‘US Early Pride’, a Very Low-seeded, Early-maturing Mandarin Hybrid

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‘Fallglo’ is an early-season mandarin hybrid that was developed by Dr. C.J. Hearne (USDA, ARS retired) and released by the USDA in 1987 (Hearn, 1987). ‘Fallglo’ is self-compatible and produces early-maturing, attractive, high color fruit with a peel that is relatively easy to remove along with abundant, colorful, and flavorful juice. ‘Fallglo’ is the earliest maturing mandarin hybrid produced in Florida, typically coming into the market in early October. In the 2009–2010 growing season ‘Fallglo’ was grown on 1476 acres in Florida, representing 21% of the ‘early tangerine’ class of fresh fruit (USDA, 2011). Although ‘Fallglo’ is valued as an early-season, high-quality cultivar for the fresh market, the fruit typically contain 30 to 40 seeds. It is widely accepted that the presence of seeds is undesirable to consumers and there is currently a belief that to be successful in the commercial market, mandarin fruit need to be seedless (Campbell et al., 2004; Vardi et al., 2008). Various approaches for developing seedless citrus fruit have been used (Hearn, 1984, 1986; Henz, 1971; Recupero et al., 2008; Soost and Roose, 1996; Vardi et al., 2008); however, using irradiation to induce seedless mutants is the only means available for elimination of seeds while preserving the desirable characteristics of commercially important cultivars. Although irradiation of seeds or mature budwood to induce seedless mutations has proven successful for several citrus scion varieties (Hearn, 1984, 1986; Henz, 1971; Vardi et al., 2008), irradiation of budwood is the preferred method. Because budwood is a clonal propagation of the parental material, characteristics of the parental type are preserved, thereby allowing the seedless mutants to maintain market identity yet have enhanced consumer appeal. Additionally, irradiation of mature budwood avoids the juvenile phase and fruit production begins much sooner than for trees originating from seeds. Budwood irradiation has resulted in the seedless mandarins ‘Tango’ (Roose and Williams, 2007) and ‘Orri’ an important seedless mandarin grown in Israel (Vardi et al., 2008).

Origin

‘US Early Pride’ is an irradiation-induced, very low-seeded mutant of the ‘Fallglo’ mandarin hybrid (‘Bower’ [Citrus reticulata Blanco × (C. paradisi Macf. × C. reticulata) × ‘Temple’]). (Hearn, 1987). Although the pedigree of ‘Temple’ is not known, it is believed to be a natural hybrid of C. sinensis × C. reticulata and is referred to as a tangor. Mature ‘Fallglo’ budwood was irradiated in 1991 using 30 Gy units of gamma irradiation from a Cobalt-60 source in an effort to generate seedless mutants. Buds from this irradiation were propagated onto rootstocks in the greenhouse at the A.H. Whitmore citrus research foundation farm in Lake County, FL, where the trees were grown to field-plantable size. Approximately 200 of these trees were planted in the field at the A.H. Whitmore farm in 1992. In 1995, two trees producing seedless fruit were identified. One of the trees (evaluated as 1-62-122, ‘US Early Pride’) performed better than the other and was selected for further evaluation. Buds were taken from 1-62-122 in 1996 and grafted onto each of four rootstocks: Swingle (C. paradisi Macf. × Poncirus trifoliata); Cleopatra mandarin (C. reticulata); sour orange (Citrus aurantium, L.); and Sun Chu Sha (C. reticulata). These trees were planted in the field in Apr. 1997 and began producing fruit in 2000. In 2003 buds of 1-62-122 were used to produce five trees on each of four rootstocks: Carrizo citrange (C. sinensis × P. trifoliata); Sun Chu Sha mandarin, and Cleopatra mandarin in the USDA greenhouse in Ft. Pierce, FL. These trees were subsequently planted in the field at the USDA farm in St. Lucie County, FL, in 2006. These trees began producing fruit in 2007 and fruit have been evaluated annually since then.

