9th Advances in PISTACHIO PRODUCTION

November 19, 2020

Above Ground Fungal Diseases of Pistachio

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Trends:

- ✓ Health benefits; good prices.
- ✓ Intensive practices to push trees to produce high yields.
- ✓ Vigorous, Verticillium –resistant rootstocks.

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November 2, 2020

Diseases of pistachio in California and Arizona

1. Botryosphaeria blight (CA, AZ, & Mediterr., Austr., S Afr.)
2. Alternaria blight (CA, & Mediterr.)
3. Botrytis blight (CA, & Intl.)

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Other diseases	Minor & rare diseases
✓Septoria leaf spot (AZ, CA, Medirr., Iran) ✓Stigmatomycosis (CA, AZ, Mediterr., Iran) ✓Aspergillus blight (CA, AZ, Intl.?) ✓Kernel decay (CA, AZ, Mediterr., Austr. Iran) ✓Rust (Mediterr.)	✓Anthracnose blight (CA, Austr.) ✓Phomopsis blight (CA) ✓Sclerotinia blight (CA) ✓Cytospora canker (CA, Italy) ✓Stem canker (CA, AZ, S. Africa)

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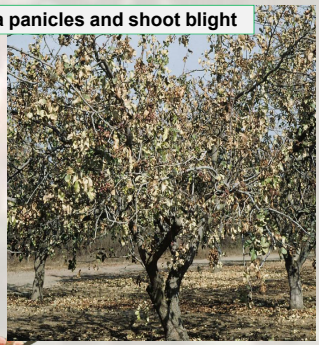
1. Botryosphaeria panicles and shoot blight

Discovered in 1984 (Butte Co).

It took 10 years to spread throughout the pistachio growing counties in California



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Epidemic in 1998
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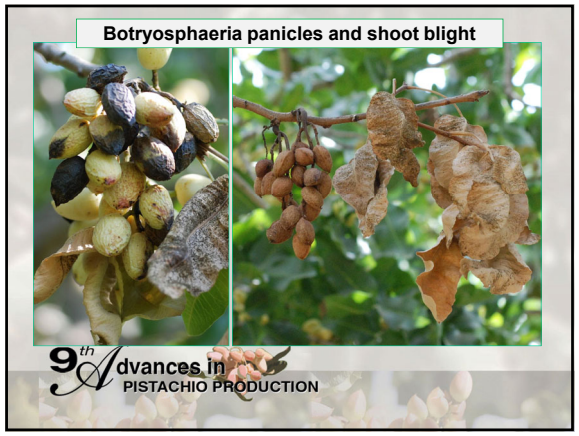
Botryosphaeria panicles and shoot blight
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Spring symptoms
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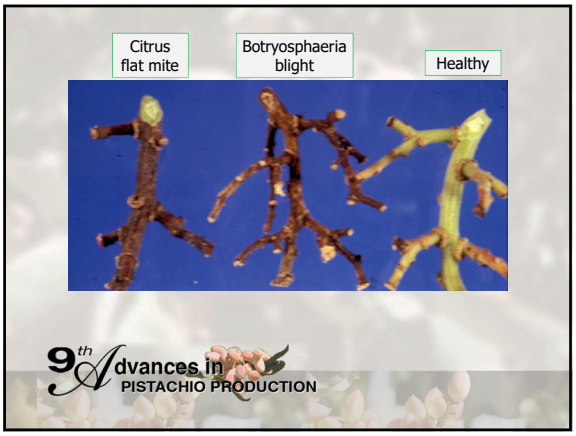
Citrus flat mite
Botryosphaeria blight
Healthy
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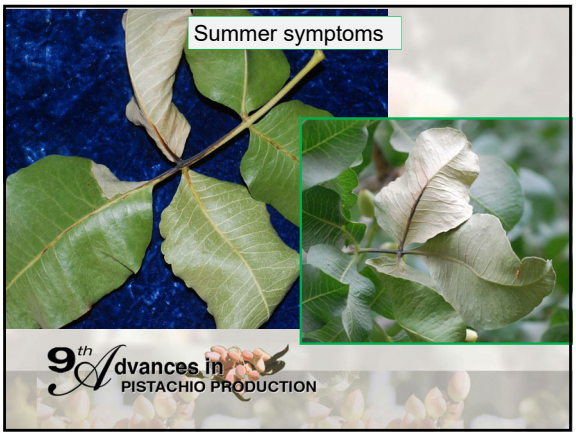
Summer symptoms
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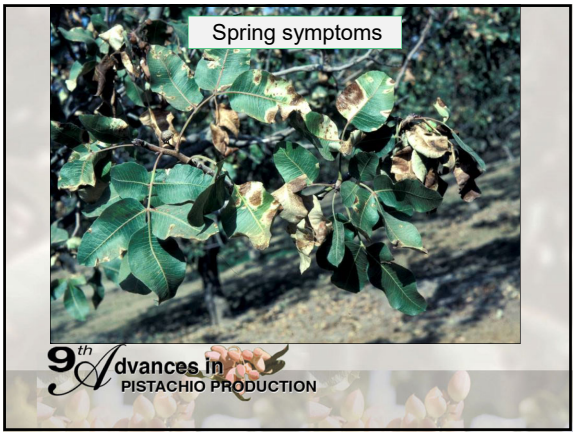
Spring symptoms
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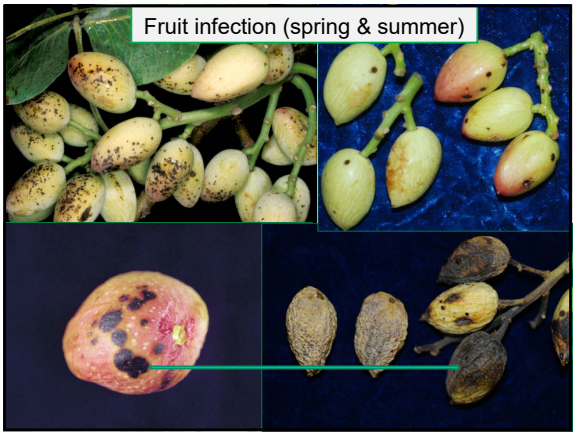
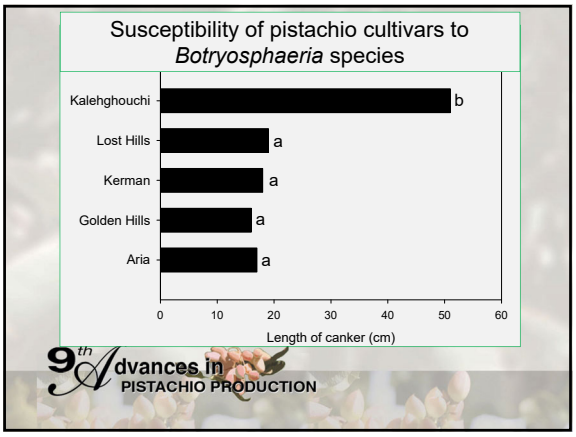

