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'US Furr' and 'US Furr-ST' Mandarins

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Abstract

This document marks the official release of 'US Furr', a hybrid of 'Clementine' x 'Murcott', and 'US Furr-ST', an irradiated variant of 'US Furr' with apparent field tolerance to citrus scab (causal agent *Elsinoe fawcetti* Bitanc. and Jenk.). The hybridization creating 'US Furr' and ultimately 'US Furr-ST' was made at the USDA Horticultural Research Laboratory in Orlando, Florida, by Dr. Phillip Reece in 1953. Seeds were sent to the USDA Date and Citrus Station in Indio, California for hybrid evaluation. Dr. Joseph Furr identified this superior selection from the resulting seedlings. 'US Furr' has been sufficiently promising that it has been introduced into at least five countries, under several different names. Budwood of 'US Furr' was introduced into Argentina, Brazil, France (Corsica), Israel, and Spain in the 1980s and 1990s using material prior to irradiation and some possibly post-irradiation. 'US Furr' and 'US Furr-ST' are high quality, December/January-maturing mandarins with excellent rind color, superior flavor, and moderate peelability (rind comes off in pieces similar to 'Sunburst' and 'Murcott'). 'US Furr' and 'US Furr-ST' are sexually self-compatible and fruit in mixed plantings average 12 to 24 highly polyembryonic seeds per fruit, and 6 to 12 seeds per fruit when planted in isolation from compatible pollinating varieties. Furthermore, very few to no fruit are set when flowers are bagged, indicative of low parthenocarpy. 'US Furr' and 'US Furr-ST' fruit average 150-215 g per fruit at maturity. 'US Furr' and 'US Furr-ST' trees are moderately vigorous, thornless, and spreading with fairly dense foliage. The diversity of names used for 'US Furr' / 'US Furr-ST' has reduced awareness that a single genotype has garnered wide attention, limiting impact and resulting in few US plantings. It is anticipated that this official release will garner increased interest in these cultivars leading to increased plantings. Many tasters report that 'US Furr' and 'US Furr-ST' are among the best tasting citrus they have eaten. These mandarin cultivars merit consideration for planting as a part of a mid-late season mandarin portfolio, and are released without any intellectual property restrictions.

This document marks the official release of 'US Furr', a hybrid of 'Clementine' x 'Murcott', and 'US Furr-ST' (ST for scab tolerant), an irradiated variant of 'US Furr' with apparent field tolerance to citrus scab (causal agent *Elsinoe fawcettii* Bitanc. and Jenk.). The hybridization creating 'US Furr' and ultimately 'US Furr-ST' was made at the USDA Horticultural Research Laboratory in Orlando, Florida, by Dr. Phillip Reece in 1953. Seeds were subsequently sent to the USDA Date and Citrus Station in Indio, California for hybrid evaluation. Dr. Joseph Furr identified this superior selection from the resulting seedlings. Therefore, he is posthumously honored by having this cultivar named after him.

Selection assessments

Evaluation – Texas. Budwood, under the name 'C54-4-4', was sent from California to Texas in 1963, for evaluation by Dr. Heinz Wutscher, USDA, Weslaco. The characteristics of 'US Furr' in Texas conditions (on sour orange rootstock, Table 1) were reported as large tree size (similar to 'Orlando' and 'Murcott') with yield for 1974 and 1969-74 cumulatively similar to 'Murcott', maturing late (similar to 'Murcott') with uniform exterior color and 20% granulation (Wutscher,

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Table 1: Fruit quality data for 'US Furr' in Texas and 'US Furr-ST' in Florida.

