

Above Ground Fungal Diseases of Pistachio



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Diseases of pistachio in CA & AZ:

1. Botryosphaeria blight (CA, AZ)
2. Alternaria blight (CA)
3. Botrytis blight (CA)

Other diseases	Occasional diseases
<ul style="list-style-type: none">✓ Septoria leaf spot (AZ, CA)✓ Stigmatomycosis (CA, AZ)✓ Aspergillus blight (CA, AZ)✓ Kernel decay (CA, AZ,)	<ul style="list-style-type: none">✓ Anthracnose blight (CA)✓ Phomopsis blight (CA)✓ Sclerotinia blight (CA)✓ Cytospora canker (CA)✓ Stem canker (CA, AZ)

Diseases of pistachio worldwide

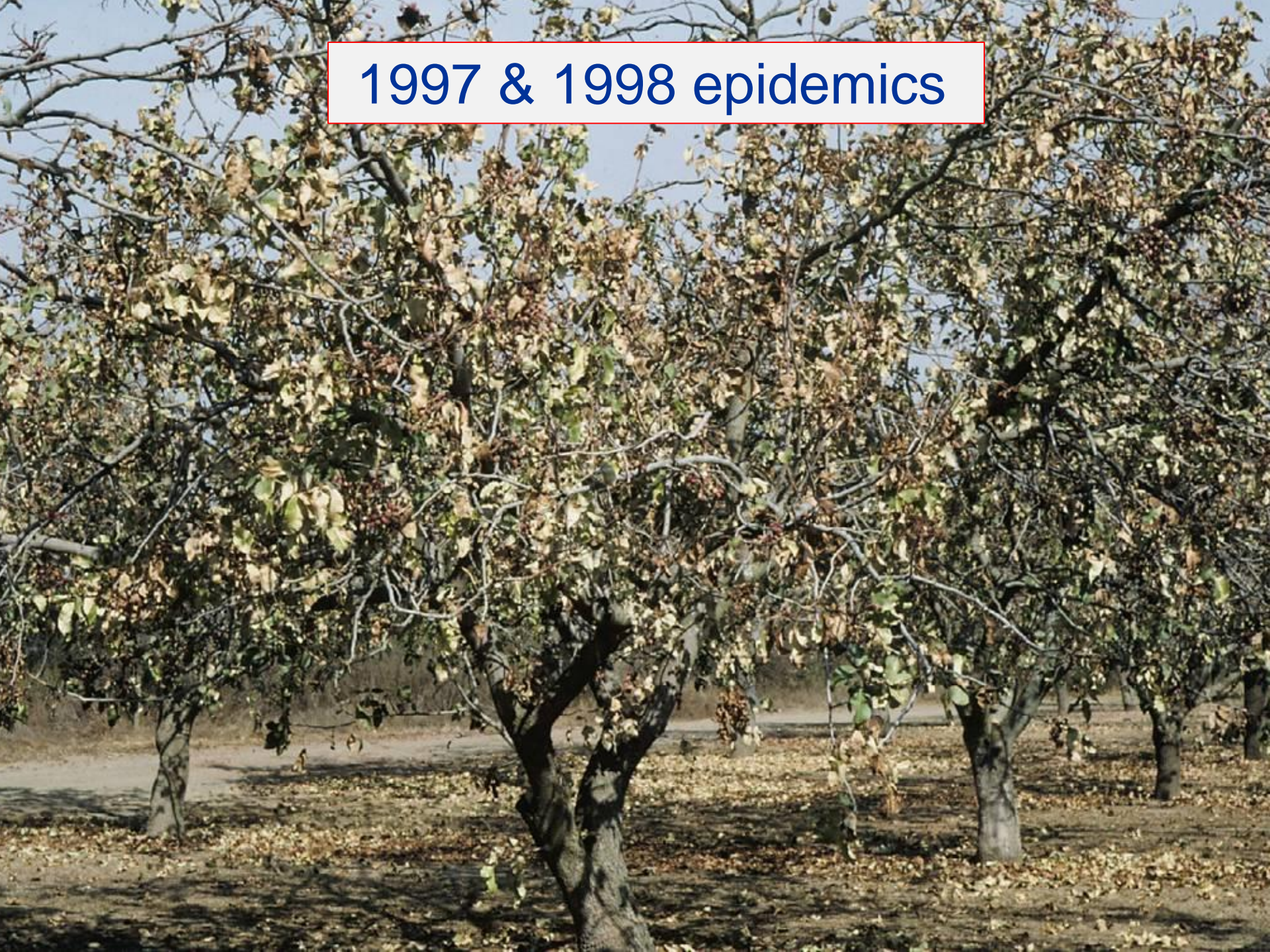
1. Botryosphaeria blight (Mediterr. Austr. SA)
2. Alternaria blight (Mediterr., Egypt)
3. Botrytis blight (???)

Other diseases	Occasional diseases
<ul style="list-style-type: none">✓ Septoria leaf spot (Mediterr.)***✓ Stigmatomycosis (Mediterr.)✓ Aspergillus blight (Worldwide)✓ Kernel decay (Mediterr., Iran, Austral.)✓ Rust (Mediterr.)	<ul style="list-style-type: none">✓ Anthracnose blight (Australia)✓ Phomopsis blight (???)✓ Sclerotinia blight (???)✓ Cytospora canker (Italy)✓ Stem canker (South Africa)

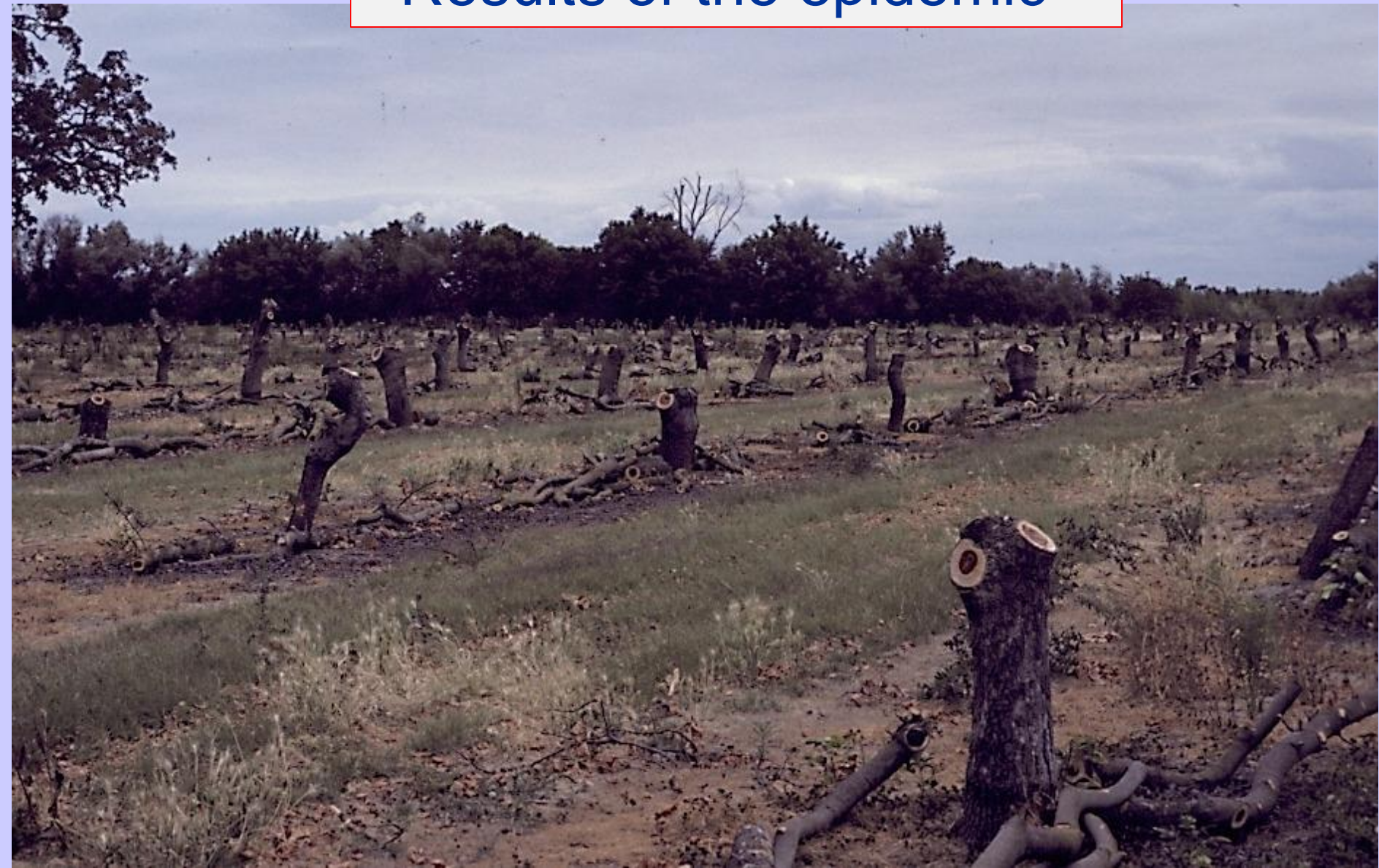
1. Botryosphaeria panicle and shoot blight



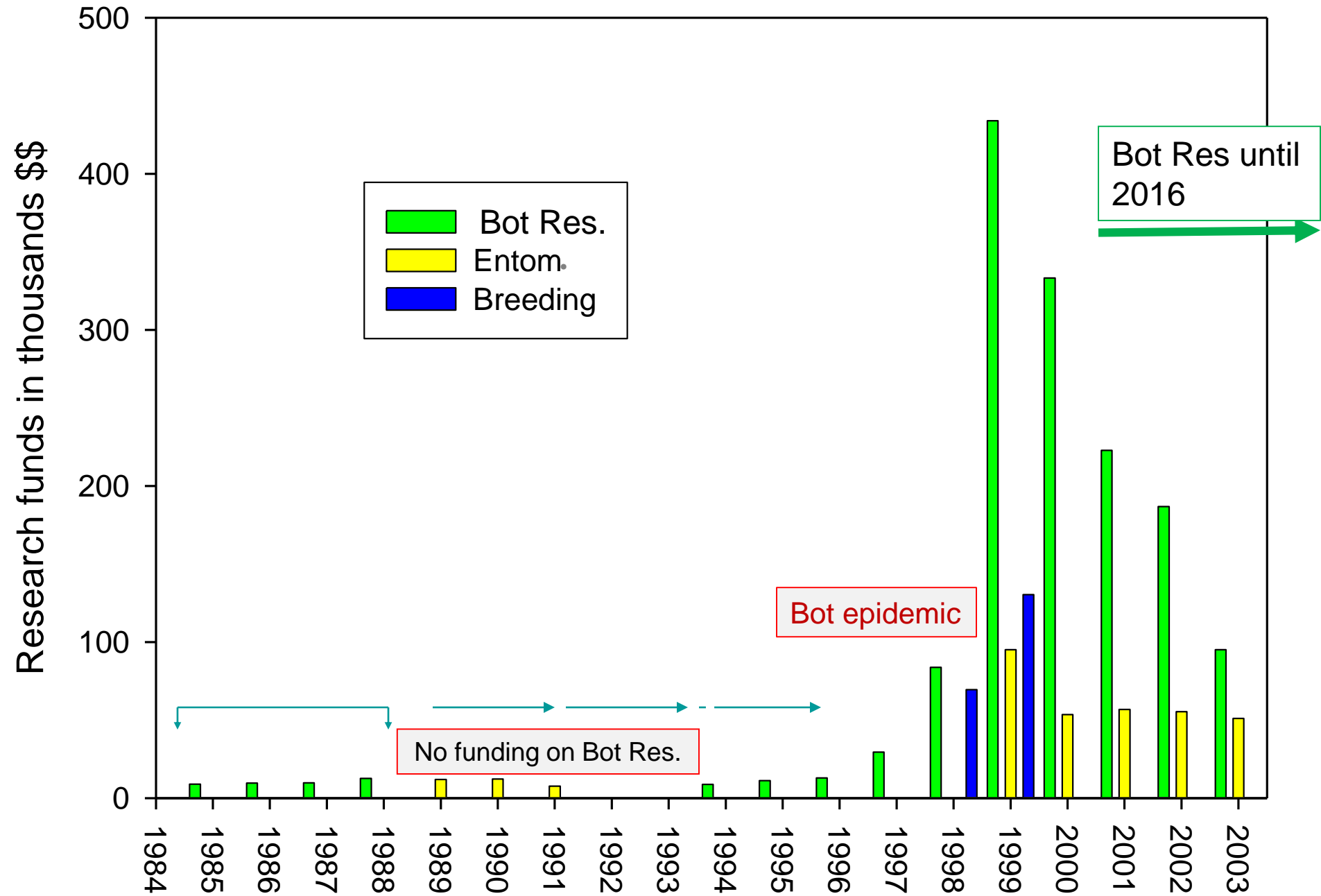
1997 & 1998 epidemics



Results of the epidemic



Funding for plant pathology, entomology, and breeding



Survey of Pistachio Orchards for *Botryosphaeria* panicle and shoot blight (1995)



● First discovery of *Bot* in Pistachio in 1984; Butte County

● Spread throughout CA in about 10-12 years.

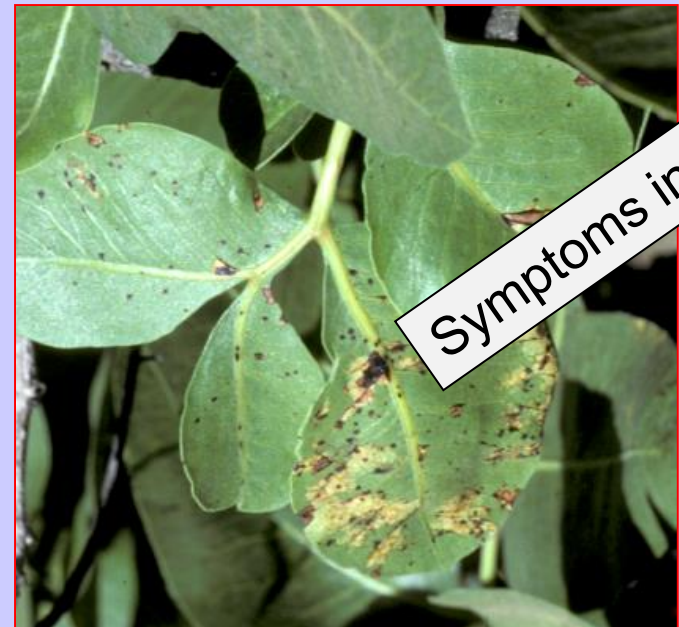
Symptoms in spring and summer



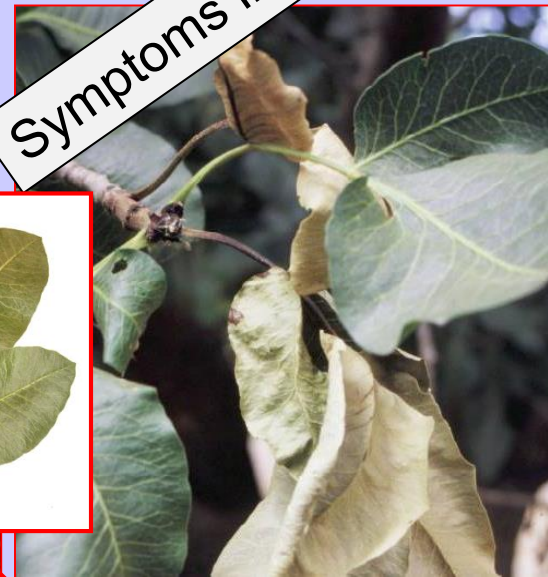
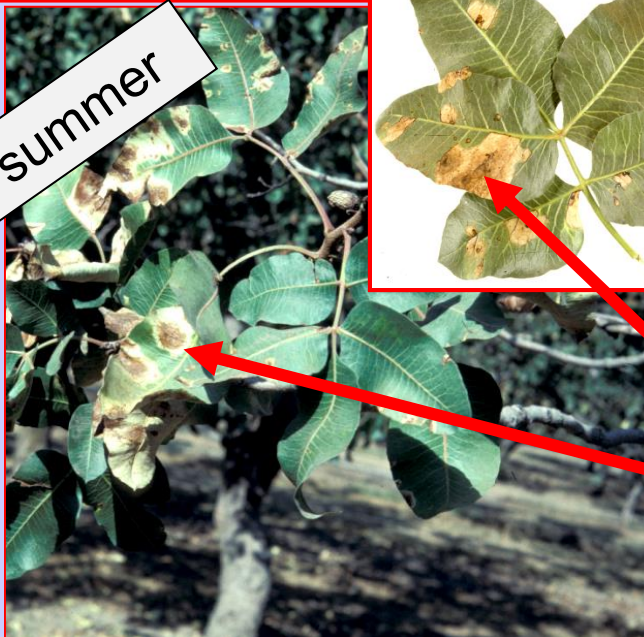
Symptoms in spring



Symptoms in summer



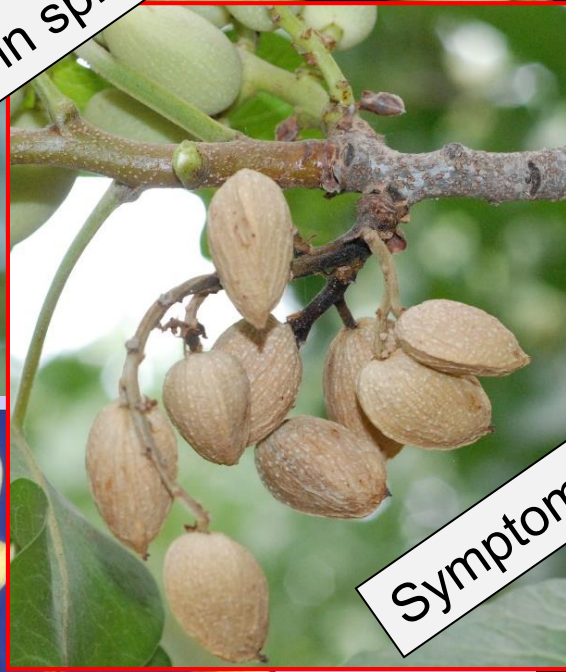
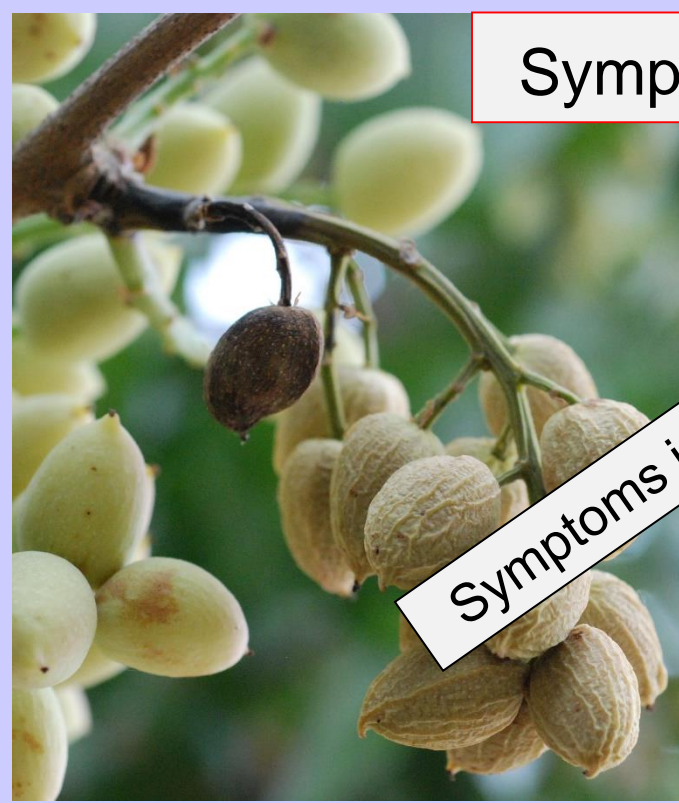
Symptoms in summer