Fruit infection (spring & summer)


Susceptibility of pistachio cultivars to
Botryosphaeria species
Kalehghouchi
Lost Hills
Kerman
Golden Hills
Aria
b
a
a
a
a
0
10
20
30
40
50
60
Length of canker (cm)
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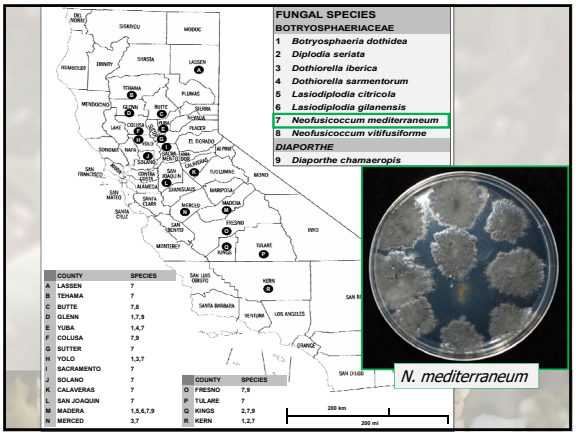
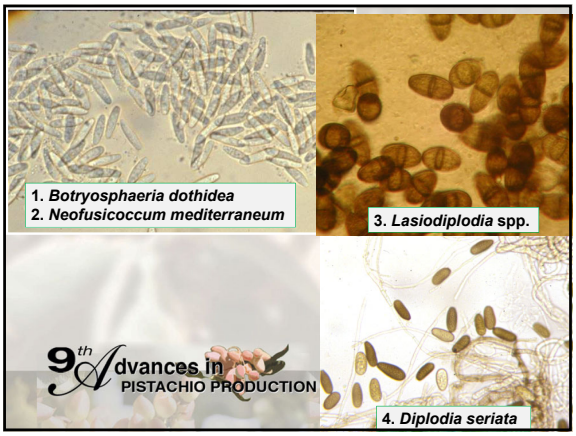

FUNGAL SPECIES
BOTRYOSPHAERIACEAE
1 Botryosphaeria dothidea
2 Diplodia seriata
3 Dothiorella iberica
4 Dothiorella sarmentorum
5 Lasiodiplodia citricola
6 Lasiodiplodia gilanensis
7 Neofusicoccum mediterraneum
8 Neofusicoccum vitifusiforme
DIAPORTHE
9 Diaporthe chamaeropis
N. mediterraneum


1. Botryosphaeria dothidea
2. Neofusicoccum mediterraneum
3. Lasiodiplodia spp.
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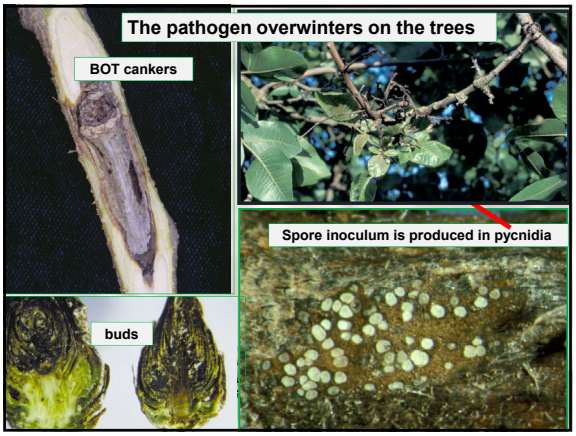
4. Diplodia seriata


The pathogen overwinters on the trees
BOT cankers
Spore inoculum is produced in pycnidia
buds

Virulence of Botryosphaeriaceae species inoculated onto shoots of pistachio cultivars

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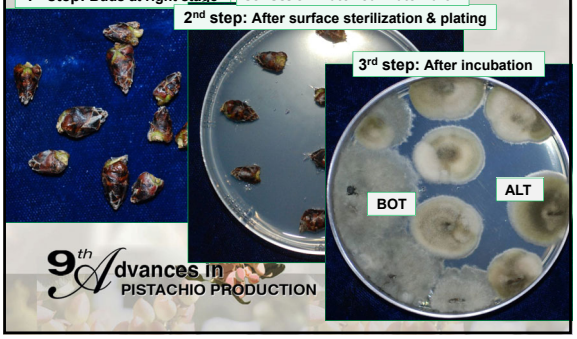
Technique to monitor and predict disease pressure in pistachio orchards (BUDMON)

1st step: Buds at right stage

Collection: Late Feb – late March

2nd step: After surface sterilization & plating

3rd step: After incubation



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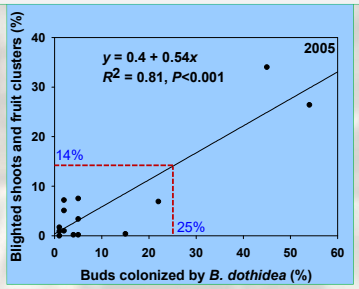
Correlation of BUDMON with disease at harvest



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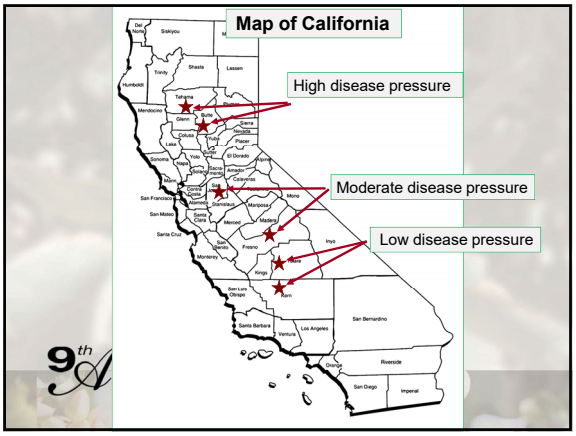

Spread of the Bot pathogens and disease

Source	propagules	Means
Pycnidia	Pycnidiospores (spores)	Water
Pseudothecia*	Ascospores	Water first; airborne then
Cankers	Pycnidiospores	Pruning equipment
Infected fruit	Pycnidiospores	Birds
Pycnidia	Pycnidiospores	Large hemiptera nsects
Pycnidia	Pycnidiospores	Grafting (budding)

* Only from other hosts (almond, walnut, riparian trees and bushes)

