Citrus root distribution as related to initial planting, nutrition, and soil pH

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TREE PLANTING

Careful planning to protect your investment

- Trees are unable to withstand stresses that were previously minor
- Root establishment has become more important
  - Sustain trees and to get to production and profit
- Choices about grove and planting design may affect root architecture
  - What we see above ground affects below the ground too
- Irrigation methods and timings also affect root health

Site characteristics

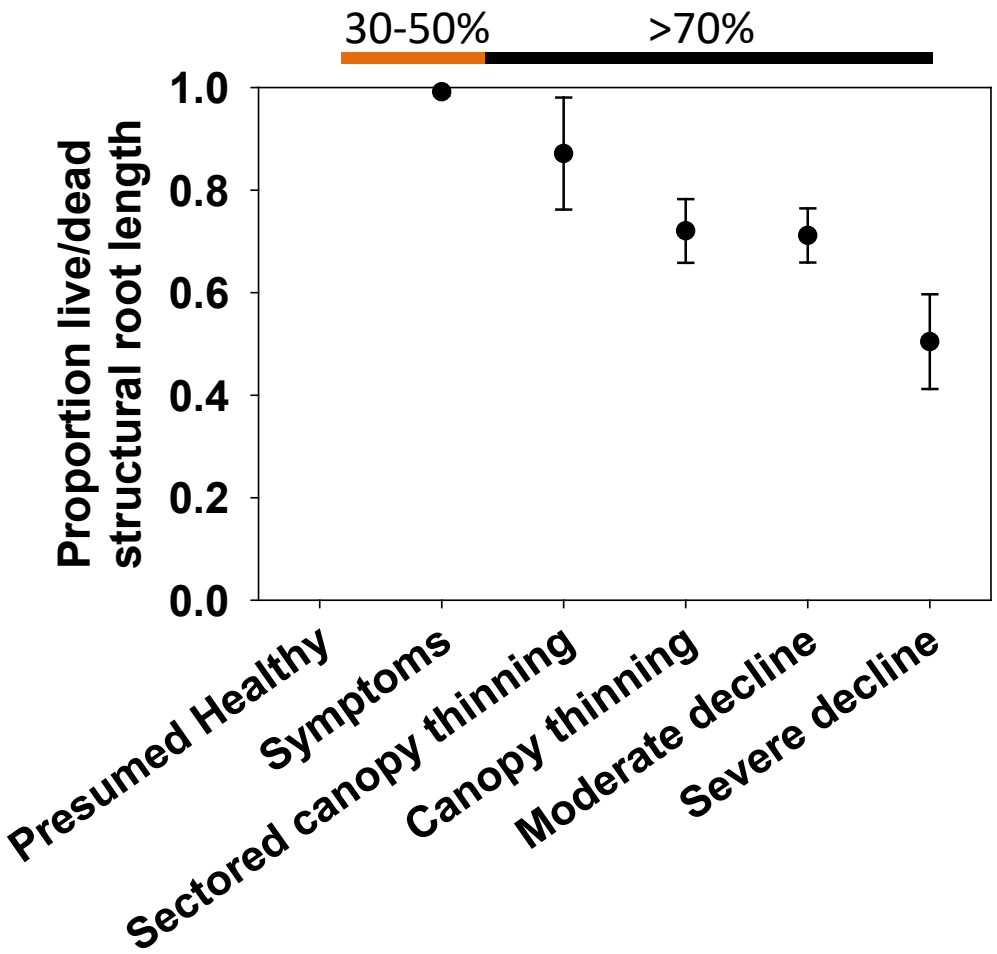
- Soil type and water table
  - Does the grove need bedding or not
  - How is the drainage of the soil?
  - Is there a clay pan leading to water-logging of trees?
- pH and salinity characteristics of soil
  - What rootstocks are known to tolerate specific conditions?
- Irrigation water quality
  - Bicarbonate concentration
- Disease and pest history of site
  - Blight, phytophthora, diaprepes, nematodes?
  - Which rootstocks have tolerance and under what conditions

Rootstock selection guide

- Need to carefully consider rootstock choice before ordering trees
  - Some tolerate adverse conditions better than others
  - Not all rootstocks are suitable for all situations
- Guide is great place to find information in one location
- https://crec.ifas.ufl.edu/extension/citrus_rootstock/index.html

HLB Structural root loss

Fibrous root loss



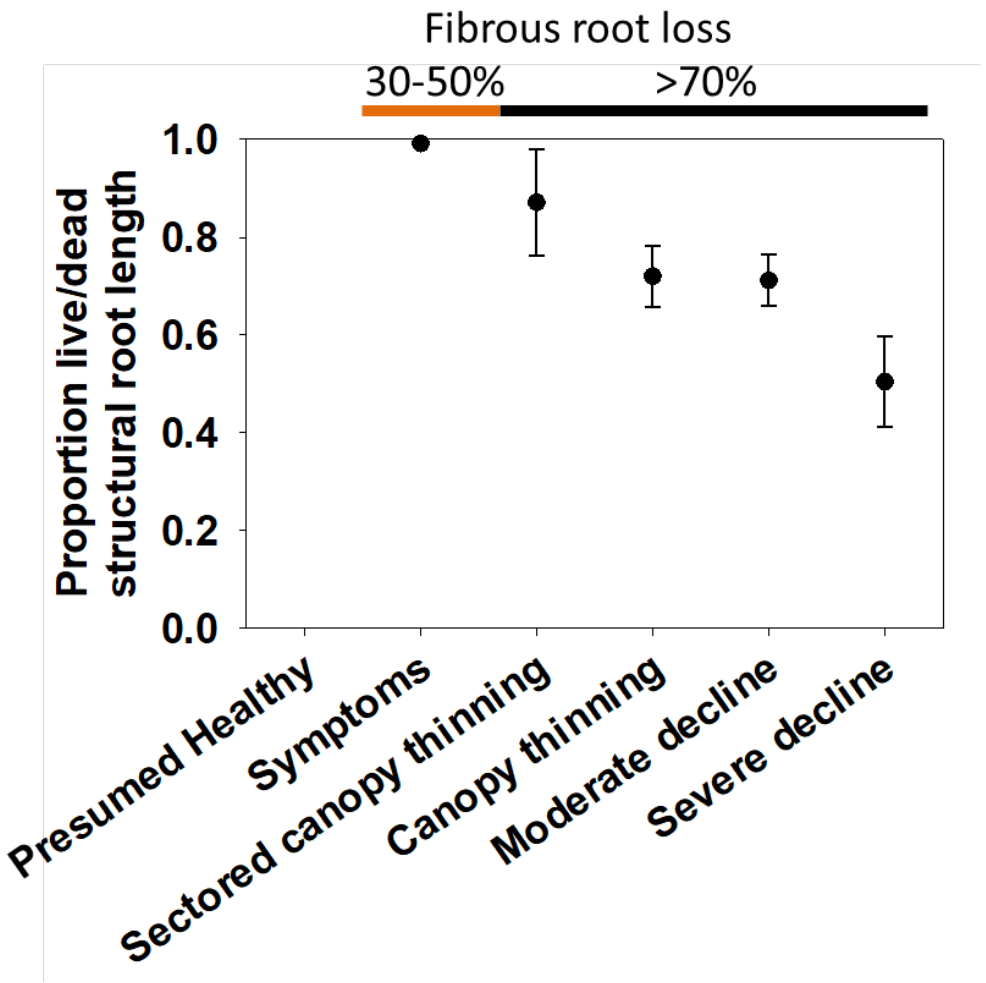
Ridge root system

30-50% root loss

>70% root loss

What does structural root loss mean for new plantings?

- Structural root system is the largest it will ever be when trees become infected
  - Timing in young trees not fully investigated
  - Structural root dieback will counteract any new growth
  - Could be cause of HLB dwarfing
- Trees need a robust established structural root system before infection
- Need optimal root health and growth from day of planting to establish structural roots



Preventable problems

- Not managing root balls of rootbound trees
- Don’t let the roots dry out
- Don’t jam trees into planting hole
  - Can lead to J-rooting if lower structural roots are bent upward
- Be careful of salt burn when fertilizing
  - Fertilizer in the planting hole will prevent outward root growth and is likely to cause salt burn of roots.
  - Can be as damaging as Phytophthora
- Phytophthora can stunt young trees
  - Monitor and treat as needed to get the best start

