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

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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](https://crec.ifas.ufl.edu/extension/citrus_rootstock/index.html)
HLB Structural root loss

Fibrous root loss

Proportion live/dead structural root length

Presumed Healthy
Symptoms
Sectored canopy thinning
Canopy thinning
Moderate decline
Severe decline

30-50% root loss
>70% root loss

Ridge root system
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

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

Photos courtesy of Jim Graham
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
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.

<table>
<thead>
<tr>
<th></th>
<th><em>P. nicotianae</em></th>
<th><em>P. palmivora</em></th>
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</thead>
<tbody>
<tr>
<td>Sweet orange</td>
<td>Susceptible</td>
<td>?</td>
</tr>
<tr>
<td>Cleopatra</td>
<td>Susceptible</td>
<td>Tolerant</td>
</tr>
<tr>
<td>Rough lemon</td>
<td>Susceptible</td>
<td>?</td>
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<tr>
<td>Sour orange</td>
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<tr>
<td>Volkamer lemon</td>
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<tr>
<td>Carrizo citrange</td>
<td>Tolerant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>Swingle</td>
<td>Moderately Resistant</td>
<td>Susceptible</td>
</tr>
<tr>
<td>Trifoliate orange</td>
<td>Resistant</td>
<td>Susceptible</td>
</tr>
</tbody>
</table>
Phytophthora palmivora sporulates earlier

From 1 spore (propagule) after 3 days

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/cm³ 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

Healthy roots

Dead or dying roots

New growing tip

Sloughing 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 (CaSO₄)
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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