
Botryosphaeria and Phomopsis Canker Management in California Walnut Orchards

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Sacramento

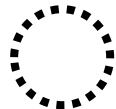
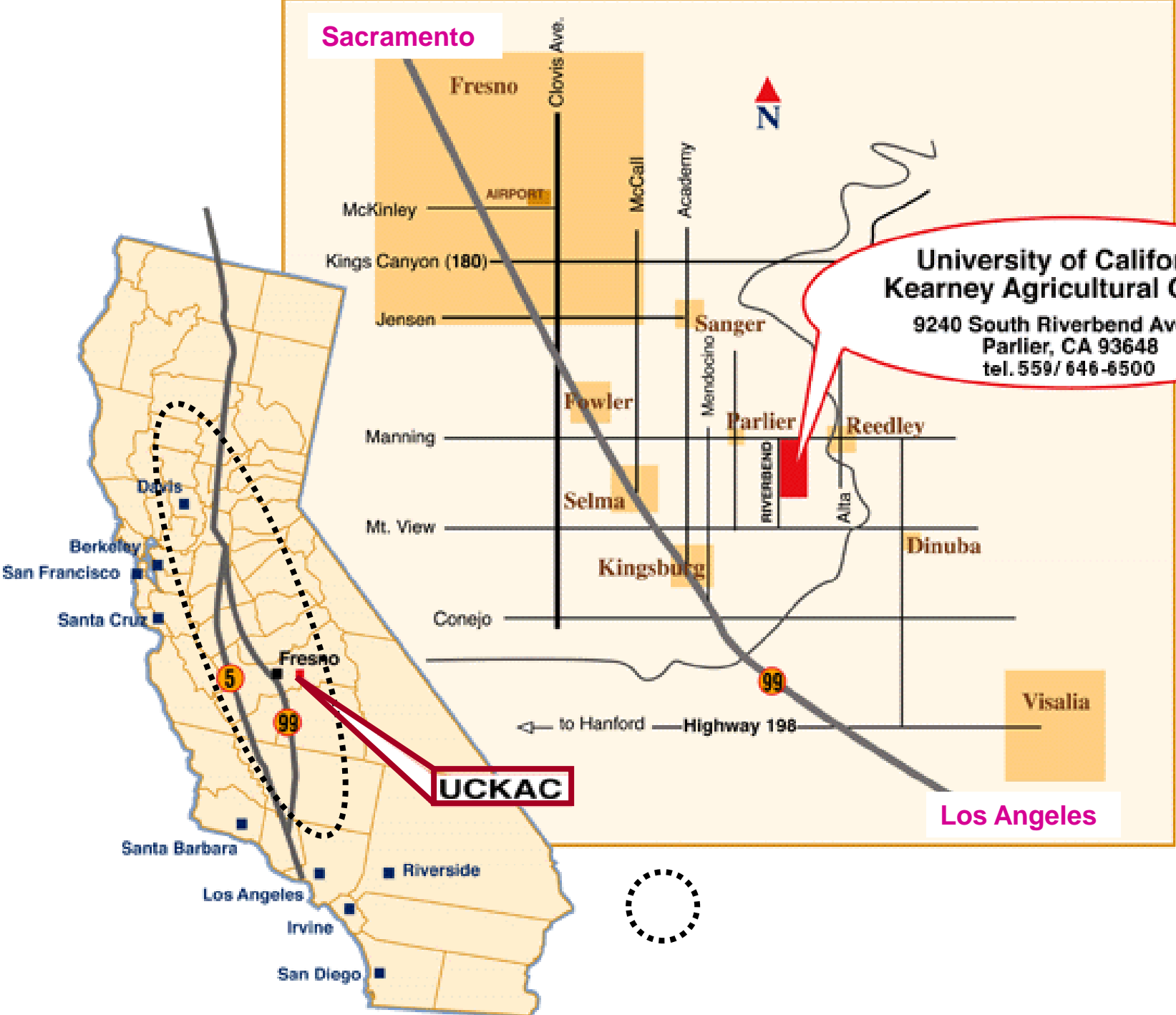


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UCKAC

Los Angeles



Branch Wilt



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



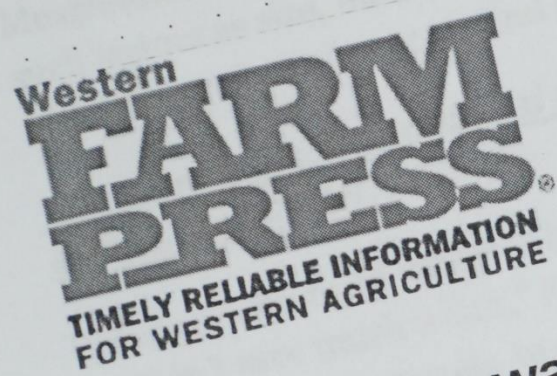
Spores



Are all these branch wilt?



Kings County walnut grower



Kings County walnut grower's crop reports a high-quality crop with declining yields

Greg Northcutt
Wed, 2014-10-15 08:54

One week into October with about two more weeks left in this year's harvest, yields in Doug Verboon Kings County walnut orchards were coming in about 20 percent under last year's levels. However, the quality and the price of the nuts are running high.

Raised on the family's farm, where his grandfather planted his first walnut trees in 1948, the 51-year-old Verboon has been growing walnuts on his own since 2006. His 185-acre farm near Hanford California included cotton and corn. Today, the land is planted solely to walnut trees. They include Serras, as well as Tulares and Chandlers ranging from six to 14 years in age. "Walnuts are not as profitable as corn we used to produce," he says.

That's a little earlier than usual. Since the harvest is usually peaking around 100 days after planting, the normal. Also,



Cultivar: Howard

A lot of dead wood!