Cultivar	Rootstock	Location	Date	Fruit weight g/fruit	Total soluble solids (°Brix)	Total acid (% citric)	TSS/ TA ratio	Juice or color	Seeds/ fruit	Tree age
US Furr	Sour orange	Lower Rio Grande Valley, TX	1969-1974	215	13.0	0.63	20.6	Deep orange	22	5-10
US Furr-ST	NA	St. Cloud, FL	27 Jan. 2005	207	13.6	0.50	27.2	44.7	23	NA
US Furr-ST	NA	St. Cloud, FL	28 Dec. 2005	176	13.5	0.86	15.7	44.4	NA	NA

Florida data are juice color score assessed using the Model D45 Citrus Colorimeter (HunterLab, Reston, VA).
NA = Data not available.

1978). The fruit was large with an average of 22 seeds per fruit. Total soluble solids (TSS) was intermediate in the varieties tested, but titratable acid (TA) was among the lowest reported. Therefore, the TSS/TA ratio was the second highest among the 29 mandarins and mandarin hybrids evaluated, with each variety harvested as "early maturing" and sampled between 1 Dec and 20 Dec. or "late maturing (harvested between 10 Jan. and 10 Feb.).

Evaluation – Florida. 'C54-4-4' was introduced into Florida in 1975 and found to be highly susceptible to citrus scab. Budwood was irradiated by H. Wutscher in 1975 and repeated in 1990, budded, and evaluated in a commercial orchard owned by Mr. Orie Lee in St. Cloud, FL. A scab-tolerant selection of 'C54-4-4' was identified and evaluated, initially proposed to be named 'Furr', and is now released as 'US Furr-ST'. Fruit quality parameters of the scab-tolerant selection were similar to those of the original 'C54-4-4' (Jan. 2005, Table 1). O. Lee reports that some scab is present on 'US Furr-ST' in some years (pers. comm.). In 2005, the Florida Division of Plant Industry (DPI) received and initiated budwood clean-up of the scab-tolerant irradiated selection, ultimately making clean budwood available under the working name of 'Furr' mandarin, and now officially designated 'US Furr-ST'.

Evaluation – California. Fruit quality evaluations of 'US Furr' were conducted in Exeter and Riverside, CA with all trees on Carrizo rootstock. 'US Furr' mean rind thickness was 3.0 mm based on 20 ten-fruit samples during November and December 2010-2012. In California, the legal minimum maturity standard for mandarins requires fruit to have a TSS/TA ratio of at least 6.5. Multiple packing houses in California use higher initial standards of 10-12 TSS/TA ratio as a minimum standard. 'US Furr' fruit met this legal maturity standard by mid to late October in Exeter, CA and by mid November to early December in Riverside CA, but the fruit were still very tart (Table 2). By early December fruit from either location met the higher initial maturity standard used by packing houses with acceptable levels of acidity. Compared to data from Texas and Fla., TSS/TA was quite low in Calif. samples even at the latest harvest date for each site and year. However, the actual harvest dates were earlier in Calif. than in the other states, and furthermore, the cooler winter nights typical of Calif. likely slowed the decline in TA.

Rind color, another characteristic of maturity, was rated based on a correlation to a

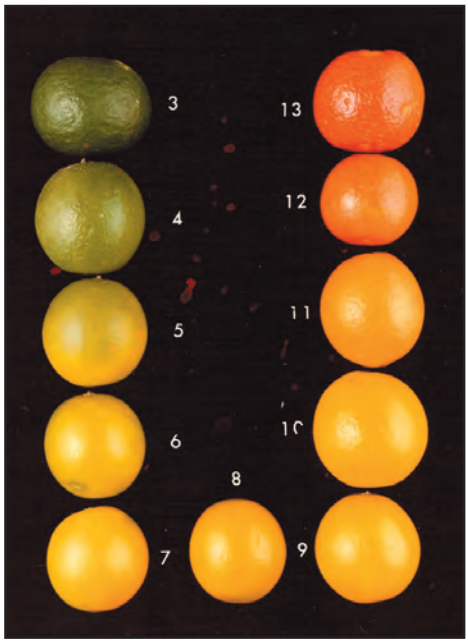

Fig. 1: Rind color rating system UC Riverside. Translating into the Ridgway (1912) system, 7-10 are Cadmium Yellow with green background from moderate to absent, 11 is Mikado Orange, and 12 is Flame Scarlet.

standard color chart on a scale from 3 to 13, with a color rating of 3 as dark green, and 5 a rind which is partially orange at color break (Fig. 1). Rind of 'US Furr' fruit reached color break from mid-November to early December in CA. The mean seed number per ten-fruit sample ranged from 15.3 to 25.2 with an overall mean of 16.7 at both locations. Juice percentage was typical of mandarin cultivars except in the 2 year old trees at Riverside.

