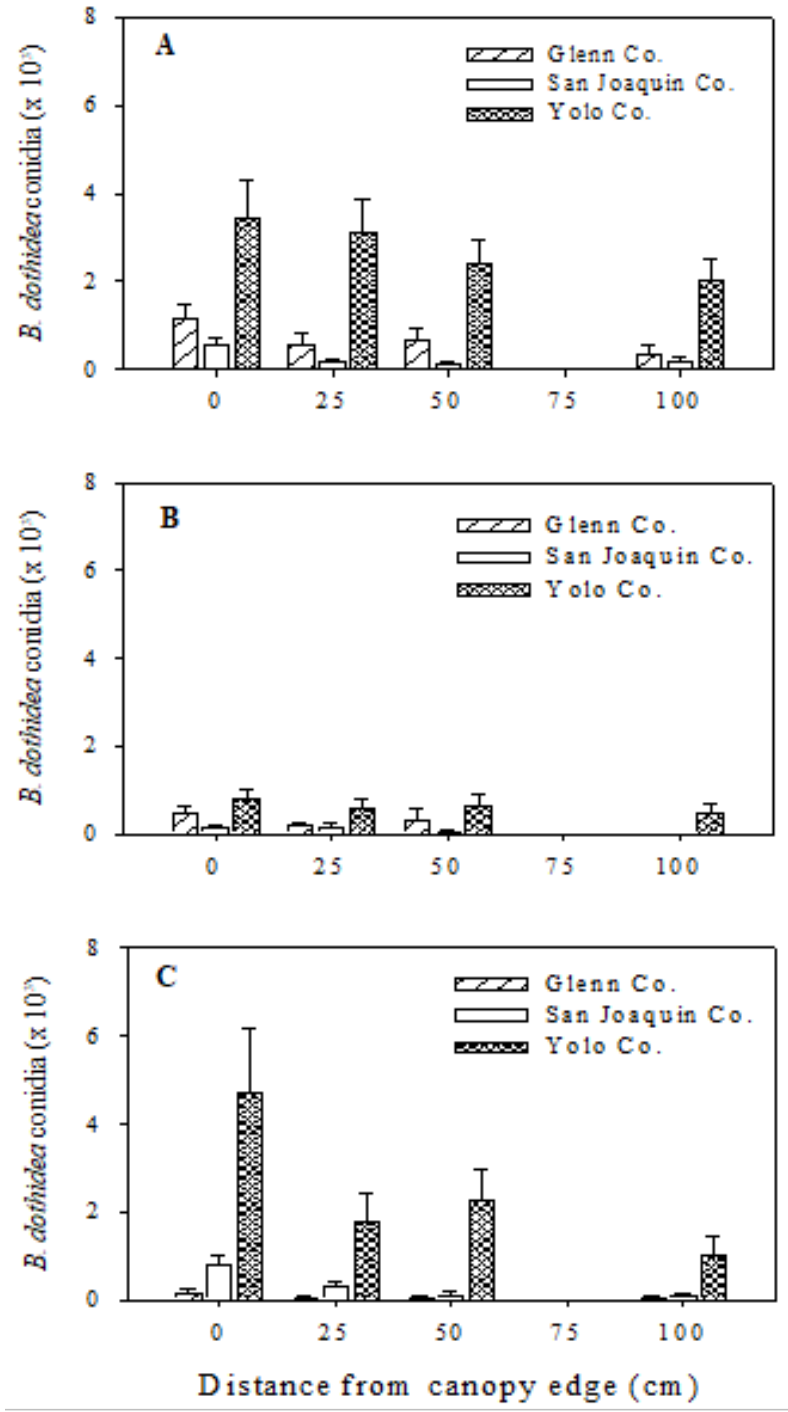
Year 1

Year 2

Year 3


Spread of Botryosphaeria spores at different heights and distances from the canopy edge

Number of Botryosphaeria conidia collected in rainwater at four distances outside tree canopy of pistachio trees in three commercial orchards



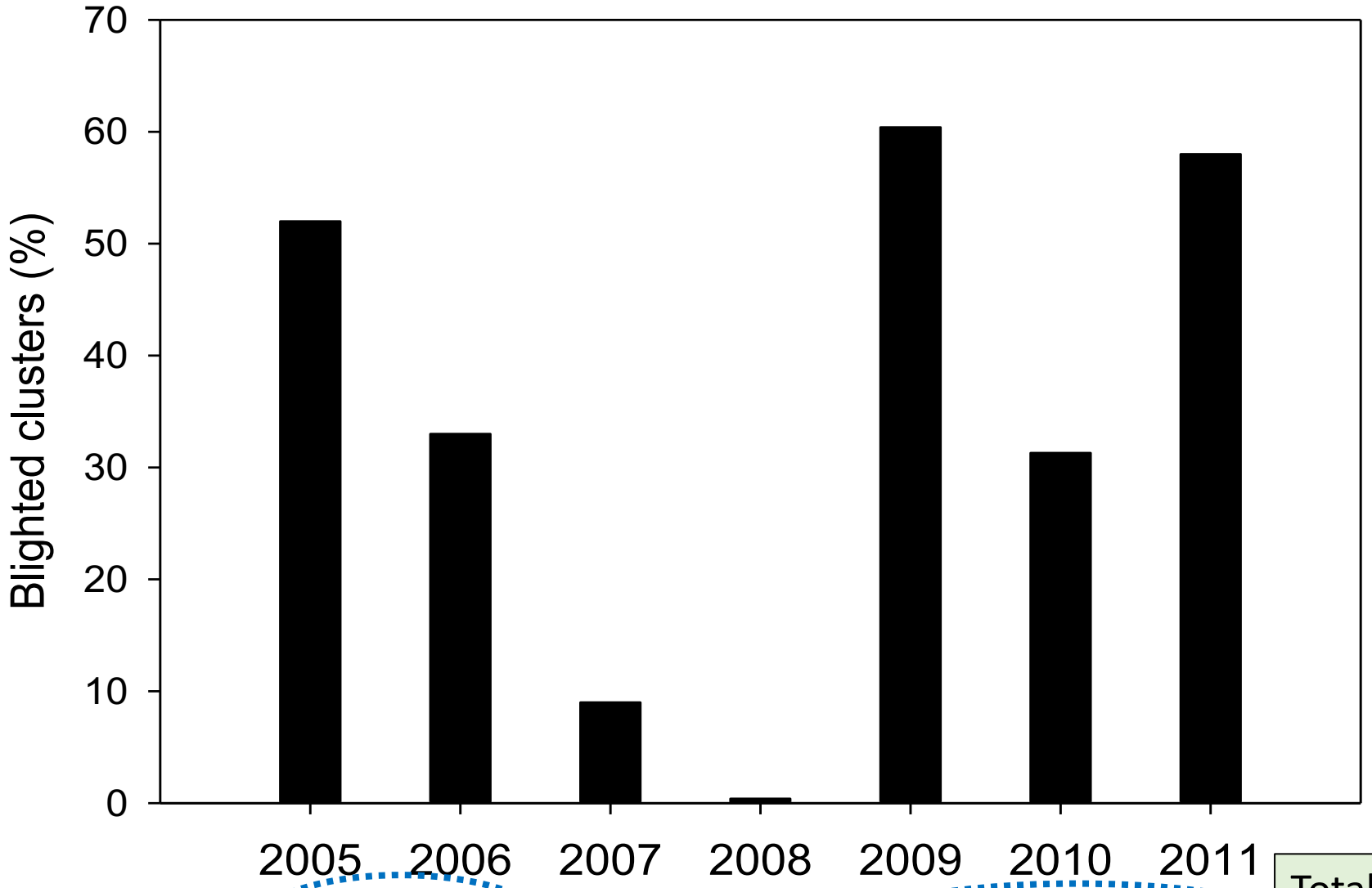
The orchard in Yolo County has higher risk <u>for disease spread</u> in the 1st & 3rd years.

Year 1

Year 2

Year 3

Botryosphaeria blight in unsprayed trees (Glenn County, California)



Total rain (mm): 48.3 48.3 25.4 35.6 40.6 61.0 48.3

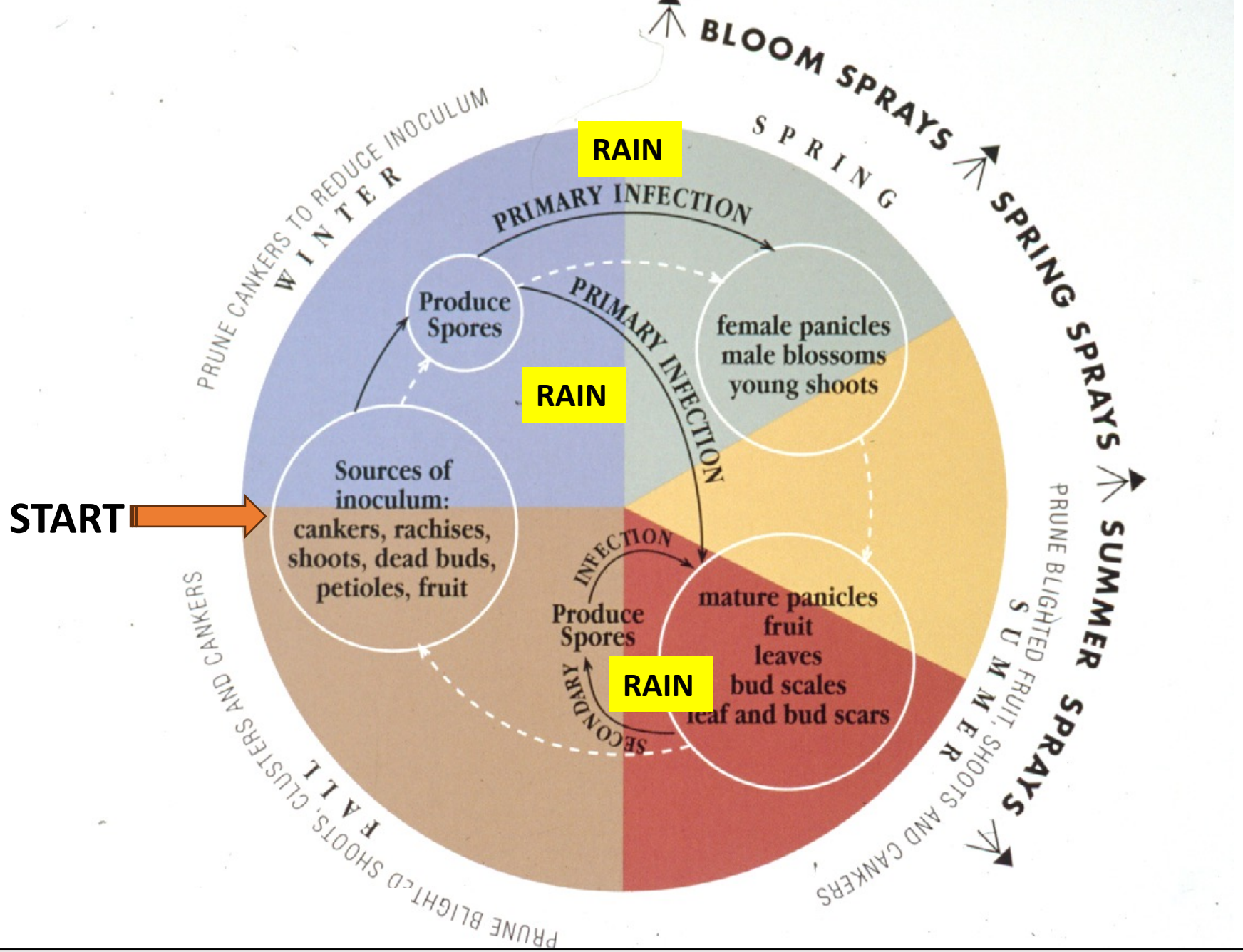
Conditions for infection events:

- ✓ At least ¼ “of rain
- ✓ At least 50 °F

Optimal Temperatures:

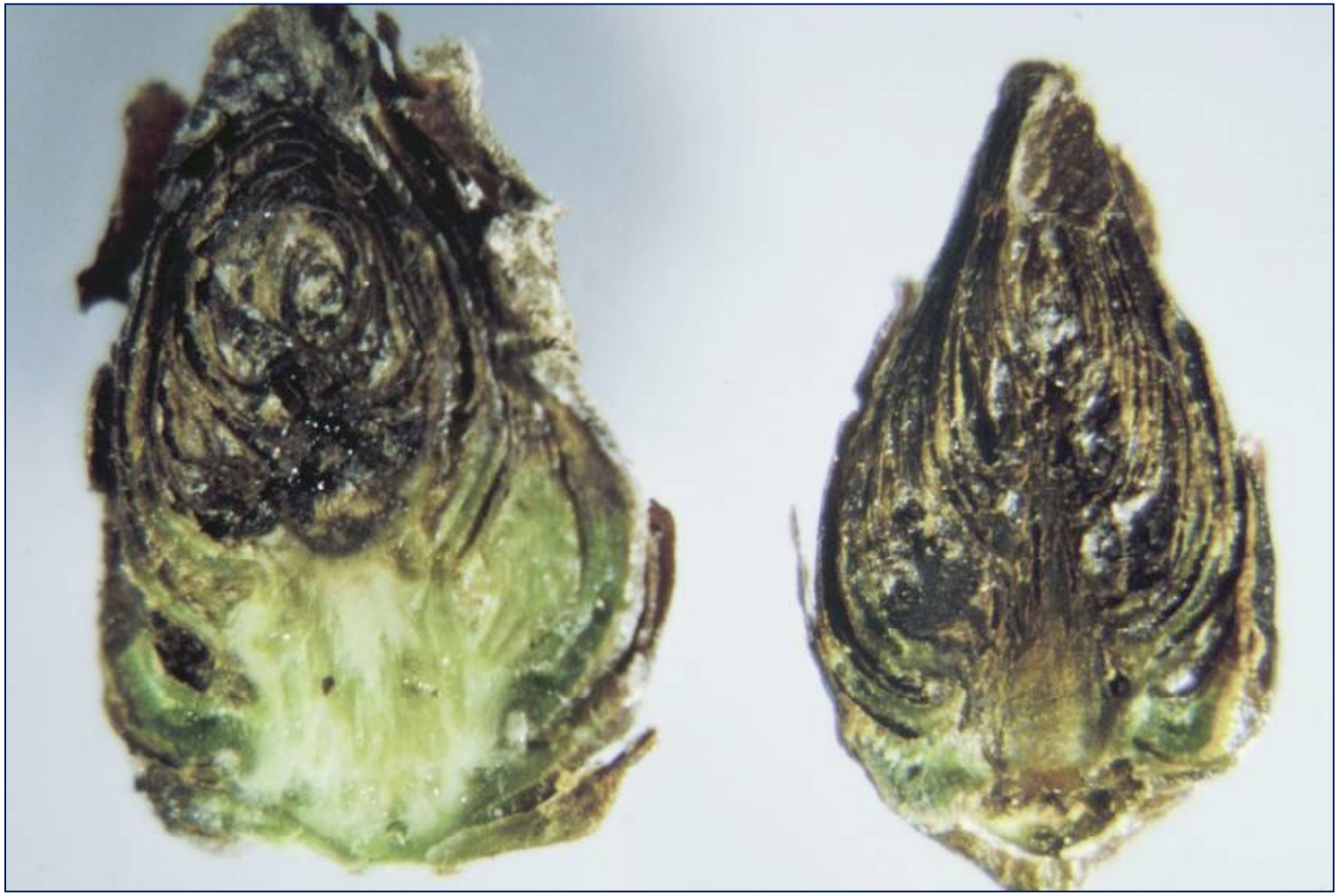
- ✓ Spore germination: 63-97 °F
- ✓ Growth: 81-86 °F
- ✓ Dis. develop. : 81- 91 °F
- ✓ Pycnidia formation: 81 °F

Total rain above 40 mm (1.6”) during Dec to April triggered severe disease levels



DISEASE CYCLE OF BOTRYOSPHAERIA PANICLE AND SHOOT BLIGHT OF PISTACHIO

The disease also kills buds (summer/fall)



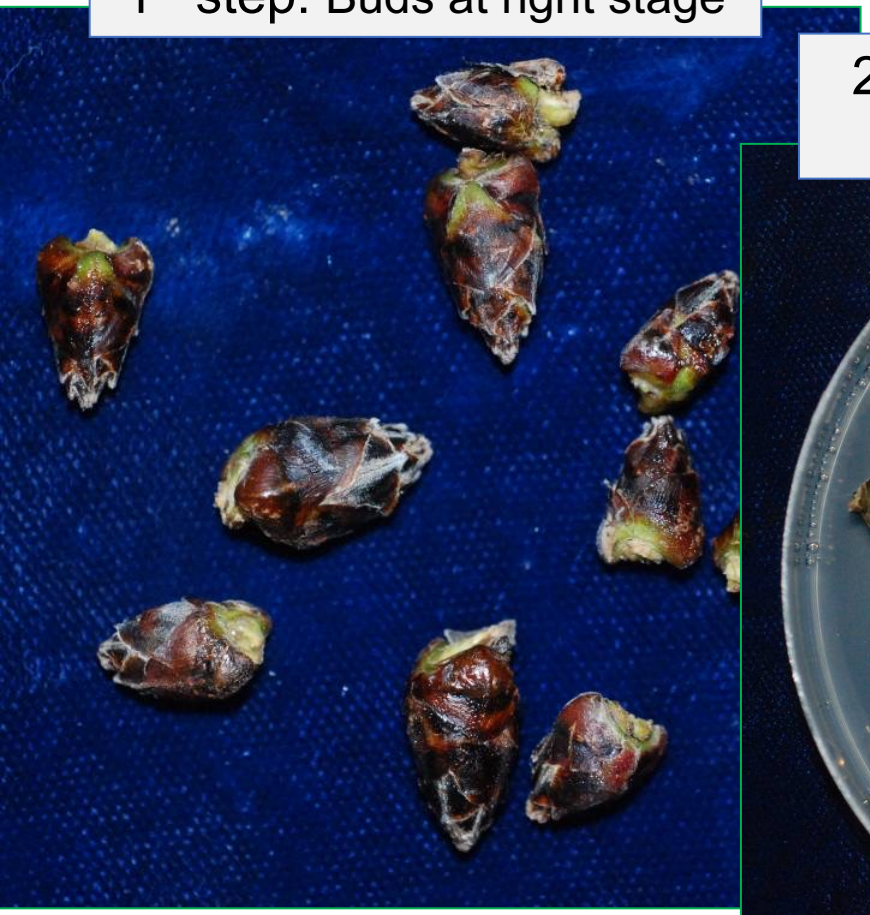
Blight of buds

Infested bud with conidia

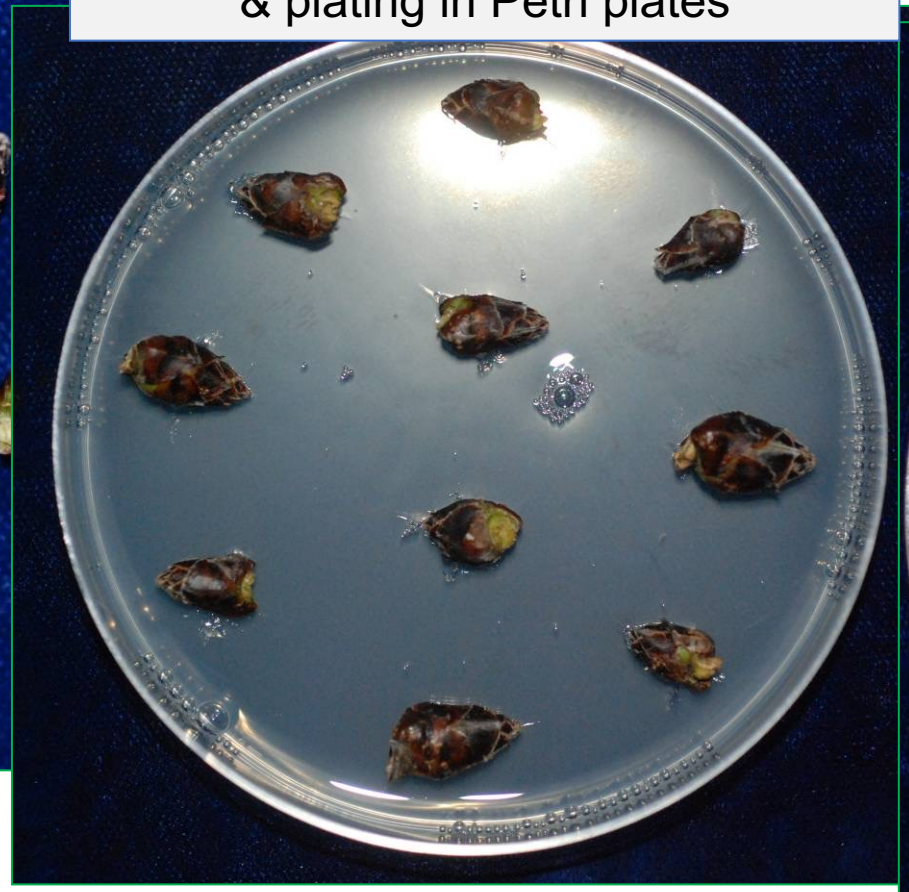
A) BUD MONitoring (BUDMON) Technique to detect and predict disease pressure in pistachio orchards

