Using good horticultural practices to maintain yield of HLB-affected groves

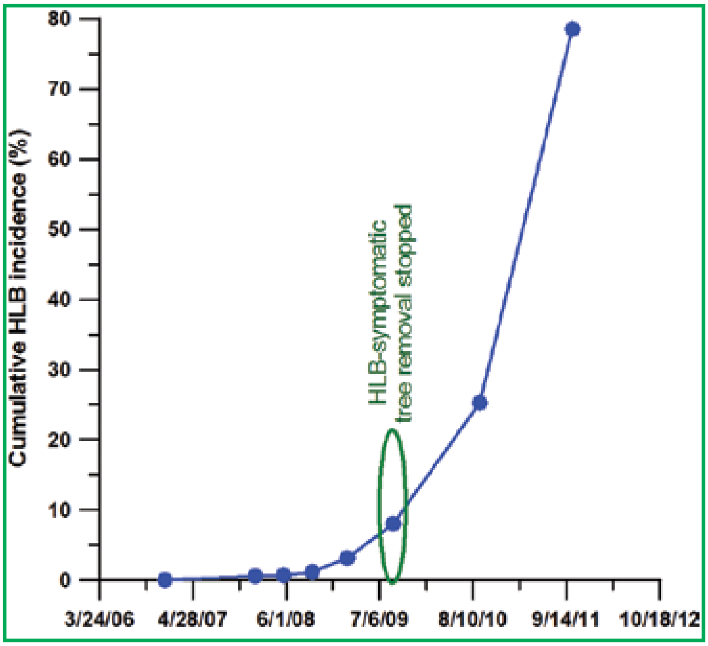

Figure 1. Cumulative HLB infection for the entire 180-acre CREF grove in Lake Placid from the initial HLB find in early 2007 through October 2011

By Timothy Spann and Arnold Schumann

By some estimates, up to 40 percent of all citrus trees in Florida are now infected with huanglongbing (HLB). Not only is it unfeasible to eradicate the disease by removing the infected trees, but also those infected trees must be kept productive to sustain the industry and support the research being conducted to find permanent solutions. Much attention has been given to what some are calling "ENPs" (enhanced nutritional programs), but these programs should more aptly be called GHPs (good horticultural practices) to better reflect the broad spectrum of tree care they provide. This article summarizes the results from two long-term studies that now, after three to four years, are showing how productive HLB-affected groves can be when well-managed.

CITRUS RESEARCH AND EDUCATION FOUNDATION GROVE, LAKE PLACID

The Citrus Research and Education Foundation (CREF) has a long-term lease on a 180-acre grove near Lake Placid. The original trees of Hamlin and Valencia oranges were established about 1990, most on Swingle rootstock. From 1999 to 2001, the grove was abandoned, and the subsequent successful rehabilitation process by the University of Florida-IFAS' Citrus Research and Education Center (IFAS CREC) began with help from Lykes Bros. and others. The grove was brought back to a profitable production level by about 2004, just as the first canker infections were discovered in the northeastern corner block. The first HLB infected trees were identified in 2007, although the disease was probably already established in the same northeast corner of the grove in 2006. It is important to note that this grove was originally established as a commercial grove and, with the exception of a few small blocks, is still managed as such today by IFAS CREC.

From the initial HLB discovery in 2007 until 2009, the grove was surveyed quarterly and HLB-symptomatic trees were immediately removed. Psyllids were controlled with frequent insecticide sprays, but the intensity of sprays was further increased to about the current nine per year when it became apparent that the spread of HLB in the grove was unchecked (Fig. 1). By September 2009, the cumulative infection was about 8 percent, and further removal of infected trees was stopped because at the exponential rate of infection observed, rapid loss of fruit yield and economic collapse of the grove was imminent. The current average HLB infection level in the grove is estimated to be >80 percent (Figs. 1 & 2).