**Botryosphaeria &
Phomopsis canker
and blight**



Cultivar: Chandler

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BERKELEY, CALIFORNIA

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

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

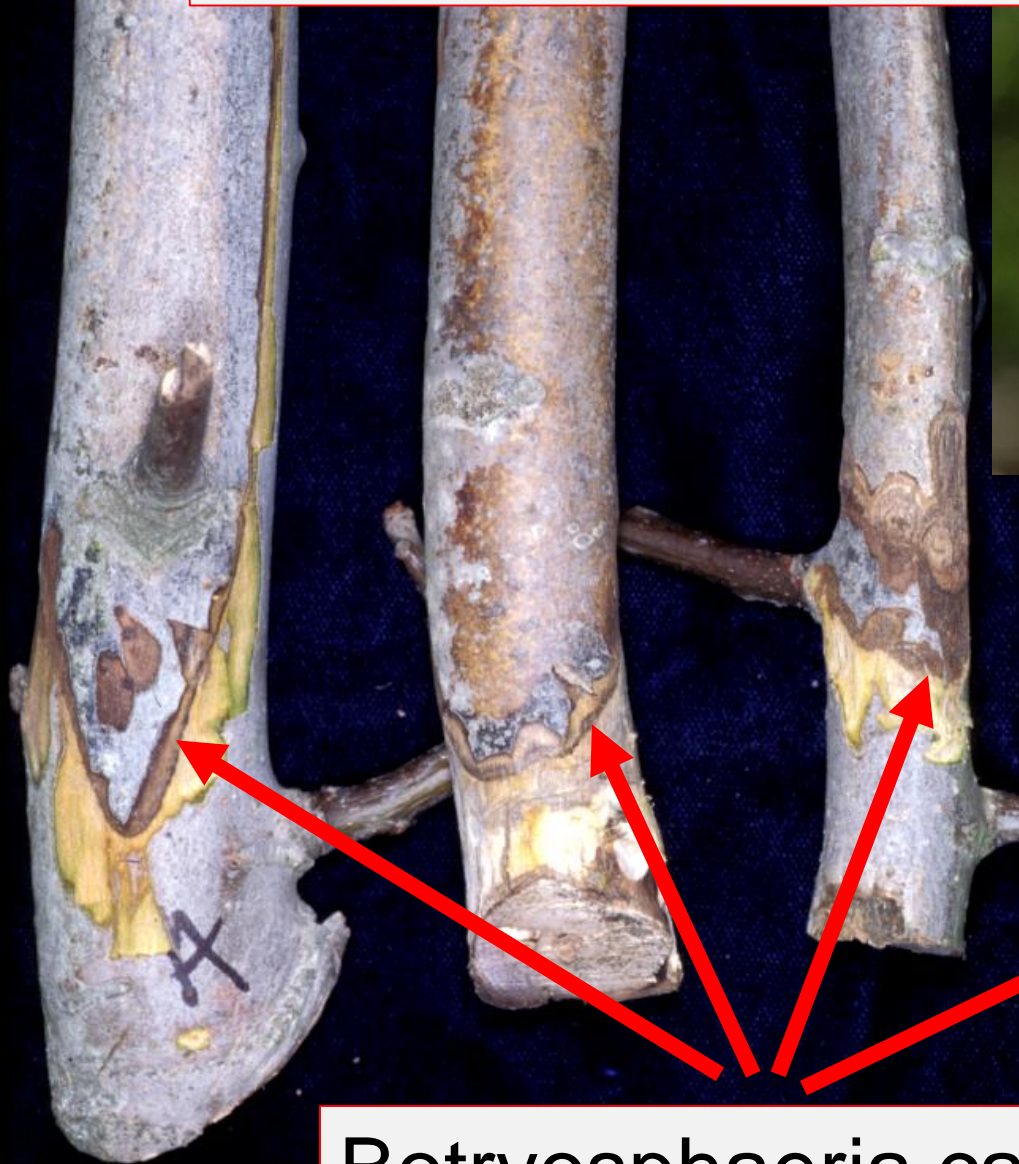
By HOWARD S. FAWCETT

BULLETIN No. 261
Berkeley, Cal., November, 1915

Nov 1915

Caused by *Botryosphaeria ribis*

Botryosphaeria canker and blight symptoms

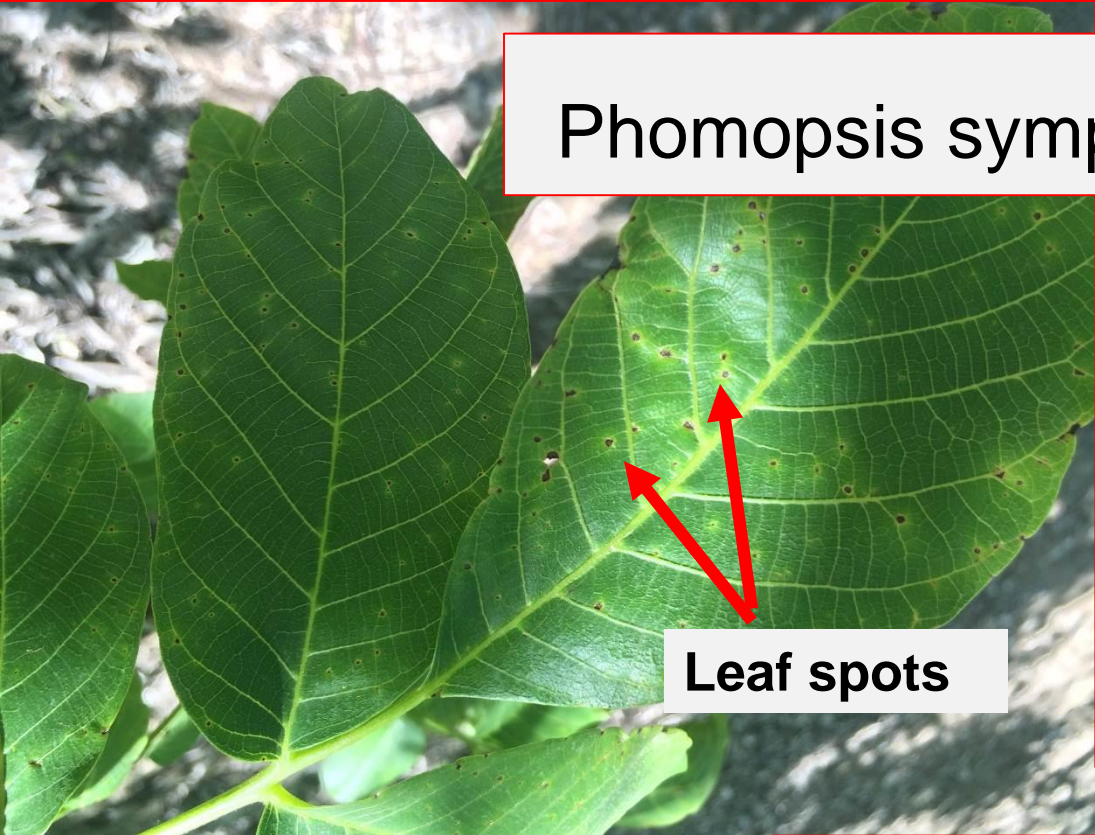


Fruit & spur blight

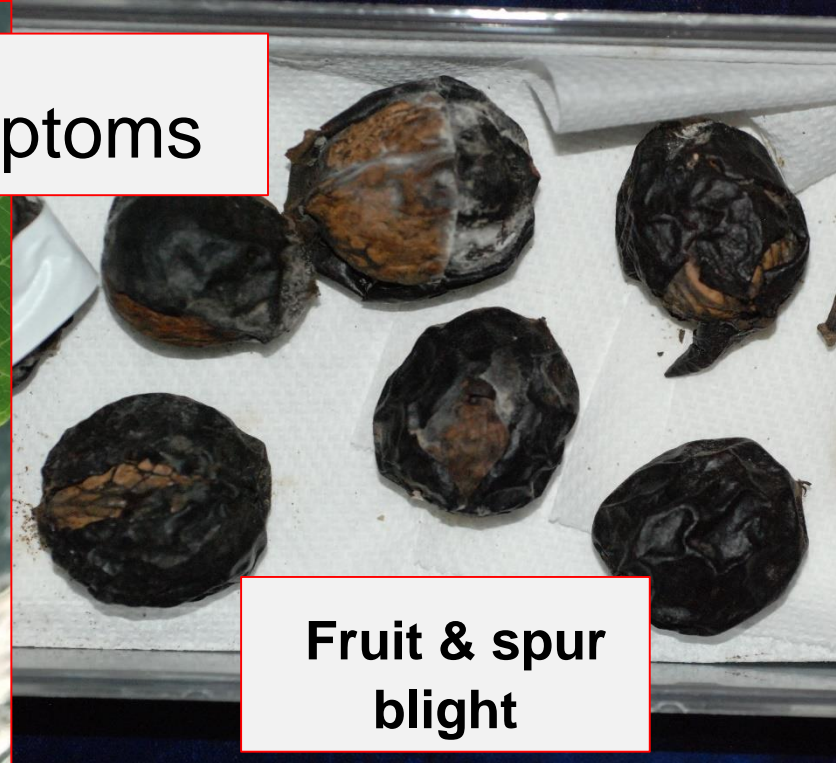


Botryosphaeria canker and blight

Phomopsis symptoms

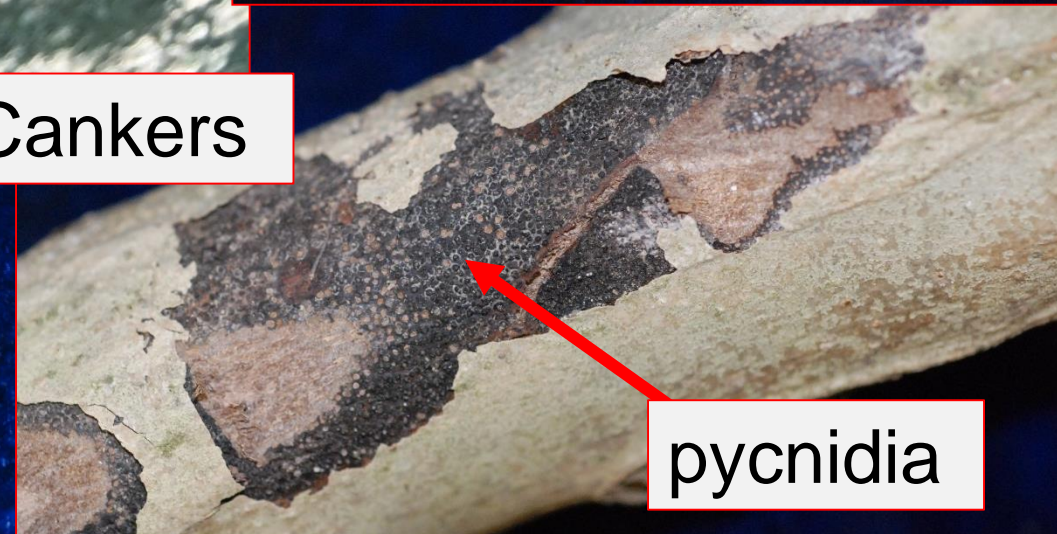


Leaf spots



Fruit & spur blight

Cankers



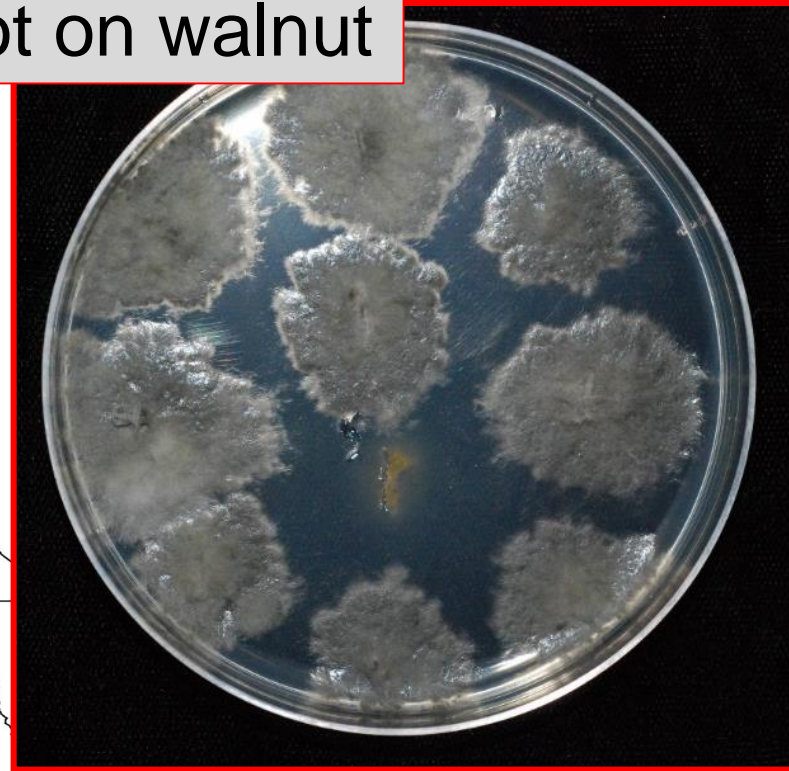
pycnidia

Phomopsis canker and blight

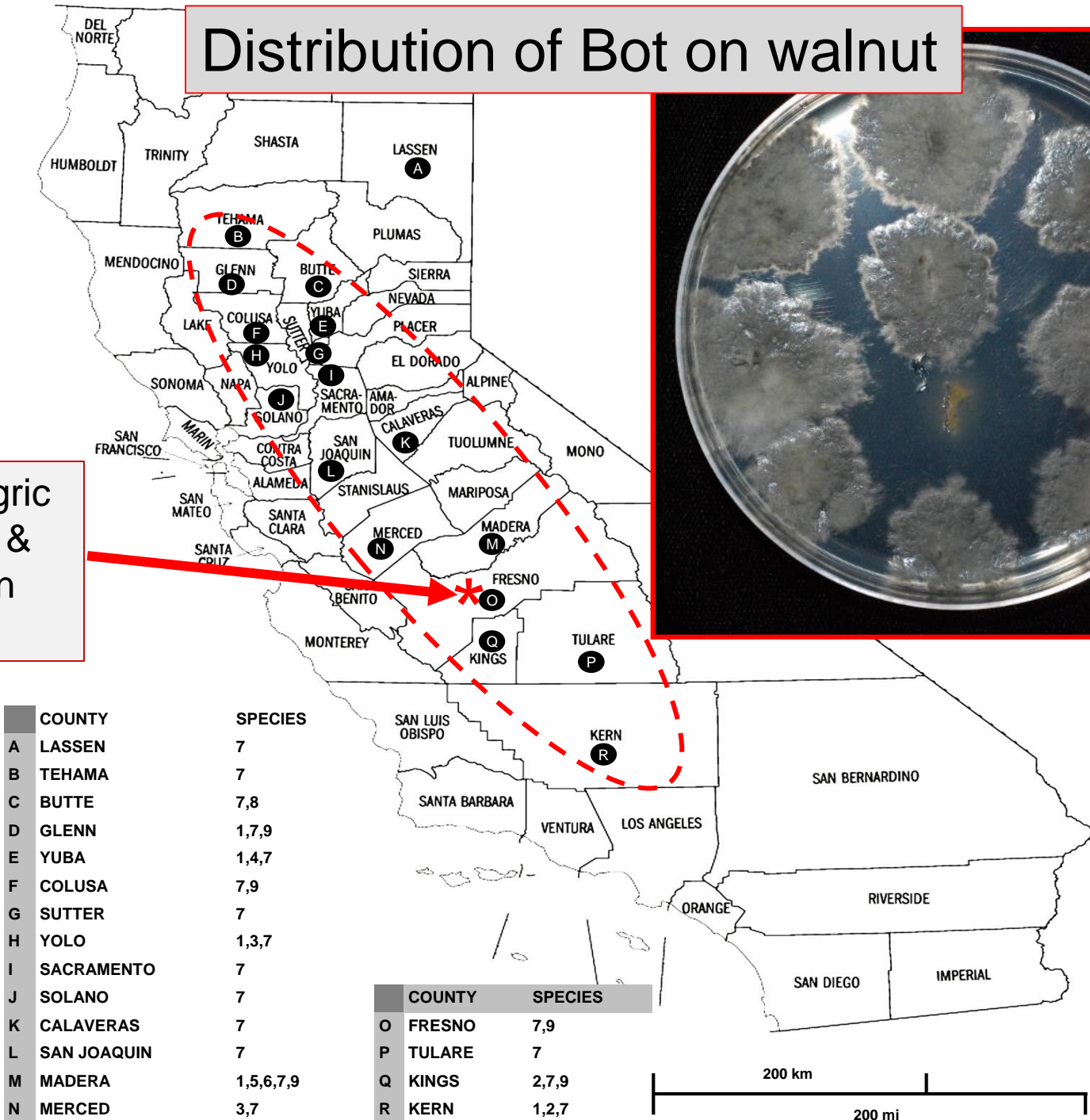
Leaf spots caused by Phomopsis



Distribution of Bot on walnut



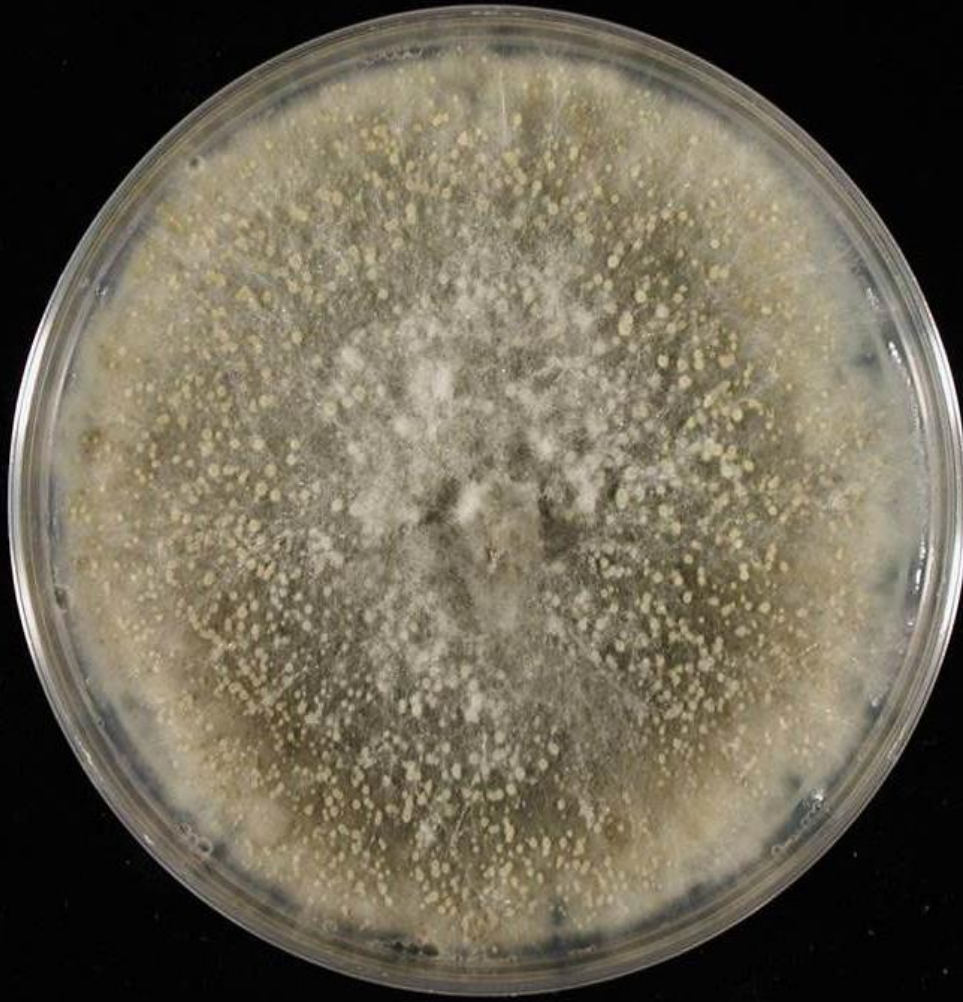
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Extension
Center



Summary of Botryosphaeriaceae in nut crops – California

Fungal species	Walnut	Pistachio	Almond
<i>Botryosphaeria dothidea</i>	+ (& ascospores)	+	+ (& ascospores)
<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 dimitiatum</i> (= <i>Hendersonula toruloidea</i>)	+	---	---
<i>Diaporthe rhusicola</i> (<i>Phomopsis</i>)	+	+	+
<i>Diaporthe neitheicola</i> (<i>Phomopsis</i>)	+	---	---

Botryosphaeria (10 species)



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



3. *Lasiodiplodia* spp.



4. *Diplodia seriata*

Phomopsis (2 species)

Diaporthe neotheicola

Diaporthe rhusicola



α - spores



β - spores



Botryosphaeriaceae

Phomopsis spp.

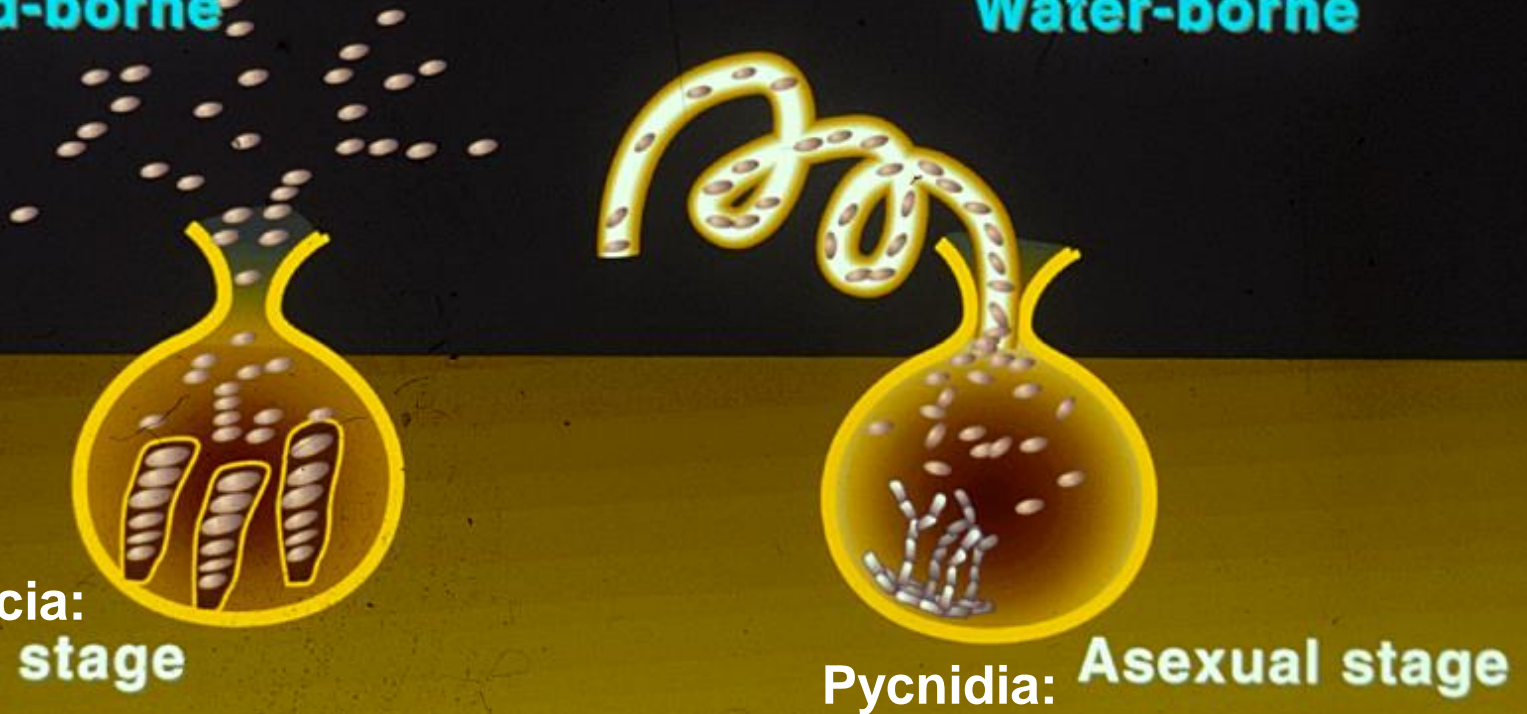
Wind-borne

Water-borne

Perithecia:
Sexual stage

Pycnidia: Asexual stage

Both pycnidia and perithecia in walnut tissues

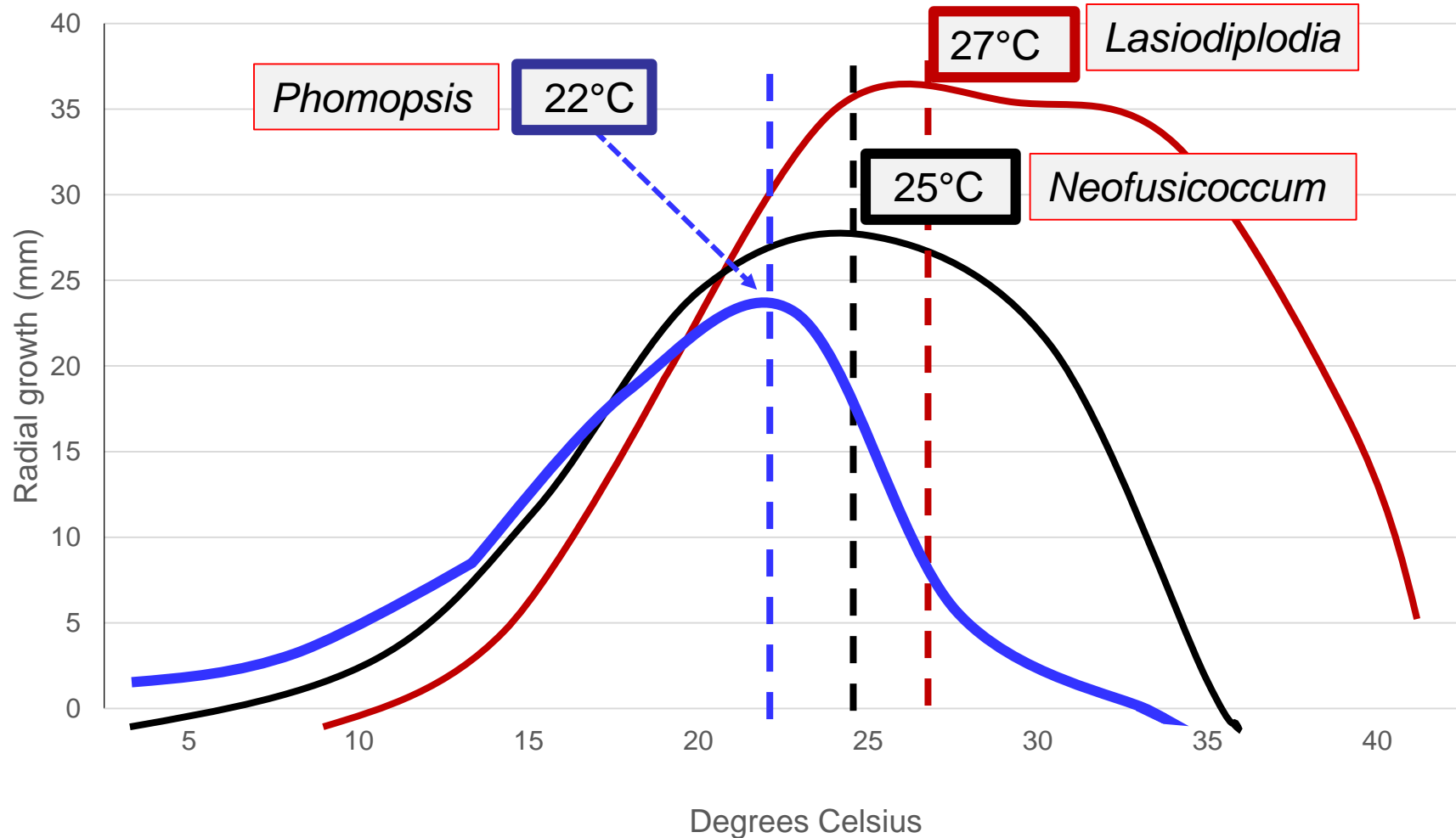


Pycnidia of Botryosphaeriaceae & *Phomopsis*



Oozing pycnidia

Effect of temperature on growth of *Phomopsis* sp., *Neofusicoccum*, and *Lasiodiplodia* spp.

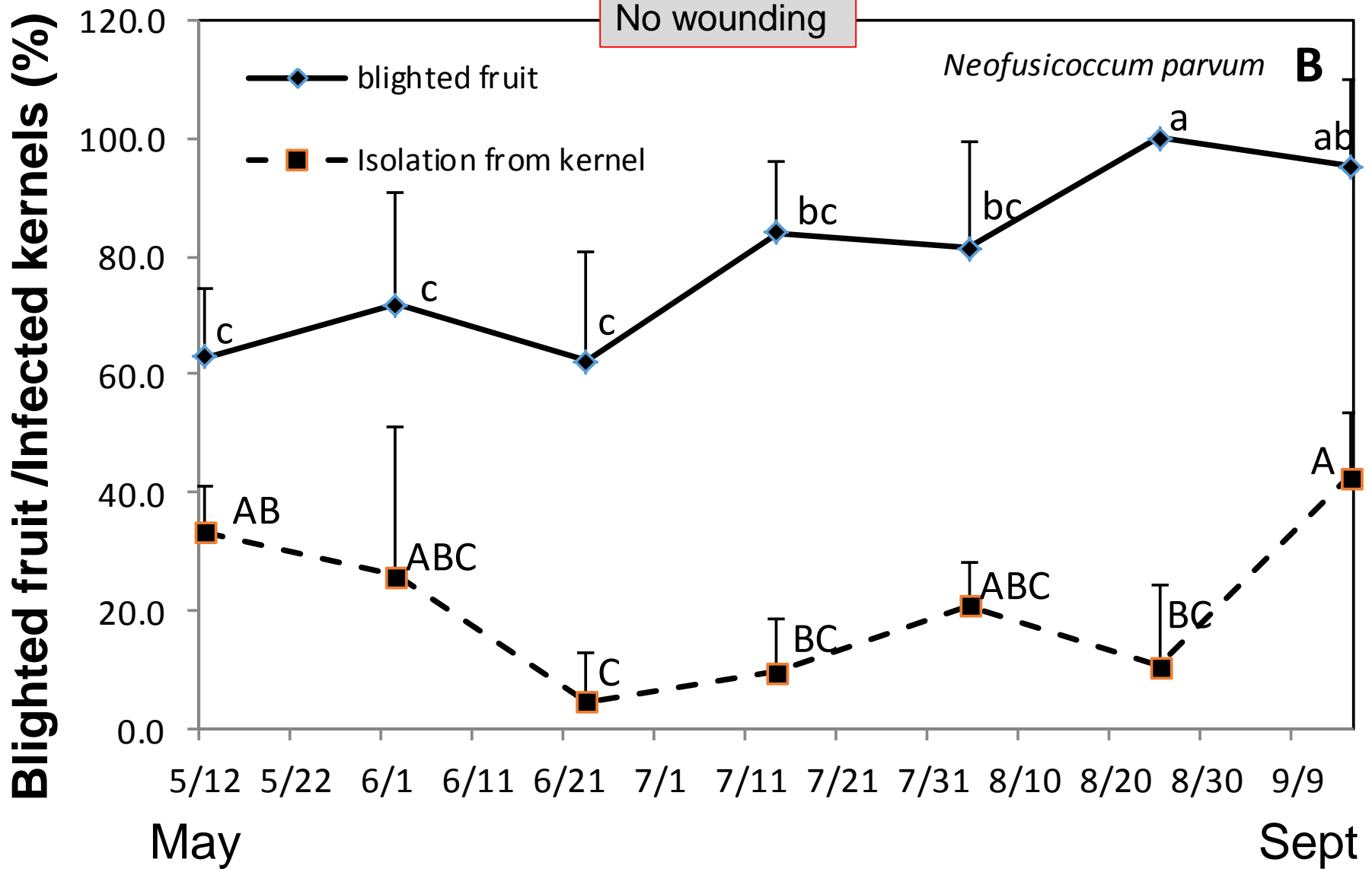


Conditions for infection:

- ✓ Presence of inoculum
- ✓ Rain: at least 4 mm rain)
- ✓ Temperature: $\geq 50^{\circ}\text{F}$
- ✓ Presence of susceptible tissues

Healthy looking nuts until August /September

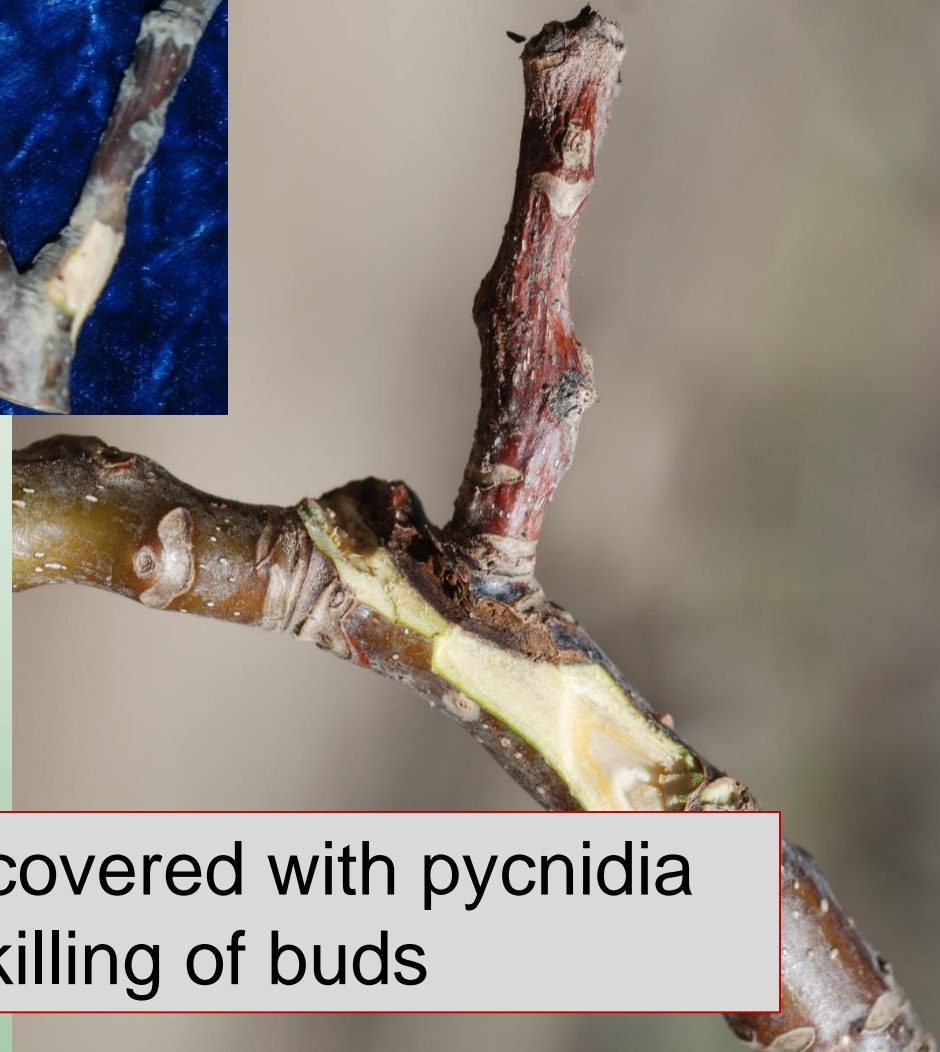
Susceptibility of walnut fruit to *Botryosphaeria*



“Botryosphaeria fruit blight” in Butte Co.

