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# Dealing with Botryosphaeria in Walnuts

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**YOLO COUNTY MEETING, WOODLAND**

**21 July, 2014**

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UNIVERSITY OF CALIFORNIA  
COLLEGE OF AGRICULTURE  
AGRICULTURAL EXPERIMENT STATION  
BERKELEY, CALIFORNIA

Melaxuma of the Walnut “*Juglans regia*”  
(A PRELIMINARY REPORT)

By HOWARD S. FAWCETT

BULLETIN No. 261

Berkeley, Cal., November, 1915

Nov 1915

Caused by *Botryosphaeria ribis*

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**Botryosphaeria Dieback**  
**(Botryosphaeria/Phomopsis Canker and Blight)**

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Are all these branch wilt?

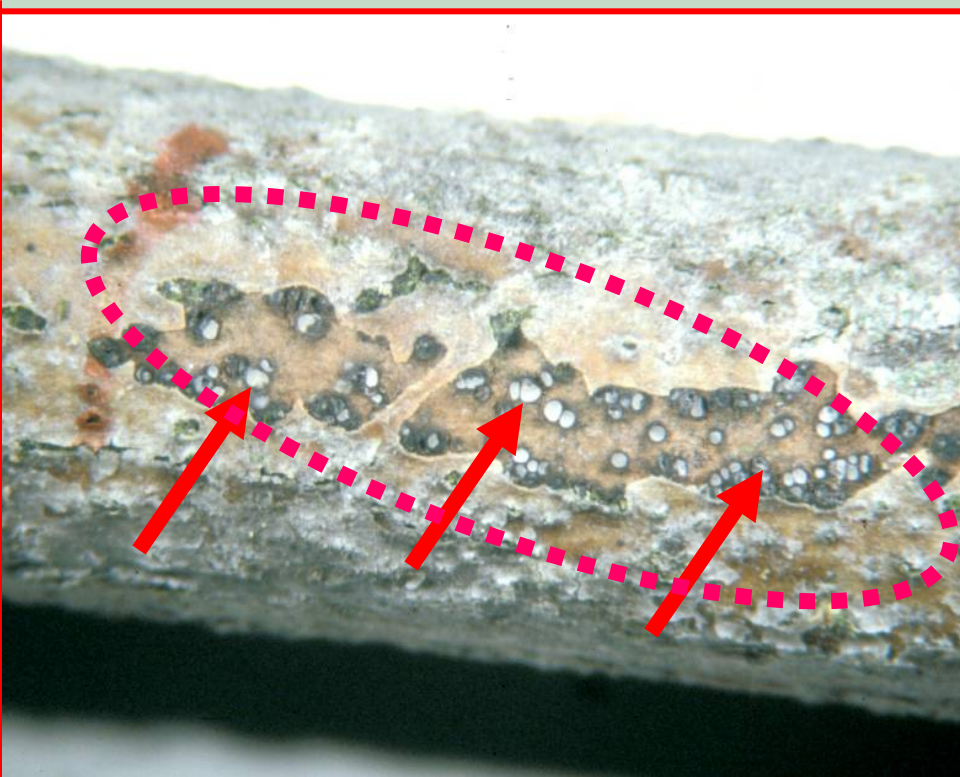




Branch wilt is caused by *Hendersonula toruloidea*  
New name: *Neoscytalidium dimittatum*



Cankers loaded with pycnidia of *Botryosphaeria*  
and/or of *Phomopsis*

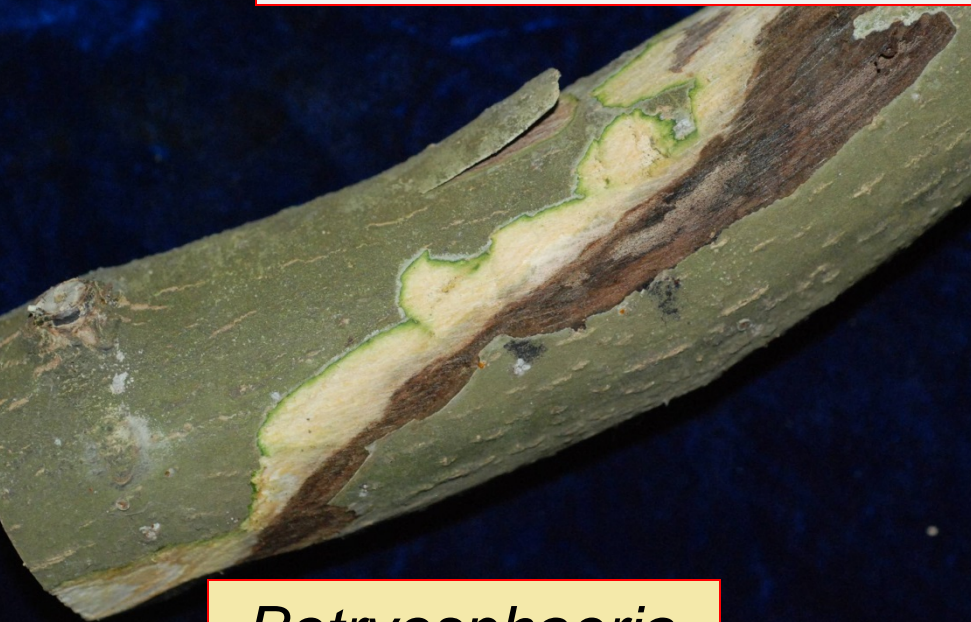


**Six types of symptoms caused by**  
**Botryosphaeria /Phomopsis:**  
**1. Cankers and blighted branches**

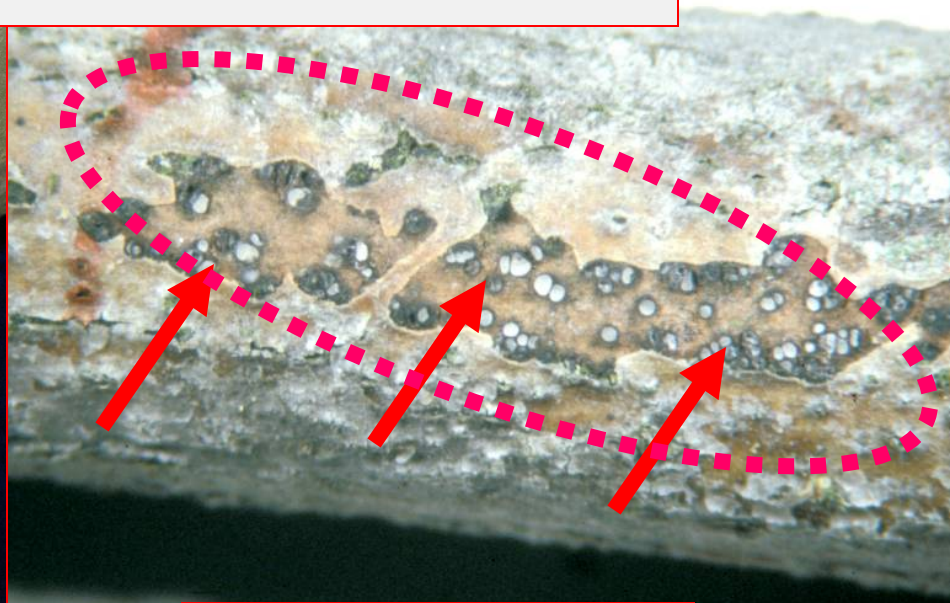




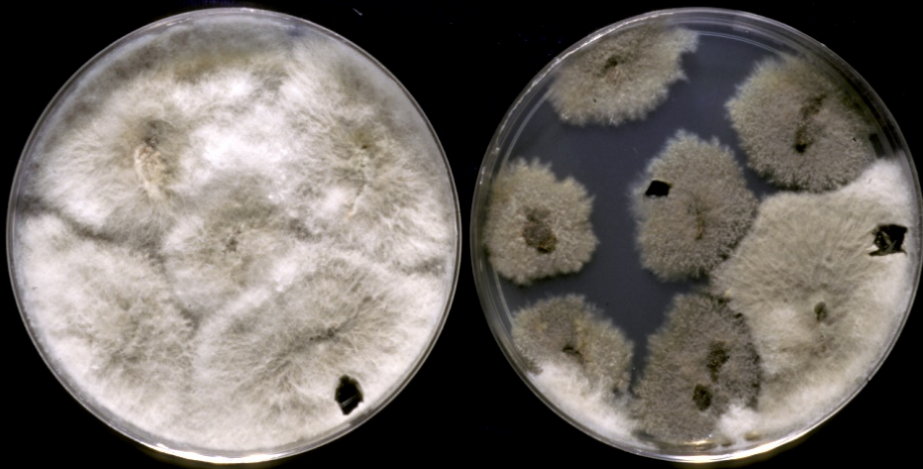
Fungi isolated from these branches

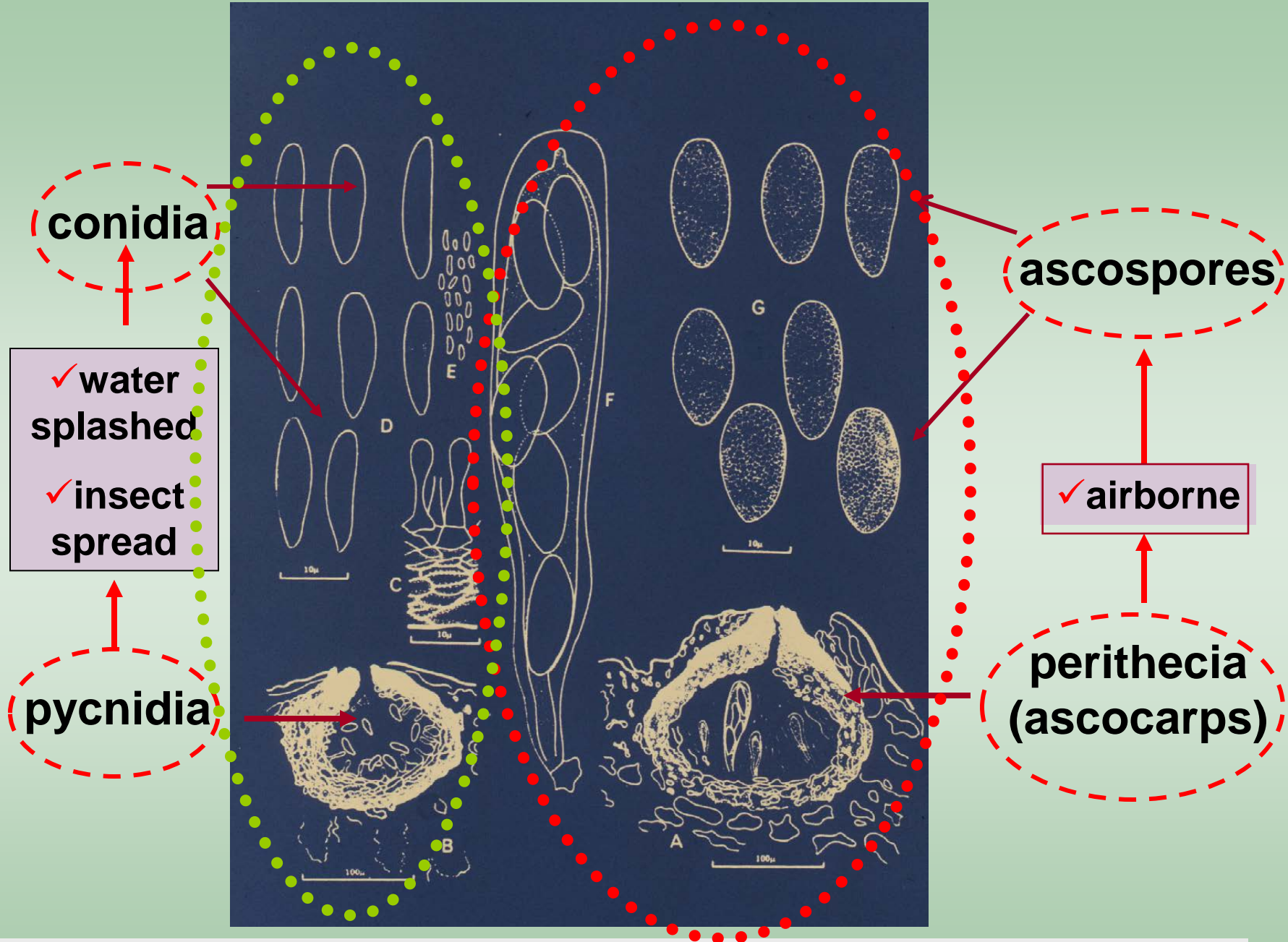


*Botryosphaeria*



*Phomopsis* spp.





***Botryosphaeria* reproductive structures in walnut**

# *Botryosphaeria dothidea*

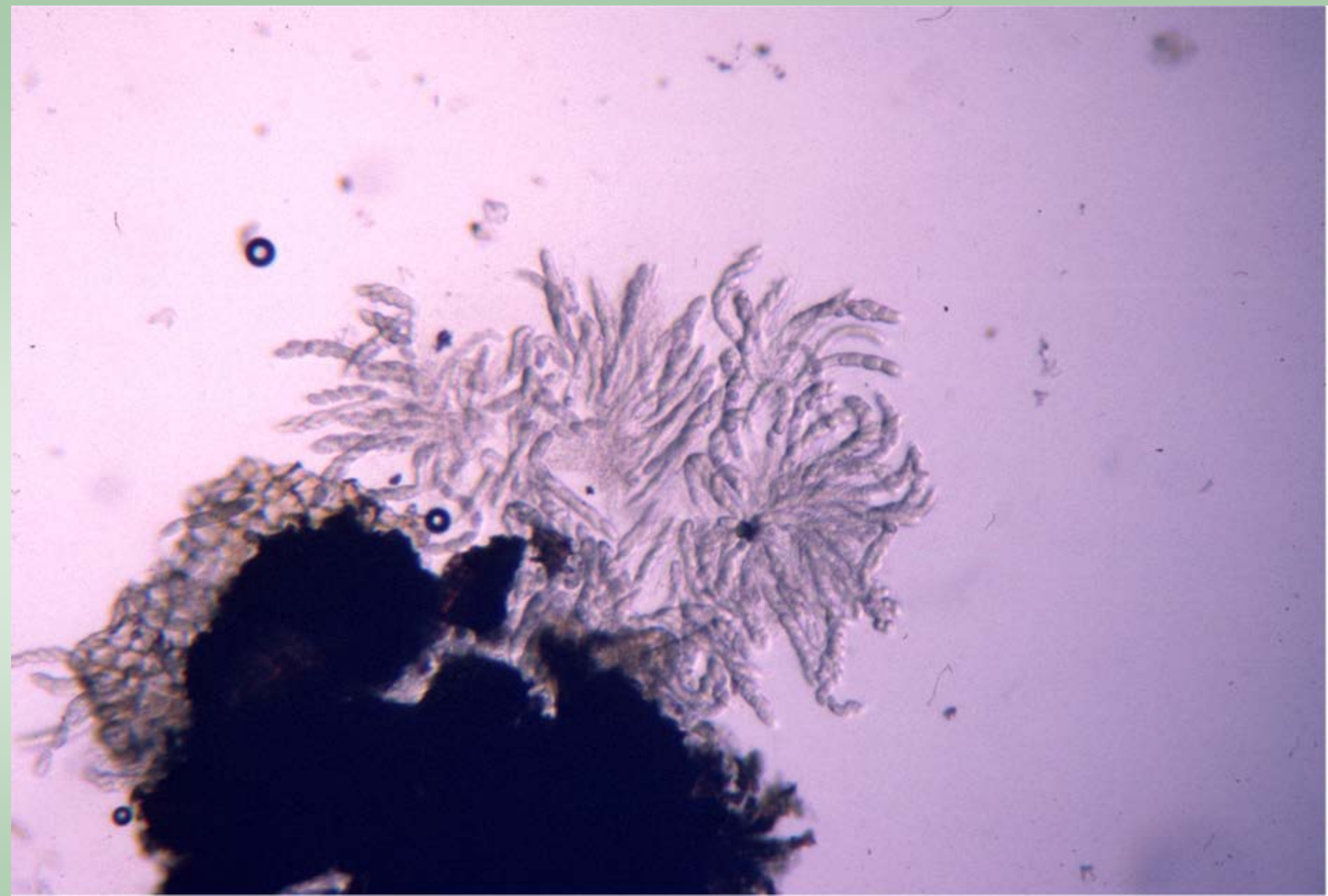
Wind-borne

Water-borne



Perithecia:  
Sexual stage

Pycnidia: Asexual stage



**Perithecia produce airborne ascospores**

# Oozing pycnidia



Spores



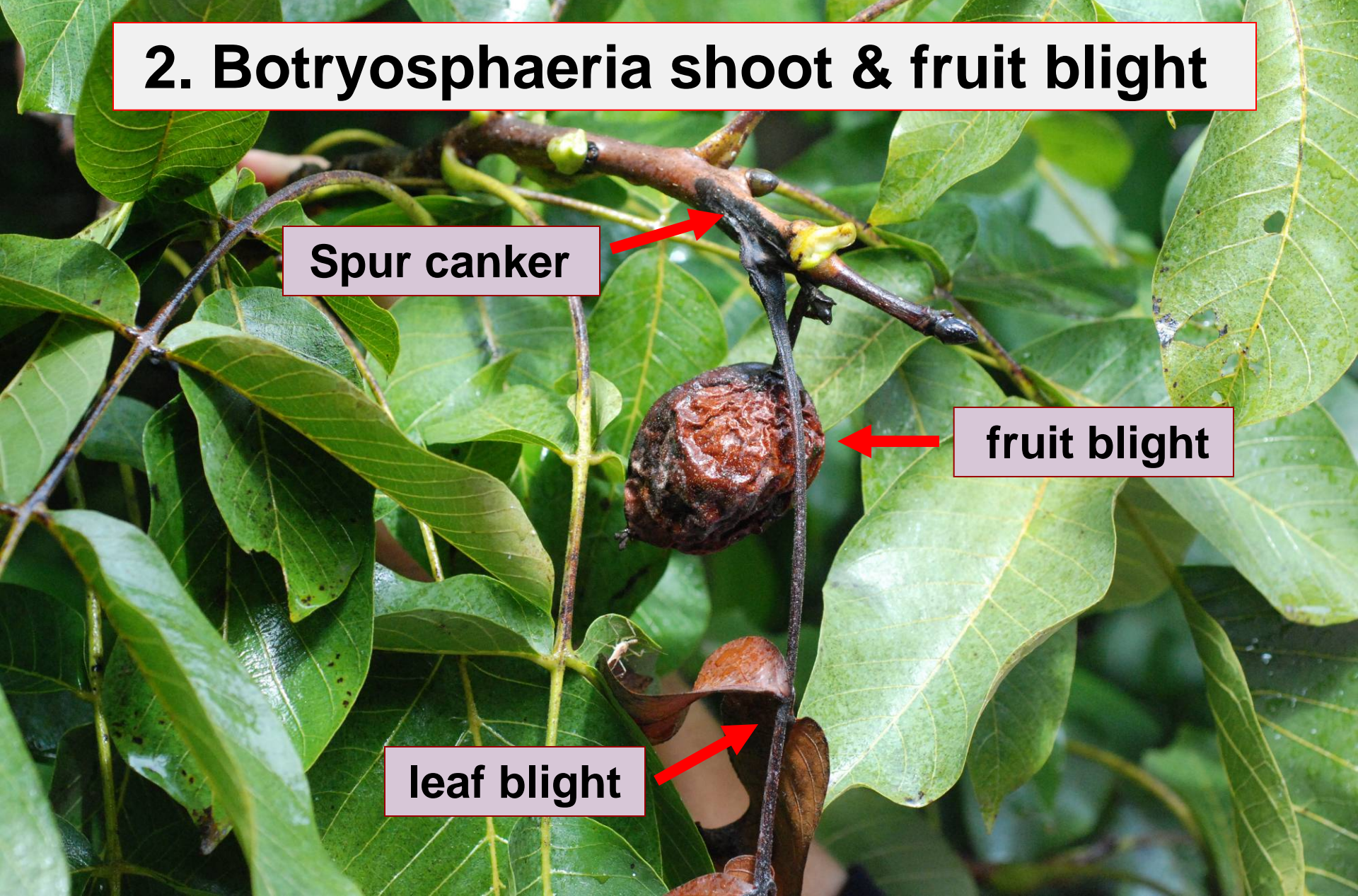
## 2. Botryosphaeria shoot & fruit blight

Spur canker

fruit blight

leaf blight

Botryosphaeria blight





September 15, 2011, Stanislaus Co.





July 3, 2014, Yolo Co.



Botryosphaeria fruit blight: Notice **peduncles attached!**

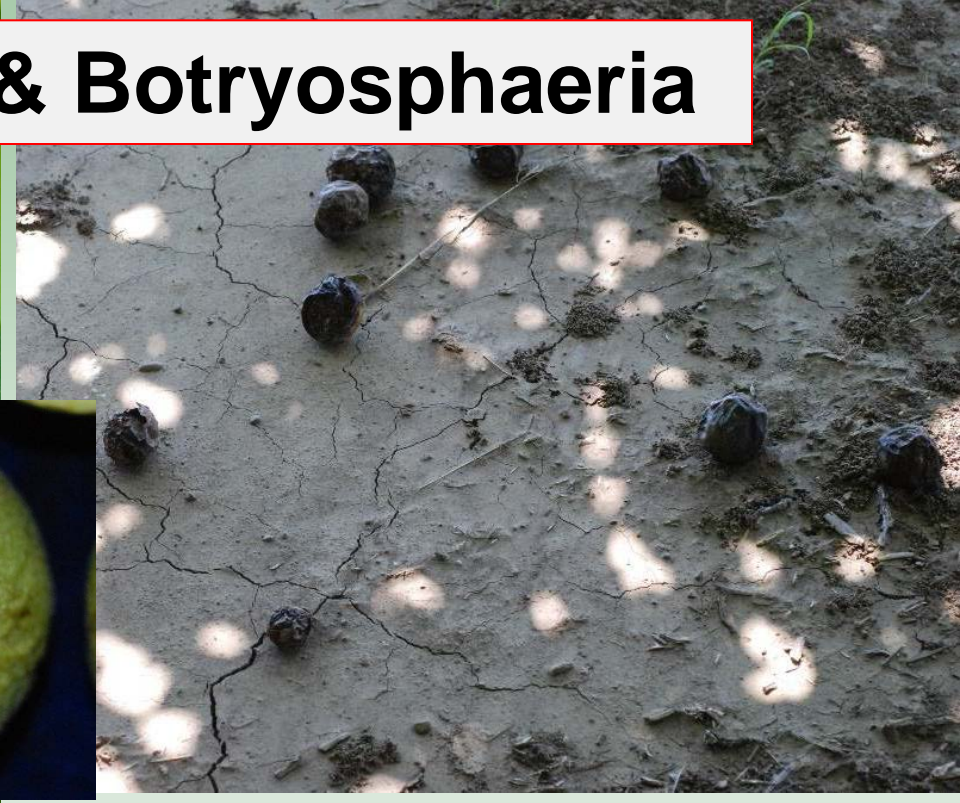
*Botryosphaeria* sp.

