Performance of ‘Oroblanco’ and ‘Melogold’ Pummelo x Grapefruit Hybrids on Nine Rootstocks on a Calcareous, Poorly Drained Soil

Ed Stover¹, Robert Pelosi, Michael Burton, Scott Ciliento, and Mark Ritenour

University of Florida, IFAS, Indian River Research and Education Center, Fort Pierce, FL 34945

Additional index words. citrandarin, citrange, citrumelo, *Citrus grandis*, *Citrus paradisi*, *Citrus reticulata*, Florida, fruit quality, grapefruit, Indian River, parthenocarp, perched water table, pummelo, triploid, x639

Abstract. Adjacent but separate trials of ‘Oroblanco’ and ‘Melogold’, both triploid pummelo [*Citrus grandis* (L.) Osbeck] x grapefruit (*Citrus paradisi* Macf.) hybrids, were established on nine rootstocks in the Indian River citrus region of Florida in 1993. The trees on the citrandarin rootstock x639 [Cleopatra mandarin (*C. reticulata* Blanco) x trifoliolate orange (*Poncirus trifoliata* L.)] were significantly more productive than trees on any other rootstock tested for ‘Oroblanco’ and all rootstocks except Swingle citrumelo (*C. paradisi* x *P. trifoliata*) and Cleopatra mandarin for ‘Melogold’. Cumulative production of ‘Oroblanco’ on x639, through year 9, was 50% higher than for Swingle or Volkamer lemon [*C. limon* (L.)], which were the next highest in yield. ‘Melogold’ displayed extremely low yield, with 45% of trees producing fewer than 50 fruit total in the 9 years of this study. Carrizo citrange (*C. sinensis* Osbeck x *P. trifoliata*) produced the smallest trees with both scion varieties, reflecting poor adaptation of this rootstock to the calcareous soil at the trial site. As expected, acidity of ‘Oroblanco’ and ‘Melogold’ was much lower than would be observed for grapefruit when fall harvested, with similar total soluble solids (TSS), and much higher TSS : titratable acidity ratio. Some rootstock effects on internal quality were observed.

The Indian River region of Florida is noted for its production of high quality fresh market grapefruit (*Citrus paradisi* Macf.), which has been largely produced on sour orange (*Citrus aurantium* L.) rootstock. Minimum standards of sugar content and sugar : acid ratio must be met before grapefruit can be legally marketed (Citrus Administrative Committee, 2003b). While a few orchards may meet these standards as early as September in some years, the availability of salable grapefruit is usually substantially less than the potential market until late October (e.g., Citrus Administrative Committee, 2003a) in most years. Many grapefruit producers think that an earlier ripening grapefruit or grapefruit-like hybrid may provide a substantial benefit by providing an expanded market season.

Plant breeders in California released two pummelo [*Citrus grandis* (L.) Osbeck] x grapefruit hybrids in the 1980s (Soost and Cameron, 1980, 1985), which are similar in flavor and appearance to grapefruit, but are earlier ripening and are seedless triploids. These hybrids, known as ‘Oroblanco’ and ‘Melogold’, had

been evaluated in California and elicited considerable grower and market interest.

The loss of sour orange as a standard rootstock for the Indian River area, because of its susceptibility to decline strains of citrus tristeza virus, remains the greatest horticultural problem for this region’s citrus industry, and no ideal replacement for sour orange has been identified (Stover and Castle, 2002). Rootstocks that are industry standards in other areas of Florida are either poorly adapted to the calcareous, poorly drained soils common in the Indian River region or do not confer premium internal fruit quality.

The purpose of the trials described in this paper was twofold: first, to assess yield and fruit quality of ‘Oroblanco’ and ‘Melogold’ in Florida, and second, to compare their performance on both standard rootstocks and potentially superior rootstocks being considered for wider planting.

Materials and Methods

Tree preparation. Budwood of ‘Oroblanco’ and ‘Melogold’ was obtained from the California Citrus Clonal Protection Program and placed in the Florida Dept. of Agriculture and Consumer Services (FDACS) Citrus Germplasm Introduction Program for pathogen indexing. It was approved for release in Florida in Nov. 1992.

