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Fruit Production in a Southwest Florida Citrus Grove Using the Boyd Nutrient/SAR Foliar Spray

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Fruit production in Mr. Boyd's Orange Hammock citrus grove in Felda has maintained its level since being confirmed with citrus greening disease known as Huanglongbing (HLB) in 2006. The trees have been receiving the Boyd foliar cocktail mix of nutrients and SARs (Systemic Acquired Resistance) since HLB was confirmed. The grove is now 95% infected with HLB. The grove consists of 'Valencia' and 'Hamlin' sweet oranges [*Citrus sinensis* (L.) Osb.] on Swingle citrumelo [*C. sinensis* × *P. trifoliate* (L.) Raf.] and Carrizo citrange (*C. paradise* Macf. × *P. trifoliate*) rootstocks. The mean yield of the 6 years before HLB was detected for 'Hamlin' was 569 boxes, and after finding HLB was 576 boxes per acre. Mean yield for 'Valencia' the 6 years before HLB was 460 boxes, and after HLB was 454 boxes per acre. Plots of 'Valencia' on Swingle citrumelo rootstock containing 100 trees (10 rows of 10 trees per row) each were PCR tested in 2008, 2010, and 2012. One sample plot contained mature 'Valencia' trees planted in 1992 and another plot of younger 'Valencia' trees planted in 1999. All trees in both plots were visually rated in 2010 and 2012 for symptoms of HLB using a 0 to 5 scale where 0 = vigorous tree with no symptoms of HLB to 5 = severely declined tree. Leaf samples were collected from each tree and processed by real-time PCR for detection of HLB bacteria at the U.S. Sugar HLB diagnostic lab. The mature trees tested 40% positive in 2008, 92% positive in 2010, and 95% positive in 2012. The percentage of HLB positive trees in the young trees increased from 81% in 2008, to 100% in 2010 and 2012. In 2012, the disease severity of all trees was rated less severe than in previous years. Thus, the citrus management practice of combined psyllid management and foliar nutrition/SAR sprays are maintaining tree health and production in the presence of HLB.

The Orange Hammock citrus grove of owner Maury Boyd has become well known in the Florida citrus industry and internationally in citrus growing regions because of the use of foliar applications of fertilizer nutrients and SAR (Systemic Acquired Resistance) products to maintain the health of HLB (Huanglongbing) infected trees. HLB, also known as citrus greening disease, was positively identified in Boyd's grove by the Florida Department of Agriculture, Division of Plant Industry in spring 2006 using PCR (Polymerase Chain Reaction). Since confirmation of HLB, the Orange Hammock grove has maintained tree health and production by producing seven years of profitable crops. The cultural production program consists of a foliar spray cocktail of nutrients and SAR products applied three times per year to coincide with the initiation of vegetative growth flushes. The application of the nutrient/SAR foliage spray program to reduce and ameliorate the HLB leaf symptoms, along with good soil-applied dry fertilizer combined with Asian citrus psyllid (*Diaphorina citri* Kuwayama) insect management programs, have allowed the trees to remain healthy and productive. The products in the foliar-applied nutrient/SAR cocktail have been published (Giles, 2009; Rouse et al., 2010). The owner acknowledges that the psyllid insecticide management program applied by fixed-wing aircraft using low volume of 5 to 10 gal per acre, with applications timed every 5 to 6 weeks during the growing season have been successful.

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Materials and Methods

The test site was the McKinnon Corporation Orange Hammock grove in Felda, FL. The grove is 333 acres, 125 acres 'Hamlin' and 208 acres 'Valencia'. It is a typical flatwoods grove bedded with two tree rows per 44-ft-wide bed, with trees planted 12 ft in the row and 22 ft between rows (165 trees/acre). Irrigation is by microsprayers. Fertilizer has been applied to the soil in four applications per year using calcium nitrate 15.5–5–0–0 19, triple super phosphate 0–40–0, muriate of potash (MOP) 0–0–61, K-Mag 0–0–22 11.1, with iron and boron as needed. Annually, the total amount of N is between 200 to 240 lb/acre and K_2O is 250 to 300 lb/acre. Boron is applied once with a herbicide application in late spring.