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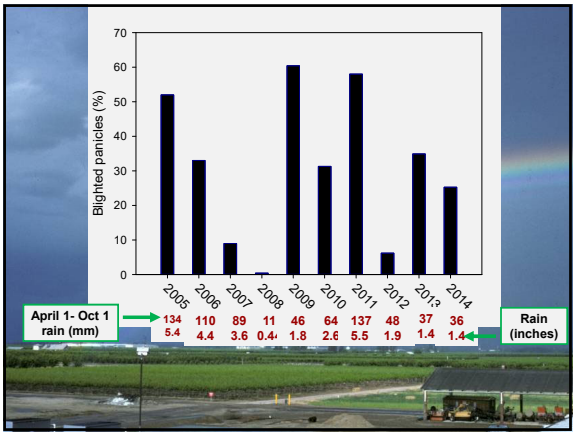
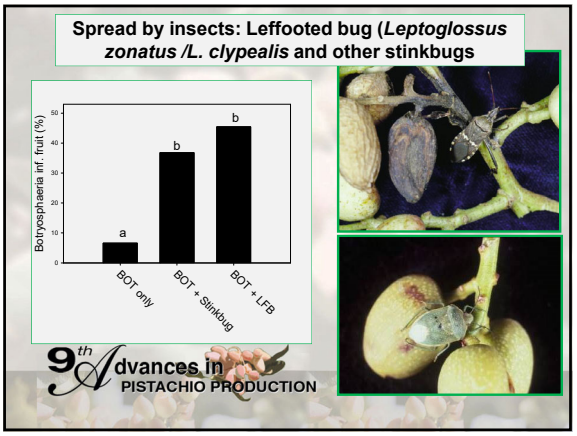

Blighted panicles (%)
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
April 1- Oct 1 rain (mm)
134 110 89 11 46 64 137 48 37 36
5.4 4.4 3.6 0.4 1.8 2.6 5.5 1.9 1.4 1.4
Rain (inches)


Spread by insects: Leffooted bug (*Leptoglossus zonatus* /*L. clypealis* and other stinkbugs
Botryosphaeria inf. fruit (%)
a
b
b
BOT only
BOT + Stinkbug
BOT + LFB
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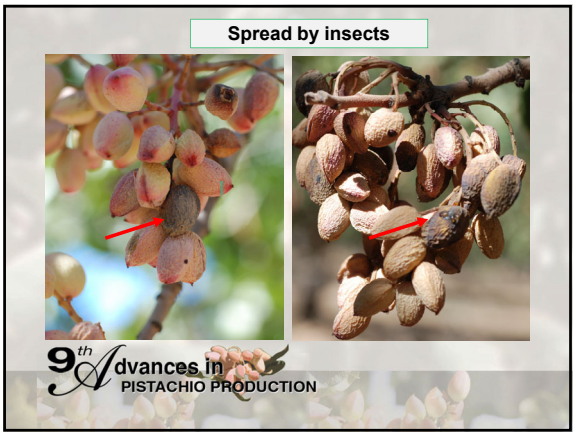
Spread by insects
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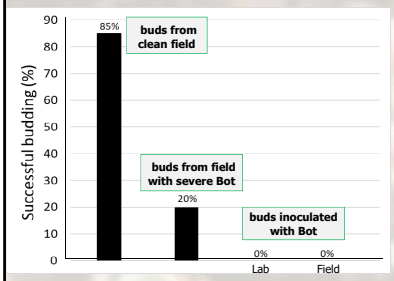
Spread by budding



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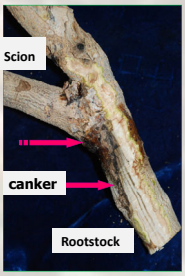
Canker at the scion union



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Infection event:

- 4 mm rain (=3/16 of an inch free moisture)
- > 10°C (50°F)
- Spores germinate and infect within 1.5 hours
- Optimum growth at 30 °C (86 °F)
- Growth from 10 °C to 35 °C (50 to 95 °F)

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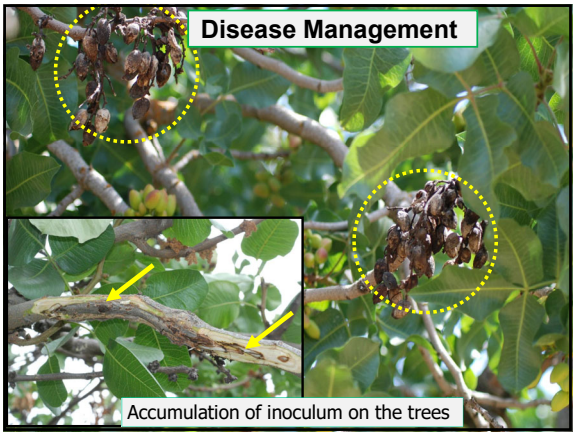
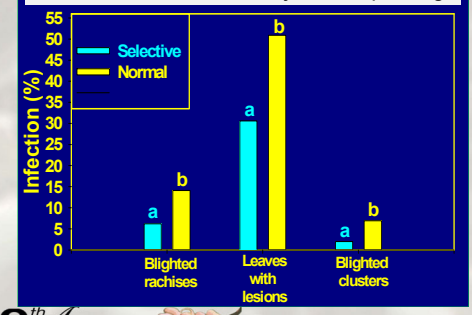

Disease Management
Accumulation of inoculum on the trees


Sanitation:
*** Winter pruning to remove inoculum


Sanitation:
*** Selective summer pruning

50% reduction of disease just with pruning



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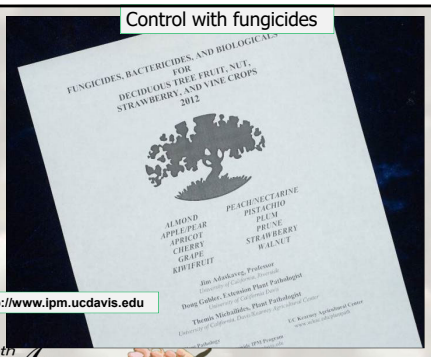
Control with fungicides



http://www.ipm.ucdavis.edu

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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	++
Merivon……..	fluxapyroxad+pyrac;pstrpbin	++++
Luna Experience	fluopyram + tebuconazole	++++
Luna Sensation	fluopyram + trifloxystrobin	++++
Fontelis	penthiopyrad	++++

