

CITRUS FRUIT QUALITY AND YIELD OF SIX VALENCIA CLONES ON 16 ROOTSTOCKS IN THE IMMOKALEE FOUNDATION GROVE

ROBERT E. ROUSE

University of Florida, IFAS

Southwest Florida Research and Education Center

2686 State Road 29 North

Immokalee, FL 34142-9515

Additional index words. *Citrus sinensis*, Rohde Red.

Abstract. Five-year mean juice quality and yields from 'Valencia' sweet orange [*C. sinensis* (L.) Osbeck] for two nucellar, two old-line, and two Rohde Red clones are reported. Data is reported for each clone on 16 different rootstocks. Yield was recorded for the 5 years from tree ages four through eight. Rootstocks included commercially used citranges, citrumelos, mandarins, lemon, sour orange types, sweet orange, grapefruit, and trifoliolate orange. Trees were planted 15 × 22 feet on two-row beds typical of flatwoods groves. Juice was removed from fruit using an industry standard FMC juice extractor. Rohde Red clone 472-11-43 had higher juice color and lower acid than other clones. Rohde Red clone 472-3-26 was found inferior to clone 472-11-43 and has been removed from the budwood program. Pound solids per box were different overall among old-line and nucellar clones, and rootstocks affected all juice quality factors except juice color score. Highest yields were found with rootstocks F80-8 citrumelo and Benton citrange. Pound solids per box multiplied by cumulative yield per tree was highest for Rohde Red clone 472-11-43.

The 'Valencia' orange has been the most popular propagated variety in Florida during the late 1990s (Fla. Dept. Agr. & Cons. Servs, 1997, 1998, 1999a). Approximately half of the nearly six million citrus nursery tree propagations each year have been of a 'Valencia' clone, either a standard 'Valencia' or 'Rohde Red Valencia' selection. The popularity of 'Valencia' juice has been stimulated by the market success of the not-from-concentrate (NFC) pasturized product that is dependent on 'Valencia' oranges. The juice quality from fruit of young trees is an important economic factor in an industry that sells its fruit based on the juice sugar content and processes over 95% of its orange crop (Fla. Dept. Agr. & Cons. Servs, 1999b).

Florida orange juice quality standards require a minimum color score of 36 to qualify as Grade A (Stewart, 1980). Juice of the late-season 'Valencia', which has the highest color of the oranges used for processing, is blended with the early-maturing varieties to meet juice quality standards. Better juice color of the 'Valencia' clone means less juice needed for blending to attain the desired color. 'Rohde Red Valencia' is a clone that has been selected for its high juice color score, but information is not available comparing yields or juice color among 'Rohde Red Valencia' selections or with other 'Valencia' clones.

The results of the first production year of juice quality has been published (Rouse and Youtsey, 1993). The objective of this report was to provide additional data to include fruit yield and juice qual-

ity compared among scion selections during the first 5 years of production, tree ages four through eight.

Materials and Methods

Field-grown nursery trees of 'Valencia' were planted in June, 1989 in a 20-acre citrus budwood foundation grove at the Southwest Florida Research and Education Center at Immokalee. Trees were planted 15 × 22 ft on two-row beds typical of flatwoods citrus plantings with each row of 66 trees being a single scion cultivar. Each scion was budded on 22 different rootstocks, and each rootstock repeated three times in each row.

Six 'Valencia' scion clones on 16 different rootstocks were selected for yield and juice quality analysis. The clones were nucellar seedling selections VS-F-55-28-X-E and VS-SPB-1-14-19-X-E, shoot-tip grafted old-line selections V-10-12-7-X-E and V-51-3-3(STG-64G-4)-X-E, and 'Rohde Red Valencia' selections RRV-472-3-26(STG-31-18)-X-E and RRV-472-11-43(STG-19-2)-X-E. Rootstocks were Cleopatra and Sun Chu Sha mandarins (*C. reticulata*), calamandarin a possible hybrid of mandarin and calamondin [*X Citrofortunella microcarpa* (Bunge) Wijnands × *C. reticulata*], sour orange (*C. aurantium*L.), Smooth Flat Seville (*C. aurantium*?), Swingle and F80-18 citrumelos [*C. paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.], Carrizo, Benton and C-35 citranges [*C. sinensis* (L.) Osbeck × *P. trifoliata*], trifoliolate orange [*P. trifoliata* (L.) Raf.] the interspecific hybrid Ridge Pineapple × trifoliolate orange (1573-26) [*C. sinensis* (L.) Osbeck × *P. trifoliata*], Rangpur lime × Troyer citrange [*C. limonia* Osbeck × (*C. sinensis* (L.) Osbeck × *P. trifoliata*)], 'Valencia' seedling (*C. sinensis* (L.) Osbeck), Duncan grapefruit (*C. paradisi* Macf.), and Vangasay lemon [*C. limon* (L.) Burm. F.].

