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Tree Survival, Growth, and Juice Quality of Early-season Sweet Orange Selections on Eight Rootstocks in Immokalee

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Abstract. **Eight early-maturing sweet orange selections that had been previously evaluated in a formal trial, including two blood oranges, and 'Earlygold', 'Itaborai', and 'Ruby', were planted in a commercial grove in 1995 south of Immokalee. The unreplicated planting was designed to observe performance of these selections on a commercial scale. It consisted of typical double-row beds planted at 10 × 24 ft with trees of one scion per bed divided among eight rootstocks. There were 80–120 trees/bed. After 9 years, the order of tree height across all scions was greatest on Smooth Flat Seville (14.5 ft; 4.4 m) > Goutou > Kinkoji > Benton citrange > Kuharske citrange > Carrizo citrange > Swingle citrumelo > C-35 citrange (11 ft; 3.4 m). Yield was not measured in the planting, but occasional observation indicated that the trees on each rootstock were cropping at commercially acceptable levels. Using trees on Swingle citrumelo rootstock, juice quality was tracked over four seasons for 'Earlygold', 'Itaborai', and 'Ruby' and compared with 'Hamlin' fruit collected from a nearby grove. Brix-acid ratios were about 20 by December. Juice color numbers of the three new selections usually exceeded that of 'Hamlin' by 1.5–2.0 points by mid-November. Pounds-solids/box were low by industry standards, about 5 pounds/box between mid-November and mid-December, with little difference among all scions. The good tree survival and growth on Smooth Flat Seville and Kinkoji suggested that they were among the most suitable for the site. Trees on C-35 citrange grew well on Wabasso fine sand soil, were relatively smaller in size, but appeared to crop well for their size.**

Florida produces primarily oranges for processing into juice products. Two sweet oranges, 'Hamlin' (early-season in maturity) and 'Valencia' (late-season), are the mainstay of that part of the industry. Desired cultivar improvements are generally viewed as new selections that lengthen the season or enhance the early season. The focus on the early part of the season is the result of the well-known poor juice quality of 'Hamlin' orange as compared to 'Valencia'. It is highly desirable to have a sweet orange with 'Hamlin' productivity, but better juice color and Brix.

A large-scale cooperative field trial was established in 1989 to look for improved early-maturing orange varieties. Several selections were identified with good juice color, flavor, and acceptable yield (Castle, 1999, 2003). In order to obtain a more commercial-like evaluation of their attributes, another field project was planted in a different region of Florida involving a range of rootstocks. Our objective was to compare the performance of those combinations with their behavior in prior field trials.

Materials and Methods

Trees of 'Aziza', 'Budd Blood', 'Earlygold', 'Itaborai', 'Mangaratiba', 'Marrs', 'Ruby', and 'Sanguinea de Mombuca' were propagated on the rootstocks Benton, C-35, Carrizo, and Kuharske citranges [*Citrus sinensis* (L.) Osb. x *Poncirus trifoliata* (L.) Raf.], Smooth Flat Seville, Goutou and Kinkoji (possible hybrids of sour orange and pummelo), and Swingle citrumelo (*C. paradisi* Macf. x *P. trifoliata*). The site was a commercial grove located south of Immokalee. The soil was Wabasso fine sand, a Spodosol with a spodic horizon at about 30 inches that is underlain by an argillic or clay layer. Soils of the Wabasso series are found at the higher elevations in the flatwoods and are generally considered to be among those best suited for citrus (Bauer et al., 2007). The trees were planted 10 × 24 ft (3 × 7.3 m) in 1995 in double-row beds with one scion on each bed, but divided among the eight rootstocks. The beds varied in length; plot size was about 10 trees/rootstock for each scion. Only one bed was planted of each scion. The site was bounded on the north and south sides by drainage canals; citrus was planted on the east and west sides. Irrigation was provided by microsprinklers and cultural practices were typical for the region.