Shell staining and kernel decay

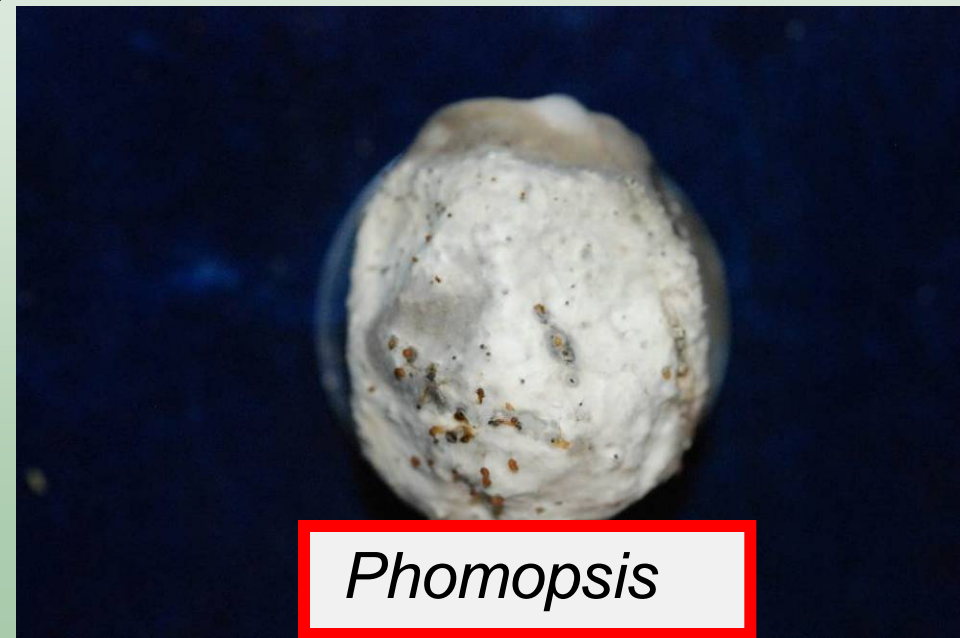




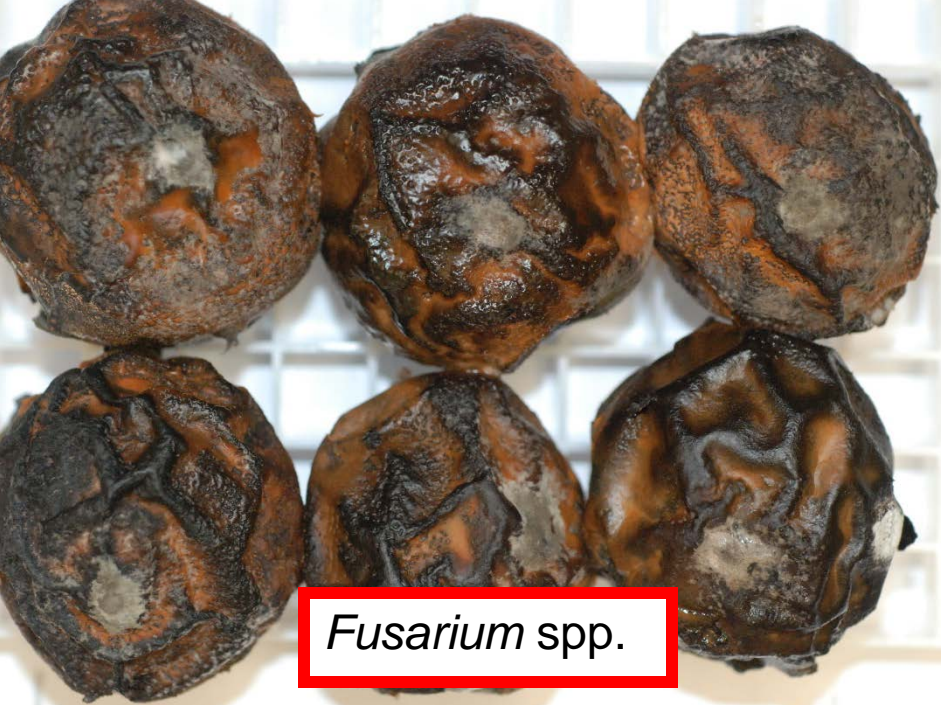
### 3. Walnut Blight & Botryosphaeria



*Botryosphaeria*



*Phomopsis*



*Fusarium* spp.



*Alternaria alternata*



*Gloeosporium*.



*Colletotrichum acutatum*

# Incidence of fungal pathogens isolated from blighted walnuts fruit collected from trees

Orchard	Collection	Walnut blight (%)	Botryosph. /Phom (%)	Other fungi (%)
1	Tree	+20	10	<i>Botryosphaeria</i>
2	Tree	+10	10	<i>Phomopsis</i>
3	Tree	+10	20	<i>Fusarium</i>
4	Tree	+20	30	<i>Alternaria</i>
5	Tree	–	50	<i>Gloeosporium</i>
6	Tree	–	0	<i>Aspergillus niger</i>
7	Tree	+	0	<i>Epicoccum</i>
				<i>Colletotrichum</i>

Is walnut blight an entry for *Botryosphaeria* infections?

# Incidence of fungal pathogens isolated from blighted fruit (collected from trees & ground)

Orchard	Collection	Walnut blight	Botryosph. /Phom (%)	Fusarium (%)
1	Tree	+	20	<i>Botryosphaeria</i>
2	Tree	-	12	<i>Phomopsis</i>
3	Tree	+	11	<i>Fusarium</i>
4	Tree	ND	80	<i>Alternaria</i>
				<i>Gloeosporium</i>
				<i>Aspergillus niger</i>
1	Ground	+	67	<i>Epicoccum</i>
				<i>Colletotrichum</i>

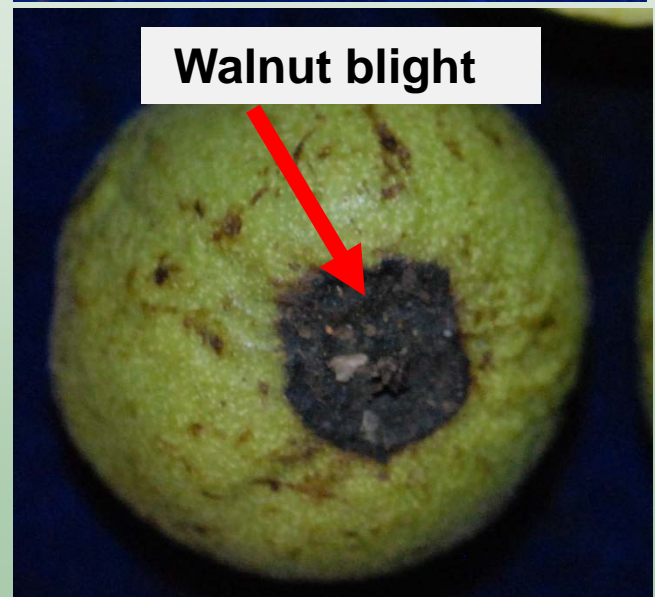
The association of **walnut blight** with **Botryosphaeria** & **other fungi** needs to be studied in detail...



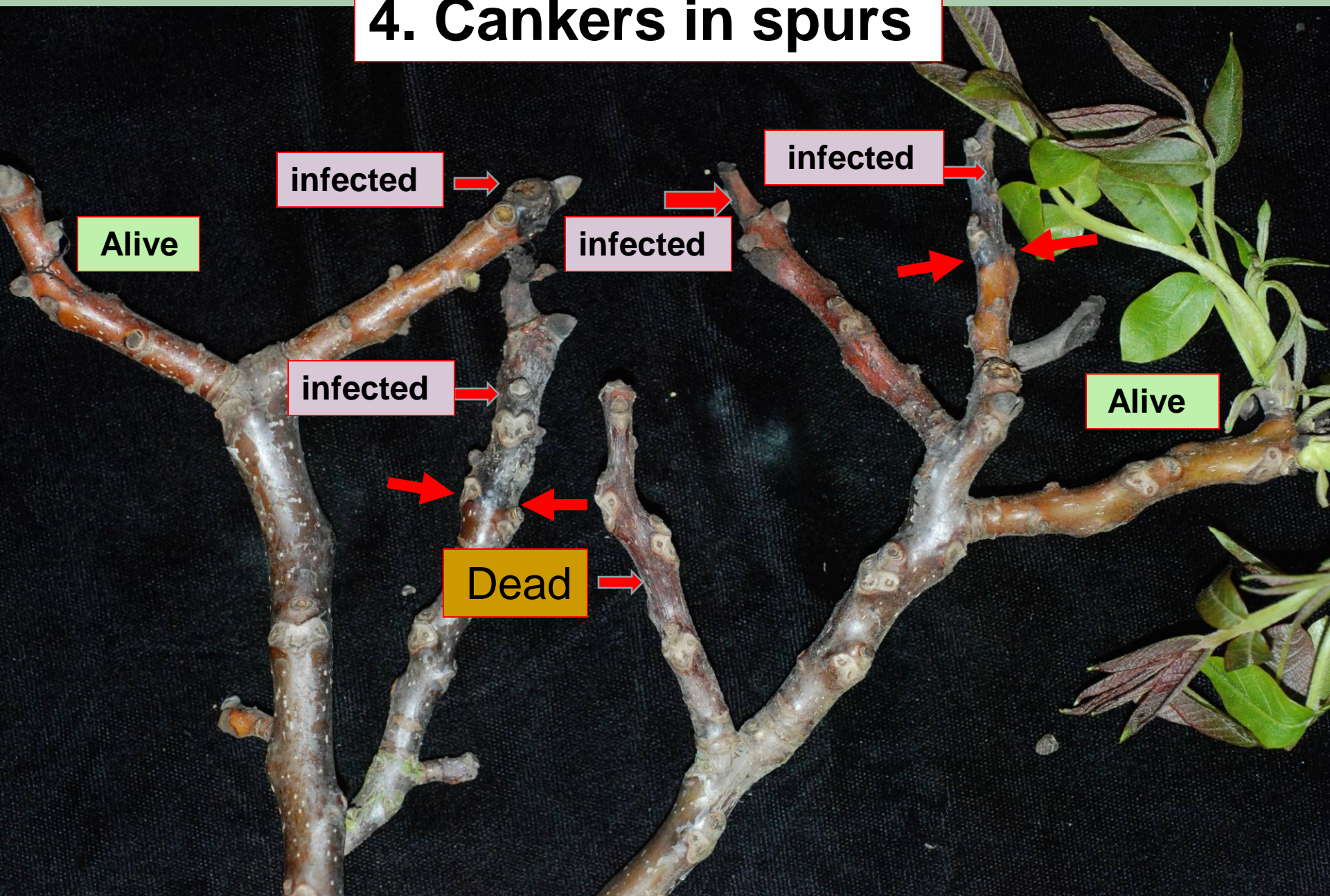
# Brown Apical Necrosis (BAN)



**Walnut blight**



# 4. Cankers in spurs



Spur dieback



Frost damage

# Spur blight, killed buds, and canker

**4 BUDS DEAD!**

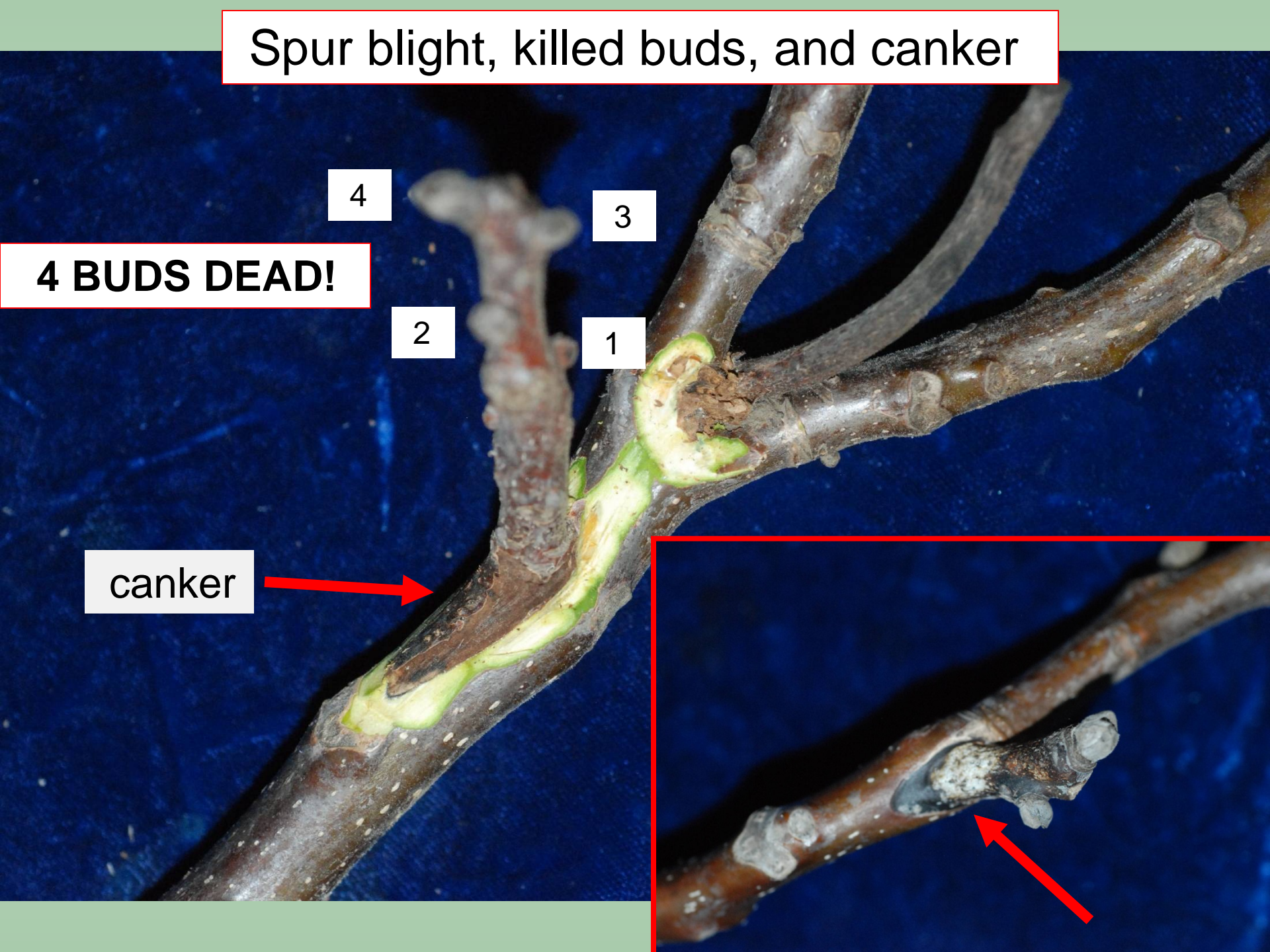
4

3

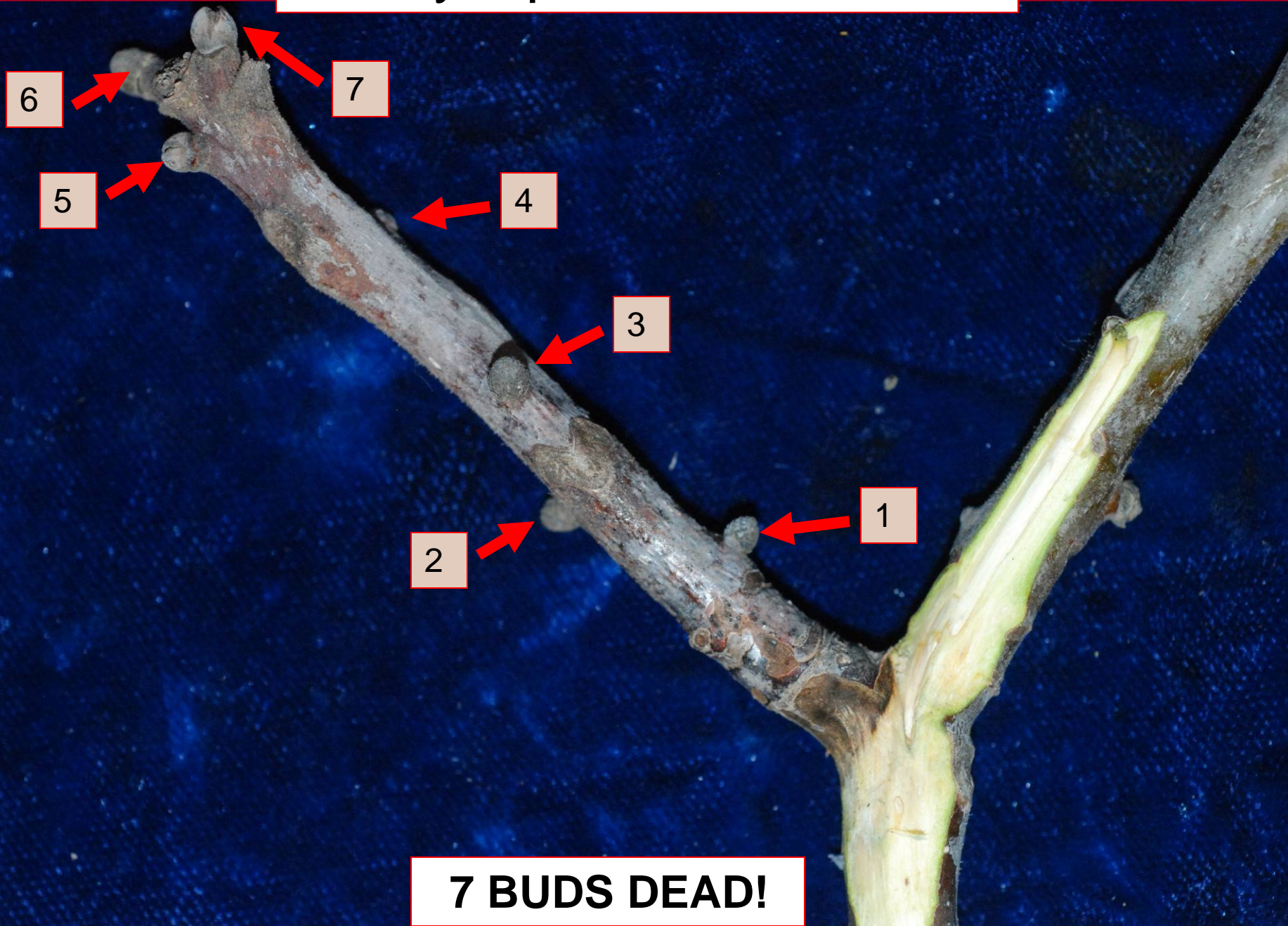
2

1

canker

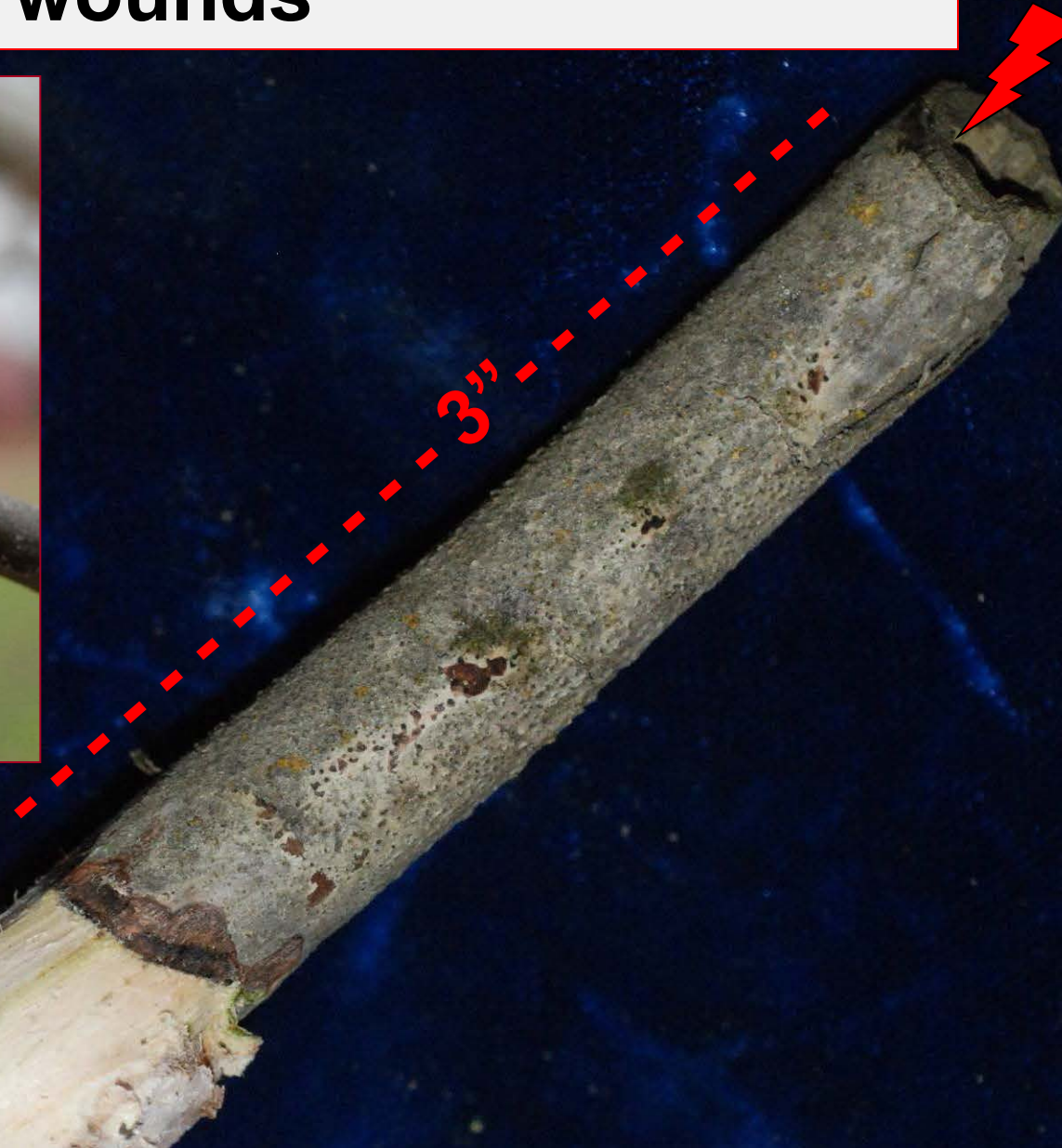
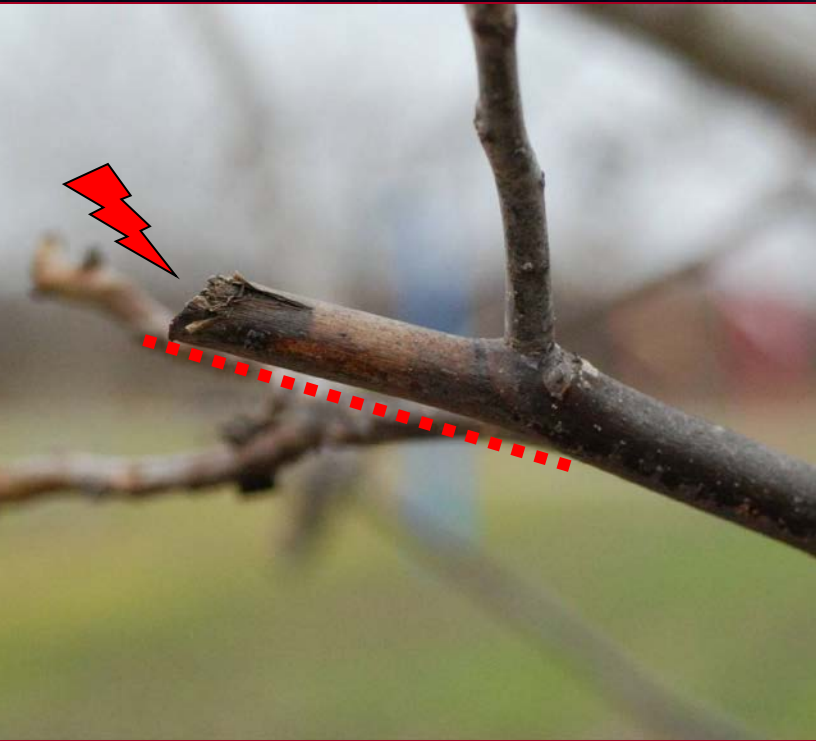


