Proc. Fla. State Hort. Soc. 94:31-33. 1981.

PRELIMINARY PERFORMANCE OF 7-YEAR-OLD 'VALENCIA' ORANGE TREES ON 21 ROOTSTOCKS[1,2]

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Additional index words. tree size, yield, fruit quality.

Abstract. **A study of fruit production, fruit quality, and tree size of 'Valencia' sweet orange** (Citrus sinensis **(L.) Osbeck) trees on 21 rootstocks was conducted from 1974 to 1981. Fruit yields and pounds solids per tree were highest on Carrizo and Yuma citranges** (C. sinensis **X** Poncirus trifoliata **(L.) Raf.), rough lemon 807, and Volkamer lemon** (C. limon **(L.) Burm. f.) rootstocks. The largest trees were on Carrizo and Yuma citranges, rough lemon, rough lemon 807, sour orange No. 2,** (C. aurantium **L.), sour orange 839, and Volkamer lemon rootstocks. Trees on Argentina and Pomeroy trifoliate orange** (P. trifoliata), **Norton citrange** (C. sinensis **X** P. trifoliata), **and sour orange hybrid 895 produced fruit with the highest total soluble solids.**

The major citrus cultivar grown throughout the world is 'Valencia' orange. Rootstock-related diseases and constantly changing cultural practices emphasize the importance of rootstock selection. Research on citrus rootstocks is time-consuming and a continuing process, because results can vary from area to area due to climate, soil, disease, and cultural practices. This report presents information on the performance of 'Valencia' orange on 21 rootstocks 7 years after planting.

Materials and Methods

The location selected for planting was in a high, blight-incidence area, and the rootstocks (Table 1) were selected for their broad genetic diversity in order to evaluate them for possible blight tolerance.

Budwood of a nucellar 'Valencia' orange selection was used in propagating the trees. The trees were planted February 13, 1974, near Ft. Pierce, Florida, in 4-row raised beds in a randomized complete-block design with 4 replications of 8-tree plots. The soil at the planting site was a shallow, poorly drained, fine-loamy, depressional, siliceous soil (Winder sand, depressional type). The beds were bordered by drainage ditches. Tree spacing was 15 x 27 ft. Records were collected from the 4 center trees of each replication. Fruit yields in 1979, 1980, and 1981 were recorded and expressed as the average number of boxes (90-lb.) of fruit harvested per tree. Juice, total soluble solids, and total acids percentages were determined by standard laboratory procedures from random samples of 12 fruit from each plot in 1981. Tree size, expressed as canopy volume, was calculated by the formula width^2 x height/4 (7) in 1981. All data were subjected to analysis of variance and the means were separated by Duncan's multiple range test.

Table 1. Cultivar and scientific names of 21 citrus rootstocks used to test 'Valencia' orange tree performance.

Cultivar[z]	Scientific name
Argentina trifoliate orange	*Poncirus trifoliata* (L.) Raf.
Carrizo citrange	*Citrus sinensis* (L.) Osb. X *P. trifoliata*
Changsha mandarin	*C. reticulata* Blanco
Citremon 1449[y]	*C. limon* (L.) Burm. f. X *P. trifoliata*
Cleopatra mandarin	*C. reticulata*
Mandarin 847	*C. reticulata*
Nasnaran	*C. amblycarpa* (Hassk.) Ochse
Norton citrange	*C. sinensis* X *P. trifoliata*
Pomeroy trifoliate orange	*P. trifoliata*
Red rough lemon 1[y]	*C. limon*
Red rough lemon 2[x]	*C. limon*
Rough lemon	*C. limon*
Rough lemon 807	*C. limon*
Smooth Flat Seville	*C. aurantium* L. hybrid
Sour orange No. 2	*C. aurantium*
Sour orange 838	*C. aurantium*
Sour orange 839	*C. aurantium*
Sour orange hybrid 895	*C. aurantium* X *C. limon*
Sun Chu Sha Kat mandarin	*C. reticulata*
Volkamer lemon	*C. limon*
Yuma citrange	*C. sinensis* X *P. trifoliata*

[z]All cultivars are from the USDA citrus collection, Orlando, FL, except where noted.
[y]Citremon 1449 and Red rough lemon 1 are CRC selections 1449 and 3185, respectively, of the University of California, Riverside, CA.
[x]Red rough lemon 2 refers to selection C-60-288-511 from the USDA Citrus and Date Station, Indio, CA.