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

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

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

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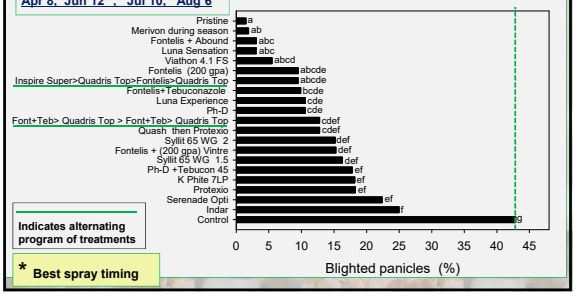
Example: Efficacy of fungicides against Botryosphaeria panicle and shoot blight

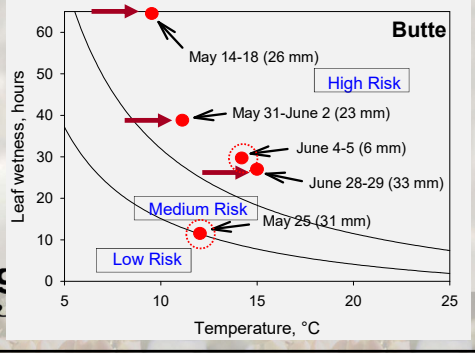
Sprays: 4X (bloom + spring)
Apr 8, Jun 12*, Jul 10, Aug 6



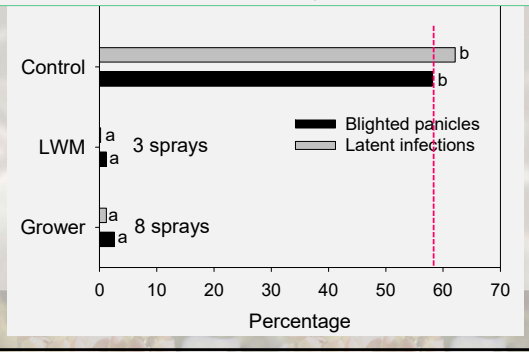
Indicates alternating program of treatments

* Best spray timing

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



Timing of Fungicide Sprays

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

Disease	Dormant	April bloom	May	June	July	August
Botryosphaeria	---	++	+++	++++	+++	---

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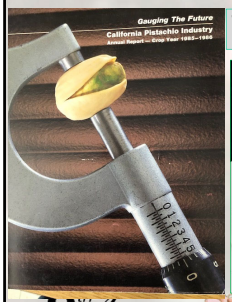
Take-home message

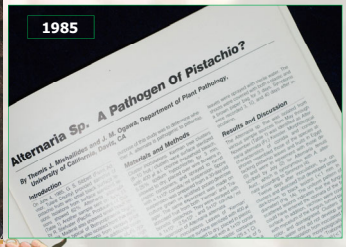
(very important to diagnose the disease in the orchard early and correctly)

- Start at 4th leaf to monitor for any occasional cluster and shoot blights.
- If not found, continue monitoring the following year.
- If found, immediately prune blighted shoots/clusters.
- Spray before or (2-3 days) after rain events (April, May, & June, July) (rains cause infection events).
- Good news! ... No resistance! Lots of registered effective fungicides; it is easy to control this disease.

2. Alternaria Late Blight



Wasfy et al. **1974.** New Alternaria disease of pistachio in Egypt. Phytopathl. Mediter. 13:110-113.



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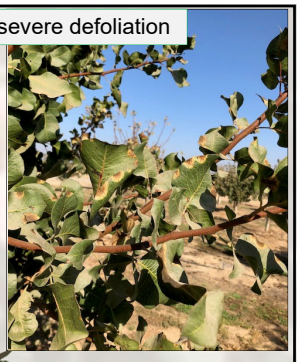
Lesions and severe defoliation



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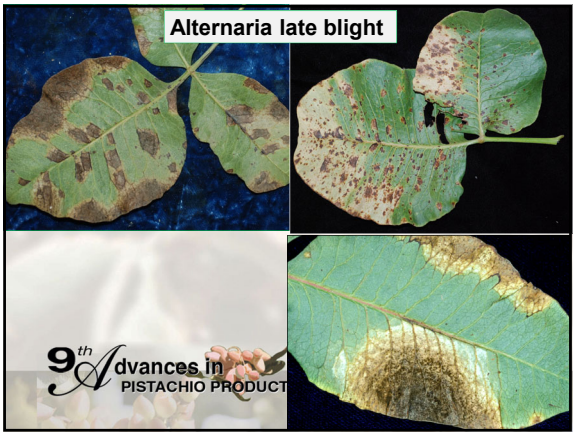
Alternaria late blight



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Kerman
Golden Hills
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Peter's scorch
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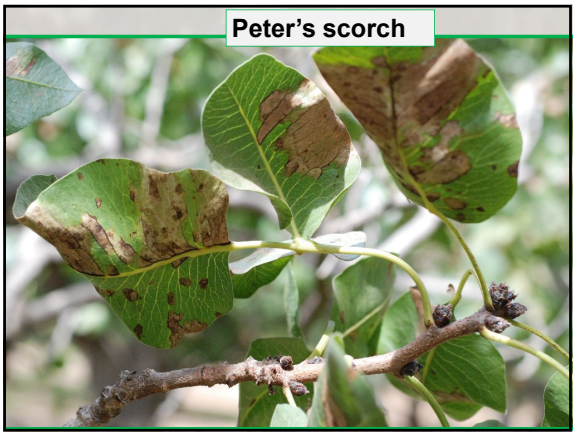
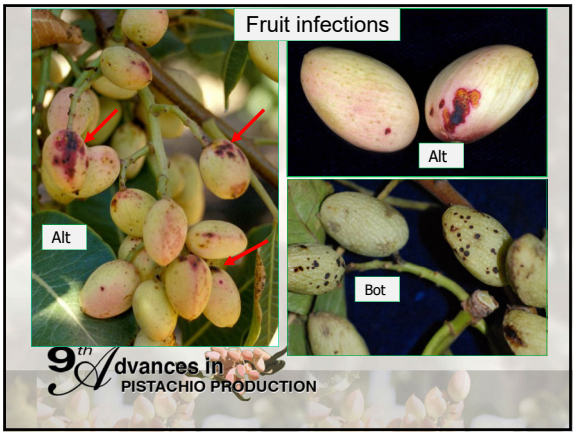
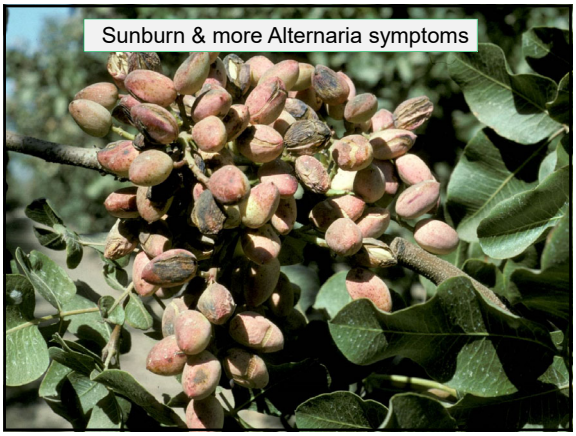