# Botryosphaeria kills buds



**7 BUDS DEAD!**

## 5. Cankers associated with pruning wounds

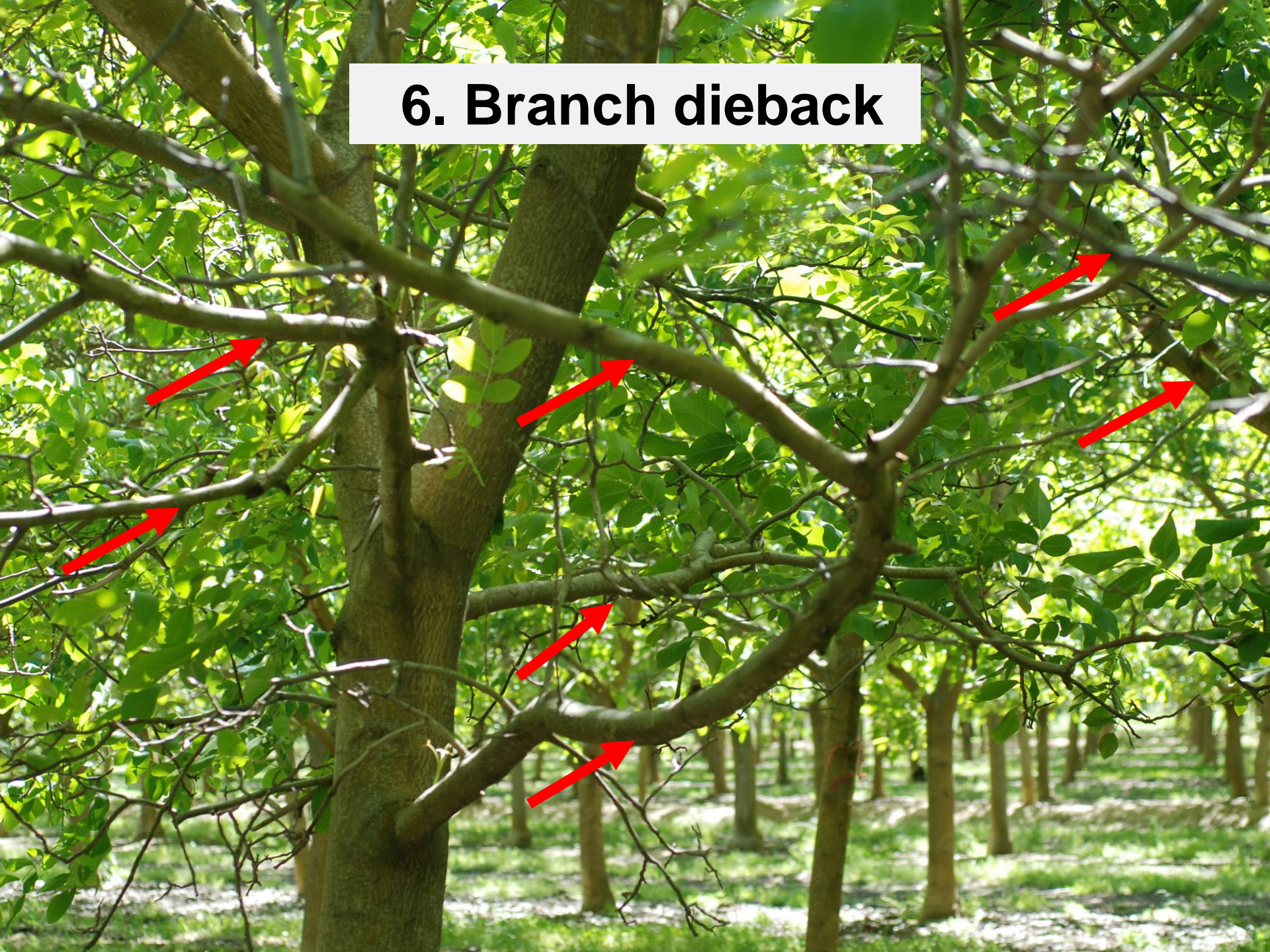




**Cultivar: Howard**

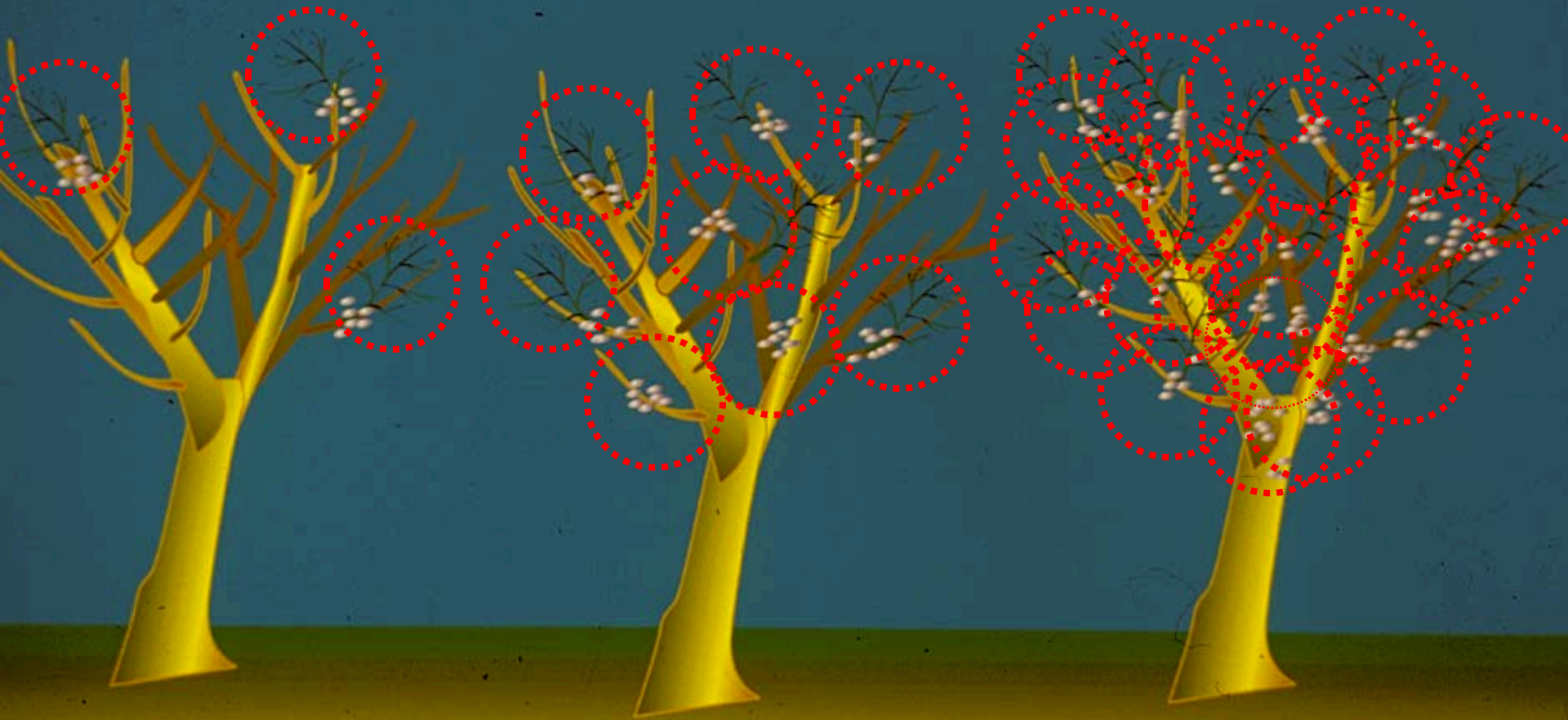
**Plenty of light; no shade;  
however, a lot of dead  
wood!**

## 6. Branch dieback

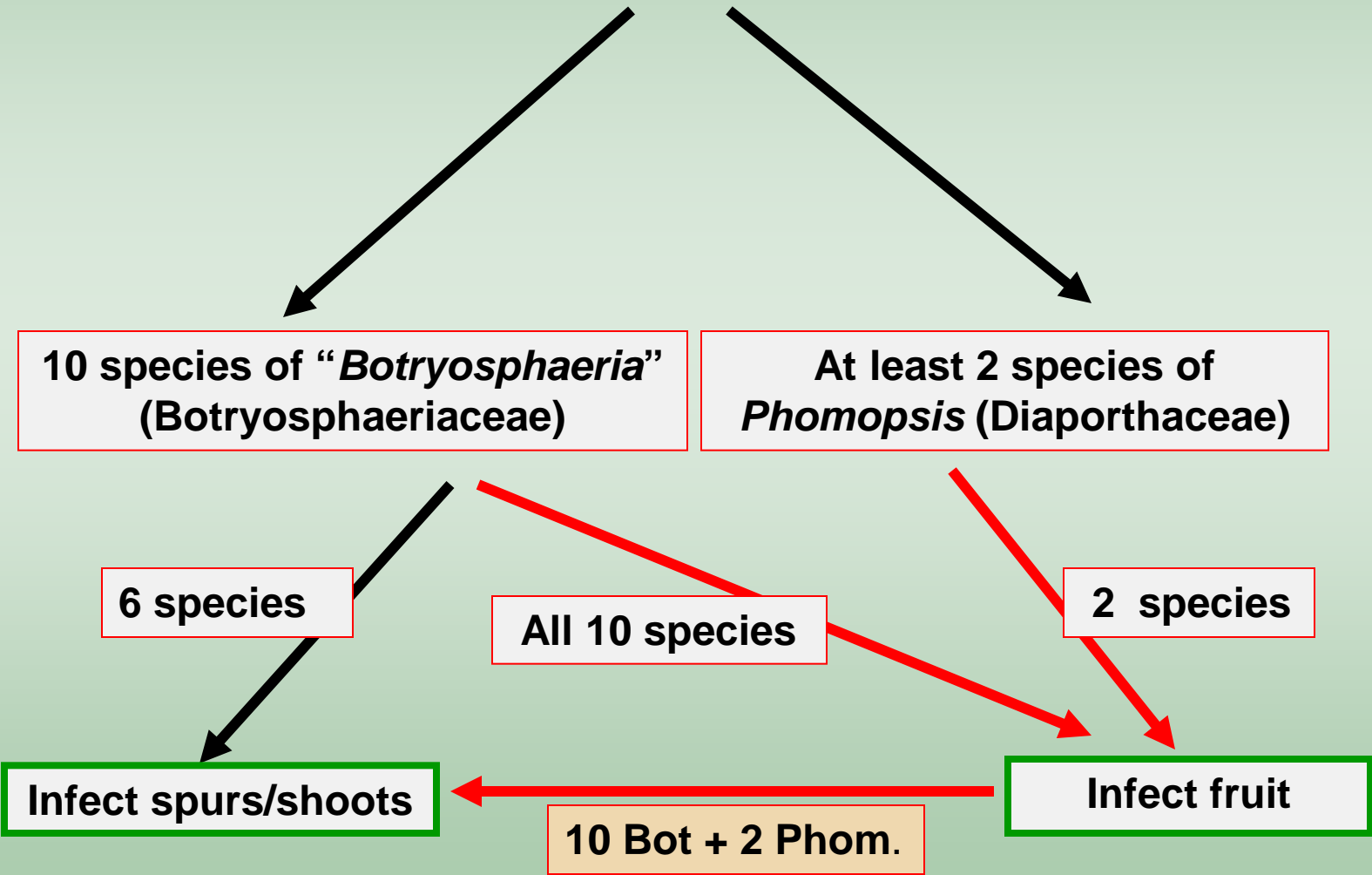


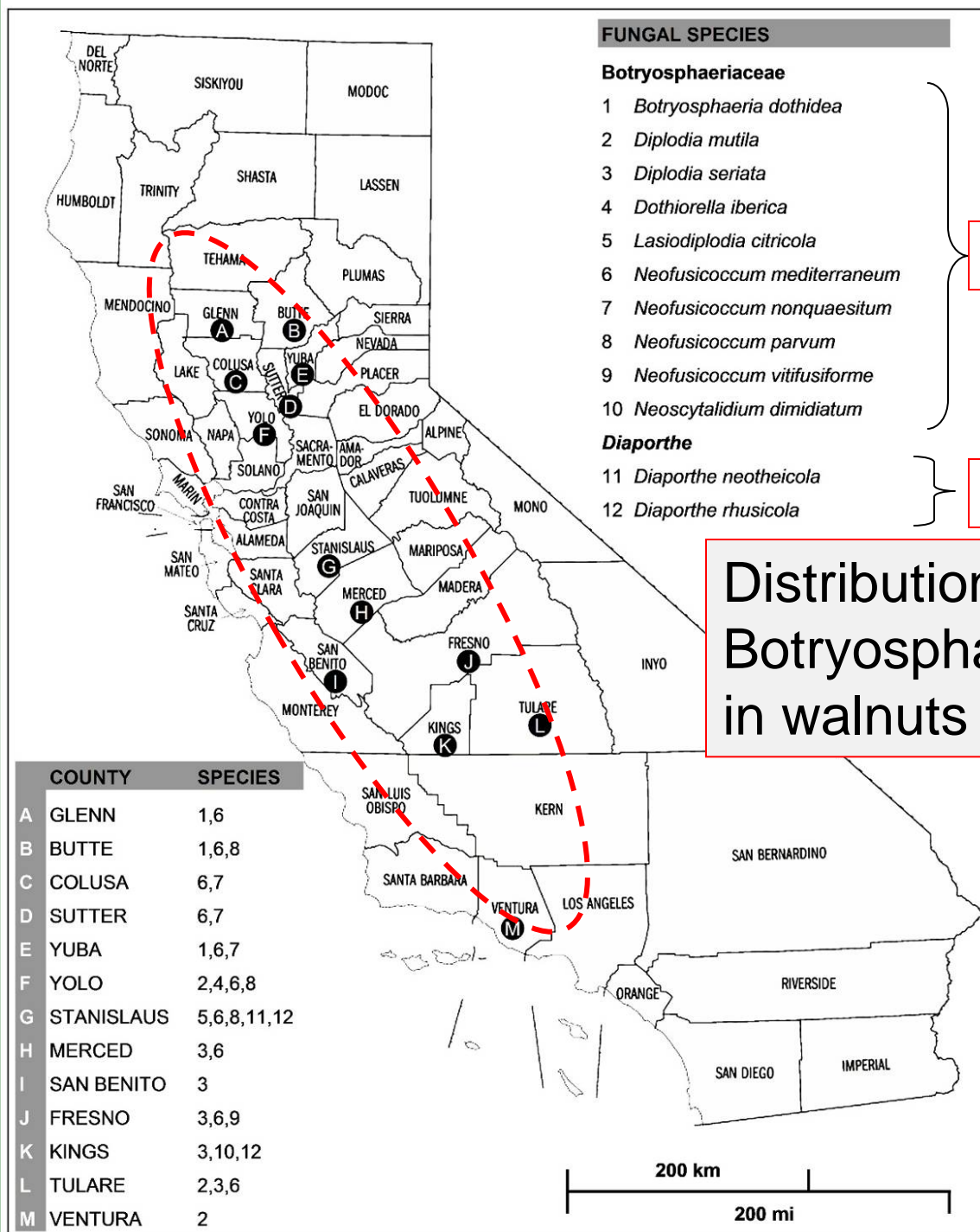


# Inoculum Build-up



# The pathogens





**FUNGAL SPECIES**

**Botryosphaeriaceae**

- 1 *Botryosphaeria dothidea*
- 2 *Diplodia mutila*
- 3 *Diplodia seriata*
- 4 *Dothiorella iberica*
- 5 *Lasiodiplodia citricola*
- 6 *Neofusicoccum mediterraneum*
- 7 *Neofusicoccum nonquaesitum*
- 8 *Neofusicoccum parvum*
- 9 *Neofusicoccum vitifusiforme*
- 10 *Neoscytalidium dimidiatum*

**Botryosphaeria**

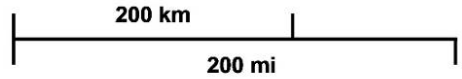
**Diaporthe**

- 11 *Diaporthe neotheicola*
- 12 *Diaporthe rhusicola*

**Phomopsis**

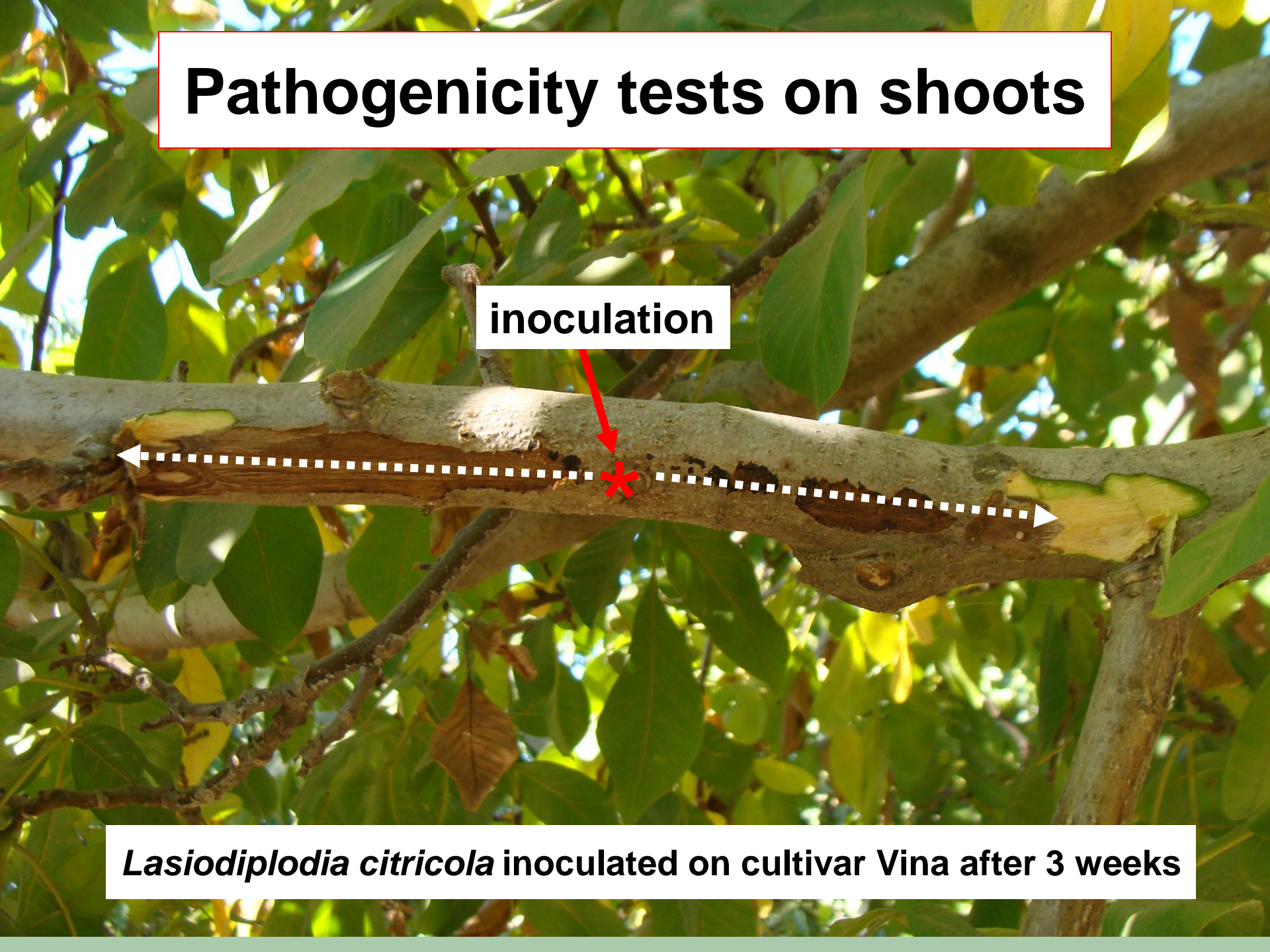
**Distribution of Botryosphaeriaceae in walnuts**

