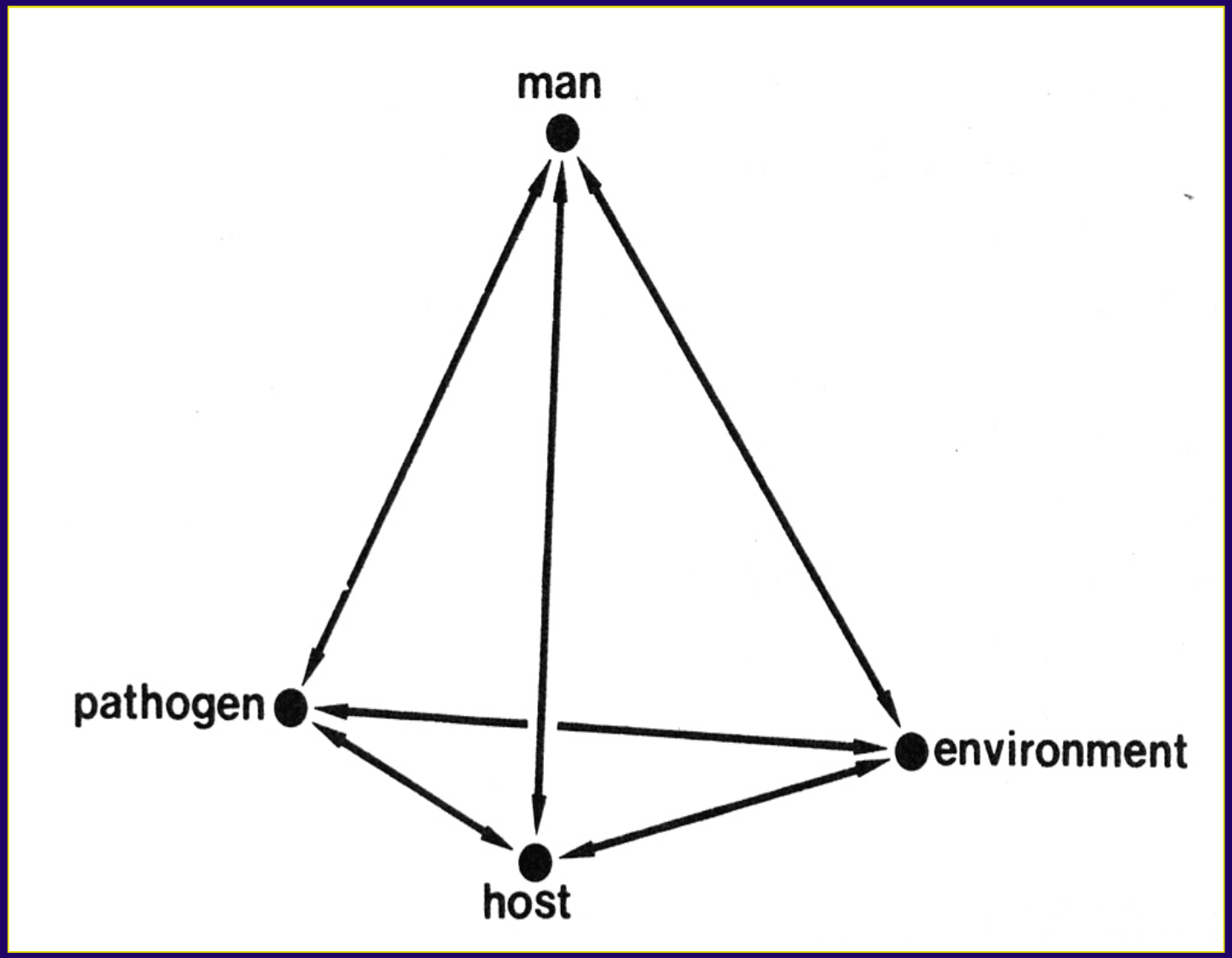
STATUS, IMPACT AND MANAGEMENT OF THE MAJOR DISEASES OF AVOCADO

Randy Ploetz
University of Florida
Homestead, FL USA
kelly12@ufl.edu
http://trec.ifas.ufl.edu/personnel_faculty_randy_ploetz.shtml

4th Australian and New Zealand Avocado Grower's Conference, Cairns, 21-24 July 2009



Disease tetrahedron

Zadoks and Schein, 1979

Disease Overview

- Important avocado diseases
- Impacts
- Geographic distributions
- Symptoms, causes and behaviour (epidemiology)
- Management
- New and emerging diseases

The most important diseases

Phytophthora root rot (PRR)

23 July, Breakout 7: Plant health - A

- Managing ***Phytophthora cinnamomi.*** Dann and Pegg
- Improved timing of phosphonate injections for ***Pc*** control in New Zealand. Partridge

The most important diseases

Phytophthora root rot (PRR)

- Most important disease of avocado worldwide

The most important diseases

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- Most important disease of avocado worldwide
- PRR has crippled avocado production in tropical America (avocados must be imported into Puerto Rico)

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The most important diseases

Phytophthora root rot (PRR)

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- In Australia, losses of A$40 million/yr; in California, losses of US$44 million in 1989

The most important diseases

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- PRR can kill or greatly debilitate trees,

The most important diseases

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•Most important di o worldwide

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Vincent Wager

•PRR can kill or greatly debilitate trees, but is often misdiagnosed

California – avocado decline in poorly drained soil

The most important diseases

Phytophthora root rot (PRR)

•Most imp

•PRR has cal America, collection

•In Austra rnia, losses of

•PRR car often misdiagn

Flooded 2 weeks

- ***P. cinnamomi*** +***P. cinnamomi***

California – avocado decline in poorly drained soil

Florida – tree mortality after hurricanes

The most important diseases

Phytop

•Most ir

•PRR h
America
collectio

•In Aust ia,
losses

•PRR c en
misdiag

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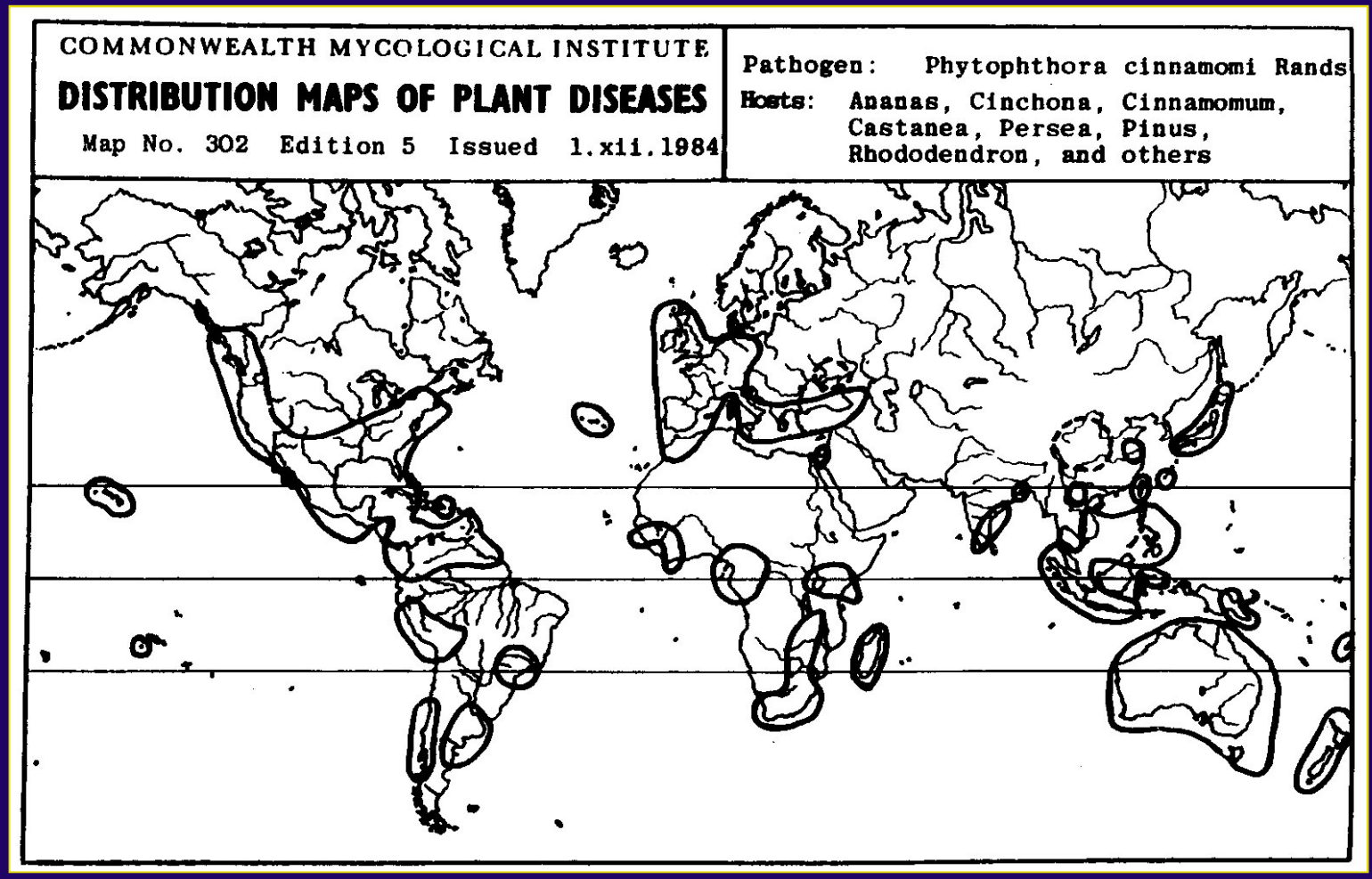
Fl

Peru – orchard decline

The most important diseases

Phytophthora root rot (PRR)

Geographic distribution of ***Phytophthora cinnamomi***



The most important diseases

Phytophthora root rot (PRR)

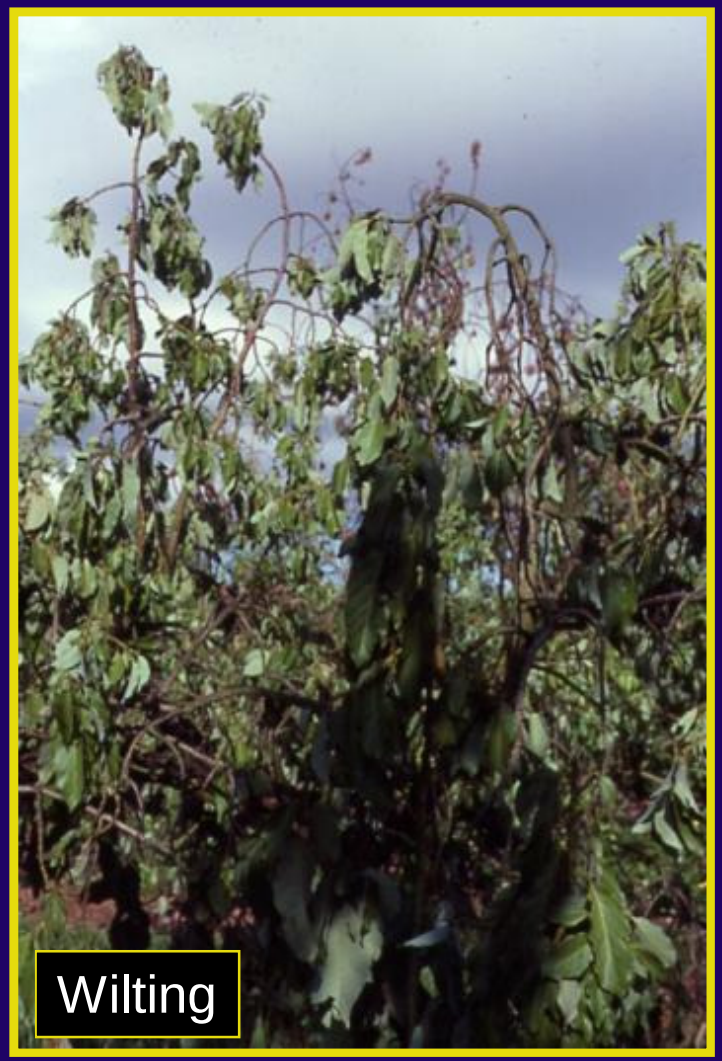
Symptoms

Dark, necrotic feeder roots

The most important diseases

Phytophthora root rot (PRR)

Symptoms



Defoliation

The most important diseases

Phytophthora root rot (PRR)

Symptoms

The most important diseases

Phytophthora root rot (PRR)