Symptoms in spring and summer

Symptoms in spring

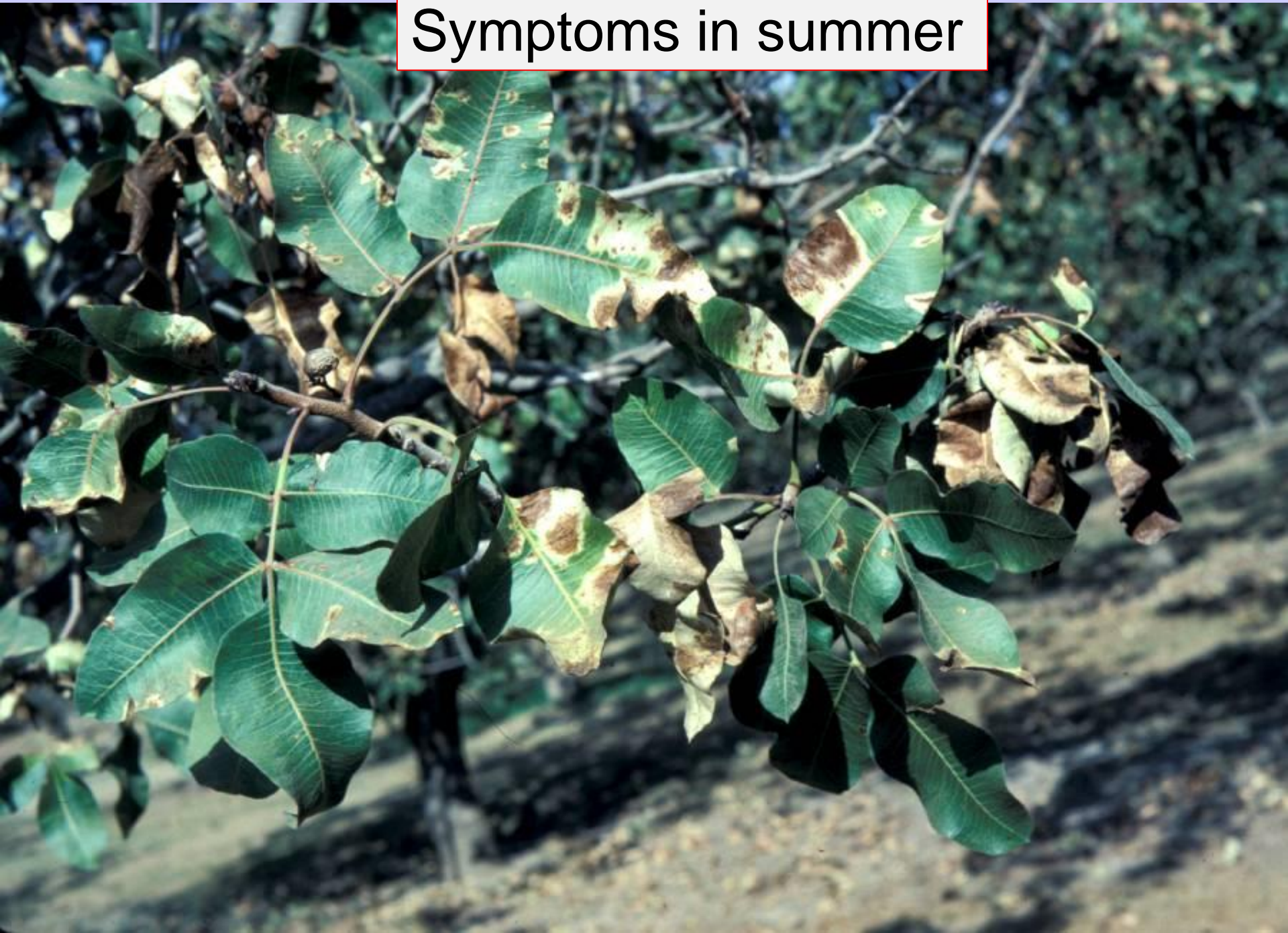
Symptoms in summer



Fruit infection (spring & summer)

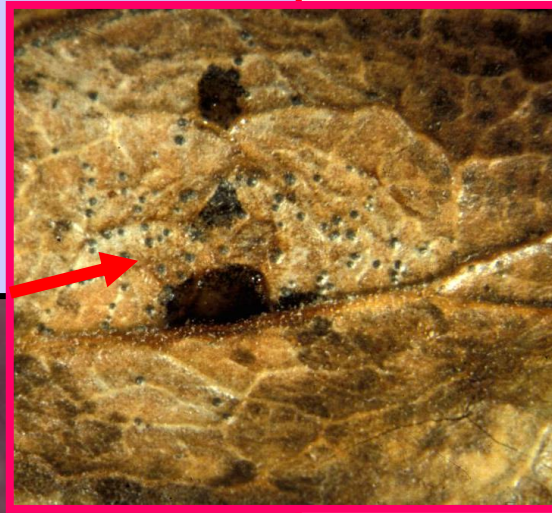


Symptoms in summer

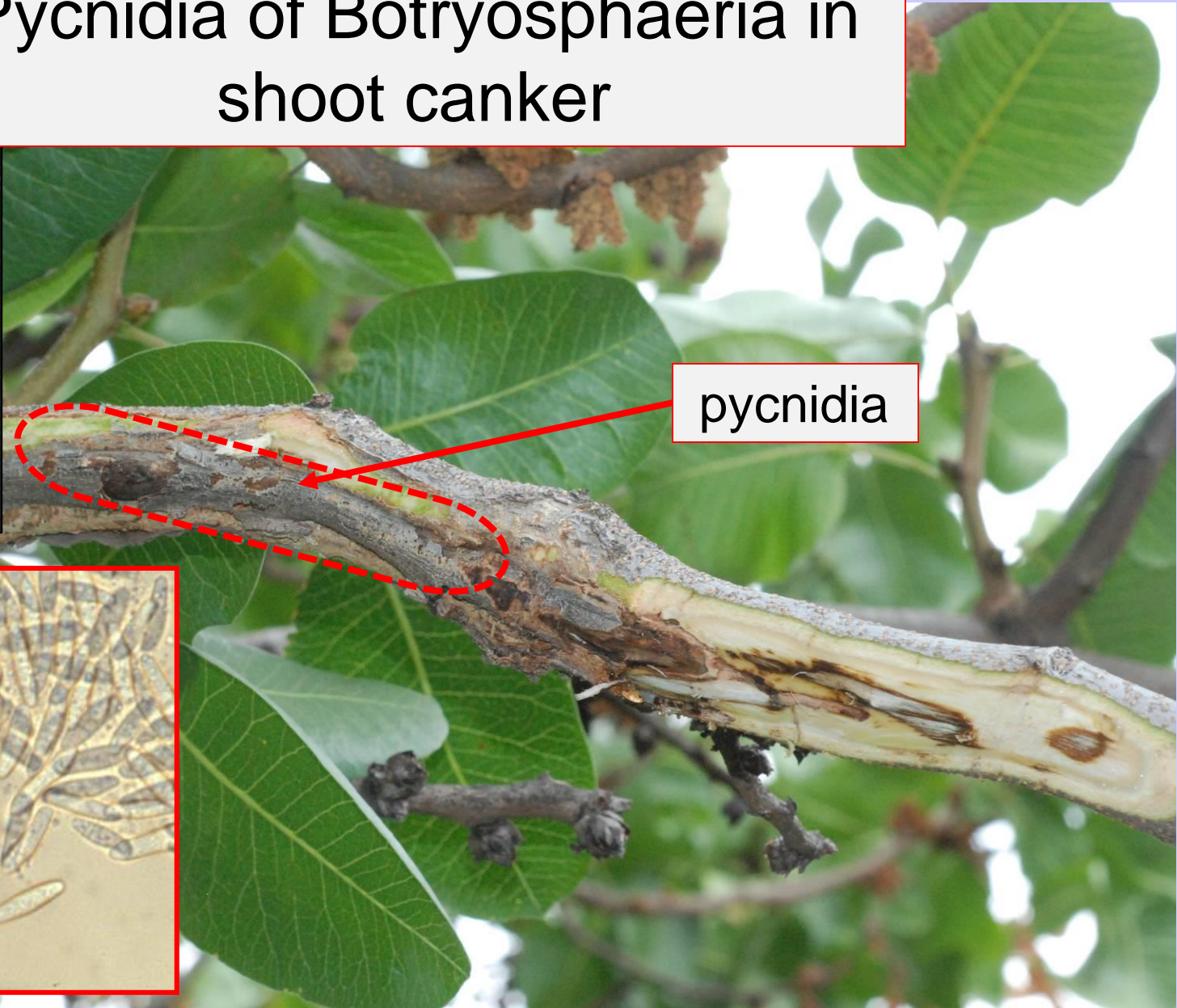


“Bot” can attack all current season growth:

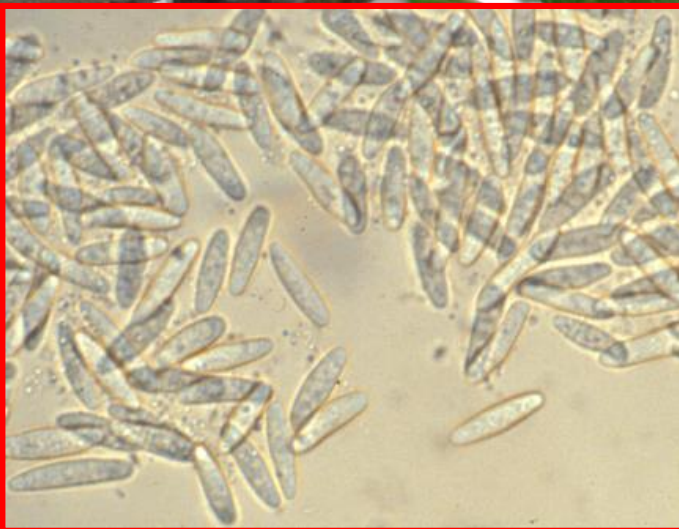
- ✓ panicles
- ✓ shoots
- ✓ leaves
- ✓ leaf petioles
- ✓ rachises
- ✓ fruit
- ✓ fruit scars
- ✓ leaf scars
- ✓ buds



Pycnidia of Botryosphaeria in shoot canker

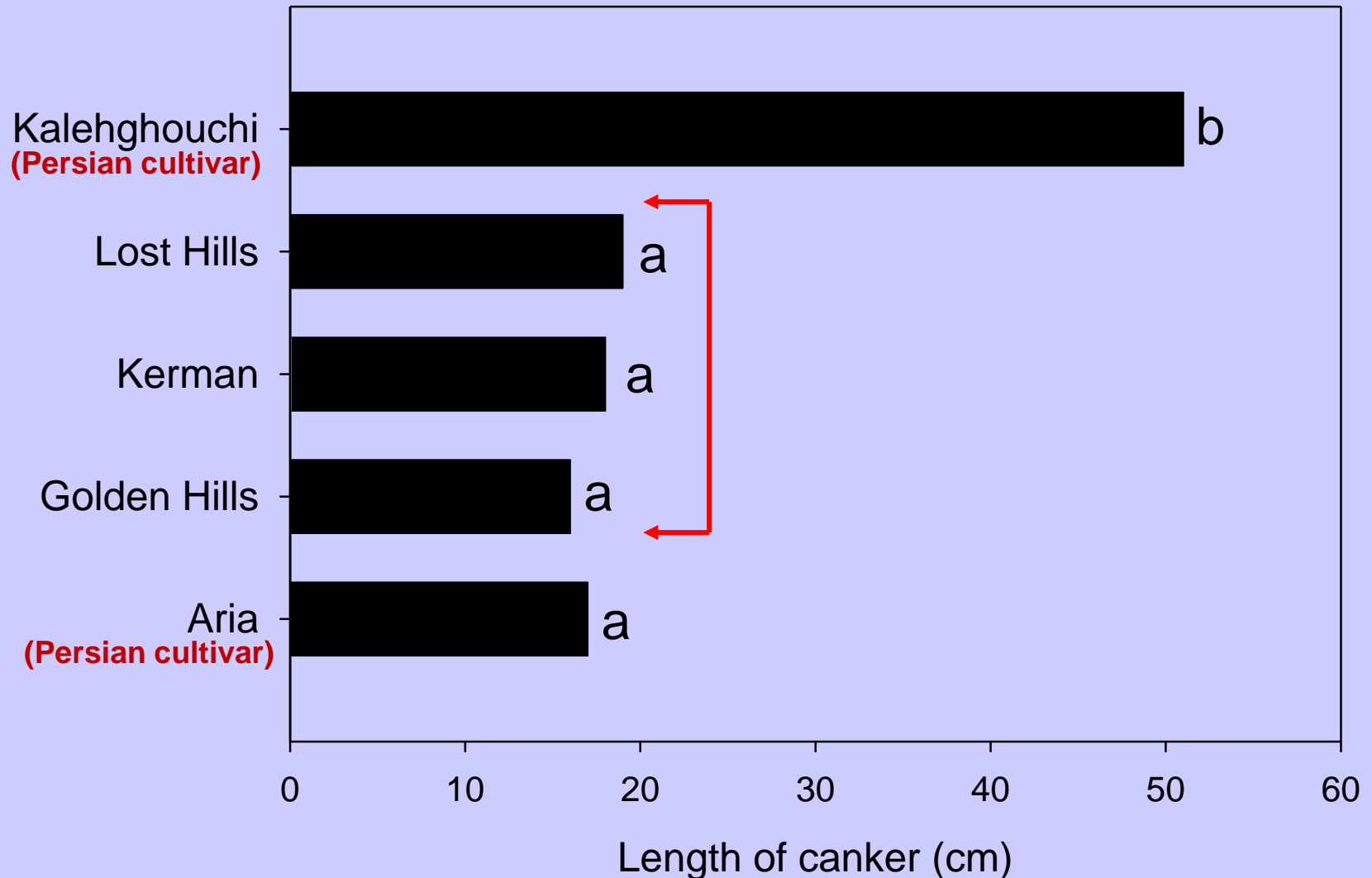


pycnidia



Pycnidia with viable spores in cankers for up to 6 years!

Susceptibility of pistachio cultivars to *Botryosphaeria*



Species and distribution of Botryosphaeria/Phomopsis in pistachio

FUNGAL SPECIES

BOTRYOSPHAERIACEAE

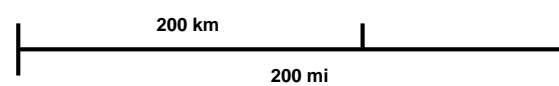
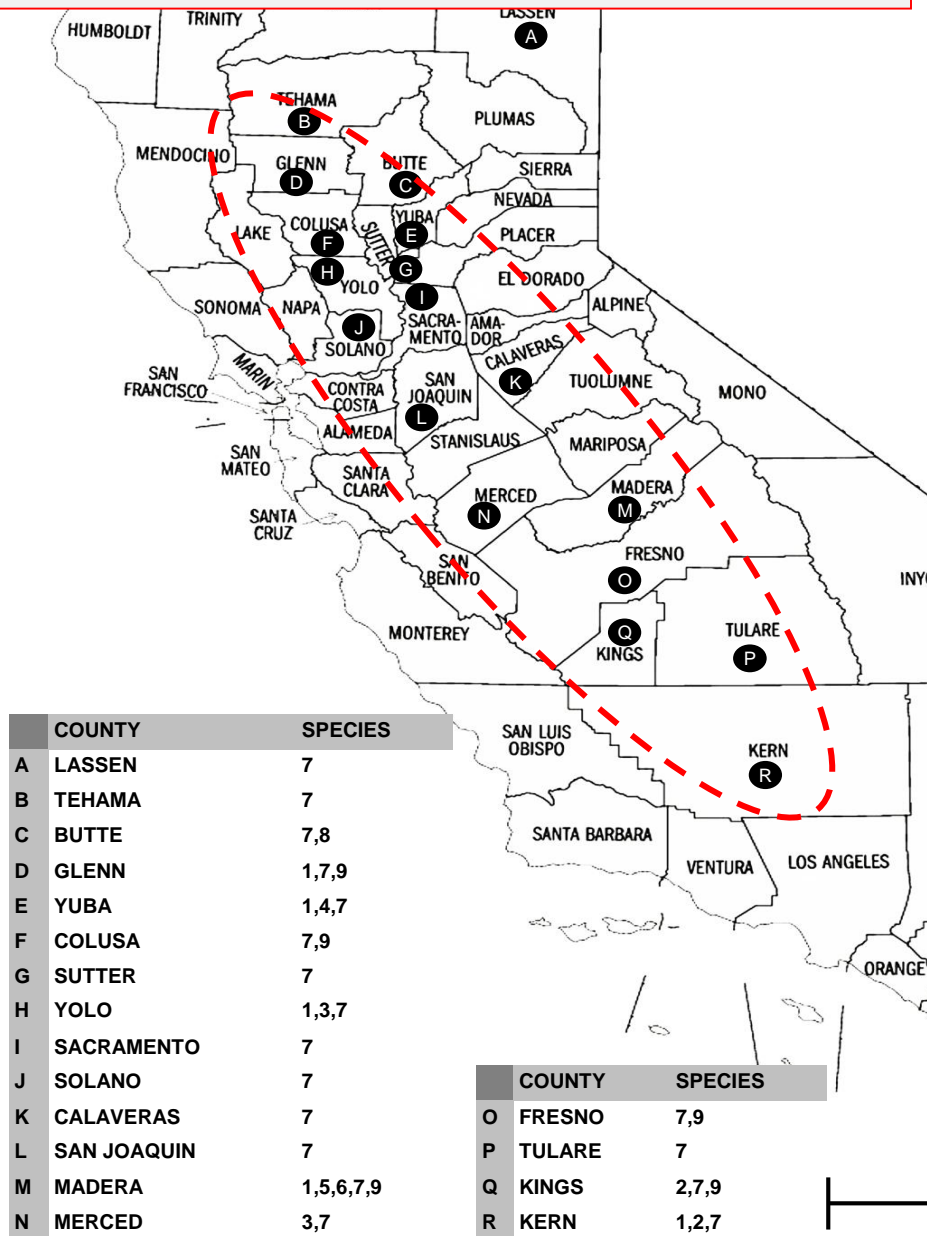
- 1 *Botryosphaeria dothidea*
- 2 *Diplodia seriata*
- 3 *Dothiorella iberica*
- 4 *Dothiorella sarmentorum*
- 5 *Lasiodiplodia citricola*
- 6 *Lasiodiplodia gilanensis*