Description

‘US Early Pride’ combines early-season maturity, moderately sized fruit, pebbled rind texture with a deep strong orange-yellow color, and a rich sweet flavor similar to ‘Fallglo’; however, ‘US Early Pride’ distinguishes itself by being very low-seeded (average less than two seeds/fruit) and relatively easy to peel. ‘US Early Pride’ fruit consistently contain less than five seeds in mixed plantings with a wide variety of other citrus cultivars, including mandarins (Citrus reticulata), pummelos [C. maxima (Burm.) Merrill], and sweet oranges (C. sinensis) (Fig. 1). Evaluation of ‘US Early Pride’ began on the original tree at the A.H. Whitmore farm in 1995. Tree size, growth, and fruit production along with fruit quality characteristics of ‘US Early Pride’ have been compared with ‘Fallglo’ grown in the same proximity. ‘US Early Pride’ trees have also been evaluated for 3 years at the USDA farm in St. Lucie County, FL. Tree size and habit of ‘US Early Pride’ have been consistent with ‘Fallglo’ throughout the evaluation.

‘US Early Pride’ fruit are oblate with no neck (Fig. 1) and occasionally a small navel at the blossom end. The fruit is large for a mandarin averaging 68 mm in diameter and 58 mm in height with a smooth, strong orange–yellow rind color (Royal Horticultural Society 22A) and relatively conspicuous, slightly raised oil glands (Table 1). The rind is somewhat adherent (relatively easy to peel) at maturity and relatively thin averaging 2.7 mm in thickness. The fruit interior has a fine flesh texture with 11 to 13 segments and a hollow axis of medium size at maturity. The fruit are juicy, averaging slightly over 55% juice with average weight of 145 g.

Although seeds are not uncommon in ‘US Early Pride’ fruit, seed counts greater than five have not been recorded. The frequency distribution of seeds per fruit in ‘US Early Pride’ is presented in Figure 3; the average number of seed per fruit in ‘US Early Pride’ is 1.8 with 92% of fruits containing fewer than four seeds. Hand pollination of ‘US Early Pride’ flowers with ‘Orlando’ tangelo pollen resulted in an average of 2.5 seeds/fruit (data not shown).

‘US Early Pride’ starts fruit production in the second year after planting. Growth of both the ‘US Early Pride’ selection and ‘Fallglo’ have generally been upright in the first 5 years followed by a tendency to grow into a spherical shape in ensuing years. At 14 years after planting, ‘US Early Pride’ trees at the A.H. Whitmore farm averaged 3.7 m high and 4.1 m wide with normal upright growth habit (Fig. 2) yielding a canopy volume of 32.7 m3. Scion circumference for ‘US Early Pride’ 10 cm above the graft union on ‘Swingle’ rootstock was 55 cm; ‘Swingle’ rootstock circumference 10 cm below the graft union was 76 cm. Scion circumference for 14-year-old ‘Fallglo’ trees averaged 51 cm with the rootstock circumference of 86 cm.