Figure 2. Block layout (left) showing block numbers (top number) and block acreage (lower number) in the CREF Lake Placid grove. The spatial distribution of HLB infection across blocks (right) with individual trees indicated by blue and pink dots as of October 2011

Beginning in the spring of 2010 through the present, the entire grove has been managed with a more intensive soil- and foliar-applied fertilizer program, more aggressive psyllid control, and only unproductive trees are being removed — most of them due to citrus blight infection. The complete

Table 1. Valencia fruit yield and quality for the 2011/12 harvest of the replicated field experiment in the CREF grove.

Treatment	Fruit yield (boxes/ac)	Acid (%)	Brix (%)	Ratio	Soluble solids (lb./box)	Fruit weight (g)	Juice (%)	Total juice (lb./ac)	Fruit count (fruits/tree)	Soluble solids yield (lb./acre)
Std. foliar spray	418	0.669	13.38	20.0	7.183	232.1	59.65	22,527	644	3019
High intensity foliar spray	417	0.686	13.66	20.1	7.379	217.3	60.01	22,539	679	3082
LSD* (0.05)	53.2	0.0377	0.325	0.977	0.2192	14.36	1.166	3,099.7	97	438.3
F-probability**	0.961 NS***	0.368 NS	0.088 NS	0.933 NS	0.079 NS	0.044 *	0.533 NS	0.994 NS	0.461 NS	0.773 NS

** LSD – least significant difference; ** F-probability – means the probability of the measured differences being real; *** NS – not significant*
The 0.044 figure in red (last row), followed by an asterisk, means that particular F-probability is the only one that is statistically significant; the others being non-significant.

ground- and foliar-applied nutrition and psyllid control programs can be found online (see "Field Day Handout" at http://www.crec.ifas.ufl.edu/extension/extension_meetings/).

Briefly, the ground fertilizer program has been applied at a nitrogen rate of 200 lb./acre, split equally four times per year. Calcium nitrate is used as the nitrogen (N) source when available; otherwise ammonium nitrate is used. In 2010, calcium nitrate was used in February and April, while in 2011, it was used in every application. The composition of the granular fertilizer in 2011 was 10-02-13 + 11.3 percent Ca, 1.7 percent Mg, 3.5 percent S, 0.03 percent Fe, 0.03 percent B.

In addition, specific research plots are receiving supplementary fertigation applied during the early spring and summer. A comprehensive hydroponics nutrient solution (see "Field Day Handout" Figure 12 at http://www.crec.ifas.ufl.edu/extension/extension_meetings/) at 0.5 lb. N /acre equivalent was injected in the daily irrigation, using an automated controller. About 20 lb./acre additional nitrogen is added to the annual total in the fertigated plots.

In addition to the ground-applied fertilizer, a high foliar nutrition program was introduced in 2010 that includes major, secondary and micronutrients applied with every pesticide spray in most of the grove (see "Field Day Handout" Table 2 at http://www.crec.ifas.ufl.edu/extension/extension_meetings/). The plant nutrient elements used are N, P, K, Ca, Mg, S, Mn, Zn, Mo, B and Fe. Non-nutrient active ingredients are phosphite as potassium phosphite, salicylic acid as potassium salicylate, and *Bacillus subtilis* biofungicide. However, certain research plots have only been receiving ground fertilization and a standard foliar nutrition program consisting of one to two annual applications (April and June, coinciding with leaf flushes) of Mn, Fe and Zn at labeled rates of 2 gal./acre (liquid formulation of 1.6 percent Fe, 2.0 percent Mn, 2.0 percent Zn).

To date in the 38-acre replicated field experiment, there are no significant differences in fruit yield among the plots receiving supplemental fertigation and/or the high foliar nutrition program, compared to those receiving the comprehensive ground-applied fertilizer plus standard foliar nutrition program (Table 1, page 7). All yield measurements were pooled in Table 1 across both fertigated and unfertigated experiments due to the lack of significant fertigation response.

The only significant treatment response was measured in the fruit weight, which indicated that the fruit sizes were smaller for trees receiving the intensive foliar spray program. This likely was a compensatory response to a slightly higher fruit count per tree. Soluble solids yield per box was nearly significantly different, in favor of the more intensive foliar sprays. This somewhat surprising outcome is good news, because it implies that HLB-infected trees can be economically sustained with good horticultural practices based on a comprehensive ground fertilization program and only minor foliar nutrient additions. The experiment is being continued for at least one more year to confirm these results.