7 *Neofusicoccum mediterraneum*

8 *Neofusicoccum vitifusiforme*

DIAPORTHE

9 *Diaporthe chamaeropsis*



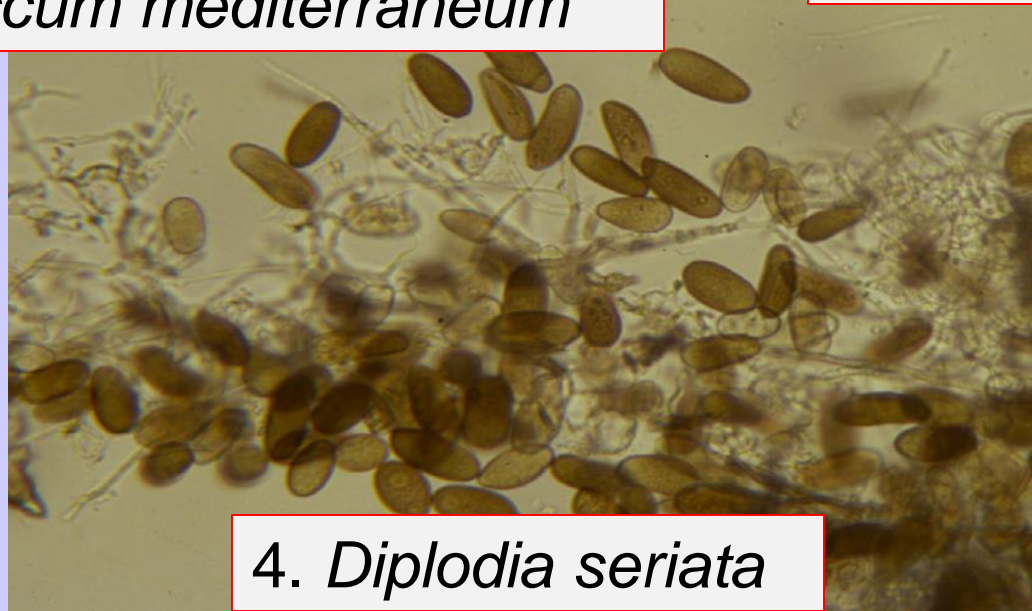


1. *Botryosphaeria dothidea*

2. *Neofusicoccum mediterraneum*

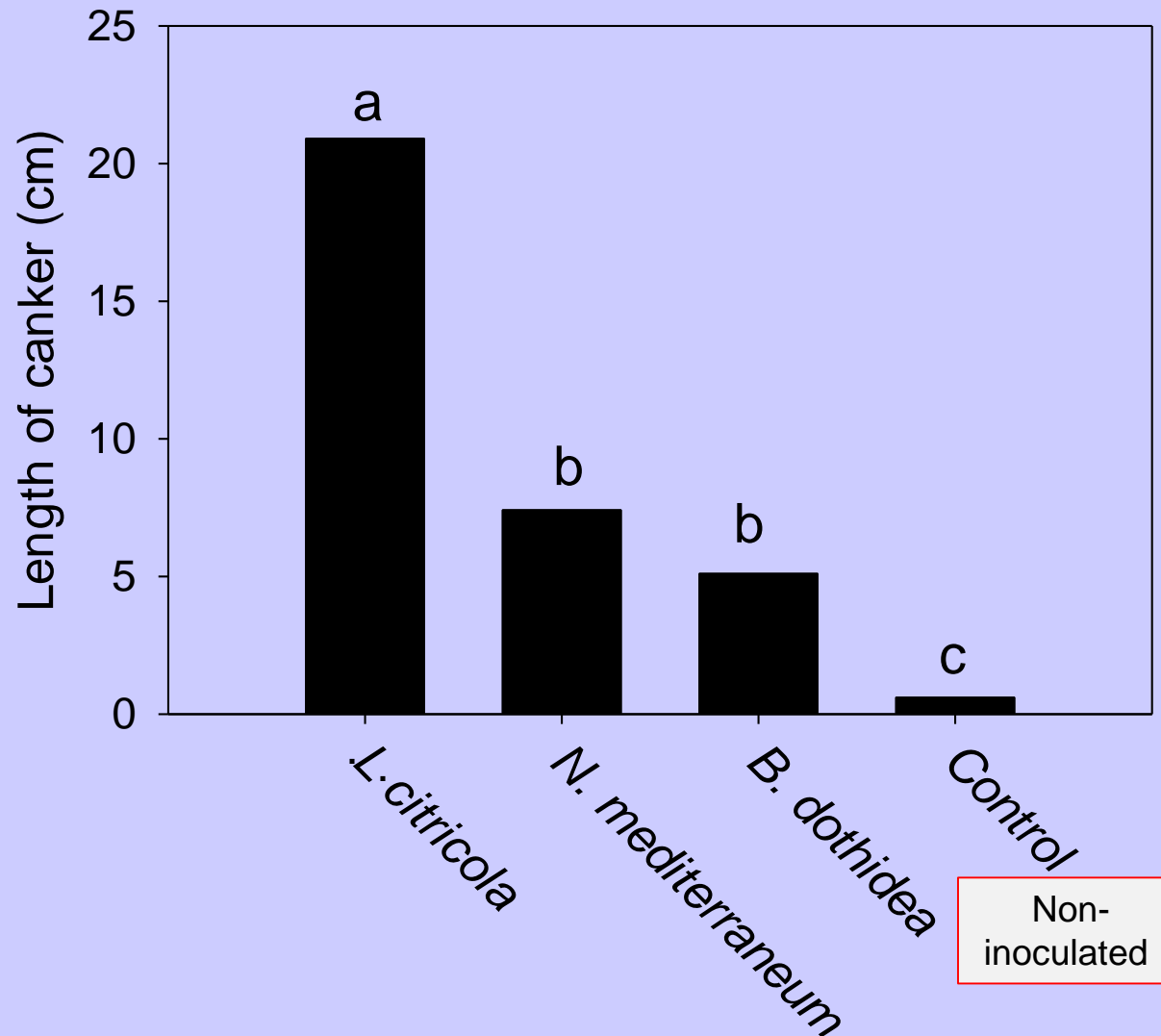


3. *Lasiodiplodia* spp.



4. *Diplodia seriata*

Virulence of Botryosphaeriaceae species inoculated onto shoots of pistachio cultivars



Botryosphaeriaceae fungi



only pycnidia-spores

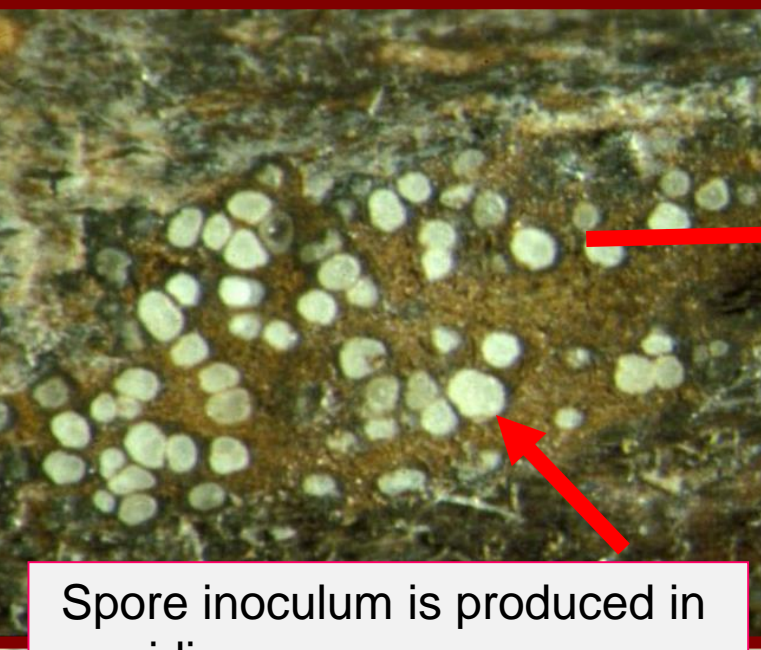
Water-borne



Pycnidia: Asexual stage

Only pycnidia in pistachio tissues

Oozing pycnidia



Spore inoculum is produced in pycnidia



pycnidiospores (spores)



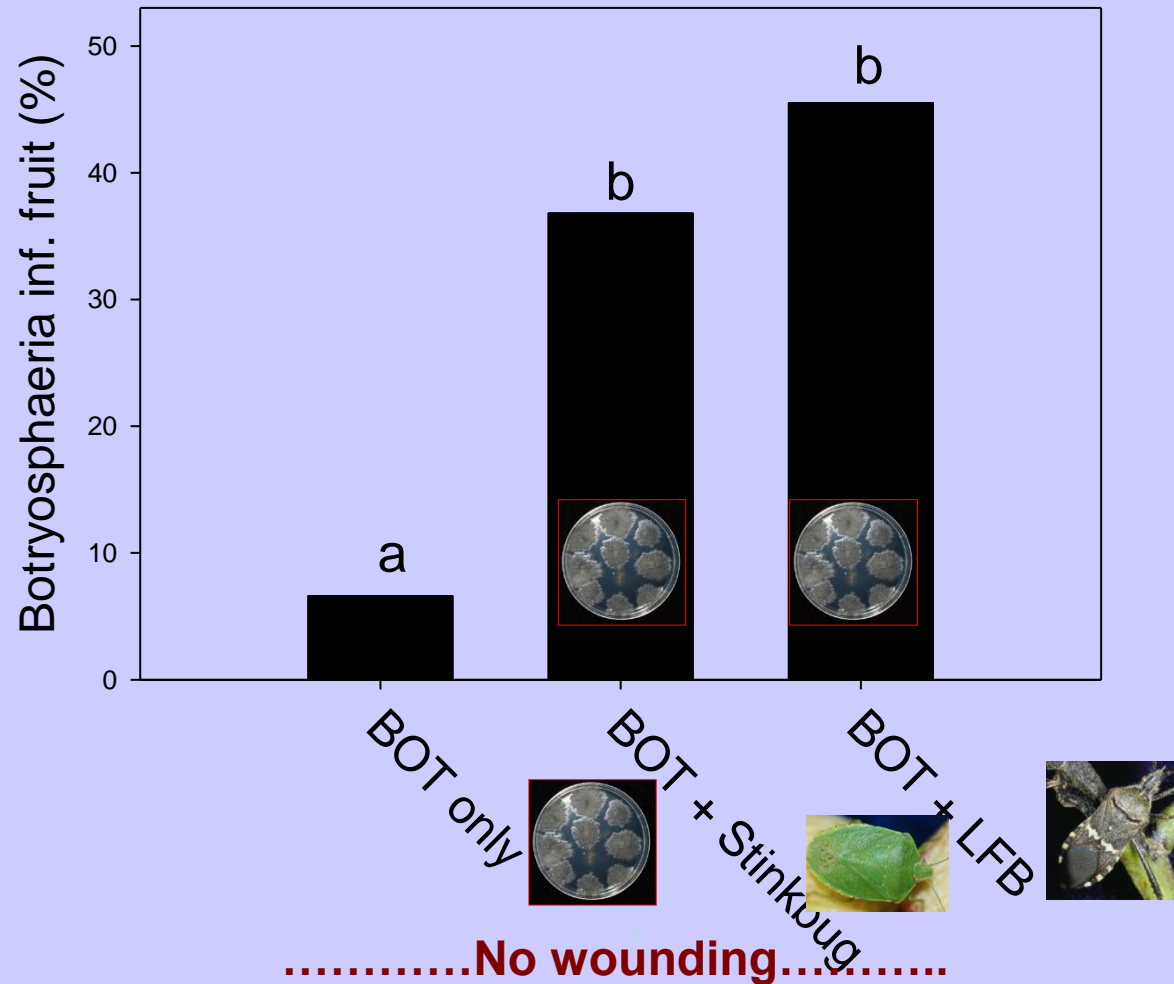
Leafooted bug (*Leptoglossus clypealis*) and stinkbugs

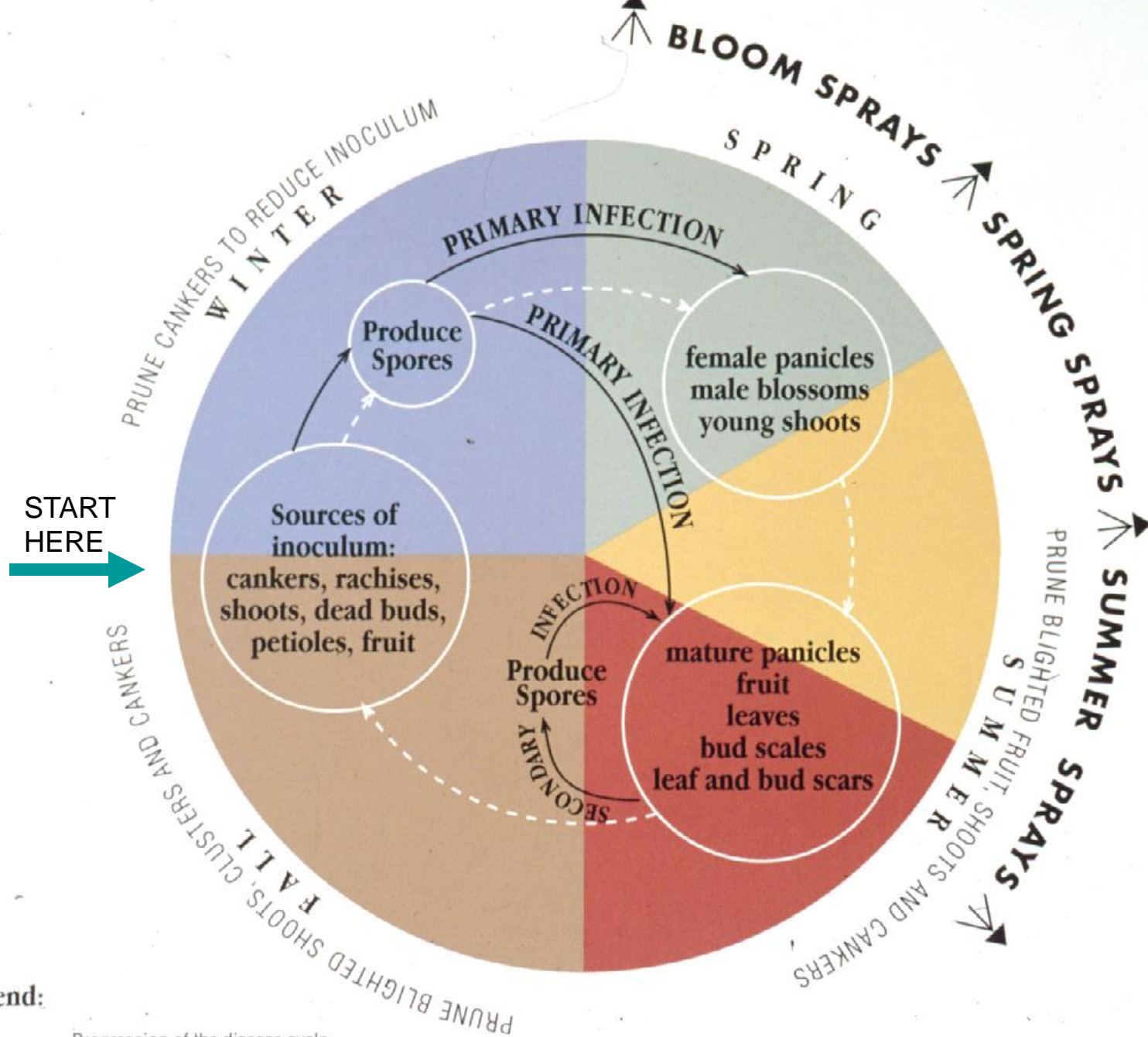


Nut punctured by LFB



Transmission of *Botryosphaeria* by stinkbugs and disease development





Legend:

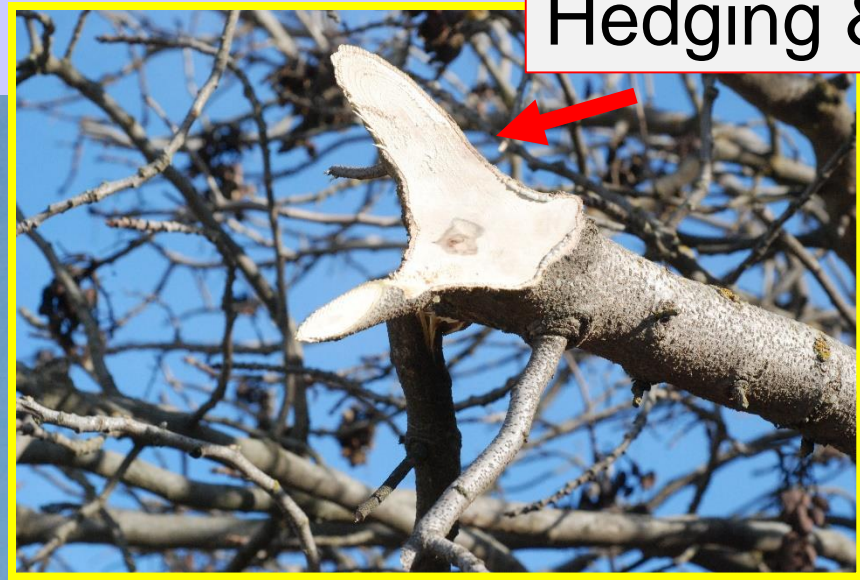
- Progression of the disease cycle
- Primary and secondary infections

Disease cycle/epidemiology

Botryosphaeria-infected parts are retained on the trees



Hedging & pruning wounds



Sanitation:

***** Winter pruning to remove inoculum**

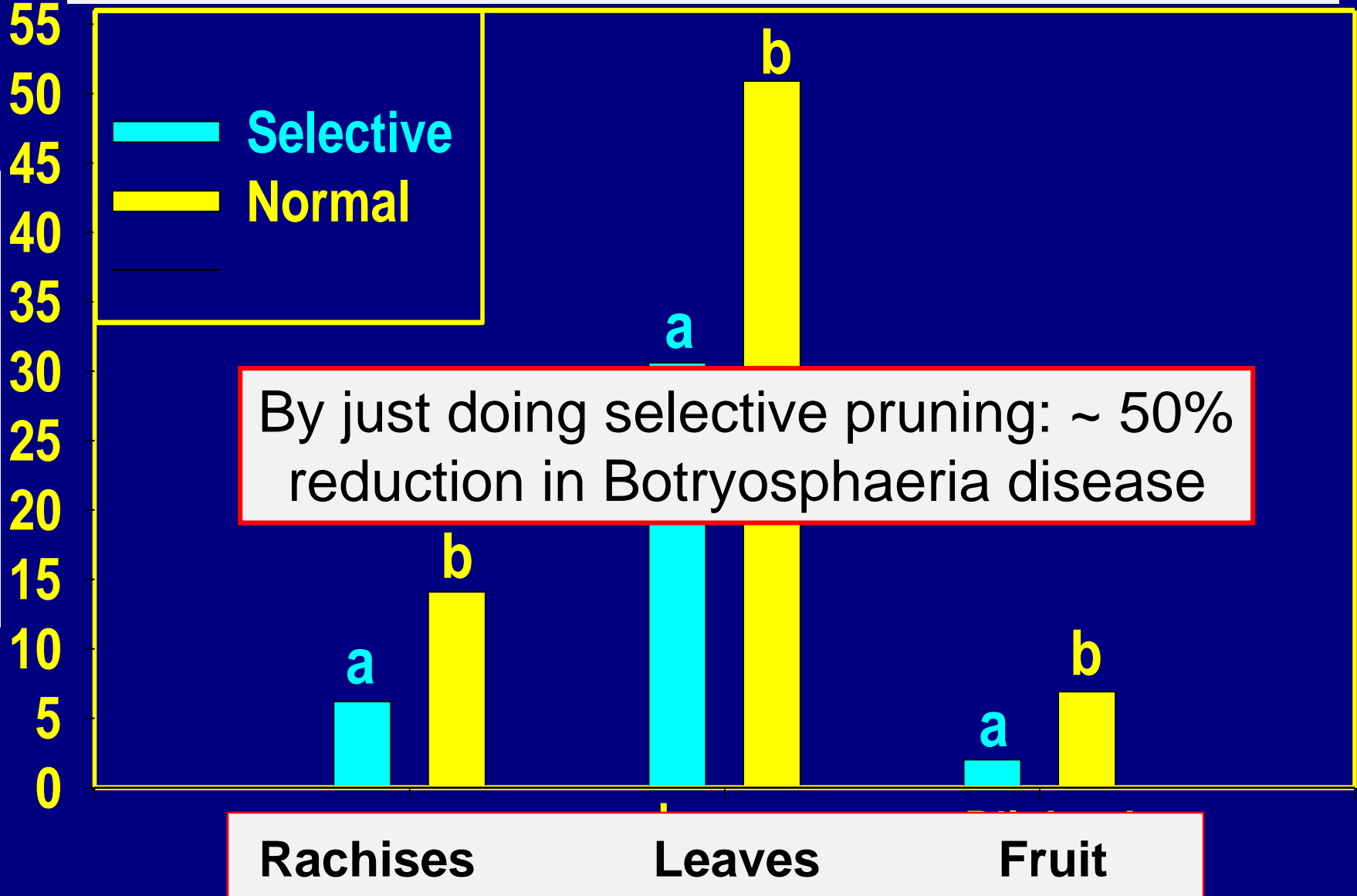


Sanitation:

