# Update on advanced citrus production system research

**By Arnold W. Schumann, Kevin Hostler, Kirandeep Mann and Laura Waldo**

Research on the advanced citrus production system (ACPS) conducted by UF/IFAS aims to develop practical solutions for replanting and profitably sustaining citrus groves in huanglongbing (HLB)-endemic Florida. Components of ACPS to achieve these goals are early canopy development, early high-fruit production and return on investment, extra trees and compensatory growth in high-density plantings to offset tree losses, optimum nutrition, enhanced tree fitness, and maximum fertilizer and water use efficiency.

These "open hydroponics" (OH) fertigation concepts were introduced in previous *Citrus Industry* articles published in August 2009 and 2010. In this article, we will update the results from the 2.5-year old Gapway Grove Corp. and UF/IFAS ACPS replant experiment on the Ridge near Auburndale and discuss future research.

The ACPS experiment was planted with Hamlin orange on Swingle and C-35 rootstocks in December 2008. There were three different planting densities (218, 303 and 363 trees per acre) and three different water/nutrient management methods (conventional granular fertilizer with grower operated microsprinkler irrigation; intensively managed microsprinkler fertigation; and intensive drip fertigation). The fertilizer rate used each year for the conventional method was the midpoint of the IFAS recommendations for young trees in the SL253 publication, "Nutrition of Florida Citrus Trees, 2nd ed." After the first year, about 50 percent of the fertilizer in the conventional method was supplied as controlled release fertilizer during the summer months. From the beginning, the fertilizer rate used in the ACPS treatments was much less than in the conventional treatment, based on assumptions of higher efficiency, leaf analyses and our observations as we developed the system.

### WHAT WE HAVE LEARNED ABOUT DRIP FERTIGATION IN ACPS

This OH drip fertigation system now works well in a commercial grove in Central Florida. In 2008, we did not know whether the root systems of citrus trees grown in Florida could be manipulated to the extent required by true OH. In OH systems used in arid or Mediterranean climates, the root systems of trees are confined to grow in only the small soil volume wetted by drip emitters, thus allowing the trees to grow on the fertigation system, ignoring the soil. Such a "root ball" culture system increases efficiencies of water and nutrient uptake and improves control of plant nutrition, water supply and tree size.

Adequate tree size control is a fundamental requirement of ACPS because the high planting densities will not support traditional large Florida citrus trees. In Florida's subtropical summer rainfall climate, we initially were skeptical whether such control of the root system and tree size could be achieved. This year we carefully excavated the root system of a tree which had grown with the drip ACPS method for 2.25 years (Fig. 1, page 16). The root system was growing in two parts: the primary feeding roots in the form of a prolific root pad or dense ball under the two drip emitters at each tree, and a less dense but more extensive conventional root system in the bulk soil.

Use of this trained root pad approach, along with daily drip fertigation, the soil water sensors, flow meters and a rain gauge are still the primary tools used to establish correct dosing of water and nutrients throughout the season. Recently we added a real-time electrical conductivity (EC) sensor to monitor the total concentration of fertilizer in the soil solution bathing the root pads. By monitoring the daily changes in solution EC, we are learning how to adjust the rate of fertilization as the demand changes due to tree growth, leaf flushing, flowering or fruit development.

We also developed and tested simple Web-based models. Now available on the Data page of our ACPS website, these models will calculate the daily transpiration water requirement of any size tree at any time of the year. Knowing daily transpiration is more important than knowing daily evapotranspiration when growing trees with precise drip fertigation, since evaporative loss of irrigation water from drippers is negligible. When leaching losses are also avoided by using soil water sensors to detect and adjust the wetted soil volume, the daily amounts of water applied per tree closely match the estimated daily transpiration during dry weather. When the bulk soil and outlying roots beyond the drip emitters are rewetted after rain, the dependency of the trees on the drip emitters and root pad diminishes temporarily because the entire wetted root system can absorb water and nutrients. As the soil dries, the trees become progressively more dependent on the smaller compact root system growing around the drip emitters. During the Florida spring weather, it takes about a week for the trees to become fully dependent on the root pads and drip fertigation again.

## ACPS FRUIT YIELD, QUALITY AND FREEZE PROTECTION

Fruit were harvested from the experiment in December 2010 when the trees were 2 years old. Although the average yield from the high-density (363 trees/acre) drip ACPS method was only 38 boxes per acre, selected trees showed that higher yields are

# Growing Communication Remains Top Priority for FDOC

*By Ken Keck*

As the only self-funded state agency, the Florida Department of Citrus (FDOC) almost by definition must be fully accountable to you, the citrus grower, as well as all industry stakeholders. We strive to be open and transparent in our business practices and to make information readily available to you.