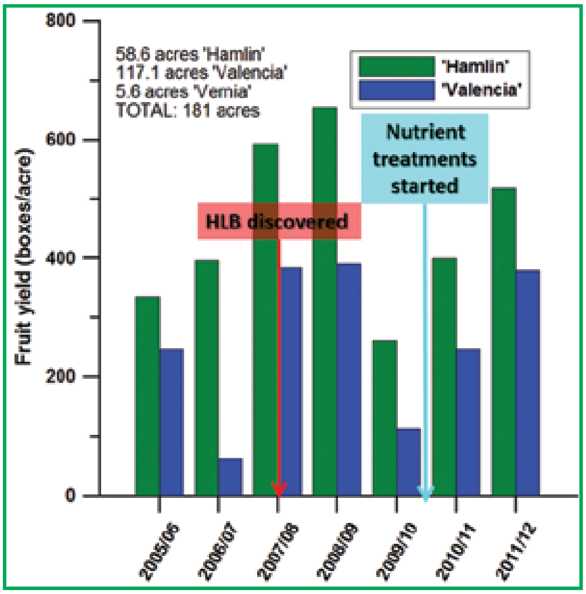

Figure 3. *The average yield across all blocks for Hamlin and Valencia trees in the CREF Lake Placid grove over the past seven harvest seasons. The total acres of each variety are indicated in the upper left corner; the Vernia trees were planted in 2011. The discovery of HLB and the initiation of the intensive management program are indicated by the red and blue arrows, respectively.*

Across the CREF grove, the improved management program (i.e., more intensive soil- and foliar-applied fertilizer program, more aggressive psyllid control program, and only unproductive trees being removed) started in 2010 has been effective at reversing the downward decline in yield that HLB and infected tree removal had caused (Fig. 3). Prior to initiating the new program in 2010, the 2009/10 harvest season Hamlin yields had declined to the lowest level since the 2005/06 season, and Valencia yields were at the second lowest level recorded. This current harvest season saw average Hamlin yields rise to 518 boxes/acre, and the average Valencia yields at 379 boxes/acre were nearly back up to the historic maximum of 390 boxes/acre previously recorded in the grove. Valencia fruit revenue from the 2011/12 season was about $4,600 to $5,400 per acre at an estimated price per pound solids of $1.50 and $1.75, respectively.

ORANGE HAMMOCK GROVE, FELDA

During the 2008/09 harvest season, we began to collect yield data from a set of Hamlin and Valencia orange trees in the McKinnon Corp./Maury Boyd Orange Hammock grove in Felda. The first HLB-affected tree was found in this grove in February 2006. Symptomatic trees were never removed, and instead, an intensive management program was instituted consisting of foliar-applied nutrient sprays, foliar-applied non-nutrient products (e.g., phosphite, salicylic acid), intensive psyllid control primarily by aerial application of pesticides, and modifications to ground-applied fertilizer (e.g., addition of boron and inclusion of calcium nitrate in every ground application). Although the grove has never been systematically scouted for HLB, sampling and PCR testing on a set of 100 trees conducted by Bob Rouse (Southwest Florida Research and Education Center), Tim Willis and Maury Boyd (McKinnon Corp.), and Tim Gast and Mike Irey (U.S. Sugar Corp.), indicated that the mature trees in the grove were approximately 40 percent positive for HLB in January 2008 and 91 percent positive in January 2010.

We were interested in knowing whether the management program being applied was sustaining the productivity of HLB-affected trees or if these trees were declining and losing yield over time. To assess this, a set of 20 mature (20 years old) Hamlin and 20 mature Valencia trees, on Swingle and Carrizo rootstocks, respectively, were selected prior to harvest in 2008. In each set, 10 of the trees did not have visual HLB symptoms and the pathogen was undetectable by PCR; the other 10 trees were selected to have moderate HLB symptoms (approximately 35 percent of the canopy affected). All of the symptomatic trees tested positive by PCR. For discussion purposes, we refer to these two sets of trees as "healthy" and "HLB," respectively, but it is likely that some, if not all, of the healthy trees were infected, but not expressing symptoms when selected.

