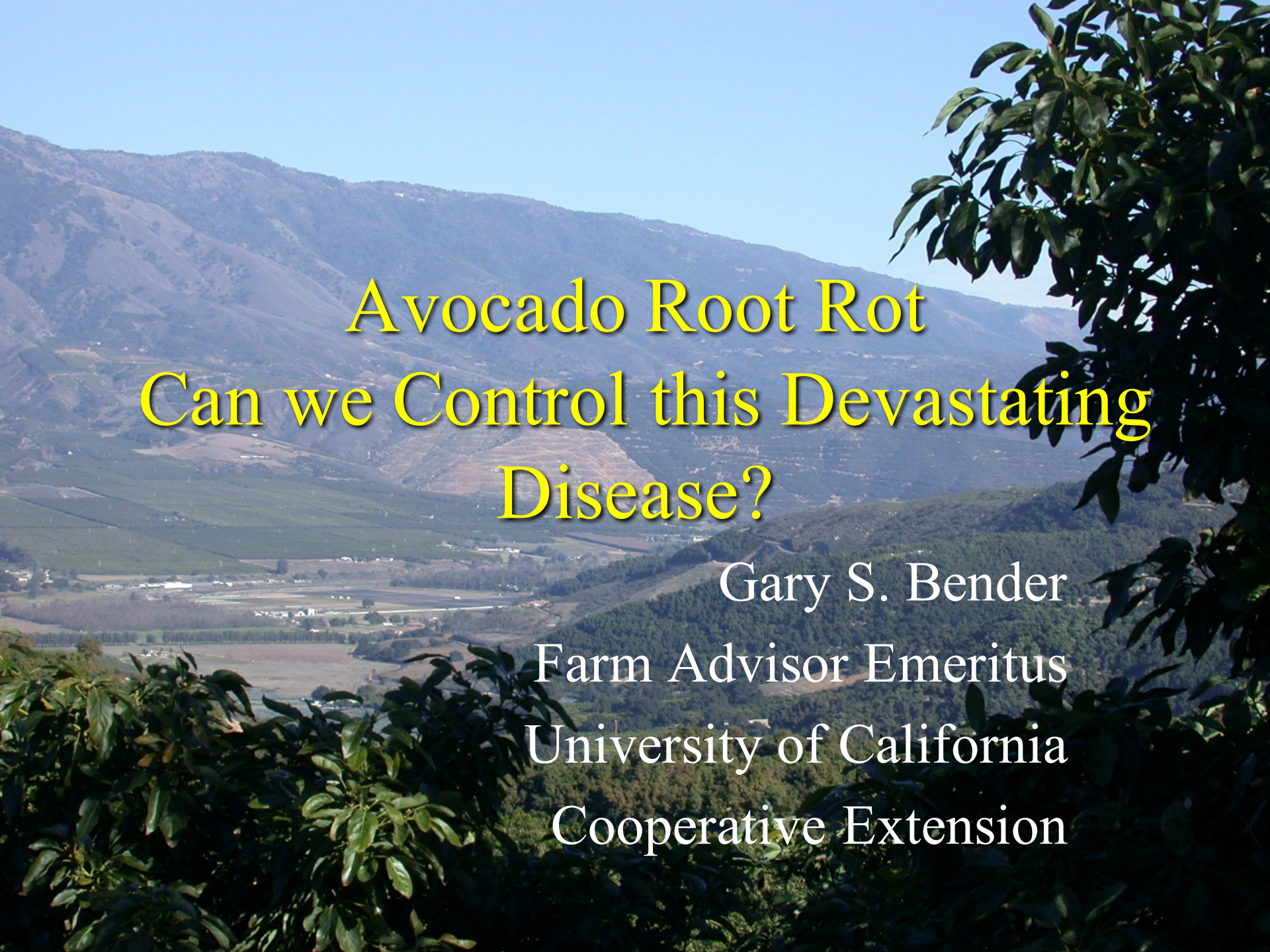

Avocado Root Rot
Can we Control this Devastating Disease?

