SuperSour and
Other New USDA Rootstocks
for Improved Yield
and Tolerance to HLB

Kim D. Bowman
USDA-ARS, Ft. Pierce, FL
Florida Industry Support

Thank you for:

CRDF Grants

Florida Citrus Research Foundation

Cooperators
Dr. Greg McCollum  
Dr. Jim Graham

David Wheeler  
Bob Adair  
Larry Black  
Duda Citrus  
Mike Monroe

- Dr. Ute Albrecht  
- Emily Domagtoy  
- Kerry Worton  
- Sailindra Patel  
- Diane Helseth

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- Dave Lindsey  
- Mike Rutherford  
- Steve Mayo  
- James Salvatore  
- Wayne Brown
USDA Rootstock Breeding

- Create new rootstocks
- Screen and select the most promising
- Test in field trials
- Release outstanding new rootstocks
Rootstocks from USDA currently in commercial use

Florida Bureau of Citrus Budwood Registration
Annual Report 2014

More than 1,000,000 new trees per year
on US rootstocks

<table>
<thead>
<tr>
<th>Rank</th>
<th>Rootstock</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>1</td>
<td>Swingle</td>
<td>1,052,152</td>
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<tr>
<td>2</td>
<td>Kuharske</td>
<td>860,228</td>
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<td>3</td>
<td>Sour Orange</td>
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<td>4</td>
<td>X-639</td>
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<td>5</td>
<td>US-802</td>
<td>384,342</td>
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<td>6</td>
<td>US-812</td>
<td>289,234</td>
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<td>7</td>
<td>US-897</td>
<td>263,589</td>
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<tr>
<td>8</td>
<td>Cleopatra</td>
<td>177,742</td>
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<td>9</td>
<td>Carrizo</td>
<td>171,593</td>
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<td>10</td>
<td>Volkamer</td>
<td>81,646</td>
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<td>11</td>
<td>US-942</td>
<td>74,516</td>
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<td>12</td>
<td>C-35 Citrange</td>
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<td>13</td>
<td>Research Stock</td>
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<td>15</td>
<td>Rough Lemon</td>
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<tr>
<td>16</td>
<td>Kinkoji</td>
<td>22,701</td>
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</table>
USDA Seed trees at Whitmore and Ft. Pierce
Supply 100s of thousands of seeds/year to industry
New Florida Rootstocks Need

Favorable effect on:
- Fruit yield
- Tree size
- Fruit sweetness
- Fruit size/shape
- Propagation
- Tree anchorage
- Tree cold tolerance
- Tree longevity
- More . . .

Tolerance to:
- Greening/HLB
- Phytophthora
- Tristeza virus
- Diaprepes weevil
- Blight
- Nematodes
- Flooding
- Salinity
- High pH
- More . . .
Flame/Swingle

USDA Rootstock Trial at FRCAS

Indian River County

2.5 years old
FLARES Rootstock Trial
Trees Pulled January 2012
Mean All Phytophthora

Mean root rating

US-1735
US-1786
Carrizo
US-1748
Cleo
US-1745
Sour #2
US-1730
US-1649
US-1744
US-1749
US-1781
US-1742
US-1627
US-1756
Sour #2
US-1899
US-1755
US-1764
US-1660
US-812
US-1757
US-1672
US-1660
US-1755
US-1876
US-1672
US-1676
US-1691
US-1671
US-1690
US-1695
US-1696
US-1687
US-1730
US-1867
US-1649
FLARES Rootstock Trial
Trees Pulled January 2012

Mean All Phytophthora

US-1735
US-1742
US-1756
Carrizo

US-1748
US-1755
US-1764

US-1744
US-1759
US-1876

US-1781
US-1760
US-1757

Sour #2
Cleo

US-1730
US-1649
US-1744
US-1748
US-1781
US-1742
US-1627
US-1756
US-1645
US-1867
US-1740
US-1671
US-1690
US-1695

Highly Susceptible

Resistant
Citrus Tristeza virus

Val/Sour

Val/US-812
Tolerance to Huanglongbing
Greenhouse testing for tolerance to HLB
Susceptible – Cleopatra mandarin

Infected

Not infected
Greenhouse testing for tolerance to HLB
Tolerant – US-897

Infected

Not infected
Field trials
USDA-Wheeler Cooperative Valencia Trial

- Lake Wales, Polk County
- Trees planted 2008
- Valencia scion
- RCB design

17 rootstocks: 21 trees per stock
USDA-Wheeler Rootstock Trial

Valencia scion

Lake Wales, Polk County
Looks great!