Collection of buds in late Feb – late March

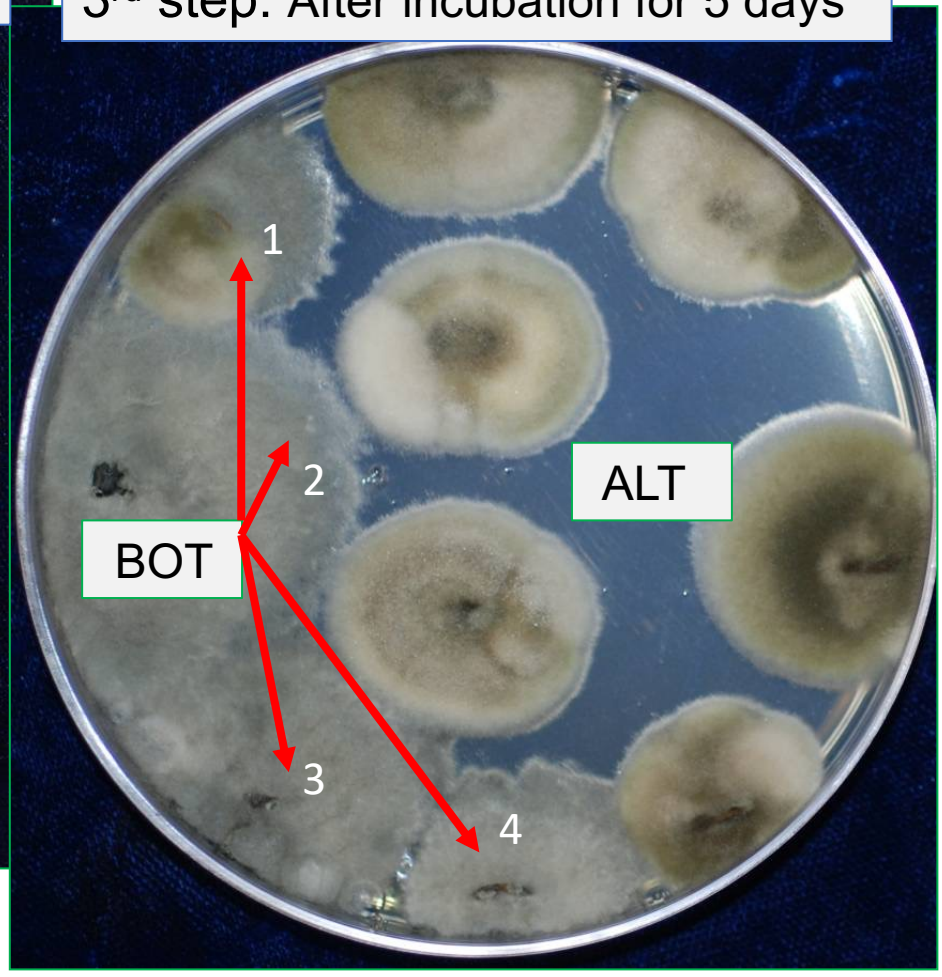
1st step: Buds at right stage



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



3rd step: After incubation for 5 days



Empirical Table

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

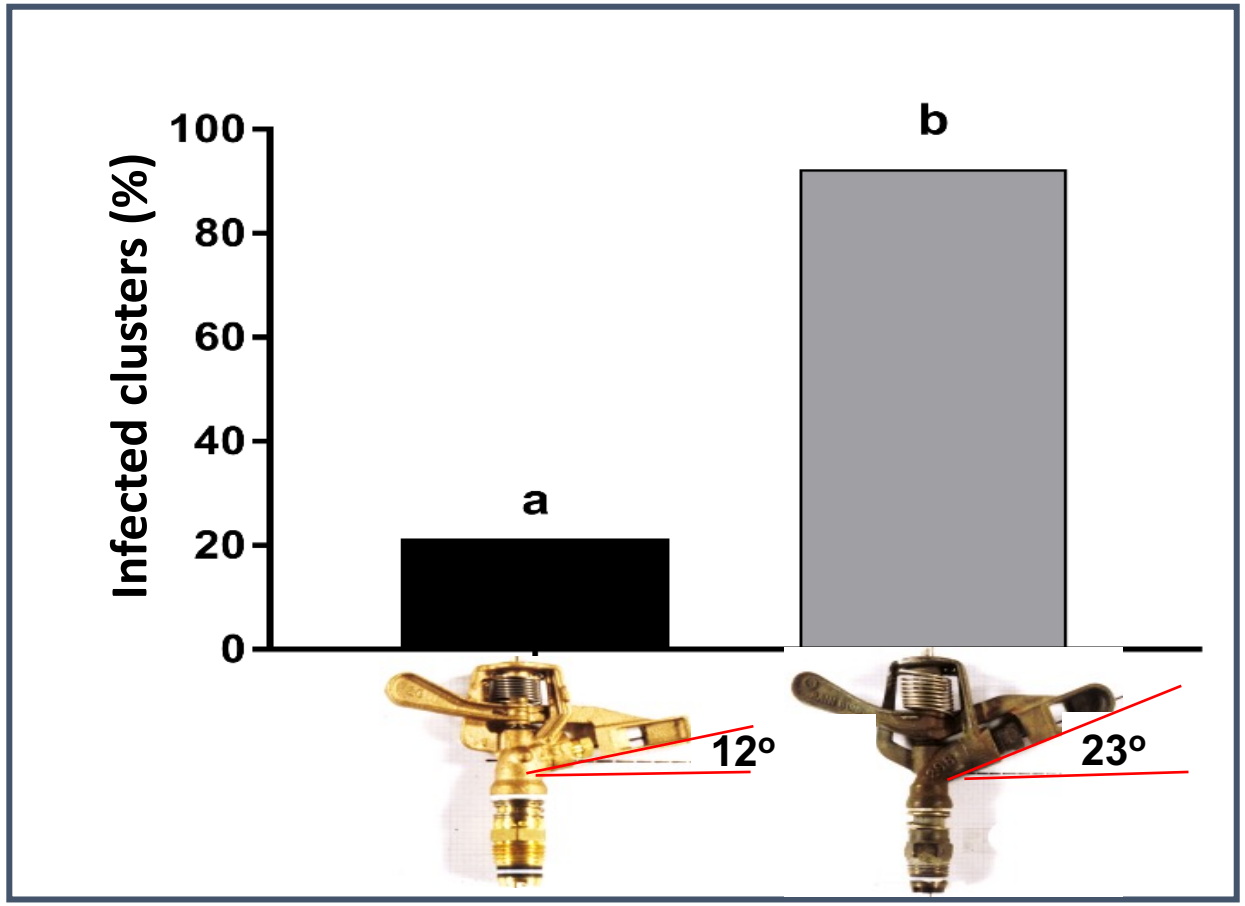
Bot in buds	Disease risk	# of sprays
0%	no risk	No sprays
1 to 3%	low risk	1 spray
4 to 8%	moderate risk	2-3 sprays
≥ 9%	high risk	3+ sprays

Disease Management

A. Cultural Control

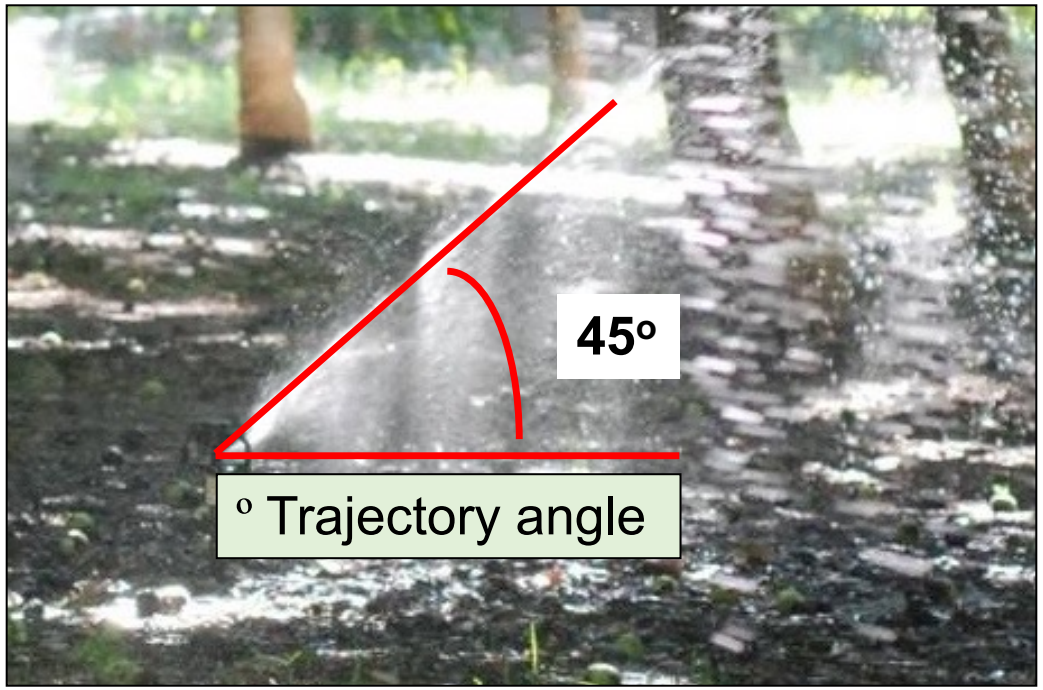
1. **Irrigation management**

12º ← **23º**



An 80% disease reduction!

Definition of trajectory angle



A. Cultural Control

2. Sanitation:

a) Winter pruning

b) Summer pruning

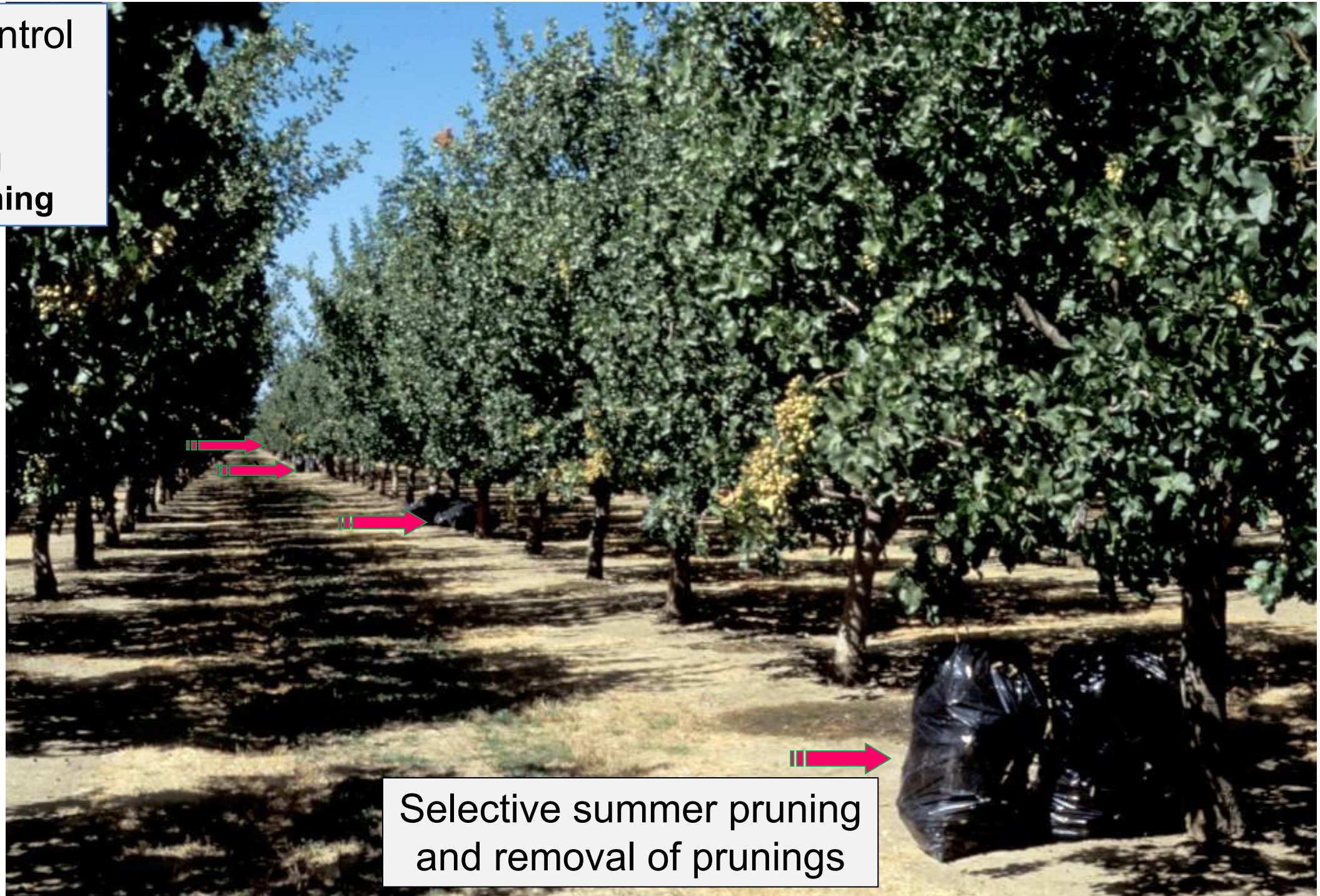
a) Winter pruning

A. Cultural Control

2. Sanitation:

a) Winter pruning

b) Summer pruning



Selective summer pruning and removal of prunings

A. Cultural Control

2. Sanitation:

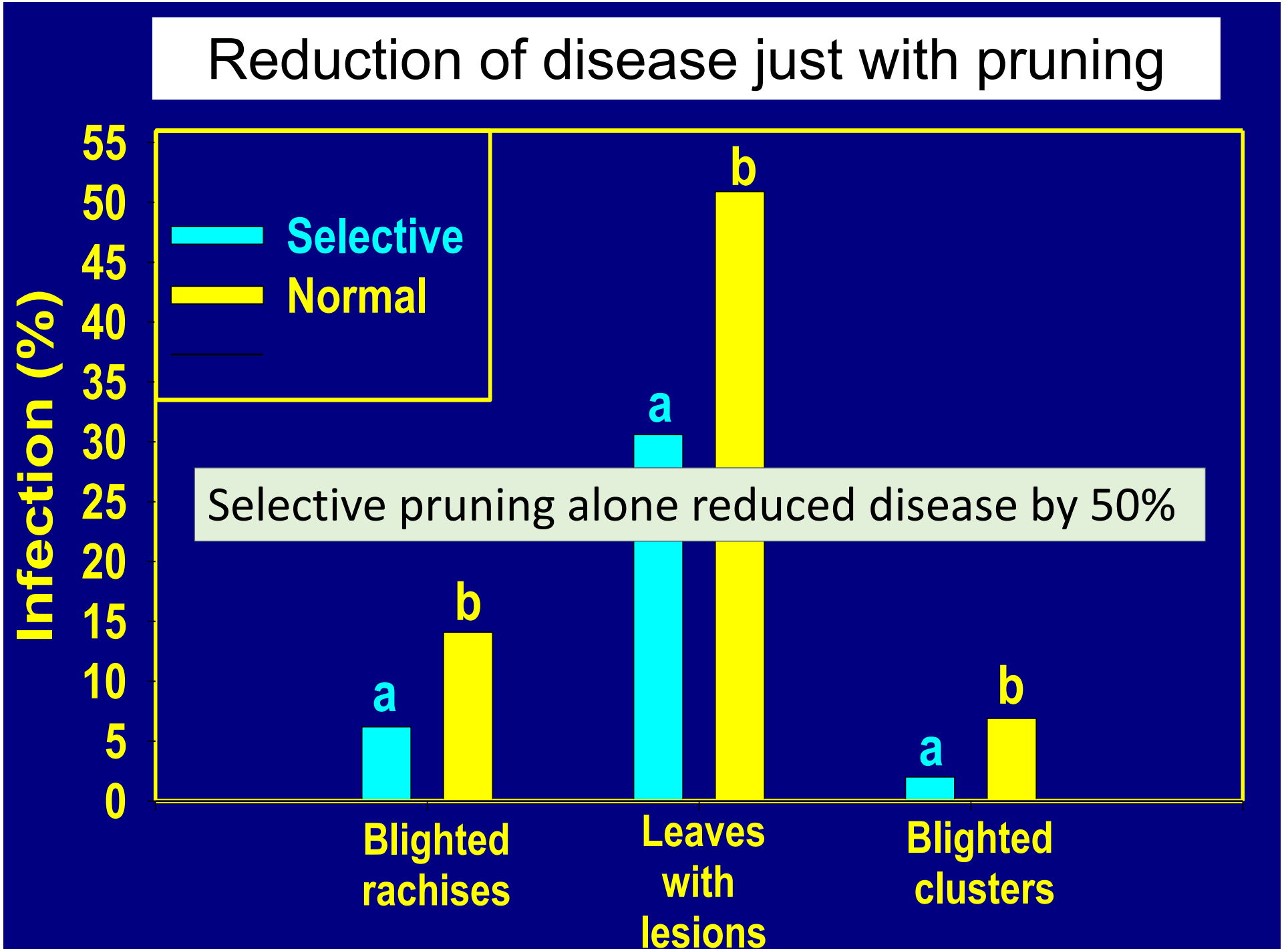
a) Winter pruning

b) Summer pruning

Burning of infected prunings outside the orchard

(if burning is permitted)

Reduction of disease just with pruning



B. Chemical control

Strobilurins (FRAC 11)
Abound (azoxystrobin)
Gem (trifloxystrobin)
Cabrio (pyraclostrobin)