Recently, we revamped the FDOCGrower.com website to serve you better. The site continues to feature the information you've requested to support your business needs, but is now presented in a clearer, more concise format. We hope that you will find the new layout — now divided into the areas of Economic Research, Scientific Research, Nutrition and Health, Domestic Marketing, International Marketing and Accountability Reports — easier to navigate so you can find items of interest more efficiently. We have also increased the interactive capability allowing you to interact directly with various FDOC departments through this venue.

*Enhanced FDOCGrower.com website puts timely information at growers' fingertips.*

The FDOC marketing team launched Citrus Segments this spring, a periodic electronic update describing the latest domestic marketing activities conducted on behalf of growers. Citrus Segments includes interactive links to videos and media placements, and provides highlights about recent advertising, shopper marketing, school, public relations, food service and in-state marketing efforts. To subscribe, simply enter your email address at the bottom right corner of the FDOCGrower.com home page.

FDOCGrower.com will continue to be your information resource about the Florida Citrus Commission (FCC). The list of new commissioners, appointed by Gov. Rick Scott, is posted on the site. We encourage you to contact these individuals directly and to attend upcoming FCC meetings to provide real-time feedback at the time of decision-making.

FCC meetings are broadcast live on Polk County Government TV whenever possible through a link on the FCC meeting page. In addition, the meeting summaries, slide presentations and video recordings are available on the website following the meetings to keep you fully informed about FCC and FDOC activities.

How are we doing? I welcome your comments, criticisms and suggestions at kkeck@citrus.state.fl.us. Please let us know how FDOC can continue to support your needs and to help ensure the future sustainability of the Florida citrus industry.

***The mission of the Florida Department of Citrus is to grow the market for the Florida citrus industry to enhance the economic well-being of the Florida citrus grower, citrus industry and the state of Florida. Ken Keck, Acting Executive Director, can be reached at 863-537-3999. For more information, visit www.FDOCGrower.com***

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***Fig. 1.*** *Exposed roots under ACPS drip emitters showing dense proliferation in the wetted soil only, and closeup of healthy white feeder roots (inset)*

***Fig. 2.*** *Example of good fruit production on a 2-year-old Hamlin orange tree grown with drip-ACPS*

possible (Fig. 2). The conventionally grown trees with microsprinklers yielded eight boxes/acre, and both the external and internal fruit quality was lower than in the ACPS-grown fruit.

The conventionally grown fruit had significantly more acid (0.72 percent) than the ACPS fruit (0.55 percent), and therefore a lower ratio. It appears that the ACPS fruit quality overcame problems associated with juvenility after just two years.

Importantly, the ACPS-grown trees with microsprinklers performed as well (yield, quality) as those on drip emitters. Thus, the frequent fertigation with a comprehensive nutrient formula seemed to be the most important factor influencing tree growth and early high yields. The microsprinklers also perform the essential function of freeze protection as required in mid-December of 2010 (Fig. 3, page 17). Since drip emitters provide no freeze protection, we had the additional cost of a second microsprinkler irrigation system for freeze protection. Disadvantages of microsprinkler ACPS, however, include lower nutrient and water efficiencies, and likely less control over tree size than with drip ACPS.

## NUTRIENT AND WATER EFFICIENCIES AND NITRATE LEACHING

The microsprinkler ACPS-grown trees received about the same amount of water (5 acre-inches) for irrigation as the conventionally grown trees in

*Fig. 3. Freeze protection of a drip-ACPS tree on Dec. 14, 2010 from irrigation water delivered with a separate microsprinkler system*

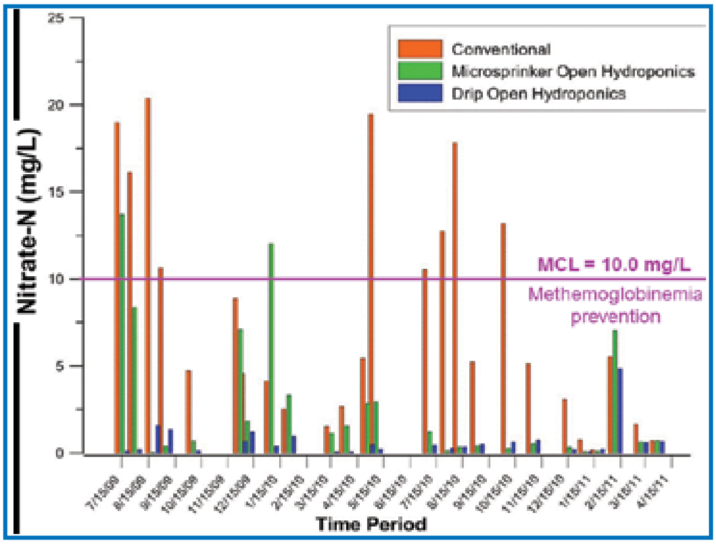


*Fig. 4. Concentration of nitrate-nitrogen in the soil leachate collected at a depth of 5 feet below trees after leaching events from 2009 to 2011*

