In both field and greenhouse studies, frequent irrigation of smaller amounts of water benefited trees with HLB.

Water requirements and irrigation scheduling for HLB-affected trees

By Kelly T. Morgan

There is an urgent need for strategies such as frequent irrigation to sustain production of citrus trees affected by huanglongbing (HLB) without depletion of fresh water resources. Understanding the role of evapotranspiration (ET) in HLB-affected trees is critical for determining if changes in water management of commercial citrus groves are necessary.

Water management districts have reported increases in water quantities applied to commercial citrus groves since HLB entered Florida in 2005. The objectives of the studies described in this article were to estimate water use as affected by ET and HLB, and determine irrigation scheduling that provides adequate water for irrigation demands of HLB-affected trees. The studies were initiated in November 2010 and ended in October 2015.

EVALUATION OF IRRIGATION CONTROL SYSTEMS

The Citrus Water Management System (CWMS) is a computer software package developed by the University of Florida at the Southwest Florida Research and Education Center (SWFREC). CWMS allows the user to store information required to simulate a water balance for each individual irrigation zone. Data required for each irrigation zone are:

1) Soil water-holding and root-depth information
2) Tree spacing and age
3) Crop water-use coefficients
4) Source of daily ET data
5) Daily irrigation run time or amounts per zone
6) Daily rainfall

Soil characteristics and water-use coefficients can be selected from a list of soils and coefficients calculated for tree age or manually entered by the user. Daily ET data can be manually entered by the user or automatically downloaded from the Florida Automated Weather Network (FAWN) once an appropriate station location is entered for each irrigation zone. In the original configuration, daily rainfall and irrigation data must be entered manually by the user. A system modification allowing for automated collection of rainfall and irrigation run time from irrigation controllers was developed in 2013.

Soil information, tree spacing and

age, and FAWN weather station data for each block of the CWMS demonstration site were entered into the CWMS from information provided by the irrigation manager. Rainfall and irrigation application for each irrigation zone are provided daily using two files read by CWMS. A program to read these two files was developed to automate data collection from the large number of irrigation zones in this large grove operation. The two files utilize the report generation system of the Motorola irrigation control system. One file contains the rainfall amount for each rain gauge installed at pump stations within the grove. The second file contains daily irrigation by run time for each irrigation zone in the grove. Irrigation schedules developed by CWMS were used for a number of irrigation zones. Most trees within each irrigation zone had been affected by HLB for several years.

Soil moisture at the demonstration grove was collected using arrays of capacitance sensors reading soil moisture at depths of 4, 8, 12 and 18 inches. Observations of soil moisture values were used to manually adjust the irrigation times scheduled for blocks containing sensors. Average soil moisture for the 4-, 8-, 12- and 18-inch depths ranged from 0.08 to 0.13 cm^3/cm^3, with the lowest values during the dry months and the highest values during the rainy season. The measured soil moisture was not significantly different than the CWMS-simulated soil moisture for either of the two years of the study.

Water use based on grove acre was calculated by dividing the water applied in a block by the grove land area. Significant increases in water use were found in 2012–2013 and 2013–2014 for blocks irrigated with schedules based on grove managers' experience compared with blocks irrigated using soil-moisture-sensor data or model simulations. Likewise, comparable reductions in irrigation system run time were found for sensor- and model-irrigation schedules.

Water use with sensors and model simulation reduced average monthly

Researchers Working on the HLB Problem Are Second to None

By Harold Browning

There are a range of emotions swirling around the Florida citrus industry on a daily, sometimes hourly, basis — from optimism to pessimism to resiliency to complacency. Probably the most prominent sentiment is frustration. Why don't we have an HLB silver bullet yet? Is anything we do going to work long-term? Believe me, I feel it.

But from the beginning, we knew this was not going to be an easy puzzle to solve. We are literally dealing with the Gordian knot of citrus diseases.

The good news is that we have an impressive stable of citrus research minds from across the globe working to untie the knot. The brainpower is extraordinary. Of course we all know the talented researchers at the University of Florida and U.S. Department of Agriculture (USDA) who are pouring an immense amount of energy into this problem. We've worked with most of them for years and understand how dedicated they are to the industry.

But outside our tight Florida circle is a roster of scientists that have long and distinguished resumes. I venture to say the research push is an unprecedented marshalling of scientific resources on behalf of a specialty crop.

For example, George Bruening continues to provide a wide-angle look at the disease and is in constant contact with the public and private sector organizations who are part of our fight. Bruening is a National Academy of Sciences Fellow, a plant pathologist/molecular biologist and an emeritus professor at the University of California, Davis. He led the National Research Council Team of the National Academy of Sciences Committee on the Strategic Planning for the Florida Citrus Industry: Addressing Citrus Greening Disease; that team developed a research plan for the Florida industry. He also chaired the Scientific Advisory Board of the Citrus Research and Development Foundation (CRDF) to provide peer review of Citrus Advanced Technology Program research proposals.

And then there is Brian Federici, insect pathologist and molecular biologist, emeritus, of the University of California, Riverside. He serves as a science advisor to the CRDF-led nuPsyllid grant project. This project, funded by USDA, is a 5-year, $9-million effort of approximately 45 scientists from 22 institutions to develop a psyllid insect population that is unable to host and transmit *CLas*, the causal agent of HLB. The result of this interdisciplinary effort will be deployed in citrus as a biological control.

