New production systems to grow HLB-free fresh citrus

By Barrett Gruber, Brian Boman, Arnold Schumann, Fred Gmitter, Jude Grosser and Ron Brlansky

Citrus tree and crop losses associated with huanglongbing disease (HLB, or "greening") have severely and negatively affected commercial growers and hobbyists alike since HLB's confirmation in the state in 2005. This disease often leads to fruit that drops prematurely, is discolored and misshapen, and has poor internal quality. Therefore, HLB has affected fresh growers particularly hard because fresh fruit must maintain commercially appealing characteristics from harvest to purchase.

One possible approach to growing HLB-free trees and fresh fruit is production underneath totally enclosed structures (citrus undercover production systems, or CUPS). This approach relies upon physically preventing young trees from coming into contact with the Asian citrus psyllid (ACP), the insect that transmits the bacterial pathogen (*Candidatus* Liberibacter asiaticus, *C*Las) associated with HLB. If young trees are physically separated from the ACP, then they should not develop HLB. CUPS is partly based upon the successful precedent set by the entire Florida citrus nursery industry, which has been employing enclosed structures to grow disease-free stock since 2007. Studies were initiated in late 2013 to compare tree growth and fruit yield and quality under CUPS versus open-air plantings.

Screen house facilities at the University of Florida's Indian River Research and Education Center (IRREC) in Fort Pierce

In November 2013, construction was completed on four 0.28 acre, totally enclosed pole-and-cable screen houses with a height of 14 feet. The polyethylene monofilament mesh screen used for these houses has approximate openings of 0.3 millimeter (mm), about one-third the width of the average adult ACP, and transmits 75 percent to 77 percent of incident sunlight through the roof panels. An irrigation/fertigation manifold was constructed that services each of the four protective screen houses and their associated open-air check plots (Figure 1). The irrigation/fertigation manifold operation is controlled by a comprehensive, on-site weather station that monitors reference evapotranspiration. Thus, irrigation/fertigation zone runtimes are calculated based upon the evaporative demands experienced by each zone.

Within each of the four protective screen houses, Ray Ruby grapefruit trees were planted in the ground and in 10-gallon plastic containers. One of the other research goals of this project is to evaluate tree growth in containers versus trees that are planted in the ground. Each tree is serviced by two

Figure 1. Left: A pole-and-cable, anti-insect screen house at the UF-IRREC in Fort Pierce. Right: Irrigation/fertigation valve manifold with liquid chemical proportional injectors in the upper right-hand corner of the image.

2-gallon-per-hour drip emitters. To maximize space within each screen house, all trees are spaced 5 feet within the row and 10 feet between rows (871 trees/acre).

Early results

Figure 2 depicts a time-lapse photographic record of tree growth inside the protective screen structures from November 2013 to October 2014. Trees planted either in the ground or in plastic containers grew rapidly during this 11-month period, with many trees' canopies touching in the within-row direction (5 feet) by the end of this time period. The most rapid period of growth during this time was from June 2014 to October 2014 (Figure 2). To date, the screen covering has excluded the ACP (adult body width is approximately 1.0 mm) (Figure 3).

Effects on Meteorological Variables

Protected screen houses could be used not only to prevent the ACP from accessing young trees, but could also positively influence the growing environment of young trees and fresh

Figure 2. Inside one of the anti-insect citrus screen houses at Fort Pierce, Ray Ruby grapefruit trees (left) planted in the ground and right, Ray Ruby grapefruit trees planted in 10-gallon plastic containers.

Figure 3. Sticky cards used to monitor insect activity outside (left) and inside (right) the anti-insect citrus screen houses at Fort Pierce. These sticky cards were deployed from September 1-30, 2014.