Peter's scorch





Reasons for managing Alternaria blight

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

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Hull infections → shell staining and kernel mold

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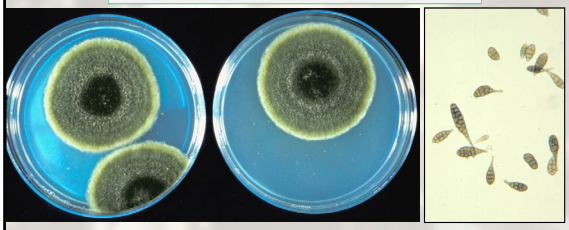
Pathogens causing Alternaria late blight:

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



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Factors that influence Alternaria blight

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

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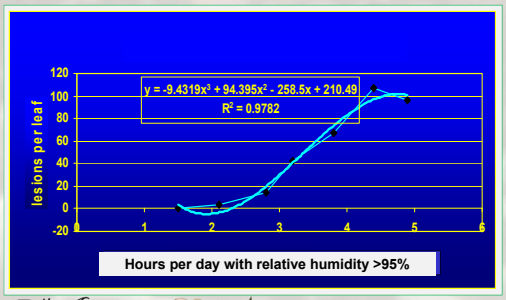
Effect of relative humidity on severity of Alternaria



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Appearance of fruit at harvests

First harvest – Sept. 10

Second harvest – Sept. 17

Third harvest – Sept. 24

Fourth harvest – October 1

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!

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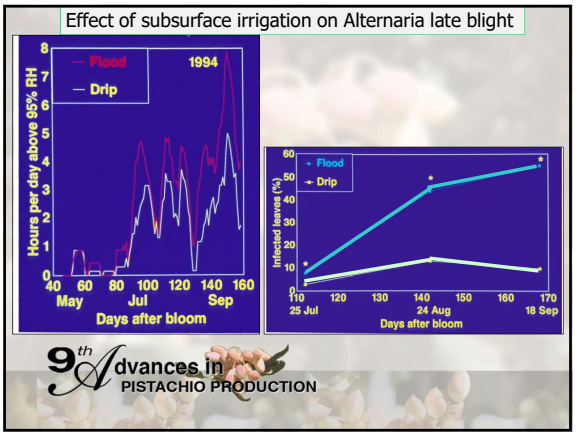
Effect of subsurface irrigation on Alternaria late blight



Discing to reduce Alternaria blight

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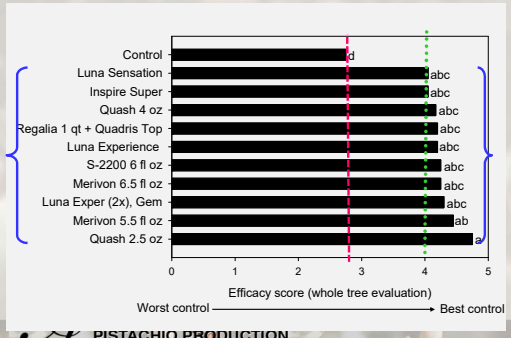
Efficacy of fungicides against Alternaria late blight



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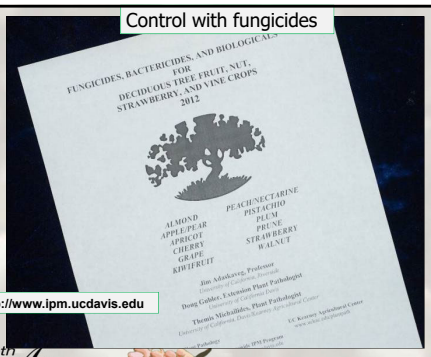
Control with fungicides



http://www.ipm.ucdavis.edu

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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	+

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Fungicide spray timing for Alternaria late blight

Disease	Dormant	April May	June	July	August
Alternaria	----	⊘	+++	+++	⊘

Best timing

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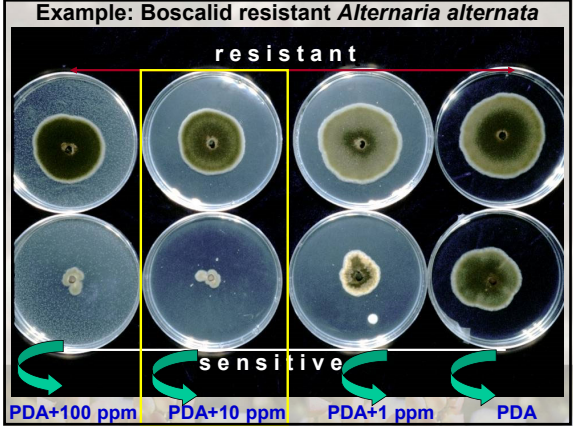
Example: Boscalid resistant *Alternaria alternata*



Cross-resistance between boscalid and carboxin in *A. alternata* isolates

Phenotype	Number of isolate	Mean EC_{50} boscalid (µg/ml)	Mean EC_{50} carboxin (µg/ml)
Boscalid-sensitive	7	<1	<20
Boscalid-resistant	38	>100	>50

→ Cross resistance between boscalid and carboxin in *A. alternata*
Similar mutations could confer resistance to both fungicides

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Resistance of Alternaria to fungicides

- Resistance to strobilurins
- Resistance to carboximides

- Cross Resistance
- Multiple resistance

✓ Monitor for resistance levels in your orchards.
✓ Use rotation of various classes of fungicides.
✓ Use max rate of the fungicide label per spray.
✓ Pay attention to good coverage.