Federici brings unique expertise to this project, having been involved in numerous similar projects to attack mosquitos that transmit human diseases. His current activities include participation in U.S. efforts to combat Zika virus and its mosquito vectors.

These are just two names out of many.

There is no doubt that scientists have made inroads toward solutions to HLB over the past decade. There is a lot of promising research out there. Science is going to get us there, and growers can ease their frustration just a bit by knowing the best minds in the business are engaged.

Harold Browning is Chief Operations Officer of CRDF. The foundation is charged with funding citrus research and getting the results of that research to use in the grove.

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water use by approximately 3,245 gallons per tree acre in 2012–2013 and 4,117 in 2013–2014, for a savings of 11 to 18 percent and an average savings of approximately 14 percent from the conventional irrigation practice.

Fruit yields for all three irrigation schedules were not significantly different in 2012–2013 or 2013–2014 and were similar to the initial year. Thus, yearly water use by HLB-affected trees can be reduced by approximately 15 percent using soil moisture sensors or model simulation with no significant reduction in yield.

WATER USE OF HEALTHY VS. HLB-AFFECTED GREENHOUSE TREES

A study was conducted at the SWFREC using lysimeters filled with Immokalee fine sand. Three-year-old Hamlin and Valencia on Carrizo trees averaging 42 inches tall were planted in a dozen 24-inch by 36-inch weighing lysimeters of each variety (six HLB-affected and six healthy trees), for a total of 24 lysimeters to determine daily tree water use. The lysimeters were built in greenhouses to exclude psyllids and maintain healthy trees. Daily water use per tree was estimated by subtracting tree and soil weight prior to daily irrigation from tree and soil weight after irrigation the previous day.

Results from the 2-year study showed significant reduction in water use for HLB-affected trees when compared to healthy ones. Citrus water uptake by HLB-affected Hamlin trees was approximately 29 percent less in 2014 and 21 percent less in 2015 than uptake by healthy Hamlin trees. Similar reductions in water uptake were found for HLB-affected Valencia trees, with 26 percent and 18 percent less water taken up, compared with healthy trees in 2014 and 2015, respectively.

All trees were irrigated daily to maintain soil water content near field capacity to provide optimum water uptake, but lower water uptake by HLB-affected trees resulted in higher soil volumetric water contents in soil-containing trees affected by HLB compared to healthy trees. All trees received similar fertilizer application rates. However, lower numbers of leaves, lower leaf area and lower water uptake of trees affected by HLB caused tree leaf nutrient concentrations to vary. Whereas leaves of healthy and HLB-affected trees contained similar concentrations of nitrogen and phosphorus, leaves from affected trees contained lower concentrations of potassium, calcium, magnesium, copper, iron, manganese, zinc and boron than leaves of healthy trees. These results suggest that HLB-affected trees must be managed differently than healthy trees by increasing the micro-elements fertilizer.

FIELD COMPARISON OF IRRIGATION SCHEDULES ON HLB-AFFECTED TREES

Mature Valencia orange trees on Swingle rootstock in three commercial groves in Avon Park, Arcadia and Immokalee were irrigated for two years with three irrigation regimes including daily, IFAS recommendation and intermediate irrigation schedules. Most trees in all three blocks were HLB symptomatic with thinning canopies and small leaves. All groves received approximately the same volume of water per week based on ET from the nearest FAWN weather station. Average water use among irrigation treatments was not significantly different at all three study sites, and was consistent with the goal of this study in that a similar amount of water should be used for all treatments.

Xylem sap flow measurements indicated significant differences among irrigation schedules, with the greatest sap flow in trees receiving daily irrigation and the lowest in trees receiving IFAS-recommended irrigation schedules. Improved sap flow suggests daily irrigation can reduce water stress in HLB-affected trees. The greater sap flow correlated well with increased average daily soil water content, further indicating more frequent irrigation with lower amounts of water improved water availability and uptake by HLB-affected citrus trees.

There was a significant difference in tree leaf densities as affected by irrigation scheduling. Greater leaf area was measured for trees with daily and intermediate irrigation schedules compared with trees irrigated using IFAS-recommended irrigation schedules. Higher leaf densities were likely the result of a significantly decreased leaf drop observed with daily irrigation treatment for all sites in 2014. Leaf drop was lower, but not significantly different, with daily irrigation schedules in 2013. Increased yield with daily irrigation was found at the Immokalee site in 2014.

Yields among all irrigation schedules at Avon Park and Arcadia were similar for both years, with a range of 250 to 304 pounds of fruit per tree. Although adoption of more frequent, lower-water-amount irrigation schedules produced a clear improvement in water uptake at the three sites, improvement in canopy density and yield did not occur until the second year. Although yields were higher in the second year for the more frequent irrigation schedule, they were only significantly greater at one site.

CONCLUSIONS

In both the field and greenhouse studies, irrigation schedules with frequent irrigation of smaller amounts of water benefited HLB-affected trees. It was observed that HLB-affected citrus trees receiving more frequent irrigation applications increased tree canopy density.

The relationship between leaf area and water uptake indicated that HLB-affected trees with thinning canopy density and corresponding lower leaf area take up less water and therefore less nutrients from the soil. Thus, it is the opinion of the author that current IFAS recommendations be revised to encourage more frequent irrigation with appropriate amounts of water.

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