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CITRUMELOS AS ROOTSTOCKS FOR FLORIDA CITRUS

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Abstract. **Swingle citrumelo [*Citrus paradisi* Macf. x *Poncirus trifoliata* (L.) Raf.] has become a significant commercial rootstock in Florida. It was the rootstock used for about 30% of the registered trees propagated in 1987-88. It has many attributes including cold, citrus tristeza virus, citrus nematode and phytophthora foot rot tolerance. Tree loss from blight in commercial plantings has been generally less than 2% after about 10 yr. A survey of the oldest groves (10 to 14 yr) plus field trial data showed that trees on Swingle yield satisfactorily, especially grapefruit, and produce medium to large-sized fruit of excellent quality. Trees were observed growing and yielding well in calcareous sites with pH values near 8.0. Swingle is sensitive to high levels of soil copper. A root distribution study showed that in a deep sand soil, Swingle roots grew to depths greater than 6 ft but fibrous root density was comparatively low at all depths. In general, commercial experience with grapefruit and navel and round orange cultivars on Swingle justifies the strong continued interest in this rootstock. Many mandarin cultivars have been propagated on Swingle but their long-term compatibility is unknown. Data, primarily from field trials, suggest that the Division of Plant Industry's F-80 series of unnamed citrumelos have many characteristics similar to those of Swingle.**

Citrumelos are hybrids of trifoliate orange and grapefruit. As a group, they were largely overlooked as potential rootstocks until the superior performance of Swingle citrumelo was demonstrated in Texas rootstock trials (1, 7). Primarily because of those results, Swingle was officially released by the U.S. Department of Agriculture (USDA) as a new rootstock cultivar in 1974 (3). Since then, Swingle has become a popular commercial rootstock in Florida. An outbreak of *Xanthomonas campestris*, a bacterial disease to which Swingle seedlings are susceptible, and limited seed supplies temporarily restricted the use of Swingle; however, Division of Plant Industry (DPI), Budwood Registration Bureau records indicate that 30% of registered trees were grown on Swingle during 1987-88. Outside of Florida, Swingle has remained largely experimental.

The current success of Swingle in Florida can be attributed to its many desirable characteristics, particularly tristeza tolerance and its apparent blight tolerance to date. Increasing problems with tristeza have seriously diminished industry interest in sour orange (*C. aurantium* L.) and blight has similarly affected Carrizo citrange [*C. sinensis* (L.) Osbeck x *P. trifoliata*], the two most common rootstocks in Florida.

In view of the significant impact Swingle has already had on the Florida rootstock situation, our objectives are to present the available general performance information regarding Swingle and other citrumelos and to supplement that information with new observations and data from a survey of Florida commercial plantings and from our rootstock plantings.

The field information presented herein was developed from visits by 2 or more of the authors to groves throughout Florida with the oldest commercial trees on Swingle. These trees ranged from about 8 to 14 yr old. Observations were made on tree appearance, the current crop, blight incidence, and samples were collected to determine soil pH and calcium (Ca) content. We also conducted some on-site interviews with grove owners or managers.

Swingle Citrumelo

Origin and early Florida history. A description of Swingle and the results of the first field experiments were published earlier (3). Briefly, Walter Swingle made a hybrid in 1907 at Eustis, Fla., between 'Duncan' grapefruit and

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trifoliate orange. It was tested as CPB 4475 and eventually named after its creator. Field work with Swingle actually began in the 1940s but the use of old-line, virus-infected budwood resulted in most trials being abandoned. Of the 2 remaining trials, one was planted in 1948. By 1967, the trees on Swingle in this trial were dwarfed compared to trees on other stocks, suggesting the presence of a viral agent not common in budwood sources today.

Nursery characteristics. Swingle seed trees bear well, producing pyriform-shaped yellow fruit with about 20 seeds/fruit. The seed are highly polyembryonic but seedling populations may contain 5 to 20% off-type plants of sexual origin. Many of these are easily identified morphologically. Recent evidence from isozyme study showed that these non-nucellar plants should be rogued out because if used, an incompatibility (bud union crease) may manifest itself within a few years after budding.