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The Most Common Avocado Diseases in California

- Avocado Root Rot (*Phytophthora cinnamomi)*
- Avocado Trunk Canker *(Phytophthora citricola)*
- Oak Root Fungus (*Armillaria mellea)*
- Dothiorella Canker
- Black Streak
- Sun Blotch Viroid

Avocado Root Rot

A Very Important Disease

Before

After

Avocado Root Rot - Diagnosis

- Small, pale green, wilted leaves
- Sparse foliage, usually leaf drop starts at the top of the tree
- New growth absent
- Branches become sunburned

Avocado Root Rot - Diagnosis

- Leaves droop – the tree looks like it needs water
- Growers sometime make the mistake of watering more!
- Sometimes many small fruit will set but will sun-burn

Avocado Root Rot

- By far the most common avocado disease
- Found in almost all of the older avocado areas
- Fungus spreads by:
  - water flow
  - soil on shoes, shovels, bins, ladders
  - dogs and coyotes moving infected fruit around

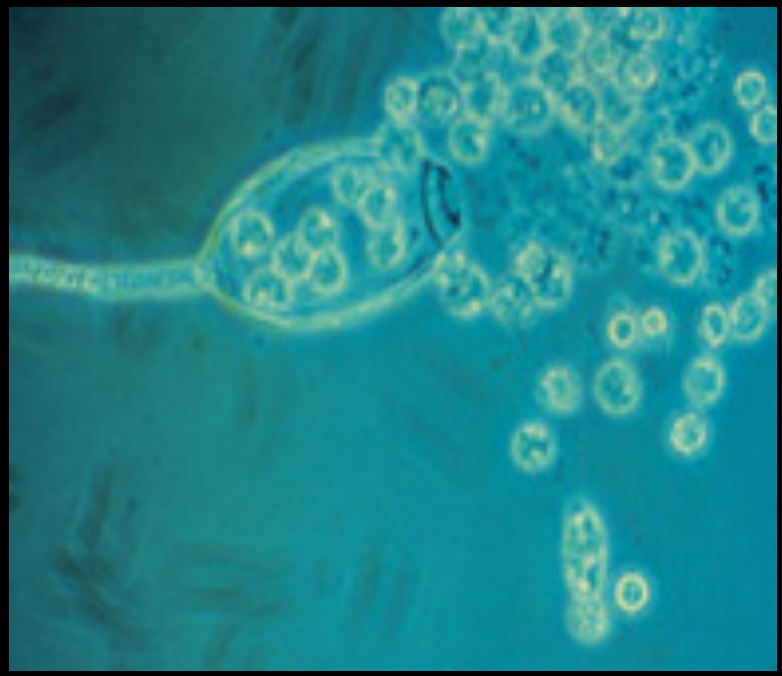
Feeder Roots

- Feeder roots became black-brown, bread with a slightly brittle snap
- Infection often begins in the root tips
- Larger roots are not infected