Two plots of 100 trees each (10 trees × 10 rows) of 'Valencia' orange on Swingle citrumelo rootstock were selected for PCR sampling for citrus greening. One plot was located in a block of mature trees planted in 1992 and a second plot located in a block of younger trees planted in 1999. A 10-leaf sample from each tree was collected and run with real time PCR in Jan. 2008, 2010, and 2012 at U.S. Sugar Corporation HLB lab in Clewiston.

For detection of HLB bacteria, *Candidatus Liberibacter Asiaticus* (Las), *Ca. Liberibacter Americanus* (Lam), and *Ca. Liberibacter Africanus* (Laf), total DNA was extracted from HLB symptomatic and non-symptomatic citrus leaf petioles chopped and processed by a modified Tris-Base β-mercapto-ethanol method of Li et al. (2006). Reactions were carried out in a 75000 Fast

Table 1. Products and amounts in 250 gal/acre of the Boyd Nutrient/SAR cocktail in 2012.

Foliar applied products	Amount/acre	Ground applied products	Amount/acre/yr
Serenade Max WP	2.0 lb	N (Calcium nitrate)	216 lb
Sonata	2.0 qt	P	43 lb
Di-Oxy Solv Organic (hydrogen peroxide)	2.0 qt	K (MOP) + K-Mag	266 lb
Renew[z]	10.0 gal	Magnesium	8.6 lb
Epsom salts (magnesium sulfate)	7.5 lb	Boron w/herbicide boom annually	1.5 lb
Techmangam (manganese sulfate)	10.0 lb	Iron where needed	Fe-EDTA or DTPA (22 lb/ton)
Zinc sulfate	2.5 lb	Copper nutritional only	As needed
Sodium molybdate	0.75 (oz dry)		
13–0–44 (spray grade potassium nitrate)	7.5 kb		
Turfpro	1.0 gal (spring)		
435 Citrus spray oil	4.5 gal		

[z]Renew (Plant Food Systems, Zellwood, FL) is a combination of products 14–7–8 w/K-Phite (1.0 pt/gal) + SAver (salicylate) on spring flush or 3–18–20 w/K-Phite (1.0 pt/gal) + Saver (salicylic acid) on summer and fall flush.

Real Time PCR System (Applied Biosystems, Foster City, CA). The Ct value is considered positive at 32 or below, negative at 36 or higher, and inconclusive between these two values.

In 2010 and 2012, trees were visually rated for tree overall condition and symptoms of HLB. The rating scale was; 0 = vigorous, no HLB symptoms; 1 = vigorous, slight HLB symptoms; 2 = slight decline (HLB symptomatic); 3 = moderate decline (HLB symptomatic); 4 = severe decline (HLB symptomatic); 5 = severely declined.

The foliar nutrient/SAR sprays have been applied since the discovery of HLB in 2006. Applications have been timed with the initiation of new vegetative flushes in the spring (March), summer (June), and autumn (September). The products and amounts for the foliar applied nutrient/SAR cocktail are given in Table 1.

Yield from the grove was collected from the grower records. The combined yield and juice quality from all blocks of the mature 'Valencia' trees was collected for seasons 1999–2000 to 2011–2012, and the combined yield and juice quality from all blocks of 'Hamlin' oranges was collected for seasons 1999–2000 to 2011–2012. Yield and juice quality from the 40 acre block of young 'Valencia' trees planted in 1999 is reported from production starting in 2003. All fruit yield is reported as boxes per acre (90 lb/box), and mean pound solids per box.

Results and Discussion

PCR leaf analysis results showed that the HLB infection has continued to spread in the Orange Hammock commercial grove from 2008 to 2012 (Table 2). Results for the mature 'Valencia' during the last 5 years of PCR analysis show that the number of infected trees increased from 40% in 2008 to 92% in 2010, and 95% in 2012. There were five weak or missing trees in this plot apparently not due to HLB and were later determined to be citrus blight. Since the number of trees testing positive between 2008 and 2010 had increased 52%, it would be expected that there were infected HLB trees that were non-symptomatic and not testing positive by PCR. This could be a contributing factor to explain why the infection percentage increased so much in 2010. During these years, psyllid management was becoming increasingly better and more intense. The grower feels he had not attained an adequate level of psyllid control until 2010 and since then, has applied insecticides every 4 to 5 weeks during the growing season by fixed wing aircraft.