Symptoms

Nonuniform distribution of affected trees

The most important diseases

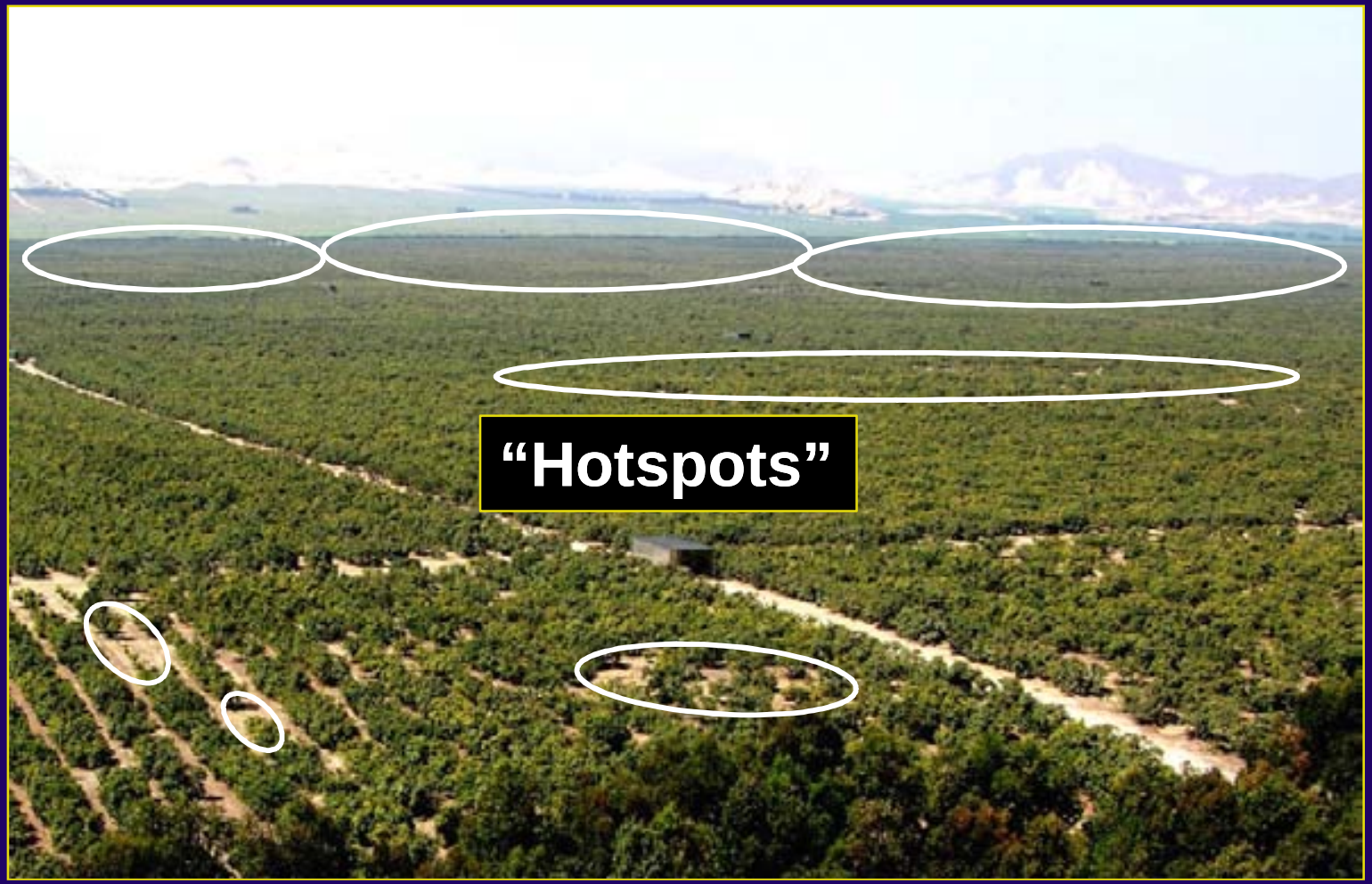
Phytophthora root rot (PRR)

Symptoms

The most important diseases

Phytophthora root rot (PRR)

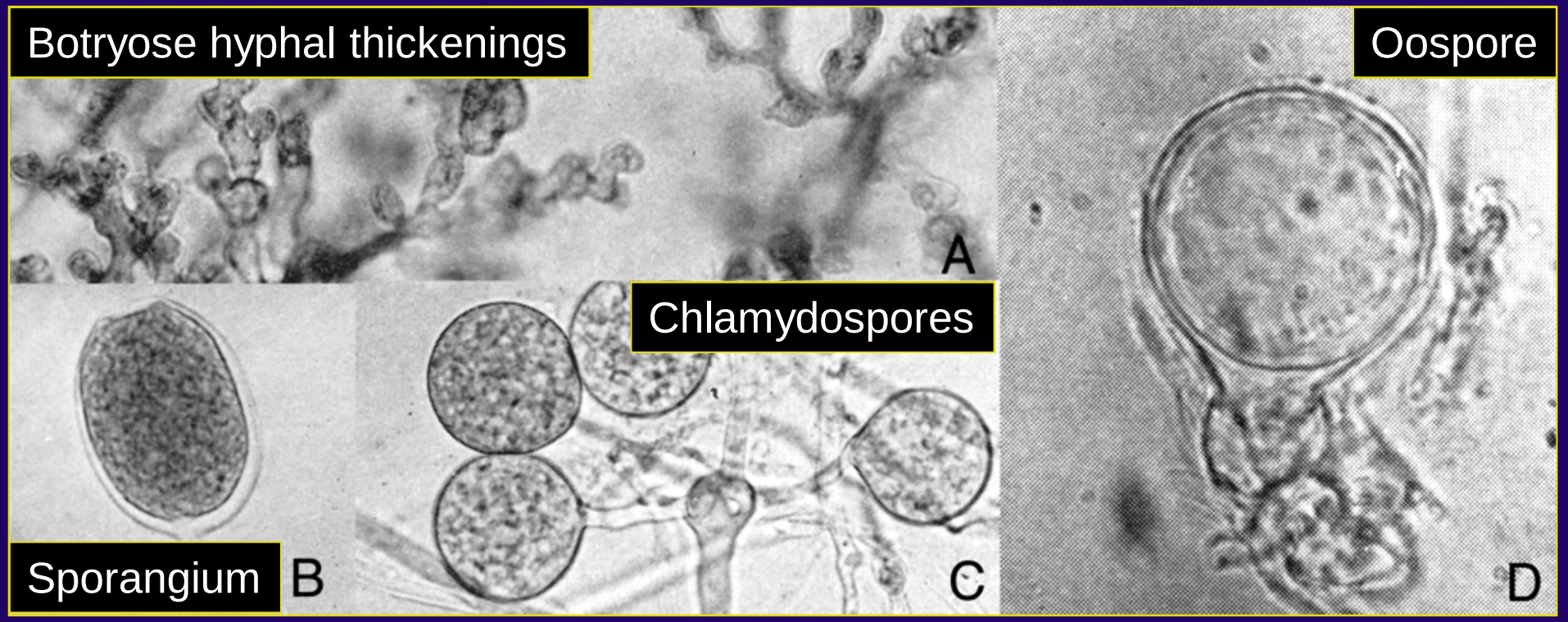
Symptoms



The most important diseases

Phytophthora root rot (PRR)

Phytophthora cinnamomi Rands



The most important diseases

Other *Phytophthora* spp. cause trunk diseases and fruit rots

Trunk cankers:

- ***P. boehmeriae*** (Mexico)
- ***P. cinnamomi*** (Australia, Brazil, Cameroon, South Africa and USA)
- ***P. citricola*** (Mexico and USA)
- ***P. heveae*** (Guatemala and Mexico)
- ***P. palmivora*** (Honduras**)**

The most important diseases

Other *Phytophthora* spp. cause trunk diseases and fruit rots

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- ***P. citricola*** (Mexico and USA)
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- ***P. palmivora*** (Honduras)

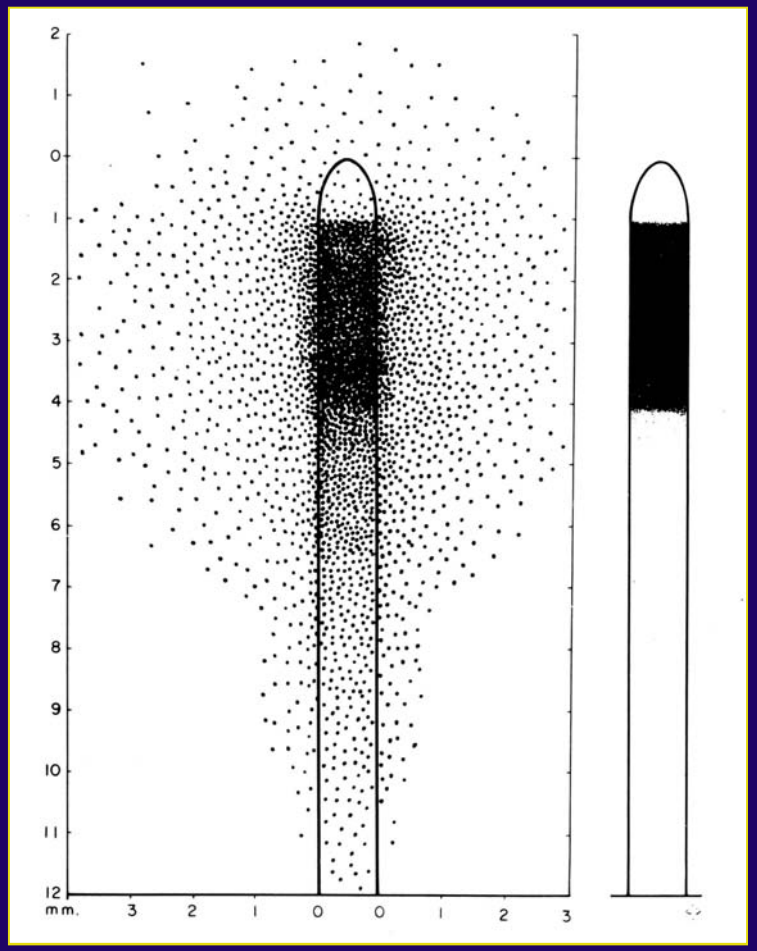
Fruit rots:

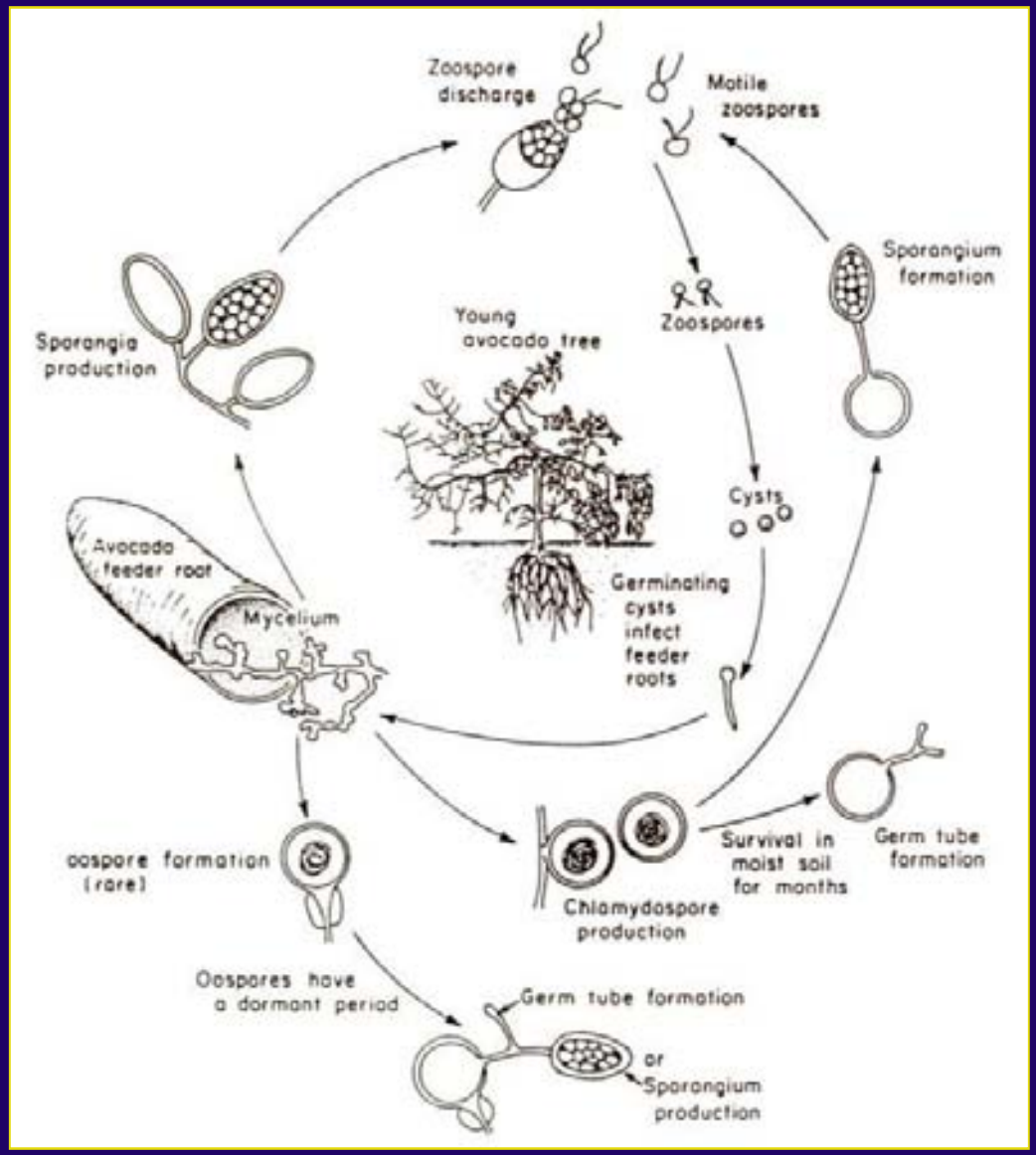
- ***P. boehmeriae*** (Mexico)
- ***P. citricola*** (USA)
- ***P. cactorum*** (Spain)

