ROOTSTOCK OPTIONS for Delta Valencia on replant soil in the Marble Hall region

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Abstract

The horticultural performance of citrus trees in replant conditions is determined by the adaptability of the rootstock to the specific soil characteristics. CRI conducted a trial to evaluate Delta Valencia on 42 different rootstocks in a replant orchard in the Marble Hall production area. The soil type for the specific trial block was divided into 70% Oakleaf and 30% Pinedene soils, with a 3 to 5 % clay content. Rootstocks included commercial, as well as a range of experimental rootstock selections. The initial evaluation was done over an eight-year production cycle from 2003 to 2007. Thereafter, to allow for better spacing, every second tree was removed in 2008 and follow-up evaluations were done in 2013 and 2014. The performance of the experimental rootstocks is presented in relation to the commercial controls. Performance parameters including tree canopy volume, yield, fruit size distribution and internal fruit quality varied over the duration of the trial. Overall however, Benton citrange and US-812 (Sunki mandarin x Benecke trifoliate) were shown to be good alternative options to Swingle citrumelo, Carrizo citrange and C-35 citrange in replant soils in this area.

Materials and methods

The trial was planted in 1998 at Moosrivier Estate in Marble Hall, Limpopo Province. Delta Valencia was selected for the trial as it is commercially grown in the area. Budwood was obtained from the Citrus Foundation Block and budded to 42 different rootstocks. Rootstock seeds were obtained locally and abroad and propagated by an accredited nursery, using standard practices.

A randomised block design was used for 22 rootstocks with two replicates of five trees each. The remaining 20 rootstocks were planted in a non-randomised design comprising 10 trees per rootstock. All 42 rootstocks were evaluated from 2003 to 2006, whereafter the 30 best performing rootstocks were further evaluated in the 2007 season. Every second tree was removed from the orchard in 2008, to allow for better tree spacing in the rows (final spacing is 6 x 4 m). Due to the trees' slow recovery, harvesting of all 42 combinations only commenced in 2013 with a final evaluation in 2014. Table 1 lists the best performing rootstocks and their abbreviations that are discussed in this article.

Performance parameters included tree canopy volume, yield, fruit size distribution and internal fruit quality, including juice content, Brix°, acid level and the Brix:acid ratio.

Results

Internal fruit quality, yield and fruit size distribution results of the five best performing rootstocks from 2003 to 2007 are presented in Tables 2 and 3, to show the seasonal variation. The export requirements for Delta Valencia are the following: juice % = 52, Brix° = 9.5, Acid (max) =1.8, Acid (min) = 0.85 and Brix:acid ratio =7.5:1.

No differences were observed with external colour development. External colour peaked between T1 and T2 for all rootstocks from 2003 to 2007.

Table 1. List of the rootstocks evaluated.

Symbol	Rootstock
BC	Benton citrange
CC	Carrizo citrange
CM	Citrus macrophylla
C32	C-32 citrange (Trifoliate orange x Ruby sweet orange)
C35	C-35 citrange (Trifoliate orange x Ruby sweet orange)
F80/3	Citrumelo selection
JT	Jacobsen trifoliate
ML	Milan lemon
Sunki 812	Sunki mandarin x Beneke trifoliate orange
RL- C	Rough lemon – Cairn
RP	Rangpur lime
SC	Swingle citrumelo
SFS	Smooth Flat Seville
FD x Sunki 1112	Flying Dragon x Sunki 1112
FD x Sunki 1116	Flying Dragon x Sunki 1116
TB	Terrabella
Volk	Volkameriana
X639	Cleopatra mandarin x Trifoliate

Table 2. Internal fruit quality of Delta Valencias at Moosrivier Estates (Marble Hall) during the 2003 to 2007 season. Data for the five best performing experimental rootstocks with Carrizo and Swingle as commercial controls are presented for each year.