Root Rot Healthy

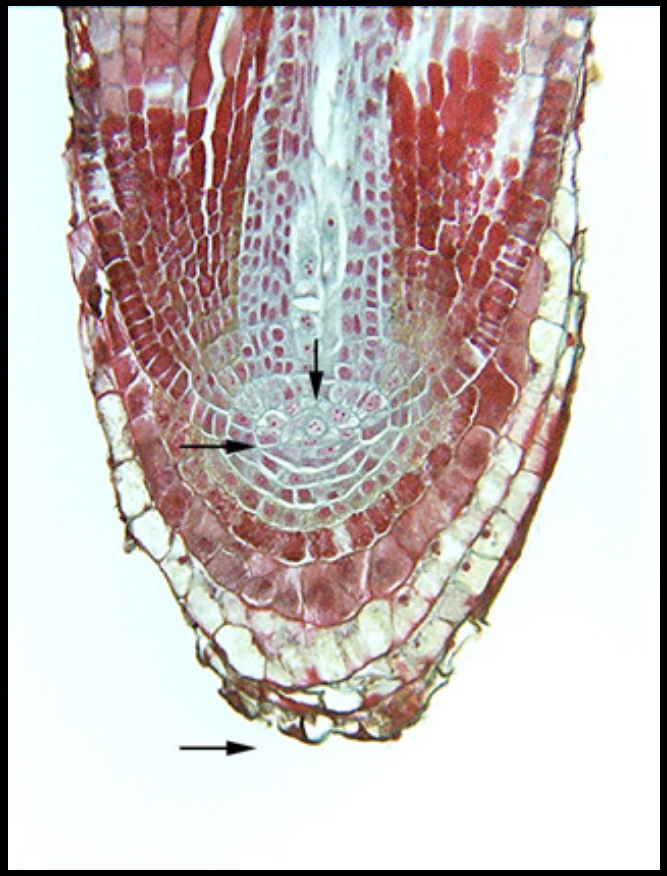
Sporangia and Zoospores

- Sporangia are formed as the soil dries
- Zoospores are released from the sporangia when the soil becomes saturated

