

UNITED STATES DEPARTMENT OF AGRICULTURE  
Agricultural Research Service  
Washington, D.C.

**RELEASE OF US-1284, Citrus Rootstock**

The Agricultural Research Service, U.S. Department of Agriculture hereby releases to nurserymen and growers the US-1284 citrus rootstock. This rootstock selection originated from a 1995 cross of Ninkat mandarin (*Citrus reticulata*) × Gotha Road #6 Trifoliate Orange (*Poncirus trifoliata*) made at the A.H. Whitmore Foundation Farm by Dr. Kim D. Bowman of the USDA, ARS, USHRL, Florida. Field testing of US-1284 was planned and conducted by Dr. Kim Bowman, in collaboration with or support from industry partners, including Florida Citrus Research Foundation, Florida Citrus Production Research Advisory Council, Florida Citrus Research and Development Foundation, and Mid-Florida Citrus Foundation. Dr. Greg McCollum (also of USDA, ARS, USHRL) collaborated in the evaluation of fruit quality from field trials. During field testing, this hybrid rootstock was identified by code numbers BS95-V6-24 or US-1284. The major positive attributes of this new rootstock are induction of superior fruit productivity and fruit quality on sweet orange trees grown in the Florida flatwoods and infected with *Candidatus Liberibacter asiaticus* (Las), the causal agent of huanglongbing (HLB). This rootstock is being released for commercial use in Florida because of the urgent need for new citrus rootstocks that have improved tolerance to HLB.

Field testing of the US-1284 rootstock has been primarily at two locations and with 'Hamlin' sweet orange scion. The longest field test involving this rootstock is a replicated trial in St. Lucie County Florida at the USHRL research farm in Ft. Pierce. The site is typical Florida flatwoods with a soil characterized as Riviera fine sand, and trees were planted in double row beds at 3.0 m x 7.6 m spacing and irrigated by microjet. In this trial, seven 'Hamlin' sweet orange trees on US-1284 were compared with a similar number of trees on 25 other rootstocks planted in 2000 and using a randomized complete block statistical design. Trees in this trial were damaged by hurricanes Frances and Jeanne in 2004, and both HLB and citrus canker (*Xanthomonas citri* subsp. *citri*) began to affect the trees in 2007-8. Fruit production of 'Hamlin' on US-1284 in this trial was first measured in the 2006 and 2007 harvest seasons, before HLB symptoms were widespread. During the 2006 and 2007 seasons, fruit production on US-1284 was found to be significantly higher than production of trees on Swingle, the most common rootstock used in Florida. In the following years, Las spread rapidly throughout the trial, and overall tree health declined. From 2008 to 2012, cropping on all rootstocks declined from the pre-HLB yields, but cropping on Swingle rootstock suffered more dramatically than cropping on US-1284 and some other rootstocks. The average fruit production during this period on US-1284 was measured at 2.4 times the fruit production on Swingle. As a result of increased application of plant nutrients, overall tree health in the trial improved during 2012-14. In the 2013 harvest season, trees on US-1284 produced 63 kg fruit per tree, or about 75 percent of the annual crop produced on those trees during the 2006 and 2007 seasons (before HLB impact). In comparison, trees on Swingle rootstock in the 2013 harvest season continued a very low fruit production, yielding 19 kg fruit per tree, or about 17 percent the annual crop produced on those trees during the 2006 and 2007 seasons. The significantly higher fruit production of trees on US-

1284 than trees on Swingle following tree infection with Las, and also following the implementation of an improved nutritional program, indicates a greater tolerance of US-1284 to HLB disease.

Fruit quality was assessed on samples from the replicated trial at the USHRL farm in St. Lucie County just before harvest in December 2012 and 2013. Average fruit weight from trees on US-1284 rootstock was 153 g and significantly higher than the 115 g fruit on Swingle in 2012. During the 2013 season, fruit from trees on US-1284 were again numerically heavier than fruit on Swingle, but differences among the rootstocks were not significant. During both the 2012 and 2013 seasons, fruit total soluble solids and TSS:acid ratio were numerically higher for trees on US-1284 than for trees on Swingle, but differences between US-1284 and Swingle were not statistically significant for either trait in either year. Significant differences among the rootstocks for other fruit quality traits, such as juice color, were not observed.