Date	Rootstock	Juice %	Brix °	Acid %	Ratio
2003	CC (control)	57.5	12.5	1.39	8.97
	SC (control)	58.3	12.7	1.52	8.38
	BC	58.6	11.5	1.25	9.22
	ML	57.9	10.4	1.42	7.35
	RP	61.8	11.8	1.59	7.40
	C35	59.5	12.0	1.28	9.35
	CM	57.1	10.9	1.18	9.22
2004	CC (control)	55.5	10.0	1.12	8.95
	SC (control)	55.6	10.5	1.35	7.74
	CM	55.6	9.4	1.15	8.13
	BC	58.8	10.4	1.45	7.17
	RP	56.3	8.8	1.06	8.34
	SFS	56.5	9.7	1.29	7.49
	RL-C	56.9	8.2	1.12	7.32
2005	CC (control)	54.2	12.1	1.10	10.97
	SC (control)	55.6	11.6	1.11	10.42
	RP	55.6	10.1	1.21	8.31
	BC	56.2	10.7	1.05	10.17
	F80/3	55.7	10.8	1.14	9.46
	TC	58.1	10.6	1.11	9.53
	RL- C	55.1	10.9	1.06	10.26
2006	CC (control)	53.2	9.8	1.15	8.52
	SC (control)	52.6	9.7	1.12	8.66
	CM	49.9	8.5	1.09	7.80
	FD x Sunki 1112	53.9	10.3	1.23	8.37
	JT	53.3	9.7	1.01	9.60
	ML	54.0	9.2	0.97	9.48
	TB	51.4	9.4	1.18	7.97
2007	CC (control)	51.3	10.9	1.31	8.32
	SC (control)	54.7	10.0	1.29	7.75
	SFS	51.9	10.1	1.32	7.65
	CM	52.2	9.4	1.20	7.83
	Volk	50.7	9.0	0.97	9.28
	FD x Sunki 1116	53.5	10.0	1.35	7.41
	RP	52.9	9.5	1.13	8.41

Average production data and fruit size distribution for the initial evaluation from 2003 to 2007 are presented in Table 3. Due to the initial tree spacing, data over this period is less informative than the final evaluations in 2013 and 2014, after tree spacing was altered. Production data for the 2013 and 2014 seasons are presented in Figures 1 to 3 (and table 5). Results for the six best performing experimental rootstocks, as well as five commercial rootstocks are presented. The 2013 season was high yielding for all rootstocks shown, but this resulted in small fruit overall. Although production in the 2014 season was lower, larger fruit was obtained. The exception in 2014 was C-32 rootstock, which had high production and small fruit size.

Table 4 shows internal fruit quality and production data for the 2013 and 2014 seasons: top-performing rootstock production met minimum export requirements.