The most important diseases

Phytophthora root rot (PRR)

Epidemiology





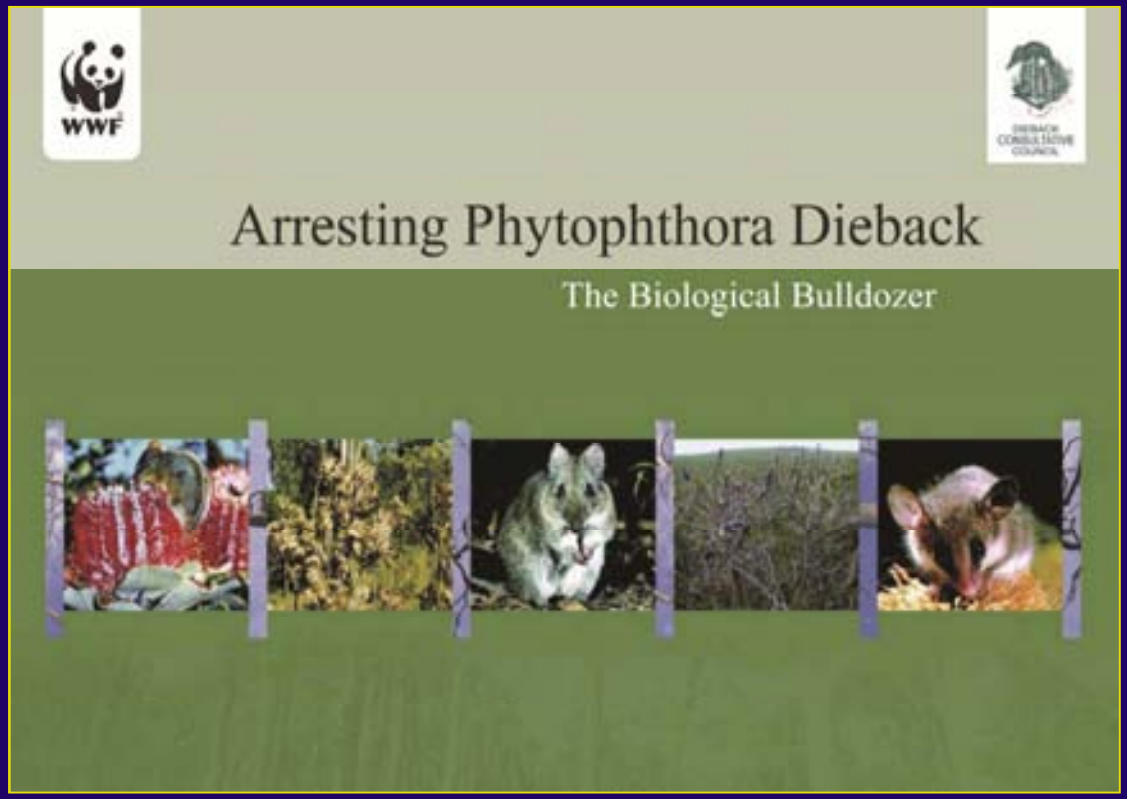
The most important diseases

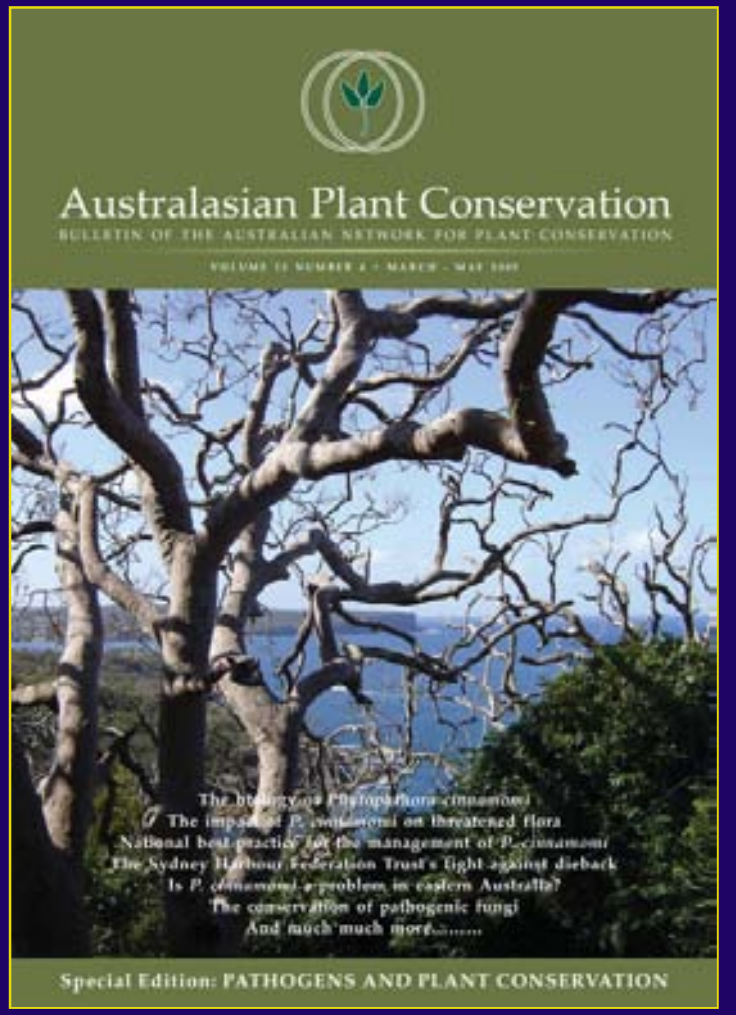
Phytophthora root rot (PRR)

Management

•Cultural

http://www.dieback.net.au/howhelp_learning.php
14 online publications





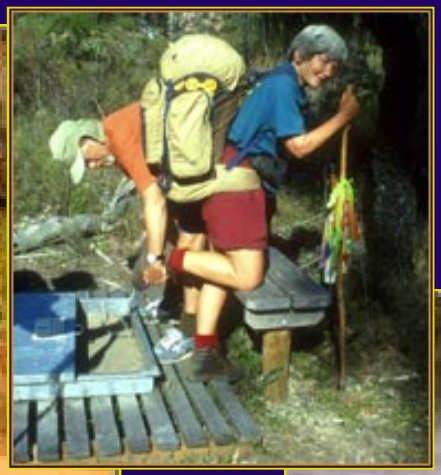
The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural

In areas where ***P. cinnamomi*** is not found, exclusion is most important



The most important diseases

Phytophthora root rot (PRR)

Management

•Cultural

In areas where ***P. cinnamomi*** is not found, exclusion is most important. Pathogen/disease-free plants are essential.

Clean soil and irrigation water are musts

ANVAS accredited nurseries

The most important diseases

Phytophthora root rot (PRR)

Management

•Cultural

In areas where ***P. cinnamomi*** is not found, exclusion is most important. Pathogen/disease-free plants are essential.

Pathogen-infested soil or water can have serious consequences in the nursery and field

The most important diseases

Phytophthora root rot (PRR)

Management

•Cultural

In areas where ***P. cinnamomi*** is not found, exclusion is most important. Pathogen/disease-free plants are essential.

Do <u>not</u> treat plants in the nursery with metalaxyl or phosphonates

The most important diseases

Phytophthora root rot (PRR)

Management

•Cultural

Surface water is often infested with pathogens; it should be disinfested. When it is available, well water should be used.

The most important diseases

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Management

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In areas where ***P. cinnamomi*** is not found, exclusion is most important. Pathogen/disease-free plants are essential.

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heat treatment…

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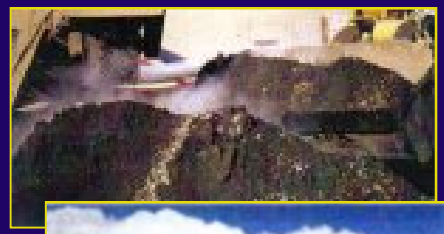
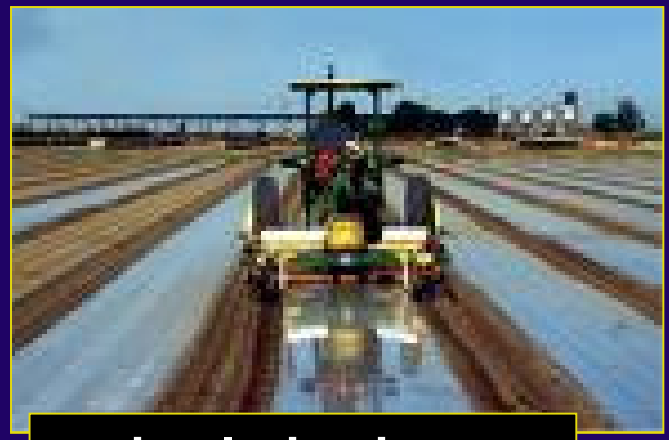
In areas where ***P. cinnamomi*** is not found, exclusion is most important. Pathogen/disease-free plants are essential.





and solarization effectively disinfest soil

The most important diseases

Phytophthora root rot (PRR)

Management

•Cultural

When ***P. cinnamomi*** is present, site selection (avoiding heavy or poorly drained soil),

The most important diseases

Phytophthora root rot (PRR)

Management

•Cultural

When ***P. cinnamomi*** is present, site selection, raised beds,

The most important diseases

Phytophthora root rot (PRR

Management

•Cultural

When ***P. cinnamomi*** is present, site Selection, raised beds, the use of composts

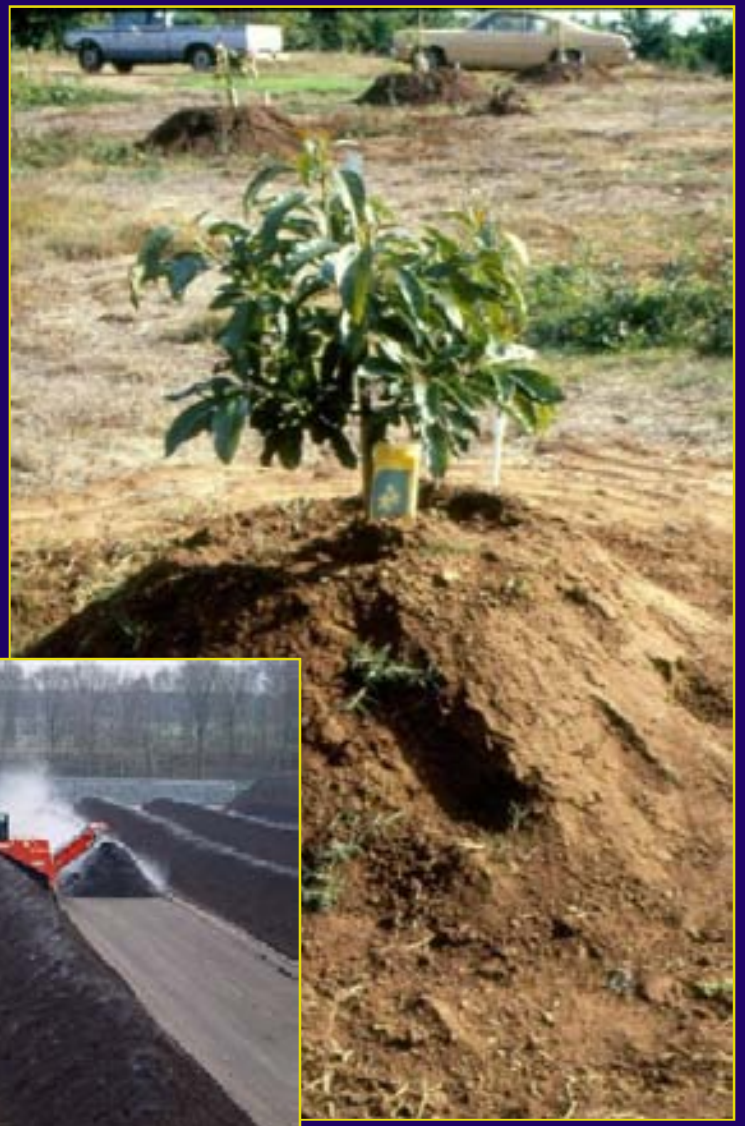
The most important diseases

Phytophthora root rot (PRR)

Management

•Cultural

When ***P. cinnamomi*** is present, site Selection, raised beds, the use of composts, and soil amendments (e.g. gypsum, organic matter) can be beneficial



The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks

-Australia (Whiley)

-Israel (Ben Yaacov)

-Mexico (?)