Planting and rootbound trees

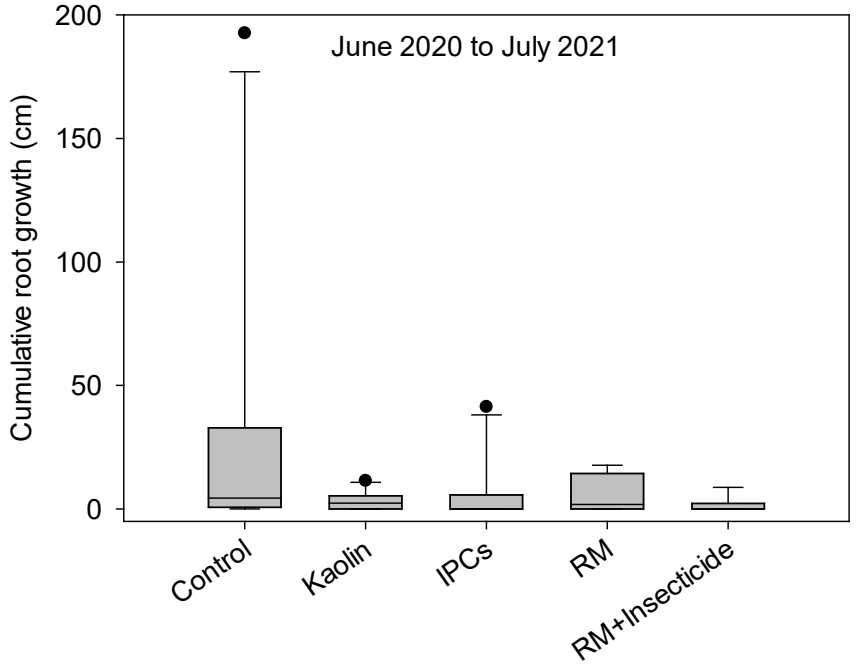
- Some growers desire larger trees at planting
  - Only helps if the root system is allowed to get larger
  - Waiting for too large a tree may cause root health problems in a few years
- Need to break up root balls at planting
  - Helps establishment and water penetration even in non-rootbound trees
    - Water does not like to move between sand and organic potting medium
  - Gives you a chance to cull trees with unhealthy root systems
- May need to trim off spiraling roots at bottom of root ball
  - More drastic cutting, up to ½” of root ball may be needed

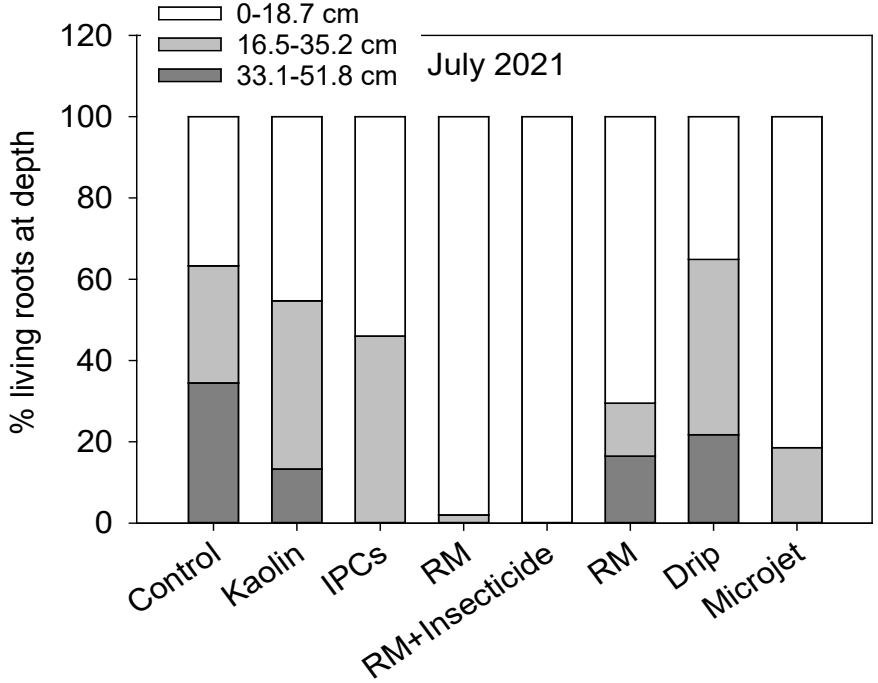
Rootbound trees develop circular structural roots

Rootbound --> Self girdling structural root ball

Planting choices affect root growth

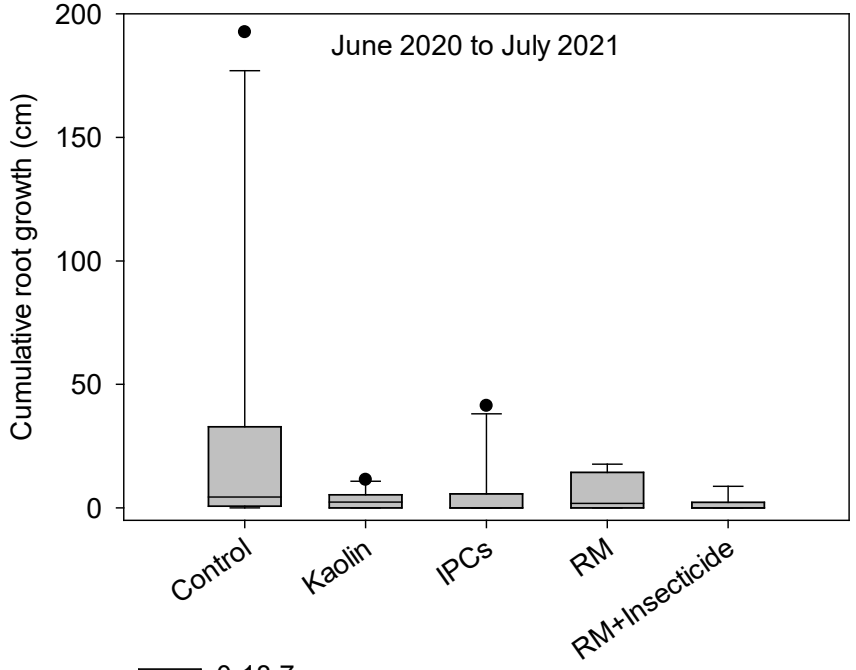
- Different grove establishment practices can change root growth patterns
- Compared in trial:
  1) Current planting practices (microjet)
  2) Kaolin applications (microjet)
  3) Individual tree covers (IPC; microjet)
  4) Reflective mulch alone (drip)
  5) Reflective mulch and insecticide (drip)
- All treatments had the same fertilization

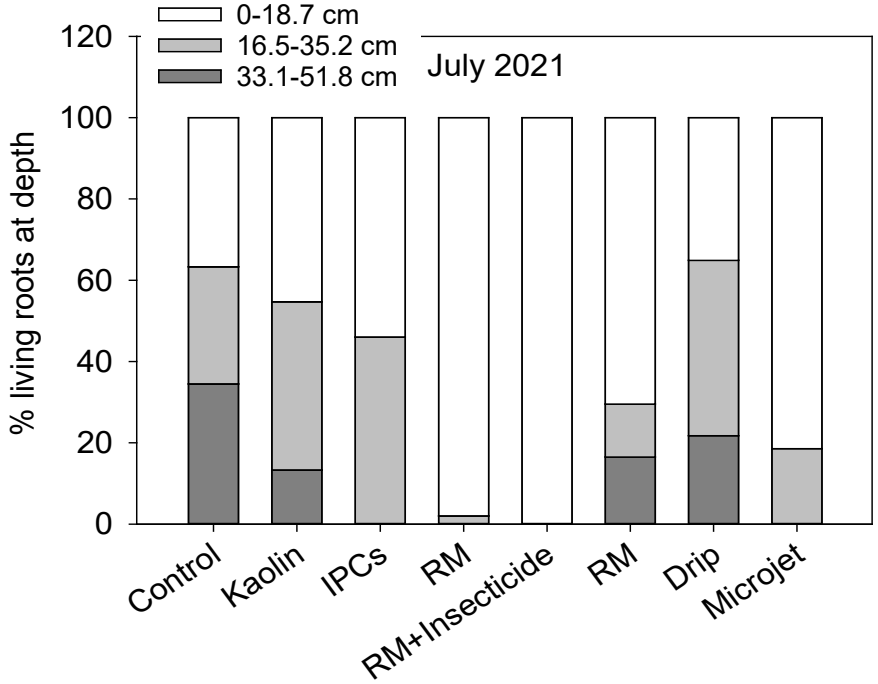




Planting choices affect root growth cont.

- One year of data
- Current planting practices with microjets had the greatest root growth
  - More trees with many living roots over time
  - Roots were found in equal numbers at all depths
- Reflective mulch with drip irrigation caused roots to be more shallow
- Kaolin applications and IPCs with microjets had more shallow roots than current practices
  - Is this because of canopy shading?





Summary

- Planting practices affect the success of trees in the field
  - Roots are often forgotten because not easily observed
- Healthy nursery trees are the foundation of a good planting
  - Make sure planters are inspecting the roots before planting
  - Eliminate poor quality root systems or take remedial actions
- Make sure planting holes are adequately sized for root systems
  - Break up the root balls for better soil to potting media contact
  - Encourage the roots to leave the root ball
  - Avoid fertilizer burn! It can permanently damage a tree

PHYTOPHTHORA AND NEW PLANTINGS

Effect of Phytophthora 2 years after planting

Photos courtesy of Jim Graham

- Greatly reduces tree vigor
- Chemical management can provide some improvement
- Best to start with clean trees

Check root health before planting

Root damage up close

- Sparse roots
- Dark unhealthy color
  - Should be creamy white to tan
- Sloughing-off of outer cortex
  - Roots will disintegrate upon slight tug
  - Leave inner vascular tissue known as the steele
- Hopefully never observed

Phytophthora prevention at planting

- Avoid highly susceptible rootstocks in sites with phytophthora history
  - Plant graft union 6-9 inches above soil
- Adequate drainage and proper irrigation are essential
- Keep area around trunk clear of weeds and avoid wounding
- Remove trunk wraps early in spring and treat for fire ants
  - Fire ants feed on and damage bark