Swingle seedlings grow vigorously and enlarge quickly near the base where budding occurs; however, scion growth is often slow. Fall and winter buds are sometimes difficult to force in a field nursery and the rootstock may grow over the bud before it begins growth. Greenhouse nurserymen have successfully propagated with Swingle throughout the year.

Stem cuttings of Swingle are easily rooted (2); in fact, many nurserymen, faced with Swingle seed shortages, found it convenient to root the portion of the seedling that is cut off when forcing the bud.

Pests and diseases. Swingle is resistant to phytophthora foot rot which largely explains why growers report very low to no tree losses among young trees on this stock. Swingle is also tolerant to citrus tristeza virus (CTV), citrus exocortis viroid (CEV), and xyloporosis viroid. A field trial with CEV inoculated 'Hamlin' trees on Swingle, however, has shown that severe strains can reduce growth without bark scaling (unpublished data, Castle and Pelosi). Exocortis infected budwood should be avoided. Certain old-line bud sources in Texas apparently contain a different viral agent, perhaps citrange stunt virus, that caused severe stunting and a bud union crease (6).

Swingle citrumelo does not tolerate burrowing nematodes but is equal to trifoliate orange and exceeds Carrizo citrange in its resistance to citrus nematodes (5).

Our observations regarding blight and Swingle are encouraging. Among the groves visited, blight was frequently absent or the rate was low. Data from several sites showed that after about 10 yr, blight loss was commonly less than 2% (Table 1). In a grove of trees on rough lemon (*C. jambhiri* Lush.) eventually replanted with Swingle because of heavy blight loss, decline among trees at the same age has been markedly lower on Swingle (Fig. 1). The blight incidence among trees on Swingle at the DPI Foundation Grove also has been very low so far (10).

Environmental factors. Swingle is an excellent rootstock concerning cold tolerance. Field evidence and controlled tests show that it is similar to sour orange in this trait (9). Trees on Swingle are moderately salt tolerant (7), being slightly better than other trifoliate orange hybrids, however, they do not seem to be as drought tolerant as trees on Carrizo citrange, sour orange, or Cleopatra mandarin.

Swingle is more sensitive than other commercial rootstocks to high levels of soil copper (Cu) based on observations and data from the DPI Foundation Grove. One part of this grove had long been a commercial planting. Soil samples collected from the surface 6 inches for this report, and extracted by the double acid method, had Cu values ranging from less than 20 to over 200 lb/acre; the mean for 25 samples was 157 lb/acre. When the land was cleared and replanted in the mid 1970s with DPI material, trees on Swingle and other citrumelos, but not other rootstocks, began showing iron (Fe) deficiency chlorosis soon after planting. The soil pH was apparently below 6.0 because liming in combination with root growth into low Cu areas seemed to correct the problem. These trees are now normal-appearing and have grown well but the Swingle fibrous roots (0 to 6-inch depth) and the roots that we collected from trees on other rootstocks, contained 300 to 800 ppm Cu and had classic Cu toxicity symptoms, i.e., they were dark brown and stubby.

Table 1. Yield and blight incidence of trees on Swingle citrumelo and Carrizo citrange rootstocks in a 1988 survey of flatwoods sites.

Scion	Rootstock	Tree age (yr)	Size of mapped site	Blight loss (%)	1988 yield (boxes/tree)
Site 1					
Hamlin	Swingle	11	10 acres	0.7	2.7
sweet orange	Carrizo	11	10 acres	2.1	3.6
Pineapple	Swingle	10	15 acres	0.7	3.7
sweet orange	Carrizo	10	15 acres	1.3	3.2
Valencia	Swingle	10	20 acres	1.5	2.8
sweet orange	Carrizo	10	20 acres	4.2	2.9
Site 2					
Redblush	Swingle	11	594 trees	7.6	9.7
grapefruit	Swingle	9	434 trees	1.4	—
Hamlin	Swingle	9	509 trees	1.8	—
Site 3					
Redblush	Swingle	11	953 trees	1.8	8.2
Site 4					
Redblush	Swingle	14	958 trees	1.0	—

[z]A box holds 90 lb (41 kg) of oranges or 85 lb (39 kg) of grapefruit.