-South Africa (Merensky and FABI)

-Spain (Gallo-Llobet)

-US (University of Florida and USDA; University of California at Riverside)

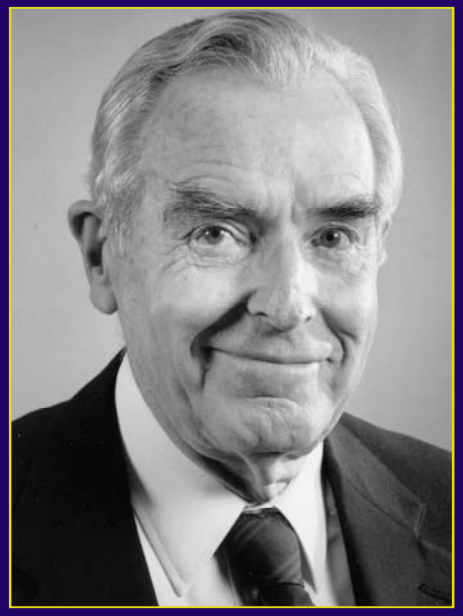
The most important diseases

Phytophthora root rot (PRR)

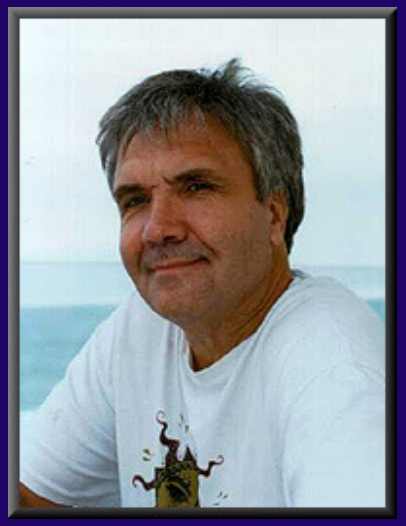
Management

- Cultural
- Resistant rootstocks

UC Riverside Plant Pathology Department



George Zentmyer



Mike Coffey

John Menge

Greg Douhan

The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks

UCR

116 advanced lines

55 tested in field

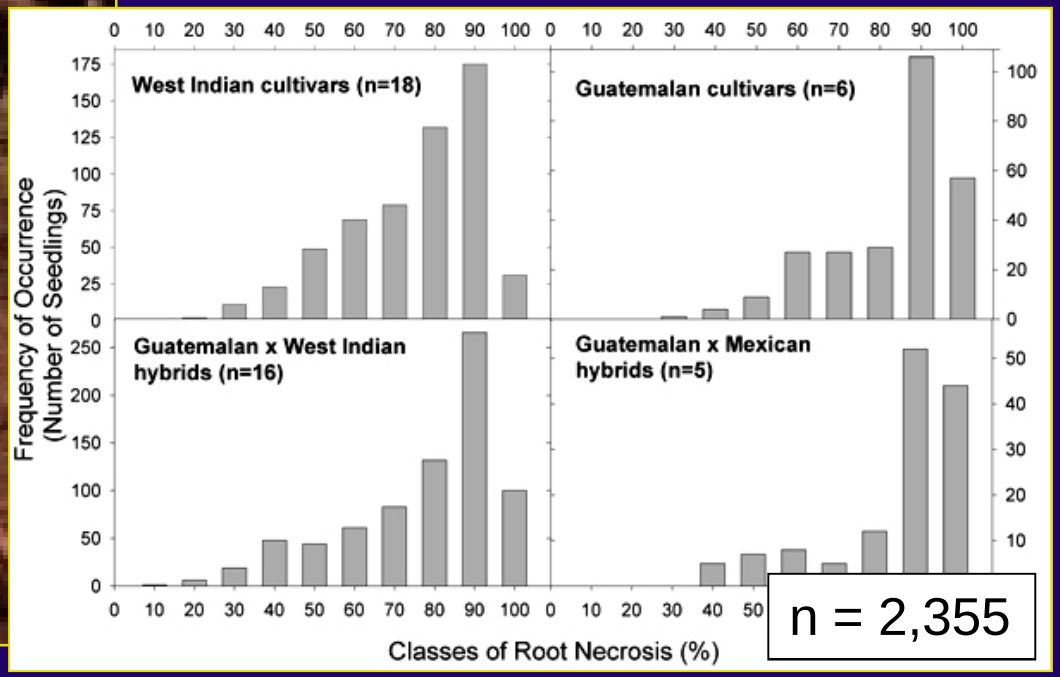
Three will be released soon:
'Zentymyer', 'Uzi' and 'Steddom'

The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks
- Numbers game - Success depends on screening many seedlings

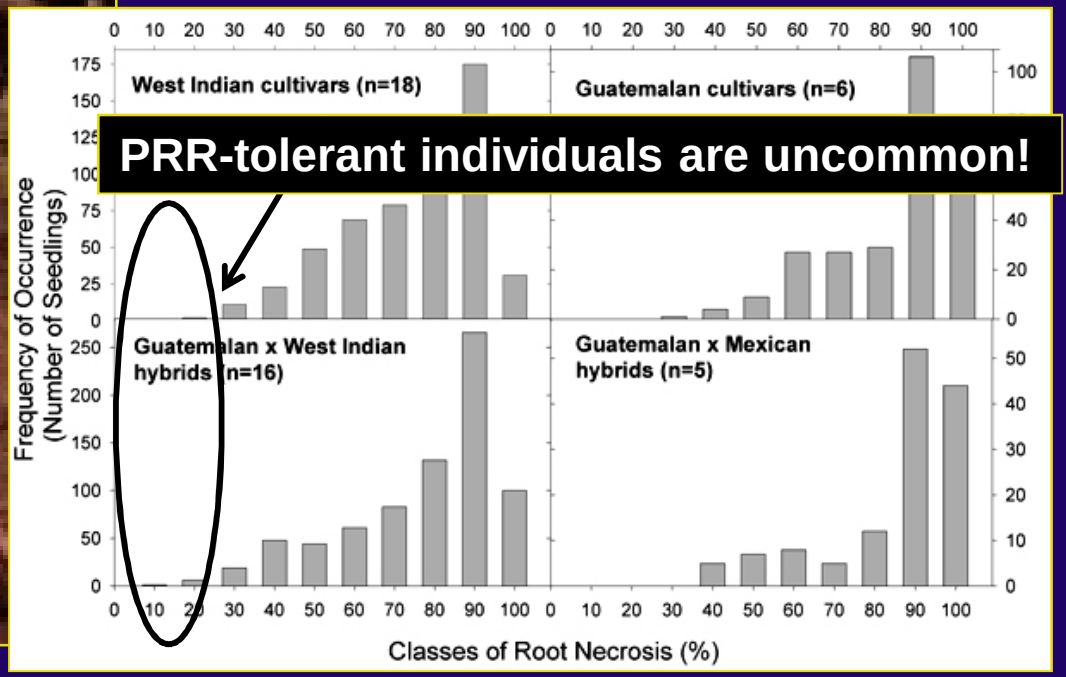


The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks
- Numbers game



The most important diseases

Phytophthora root rot (PRR)

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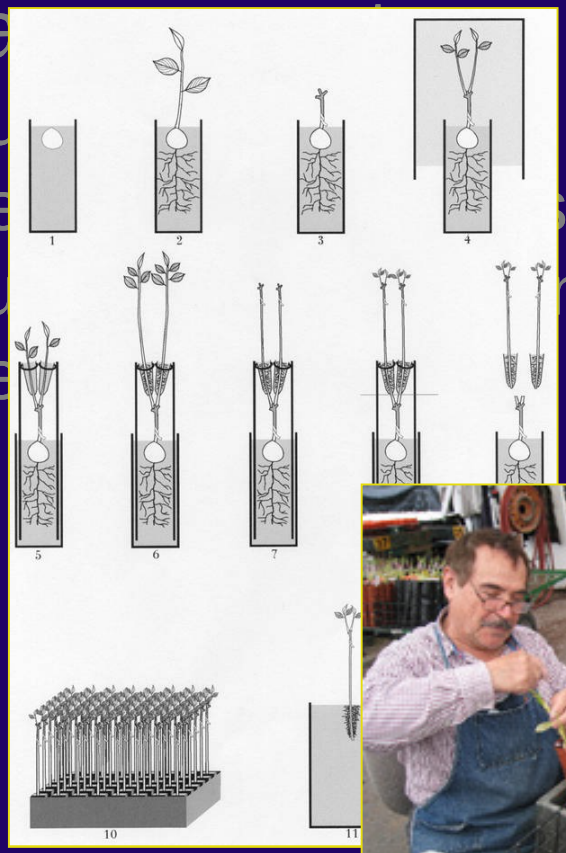
see



Selections must be cloned

The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks
- Chemical

Difficult prior to acylalinines (e.g. metalaxyl)

The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks
- Chemical

Difficult prior to acylalinines (e.g. metalaxyl)

-expensive before patent lapse

-not effective in badly damaged trees (xylem mobile)

-resistance

-enhanced breakdown

The most important diseases

Phytophthora root rot (PRR)

Management

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Aliette, phosphoric acid products (phosphonates)

The most important diseases

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- Chemical

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-not effective in badly damaged trees (xylem mobile)

-resistance

-enhanced breakdown

Aliette, phosphoric acid products

-active ingredient is xylem and phloem mobile: products can be injected for eventual redistribution to roots

-Australia successfully contests Rhone-Poulenc's patent

The most important diseases

Phytophthora root rot (PRR)

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Pioneers in the use of phosphonates to manage PRR

The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks
- **Chemical**

Phosphonates can be injected into severely affected trees

The most important diseases

Phytophthora root rot (PRR)

Management

- **Cultural**
- **Resistant rootstocks**
- **Chemical**

Phosphonates can be injected into severely affected trees, and in trees that have begun to recover can be applied as foliar sprays

The most important diseases

Phytophthora root rot (PRR)

Management

- **Cultural**
- **Resistant rootstocks**
- **Chemical**

Phosphonates can be injected into
or in trees that have begun to reco
foliar sprays, trunk sprays

The most important diseases

Phytophthora root rot (PRR)

Management

- **Cultural**
- **Resistant rootstocks**
- **Chemical**

Phosphonates can be injected into severely affected trees, or in trees that have begun to recover can be applied as foliar sprays, trunk sprays, or soil drenches (albeit less effectively)