Seedlings of x639, a Cleopatra mandarin

(Cleo, *C. reticulata* Blanco) x trifoliolate orange (*Poncirus trifoliata* L.) hybrid originating in South Africa (Castle et al., 1993b) were obtained from the FDACS Division of Plant Industry. Seedlings of Carrizo citrange (Carrizo, *C. sinensis* Osbeck x *P. trifoliata*); Cleo; Goutou (an unidentified *Citrus* hybrid); rough lemon 8166 (RL-8166, *C. limon* L.); Smooth Flat Seville (SFS, an unidentified *Citrus* hybrid); Sun Chu Sha mandarin (SCS, *C. reticulata* Blanco), Swingle citrumelo (Swingle, *C. paradisi* x *P. trifoliata*); and Volkamer lemon (Volk, *C. limon* L.) were produced by collecting seed from source trees and sowing them in soilless mix in Feb. 1992. Rootstock seedlings were grown in the greenhouse using frequent irrigation and fertilization, with pest control provided as needed. In Nov. 1992, when seedlings were 7–10 mm in diameter, they were T-budded at 15 cm above the soil line. Young trees were maintained in the greenhouse and were field planted in July 1993.

Field site and cultural practices. Plantings were made at the Indian River Research and Education Center in Ft. Pierce, Fla. The orchards were established as separate but contiguous rootstock trials for ‘Oroblanco’ and ‘Melogold’ using a randomized complete-block design, with six blocks in each trial and two-tree plots of each rootstock. Blocks were established so that drainage was as similar as possible within each block. Typical of older Indian River region citrus orchards, the planting site had been formed into single-row beds to improve drainage, and had been planted to citrus since 1934. Spacing was 9.2 m between rows and 5.4 m within rows. The site’s soil was mapped as primarily Winder sand depressional (fine-loamy, siliceous, hyperthermic, typic glossaqualfs) with some inclusions of Wabasso sand (sandy, siliceous, hyperthermic, alfic haploquads). Microsprinkler irrigation was used. Fertilization and pest control were typical of grapefruit grown for processing in the Indian River area.

Data collection. From 1998 through 2002, the total number and weight of fruit were recorded for each tree when harvested in October through December of each year. Beginning in September, ‘Oroblanco’ fruit were sampled on 3–4 dates each year to test internal fruit quality characteristics, with number and weight of fruit and source tree recorded for inclusion in overall yield data. Cropping was so poor on ‘Melogold’ that sampling for fruit quality was restricted to a single date each year. Internal quality tests on each date were conducted using 10 fruit from each of three trees of each sampled rootstock. These fruit quality samples were compared to fruit samples from nearby plantings of standard grapefruit varieties. Quality variables collected at each sampling included percent juice following hand squeezing, total soluble solids (TSS; measured using a benchtop, temperature-compensated refractometer; Spectronic Instruments, Rochester, N.Y.), percent titratable acidity (TA; measured using a Mettler titrator, model DL12, Hightstown, N.J.), and ratio of TSS : TA. On 7 Dec. 2001, 10 fruit at final harvest were randomly selected from each ‘Oroblanco’ tree and were assessed

Received for publication 8 July 2003. Accepted for publication 2 Sept. 2003. This research was supported by the Florida Agricultural Experiment Station, and approved for publication as Journal Series No.R-09551.

¹To whom reprint requests should be addressed. E-mail address: ewstover@mail.ifas.ufl.edu

for presence of vesicle drying. In Jan. 2003, following harvest in the ninth year of these plantings, data were collected on tree height, width (east–west and north–south), trunk cross-sectional area (TCSA) above the bud union, and tree mortality. No data were collected on cause of tree mortality.

Statistical analysis. Yield data are presented as production per tree for the surviving trees. Data comparing effect of rootstock on cumulative production of >50 fruit on ‘Melogold’ were analyzed using chi-square analysis. All other data were analyzed by analysis of variance (ANOVA) using ProcGLM (SAS Institute, Cary, N.C.). Where the treatments were found significantly different at $P \leq 0.05$, means were separated using DMRT. Data for percentage of ‘Oroblanco’ fruit with dry vesicles were transformed using arcsin square root and were still found to diverge slightly from a normal distribution but were not heterogeneous for variance by Levene’s test, and transformed data were subjected to ANOVA.