Canopy size was measured on the trees in the replicated trial at the USHRL farm in St. Lucie County in August 2014. Trees on US-1284 had the largest canopy height and width in the trial, and were significantly larger than trees on Swingle. Calculation of canopy area and canopy volume confirmed that canopy size was significantly larger for trees on US-1284 as compared with trees on Swingle. To assess whether measured differences in performance of 'Hamlin' trees on US-1284 and Swingle rootstocks were due to differences in infection rate with Las or bacterial titer in plant tissues, trees were tested by canopy sampling and PCR in August 2014. All trees on all rootstocks in the trial were observed to be PCR positive for Las at that time. The amount of Las (Las genome copy number per gram of plant tissue) detected in random leaf samples from the canopy of trees on US-1284 and Swingle were not significantly different. It can be inferred that improved yield and other traits of trees on US-1284 in comparison with Swingle were not because of an induction of increased resistance to Las infection or reduced Las growth in the scion tissues, but rather to an increased tolerance of the tree to HLB following Las infection.

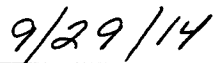
The rootstock US-1284 was also tested in a trial with 'Hamlin' scion planted in 2002 at the Water Conserv II research grove in Orange County, Florida. The trial contained 12 trees on each rootstock and was planted in a randomized complete block statistical design. This site is on soil characterized as Candler fine sand, and trees were planted at 4.5 m x 7.5 m, and irrigated with microjets. Crop yield measurements were taken from the trial between 2005 and 2013. By 2013, the effects of HLB and reduced tree care in this trial resulted in declining yields for all rootstocks, in comparison to 2009. Cumulative crop yields of trees on US-1284 were numerically higher than those on Swingle, but only in 2009 was this difference statistically significant. There was not a significant yield advantage of US-1284 over Swingle at this ridge site. It can also be noted that the rootstock US-942 (released by USDA in 2010) performed better at this ridge site with HLB than US-1284, and cumulative yields of trees on US-942 were significantly higher than trees on Swingle. The comparison of results from the two trials suggest that US-1284 is clearly superior to Swingle rootstock for use on a Florida flatwoods site with HLB, but is not clearly superior to Swingle at a Florida ridge site with HLB. Further definition of the advantages and faults of US-1284 rootstock will be resolved through additional field testing.

For field testing, US-1284 was propagated by cuttings. It is anticipated that US-1284 will produce nucellar seed that can be used for uniform nursery propagation, but a mature seed source is not available and nursery performance of seedlings has not been assessed. Source plant material for US-1284 has been tested and found free of Las and CTV. Source plant material for US-1284 has been provided to the Florida Bureau of Citrus Budwood Registration clean budwood program (3027 Lake Alfred Road - Highway 17, Winter Haven, Florida 33881) and will be distributed, following USDA release, according to Florida Department of Agriculture and Consumer Services regulations. Plant tissue for research and additional information on US-1284 may be obtained from Kim D. Bowman, USDA, ARS, USHRL, 2001 South Rock Road, Ft. Pierce, Florida 34945 (kim.bowman@ars.usda.gov). Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new cultivars. Appropriate recognition should be made if this germplasm contributes to the development of a new breeding line or cultivar.

Signature:



Deputy Administrator, Crop Production and Protection  
Agricultural Research Service, U.S. Department of Agriculture



Date

Addendum: RELEASE OF US-1284, Citrus Rootstock - TABLES  
Kim D. Bowman and Greg McCollum

Table 1. Fruit yield of ‘Hamlin’ sweet orange on US-1284 and other rootstocks in comparison with Swingle at a replicated trial in St. Lucie County on flatwoods soil. Yields for 2008-12 are shown as percent of cumulative highest yielding rootstock in the trial.