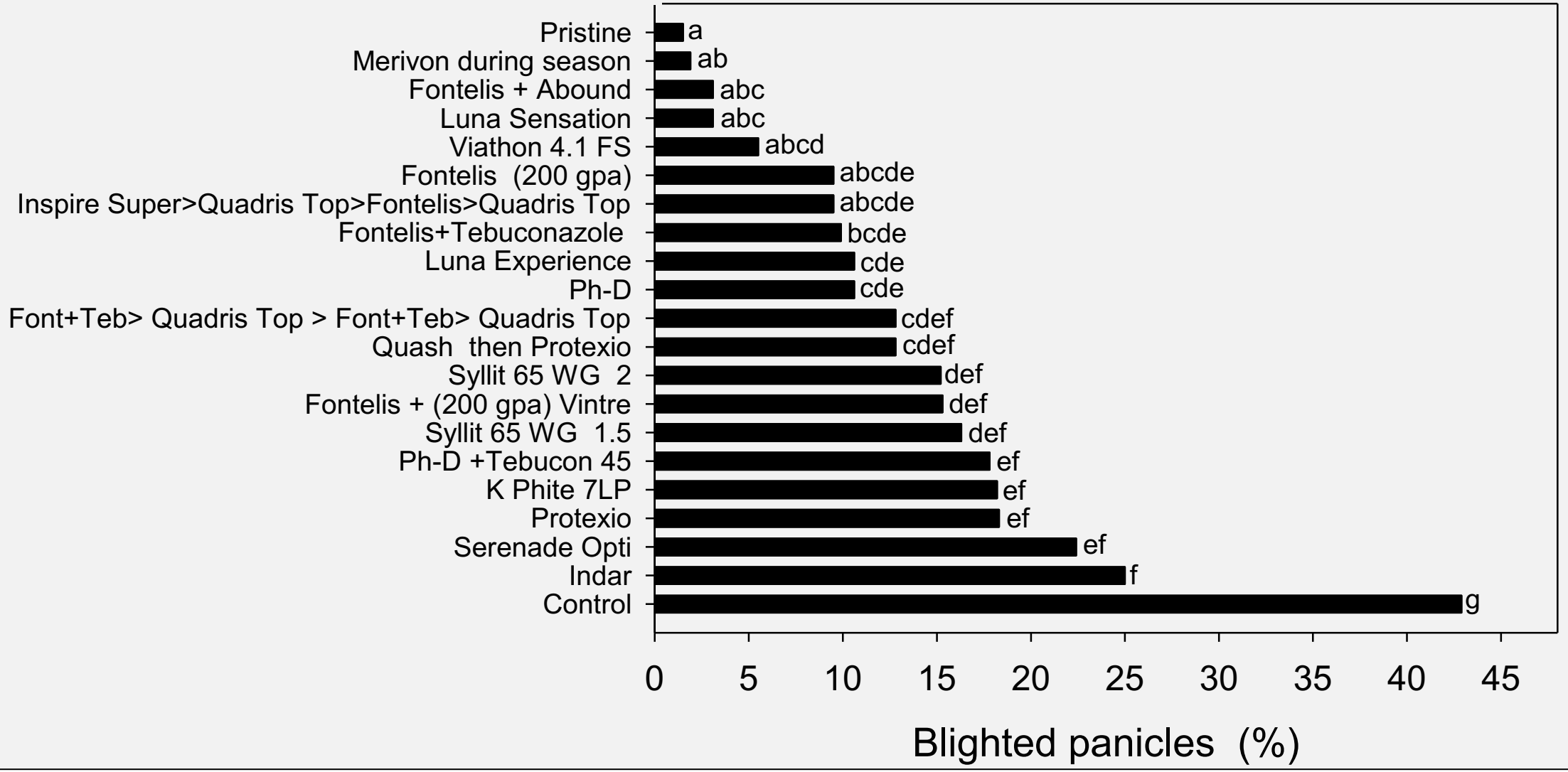
SDHI (FRAC 7)
Endura (boscalid)
Luna Privilege (fluopyram)
Fontelis (penthiopyrad)

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)

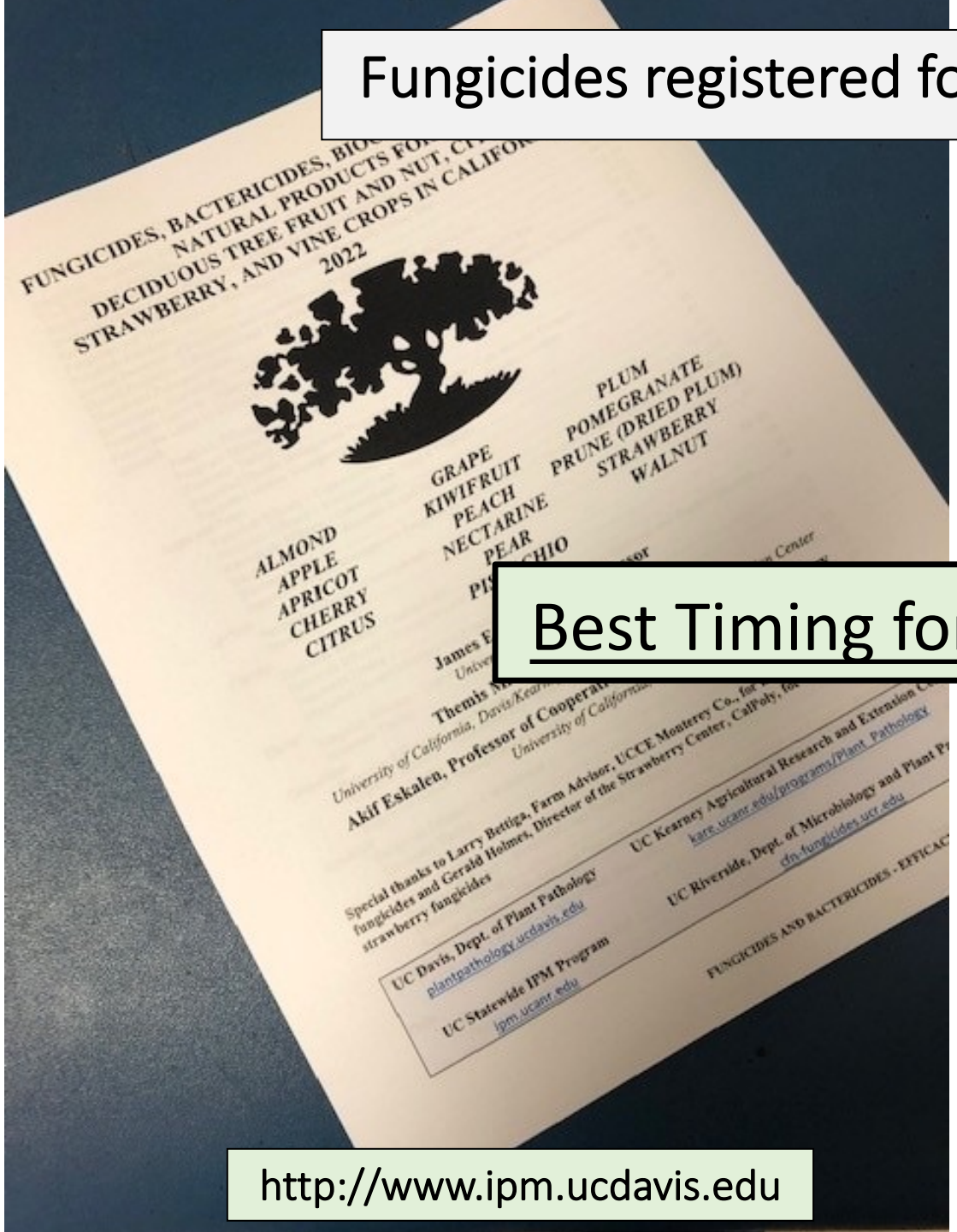
Biologicals show low efficacy against Bot panicle & shoot blight

Fungicide efficacy example

Timing: Apr 8, Jun 12*, Jul 10, Aug 6



Fungicides registered for Bot panicle & shoot blight



Best Timing for one spray: early June

Fungicide	Active ingredient (FRAC)	Efficacy
Abound …….	azoxystrobin (11)	**4**
Caprio ……	pyraclostrobin (11)	**4**
Flint Extra……	trifloxystrobin (11)	**4**
Inspire Super….	difenoconazole + cyprodinil (3/9)	**4/5**
Quadris Top……	azoxystrobin+difenoconazole(3/11)	**4/5**
	yraclostrobin (7/11)	**5**
	clostrobin (7/11)	**5**
	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	pydiflumedofen + 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**

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5 = excellent & consistent; 4 = good & reliable

Summary

1. Botryosphaeria panicle and shoot blight is a yield reducing fungal disease because it kills fruit clusters, current growth shoots, and fruiting buds.

2. These pathogens are widespread because they attack multiple hosts and can move among the nut crops easily due to continuous large nut crop plantings.

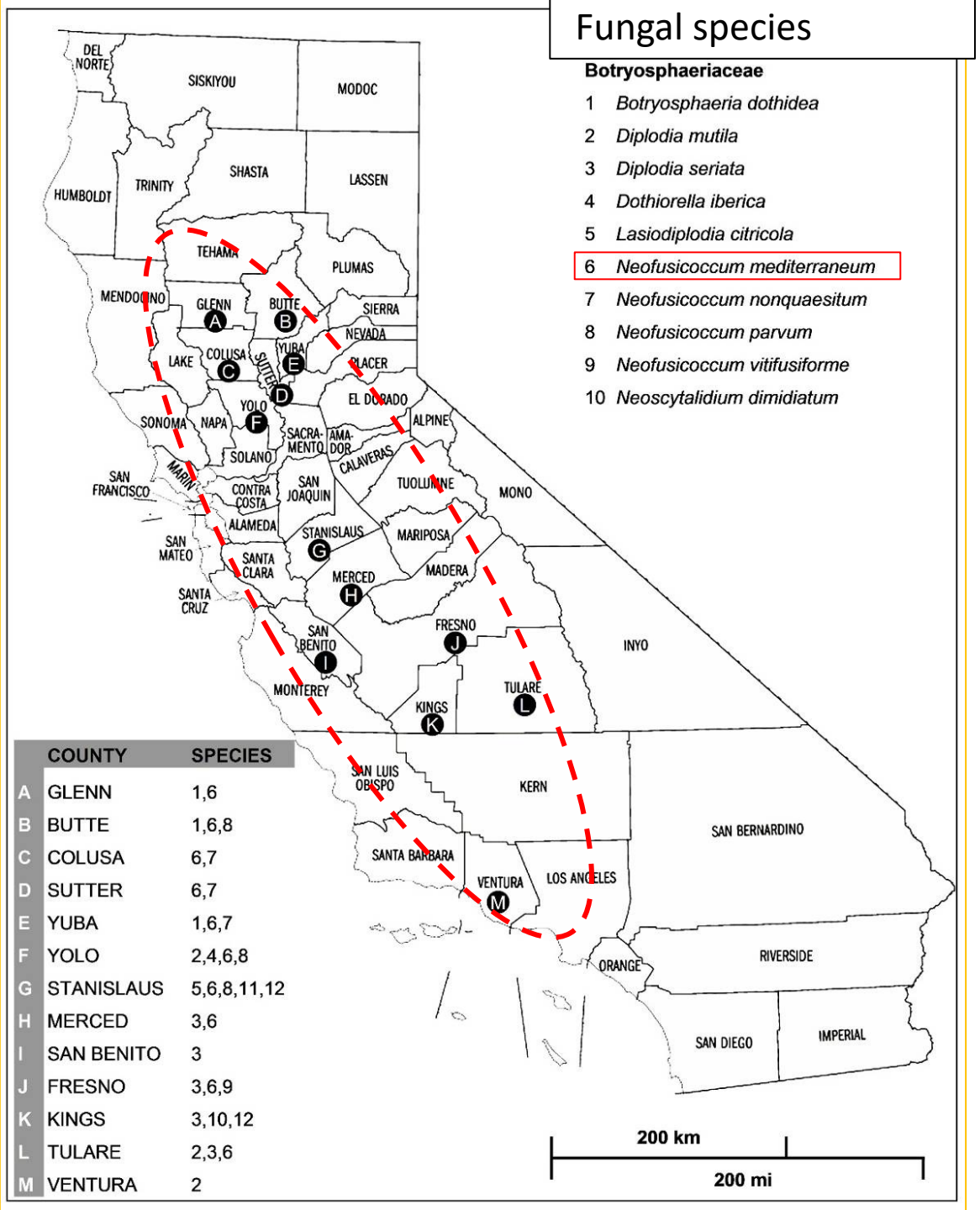
3. Botryosphaeria pathogens overwinter on infected trees in pycnidia that produce spores that are mainly spread by rain.

4. Botryosphaeria panicle and shoot blight could become very severe in an orchard bearing inoculum load and following a wet winter and spring, if disease management measures (cultural and fungicide sprays) were not implemented. (example hurricane Hilary.)

5. Cultural control of the disease mainly involves pruning infected shoots and branches and chemical control is done to control stinkbugs and by spraying fungicides starting at bloom (April) to the end of July.

2. Botryosphaeria canker and blight of walnut

Distribution of Botryosphaeriaceae in walnuts in California

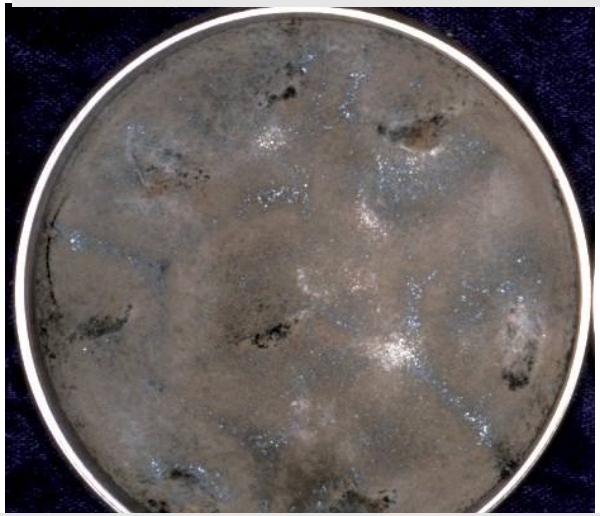


	COUNTY	SPECIES
A	GLENN	1,6
B	BUTTE	1,6,8
C	COLUSA	6,7
D	SUTTER	6,7
E	YUBA	1,6,7
F	YOLO	2,4,6,8
G	STANISLAUS	5,6,8,11,12
H	MERCED	3,6
I	SAN BENITO	3
J	FRESNO	3,6,9
K	KINGS	3,10,12
L	TULARE	2,3,6
M	VENTURA	2

Summary of Botryosphaeriaceae in nut crops – California

Fungal species	Walnut	Pistachio	Almond
Botryosphaeria dothidea	+	+	+
Neofusicoccum parvum	+	+	+
Neofusicoccum mediterraneum	+	+	+
Diplodia mutila	+	*Diplodia serriata*	---
Neofusicoccum nonquaesitum	+	*Lasio. americana*	+
Neofusicoccum vitifusiforme	+	+	---
Diplodia seriata	+	+	+
Dothiorella iberica	+	+	+
Lasiodiplodia citricola	+	+	+
*Neoscytalidium dimitiatum**** (=*Hendersonula toruloidea*)	+	+	+

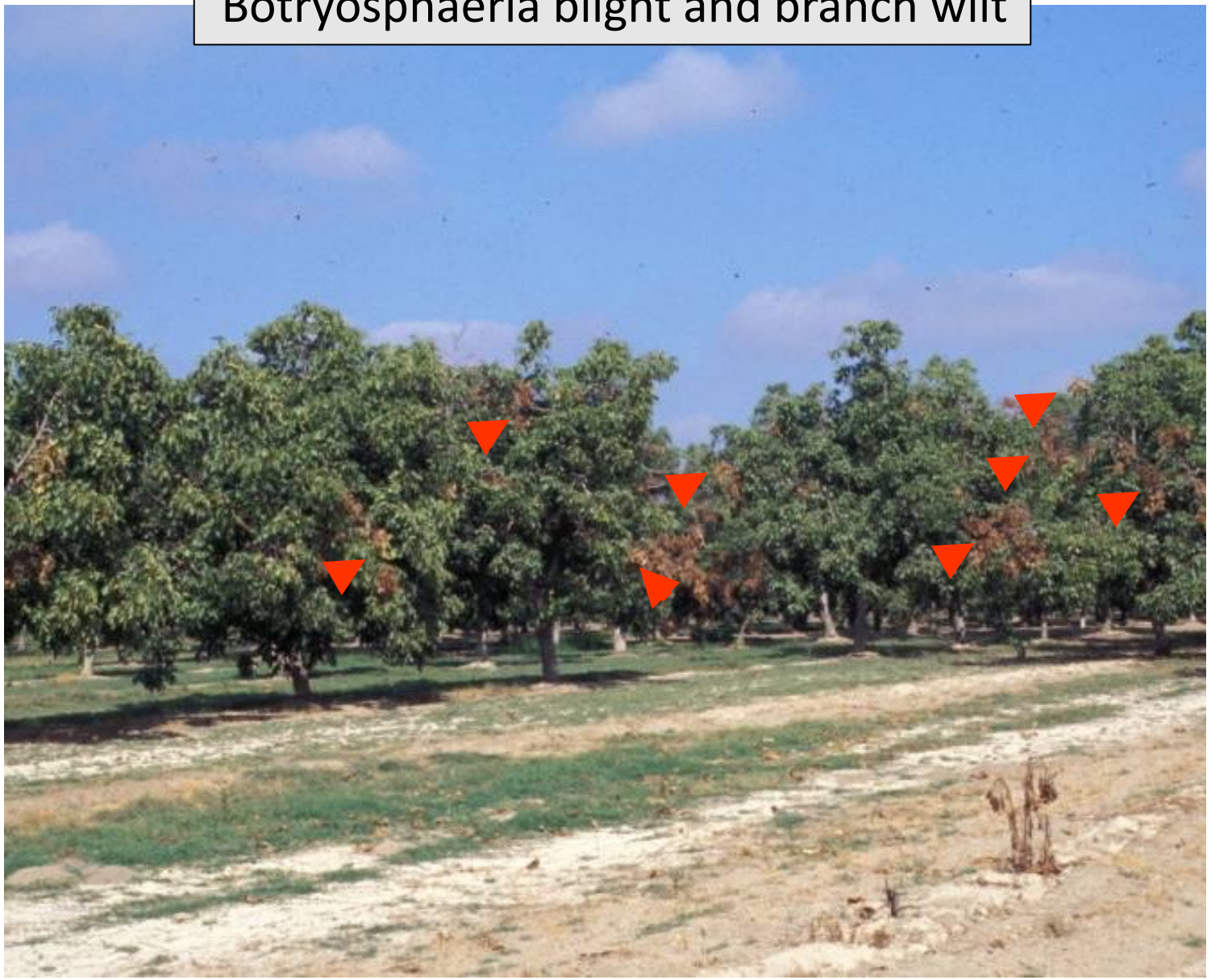
Neofusicoccum mediterraneum



Neoscytalidium dimitiatum

Branch wilt

Botryosphaeria blight and branch wilt



Conditions for infection event:

- ✓ Presence of inoculum
- ✓ Rain: at least 1/4”
- ✓ Temperature: ≥ 50°F
- ✓ Presence of susceptible tissues

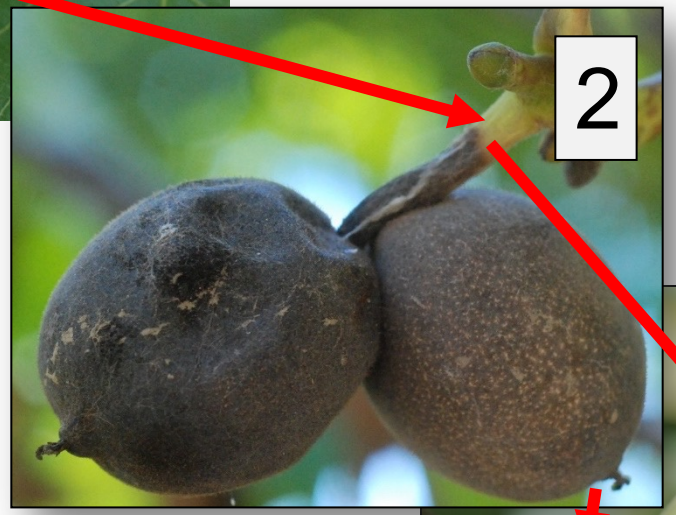
When rains in the spring:
Walnut blight

Healthy looking nuts until August/September (exception walnut blight)

--- Disease Progress ---

Infection of intact fruit in the orchard

(August –September)