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



# Pathogenicity tests on shoots

inoculation

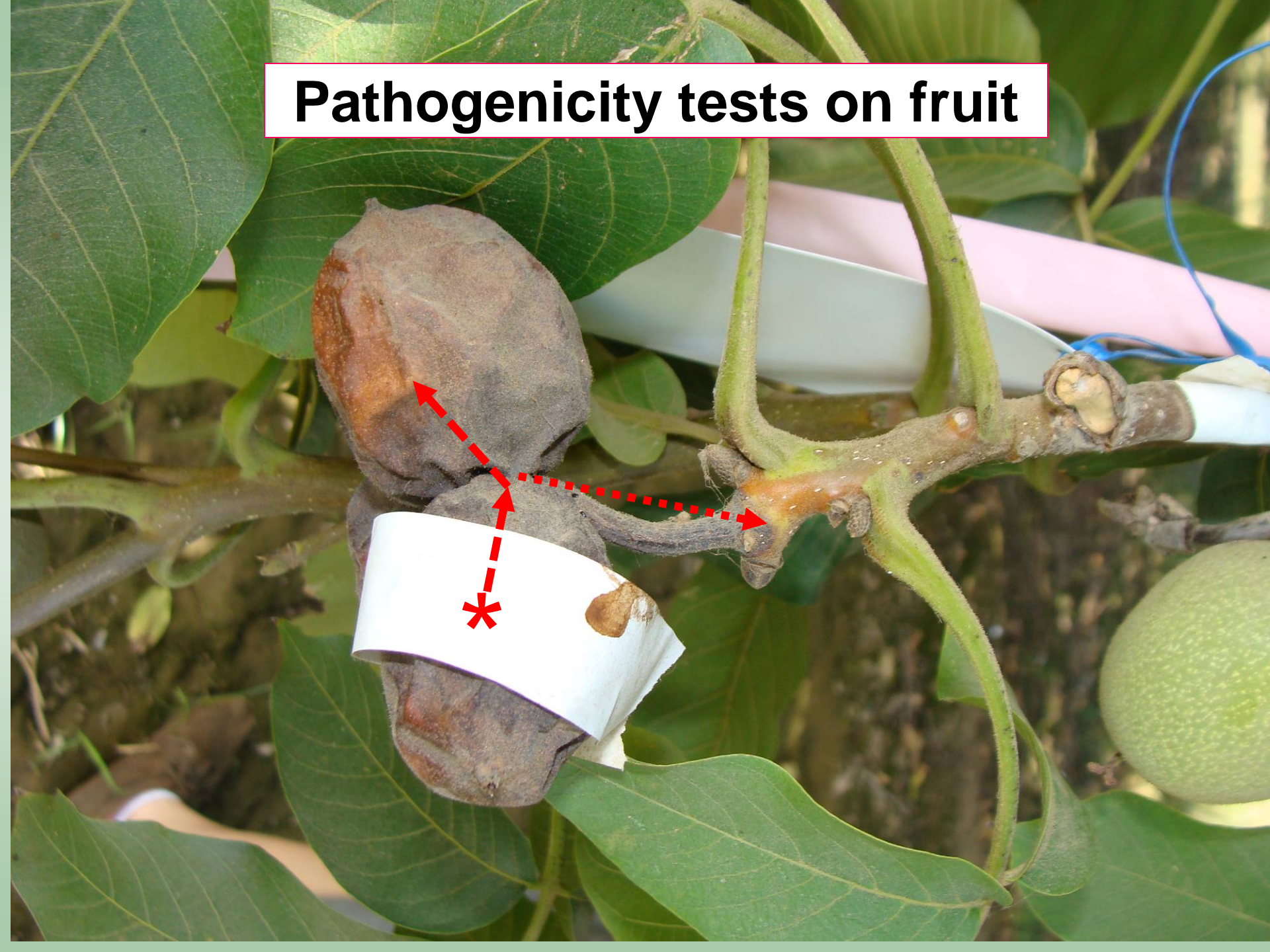


*Lasiodiplodia citricola* inoculated on cultivar Vina after 3 weeks

# After artificial inoculation



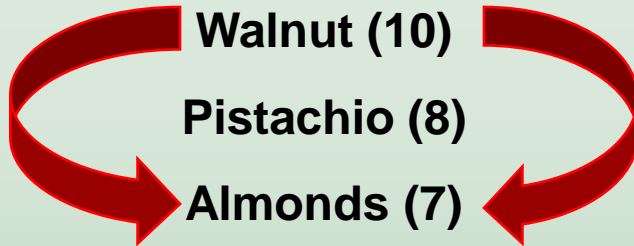
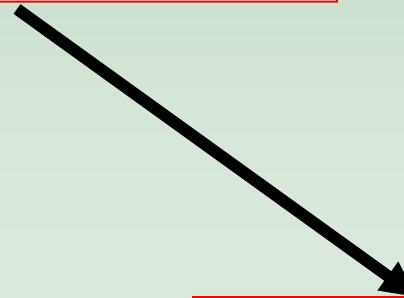
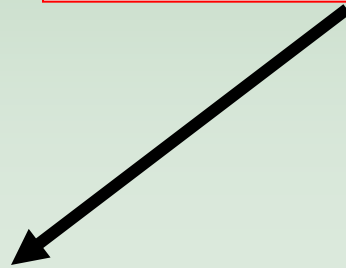
# Pathogenicity tests on fruit



# The pathogens

*"BOTRYOSPHERA"*

*"PHOMOPSIS"*



**Walnut (10)**

**Pistachio (8)**

**Almonds (7)**

**At least 35 other  
tree hosts in  
California**

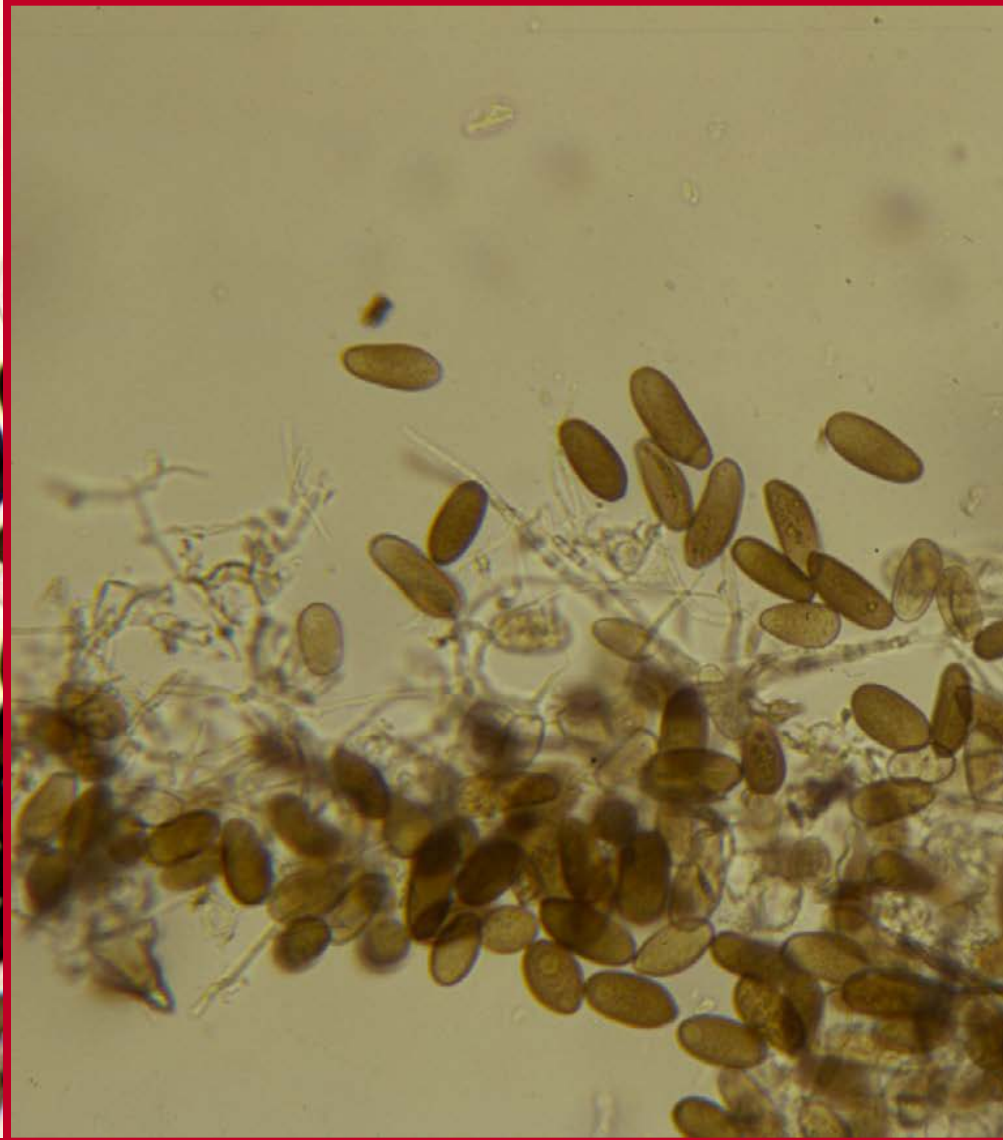
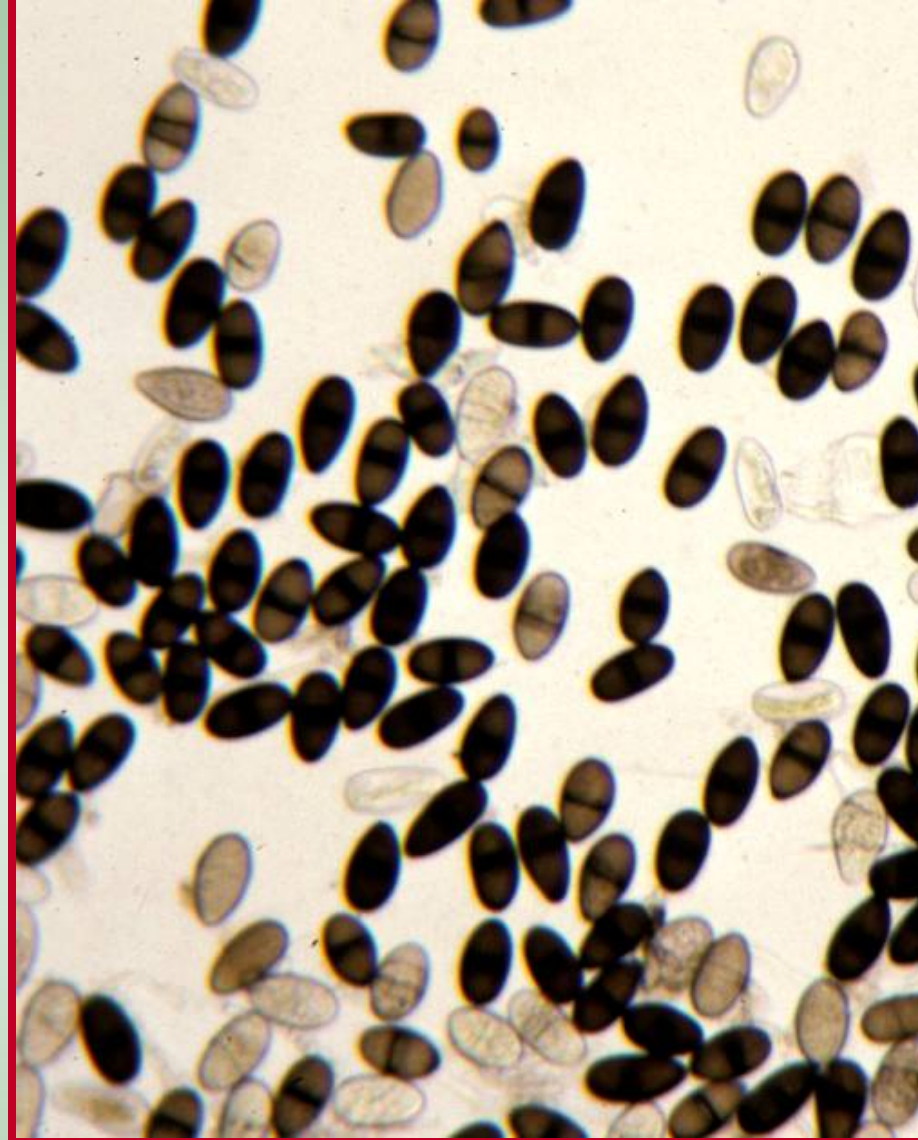
# Summary of Botryosphaeriaceae in nut crops – California

<b>Fungal species</b>	<b>Walnut</b>	<b>Pistachio</b>	<b>Almond</b>
<i>Botryosphaeria dothidea</i>	+ (& asc.)	+	+ (& asc.)
<i>Neofusicoccum parvum</i>	+	+?	+
<i>Neofusicoccum mediterraneum</i>	+	+	+
<i>Diplodia mutila</i>	+	---	---
<i>Neofusicoccum nonquaesitum</i>	+	---	+
<i>Neofusicoccum vitifusiforme</i>	+	+	---
<i>Diplodia seriata</i>	+	+	+
<i>Dothiorella iberica</i>	+	+	---
<i>Lasiodiplodia citricola</i>	+	+	---
<i>Neoscytalidium dimittatum</i> ( <i>Hendersonula toruloidea</i> )	+	---	---
<i>Diaporthe rhusicola</i> ( <i>Phomopsis</i> )	+	+	+
<i>Diaporthe neitheicola</i> ( <i>Phomopsis</i> )	+	---	---



1. *Botryosphaeria dothidea*
2. *Neofusicoccum mediterraneum*
3. *Neofusicoccum parvum*
4. *Neofusicoccum nonquaesitum*
5. *Dothiorella vitifusiforme*
6. *Dothiorella sarmentorum*



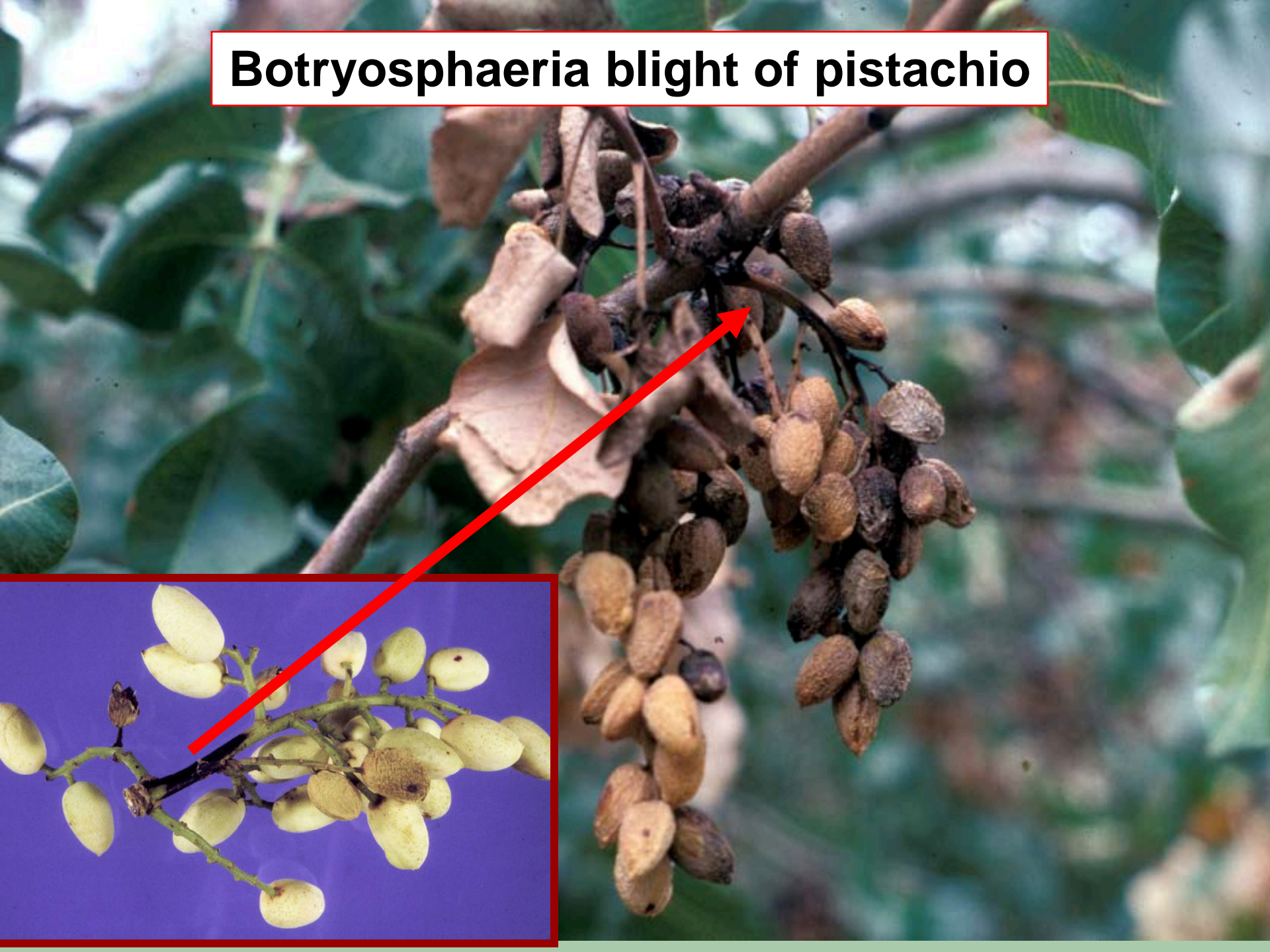


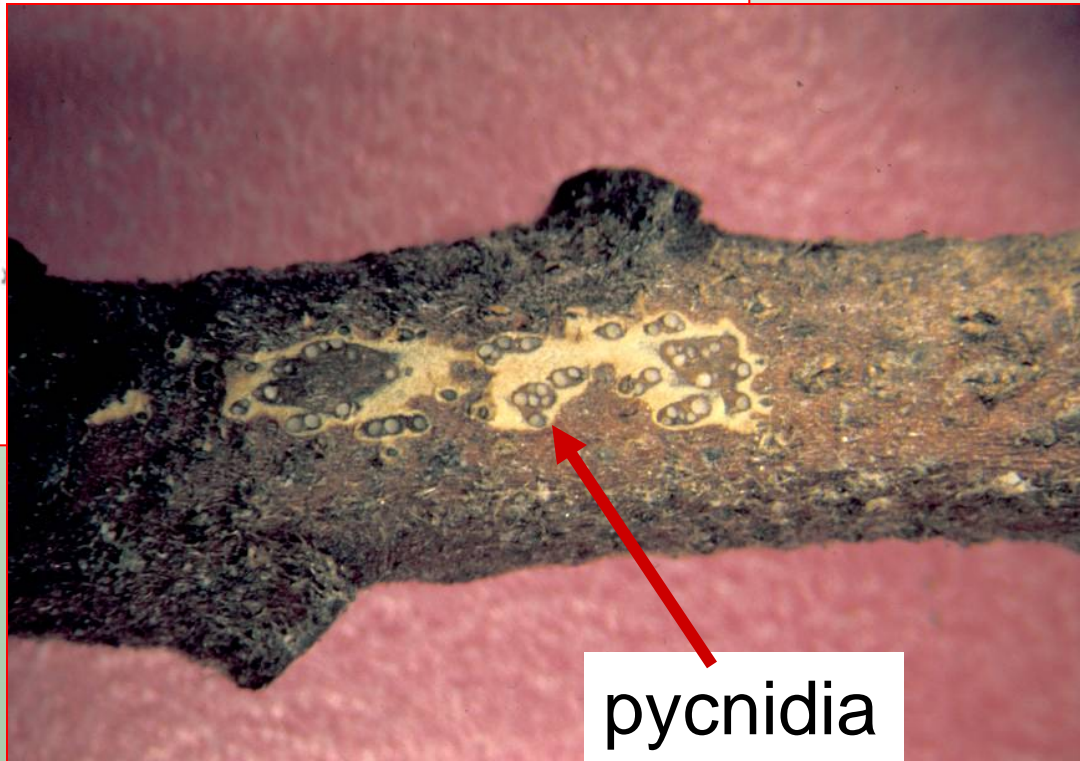
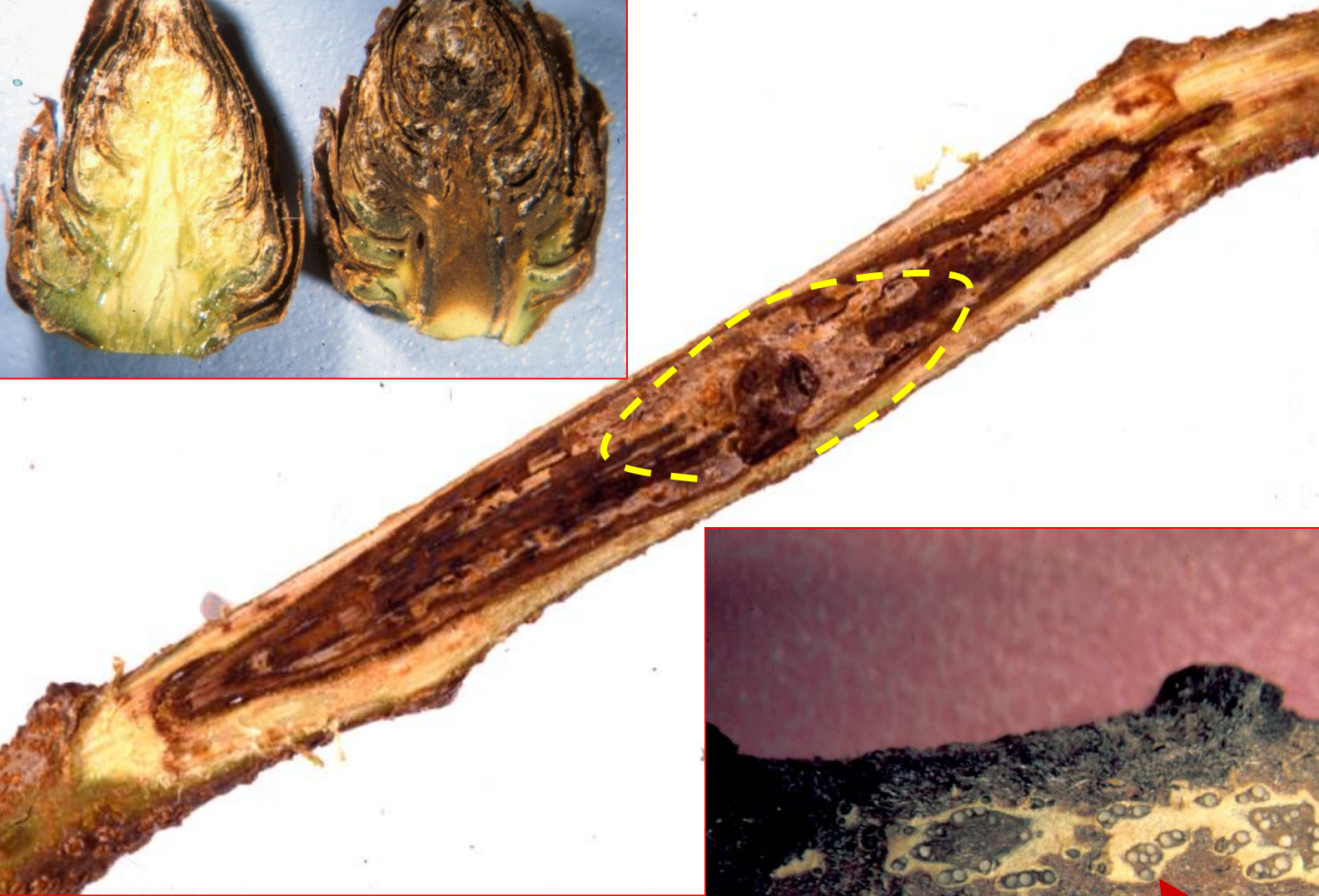
**1.** *Lasiodiplodia  
citricola*