Year	Rootstock	Count						Yield (kg/tree)
		48	56	72	88	105/125	144	
2003	CC (control)	0.00	0.7	6.7	12.2	56.3	24.1	37.0
	SC (control)	0.0	0.7	3.8	10.3	50.1	35.2	40.0
	BC	0.4	5.9	19.9	25.2	39.0	9.6	61.7
	ML	0.6	7.2	19.4	23.8	41.2	7.7	60.5
	RP	0.1	2.2	13.0	24.8	49.1	10.9	59.4
	C35	0.1	5.1	19.0	27.3	39.3	9.2	58.4
	CM	0.4	6.9	24.7	29.7	34.5	3.8	57.4
2004	CC (control)	4.4	29.8	32.9	22.1	10.3	0.5	22.0
	SC (control)	0.5	15.7	27.8	25.0	23.6	7.4	10.9
	CM	0.5	13.6	31.0	30.0	22.7	2.2	51.0
	BC	1.1	17.7	29.7	23.4	24.7	3.5	47.7
	RP	4.2	15.1	26.4	20.6	28.3	5.5	45.7
	SFS	2.8	28.2	35.3	19.1	12.7	1.9	40.1
	RC	1.8	27.5	39.2	19.1	10.6	1.8	37.4
2005	CC (control)	2.0	16.7	29.6	21.4	26.2	4.2	45.2
	SC (control)	1.1	7.7	15.3	15.3	34.3	26.3	27.3
	RP	1.4	13.4	21.7	18.0	34.3	11.1	79.8
	BC	0.6	10.2	18.8	23.2	36.5	10.7	66.5
	F80/3	0.4	5.7	14.9	18.9	39.1	21.0	53.8
	TC	1.0	11.0	16.6	17.8	37.4	16.1	52.8
	RL- S	0.5	3.2	12.2	17.6	42.9	23.6	52.0
2006	CC (control)	7.8	42.4	32.3	13.3	4.0	0.2	95.6
	SC (control)	5.3	30.5	30.3	20.3	12.2	1.3	80.2
	CM	6.5	27.2	33.6	19.3	12.5	0.9	112.9
	FD x Sunki 1112	4.0	20.6	33.1	25.0	16.4	1.0	101.8
	JT	10.8	26.8	29.8	17.4	12.2	3.0	96.5
	ML	2.6	17.1	27.6	21.5	26.0	5.3	93.9
	TB	2.0	21.8	34.6	24.5	16.0	1.2	90.8
2007	CC (control)	0.1	2.4	13.5	30.7	46.5	6.9	77.6
	SC (control)	0.0	2.7	10.4	23.8	49.3	14.0	79.3
	SFS	0.0	4.2	15.7	29.0	44.2	6.9	115.4
	CM	0.0	2.3	16.2	33.0	43.7	4.9	104.6
	Volk	0.0	1.9	10.9	23.0	49.9	14.3	101.1
	FD x Sunki 1116	0.1	2.0	10.3	21.4	48.0	18.3	92.4
	RP	0.4	3.0	13.9	23.4	48.3	11.1	89.0

Table 3. Fruit size distribution (% fruit) for Deltas at Moosrivier Estates (Marble Hall) from the 2003 to the 2007 season per rootstock with the best yield (kg/tree) for the top five rootstocks. Carrizo and Swingle were commercial controls. Count distributions refer to the number of fruit that would be packed in a 15 kg telescopic carton.

Table 4. Internal fruit quality data per rootstock for Deltas at Moosrivier Estates (Marble Hall) during the 2013 and 2014 seasons.

	2013				2014			
Rootstock	Juice %	Brix °	Acid %	Ratio	Juice %	Brix °	Acid %	Ratio
RL - C (control)	50.0	10.5	1.2	9.05	53.7	11.0	0.91	12.09
CC (control)	57.8	12.0	1.4	8.33	53.4	10.7	0.95	11.26
SC (control)	58.1	11.3	1.5	7.69	51.3	11.7	1.07	10.93
X639 (control)	55.5	11.3	1.3	8.76	53.3	11.3	1.05	10.76
C35 (control)	58.0	12.0	1.5	8.05	56.3	11.6	1.07	10.84
BC	56.5	11.2	1.5	7.52	54.1	9.9	1.12	8.84
C32	54.8	11.7	1.5	8.07	53.1	8.9	0.81	10.99
F80/3	57.4	9.8	1.4	7.21	54.8	11.0	1.04	10.58
Sunki 812	57.2	11.7	1.4	8.18	54.8	12.1	1.18	10.25
FD x Sunki 1112	56.3	12.0	1.7	7.19	54.6	11.2	1.06	10.57
TB	54.1	11.1	1.8	6.13	54.4	10.5	0.98	10.71

Figure 1. Average production data (kg/tree) for 2007, 2013 and 2014 for the Delta trees per rootstock. The top six experimental rootstocks versus the five commercial rootstocks (RL, CC, SC, X639 and C35) are shown.