Results and Discussion

Tree size and survival. The Winder soil that comprised the trial site is one of the major soil types for Indian River citrus production. These

soils have a hardpan at <60 cm, which results in a perched water table that is sometimes within 25 cm of the soil surface even on bedded groves and is likely to influence tree growth (Boman, 1987). Between 1993 and 2002, tree loss was not significantly different between rootstocks in this experiment, with no more than two of 12 trees lost for any rootstock/scion combination (data not shown). By Fall 2002, ‘Oroblanco’ trees were similar in height on all rootstocks except Carrizo, which produced smaller trees with a mean height of 3 m vs. heights of 3.4–3.8 m among the other rootstocks (Table 1). Canopy volume of ‘Oroblanco’ trees on x639 was the greatest among the rootstocks tested, but only trees on Carrizo and RL-8166 had significantly smaller canopies. Carrizo also produced significantly shorter trees for ‘Melogold’ than those of all other rootstocks except SFS, Goutou, and SCS, and significantly lower canopy volume than those of all other rootstocks except Goutou, SFS, SCS, and Swingle (Table 2). Carrizo normally produces a rather large tree, but this rootstock performs poorly on calcareous soils (Castle et al., 1993b) such as those at the trial site. It should be noted that Swingle also performs poorly on calcareous soil (Stover and Castle, 2003), but tree size was fairly typical for trees on Swingle in this trial.

For ‘Melogold’, trees on Volk, x639, RL-8166, and Cleo were in the largest category for both height and canopy volume (Table 2).

Yield and fruit size of ‘Oroblanco’. Commercially significant croploads were borne on ‘Oroblanco’ trees beginning in 1998, 5 years after planting (Fig. 1). Average yield across all rootstocks reached 98 kg per tree in 2001 (Fig. 1), which was substantially less than the 210 kg per tree considered a standard yield for 5- to 15-year-old grapefruit in the Indian River area (Muraro et al., 2002). Only the trees on x639 produced yields approaching 200 kg per tree, and only in 2001 (Fig. 1). Trees on x639 produced significantly higher cumulative numbers of fruit and yield than any of the other rootstocks used for ‘Oroblanco’ in this trial, with 48% higher cumulative yield than trees on Swingle citrumelo, which provided the second highest cumulative yield (Table 1). Trees on Goutou, which has received limited use as a substitute for sour orange in calcareous sites (Castle et al., 1993a), produced the lowest cumulative yield, which was significantly lower than x639, Swingle, or Volk (Table 1). Yield expressed as kg per cm² trunk cross-sectional area (TCSA) followed essentially the same pattern as cumulative kg per tree, with significantly higher values for trees on x639 compared to

Table 1. Tree characteristics and cumulative yield following 9 years of growth (1993–2002) of ‘Oroblanco’ on nine rootstocks in Ft. Pierce, Fla.

Rootstock ^z	Tree ht (m) ^y	Canopy vol (m ³) ^{y, w}	TCSA (cm ²) ^y	Cumulative no. fruit/tree	Cumulative yield (kg/tree)	Mean fruit size (g) ^y	Cumulative fruit/TCSA	Cumulative fruit/m ³ CV ^w	Incidence ^u of fruit drying (%)
All	3.5	31.0	218	819	341	430	3.7	26.6	16.7
x639	3.7 a ^x	37.7 a	215 bc	1498 a	577 a	389 c	6.9 a	40.1 a	16.7 ab
Cleo	3.6 a	36.2 ab	244 ab	644 b–d	266 bc	431 bc	2.6 c	17.9 cd	13.6 ab
Swingle	3.5 a	29.7 a–c	191 bc	929 b	390 b	426 bc	4.5 b	29.7 a–c	0.0 b
Carrizo	3.0 b	21.2 c	172 c	696 b–d	307 bc	437 bc	3.9 bc	33.8 ab	21.8 ab
Volk	3.8 a	36.1 ab	296 a	952 b	379 b	403 c	3.1 bc	25.7 b–d	33.3 ab
RL-8166	3.5 a	28.3 bc	272 a	754 b–d	299 bc	407 c	2.7 c	27.9 a–c	41.8 a
SFS	3.4 a	29.3 a–c	190 bc	861 bc	358 bc	410 bc	4.4 b	29.5 a–c	2.5 b
SCS	3.5 a	29.2 a–c	218 bc	574 cd	267 bc	460 ab	2.6 c	20.1 cd	0.9 b
Goutou	3.6 a	30.6 ab	167 c	440 d	220 c	504 a	2.5 c	14.7 d	17.5 ab

^zRootstock codes are: x639 (Cleo x trifoliolate); Cleo (Cleopatra mandarin); Swingle (citrumelo); Carrizo (citrange); Volk (Volkamer lemon); RL-8166 (rough lemon); SFS (Smooth Flat Seville, Citrus hybrid); SCS (Sun Chu Sha mandarin); and Goutou (Citrus hybrid).