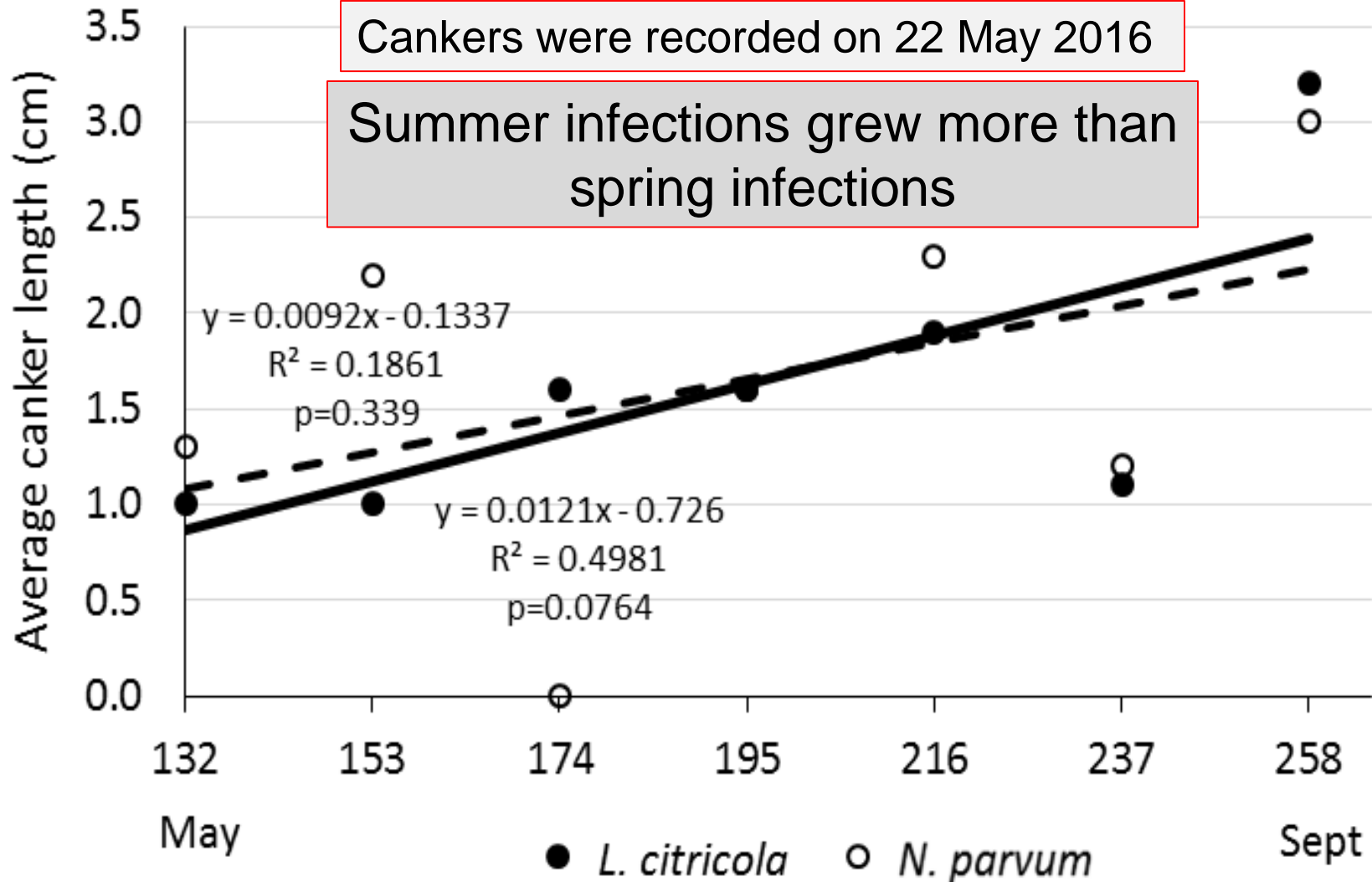


Infection moving
down the spur



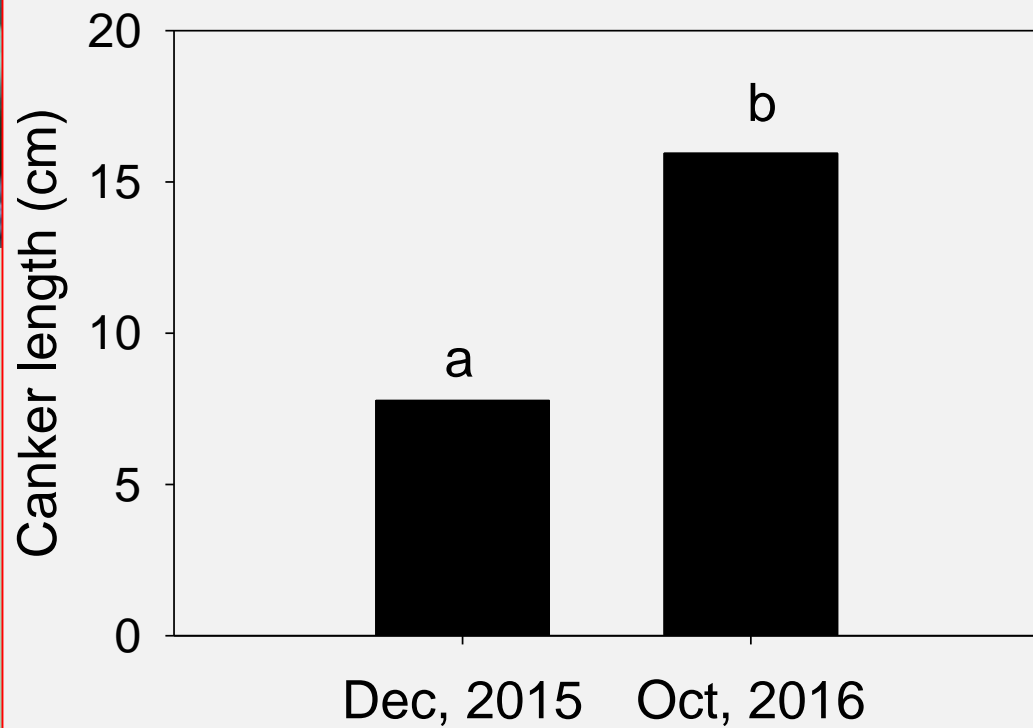
Spurs with cankers covered with pycnidia resulting in killing of buds

Cankers in Vina shoots from inoculations of fruit from 12 May to 15 September 2015





Growth of cankers which started from inoculated and infected walnut fruit in 2015



In addition to direct fruit infection, infection courts:

A. During the season:

- ✓ Pruning wounds
- ✓ Wounds from hail, frost, wood peckers
- ✓ Scale wounds
- ✓ Walnut blight lesions

B. At harvest:

- ✓ Scars from peduncle
- ✓ Leaf scars
- ✓ Mechanical wounds

C. Postharvest:

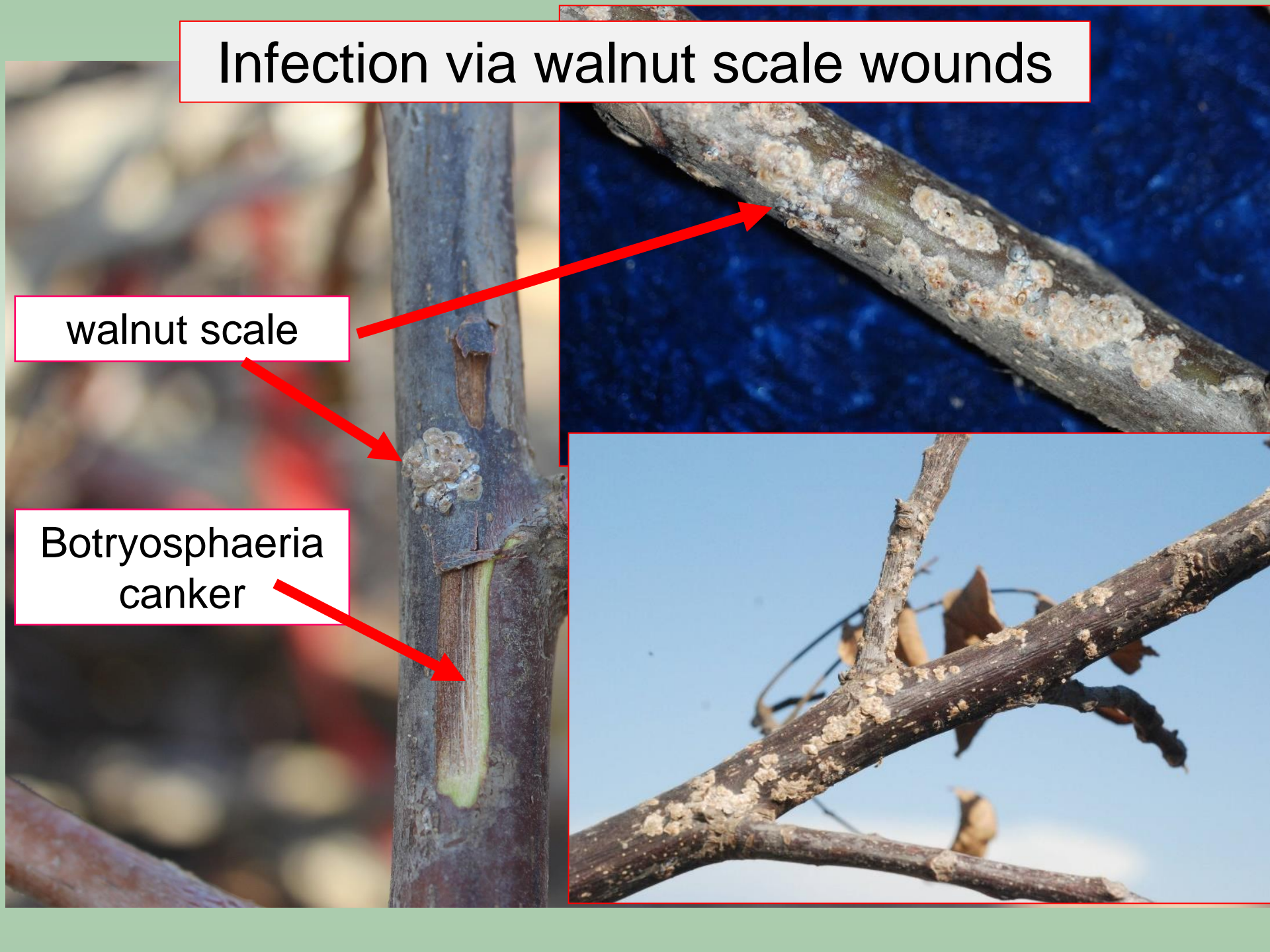
- ✓ Peduncle scars
- ✓ Leaf scars
- ✓ Husks (remaining on the tree)
- ✓ Pruning wounds
- ✓ Wounds from freeze damage
- ✓ Injuries from wood peckers
- ✓ Other type of injuries

* *BAN = Brown Apical Necrosis = walnut blight + other fungi*

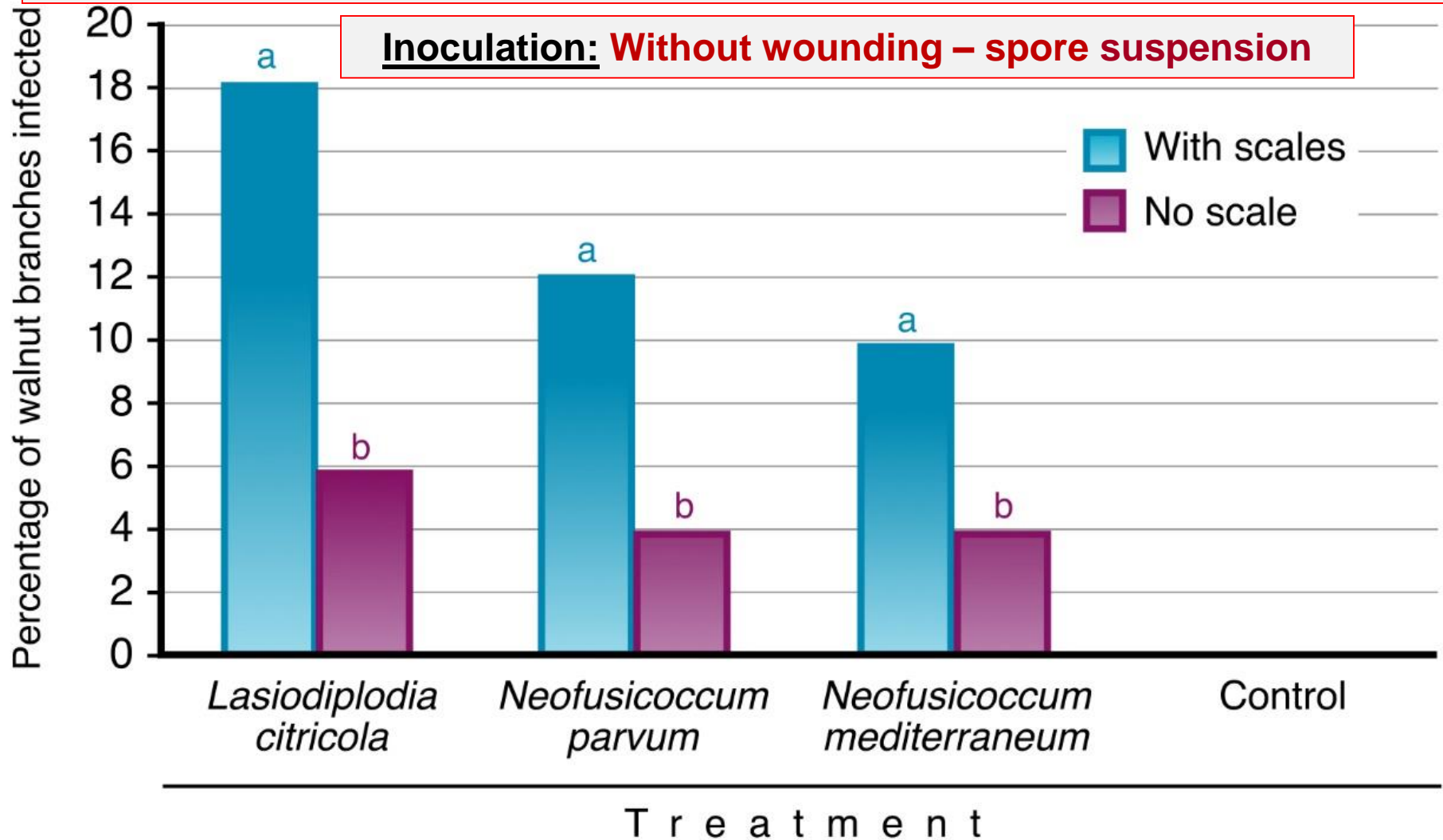
Infection via walnut scale wounds

walnut scale

Botryosphaeria
canker

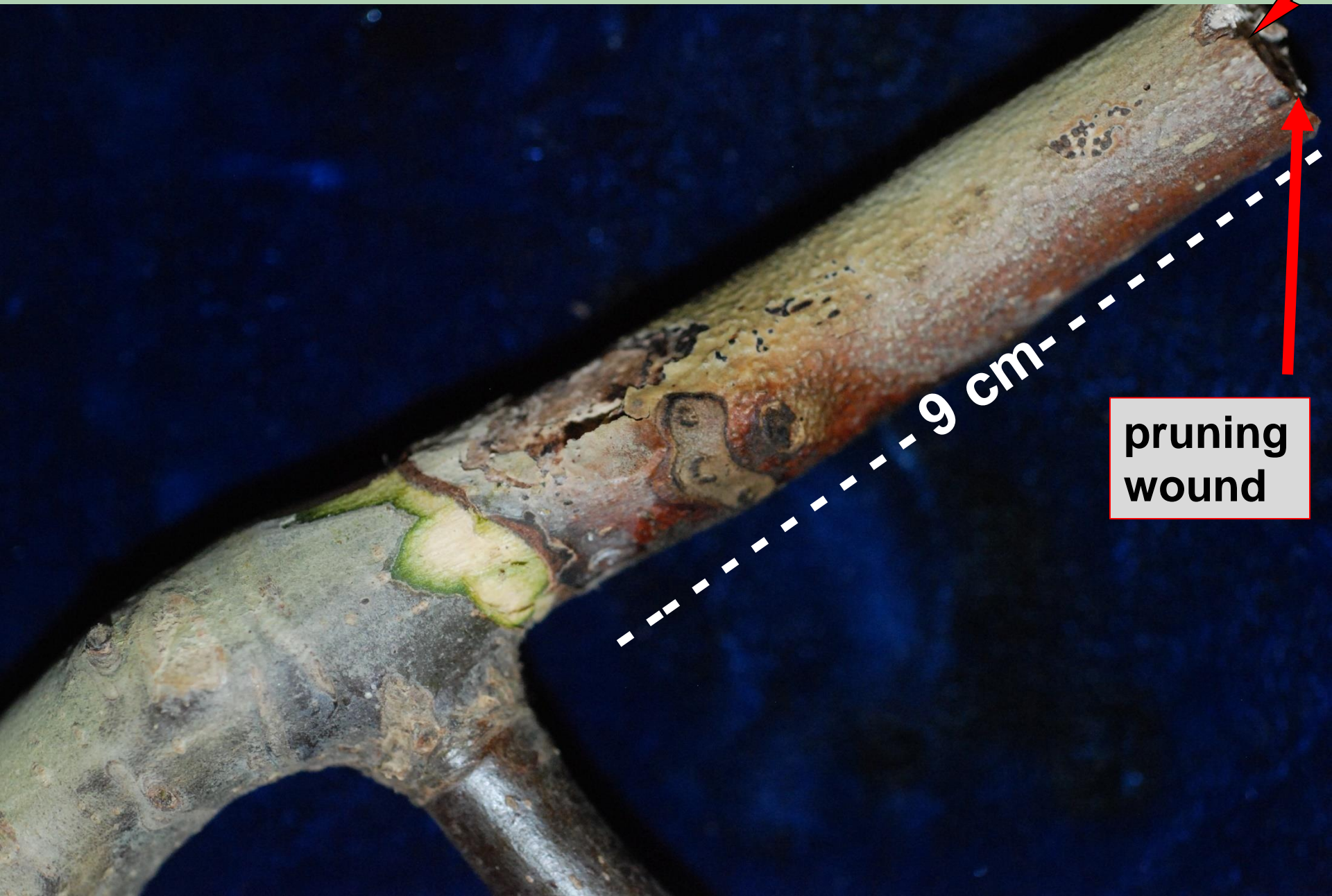


Effect of walnut scales on infection of walnut by Botryosphaeriaceae (cv. Vina)



✓ 60-75% more shoots were infected when scales were present

Cankers associated with pruning wounds

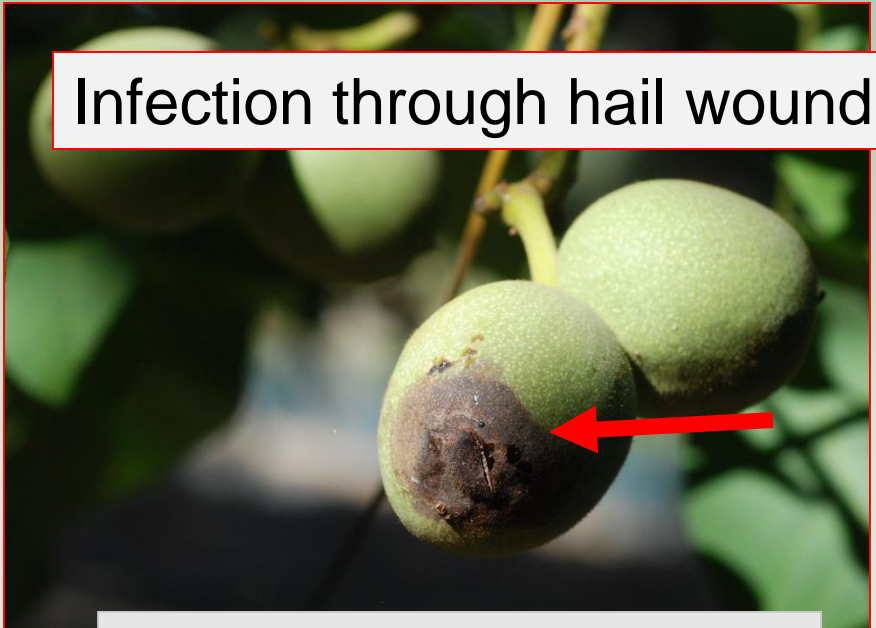
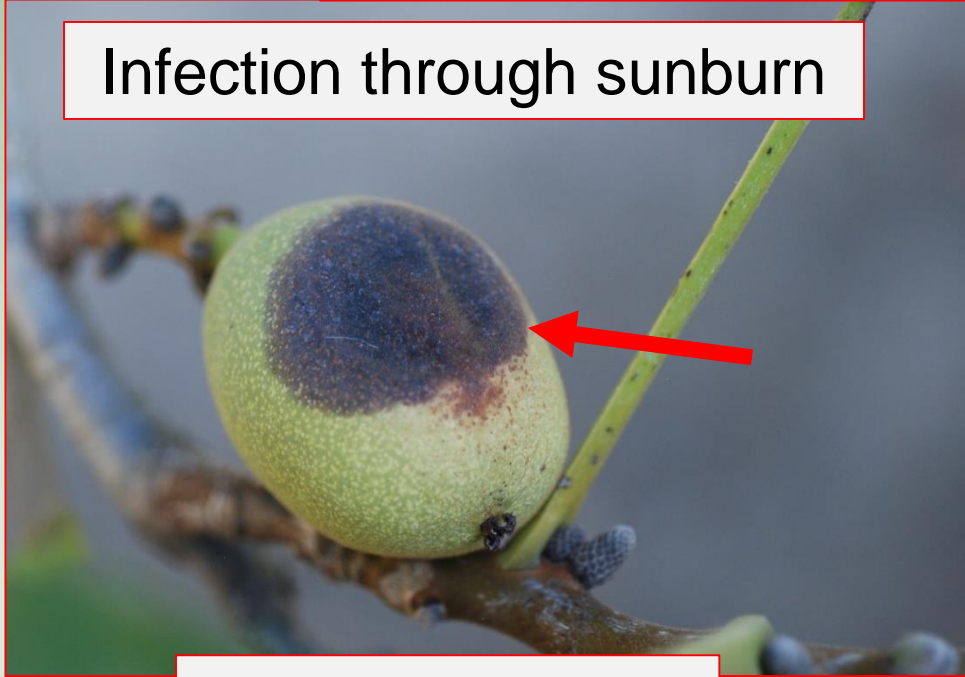