Looks sick

USDA-Wheeler Valencia Rootstock Trial
<table>
<thead>
<tr>
<th>Rootstock</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>Total lbs/tree</th>
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<td>94</td>
<td>147</td>
<td>145</td>
<td>386 a</td>
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<td>80</td>
<td>141</td>
<td>134</td>
<td>355 ab</td>
</tr>
<tr>
<td>US-1516</td>
<td>71</td>
<td>132</td>
<td>118</td>
<td>321 abc</td>
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<tr>
<td>US-1503</td>
<td>64</td>
<td>104</td>
<td>131</td>
<td>299 bcd</td>
</tr>
<tr>
<td>US-802</td>
<td>59</td>
<td>130</td>
<td>104</td>
<td>293 bcd</td>
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<tr>
<td>Swingle</td>
<td>60</td>
<td>104</td>
<td>109</td>
<td>273 cde</td>
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<tr>
<td>Kuharske</td>
<td>70</td>
<td>99</td>
<td>104</td>
<td>272 cde</td>
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<tr>
<td>Carrizo</td>
<td>56</td>
<td>108</td>
<td>106</td>
<td>270 cde</td>
</tr>
<tr>
<td>Cleopatra</td>
<td>34</td>
<td>76</td>
<td>113</td>
<td>223 de</td>
</tr>
<tr>
<td>Kinkoji</td>
<td>42</td>
<td>86</td>
<td>83</td>
<td>211 e</td>
</tr>
<tr>
<td>Rootstock</td>
<td>Lbs fruit/tree</td>
<td>Percent juice</td>
<td>Percent sugar (brix)</td>
<td>Lbs sugar/tree</td>
</tr>
<tr>
<td>-----------</td>
<td>---------------</td>
<td>---------------</td>
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<td>---------------</td>
</tr>
<tr>
<td>US-942</td>
<td>147</td>
<td>56</td>
<td>10.7</td>
<td>8.81</td>
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<td>US-896</td>
<td>141</td>
<td>57</td>
<td>11.1</td>
<td>8.92</td>
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<td>US-802</td>
<td>130</td>
<td>52</td>
<td>10.2</td>
<td>6.90</td>
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<td>US-1516</td>
<td>132</td>
<td>53</td>
<td>9.8</td>
<td>6.86</td>
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<td>Carrizo</td>
<td>108</td>
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<td>54</td>
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<td>Kinkoji</td>
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<td>56</td>
<td>10.4</td>
<td>5.01</td>
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<tr>
<td>Cleopatra</td>
<td>76</td>
<td>56</td>
<td>10.0</td>
<td>4.26</td>
</tr>
</tbody>
</table>
Hamlin Rootstock Trial

- Ft. Pierce, St. Lucie County
- Trees planted 2000-2001
- Hamlin 1-4-1 scion
- RCB design
- Infected with HLB 2006-2007

About 60 different rootstocks
USDA Rootstock Trial

Hamlin scion

St. Lucie County
<table>
<thead>
<tr>
<th>Rootstock</th>
<th>2006-7</th>
<th>2008-12</th>
<th>2013 lbs/tree</th>
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</thead>
<tbody>
<tr>
<td>US-1319</td>
<td>118 lbs/tree</td>
<td>95%</td>
<td>168 a</td>
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<tr>
<td>US-1283</td>
<td>166</td>
<td>74</td>
<td>148 ab</td>
</tr>
<tr>
<td>US-1282</td>
<td>162</td>
<td>100</td>
<td>138 ab</td>
</tr>
<tr>
<td>US-1284</td>
<td>168</td>
<td>78</td>
<td>138 ab</td>
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<tr>
<td>US-1279</td>
<td>153</td>
<td>71</td>
<td>135 ab</td>
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<td>US-1318</td>
<td>144</td>
<td>61</td>
<td>118 bc</td>
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<tr>
<td>US-1281</td>
<td>158</td>
<td>72</td>
<td>115 bc</td>
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<tr>
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<td>91</td>
<td>51</td>
<td>76 cd</td>
</tr>
<tr>
<td>US-1273</td>
<td>87</td>
<td>37</td>
<td>65 d</td>
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<tr>
<td>Swingle</td>
<td>114</td>
<td>32</td>
<td>41 d</td>
</tr>
</tbody>
</table>
New Rootstocks with HLB tolerance, higher YIELD, and excellent fruit QUALITY

Released by USDA in 2014

- US-1279  Changsha x Gotha Road
- US-1281  Cleopatra x Gotha Road
- US-1282  Cleopatra x Gotha Road
- US-1283  Ninkat x Trif. Orange
- US-1284  Ninkat x Trif. Orange
More HLB-tolerant rootstocks to be released in 2015
Seed trees planted at Whitmore this year for coming rootstock releases, including Supersour
For the near future, many new USDA rootstocks will be propagated by cuttings or microprop.
Liners of US-1283 propagated by cuttings
Nursery trees in USHRL greenhouse
Valencia/Supersours budded for field trials
Valencia/Supersour Nursery trees prepared for field trials at USDA Picos farm and Duda
New rootstock field trials
USDA Rootstock Trial
Cara Cara scion
Lake County
USDA and UF Working Together: New Rootstock Project Funded by HLB MAC

- Field test 24 HLB tolerant rootstocks from USDA and UF each year
- Plant 6 grower field trials per year with trees from commercial nursery
- Trees will be purchased by MAC
- See me if you are interested in hosting one of these trials – scion is your choice
For the future

- Transgenic rootstocks with HLB resistance
- Focus on optimizing expression of citrus defense genes in commercial cultivars
- Citrus genes: CtNDR1, CtSID2, CtSFD1, CtPAD3, CtCDR1, CtNHL3, CtNHO1, CtDIR1, CtAZL1, CtMPK4, CtTGA7, CtDIR1, CtERF1, CtFAD7, CtFMO1, CtAZL1, and CtNHL25
For the future

- Understanding what genes provide HLB resistance and breeding use
Leaves and Roots

Leaves

Roots

Valencia

Cleopatra

US-802

US-897

US-942

Principal Component Analysis
For the future

- New conventional rootstocks with high level of HLB resistance along with other essential traits
Wrong rootstock

The right rootstock