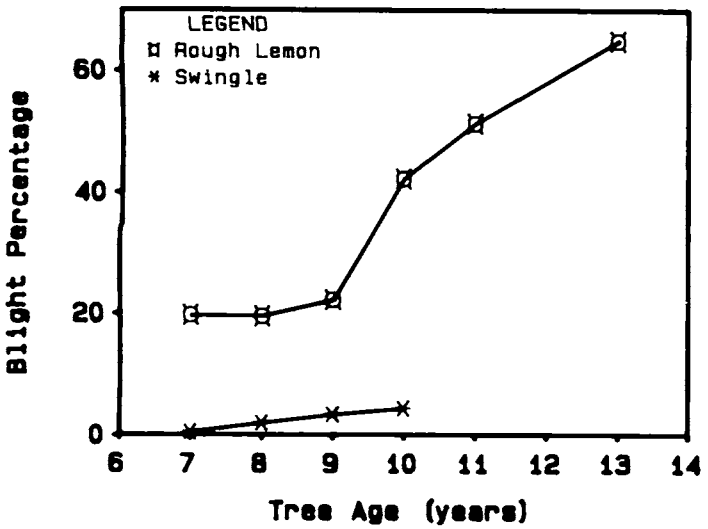

Fig. 1. Blight incidence in a block of sweet orange trees planted in a flatwoods site. The remaining 'Valencia' on rough lemon trees of the original planting were removed after 13 yr and the entire block replanted with 'Hamlin' on Swingle citrumelo.

Another soil-related issue of some concern is the performance of citrumelos in calcareous sites. Trifoliate orange does poorly in the presence of high soil Ca. Trees on citranges have suffered severe chlorosis in calcareous sites and thus, citrumelos might also be considered unsuitable because both are trifoliate orange hybrids. Less is known about citrumelos in this regard. Our survey observations and data suggest that trees on Swingle can be grown where the soil pH is 8.0 and the Ca content is 2,000 lb/acre or greater in the surface 6 inches (Table 2); the only apparent exceptions were when trees were growing in localized surface limerock areas. For example, 'Valencia' trees in site 3 (a) and (b) were less than 50 ft apart in the same bed but the pH values were similar at each location and the soil Ca values were high (Table 2). The only differences were that one set of trees was smaller and severely chlorotic and clearly growing more in rock than in soil. The same differences existed between site 3 (c) and (d). In another, non-rocky, high pH grove, site 4 (Table 2), the trees were described by the owner as slow-growing and chlorotic for the first 2 to 3 yr after planting. The trees apparently responded to a one-time soil application of a

Table 2. Soil pH and calcium levels in several flatwoods sites planted with trees on Swingle citrumelo.

Scion	Tree age (yr)	Soil pH[z]	Soil Ca[y] (ppm)	Remarks
Site 1				
Hamlin sweet orange	3	6.0	487; 511	Trees 6 to 8 ft tall with a healthy, normal appearance. Excellent crop.
Site 2				
Redblush grapefruit	12	6.5, 6.7	873; 995	Large, healthy trees with mild micronutrient deficiency occurring in < 10% of the leaves. Good crop.
Hamlin	9	6.5	560	Healthy trees. Good crop.
Site 3				
Navel sweet orange	8	4.5, 4.9	150; 210	Trees about 8 ft tall and healthy.
Redblush	12	4.8, 4.3	200; 462	Large, healthy trees. Excellent crop.
Valencia sweet orange	2	8.0 (a) 7.9 (b) 8.2 (c) 8.1 (d)	4,560 1,200 3,680 3,280	These trees were planted in a low, organic area filled with material containing Ca and limerock from nearby ditches and canals (see text).
Site 4				
Redblush, Valencia	~10	7.9, 8.1	No data	Loose marl and sea shells present in the surface 6 inches of soil. Trees grew poorly after planting and were chlorotic (see text). Winder, Chobee, and Riviera soils. Good crop.
Site 5				
Hamlin	10	7.9	No data	Trees stunted and severely chlorotic. Large pieces of limerock were present at the the surface. Winder soil. Few fruit.
	10	5.3	No data	Near the block of trees on Winder soil but no large sized calcareous materials apparently present. Good crop.
Site 6				
Hamlin	10	7.4	No data	Riviera soil. See Fig. 1 and text. Tree appearance excellent. Very good crop.
Site 7				
Hamlin	9	8.3, 8.0	No data	Pineda soil with large limerocks present at the surface. Some trees chlorotic, others not.
Redblush	10	8.1, 7.9	No data	Pineda soil; marl and sea shells present. Trees typical for age and healthy in appearance. Good crop.
Site 8				
Valencia	6	4.2 6.6	393 1,667	Trees typical for age with little or no chlorosis. Trees mildly chlorotic. Large pieces of limerock present.
Valencia	10	5.5, 6.4	310; 1,040	Trees growing in soil about 12 inches deep over large limerock areas. Tree appearance and crop excellent.