‘US Early Pride’ (1-62-122) has been under evaluation in Lake County, FL, for 15 years and in St. Lucie County, FL, for 3 years. Yield of ‘US Early Pride’ has not been recorded, but crop estimates for trees in mixed plantings indicate that production is similar to that of ‘Fallglo’. Alternate bearing does not appear to be a problem. The selection is thornless. Flowers of ‘US Early Pride’ are hermaphroditic with white petals and yellow anthers and are borne in clusters. In Lake County, FL, flower buds form in late January. Flowering occurs late February through early April depending on annual weather conditions. Mature fruit quality characteristics for ‘US Early Pride’ produced in either Lake or St. Lucie Counties over 4 years of sampling are presented in Table 2. Fruit from the Lake County test site tended to be larger with a deeper orange rind color and slightly higher in total soluble solids than did fruit from the St. Lucie County test site.
‘US Early Pride’ fruit meet minimum maturity requirements by the fourth week of October in Florida and can be harvested as late as the end of November (Table 3). Fruit size of ‘US Early Pride’ is consistently slightly smaller than ‘Fallglo’ (Table 3). This difference is no doubt a consequence of the absence of seeds; fruit weight has been shown to be positively correlated with seed number in grapefruit (Wallace et al., 2002) and in ‘Orlando’ tangelo (Krezdorn, 1967). In addition, ‘US Early Pride’ fruit did not meet minimum maturity standards until 2 weeks later than ‘Fallglo’. Total soluble solids in ‘US Early Pride’ tended to be slightly lower than for ‘Fallglo’ (Table 3). Although this difference was consistent, it was slight and unlikely that it would be detrimental to the overall acceptability of ‘US Early Pride’, especially because the fruit are seedless. In a large consumer survey, there was a slight, but non-significant, preference for ‘US Early Pride’ fruit compared with ‘Fallglo’ (data not shown). Postharvest behavior of ‘US Early Pride’ and ‘Fallglo’ was similar in response to postharvest ethylene treatments (data not shown). Fruit of each scion held good condition during storage for 3 weeks at 5 °C (Table 4). The seedless character of ‘US Early Pride’, coupled with its similarity to ‘Fallglo’ in terms of maturity, fruit quality, and postharvest behavior, suggests it will be an attractive alternative to ‘Fallglo’ for an early-season mandarin.

**Table 1. Fruit characteristics of ‘US Early Pride’ mandarins.**

| Characteristics                             | ‘US Early Pride’ | ‘Fallglo’    |
|---------------------------------------------|------------------|--------------|
| Season of maturity                          | Early (mid-October to late November) |             |
| Fruit shape                                 | Oblate           |              |
| Fruit diameter (mm)                         | 68                | 90           |
| Fruit height (mm)                           | 58                | 92           |
| Fruit: shape of basal end                   | Flat              |              |
| Fruit: shape of distal end                  | Flat              |              |
| Fruit neck                                 | Not present       |              |
| Rind texture                                | Smooth            |              |
| Oil glands                                  | Conspicuous, slightly raised |         |
| Rind color                                  | RHS 22A (yellow–orange) | RHS 22A (yellow–orange) |
| Rind thickness (mm)                         | 2.7               | 3.2          |
| Albedo thickness (mm)                       | 1.2               | 1.5          |
| Albedo color                                | RHS 158A (yellow–white) | RHS 158A (yellow–white) |
| Rind adherence                              | Moderately weak   |              |
| Rind separation                             | Relatively easy   |              |
| Flesh (pulp) color                          | RHS N25B (orange) | RHS N25B (orange) |
| Flesh (pulp) texture                        | Fine              |              |
| Number of segments                          | 11–13             |              |
| Axis: structure                             | Hollow            |              |
| Axis: size (mm)                             | 8.3               |              |
| Navel presence                              | Occasional        |              |
| No. of seeds/fruit                          | Less than 2 on average (cross-pollinated conditions) | Less than 2 on average (cross-pollinated conditions) |
| Fruit weight (g)                            | 145               | 165          |
| Percent juice (%)                           | 55                |              |
| Percent soluble solids (at maturity)        | 11% to 12%        |              |
| Percent acid (at maturity)                  | 1.1% to 0.9%      |              |
| Fruit holding ability on tree past maturity | 1 month           |              |
| Fruit quality after storage (5 °C, 21 d)    | Excellent         |              |

**Fig. 1. ‘US Early Pride’ fruit harvested in Lake County, FL, in November.**

**Fig. 2. ‘US Early Pride’ tree at 14 years of age grown in Lake County, FL.**

**Fig. 3. Frequency distribution of seeds in ‘US Early Pride’ fruit. Seeds were counted in fruit sampled over 4 years; n = 182; mean number seeds/fruit = 1.8.**