^yTree height, bearing volume, and trunk cross-sectional area (TCSA) were measured Jan. 2003 after harvest in ninth year.

^wMeans within a column not followed by the same letter were found significantly different by DMRT at $P \leq 0.05$.

^xCanopy volume (CV) was calculated by assuming that the shape of the trees approximated one-half of a prolate sphere (volume = $0.6667 \times \pi \times \text{height} \times \text{radius}^2$).

^uMean fruit size over 5 years of harvest data, in years 5–9 of this planting.

^vOn 7 Dec. 2001, 10 random fruit were selected from each tree during final harvest and tested for presence of vesicle drying.

Table 2. Tree characteristics and cumulative yield following 9 years of growth (1993–2002) of ‘Melogold’ on nine rootstocks in Ft. Pierce, Fla.

Rootstock ^z	Tree ht (m) ^y	Canopy vol (m ³) ^{y, w}	TCSA (cm ²) ^y	Cumulative no. fruit/tree	Cumulative yield (kg/tree)	Mean fruit size (g) ^y	Cumulative fruit/TCSA	Cumulative fruit/m ³ CV ^w	Trees with <50 cumulative fruit (%) ^u
All	3.1	24.6	190	90	72	825	0.51	4.3	45
x639	3.4 ab ^x	33.3 ab	208 b	191 a	160 a	862 a	0.94 a	6.2 a	0 a
Cleo	3.2 ab	26.8 a–d	206 b	114 ab	91 ab	886 a	0.56 ab	5.0 a	40 a–c
Swingle	3.2 a–c	22.6 b–e	153 b–d	148 ab	108 ab	743 a	0.69 ab	4.7 a	58 bc
Carrizo	2.6 d	13.3 e	118 d	79 ab	58 b	746 a	0.70 ab	6.5 a	33 a–c
Volk	3.5 ab	34.2 a	285 a	84 ab	72 b	896 a	0.32 b	2.9 a	25 ab
RL-8166	3.5 a	30.8 a–c	283 a	88 ab	69 b	837 a	0.33 b	3.1 a	50 bc
SFS	2.7 cd	21.1 c–e	146 b–d	48 b	39 b	821 a	0.39 b	3.5 a	58 bc
SCS	3.1 a–d	21.6 c–e	182 bc	40 b	29 b	690 a	0.37 b	3.8 a	67 bc
Goutou	3.0 b–d	18.5 de	131 cd	30 b	29 b	896 a	0.27 b	2.1 a	75 c

^zRootstock codes are: x639 (Cleo x trifoliolate); Cleo (Cleopatra mandarin); Swingle (citrumelo); Carrizo (citrange); Volk (Volkamer lemon); RL-8166 (rough lemon); SFS (Smooth Flat Seville, Citrus hybrid); SCS (Sun Chu Sha mandarin); and Goutou (Citrus hybrid).

^yTree height, bearing volume, and trunk cross-sectional area (TCSA) were measured Jan. 2003 after harvest in ninth year.

^wMeans within a column not followed by the same letter were found significantly different by DMRT at $P \leq 0.05$.

^xCanopy volume (CV) was calculated by assuming that the shape of the trees approximated one-half of a prolate sphere (volume = $0.6667 \times \pi \times \text{height} \times \text{radius}^2$).

^uMean fruit size over 5 years of harvest data, in years 5–9 of this planting.

^vChi square test for difference between rootstocks was significantly different at $P = 0.007$.

Fig. 1. Mean annual harvest of 'Oroblanco' by rootstock.

Fig. 2. Mean annual harvest of 'Melogold' by rootstock.

'Oroblanco' on other rootstocks (Table 1). While kg per m³ of canopy volume was also numerically greatest for 'Oroblanco' on x639, this parameter was only significantly lower for trees on Goutou, Cleo, SCS, and Volk.