pruning
wound

9 cm

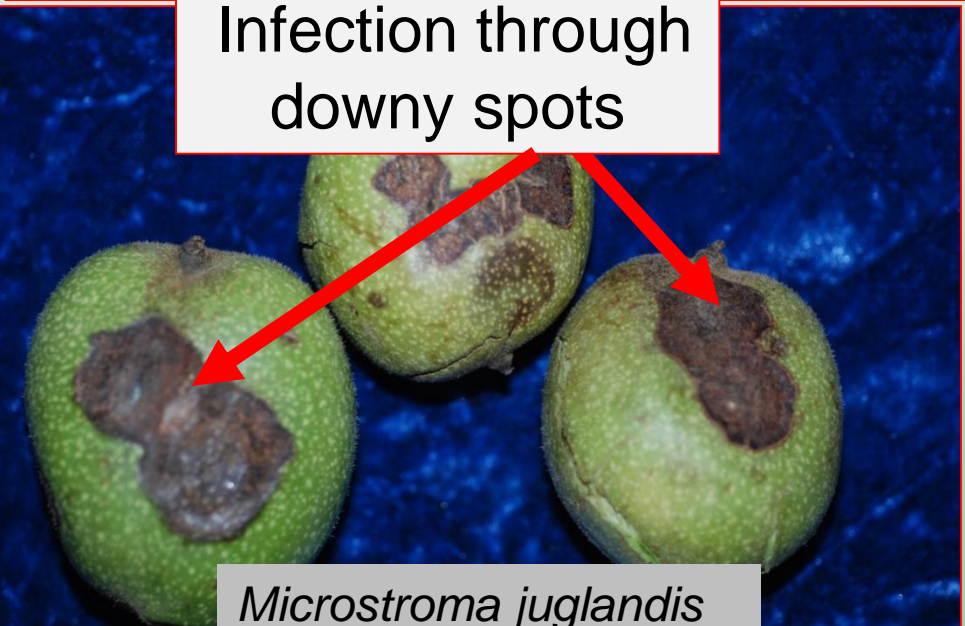
Examples of wound infections

Infection through sunburn



Infection through hail wound

Infection through downy spots

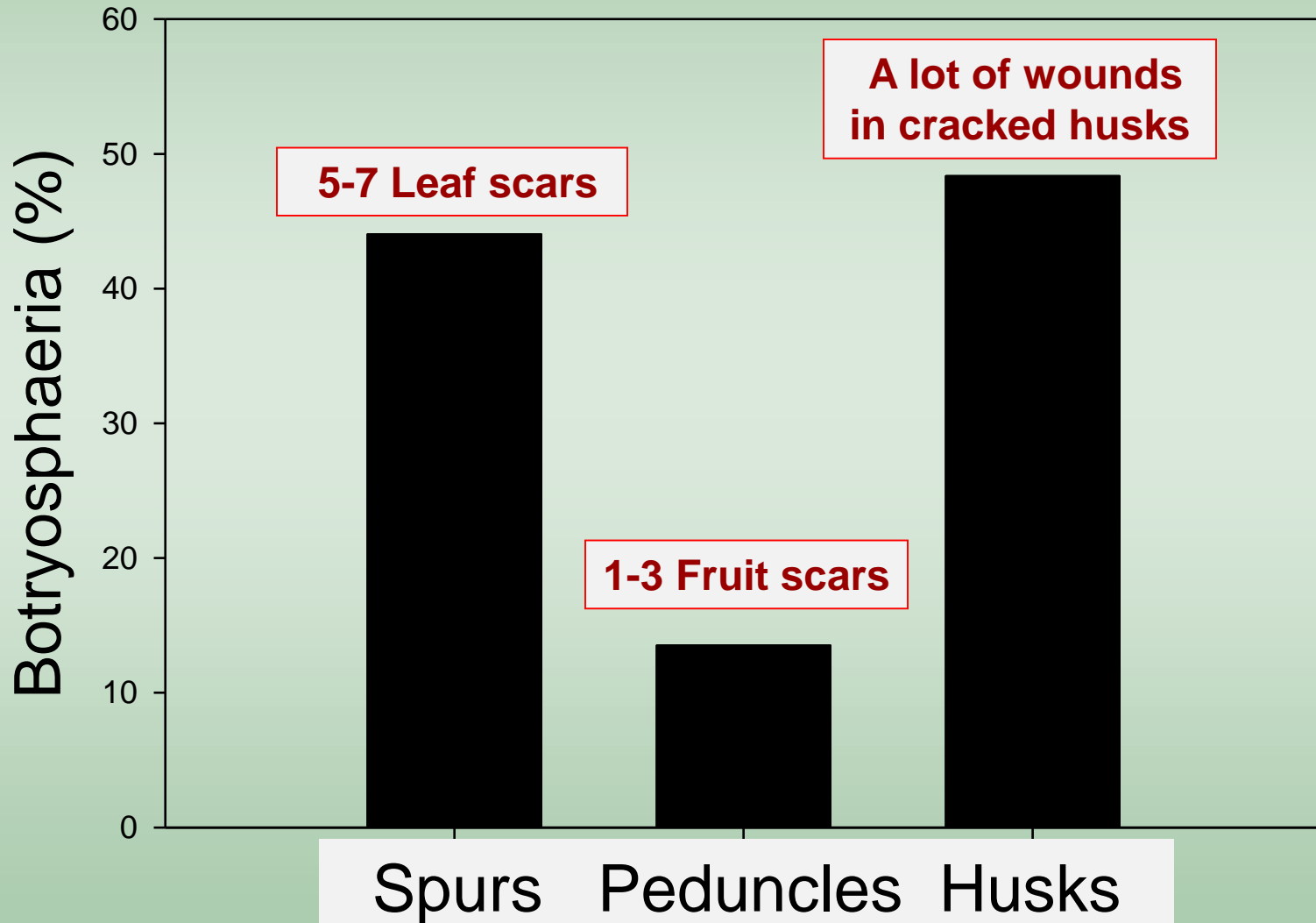


Microstroma juglandis

Infection of leaf scars



Relationship of wounds and Bot disease levels



Cultural practices and other factors affecting Bot canker and blight

- ✓ Irrigation
- ✓ Pruning/hedging
- ✓ Insects (i.e. scale)
- ✓ Walnut blight (and/or other diseases)

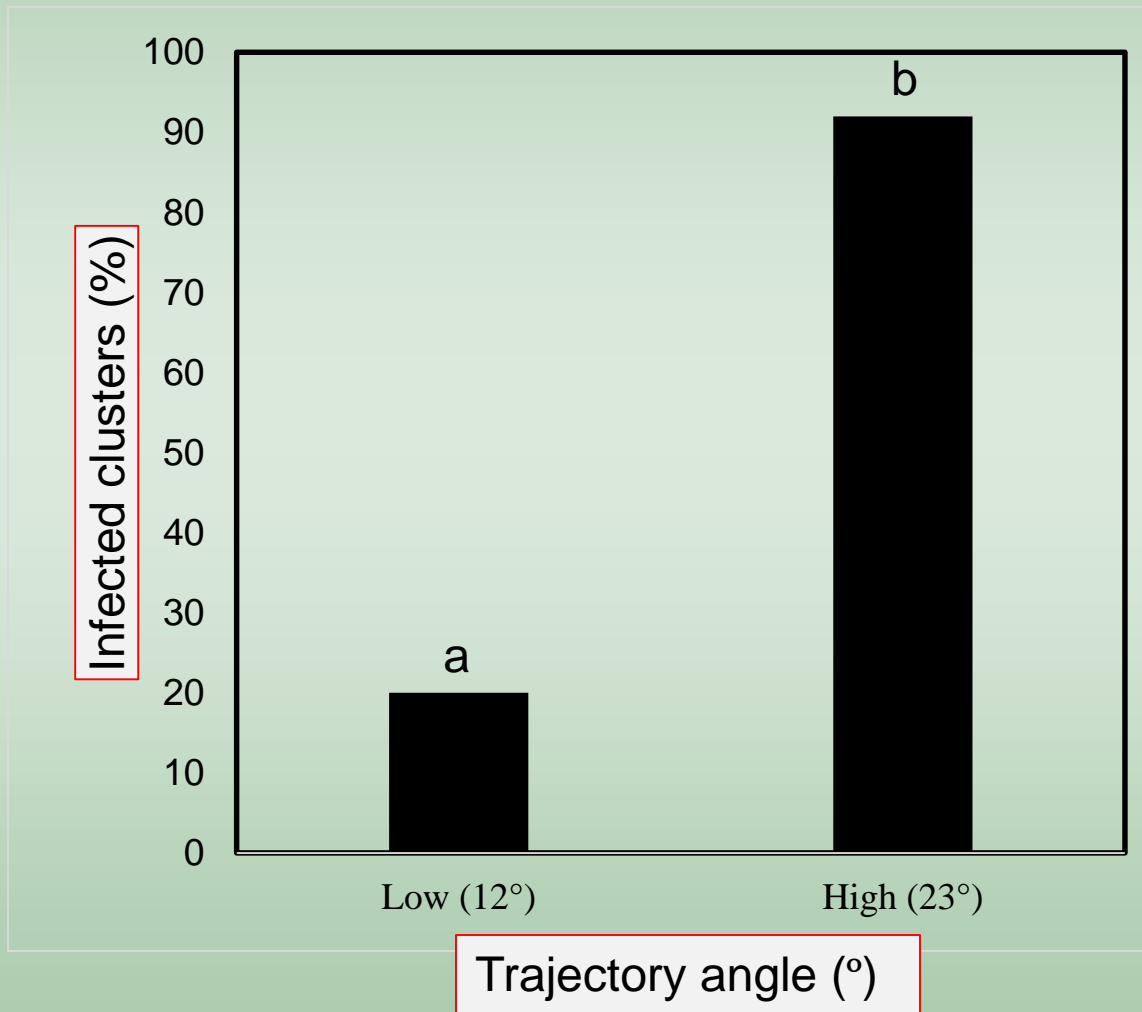
Effect of Irrigation



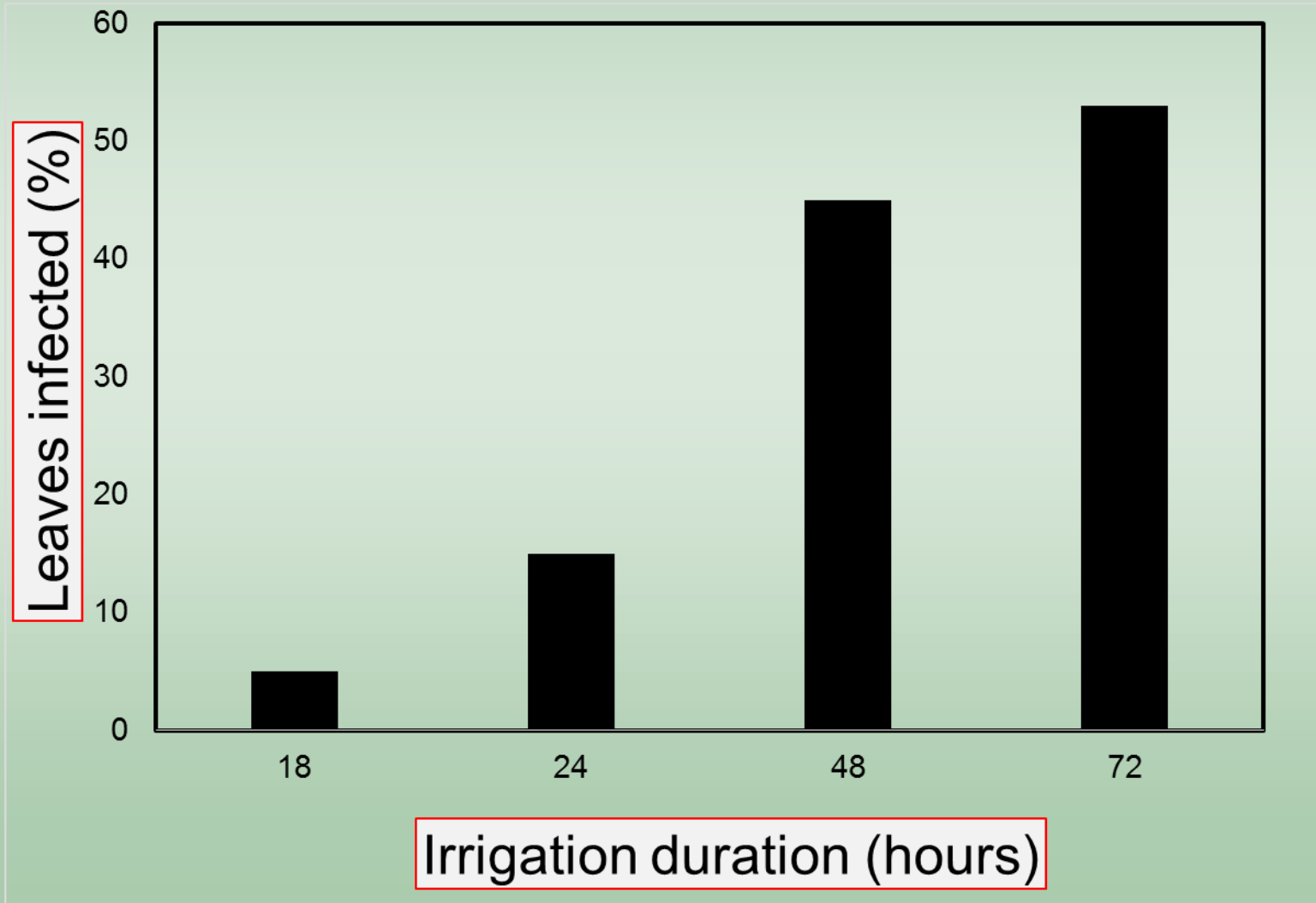
° Trajectory angle

Sprinkler irrigation wetting the tree canopy - 15 September

Effect of trajectory angle of sprinkler irrigation on *Botryosphaeria* panicle and shoot blight (pistachio)



Effect of sprinkler irrigation duration on Botryosphaeria panicle and shoot blight (pistachio)

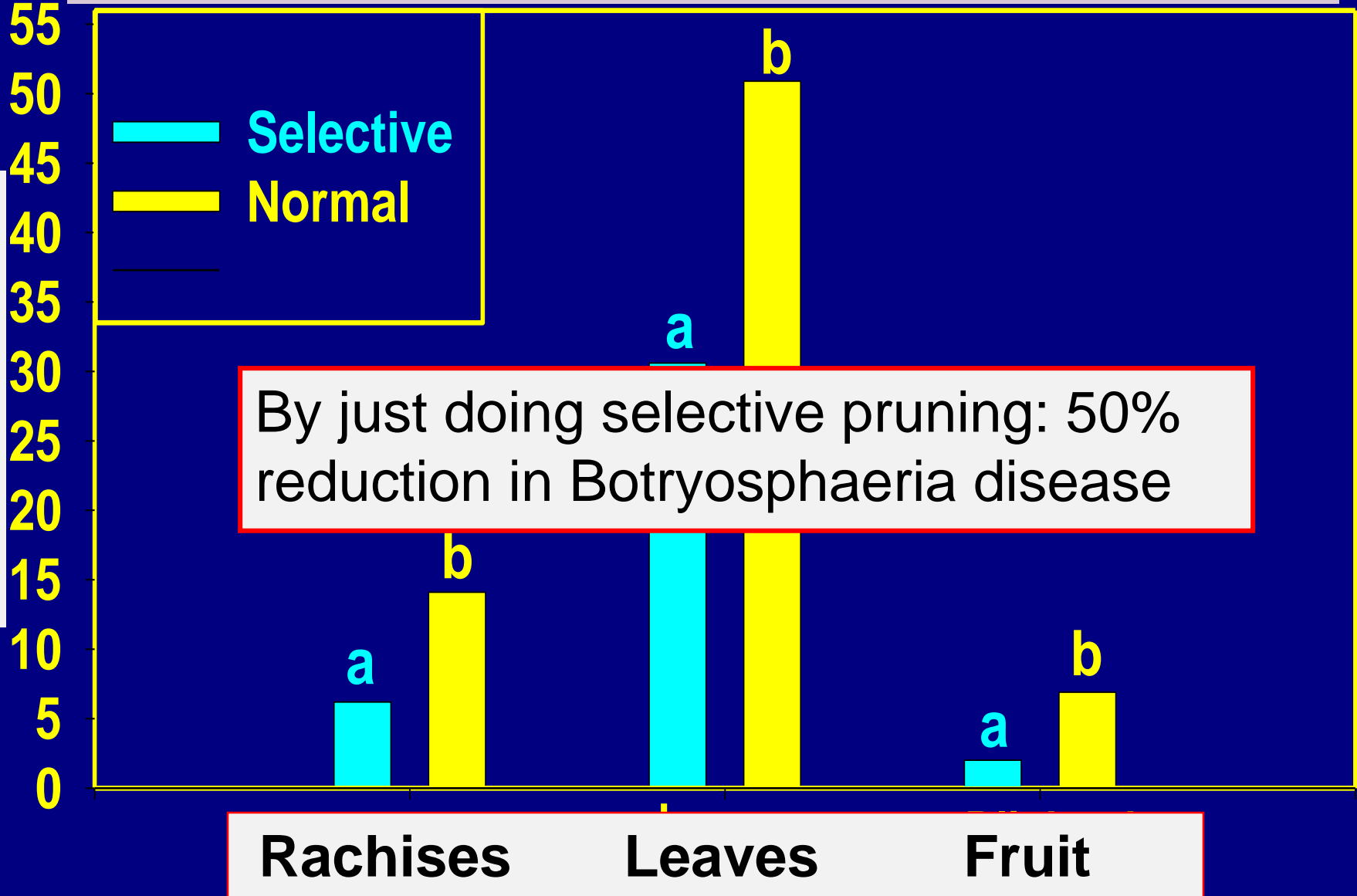


Effect of pruning/hedging



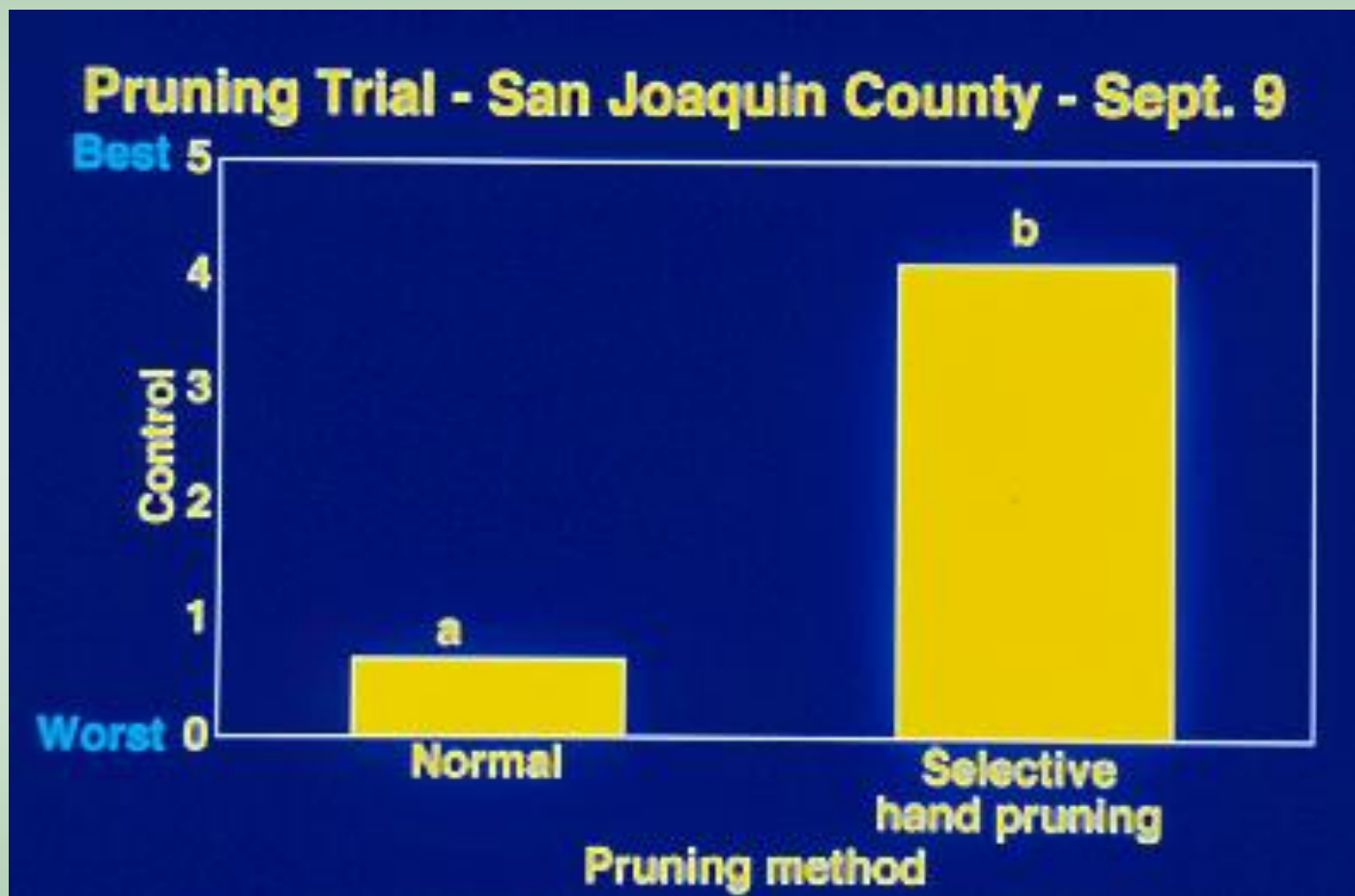


Selective pruning of Botryosphaeria cankers & blighted shoots of pistachio



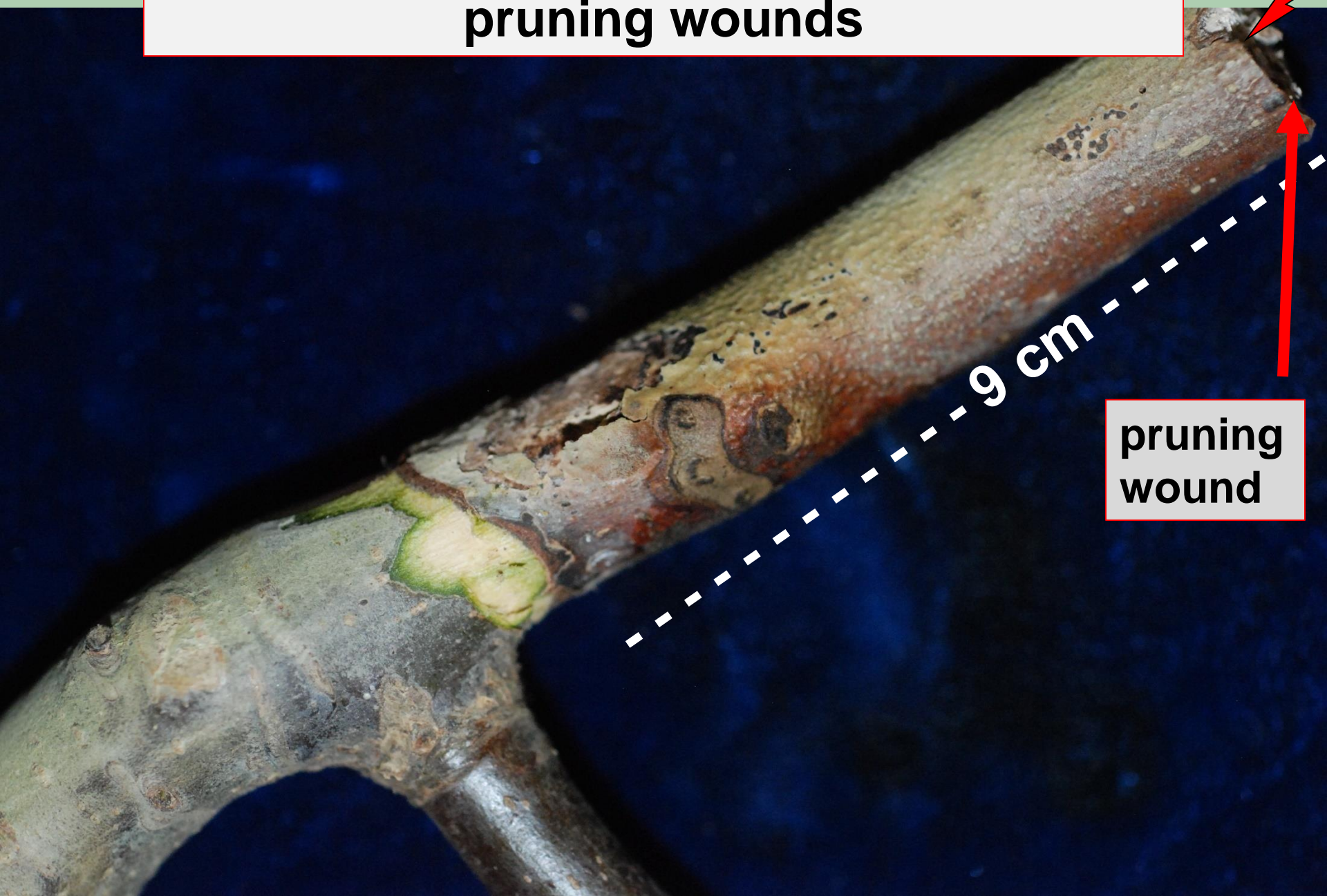
By just doing selective pruning: 50% reduction in Botryosphaeria disease