All the species of *Botryosphaeria* and *Phomopsis*

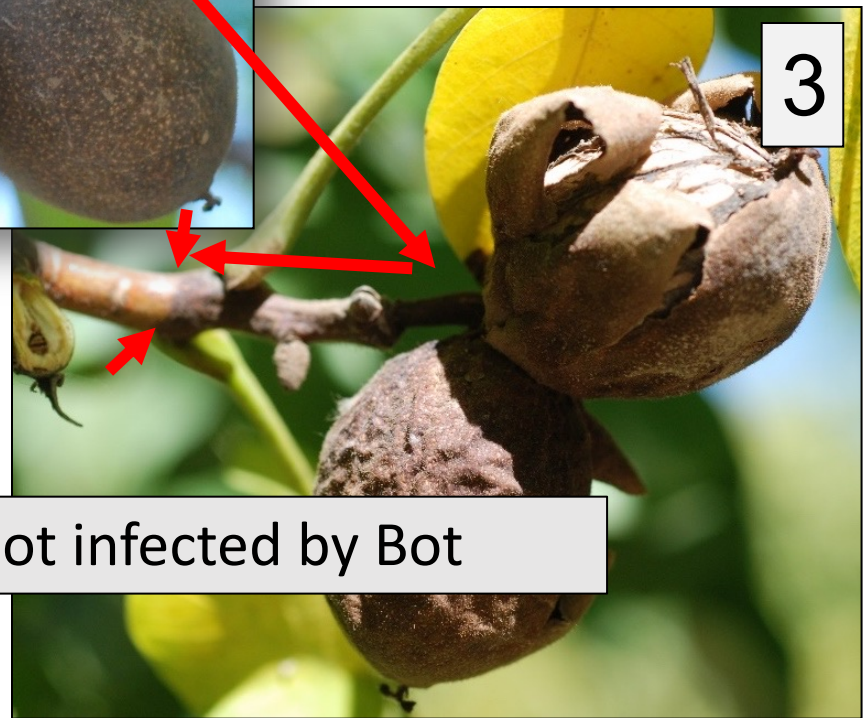
Fruit → Fruit

↓

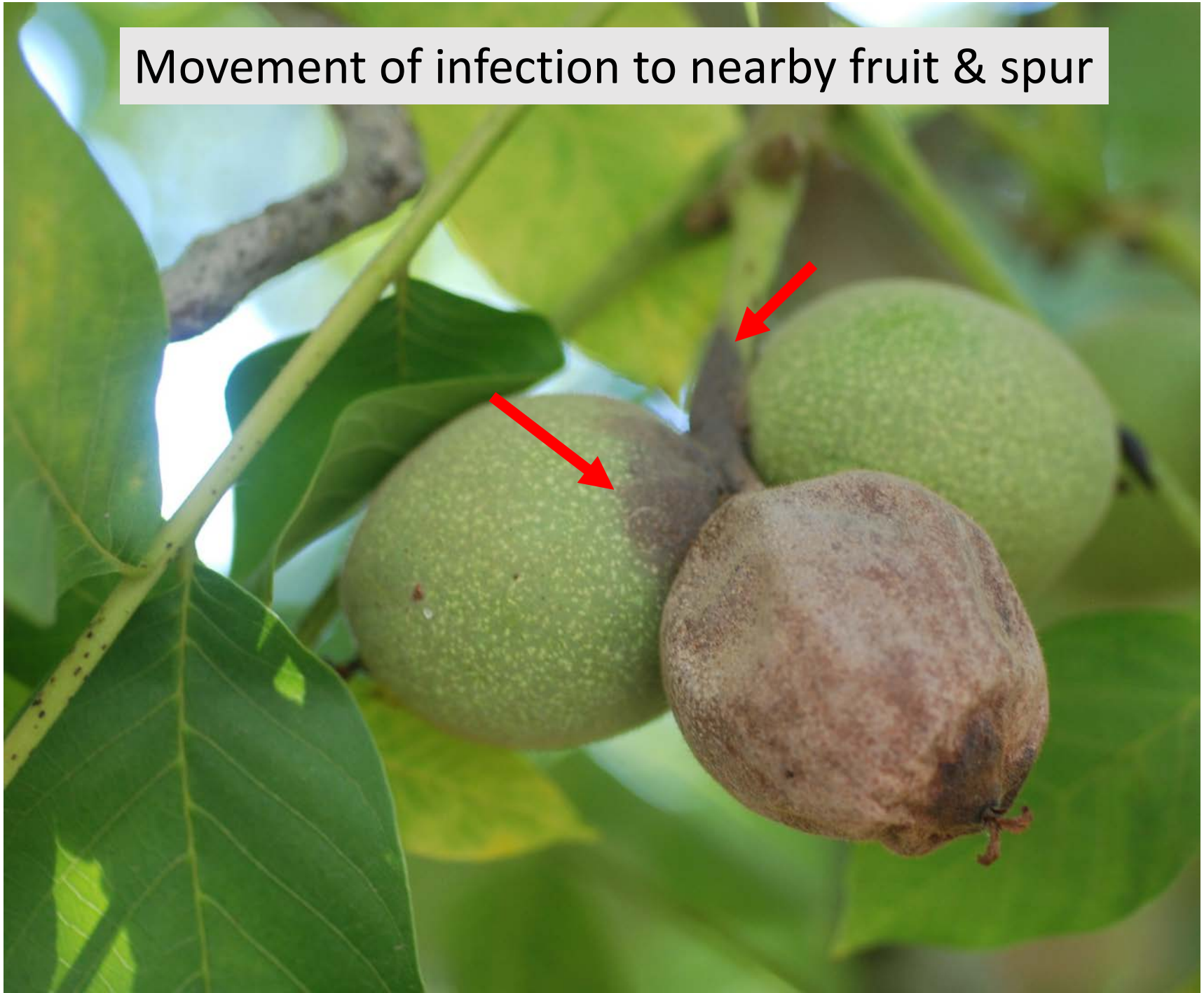
Peduncle

↓

Infects & kills spurs/ buds & shoots

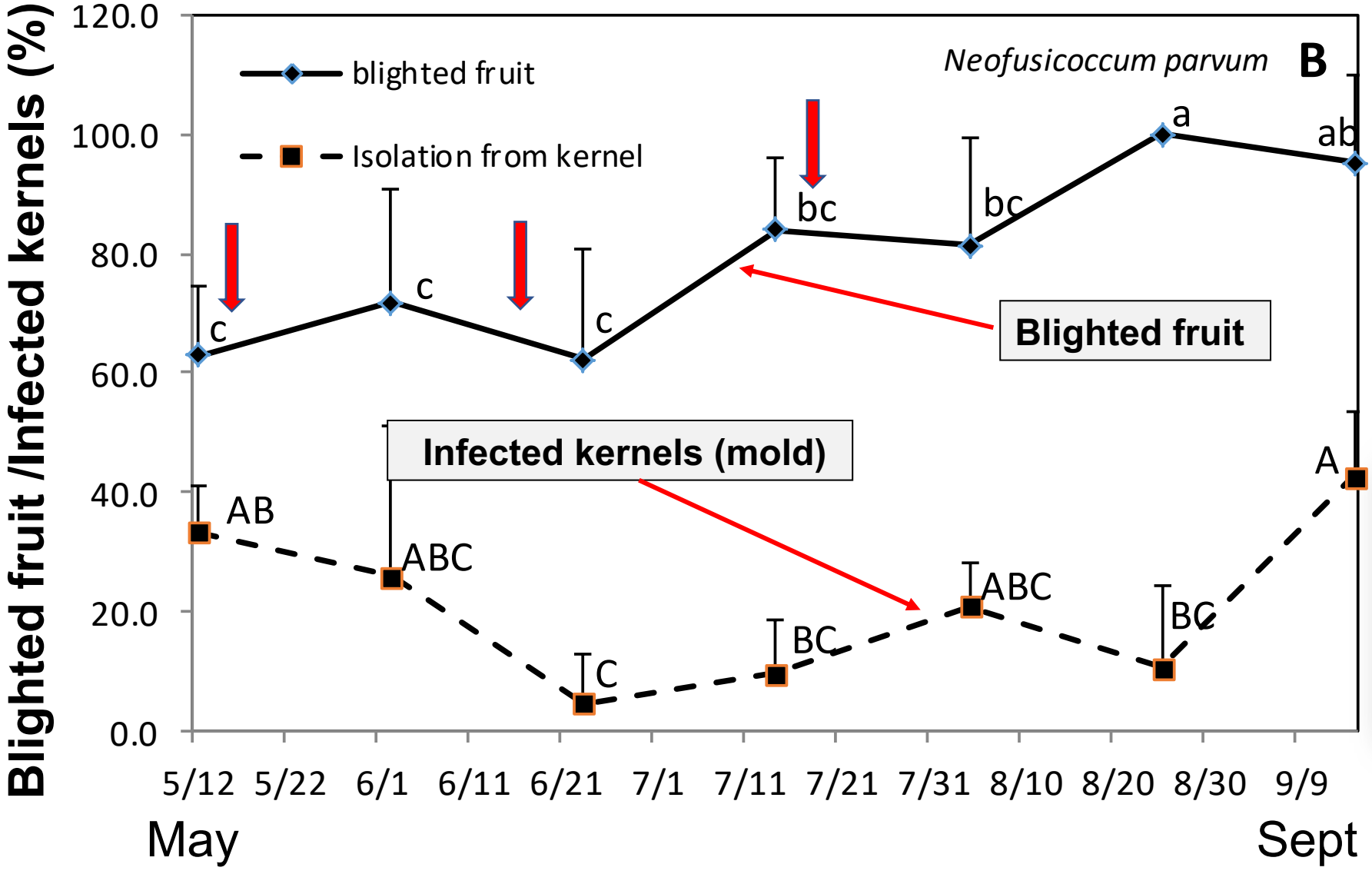


Walnut leaves are not infected by Bot

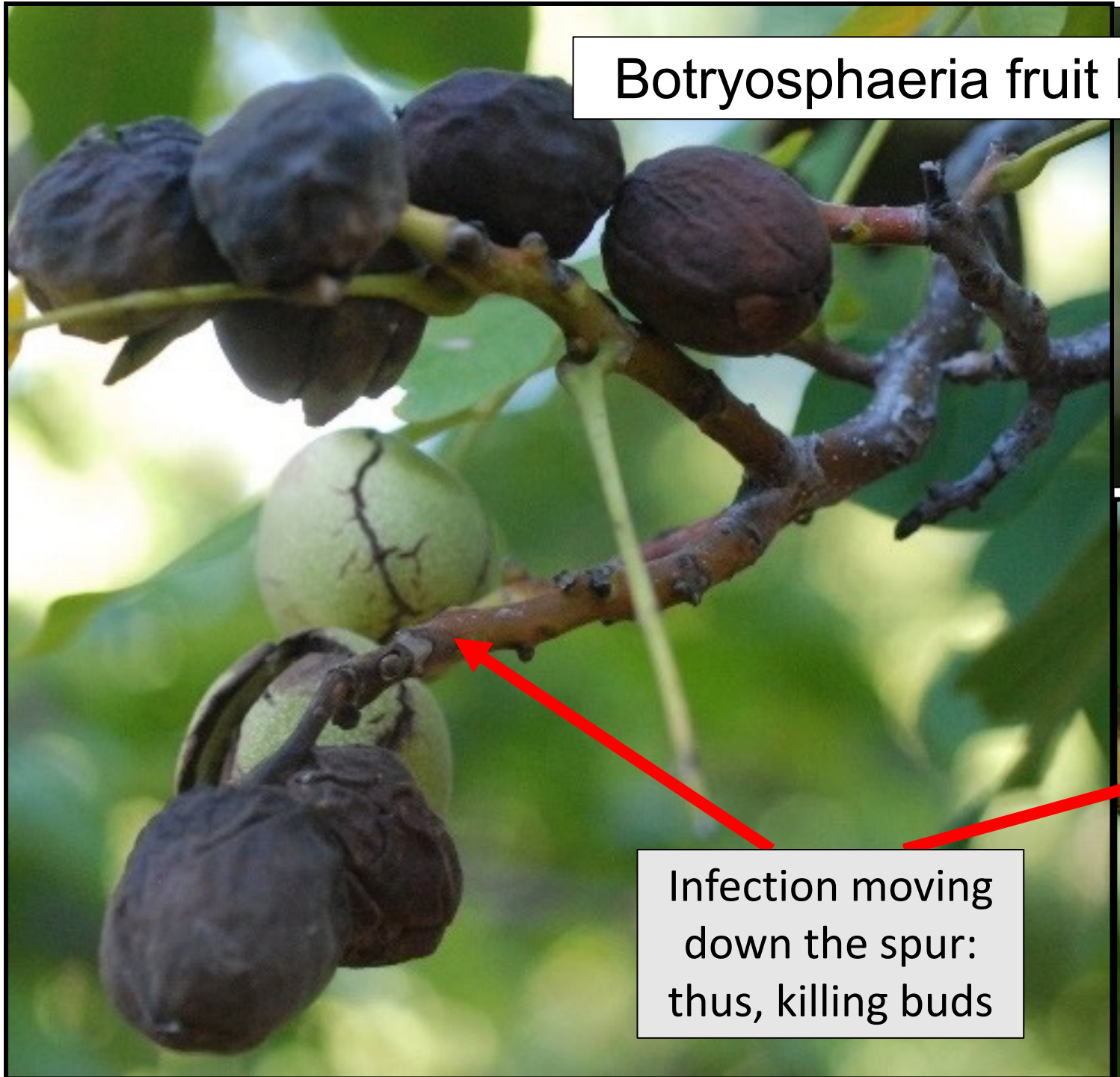

Movement of infection to nearby fruit & spur

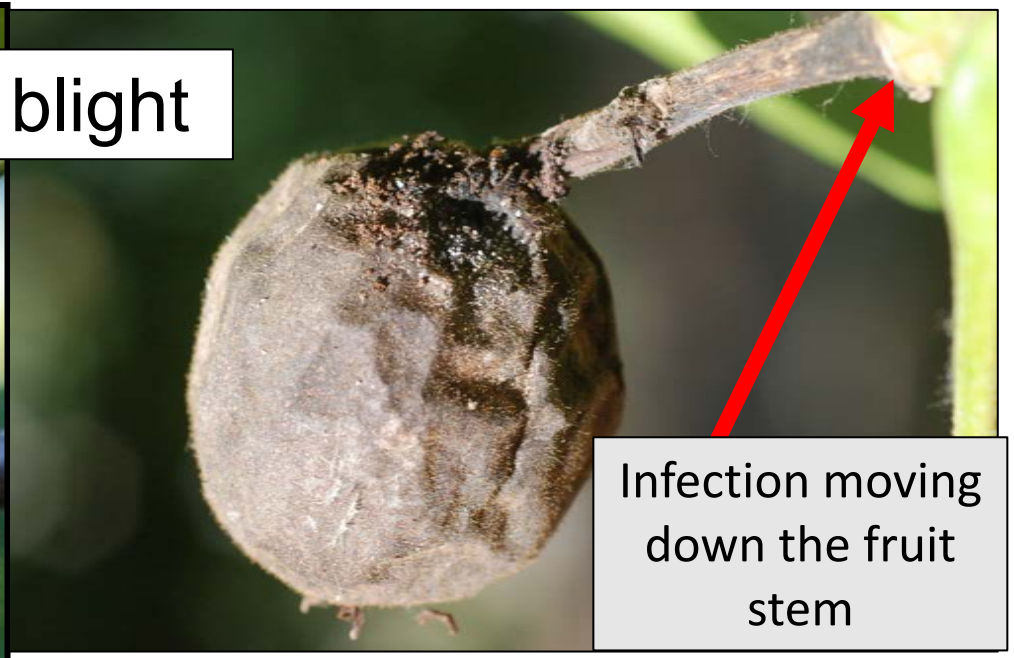
Inoculations in the field

Susceptibility of walnut fruit to *Botryosphaeria*



Botryosphaeria fruit blight

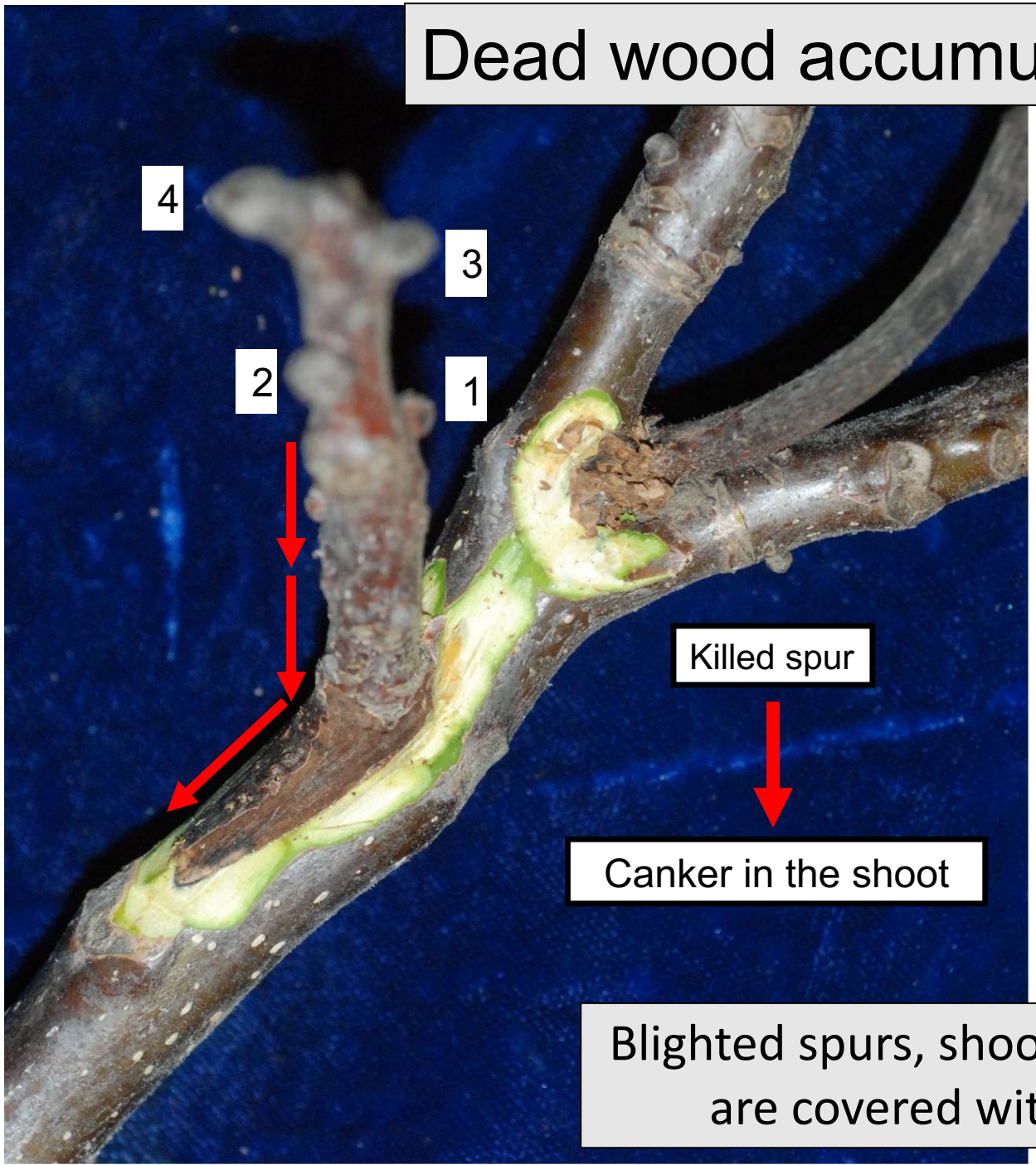


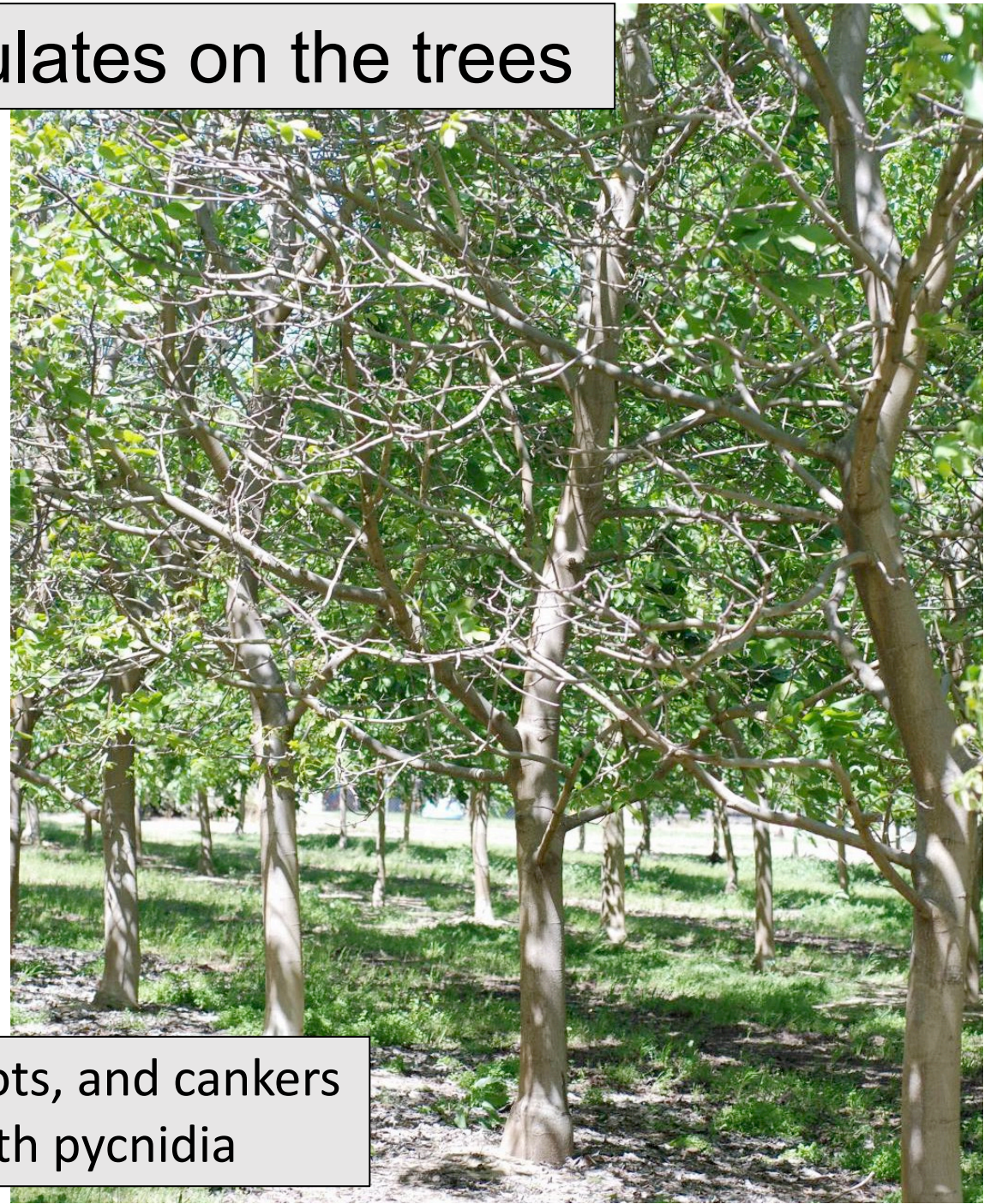