[z]Soil pH measured in water (1:1). Sampling depth mostly 12 inches with a few samples only to 6 inches.
[y]Soil Ca by the double acid extraction method.

Table 3. Performance of 'Redblush' (RB) grapefruit and 'Pineapple' (PA) sweet orange on selected rootstocks in a trial at Lake Alfred.[z]

Rootstock	Tree survival[y] (%)		Cum. yield[y] (boxes/tree)		TSS/box[y] (lb)		Pineapple juice color number (1988)
	RB	PA	RB (10 yr)	PA (9 yr)	RB	PA	
Swingle citrumelo	100	50	23.1 abc[x]	7.2 bcd	5.4 c-f	6.7 ab	34.9 ns
Citrumelo F80-3	100	50	20.4 abcd	12.7 a	5.3 c-f	5.9 c	34.7
F80-5	100	37	25.1 ab	9.1 bc	5.5 bcde	6.0 bc	33.8
F80-6	100	63	19.3 abcd	7.4 bcd	5.4 b-f	6.3 abc	34.1
F80-8	63	75	15.9 de	7.1 bcd	5.5 b-f	6.2 abc	34.9
F80-14	100	—	20.1 abcd	—	5.6 bcd	—	—
F80-19	100	75	25.9 a	9.6 ab	5.2 def	6.2 abc	33.7
Carrizo citrange	37	75	9.7 efg	8.5 bc	4.7 f	6.0 bc	34.8
Citrange F81-10	63	—	13.5 def	—	5.7 ab	—	—
F81-12	37	37	6.8 g	5.4 cde	No data	6.2 abc	34.8
F81-13	75	37	14.9 de	7.0 bcd	5.2 ef	6.3 abc	34.5

[z]Data are from an experiment planted in 1975 as a randomized complete block with 4 replications of 2-tree plots for each of 22 rootstocks. Spacing: 15 x 20 ft. Tree loss is mainly from cold damage.
[y]As of the 1987-88 season. A box is 90 lb (41 kg) of oranges or 85 lb (39 kg) of grapefruit.
[x]Mean separation within columns by Duncan's multiple range test, 5% level. NS = nonsignificant.

manganese sulfate, zinc sulfate, Fe-chelate mixture and are now normal-sized, healthy, and productive. In flatwoods sites where the level of soil Ca is markedly higher in the surface 6 or 12 inches than deeper in the profile, roots grow out of this zone eventually and Ca-related chlorosis problems may correct themselves. Micronutrient sprays are used by some growers; however, the cost of any cultural program designed to permit the use of Swingle in calcareous sites may not be justified. The trees may survive but not grow or yield well; therefore, until the characteristics of calcareous sites in relation to citrumelo performance are better defined and understood, such sites should be avoided if possible.

Root system. The first study of the Swingle root system was conducted using the 'Valencia' trees at Avon Park (Table 6). Measurements were made of fibrous root distribution and density at the canopy dripline. Roots were found to a depth of 6 ft with about 30% occurring in the surface 12 inches. Root density, as compared to other rootstocks, was significantly lower at all depths supporting the common observation that the Swingle fibrous root system consists mainly of relatively unbranched, coarse roots.

Horticultural performance. The grapefruit trees we observed were large and bearing an excellent crop which is consistent with other information (Table 3; ref. 7). Data from our rootstock experiments (Tables 3-7) and other published reports (4, 8) show that fruit size, in general, is medium to large when trees are grown on Swingle. Juice color and quality are equal to or better than those of fruit from trees on sour orange, Carrizo citrange, and Cleopatra mandarin (*C. reshni* Hort. ex Tan.).