Global evaluation. 'US Furr' has been sufficiently promising that it has been introduced into at least five countries, under several different names. Budwood of 'US Furr' was introduced into Argentina, Brazil, France (Corsica), Israel, and Spain in the 1980s and 1990s using material prior to irradiation and some possibly post-irradiation. The name has often been maintained as 'C54-4-4' in research collections but has sometimes been changed following importation. In Brazil 'US Furr' and/or 'US Furr-ST' were introduced and tested under the names 'Diamantina', 'Murcotão', 'Olé', and 'Piemonte' (de Almeida and Passos, 2011; Graham Barry, personal communication). **'**C54-4-4' was selected for re-introduction to California in 1997 by members of the California Citrus Nurserymen's Society (CCNS) during a tour of the INRA-CIRAD Station de Recherches Agronomiques in San Giuliano, Corsica (where it was designated 'SRA 337'), associated with the Congress of the International Citrus Nurserymen's Society (Siebert et al., 2010). Budwood from this source under the names 'SRA 337' and 'C54-4-4 Mandarin' (VI 672) has been distributed by the California Citrus Clonal Protection Program since 2009, and now will be designated as 'US Furr'. A nucellar seedling of 'US Furr' appears to be the cultivar known as 'Taylor Lee' in Australia, where it has been grown commercially, albeit on a small scale (Graham Barry, personal comm.). 'US Furr-ST' was introduced into South Africa as "Murcott x Clem (C54-4-4)" and is now called 'Clemcott' (Graham Barry, personal comm.), where it is being grown on a small scale commercially, and was deemed sufficiently promising for Citrus Research International to seek rights to the material for propagation and dissemination in South Africa.

Future developments

The use of this material in plant improvement further underscores the potential of 'US Furr' / 'US Furr-ST'. What appears to be a low-seeded variant of 'US Furr' is currently in quarantine at Florida DPI as 'Taylor Lee LS'. 'US Furr-ST' has been used as a parent in the University of Florida citrus breeding program with the objective of producing polyploid easy-peel mandarins (Grosser et al., 2010).

Budwood from the non-irradiated 'US Furr' was distributed as 'C54-4-4' by the National Clonal Germplasm Repository for Citrus and Dates (NCGRCD) in Riverside, CA (under accession number RRUT 223 and

Table 2: Fruit quality data for two ten-fruit samples of 'US Furr' fruit per sample date collected from Exeter and Riverside, CA 2010-2013. All trees were grown on Carrizo rootstock. Values are shown ± SD.

