Citrus Greening in Florida and Texas (and Mexico and India)

Glenn C. Wright
University of Arizona
Current Status of the Florida Industry

• Acreage and Yield decline
• Abandoned acres
• Tree health decline
  o Fruit and leaf symptoms
  o Fruit drop
  o Root loss
• Economic Impact
Florida Acreage and Production since 1994

Florida Citrus Acreage and Production since 1994

Acreage (x 1000 acres)

Production (x 1,000,000 tons)

Year

Abandoned acres

- 2015 – 130,108 acres
Tree Health Decline - Symptoms
Citrus Fruit Drop


• Stress factors such as drought and HLB can lead to premature ethylene production. Ethylene stimulates the cell wall dissolving enzymes in the fruit abscission zone, leading to fruit abscission (drop). Water stress leads to ethylene production.

• Drop also caused by Diplodia (Lasiodiplodia theobromae) fungi – leading to Stem End Rot (SER)
Preharvest Fruit Drop

- Brown discoloration may be present in the calyx abscission zone located at the pedicel-fruit interface
- HLB-affected fruit are located on HLB-symptomatic branches.
- Many fruit drop prematurely from affected branches,
- This causes a reduced yield as the disease severity increases.
HLB and Preharvest Fruit Drop

- *Lasiodiplodia theobromae* (diplodia) is the causal organism of citrus stem end rot (SER).
- The pathogen infects citrus fruit under the calyx abscission zone (AZ-C) and is associated with cell wall hydrolytic enzymes similar to plant enzymes involved in abscission.
- Diplodia was found in “Ca. Liberibacter asiaticus”-positive juice from HLB-symptomatic fruit (S) but not in “Ca. Liberibacter asiaticus”-negative juice.
Two weeks after exposure to ethylene, the incidences of Stem End Rot in diplodia symptomatic (S) fruit were 66.7% (Hamlin) and 58.7% (Valencia), whereas for asymptomatic fruit (AS) fruit the decay rates were 6.7% (Hamlin) and 5.3% (Valencia).

HLB likely reduces the plant defense mechanisms leading to diplodia colonization. Also, HLB increases starch in the phloem, and starch is a good substrate for diplodia growth.
HLB and Root Health

Soil pH and well water quality affect root health and HLB disease expression

- Microjet irrigation concentrates fibrous roots in the wetted zone
- Some groves (e.g. fresh fruit blocks) have history of dolomite liming for control of copper toxicity
- **Common condition**: pH > 6.5 in wetted zone is associated with well water high in bicarbonate (>100 ppm) and > HLB expression (i.e. fruit drop)
- Bicarbonate reduces root uptake of Ca, Mg, K, Fe (e.g. high Ca in soil/moderate levels in leaves)
- Groves with bicarbonate stress are experiencing > deterioration in fibrous root density, lifespan and function in root uptake
- Rootstock sensitivity: **Swingle** > Carrizo > Sour orange > Cleopatra
Phytophthora is worse where water Ph is high (>6.5)

**Flatwoods:** Phytophthora disease load at damaging level increased until fall fungicide application

**Ridge:** Phytophthora disease load was zero or low and decreased over the season
More HLB in roots than in leaves up to 10 months after infection.
Root Mass drops in Trees with HLB

Figure 4  Root mass density (grey bars) and corresponding root starch content (white bars) in HLB-affected trees (a) with visible symptoms in an isolated branch ($n = 4$) or in the whole tree ($n = 5$) compared to symptomless trees ($n = 5$), and (b) in trees prior to visible symptoms with ‘Candidatus Liberibacter asiaticus’ (Las) detected in the roots only ($n = 8$) or root and leaf (whole tree, $n = 5$) compared to presumptive healthy trees ($n = 5$). Root weights and densities with different letters are significantly different from each other at $P \leq 0.05$. An asterisk denotes significant difference in starch content from other treatments at $P \leq 0.05$. 
HLB and Root Loss – Root growth is not inhibited, but root density is.