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Take-home message

(It is important to diagnose the disease in the orchard correctly – know the history of the orchard)

- **No bloom spray(s)*****
- **Start sprays in early June and finish by end of July).**
- **For one spray, the best time is end June /early July.**
- **Bloom sprays (April & May) and August sprays are not effective.**

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

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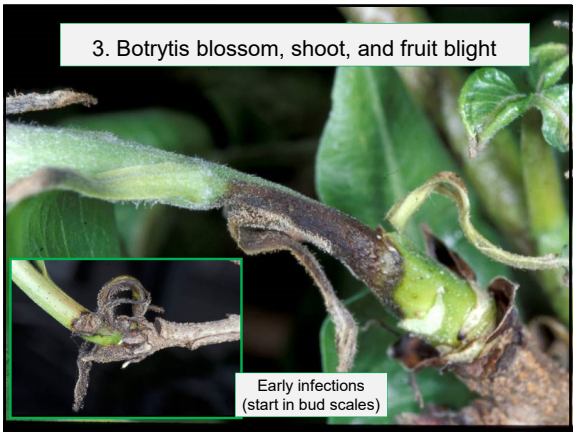
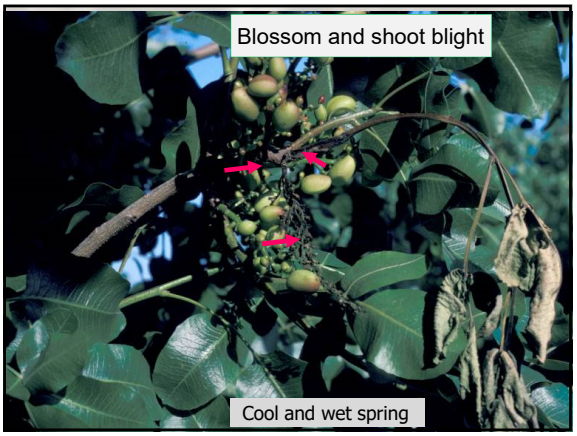
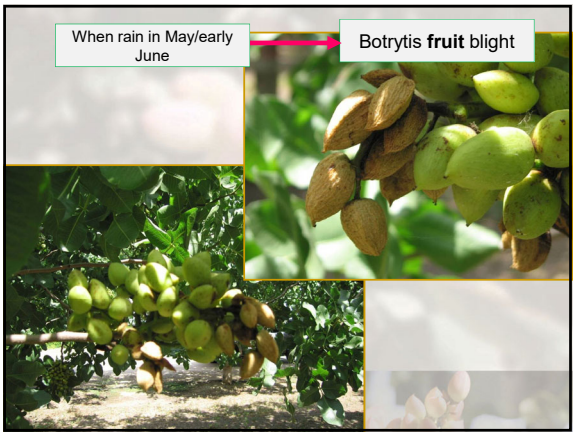
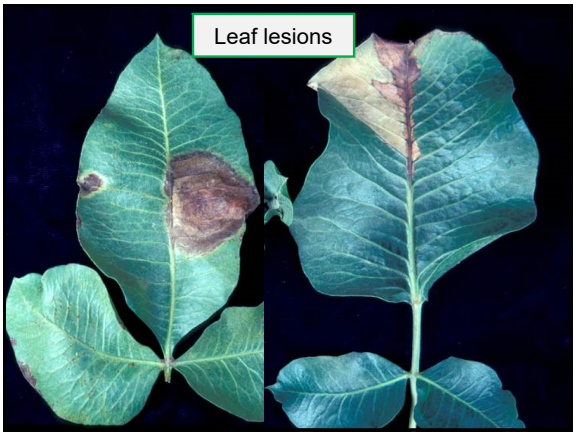
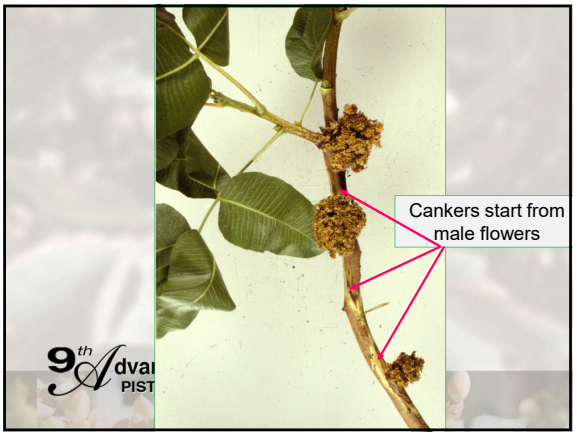
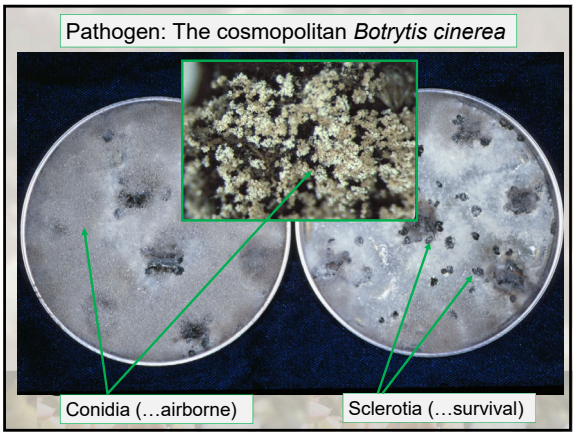

3. Botrytis blossom, shoot, and fruit blight
Early infections
(start in bud scales)


Blossom and shoot blight
Cool and wet spring


When rain in May/early June
Botrytis **fruit** blight


Leaf lesions


Cankers start from male flowers


Pathogen: The cosmopolitan *Botrytis cinerea*
Conidia (…airborne)
Sclerotia (…survival)

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

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	++++

Other diseases of pistachio
(California, Arizona, New Mexico, and International)

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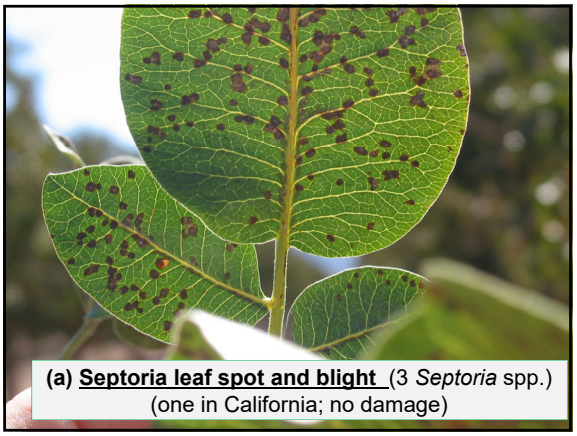

(a) Septoria leaf spot and blight (3 *Septoria* spp.)
(one in California; no damage)


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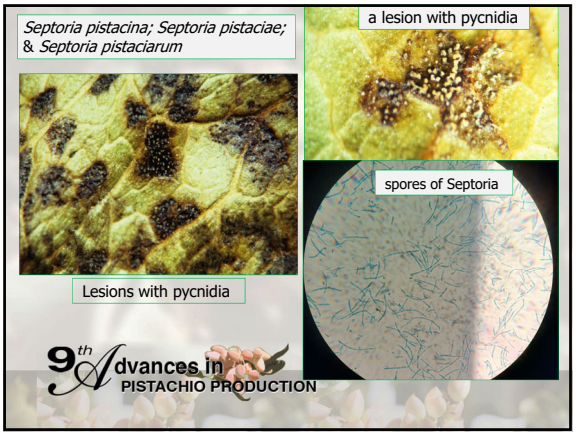
Septoria pistacina; Septoria pistaciae;
& *Septoria pistaciarum*
a lesion with pycnidia
spores of Septoria
Lesions with pycnidia
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Septoria in a Red Aleppo pistachio (California)