Infection moving down the fruit stem

Infection moving down the spur: thus, killing buds

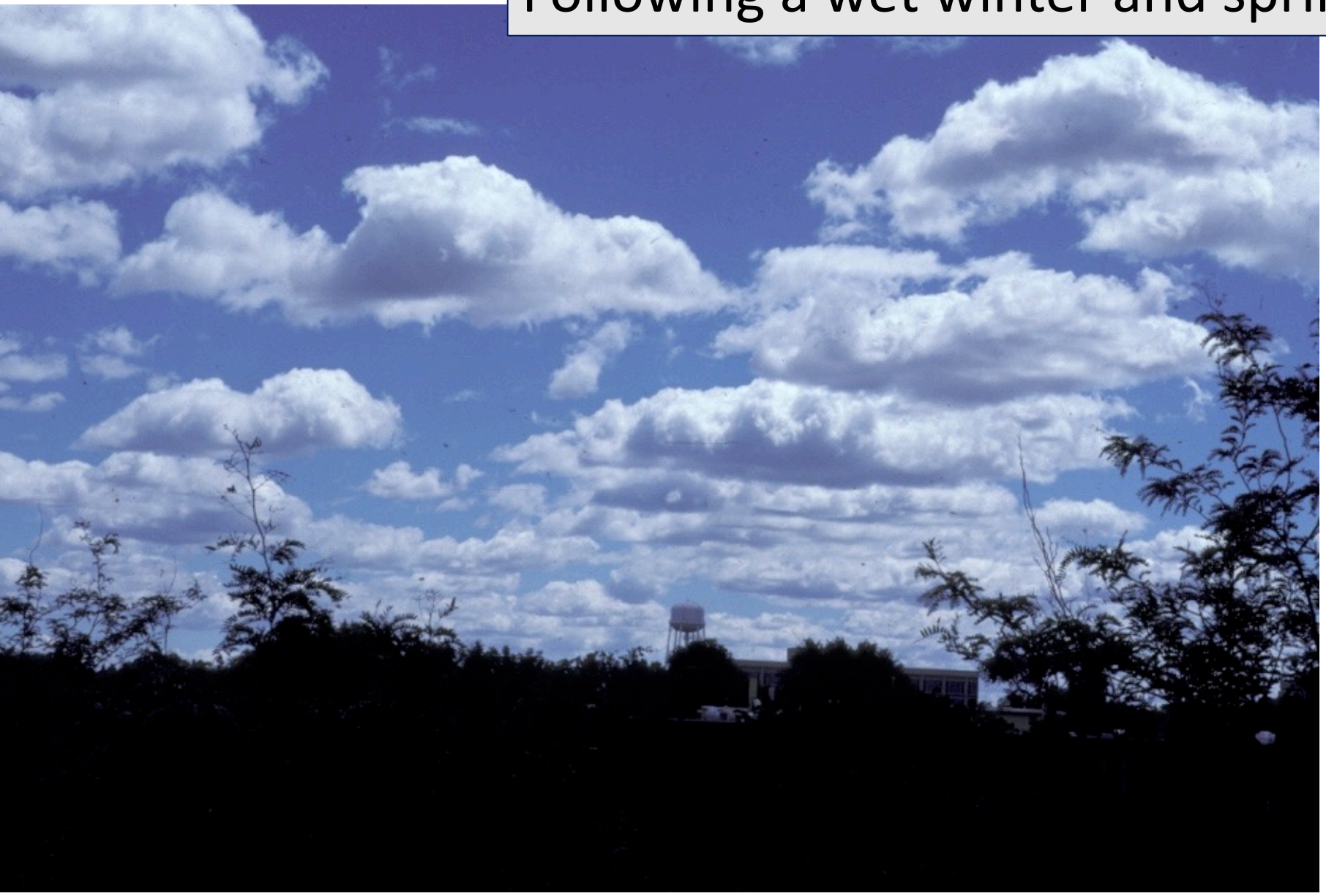
Dead wood accumulates on the trees



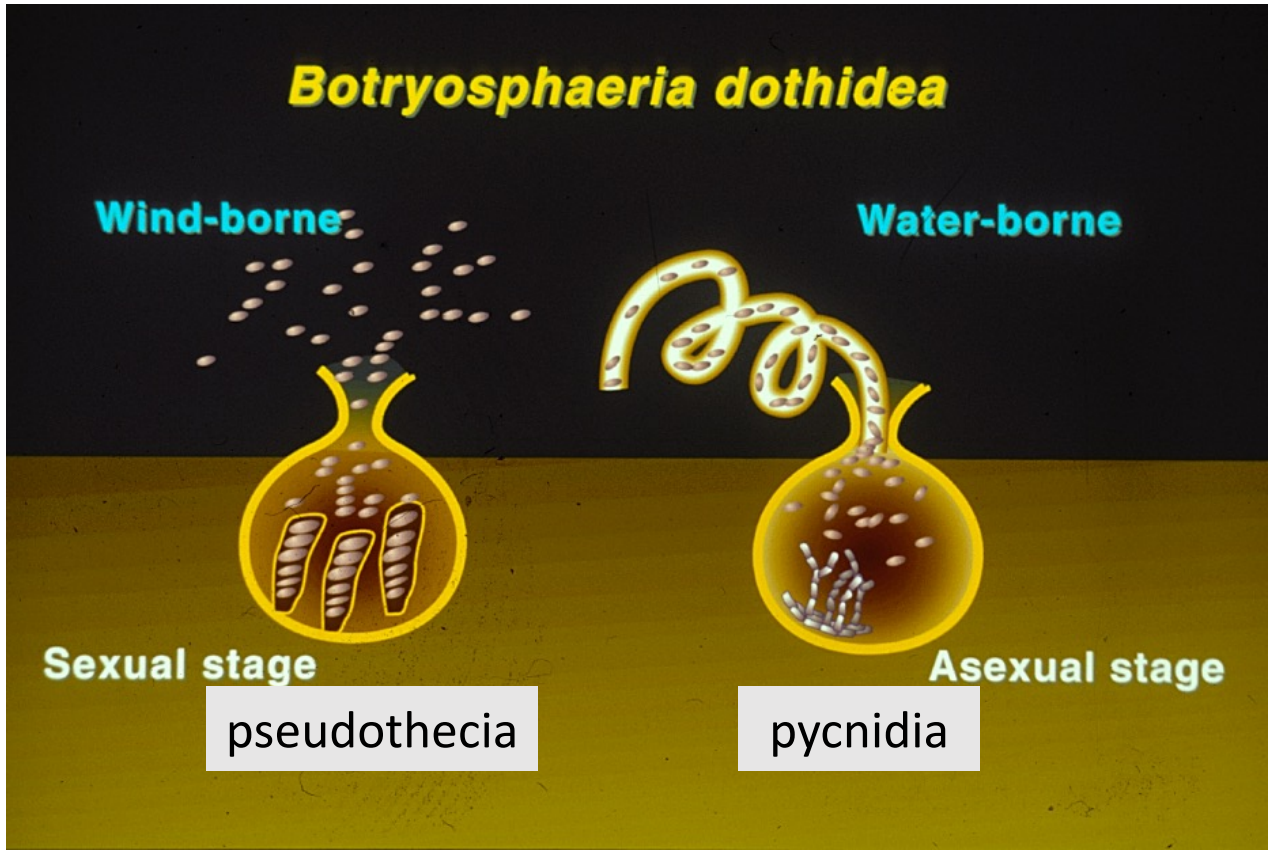


Blighted spurs, shoots, and cankers are covered with pycnidia

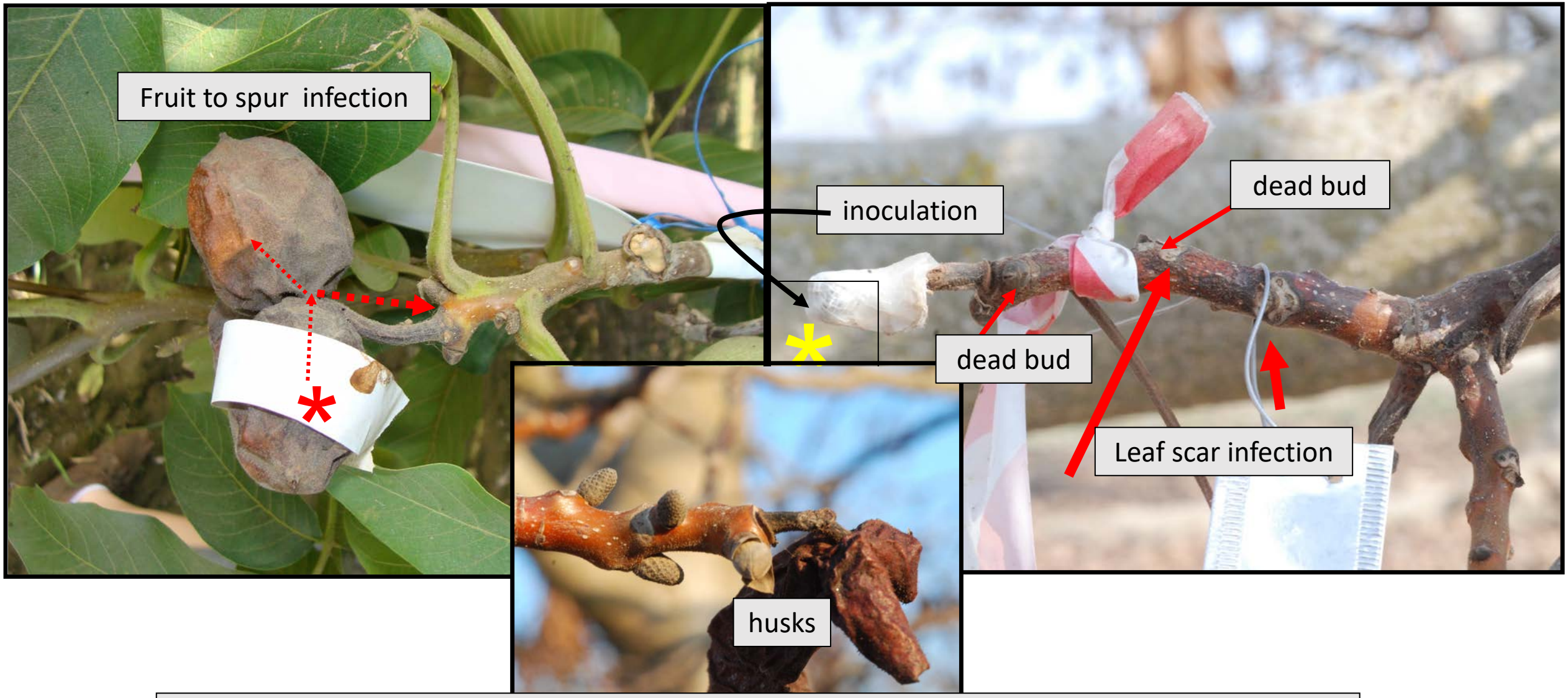
Following a wet winter and spring



Rains: Oozing pycnidia & ascospore release



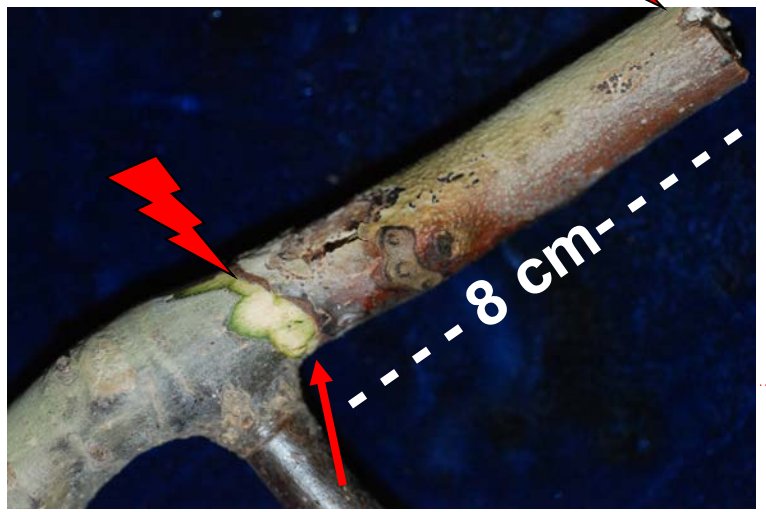
When we have rain in the fall and temperatures are high



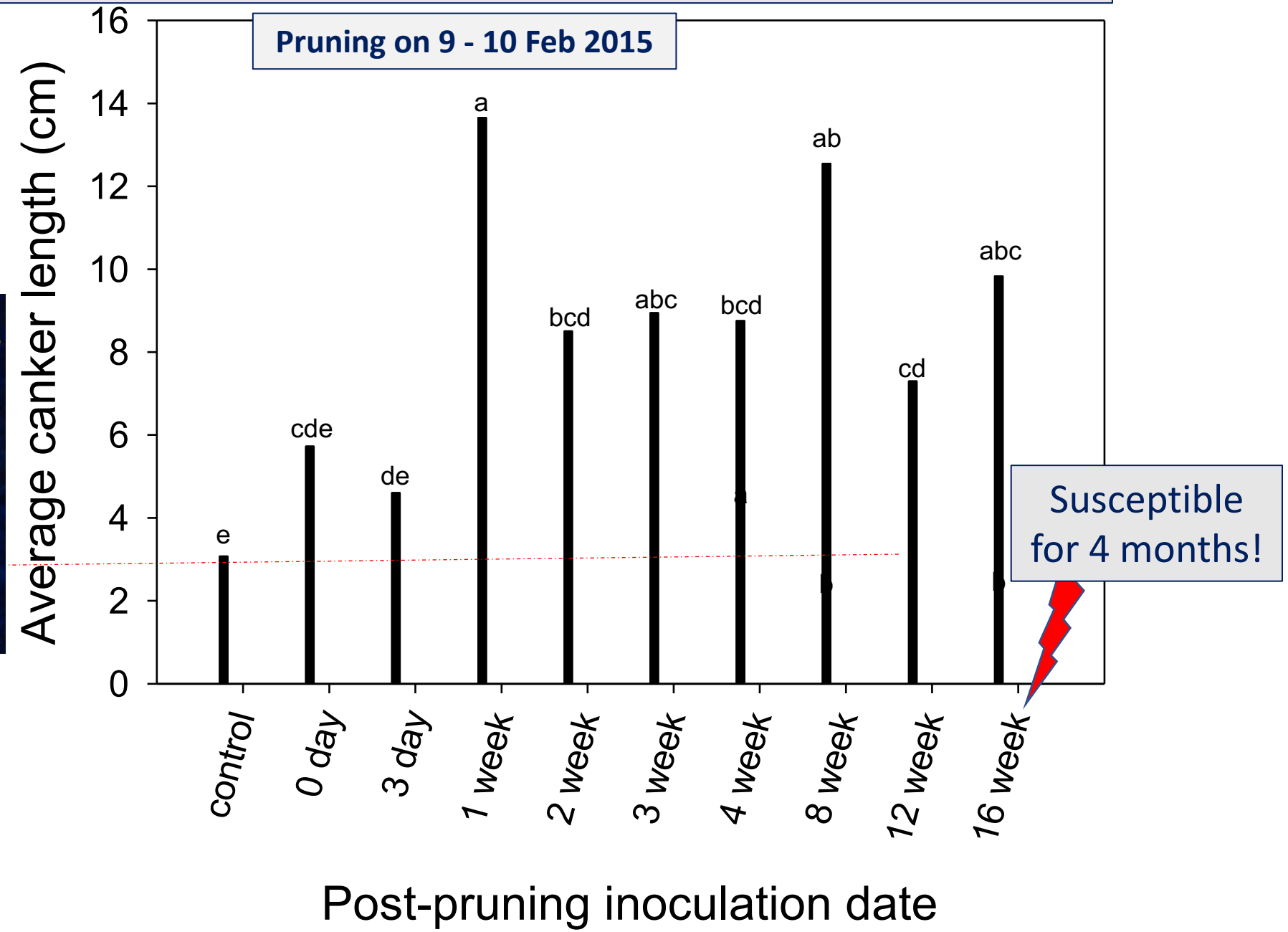
In addition to fruit, fruit stem scars, leaf scars, buds, & husks are infected