<table>
<thead>
<tr>
<th>Presumed Healthy</th>
<th>New Growth</th>
<th>Root Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinning trees</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Root Growth is not inhibited
HLB and Phytophthora interaction – J. Graham

- HLB reduces root health by directly causing root loss and increasing Phytophthora infection
- HLB reduces the effectiveness of Aliette and Ridomil against Phytophthora
- While the effects of these treatments on yield in groves with both diseases is still being investigated, these findings emphasize the need to use Phytophthora-free planting material and drainage management to reduce the incidence of Phytophthora spp. in HLB-affected areas
Economic Impact

- HLB caused a cumulative loss of more than $2.9 billion in grower revenues during the past eight seasons.
- This resulted in an average annual loss of more than 7,500 jobs and $975 million in overall industry output.
Control Methods

- ACP Control
  - Spraying
  - CHMA’s
  - Biological Control
- Tree Removal
- Citrus Nutritionals
- Thermotherapy
- Antibiotics
- Rootstock and Scion Tolerance
- Early Detection
- GMO Citrus
ACP Control
There are many foliar products available that are applied following scouting. “Soft” chemistries and natural enemies are used during bloom to reduce effects on bees.

### SEASON-LONG ACP CONTROL ON YOUNG TREES

<table>
<thead>
<tr>
<th>Tree size</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset (&lt;3’)</td>
<td>P</td>
<td></td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2 yr (3-5’)</td>
<td>P</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td></td>
<td>P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-5 yr (5-9’)</td>
<td>P</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A= Admire (imidacloprid); B= Belay (clothianidin); P= Platinum (thiamethoxam); timing of foliar applications with different modes of action to prevent pesticide resistance to neonics depicted by white boxes.

1EPA SLN No. FL-12008 now permits up to 2 applications of Admire Pro at a rate of 14 fl oz/A per 12 months for trees 5-9’ in height; Belay section 18 label permits 2 applications at 12 fl oz/A per 12 months for trees 5-9’ in height. Always read and follow label directions.
48 CHMAs encompassing 486,000+/- acres of commercial citrus
• Florida Citrus Health Management Areas (CHMAs): treating 8-12 times per year
• **Florida Area Wide Spray Program**

• Several CHMA’s in Florida. Gulf CHMAs include 100,000 acres of citrus, almost all oranges

• First spray application in 2007 – organized by growers through the Gulf Citrus Growers. No govt. assistance due to backlash against citrus canker removal programs.

• Coordinate 2 to 3 dormant sprays, Oct./Nov. and Jan. or Feb., and Mar-Apr.

• 92% participation rate. Almost everyone who participates does 2 sprays.

• Program is voluntary
Florida Area Wide Spray Program – Other considerations

• 2015 is the 8\textsuperscript{th} year for the program
• They have changed the tax laws to allow owners to remove abandoned groves, but still allow the tax exemption for an additional 3 years.
• Dooryards are not considered. Nobody wants to deal with that.
• 80 to 90\% of the trees in the state are infected with HLB
Tree Removal

• One of the four recommended actions necessary to control HLB
  1. Removal of alternate hosts (chiefly Murraya)
  2. Psyllid control program (insecticides)
  3. Production of new trees in protective structures
  4. Scouting of trees for symptoms and removal of trees once symptoms are found

• Based on the experiences of growers in Brazil and the work of Josy Bové, an eminent Plant Pathologist

• Actions endorsed by University of Florida scientists and others around the world
Farms without vector control or eradication

No economic productivity
Tree Inspections - Brazil
Training and motivation = is the key of the success in Greening Handling
Brazilian Block 35 with more than 15% Greening = all Block are eradicated
Tree Removal

Arguments for...
• Based on long term research
• Record of success in Brazil (?)
• Removal of Inoculum

Arguments against ...
• Tree removal = income loss
• Brazilian success not assured
• Costly
• Most growers are not diligent enough
• All trees in area are infested
• Bad neighbors a problem
• Cannot eliminate the disease