*** Selective summer pruning



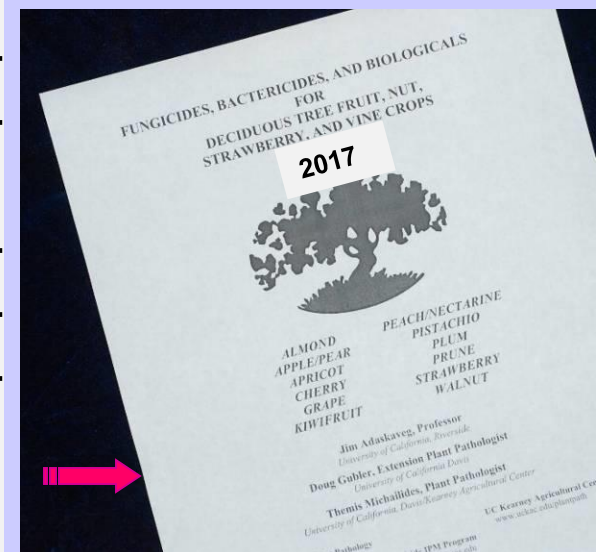
Selective pruning of Botryosphaeria cankers & blighted shoots of pistachio



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

Fungicide efficacy against 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	++++



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

Timing of Calendar Fungicide Sprays

Disease	Dormant	April May	June	July	August
Botryosphaeria	+?	Bloom ++	++++	+++	

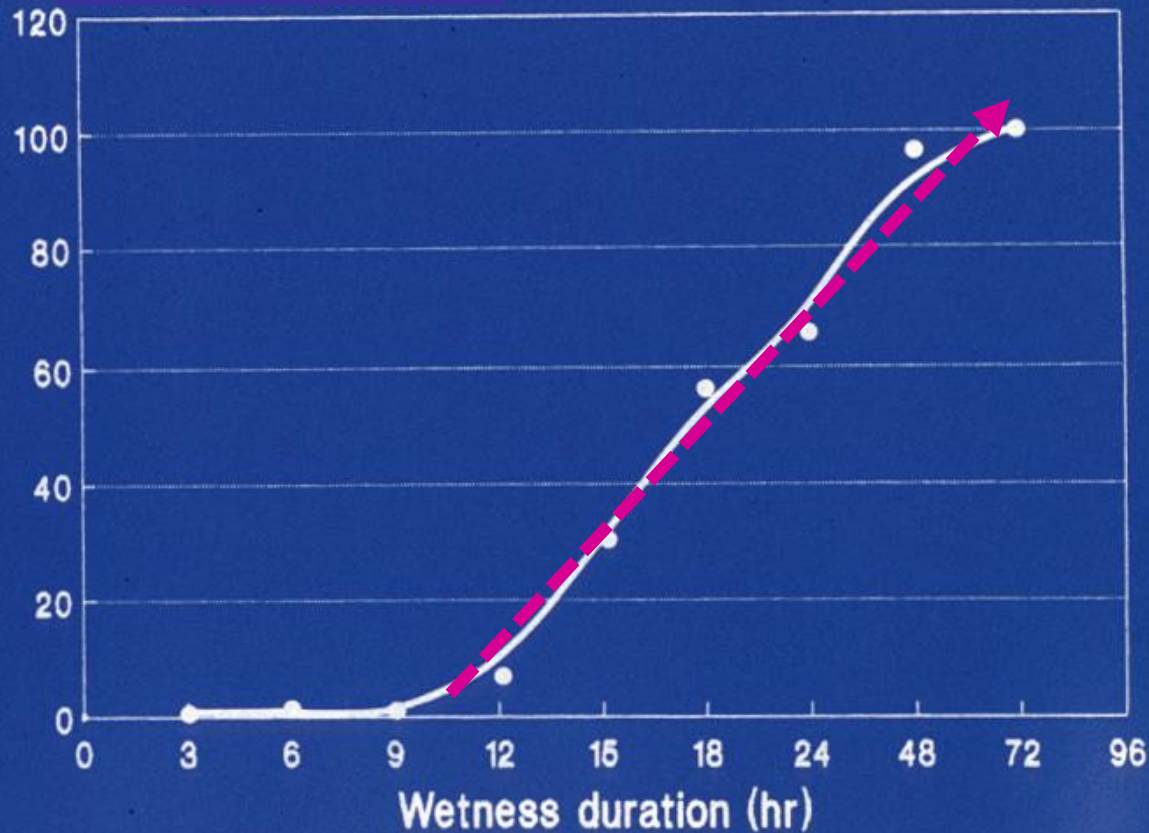


Source: <http://www.ipm.ucdavis.edu>

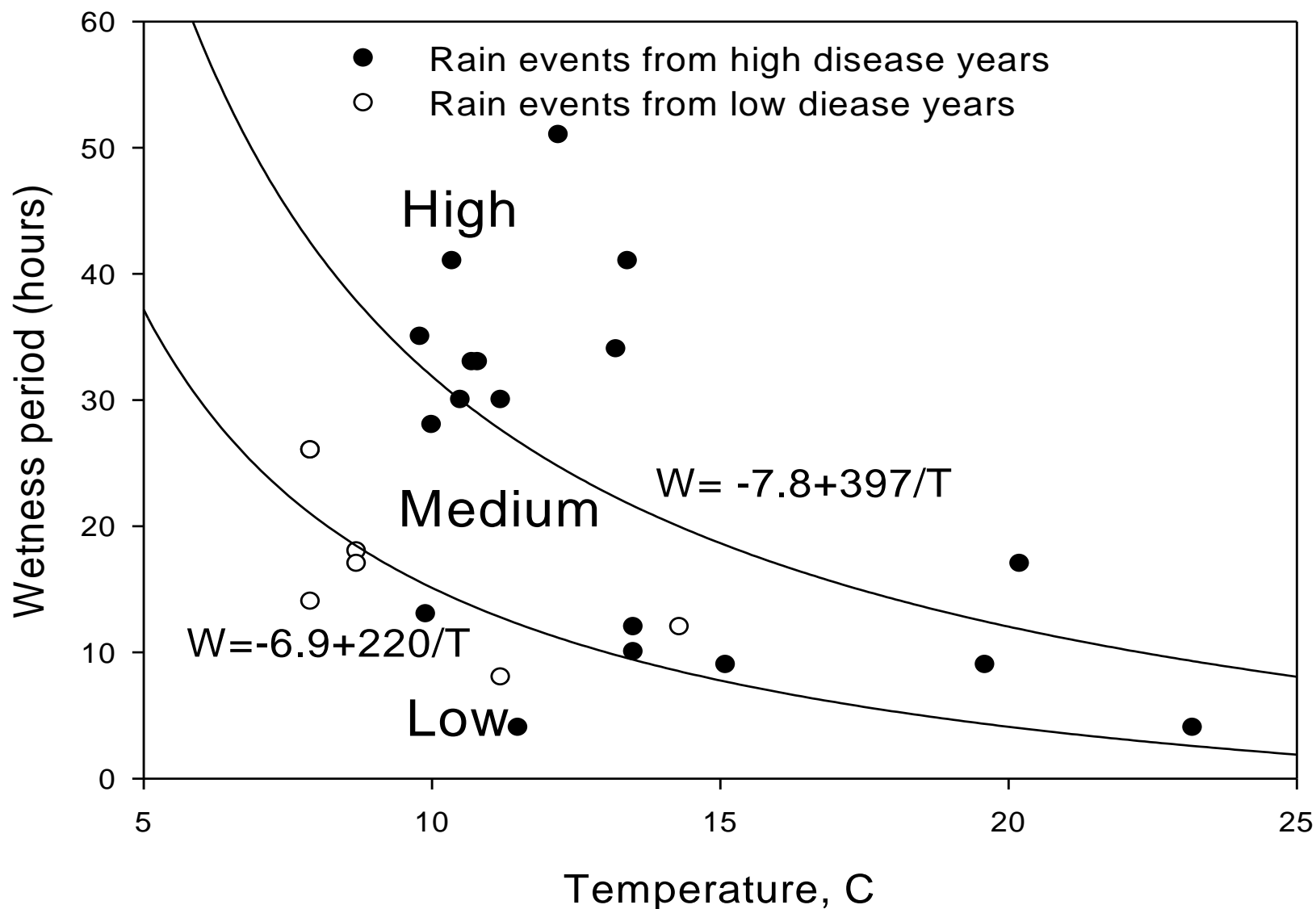
Conditions for infection:

- ✓ Presence of inoculum
- ✓ Rain: at least 1/4" (6.3 mm)
- ✓ Temperature: $\geq 50^{\circ}\text{F}$ (10°C)
- ✓ Presence of susceptible tissues

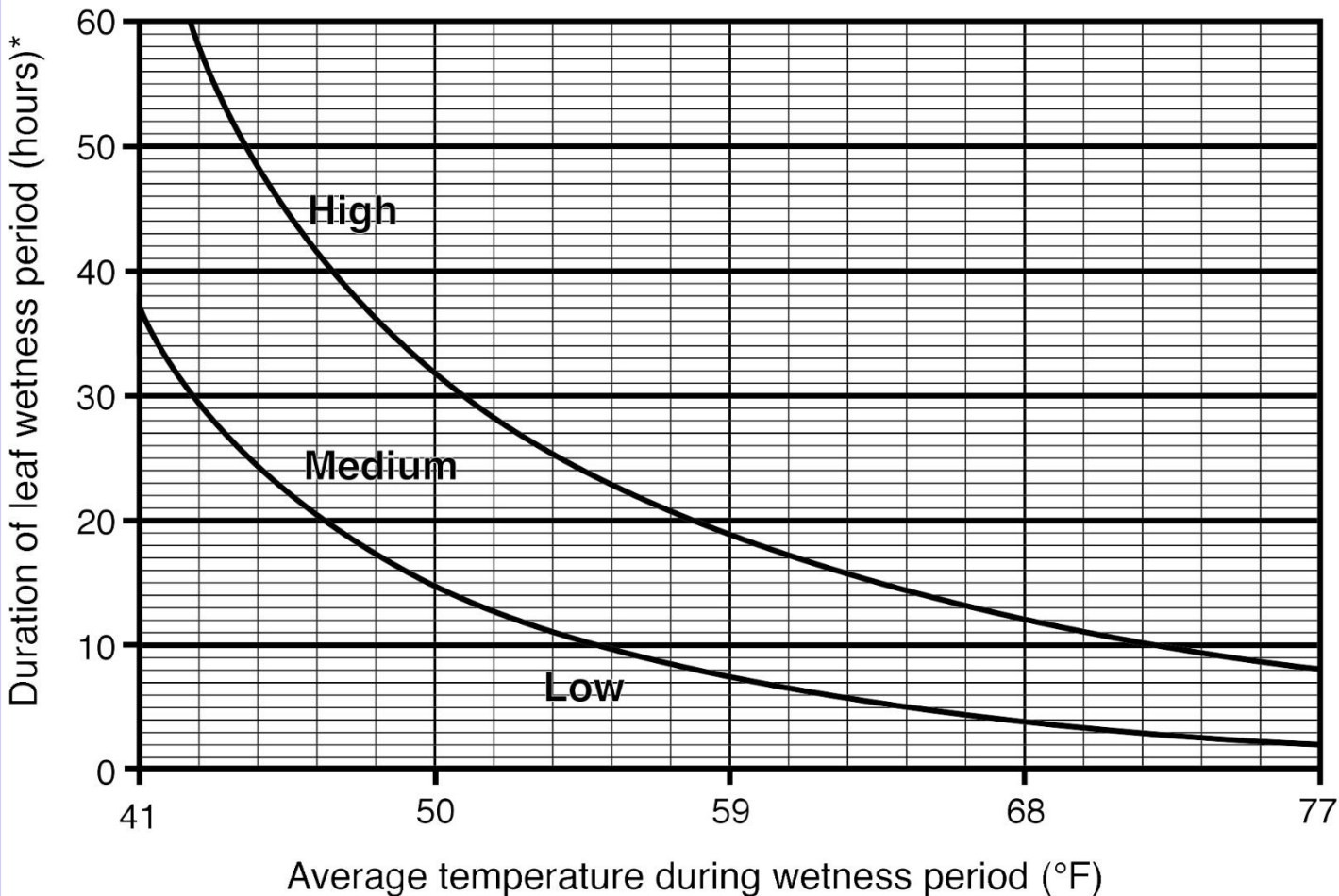
Disease (%)



Risk of infection of pistachio fruit by *Botryosphaeria* based on wetness period (W) events and Temperature (T)



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

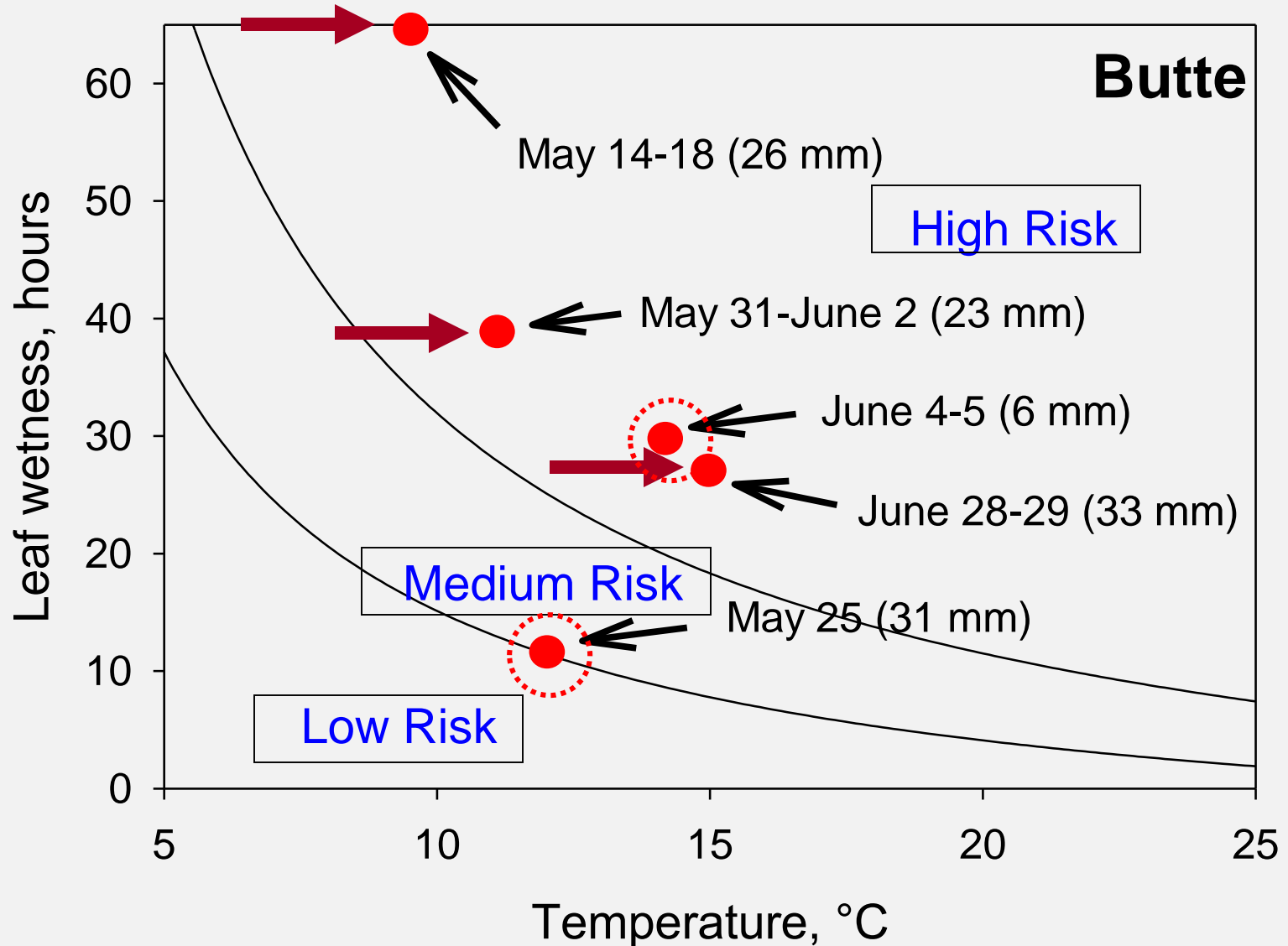


Notes:

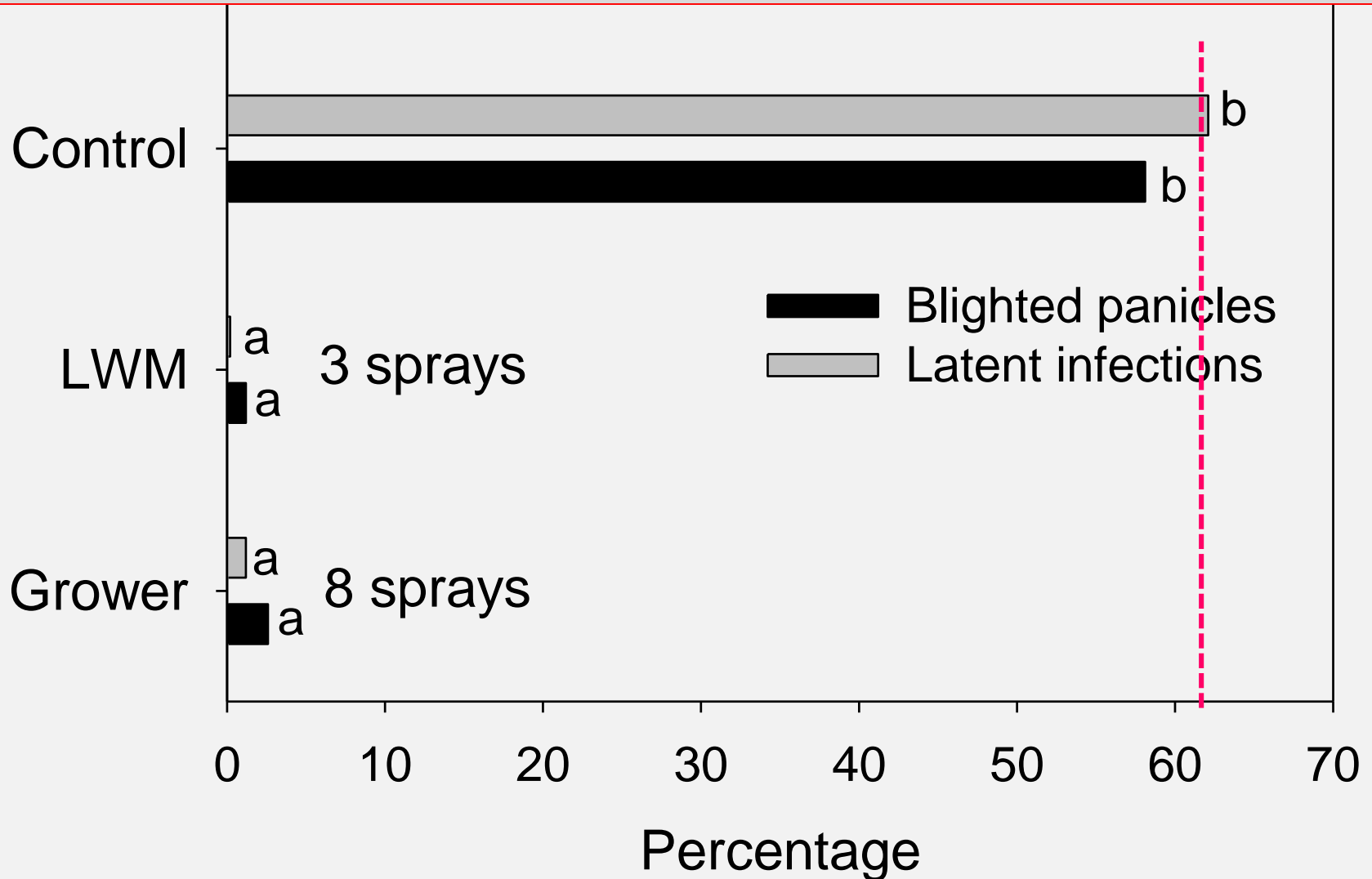
Based on rainfall amount and temperature, use this LWM graph during a rain event to pinpoint the BOT risk zone and determine whether a spray is needed. A spray is applied when points fall in medium and high risk. If a point falls on the line separating low and medium risk, a spray is also applied.