Susceptibility of pruning wounds to infection by Botryosphaeria

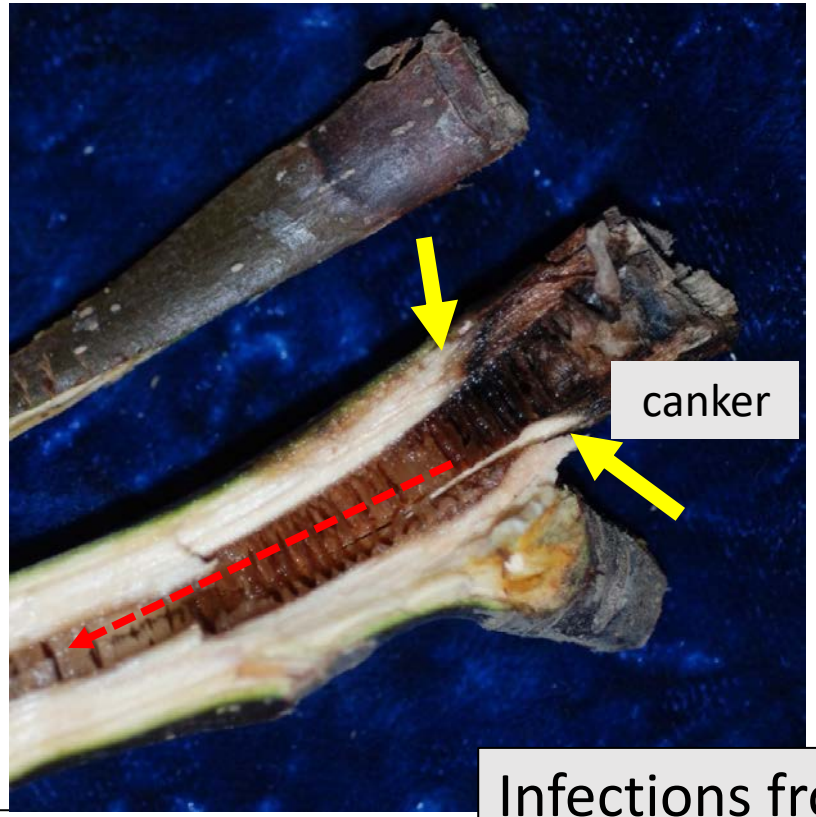
pruning wound

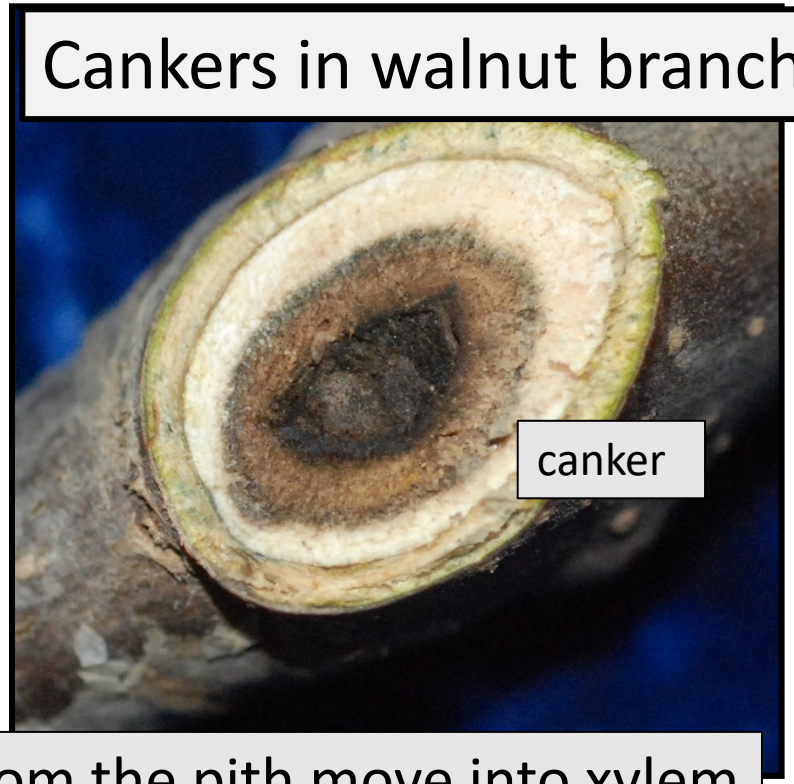


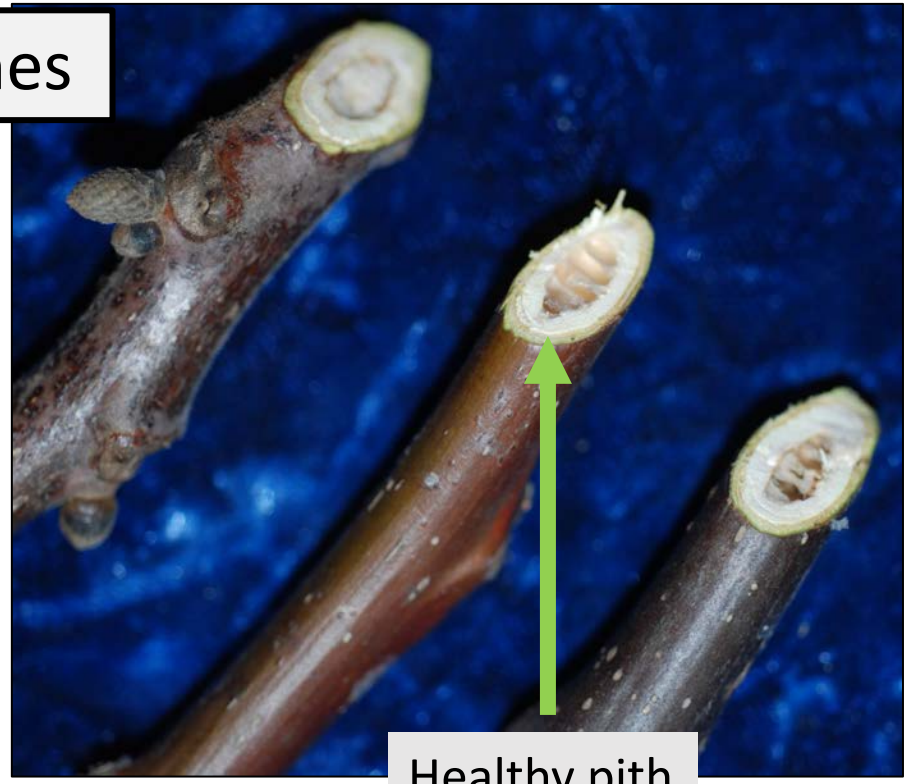
Cankers associated with pruning wounds



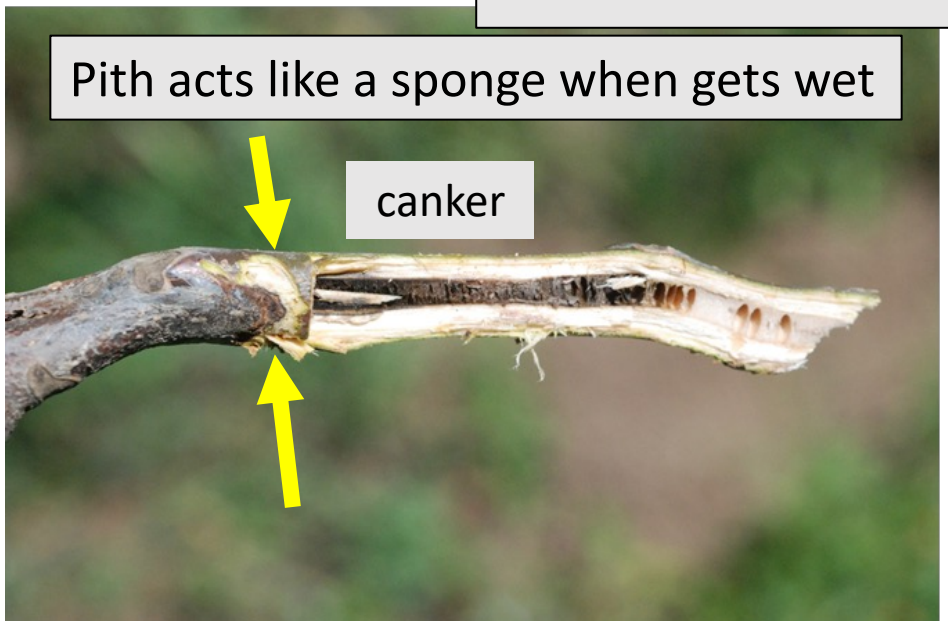
Cankers in walnut branches

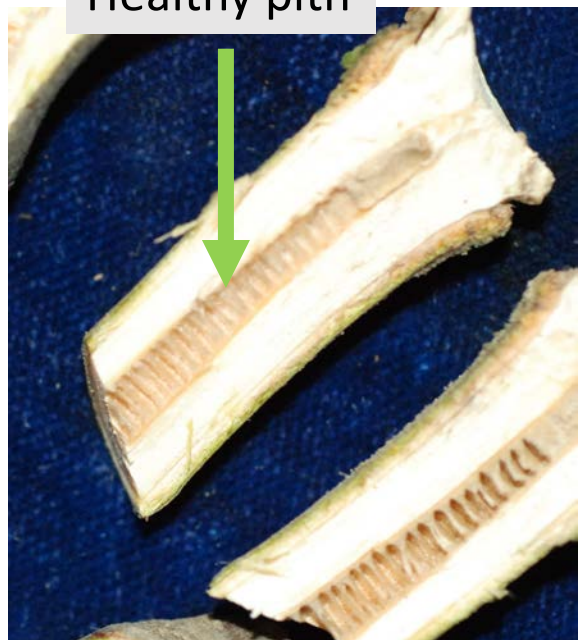




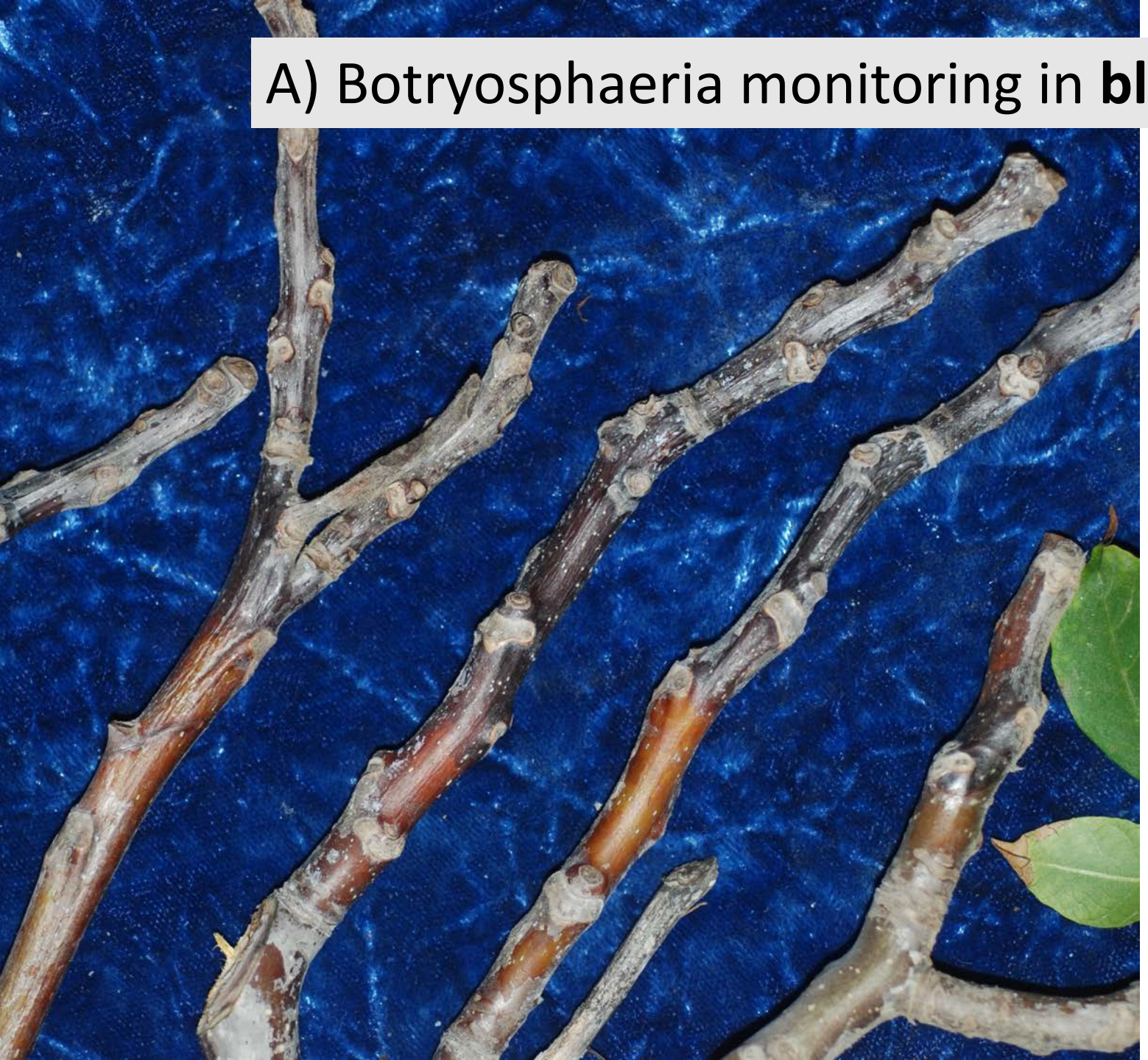


Infections from the pith move into xylem

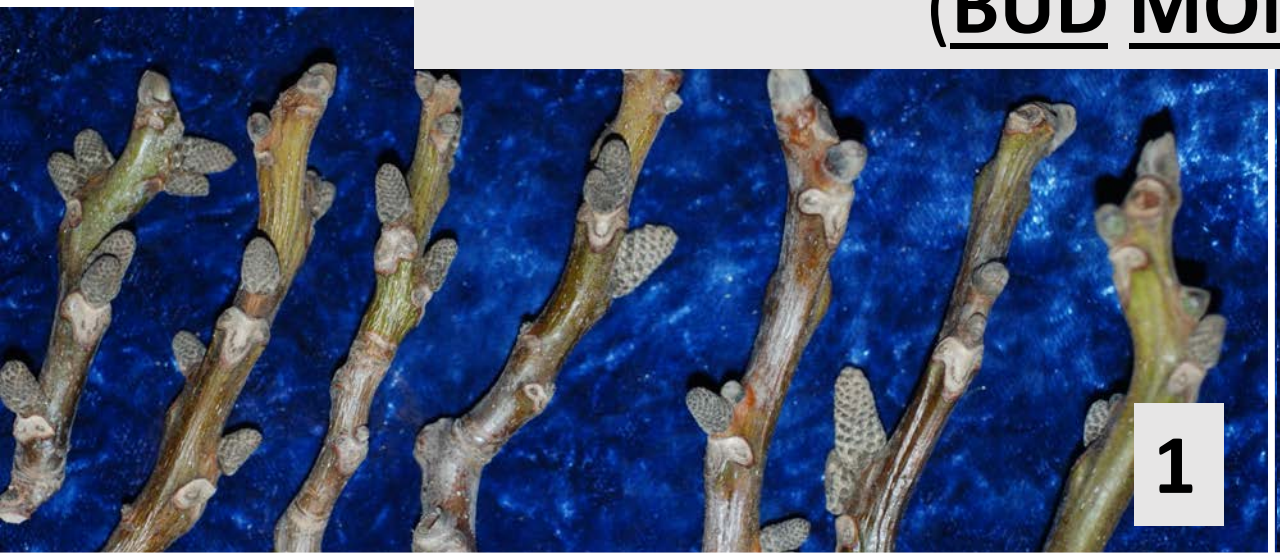


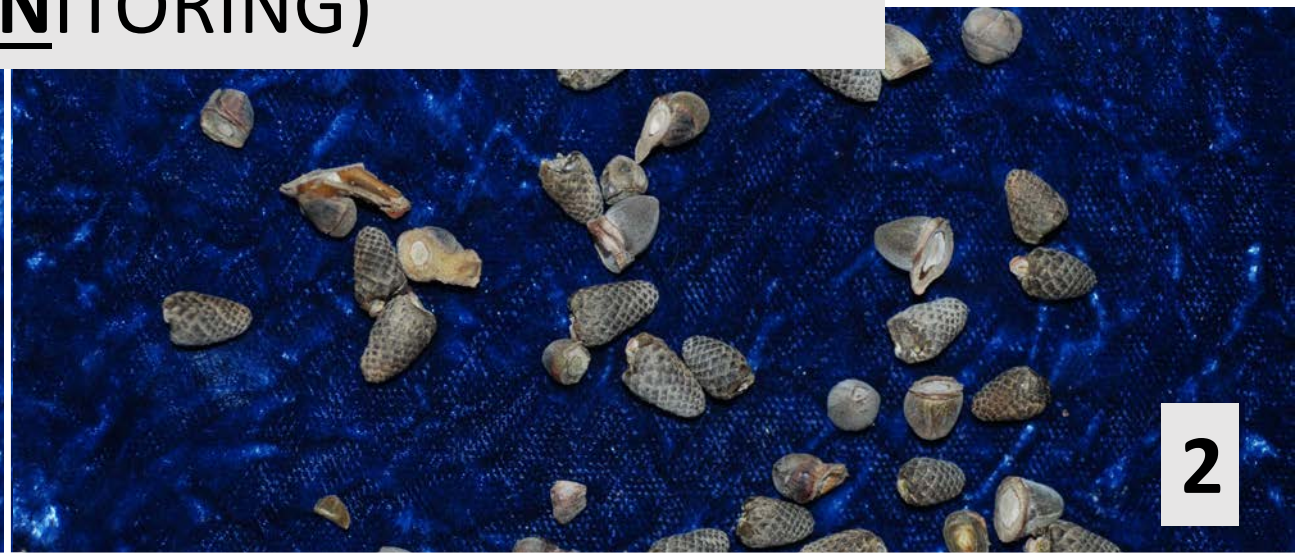


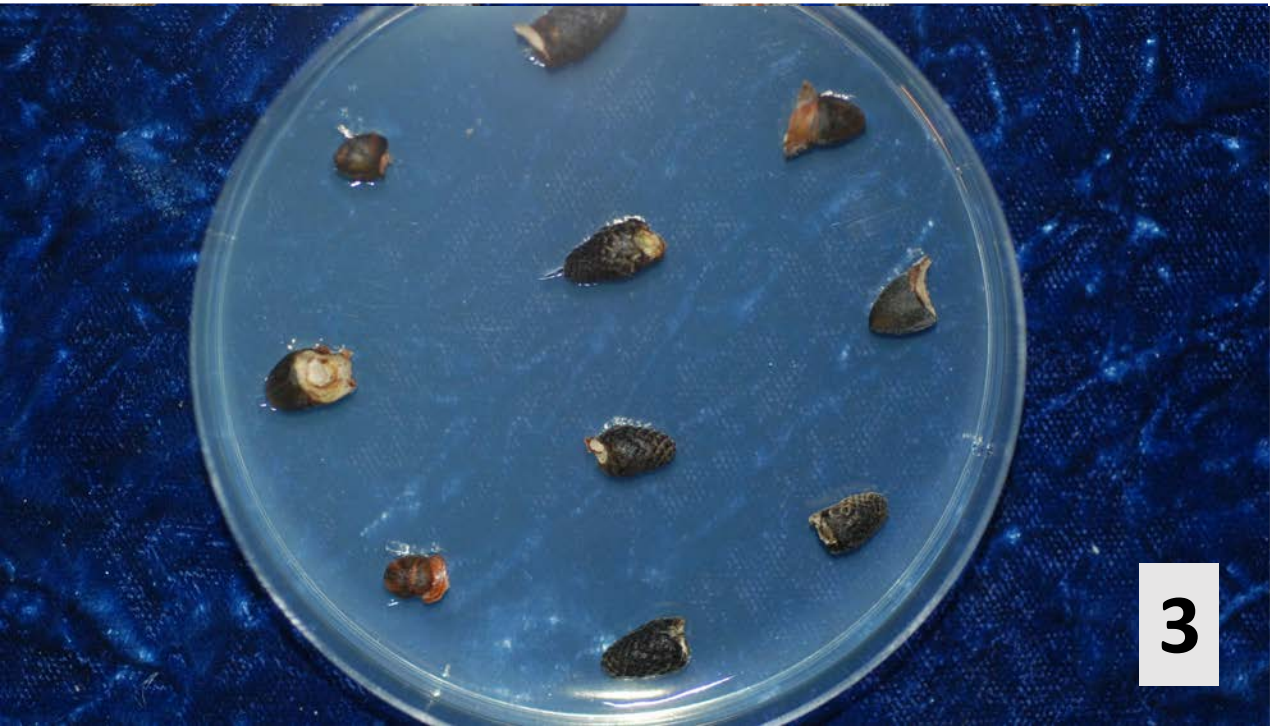
A) Botryosphaeria monitoring in **blighted twigs/spurs**