The most important diseases

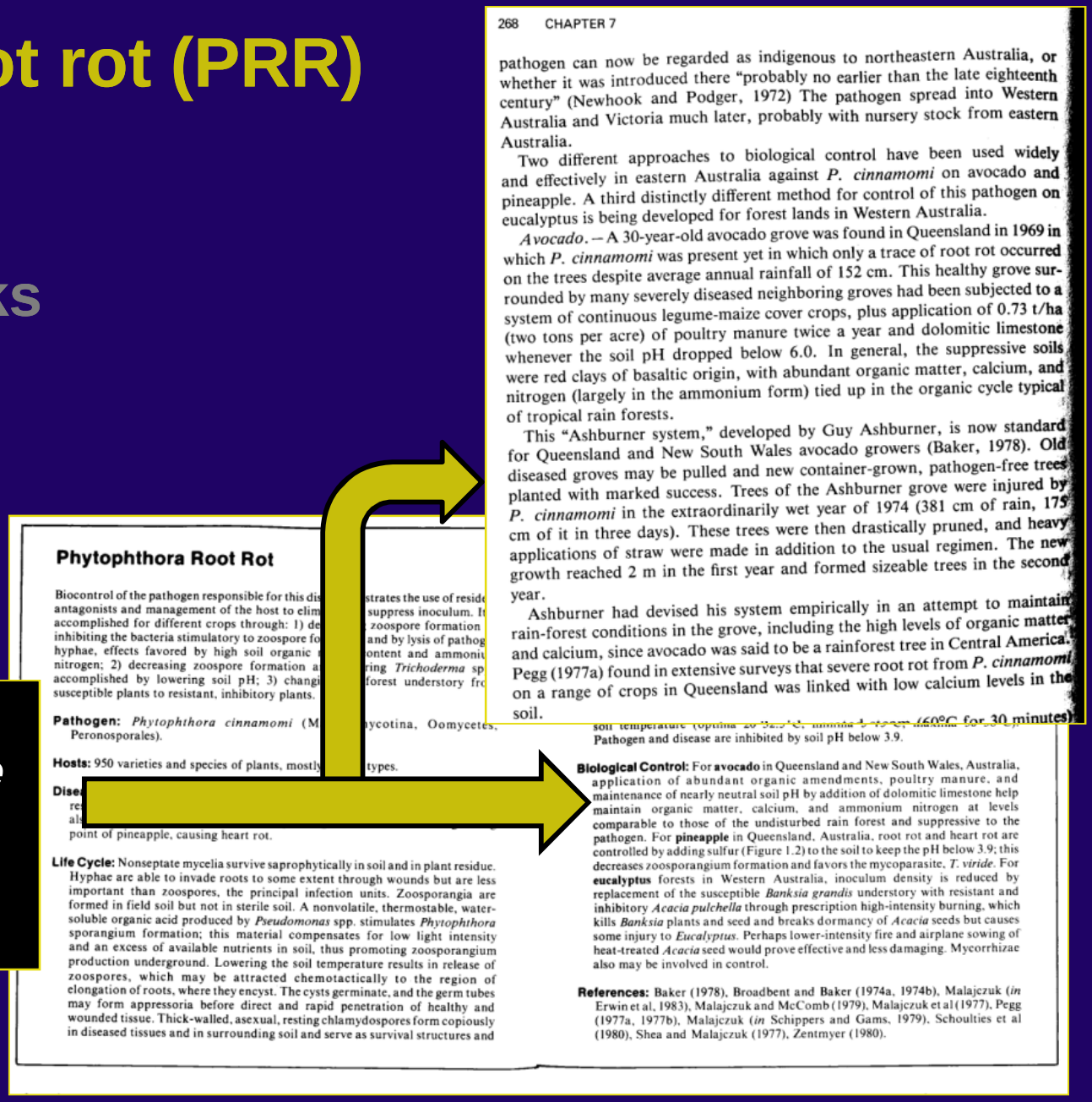
Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks
- Chemical
- **Biological**

Considerable interest

Cook, R.J. and Baker, K.F. 1983. ***The Nature and Practice of Biological Control of Plant Pathogens***.



268 CHAPTER 7

pathogen can now be regarded as indigenous to northeastern Australia, or whether it was introduced there "probably no earlier than the late eighteenth century" (Newhook and Podger, 1972) The pathogen spread into Western Australia and Victoria much later, probably with nursery stock from eastern Australia.

Two different approaches to biological control have been used widely and effectively in eastern Australia against *P. cinnamomi* on avocado and pineapple. A third distinctly different method for control of this pathogen on eucalyptus is being developed for forest lands in Western Australia.

Avocado.—A 30-year-old avocado grove was found in Queensland in 1969 in which *P. cinnamomi* was present yet in which only a trace of root rot occurred on the trees despite average annual rainfall of 152 cm. This healthy grove surrounded by many severely diseased neighboring groves had been subjected to a system of continuous legume-maize cover crops, plus application of 0.73 t/ha (two tons per acre) of poultry manure twice a year and dolomitic limestone whenever the soil pH dropped below 6.0. In general, the suppressive soils were red clays of basaltic origin, with abundant organic matter, calcium, and nitrogen (largely in the ammonium form) tied up in the organic cycle typical of tropical rain forests.

This "Ashburner system," developed by Guy Ashburner, is now standard for Queensland and New South Wales avocado growers (Baker, 1978). Old diseased groves may be pulled and new container-grown, pathogen-free trees planted with marked success. Trees of the Ashburner grove were injured by *P. cinnamomi* in the extraordinarily wet year of 1974 (381 cm of rain, 175 cm of it in three days). These trees were then drastically pruned, and heavy applications of straw were made in addition to the usual regimen. The new growth reached 2 m in the first year and formed sizeable trees in the second year.

Ashburner had devised his system empirically in an attempt to maintain rain-forest conditions in the grove, including the high levels of organic matter and calcium, since avocado was said to be a rainforest tree in Central America. Pegg (1977a) found in extensive surveys that severe root rot from *P. cinnamomi* on a range of crops in Queensland was linked with low calcium levels in the soil.

Phytophthora Root Rot

Biocontrol of the pathogen responsible for this dis… strates the use of reside… antagonists and management of the host to elim… suppress inoculum. It… accomplished for different crops through: 1) de… zoospore formation … inhibiting the bacteria stimulatory to zoospore fo… and by lysis of pathog… hyphae, effects favored by high soil organic … ontent and ammoniu… nitrogen; 2) decreasing zoospore formation a… ring *Trichoderma* sp… accomplished by lowering soil pH; 3) changi… forest understory fr… susceptible plants to resistant, inhibitory plants.

Pathogen: *Phytophthora cinnamomi* (M… …ycotina, Oomycetes, Peronosporales).

Hosts: 950 varieties and species of plants, mostly … types.

Dise… re… al… point of pineapple, causing heart rot.

Life Cycle: Nonseptate mycelia survive saprophytically in soil and in plant residue. Hyphae are able to invade roots to some extent through wounds but are less important than zoospores, the principal infection units. Zoosporangia are formed in field soil but not in sterile soil. A nonvolatile, thermostable, water-soluble organic acid produced by *Pseudomonas* spp. stimulates *Phytophthora* sporangium formation; this material compensates for low light intensity and an excess of available nutrients in soil, thus promoting zoosporangium production underground. Lowering the soil temperature results in release of zoospores, which may be attracted chemotactically to the region of elongation of roots, where they encyst. The cysts germinate, and the germ tubes may form appressoria before direct and rapid penetration of healthy and wounded tissue. Thick-walled, asexual, resting chlamydospores form copiously in diseased tissues and in surrounding soil and serve as survival structures and … soil temperature (optima … (60°C for 30 minutes). Pathogen and disease are inhibited by soil pH below 3.9.

Biological Control: For **avocado** in Queensland and New South Wales, Australia, application of abundant organic amendments, poultry manure, and maintenance of nearly neutral soil pH by addition of dolomitic limestone help maintain organic matter, calcium, and ammonium nitrogen at levels comparable to those of the undisturbed rain forest and suppressive to the pathogen. For **pineapple** in Queensland, Australia, root rot and heart rot are controlled by adding sulfur (Figure 1.2) to the soil to keep the pH below 3.9; this decreases zoosporangium formation and favors the mycoparasite, *T. viride*. For **eucalyptus** forests in Western Australia, inoculum density is reduced by replacement of the susceptible *Banksia grandis* understory with resistant and inhibitory *Acacia pulchella* through prescription high-intensity burning, which kills *Banksia* plants and seed and breaks dormancy of *Acacia* seeds but causes some injury to *Eucalyptus*. Perhaps lower-intensity fire and airplane sowing of heat-treated *Acacia* seed would prove effective and less damaging. Mycorrhizae also may be involved in control.

References: Baker (1978), Broadbent and Baker (1974a, 1974b), Malajczuk (*in* Erwin et al, 1983), Malajczuk and McComb (1979), Malajczuk et al (1977), Pegg (1977a, 1977b), Malajczuk (*in* Schippers and Gams, 1979), Schoulties et al (1980), Shea and Malajczuk (1977), Zentmyer (1980).

The most important diseases

Phytophthora root rot (PRR)

Management

- Cultural
- Resistant rootstocks
- Chemical
- Biological

Considerable interest

Most success reported in glasshouse trials

The most important diseases

Phytophthora root rot (PRR)

Management

- **Cultural**
- **Resistant rootstocks**
- **Chemical**
- **Biological**

Considerable interest

Most success reported in glasshouse trials

Transferring glasshouse results to the field is a major challenge

The most important diseases

Phytophthora root rot (PRR)

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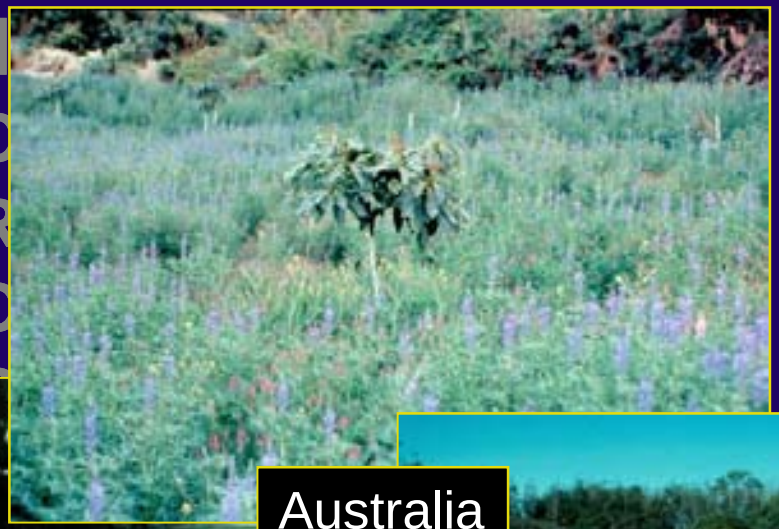
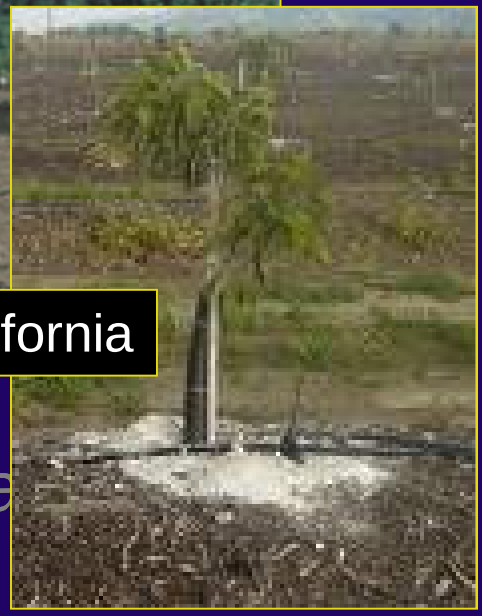


Australia

California



ouse trials

o the field a ma

Greatest success with natural disease suppression (e.g. Ashburner system)

The most important diseases

Phytophthora root rot (PRR)

Management

- **Cultural**
- **Resistant rootstocks**
- **Chemical**
- **Biological**

Considerable interest

Most success reported in glasshouse trials

Transferring glasshouse results to the field a major challenge

Natural disease suppression

Holistic combinations of 2 or more cultural, rootstock, chemical and biological tactics are most effective

The most important diseases

Pre- and post-harvest fruit diseases

22 and 23 July, Breakouts 6 and 10: Fruit quality
Impacts of fruit disease management on quality. Dann and Coates

The most important diseases

Pre- and post-harvest fruit diseases

Anthracnose

- Most important fruit disease in humid environments

The most important diseases

Pre- and post-harvest fruit diseases

Anthracnose

- Most important fruit disease in humid environments
- Pre-harvest

The most important diseases

Pre- and post-harvest fruit diseases

Anthracnose

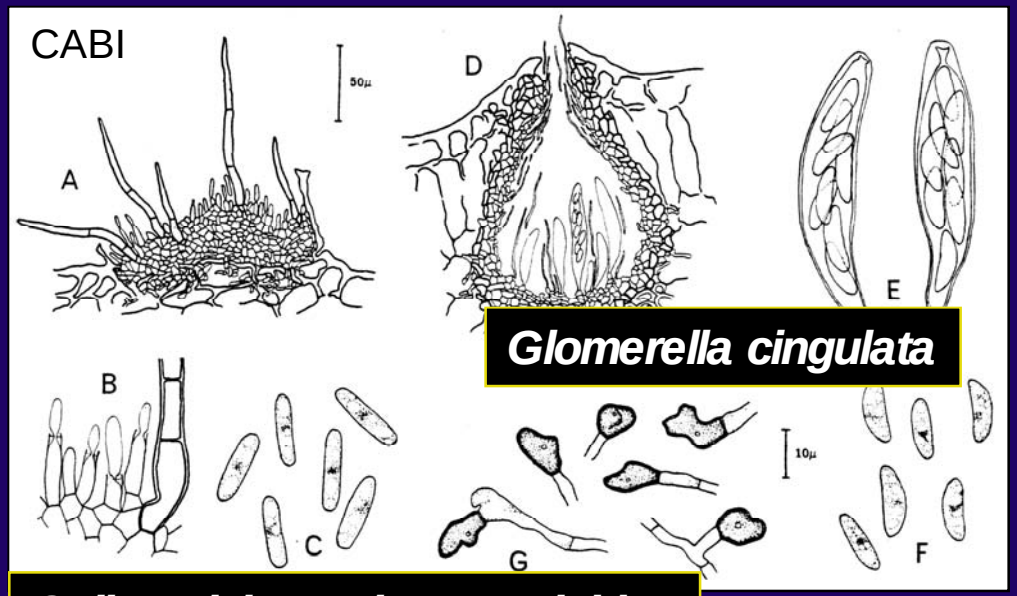
- Most important fruit disease in humid environments
- Pre-harvest and post-harvest damage can occur; losses of up to 37% have been reported