'Hamlin' and 'Pineapple' oranges yield well on Swingle in comparison with other stocks (Table 3, 4). In a flatwoods trial on a soil with a high organic matter content, 'Hamlin' on Swingle and Volkamer lemon (*C. volkameriana* Ten. and Pasq.) had equal cumulative yields (Table 4; ref. 8). The Swingle trees survived well illustrating their phytophthora foot rot resistance.

The tree size of round orange cultivars on Swingle is relatively small. Usually the trees are larger than those on trifoliate orange but smaller than ones on sour orange (Table 2). Round oranges on Swingle bear efficientiy (relatively high yield/unit of canopy volume) but yield/tree is less than for trees on Carrizo citrange or Cleopatra mandarin (Tables 5-7).

The performance of trees on Swingle is influenced by soil type and its water-holding capacity. Trees on Swingle generally appear to grow more vigorously at first, and eventually become large, in flatwoods groves where the soils are more retentive of water than in the well-drained Ridge soils planted to citrus. At one location (Table 1, site 1), trees on Swingle and Carrizo were comparable in size and yield unlike their relative performance at a Ridge site (Table 6). In the 'Valencia' field trial at Indiantown (Table 5), the soil is quite variable and calcareous in many individual tree sites. There has been as much as a 3-fold difference in yield in recent years between the poorest and the best sites for the trees on Swingle.

Grower experience with nucellar navel oranges on Swingle has been very favorable. The trees are vigorous and yield well for this cultivar. Plantings of virtually all of

Table 4. Performance of 'Hamlin' orange on selected rootstocks in a trial at Indiantown (8).[z]

Rootstock	Tree survival[y,x] (%)	Yield (boxes/tree)		Juice Color number[w]
		1986-87	Cum. (4 yr)[y]	
Citrumelo F80-18	100 a[v]	4.0 ab	10.9 a	33.8 abcd
Citrumelo F80-8	48 d-i	2.8 c-i	8.1 bcd	33.7 a-e
Citrumelo 2610 S	85 ab	2.9 c-g	8.2 bc	33.6 a-e
Swingle citrumelo	95 ab	3.8 abc	11.3 a	33.8 abcd
Volkamer lemon	55 c-h	4.3 a	11.4 a	33.7 a-e
Rough lemon	40 e-i	2.3 e-l	7.0 b-f	33.2 e
Sour orange	30 g-i	3.1 b-e	7.6 b-e	33.4 b-e
Precoce de Valence sweet orange	40 e-i	1.8 i-l	5.0 g-k	33.7 a-e
Trifoliate orange	78 a-e	2.9 c-g	8.0 bcd	34.3 a
Troyer citrange	85 ab	3.0 c-f	8.7 b	34.0 abc
(Expt. mean)	60	2.6	5.6	33.7

[z]Data are from an experiment planted in 1979 as a randomized complete block with 8 replications of 5 trees for each of 30 rootstocks. Spacing: 10 x 20 ft.
[y]As of the 1986-87 season. A box is 90 lb (41 kg) of oranges or 85 lb (39 kg) of grapefruit.
[x]Losses occurred largely from tristeza and phytophthora foot rot.
[w]3-yr mean.
[v]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 5. Performance of 'Valencia' orange on selected rootstocks in a trial at Indiantown.[z]

Rootstock	Blight loss[y] (%)	Yield (boxes/tree) 1987-88	Yield (boxes/tree) Cum. (8 yr)[y]	TSS/box[x] (lb)	Juice color number[x]
Rough lemon	27[w]	6.1 ab[v]	31.1 a	6.8 cd	38.5 cd
Volkamer lemon	23[w]	6.5 a	31.8 a	6.9 cd	38.5 cd
Sour orange	0	4.2 def	16.6 bc	7.4 ab	38.8 abc
Cleopatra mandarin	5	4.0 efg	18.3 bc	7.3 ab	39.0 a
Carrizo citrange	13	4.6 cdef	21.3 b	7.6 a	39.0 a
Swingle citrumelo	5	3.0 g	14.5 c	7.2 bc	39.1 a
Trifoliate orange	8	3.5 fg	15.7 bc	7.6 a	39.0 a
Ridge Pineapple sweet orange	2[w]	4.5 cdef	18.9 bc	7.3 ab	38.9 ab

