Advanced production systems for Florida citrus: research update, huanglongbing impacts and production forecasts

An advanced production system grove using drip-open hydroponic fertigation and C35 rootstock. The photo was taken at harvest time on Dec. 4, 2011 when the trees were almost exactly 3 years old.

By Arnold Schumann, Kevin Hostler, Laura Waldo and Kirandeep Mann

The Hamlin orange Advanced Production System (APS) field experiment near Auburndale was planted in December 2008. The original purpose of this experiment was to test and adapt the open hydroponics (OH) concepts of fruit production in Florida's subtropical climate and soils, and with Florida citrus varieties and rootstocks. The timing of the research coincided with new urgency for rapidly developing short- and long-term solutions for the huanglongbing (HLB) or "greening" disease which was discovered in Florida a couple of years earlier. Specifically, APS was envisaged as an essential tool for profitably replanting citrus in the age of endemic HLB. In this article we will review the trial's progress at 3.5 years and offer preliminary forecasts for production and HLB impacts. For additional background information about this experiment, please refer to three previous August editions of *Citrus Industry* (2009 to 2011).

EARLY FRUIT PRODUCTION – ARE WE ON TARGET?

The December 2011 fruit yield at three years was the first commercial harvest (Figure 1). The block was also harvested in the previous season, but the 2-year yields were less than 40 boxes/acre. The highest fruit yield in year 3 was 222 boxes/acre for the drip open hydroponic (OH) fertigation, 363 trees/acre, and C35 rootstock combination, yielding 2.4 times more than the standard treatment (91 boxes/acre).

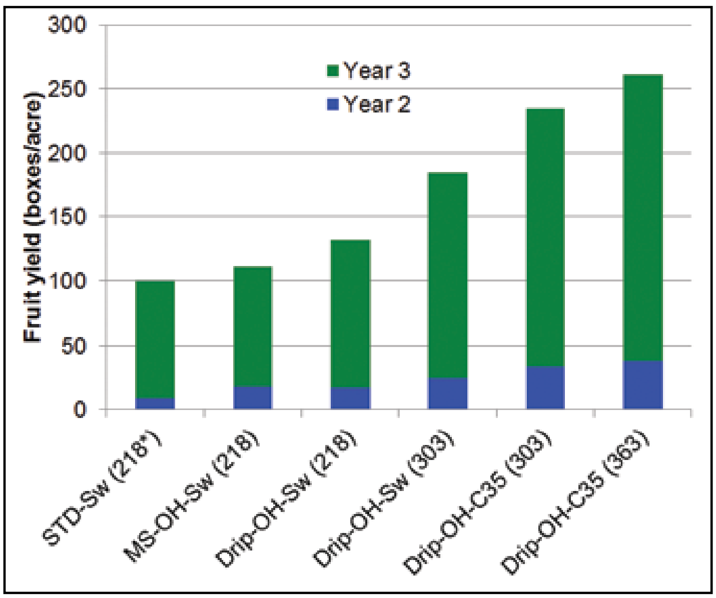

Figure 1. *Fruit production of Hamlin orange for different experiment treatments. *Numbers in parentheses are planting densities (trees/acre); STD = the standard grower practice (granular fertilizer, micro sprinkler irrigation); MS = micro sprinkler fertigation; Drip = drip fertigation; OH = open hydroponics; Sw and C35 = Swingle and C35 rootstocks, respectively.*

With a favorable juice price at the end of 2011 near $2/lb. solids, and a soluble solids yield of about 5 lb./box, the best APS treatment was therefore approximately breaking even with annual production costs in year 3 ($2,206 fruit revenue). The estimated fruit revenue from the standard treatment in year 3 was $844, and not yet breaking even with annual production costs. The third year fruit yield from the micro sprinkler (MS)-OH fertigation treatment (93 boxes/acre) was similar to the standard treatment and lower than expected. Inadequate nutrient supply-demand matching during fruit set and development phases was identified as a likely cause, and was successfully corrected in the current season. The micro sprinkler fertigation system has a strategic advantage over drip fertigation because it will also provide freeze protection in the winter months.

