Diagnosis and Management of Trunk and Scaffold Canker Diseases of Almond in California

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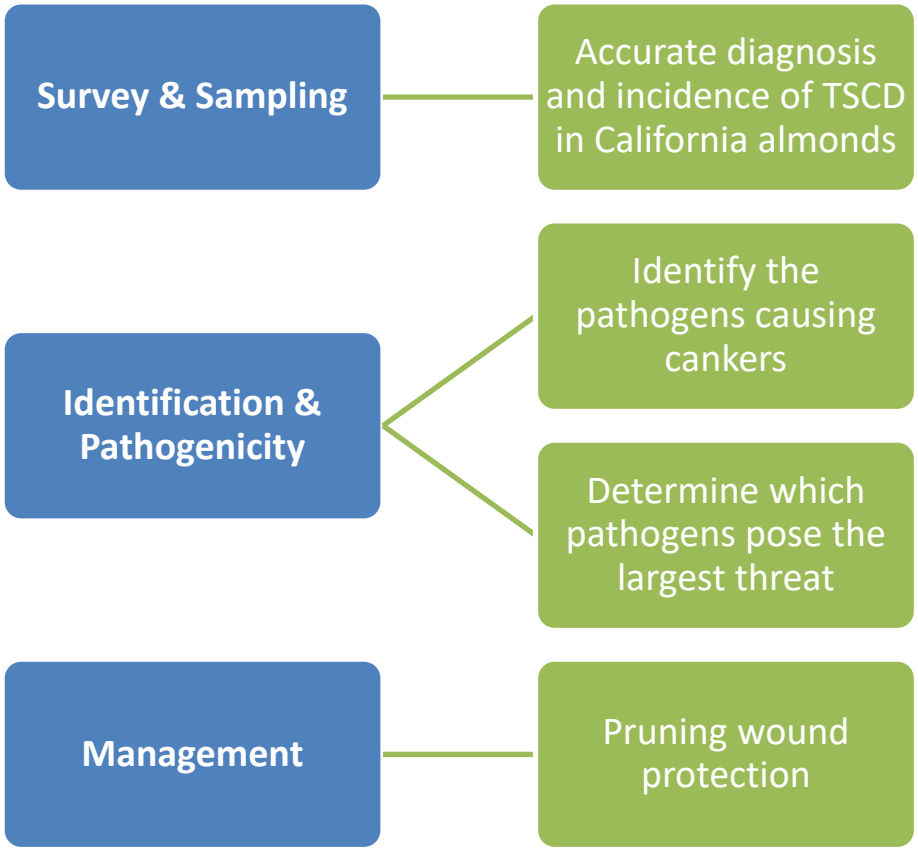
Almond canker diseases – what are we talking about?

Trunk and scaffold canker diseases (TSCD):

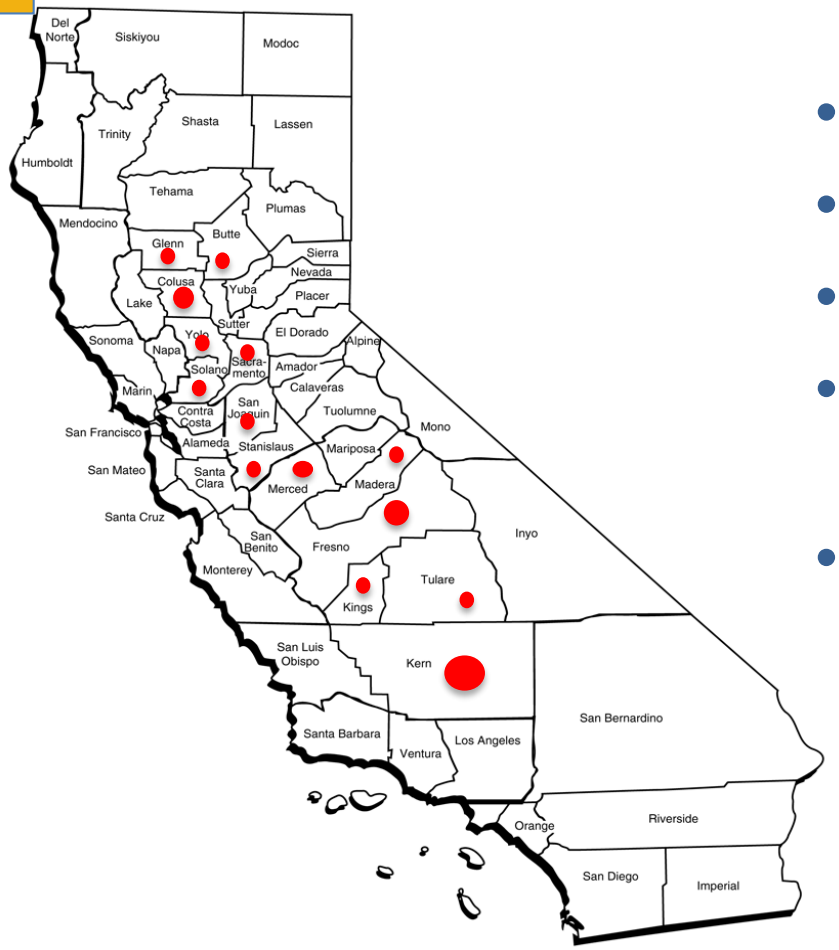
- Fungal canker diseases
  - Ceratocystis, Botryosphaeria, Eutypa, Cytospora, Silver leaf
- Aerial Phytophthora
- Bacterial canker
- Foamy canker