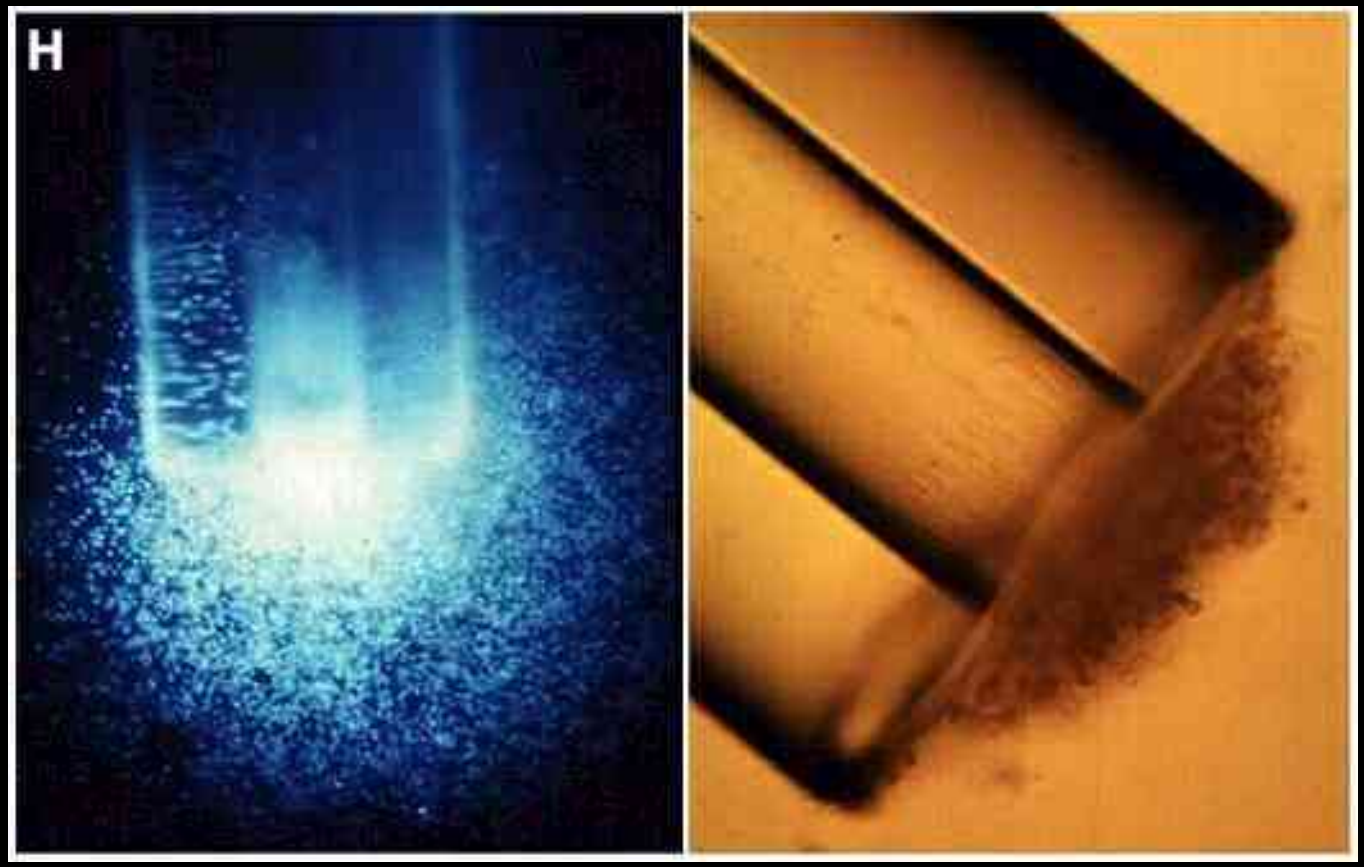


Zoospores Swim to the Root Tips

- They are attracted to carbohydrates and amino acids leaking from the thin walls



Zoospores encysting at the end of a capillary tube filled with asparagine (left) and malt extract (right).
Salt degrades the root tips allowing an increase in root exudates



Over-watering problems

- Saturated soils increase the zoospore infection and weaken the defenses of the roots
- Clay soils are worse than sandy soils
- If you have clay soils you have to mound before planting trees

This is a fungus with more than 1000 hosts

- Wide host range includes pines, eucalyptus, camellias, etc.
- Avocado grafted on Mexican seedling rootstocks are the most susceptible
- The fungus is not in the native soils or plants in California

Where did this fungus come from?

- *Phythophthora cinnamomi* is native to New Guinea
- Avocado is native to Mexico, Central America and South America
- Avocado did not evolve with this fungus
- So, there is very little natural resistance to this fungus in avocado.

Control of Phytophthora

- Sanitation
- Clean Nursery Stock
- Planting in Mounds
- Irrigation Management
- Mulches
- Gypsum
- Chemicals
- Rootstocks

Don’t Forget!

- The easiest thing to do is replant to a non-host, such as citrus or cherimoya
- But most avocado growers don’t want to do this

Sanitation Comes First

- Fungus can spread on everything! (contaminated nursery stock, water in contact with infested soil including reservoirs,. Fungus can spread on anything that moves soil, including horse hooves, ladders, boxes and bins, shoes and cultivation equipment).

Irrigation Management

- Careful irrigation,
- Do not over-water
- Sick trees should be on a different irrigation block, or have sprinklers with less output until trees recover

Methods of Moving *Phytophthora*

- Zoospores in Irrigation Water

Methods of Moving *Phytophthora*

- Soil on Bins and Ladders (are these grooves necessary?)

Methods of Moving *Phytophthora*

Boots

Methods of Moving *Phytophthora*

- Infected nursery trees (Beware of ‘good deals’ or ‘close-out’ prices)

Planting and Re-planting

- Use only clean nursery stock. Inspect the roots for black, brittle roots at the bottom of the root ball before the trees are planted.
- In California, the nurseries appear to be clean at this time, but this wasn't always the case!

Planting in Mounds

Mulch Treatment

- Mulch heavily with wood chip-based greenwaste mulch. Keep it 8 inches away from trunk. Mulch can be up to 4 inches deep under the tree. 100% manures are ineffective at control of the fungus.
- Fungi breaking down wood chip mulches produce cellulase enzymes. These enzyme also break down the cell walls of Phythophthora, killing the fungus.


Fungal cellulase production is antagonistic to *Phytophthora*

Mulch has Other Benefits

- Composted organic yard waste
  - Root rot control
  - Water retention
  - Improved soil fertility
  - Weed suppression
  - Improved plant growth

Gypsum (or another Calcium material)

- Apply gypsum under the mulch, 25 lbs per large mature tree. This supplies calcium with reduces the ability of the fungus to form sporangia
- Calcium is a type of mild fungicide.