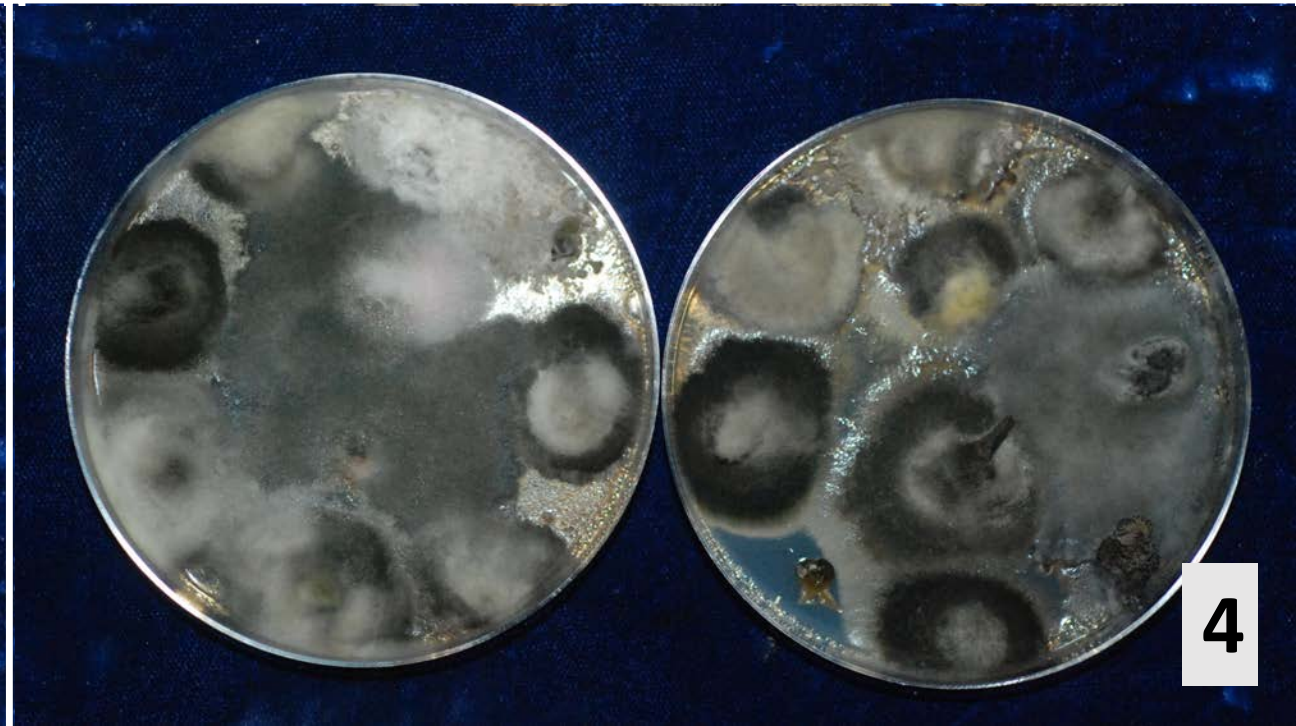


B) Monitoring of Botryosphaeria with **BUDMON** (**BUD MON**ITORING)









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

Disease Management

- **A. Cultural control:** Prune dead branches or blighted shoots (reduce inoculum in the orchard), avoid sprinkler irrigation that wets the canopy (use sprinklers with low (12˚) trajectory angle.

  +

- **B. Control of walnut scale:** Walnut scale and other that scales predispose shoots to infection by Botryosphaeria.

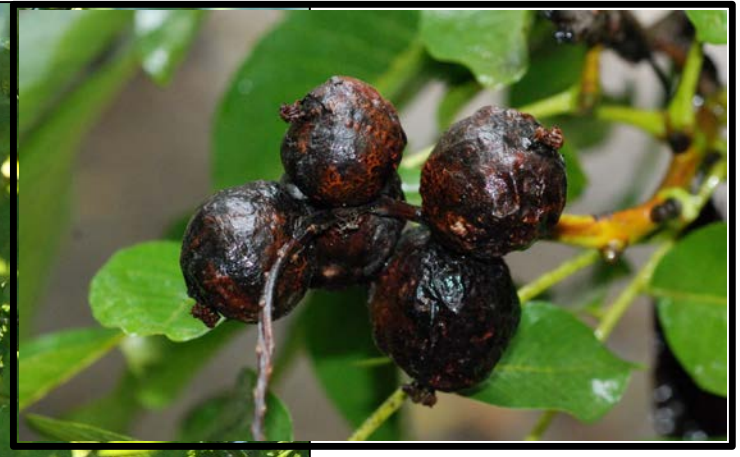
  +

- **C. Chemical control:** Apply effective fungicides (no resistance in these fungi!)

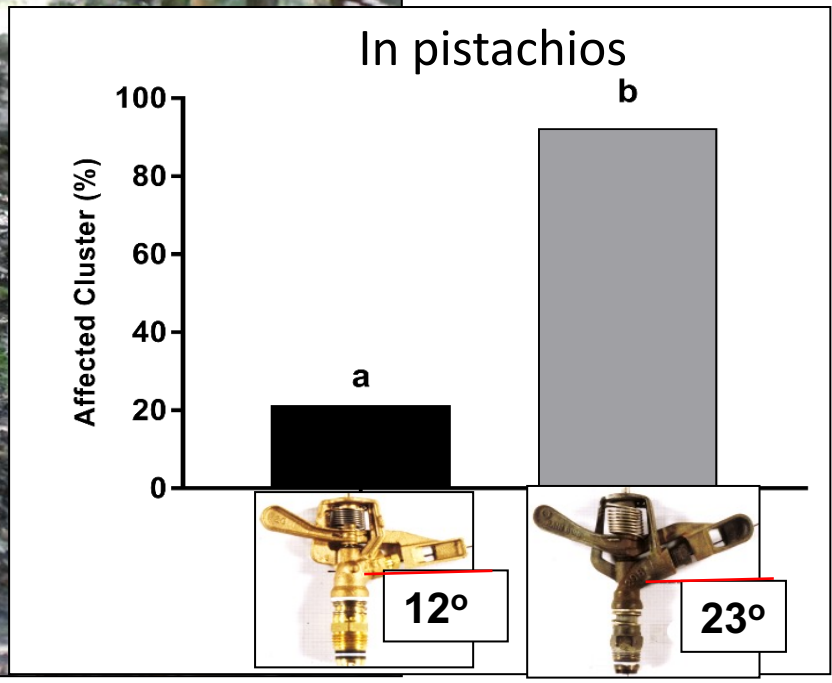
Best management by intergrading cultural, scale, & chemical control practices

A. Cultural Control

1. Irrigation management



° Trajectory angle



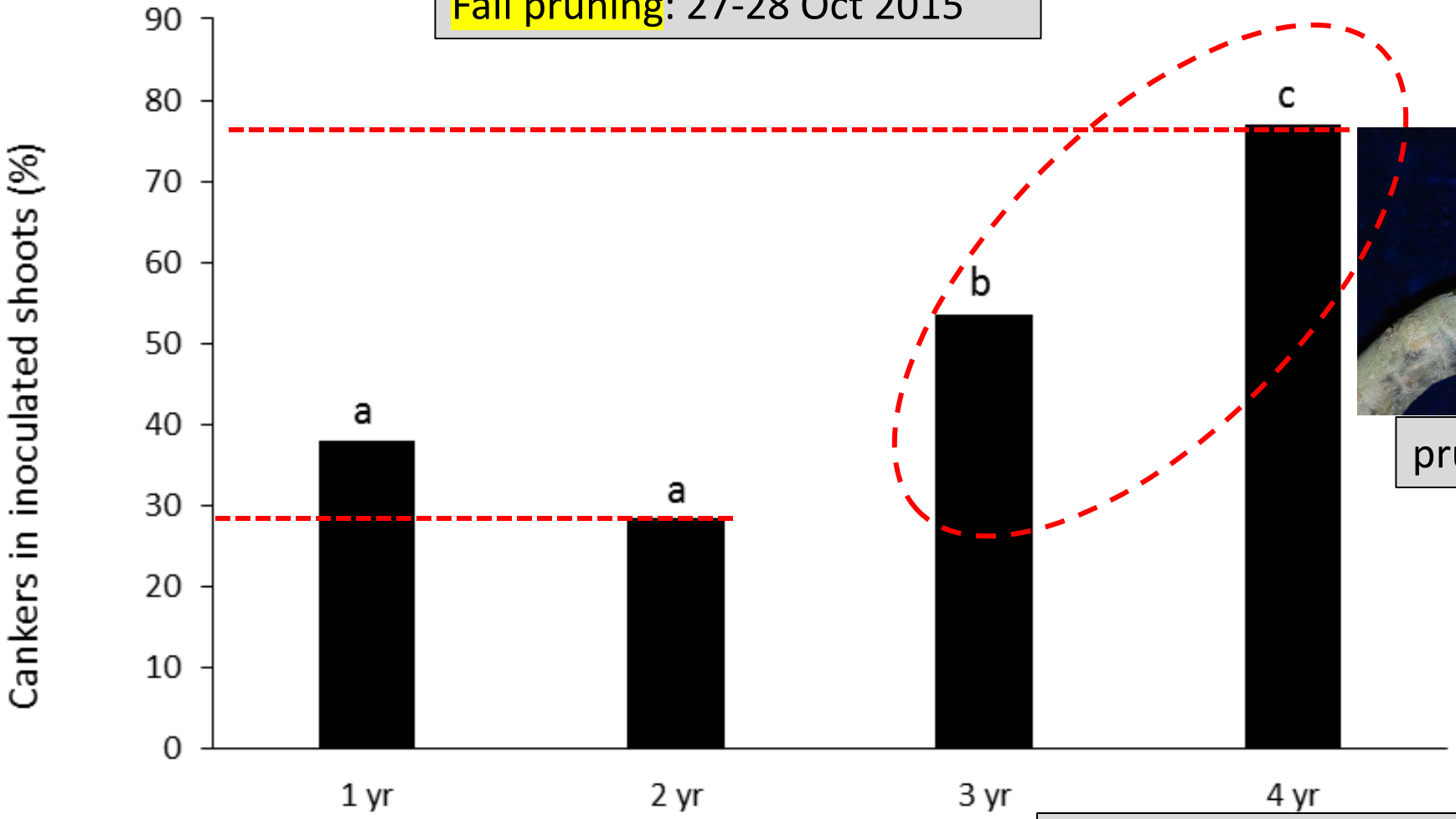
Adjust sprinkler irrigation so it does not wet the tree canopy

A. Cultural Control

2. Sanitation: Fall or Winter pruning; removing pycnidia inoculum.

Susceptibility of pruning wounds of 1-, 2-, 3-, and 4-year-old shoots to infection by Bot after fall pruning

Fall pruning: 27-28 Oct 2015

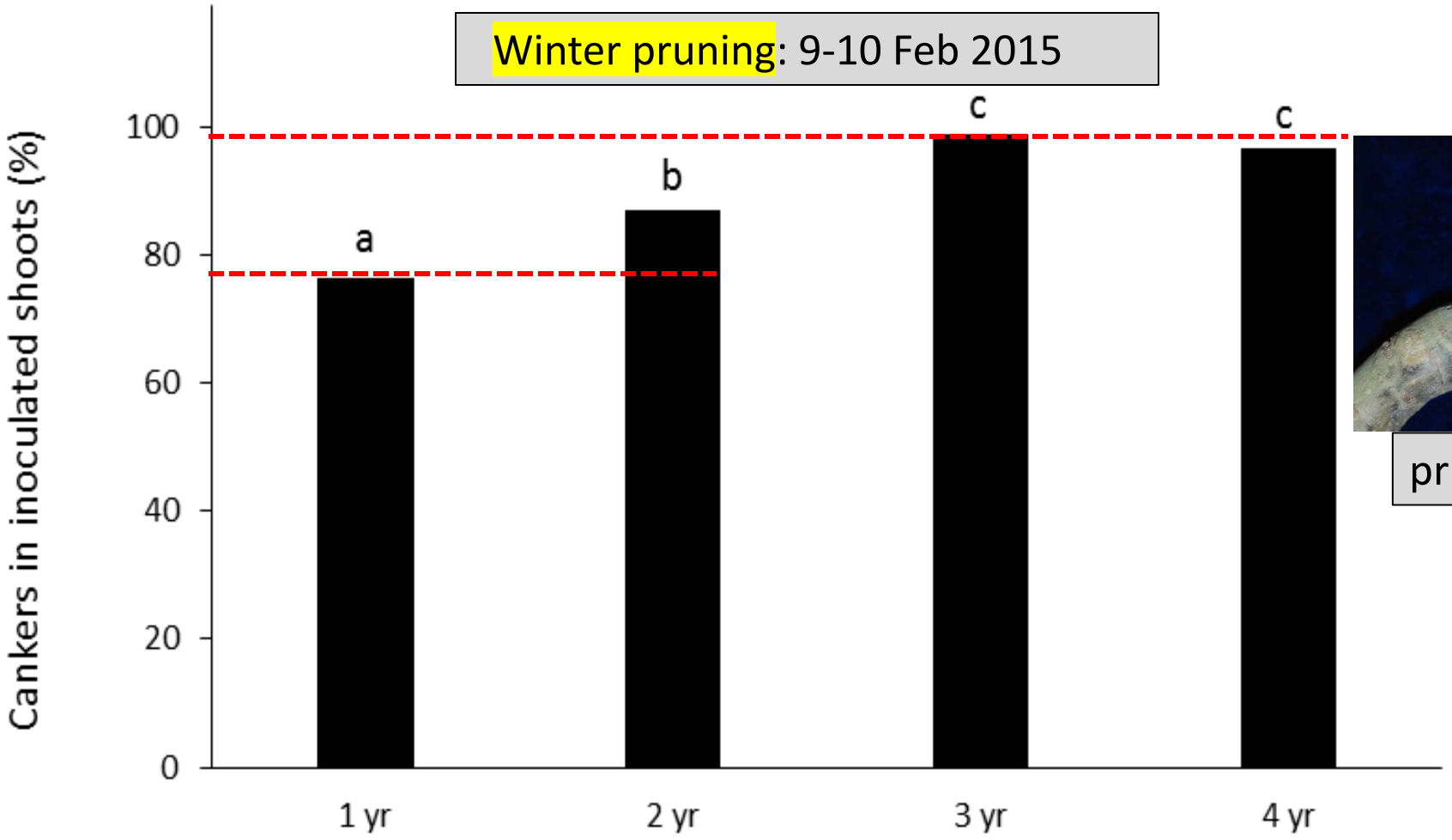


pruning wound

Measurements 14 November 2016:
30 to 75% infected

Susceptibility of pruning wounds of 1-, 2-, 3-, and 4-year-old shoots to infection by Bot after winter pruning

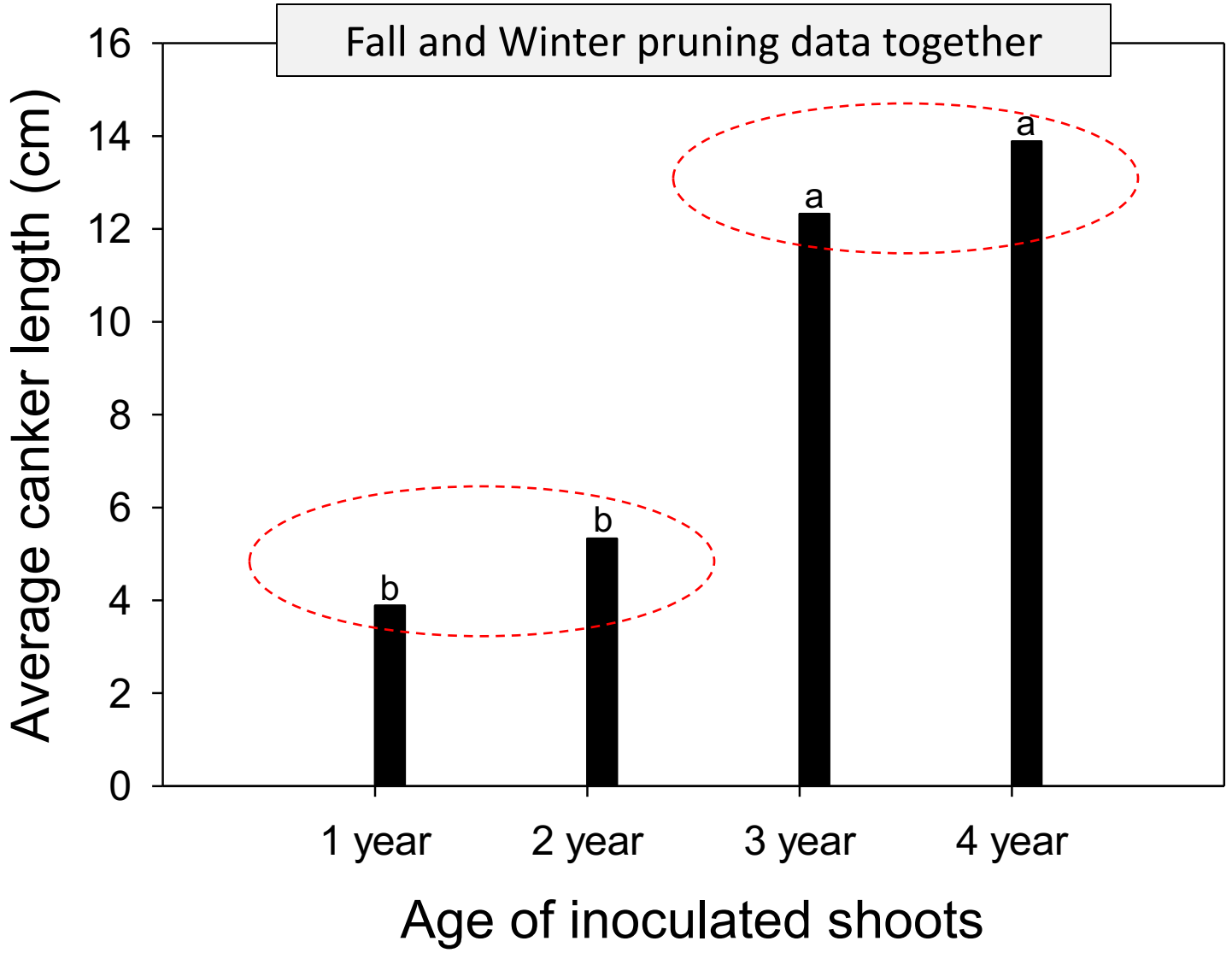
Winter pruning: 9-10 Feb 2015



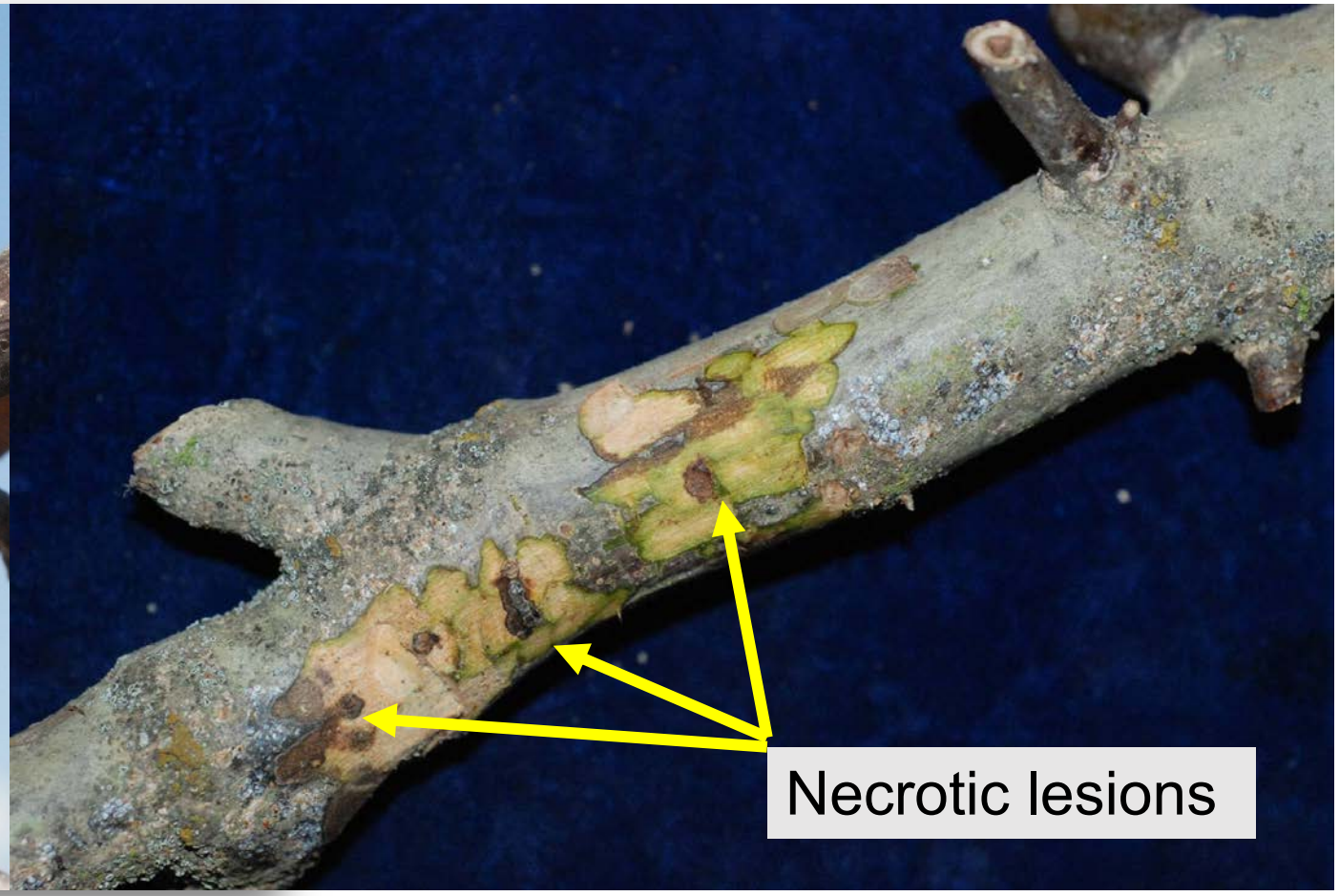
pruning wound

Measurements 4-7 March 2016:
80 to 100% infected

Susceptibility of pruning wounds to infection by Botryosphaeria as affected by age