In general, the C35 rootstock outperformed Swingle citrumelo in both production years, and the Hamlin orange canopies were noticeably more compact on C35 than on Swingle, making C35 a better choice for high-density planting. The effects of higher planting density proved most useful with both rootstocks to bring the trees into economic production earlier. There are also important production efficiency advantages of higher planting densities because more trees can be treated with the same foliar broadcast pesticides per acre than in lower, conventional densities. Planting density was identified as the most significant contributor to higher early yields in this experiment, with a nearly linear 1:1 relationship for economic return on the additional investment in tree planting costs, provided that the trees have not yet reached containment (Figure 2).

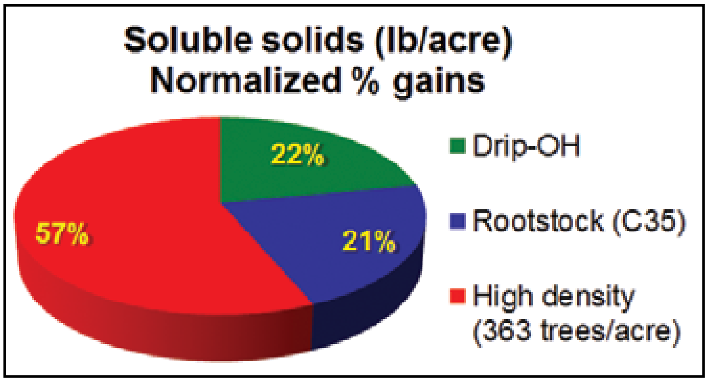

Figure 2. *Percentage contributions of drip-OH fertigation, C35 rootstock, and high-density planting to increases in juice soluble solids yields over conventional production systems (granular fertilizer, micro sprinkler irrigation, 218 trees/acre) and Swingle rootstock*

In summary, these third-year results show that we are on target with early high fruit production using APS. The integration of OH, high-density planting and superior rootstock combinations can produce early high fruit yields which are also efficiently grown and economically viable in Florida conditions. APS effectively achieves a given production level equivalent to conventionally grown trees at 5 years of age, but in 1 to 2 years less time. The years of production costs saved constitute a significant economic advantage in the age of endemic HLB.

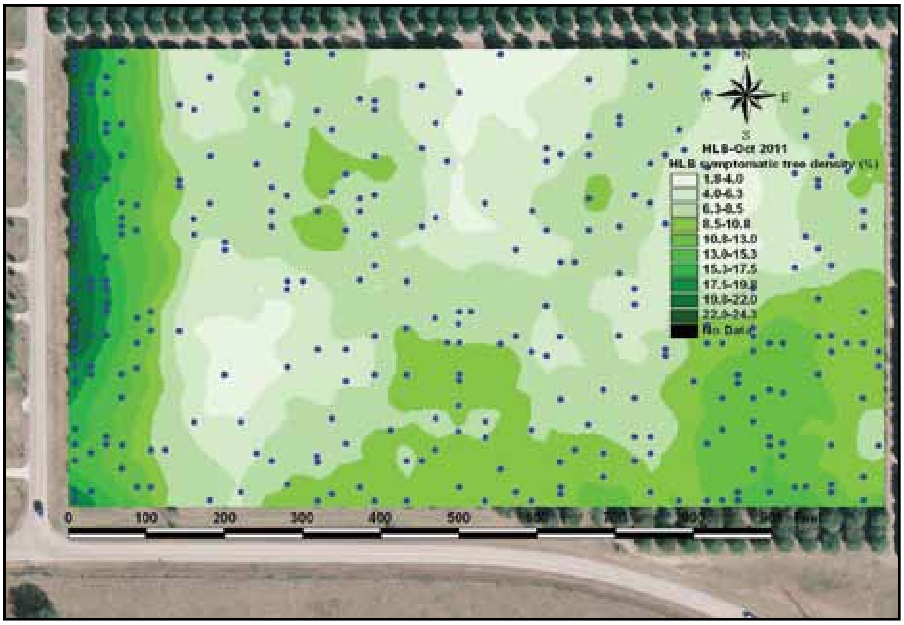

Figure 3. *Location of HLB-symptomatic trees (blue dots) and interpolated percentage HLB incidence in the APS young tree block.*