Individual trees were harvested and a 40-lb fruit sample (approximately 100 fruit) was collected from each scion tree on each rootstock in Apr. or May of each crop year from 1993-97. Juice from each sample was obtained using an FMC® model 091-B standard state juice extractor (Food Machinery Corporation, Lakeland, FL). Juice was analyzed for maturity factors of percentage juice per fruit on a weight basis, percentage total soluble solids (TSS) as °Brix, percentage titratable acid, and juice color score using a HunterLab® D45-2 Citrus Colorimeter (Hunter Assoc., Fairfax, VA). Calculations were made to obtain TSS (°Brix) to acid ratio, and pound solids per box based on the standard 90-lb field box.

Grove cultural practices since the time of planting have followed University of Florida, IFAS standard recommendations. Cultural management has included application of fertilizer with micro-elements applied as a dry formulation and as fertigation, chemical weed control, and irrigation by micro-sprinklers.

Statistical analysis was performed on the juice data using the SAS General Linear Models Procedure (GLM) with LSD calculated to separate means (SAS Institute, 1982). Mean yields and juice quality are reported for the individual 'Valencia' scions. Means for juice quality factors comparing rootstocks are averaged across all six 'Valencia' clones.

Florida Agricultural Experiment Station Journal Series No. N-01930. The author wishes to express his gratitude to Mr. Tommy Long and Dr. Bill Miller and from the Department of Citrus for performing juice maturity analysis and juice color determinations, respectively.

Table 1. Five-year cumulative means of Valencia scion clone juice quality and yield. Means by scion summed across all 16 rootstocks for tree age four through eight.

Clone	Juice/fruit (%)	TSS (°Brix)	Acid (%)	Ratio (TSS:acid)	Color score	Lb solids per box	Cumulative yield/tree (boxes)	Cumulative lbs solids/tree
Val-S-SPB-1-14-19	58.8 b ²	12.6 a	0.61 a	20.9 a	37.6 c	6.53 ab	8.30 b	54.2 cd
Val-SF-55-28	59.2 ab	12.0 b	0.61 a	20.1 b	37.5 cd	6.33 c	8.90 ab	56.3 c
Val-51-3-3	59.7 ab	12.0 b	0.61 a	19.9 bc	37.3 de	6.27 c	8.63 ab	53.9 cd
Val-10-12-7	60.7 a	12.4 a	0.61 a	20.6 a	37.1 e	6.62 a	8.86 ab	58.9 ab
RRV-472-3-26	59.4 ab	11.6 c	0.60 a	19.4 c	38.5 b	6.09 d	8.17 b	49.9 e
RRV-472-11-43	58.6 b	12.1 b	0.59 b	20.7 a	38.8 a	6.39 bc	9.27 a	59.4 a

²Mean separation in columns by LSD, 5%.

Results and Discussion

There were no differences in percentage juice per fruit among the standard old-line and 'Rohde Red Valencia' clones (Table 1). The only difference found in juice content among 'Valencia' selections was between Val-51-3-3 which had the highest juice content with 60.3% and nucellar VS-SPB-1-14-19 with the lowest at 58.1%.

Percentage acid was significantly lower for RRV-472-11-43 than the other 'Valencia' selections, including RRV-472-3-26. This difference was reported in 1993 and has continued to be a difference between these two 'Rohde Red Valencia' selections.

'Rohde Red Valencia' selection RRV-472-3-26 had lower Brix than the other 'Valencia' selections. The nucellar VS-SPB-1-14-19 and old-line Val-10-12-7 had the highest Brix and with RRV-472-11-43, the highest TSS/Brix ratio. Brix of RRV-472-3-26 was the lowest of all selections.

'Rohde Red Valencia' selection RRV-472-11-43, Val-1-14-19, and Val-10-12-7 had the highest TSS:acid ratio. RRV-472-11-43 had a ratio comparable to the old-line and nucellar selections, due primarily to the low acid content.

Juice color was highest from 'Rohde Red Valencia' selections by more than one color score number. Mean color score for nucellar (Val-1-14-19 and Val 55-28) and old-line (Val-51-3-3 and Val-10-12-7) selections was 37.6 and 37.2, respectively. The two 'Rohde Red Valencia' selections mean juice color score was 38.7.