***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.

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)



Take-home message

(Attention: diagnose the disease in the orchard early and correctly)

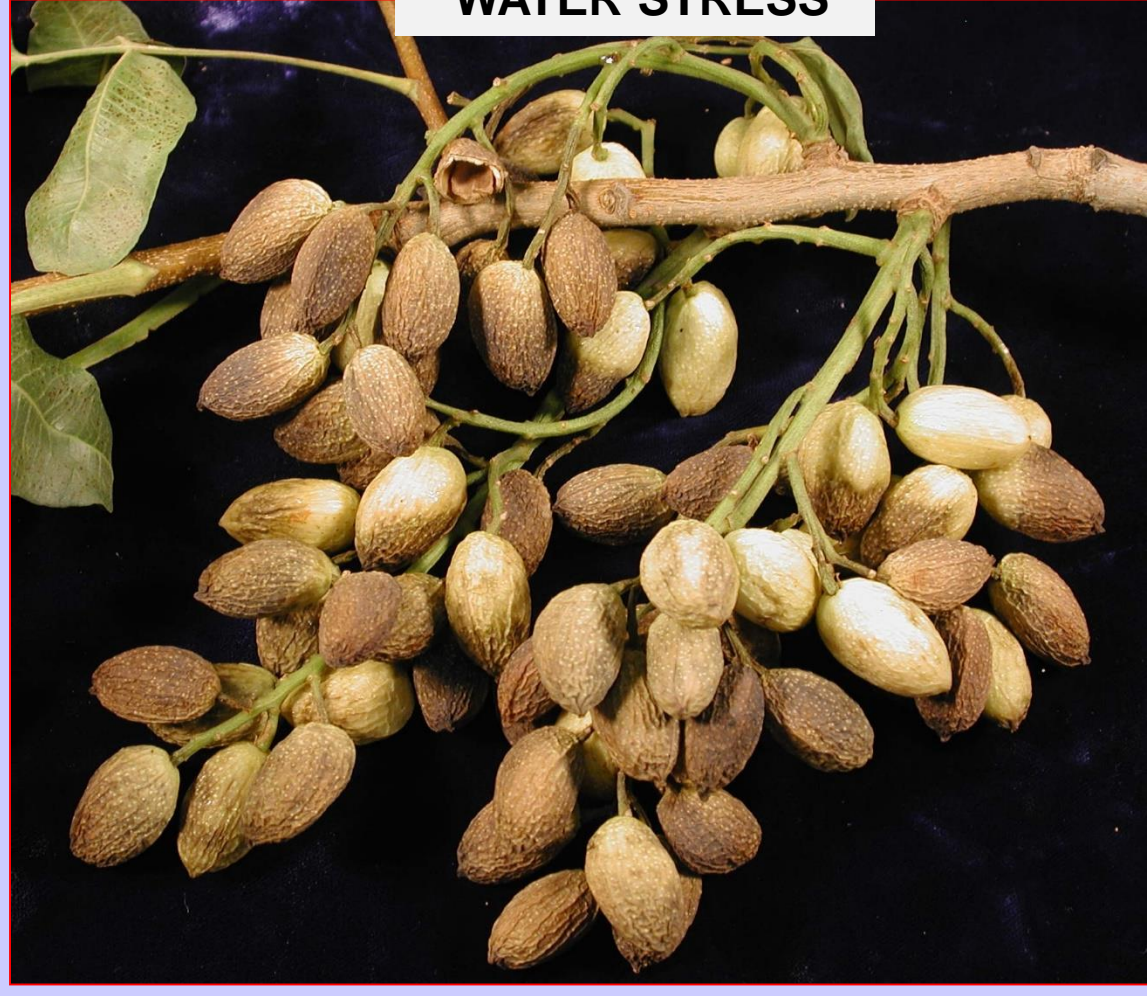
- Monitor young orchards frequently; if found, immediately prune blighted shoots/clusters.
- Spray before or 2-3 days after rain events (April, May, & June) (rains cause infection events).
- There is no fungicide resistance in the Botryosphaeria!
Lots of registered fungicides!
- Also, control hemipteran Insects (stinkbugs).
- Newly released UC cultivars equally to Kerman's susceptibility to Botryosphaeria.

Comparison of Botryosphaeria with water stress

BOT



WATER STRESS



Comparison of Botryosphaeria with citrus flat mite

BOT



2. Alternaria late blight

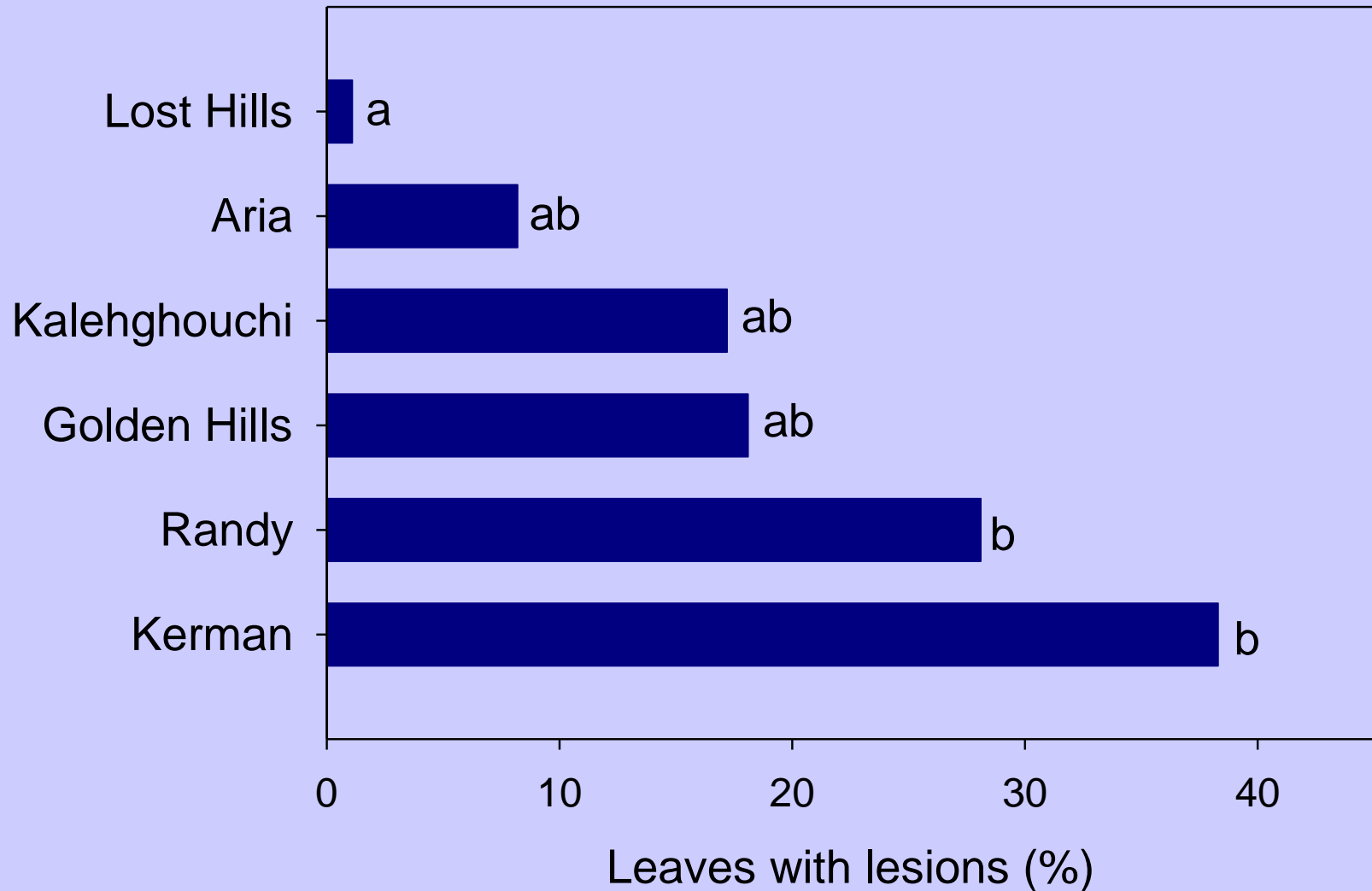


Solid shade! Chronic severe Alternaria late blight

Factors that influence Alternaria late blight

- ✓ Inoculum builds up during the season.
- ✓ Relative humidity in the orchard.
- ✓ Dew formation.
- ✓ Physiological stage of the crop.

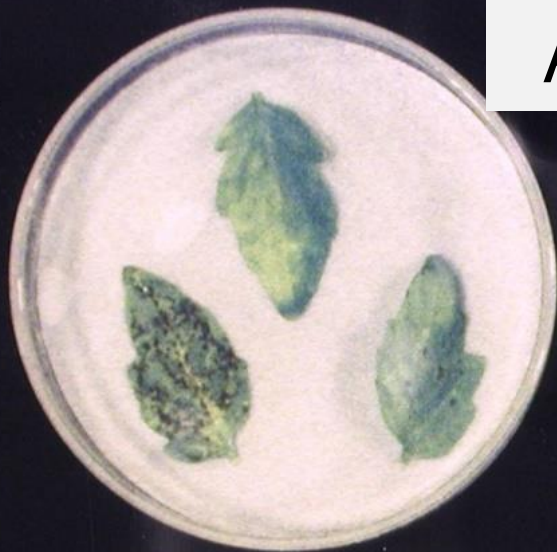
Susceptibility of pistachio cultivars to *Alternaria*



Leaf symptoms



Alternaria TA toxin



As273p3 (tox +)



BLM (tox -)



TA toxin



Pist. 5E9

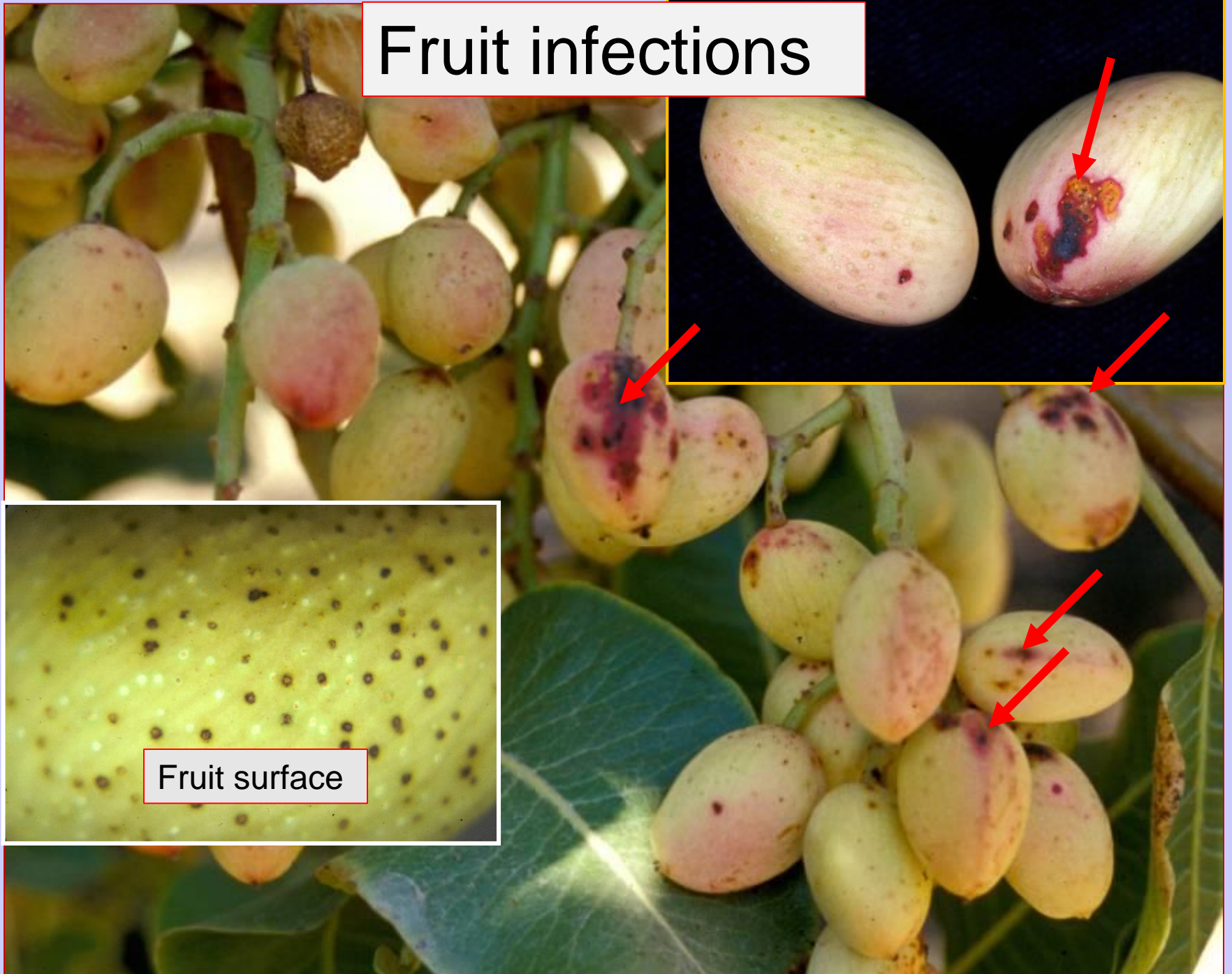


Pist. 142

Peter's scorch



Fruit infections



Fruit surface

Moldy nuts due to *Alternaria* infection



Appearance of fruit at harvests

First harvest – Sept. 10



Second harvest – Sept. 17



Third harvest – Sept. 24



Fourth harvest – October 1



Pathogens causing Alternaria late blight:

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



Reasons for managing Alternaria blight

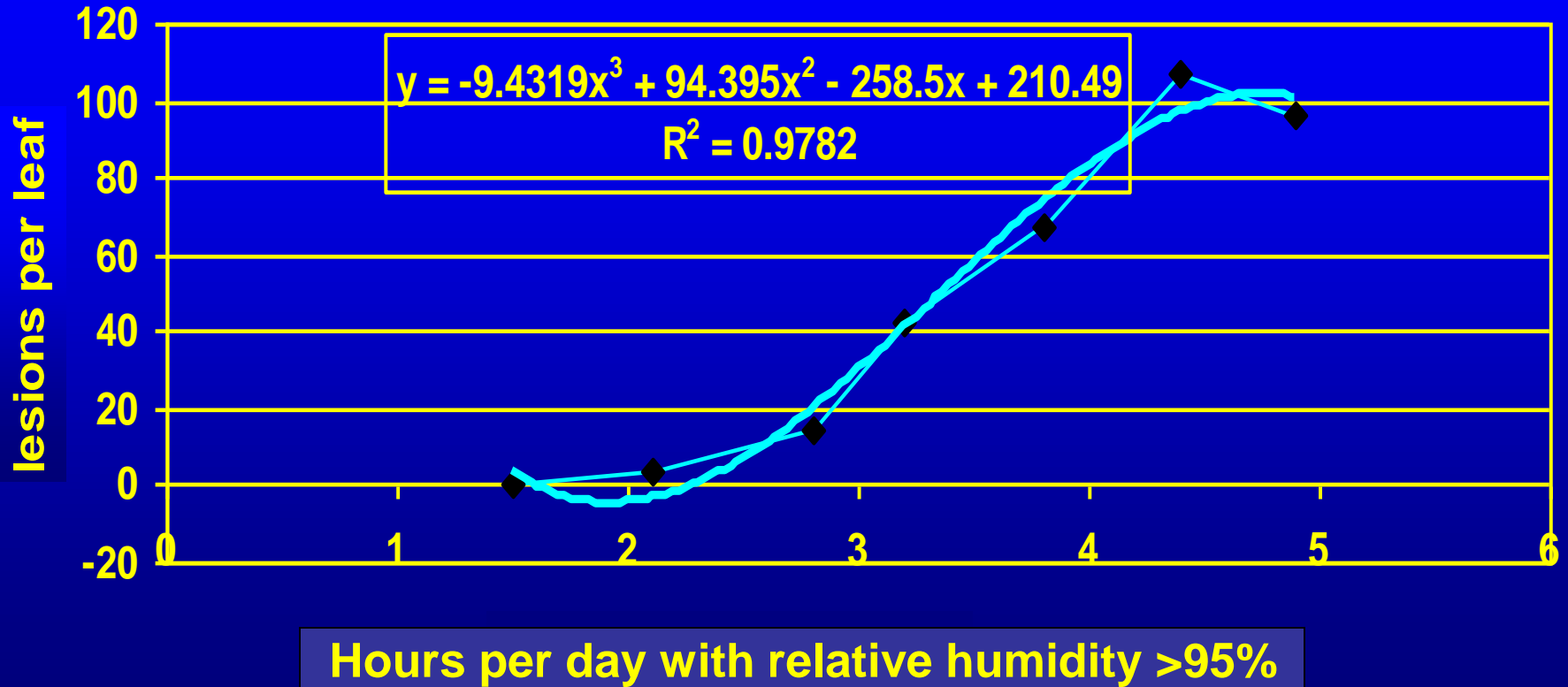
1. Shell staining (reduction of nut quality).
2. Early defoliation of trees and reduction of photosynthetic area/it weakens trees?
3. Problems at harvest (excess defoliation during mechanical harvest)
4. Kernel mold.