Most Florida growers have stopped removing infected trees
Citrus Nutritionals

- Developed by an individual grower (Maury Boyd)
- Contains micronutrients, salicylic acid, peroxide, potassium phosphite and KeyPlex
- Now, there are many additional programs, not all effective
- Requires multiple sprays
- Cost is high (up to $500 per acre)
- Effectiveness in some areas is better than in others
- Growers must be diligent
- Healthy appearing trees may still drop some fruit
• Boyd Grove with original infestation
Valencia March 2010
## Components of Nutritional Sprays

<table>
<thead>
<tr>
<th>Program Name</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>B</th>
<th>Ca</th>
<th>Co</th>
<th>Cu</th>
<th>Fe</th>
<th>Mg</th>
<th>Mn</th>
<th>Mo</th>
<th>Ni</th>
<th>S</th>
<th>Zn</th>
<th>MnPC</th>
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<tbody>
<tr>
<td>Boyd Mix (vers 1.0)</td>
<td>21</td>
<td>39</td>
<td>54</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.50</td>
<td>8.16</td>
<td>0.06</td>
<td>-</td>
<td>-</td>
<td>9.63</td>
<td>2.98</td>
</tr>
<tr>
<td>Chemical Dynamics</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>0.58</td>
<td>1.32</td>
<td>0.02</td>
<td>0.78</td>
<td>0.53</td>
<td>3.77</td>
<td>0.01</td>
<td>9.63</td>
<td>2.98</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Diamond R Generic Foliar</td>
<td>16</td>
<td>14</td>
<td>37</td>
<td>0.12</td>
<td>-</td>
<td>0.00</td>
<td>0.67</td>
<td>2.78</td>
<td>4.60</td>
<td>0.02</td>
<td>4.50</td>
<td>5.04</td>
<td>yes</td>
<td>yes</td>
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<tr>
<td>Florida Phosphorus Fortress</td>
<td>6</td>
<td>5</td>
<td>18</td>
<td>0.05</td>
<td>0.32</td>
<td>0.01</td>
<td>0.05</td>
<td>0.24</td>
<td>0.28</td>
<td>0.01</td>
<td>0.01</td>
<td>0.48</td>
<td>yes</td>
<td>yes</td>
<td></td>
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<tr>
<td>Griffin Program</td>
<td>20</td>
<td>11</td>
<td>26</td>
<td>0.18</td>
<td>-</td>
<td>0.17</td>
<td>0.16</td>
<td>2.13</td>
<td>1.12</td>
<td>0.00</td>
<td>1.30</td>
<td>1.15</td>
<td>no</td>
<td>no</td>
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<tr>
<td>KeyPlex Program</td>
<td>13</td>
<td>7</td>
<td>3</td>
<td>0.08</td>
<td>0.24</td>
<td>-</td>
<td>0.41</td>
<td>0.57</td>
<td>0.83</td>
<td>0.00</td>
<td>0.65</td>
<td>0.81</td>
<td>no</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td>Plant Food Systems</td>
<td>34</td>
<td>31</td>
<td>33</td>
<td>0.11</td>
<td>-</td>
<td>-</td>
<td>0.46</td>
<td>1.30</td>
<td>0.93</td>
<td>0.01</td>
<td>-</td>
<td>0.50</td>
<td>1.72</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>

*Comparison of foliar nutritional programs by elements (pounds per year).*
Citrus Nutritionals

Arguments for...
• Citrus trees have had HLB since 2006 and are still productive
• Groves have been rehabilitated using nutritionals
• Not removing income
• May have a physiological basis

Arguments against ...
• Does not eliminate the bacteria
• Inoculum remains in the grove
• Grove will, in time, become 100% infected
• Must control psyllids
• Duration of effect?
• Quality of fruit?
  o Important to maintain fruit quality, not just yield
• Fruit size smaller than healthy trees
• Trees more susceptible to drought and root disease
• Cost
  o We don’t yet know the exact recipe needed
Thermal Therapy

- Solar tent and supplemental heat with steam or hot water
- Thousands of trees treated
  - Time/temperature refinement
  - Evaluation of CLas reduction and tree response
- More growers treating small trees with tents
- Commercial scale-up
Steaming Trees