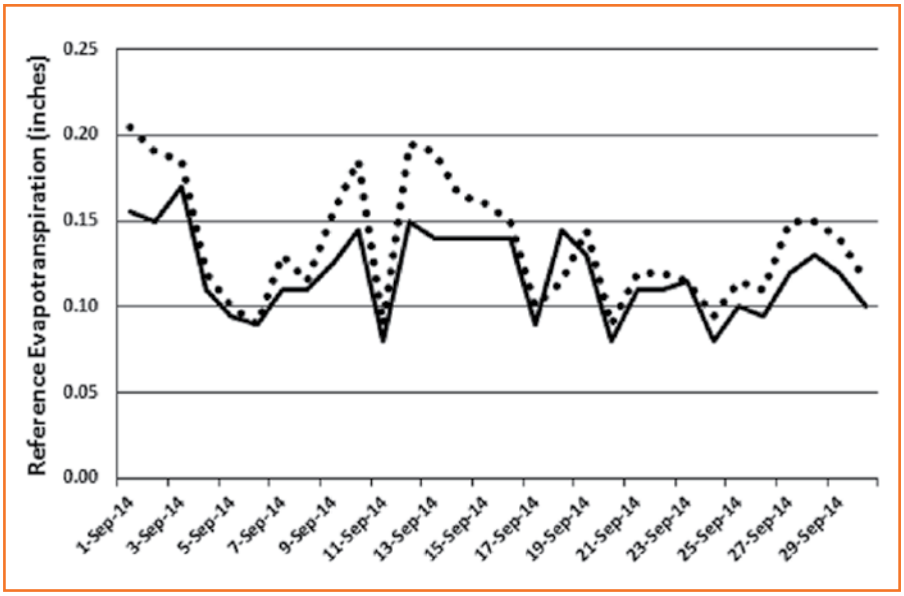

Figure 4. Average daily reference evapotranspiration (inches of water) outside (dotted line) and inside (solid line) the anti-insect citrus screen houses in Fort Pierce. Data were collected from September 1-30, 2014.

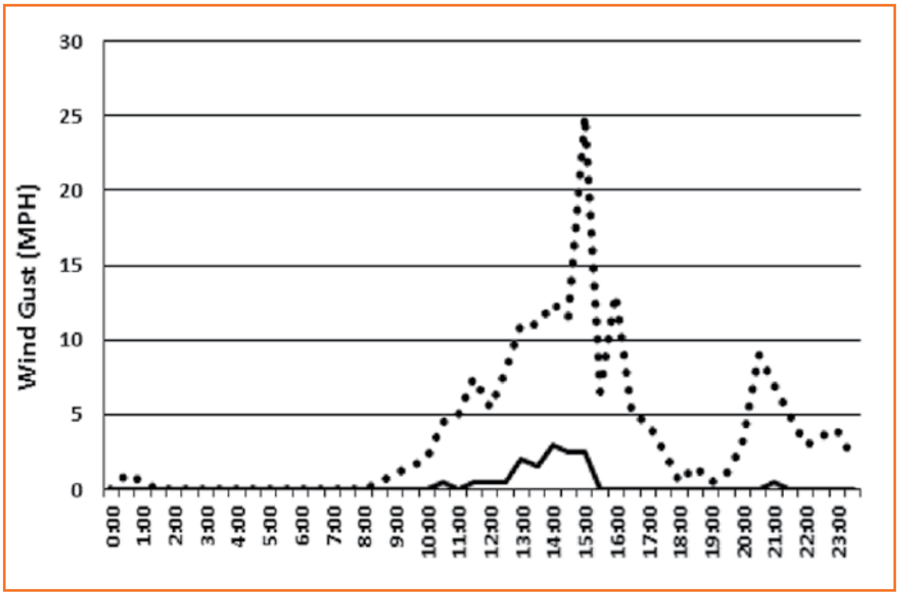

Figure 5. Average wind gust speed (miles per hour) outside (dotted line) and inside (solid line) the anti-insect citrus screen houses in Fort Pierce. Data were collected every 30 minutes from 12 a.m. (0:00) to 11:30 p.m. (23:30) on September 5, 2014.

fruit. For example, during the month of September 2014, daily rates of reference evapotranspiration (measured in inches of water) were greater outside the protective citrus structures when compared to inside the structures (Figure 4). The day with the greatest evaporative demand outside the houses was September 1, 2014 with 0.21 inches, while the greatest demand for water inside the houses was on September 3, 2014 with 0.17 inches (Figure 4).

Young citrus trees grown inside protective screen house structures likely experience less water stress than trees grown in open-air environments. This has implications for realizing reductions in irrigation usage and more efficient use of applied water by young trees. In addition, wind gust speed is greatly reduced within the insect-excluding citrus screen houses (Figure 5). For example, on September 5, 2014, wind gust speed was nearly 8.5 times greater outside than inside the screen houses (Figure 5). Thus, protective screen houses act as windbreaks and would likely reduce fruit wind-scarring and the spread of citrus canker disease.