Fungicide use in young trees

- Warranted only if cultural practices fail
- Treatment decision based on:
  - Rootstock susceptibility
  - Likelihood of nursery infection
    - What did you see when you looked at the roots?
  - Site history, e.g. Diaprepes, root rot
  - May want to request nursery treatment with Revus (labelled for nursery use)
- See Florida Citrus Production Guide for treatment options

Summary

- Phytophthora infection in newly planted trees can lead to severe stunting
  - Trees never thrive or produce adequate fruit
- Trees exhibiting phytophthora damage should not be planted
- Cultural practices are the first line of defense against disease
- Fungicides should only be used when all other measures have failed

PHYTOPHTHORA DISEASES

Phytophthora diseases

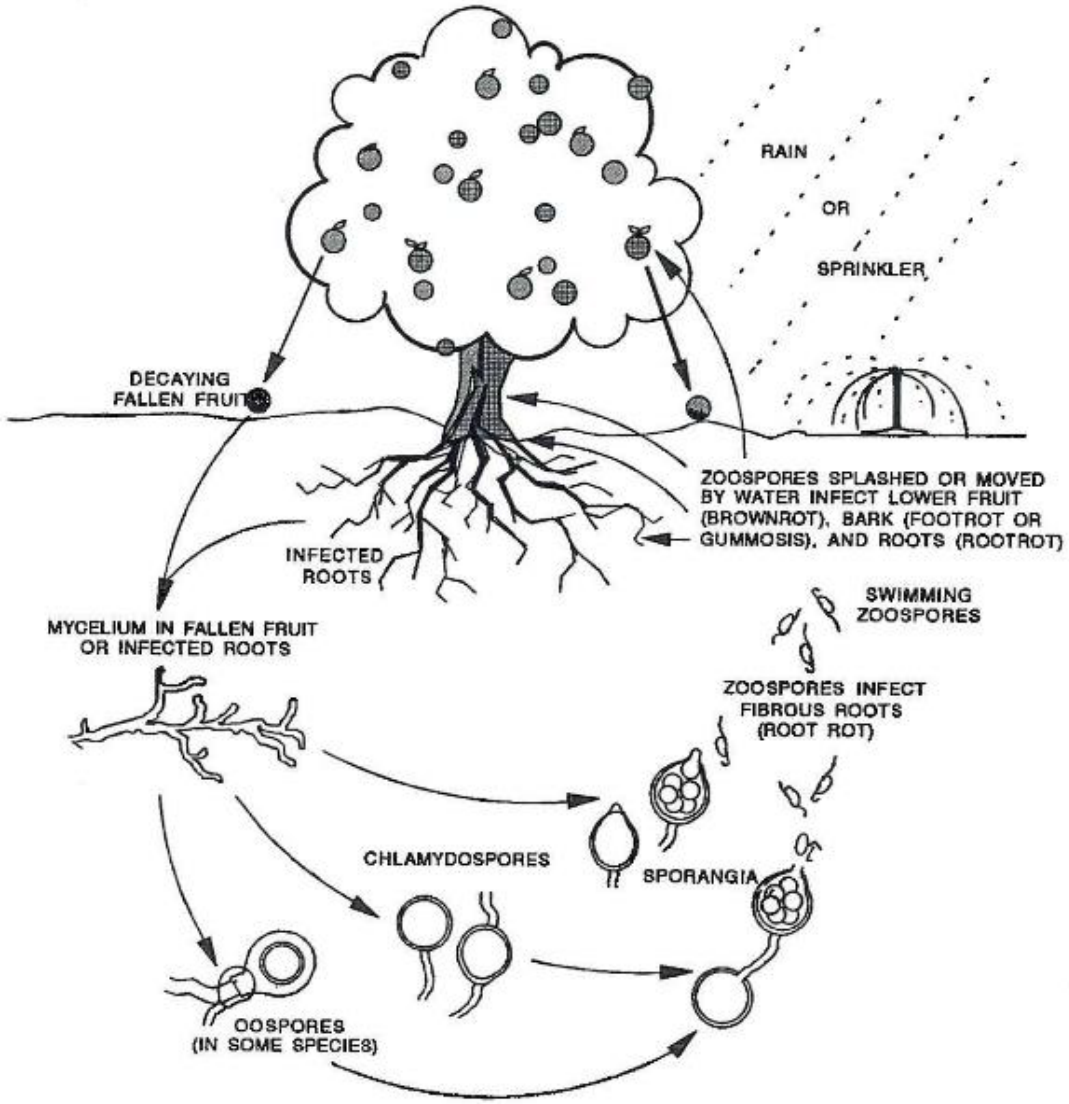
- Soilborne disease that can travel into canopy

- Causal agents of
  - Root Rot
  - Foot Rot
  - Brown rot of fruit

- Yield reduction estimate
  = 3-6% per year

All diseases connected

- Susceptibility of roots
  - Highest during very wet to very dry cycles
- Wetting and drying increases root exudation
  - Attracts zoospores
- HLB infected roots also give out more exudates that promote infection

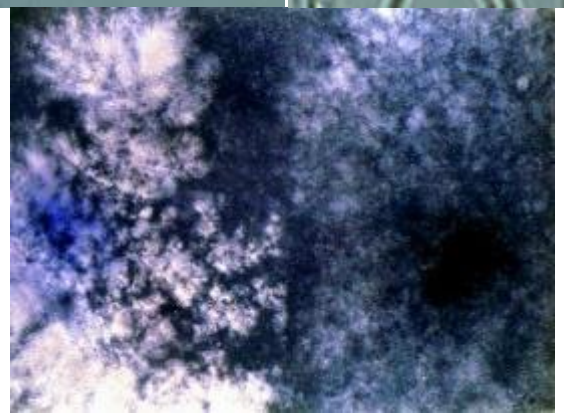


Phytophthora in Florida citrus

- *Phytophthora nicotianae (parasitica)*
  - common cause of foot rot and root rot statewide
  - Minor brown rot problem
- *Phytophthora palmivora*
  - Prefers poorly drained soils with high water tables (Indian River)
  - Sporadic outbreaks
  - Major brown rot concern

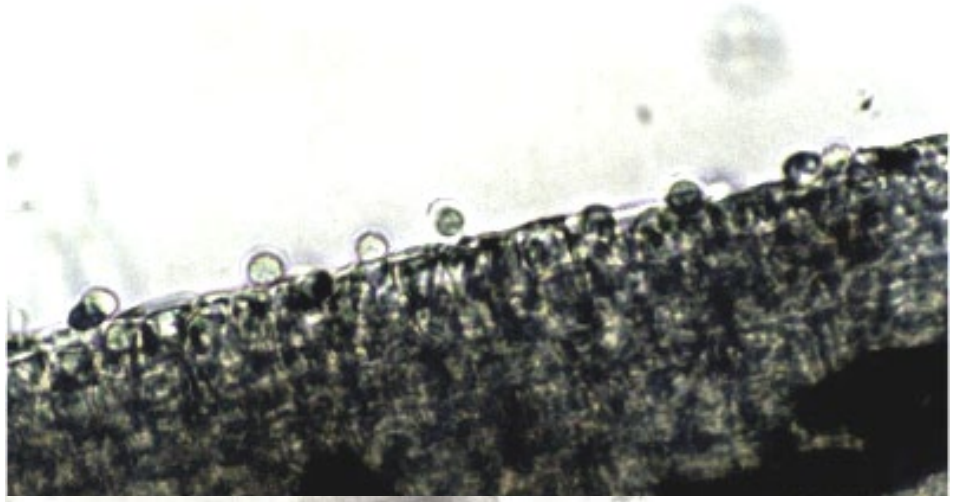
P. palmivora
Sporangia elongated

P. nicotianae
Sporangia round



Phytophthora infection cycle under favorable conditions

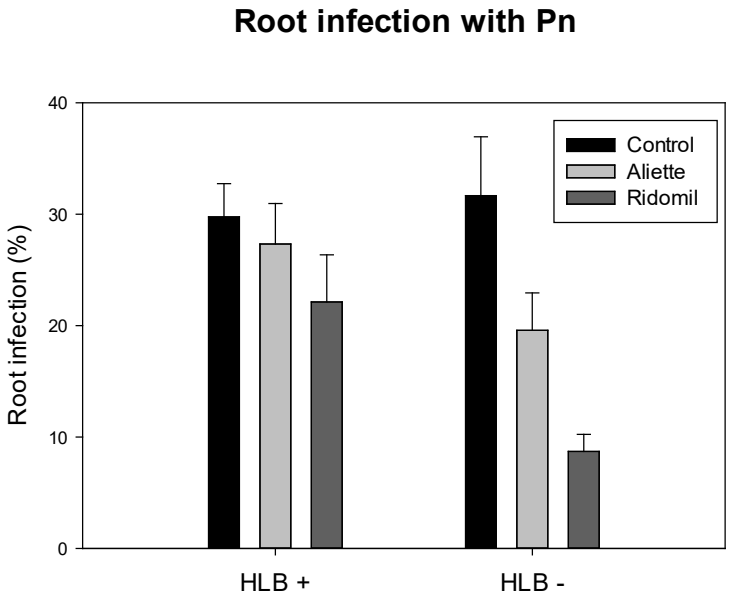
- Zoospores are released from sporangia
  - Swim or splash to the root, bark, or fruit
- Spores encyst, germinate, and infect tissues within 24 hours

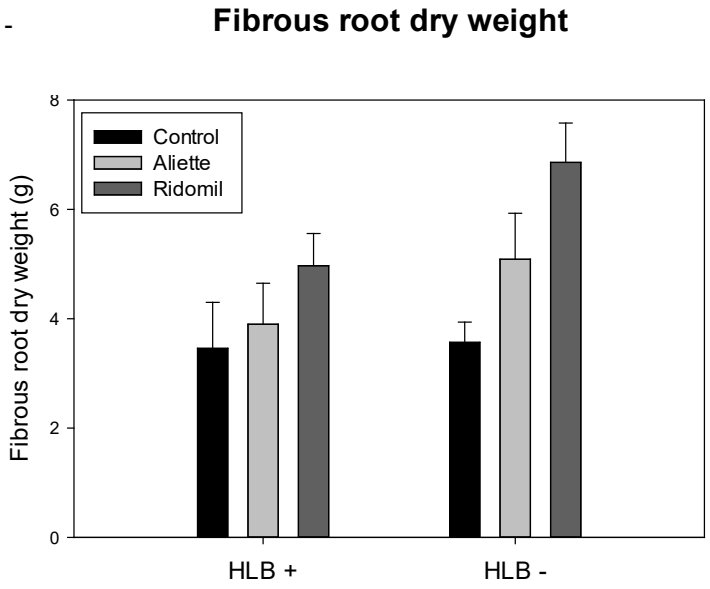


Phytophthora management with HLB

Why the focus on new plantings?

