COVER STORY

Horticultural and economic evaluations of nutritional treatments for HLB

By Bob Rouse and Fritz Roka

HLB was confirmed in Florida during August 2005 in a dooryard pomelo tree in south Miami, Dade County. By February 2009, HLB had been confirmed in all counties with commercial citrus plantings.

Citrus growers at first were confused by the symptoms being similar to nutritional symptoms of Zn and Mn deficiencies and uncertain how to approach the disease from a management perspective.

The industry's initial response was to follow the Brazilian and plant pathology standard approach toward a vectored bacterial infection — control the vector population (psyllids), and scout and remove symptomatic trees to control — if not reduce — inoculum. It quickly became apparent to many growers that following a protocol of eradicating symptomatic trees could put them out of business.

Growers faced great uncertainty as to which trees were in fact infected because trees could remain infected for several years as host plants before expressing symptoms. There was also a fear that replanted trees would become infected and never reach economic production.

THE BOYD PROGRAM

Maury Boyd, a grower in southwest Florida, decided against symptomatic tree removal and instead began treating the nutritional symptoms with foliar applications of macro and micronutrients along with SAR (systemic acquired resistance) products and other components. Boyd's Orange Hammock citrus grove has become well known in the Florida citrus industry and internationally in citrus-growing regions of the world for use of a nutritional program to maintain the health and production of HLB-infected trees. The nutritional program was combined with an aggressive Asian citrus psyllid insect management program, a good soil applied dry fertilizer program and foliar-applied nutrients. His trees have remained healthy and productive since HLB was detected in the grove in 2006.

In 2008, a trial using various combinations of the components of Boyd's nutritional cocktail was established in a planting of Hamlin orange on Swingle citrumelo rootstock at the University of Florida, IFAS, Southwest Florida Research and Education Center (SWFREC) in Immokalee. An objective of this research was to determine if the results being observed in the Orange Hammock grove could be duplicated in other locations. Another objective was to determine if there were specific ingredients in the nutritional/SAR cocktail mix that were responsible for the success in Boyd's grove.

The SWFREC trees had been planted in 2003 and were used for weed management and entomology studies on insecticidal psyllid management. The trees were continually pruned to stimulate new growth to encourage psyllid feeding. By 2008, the trees were in decline — small, unhealthy, non-fruiting and 100 percent infected with HLB.

Boyd's trees have remained healthy and productive since HLB was detected in the grove in 2006.

The nutritional trial began in March 2008. The foliar nutritional treatments and products are listed in Table 1 (page 12). Nutritional applications were synchronized during the year with the three vegetative growth flushes typical of citrus in Florida: Treatments were applied each year in March when the spring flush emerged, in June during summer flush, and with the fall (September) flush.

All treatments received a ground application of dry fertilizer made three times per year using calcium nitrate 9-1-14 + Mg, Mn, Zn, Fe, Cu and B. The annual total was 160 lb/acre N and 205 lb/acre K_2O.

Hamlin/Swingle orange tree at SWFREC with HLB in 2008 before receiving supplemental foliar nutrition (photo 1), in 2012 after five years with foliar nutrition (photo 2), and in 2014 (photo 3).

Visual observations were made during the year of tree condition, expression of nutritional deficiencies, and HLB symptoms. Observations included foliage canopy color and general tree health.

Fruit was harvested each year in November or December. Yield was measured by harvesting and weighing all fruit from each tree. Average pounds of fruit per tree were multiplied by 150 (trees) to project fruit yield per acre. Juice quality as measured by legal maturity factors was determined with an official commercial FMC juice extractor used by the Florida Department of Agriculture and Consumer Services.

LEAF SYMPTOMS

It was observed that the control trees showed HLB symptomatic leaves throughout the year and became visibly yellow and chlorotic during the fall and winter. The trees receiving foliar treatments without micronutrients exhibited micronutrient symptoms of Mn, Zn and B deficiencies throughout the year and some chlorotic leaves including HLB blotchy mottle. Trees receiving treatments with micronutrients rarely expressed symptoms of micronutrient deficiencies during the growing season and, if present only, on a few select shoots. Trees receiving macro and micronutrients appeared greener and healthier than other trees. All trees showed moderate visible HLB symptomatic leaves during fall and winter. The trees receiving macro and micronutrients were less symptomatic of HLB during the winter than the control and other treatments. The trees receiving the complete complement of nutrients remained mostly free of HLB symptomatic leaves during the growing season with only a minor amount of symptomatic leaves during the winter.

Table 1. Treatments of foliar nutrient/SAR sprays to Hamlin trees planted 8/15/2003. Trial began March 2008 with three applications per year with flushes (March, June, September).

Treatment	Products
1	Macro[1] & micronutrients[2], Di Oxy Solv[3], K-phite 7LP[4], SAver[5], [6]Serenade, KNO_3[6], citrus oil
2	Macro & micronutrients, K-phite 7LP, KNO_3, citrus oil
3	Micronutrients, KNO_3, citrus oil
4	KNO_3, citrus oil
5	Serenade, KNO_3, SAver, citrus oil
6	Macronutrients, Serenade, K-phite 7LP, SAver, KNO_3, citrus oil
7	Micronutrients, Serenade, SAver, KNO_3, citrus oil
8	Macronutrients, K-phite 7LP, KNO_3, citrus oil
9	Macro & micronutrients, Serenade, K-phite 7LP, SAver, KNO_3, citrus oil
10	Control (annual summer oil spray)

[1]Macro is macronutrients as liquid 3-18-20, [2]Micronutrients [$MnSO_4$, $ZnSO_4$, Na_2MoO_4, B (sodium borate)], [3]Di Oxy Solv is hydrogen peroxide, [4]K-phite 7LP (Plant Food Systems, Zellwood, FL) is phosphorous acid, [5]SAver (Plant Food Systems, Zellwood, FL) is potassium salicylate (salicylic acid), [6]Serenade ASO is *Bacillus subtilis* (Agraquest, Inc., Davis, CA), [7]KNO_3 is potassium nitrate spray grade.