It should be noted that Winder soil, of which most of the trial site was comprised, has been identified as especially problematic for Swingle rootstock, with thousands of acres lost to "Swingle decline" before this association was identified (Stover and Castle, 2003). Indian River soils with substantial calcareous material and/or clay content, such as the Winder soil at the trial site, have been frequently planted

with SFS rootstock in the last few years (Stover and Castle, 2002). In this trial, 'Oroblanco' on SFS produced yields and tree size comparable to most of the rootstocks, but trees on SFS provided significantly lower yield than did trees on x639.

Mean fruit size over the entire study period was inversely associated with mean cumulative fruit per TCSA ($F = 0.005$), but the relationship was very weak ($r^2 = 0.08$). 'Oroblanco' on Goutou, which produced the lowest cumulative yield, provided a larger mean fruit size than trees on any other rootstock except SCS (Table 1). Fruit from trees on SCS had

a larger mean weight than fruit from trees on RL-8166, Volk, and x639. Overall, mean fruit size for 'Oroblanco' corresponded to typical grapefruit market sizes, ranging from 36 to 48 fruit per 28-L carton.

Yield and fruit size of 'Melogold.' Commercially acceptable croploads were never achieved on 'Melogold' trees in this trial (Fig. 2). Average yield across all rootstocks reached 38 kg per tree in 2002 (Fig. 2) and cumulative yield averaged only 72 kg per tree (Table 2). Forty-five percent of all trees in this trial produced <50 fruit total in the first 9 years after planting (Table 2). While the initial data

Table 3. Internal quality statistics for early season Florida grapefruit, 10-year averages 1991–2001 (Florida Agricultural Statistics Service, 2003a, 2003b). Data are collected for regular bloom fruit from identical sample trees.

Date	White seedless grapefruit				Colored seedless grapefruit			
	Juice content (% w/w)	Total soluble solids (TSS) (°Brix)	Titrateable acidity (TA)	Ratio TSS : TA	Juice content (% w/w)	Total soluble solids (°Brix)	Titrateable acidity	Ratio TSS : TA
1 Sept. ²	37	10.0	1.8	5.7	38	10.1	1.7	5.9
1 Oct.	44	9.9	1.5	6.6	44	9.9	1.5	6.7
1 Nov.	48	9.9	1.4	7.1	49	10.0	1.3	7.5
1 Dec.	51	10.2	1.4	7.6	52	10.4	1.3	8.1

²1 Sept. data not collected 1991–96, averages for 1997–2001.

indicated that trials at Riverside, Calif., had moderate to heavy yields (Soost and Cameron, 1985), production in other trials has been quite low, although variable, but with a tendency for yield to increase substantially after year 8 (Mikeal Roose, Univ. of Calif., Riverside, personal communication). However, in the poor-yielding California trial, ‘Melogold’ on Carrizo produced 360 kg per tree through year 9 (Roose, unpublished). The highest yield of ‘Melogold’ in our Indian River trial was realized with x639 rootstock, but was only 160 kg per tree (Table 2). This was significantly higher than production from trees on all other rootstocks except Cleo and Swingle (Table 2). It is notable that no trees on x639 produced fewer than 50 fruit during the trial period. Yield expressed as kg per cm² TCSA followed essentially the same pattern as cumulative kg per tree, but there was no difference between rootstocks for kg yield per m³ of canopy volume (Table 2).

Mean ‘Melogold’ fruit size over the entire study period was not different between rootstocks (Table 2). Overall, mean fruit size was larger than typical grapefruit market sizes, ranging from 20 to 26 fruit per 28-L carton. This is consistent with reports that ‘Melogold’ fruit size is substantial larger than grapefruit in comparative trials (Soost and Cameron, 1985); however, low croploads may have also influenced fruit size.

Fruit quality measurements. Minimum fruit quality standards for fresh grapefruit shipped from Florida are a TSS of 8.0% with a TSS : TA ratio of 7.5 (Citrus Administrative Committee, 2003b). Ten-year internal quality averages demonstrate that grapefruit do not routinely meet these standards until November or December (Table 3), although individual orchards can pass much earlier. As expected, acidity of ‘Oroblanco’ and ‘Melogold’ was much lower than would be observed for grapefruit when fall harvested, with similar TSS, and a much higher TSS : TA ratio. Across all three harvest dates in 2002, ‘Oroblanco’ averaged $\approx 0.5\%$ TA, and TSS : TA ratios were in excess of 15 (Table 4). Grapefruit grown in the same area were sampled during this period and routinely had TA > 1% and did not meet standards for fresh sale (data not shown). Among ‘Oroblanco’ and ‘Melogold’ grown on the five rootstocks evaluated, minimum grapefruit standards were met at each harvest except for ‘Oroblanco’ on Volk, which never achieved 7.5% TSS, and two harvests of ‘Oroblanco’ on Swingle, which were only 7.9% TSS (mean Table 4; individual harvest data not shown). Data for the single harvest of ‘Melogold’ on 20 Sept. 2002 displayed TAs of 0.6–0.7 and