Etiology and management of almond canker diseases: Research in my lab



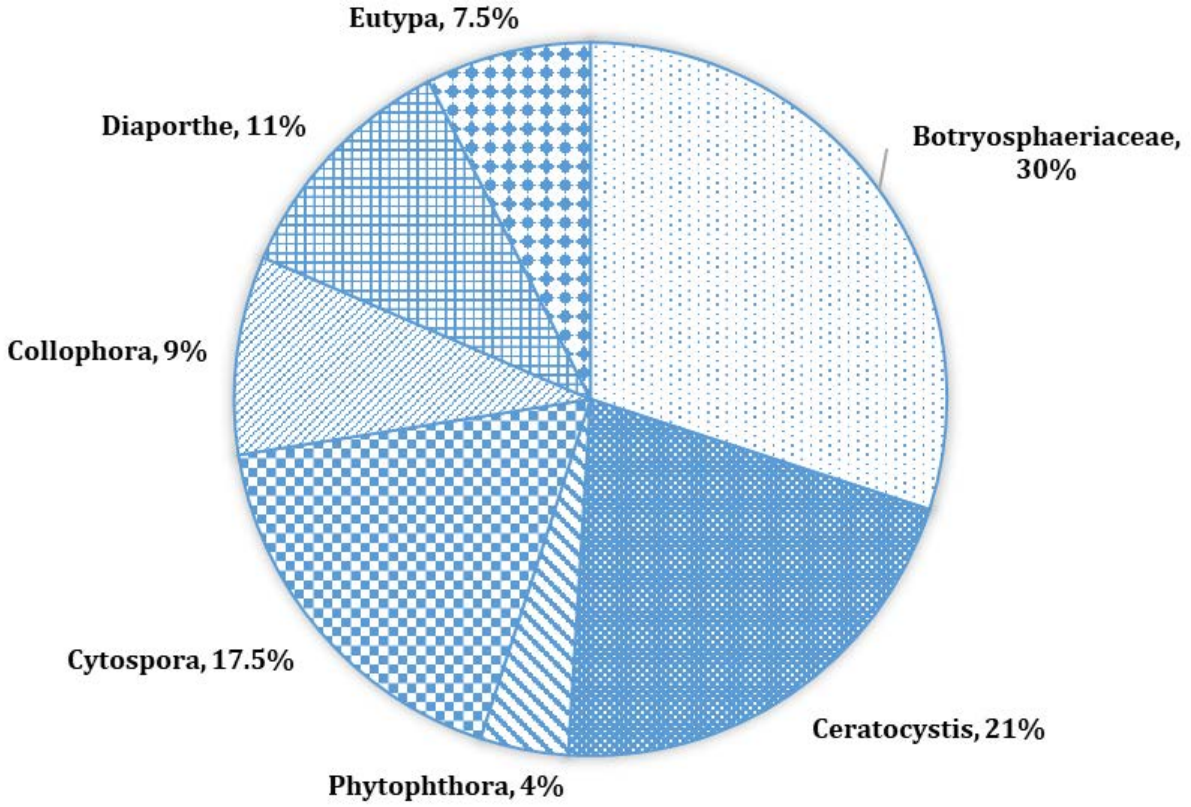
Objectives

Field surveys and sampling:



- 2015, 2016, 2017
- 100 orchards, 13 counties
- Approx. 350 fungal isolates
- Annotation of symptoms (dieback, gumming, scaffold or trunk cankers)
- Orchards 2- to 25-year-old

Species associated with almond TSCD:



Species associated with almond canker diseases:

Most of these pathogens also occur in Spain

Botryosphaeriaceae

- *Botryosphaeria dothidea*
- *Neofusicoccum mediterraneum*
- *Neofusicoccum vitifusiforme*
- *Neofusicoccum parvum*
- *Neofusicoccum arbuti*
- *Diplodia seriata*
- *Diplodia mutila*
- *Dothiorella iberica*
- *Macrophomina phaseolina*
- *Spencermartinsia viticola*
- *Neoscytalidium dimidiatum*

26 fungal species!

Ceratocystis fimbriata

Collophora hispanica
Collophora paarla

Cytospora eucalypti
Cytospora sorbicola
Cytospora sp. 1
Cytospora sp. 2
Cytospora sp. 11
Cytospora sp. 13

Diaporthe australafricana
Diaporthe eres
Diaporthe rhusicola

Eutypa lata

Phytophthora cinnamomi
Phytophthora cactorum

Ceratocystis canker:

- Caused by the fungus *Ceratocystis variospora* (syn. *Ceratocystis fimbriata*)
  - Associated with mechanical-harvest injuries and pruning wounds
  - Amber gum at the canker margin
  - Cankers are most active during the growing season
  - Bark injuries and pruning wounds are susceptible for up to 14 days
  - May be unique to CA almond production systems
  - Not yet reported in Spain

Ceratocystis canker:

Ceratocystis canker:

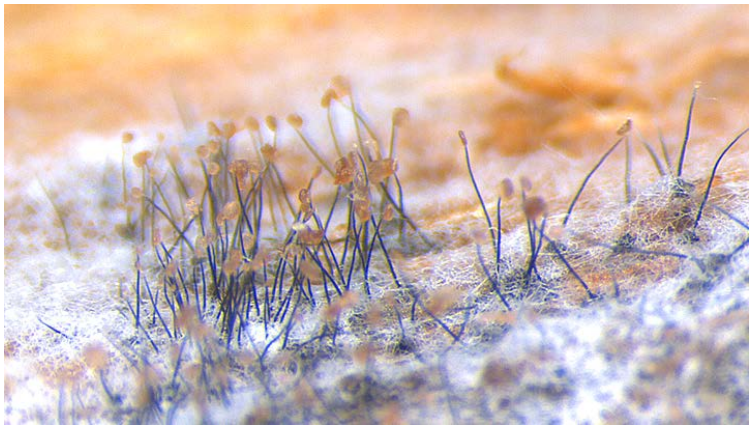
Ceratocystis canker:

- Pruning wounds

Ceratocystis canker: Thinning almond trees…

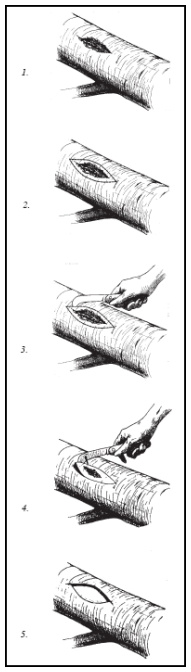
Ceratocystis canker:

- The fungus develops only in the cambium and xylem tissue of the current year
- Perithecia containing the infectious spores are formed in mycelial mats under the bark of injured trees
- Sticky spore droplet can be picked up or ingested by insects (sap-feeding beetles and a drosophilid fly) and moved to fresh wounds



Management of Ceratocystis canker:

- Avoid shaker injuries and intensive pruning
- Clean wounded area to promote healing/callusing
- Copper-oil treatment, Thiophanate methyl
- Paint, sealer or tape NOT needed
- Surgery in winter when insects are not active

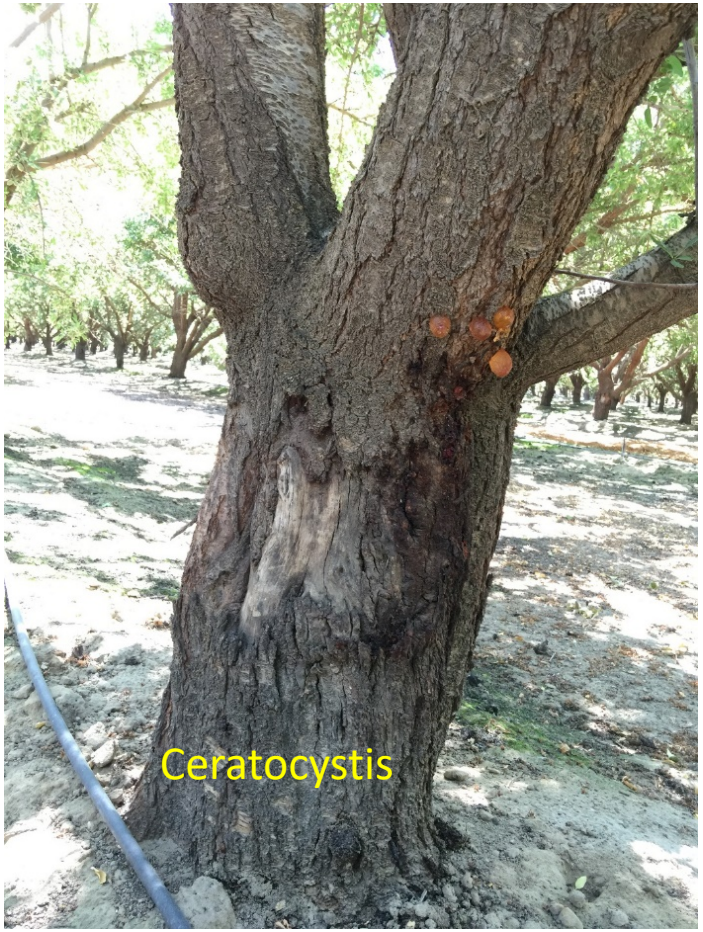


Perennial Phytophthora cankers:

- Caused by oomycetes *Phytophthora citricola* and *P. cactorum*
  - Associated with scaffold crotch pocket
  - Cankers are fast growing
  - Tree may die over one or two growing season
  - Gum balls occur throughout the disease area
  - Inoculum blown onto trees during harvest

Perennial Phytophthora cankers:

Perennial Phytophthora cankers:



Perennial Phytophthora cankers:

Photo: B. Holtz

Photo: R. Bostock

Perennial Phytophthora cankers:

Phytophthora cankers:

Perennial Phytophthora cankers:

- Management
  - The bud union of almond trees should be planted to remain above the soil surface
  - Proper scaffold selection to avoid pockets to form at the tree crotch
  - Phosphite drench and foliar applications
  - EU recently decided that all phosphite (phosphonate, phosphorous acid) products are exclusively pesticides
  - This has triggered the need for a Maximum Residue Limit (MRL)
  - Early spring application of mefenoxam (Ridomil Gold SL) (Preventive)

Botryosphaeria canker diseases:

- Band Canker: currently a major problem in California almonds, possibly emerging in Spain
  - Associated with growth cracks
  - 2 to 6-year-old trees, vigorous cultivars (NP, Carmel, Padre, Butte)
  - Orchards receiving excessive amounts of N and water

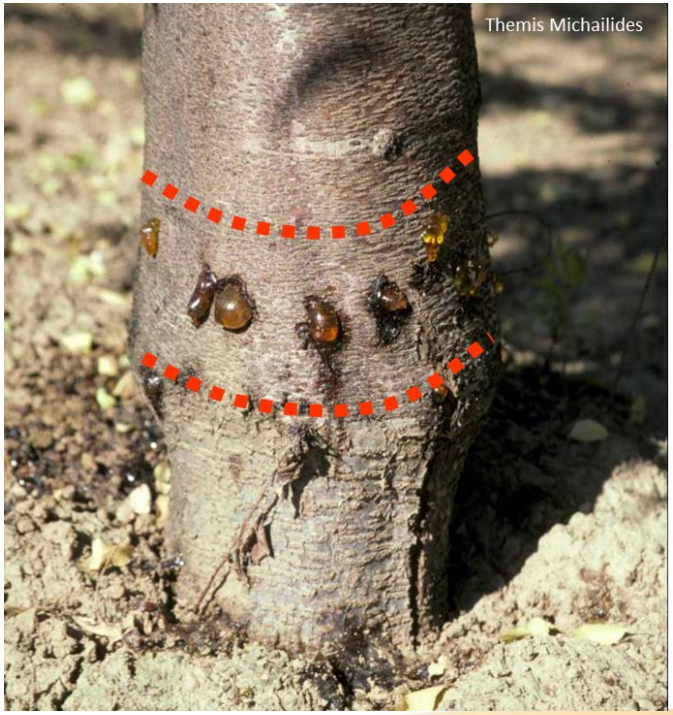


Photo credits: Roger Duncan

Botryosphaeria canker diseases: **Band canker**

- Multiple forms of symptoms



Photo credits: Catherine Pope

Band canker:

- Trees usually do not die but severe cases are now reported in California

Sprinklers wetting the trunk favor Band canker: use splitters or drip

Photo: M. Jansen

Photo: D. Lightle

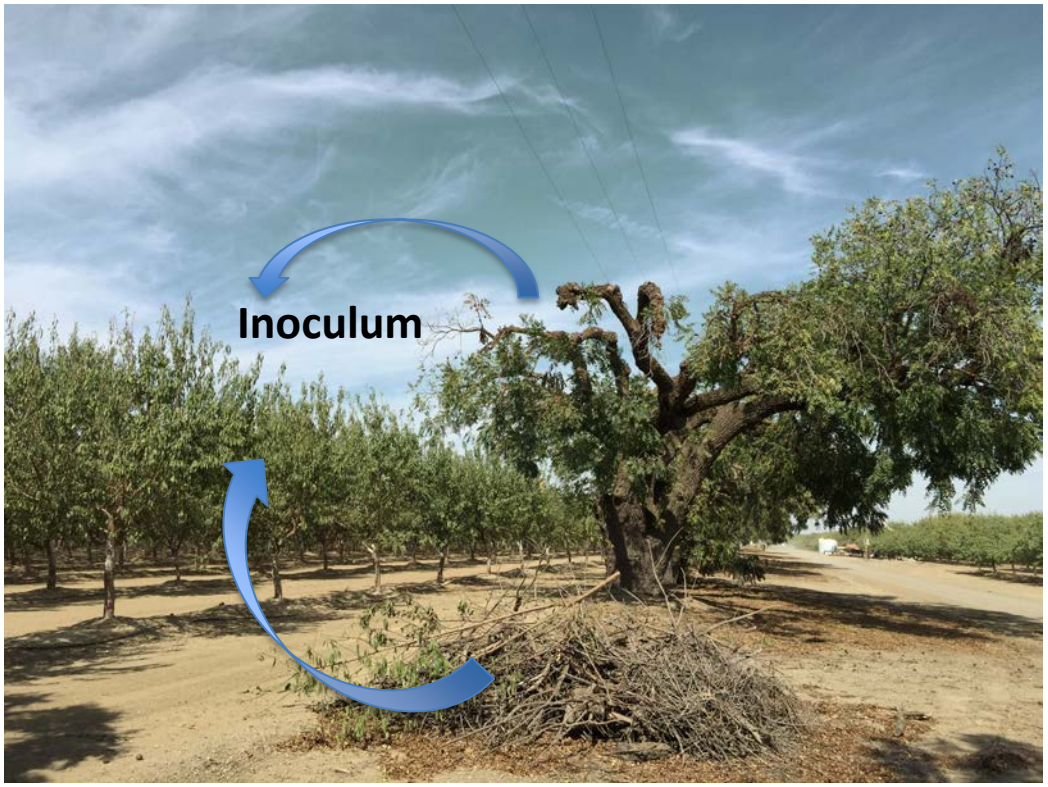
Botryosphaeria canker diseases:

- Cankers at pruning wounds on trunk and branches



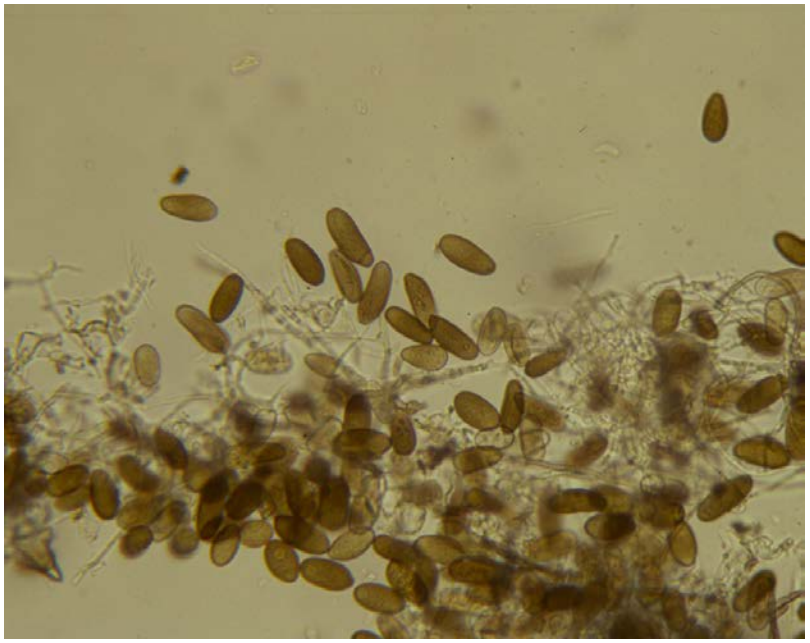

Botryosphaeria canker diseases:

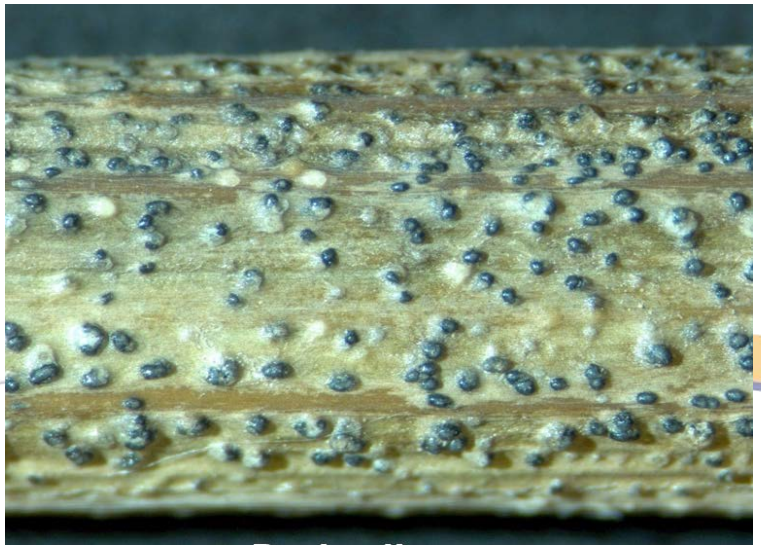
- Disease epidemiology:
  - Caused by fungal pathogens Botryosphaeria
  - Broad host range
  - Common in riparian areas
  - Ornamental
  - Walnut, pistachio, olive
  - Grapevine
  - Requires pruning wounds or cracks to infect
  - Infect trees during rain events
  - Sprinkler irrigation

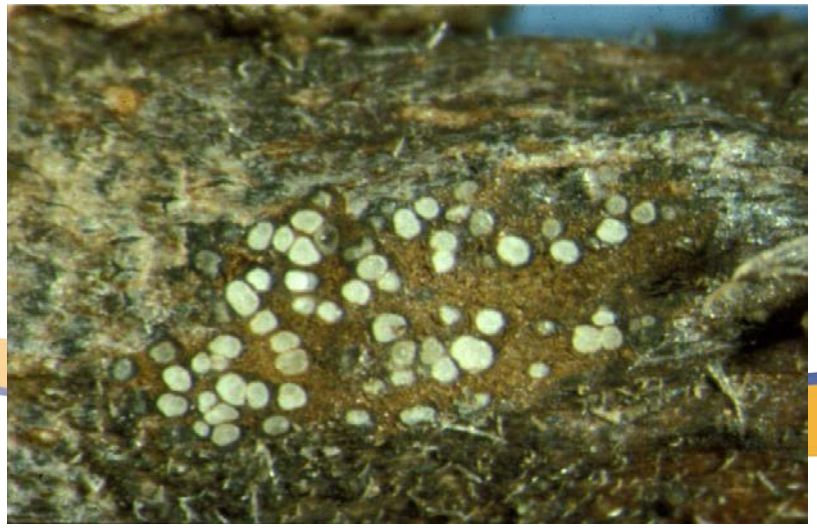


Botryosphaeria canker diseases:

Photo credits: Themis Michailides

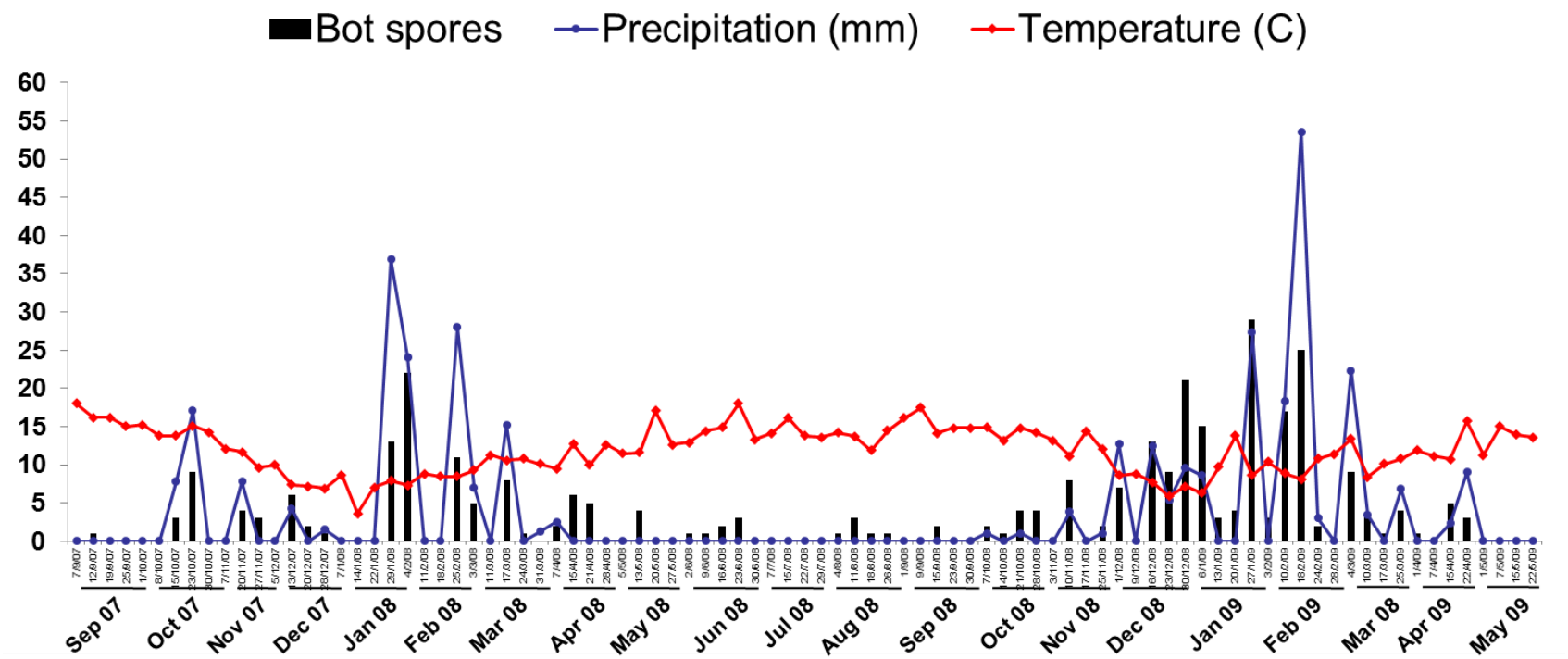






Botryosphaeria canker diseases:

- Disease epidemiology
  - Spore trapping study in grapevine:



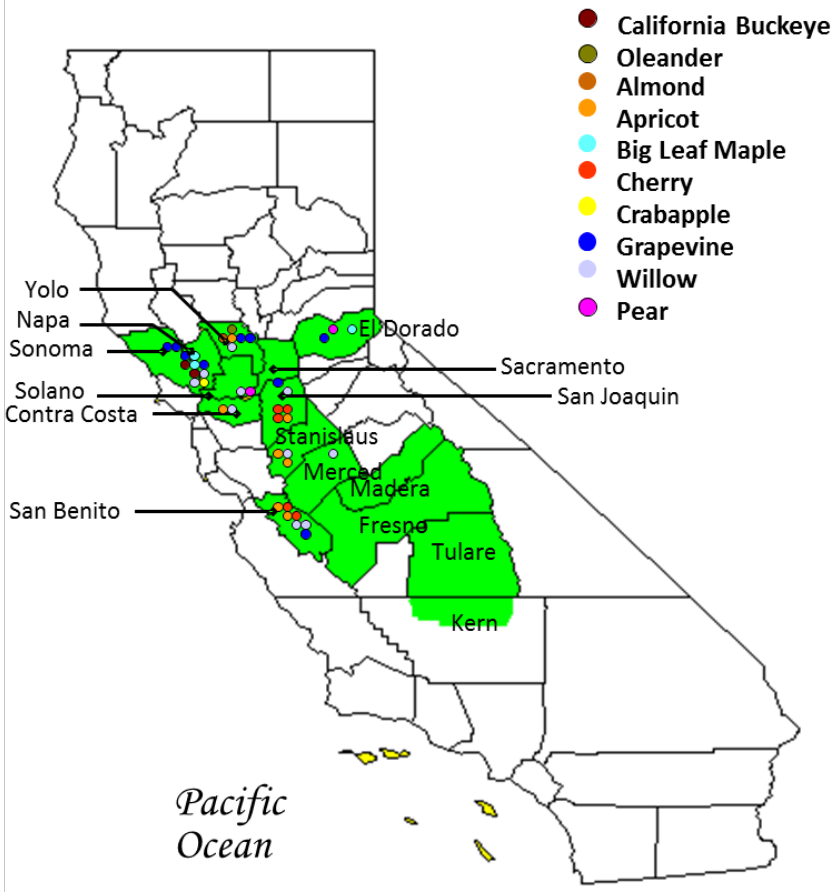
J.R Urbez-Torres

Eutypa dieback:

- Caused by *Eutypa lata*
  - Associated with scaffold crotch pocket and pruning wounds
  - It likes more humid regions
  - Common disease of apricot, sweet cherry and grapevine

Eutypa dieback:

- Disease epidemiology
  - Inoculum sources: Perithecia on dead wood of apricot



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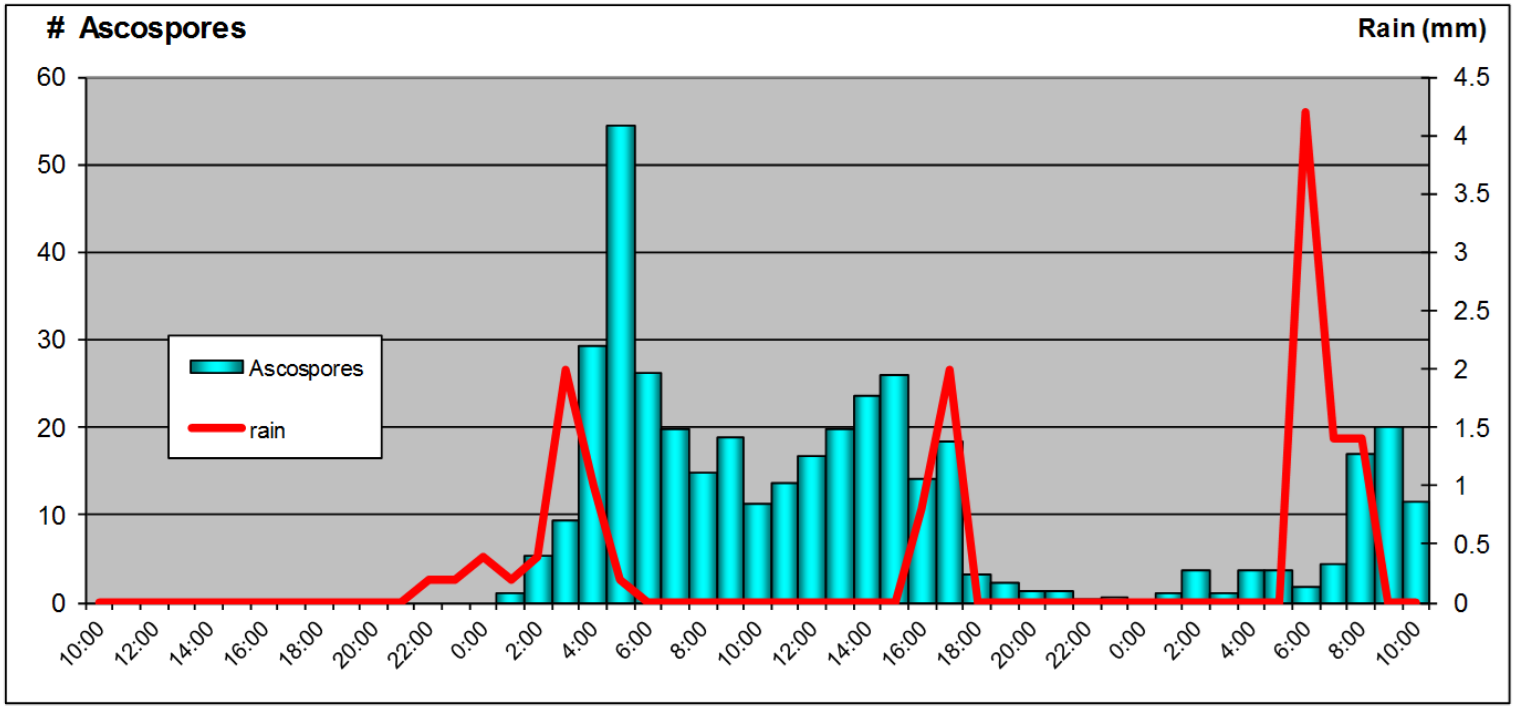