2. Control of walnut scale (*Quadraspidiotus juglansregiae*)

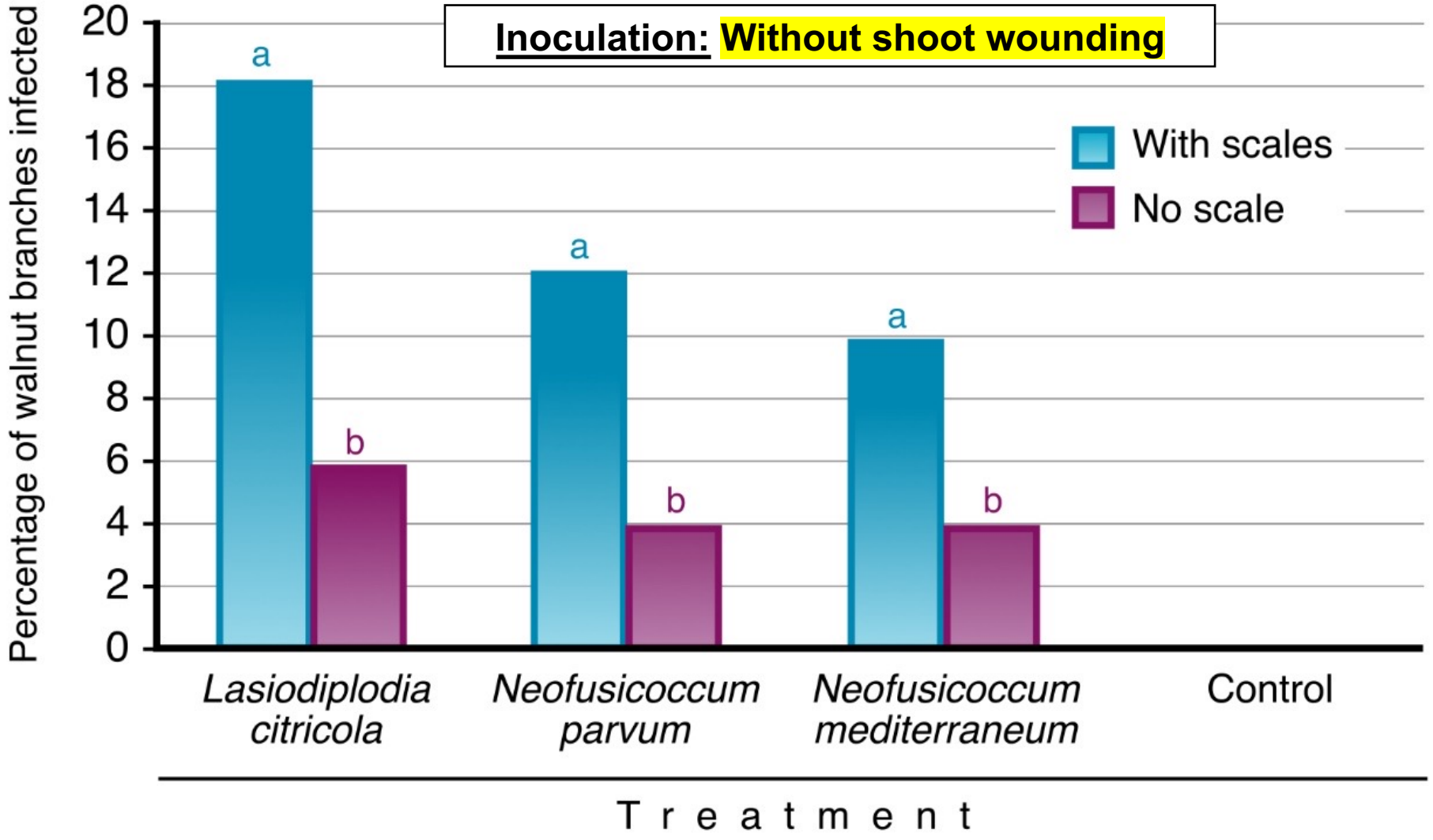


SCALES OF WALNUT:

- ✓ **Walnut scale**
- ✓ San Jose scale
- ✓ European fruit lecanium
- ✓ Italian pear scale

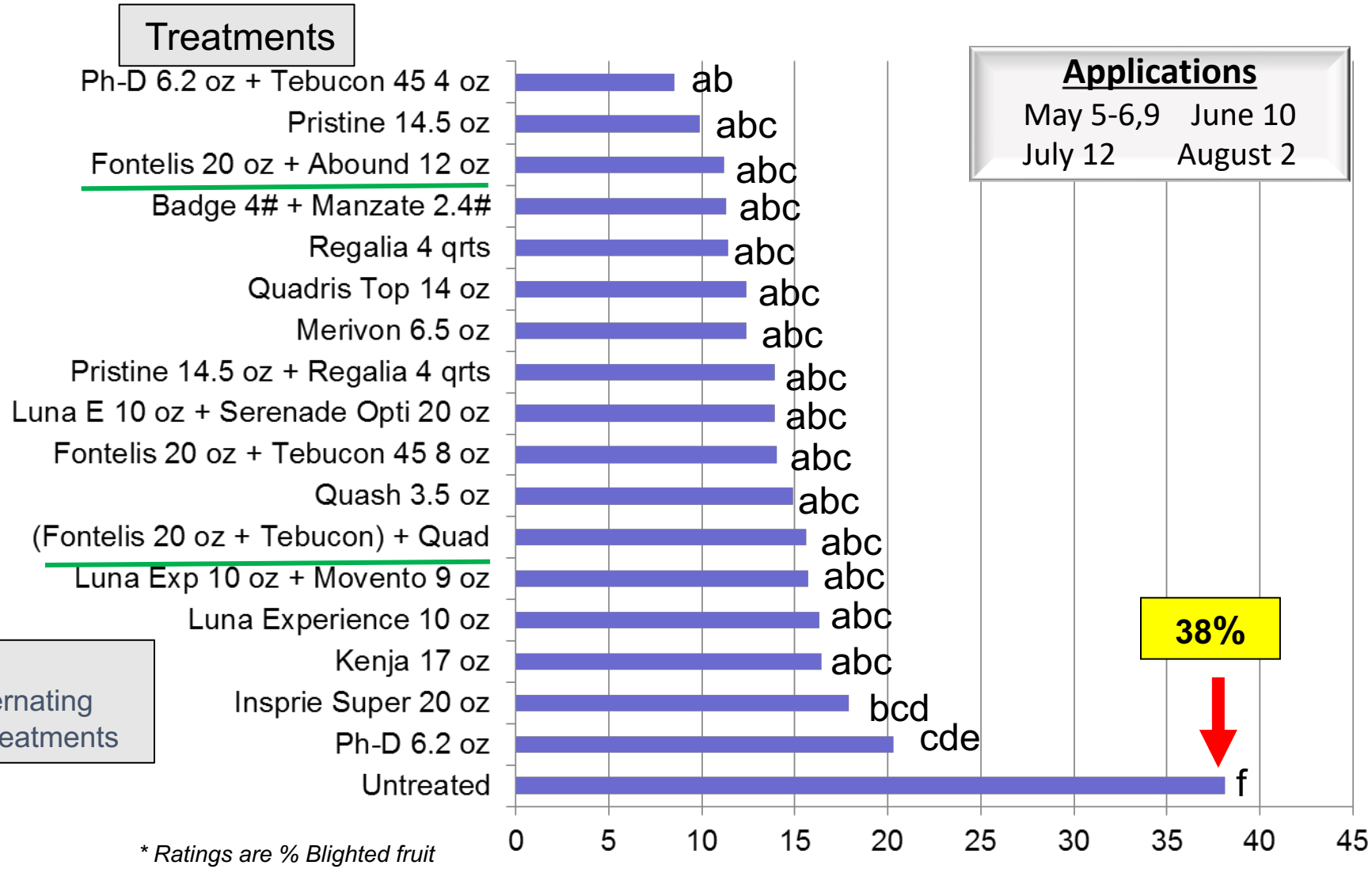
More than 50% of the necrotic lesions had *Botryosphaeria* spp.!

Effect of walnut scale on infection by Botryosphaeriaceae (cv. Vina)



60-75% more shoots were infected when walnut scale was present

3. Chemical Control: Efficacy of treatments against Botryosphaeria fruit blight
(Chandler walnut, Butte Co., 2016)



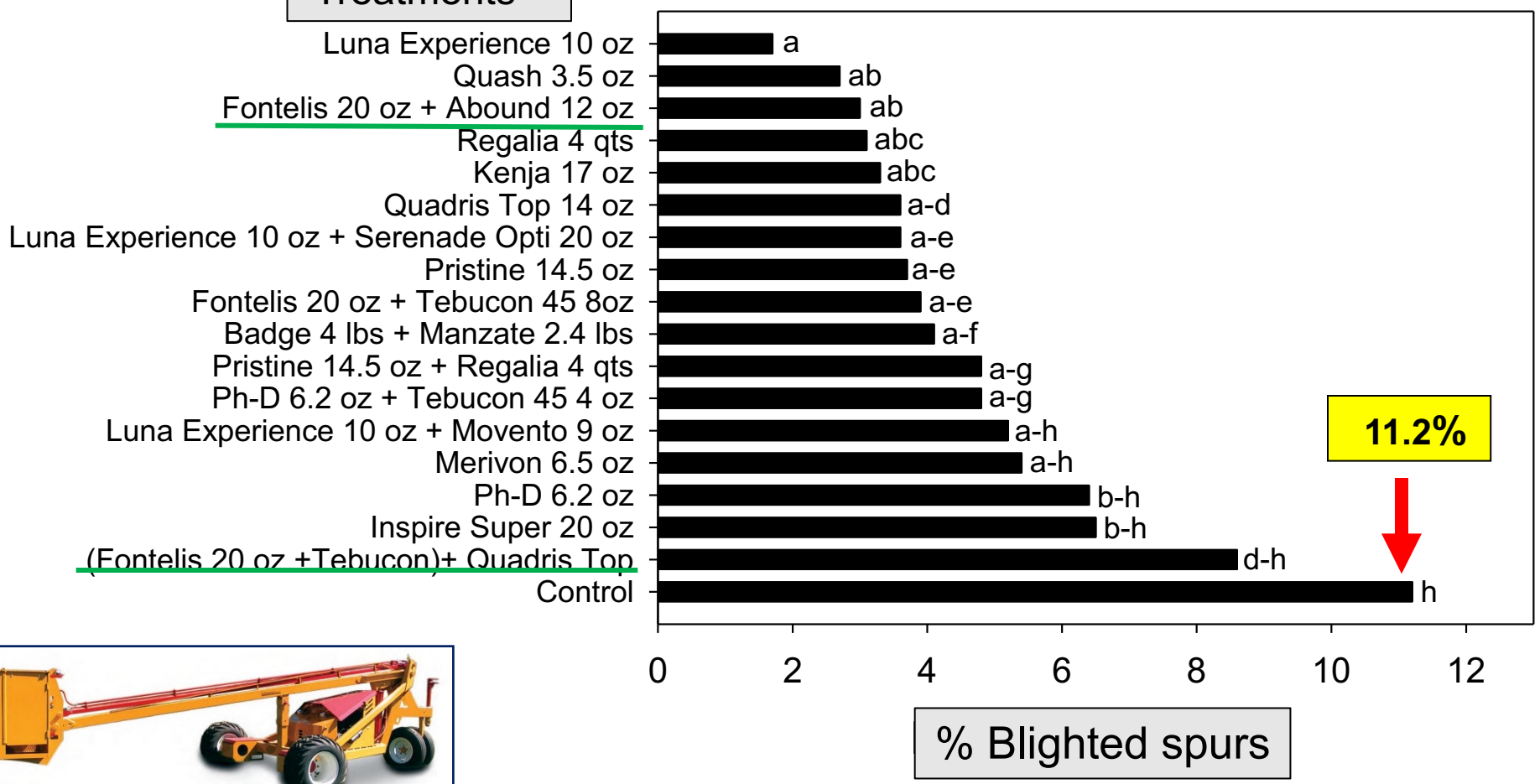
Indicates alternating program of treatments

** Ratings are % Blighted fruit*

Single tree plots, replicated 5 times.
Disease assessments were performed on 7- 20-16

Another example: Efficacy* of treatments against Botryosphaeria **blight of spurs**
(Chandler walnut, Butte Co., 2016)

Applications
May 5-6,9 June 10
July 12 August 2



YIELD REDUCTION IN THIS ORCHARD IN 2016 & 2017

Brown (blighted)

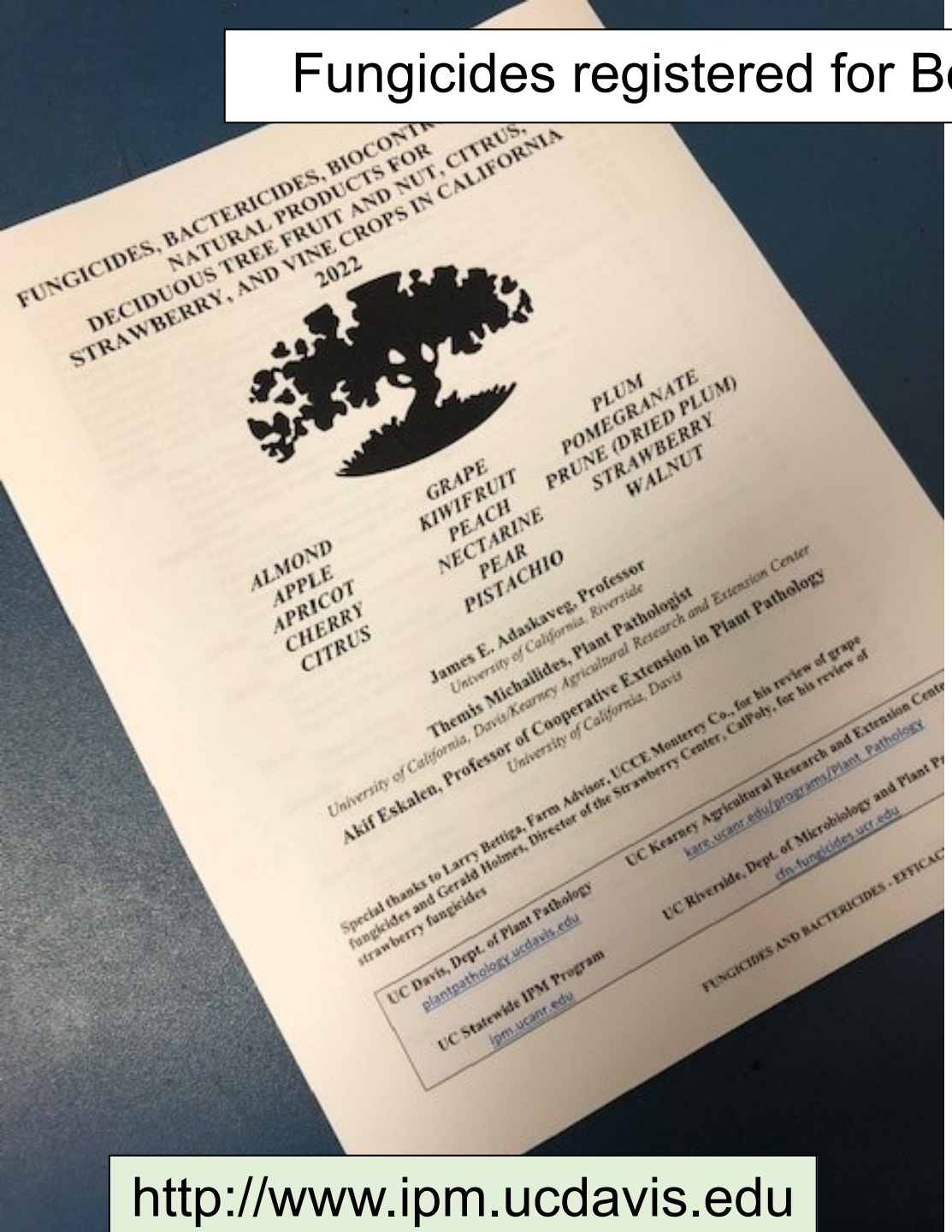
Black (blighted)

TREES NOT SPRAYED WITH FUNGICIDES HAD:

Blighted fruit 38% x 0.8^{BOT} = **30% blighted fruit due to Bot in 2016**

In the same year: 11.2% killed spurs due to Bot: 11.2% x 2 fruiting buds each x 2 fruit per bud = 4 fruit/spur = **44.8 blighted fruit are lost** out of 100 blighted spurs (potential **yield loss for 2017**)

Fungicides registered for Botryosphaeria canker and blight of walnut



http://www.ipm.ucdavis.edu

Fungicide	Active ingredient (FRAC)	Efficacy
Abound ……..	azoxystrobin (11)	**4**
Caprio ……	pyraclostrobin (11)	**4**
Flint Extra……	trifloxystrobin (11)	**4**
Inspire Super….	difenoconazole + cyprodinil (3/9)	**4/5**
Quadris Top……	azoxystrobin+defenoconazole(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	pydiflumedofen + 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 control ; 4 = good & reliable control

Conclusions

1. Botryosphaeria canker and blight of walnut can be a very devastating disease **by reducing yield in rainy years.**

2. **All the green parts** of walnut can be infected, except the leaves.

3. Pruning wounds are susceptible for at least 4 months due to the pith acting like **a sponge in rainy weather**. Fall pruning is better than winter pruning.

4. Walnut scale predisposes branches and shoots to infection leading to shoot blight and **needs to be controlled**.

5. Effective management by combining pruning of dead wood, control of walnut scale, and fungicide sprays in the spring (April to end mid-July). A fungicide program should be definitely used **in rainy years.**

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