The screen house facility at the University of Florida Citrus Research and Education Center (CREC) in Lake Alfred

The screen house at the CREC is similar in design and screen specification to the four described at the IRREC, but was constructed to accommodate all the citrus experiments in a single one-acre high-density planted block (Figure 6, see page 14).

Research objectives and experiments with the 1,077 available trees in the 58,000-square-foot screen house are aimed at developing improved long-term sustainable growing systems for maximizing profitable fresh fruit production, and include:

- Maintaining a pest- and disease-free growing environment by physical exclusion with a 50-mesh, anti-insect screen (0.3 mm), while minimizing pesticide use and costs.
- Comparison of two super-high planting densities using container hydroponics-grown citrus on trellises: 4x8 foot (1,361 trees/acre) and 5x10 foot (871 trees/acre)
- Hydroponically grown trees in-ground compared with soilless container-grown trees
- Comparison of three different container sizes (5-, 7-, 10-gallon)

• Comparison of three different containers designed to prevent harmful root circling (standard nursery pot [control], Root maker®, Routing pot® and Air pot®)

• Testing the efficacy of white reflective ground covers to increase canopy lighting and enhance tree growth/fruit production

• Evaluation of two main commercial fresh citrus varieties (Murcott and Ray Ruby grapefruit), and five commercial rootstocks (C35, X639, US897, Sour orange and Kuharske)

• Evaluation of rooted cuttings of W. Murcott, Ray Ruby grapefruit versus budded trees on rootstocks

• Demonstration of smaller quantities of other promising commercial varieties (W. Murcott, Persian lime, Eureka lemon, Meyer lemon, Page orange, Cara Cara navel, Blood orange, Hamlin orange, Valencia orange

• Evaluation of an array of new experimental fresh fruit scion and rootstock combinations produced by Jude Grosser and Fred Gmitter at the CREC; their unique new fresh fruit selections may produce products that demand premium prices

• One acre of high-density, container-grown, trellised hydroponics citrus (871 trees) was established in the summer of 2014 next to the screen house at the CREC. It was established to serve as a control for the screen house, and for extensive testing of whole-tree thermotherapy (WTT).

Figure 6. View of the CUPS screen house at the CREC, showing trellised container hydroponics-grown Cara Cara navel orange trees at 871 trees/acre planting density.

WTT for outdoor container-grown citrus

Although screen house-protected agriculture is the preferred method for comprehensively excluding systemic vector-borne diseases like

HLB, the higher price of screen house construction is a major establishment cost which slows the rate of return on the investment. For potted trees grown outdoors, WTT, where the potted root systems as well as canopies of HLB-affected trees are heat-treated for sufficient time at a high enough temperature to kill *C*Las, may be an economical alternative. This approach is being investigated for sustainable citrus production in HLB-endemic environments as part of this project. Results from these efforts will be reported in a future article.

Summary

HLB is associated with a pathogenic bacterium which is spread from tree-to-tree by the ACP. The current project is to determine if using protective screen house structures will physically separate the ACP from young citrus trees and yield quality fresh fruit. Young trees are growing well inside the enclosed screen structures and no HLB symptoms have been observed inside the houses. Insect activity of any kind is almost nonexistent inside the screen houses when compared with open-air plantings. Thus, not only are the enclosed screen houses capable of excluding the ACP, but there exists a possibility that yearly applications of synthetic insecticides could be reduced.

In addition, the meteorological conditions inside the houses could be better suited for more efficient fresh citrus production. For example, observed reference evapotranspiration rates inside protective screen structures are markedly lower over time, relative to open-air environments. This has potential implications for increased crop water use efficiency, irrigation savings and resource stewardship.

A major fruit grading defect for Florida fresh citrus is wind-scarring. Our preliminary work has demonstrated that wind gust speeds within insect-excluding screen structures are typically around five to 10 times less than open-air environments. Such reductions in wind speeds could lead to noticeably less wind-scarring in fresh fruit. In addition, we are also refining the use of whole-tree thermotherapy techniques to eliminate bacteria in outdoor container-grown citrus trees. Growing trees in containers offers a number of potential benefits, not the least of which is the reality of successfully eliminating infection with heat treatments. Using protective structures to cultivate fresh citrus fruit is not only a method for preventing HLB development, it is a potential opportunity to create new environmental growing platforms to raise Florida's signature crop more efficiently.

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