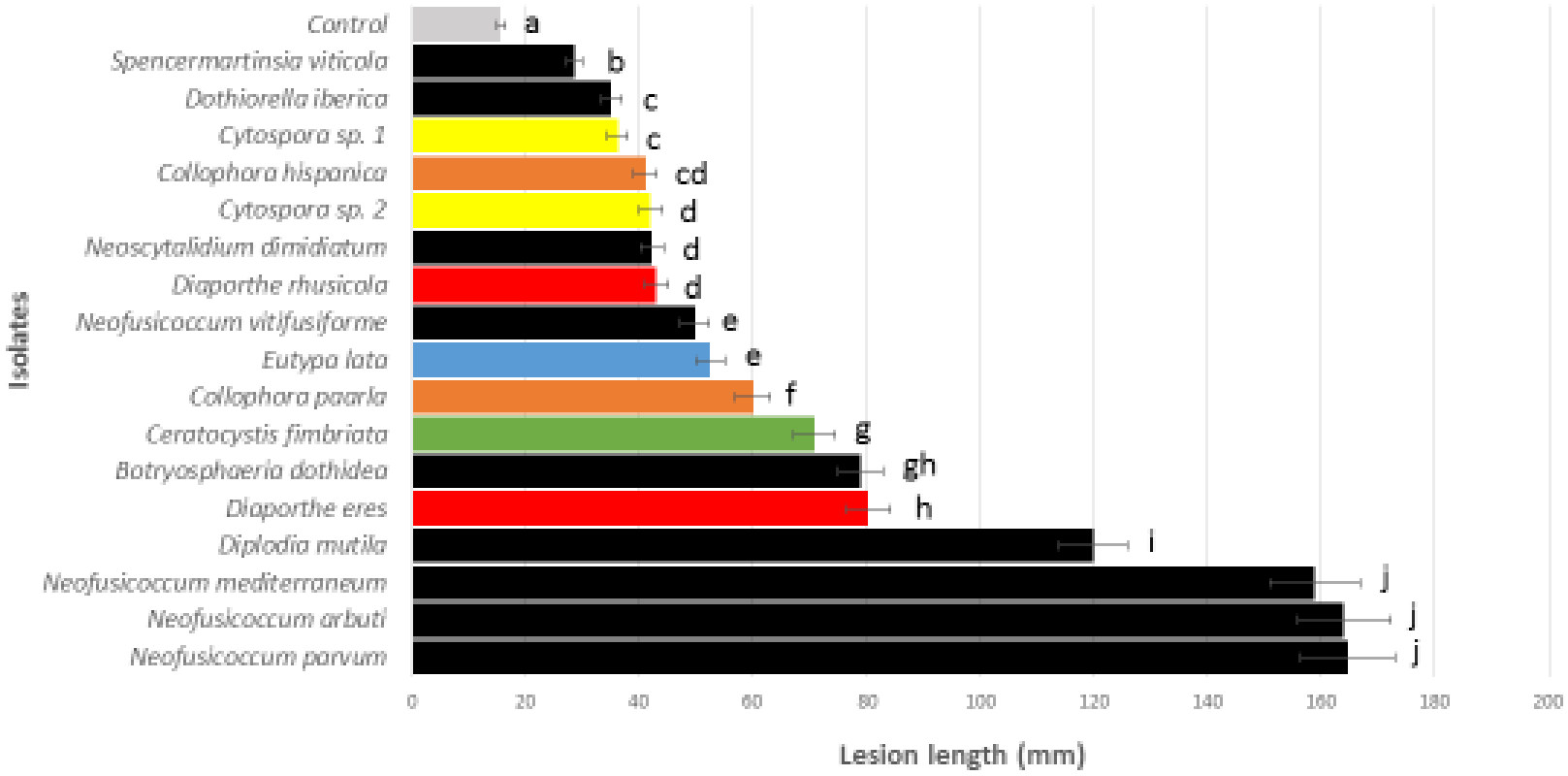
Collophora canker:

- Reported in California and Spain

Cytospora canker:

Cytospora canker: devastating the prune industry in CA

Results – Pathogenicity on almond



Cultural practices that creates wounds (=sites of infection) in almond production

1st to 2nd leaf

Scaffold selection

Annually, starting at 4th leaf

Mechanical harvesting

As needed

Maintenance pruning

Trunk/Scaffold canker diseases:

- Cankers develop at pruning wounds on trunk and branches

Botryosphaeria

Ceratocystis

Eutypa

Cytospora

Almond tree pruning:

Slide credits: Roger Duncan

Standard trained, pruned annually

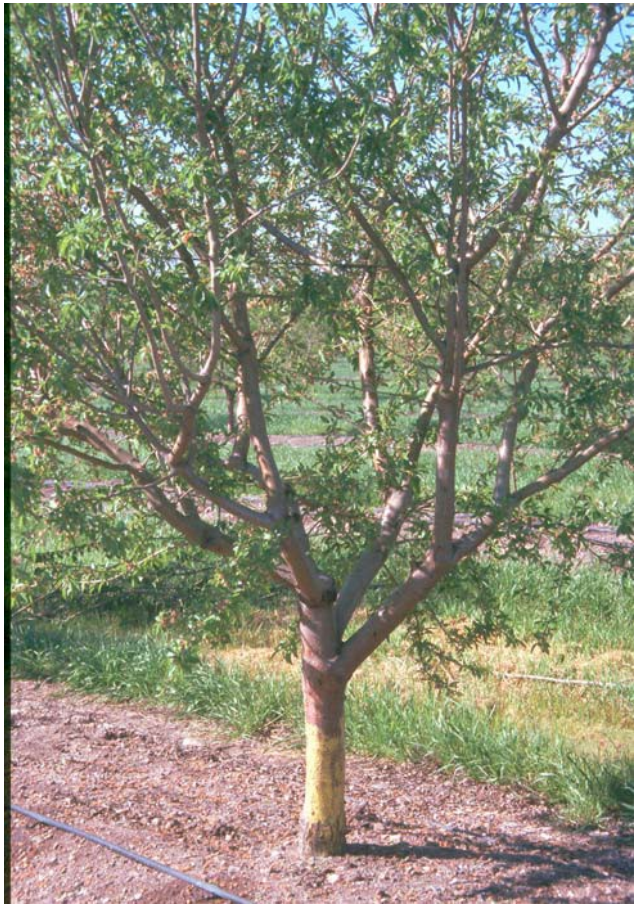
Minimally trained, minimally pruned

Untrained, unpruned

Almond tree pruning:

Slide credits: Roger Duncan

Standard trained, pruned annually



Minimally trained, minimally pruned

Untrained, unpruned

Management of trunk canker diseases:

- Protect pruning wounds following scaffold collection
  - Protect wounds on the trunk
  - Prevent disease establishment in the early years

Management of trunk/scaffold canker diseases:

- Fungicides, pastes, sealants, paints, biocontrol agents were tested

#	Products	active ingredient(s)	FRAC	Class	Type
1	Water (control)				Control
2	AMV4002	*Trichoderma atroviride*			biocontrol
3	Pruning wound sealant	acrylic paint (brand: Tanglefoot)			sealant
4	CropSeal	wax			sealant
5	Ziram	ziram	M3	Carbamate (DMDC)	fungicide
6	Bravo	chlorothalonil	M5	Chloronitrile	fungicide
7	Quash	metconazole	3	DMI-triazole	fungicide
8	Luna Experience	fluopyram/tebuconazole	3 & 7	DMI-triazole/SDHI	fungicide
9	Merivon	pyraclostrobin/fluxapyroxad	7 & 11	SDHI/QoI	fungicide
10	Topsin M	thiophanate-methyl	1	MBC	fungicide
11	Inspire Super	difenoconazole/cyprodinil	3 & 9	DMI-triazole/AP	fungicide
12	Quadris Top	difenoconazole/azoxystrobin	3 & 11	DMI-triazole/QoI	fungicide
13	Pristine	pyraclostrobin/boscalid	7 & 11	SDHI/QoI	fungicide
14	EXP1	thyme oil			biofungicide
15	EXP2	neem oil			biofungicide
16	Quilt Xcel	propiconazole/azoxystrobin	3 & 11	DMI-triazole/QoI	fungicide
17	Fontelis	penthiopyrad	7	SDHI	fungicide
18	Viathon	tebuconazole/phosphonate	3 & 33	DMI-triazole/phosphonate	fungicide
19	Luna Sensation	fluopyram/trifloxystrobin	7 & 11	SDHI/QoI	fungicide
20	Abound	azoxystrobin	11	QoI	fungicide
21	Rally	myclobutanil	3	DMI-triazole	fungicide
22	Indar	febuconazole	3	DMI-triazole	fungicide