The height of two representative trees in each plot was measured periodically beginning in 1998. Changes in juice quality of 'Earlygold', 'Itaborai', and 'Ruby' fruit from trees on Swingle citrumelo were followed seasonally for 4 years by sampling 60 to 70 fruit from each plot about every 3 weeks from late September until late November. 'Hamlin' trees on Swingle citrumelo at the UF Center in Immokalee were also sampled to provide a standard for comparison. No juice quality samples were collected from the other scion–rootstock combinations. Juice was extracted and analyzed at the CREC commercial test house. Tree losses were recorded annually from planting until 2008. Yield was not measured, but was estimated periodically. This project was largely observational and without replication; thus, the data were not statistically analyzed.

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Table 1. Percentage of tree survival (%) after 13 years and average tree height of eight sweet orange cultivars on eight rootstocks grown in Wabasso fine sand near Immokalee. (1 ft = 0.305 m).

		Scion								
Rootstock	Variable	Aziza	Budd Blood	Earlygold	Itaborai	Mangaratiba	Marrs	Ruby	Sang. de Mombuca	Mean
Benton citrange	Survival, %	53	92	58	67	91	100	85	38	73
	Tree ht., ft	14.5	14.0	12.8	12.4	12.4	10.2	13.8	13.8	13.0
C-35 citrange	Survival, %	70	36	100	93	100	100	93	87	85
	Tree ht., ft	11.7	10.6	12.2	11.0	11.0	8.5	12.0	11.5	11.1
Carrizo citrange	Survival, %	41	86	57	36	20	80	36	10	46
	Tree ht., ft	12.8	14.2	12.9	11.7	11.9	11.2	12.4	13.5	12.6
Goutou	Survival, %	96	100	88	74	78	60	80	82	82
	Tree ht., ft	13.6	13.5	14.3	15.0	15.0	13.7	13.8	15.0	14.2
Kinkoji	Survival, %	100	100	91	100	93	89	100	100	97
	Tree ht., ft	12.4	12.8	13.5	13.9	12.3	13.0	13.7	14.0	13.2
Kuharske citrange	Survival, %	72	41	93	76	76	93	80	88	77
	Tree ht., ft	13.3	13.4	13.5	12.3	12.5	10.5	13.3	14.1	12.9
Smooth Flat Seville	Survival, %	92	96	100	86	83	90	83	91	90
	Tree ht., ft	19.0	16.2	14.2	14.5	14.0	14.1	13.8	14.0	15.0
Swingle citrumelo	Survival, %	96	91	60	50	92	100	100	83	84
	Tree ht., ft	13.3	12.4	12.2	12.4	10.6	10.9	13.3	12.5	12.2
Mean-survival (%)		*78*	*80*	*81*	*73*	*79*	*89*	*82*	*72*	
Mean-tree ht (ft)		*13.7*	*13.3*	*13.3*	*13.0*	*12.5*	*11.7*	*13.2*	*13.5*	

Results and Discussion

Tree survival. Across all scions, only 46% of the trees survived on Carrizo citrange with about 80% to 90% survival for those on other rootstocks and 97% for those on Kinkoji (Table 1). Differences among rootstocks were the result of losses primarily to blight and other unknown declines. Streaks of calcareous material were apparent on the soil surface in the site and calcareous subsurface soil removed during excavation of the waterways had been worked into the ends of many beds during their formation. The citrange rootstocks, in general, responded poorly when growing in such locations at the site. The trees on Carrizo were located in a disproportionate number of such places. Thus, site variability explains the generally low survival of the trees on Carrizo and of individual combinations like 'Aziza' on Benton citrange. In contrast to Carrizo, few trees were lost on Smooth Flat Seville and especially on Kinkoji, two rootstocks considered to be well-suited to most soils (Castle et al., 1992, 2006). If the lowest survival percentage is removed from the calculation of the rootstock average, then most differences among rootstocks are minor.

Tree growth. The largest difference in height, ≈4 ft (1.2 m), was between the trees on C-35 citrange (11.1 ft; 3.4 m) and those on Smooth Flat Seville (15 ft; 4.6 m). The trees on the remaining rootstocks were about 12 to 13 ft (3.7–4 m) tall with little difference among rootstocks. All the rootstock differences were similar to those observed in other field trials (Castle and Baldwin, 2005; Castle et al., 2000). There were virtually no differences in tree size among the scions; the shortest trees, regardless of rootstock, were 'Marrs', a cultivar known for its precociousness and strong early bearing (Hodgson, 1967), traits observed in our trial that may have limited tree growth.