Each year since 2008, the trees have been hand-harvested, keeping the fruit from each tree separate. The fruit is transported back to the CREC in Lake Alfred and graded in our packinghouse. The total number of fruit per tree and the average diameter, volume and weight of each fruit is obtained. Preliminary work in the Orange Hammock grove and three others around the state by Chris Oswalt and Tim Spann determined that > 95 percent of the symptomatic fruit on an HLB-affected tree are < 2⅜" (60 mm) in diameter. Thus, the severity of infection can be assessed by evaluating the proportion of fruit on a tree below this size threshold, bearing in mind that a small portion of healthy fruit will fall below this threshold.

The data for the four years of observation at the Orange Hammock grove are shown in Tables 2 and 3. When looking at these data, the difference between healthy and HLB trees is immediately evident. Over the four years, the HLB Hamlin trees averaged > 10 percent symptomatic fruit (i.e., fruit < 2⅜"), and the Valencia trees averaged about 5 percent. As indicated by the p-value (p-values < 0.05 are considered statistically significant) for tree health, the difference between healthy and HLB trees is, not unexpectedly, highly significant. Also, not unexpectedly, there is a significant difference between harvest years for both varieties. This is likely due to environmental factors (e.g., freezes, drought, tropical storms) that can have major impacts on fruit size development.

Table 2. The proportion (percentage) of fruit smaller than 2⅜" diameter for 10 healthy and 10 HLB-symptomatic Hamlin trees managed using a comprehensive horticultural program at the McKinnon Corp. Orange Hammock grove in Felda, Fla. over four years.

Tree health status	Harvest Season 2008/09	2008/10	2010/11	2011/12
HLB	12.56	15.70	19.77	5.89
Healthy	0.99	6.51	5.43	1.46
	Statistical significance			
Tree health x year	P = 0.1355			
Tree health	P = <0.0001			
Year	P = 0.0004			

Table 3. The proportion (percentage) of fruit smaller than 2⅜" diameter for 10 healthy and 10 HLB-symptomatic Valencia trees managed using a comprehensive horticultural program at the McKinnon Corp. Orange Hammock grove in Felda, Fla. over four years.

Tree health status	Harvest Season 2008/09	2008/10	2010/11	2011/12
HLB	7.83	5.74	3.95	2.83
Healthy	1.01	0.74	0.37	0.42
	Statistical significance			
Tree health x year	P = 0.1404			
Tree health	P = <0.0001			
Year	P = 0.0137			

The important part of these two tables, however, is the lack of statistical significance for the interaction between tree health and year (p-values much higher than 0.05). This indicates that the changes occurring over time are the same for both healthy and HLB trees, indicating that the year-to-year changes are most likely due to environmental or other factors common to both sets of trees and not HLB. Put another way, there is no evidence from these data that the HLB trees produced more symptomatic fruit in 2011/12 than they did at the start of the study. The yield of HLB-affected trees is being sustained.

Total yield data, expressed as pounds of fruit per tree, followed the same pattern for the four-year period as the proportion of fruit < 2⅜". That is, tree health was significant – healthy trees yielded more than HLB-affected trees – and year was significant – yield varied significantly from year to year. Again, there was no interaction between tree health and year, indicating that the yield was not changing over the four years of the study due to tree health. Averaged over the four-year period, healthy and HLB Hamlin trees yielded 427.7 and 212.7 lbs. of fruit per tree, respectively, and healthy and HLB Valencia trees yielded 264.3 and 153.8 lbs. of fruit per tree, respectively.

It is important to note that our sets of trees were not chosen to be representative of "average" trees in the grove, but rather to represent the two extremes of trees in the grove. Therefore, extrapolating to per-acre yields or determining average yield loss per tree due to HLB from these data is not valid. That said, the actual per-acre yields for Hamlin and Valencia trees from the Orange Hammock grove for the past 13 years are shown in Fig. 4. These data show that there is no discernible trend – positive or negative – in boxes per acre yield or pounds solids per box since the discovery of HLB in 2006.