HLB DISEASE STATUS

HLB was first found in this experiment in August 2010, and remained low (0.1 percent) until the middle of 2011, and infected trees were destroyed as recommended for low infection rates. In October 2011, the HLB incidence exploded dramatically to an average of 8.5 percent, with close to 24 percent in the western boundary of the block (Figure 3). Closer examination revealed a number of infected neighborhood yard trees with a separation of only 95 feet from the experiment's western boundary. We suspect that adult psyllid fly-ins from the neighboring trees contributed greatly to the rapid upturn in HLB incidence. Other factors contributing to the alarming HLB infection include a diminishing efficacy of systemic soil-drench neonicotinoid pesticides as the trees grow beyond 6 feet tall, the recent increase in PCR-positive adult psyllids in this region of Polk County, and the inability to spray contact insecticides during the spring bloom period when bees are actively foraging in the grove.

In January 2012, additional HLB-

Figure 4. *Illustration of HLB severity scores: left to right, 1 = low, 3 = moderate, 5 = severe. Photos were taken on May 25, 2012.*

symptomatic trees were identified, bringing the cumulative HLB incidence for the 14-acre block to 10 percent. Due to the exponential trend of HLB infection rate, the inability to eliminate *Candidatus* Liberibacter asiaticus (cLas) inoculum in the neighborhood trees or to control the Asian citrus psyllid (ACP) populations on the same trees, the decision was made to stop removing infected trees and instead to conduct research on the behavior of young HLB-infected trees under intensive APS management. Fruit yields were sampled separately from HLB-symptomatic and asymptomatic trees in December 2011 for comparison. At that early stage of infection, average yields and fruit size per tree were the same. Most likely the lack of differences in fruit yield and quality was due to the development of HLB symptoms in the late phase of fruit development. The following year's new fruit crop (2012) will be analyzed to measure the impact of HLB on the entire fruit development season.

A comprehensive survey of the 345 HLB-symptomatic trees consisting of photographic recording of symptoms and visual HLB severity scoring was completed on May 25, 2012 (Figure 4). The HLB severity scores and incidence data were analyzed with analysis of variance according to the treatment plots where they occurred in order to assess the impacts of management factors on disease. HLB *incidence* was significantly higher in the standard management treatment than in the APS treatments. In addition, HLB *severity* was significantly higher in the standard management treatment using Swingle rootstocks than in the APS treatments using C35 rootstocks. These results suggest that the best combinations of APS components which optimize early yields are also effective in partially mitigating the incidence and severity of HLB in the research block.

WILL HLB-INFECTED YOUNG TREES BECOME PRODUCTIVE AND REMAIN SUSTAINABLE?

The resulting classifications of the HLB severity scores showed that 40 percent of the infected trees were in the 0-2 score (low severity) classes, 49 percent were in the moderate severity (score 3) class, and 11 percent were in the severe (score 4-5) classes (see Figure 4, page 9). These early results seem encouraging for any disease mitigation approach because of the lower proportion of severely affected trees, but only additional time will answer the question of sustainability in this citrus block.

However, some forecasts were attempted based on current status and past experience with HLB infection of groves. In the absence of HLB infection, the yield curve of the best performing APS combination (drip OH fertigation, 363 trees/acre, C35 rootstock) is expected to be 38, 222, 450 and 650 boxes/acre in years 2, 3, 4 and 5, respectively. In a worst-case scenario, the HLB incidence will double every year, resulting in 100 percent infection by years 7 and 8. If continued APS management integrated with foliar nutrition cultural methods can prolong the survival of infected trees and limit mortality to less than 1 percent per year, then a viable scenario may be possible.