Effect of selective hand pruning of dead wood and cankers on Bot disease in the following crop year (**pistachio**)



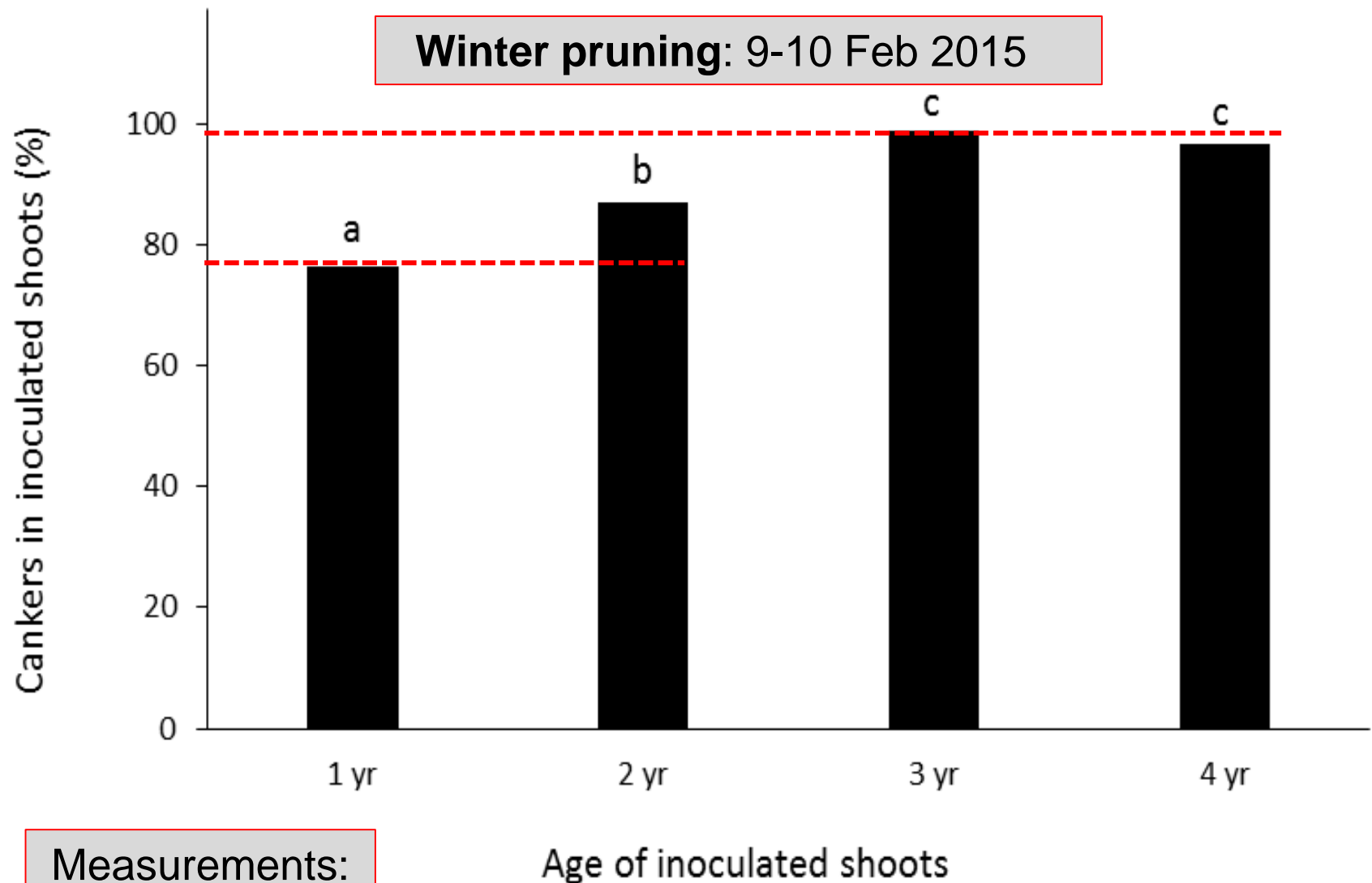
By just doing selective pruning, we had an 80% increase in Bot disease control

Effect of pruning/hedging on infection of pruning wounds



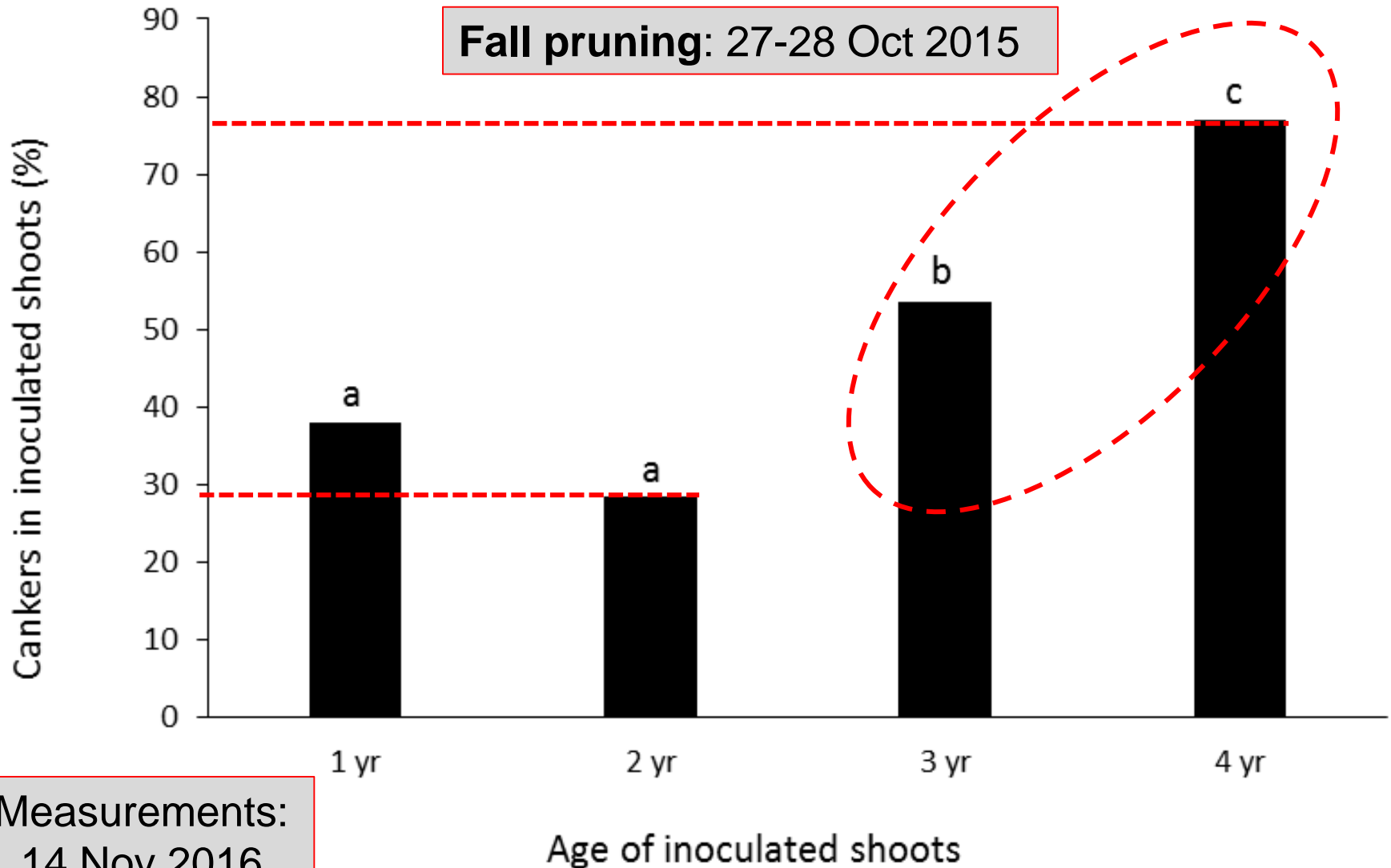
pruning
wound

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

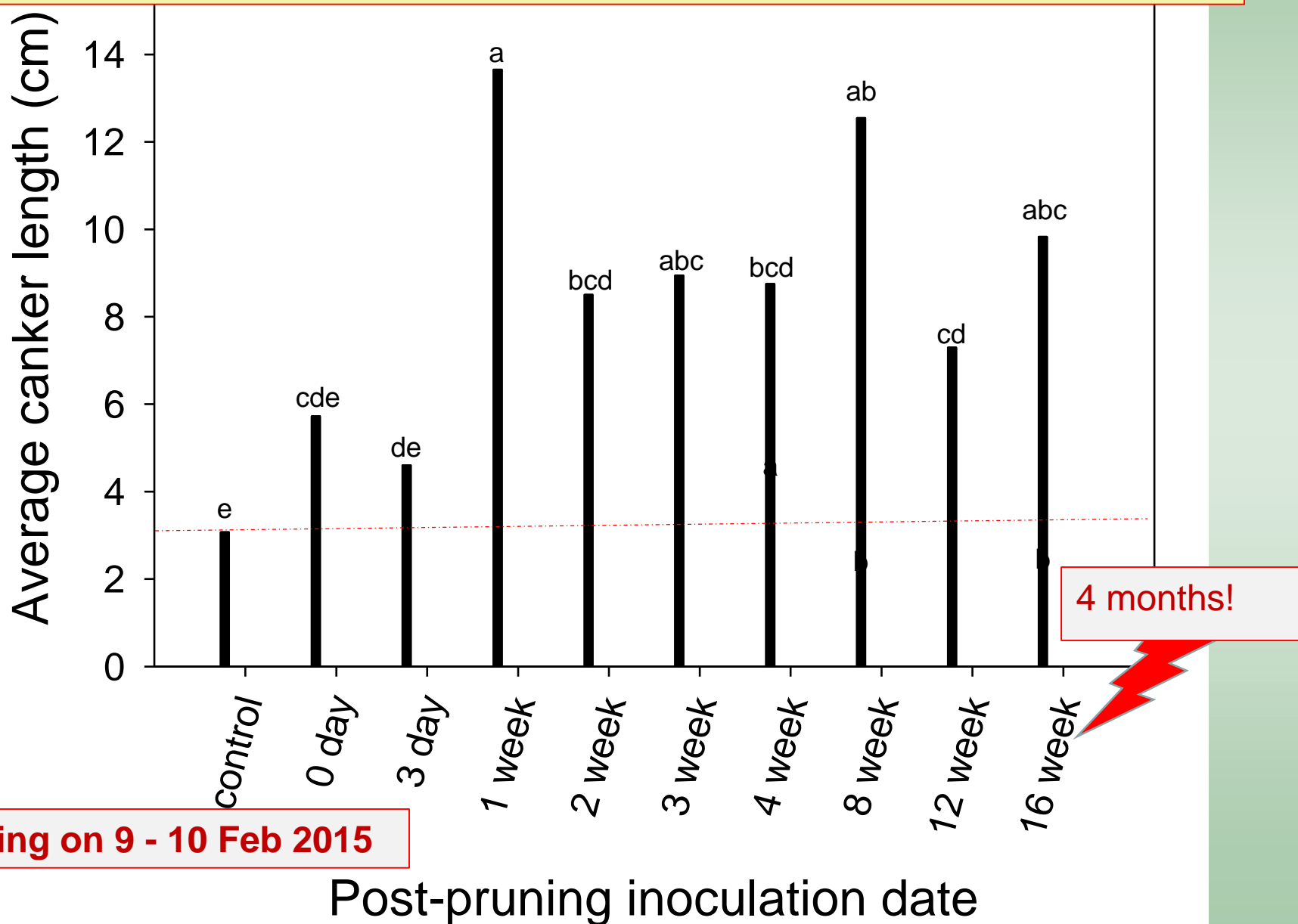


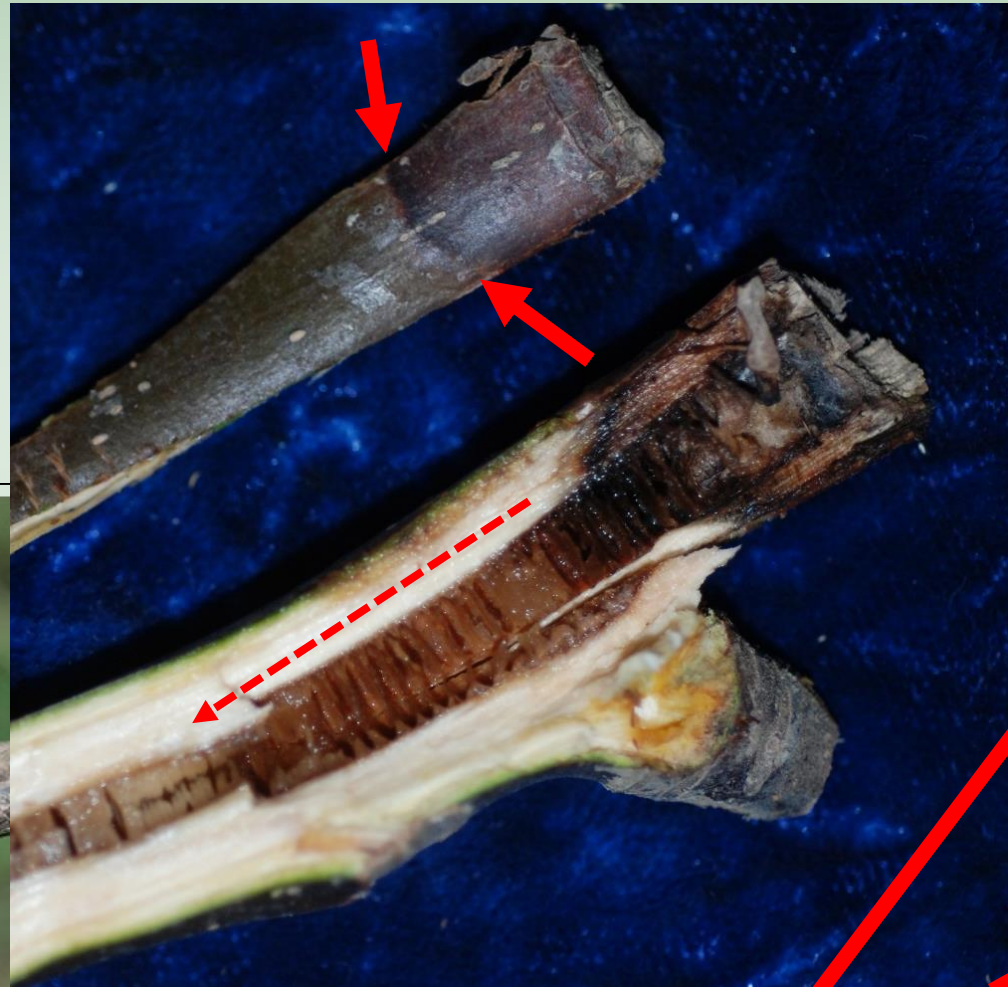
Measurements:
4-7 March 2016

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

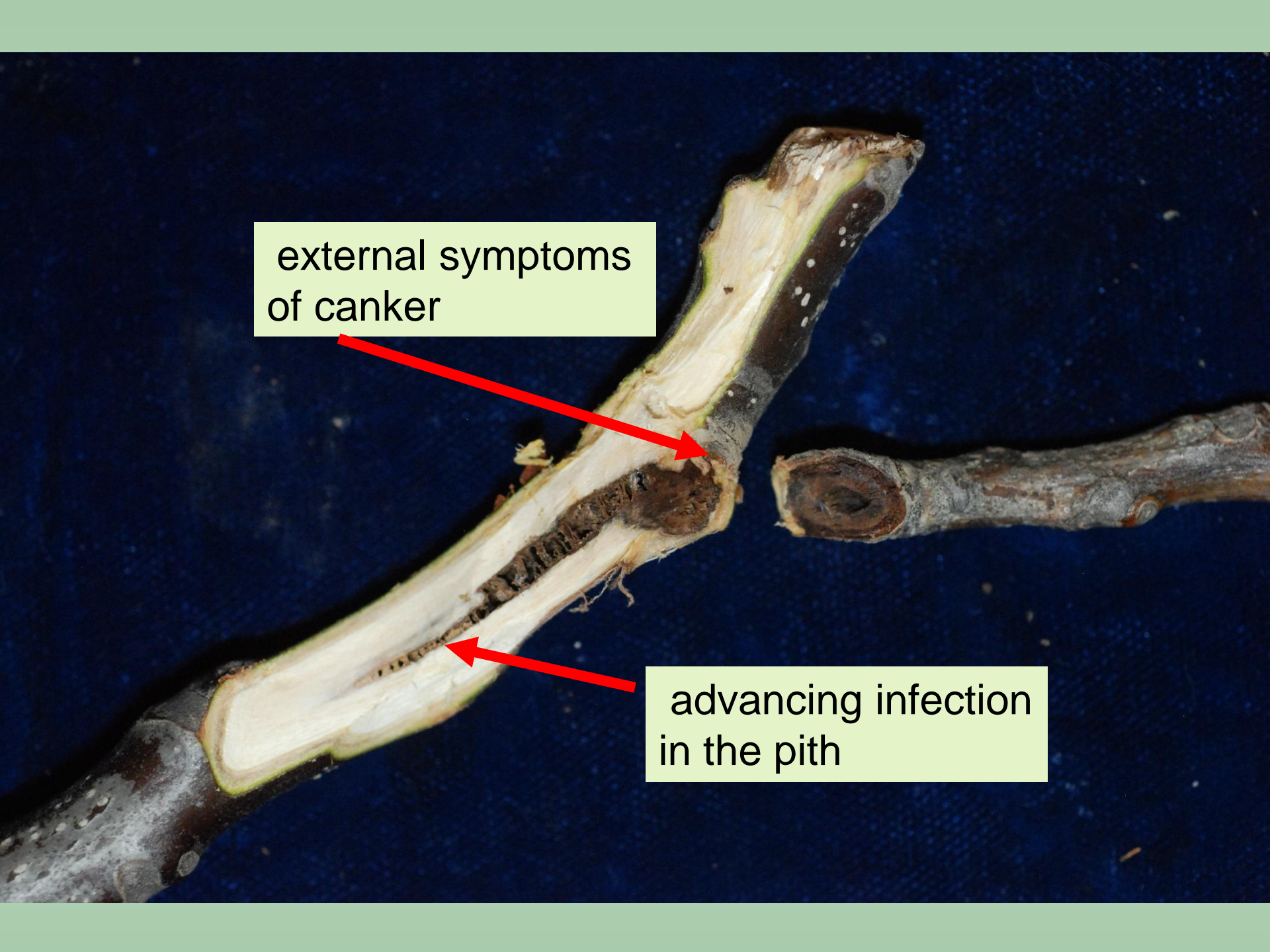


Susceptibility of pruning wounds of (1-, 2-, 3-, & 4-year old wood to infection by Bot





Cankers in walnut branches



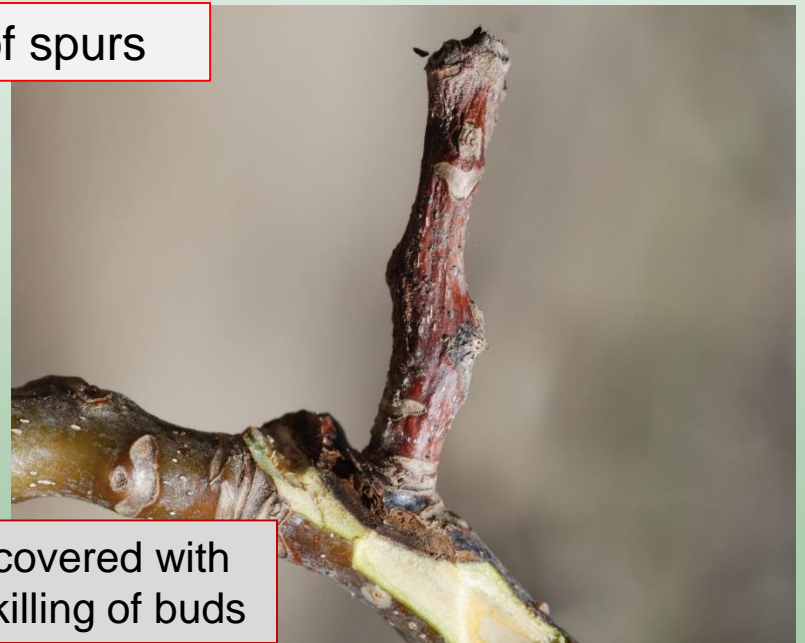
external symptoms
of canker

advancing infection
in the pith

Botryosphaeria infections



Bot Blight of spurs



Spurs with cankers covered with pycnidia resulting in killing of buds

A large pile of coconut husk debris and shells is shown on a concrete surface. The debris consists of many small, light-brown coconut shells and dark brown husk fragments, along with some dry twigs. The pile is spread out across the frame.