There was significant difference between the two 'Rohde Red Valencia' selections. RRV-472-11-43 was at 38.8 and RRV-472-3-26 was 38.5, although in some years RRV-472-11-43 was almost one color score number higher than RRV-472-3-26. This higher color score with RRV-472-11-43 was reported previously (Rouse and Youtsey, 1993).

Calculated TSS (Brix) per 90-lb box were highest with selections Val-10-12-7 and Val-1-14-19. Selections RRV-472-11-43, Val 55-28, and Val 51-3-3 were intermediate in TSS/box, but still acceptable. RRV-472-3-26 had the lowest pound solids per box.

Cumulative fruit yield during the 5 years was highest with RRV-472-11-43, although not significantly greater than Val-55-28, Val 10-12-7, and Val-51-3-3. Selections Val-1-14-19 and RRV-472-3-26 were significantly lower in fruit yield than RRV-472-11-43. The five-year cumulative mean pound solids per tree was calculated by multiplying the mean of soluble solids per box times the cumulative yield in 90-pound boxes per tree. Five-year pound solids were highest for RRV-472-11-43 and Val-10-12-7. The significantly higher juice color of the RRV-472-11-43 should be an advantage to processors and may give a harvesting advantage to growers during large crop years. Rootstock influence on juice quality across all 'Valencia' scions was minimal and generally what might be expected (Table 2). Juice quality from trees on Cleopatra mandarin and Sun Chu Sha were comparable, and although Sun Chu Sha appeared to have higher acid and Brix, it was not significant. Smooth Flat Seville and sour orange used as root-

Table 2. Comparison of mean² juice quality of six 'Valencia' selections by rootstock Juice analysis from fruit harvested Apr./May 1993-97.

Rootstock	Juice/fruit (%)	Acid	TSS (%) (°Brix)	Ratio (TSS:acid)	TSS/box (lbs)	Juice color no.
Cleopatra mandarin	60.7 a ²	0.63 ab	12.1 b	19.4 b	6.5 ab	37.9 a
Sun Chu Sha mandarin	60.8 a	0.65 a	12.6 ab	19.7 b	6.7 a	37.9 a
Calamandarin	61.6 abc	0.66 a	12.5 ab	18.9 b	6.7 a	37.8 a
Sour orange	60.4 abc	0.62 ab	12.3 ab	20.2 ab	6.6 ab	37.7 a
Smooth Flat Seville	58.7 abc	0.60 bcd	11.9 b	19.9 b	6.4 ab	37.8 a
Swingle citrumelo	59.4 abc	0.60 bcd	11.8 bc	19.9 b	6.2 bc	38.0 a
F80-18 citrumelo	59.8 ab	0.59 bcd	11.8 bc	20.2 ab	6.2 bc	37.6 a
Carrizo citrange ³	60.5 abc	0.56 cde	12.0 b	21.6 a	6.3 bc	37.7 a
Benton citrange	60.3 abc	0.59 bcd	12.2 b	20.9 ab	6.5 ab	38.3 a
C-35 citrange	60.8 bcd	0.61 bcd	12.1 b	20.2 ab	6.4 b	38.2 a
Poncirus trifoliata	59.5 abc	0.59 bcd	12.2 b	20.9 ab	6.3 b	38.0 a
Ridge pineapple × P. trif. (1573-26)	57.5 d	0.63 ab	13.3 a	21.3 a	6.6 a	37.7 a
Rangpur × Troyer	59.8 cd	0.55 e	11.7 bc	21.2 a	6.1 bc	37.9 a
Valencia seedling	60.5 abc	0.60 bcd	12.1 b	20.3 a	6.4 ab	37.8 a
Duncan grapefruit	60.8 ab	0.61 bcd	12.2 b	20.1 b	6.5 ab	37.8 a
Vangasay lemon	56.5 e	0.57 e	11.1 c	19.7 b	5.5 c	36.9 a

²Means for six 'Valencia' clones are summed by rootstocks.

³Mean separation in columns by LSD, 5%.

Table 3. Five-year cumulative 'Valencia' orange yield on selected rootstocks. Tree ages four through eight.