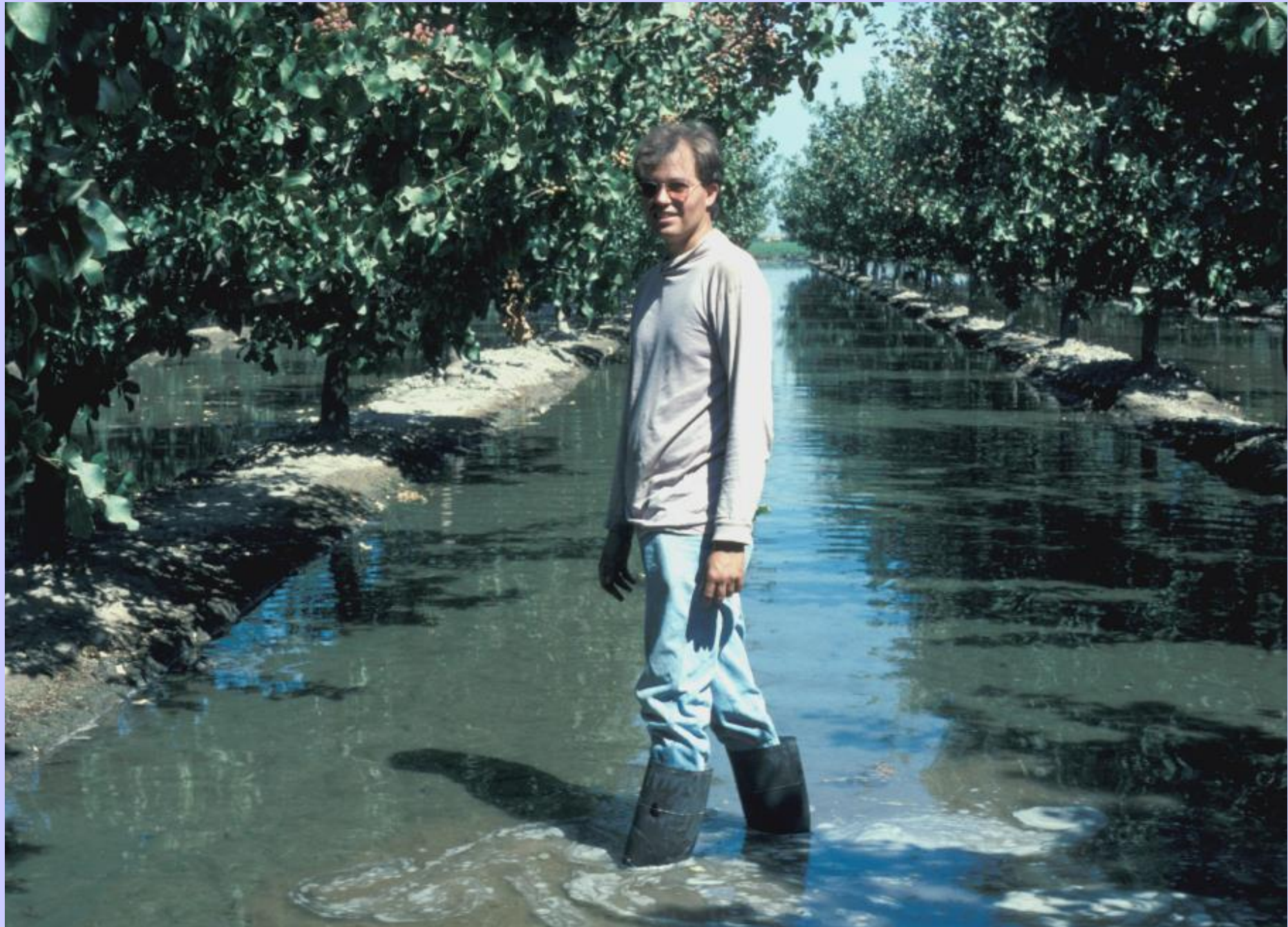
Management of Alternaria late blight

(IPM = Integrated Pest Management)

- **Cultural control** (manage irrigation, improve water infiltration, buried drip, hedge trees to increase air movement, no cover crops, disc soil, etc.)
- **Chemical control** (apply fungicides)... **difficult** (due to fungicide resistance).
- **Integrated disease control** (use both cultural & chemical control).....**the best effect!**

Effect of relative humidity on severity of Alternaria





Alternaria late blight management with buried-drip irrigation



FUNGICIDES, BACTERICIDES, AND BIOLOGICALS
FOR
DECIDUOUS TREE FRUIT, NUT,
STRAWBERRY, AND VINE CROPS

2017



ALMOND
APPLE/PEAR
APRICOT
CHERRY
GRAPE
KIWIFRUIT

PEACH/NECTARINE
PISTACHIO
PLUM
PRUNE
STRAWBERRY
WALNUT

Jim Adaskaveg, Professor
University of California, Riverside

Doug Gubler, Extension Plant Pathologist
University of California Davis




Themis Michailides, Plant Pathologist
University of California, Davis/Kearney Agricultural Center

UC Kearney Agricultural Center
www.uckearney.edu/plantpath

Fungicides registered in California for Alternaria late blight

Fungicide	Active ingredient	Efficacy
Abound	Azoxystrobin	++
Adament	Trifloxystrobin+tebuconazole	+++
Bravo	chlorothalonil	++
Bumper/Tilt	propiconazole	+++
Cabrio	pyraclostrobin	+++
Gem	trifloxystrobin	+++
Quash	metconazole	+++(+)
Fontelis	penthiopyrad	++++
Pristine	boscalid+pyraclostrobin	+++(+)
Luna sensation	fluopyram+trifloxystrobin	++++
Luna experience	fluopyram+tebuconazole	+++(+)
Inspire Super	difenoconazole+cyrodinil	++++
Quilt-Xcel	azoxystrobin+propiconazole	+++(+)
Scala	pyrimethanil	++
Switch	cyprodinil+fludioxonil	+++
Tebuzol	tebuconazole	+++
Copper	Copper	+

Fungicide spray timing for Alternaria late blight

Disease	Dormant	April /May	June	July	August
Alternaria					

**Best timing: late June/early July
(4th of July!)**



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

Alternaria develops resistance to fungicides easily

- Resistance to strobilurins
- Resistance to carboximides
- Multiple resistance

**Rotate various FRAC groups to
manage resistance**

Take-home message

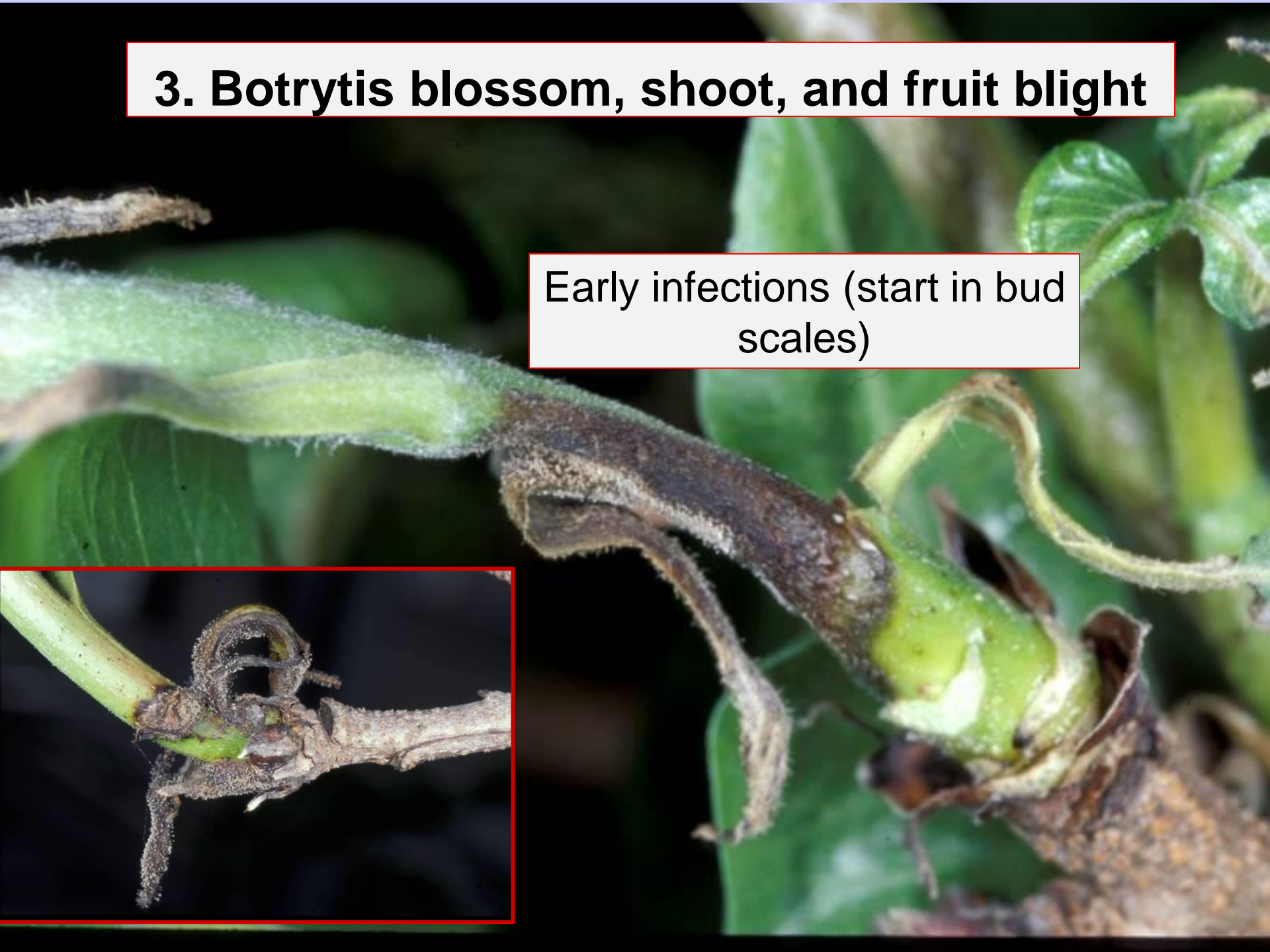
(Attention: It is important to diagnose the disease correctly in the orchard)

- Start sprays in early June and finish by end of July).
- For one spray, the **best time** is end June /early July (4 July, Independence Day!).
- Rotate fungicide FRAC groups to avoid resistance selection.
- Bloom sprays (April & May) and August sprays are not effective against Alternaria blight.

However, if cool and wet weather during bloom, then spray at bloom for Botrytis blight

3. Botrytis blossom, shoot, and fruit blight

Early infections (start in bud scales)



Blossom and shoot blight



Fruit blight



Rains in May and June

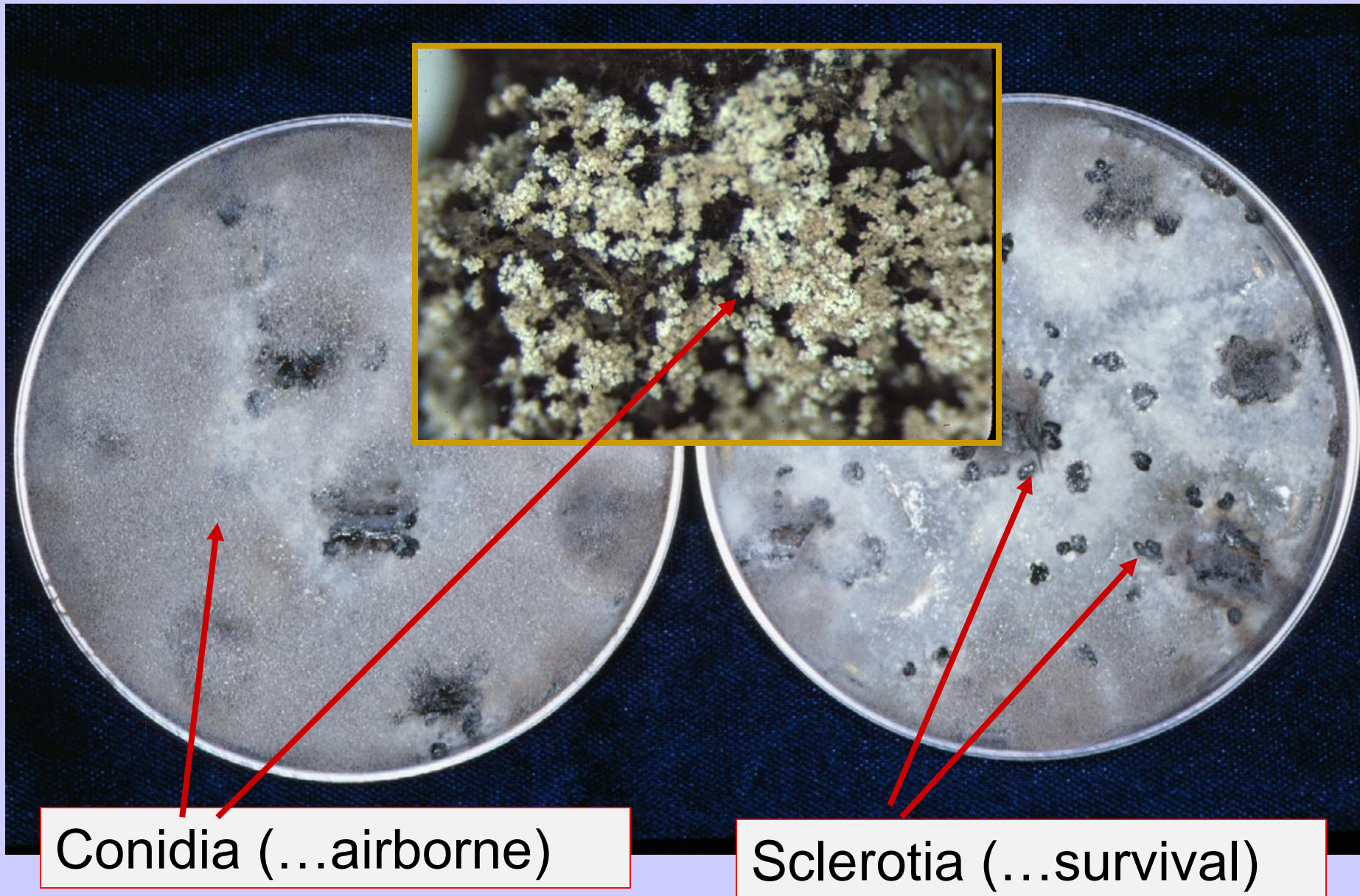
Leaf lesions



Cankers start from male flowers



Pathogen: *Botrytis cinerea*



Fungicides registered for Botrytis blight

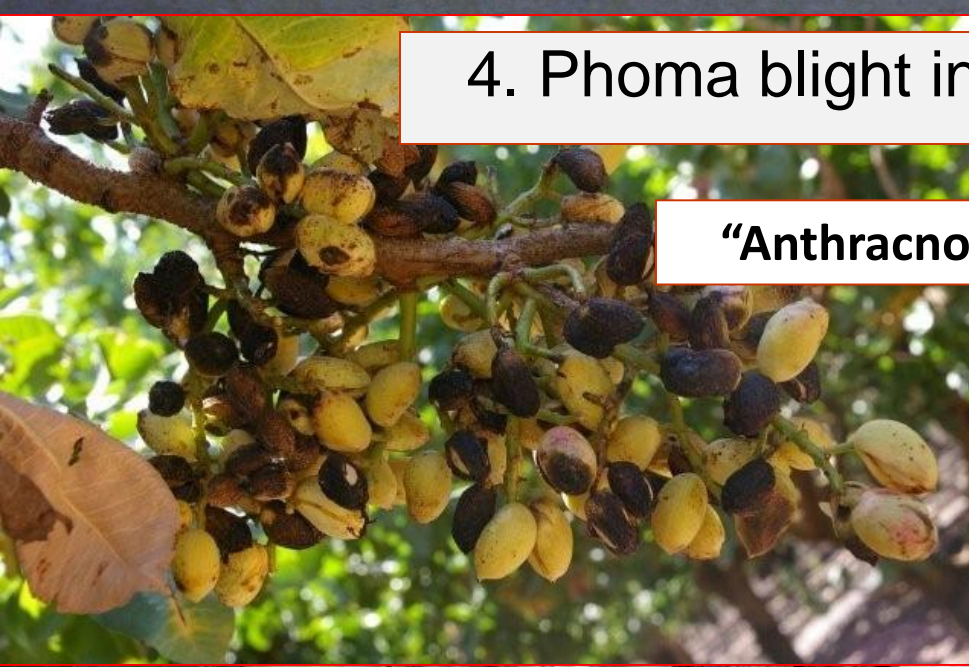
Fungicide	Active ingredient	Efficacy
Adament.....	Trifloxystrobin+tebuconazole	+++
Fontelis	penthiopyrad	++++
Bravo.....	chlorothalonil	---
Bumper/Tilt.....	propiconazole	+
Cabrio.....	pyraclostrobin	---
Elevate.....	fenhexamid	++++

Timing: 1 to 2 sprays in the spring

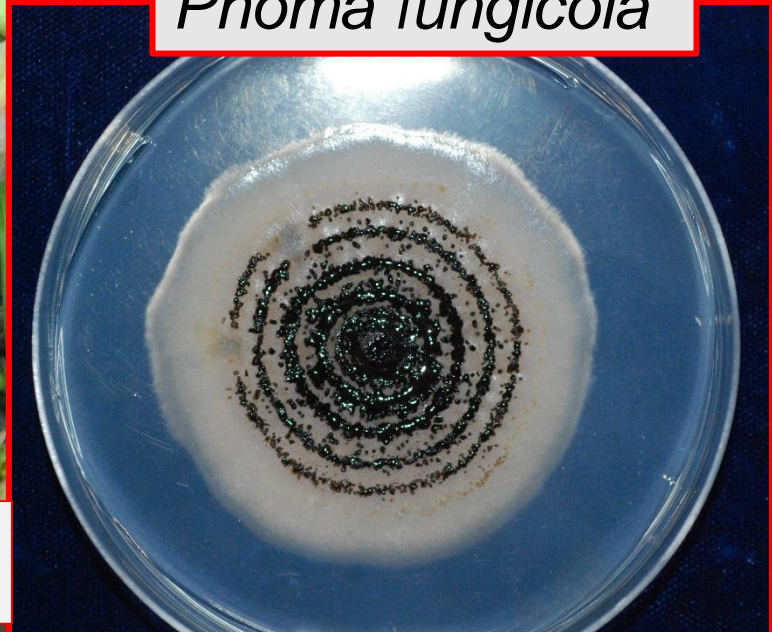
Scala.....	pyrimethanil	+++
Switch.....	cyprodinil+fludioxonil	+++
Tebuzol.....	tebuconazole	+
Topsin-M.....	thiophanate-methyl	+++ (***)
Copper.....	copper	---
Luna Experience	fluopyram+tebuconazole	++++
Luna Sensation	fluopyram+trifloxystrobin	++++

4. Phoma blight in Arizona pistachios

“Anthracnose-like” disease



Phoma fungicola



In Cooperation with: Joshua Sherman, Extension Agent,
Univ. of Arizona & Pistachio Growers in Arizona