- Need strong root establishment prior to HLB
- HLB reduces efficacy of Phytophthora management
- Cost-effectiveness uncertain once tree infected with HLB





Phytophthora nicotianae is common

- Can be found in many grove soils at low levels
  - Lower than causes measurable disease
  - Can occur in ridge and flatwood soils
- Overwatering and wetting of trunks can promote disease

P. palmivora still causes root rot

- More restrictive environmental preferences
- Rootstock sensitivity is different than *P. nicotianae*
- Sporulates more rapidly
- Inoculum can move further

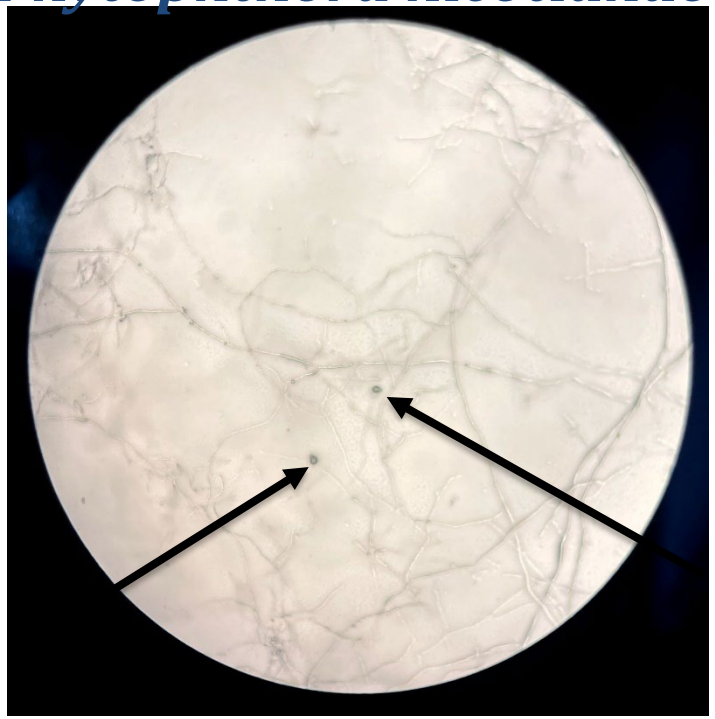
Rootstock susceptibility to root rot depends on *Phytophthora* spp.

	P. nicotianae	*P. palmivora*
Sweet orange	Susceptible	?
Cleopatra	Susceptible	Tolerant
Rough lemon	Susceptible	?
Sour orange	Susceptible	Tolerant
Volkamer lemon	Tolerant	Tolerant
Carrizo citrange	Tolerant	Susceptible
Swingle	Moderately Resistant	Susceptible
Trifoliate orange	Resistant	Susceptible