CONCLUSIONS

The information shared in this article demonstrates that in a well-managed grove, the combination of foliar-applied mineral nutrients and non-nutrient elements, excellent psyllid management and some improvements to ground-applied fertilizer programs (e.g., use of calcium nitrate, inclusion of boron) does sustain individual HLB-affected trees and maintains or increases total grove yields. However, from the research described in this article, we cannot determine the specific nutrient elements, compounds or products essential for success in every case. It is likely that factors unique to each site (e.g., soil pH) interact with HLB management practices such that no one program will work in every location.

The evidence continues to mount that HLB is not the rapid death sentence for Florida citrus that it was once purported to be. Good horticultural practices, focused on minimizing plant stress — nutrient deficiencies, drought, etc. — and maximizing productivity are tried-and-true cultural practices that have and will continue to grow the Florida sunshine tree. It is important to remember that the pathogen that causes HLB is transmitted by the Asian citrus psyllid, and therefore a successful management program, such as described in this article, starts with excellent psyllid control.

The authors wish to acknowledge the generous product donations made by GP Solutions for the research at the CREF Lake Placid grove, and Maury Boyd and Tim Willis of McKinnon Corp. for their assistance and generous donation of fruit for the duration of the research at the Orange Hammock grove. Funding for research is provided by USDA/SCRI specialty crops block grant at the CREF Lake Placid grove, and by the CRDF at the Orange Hammock grove.

Timothy Spann is an assistant professor and Arnold Schumann is an associate professor, both at the University of Florida-IFAS' Citrus Research and Education Center at Lake Alfred.

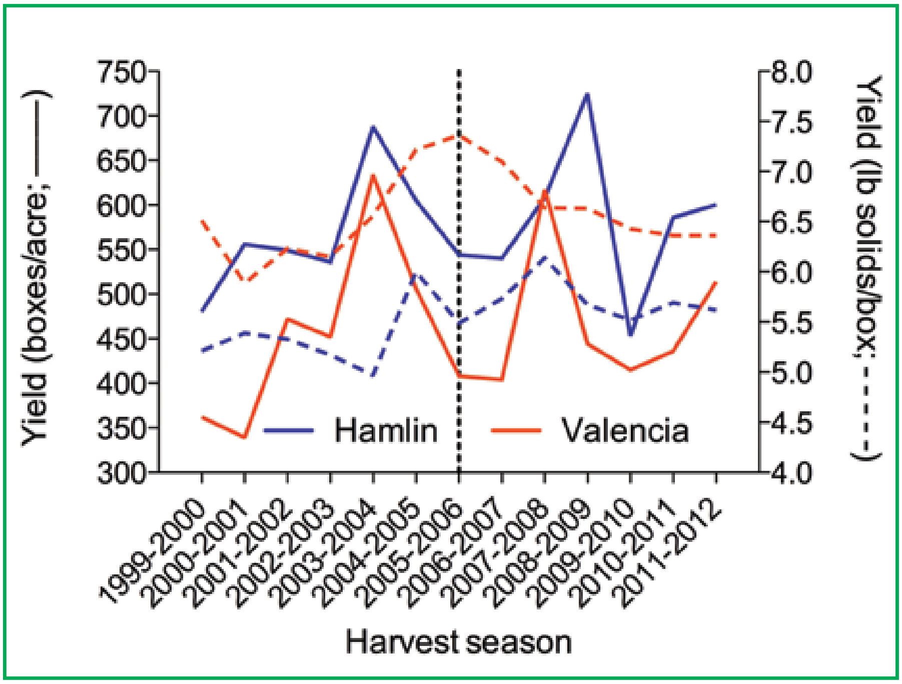

Figure 4. *Thirteen-year yield history for Hamlin and Valencia orange trees in the McKinnon Corp. Orange Hammock grove in Felda. The solid lines indicate the yield in boxes per acre and the dashed lines the yield in pounds solids per box. The vertical dashed line indicates the season during which HLB was discovered in the grove.*