Chemical Treatment

- For mature trees that are diseased, the best treatment appears to be trunk injection with a registered fungicidal buffered phosphorous acid, or a phosphorous acid registered as a fertilizer
- Trunk injection is effective because the root system is not healthy enough to take up the chemical

Phosphorous Acid or Phosphonate

- Phosphorous acid injection works!, but doesn't eradicate the fungus.
- Buffered material is preferred, (0-28-25)
- Acid form is 0-60-0, severe damage to bark
- Australian recommendation: multiply tree canopy diameter (in meters) by 15 to obtain total amount of 20% phosphonate product to inject 4m x 15 = 60ml of 20% phosphonate

Drilling the Holes

Phosphorous Acid 0-60-0, unbuffered

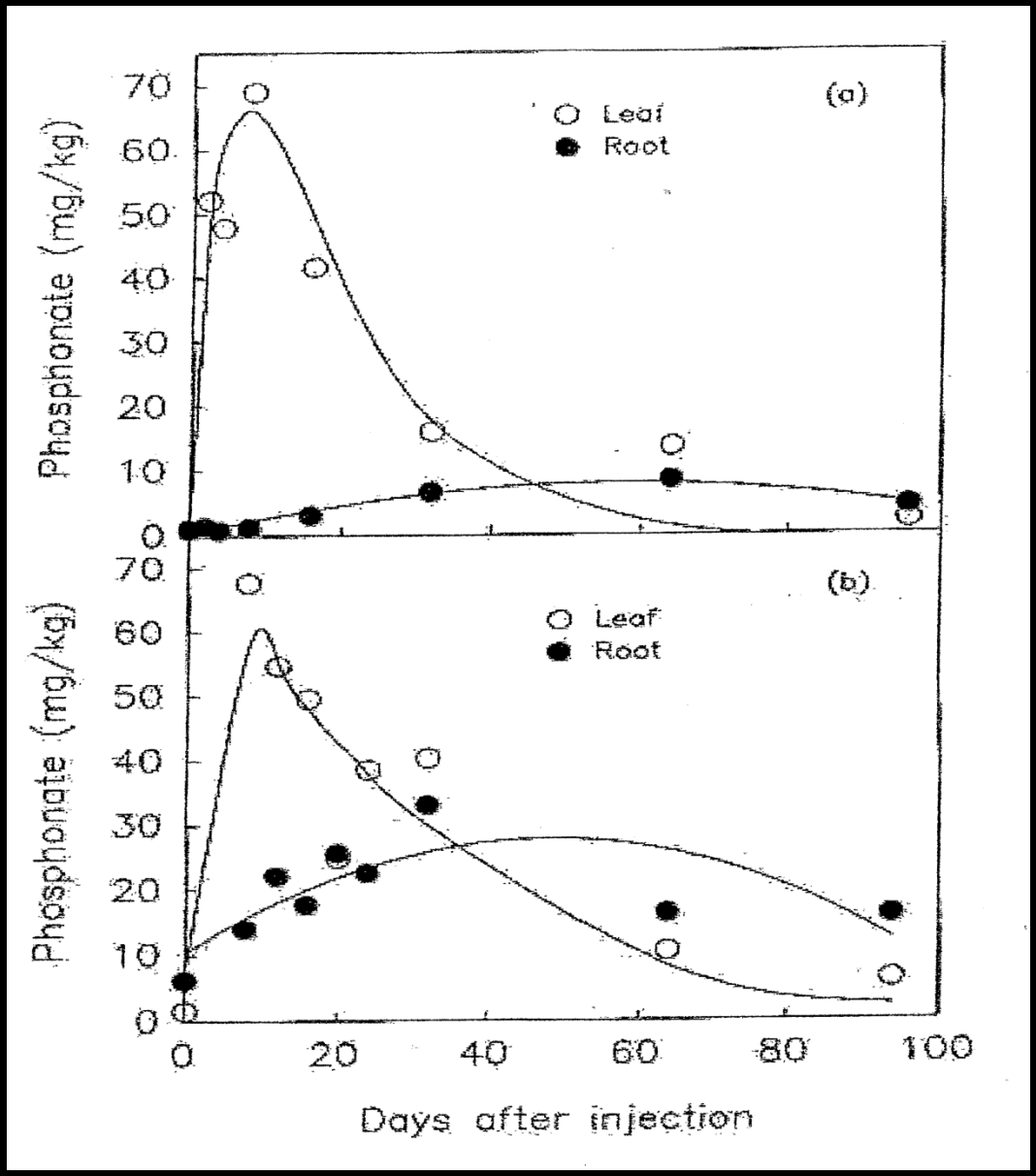
- Damaged trunk

Phosphorous Acid, 0-27-25, buffered

Less trunk damage, uses twice as much product (compared to 0-60-0)

Roots one year after phos acid injection

Roots from non-injected tree, same disease rating at start of trial


Phosphonate (mg/kg)
70
60
50
40
30
20
10
0
Leaf
Root
(a)
(b)
0
20
40
60
80
100
Days after injection