‘US Early Pride’ fruit meet minimum maturity requirements by the fourth week of October in Florida and can be harvested as late as the end of November (Table 3). Fruit size of ‘US Early Pride’ is consistently slightly smaller than ‘Fallglo’ (Table 3). This difference is no doubt a consequence of the absence of seeds; fruit weight has been shown to be positively correlated with seed number in grapefruit (Wallace et al., 2002) and in ‘Orlando’ tangelo (Krezdorn, 1967). In addition, ‘US Early Pride’ fruit did not meet minimum maturity standards until 2 weeks later than ‘Fallglo’. Total soluble solids in ‘US Early Pride’ tended to be slightly lower than for ‘Fallglo’ (Table 3). Although this difference was consistent, it was slight and unlikely that it would be detrimental to the overall acceptability of ‘US Early Pride’, especially because the fruit are seedless. In a large consumer survey, there was a slight, but non-significant, preference for ‘US Early Pride’ fruit compared with ‘Fallglo’ (data not shown). Postharvest behavior of ‘US Early Pride’ and ‘Fallglo’ was similar in response to postharvest ethylene treatments (data not shown). Fruit of each scion held good condition during storage for 3 weeks at 5 °C (Table 4). The seedless character of ‘US Early Pride’, coupled with its similarity to ‘Fallglo’ in terms of maturity, fruit quality, and postharvest behavior, suggests it will be an attractive alternative to ‘Fallglo’ for an early-season mandarin.

**Culture**

Longevity and long-term productivity of trees on various rootstocks have not been evaluated; however, no incompatibilities have been observed with the rootstocks on which ‘US Early Pride’ has been grown. Tree growth is generally vigorous with normal cultural practices. ‘US Early Pride’ trees showed only minor cold damage during multiple freezes in the winter of 2009–2010. The productivity of ‘US Early Pride’ in large, solid-block plantings with no available pollenizer is unknown. ‘US Early Pride’ pollen viability (estimated by staining and in vitro germination) is less than 20%; therefore, we do not recommend planting this variety in isolated blocks until its pollination requirement is better understood.

**Table 1. Fruit characteristics of ‘US Early Pride’ mandarins.**

| Season of maturity | Early (mid-October to late November) |
|--------------------|--------------------------------------|
| Fruit shape        | Oblate                               |
| Fruit diameter     | 68 mm                                |
| Fruit height       | 58 mm                                |
| Fruit: shape of    | Flat                                 |
| basal end          |                                      |
| Fruit: shape of    | Flat                                 |
| distal end         |                                      |
| Fruit neck         | Not present                          |
| Rind texture       | Smooth                               |
| Oil glands         | Conspicuous, slightly raised         |
| Rind color         | RHS 22A (yellow–orange)              |
| Rind thickness     | 2.7 mm                               |
| Albedo thickness   | 1.2 mm                               |
| Albedo color       | RHS 158A (yellow–white)              |
| Rind adherence     | Moderately weak                      |
| Rind separation    | Relatively easy                      |
| Flesh (pulp) color | RHS N25B (orange)                    |
| Flesh (pulp) texture | Fine                  |
| Number of segments | 11–13                                |
| Axis: size         | 8.3 mm                               |
| Axis: structure    | Hollow                               |
| Navel presence     | Occasional                           |
| No. of seeds/fruit | Less than 2 on average (cross-pollinated conditions) |
| Fruit weight       | 145 g                                |
| Percent juice      | 55                                   |
| Percent soluble solids (at maturity) | 11% to 12%                      |
| Percent acid (at maturity) | 1.1% to 0.9%                    |
| Fruit holding ability on tree past maturity | 1 month                      |
| Fruit quality after storage (5 °C, 21 d) | Excellent                     |

RHS = Royal Horticultural Society.
Table 2. Mature fruit characteristics of ‘US Early Pride’ mandarins grown at two locations in Florida over four seasons. 