Results and Discussion

Table 2 shows the number of trees lost to diseases. Several trees declined and died within 3 years after the experiment was planted. The apparent causes of this loss were foot rot and root rot caused by *Phytophthora parasitica* (Dastur) (G. R. Grimm, personal communication). No trees were lost on Argentina trifoliate orange rootstock. The greatest losses were on Cleopatra mandarin, rough lemon, Red rough lemon 1, and Red rough lemon 2 rootstocks, which have been reported to be susceptible to *P. parasitica* (1, 6). Subsequently, several trees on sour orange No. 2, sour orange 838, sour orange 839, and sour hybrid 895 were lost due to citrus tristeza virus (S. M. Garnsey, personal communication).

Table 3 shows canopy volume, fruit yields in 1979, 1980, 1981, and the 3-year cumulative yield. Fruit production in the first 2 years (1979 and 1980) was erratic when compared to the yields in 1981. The highest yields in 1981 and highest 3-year cumulative yields were obtained on Carrizo citrange, rough lemon 807, Volkamer lemon, and Yuma citrange rootstocks; the lowest yielding trees were on mandarin 847, Norton citrange, Pomeroy trifoliate orange, Red rough lemon 1, Red rough lemon 2, and sour orange hybrid 895 rootstocks. The largest trees were on Carrizo citrange, rough lemon, rough lemon 807, sour orange No. 2, sour orange 839, Volkamer lemon, and Yuma citrange.

Fruit quality and pounds solids-per-tree in 1981 are presented in Table 4. Fruit from trees on Argentina trifoliate orange, mandarin 847, rough lemon, and Red rough lemon

[1]The authors express appreciation to L. M. Clinton for his assistance in the collection and analysis of data.
[2]The experiment was planted under a cooperative agreement with the Foods Division, Coca-Cola, Inc., Ft. Pierce, FL. Special thanks are due Coca-Cola. Inc., for care of the planting and for making yield records possible.

Table 2. Number of 'Valencia' orange trees originally planted on 21 rootstocks, and number trees lost.

Rootstocks	No. trees planted	No. trees lost to *P.p.*[z]	No. trees lost to CTV[y]
Argentina trifoliate orange	32	—	—
Carrizo citrange	32	2	—
Changsha mandarin	32	3	—
Citremon 1449	32	2	—
Cleopatra mandarin	32	14	—
Mandarin 847	32	3	—
Nasnaran	32	5	—
Norton citrange	32	1	—
Pomeroy trifoliate orange	32	2	—
Red rough lemon 1	32	19	—
Red rough lemon 2	32	16	—
Rough lemon	32	18	—
Rough lemon 807	32	2	—
Smooth Flat Seville	32	7	—
Sour orange No. 2	32	1	3
Sour orange 838	32	3	5
Sour orange 839	32	2	2
Sour orange hybrid 895	32	4	1
Sun Chu Sha Kat mandarin	32	6	—
Volkamer lemon	32	3	—
Yuma citrange	32	1	—

[z]Trees lost as of December 1, 1976, apparently to *Phytophthora parasitica* P.p.).
[y]Trees lost in 1980 and 1981 to citrus tristeza virus (CTV).