ratios of 13 to 15 (Table 5). As in ‘Oroblanco’, trees on Volk rootstock also had significantly lower TSS in ‘Melogold’; however, they surpassed minimum grapefruit standards (Table 5). Juice content of ‘Oroblanco’ on Volk was significantly lower than for ‘Oroblanco’ on x639 or Swingle (Table 4).

Vesicle drying was frequently observed in ‘Oroblanco’ and ‘Melogold’, even when harvested in September and October, but data were only collected on 7 Dec. 2001, and only for ‘Oroblanco’. Variability was great for this parameter. Across all rootstocks, 17% of ‘Oroblanco’ fruit displayed vesicle drying, with significantly greater severity in RL-8166 and Volk compared to Swingle, SCS, and SFS, which had low incidence of vesicle drying (Table 1).

Overall assessment. ‘Oroblanco’ and ‘Melogold’ do offer the potential for producing an earlier maturing grapefruit-like citrus product in the Indian River area. ‘Oroblanco’ fruit are very similar in appearance to white grapefruit, while ‘Melogold’ are more similar to white-fleshed pummelos. Area growers experimenting with these varieties have also experienced extremely low yields in ‘Melogold’, suggesting that this variety may not be commercially viable in the Indian River area. Small plantings of ‘Oroblanco’ and ‘Melogold’ at the Citrus Research and Education Center in Lake Alfred,

Fla., also show extremely low yields of ‘Melogold’ on a wide range of rootstocks through 10 years of age (Castle, personal communication). Indian River experiments with GA₃ applications to ‘Melogold’ at bloom have shown no increase in fruit set, even though flowers are present (Stover, unpublished). The authors have visited orchards where solid-set blocks of ‘Melogold’ have poor yields, but trees of the same age topworked to ‘Melogold’ within a row of ‘Temple’ (*C. reticulata* × *C. sinensis*) pollinizers carried substantial yields. Environmental conditions and/or presence of pollinizers can influence parthenocarpic set of citrus fruits, which varies greatly among genotypes (Frost and Soost, 1968), and may be reduced in a subtropical climate like Florida compared to Mediterranean climate areas such as California. The triploid ‘Melogold’ has poor pollen fertility (Roose, unpublished data) and pollination may be desirable in Florida conditions.

Several local growers indicate some success in identifying premium markets for ‘Oroblanco’ and ‘Melogold’ fruit, but also have encountered considerable resistance (Indian River growers, personal communication). Efforts to identify purchasers for fruit from this trial have been unsuccessful and many tasters consider the fruit to have an unpleasant flavor or aftertaste. Developing additional markets for these fruit may be challenging. However,

Table 4. Fruit quality of ‘Oroblanco’ on five selected rootstocks in 2002. Data are pooled across sampling dates on 20 Sept., 7 Oct., and 1 Nov.

Rootstock ²	Juice content (% w/w)	Total soluble solids (TSS) (°Brix)	Titrateable acidity (TA)	Ratio (TSS : TA)
x639	47 a ³	8.2 a	0.46 a	18.0 a
Cleo	45 ab	8.4 a	0.46 a	18.8 a
Swingle	46 a	8.0 a	0.51 a	15.7 bc
Volk	41 b	7.1 b	0.48 a	15.1 c
SFS	44 ab	8.4 a	0.50 a	17.2 ab

²Rootstock codes are: x639 (Cleo × trifoliolate); Cleo (Cleopatra mandarin); Swingle (citrumelo); Volk (Volkamer lemon); and SFS (Smooth Flat Seville, *Citrus* hybrid).

³Means within a column not followed by the same letter were found significantly different by DMRT at $P \leq 0.05$.