Rootstock	Yield (lbs)	Boxes (90 lb)
F80-8 citrumelo	1010.7 a ^z	11.2 a
Benton citrange	996.5 a	11.1 a
C35 citrange	946.6 b	10.5 b
Carrizo citrange	941.0 b	10.4 b
Vangasay	922.9 b	10.3 b
Swingle citrumelo	884.9 bc	9.8 bc
Smooth Flat Seville	861.6 cd	9.6 cd
F80-18 citrumelo	850.0 cd	9.4 cd
P. trifoliata	834.3 cde	9.3 cde
Duncan grapefruit	819.6 cde	9.1 cde
Rangpur × Troyer	782.1 def	8.7 def
Valencia seedling	719.4 ef	8.0 ef
Sour Orange	707.8 fg	7.9 fg
Cleopatra mandarin	701.3 fg	7.8 fg
Sun Chu Sha	685.1 g	7.6 g
Calamandarin	666.5 g	7.4 g
P. trif. × Ridge pineapple	259.1 h	2.9 h

^zMean separation in columns by LSD, 5%.

stocks produced similar juice quality, and although they regularly had slightly higher Brix, it was not significant. Swingle citrumelo, Carrizo, Benton, and C-35 citranges were comparable except that Carrizo had higher TSS/acid ratio than Swingle across all 'Valencia' scion selections.

Percentage juice per fruit was not significantly different among rootstocks except for the interspecific hybrid Ridge Pineapple × P. trifoliata (1573-26), Rangpur × Troyer, and Vangasay lemon which were low. TSS were highest for Ridge Pineapple × P. trifoliata (1573-26) and lowest for Vangasay lemon. Ratio of TSS/acid was highest for 'Valencia' on Rangpur × Troyer rootstock and lowest for Cleopatra mandarin rootstock.

Calculated TSS per box was highest from Sun Chu Sha and calamandarin which was significantly higher than Swingle citrumelo, C-35 citrange, Rangpur × Troyer, but not Benton citrange. Vangasay lemon was significantly lower than all rootstocks.

Across all six 'Valencia' selections there was no significant difference in juice color score by rootstock in this test. This is the same finding reported in the 1993 study (Rouse and Youtsey,

1993). There are few reports of rootstock influence on juice color. Published works from the 1940s indicate no effect (Harding, et al., 1940; Miller, et al., 1941), although these results are contradicted by more recent works (Foguet, et al., 1970; Wutscher & Bistline, 1988). Reported differences seem to occur among extreme juice color scores from a given year and may vary with scion clone and with time of testing, i.e. color improves as the season progresses.

In summary these 5-year cumulative mean data from trees producing fruit in years 4 through 8 years of age favors RRV-472-11-43 and old-line Val -10-12-7 from an economic position where growers are paid on the TSS (sugar) in the juice. Valencia selections Val-55-28, Val-1-14-19, and Val 51-3-3 were intermediate. Rohde Red selection RRV-472-3-26 was found inferior and has been removed from the citrus budwood program. The 'Rohde Red Valencia' selections had the highest juice color score with RRV-42-11-43 being highest, and there was no difference in juice color of old-line and nucellar selections. Juice color was not affected by rootstock when compared across all scion selections.

Literature Cited

- Florida Department of Agriculture and Consumer Services. 1997. Bur. of Citrus Budwood Registration Annu. Rpt. July 1, 1996-June 30 1997. p.14.
- Florida Department of Agriculture and Consumer Services. 1998. Bur. of Citrus Budwood Registration Annu. Rpt. July 1, 1997-June 30 1998. pp. 24-25.
- Florida Department of Agriculture and Consumer Services. 1999a. Bur. of Citrus Budwood Registration Annu. Rpt. July 1, 1998-June 30 1999. pp. 12-13.
- Florida Department of Agriculture and Consumer Services. 1999b. FL. Agr. Facts. p. 27.
- Foguet, J. L., C. A. Oste, J. T. Jubes and S. Alvarez. 1970. Influencia de tres portainjertos sobre la pigmentacion antocianica de la naranja Ruby Blood. Revista Industrial Y Agricola de Tucuman. 47:39-45.
- Harding, P. L., J. R. Winston and D. F. Fisher. 1940. Seasonal changes in Florida oranges. USDA Tech. Bull. 753.
- Miller, E. V., J. R. Winston and D. F. Fisher. 1941. A physiological study of carotenoid pigments and other constituents in the juice of Florida oranges. USDA Tech. Bull. 780:1-31.
- SAS Institute. 1982. SAS user's guide: statistics. SAS Inst., Cary, NC.
- Rouse, R. E. and C. O. Youtsey. 1993. Juice quality from young trees of 6 Valencia clones on 16 rootstocks in the Immokalee Foundation Grove. Proc. Fla. State Hort. Soc. 106:55-57.
- Stewart, I. 1980. Color as related to quality in citrus, pp. 129-149. In S. Nagy and J. A. Attaway (eds.). Citrus nutrition and quality. ACS Symp. Series 143. Amer. Chem. Soc., Washington, DC.
- Wutscher, Heinz K. and Fred W. Bistline. 1988. Rootstock influences juice color of 'Hamlin' orange. HortScience 23:724-725.