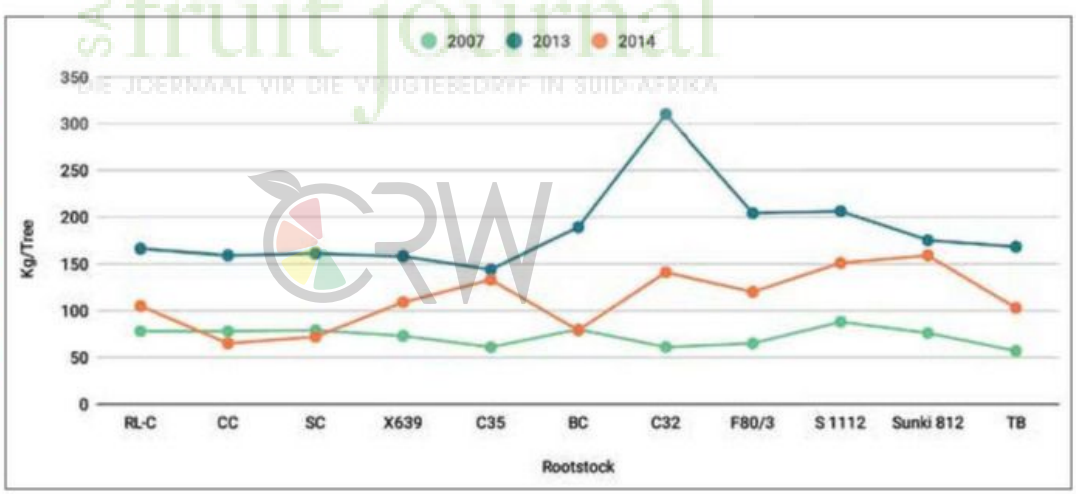


Figure 2. The 2013 Delta tree canopy volume chart of the top performing scion:rootstock combinations

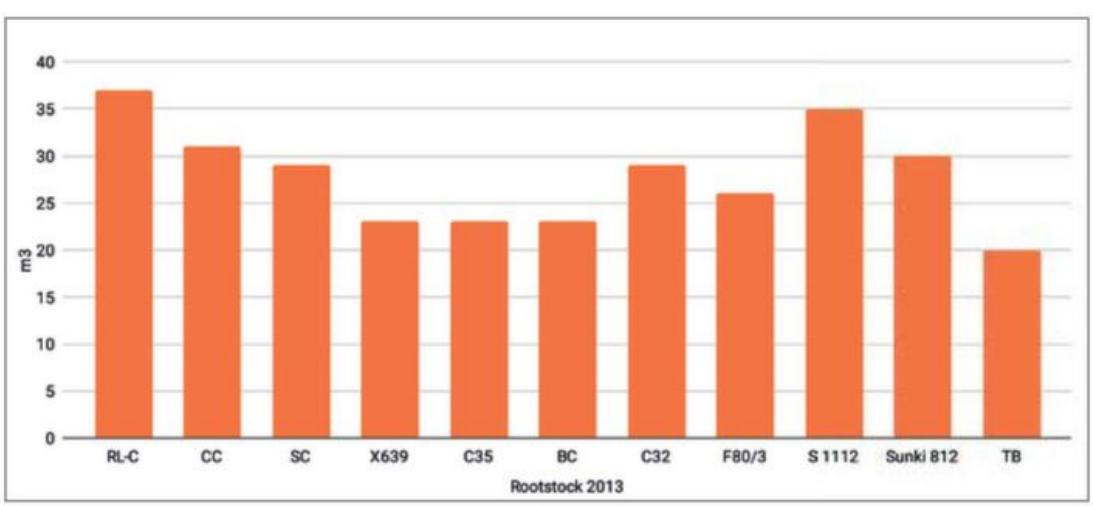
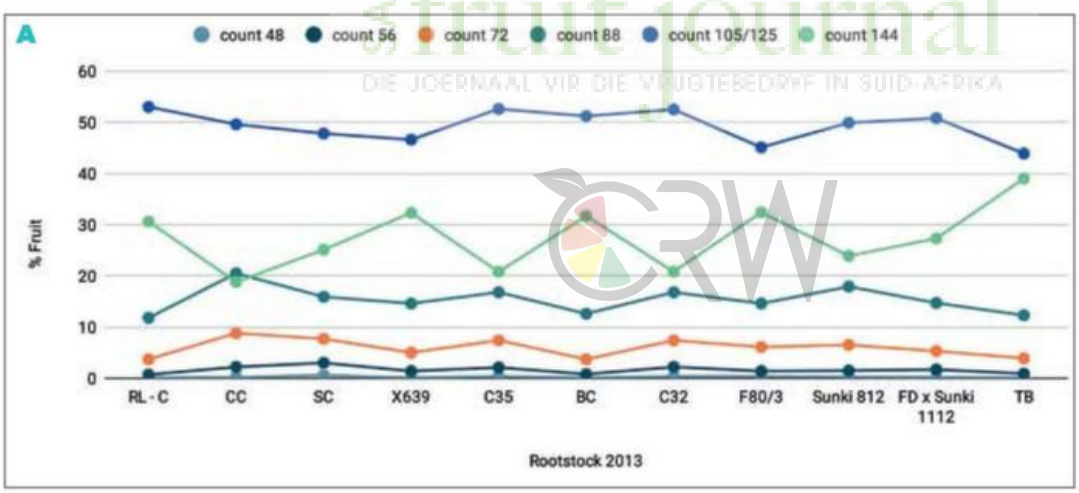