Location	Sample date	Tree age[z] (years)	Total soluble solids (°Brix)	Titratable acidity (% citric acid)	Ratio of total soluble solids to percentage titratable acidity	Fruit weight (g)	External rind color[y]	Seed number per fruit	Juice (%)
Exeter, CA	17 Oct. 2010	7	11.6 ± 0.3	1.7 ± 0.0	6.8 ± 0.1	108.3 ± 2.7	3.3 ± 0.1	19.2 ± 3.3	42.4 ± 3.3
Exeter, CA	7 Nov. 2010	7	11.5 ± 0.0	1.3 ± 0.1	9.1 ± 0.5	121.7 ± 3.9	3.7 ± 0.1	13.4 ± 1.7	46.6 ± 1.0
Exeter, CA	9 Dec. 2010	7	11.6 ± 0.4	0.9 ± 0.0	12.3 ± 0.2	159.5 ± 13.2	8.3 ± 0.4	15.4 ± 0.6	49.3 ± 1.7
Exeter, CA	2 Jan. 2011	7	12.1 ± 0.1	0.9 ± 0.0	14.0 ± 0.5	171.4 ± 0.8	11.0 ± 0.0	13.4 ± 0.3	49.7 ± 0.0
Exeter, CA	17 Oct. 2011	8	9.4 ± 0.7	1.7 ± 0.1	5.5 ± 0.6	129.7 ± 10.0	3.1 ± 0.1	16.0 ± 0.9	46.9 ± 1.4
Exeter, CA	10 Nov. 2011	8	10.5 ± 0.9	1.3 ± 0.1	8.0 ± 1.2	160.0 ± 15.8	3.4 ± 0.3	15.3 ± 1.3	50.2 ± 2.8
Exeter, CA	1 Dec. 2011	8	10.6 ± 0.4	1.0 ± 0.0	10.3 ± 0.5	193.7 ± 7.7	6.0 ± 0.0	17.5 ± 2.9	48.6 ± 0.3
Exeter, CA	12 Oct. 2012	9	7.6 ± 0.3	1.7 ± 0.1	4.4 ± 0.1	112.4 ± 7.7	3.0 ± 0.0	18.3 ± 2.3	46.8 ± 1.7
Exeter, CA	5 Nov. 2012	9	10.7 ± 1.7	1.1 ± 0.0	9.9 ± 1.8	134.6 ± 1.4	3.0 ± 0.0	21.6 ± 5.2	41.8 ± 4.9
Exeter, CA	14 Dec. 2012	9	10.0 ± 0.2	0.9 ± 0.0	11.3 ± 0.8	172.2 ± 3.4	12.0 ± 0.0	19.3 ± 1.3	44.4 ± 4.0
Exeter, CA	18 Oct. 2013	10	11.7 ± 0.0	1.6 ± 0.0	7.5 ± 0.1	125.2 ± 3.6	4.0 ± 0.0	17.2 ± 1.6	42.7 ± 0.5
Exeter, CA	11 Nov. 2013	10	12.3 ± 0.7	1.1 ± 0.0	11.3 ± 1.0	150.4 ± 9.8	5.0 ± 0.0	19.6 ± 0.2	44.0 ± 3.0
Exeter, CA	13 Dec. 2013	10	12.9 ± 0.2	1.1 ± 0.0	12.0 ± 0.2	174.0 ± 2.3	12.0 ± 0.0	20.8 ± 0.1	38.9 ± 4.7
Riverside, CA	7 Nov. 2010	2	10.5 ± 0.0	1.8 ± 0.4	6.0 ± 1.3	85.9 ± 12.0	5.0 ± 0.0	12.4 ± 6.5	28.6 ± 4.7
Riverside, CA	6 Dec. 2010	2	11.9 ± 0.5	2.0 ± 0.7	6.2 ± 2.0	89.9 ± 30.3	7.1 ± 0.1	14.7 ± 2.4	27.1 ± 5.9

[y] Tree age is the number of years in the ground since planting.
[z] External rind color data is based on a color rating system (Fig. 1). Rind with a rating of 3 is dark green, 5 is color break between green and orange and 13 is orange red in color

RCRC 4238). The irradiated and scab-tolerant 'US Furr-ST' is currently in quarantine at the NCGRCD (under accession number RRUT 458) and was obtained directly from Florida DPI.