Phytophthora palmivora sporulates earlier

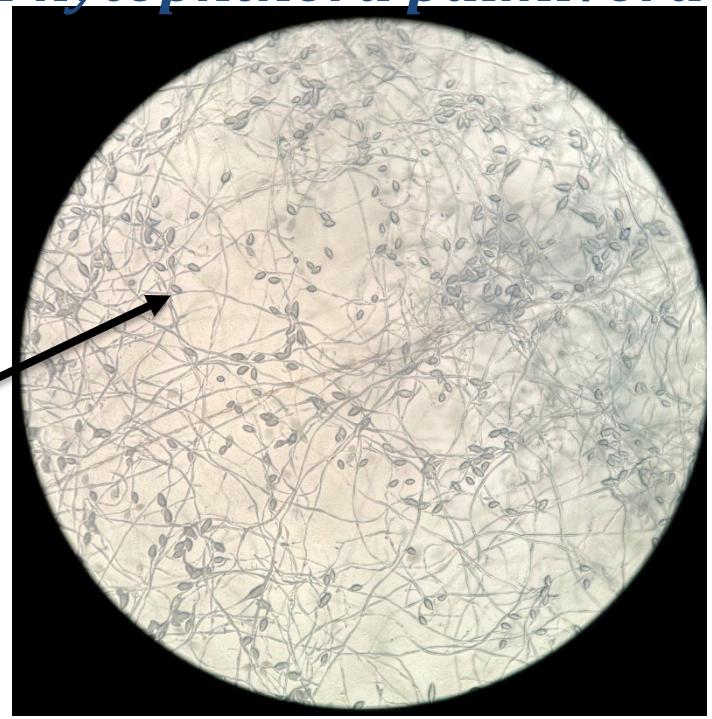
From 1 spore (propagule) after 3 days

Phytophthora nicotianae



100x magnification

Phytophthora palmivora

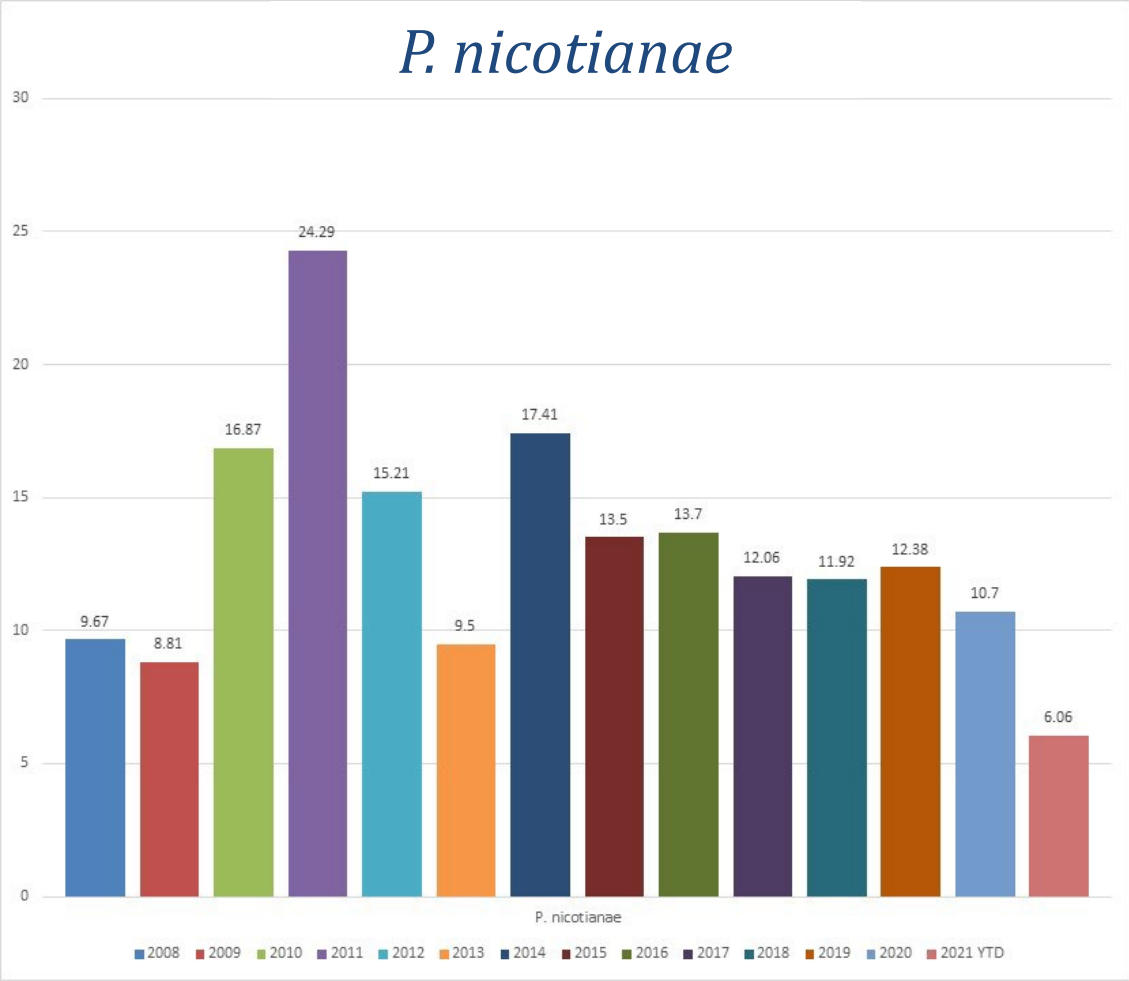


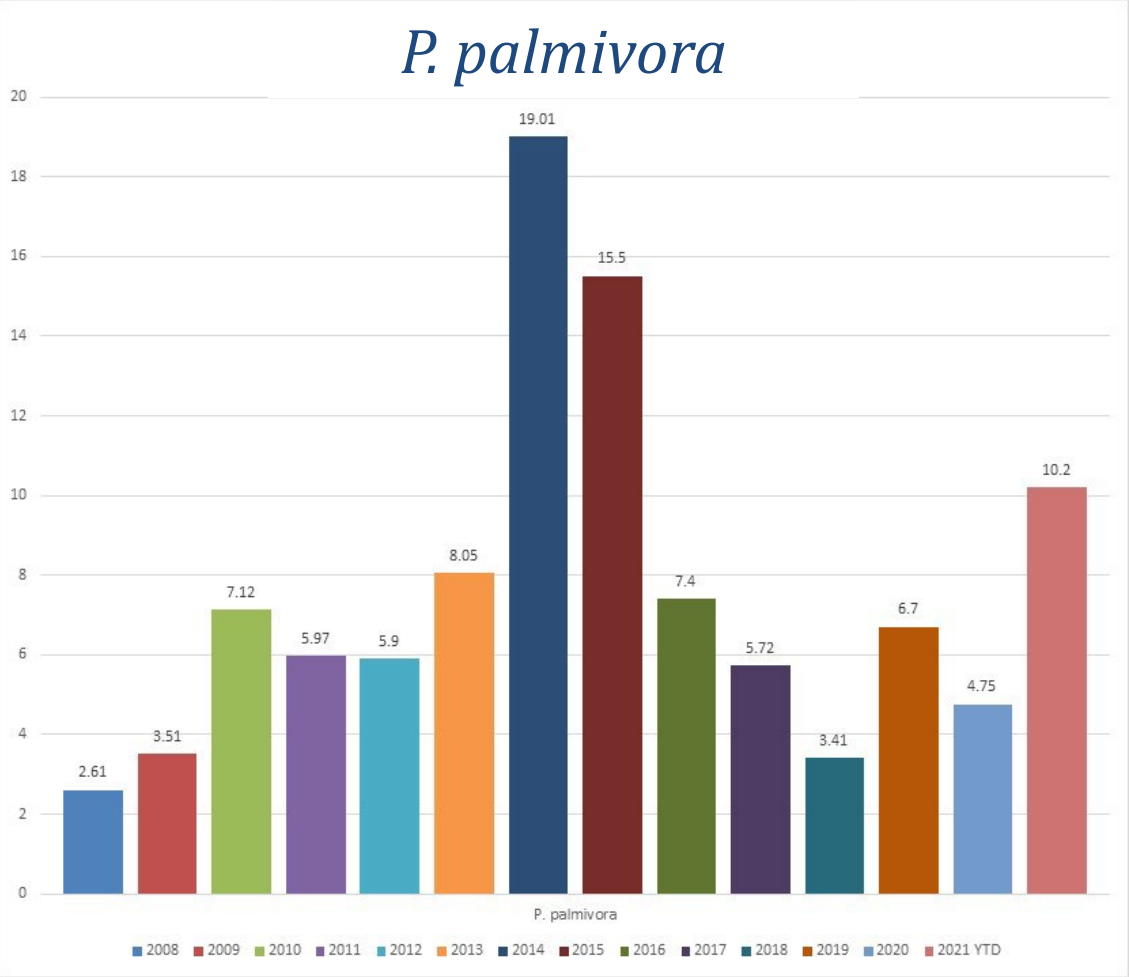
100x magnification

GROUNDWORK LABORATORY

Images courtesy of Groundwork Laboratory

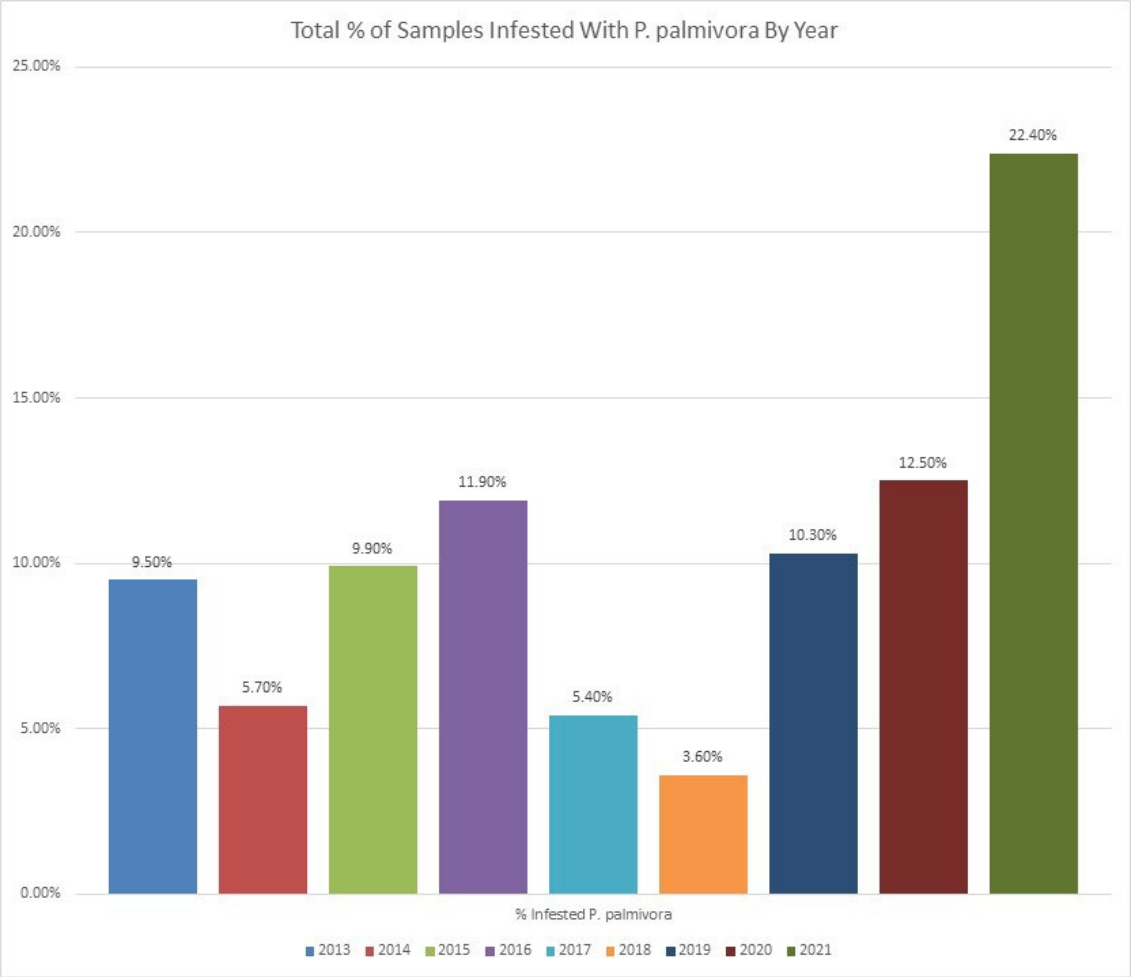
P. palmivora is surging again





Data courtesy of Syngenta

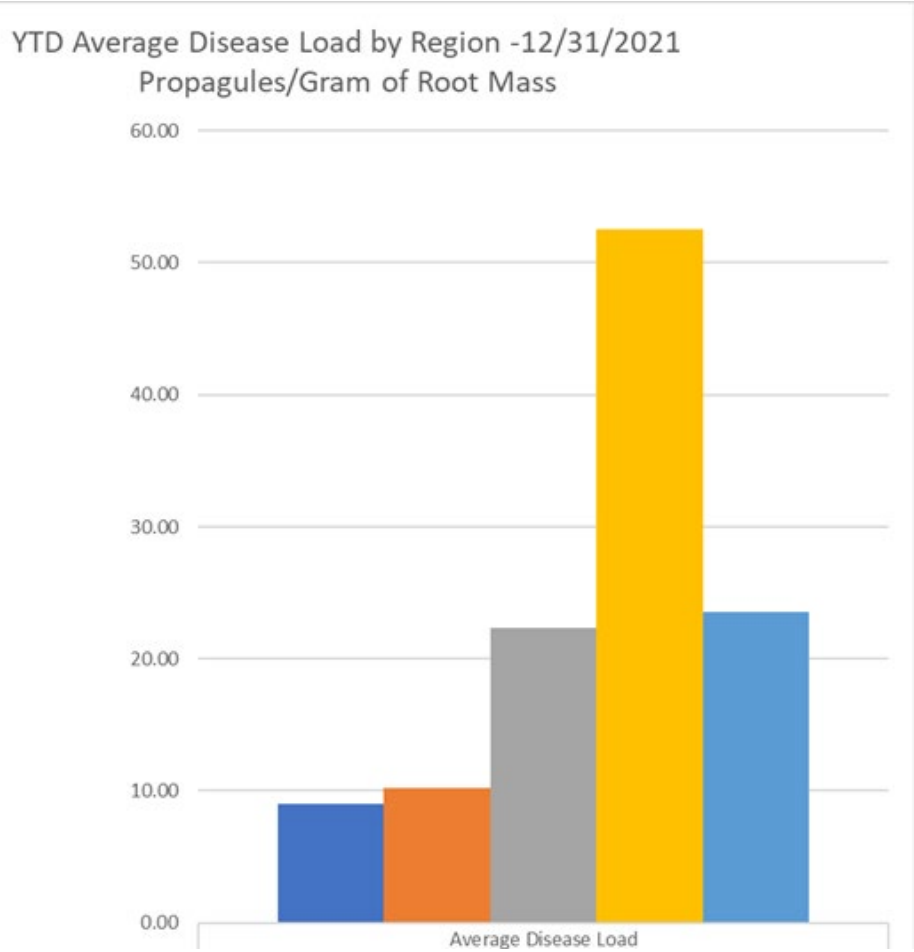
High % of blocks infested with *P. palmivora*

