

2019–2020 Florida Citrus Production Guide: Root Health Management¹

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Developing and maintaining a healthy root system is important for establishment and long-term productivity of trees. Roots take up nutrients and water from the soil to transport them to the tree canopy (the leaves and fruit). The root system also acts as an anchor for the tree, which is important during high wind conditions, such as thunderstorms and tropical systems. At the same time, the leaves provide carbohydrates to grow and maintain a functional root system. In a healthy tree, the carbohydrate supply is balanced between new leaves, fruit, and roots. When root health is compromised, the root system has reduced nutrient and water uptake capacity, which can subsequently affect growth of new leaves and fruit.

Root health can be compromised by pests, pathogens, and environmental (abiotic) factors. Citrus root pests include *Diaprepes* root weevil, burrowing nematode, sting nematode, and others. Historically, the most damaging root pathogens in citrus have been *Phytophthora* spp. that cause root, crown, and foot rot. The most common detrimental environmental factors for roots in Florida citrus are soil pH, salinity, and flooding. An increase in soil pH above 7.0 results in precipitation of phosphorus, calcium, magnesium, and other plant nutrients, reducing the concentration of nutrients in solution available for uptake by the roots. Extended waterlogging (oxygen deprivation) and salinity can cause root decline and death. Site-specific decisions made while preparing to plant will reduce the risk and

impact of these biotic and abiotic causes of root health decline. Management of root health problems depends on cultural and, when necessary, chemical management tools.

The root system has two main types of roots, structural and fibrous (feeder), that serve different essential functions for the tree. The structural roots provide the anchoring scaffold of the root system and act as the major transport corridors for nutrients, water, and carbohydrates. The fibrous roots form the interface with the soil where water and nutrients are absorbed. Both kinds of roots are important for root and tree health and are affected differently by pests, pathogens, environmental factors, and any interactions of the three. Structural roots often extend outward to the edge of the wetted zone or canopy and then continue down and outward beyond the canopy. Fibrous roots only grow in high-density clusters from structural roots where water and nutrients are most abundant. In irrigated trees, the fibrous roots are concentrated in the wetted zone of the irrigation system. For example, microsprinkler irrigation concentrates 80% of the fibrous roots in the top 10 inches of the wetted zone under the canopy. Root systems are important to understand because root health management should be focused on these areas of high fibrous-root density.

Introduction of *Candidatus Liberibacter asiaticus* (CLas), the cause of huanglongbing (HLB), into Florida greatly complicates citrus root health management. CLas infection

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causes severe damage to fibrous roots that exacerbates the effects of the other root pests and pathogens and can reduce the efficacy of treatments. Root health management has become more challenging and more important because most citrus trees in Florida are now affected by HLB.

Huanglongbing and Root Health

HLB severely affects root health, causing 30%–50% root loss early in disease development and greater than 70% root loss once canopy decline begins (sectored leaf drop and dieback). This root loss results from a shortened lifespan of 1.5–4 months for fibrous roots compared to 9–12 months for healthy roots. The shortened lifespan is accompanied by increased root growth, leading to an imbalance in carbohydrate demand in the tree and reducing the total uptake capacity of the root system. Structural roots also die back from HLB, with ~20% dieback within the wetted zone as canopy decline begins, continuing inward toward the trunk. Currently, there is no proven management option for prevention of HLB-associated root loss. Treatments that stimulate root growth are **not** recommended because they may increase the root-canopy imbalance. Instead, growers should focus on altering soil applications to adapt to the limited uptake capacity and, when economically feasible, attempt to prevent further damage to the existing roots to maintain or improve root longevity. This includes irrigation and fertilization in small and frequent doses to balance the water and nutrient supply with uptake capacity and adjustment of soil pH below 6.5 to avoid additional stress on the root system.

Managing Root Health

A healthy root system improves productivity of trees and improves their tolerance of major stresses, such as freezes, drought, and high winds. Starting a grove with a healthy root system allows for rapid tree establishment and growth. Maintaining a healthy root system in existing groves lengthens the productive life of the trees.