Fruit characteristics

'US Furr' and 'US Furr-ST' are sexually self-compatible and fruit in mixed plantings average 12 to 24 highly polyembryonic seeds per fruit, and 6 to 12 seeds per fruit when planted in isolation of compatible pollinating varieties. Furthermore, very few to no fruit are set when flowers are bagged, i.e. low parthenocarpy (Graham Barry, personal comm.). 'US Furr' and 'US Furr-ST' fruit average

Fig. 2: 'US Furr-ST' Ft. Pierce, FL

Fig. 4: 'US Furr'

Fig. 3: 'US Furr-ST' Ft. Cloud, FL

Fig. 5: Trees of 'US Furr-ST' St. Cloud, FL

150-215 g per fruit at maturity (Tables 1 and 2). The fruit have an oblate shape, flattened at the apex and usually with a small navel on the blossom-end (Figs. 2, 3, and 4). The calyx is usually retained on the fruit when snap-picked. The rind surface is smooth to lightly pebbly with prominent oil glands. The rind averages 3-5 mm in thickness and is easily removed. Rind color is Mikado Orange to Flame Scarlet (Ridgway, 1912) when fruit mature. There are 12 to 14 segments that separate easily. Flesh color is Flame Scarlet and fruit are juicy with extremely rich mandarin flavor. The fruit core typically displays a small void. Juice is highly colored and is suitable for juice blending.

In summary description, 'US Furr' and 'US Furr-ST' are high quality, December/January-maturing mandarins with excellent rind color (Figs. 2, 3, and 4), superior flavor, and moderate peelability (rind comes off in pieces similar to 'Sunburst' and 'Murcott').

Tree Characteristics

'US Furr' and 'US Furr-ST' trees are moderately vigorous, thornless, and spreading with fairly dense foliage (Fig. 5). 'US Furr' is quite susceptible to citrus scab in Florida with much less scab on 'US Furr-ST', while the variant 'Taylor Lee' is reported to be

susceptible to Alternaria brown spot (causal agent *Alternaria alternata* Fr. (Keissler) pv. *citri* Solel) in Queensland, Australia, and similar reports for 'US Furr-ST' in Sundays River Valley, South Africa, but it is less susceptible than 'Murcott' (Graham Barry, personal comm.). Data on fruit yield is limited, but data and visual estimation indicate yields similar to 'Murcott'.

Postharvest characteristics

A study of postharvest performance of 'US Furr-ST' (McCollum, unpublished), indicated no decay or breakdown for fruit harvested 28 Dec. 2005, and held 28 days at 5°C: at harvest and following 2 weeks of storage a taste panel of 12 to15 people all scored the taste as "like" or "extremely like".

The diversity of names used for 'US Furr' / 'US Furr-ST' has reduced awareness that a single genotype has garnered wide attention, limiting impact and resulting in few US plantings. It is anticipated that this official release will garner increased interest in these cultivars leading to increased plantings. Many tasters report that 'US Furr' and 'US Furr-ST' are among the best tasting citrus they have eaten. These mandarin cultivars merit consideration for planting as a part of a mid-late season mandarin portfolio, and are released without any intellectual property restrictions.

Acknowledgements

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Effects of tetraploidy on olive floral and fruit biology

Abstract

Floral biology and fruit development were studied in Leccino Compact (LC), a polyploid olive mutant of cultivar Leccino (L). This mutant, considered a mixoploid with both diploid and tetraploid cells, has thicker leaves and fruit size similar to the diploid cultivar. So far, no information is available on its floral biology. In this study, the ploidy level of the LC fruit epicarp, analyzed by flow cytometry, was determined to be tetraploid. Pollen size distribution confirmed that most flowers were tetraploid. Morphological and histological measurements of various floral structures and fruits were carried out on the two genotypes, and LC showed larger floral structures (i.e. rachis, flower and ovary) and slightly higher pistil abortion rates. The total number of flowers per inflorescence was not significantly different between L and LC. The large difference (about 2 fold) in ovary cross sectional area between LC and L ovaries was mainly due to increased cell size. LC had slightly larger fruit cross-sectional area (but not greater fruit volume, since LC fruits were less elongated), with much larger cells. Therefore tetraploidy resulted in larger floral structures, as normally occurs in tetraploid plants, but had little effect on fruit size, despite much larger cell size.

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