The most important diseases

Pre- and post-harvest fruit diseases

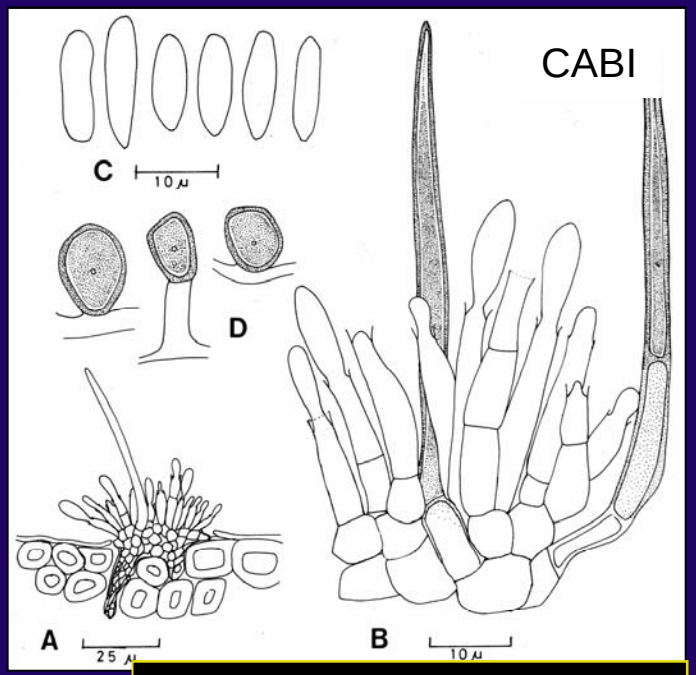
Anthracnose

- Most important fruit disease in humid environments
- Pre- and post-harvest damage can occur; losses of up to 37% have been reported
- ***Colletotrichum gloeosporioides***, and in cooler environs ***C. acutatum,*** are responsible



Glomerella cingulata

Colletotrichum gloeosporioides



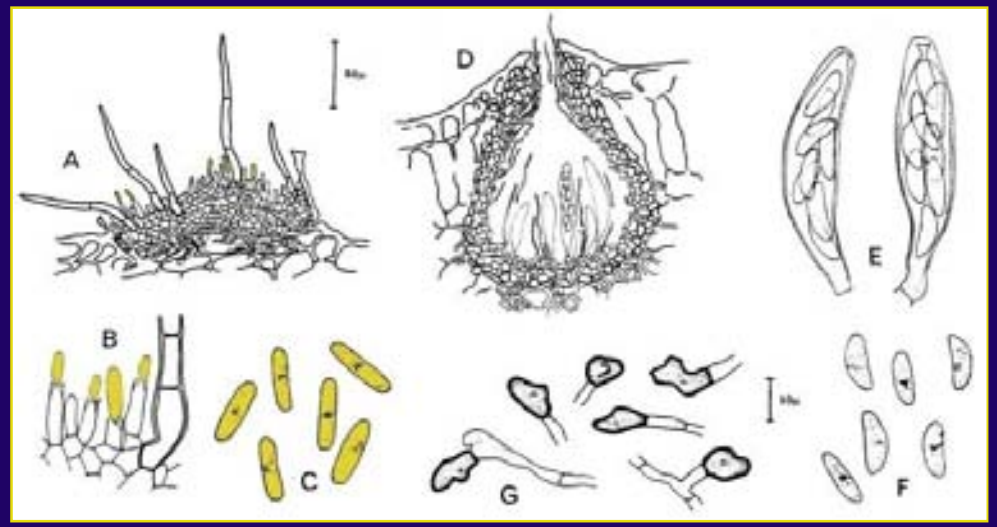
Colletotrichum acutatum

The most important diseases

Pre- and post-harvest fruit diseases

Anthracnose

- Most important fruit disease in humid environments
- Pre- and post-harvest damage can occur; losses of up to 37% have been reported
- ***Colletotrichum gloeosporioides***, and in cooler environs ***C. acutatum,*** are responsible
- Conidia are most important inoculum,



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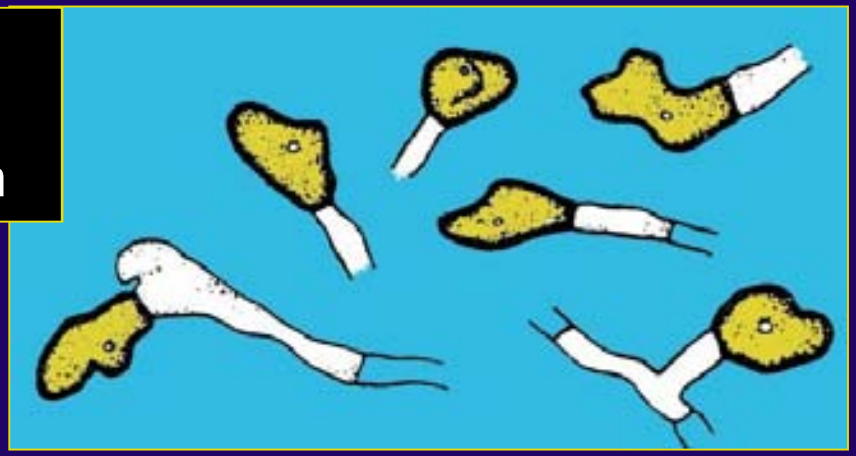
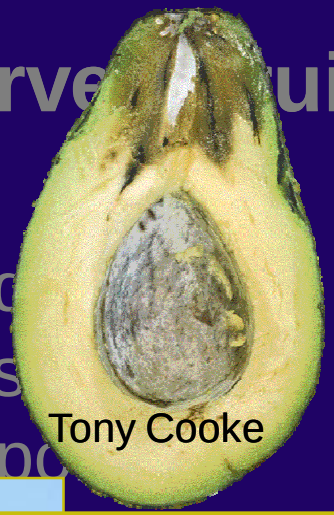
Melanized appressoria are responsible structures; they germinate/infect as fruit ripen



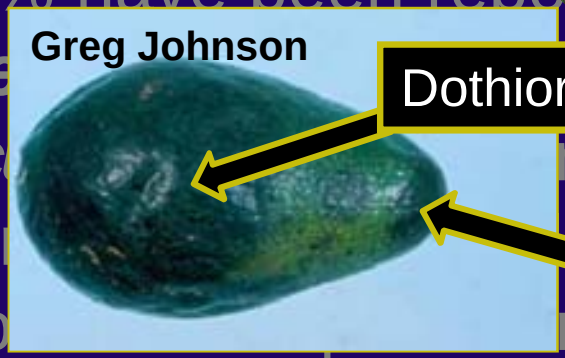
The most important diseases


Salvador Ochoa


Tony Whiley


Tony Cooke


Salvador Ochoa


Greg Johnson

Dothiorella fruit rot

Stem-end rot

Stem-end rots and Dothiorella fruit rot

- Most important fruit diseases after anthracnose

The most important diseases

Pre- and po

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Stem-end r t

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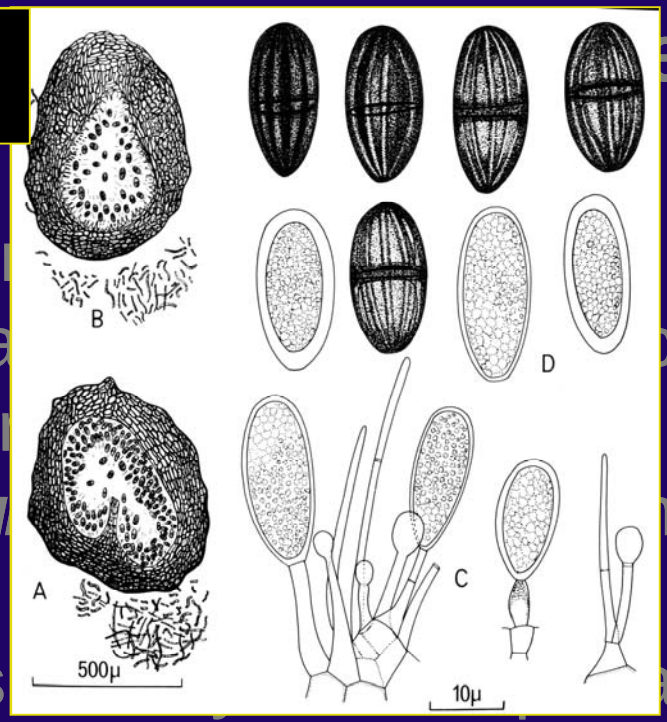
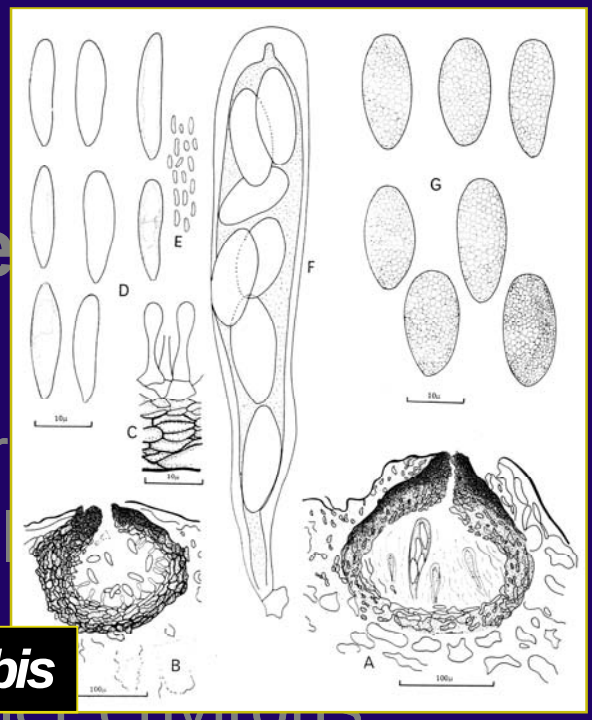
•Pathogens are endophytes, also affect other organs

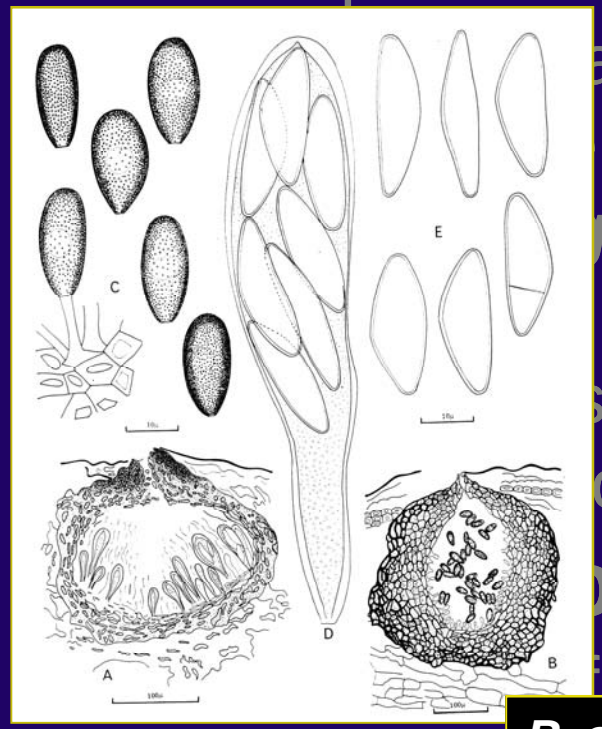
The most important diseases

B. rhodina (***Lasiodiplodia theobromae***)

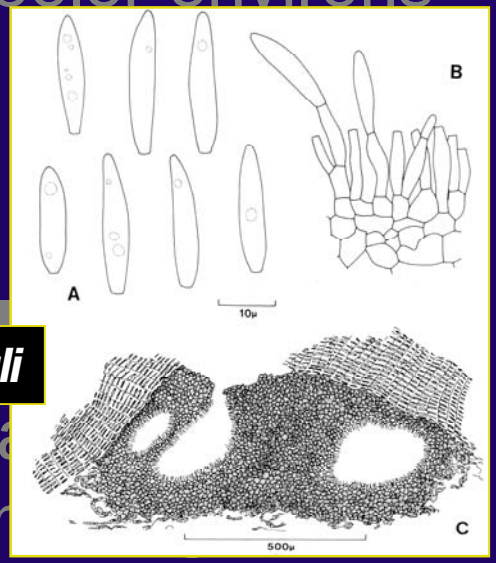




B. ribis



B. obtusa



Fusicoccum aesculi

- •Most important f… envir…
- …ccur; …
- …n cooler climates
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The most important diseases

Scab

The most important diseases

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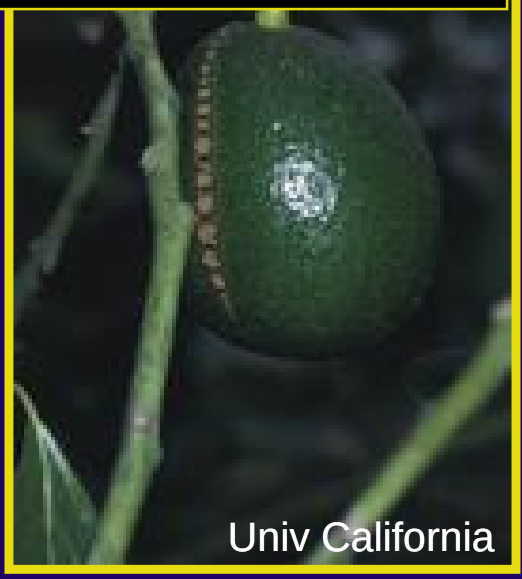
Physical abrasion – superficial resemblence to scab



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Anthracnose development associated with scab damage

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- Considerable variation in cultivar susceptibility
- Early fungicide applications are critical (vs anthracnose, SER)

The most important diseases

Sunblotch

23 July, Breakout 15: Plant health – B

Better control of avocado sunblotch disease through improved diagnostic technologies. Geering

The most important diseases

Sunblotch

•Widespread problem which decreased in importance as cause and epidemiology better understood.