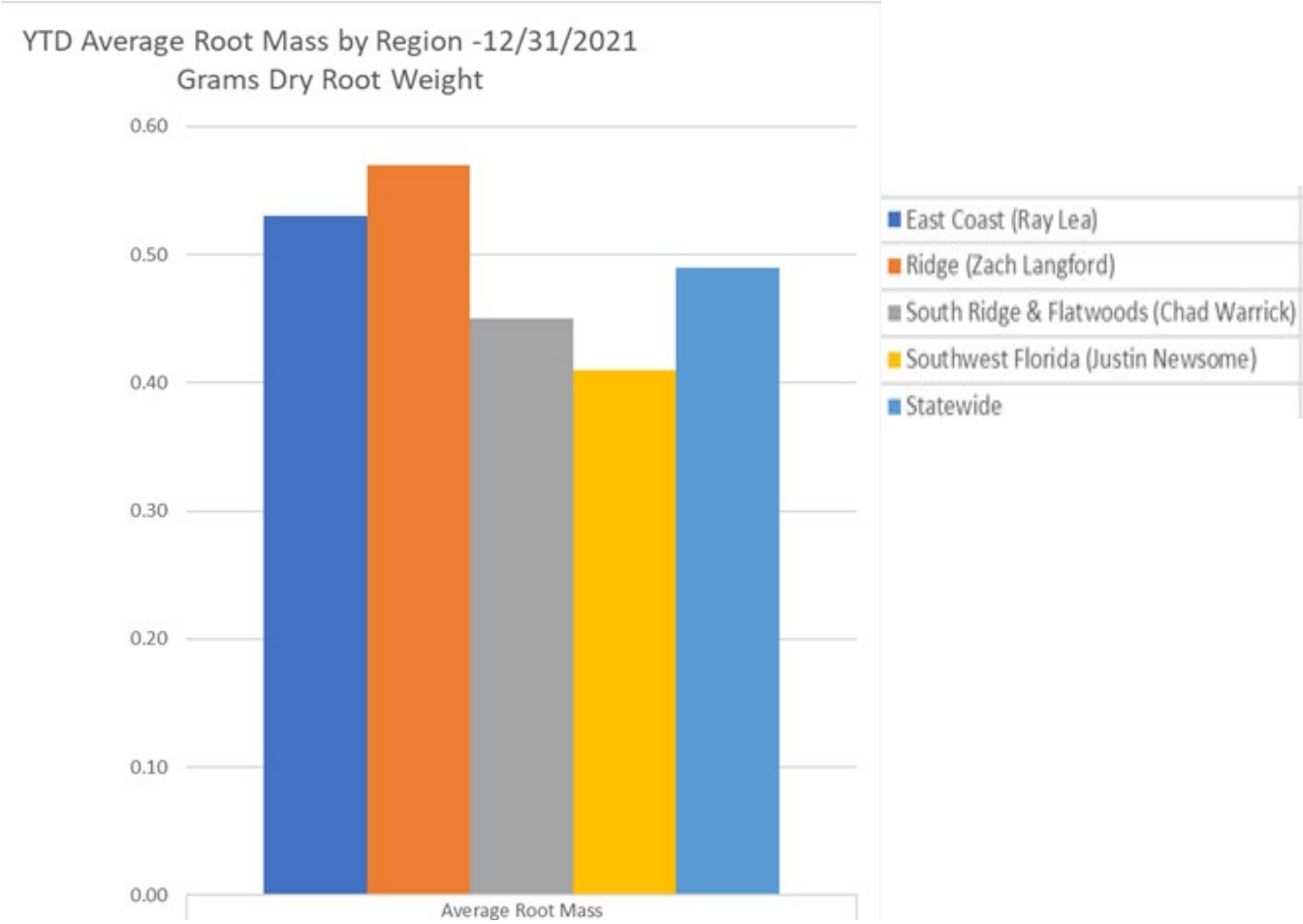


- Doubling of infested blocks since last year
- Highest percent of *P. palmivora* samples infested since at least 2008

Data courtesy of Syngenta

Root mass and phytophthora by region





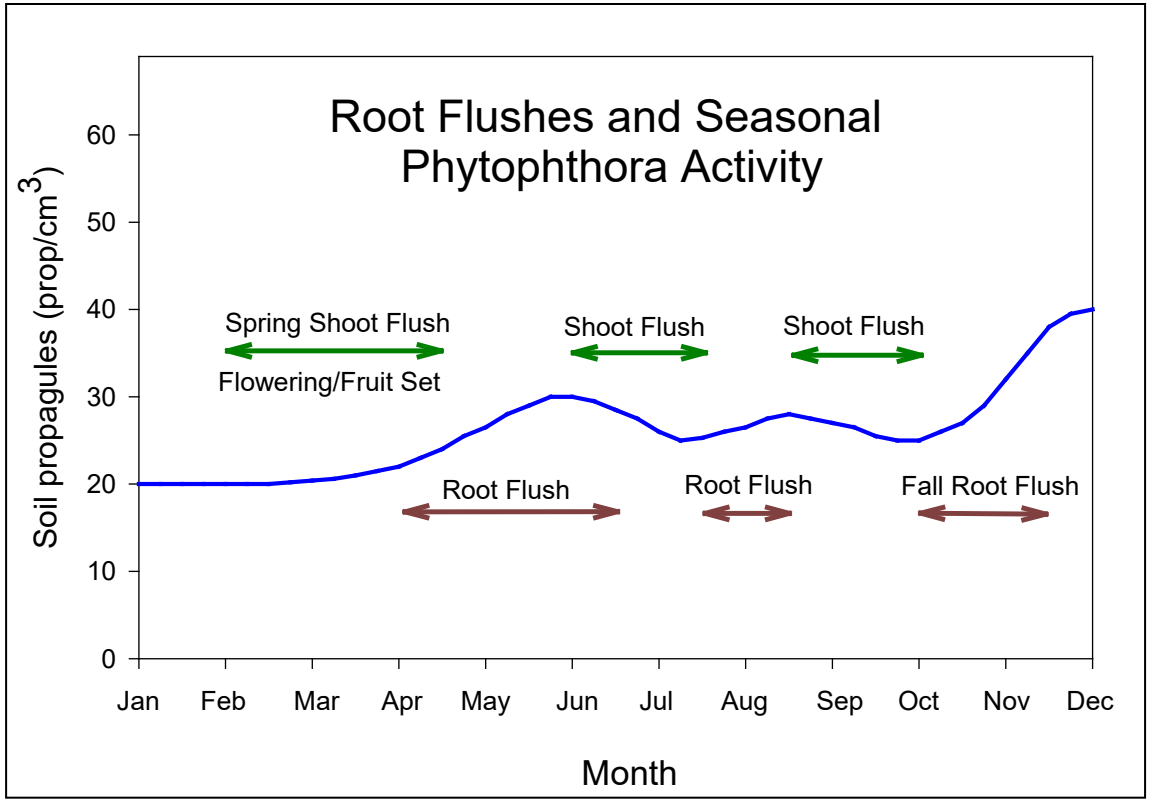
Data courtesy of Syngenta

Phytophthora management

- *P. palmivora* can quickly get out of control if unmanaged
- Need to know the species in your groves
  - Susceptibility of rootstock
  - May not be the same in all regions or grove blocks
- Do not assume you require treatment
  - Need to sample for phytophthora to find out how much inoculum present
  - 10 to 20 propagules/cm^3 soil of either species actionable level
  - Sampling procedures in Florida Citrus Production Guide

Managing root rot

- Fungicides
  - Phosphites/Fosetyl-Al – induces defenses, limited direct action
  - Mefanoxam – requires root uptake for efficacy
  - Oxathiapiprolin (Orondis)
  - Fluopicolide (Presidio)
  - Mandipropamid (Revus: Brown rot or nurseries)
- Rotate phosphites with more effective products



Summary

- Phytophthora diseases are interrelated and caused by the same organisms on different plant parts
- HLB makes fungicidal control of phytophthora less effective
- Rootstocks are not equally susceptible to the two phytophthora organisms
- Currently, *P. palmivora* is at high levels in southwest Florida
- Measure your inoculum pressure before deciding to treat
- Apply fungicides targeting spring and fall root flushes