2 had the lowest juice content as compared to fruit from trees on other rootstocks. Fruit with the highest total soluble solids content was produced by trees on Argentina trifoliate orange, Norton citrange, Pomeroy trifoliate orange, and sour orange hybrid 895. Conversely, the fruit with lowest total soluble solids was on Red rough lemon 1, Red rough lemon 2, rough lemon, rough lemon 807, and Volkamer lemon. Trees on Argentina trifoliate orange, Changsha mandarin, Norton citrange, Pomeroy trifoliate orange, sour orange 838, and sour orange 839 rootstocks produced fruit relatively high in total acids. Low-acid fruit was produced by trees on Cleopatra mandarin, mandarin 847, Red rough lemon 1, Red rough lemon 2, rough lemon, rough lemon 807, and Volkamer lemon rootstocks. The highest yielding trees, those on Carrizo citrange, rough 807, Volkamer lemon, and Yuma citrange, also produced the greatest quantity of pounds solids per tree. Trees on mandarin 847, Norton citrange, Pomeroy trifoliate orange, Red rough lemon 1, Red rough lemon 2, and sour orange hybrid 895 produced the least pounds solids per tree.

The data presented in this paper are from relatively young citrus trees (7 years old); however, the results showed that the largest trees were producing the largest fruit

Table 4. Fruit quality and pounds solids per tree for 'Valencia' orange trees on 21 rootstocks.[z]

Rootstock	Juice (%)	Total soluble solids (%)	Total acids (%)	Solids/ tree (lb.)
Volkamer lemon	50 abc[y]	11.6 ijk	0.81 fgh	17.7 a
Rough lemon 807	50 abc	11.5 ijk	0.82 fgh	15.4 ab
Yuma citrange	48 abc	12.7 bcdefg	0.92 cdefg	14.9 abc
Carrizo citrange	48 abc	12.9 bcde	0.93 cdefg	14.3 abcd
Sun Chu Sha Kat mandarin	51 ab	12.7 bcdefg	0.94 cdef	12.9 bcde
Sour orange 839	52 a	12.8 bcdef	1.00 abcd	12.4 bcdef
Sour orange No. 2	49 abc	12.4 defgh	0.98 bcde	12.0 bcdef
Smooth Flat Seville	49 abc	12.3 defghi	0.90 cdefgh	11.8 bcdef
Argentina trifoliate orange	47 bcd	13.5 ab	1.08 ab	10.9 cdefg
Rough lemon	46 cd	11.2 jk	0.86 efgh	10.5 cdefg
Citremon 1449	49 abc	12.5 defgh	0.90 cdefgh	10.4 defg
Cleopatra mandarin	49 abc	12.0 fghij	0.83 fgh	10.3 defg
Sour orange 838	50 abc	12.7 bcdefg	1.01 abc	10.0 defg
Changsha mandarin	51 ab	12.2 efghi	1.01 abc	9.9 defg
Nasnaran	48 abc	12.6 cdefg	0.94 cdef	9.5 efg
Norton citrange	49 abc	13.8 a	1.13 a	8.6 efg
Pomeroy trifoliate orange	48 abc	13.4 abc	1.10 ab	8.5 fg
Sour orange hybrid 895	49 abc	13.1 abcd	0.97 bcde	8.3 fg
Mandarin 847	47 bcd	11.9 ghij	0.80 gh	7.0 g
Red rough lemon 1	49 abc	11.2 jk	0.85 efgh	6.8 g
Red rough lemon 2	44 d	11.0 k	0.79 h	6.6 g

[z]1981 data.
[y]Means within a column followed by the same letter are not significantly different at P = 0.05 according to Duncan's multiple range test.

Table 3. Fruit yields in 1979, 1980, 1981, and 3-year cumulative yield and canopy volume of 'Valencia' orange on 21 rootstocks.