2.5 years. During the same period, the water used for freeze protection for all growing methods was more than 17 inches. The drip ACPS trees at 218 trees/acre received 33 percent less irrigation water than the conventionally grown trees, but at the highest density (363 trees/acre), their water requirement was 28 percent more. When the amounts of water used to grow canopy (efficiencies) are compared, however, the microsprinkler ACPS was 1.24 times more efficient than the conventional method. The drip ACPS was 1.95 times more efficient than the conventional method using microsprinklers.

Comparing nitrogen (N) efficiencies, the microsprinkler ACPS was 5.2 times and the drip ACPS was eight times more efficient than the conventional method. Cumulative N fertilizer applied to the drip ACPS trees during 2.5 years was only 48 lb./acre. Since the drip ACPS received 6.3 times less fertilizer and 1.45 times less irrigation water than the conventional method during the two years required to produce fruit, the yield efficiency gains were 14.7 times and 3.4 times for N and irrigation water, respectively. Yield efficiency gains for the microsprinkler ACPS method were seven times for N fertilizer and two times for irrigation water.

Improved water and nutrient utilization efficiencies achieved with ACPS directly translated to reduced nutrient losses from the grove. Figure 4 shows

***Fig. 5.*** *HLB-infected ACPS-drip grown, 2.5-year-old Hamlin orange tree, 12 months after first showing visible symptoms (right inset), at which time it was caged in psyllid-proof netting (left inset)*

that the leached nitrate-N measured at a depth of 5 feet below the trees was always below the EPA's maximum contaminant level (MCL) for drinking water of 10 mg/L (ppm) for drip ACPS, slightly higher but only twice exceeding 10 ppm for microsprinkler ACPS, and was above 10 ppm nine times for the conventional method. These data are not nitrate concentrations in the groundwater, but the advantages of nutrient and water conservation through enhanced efficiencies are clearly evident.

## HLB INCIDENCE, CURRENT FRUIT CROP AND FUTURE OUTLOOK

After about 19 months, the first four HLB-symptomatic trees were identified. Three infected trees were removed and we are keeping one in a psyllid-free enclosure (Fig. 5) for further study. This tree is growing in the drip ACPS treatment and is also receiving supplementary feeding from controlled release granular fertilizer and occasional foliar nutrient sprays. About one year later, the tree is still growing and producing a small crop of normal looking fruit (Fig. 6, page 20) along with some classic visual symptoms of HLB infection in the lower foliage. Fortunately, the HLB incidence detected so far in the 15-acre experiment is only 0.1 percent.

Good current fruit set in 2011, now on larger trees than in 2010 (Fig. 7, page 20), suggests that we could expect a profitable yield from ACPS at the end of the third year. Since even earlier high yields could be achieved

**Fig. 6 (top left).** *HLB-infected ACPS-drip grown Hamlin orange tree at 2.5 years field age, showing healthy foliage and a few normal fruit in June 2010*
**Fig. 7 (top right).** *Good fruit set in 2011 suggests a profitable yield could be expected from ACPS at the end of the third year.*
**Fig. 8 (left).** *"Tramline" configurations will be used in a new experiment to test densities up to 850 trees/acre.*

simply by increasing the planting density even more, we will be planting a new experiment to test densities up to 850 trees/acre, some in special "tramline" configurations (Fig. 8). Advantages of tramline configurations are less driving required for grove equipment, earlier canopy formation, less weed control due to better interception of sunlight by canopies, and earlier, higher fruit yields. Specialized narrow farm equipment based on a 48-inch wide tractor will be tested in our new high-density grove research and will be essential for long-term sustainable production with super-high-density ACPS.

UF/IFAS research is showing that tree growth can be enhanced, fruit yield may be achieved at least a year earlier, and water and fertilizer use efficiencies can be significantly improved with ACPS over conventional methods in Florida. Long-term sustainability and profitability of ACPS in the face of endemic HLB infections will be determined in the following years.

We thank the Citrus Research and Development Foundation, Southwest Florida Water Management District and the UF/IFAS research dean for funding this research, and for the excellent in-kind support from our grower cooperator, John Strang and Gapway Grove Corp. Details of the ACPS can be obtained from our CREC website (www.crec.ifas.ufl.edu > research > advanced citrus production) or by contacting Arnold Schumann at schumaw@ufl.edu.

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