Seasonal juice quality. Data from the 2001–02 season are representative of the four seasons in which juice changes were measured (Table 2). By the end of November, fruit of the new early-season cultivars, 'Earlygold', 'Itaborai', and 'Ruby', typically developed higher juice Brix values than 'Hamlin' fruit, but pounds-solids/box were usually equivalent to or lower than those of 'Hamlin', apparently because of lower juice contents; juice color numbers of the new cultivars exceeded those of the 'Hamlin' fruit and had sufficient color to allow the juice to be used without blending according to industry standards, a point not reached by the 'Hamlin' fruit juice (Fellers, 1990).

Table 2. Changes in juice quality during the 2001–02 season (n = 2) for trees of four sweet orange cultivars on Swingle citrumelo rootstock growing near Immokalee.

Cultivar	Date sampled	% Juice	Acid	SS[z] concn	Ratio	Color no.	PS/box[z]
Earlygold	29 Sept.	51.2	0.6	8.5	15.0	34.3	3.9
	12 Oct.	56.9	0.5	8.6	17.0	35.3	4.4
	25 Oct.	55.8	0.4	8.9	19.6	35.2	4.5
	8 Nov.	57.6	0.4	9.3	21.2	36.0	4.8
	28 Nov.	56.8	0.5	9.8	21.6	36.2	5.0
Hamlin	29 Sept.	53.4	0.7	8.4	12.6	34.1	4.0
	12 Oct.	55.4	0.6	8.7	15.0	33.8	4.3
	25 Oct.	56.1	0.5	8.8	17.3	34.1	4.4
	8 Nov.	60.3	0.5	9.3	18.4	34.5	5.0
	28 Nov.	59.4	0.5	9.3	19.8	33.9	5.0
Itaborai	29 Sept.	52.6	0.7	8.2	12.4	34.0	3.9
	12 Oct.	55.9	0.6	8.5	14.1	35.0	4.3
	25 Oct.	53.4	0.7	8.6	12.5	34.8	4.1
	8 Nov.	55.0	0.5	9.0	16.6	36.1	4.4
	28 Nov.	55.0	0.5	9.6	19.0	36.2	4.7
Ruby	29 Sept.	55.4	0.6	8.4	14.4	33.8	4.3
	12 Oct.	53.4	0.5	8.4	15.7	34.6	4.0
	25 Oct.	54.5	0.5	8.7	17.3	34.5	4.2
	8 Nov.	57.1	0.4	9.1	20.3	35.3	4.7
	28 Nov.	54.6	0.4	9.8	23.5	36.1	4.8

[z]SS = soluble solids; PS/box = pounds-solids per box.

Conclusions

In the context of our field evaluations, we define a *trial* as an experiment with proper replication and statistical design. A *planting* is a larger-scale project usually conducted cooperatively on commercial property without replication. The purpose of a planting is to evaluate advanced scion and/or rootstock selections in a commercial setting and to determine if they perform as they have in previously recorded research settings. On that basis, our data and observations indicated that although yield was not measured, estimated productivity in this planting ranged from two 90-lb (40 kg) boxes/tree when they were about 5 years old to five+ boxes/tree when they were 10 years old. 'Earlygold', 'Itaborai', and 'Ruby' have been planted commercially for their early maturity and juice color and flavor. The first two traits were measured and confirmed for those cultivars among the trees on Swingle citrumelo rootstock at the Immokalee site. All scions were also sampled preharvest by the grove caretaker and found to be acceptable, but as with our data, some combinations had low pounds-solids/box and high Brix/acid ratios. The caretaker's sampling was not by rootstock, but by bed. Their results probably combined fruit from trees on the eight rootstocks and led to different conclusions than ours regarding the fruit meeting minimum maturity standards.

Tree growth and survival according to rootstock and independent of the scion was as we have experienced in other field trials (Castle et al., 2006). Setting aside site variability as a factor, noteworthy rootstocks that compared well with Swingle citrumelo, the industry standard, were Smooth Flat Seville and Kinkoji. Their good survival and tree growth suggested that they were among the most suitable for the site. Also, trees on C-35 citrange seemed to grow well on Wabasso fine sand soil, were relatively smaller in size, and appeared to crop well for their size.

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