Table 5. Fruit quality of ‘Melogold’ on five selected rootstocks in 2002. Data are from 20 Sept.

Rootstock ²	Juice content (% w/w)	Total soluble solids (TSS) (°Brix)	Titrateable acidity (TA)	Ratio (TSS : TA)
x639	43 ^{ns}	8.6 b ^y	0.67 a	12.9 ^{ns}
Cleo	42 ^{ns}	9.0 ab	0.63 ab	14.3 ^{ns}
Swingle	42 ^{ns}	9.1 a	0.66 ab	13.8 ^{ns}
Volk	44 ^{ns}	8.1 c	0.55 b	15.1 ^{ns}
SFS	41 ^{ns}	8.8 ab	0.64 ab	13.9 ^{ns}

²Rootstock codes are: x639 (Cleo × trifoliolate); Cleo (Cleopatra mandarin); Swingle (citrumelo); Volk (Volkamer lemon); and SFS (Smooth Flat Seville, *Citrus* hybrid).

^yMeans within a column not followed by the same letter were found significantly different by DMRT at $P \leq 0.05$.

Israel has developed substantial Asian markets for their 'Oroblanco' which are marketed as 'Sweetie' (USDA, 2000).

Influence of standard rootstocks on yield and fruit quality were largely as expected based on performance of these rootstocks with other scion varieties (Castle et al., 1993a; Stover and Castle, 2002). The poor performances of trees on SFS and Goutou, which have been increasingly used in the Indian River region, are disappointing, since the trial site typifies the conditions in which such sour orange substitutes are needed (Castle et al., 1993b).

The mandarin rootstock SCS has also been used more frequently for recent plantings in the Indian River area. Both SCS and x639 may be viewed as potential replacements for Cleo. In this trial, as has been generally reported (Stover and Castle, 2002), trees on SCS performed much like trees on the well-established Cleo rootstock (Tables 1 and 2). 'Oroblanco' trees on x639 were more productive than trees on Cleo or SCS (Table 1), while 'Melogold' trees on x639 were more productive than trees on SCS but similar to trees on Cleo (Table 2). Fruit quality from trees on x639 was similar to that of fruit from trees on Cleo (Tables 4 and 5). Interestingly, while 'Oroblanco' on Cleo displayed the low early production characteristic of grapefruit and oranges on this rootstock (Stover and Castle, 2002), 'Oroblanco' on x639 produced yields comparably to the highest yielding rootstocks in 1998 and 1999, before greatly exceeding yields of trees on all other rootstocks in 2000 and 2001 (Fig. 1).

The excellent performance of x639 in this trial is very encouraging. We can find no refereed reports and few published reports on x639 performance. In a trial comparing 'Washington Navel' on 21 rootstocks in Ft. Pierce, Fla., trees on x639 were among those largest in size, highest yielding, and producing the largest mean fruit size, although soluble solids were in the poorest performing category (Castle et al., 2000). Data are published on several other Florida trials, including x639 rootstock, and these were all for trials conducted on deep sand soils characteristic of the Central Florida Ridge, using sweet orange scion varieties, and with no statistical separation of means. Two trials conducted by the Florida Dept. of Agriculture

and Consumer Services (2003) included x639, and in both cases this rootstock produced the highest cumulative yield. Castle et al. (1993b) include data on a trial in which trees on x639 produced slightly lower cumulative yield than the highest yielding rootstocks, but slightly more than trees on Swingle or Carrizo. In the oldest known planting of trees on x639 in Florida, now at 17 years of age, citrus blight is becoming apparent, but is of only moderate severity and similar to that of Cleo (Castle, personal communication). Trees on x639 rootstock are also performing well in two other replicated trials in the Indian River area (Castle, personal communication). Interestingly, developing and identifying superior mandarin x trifoliate orange rootstocks (citrandarins) has been a focus of the USDA Florida citrus rootstock breeding program (Wutscher and Bowman, 1999). Since the 1980s, two of these USDA citrandarin rootstocks (US-852 and US-812) have been released, and several others appear promising and are still under evaluation (Bowman, 2000; Bowman et al., 2000). x639, and other citrandarin rootstocks, appear to merit considerable attention as potential replacements for sour orange in calcareous, poorly drained soils.