[z]Data are from an experiment planted in 1976 as a randomized complete block with 10 replications of 6-tree plots for each of 12 rootstocks. Spacing: 17 x 25 ft.
[y]As of the 1987-88 season. A box is 90 lb (41 kg) of oranges or 85 lb (39 kg) of grapefruit.
[x]For the 1987-88 season.
[w]Additional losses have occurred from *Phytophthora* damage.
[v]Mean separation within columns by Duncan's multiple range test, 5% level.

the commercial mandarin cultivars have been established on this rootstock. The older commercial groves are approaching 10 yr of age. At the DPI Foundation Grove, there are 15-yr-old 'Murcott,' 'Minneola' and 'Orlando' tangelo, and 'Nova' trees on 2 unnamed citrumelos. These trees have been reasonably productive but generally have not yielded as well as those on Cleopatra mandarin.

Unnamed Citrumelos

The advantages and early commercial success of Swingle citrumelo in Florida have stimulated interest in other citrumelos of potential value. A number of unnamed citrumelos are available in Florida. These hybrids came from the work of Dr. Mortimer Cohen (retired University of Florida professor of plant pathology). When employed by the DPI, he crossed 'Duncan' grapefruit with *Poncirus trifoliata* in the spring of 1955. Selections were made among the resulting plants and serially designated as F-80-1, F-80-2, etc. They are maintained at the DPI Foundation Grove as seed source trees. There are also some citranges made by Cohen. These citrumelos and citranges have been examined for germination and seedling uniformity and vigor. Promising ones are currently under field trial. The data from these experiments, the DPI Foundation Grove, and small commercial plantings clearly show that the citrumelos are substantially similar in their characteristics to those of Swingle (Tables 3 and 4). Trees on the various citrumelos at Lake Alfred survived well after repeated freezes seriously damaged or killed the trees on most of the other rootstocks (Table 3); also, the site is citrus nematode-infested but the trees grew vigorously (Table 3). 'Hamlin' trees on F-80-18 showed excellent survival in a wet site and were very productive (Table 4). Although blight has affected a small number of trees in some plantings, growers are encouraged to test these citrumelos but only in small plantings.

Summary

Florida needs new rootstocks that do not have the same deficiencies, or at least level of risk, as the current commercial stocks. There is little doubt that Swingle and other citrumelos are an improvement regarding 2 presently limiting factors—freezes and citrus tristeza virus. The relative value of citrumelos is also strengthened by their phytophthora foot rot and citrus nematode resistance. Trees on citrumelos produce excellent quality fruit; long-term yield performance and blight tolerance are the principal unknowns. From our observations of essentially 10-

Table 6. Performance of 'Valencia' orange on selected rootstocks in a trial at Avon Park.[z]

Rootstock	Tree survival[y] (%)	Yield (boxes/tree) 1987-88	Yield (boxes/tree) Cum. (8 yr)[y]	TSS/box[x] (lb)	Juice color number[x]
Rough lemon	77 (B,F)[w]	6.7 a[v]	25.0 a	6.2 de	37.6 c
Volkamer lemon	84 (F)	6.3 ab	28.2 a	5.8 f	37.8 bc
Sour orange	100	5.1 cd	19.0 bc	6.4 bc	38.4 a
Cleopatra mandarin	96 (B)	4.7 de	18.2 bc	6.1 bcd	38.3 a
Carrizo citrange	90 (B)	6.0 ab	23.0 ab	6.4 bc	38.5 a
Swingle citrumelo	100	4.1 ef	16.0 c	6.5 b	38.4 a
Trifoliate orange	96 (B)	3.8 i	17.5 c	6.9 a	38.4 a
Ridge Pineapple sweet orange	80 (F)	4.7 de	14.6 c	6.3 bcd	38.4 a