| <u><b>Rootstock</b></u> | <u><b>2006+7</b></u><br><u><b>(kgs/tree)</b></u> | <u><b>2008-12</b></u><br><u><b>(Percent)</b></u> | <u><b>2013</b></u><br><u><b>(kgs/tree)</b></u> |
|-------------------------|--------------------------------------------------|--------------------------------------------------|------------------------------------------------|
| US-1283                 | 166 ab                                           | 74 a                                             | 67 a                                           |
| US-1282                 | 162 ab                                           | 100 a                                            | 63 a                                           |
| <b>US-1284</b>          | <b>168 a</b>                                     | <b>78 a</b>                                      | <b>63 a</b>                                    |
| US-1279                 | 153 abc                                          | 71 a                                             | 61 a                                           |
| US-1281                 | 158 abc                                          | 72 a                                             | 52 a                                           |
| Swingle                 | 114 c                                            | 32 b                                             | 19 b                                           |
| Flying Dragon           | 57 d                                             | 30 b                                             | 16 b                                           |

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

Table 2. Individual fruit weight (g) in the replicated trial in St. Lucie County. Fruit samples were collected 14 November 2012 and 14 November 2013.

| <u><b>Rootstock</b></u> | <u><b>2012</b></u> | <u><b>2013</b></u> | <u><b>Average</b></u> |
|-------------------------|--------------------|--------------------|-----------------------|
| US-1283                 | 153 a              | 127                | 140                   |
| US-1282                 | 161 a              | 127                | 144                   |
| <b>US-1284</b>          | <b>153 a</b>       | <b>126</b>         | <b>140</b>            |
| US-1279                 | 159 a              | 129                | 144                   |
| US-1281                 | 161 a              | 118                | 140                   |
| Swingle                 | 115 b              | 112                | 114                   |
| Flying Dragon           | 151 a              | 112                | 132                   |

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

Table 3. Fruit total soluble solids content (brix) in the replicated trial in St. Lucie County. Fruit samples were collected 14 November 2012 and 14 November 2013.

| <u><b>Rootstock</b></u> | <u><b>2012</b></u> | <u><b>2013</b></u> | <u><b>Average</b></u> |
|-------------------------|--------------------|--------------------|-----------------------|
| US-1283                 | 7.7 b              | 8.0 ab             | 7.8                   |
| US-1282                 | 8.0 ab             | 8.6 a              | 8.3                   |
| <b>US-1284</b>          | <b>8.1 ab</b>      | <b>8.2 ab</b>      | <b>8.2</b>            |
| US-1279                 | 7.9 ab             | 8.1 ab             | 8.0                   |
| US-1281                 | 8.3 ab             | 8.5 ab             | 8.4                   |
| Swingle                 | 7.6 b              | 7.6 b              | 7.6                   |
| Flying Dragon           | 8.8 a              | 8.6 a              | 8.7                   |

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

Table 4. Fruit juice TSS:acid ratio in the replicated trial in St. Lucie County . Fruit samples were collected 14 November 2012 and 14 November 2013.

| <u><b>Rootstock</b></u> | <u><b>2012</b></u> | <u><b>2013</b></u> | <u><b>Average</b></u> |
|-------------------------|--------------------|--------------------|-----------------------|
| US-1283                 | 12.8 ab            | 13.4 ab            | 13.1                  |
| US-1282                 | 14.0 a             | 14.8 a             | 14.4                  |
| <b>US-1284</b>          | <b>12.9 ab</b>     | <b>13.1 ab</b>     | <b>13.0</b>           |
| US-1279                 | 13.7 a             | 14.4 a             | 14.0                  |
| US-1281                 | 13.7 a             | 14.2 a             | 14.0                  |
| Swingle                 | 11.6 b             | 11.8 b             | 11.7                  |
| Flying Dragon           | 13.4 a             | 13.9 ab            | 13.6                  |

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

Table 5. Fruit juice color (cn) in the replicated trial in St. Lucie County. Fruit samples were collected 14 November 2012 and 14 November 2013.

| <u><b>Rootstock</b></u> | <u><b>2012</b></u> | <u><b>2013</b></u> | <u><b>Average</b></u> |
|-------------------------|--------------------|--------------------|-----------------------|
| US-1283                 | 34.7               | 33.5               | 34.1                  |
| US-1282                 | 35.1               | 33.7               | 34.4                  |
| <b>US-1284</b>          | <b>34.7</b>        | <b>33.4</b>        | <b>34.0</b>           |
| US-1279                 | 34.8               | 33.5               | 34.2                  |
| US-1281                 | 34.8               | 33.5               | 34.2                  |
| Swingle                 | 34.7               | 33.7               | 34.2                  |
| Flying Dragon           | 34.7               | 33.5               | 34.1                  |