**3.** *Neoscytalidium dimitiatum*  
(*Hendersonula toruloidea*)

**2.** *Diplodia seriata*

# Botryosphaeria blight of pistachio



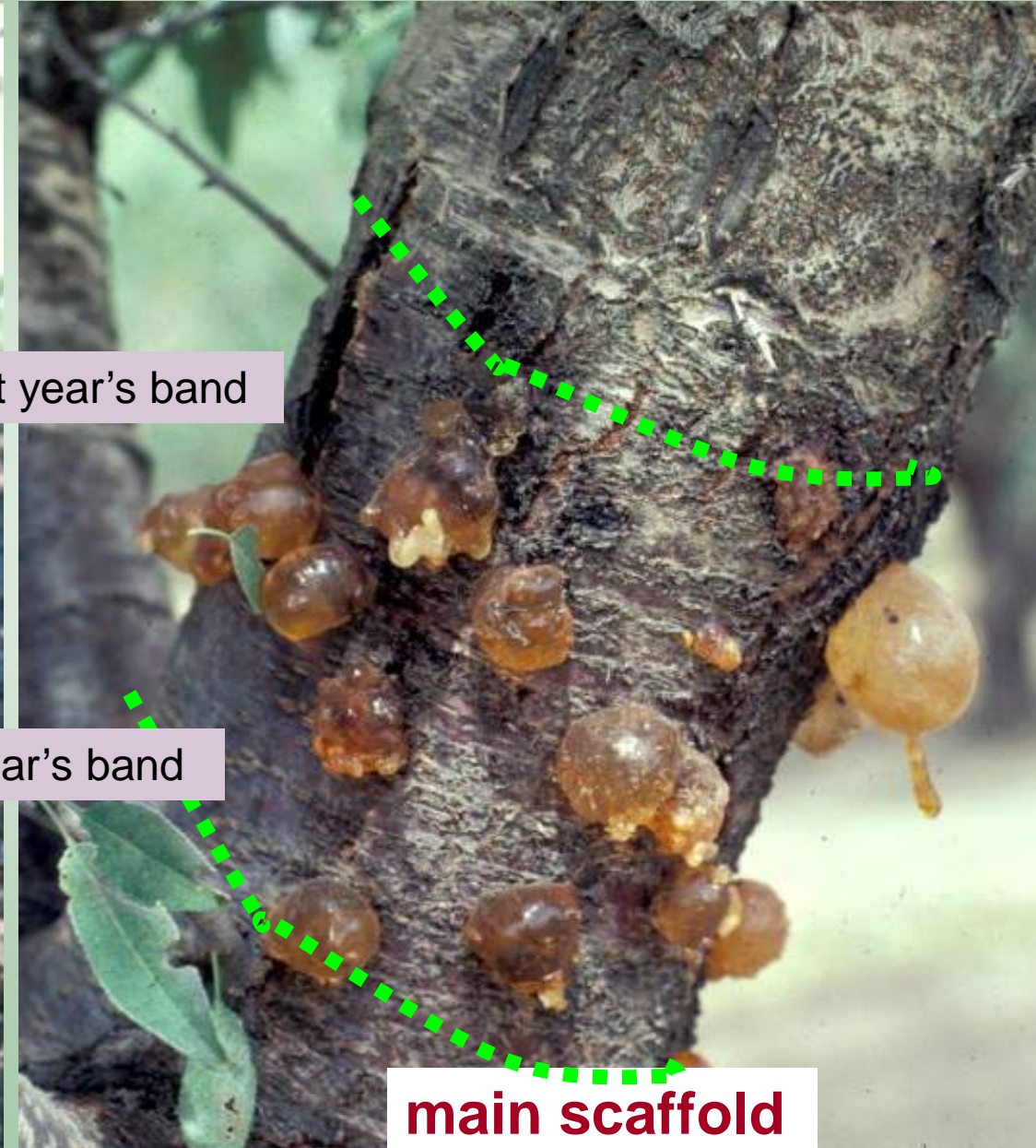
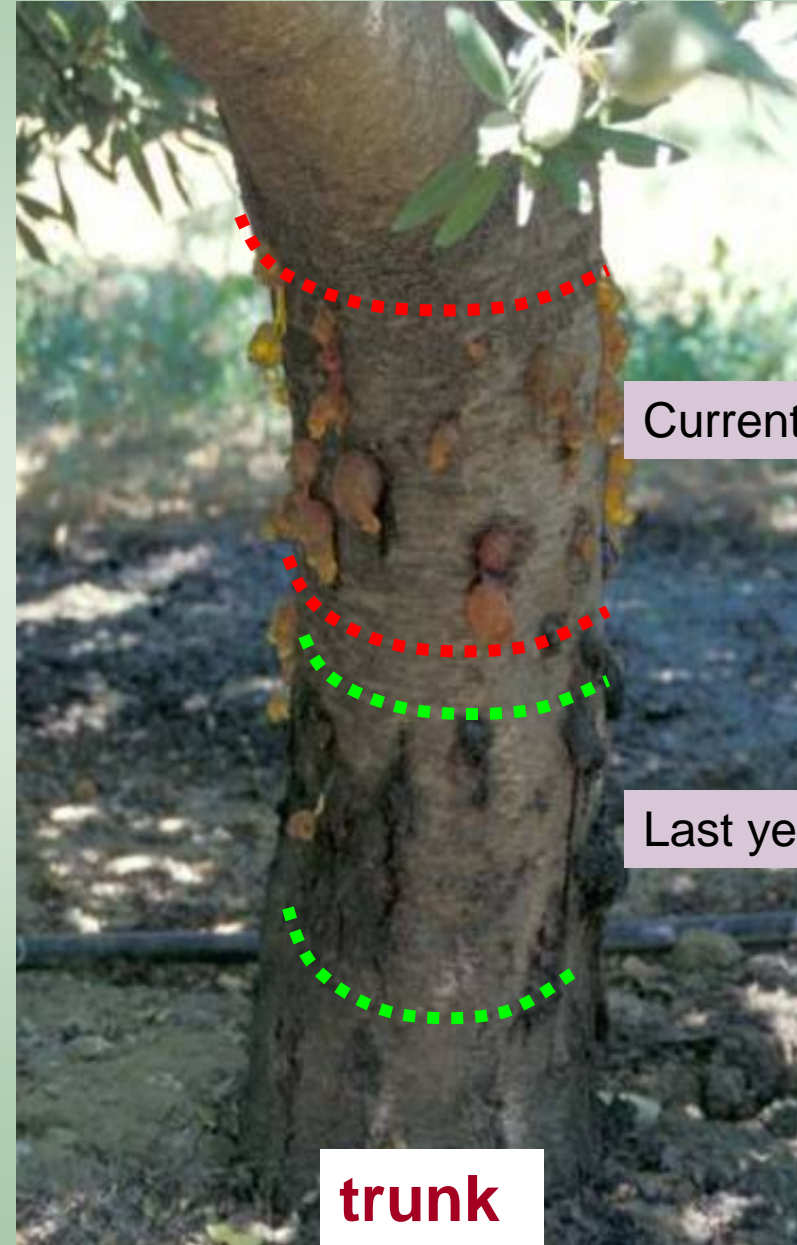


pycnidia

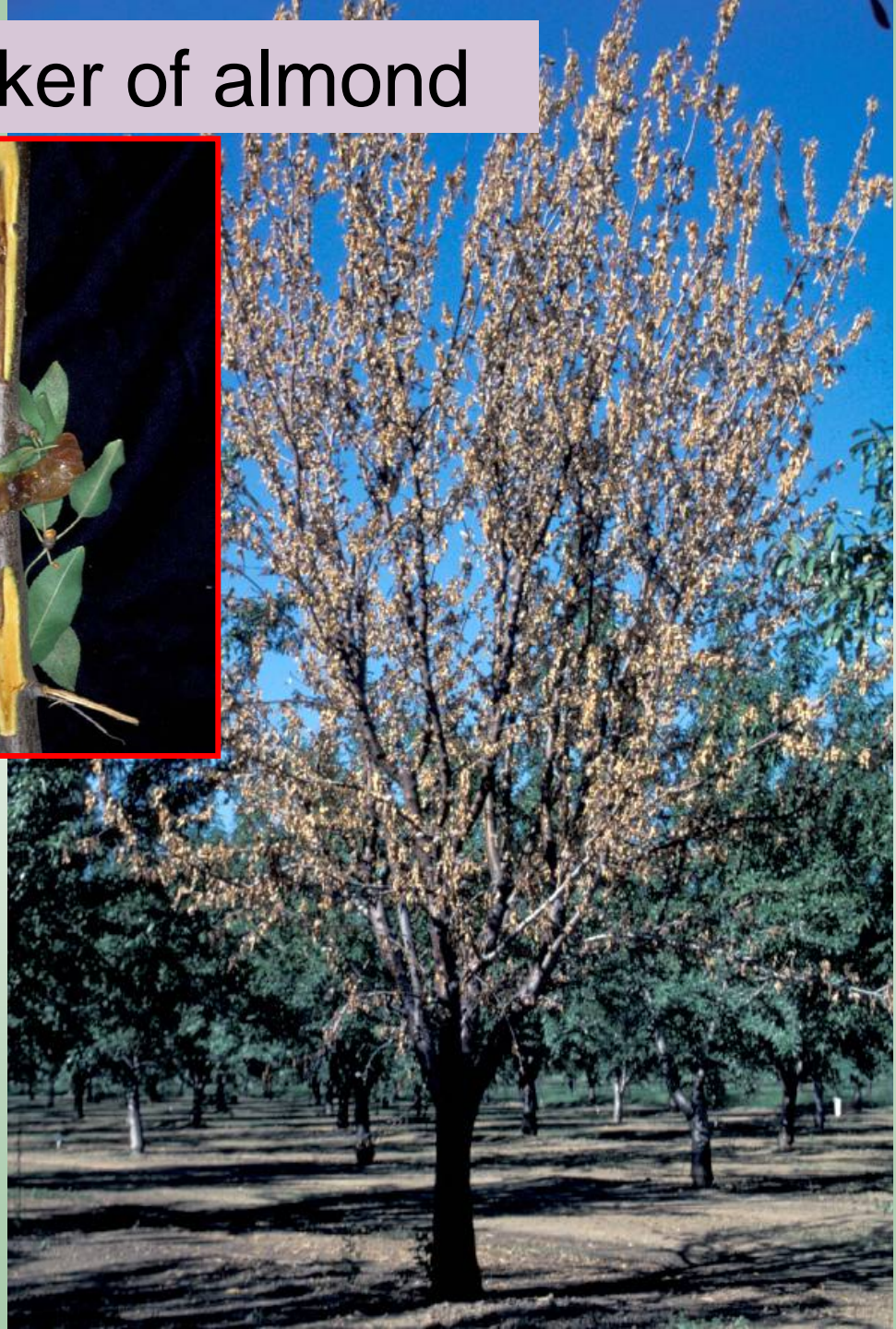




# Band canker of almond



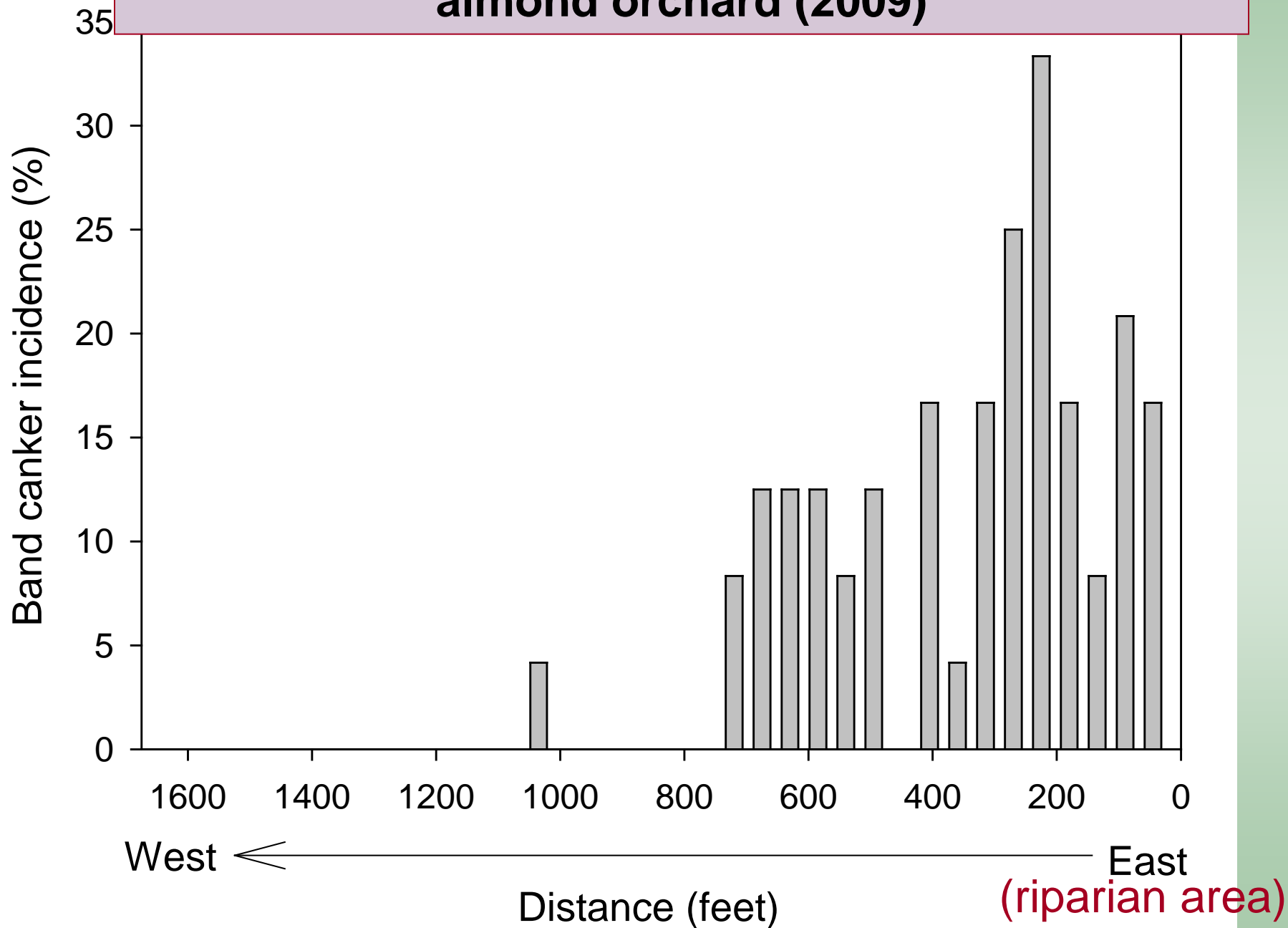
# Band canker of almond







# Distribution of almond band canker in a third-leaf almond orchard (2009)



airborne spores

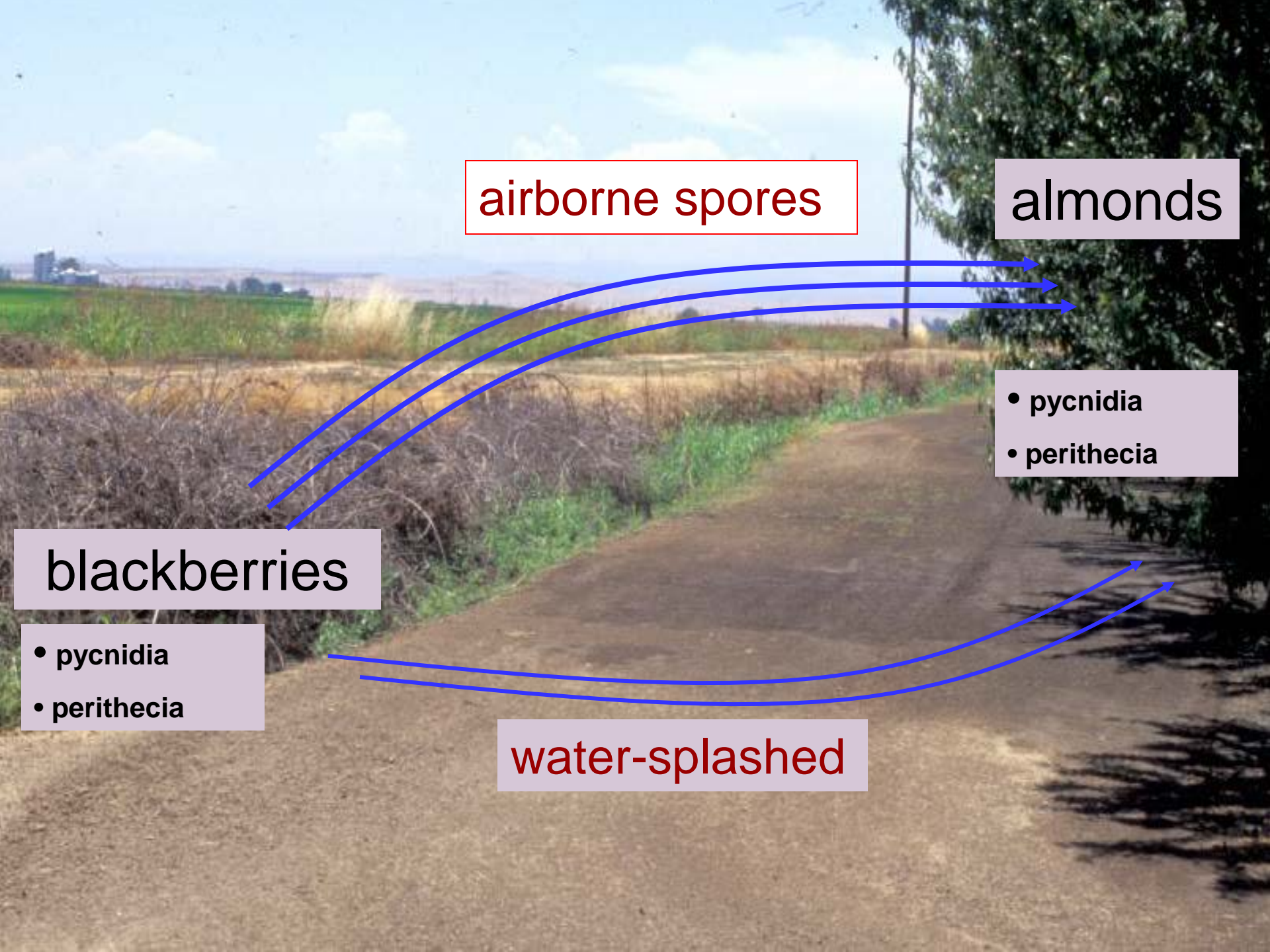
almonds

- pycnidia
- perithecia

blackberries

- pycnidia
- perithecia

water-splashed



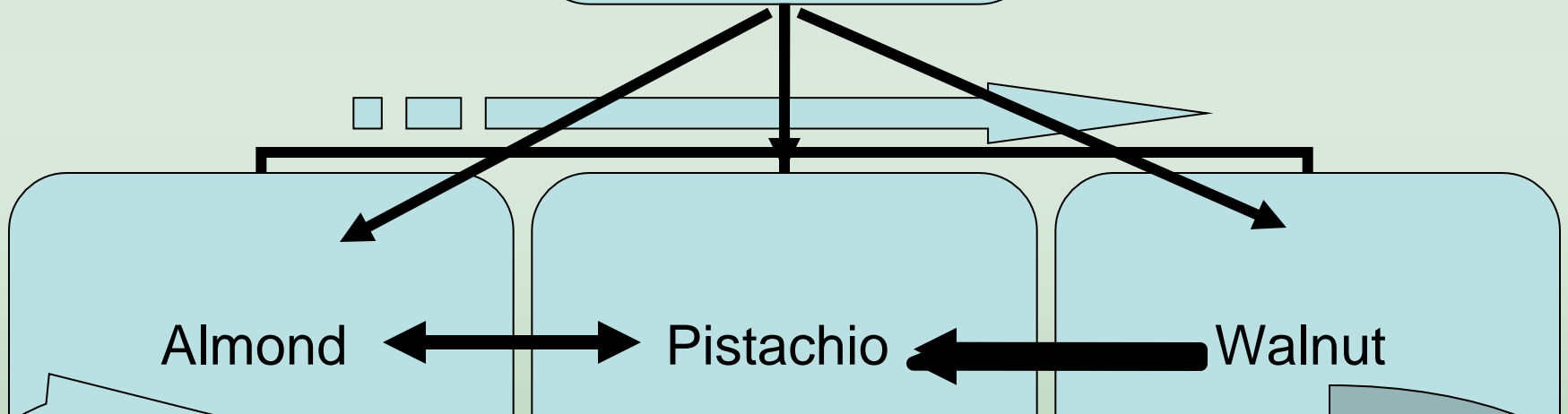
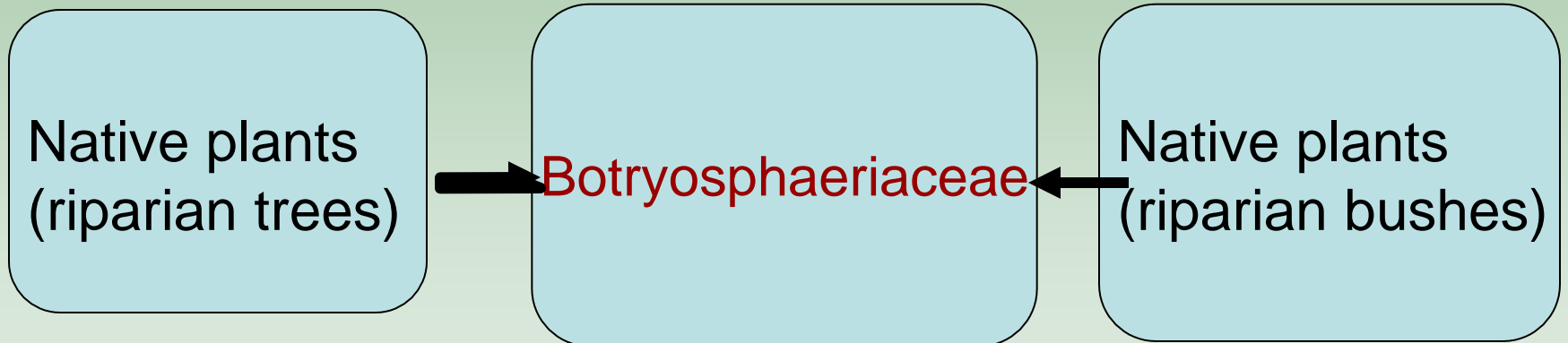
# Severe Botryosphaeria blight on Sequoia trees (in Sacramento)