Phosphorous Acid

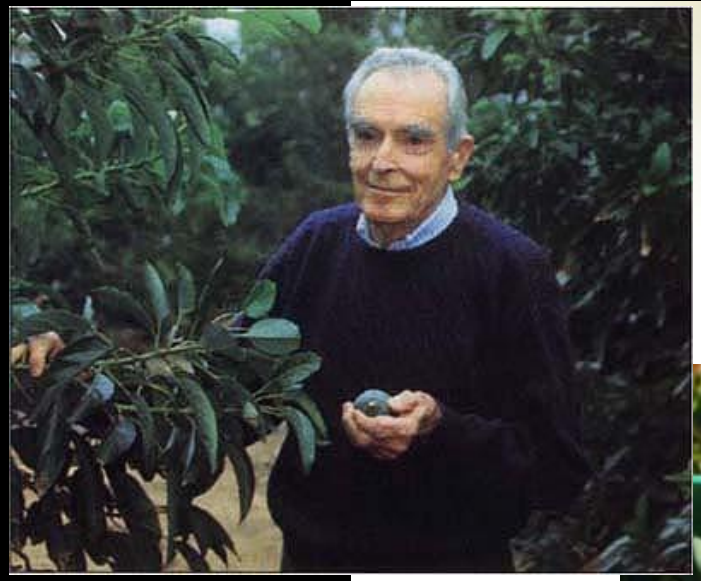
- Registered in California as a fertilizer
- Often confused with phosphoric acid, also registered as a fertilizer but this has no activity as an anti-fungal chemical
- Stimulates a defense response in the tree, e.g. tree produces it's own anti-fungal chemicals in response to the injection of phos acid
- Possibly stimulates the salicylic acid pathway
- All brands on the market work equally well

What about Healthy Trees near Root Rot Trees?

- For areas that could be threatened by the fungus, soil treatments with registered fertilizer-type buffered or non-buffered phosphorous acids appears to be beneficial
- In California we use 1-2 gallons/acre twice a year (May-June and September)

Rootstocks with Resistance to Root Rot

- Research started in 1948 with work by Dr. George Zentmyer at University of California, Riverside. The work continued under Dr. Michael Coffey, Dr. John Menge, Dr. Greg Douhan, and now Dr..
- The first clonal rootstock was Duke 7, followed by others such as Toro Canyon, D9, G755, Thomas, Uzi, Zentmyer, Steddom