ANOVA within columns were not significant

Table 6. Comparison of tree sizes in the replicated trial in St. Lucie County. Trees were measured in August 2014.

| <u><b>Rootstock</b></u> | <u><b>Canopy<br/>Height (m)</b></u> | <u><b>Canopy<br/>Width(m)</b></u> | <u><b>Canopy<br/>Area (sq m)</b></u> | <u><b>Canopy<br/>Volume (cu m)</b></u> |
|-------------------------|-------------------------------------|-----------------------------------|--------------------------------------|----------------------------------------|
| US-1283                 | 2.6 ab                              | 2.5 ab                            | 4.9 ab                               | 4.1 ab                                 |
| US-1282                 | 2.6 ab                              | 2.4 ab                            | 4.8 ab                               | 3.9 ab                                 |
| <b>US-1284</b>          | <b>2.7 a</b>                        | <b>2.8 a</b>                      | <b>6.1 a</b>                         | <b>5.3 a</b>                           |
| US-1279                 | 2.6 ab                              | 2.4 ab                            | 4.9 ab                               | 4.0 ab                                 |
| US-1281                 | 2.5 b                               | 2.2 bc                            | 3.8 bc                               | 3.0 bc                                 |
| Swingle                 | 2.4 b                               | 1.9 bcd                           | 2.8 c                                | 2.2 c                                  |
| Flying Dragon           | 2.1 c                               | 1.7 d                             | 2.3 c                                | 1.6 c                                  |

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

Table 7. Comparison of Las infection and bacterial titers in the replicated trial in St. Lucie County. Trees were sampled randomly across the canopy in August 2014.

| <b><u>Rootstock</u></b> | <b><u>N</u></b> | <b><u>Las Infected<br/>Trees (%)</u></b> | <b><u>Average<br/>Ct Las</u></b> | <b><u>Average<br/>Las Copy No. per q</u></b> |
|-------------------------|-----------------|------------------------------------------|----------------------------------|----------------------------------------------|
| US-1283                 | 7               | 100                                      | 25.1                             | 1,507,681                                    |
| US-1282                 | 7               | 100                                      | 24.7                             | 2,143,900                                    |
| <b>US-1284</b>          | <b>7</b>        | <b>100</b>                               | <b>24.5</b>                      | <b>2,432,189</b>                             |
| US-1279                 | 7               | 100                                      | 25.1                             | 1,831,557                                    |
| US-1281                 | 7               | 100                                      | 24.7                             | 2,016,472                                    |
| Swingle                 | 7               | 100                                      | 25.1                             | 1,584,108                                    |
| Flying Dragon           | 6               | 100                                      | 25.1                             | 1,482,230                                    |

ANOVA within columns were not significant (P>0.8).

Table 8. Fruit yield of ‘Hamlin’ sweet orange on US-1284 and other selected rootstocks in comparison with the rootstocks Swingle, US-812, and US-942 at a replicated trial in Orange County on ridge soil.

| <b><u>Rootstock</u></b> | <b><u>2005-8<br/>(kqs/tree)</u></b> | <b><u>2009<br/>(kqs/tree)</u></b> | <b><u>2011<br/>(kqs/tree)</u></b> | <b><u>2013<br/>(kqs/tree)</u></b> | <b><u>2005-13<br/>(kqs/tree)</u></b> |
|-------------------------|-------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|--------------------------------------|
| US-942                  | 237 a                               | 140 a                             | 134 a                             | 85                                | 597 a                                |
| US-812                  | 216 ab                              | 127 ab                            | 94 ab                             | 91                                | 528 ab                               |
| US-1283                 | 194 bc                              | 124 ab                            | 112 ab                            | 89                                | 519 abc                              |
| <b>US-1284</b>          | <b>186 bc</b>                       | <b>122 ab</b>                     | <b>81 ab</b>                      | <b>54</b>                         | <b>443 bcd</b>                       |
| Swingle                 | 166 c                               | 82 c                              | 106 ab                            | 71                                | 424 cd                               |
| US-1279                 | 154 c                               | 102 bc                            | 90 ab                             | 65                                | 411 d                                |
| US-1277                 | 107 d                               | 83 c                              | 72 b                              | 55                                | 316 e                                |

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