Soil and water pH play a key part in nutrition

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In the past few years, horticultural citrus grove management practices have changed significantly in Florida. It is a common observation across the state that huanglongbing (HLB)-affected trees respond well to complete and balanced nutrition programs. Therefore, citrus growers are currently focusing on intensive management of irrigation and nutrition.

HLB-affected trees suffer a significant root loss. In some cases, up to 80 percent root loss has been observed. Nonetheless, the roots of HLB-affected plants are functional and efficient in nutrient uptake. But due to reduced biomass and surface area, the amount of nutrient absorbed by roots is limited. Application of large volumes of fertilizer or water are therefore likely to leach out of the root zone before the tree can absorb them. Hence, application of small and frequent doses of fertilizer and water is recommended to improve nutrient availability and potential absorption by the tree.

NUTRIENT RECOMMENDATIONS

A fertilizer program should include a balanced supply of all the essential nutrients. Every nutrient is indispensable; an excess or deficiency of any single nutrient can adversely affect tree performance. Foliar application of certain nutrients can be beneficial for the tree, especially when dealing with a known nutrient deficiency, but the focus should be on an all-nutrient soil-applied fertilizer program.

The soil-applied nutrients are absorbed by the roots along with the water uptake, so mobile (e.g., nitrogen and potassium) and immobile (e.g., boron, zinc, iron and calcium) plant nutrients are distributed throughout the plant as needed. It is important to ensure that the fertilizer is available to the trees year-round, since the growth season is long in Florida.

When applying fertilizer, the focus should be on the 4Rs (right source, rate, timing and place) of plant nutrients. However, with a soil-applied fertilizer program, another factor that is as important as the 4Rs is soil pH.

SOIL pH AFFECTS NUTRITION

Soil pH of the root zone is a very critical factor that affects nutrient availability and uptake. Most of the micronutrients become less available at higher, alkaline (pH>7.0) soil pH and reach toxic levels at low acidity (pH<5.0). Many Florida soils and irrigation waters are alkaline, which can limit nutrient availability if not corrected.

In addition, irrigation water in Florida is often high in bicarbonates, which after long periods of use can increase soil pH, affect tree health and reduce yields. The increase in soil pH and effect of bicarbonate-rich irrigation water depends on the bicarbonate concentration in the water, irrigation timing and quantity, the buffering capacity of soil and the rootstock variety.

Field studies done by Jim Graham and Kelly Morgan suggest that in groves where soil pH is neutral to alkaline and the irrigation water contains high concentrations of bicarbonates, trees often exhibit increased HLB symptoms and decline severely. Leaf nutrient analyses of such groves exhibit multiple nutrient deficiencies. In another survey, Graham and Morgan found that groves with soil pH higher

Table 1. Total leaf drop and plant death in healthy and HLB-affected plants when irrigated with water at different pH levels.

Irrigation Water pH	Disease	Total Number of Dead Plants (%)	Leaf Drop (%)
5.8	Healthy	0.0	21c*
5.8	HLB	0.0	16c
7.0	Healthy	0.0	50b
7.0	HLB	12.5	57b
8.0	Healthy	12.5	60ab
8.0	HLB	37.5	83a

*Leaf drop percentages followed by the same letter are not statistically different.