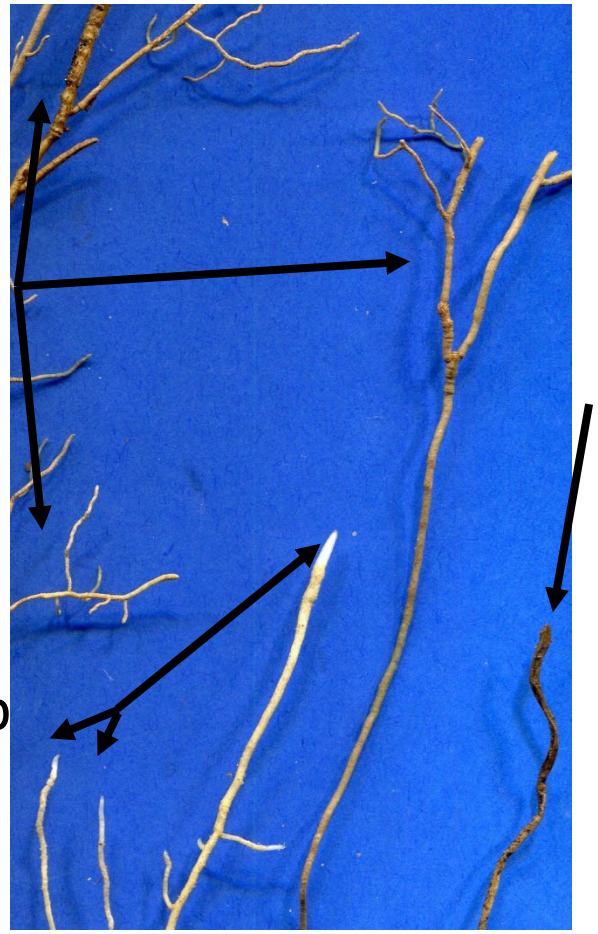
HLB AND ROOT HEALTH

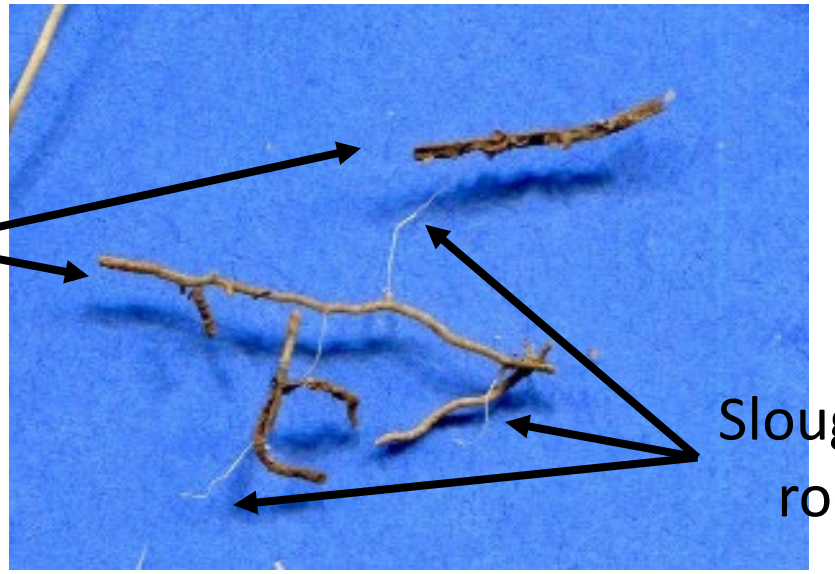
Root health and HLB

- Consider the whole tree when managing HLB
  - Canopy and roots interact throughout year
- Target root function and longevity in management of HLB trees
  - Adjust for limited uptake capacity – timing and duration
  - Reduce other stresses on the root system
- Management needs to be site specific
  - Soil, pests, pathogens, drainage, rootstock
- New plantings need strong root establishment prior to HLB
  - Select rootstock for the site

METHODS FOR TESTING ROOT HEALTH

Visual assessment of roots





All fibrous roots

Fast visual assessment of roots

- Hand
  - Quick visual assessment of root health
- Shovel
  - Depth profile
  - Visual ratio of new, healthy, and dying roots

Quantitative root assessment

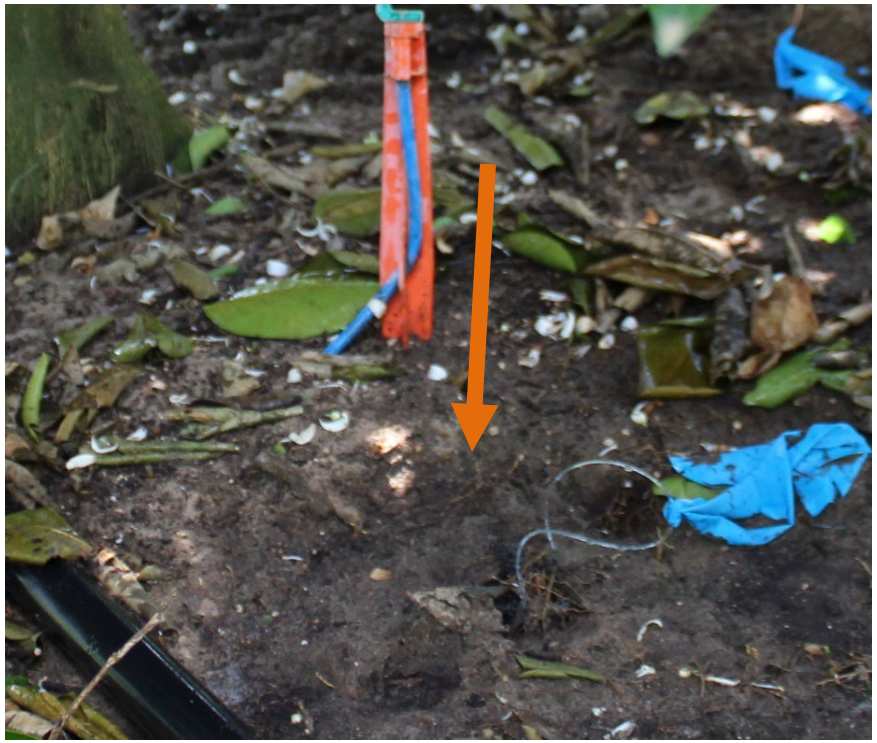
- Soil corer
  - Fast, easily pooled from multiple trees

- Auger
  - Can go to greater depths

Labor and cost intensive root assessment

- Minirhizotrons

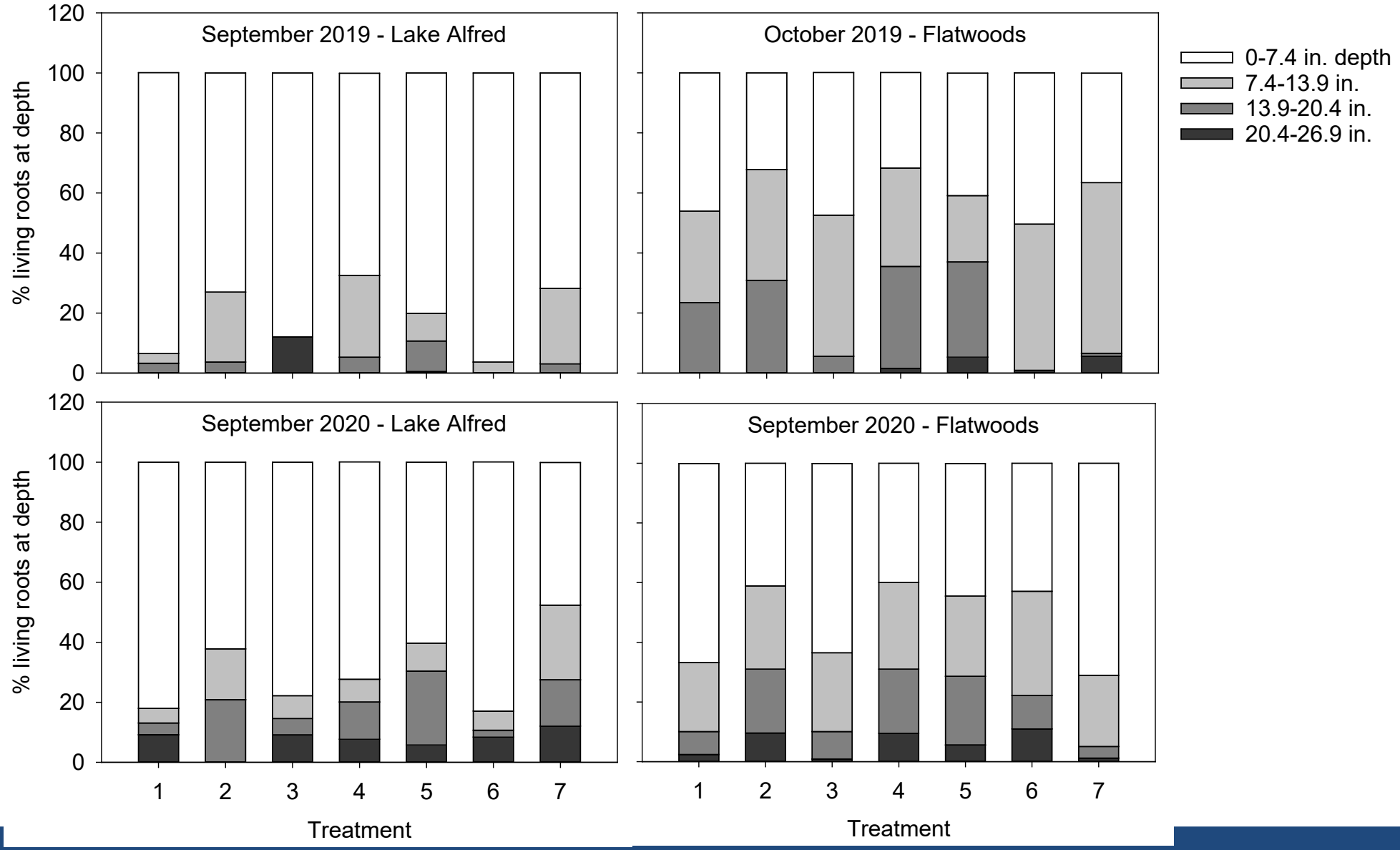
- Root cages



Influence of fertilization

- Fertilizer can influence how deep roots will grow
  - Effect appears to be site specific
  - Fertilization a mix of different micro- and macronutrients
  - No consistent patterns have been determined yet
- Reason for why one program would change root depth compared to another not understood
- If not finding shallow roots, don’t panic!
  - Try sampling at a greater depth with an auger