Septoria in Kerman pistachios (Arizona)

Fungicide trial against Septoria leaf spot of pistachio (Arizona) (by 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

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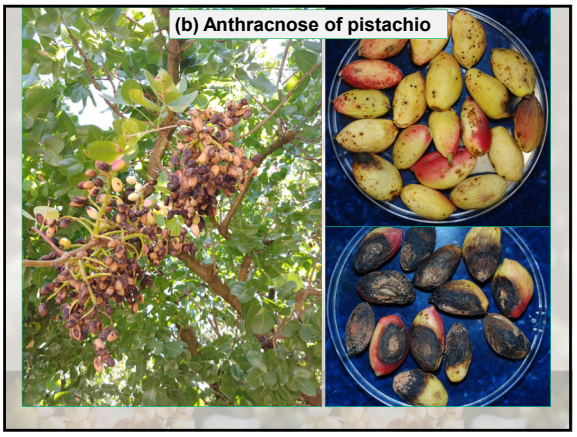
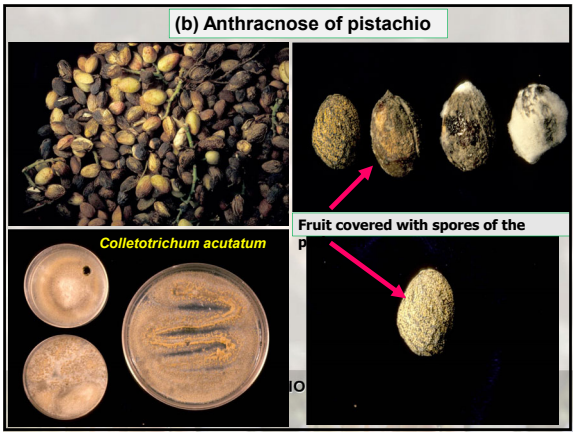
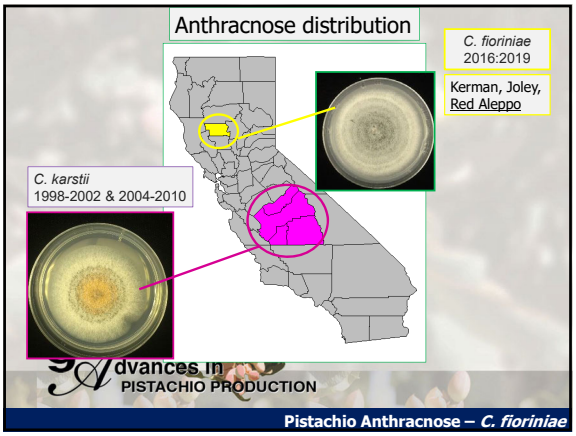
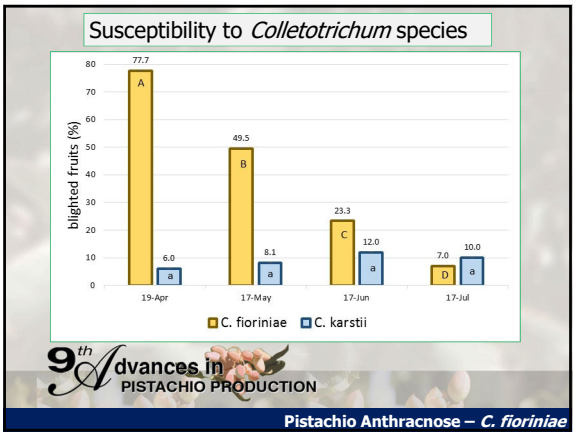



(b) Anthracnose of pistachio
Colletotrichum acutatum
Fruit covered with spores of the


Anthracnose distribution
C. fioriniae
2016:2019
Kerman, Joley,
Red Aleppo
C. karstii
1998-2002 & 2004-2010
dvances in
PISTACHIO PRODUCTION
Pistachio Anthracnose – C. fioriniae


Susceptibility to Colletotrichum species
blighted fruits (%)
77.7
A
6.0
a
49.5
B
8.1
a
23.3
C
12.0
a
7.0
D
10.0
a
19-Apr
17-May
17-Jun
17-Jul
C. fioriniae
C. karstii
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PISTACHIO PRODUCTION
Pistachio Anthracnose – C. fioriniae

A 75% destruction of the crop in Australia (2010)

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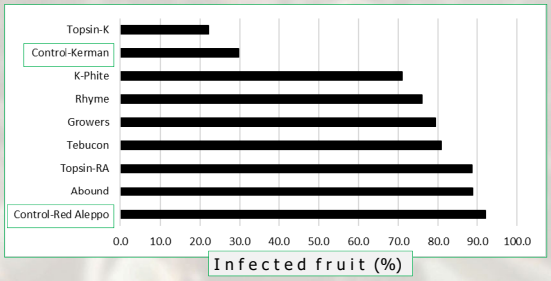
Control of anthracnose with fungicide sprays



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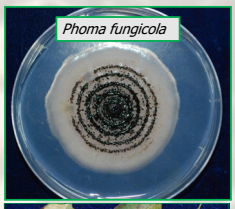
(c) Phoma blight in Arizona pistachios



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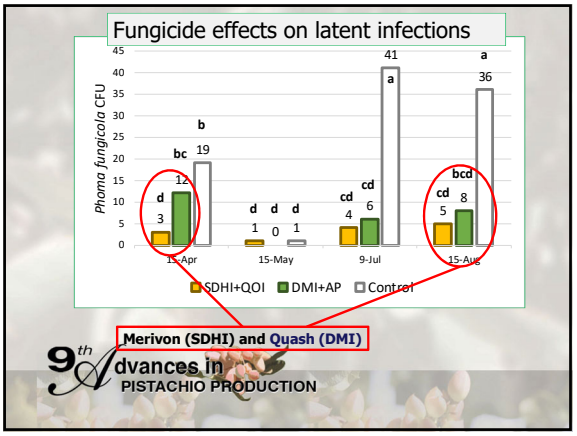
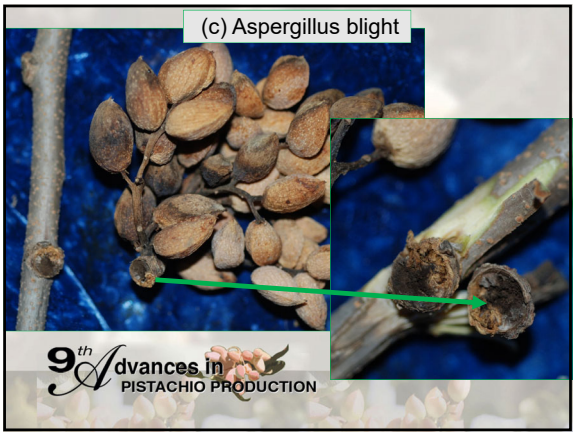