Zentmyer

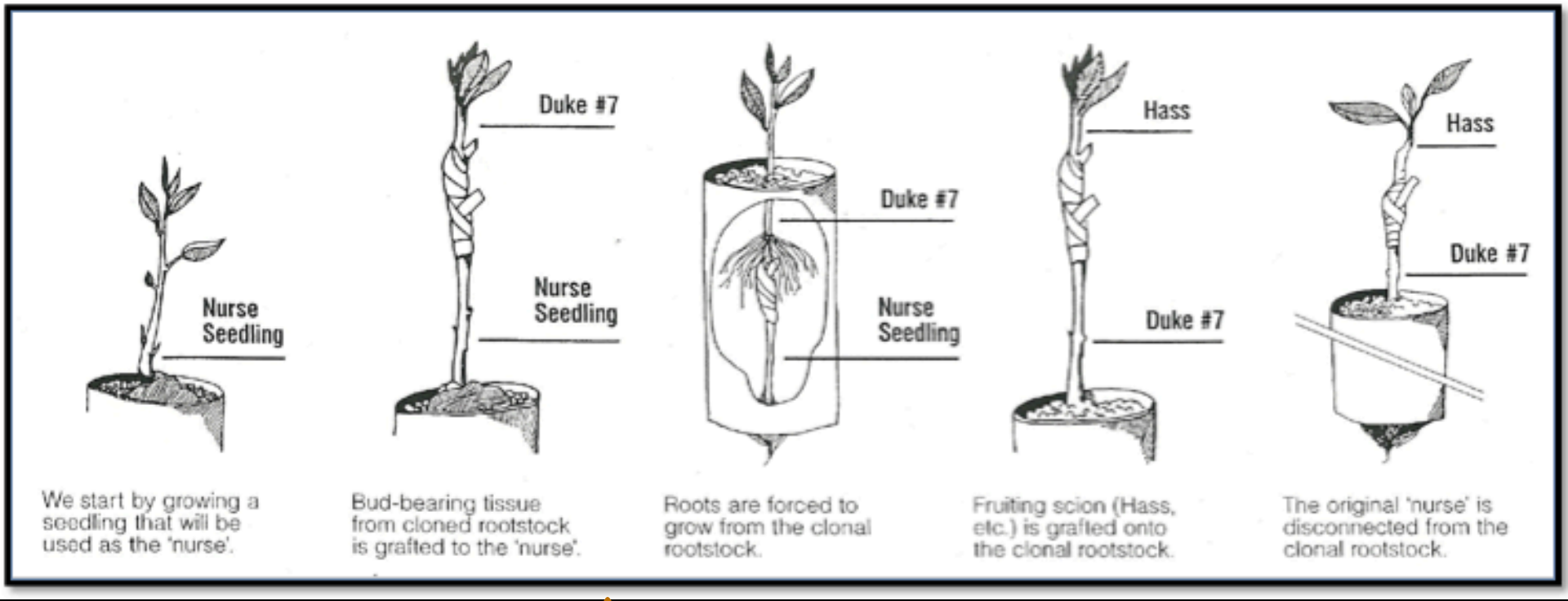
Manosalvo

Douhan

Menge

Rootstock Research in South Africa

- ‘Dusa’ rootstock was developed in South Africa
- ‘Dusa’ is currently the most popular in California with over 700,000 sold since 2001
- ‘Dusa’ has shown the best Phytophthora tolerance along with some salt tolerance.



Dark for 10 days

Clonal Rootstock Trial in Escondido, San Diego County
Heavy Disease Pressure, 5 year old trial
May, 2006

Rootstock	Total fruit weight (lb)	Individual fruit weight (lb)
Dusa	117.0 a	0.40 a
Zentmyer	113.8 a	0.48 a
Latas	111.0 a	0.51 a
Uzi	96.1 a	0.42 a
Steddom	90.2 a	0.44 a
VC 241	61.5 a	0.44 a

Table 2. Four-year-old drought-stressed field plot in Phytophthora-infested soil in Carpinteria CA, 2003 [1]

Rootstock	Tree rating (0-5; 5=dead)	Canopy vol (cu ft)	Trunk diam (cm)	Fruit set	Canker	Salt Burn	Dead trees (%)
				(0-5; 5=heavy)			
Uzi	0.72 f	167.5 a	6.51 a	3.25 a	0.85 c	2.15 a	6
Zentmyer	1.06 ef	140.0 ab	6.31 a	3.28 a	0.58 c	1.44 ab	0
Merensky II	1.50 def	104.5 bc	5.36 ab	2.63 abc	0.76 c	0.85 b	11
Merensky III	1.71 de	74.4 cde	4.86 bc	1.53 c	1.27 c	0.63 b	11
Merensky I	2.13 cd	72.5 cde	4.83 bc	2.71 ab	1.72 bc	0.63 b	16
Thomas	2.63 bc	77.7 cd	4.12 bcd	2.37 abc	1.12 c	2.12 a	32
McKee	3.29 b	50.2 de	2.85 d	1.61 bc	1.56 bc	1.78 a	53
Merensky IV	3.42 b	36.8 ef	3.47 cd	1.53 c	1.46 bc	0.58 b	32
Aquacate	4.92 a	1.6 f	0.52 e	0.00 d	3.00 ab	0.67 b	84
PolyN	4.95 a	0.7 f	0.34 e	0.00 d	4.50 a	2.00 a	95