Literature Cited

- Boman, B.J. 1987. Effects of soil series on shallow water table fluctuations in bedded citrus. *Proc. Fla. State Hort. Soc.* 100:137-141.
- Bowman, K.D. 2000. New hybrid citrus rootstocks developed by U.S. Dept. of Agriculture. *Proc. Intl. Soc. Citricult.* 9:51.
- Bowman, K.D., H.K. Wutscher, D.T. Kaplan, and J.X. Chaparro. 2000. A new hybrid citrus rootstock for Florida: US 852. *Proc. Fla. State Hort. Soc.* 112:54-55.
- Castle, W.S., J.C. Baldwin, and J.W. Grosser. 2000. Performance of 'Washington' navel orange trees on rootstock trials located in Lake and St. Lucie counties. *Proc. Fla. State Hort. Soc.* 113:106-111.
- Castle, W.S., R.R. Pelosi, C.O. Youtsey, F.G. Gmitter Jr., R.F. Lee, C.A. Powell, and X. Hu. 1993a. Rootstocks similar to sour orange for Florida citrus trees. *Proc. Fla. State Hort. Soc.* 105:56-60.
- Castle, W.S., D.P.H. Tucker, A.H. Krezdorn, and C.O. Youtsey. 1993b. Rootstocks for Florida citrus. Univ. Fla. Coop. Ext. Publ. SP 42.
- Citrus Administrative Committee. 2003a. 2001-2002 annual statistical report: Grapefruit. <http://www.citrusadministrativecommittee.org/Annual%20Report%202001-02/Grapefruit-2001-2002/GrapefruitSection-2001-2001.pdf>. May 2003.
- Citrus Administrative Committee. 2003b. 2002-2003 Season: Regulation Bulletin No. 1. <http://www.citrusadministrativecommittee.org/regulations/02-03/Regulation%20-1%202002-03.pdf>. May 2003.
- Florida Agricultural Statistics Service. 2003a. Maturity yield and test results 1991-92 through 2000-01, white seedless grapefruit. <http://www.nass.usda.gov/fl/citrus/cm01/01cm27.htm>. May 2003.
- Florida Agricultural Statistics Service. 2003b. Maturity yield and test results 1991-92 through 2000-01, colored seedless grapefruit. <http://www.nass.usda.gov/fl/citrus/cm01/01cm28.htm>. May 2003.
- Florida Dept. of Agriculture and Consumer Services. 2003. Yield data. <http://www.doacs.state.fl.us/~pi/budwood/yields.html>. May 2003.
- Florida Dept. of Citrus. 2003. Citrus reference book 2003: Florida grapefruit standards. <http://www.fred.ifas.ufl.edu/citrus/pubs/ref/stand.pdf>. May 2003.
- Frost, H.B. and R.K. Soost. 1968. Seed reproduction: Development of gametes and embryos, p. 290-324. In: W. Reuther, L.D. Batchelor, and H.J. Webber (eds.). *The citrus industry*, Vol II. Univ. of California Press, Riverside.
- Muraro, R.P., J.W. Hebb, and E.W. Stover. 2002. Budgeting costs and returns for Indian River citrus production, 2001-2002. IFAS Econ. Info. Rpt. EI 02-11.
- Roose, M.L., D.A. Cole, D. Atkins, and R.S. Kupper. 1989. Yield and size of four citrus cultivars on 21 rootstocks in California. *J. Amer. Soc. Hort. Sci.* 114:678-684.
- Soost, R.K. and J.W. Cameron. 1980. 'Oroblanco', a triploid pummelo-grapefruit hybrid. *HortScience* 20:1134-1135.
- Soost, R.K. and J.W. Cameron. 1985. 'Melogold', a triploid pummelo-grapefruit hybrid. *HortScience* 20:1134-1135.
- Stover, E. and W. Castle. 2002. Citrus rootstock usage in the Florida Indian River region. *Hort-Technology* 12:143-147.
- Stover E. and B. Castle. 2003. Swingle: A workshop summary. *Citrus and Veg. Mag.* 67(6):8-13.
- U.S. Dept. of Agriculture. 2000. Foreign Agricultural Service, GAIN report: Israel citrus semi-annual 2000. <http://www.fas.usda.gov/gainfiles/200006/25677755.pdf>. May 2003.
- Wutscher, H.K. and K.D. Bowman. 1999. Performance of 'Valencia' orange on 21 rootstocks in central Florida. *HortScience* 34:622-624.