All nut crops grown in California can be infected by *Botryosphaeriaceae* fungi

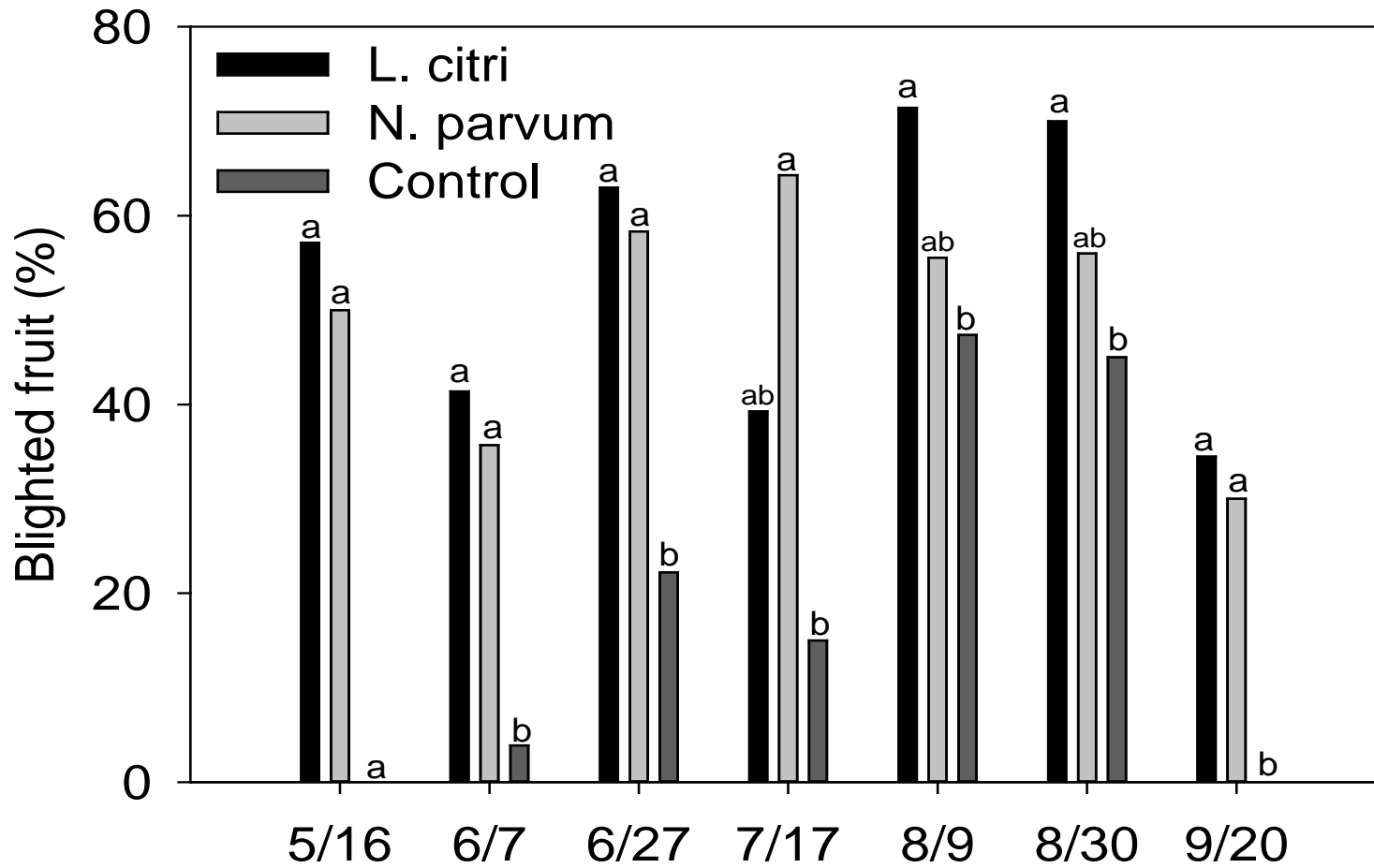
<b>Host</b>	<b>Scientific name</b>	<b>Family</b>
<u>Almond</u>	<i>Prunus dulcis</i>	Rosaceae
<u>English walnut</u> <u>and black walnut</u>	<i>Juglans regia</i> <i>Juglans hinsii</i>	Juglandaceae
<u>Pistachio</u>	<i>Pistacia vera</i> 'Kerman', 'Peters'	Anacardiaceae
<u>Pecan</u>	<i>Carya illinoensis</i>	Juglandaceae
35 more species*	---	in 18 plant families

\* including fruit trees, ornamentals, and forest trees.



*A close association of Botryosphaeriaceae and nut crops in California*

# Periodic inoculations of walnut fruit with *Lasiodiplodia citricola* or *Neofusicoccum parvum* - 2013



... after wounding...

... after wounding...

Incidence of fungal pathogens isolated from blighted fruit (collected from trees & ground)

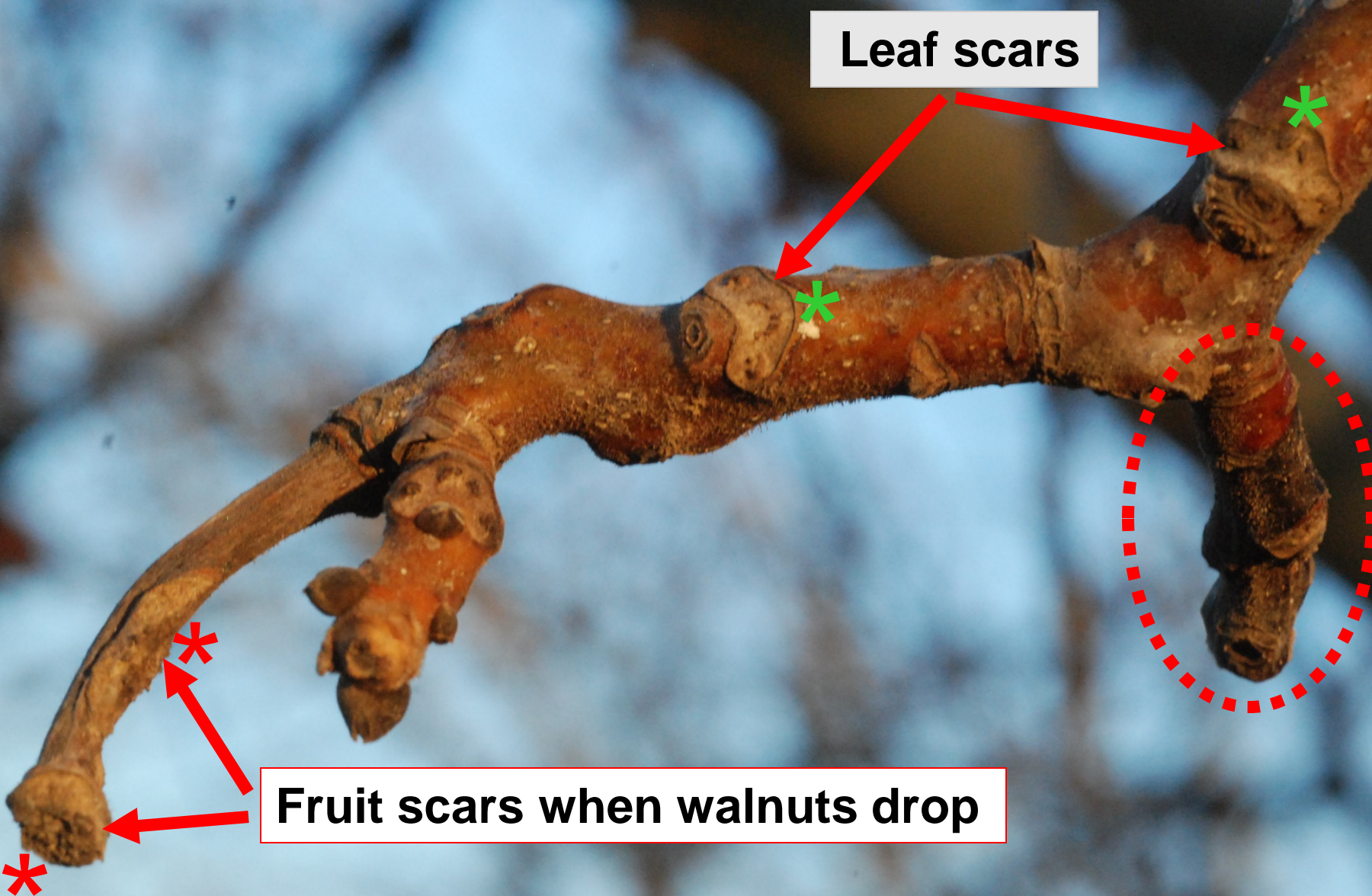
Orchard	Fruit collection from:	Walnut blight	Botryosph. /Phom (%)	Other fungi (%)
1	Tree	+ *	20	68
2	Tree	-	12	84
3	Tree	+ *	11	63
4	Tree	ND	80	20
1	Ground	+ *	67	100
4	Ground	-	50	75

**\* It seems that walnut blight can serve as an entry for *Botryosphaeria* infections**



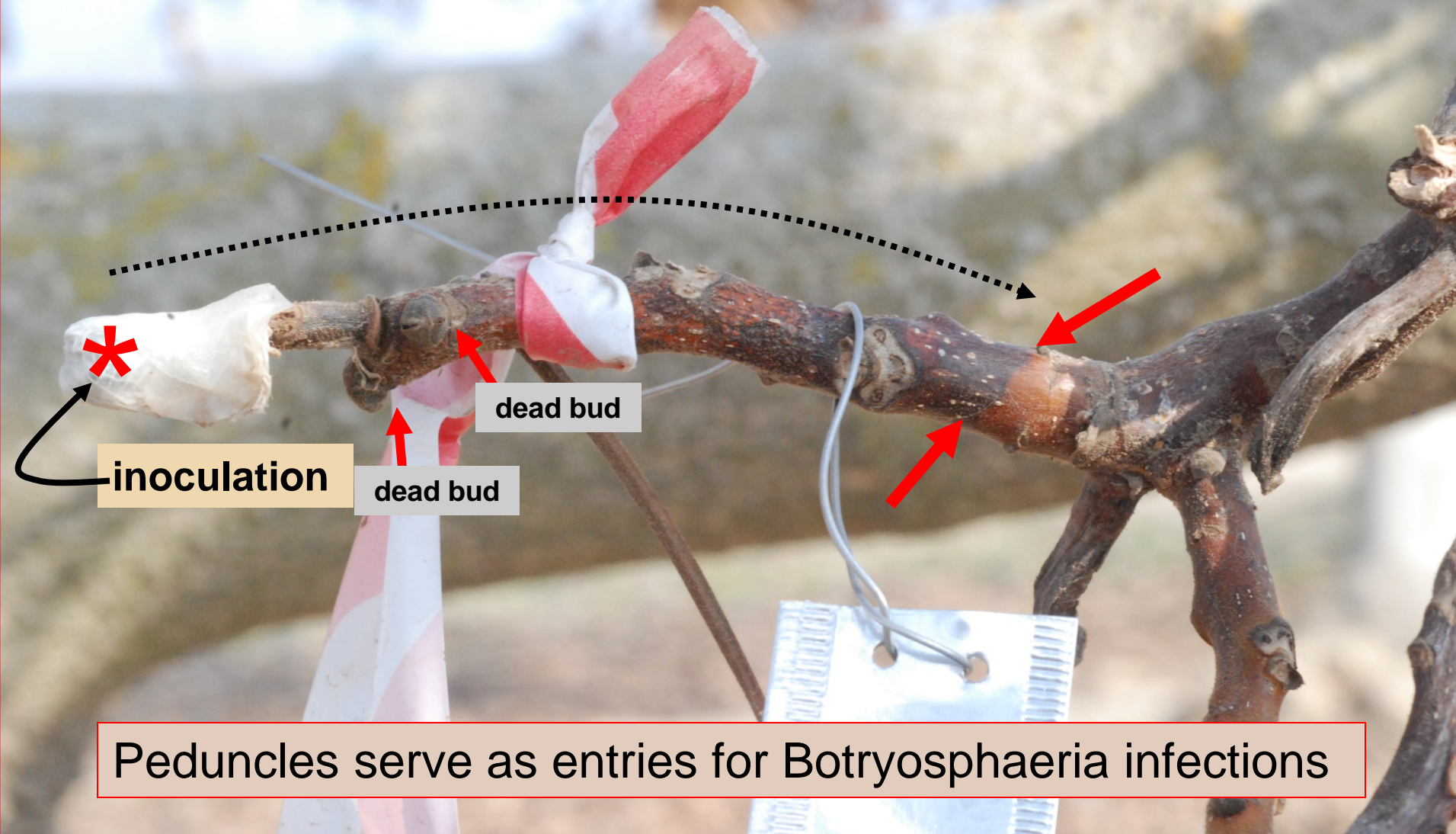
Natural wounds in the field during a) the season,  
b) at harvest and c) postharvest

**Leaf scars**



**Fruit scars when walnuts drop**

# Inoculation of peduncles with *Botryosphaeria* in the field



Peduncles serve as entries for *Botryosphaeria* infections

# Infection of husks by Botryosphaeriaceae

Inoculation  
of husks



# Effects of walnut scales on *Botryosphaeria*

walnut scales

Injuries from scales

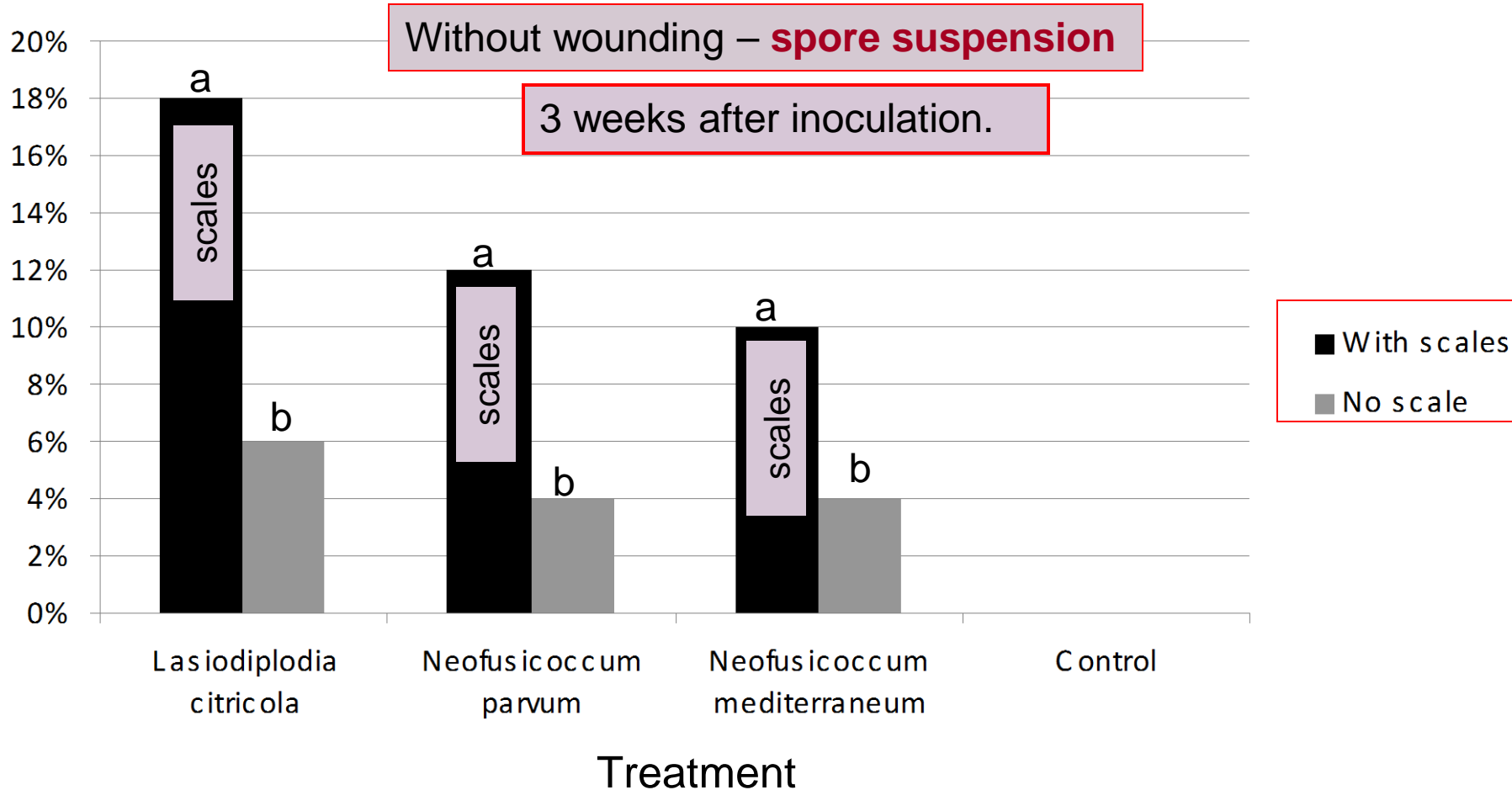
Necrotic lesions

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

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

# Effect of walnut scales on infection of walnut shoots by Botryosphaeriaceae (cultivar Vina)

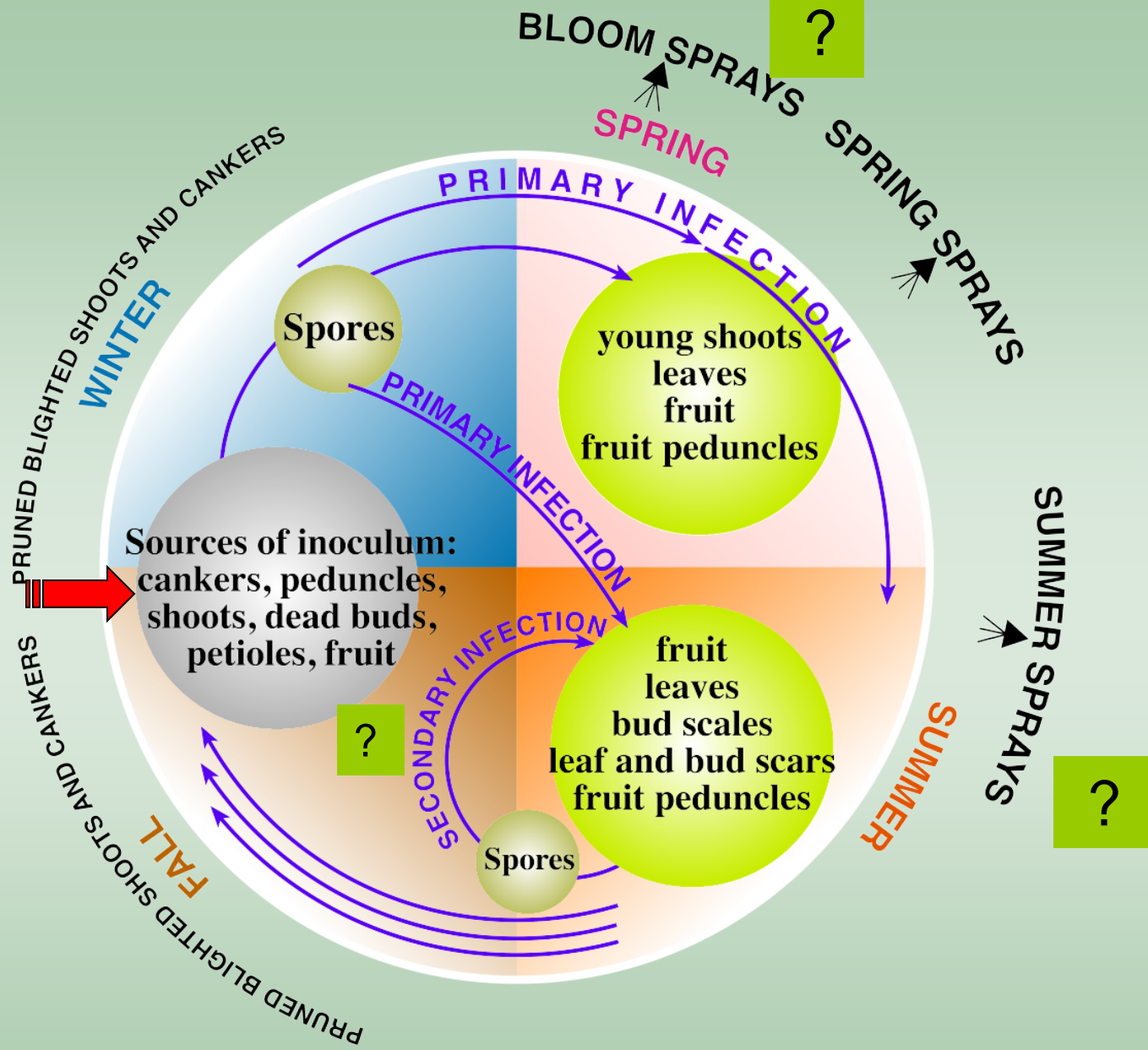
Percentage of walnut branches infected



✓ Shoots with scales showed 60-75% more infection by Botryosphaeriaceae

# Infection Courts of *Botryosphaeria* and *Phomopsis*

- ✓ **Fruit** scars
- ✓ **Peduncle** scars
- ✓ **Leaf** scars
- ✓ **Pruning** wounds
- ✓ **Any** wounds
- ✓ **Walnut blight** lesions
- ✓ **Scale** injuries



Botryosphaeria/Phomopsis blight & canker disease cycle & management

# **CONCLUSIONS** (biology of disease)

- ✓ Multiple species of Botryosphaeriaceae and *Phomopsis* cause cankers and blights in walnut.
- ✓ Some of them are aggressive and infect shoots directly; all can infect walnut fruit; & all through the fruit can infect shoots.
- ✓ These pathogens produce both water-spread spores and spores spread by air (walnut & almond).
- ✓ Infection courts include fruit, peduncle, and leaf scars, pruning wounds, lesions caused by walnut blight, injuries caused by scales, and any other type of injuries.
- ✓ Disease symptoms show late in season (summer & fall).