Table 5. Fruit size distribution (% fruit) per rootstock for Deltas on the best performing rootstocks at Moosrivier Estates (Marble Hall) during the 2013 and 2014 seasons.

Rootstock	Count (2013)						Count (2014)					
	48	56	72	88	105/125	144	48	56	72	88	105/125	144
RL - C (control)	0.1	0.7	3.7	11.8	53.0	30.6	0.5	7.9	22.0	30.2	34.1	5.3
CC (control)	0.2	2.2	8.8	20.5	49.6	18.8	4.3	27.4	34.9	21.2	10.5	1.7
SC (control)	0.6	3.0	7.7	15.9	47.8	25.1	4.3	30.6	33.5	19.8	9.8	1.9
X639 (control)	0.1	1.4	5.0	14.6	46.6	32.3	1.7	12.1	25.5	27.7	27.4	5.6
C35 (control)	0.4	2.1	7.4	16.8	52.6	20.8	1.8	11.0	23.9	30.0	28.7	4.7
BC	0.1	0.8	3.7	12.6	51.2	31.7	15.3	34.2	26.6	13.3	8.1	2.5
C32	0.4	2.2	7.4	16.8	52.5	20.8	2.3	12.0	25.2	28.7	27.7	4.2
F80/3	0.4	1.4	6.1	14.6	45.1	32.4	8.5	26.9	30.1	18.2	13.5	2.8
Sunki 812	0.3	1.5	6.5	17.9	49.9	23.9	3.1	15.8	27.3	26.1	22.6	5.1
FD x Sunki 1112	0.2	1.7	5.3	14.7	50.8	27.3	2.0	14.9	31.2	29.9	19.2	2.7
TB	0.1	0.9	3.9	12.3	43.9	39.0	7.9	30.8	28.6	17.9	12.9	1.9