Fungicide effects on latent infections
Phoma fungicola CFU
45
40
35
30
25
20
15
10
5
0
d 3
bc 12
b 19
d 1
d 0
d 1
cd 4
cd 6
41
a
cd 5
bcd 8
a 36
15-Apr
15-May
9-Jul
15-Aug
SDHI+QOI
DMI+AP
Control
Merivon (SDHI) and Quash (DMI)
9th Advances in PISTACHIO PRODUCTION


(c) Aspergillus blight
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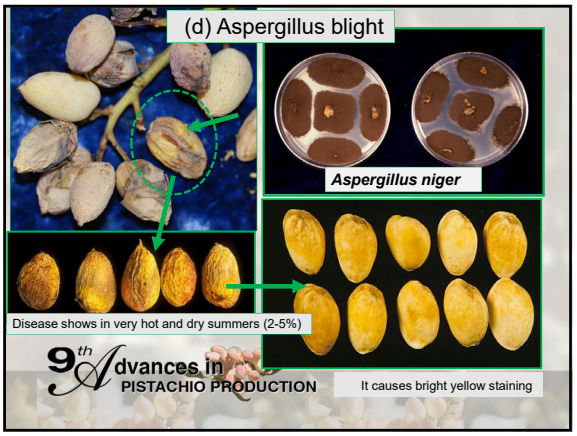
(d) Aspergillus blight
Aspergillus niger
Disease shows in very hot and dry summers (2-5%)
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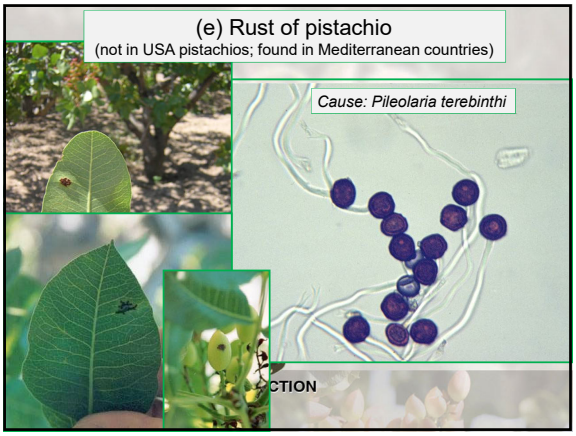
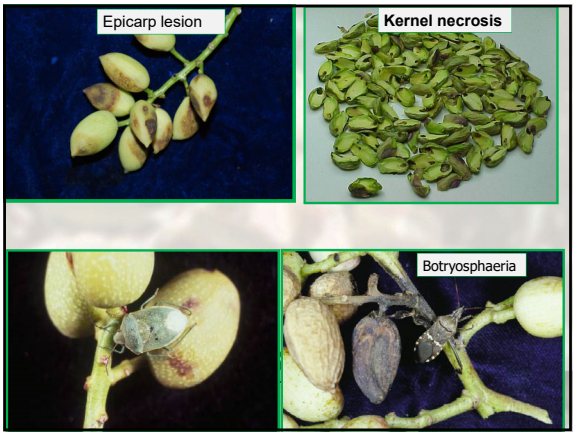
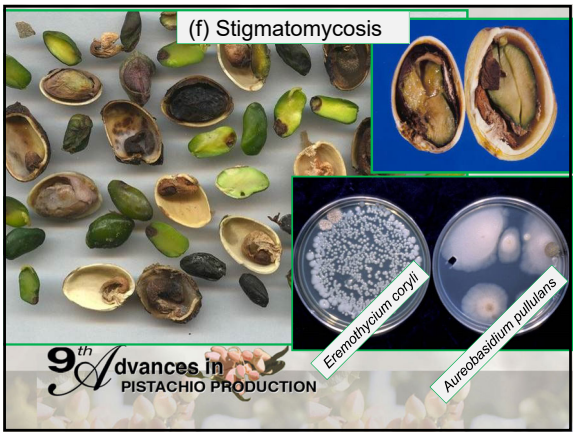
It causes bright yellow staining


(e) Rust of pistachio
(not in USA pistachios; found in Mediterranean countries)
Cause: Pileolaria terebinthi
CTION


Epicarp lesion
Kernel necrosis
Botryosphaeria


(f) Stigmatomycosis
Eremothycium coryli
Aureobasidium pullulans
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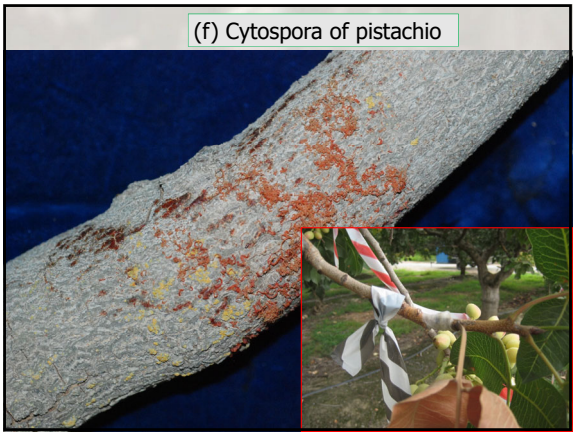
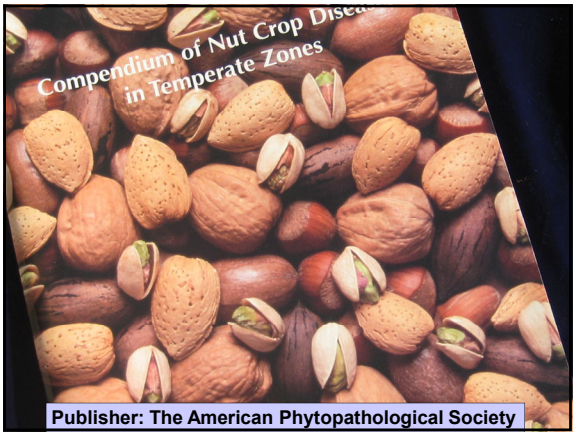

(f) Cytospora of pistachio


Compendium of Nut Crop Dise
in Temperate Zones
Publisher: The American Phytopathological Society


Special thanks to my lab and to a number of farm advisors and pistachio growers.
CALIFORNIA PISTACHIOS


THANK YOU!
QUESTIONS?
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