Root Health in New Plantings

The best way to manage root health is to prevent problems from starting. This requires careful consideration and planning before ordering trees and planting a new grove. The largest contributor to root health that will affect pests, pathogens, and the tree itself is the soil and water at the site. The most cost-effective way to manage root health is proper field preparation for planting and choosing rootstocks based on site-specific knowledge of the soil and irrigation water. Flooding and water table problems that affect root health can be managed with land preparation including

drainage and bedding (see Grove Planning and Establishment chapter). Many of the soil, pest, and pathogen problems can be addressed by choosing the best-adapted rootstock. To select a rootstock you need to know the site history, such as existing nematode problems or previous infestations of Diaprepes. It may also be important to know what has been done in the past to modify soil pH. If recent efforts were made to change the soil pH with liming or sulfur, it is likely that the soil will slowly shift back to its native pH. To avoid the perennial expense of adjusting the pH in your grove, select a rootstock with an appropriate pH tolerance. Rootstock selection can be difficult because there is limited knowledge about soil preference and pest and pathogen resistance for some rootstocks (especially newly released rootstocks). To help in the selection process, a summary of what is known for commercially available rootstocks can be found in the rootstock selection chapter of this guide and the Citrus Rootstock Selection Guide (http://www.crec.ifas.ufl.edu/extension/citrus_rootstock/templates/guide/). Some locations may have multiple pest, pathogen, and environmental problems. In these cases, a rootstock that addresses all the problems may not be available. It is important to consider which problems are the most severe at the site, and which can be most easily and economically managed by land preparation or on a regular long-term basis. In situations where multiple problems cannot be addressed by proper rootstock selection, alternative crops should be investigated.

Starting with healthy root establishment is also important. When planting trees, it is important to give them the best chance to establish a healthy root system. This requires inspecting the root balls for signs of phytophthora damage, pot-bound root system, or dry potting medium. Phytophthora damage will slow or prevent root establishment, immediately stunting trees. Dry potting media will inhibit water penetration after planting, leading to tree stunting or death. Pot-bound root systems can lead to intertwined structural roots that can cause tree stunting and decline a few years after planting as the structural roots begin to girdle each other. For more details, see the Grove Planning and Establishment chapter of this guide.

Root Health for Existing Groves

Unlike new plantings, root health problems in existing groves have to be managed instead of avoided. However, like new plantings, root health in existing groves requires site-specific management. The first step is to identify the problems present in the grove. Take soil samples for pH and nutrient analysis as well as phytophthora and nematode counts. Determine the pH, salinity, and bicarbonate content

of irrigation water. Bicarbonates are leached from limestone in the aquifer and act as a buffer raising the pH of the water and irrigated soil. Groves should be scouted for the presence of *Diaprepes* root weevil, and if they are known to be a problem, see the Citrus root weevils chapter. Once the root health problems are identified, develop a decision-making process to determine which problems are the most severe and should be managed first. For example, if *Phytophthora* spp. are at damaging levels on roots, but there are also problems with soil pH and *Diaprepes*, addressing soil pH or *Diaprepes* may effectively reduce *Phytophthora* populations in a grove soil because these factors interact with *Phytophthora* to make it worse than it would otherwise be. Therefore, pH or *Diaprepes* should be treated first, and *Phytophthora* counts should be reassessed to determine if chemical applications for *Phytophthora* spp. are still needed. HLB-induced root damage also interacts with *Phytophthora* spp. by increasing the exudation of sugars from roots. This sugar exudation attracts *Phytophthora* zoospores, increasing infection. HLB also reduces the efficacy of fungicides (phosphite, fosetyl-Al, fluopicolide, and mfenoxam) for control of *Phytophthora* spp. Timing is essential to maintain efficacy of *Phytophthora* management applications. Propagule counts should be monitored carefully for developing problems, so late summer or fall root flushes (root flushes follow leaf flushes) can be protected. For more information, see the *Phytophthora* foot rot, crown rot, and root rot chapter.

Soil pH and bicarbonates in irrigation water have gained attention because HLB has reduced the tolerance for pH incompatibilities on rootstocks mismatched with grove soil, such as Swingle on high pH soils. In many cases, especially in the flatwoods, management of pH and bicarbonates resulted in increased root density of trees with HLB. For yet-to-be-determined reasons, groves on ridge soils do not respond as well to pH and bicarbonate management. Soil pH or high-bicarbonate irrigation water can be treated with ground-applied sulfur or by acidifying irrigation water with injections of sulfuric or N-phuric acid. For Swingle rootstock, the ideal pH range is 5.5 to 6.5. Recent field experiments have determined that maintaining soil pH in the 5.5 to 6.5 range increases nutrient uptake and root density. Test the pH before and after treatment because over-acidification could lead to the release of toxic amounts of copper and other metals and depletion of essential nutrients, such as calcium and magnesium, from the soil. Extra care needs to be taken to avoid over-acidification when using sulfur. Sulfur acidification is dependent on microbial breakdown of elemental sulfur and can take a year or more before soil pH drops. The soil pH is very likely

to drop below the optimum range if other acidification methods are used before the sulfur takes effect.

Depending on the results of soil tests for nutrients such as calcium, supplemental application may be necessary to replenish those lost from leaching and to prevent copper toxicity to roots. When pH management is necessary, sources of calcium that don't counteract pH management should be chosen; for example, gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) instead of lime can add calcium without increasing the soil pH.