The most im

Sunblotch

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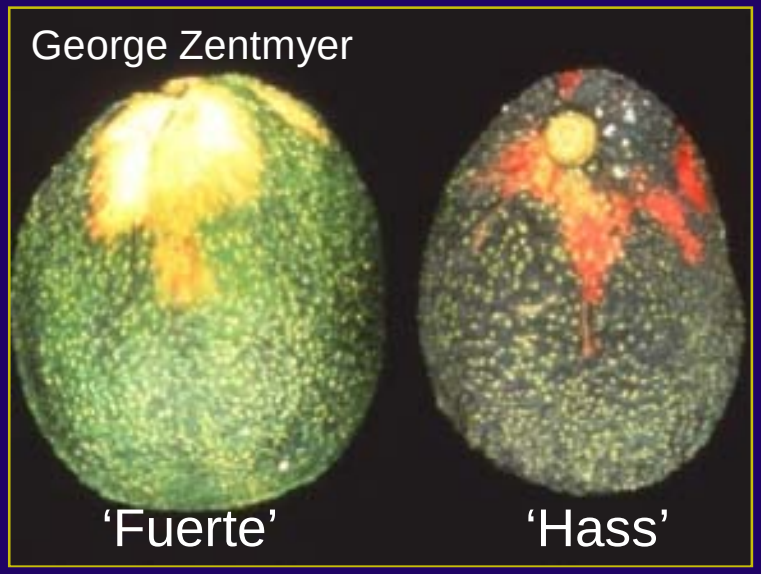

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- New trees should be established with ASBVd-free materials (ANVAS accredited nurseries)

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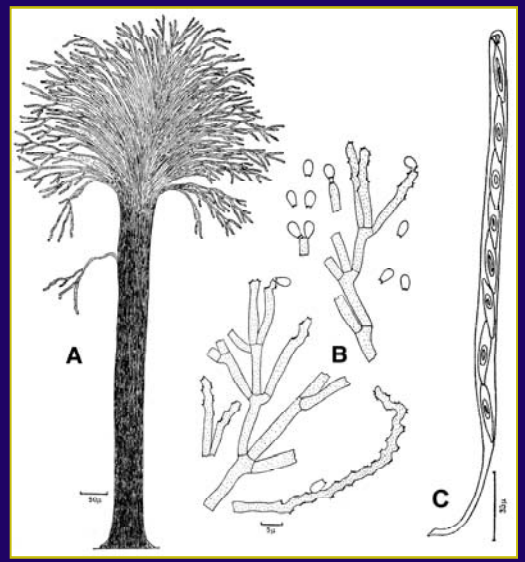

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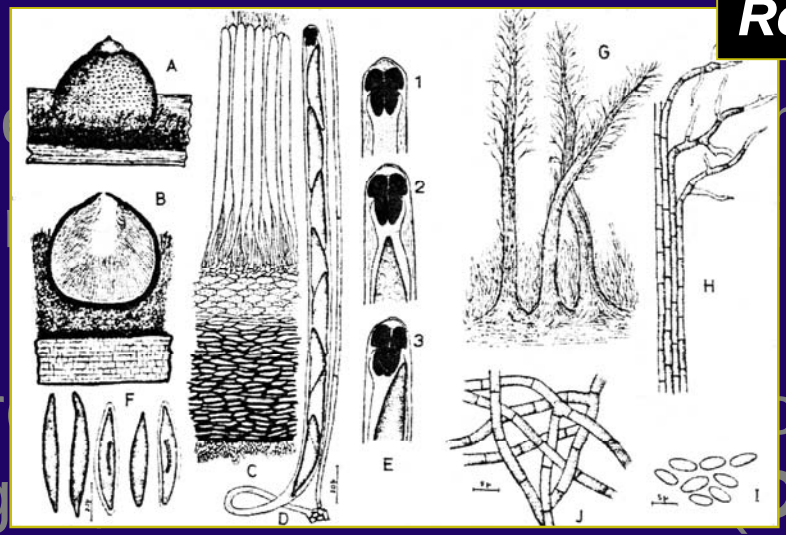

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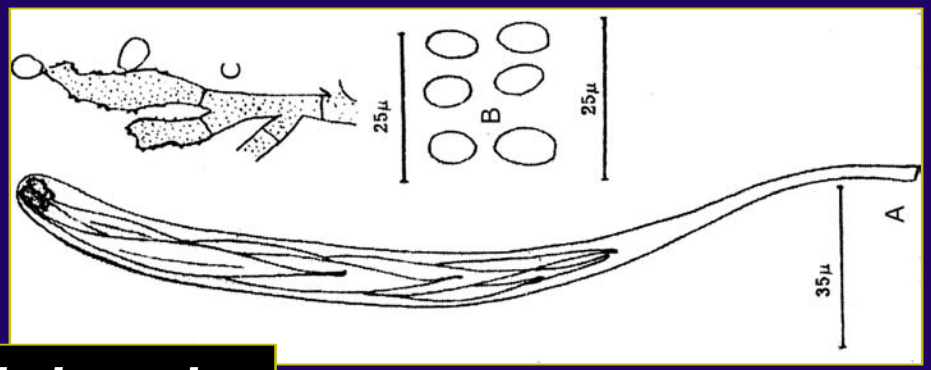

Rosellinia bunodes

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- Pathogens move via hyphae/infested host material; management requires removal of affected trees, roots

New diseases

23 July, Breakout 15: Plant health – B

- Preparing for biosecurity issues. Fraser
- Laurel wilt: A global threat to avocado production. Ploetz

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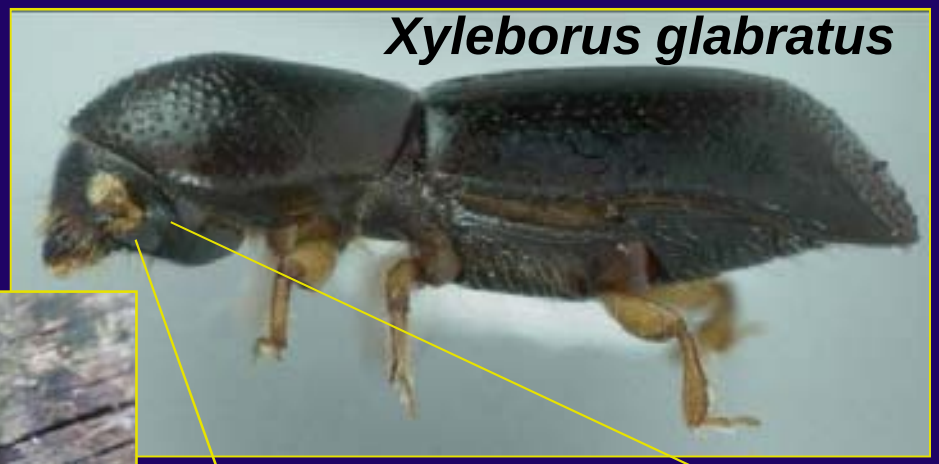
New pathogen (new encounter)