FRUIT PRODUCTION

Fruit production for the five years is given in Table 2 (page 14). Fruit yield of Hamlin harvested at the end of the first year of foliar nutritional treatments in 2008 was representative of HLB trees with poor growth and dieback. Although the trees had produced some new growth during the year, very little fruit was set in the spring due to the tree condition at the end of 2007. The control treatment which had received only a summer oil spray had less fruit than any of the nutritional treatments. Each year for the five years of the trial, the yield increased on trees in each treatment. The highest yields were in the fifth year and reached three to four boxes per tree on 8- to 9-foot-tall trees.

The better treatments were consistently treatments that contained some combination of macro and micronutrients, a phosphite and salicylate (salicylic acid). The salicylate appeared to increase vegetative bud break, resulting in more vegetative

shoots and leaves. The additional leaves provided additional leaf surface on which to apply the foliar nutrients; this may have increased absorption of the nutrients into the tree. The additional leaves may also help the trees support a larger crop of fruit.

JUICE QUALITY

Juice quality as measured by standard maturity factors of percentage juice per fruit, acid, degree Brix, Brix/acid ratio, and pounds solids per 90-pound box was similar to juice reported from trees before HLB. Neither juice quality nor fruit size in this trial was affected by HLB when treated with foliar nutritional therapy.

TREATMENTS AND ECONOMIC RESULTS

Treatments are shown in Table 1 (page 12). The control treatment 10 (annual summer oil) was used as a reference for both production and economic evaluations. The annual cost of treatment 10 was $131 per acre. The costs of other nutritional combinations are shown in Table 2 and ranged from $231 (treatment 4) to $680 (treatment 1), or an added cost of $100 and $549, respectively, per acre more than treatment 10.

All treatments produced more yield than the control (treatment 10). The cumulative production advantage in terms of 90-lb boxes for each treatment is shown in Table 3.

Treatment 2 enjoyed the largest yield gain among the nine treatments. Revenue gains were valued by assuming 5.6 pound solids per box, a delivered-in fruit price of $1.70 per pound solid, and $3 per box harvest and haul costs.

Over the 5-year trial, treatment 7 produced the highest cumulative gain in revenues, earning more than $5,500 per acre greater than the control, treatment 10.

When costs of the nutritional programs were considered, however, treatment 4 earned the highest net gains.

Treatment 8 actually lost money when compared to the control.

In general, nutritional programs with both micro and macro elements achieved the highest fruit gains. As shown in Table 2, several programs achieve similar production gains. Hence, growers have some flexibility with respect to managing costs and achieving higher gains in net income.

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Table 2. Hamlin fruit yield per tree by treatment for seasons 2008–2012 and cumulative yield.

Year	2008	2009	2010	2011	2012	Cumulative Yield	Cost $/ac-yr
Treatment	Pounds of fruit per tree						
1	21.5 ab*	48.0 bc	109.4 ab	170.7 a	286 ab	635.6	$680.50
2	37.0 a	78.2 a	118.1 a	196.2 a	360 a	789.5	$542.70
3	24.1 ab	42.5 bc	96.2 abc	188.7 a	251 ab	602.5	$382.70
4	30.4 ab	58.8 ab	74.0 cde	187.3 a	330 a	680.5	$231.40
5	18.6 b	35.6 bc	63.4 cde	149.6 b	269 ab	536.2	$327.20
6	18.9 b	48.3 bc	45.6 de	195.8 a	324 ab	632.6	$583.20
7	18.3 b	38.0 bc	85.6 abc	181.4 a	346 a	669.3	$382.50
8	14.8 b	28.7 c	43.6 e	108.3 b	207 bc	402.4	$487.40
9	24.9 ab	56.0 ab	79.6 bcd	174.5 a	329 a	664.0	$638.50
10	6.9 c	18.2 d	67.0 cde	56.5 c	132 c	280.6	$131.00

*Within a column, means followed by the same letter are not significantly different at the P>0.05 (Duncan's multiple range test).

Table 3. Added yield, revenue and cost by nutritional treatment relative to control (Treatment 10) and cumulative over the 5-year trial period, 2008–2012.

Treatment	Treatment Description	Added Yield	Added Revenue	Added Cost	Net Gain
		5-yr total bx/ac	5-yr total $/ac	5-yr total $/ac	$/ac
1	Micro+Macro+H_3PO_3+SAR+H_20_2	592	$3,858	$2,748	$1,110
2	Micro+Macro+H_3PO_3	848	$5,530	$2,059	$3,472
3	Micro+KNO_3+H3PO_3	537	$3,498	$1,259	$2,239
4	KNO_3	667	$4,346	$502	$3,844
5	SAR+KNO_3	426	$2,778	$981	$1,797
6	Macro+H_3PO_3+SAR	587	$3,825	$2,261	$1,564
7	Micro+KNO_3+SAR	648	$4,224	$1,258	$2,966
8	Macro+H_3PO_3	203	$1,324	$1,782	-$(458)
9	Micro+Macro+H_3PO_3+SAR	639	$4,166	$2,538	$1,629
10	Pre-HLB Standard (Summer oils with micros)	-	-	-	-

Assumptions: 150 trees per acre; 5.6 pound solids per box; $1.70 per pound solids delivered-in price; $3.00 per box to harvest and haul.