• In this case, temperatures of 120F for 32 seconds

http://www.highlandstoday.com/hi/local-news/highlands-growers-are-steaming-trees-20160311
Some examples
Steamer Video
Antibiotics

The Florida Commissioner of Agriculture, the Honorable Adam Putnam has exercised his authority under the Emergency Exemptions provisions of FIFRA to declare a crisis that will allow use of the antibiotics:

- Streptomycin Sulfate (FireWall™ 50WP, AgroSource, Inc),
- Oxytetracycline Hydrochloride (FireLine™ 17WP, AgroSource, Inc), and Oxytetracycline
- Calcium Complex (Mycoshield®, Nufarm Americas, Inc.)

in foliar applications to enhance the overall tree health of Huanglongbing infected trees in Florida citrus groves.

This was allowed on March 4th as an emergency declaration prior to the EPA review of the compounds.
# Antibiotic Reference Sheet

## Suggested Antibiotic Use Pattern for Huanglongbing (HLB; citrus greening) Management

The information in this document is a suggested use pattern of antibiotics in Florida citrus. This is not an official University of Florida recommendation. Information based on crisis declaration of March 4, 2016. Document is invalid after the establishment of a Section 3 or 18 label.

### Antibiotic Application Schedule

Application schedule should be adjusted based on harvest and flush timing. Antibiotics should NEVER be applied during harvest. ALWAYS rotate.

<table>
<thead>
<tr>
<th>Citrus Type</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Season Varieties (Ex. Hamlin, Navel, Falliglo)</td>
<td>STP</td>
<td>OXY</td>
<td>STP</td>
<td></td>
<td></td>
<td>STP</td>
<td>OXY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid Season Varieties (Ex. Murcott, Pineapple, Midsweet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late Season Varieties (Ex. Valencia)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>STP</td>
<td>OXY</td>
<td>STP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grapefruit (Ex. Ray Ruby, Flame, Ruby Red)</td>
<td>STP</td>
<td>OXY</td>
<td>STP</td>
<td></td>
<td></td>
<td>STP</td>
<td>OXY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STP: streptomycin; OXY: oxytetracycline
Apply with initiation of final flush

### Product Details

<table>
<thead>
<tr>
<th></th>
<th>FireWall 50 WP**</th>
<th>FireLine 17 WP***</th>
<th>Mycoshield***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preharvest Interval (days)</td>
<td>40</td>
<td>40</td>
<td>21</td>
</tr>
<tr>
<td>Maximum Number of Applications per Calendar Year</td>
<td>3</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Minimum Retreatment Interval (days)</td>
<td>31</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>Re-entry Interval (hours)</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Total amount of product per year</td>
<td>2.07 lbs product 1.36 lbs a.i.</td>
<td>4.50 lbs product 0.81 lbs a.i.</td>
<td>12.0 lbs product 2.04 lbs a.i.*</td>
</tr>
<tr>
<td>FRAC Group</td>
<td>25</td>
<td>41</td>
<td>41</td>
</tr>
</tbody>
</table>

*not more than 2.04 lb a.i. (oxytetracycline) per season no matter product used

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### Antibiotic programs do not replace Asian citrus psyllid management programs.

- Antibiotics are only labeled for airblast ground sprays (no low volume applications)
- When mixing antibiotic with surfactant, agitation is required
- Alternate mode of action (MOA)

### THE LABEL IS THE LAW!

Refer to label for additional information. This guide does not supersede the label.

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1. Megan M. Dowdrey, associate professor, Department of Plant Pathology, Citrus Research and Education Center and James H. Graham, professor, Soil and Water Science Department, Citrus REC; UF/IFAS Extension; Gainesville, FL 32611.
Lasers – A new way to apply antibiotics?

- Inability to deliver antibiotics to the phloem – penetration of externally delivered antibiotics is poor.
- Lasers enhance the penetration of the foliar applied substances into the phloem.
- Microscopic indentions of 250 microns in diameter, one cell layer deep.
- Application of oils to leaf tissue after lasering prevents damage.
- A sprayer with nozzles for laser lights, antimicrobial spray and wax is being developed.