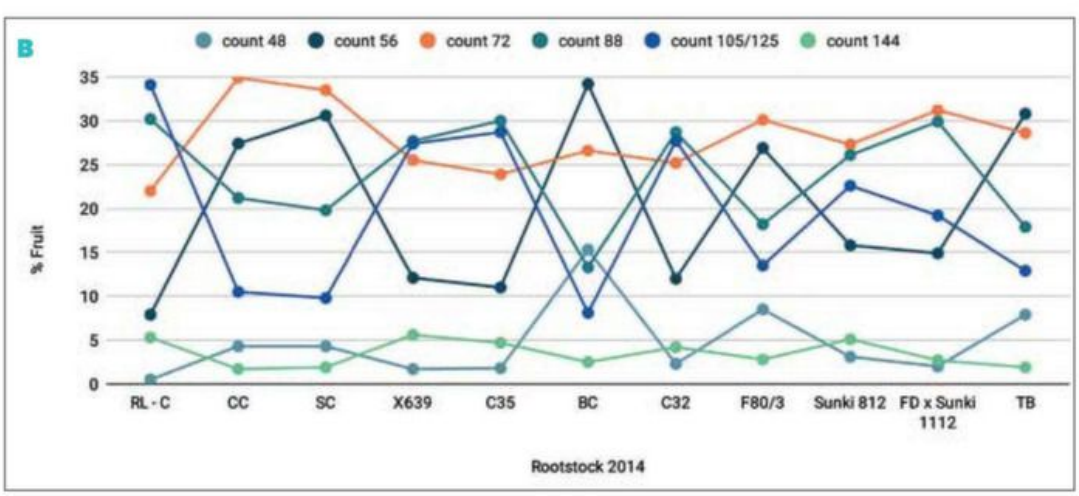


Figure 3. Fruit size distribution (% fruit) per rootstock for Deltas on the best performing rootstocks at Moosrivier Estates (Marble Hall) during the 2013 (A) and 2014 (B) seasons.

Discussion

C35, CC, RL-C, SC and X639 were included as commercial controls in the trial to evaluate the experimental range. The six best performing (kg/tree) experimental rootstocks are discussed in more detail below.

Benton citrange and Rangpur lime were in the top three best yielding rootstocks for the 2003, 2004 and 2005 production seasons. Benton was also associated with high juice content throughout the evaluation and gave a favourable fruit size range in 2014. Benton citrange was imported from Australia in an attempt to identify rootstocks compatible with Eureka lemon. Trees on Benton are more compact compared to trees on Swingle and Carrizo, resulting in more manageable trees with closer spacing and superior production per hectare (similar to C35). Nursery trees of Benton citrange have a "bushy" growth habit with a shrub-like appearance.

Citrus macrophylla featured in 2004, 2006 and 2007 as one of the best crop producers with bigger fruit size compared to the other rootstocks apart from CC in 2007. Fruit size is large, but the fruit on young trees generally have lower juice and Brix content and tend to dry out earlier. The potential downside of this rootstock is its sensitivity to citrus tristeza virus, which may contribute to decline over time.

Flying Dragon x Sunki 1112 rootstock featured in the top three producing rootstocks in 2006, 2013 and 2014. Tree size is fairly large, smaller only than RL. This rootstock was associated with an open tree canopy, allowing light penetration for better fruit set inside the tree. Internal quality was very good to excellent with high juice, Brix and acid levels.

Terrabella developed fairly high acids in the fruit; resulting in a lower Brix:acid ratio compared to the other rootstocks in the trial. The fruit size over the 2013 production year peaked at count 144 (small fruit) due to the heavy crop on the trees with the smallest tree canopy, followed by C35, BC and X639.

C-32 citrange outperformed the other rootstock combinations in 2013 with the highest production, also yielding good internal quality and Brix:acid ratio. However, crop load on the trees dropped by more than 50% in the 2014 season, indicating possible alternative bearing patterns of this rootstock. Seed production of C-32 is notoriously low, averaging two to three seeds per fruit, thus limiting the usage of this rootstock in the SA citrus industry, as rootstock propagation by cuttings is not a process used locally.

F80/3, one of the citrumelo selection, also performed well in the 2013 to 2014 seasons compared to all the commercial rootstocks (RL, CC, SC, C35, X639) used as controls in the trial. The canopy volumes were slightly smaller compared to Swingle citrumelo.

Trees on US-812 performed well after every second tree was removed for better tree spacing; internal quality was very good to excellent with better fruit size distribution in the 2014 season. The tree structure of Delta Valencia on US-812 rootstock is compact with a closed canopy.

The recommendation from this trial is to include Benton citrange and US-812 in a semi-commercial trial at appropriate spacing to account for the canopy volume, again comparing them to existing commercial rootstocks.

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Delta Valencia on (A) US-812 - compact tree canopy (Left) and (B) FD x Sunki 1112 – open tree canopy (Right)