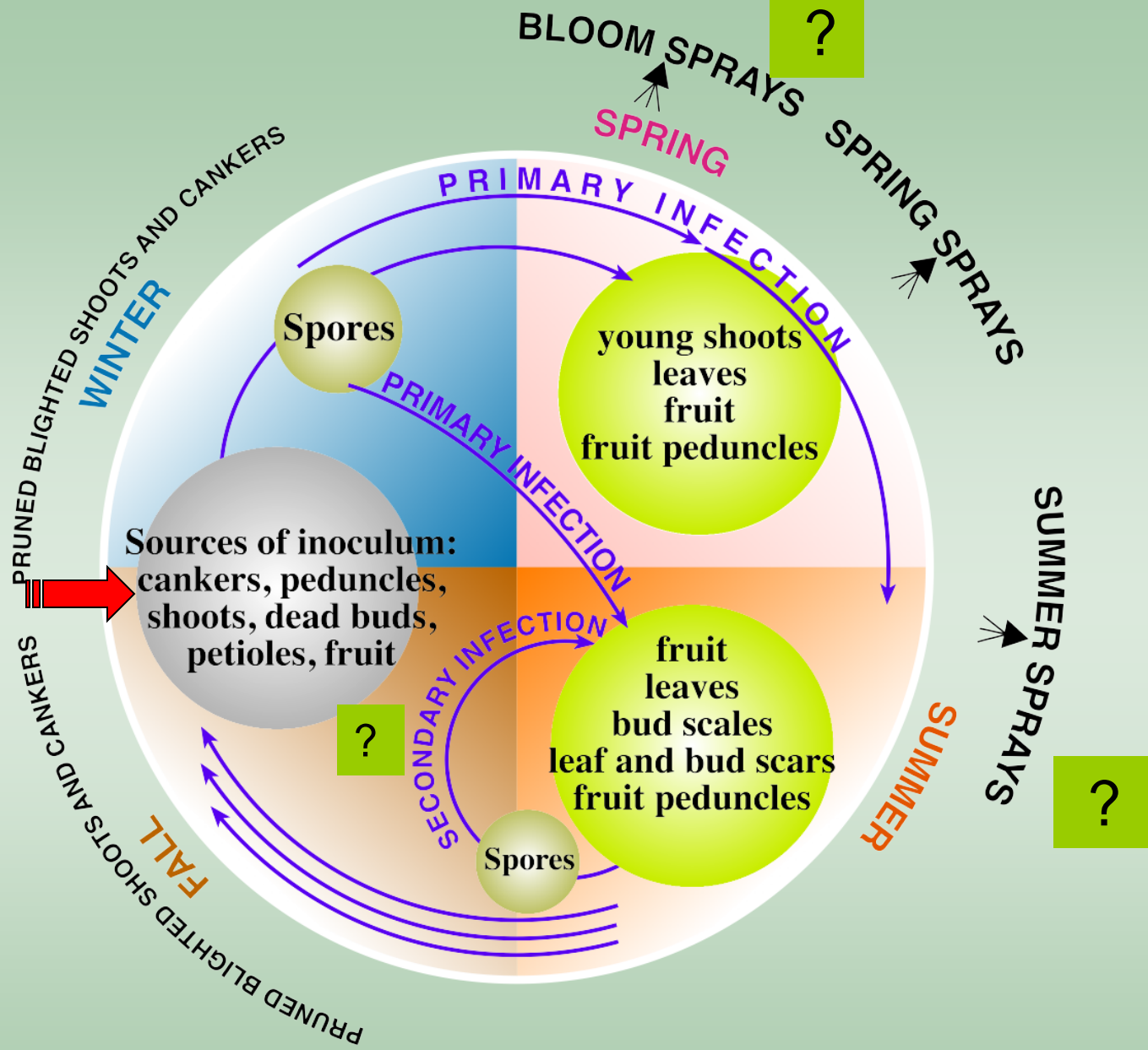


# **Management of Botryosphaeria and Phomopsis blight and canker of walnut**

2<sup>nd</sup> PART

YOLO COUNTY MEETING, WOODLAND

21 July, 2014

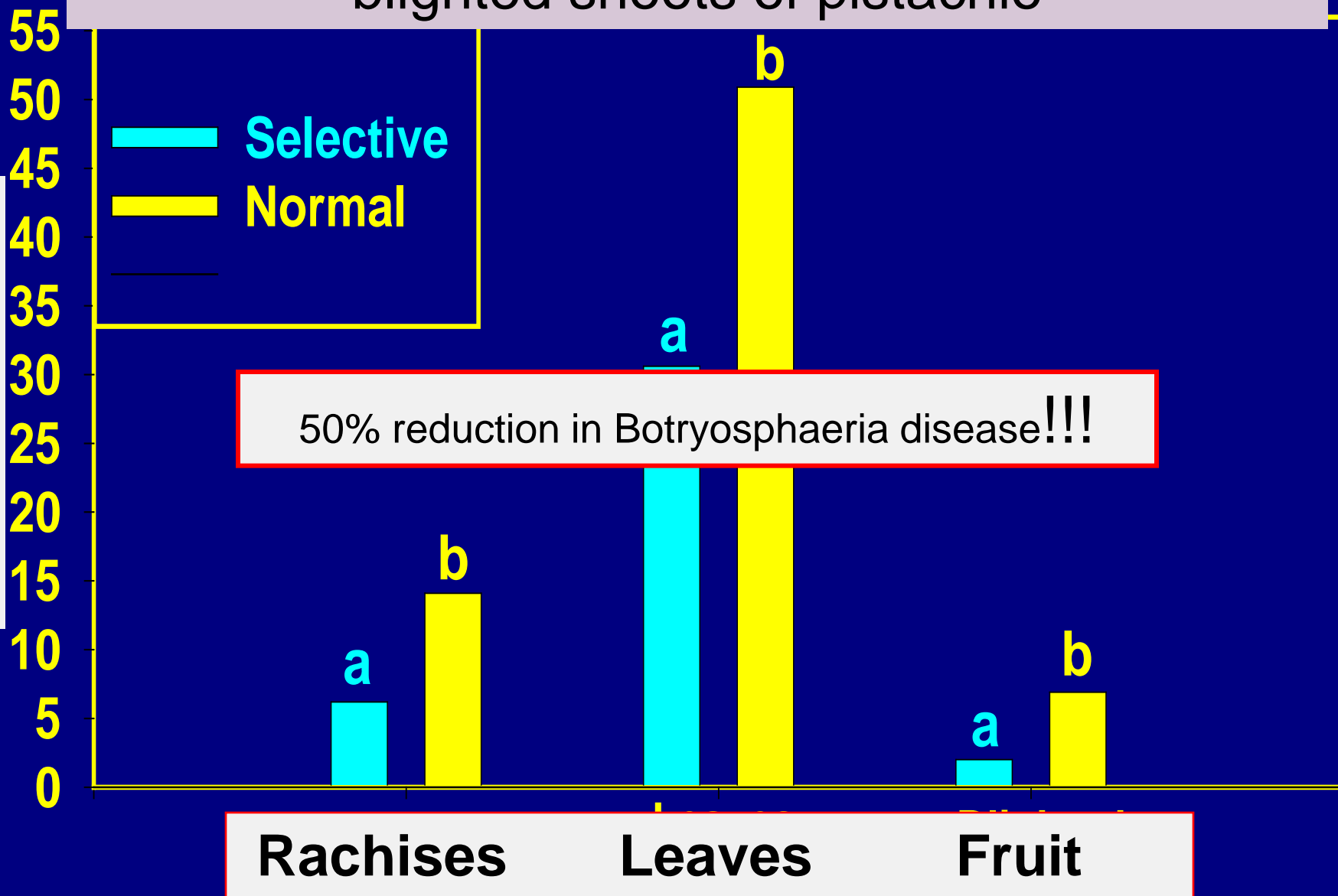


Botryosphaeria/Phomopsis blight & canker disease cycle & management

# Sanitation by pruning



# Selective pruning of Botryosphaeria cankers & blighted shoots of pistachio



# Burning of prunings outside of orchard



# Summer pruning - removal of prunings



# Walnut Prunings

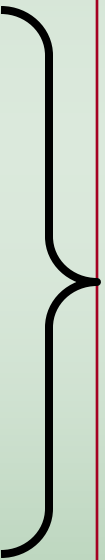
- ✓ *Botryosphaeria* can survive in shredded prunings for 1.5 years (i. e. pistachio)
- ✓ Not known how long Bot/Phomopsis can survive in walnut prunings (suspect shorter time...walnut is softer wood than pistachio wood)
- ✓ Better to remove and destroy the prunings because the walnut *Botryosphaeria* has also airborne spores

# Best Control for Botryosphaeria Diseases by Intergrading Cultural and Chemical Control Practices

➤ **Cultural control:** Prune dead branches or blighted shoots; avoid sprinkler irrigation that wets the canopy.

+

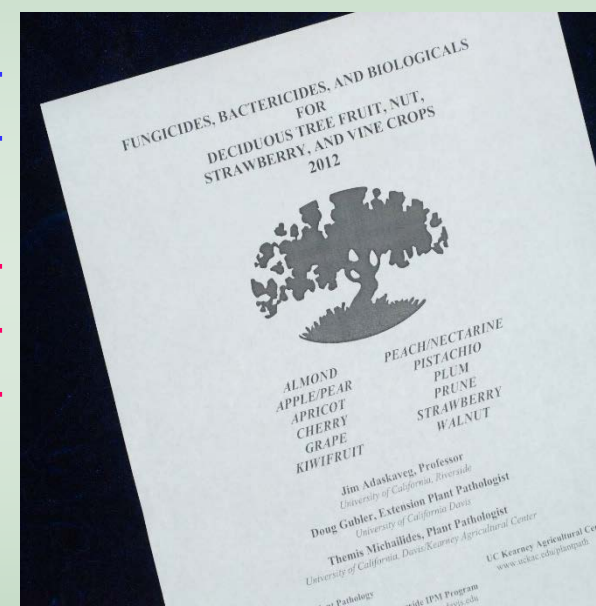
➤ **Chemical control:** Apply effective fungicides (no resistance in these fungi!)





# Fungicides registered for Botryosphaeria blight in pistachio

Fungicide	Active ingredient	Efficacy
Adament.....	trifloxystrobin+tebuconazole	+++
Abound .....	azoxystrobin	++++
Bravo.....	chlorothalonil	++
Bumper/Tilt.....	propiconazole	++
Cabrio.....	pyraclostrobin	++++
Gem .....	trifloxystrobin	++++
Quash.....	metconazole	+++
Inspire Super...	difenoconazole + cyprodinil	++++
Pristine .....	boscalid + pyraclostrobin	++++
Quilt-Xcel.....	azoxystrobin + propiconazole	++++
Scala.....	pyrimethanil	+++
Switch.....	cyprodinil + fludioxonil	++
Tebuzol.....	tebuconazole	+++
Topsin-M.....	thiophanate-methyl	++
Copper.....	copper	+/-
Luna Experience	fluopyram + tebuconazole	++++
Luna Sensation	fluopyram + trifloxystrobin	++++
Fontelis	penthiopyrad	++++
Merivon	fluxopyroxad	++++



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

## Fungicides and rates applied to control *Botryosphaeria* blight of walnut (Butte Co.; MM grower)

Fungicide	Active ingredient	Amount/acre
Fontelis .....	20.4% penthiopyrad + R-11	20 oz
Pristine .....	12.8% pyraclostrobin + 25.2% boscalid + R-11	14.5 oz
Luna Experience .....	17.6% fluopyram + 17.6% tebuconazole	9.6 fl oz
Luna Sensation .....	21.4% trifloxystrobin + 17.6% fluopyram	7.6 fl oz
Abound.....	22.9% azoxystrobin	12.0 fl oz
Quadris Top.....	18.2% azoxystrobin + 11.4% difenoconazole	14.0 fl oz
Quilt Excel.....	13.5% azoxystrobin + 11.7% propiconazole	21 fl oz
Untreated	---	