New diseases

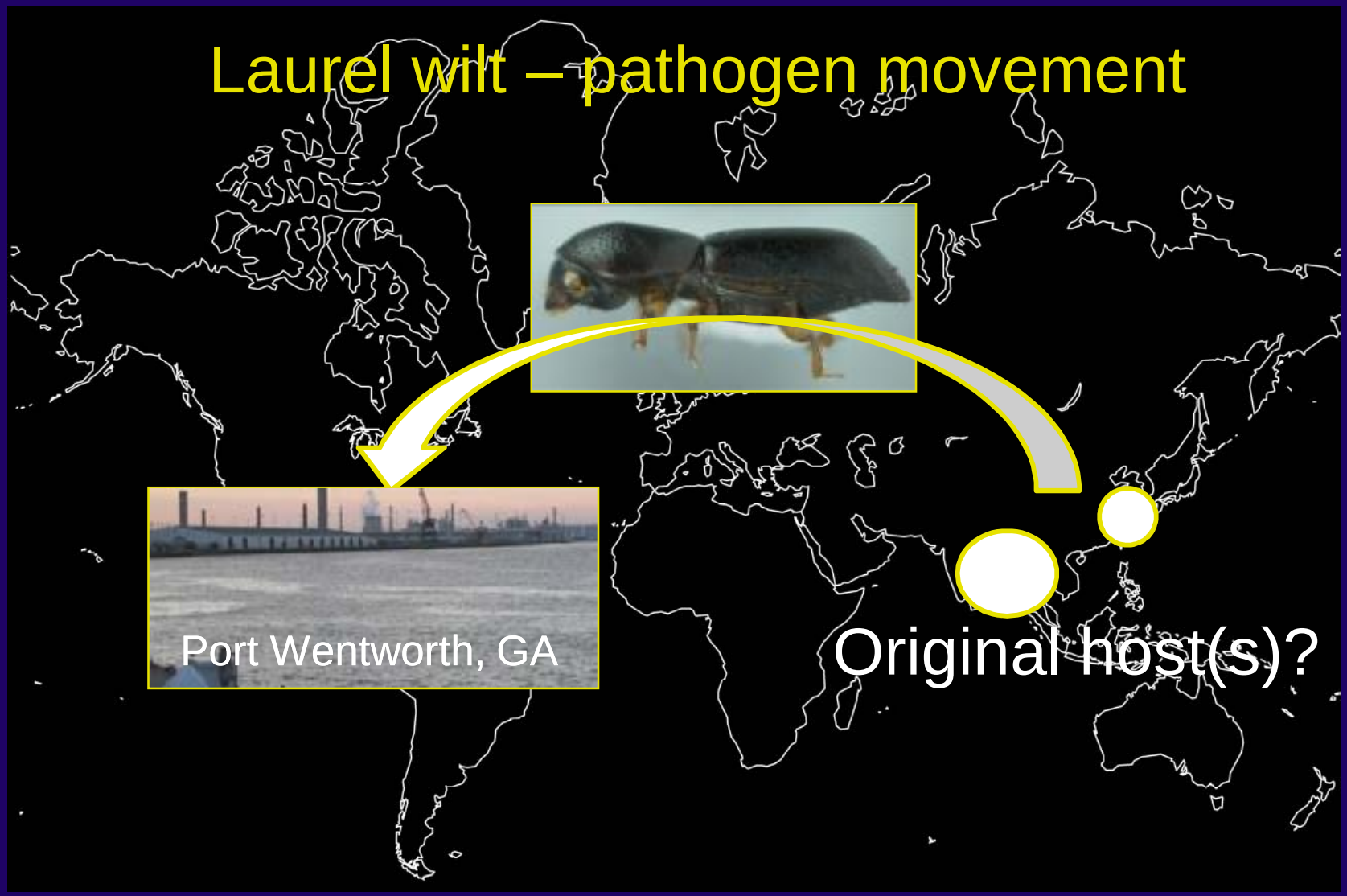
Laurel wilt
Southeast US

New diseases



mycangial x-section

New diseases



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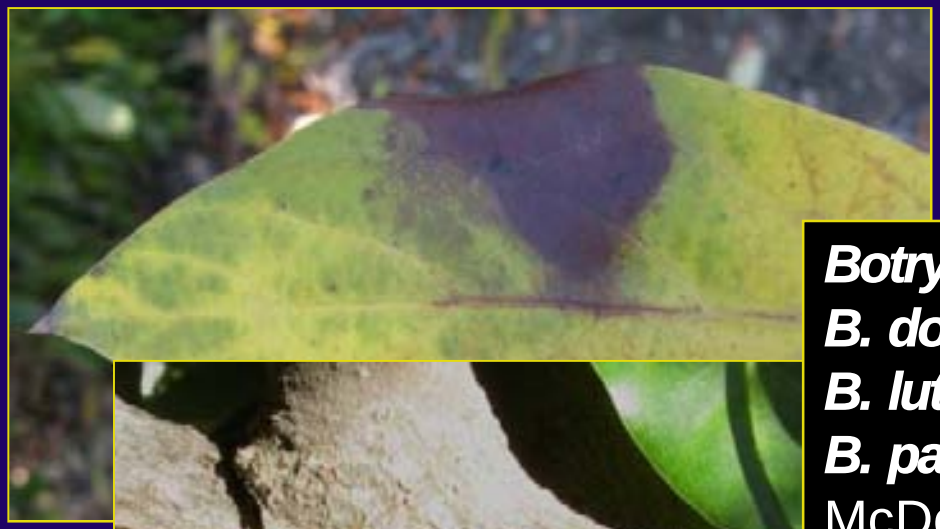
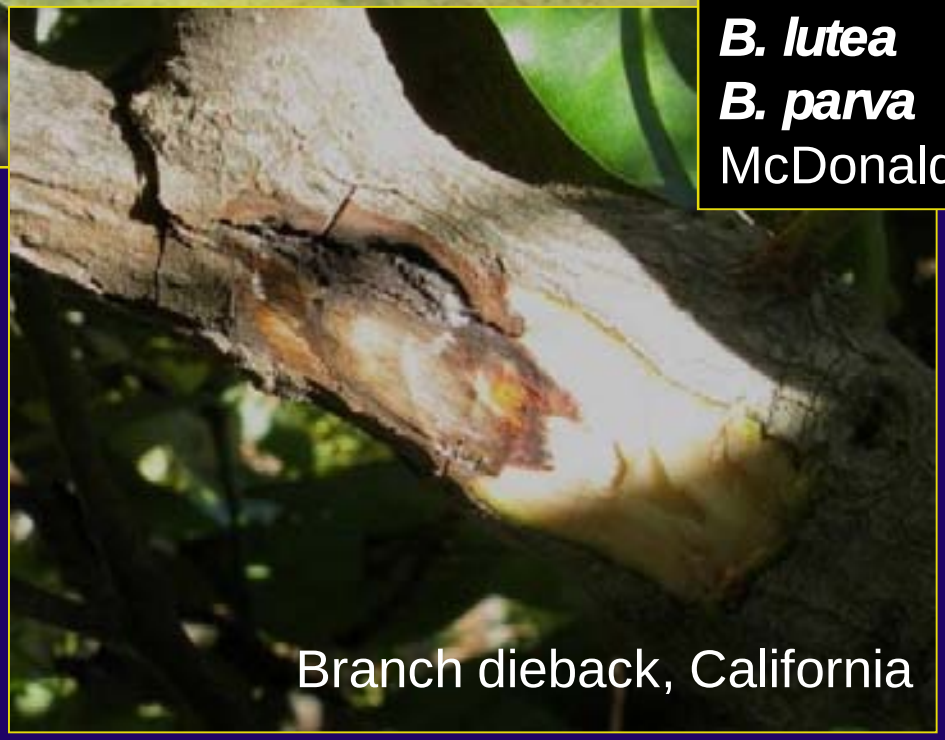
New diseases

Diseases caused by *Botryosphaeria* spp.





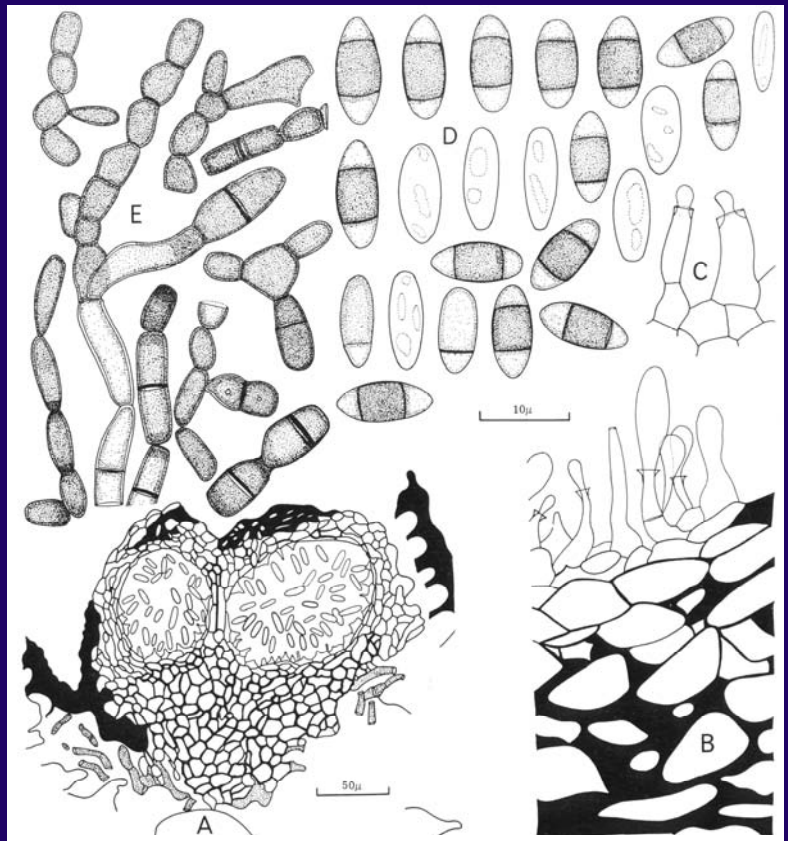
Branch dieback, California

Botryosphaeria australis
B. dothidea
B. lutea
B. parva
McDonald et al. 2009. Phytopathology 99:S81.

New diseases

Diseases caused by *Botryosphaeria* spp.

Fruit rot, Taiwan
Ni et al. 2009. Plant Disease 93:760



Neofusicoccum mangiferae

New diseases

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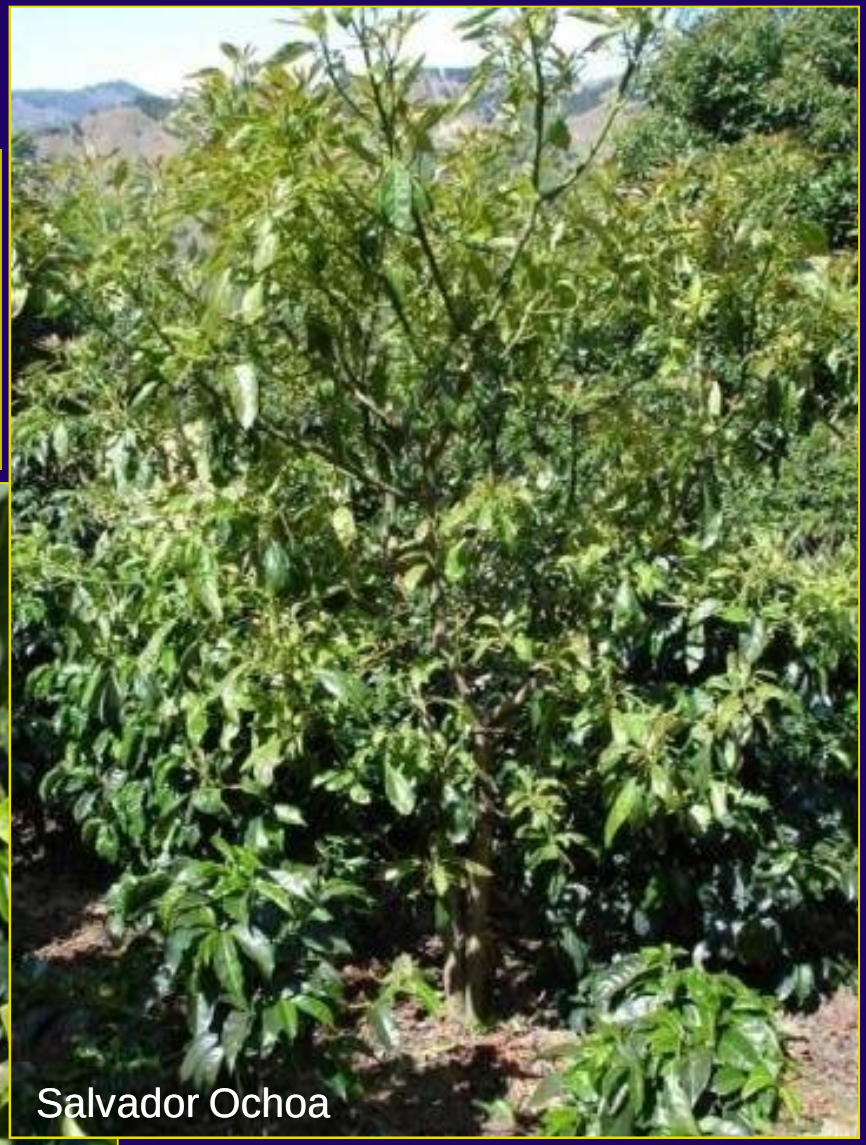
New pathogen, new encounter disease

New host, previously described pathogen

Old pathogen (new host

New diseases

Leaf scorch, distortion and defoliation
Costa Rica, ***Xylella fastidiosa***


Salvador Ochoa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New diseases

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New pathogen, new encounter disease

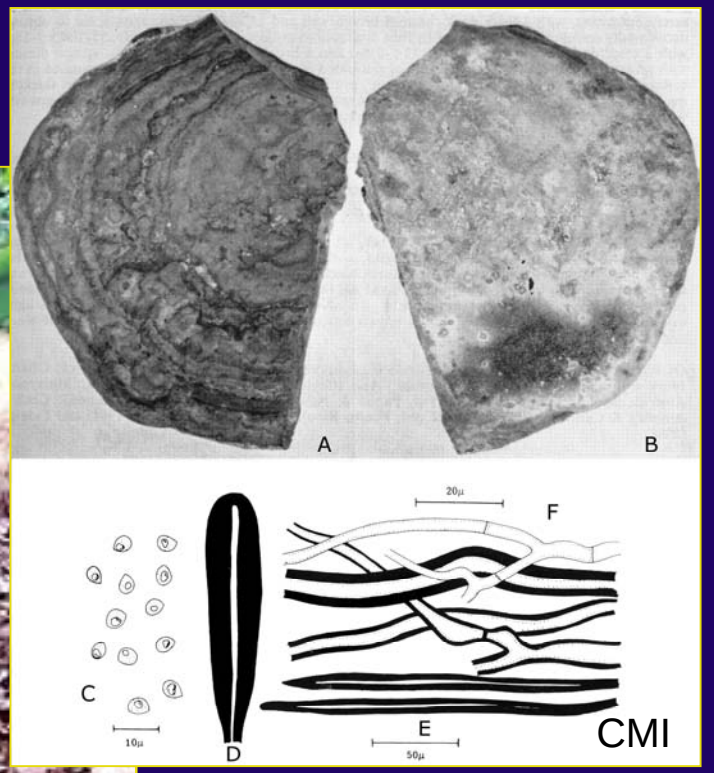
New host, previously described pathogen

Old pathogen (new host, climate change?)

New diseases

23 July, Breakout 7: Plant health - A

Phellinus noxius: brown root rot in avocado. Smith



Summary

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Of the diseases that have global distributions, PRR, anthracnose and SER have the greatest impacts

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Depending upon the location, markets and resources for management, diseases with restricted distributions can also be destructive to (e.g. Armillaria root rot, Rosellinia root rot, sunblotch)

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Depending upon the location, markets and resources for management, diseases with restricted distributions can also be destructive to (e.g. Armillaria root rot, Rosellinia root rot, sunblotch), or potentially devastate (i.e. laurel wilt), local production

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- Management

Awareness of existing diseases and the prompt diagnosis of new or unrecognized problems are essential

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Effective and economically justified measures to manage diseases depend on accurate understandings of the causes of and extent to which different diseases impact production

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- New and emerging diseases

With increased international travel and commerce, new production practices, and changing environments, new diseases will arise or emerge worldwide.

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With increased international travel and commerce, new production practices, and changing environments, new diseases will arise or emerge worldwide. Now, more than ever, effective plant health quarantines are needed.

Thank you

- **Avocados Australia and the New Zealand Avocado Growers Association**
- **The ANZAGC09 meeting organizers**

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- Florida Avocado Committee
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- USDA-APHIS

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