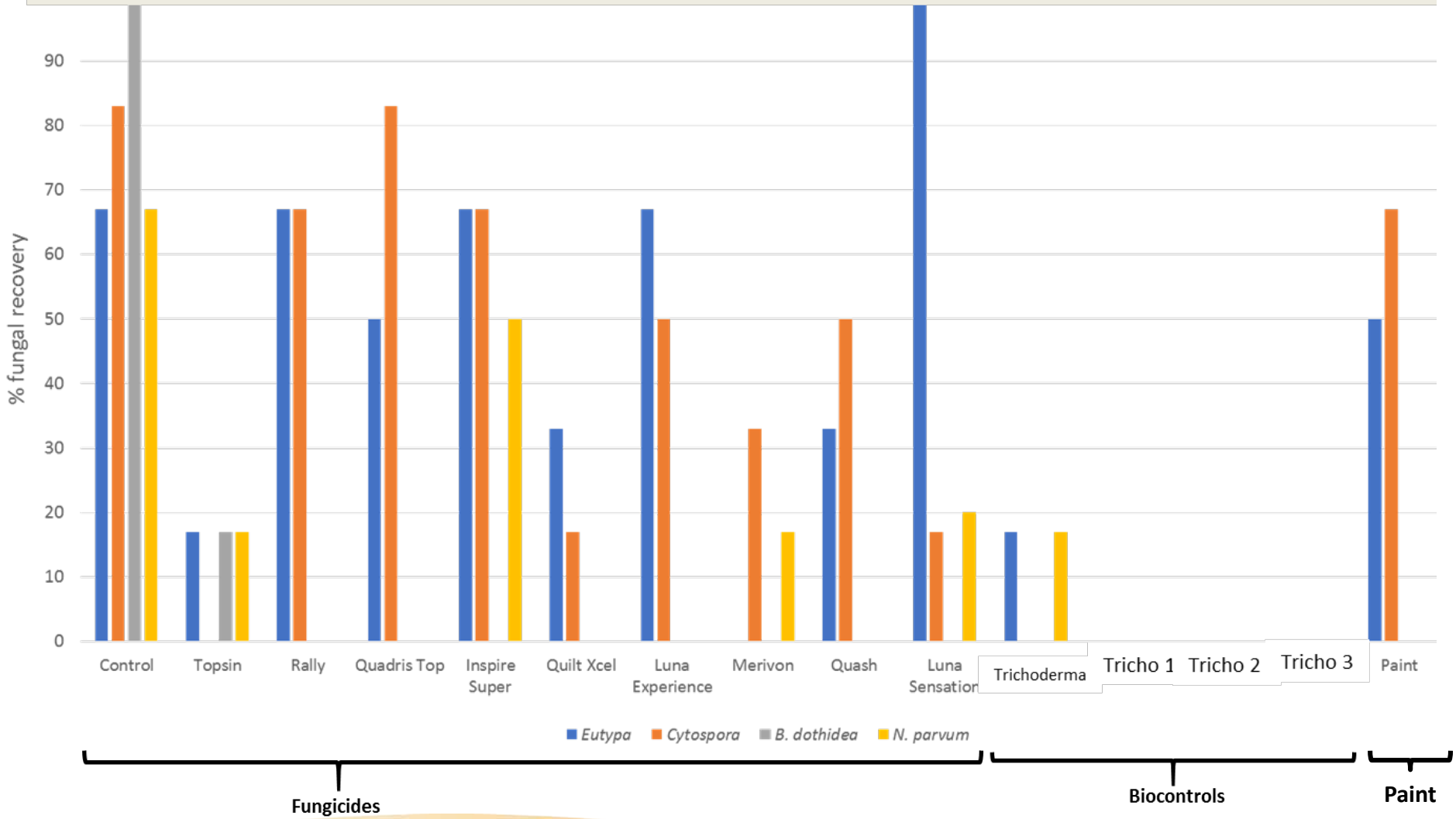
Eutypa lata, Ceratocystis variospora, Cytospora sp., Botryosphaeria dothidea, Neoscytalidium dimidiatum, Neofusicoccum parvum, Neofusicoccum mediterraneum, Diplodia mutila

Pruning wound protection trials:

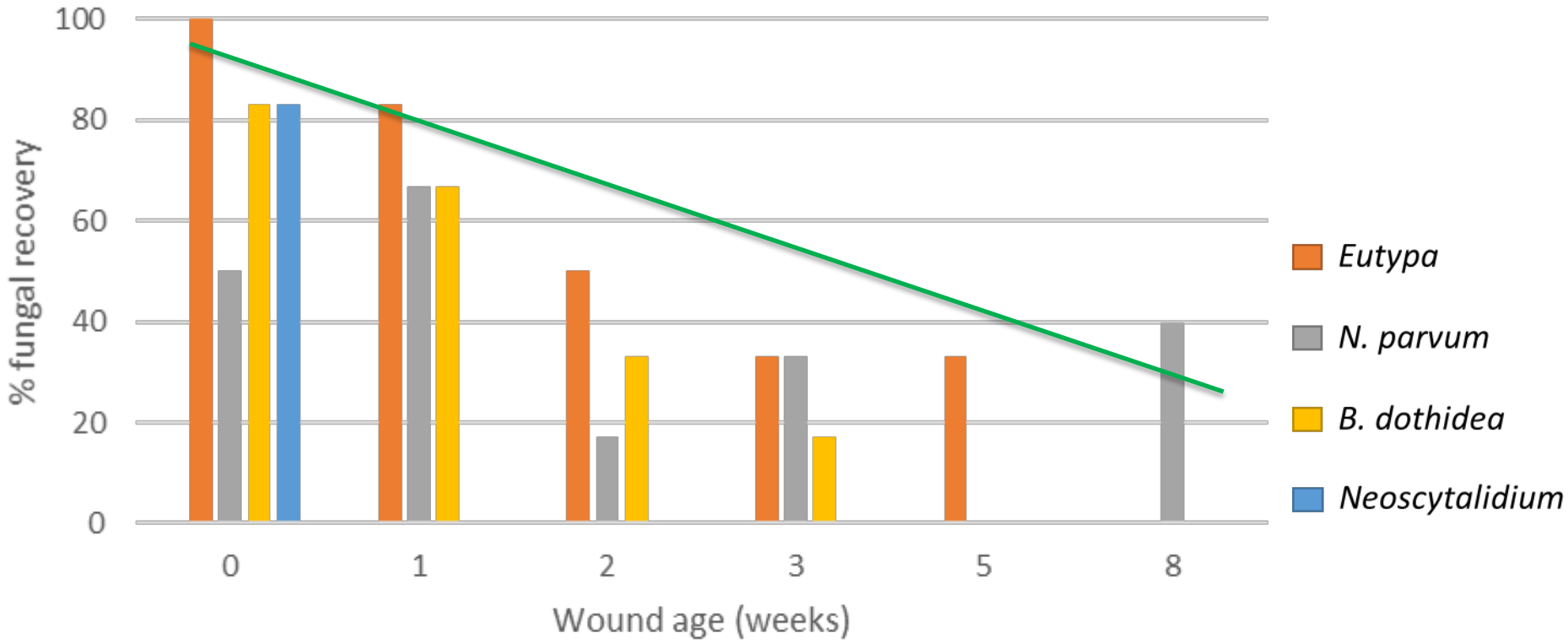
Pruning wound protection trials:

Product	*Cytospora sp.*	*Eutypa lata*	*C. fimbriata*	*B. dothidea*	*N. parvum*	*N. mediterraneum*	*Neosc. dimidiatum*	Avg. recovery
Control	25	75	50	50	100	50	50	57.1
fluopyram/tebuconazole	75	25	25	25	0	25	25	28.6
pyraclostrobin/fluxapyroxad	50	25	25	0	25	50	50	32.1
thiophanate-methyl	0	0	0	0	0	0	0	0
metconazole	25	50	0	0	25	50	50	28.6
difenoconazole/cyprodinil	25	75	0	0	0	25	25	21.4
difenoconazole/azoxystrobin	100	0	0	0	0	0	100	28.6
myclobutanil	50	25	0	0	25	0	50	21.4
thyme oil #1	100	100	0	75	50	75	50	64.2
thyme oil #2	75	25	0	50	100	75	100	60.7
neem oil	100	100	0	100	100	100	100	85.7
Avg. recovery	56.8	45.4	9.1	27.3	38.6	40.9	54.5	

Pruning wound protection - Trial 4 fungal recovery



Duration of pruning wound susceptibility (Fresno Co.)