Spray dates: 17 May; mid June; & mid July

### **On 25 October 2013 collected:**

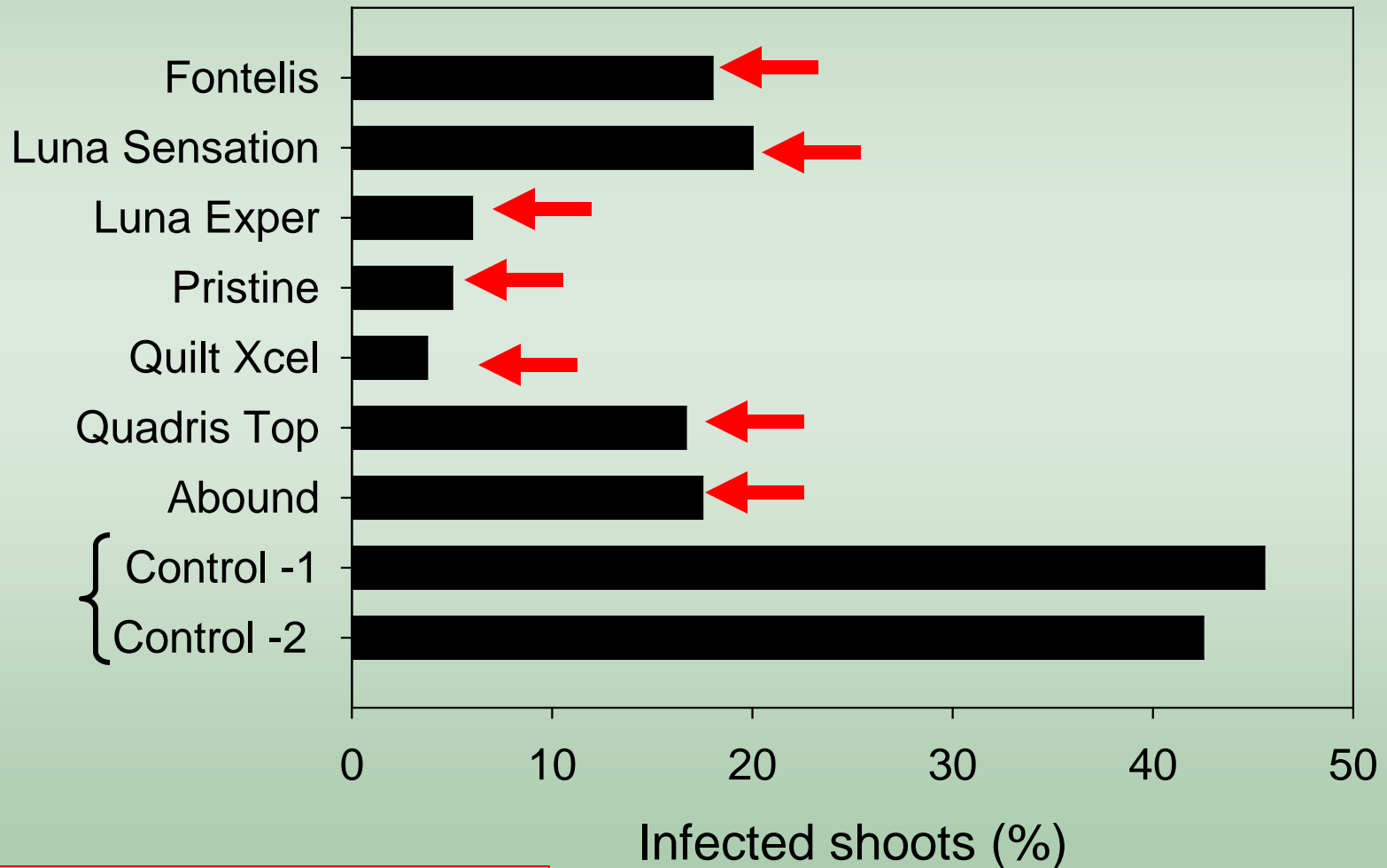
- peduncles
- current growth shoots

Partial infection of peduncles; some may be natural senescence

Infections that have moved from the peduncles into the sustaining shoot

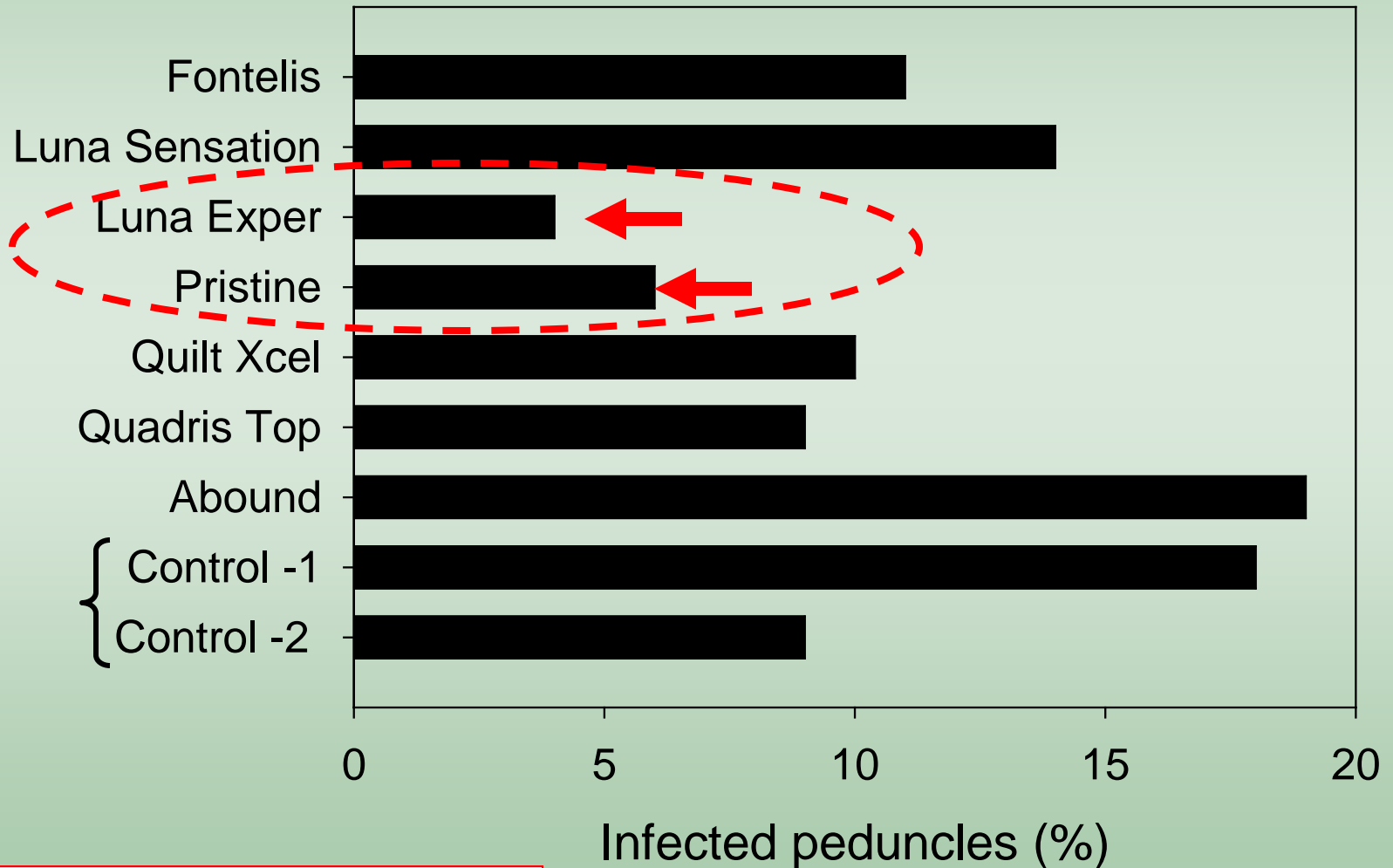


# Effects of fungicides on Botryosphaeria in walnut shoots (Butte Co.; MM grower)



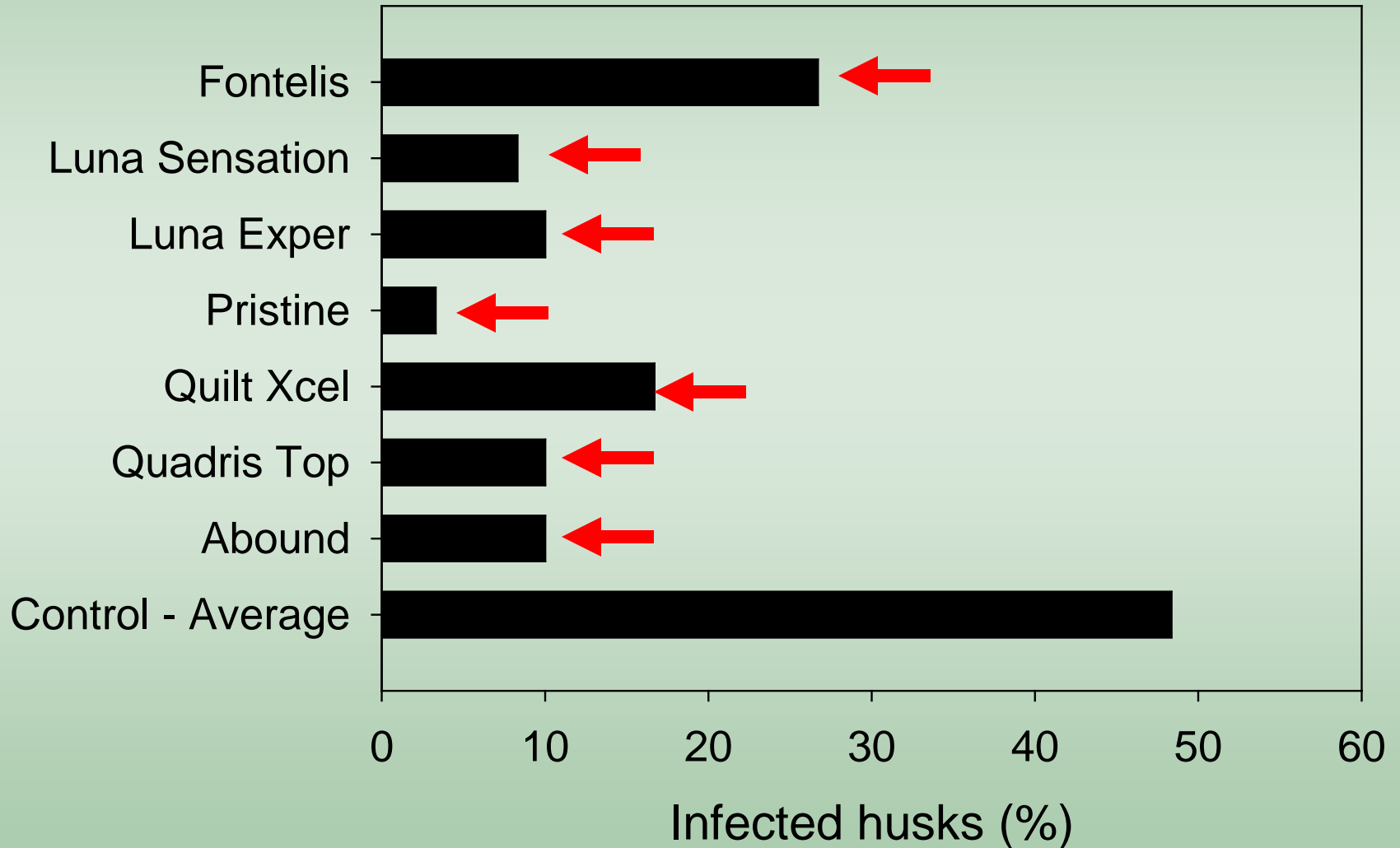
Spray dates: 17 May; mid June; & mid July

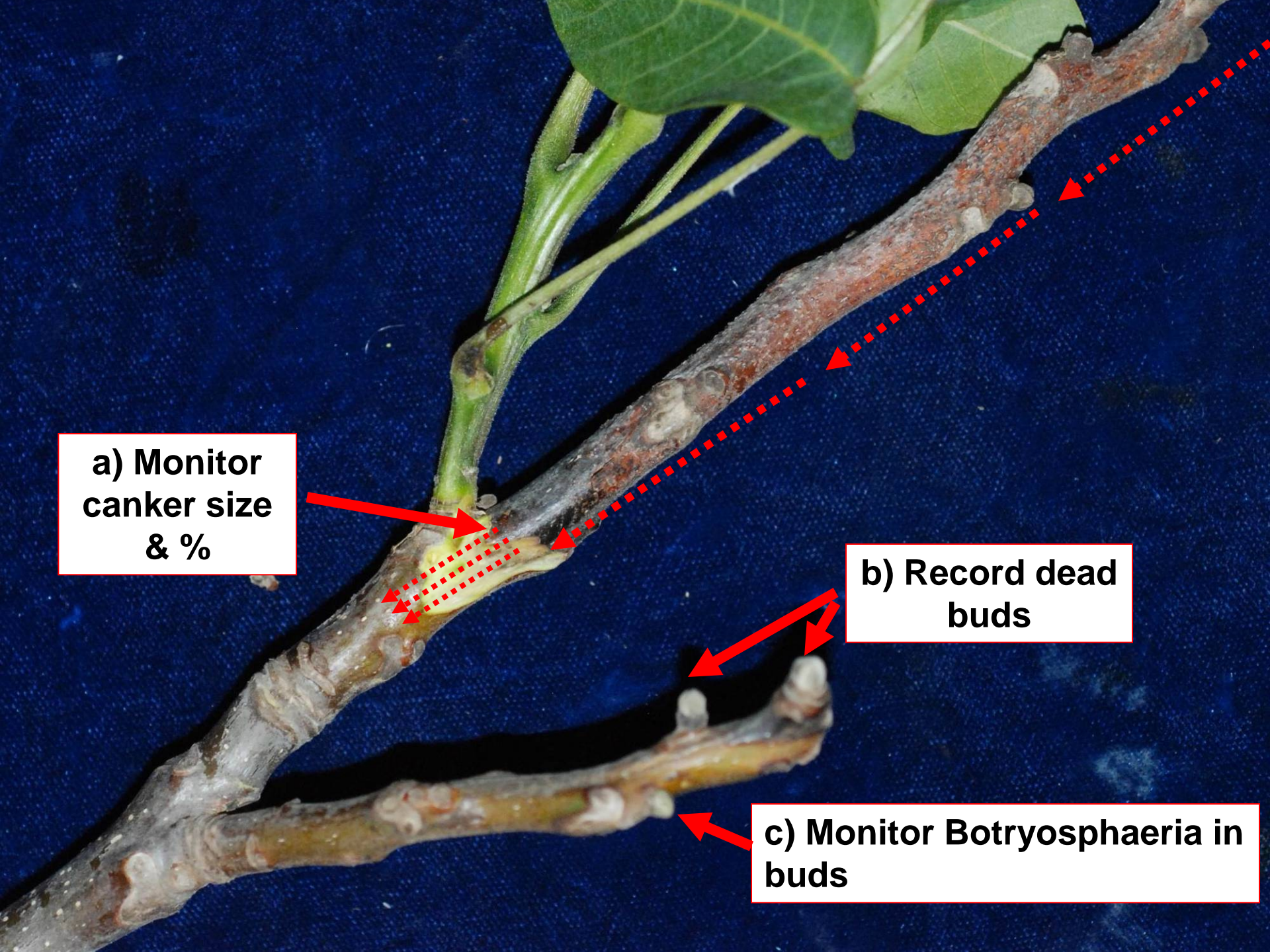
# Effects of fungicides on Botryosphaeria in peduncles (Butte Co.; MM grower)



Spray dates: 17 May; mid June; & mid July

# Effects of fungicides on Botryosphaeria in husks (Butte Co.; MM grower)





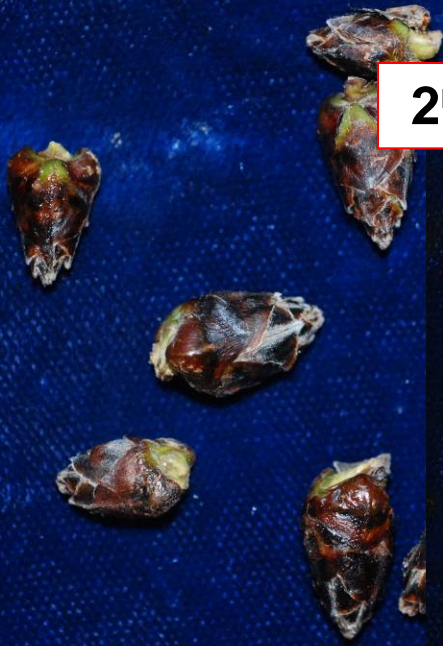
**a) Monitor  
canker size  
& %**

**b) Record dead  
buds**

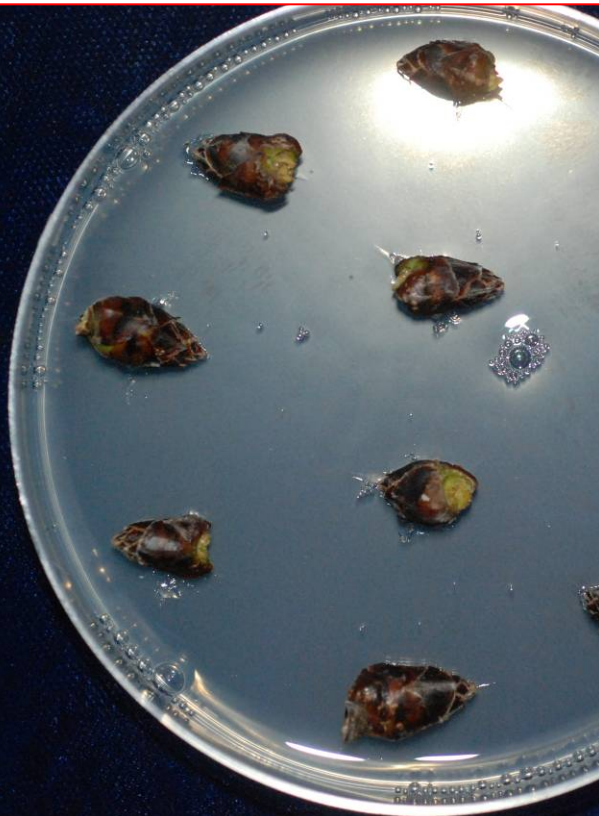
**c) Monitor Botryosphaeria in  
buds**

# Technique to monitor and predict disease pressure in pistachio orchards (BUDMON)

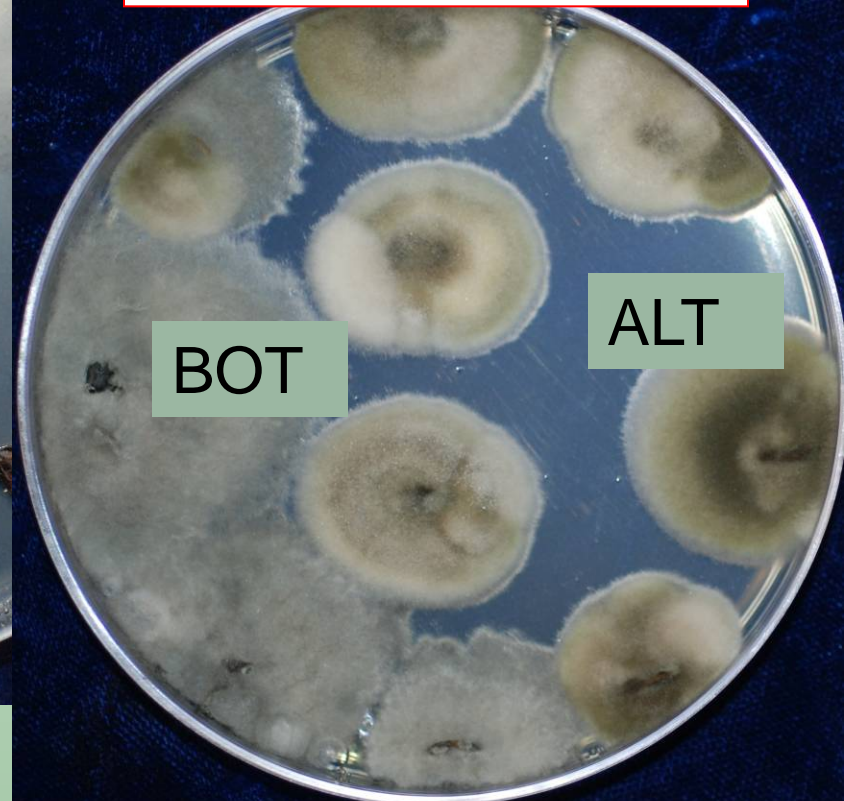
**1<sup>st</sup> step:** Buds at collection



**2<sup>nd</sup> step:** After surface sterilization & plating

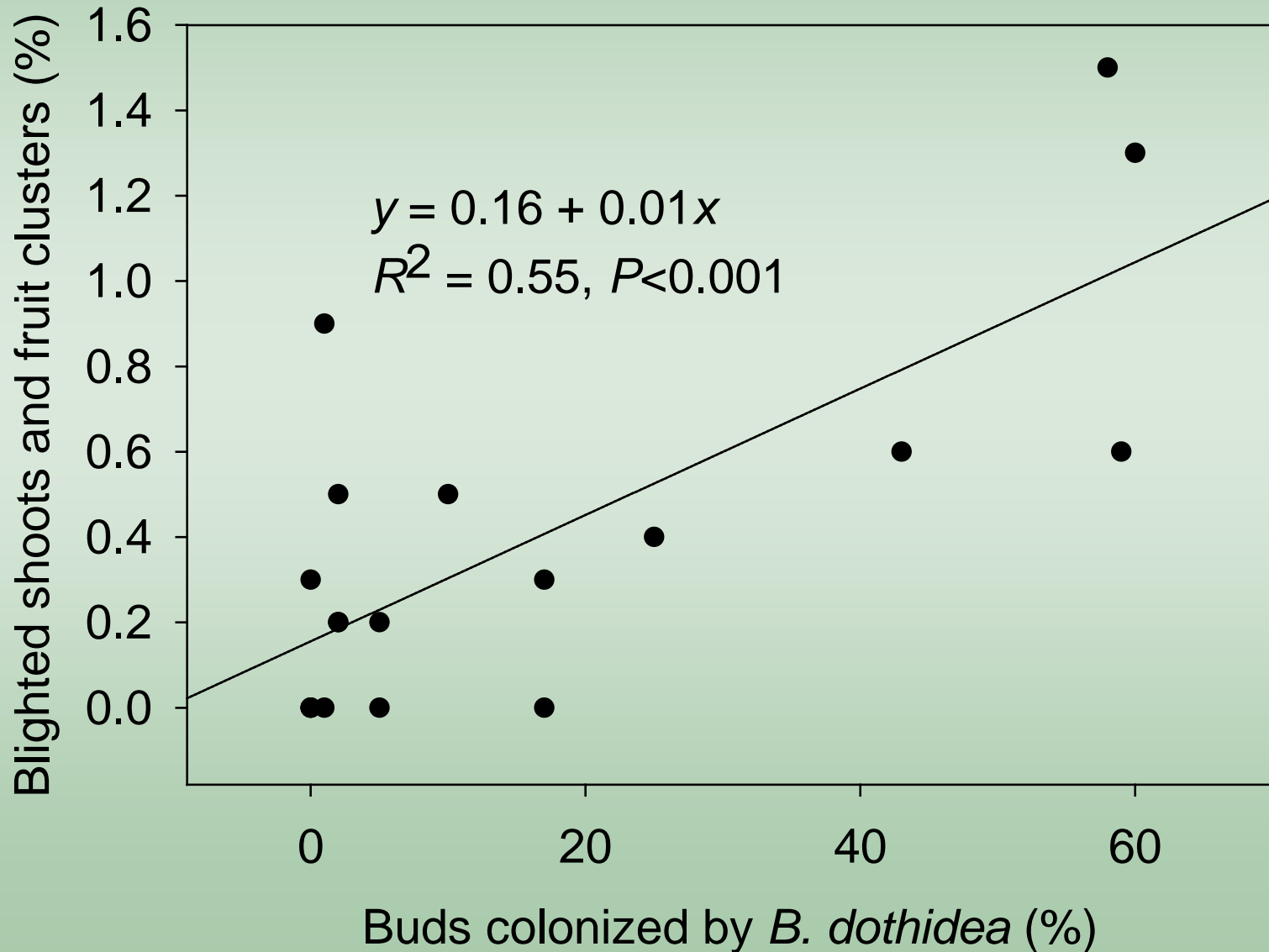


**3<sup>rd</sup> step:** After incubation

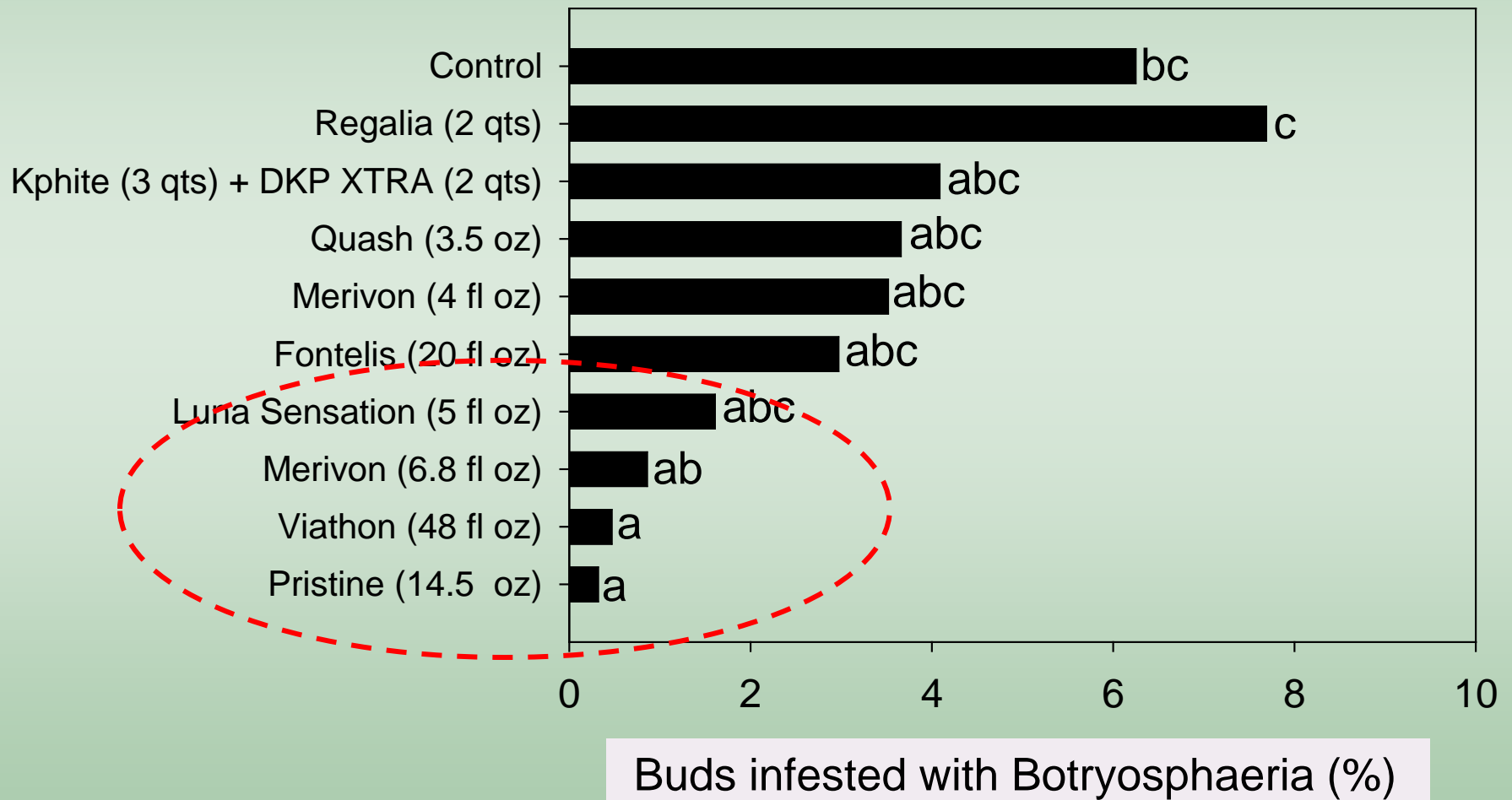




# Relationship between BUDMON (sampled in late winter) and disease at harvest – (Year 1)



# Long-term fungicide activity from 2013 sprays in a San Benito walnut orchard (sampled on Feb. 25 2014)



# Trial 1 (Howard, Sutter Co.) - 2014

<u>Treatment</u>	Rate Form/ac	Sprays	Timing
Untreated	---	---	---
Merivon	6.5 fl oz	1	Bloom
Merivon	6.5 fl oz	1	Postharvest
Merivon	6.5 fl oz	2	Bloom+Postharv
Luna Exp	10.0 fl oz	1	Bloom
Luna Exp	10.0 fl oz	1	Postharvest

## Trial 2 (Chandler, Sutter Co.) - 2014

<u>Treatment</u>	Rate Form/ac	Sprays	Timing
Untreated	---	---	---
Merivon	6.5 fl oz	3	Mid-May, mid-June, mid-July
Luna Exp.	10.0 fl oz	3	Mid-May, mid-June, mid-July
Fontelis + Tebucon	20.0 fl oz + 8 oz	3	Mid-May, mid-June, mid-July
Quadris top	14 fl oz	3	Mid-May, mid-June, mid-July

# CONCLUSIONS (disease management)

- ✓ Pruning infected branches can help reduce spore inoculum.
- ✓ Lower trajectory angle of sprinkler irrigation.
- ✓ Fungicide sprays during May through July seem to reduce Botryosphaeria infections.
  
- ✓ Future research plans:  
Emphasis on **latent infections on green fruit**, the **postharvest disease development**, and **disease management**.

(More information: UC IPM site; UCCE Sutter/Yuba Co. site c/o Janine Hasey)