Rootstock and Scion Tolerance

• Slides and information by:
  • Ed Stover – USDA
  • Kim Bowman – USDA
  • Jude Grosser – UF
  • Fred Gmitter - UF
Some mandarins and their hybrids seem to have substantial HLB tolerance - trees below in heavily HLB-infected USDA Ft. Pierce Farm, no ACP control.

Clementine

Fairchild (Clem x Orl)

Fortune (Clem x Dancy)

Bower (Clem x Orl)

Dancy

Kunembo (C. nobilis)
5-51-2-Easy peeler
Clementine x Orlando cross
by J. Hearn

So far really amazing HLB
tolerance
at our Ft. Pierce farm

Just found low-seeded
variants

Seedlings from Fairchild
x Fortune mapping pop’n
and other Clem x
Orlando planted in 2015
(with Roose)
Further afield- Genera in citrus gene pool

• Field experiment with genebank at Riverside CA of 85 citrus relative genotypes - showed Poncirus among most-resistant to HLB and also psyllid colonization (ARS CA and FL)

• With genebank, additional trial focusing on P. trifoliata

• Eremocitrus and Microcitrus, also showed strong Las and psyllid resistance and we have new collaboration with Queensland citrus breeder Malcolm Smith
100+ Poncirus hybrid genotypes all replicated and exposed to HLB/ACP for 52 months (planted 9/2011)

- U of Florida (Fred Gmitter et al.), UC Riverside (Roose) & USHRL (Stover and Hall) collaborating to identify genes associated with HLB/ACP-resistance
- Includes near commercial quality advanced Poncirus trifoliata (Pt) hybrids
- Gmitter group analyzed Clas data Jan 2015 and all Pt still CLas-free; Hall-led data only pure Pt low ACP colonization.
- Making backcrosses 2016
in replicated trial exposed to HLB at planting

See also: http://phys.org/news/2016-03-citrus-scionrootstock-combinations-tolerance-huanglongbing.html
HLB Tolerant Rootstocks

Kuharske – 86% HLB frequency
Orange #15 – 14% HLB frequency
Swingle – 70% HLB frequency
Orange #19 – 23% HLB frequency

HLB-infected trees in the St. Helena Project
– differences in infection frequency & disease severity
HLB Tolerant Rootstocks

Table 2. Yield of Hamlin trees on eight rootstocks in a St. Lucie County trial, planted 2000.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Yield 2006 (kg/tree)</th>
<th>Yield 2007–12 (kg/tree)</th>
<th>Yield 2013 (kg/tree)</th>
<th>Yield 2014 (kg/tree)</th>
<th>Yield 2013–14 (kg/tree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-1282</td>
<td>54 ab</td>
<td>206 a</td>
<td>63 a</td>
<td>51 a</td>
<td>114 a</td>
</tr>
<tr>
<td>US-1283</td>
<td>51 ab</td>
<td>188 a</td>
<td>67 a</td>
<td>42 a</td>
<td>109 a</td>
</tr>
<tr>
<td>US-1284</td>
<td>73 a</td>
<td>171 a</td>
<td>63 a</td>
<td>47 a</td>
<td>109 a</td>
</tr>
<tr>
<td>US-1279</td>
<td>49 ab</td>
<td>174 a</td>
<td>61 a</td>
<td>45 a</td>
<td>107 a</td>
</tr>
<tr>
<td>US-1281</td>
<td>64 ab</td>
<td>165 a</td>
<td>52 a</td>
<td>38 a</td>
<td>90 a</td>
</tr>
<tr>
<td>Carrizo</td>
<td>44 bc</td>
<td>166 a</td>
<td>45 a</td>
<td>29 ab</td>
<td>74 a</td>
</tr>
<tr>
<td>Flying Dragon</td>
<td>23 c</td>
<td>64 b</td>
<td>16 b</td>
<td>9 bc</td>
<td>26 b</td>
</tr>
<tr>
<td>Swingle</td>
<td>47 bc</td>
<td>100 b</td>
<td>19 b</td>
<td>7 c</td>
<td>26 b</td>
</tr>
</tbody>
</table>

Mean separations for significant ANOVA within columns were by Duncan’s multiple range test at $P < 0.05$.