Management of trunk/scaffold canker diseases:

Prevention and appropriate cultural practices

- Prevent disease establishment in the early years
- Protect wounds near the trunk
- Pruning sealers and Acrylic paint are not so great
- Promising fungicides: Topsin M, Trichoderma
- Don’t prune trees during rainy weather
- Remove dead wood, stumps and dead trees from the orchard
- Avoid wetting the tree trunks with sprinklers
- Remedial surgery, cut into the clean wood
- Now testing spray application of fungicides

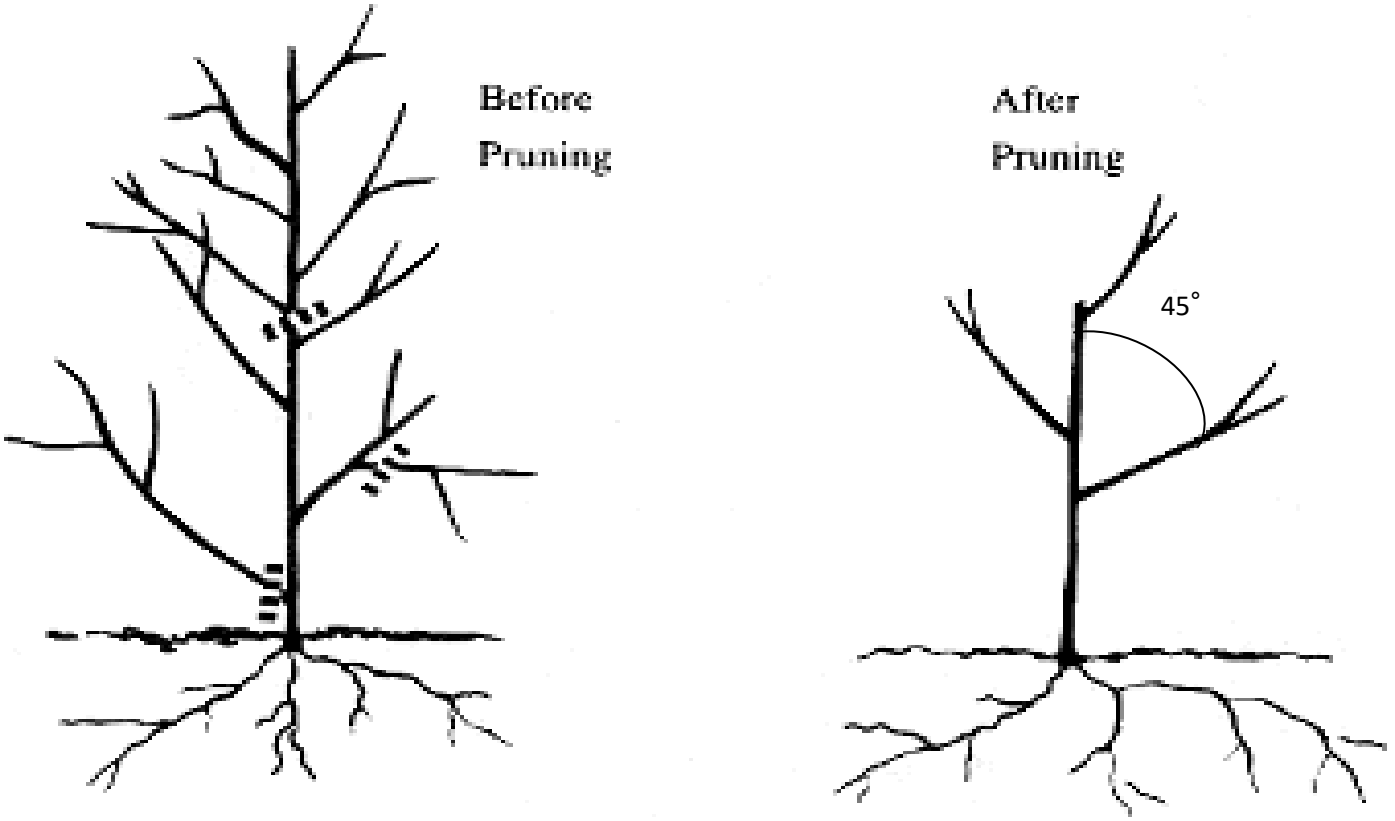
Appropriate tree training and scaffold selection, or minimal pruning

Trunk/Scaffold canker diseases:

- Cankers at cracks formed at the tree crotch

Management of trunk canker diseases:

- Appropriate tree training and scaffold selection to prevent crack formation

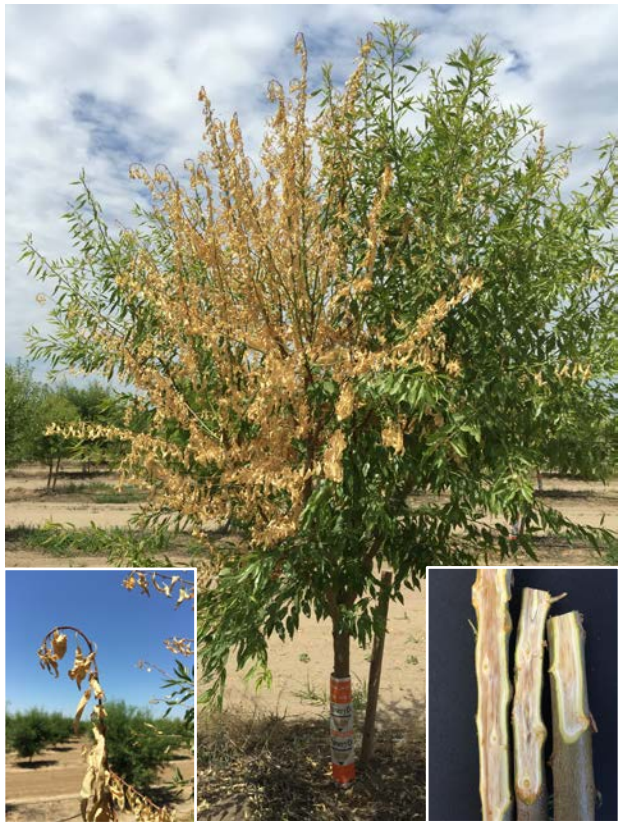


Foamy canker: etiology unknown

Photo: D. Doll

Ceratocystis canker vs Verticillium vs herbicide injury:

Ceratocystis



Verticillium

Herbicide uptake

Bacterial canker vs Phytophthora vs Acid burn:

Bacterial canker

Phytophthora

Acid burn

Acid burn:

Boron toxicity:

Glyphosate injury: Trunk

Root bound: potted almond trees

Thank you!

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