Table 2. Percentage of 100-tree sample of citrus tree testing positive for HLB by PCR in 2008, 2010, and 2012 in the Orange Hammock grove near Felda, FL.

	HLB positive trees (%)	
Year	Mature 'Valencia'	Young 'Valencia'
2008	40	81
2010	92	100
2012	95	100

Results for the young 'Valencia' during the 5 years of PCR analysis showed that the number of infected trees increased from 81% in 2008 to 100% in 2010 and remained at100% in 2012. There were no missing trees in this plot. The infection increased to the maximum in 2 years and many of the trees not testing positive in 2008 were probably already infected but didn't test positive until 2010.

Tree ratings were done in 2010 and 2012 and the results are given in Figures 1 and 2. Symptom ratings in 2010 (Fig. 1) for the mature trees ranged from 0 to 5 with most trees being rated between 1.0 and 2.0, indicating vigorous trees with slight symptoms to slight decline. Symptom ratings in the young trees ranged from 1.0 to 4.0 with most trees between 1.5 and 3.0, indicating symptomatic with slight to severe decline. These young trees had a higher percentage of infected trees as indicted by the percent-

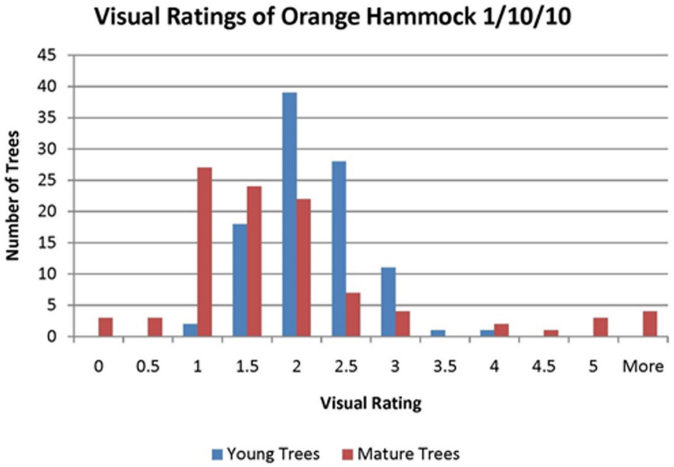

Fig. 1. Visual ratings of tree condition and HLB symptoms from 100 trees in the young and the mature 'Valencia' blocks in 2010.

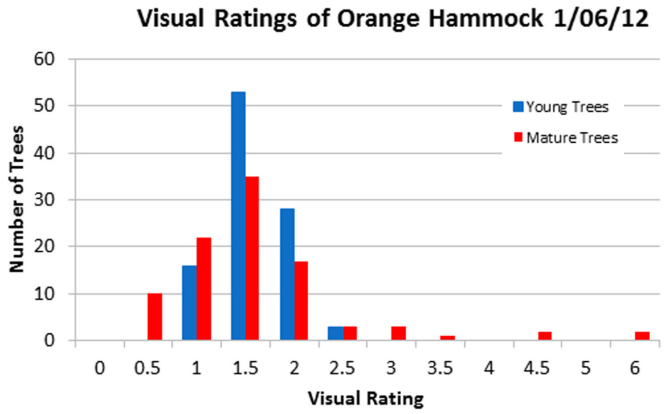

Fig. 2. Visual ratings of tree condition and HLB symptoms from 100 trees in the young and the mature 'Valencia' blocks in 2012.

age of PCR positive trees and were more severely infected as indicated by the visual ratings.

Ratings of symptoms in 2012 (Fig. 2) on the mature trees ranged mostly between 0.05 and 2.0, indicating a slight improvement in visible tree health with less HLB symptoms. Symptom ratings of the young trees ranged from 1.0 to 2.5, with most trees between 1.0 and 2.0, indicating a significant improvement in tree health with less HLB symptoms.