Table 4. Fruit quality of Hamlin on eight rootstocks in a St. Lucie County trial.

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Fruit wt (g)</th>
<th>TSS</th>
<th>TSS/acid</th>
<th>Juice color (CN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-1282</td>
<td>193.6 a</td>
<td>8.67 bc</td>
<td>14.22 abc</td>
<td>34.9</td>
</tr>
<tr>
<td>US-1283</td>
<td>189.5 ab</td>
<td>8.43 c</td>
<td>13.62 bcd</td>
<td>34.7</td>
</tr>
<tr>
<td>US-1284</td>
<td>185.2 ab</td>
<td>8.77 abc</td>
<td>13.36 cd</td>
<td>34.6</td>
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<td>US-1279</td>
<td>192.7 a</td>
<td>8.80 abc</td>
<td>14.08 abcd</td>
<td>34.6</td>
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<td>US-1281</td>
<td>190.0 ab</td>
<td>8.90 abc</td>
<td>14.40 abcd</td>
<td>34.7</td>
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<tr>
<td>Carrizo</td>
<td>189.9 ab</td>
<td>9.06 ab</td>
<td>14.99 a</td>
<td>34.8</td>
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<tr>
<td>Flying Dragon</td>
<td>176.1 b</td>
<td>9.15 a</td>
<td>14.83 a</td>
<td>34.9</td>
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<tr>
<td>Swingle</td>
<td>159.8 c</td>
<td>8.51 c</td>
<td>13.19 d</td>
<td>34.9</td>
</tr>
</tbody>
</table>

TSS = total soluble solids; CN = color number.
Mean separations for significant ANOVA within columns were by Duncan’s multiple range test at $P < 0.05$. 
HLB Early Detection

- Researchers are working on developing a mobile VOC (volatile organic compound) sniffer device that could be used in citrus groves to pick up traces of HLB off-gassing from infected trees. Devices being tested are sensitive to VOCs below parts-per-billion levels.
- The systems are about a year or two away, which is much closer than the estimated 10 years to 15 years it will take to get disease-resistant rootstock.
- Another early-detection approach involves testing citrus leaves to detect metabolites produced by the bacteria or the tree.
- In Florida, dogs are being trained to detect the presence of the bacterium.
- California researchers are also testing a twist-tie system that would indicate HLB presence in trees, and scientists are developing field DNA test kits.
The most advanced was developed by Dr. Erik Mirkov, TAMU in cooperation with Southern Gardens Citrus (US Sugar Corp.)

First in ground planting in 2009

Includes a gene from spinach that encodes a protein that has broad-spectrum antimicrobial activity against bacterial and fungal plant pathogens.

Known as a defensin, the protein binds to the HLB bacterium cell wall, makes holes in the cell wall, then dies.

Six generations of transgenic trees have been developed since 2009, each is an improvement over its predecessor.

Other transgenic trees, developed by other researchers are in the field as well.

Regulatory hurdles for this may be high, and industry and consumer resistance will likely occur.

While 88% of scientists believe genetically modified organisms (GMOs) are safe, only 37% of the general public agrees.
Transgenic (GMO) Citrus
What’s new in Texas?
Texas

- HLB found in TX in 2012.
- They have not seen rapid tree decline, as has been
- In TX, they have collected about 100,000 tissue and ACP samples since 2010.
- 225 residential trees and 56 trees in commercial groves are HLB positive as of January 2015. Likely more positives as of today.
- About 1,700 infested trees found as of January 2016
430 HLB infested trees found as of August 2014. Today, over 1,700 trees identified.
Mexico in 2008 …

- Psyllid found in Mexico in 2004.
- Psyllid found in Sonora in April, 2006, and Baja California Sur in June, 2006.
- No survey for psyllid or HLB has yet occurred in Sonora.
- Mexican researchers have been trained to test for HLB.
- Mexican inspectors have been trained to survey for HLB.
HLB in Mexico (2010)
HLB in Mexico Today