| Year | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie | Lake St. Lucie |
|------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 2007 | 59.8           | 55.3           | 73.7           | 69.4           | 188.4          | 153.2          | 68.0           | 70.2           | 9.4            | 10.0           | 1.10           | 1.21           | 8.7            | 12.1           | —              |
| 2008 | 69.2           | 59.8           | 69.2           | 73.7           | 167.8          | 172.3          | —              | 79.6           | 9.1            | 10.3           | 1.03           | 1.21           | 9.3            | 11.2           | —              |
| 2009 | 59.0           | 54.4           | 66.9           | 66.4           | 131.1          | 133.4          | 81.5           | 71.3           | 10.3           | 9.3            | 1.10           | 0.79           | 9.4            | 11.8           | —              |
| 2010 | 58.65          | 55.5           | 72.34          | 68.8           | 169.8          | 136.9          | 69.3           | 71.3           | 11.3           | 9.16           | 0.72           | 0.75           | 15.8           | 12.1           | —              |

Mean 61.6 56.3 70.5 69.6 146.3 149.0 72.9 73.1 10.0 9.8 0.99 0.99 10.8 11.8 — 41.4

Table 3. Comparison of fruit quality characteristics of ‘US Early Pride’ and ‘Fallglo’ at five harvest dates in 2009.

| Harvest date | Fruit wt (g) | Total soluble solids (%) | Rind color (hue angle) |
|--------------|--------------|--------------------------|------------------------|
|              | Mean SE      | Mean SE                  | Mean SE                |
|              | US Early Pride | Fallglo                | US Early Pride | Fallglo | US Early Pride | Fallglo |
| 2 Oct.       | 117.4 7.7 | 140.6 6.5 | 9.7 0.3 | 10.6 0.3 | 7.5 0.2 | 8.6 0.2 | 130.0 5.7 | 126.0 7.2 |
| 14 Oct.      | 131.1 3.7 | 153.8 12.1 | 10.3 0.1 | 10.3 0.3 | 9.6 0.3 | 8.7 0.2 | 131.1 5.0 | 99.8 1.8 |
| 29 Oct.      | 140.2 3.6 | 161.5 12.3 | 10.7 0.2 | 11.3 0.1 | 10.5 0.2 | 10.2 0.4 | 81.8 0.7 | 80.1 2.0 |
| 13 Nov.      | 151.8 3.5 | 211.5 21.8 | 11.3 0.2 | 11.7 0.2 | 11.5 0.2 | 12.1 0.4 | 68.7 0.6 | 69.7 1.3 |
| 25 Nov.      | 157.7 5.8 | 206.8 15.5 | 11.9 0.2 | 12.3 0.4 | 12.9 0.4 | 13.1 0.7 | 61.6 0.4 | 62.0 0.8 |

Table 4. Fruit quality characteristics of ‘US Early Pride’ and ‘Fallglo’ at harvest and during 3 weeks of storage at 5°C.

| Harvest date | Total soluble solids (%) | Total soluble solids/acid ratio |
|--------------|--------------------------|-------------------------------|
|              | Mean SE                  | Mean SE                       |
|              | US Early Pride | Fallglo | US Early Pride | Fallglo | US Early Pride | Fallglo |
| Initial      | 11.1 0.08 | 10.5 0.06 | 8.7 0.26 | 8.6 0.68 |
| 1 week       | 11.2 0.23 | 10.7 0.22 | 9.4 0.44 | 8.9 0.26 |
| 2 week       | 11.0 0.16 | 10.6 0.05 | 9.0 0.16 | 8.5 0.54 |
| 3 week       | 11.2 0.32 | 11.0 0.27 | 9.5 0.39 | 8.8 0.18 |

Availability

The USDA-ARS has applied for a patent to ‘US Early Pride’. Research materials can be obtained by writing the author. ‘US Early Pride’ is available to growers to plant for early production. Research materials can be obtained by writing the author. ‘US Early Pride’ will be made available on a non-exclusive basis.

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