Debris from hullers

Sanitation done during harvest

A close-up view of dark, crumbly compost material. The compost is a deep black color and has a highly textured, fragmented appearance. It is piled on a red surface, likely a tarp or mat.

compost

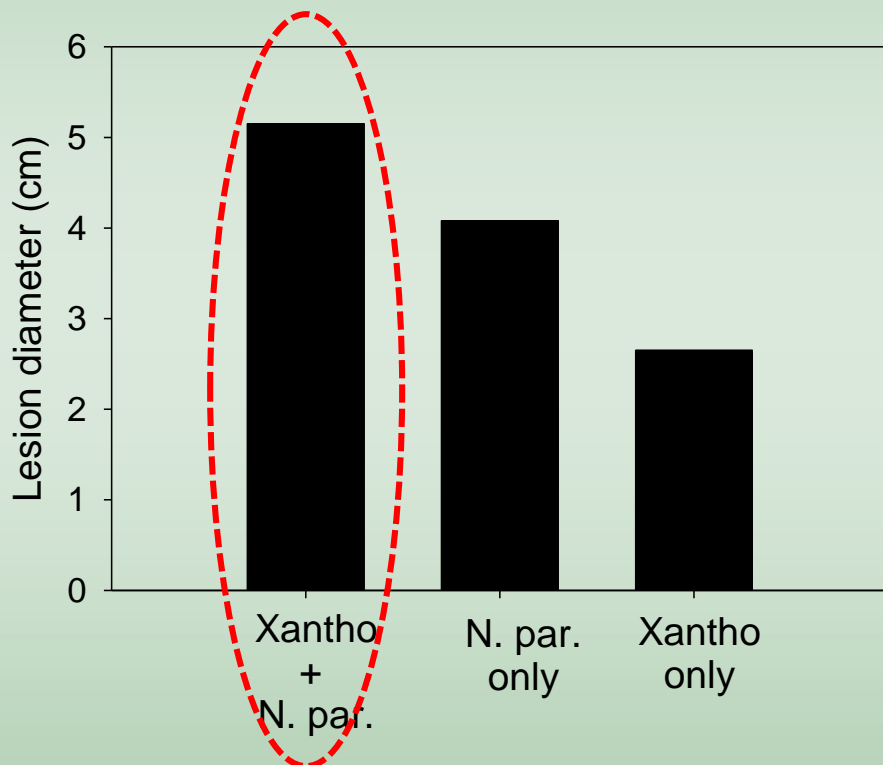
Effect of other diseases: walnut blight



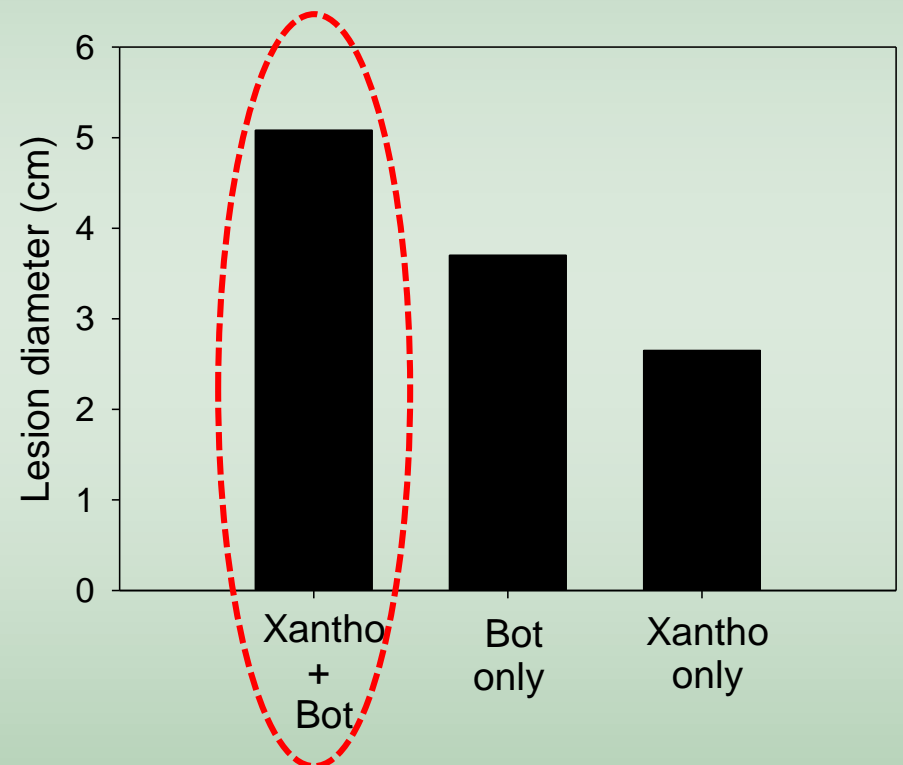
Is walnut blight an entry for Botryosphaeria infections?

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

Effect of walnut blight on development of *Neofusicoccum* & *Botryosphaeria*



Neofusicoccum parvum



Botryosphaeria dothidea

Disease Management

➤ **Cultural control:** Avoid sprinkler irrigation that wets the canopy; prune dead branches or blighted shoots (to reduce inoculum); control walnut scale and walnut blight.

+

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

Best Disease Management: *Intergrading Cultural and Chemical Control Practices*

Sanitation pruning during the summer



Sanitation Pruning Scenarios

✓ **Orchards - Heavy infection-saturated (>50%):** Prunings need to be chipped and may be left in the orchard; yearly, full spray fungicide program. **WATCH FOR RAINS**

✓ **Orchards – Moderate infection (20% - 50%):**
Prune or hedge these orchards first and then move into more infected orchards; prunings need to be removed out of the orchard; some spraying. **WATCH FOR RAINS**

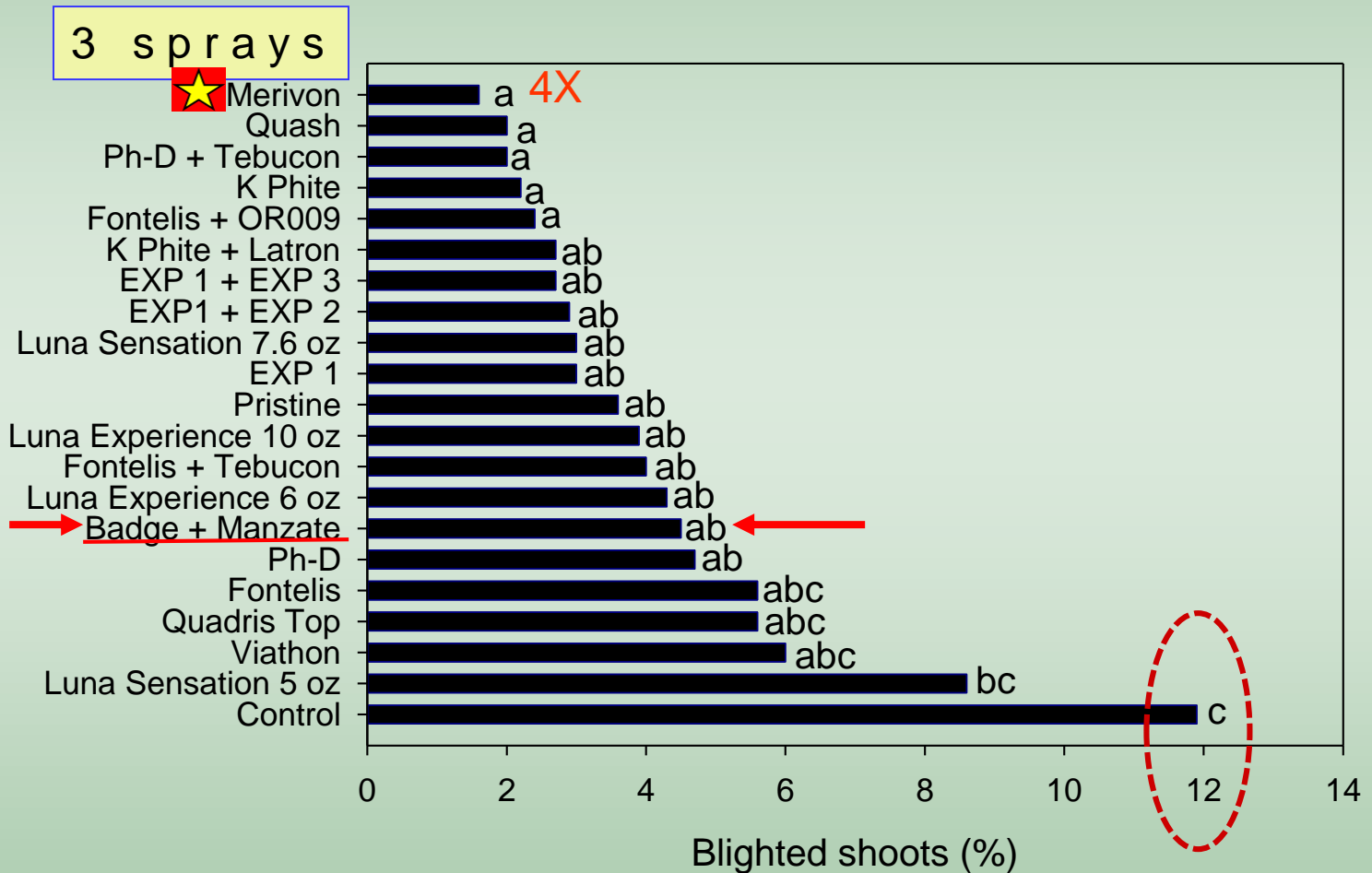
✓ **Orchards – Light infection (1% - 20%):**
Prune or hedge these orchards first and then move into more infected orchards; prunings need to be removed out of the orchard and one mid-June/July spray. **WATCH FOR RAINS**

✓ **Young Orchards (< 5-7 years old)– No Botryosphaeria yet (0%):** Prunings can be chipped and left in the orchard; no sprays are needed.

Chemical Control

- ✓ Botryosphaeria (Chandler orchard)
 - ✓ Anthracnose (Serr orchard)
 - ✓ [Walnut blight (Serr orchard)]
- (New 2016 Data)

Effects of fungicides on Botryosphaeria in Chandler walnut shoots (Butte Co., 2014)



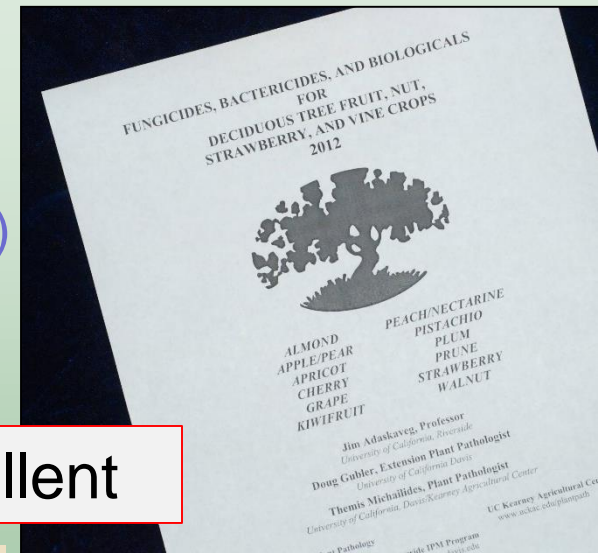
21 treatments sprayed on May 8, June 12, and July 10

Efficacy of registered fungicides against *Botryosphaeria* canker and blight of walnut

Fungicide	Active ingredient	Efficacy
Quash.....	metconazole	++++
Merivon.....	fluxopyroxad+pyraclostrobin	++++
Pristine	boscalid + pyraclostrobin	+++
Quadris Top.....	difenoconazole + azoxystrobin	+++
Switch.....	cyprodinil + fludioxonil	++++
PhD.....	Polyoxin-D	+++
Viathon.....	tebuconazole + phosphite	+++
K-Phite	potassium polyphosphite	++++
Luna Experience	fluopyram + tebuconazole	+++
Luna Sensation	fluopyram + trifloxystrobin	++
Fontelis	penthiopyrad	+++
Manzate	copper-mancozeb	++(+)

+ = poor; ++ = fair; +++ = good; ++++ = excellent

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



Chandler harvest-2016

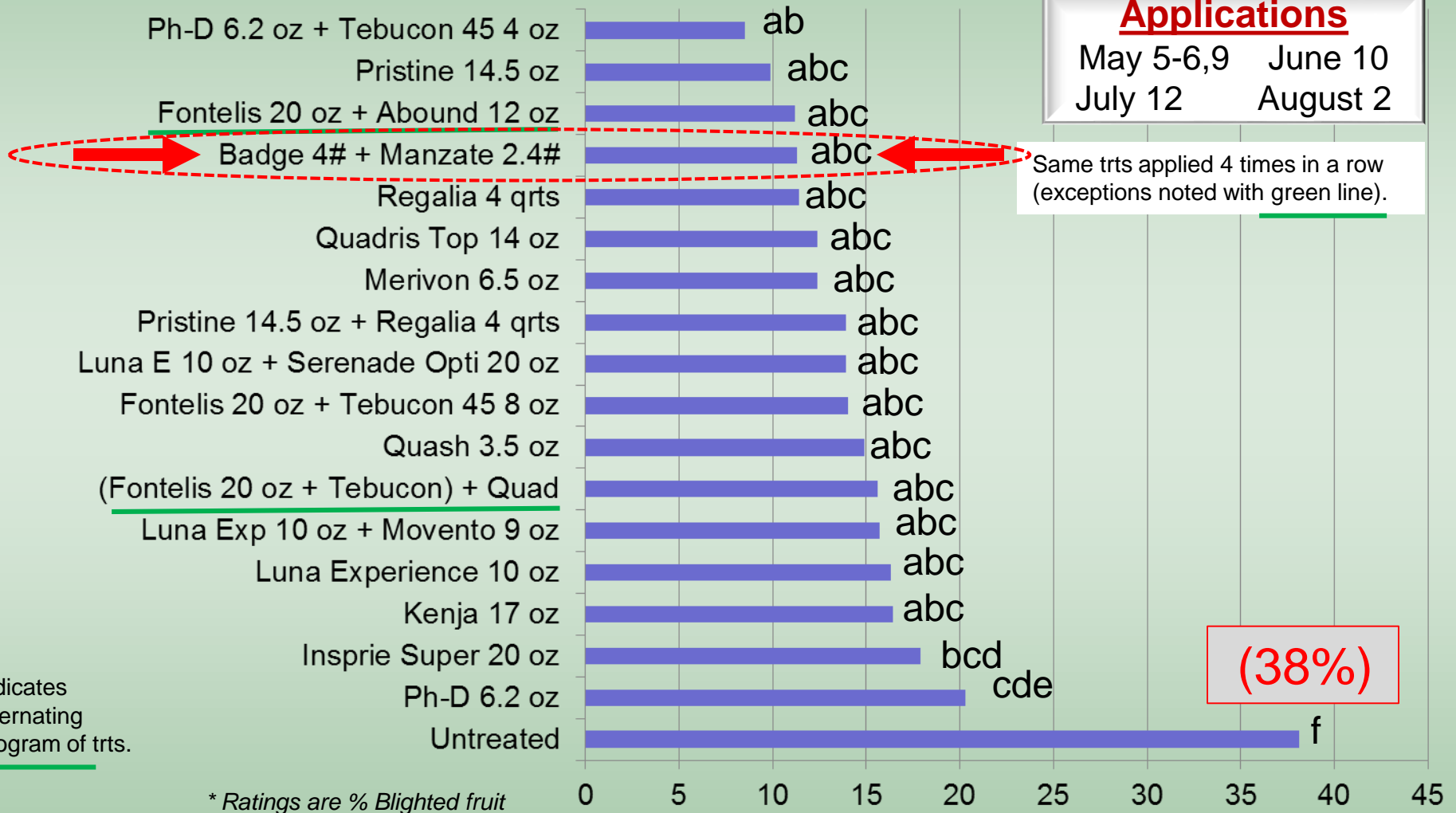


Efficacy* of treatments against Botryosphaeria fruit blight in a Chandler walnut (Butte Co., 2016)

Treatment(s)

Applications

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



Same trts applied 4 times in a row (exceptions noted with green line).

(38%)

% Blighted fruit

Indicates alternating program of trts.

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

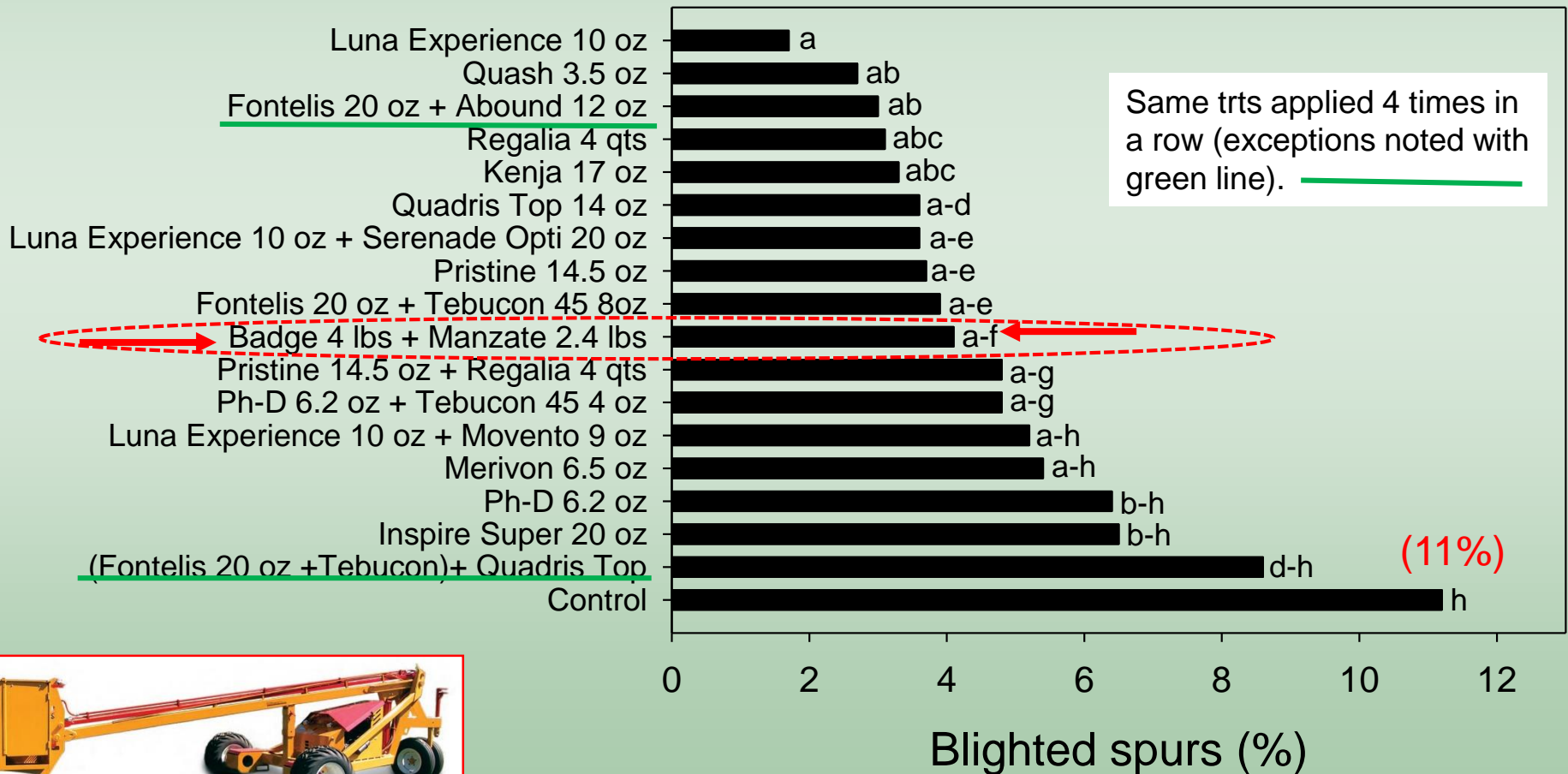


Bot/Phomopsis blight of
walnut in Spain

Efficacy* of treatments against Botryosphaeria blight of spurs in a Chandler walnut (Butte Co., 2016)