Bud Monitoring for Phoma (BUDMON) -Technique

A pre-season assay to determine Phoma risk

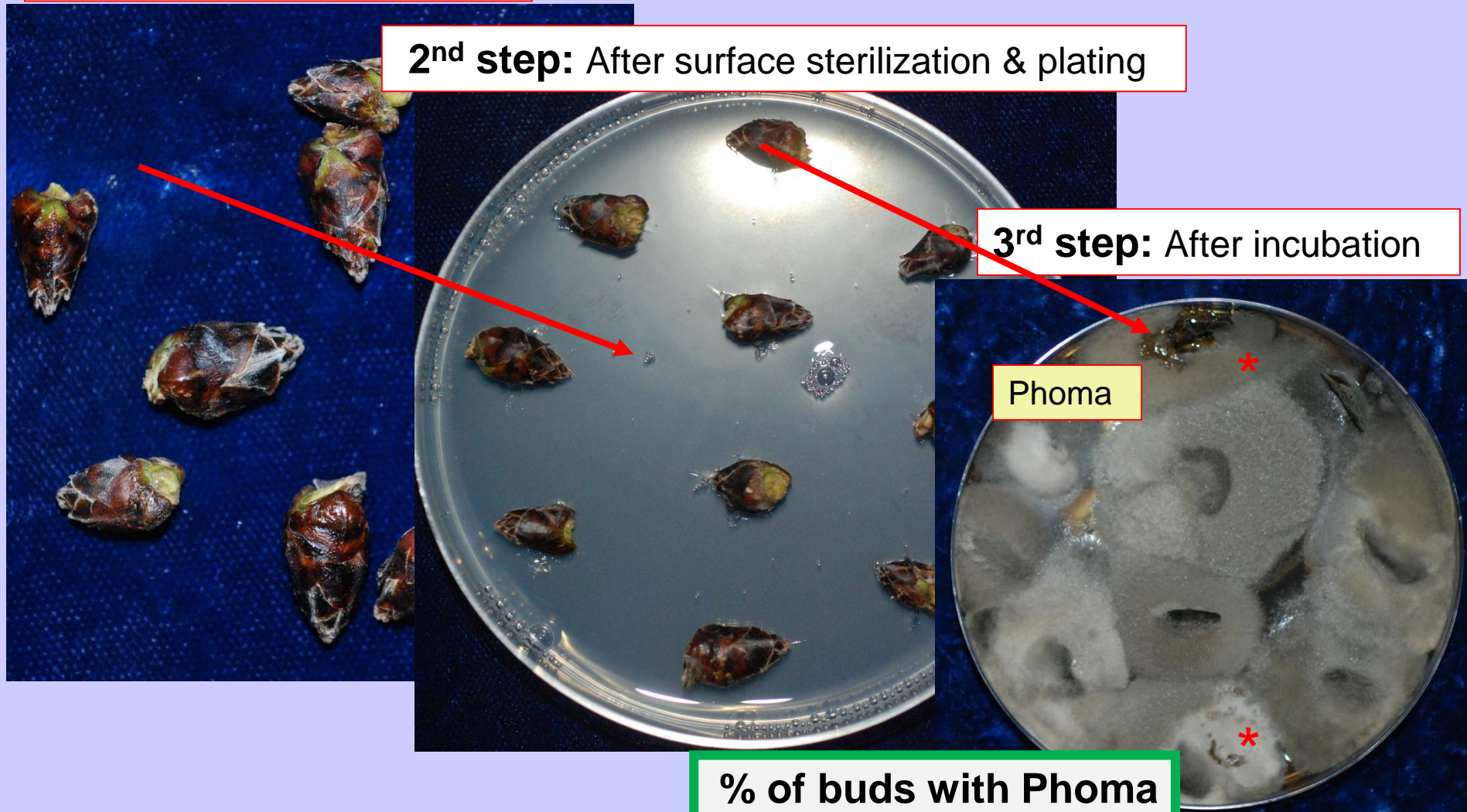
1st step: Buds at collection

2nd step: After surface sterilization & plating

3rd step: After incubation

Phoma

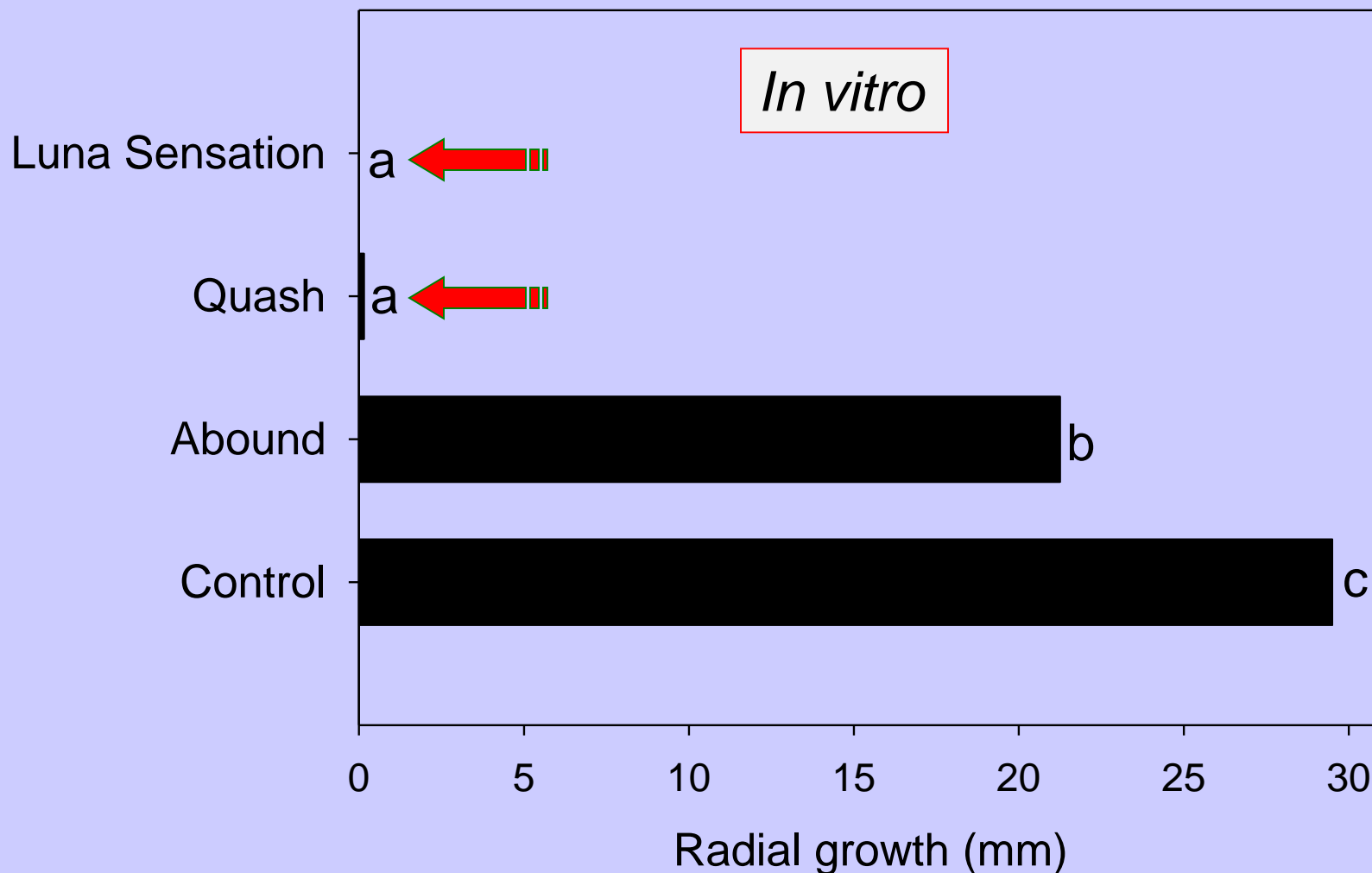
% of buds with Phoma



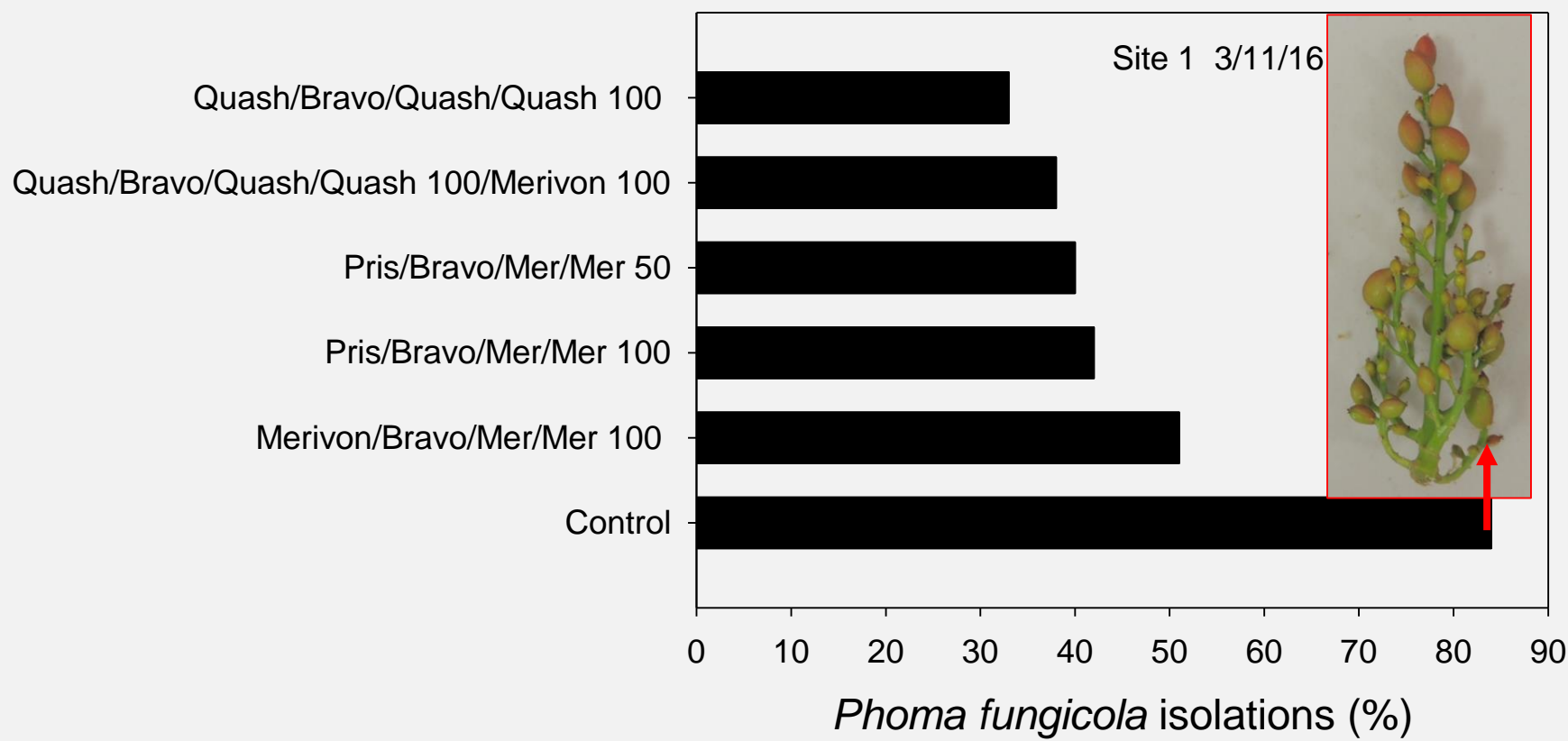
Latent infections



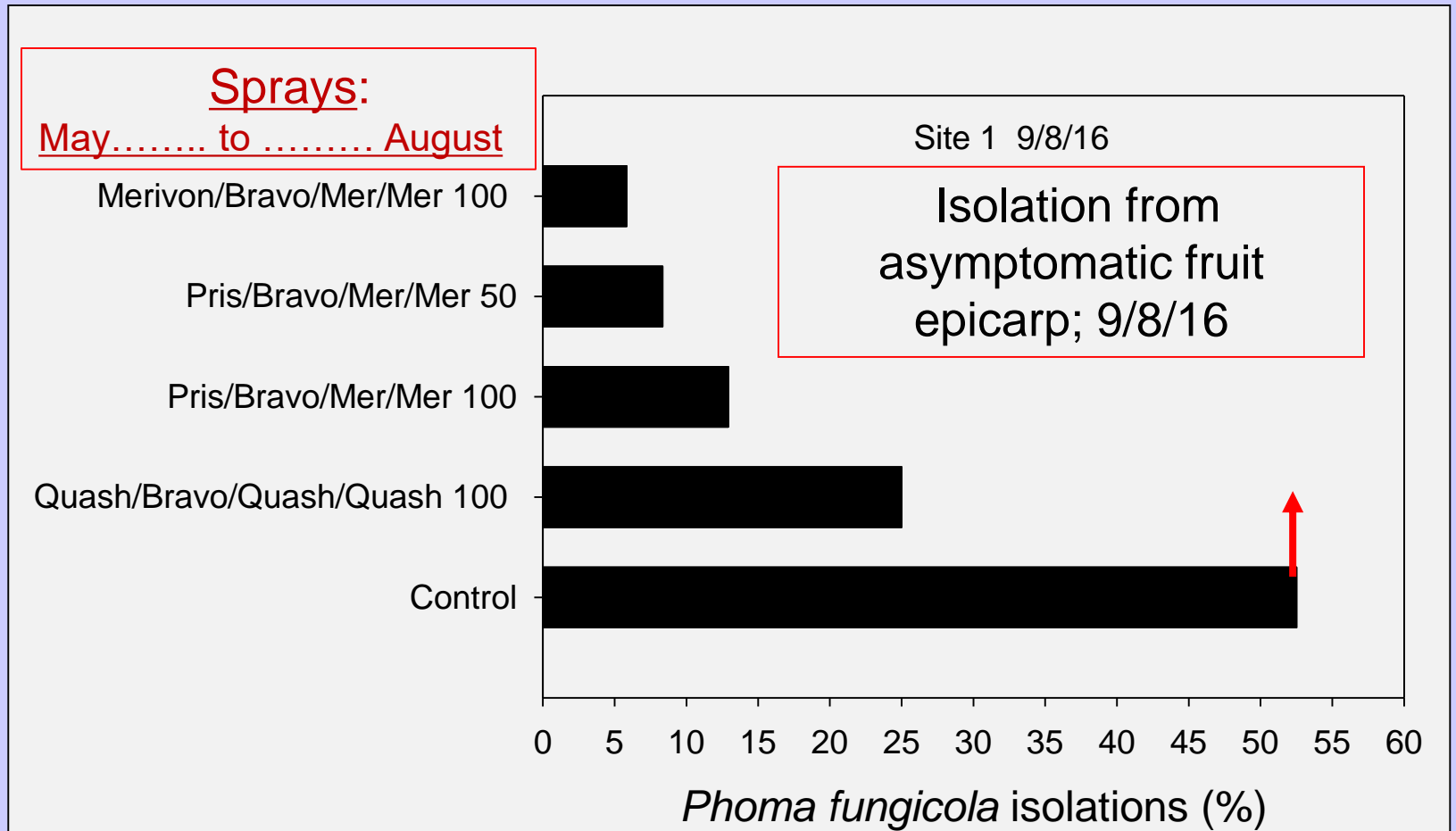
Effects of fungicides at 10 ppm a.i. on radial growth of *Phoma fungicola*



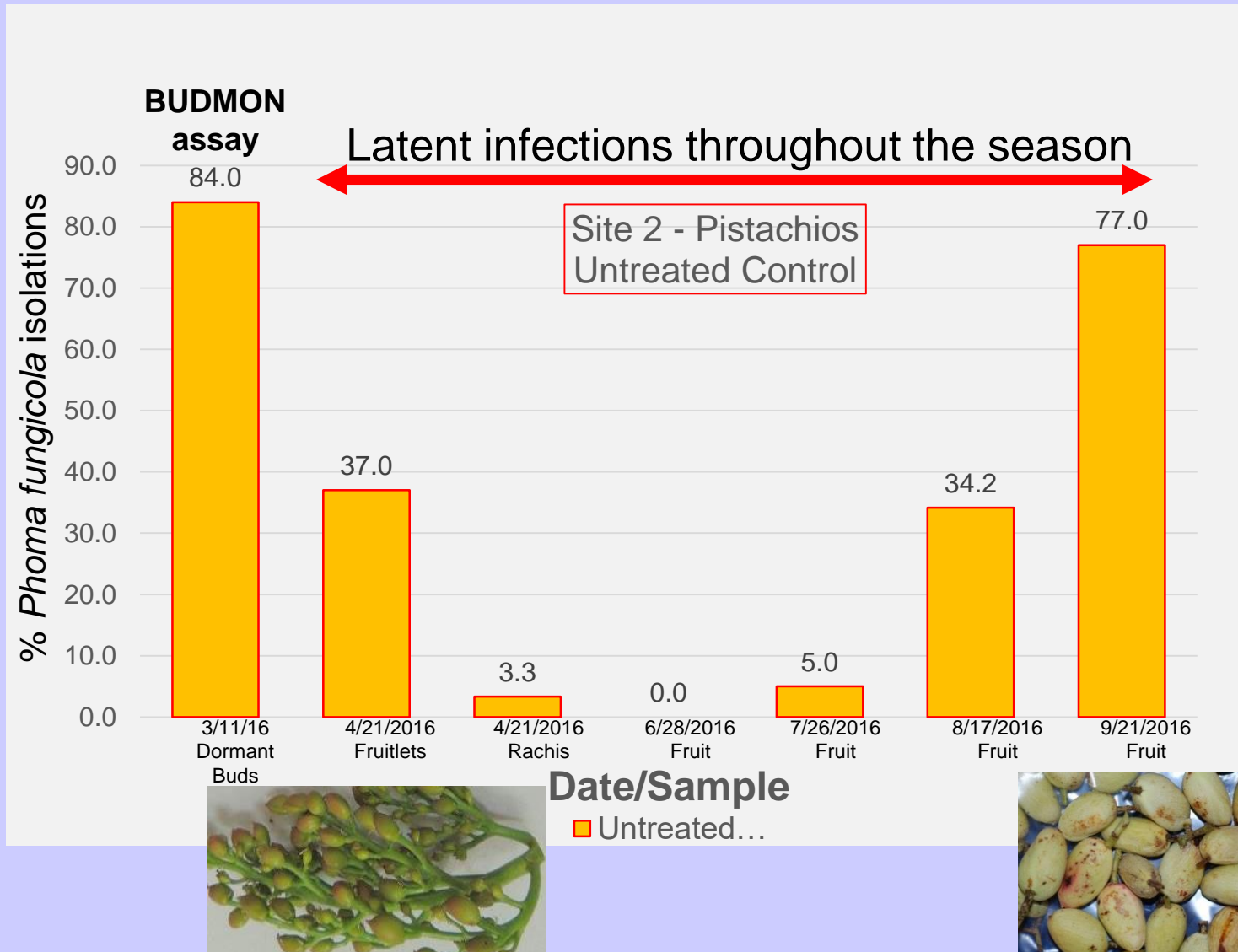
Effect of fungicide programs on latent infections by *Phoma fungicola* (March 11, 2016)



Effect of fungicide programs on latent infections by *Phoma fungicola* (Site 1: September 8, 2016)