Rootstock	Avg. boxes fruit per tree[z] 1979	1980	1981	Cumulative yield 1979-1981	Canopy[y] volume (ft^3)
Volkamer lemon	1.5 ab[x]	2.1 ab	3.4 a	7.0 a	284 ab
Rough lemon 807	1.7 a	2.2 a	3.0 ab	6.9 a	325 a
Yuma citrange	1.5 ab	2.0 abc	2.8 abc	6.3 ab	256 abcd
Carrizo citrange	1.4 abc	1.9 abc	2.6 abcd	5.9 bc	244 abcdef
Rough lemon	1.1 bcde	1.7 abc	2.3 bcde	5.1 bcd	251 abcde
Sour orange No. 2	1.2 bcd	1.6 abc	2.2 bcdef	5.0 bcde	262 abc
Sun Chu Sha Kat mandarin	1.1 bcde	1.5 abc	2.2 bcdef	4.9 cde	243 bcdef
Smooth Flat Seville	1.0 cdef	1.7 abc	2.2 bcdef	4.9 cde	180 defghi
Sour orange 839	1.3 abc	1.5 abc	2.1 cdefg	4.8 cdef	247 abcde
Argentina trifoliate orange	1.3 abc	1.4 abc	1.9 defg	4.7 cdef	172 efghi
Sour orange 838	1.3 abc	1.6 abc	1.8 defg	4.7 cdef	211 bcdefg
Citremon 1449	1.1 bcde	1.5 abc	1.9 defg	4.5 defg	150 ghi
Nasnaran	1.1 bcde	1.4 abc	1.8 defg	4.3 defgh	218 bcdefg
Cleopatra mandarin	0.8 def	1.4 abc	1.9 defg	4.1 defgh	154 ghi
Pomeroy trifoliate orange	1.1 bcde	1.3 abc	1.5 efg	3.9 defghi	128 hi
Red rough lemon 2	1.1 bcde	1.2 abc	1.5 efg	3.8 defghi	188 cdefgh
Changsha mandarin	0.7 ef	1.2 abc	1.8 defg	3.7 efghi	147 ghi
Norton citrange	1.0 cdef	1.1 abc	1.4 fg	3.5 fghi	166 fghi
Mandarin 847	0.8 def	1.1 abc	1.3 g	3.3 ghi	122 hi
Sour orange hybrid 895	0.6 f	1.0 bc	1.5 efg	3.1 hi	106 i
Red rough lemon 1	0.6 f	0.9 c	1.4 fg	2.8 i	126 hi

[z]90 lb. fruit per box.
[y]1981 data.
[x]Means within a column followed by the same letter are not significantly different at P = 0.05 according to Duncan's multiple range test.

yields. This is in general agreement with reports by researchers previously working on older trees (2, 5, 7). This would support speculation that information on tree size and fruit yield of young trees is an indication of their performance as mature trees. An exception to this statement would be Rusk citrange (*C. sinensis* X *P. trifoliata*), which produces vigorous and high-yielding young trees, but old trees on Rusk are small and low-yielding (3, 4, 7). The tree loss to *P. parasitica* and tristeza shows the importance of rootstock selection prior to planting citrus trees.

In conclusion, the data presented show that Carrizo citrange, rough lemon 807, Volkamer lemon, and Yuma citrange perform well as rootstocks for young trees of 'Valencia' orange in the Ft. Pierce (Indian River) area. Carrizo citrange rootstock is commonly used in Florida. Further observational and performance data are needed for rough lemon 807, Volkamer lemon, and Yuma citrange to determine their potential as rootstocks in Florida.

Literature Cited

1. Carpenter, J. B., R. M. Burns, and J. R. Furr. 1975. *Phytophthora* tolerant rootstocks for lemons. Plant Dis. Rptr. 59:54-56.
2. Castle, W. S. 1980. Citrus rootstocks for tree size control and higher density plantings in Florida. Proc. Fla. State Hort. Soc. 93:24-27.
3. Gardner, F. E., and G. E. Horanic. 1961. A comparative evaluation of rootstocks for Valencia and Parson Brown oranges on Lakeland fine sand. Proc. Fla. State Hort. Soc. 74:123-127.
4. ———, and ———. 1966. Growth, yield, and fruit quality of Marsh grapefruit on various rootstocks on the Florida east coast—a preliminary report. Proc. Fla. State Hort. Soc. 79:109-114.
5. Hilgeman, R. H. 1975. Yield and tree growth of seven 'Valencia' orange type cultivars on four rootstocks. HortScience 10:66-68.
6. Hutchison, D. J. 1977. Influence of rootstock on the performance of 'Valencia' sweet orange. Proc. Int. Soc. Citriculture 2:523-525.
7. ———, J. H. O'Bannon, G. R. Grimm, and G. D. Bridges. 1972. Reaction of selected citrus rootstocks to foot rot, burrowing and citrus nematodes. Proc. Fla. State Hort. Soc. 85:39-43.