Applications

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



Estimation of yield loss

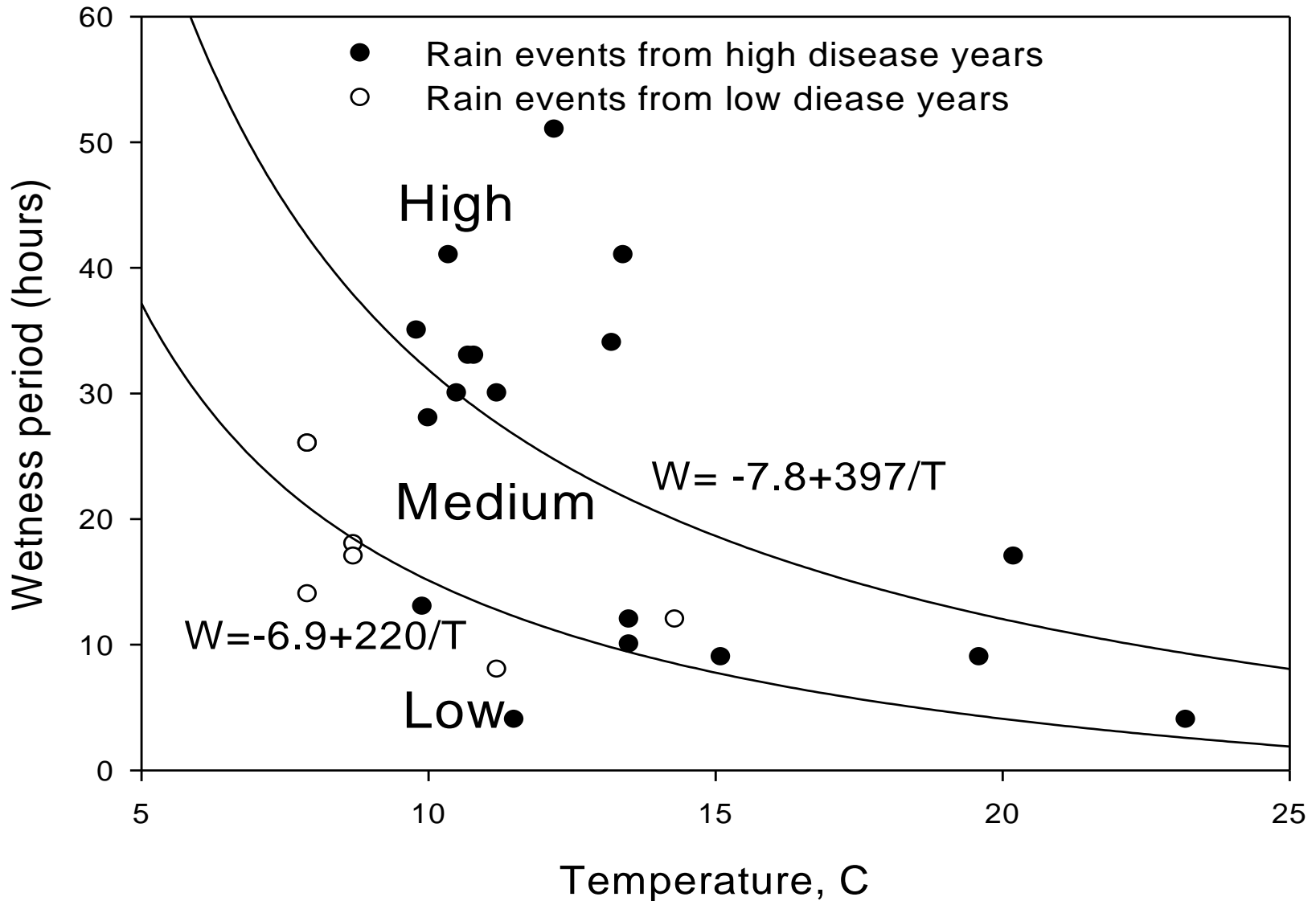


TREES NOT SPRAYED WITH FUNGICIDES HAD:

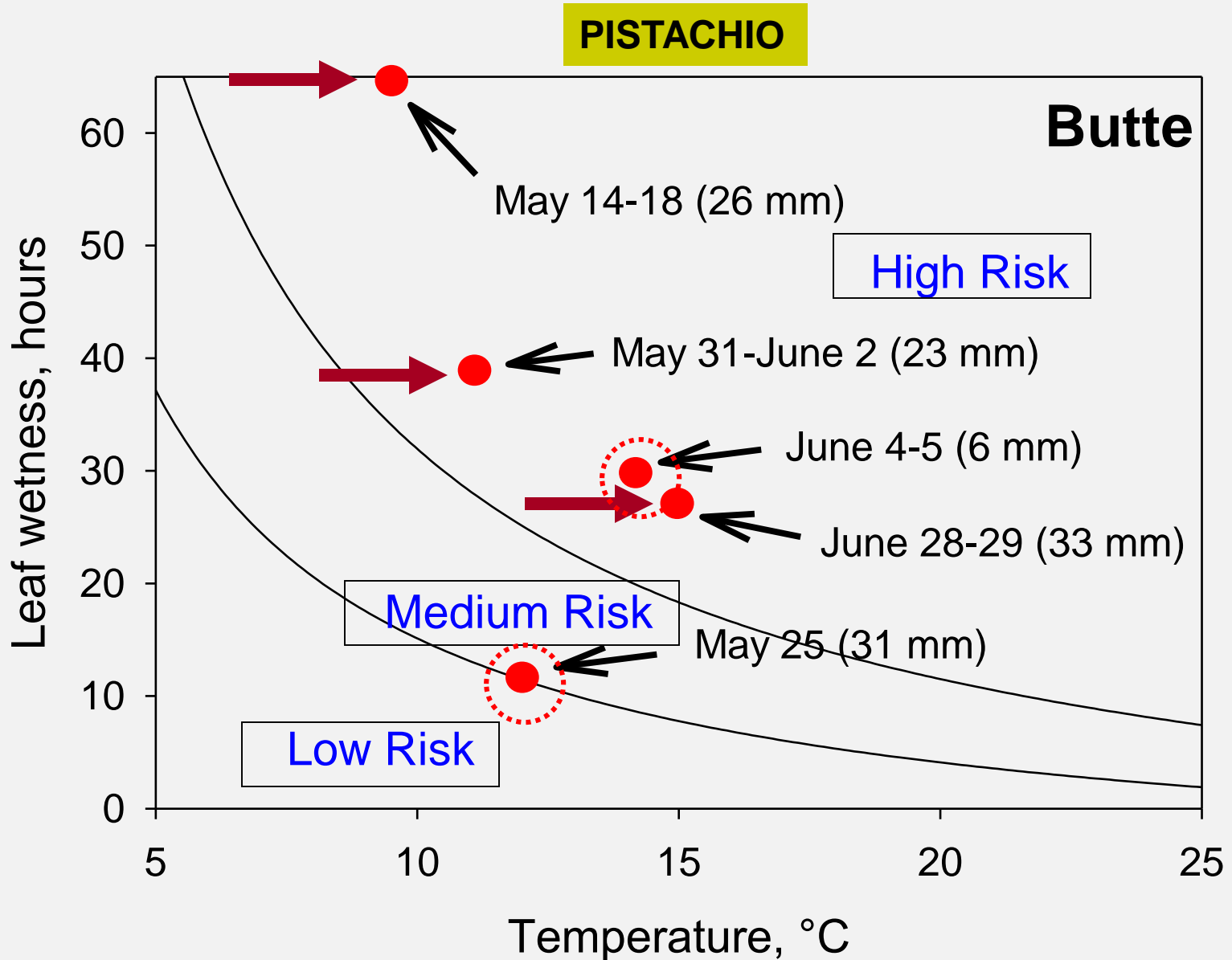
Blighted fruit 38% x 0.8^{BOT} = 30% blighted fruit due to Bot in 2016

**In 2016: killed spurs (11.2%): 11.2% x 4 - 6 fruit/spur = For each 100 spurs,
45 to 67 fruit are lost (potential loss for 2017 crop)**

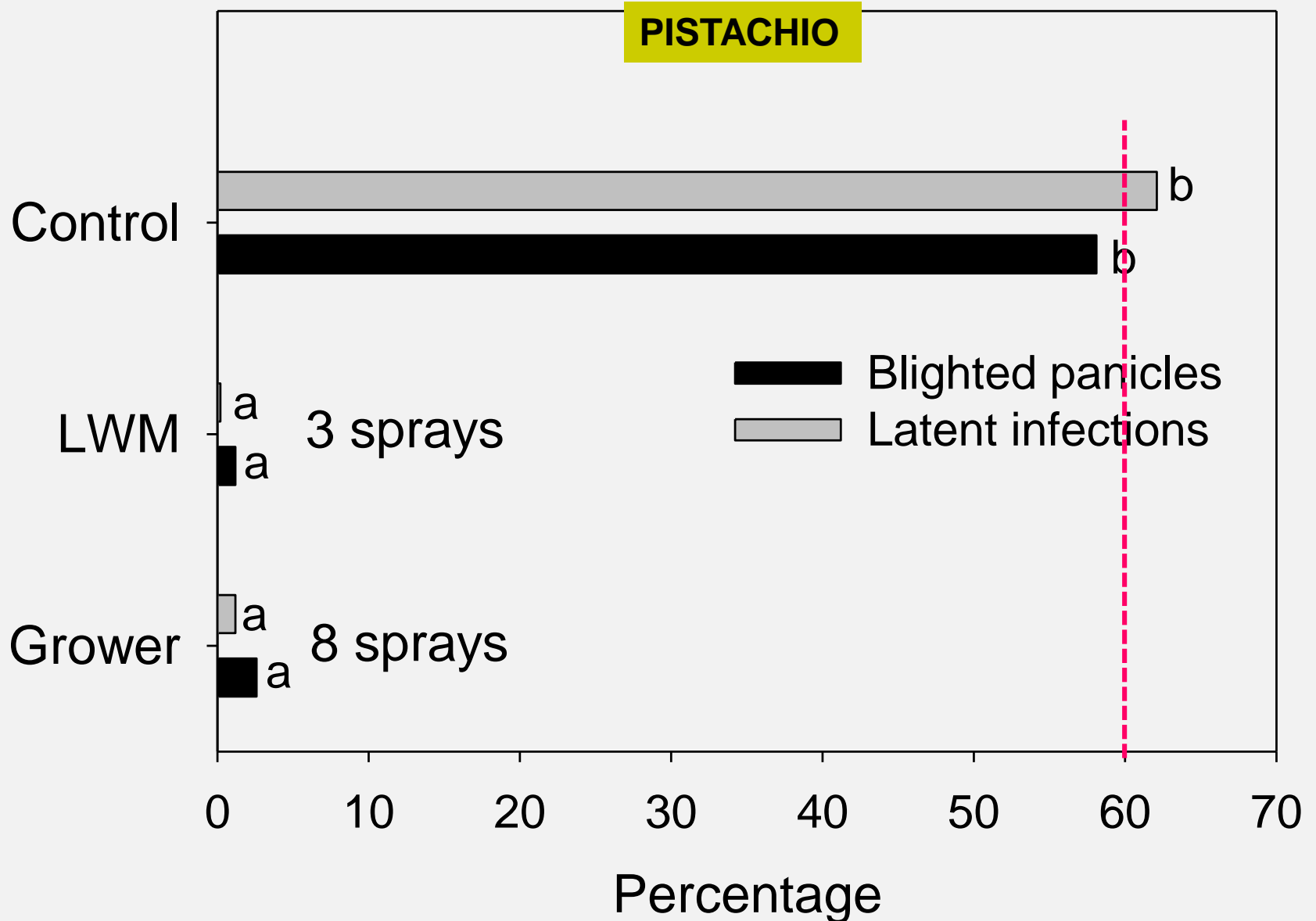
Relative risk of infection of pistachio fruit by *B. dothidea* by wetness period (W) events and Temperature (T)



Leaf Wetness Model (LWM) in Butte County (Medium and high risk infection events (2011))

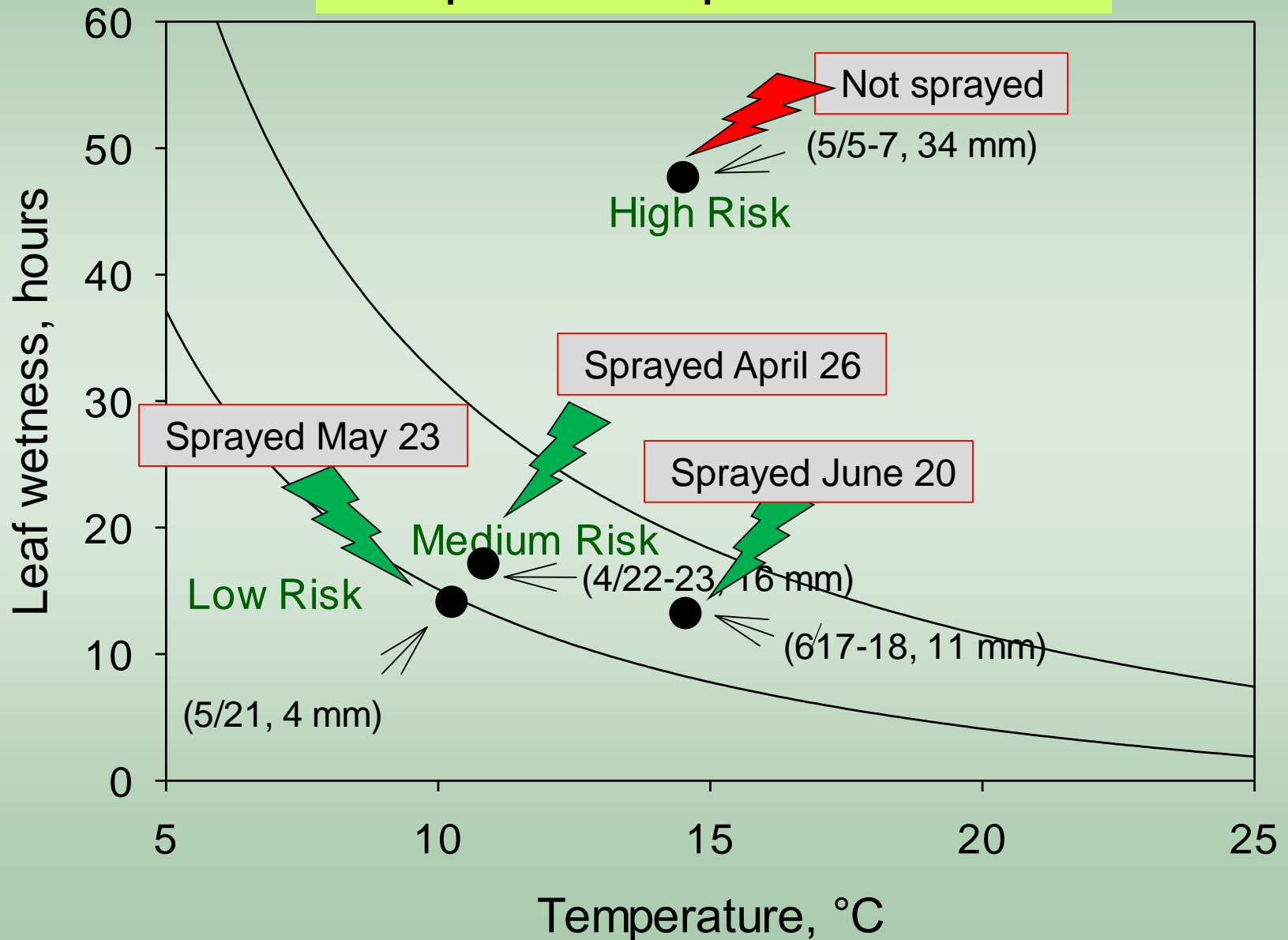


Results of Leaf Wetness Model predicated fungicide sprays in Butte County (2011)



Leaf Wetness Model (LWM) in 2016: Infection events

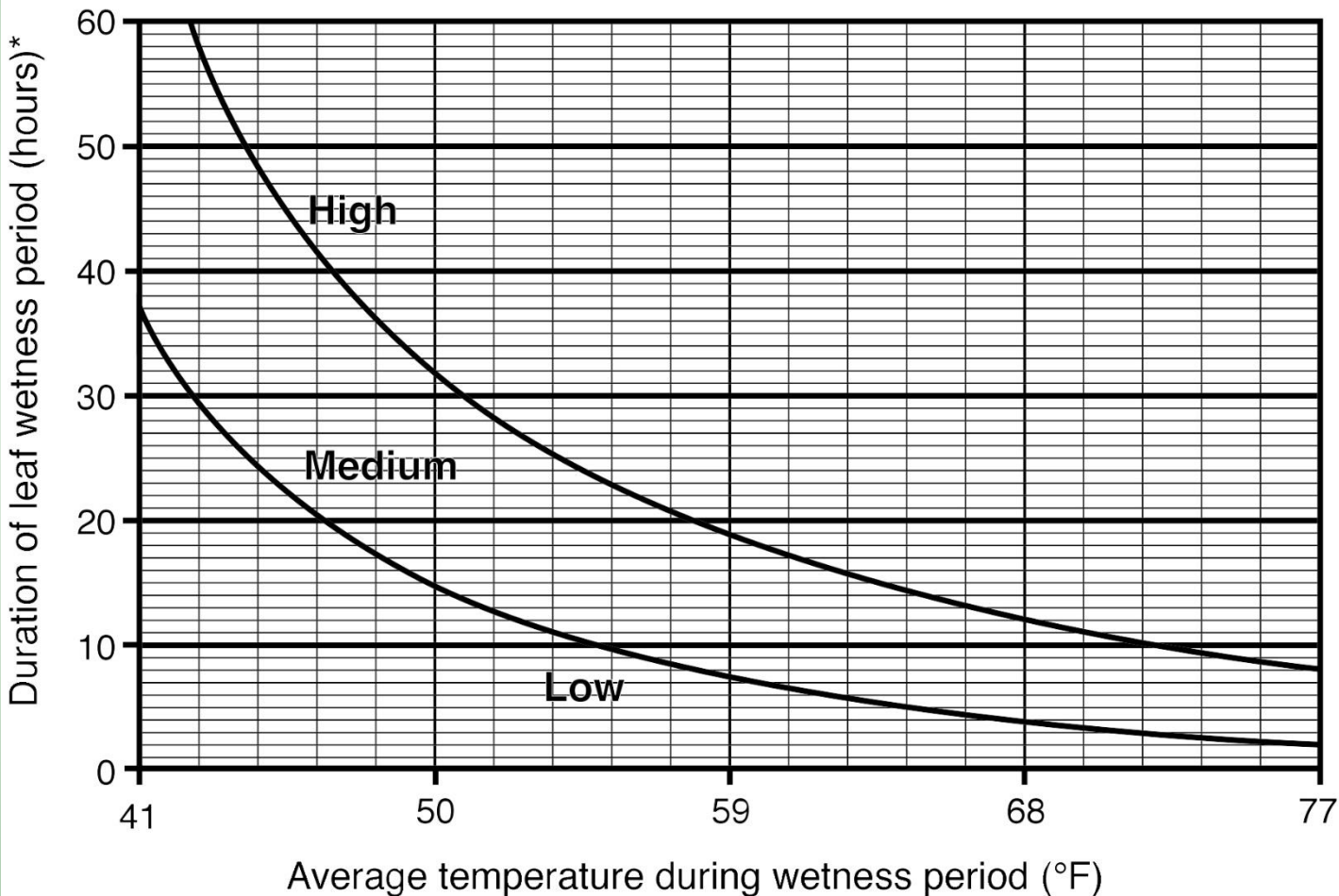
... adapted from our pistachio research ...



Efficacy of various treatments against Bot canker and blight - 2016

Treatment (X= # of sprays)	Blighted fruit (%)	Cankered spurs (%)
Not sprayed	38.0 a	11.2 a
→ LWM (3X)	12.9 b	3.4 b
Std (May-Jun-Jul) (3X)	15.5 b	4.4 b
Bloom + Std (4X)	8.3 b	3.5 b
→ Bloom (1X)	→ 21.2 b	→ 4.7 b

Relative risk of infection of pistachio or walnut by *Botryosphaeria* as affected by wetness period (W) events and Temperature (T)



Notes:

Based on rainfall amount and temperature, use this LWM graph during a rain event to pinpoint the BOT risk zone and determine whether a spray is needed. A spray is applied when points fall in medium and high risk. If a point falls on the line separating low and medium risk, a spray is also applied.

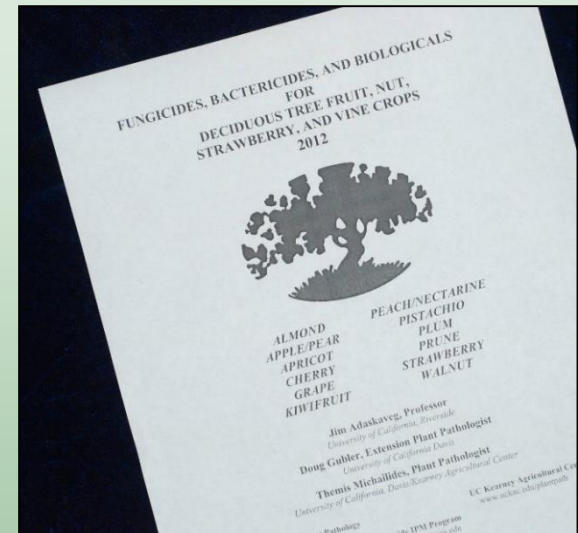
***Leaf wetness period** in hours starts as soon as a rain begins to the end of the rain + 1/2 hour or +1 hour when it is overcast after the end of the rain. If rain is off-and-on but with less than 1/2 hour of clear skies or less than 1 hour of cloudy skies between showers, that also counts towards the leaf wetness period. For more precision, use a leaf wetness sensor.

Efficacy of registered fungicides against *Botryosphaeria* canker and blight of walnut

Fungicide	Active ingredient (FRAC)	Efficacy
Quash.....	metconazole (3)	++++
Merivon.....	fluxopyroxad+pyraclostrobin (7/11)	++++
Pristine	boscalid + pyraclostrobin (7/11)	++++
K-Phite	Polyphosphite (33)	++++
Luna Experience	fluopyram + tebuconazole (3/7)	++++
Luna Sensation	fluopyram + trifloxystrobin 7/11)	++++

++++ = excellent!