Yield in boxes of fruit per tree and pounds solids per box are given in Tables 3 and 4. Table 3 shows the yield from mature 'Hamlin' and 'Valencia' orange trees since 1999. Production of 500 to 700 boxes per acre for 'Hamlin' and 400 to 600 boxes per acre for 'Valencia' was among the top groves in Florida. Production the past 13 years has remained steady considering the variability of the conditions from year to year. Table 4 shows the production from the young 'Valencia' block since it began production in 2003. This young block has been slower to increase production due to the infection with HLB since 2006, hurricanes that occurred in 2

Table 3. Total yield by season and variety from the Orange Hammock Grove in Hendry County. The lower text **in boldface** represents years HLB (citrus greening) was present in the grove.

	'Hamlin' orange			Valencia' orange		
Season	Wt boxes	Lb solids/box	Boxes/acre	Wt boxes	Lb solids/box	Boxes/acre
1999–00	58,206	5.21	480	61,602	6.51	362
2000–01	67,425	5.39	556	57,659	5.89	339
2001–02	66,565	5.33	549	80,376	6.23	472
2002–03	65,004	5.17	536	76,911	6.15	452
2003–04	83,403	4.97	688	107,933	6.56	634
2004–05	73,381	6.00	605	86,104	7.22	503
2005–06	**65,981**	**5.49**	**544**	**69,423**	**7.36**	**408**
2006–07	**65,495**	**5.73**	**540**	**68,791**	**7.10**	**404**
2007–08	**73,671**	**6.14**	**608**	**105,045**	**6.64**	**617**
2008–09	**87,938**	**5.67**	**725**	**75,580**	**6.63**	**444**
2009–10	**54,942**	**5.52**	**453**	**70,660**	**6.43**	**415**
2010–11	**70,996**	**5.67**	**586**	**74,223**	**6.36**	**436**
2011–12	**72,697**	**5.62**	**599**	**87,587**	**6.37**	**514**

Table 4. Yield and fruit quality (lb solids/box) from the Orange Hammock Grove young tree 'Valencia' block.

Year	Yield (box/acre)[z]	Pound solids per box[y]
1999 (trees planted)	0	0
2003	83	6.56
2004	83	6.56
2005 (Hurricane Charlie, Aug. 2004)	83	7.22
2006 (Hurricane Wilma, Oct. 2005)	165	7.36
2007	165	7.10
2008 (T.S. Fay, Aug. 2008, 25 inches rain)	165	6.64
2009 (3 freezes)	124	6.63
2010 (freeze, 11 Jan. 2010)	142	5.56
2011 (2 freezes in December)	155	5.45
2012 (Freezes, 4–5 Jan.)	242	6.03

[z]Yield estimated 2003 through 2009 as fruit from young trees was combined with other blocks. Estimate was based on amount harvest from young trees divided by acres. Yield in 2010, 2011, and 2012 actual boxes/acre harvested. Box equals 90 lb of oranges.

[y]Pound solids in °Brix.

years, and freezes. This young block is increasing in production and fruit quality has maintained.

Conclusions

The citrus management practices of combined psyllid management and foliar nutrition/SAR sprays are being used successfully in Florida to maintaining tree health and production in the presence of HLB. The past seven-year production history at the Orange Hammock grove showed that production has not decreased since HLB was introduced. Nutritional/psyllid management programs have given hope to citrus growers that they can stay profitable in the citrus business until a more sustainable solution can be found. More than 90% of the Florida growers currently use the foliar nutrition/psyllid management approach in their production program and are maintaining their trees economically productive. The ideal is for a long-term solution to HLB that would include genetic resistance. The current production management practices that maintain tree health are allowing the citrus growers to remain in the citrus business in Florida. The cost of the Boyd program in the Orange Hammock grove is an economic question that must be addressed. The current cost of the three foliar sprays as formulated and applied each year exceeds $600 per acre. This program is currently possible if product costs remain affordable, juice prices remain above $1.50 pound solids, and high yields can be maintained.

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