[z]Data are from an experiment planted in 1977 as a split plot trial with 4 replications of the main plot treatment, methyl bromide fumigation. There were 12 rootstocks in 6-tree subplots. Spacing: 15 x 20 ft. Data are averaged across the main plot treatment, which was not a significant factor.
[y]As of the 1987-88 season. Yield not obtained in the 1981-82 season. A box is 90 lb (41 kg) of oranges or 85 lb (39 kg) of grapefruit.
[x]For the 1987-88 season.
[w]Losses primarily from blight (B) or phytophthora foot rot (F).
[v]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 7. Performance of 'Valencia' orange on selected rootstocks in a trial at St. Cloud.[z]

Rootstock	Tree ht[y] (%)	Yield (boxes/tree) 1987-88	Yield (boxes/tree) Cum. (8 yr)[y]	TSS/box[x] (lb)	Juice color number[x]
Volkamer lemon	14.4	7.4	25.7	5.9 g[w]	37.7 h
Sour orange	12.3	4.7	16.9	6.8 bcd	38.3 def
Cleopatra mandarin	13.3	5.6	18.0	6.9 bcd	38.4 cde
Carrizo citrange	13.2	4.8	17.6	6.8 bcd	38.6 abc
Swingle citrumelo	11.5	4.1	15.6	6.8 bcd	*38.7 ab*
Trifoliate orange	10.3	3.0	12.4	7.4 a	38.8 a

[z]Data are from a split plot experiment planted in 1978 with 4 replications of the main plot treatments (irrigation and no irrigation) and 12 rootstocks in 2-tree subplots. There has been no tree loss as of 1988.
[y]As of the 1987-88 season. A box is 90 lb (41 kg) of oranges or 85 lb (39 kg) of grapefruit.
[x]For the 1987-88 season.
[w]Mean separation within columns by Duncan's multiple range test, 5% level. Tree height and yield data for each rootstock were dependent on the irrigation treatment. The data for these variables are the responses with irrigation.

yr-old commercial groves and from our data, Swingle will certainly be a profitable rootstock for grapefruit and can be expected to perform similar to sour orange and Carrizo citrange as a rootstock for sweet orange cultivars. There is no evidence to date that Swingle will not be satisfactory for at least some mandarin scions; however, large plantings are not suggested until more is known about the long-term compatibility of mandarins with citrumelos.

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THE PERFORMANCE OF 'SUNSTAR,' 'MIDSWEET,' AND 'GARDNER' ORANGES

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Abstract. **'Sunstar,' 'Midsweet,' and 'Gardner' oranges, *Citrus sinensis* (L.) Osbeck, were released from the USDA breeding program in 1987. Fruit of these varieties attain processing maturity by mid- to late January but can be held on the tree through March. 'Midsweet' and 'Sunstar' produce approximately the same quantity of fruit and pounds of solids per acre as 'Hamlin.' 'Gardner' produces about the same amount of fruit and pounds of solids per acre as that of 'Pineapple' and 'Valencia.' The net crop value on the tree for 'Midsweet' has been slightly higher than that of 'Sunstar' and 'Hamlin.' The net on-the-tree value for 'Gardner' has been higher than that of 'Valencia' and 'Pineapple.' The juice color number of 'Midsweet' and 'Sunstar' has been about one point higher than that of 'Hamlin' juice, while that of 'Gardner' has been about 1.5 points higher than 'Hamlin.' A freeze in 1986 caused significant defoliation of 'Pineapple' trees but no damage to 'Sunstar,' 'Midsweet,' and 'Gardner.' Fruit drop following the freeze was greatest on 'Pineapple.' Fruit rind creasing was substantial for 'Pineapple' and less for 'Gardner,' while 'Midsweet' and 'Sunstar' showed none. 'Midsweet,' 'Sunstar,' and 'Gardner' should help fill the need in Florida for mid-season oranges for fresh fruit and processing.**

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Materials and Methods

Open-pollinated seeds of numerous cultivars were collected at the USDA Hiawassee Farm near Orlando, Florida, in 1960 and planted in 1961 at the A. H. Whitmore Foundation Farm near Leesburg to establish virus-free nucellar trees. Ten seedlings of each cultivar were planted in the nursery in the spring of 1962, frozen back in December 1962, and, in the fall of 1963, P. C. Reece and C. J. Hearn selected 2 plants considered to be true-to-