There is no fungicide resistance selection in *Botryosphaeriaceae*

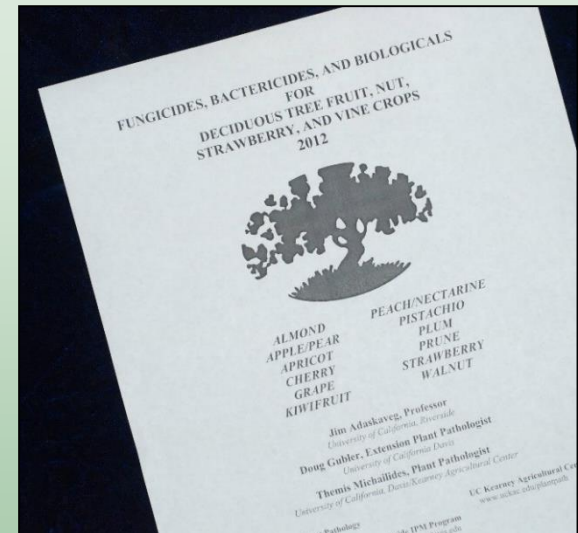


<http://www.ipm.ucdavis.edu>

Efficacy of registered fungicides against *Botryosphaeria* canker and blight of walnut

Fungicide	Active ingredient (FRAC)	Efficacy
Fontelis.....	penthiopyrad (7)	+++
Ph-D.....	Polyoxin-D (19)	+++
Quadris Top.....	difenaconazole+azoxystrobin (3/11)	+++
Tebucon/Teb/Toledo	tebuconazole (3)	+++
Viathon.....	tebuconazole /phosphite (3/33)	+++
→ Copper -mancozeb	copper + mancozeb (M1 + M2)	++(+)

+++ = good control



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

Walnut Objective Measurement Report

Published September 2, 2016

Record Walnut Production Forecast

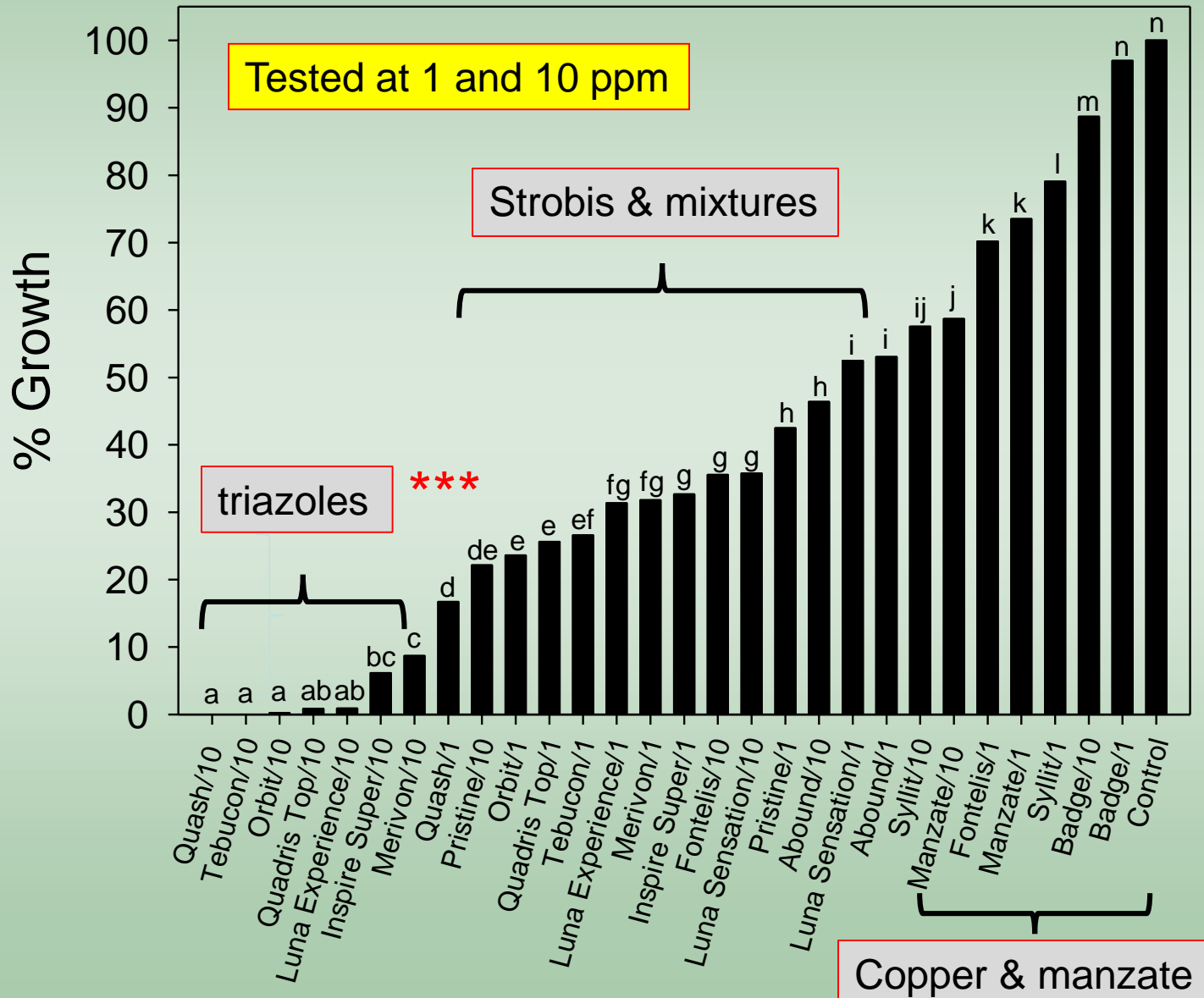


The 2016 California walnut production is forecast at 670,000 tons, up 11 percent from 2015's production of 603,000 tons, according to USDA's National Agricultural Statistics Service. This forecast is based on the 2016 Walnut Objective Measurement (O.M.) Survey, which was officially conducted August 1 through August 23, 2016. There were a few samples completed before August 1 for training and scheduling purposes.

The 2016 walnut season began well with adequate chilling hours and a fair amount of winter rains. Weather during bloom was considered average, with some ideal days and some days of stronger winds and wet weather. Spring rain increased the threat of blight. Hot weather in August resulted in an earlier than usual start to harvest, which is expected to begin in early

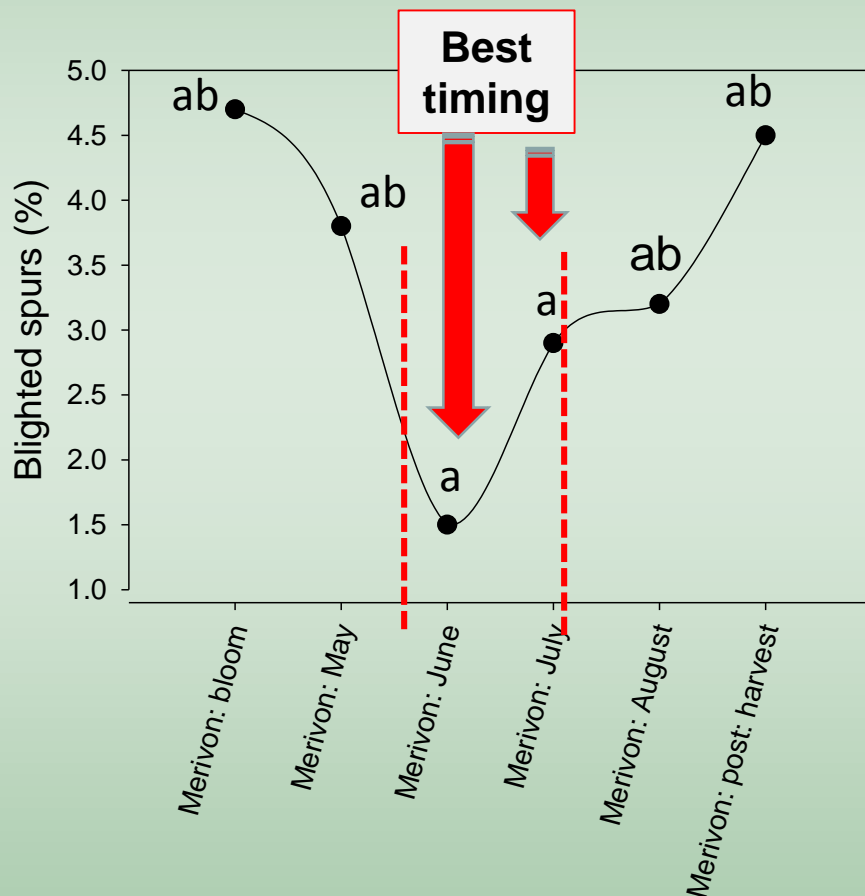
sample trees per

Efficacy of fungicides against the growth of *Phomopsis* (isolate: 9-E52)



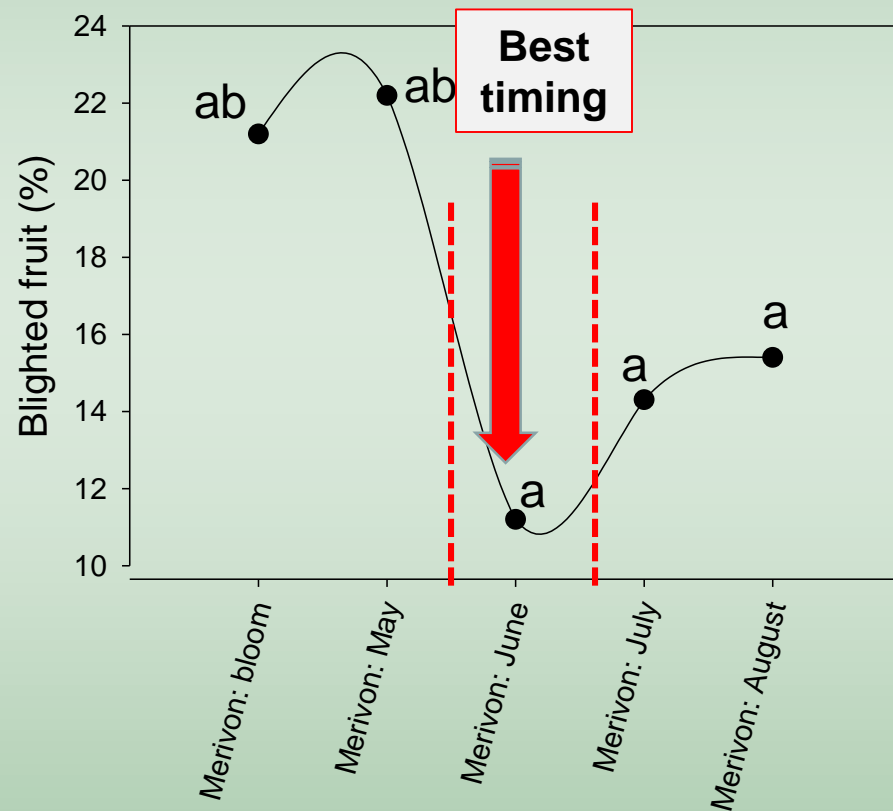
Best-timing of a single Merivon[®] spray in reducing blighted spurs or fruit in a Chandler orchard in Butte Co.

2015 - spurs



Untreated: 8% cankered spurs

2016 – fruit



Untreated: 38% blighted fruit

Spray timing for walnut

Disease	April	May	June	July	August	October
Anthracnose	++	+++	++			
Botryosphaeria blight	+	+	+++ *	+++	++	+

Bloom spray

Best timing

postharvest

CONCLUSIONS

- ✓ Bot is widespread; all walnut cultivars in California are susceptible.
- ✓ The pathogens (*Botryosphaeria* & *Phomopsis* spp.) produce easily and abundantly both water-spread and airborne spores.
- ✓ Spores can infect intact fruit (**latent infection**) and wounds throughout the season and postharvest (leaf scars, etc. ...)
- ✓ Best management of the disease requires all, sanitation (pruning), management of irrigation, control of walnut blight, control of walnut scale, and fungicide sprays.

CONCLUSIONS

- ✓ Fungicides sprays from bloom through July/early August reduce Botryosphaeria/Phomopsis
Check: <http://www.ipm.ucdavis.edu>
- ✓ Spraying before or after an infection event (rain) is very effective: **WATCH FOR RAINS!**
- ✓ The best-timing spray seems to be around mid-June to mid-July.
- ✓ A postharvest spray can also reduce disease.

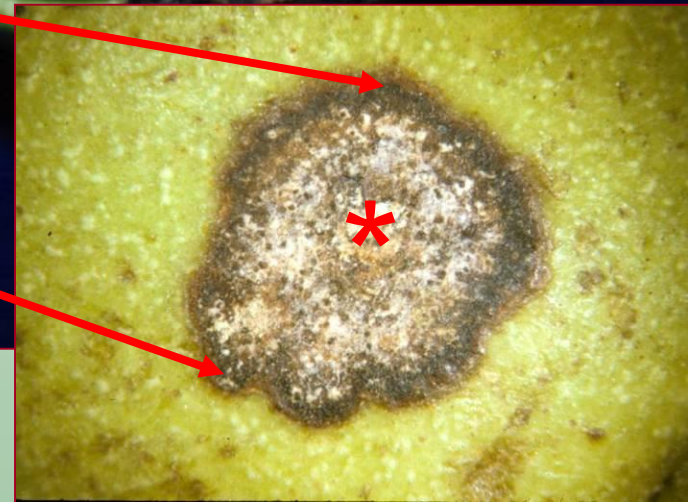
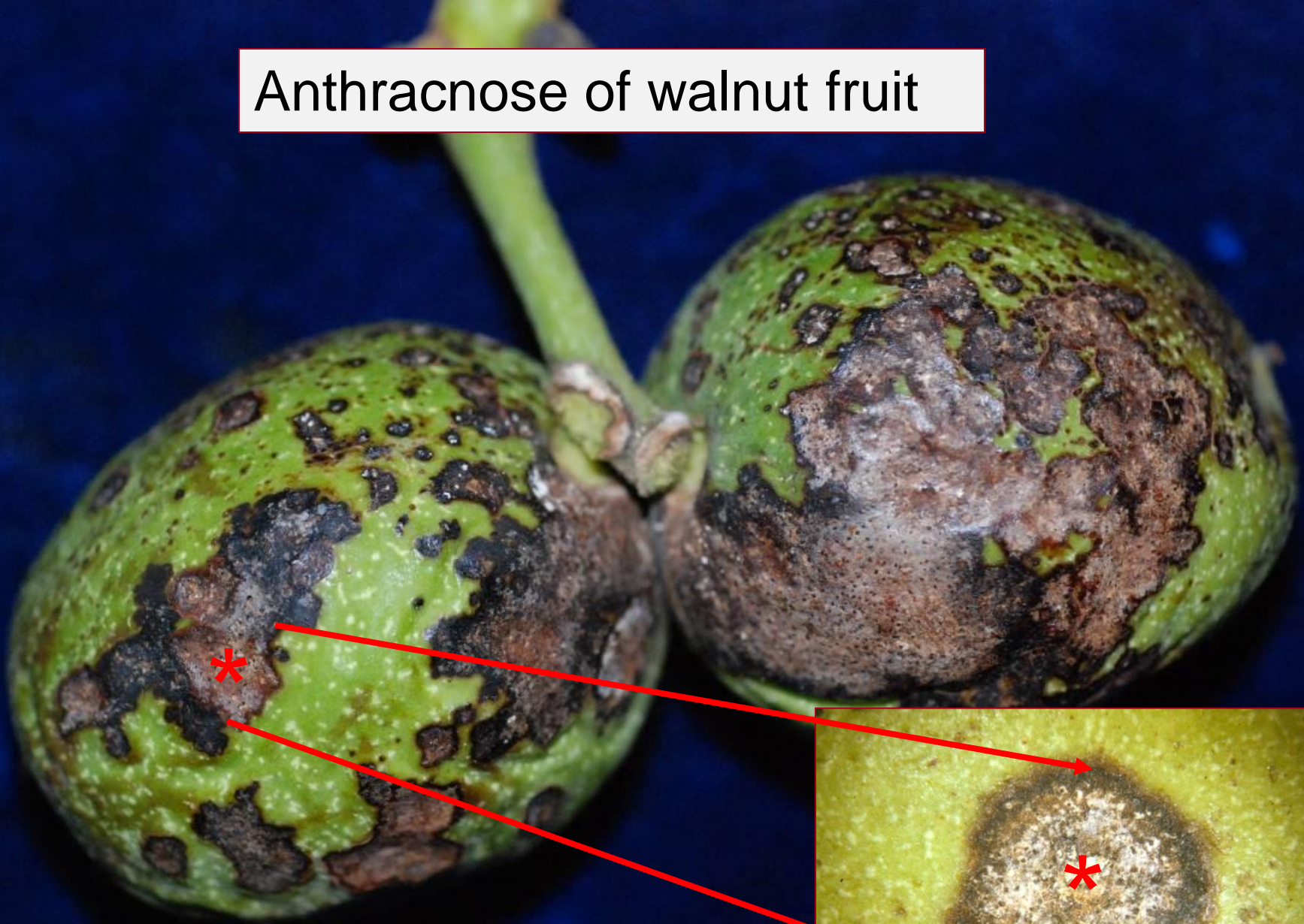
Remember: Bot disease is a Sleeping Giant



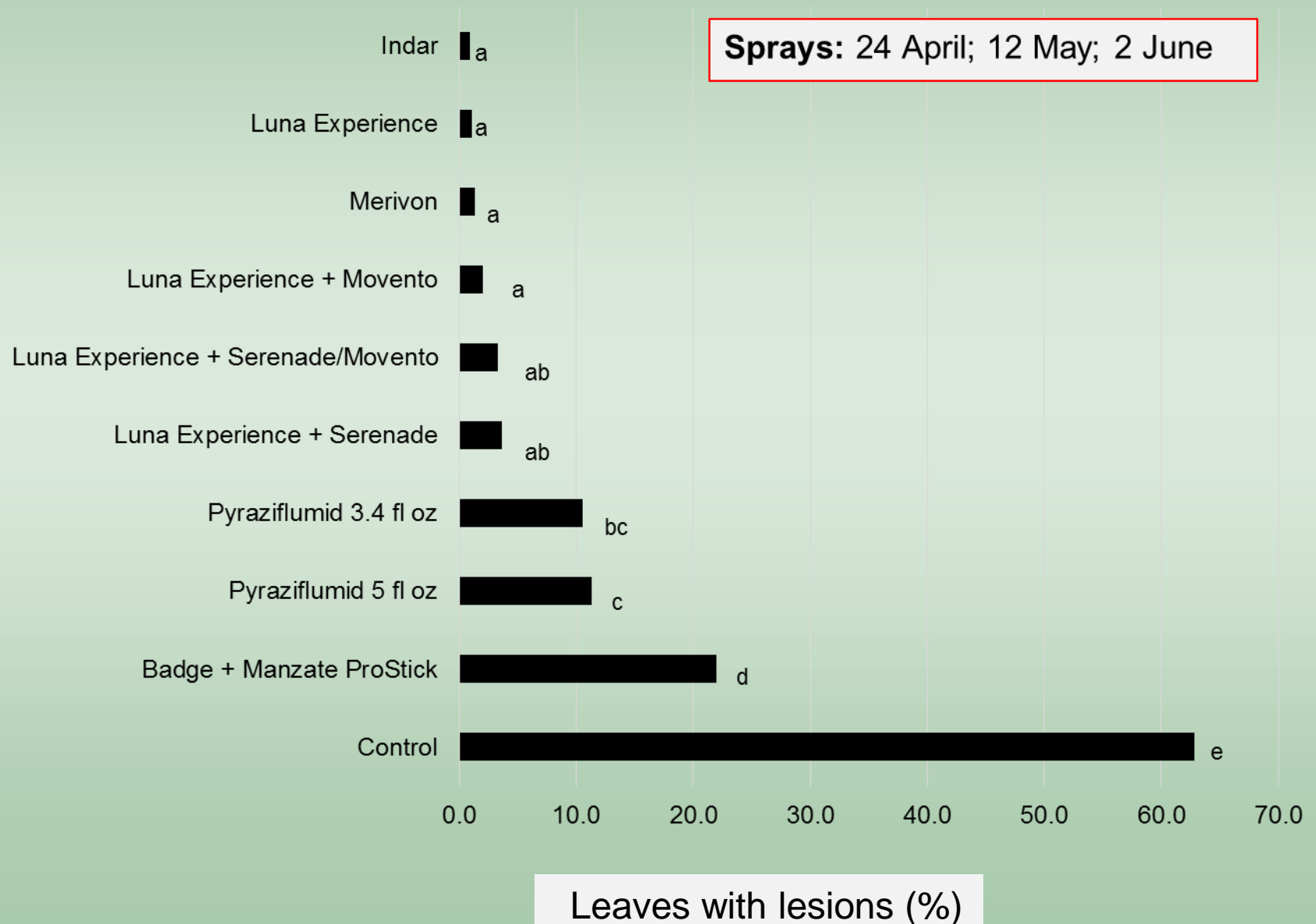
Severe anthracnose of walnut in San Benito Co. (cv. Serr) - 2016



Anthracnose of walnut fruit



Efficacy of fungicides against anthracnose of walnut -2017



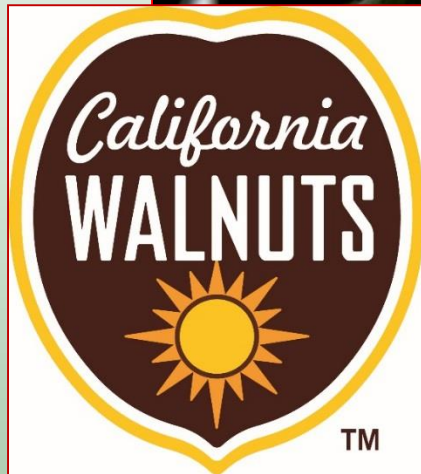
Acknowledgments



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and Various Chem.
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Thank you