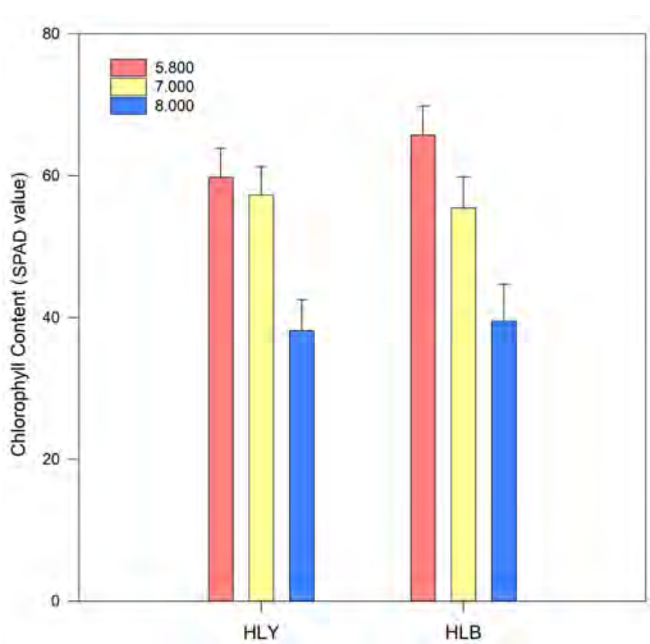
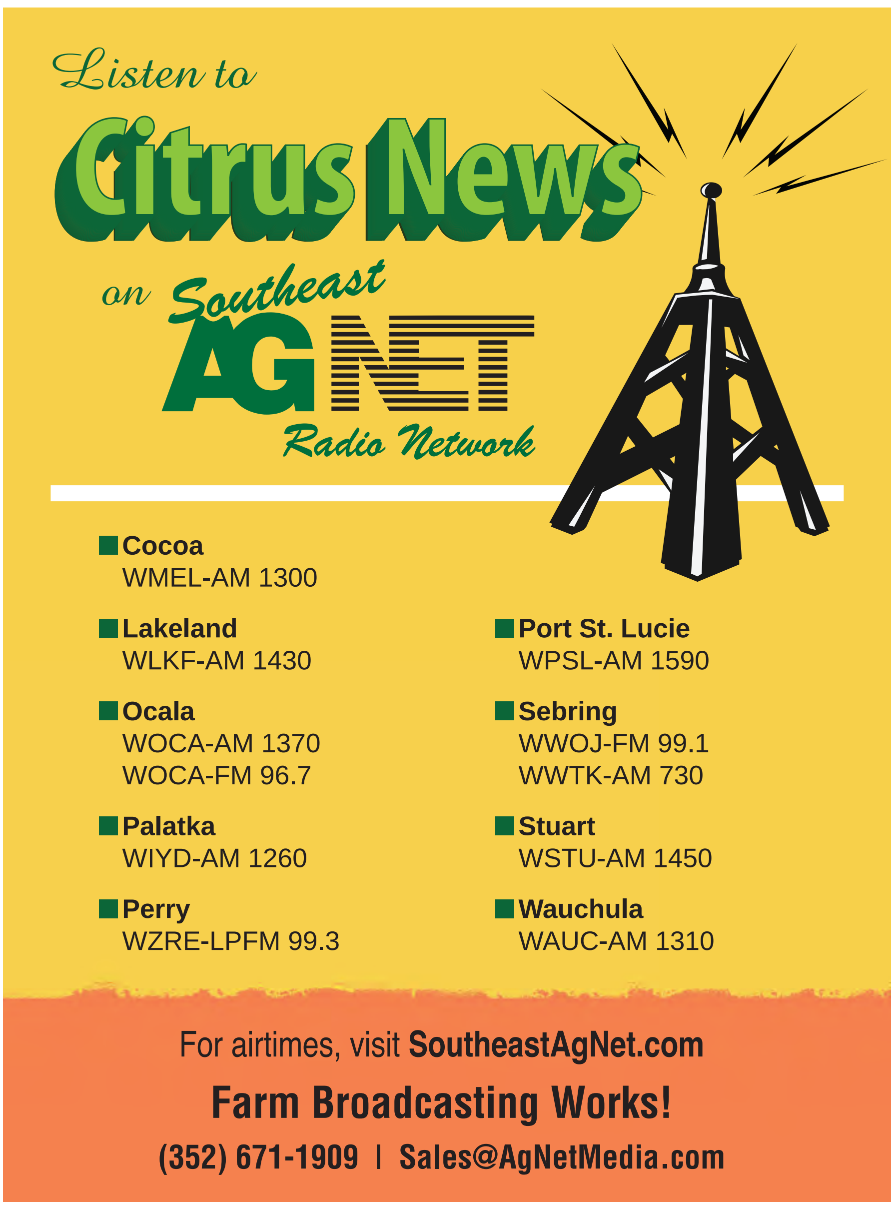


Figure 1. Leaf chlorophyll index in healthy (HLY) and HLB-affected (HLB) plants irrigated with water at pH 5.8, 7.0 and 8.0



than 6.5 and bicarbonates greater than 100 parts per million in irrigation water suffered from increased feeder root loss as well as reduced yields. A clear correlation of yield loss was observed in trees under bicarbonate stress and with lower root density when compared to low-bicarbonate stress trees. (For more information, see https://crec.ifas.ufl.edu/extension/trade_journals/2015/2015_May_bicarbonates.pdf). Therefore, most growers are currently using some method to reduce the soil pH.