Depth of roots is dependent on fertilizer



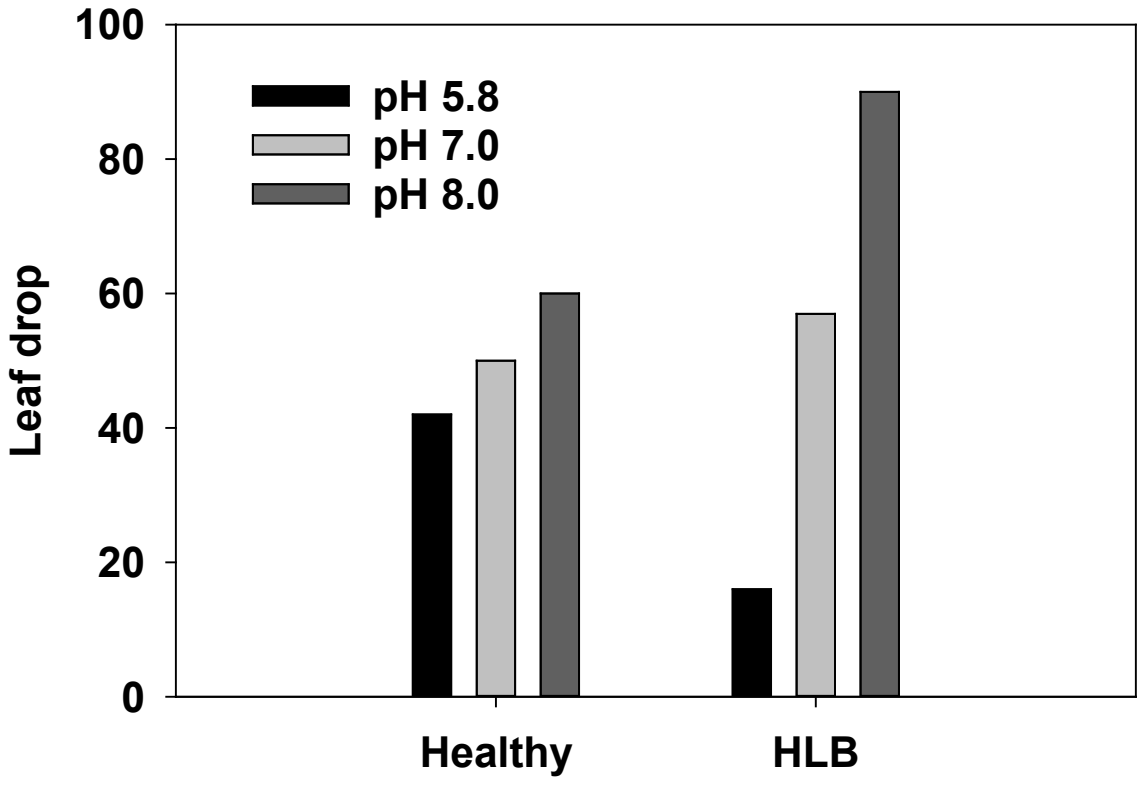
pH UPDATE

pH management has had mixed results

- Works well on the flatwoods
  - Calcareous soils
  - Most roots in the wetted zone
    - Roots contained by beds and water table
- Limited yield response on Ridge
  - Low Ca/Mg soils – rapidly leached
  - Root zone extends well beyond wetted zone
  - Supplemental Ca and Mg is recommended

pH – HLB Interaction

- HLB amplifies the response of rootstocks to pH
- Swingle/Carrizo prefer 5.5-6.5
  - Low end risks nutrient leaching
  - Toxic metals start becoming more available
  - Too low will damage roots



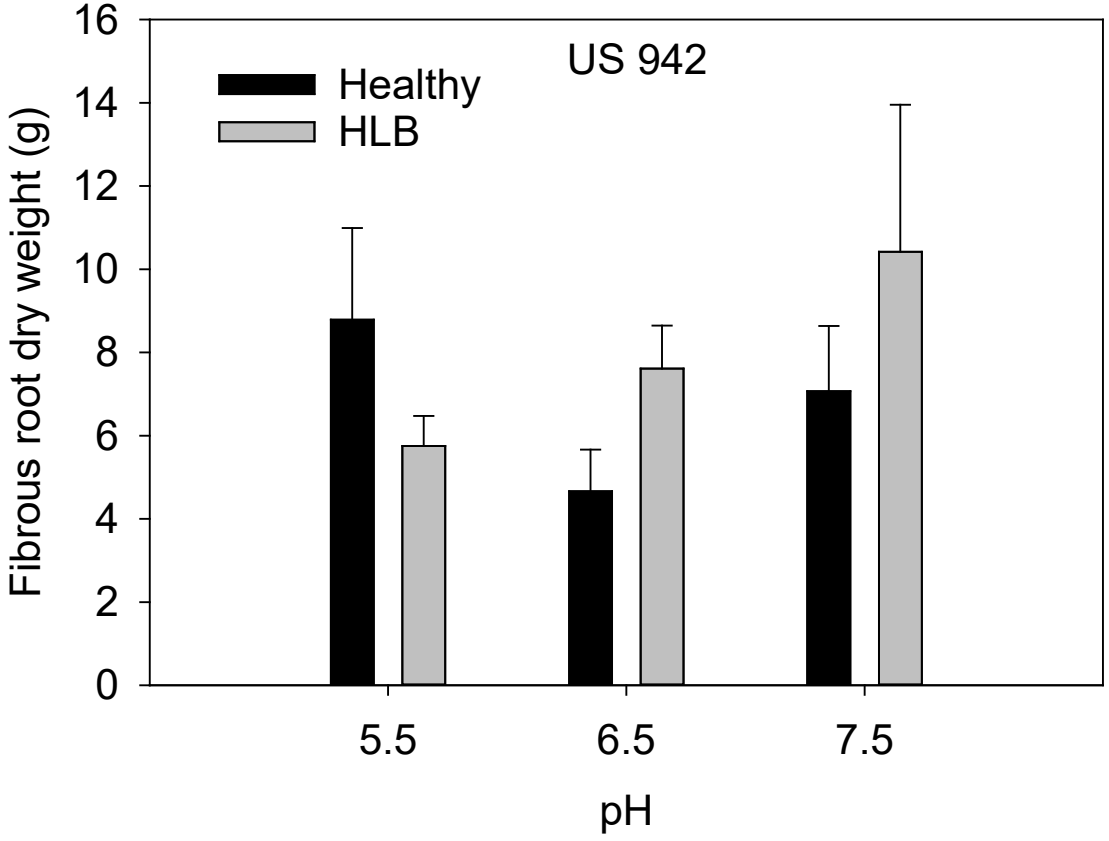
Data Courtesy of Tripti Vashisth

Why is pH response regional?

- Is it nutrient leaching?
- Is it negative effects of pH on rootstock?
  - Reducing rootstock vigor?
- Split root rhizotron to mimic roots inside and outside pH treated soil zone

Rootstocks and pH

- Preliminary greenhouse results
  - Well water acidified with sulfuric acid
- HLB causes a shift in pH tolerance
- pH tolerance is rootstock specific
- Needs confirmation in field trees



pH management – Current recommendations

- Works well on trees in the flatwoods
  - Response of trees on ridge uncertain
- Check soil pH first (wetted zone)
- pH range is rootstock specific
  - Little knowledge of pH range for new rootstocks
- Target pH 6.0-6.5 for Swingle/Carrizo, gives room for accidental over-application

How to modify pH

- Inject N-furic into irrigation
  - Fast
  - Requires regular upkeep
- Broadcast sulfur in wetted zone
  - Can take 9 months to 2 years to change soil pH – dependent on microbial breakdown
  - Easy to drop pH too low and cause more damage
- May require supplemental Ca and Mg fertilization
  - Use pH neutral products like Gypsum ($CaSO_4$)

Summary

- HLB has required growers to pay more attention to root health
- Can get rudimentary assessment of root health with sampling
  - Type of sampling based on need and purpose
- Root depth can be changed unexpectedly by factors like nutritional programs
  - If you don’t find many shallow roots, try sampling at lower depths
- pH modification should only be done when there is a need
  - Can be beneficial, especially on flatwoods soils
  - Easy to get wrong and difficult to reverse

Acknowledgments

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Any Questions?

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