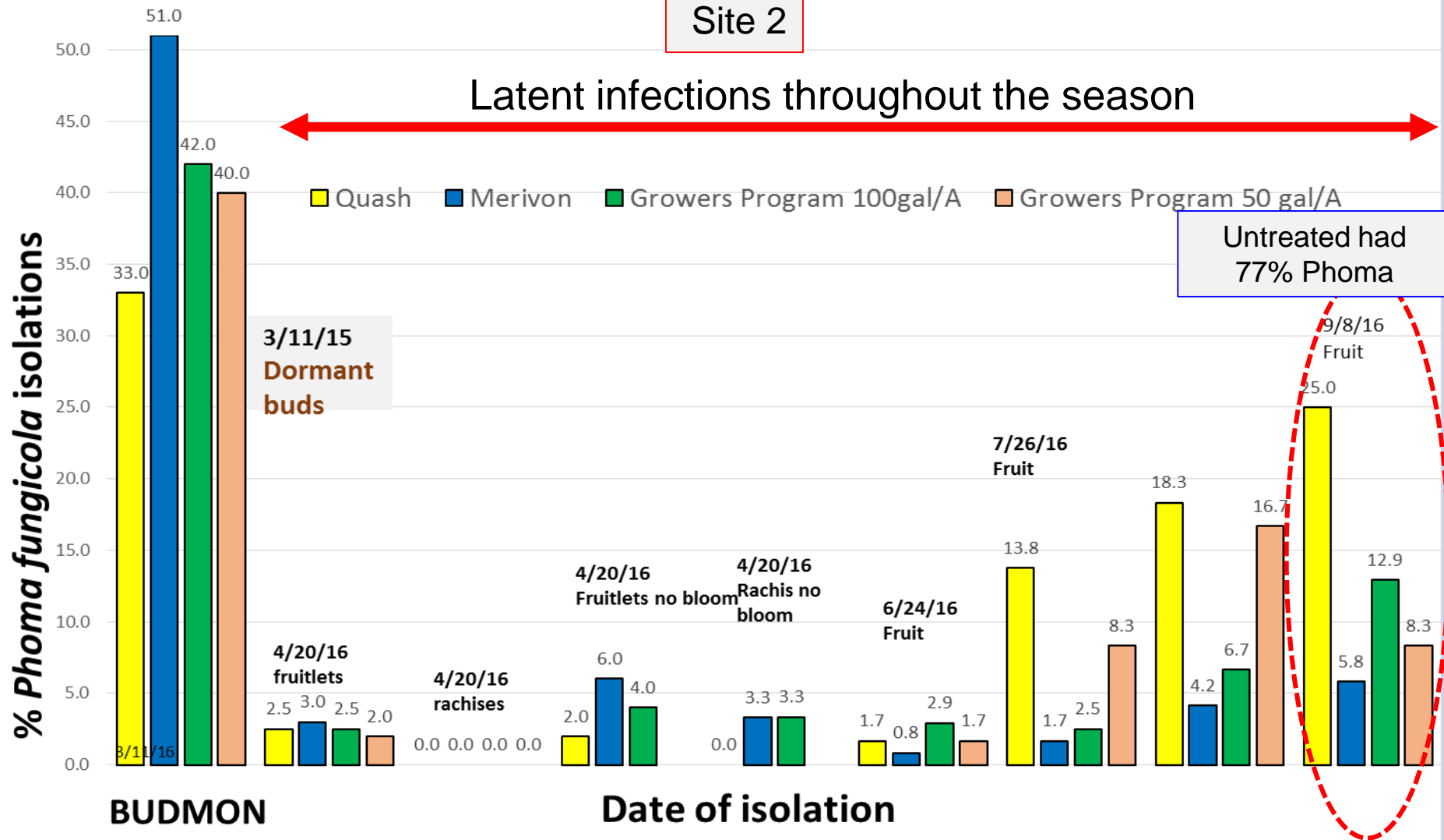
Incidence of latent infection of untreated pistachios by *Phoma fungicola* in Arizona



Effect of fungicide programs on BUDMON and latent infections of pistachio by *Phoma fungicola* in Arizona

Untreated buds had 84% Phoma

Site 2



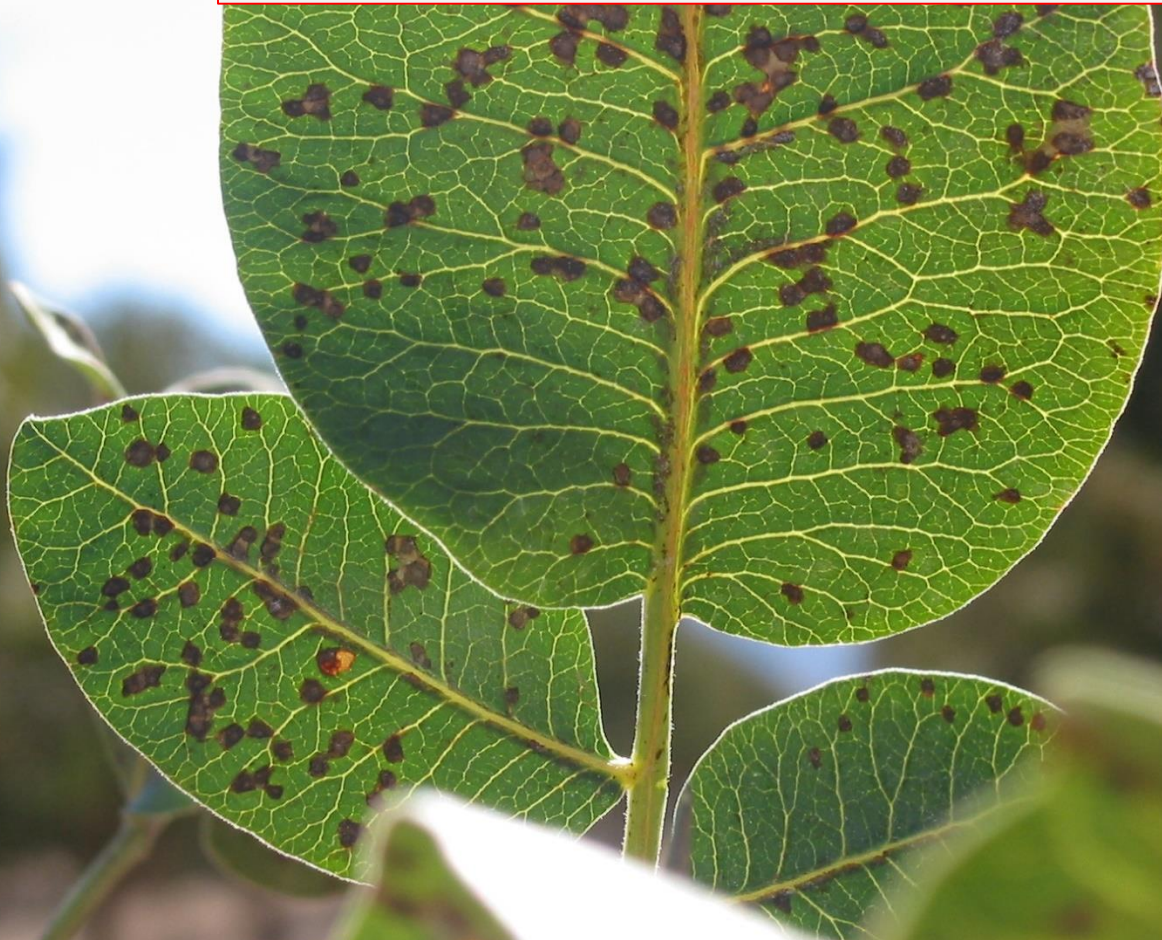
Untreated had 77% Phoma

Conclusions:

- We are trying to figure out the life cycle of the pathogen.
- Then determine critical points in the disease cycle for an effective disease control.
- Final goal to develop a control program for Phoma blight in AZ pistachios.

Other diseases

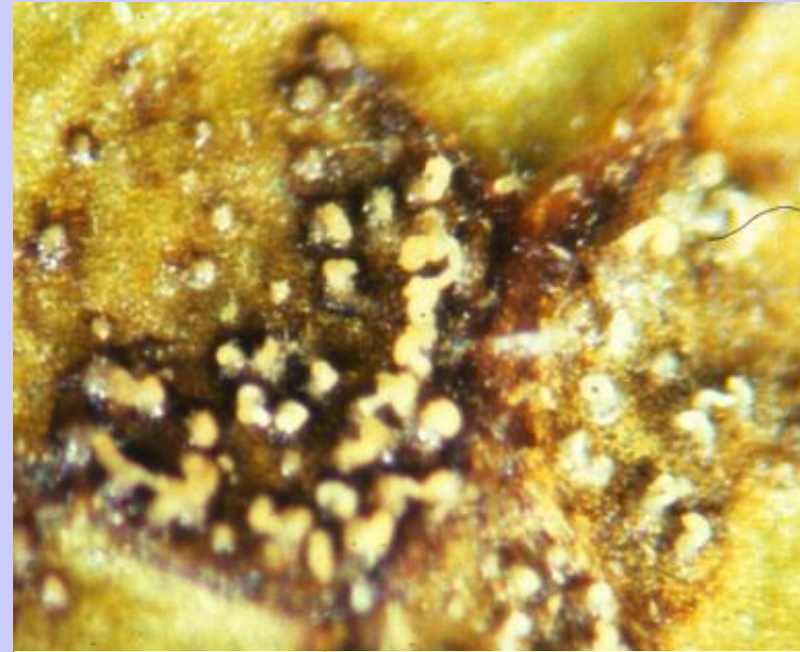
(A) Septoria leaf and fruit



(a) Septoria leaf spot and blight (3 *Septoria* spp.) (one in California; no damage)

Septoria species causing leaf spots:

1. *Septoria pistacina*
2. *Septoria pistaciarum*
3. *Septoria pistaciae*



Fruit spots caused by *Septoria pistachiarum*



Septoria in Red Aleppo pistachio (Glenn Co.)





Septoria in Kerman pistachios, AZ



Severe defoliation at harvest in AZ

Fungicide trial against Septoria leaf spot of pistachio (Arizona) (R.E. Call & M. E. Matheron)

Fungicide	Active ingredient	Rate per acre	Avg spots per leaf
Flint 50WG	trifloxystrobin	0.125 lb	22 a
Abound 2.08SC	azoxystrobin	15 fl oz	62 b
Procop R	Copper hydroxide	8.0 lb	74 bc
Break EC	propiconazole	6.0 fl oz	128 cd
Elite 45DF	tebuconazole	0.5 lb	259 de
Bravo 720 F	chlorothalonil	2.25 lb	293 e
Non treated	---	----	293 e

Current program: Quash (July to early August); and/or Bravo

(B) Anthracnose of pistachio



Fruit covered with spores of the pathogen

Colletotrichum acutatum



Almost total destruction of the crop - Australia



Clusters infected by anthracnose



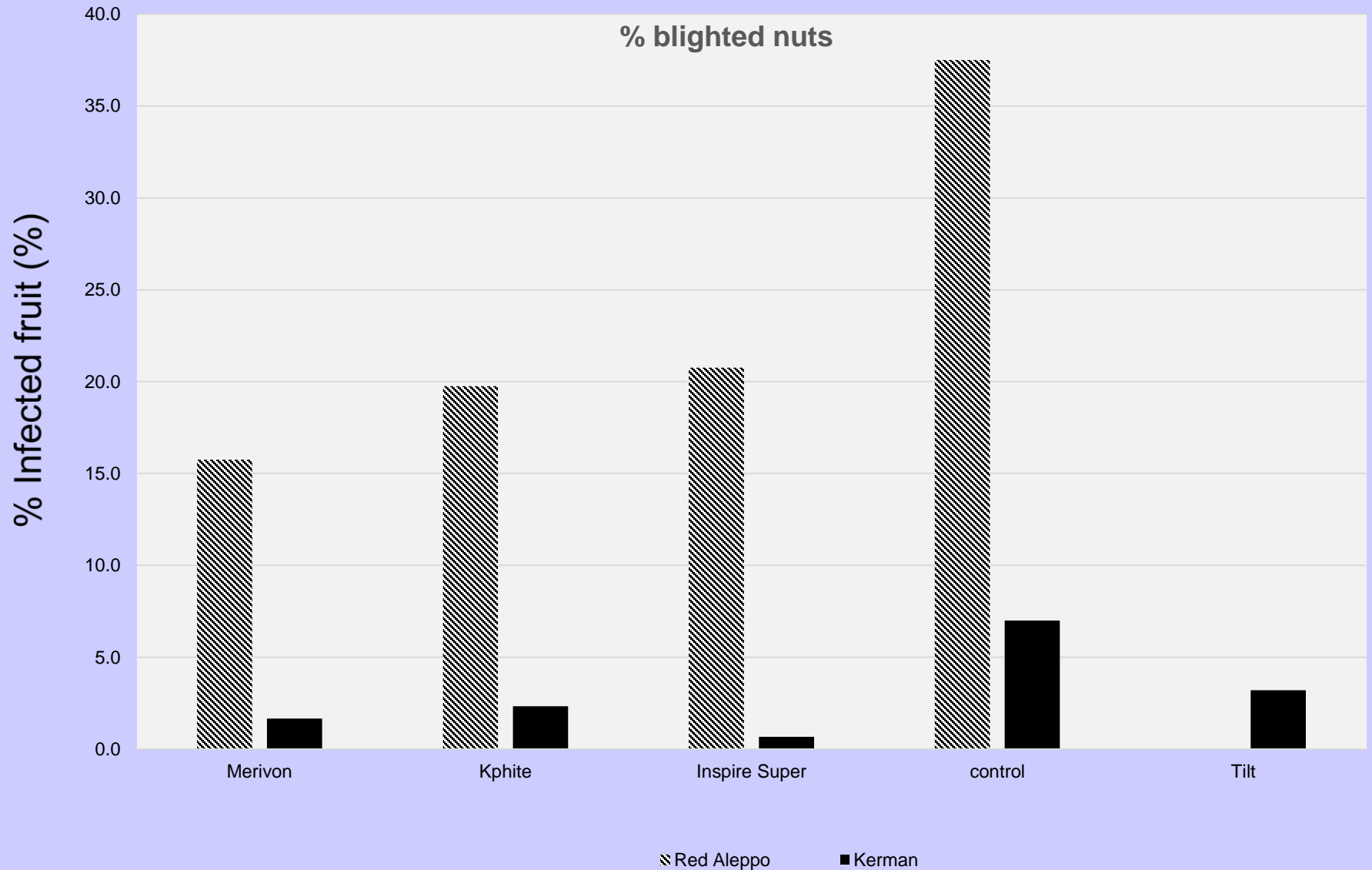
Anthracnose on Red Aleppo leaves



Anthracnose on Red Aleppo fruit



Efficacy of Fungicides against anthracnose of pistachio

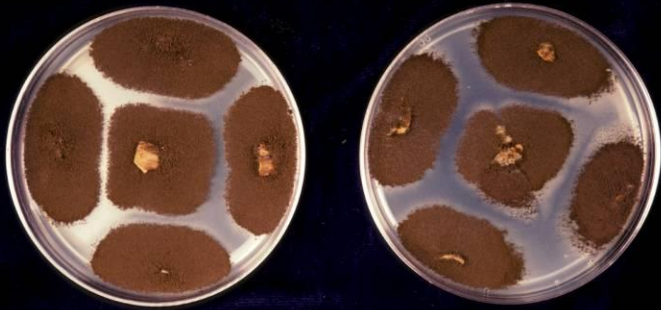


(C) Aspergillus blight



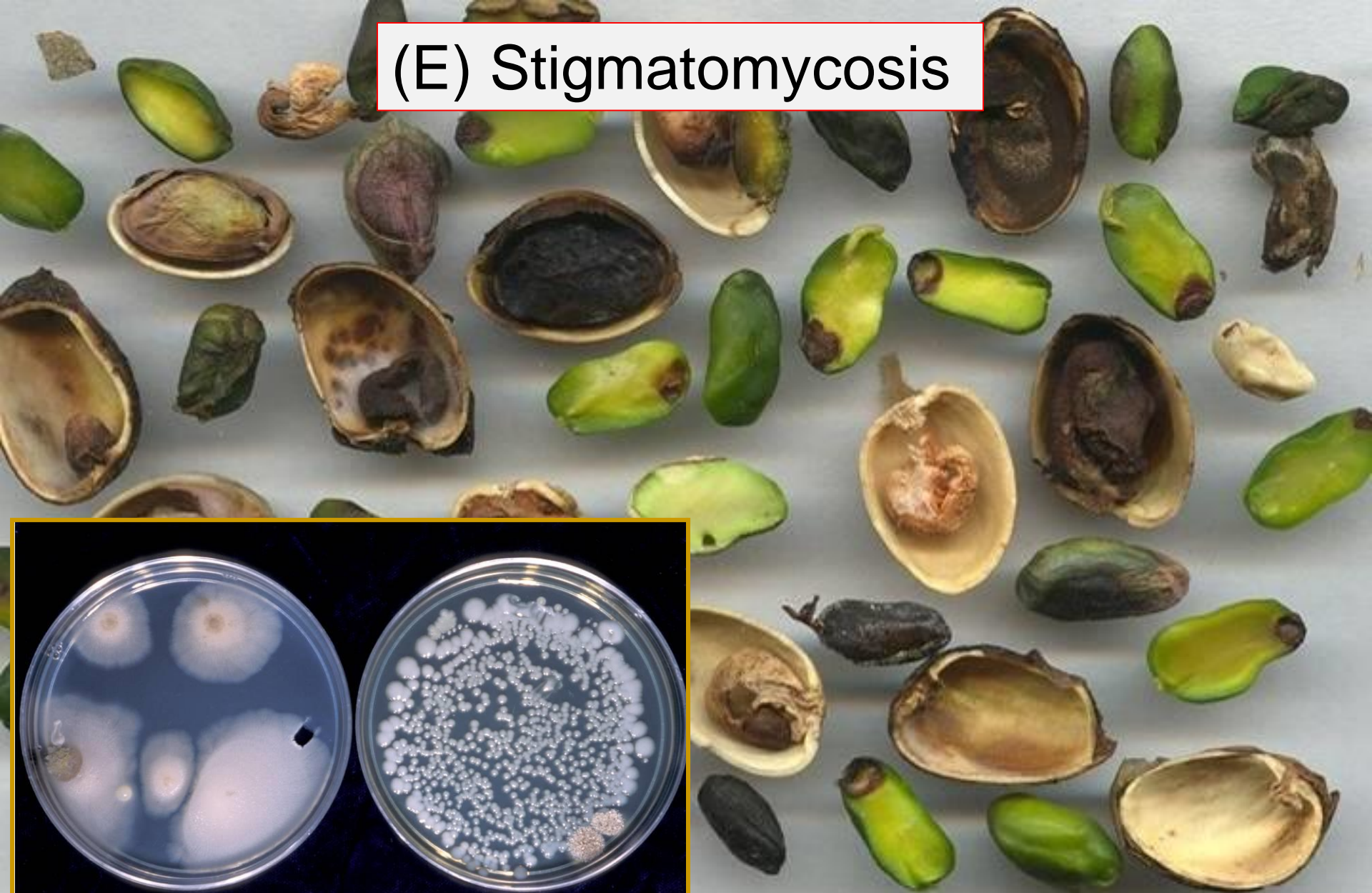
Disease shows in very hot and dry summers (2-5%)

Aspergillus niger



It causes bright yellow staining

(E) Stigmatomycosis



Caused by *Eremothycium coryli* & *Aureobasidium pullulans*
(yeasts)

**Epicarp lesion
(damage by
hemiptera)**



**Kernel necrosis
(damage by large
hemiptera)**

Stigmatomycosis



Unusual kernel necrosis - 2017





**Compendium of Nut Crop Diseases
in Temperate Zones**

Publisher: The American Phytopathological Society - 2002

Individuals involved in research on pistachio diseases

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