[1] Mean values in each column followed by identical letters are not statistically different according to Waller's k-ratio t test.

Have we got the perfect rootstock yet? No!

- So, do your best to keep root rot out of your grove!

Some Other Diseases

Avocado Sunblotch (sunken yellow lesions)

Other symptoms: stunted weeping growth, crocodile bark, yellow streaking on young branches. Symptoms will often appear after stress, topworking or freeze damage.

In severe cases, no or little fruit production

Spread by infected graft wood, infected rootstocks, root grafting, pollen, and possibly pruning.

Sunblotch


UC Statewide IPM Program
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Sunblotch

- Sunblotch is caused by a small circular strand of RNA without a protein coat (a "naked" virus)
- Tree removal is recommended because it can spread by root grafting and pollen (to the seed in the fruit of a neighboring tree).
- Sterilize pruning tools and harvesting clippers between trees.

What can you do about Sunblotch?

- Remove the infected trees, there is no cure
- Make sure the nurseries are not using budwood and seeds from non-infected trees.

Dothiorella Canker

- Cause: fungus *Dothiorella gregaria,* same fungus that causes fruit rot
- Symptoms: white powder that exudes from the bark and cracking and shedding of the outer bark
- Symptoms disappear after problem corrected

Dothiorella Canker

- Disease favored by moisture, keep leaves and debris away from lower trunk, especially if the bud-union is buried
- Guatemalan varieties are most susceptible
- The graft union Hass/Dusa is very susceptible
- We are finding this disease is caused by several species of *Botrysphaeria*

Avocado Bacterial Canker

Xanthomonas campestris

Water/Salt related stress

Can often be corrected by simply correcting irrigation distribution

Pocket of fluid builds up under the white exudate. When dried up there is a little flap of bark left.

Trunk Canker caused by *Phytophthora mengii*

- Second most important disease in coastal CA
- Fungus has a wide host range: walnut, cherry, cherimoya, fir
- Occurs on the base of the trunk

Trunk Canker caused by *Phytophthora mengii*

- Red resinous exudation, when dried will turn into a white crystalline deposit
- Beneath the exudation, (when cut with a knife) lesion will be orange-tan to brown
- Fungus will grow around the tree in the phloem and cambium and will ring-bark the tree
- Tree death can be very slow
- Phos acid trunk sprays frequently corrects

Fusarium Dieback
Pest/Disease Complex
Slow dieback of canopy
Localized to Southern California and Israel

Polyphagous shot hole borer

Apparently native to Vietnam and Taiwan

An Ecological Disaster Coming our Way – The Situation in Florida

6 months from infection to collapse

Strings of compacted ambrosia beetle sawdust

Laurel Wilt Disease
Raffaelea lauricola fungus

spread by
Redbay Ambrosia Beetle
Xyleborus glabratus

Pest-Disease Complex

Ambrosia Beetles (>34,000 species world-wide)
order: Coleoptera
Usually bore into dead trees
Characterized by boring into trees and forming galleries in the sapwood.
Beetle carries the fungus which digests the wood disrupting the flow of water and nutrients
The adult and larvae feed on the mycelium and spore clusters of the fungus
Typically attack trees under stress (e.g. drought)
It only takes one beetle to cause the infection
Arrived in commercial orchards – Miami, 2012

Be diligent and do "Good Farming Practices"
Thank you for your attention

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