Assuming a yield reduction of 50 percent for HLB-symptomatic trees, the modified yield curve for this high-density setting at exponential infection rates shows yields reaching a lower plateau at around 500 to 600 boxes/acre in year 7 or 8. To sustain that yield, each tree need only produce 1.5 boxes of fruit per year (1.5 boxes/tree x 363 trees/acre = 544 boxes/acre). Under such reduced yield conditions, the 363 trees/acre grove is expected to take about three additional years to reach the economic break-even point, at which time all establishment and production costs are paid. Additional assumptions for this simple calculation were a favorable juice price of $1.50 per pound of solids, a soluble solids yield of 5 lb./box, an annual production cost of $2,000/acre, and an establishment cost of about $15,000/acre. More sophisticated forecasting methods would use a fluctuating simulated juice price. At a high juice price of $2, the additional time to break even is expected to be only 1 year, but at a low price of $1, an additional 12 years may be needed to break even.

In summary, HLB-infected new blocks might become productive, but the importance of a favorable juice price is underlined in this preliminary simulation exercise, and unfortunately it is the economic factor over which the grower has no control. The higher juice price helps offset some of the yield losses from HLB. High densities appear to favor success in HLB endemic conditions. HLB-infected trees will remain smaller, with lower yields per tree — conditions which are better dealt with and compensated for with high planting densities and APS than with traditional low densities and conventional citriculture.

PRELIMINARY CONCLUSIONS AND FUTURE RESEARCH

Although not a "silver bullet," APS is proving to be an important component of a comprehensive integrated solution for young citrus groves to become productive and remain viable in the presence of ACP and HLB. HLB-tolerant rootstocks are another promising outcome of current research efforts at UF/IFAS and USDA, which if combined with APS, may permit nearly normal profitable production levels. Important features of APS for growing citrus in the age of HLB are:

1. Full economic fruit production is reached one to two years earlier than with conventional methods.

2. High planting densities achieve greater efficiencies in grove care operations like broadcast pesticide spraying.

3. High planting densities offer greater compensatory growth and yield if infected trees are removed, and higher yield per acre if infected trees are retained and each produces only a partial yield.

4. APS fertigation allows unlimited variable control of nutrient combinations which may be prescribed to mitigate HLB symptoms.

5. High-density APS groves are managed to grow smaller trees. Tools like dwarfing rootstocks, high fruit loads, and selective hedging are used to manage tree sizes so that the canopy volume of many smaller trees replaces fewer larger trees under conventional culture.

6. Smaller trees in an APS are more efficiently protected from Asian citrus psyllids and other pests than larger trees in conventional groves because systemic pesticides are most efficiently absorbed by and incorporated into smaller trees with a limited root system and compact canopies.

New APS research experiments were scheduled for planting in July (Valencia orange, Lake Alfred) and in early 2013 (grapefruit, Fort Pierce). Barrett Gruber, who is based at the Indian River Research and Education Center, recently joined IFAS and the APS project, and will be conducting the new fresh fruit grapefruit experiment. One objective of the new research will be to evaluate different grove designs using alternating double-row configurations, dubbed "tramlines," to achieve the highest grove space utilization efficiencies and earlier fruit production.

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Coming events

The **2012 Citrus Expo** will take place Aug. 15-16 at Lee Civic Center in North Fort Myers. See www.CitrusExpo.net for more information.

A **Florida Agriculture Financial Management Conference** will be conducted Sept. 9-11 at the Gaylord Palms Resort and Convention Center in Kissimmee. Information is available at www.FAFMC.org

A **Pomegranate Association meeting and conference** is scheduled for Sept. 14 at the Citrus Research and Education Center in Lake Alfred. More information is available from Cindy Weinstein at flpomegranate@gmail.com; phone (863) 604-3778.

A **Citrus Mechanical Harvesting Workshop** will be conducted at the Nov. 18-23 Citrus Congress in Spain. Contact Enrique Molto (molto@ivia.es) or Reza Ehsani (ehsani@ufl.edu) for information.