The interaction between soil bicarbonates, pH and HLB is still unclear. Whether the bicarbonates increase the soil pH and therefore reduce the nutrient availability to the tree, or whether the presence of disease causes physiological changes to the tree remains to be answered. It is noteworthy that the soil bicarbonates in Florida have always been present, but pre-HLB tree performance was acceptable, even with alkaline pH-susceptible rootstocks. To better understand this interaction, we conducted an irrigation experiment with healthy and HLB-affected plants.

IRRIGATION WATER pH EXPERIMENT

The experiment was performed in a greenhouse because it is nearly impossible to keep trees free of HLB under open-field conditions. Healthy and HLB-affected Midsweet orange trees grafted on Kuharske rootstock were grown in potted grove soil. Plants were irrigated with water at pH 5.8, 7.0 or 8.0 every two to three days.

The pH of irrigation water was adjusted with sodium phosphate buffers. The tree performance was monitored over a period of 60 days. HLB-affected plants watered with pH 8.0 showed more than 80 percent leaf drop; healthy plants dropped about 60 percent of leaves (Table 1, page 26). About 40 percent of HLB-affected trees irrigated with pH 8.0 water died within 60 days. The leaf chlorophyll index decreased with higher pH (Figure 1, page 26) in both HLB-affected and healthy plants.

No significant differences in total root biomass were observed with different irrigation water pH. However, Figure 2 (page 29) shows that plants irrigated with higher pH water had

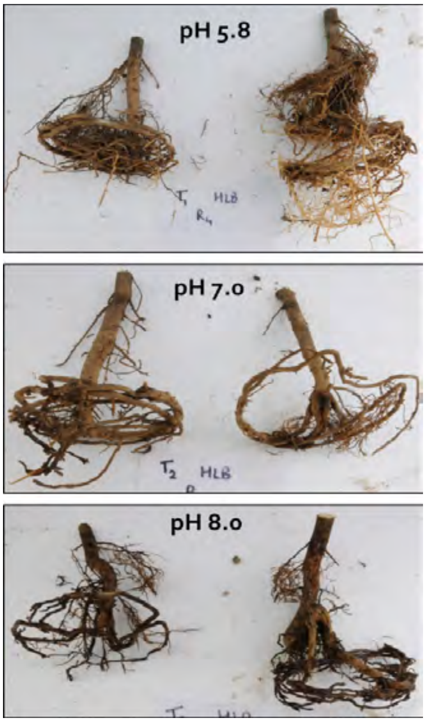


Figure 2. Root systems of HLB-affected plants at the end of the experiment, irrigated with water at pH 5.8, 7.0 and 8.0 for 60 days.

less visible feeder roots compared to pH 5.8. At the end of the study, it was observed that the HLB-affected plants irrigated with pH 5.8 water showed more growth than the healthy plants.

When irrigated with water at pH 7.0, leaf drop and stem dieback were apparent in HLB-affected plants, but healthy plants were less affected. With irrigation water at pH 8.0, both HLB-affected and healthy plants showed leaf drop and stem dieback, but these observations were more pronounced in HLB-affected plants.

Leaf nutrient analysis revealed that all the nutrients were in the optimum range for healthy and HLB-affected plants irrigated with water at pH 5.8 and 7.0. HLB plants irrigated with pH 8.0 showed deficiencies for magnesium, calcium and zinc, while other nutrients were in the optimal range.

Even though plants were watered at three different pH levels every time, the soil pH did not change dramatically, and remained close to 7.0. As the experiment progressed, the soil pH changed slightly depending on the irrigation water pH. This suggests that the soil buffering capacity and the rootstock have a major role to play in soil pH adjustment. So any efforts to manipulate soil pH should be for the long term and will require patience.

Overall, HLB-affected plants perform better when irrigated with low pH (moderately acidic) water. In the study, there was an interaction between HLB-affected plants and soil pH. The HLB-affected plants tended to perform better when soil pH was close to 6.0. When pH was above 6.5 to 7.0, the HLB plants began to decline. Healthy plants performed well at a wider pH range (6.0 to 7.0). Currently, we are conducting in-depth analyses to understand this interaction of soil pH and disease severity.

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