Proc. Fla. State Hort. Soc. 94:33-36. 1981.

EVALUATION AND NATURE OF CITRUS NEMATODE RESISTANCE IN SWINGLE CITRUMELO[1]

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Abstract. **Greenhouse and field evaluations have indicated that Swingle citrumelo** (Citrus paradisi **Macf. X** Poncirus trifoliata **(L.) Raf.) is resistant to citrus nematode** (Tylenchulus semipenetrans **Cobb) populations commonly found in Florida citrus groves. Swingle citrumelo reduced citrus nematode populations to nondetectable levels within 2 years under field conditions. In greenhouse studies, citrus nematode populations were significantly reduced by Swingle citrumelo seedlings within 2 months of inoculation. Resistance was correlated with lower numbers of nematodes becoming associated with the rhizoplane and infecting feeder roots. Citrus nematode infection of Swingle citrumelo resulted in a hypersensitive-type response in the root hypodermis accompanied by wound periderm formation.**

Introduction

The citrus nematode, *Tylenchulus semipenetrans* Cobb, is distributed throughout the citrus-growing regions of the world, and often causes significant reductions in tree growth and yield (10). In Florida, the citrus nematode is widespread, having been detected in approximately 50% of the citrus groves throughout the state (1). Symptom severity (chlorosis, twig dieback, stunting, reduced fruit quality and quantity, and poor vigor) varies with tree age, nematode population size, grove management practices, and edaphic conditions in the grove. Historically, citrus nematode control in Florida has depended upon the use of nematicides, sanitation, and a nursery-stock certification program. The importance and value of resistant citrus rootstocks in management of nematode diseases are recognized. However, the commercially acceptable citrus nematode-resistant rootstocks currently available (2) are not well adapted for general use in Florida.

In this paper, we report the results of field and greenhouse evaluations of Swingle citrumelo (*Citrus paradisi* Macf. X *Poncirus trifoliata* (L.) Raf.) for citrus nematode resistance, and laboratory research designed to determine cellular changes in roots associated with resistance.

Materials and Methods

The influence of Swingle citrumelo and Volkamer lemon (*C. limon* (L.) Burm. f.) on citrus nematode population dynamics was studied under Florida field conditions. Thirty-two 6-month-old seedlings of each rootstock were budded with a grapefruit scion, and half of the trees of each cultivar were planted in screenhouse-soil tanks infested with the citrus biotype of *T. semipenetrans* (3). The remaining trees were planted in an adjacent noninfested soil tank. Eight months later all trees were transplanted to the field in a randomized-design split plot. *T. semipenetrans*-infected rough lemon (*C. limon*) seedlings were also planted with each tree taken from the nematode-infested tank to assure the presence of the citrus nematode among all nematode-inoculated trees, but were not planted adjacent to noninoculated trees. After 1 year, the rough lemon seedlings were removed and test trees were sampled twice each year for 3 years. Nematodes were extracted from root samples taken from each tree (2 samples/tree) (11), and data expressed as numbers of nematodes/gram root (fresh weight).

The influence of Swingle citrumelo on citrus nematode reproduction under greenhouse conditions was compared with that of several other rootstocks. *C. limon* cv. Milam lemon, *C. reticulata* Blanco cv. Cleopatra mandarin, *Fortunella margarita* (Lour.) Swing. cv. Nagami kumquat,

[1]This paper reports the results of research only. Mention of a trademark, proprietary product, or pesticide does not constitute a recommendation for its use by the U.S. Department of Agriculture to the exclusion of other suitable products, nor does it imply registration under FIFRA as amended.