Timing of a postbloom spray for melanose control can be expressed more appropriately on a calendar basis than in relation to the time of bloom. If the bloom is earlier than normal, the timing need not be amended because the chances of melanose infection in March, as in April are relatively low. However, in years of late or extended bloom one spray, timed for late-April or early-May, will not provide adequate protection. Late-bloom fruit remain susceptible into July and they will be more severely affected by June attacks than fruit set at the normal time. Therefore, when the bloom is late or unduly extended, 2 postbloom copper sprays are advisable, the first in late-April and the second 3 to 4 weeks later.

The principle of delaying a postbloom copper fungicide for melanose control until late-April or early-May also applies to groves that receive overhead sprinkler irrigation. Such irrigation, even when applied for 12 hr, promotes little or no melanose attack under Florida conditions (Whiteside, unpublished data). Therefore, any effects of overhead irrigation in promoting melanose attack are likely to be negligible compared with the risks of later rainfall-induced infection.

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CITRUS ROOTSTOCKS FOR TREE SIZE CONTROL AND HIGHER DENSITY PLANTINGS IN FLORIDA[1]

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Abstract. **A closely spaced planting of virus-free nucellar 'Marsh' grapefruit** (Citrus paradisi **Macf.) and 'Valencia' sweet orange** [C. sinensis **(L.) Osb.], respectively, on 18 rootstocks was established in 1968 in Candler fine sand, a soil typical of the well-drained citrus-growing sites of central Florida. Rootstock influenced tree growth, fruit quantity and quality and production efficiency calculated as yield/unit of canopy volume or ground area. Trees on all stocks were smaller than those on rough lemon and in some instances had a greater yield/tree. The smallest trees were not necessarily the most desirable nor was it apparent that vigorous stock-scion combinations should be discarded for use in higher density plantings. Rootstocks with promise for use in such plantings were Rubidoux trifoliate orange** (Poncirus trifoliata **Raf.), Rusk citrange** (P. trifoliata x C. sinensis), **Koethen sweet orange x Rubidoux and Rangpur lime** (C. limonia **Osb.) x Troyer citrange. Preliminary data were obtained from a nearby 5-year-old planting of 'Ruby' grapefruit and 'Pineapple' orange trees on 28 rootstocks spaced 15 x 20 ft. Trees on Flying Dragon trifoliate orange, Changsha mandarin** (C. reticulata **Blanco), Rangpur lime x Troyer citrange,** Citrus sunki **(Hort ex Tanaka) x Swingle trifoliate orange and Morton citrange exhibited favorable horticultural performance which in some instances was superior to that of trees on Carrizo citrange.**

A primary objective of the rootstock research program at the Lake Alfred Research Center is tree-size-control (4). Several approaches to this goal, for example, viral dwarfing, and the use of plant material from the genus *Citrus* and related genera as interstocks, are being examined. In addition, conventional field trials to evaluate new rootstocks are also a part of the research effort. The development of plant material and techniques which provide trees of predictable, favorable behavior is an essential element in our tree spacing and management investigations.

The performance of 44 rootstocks presently being evaluated for their effects on tree vigor, yield and fruit quality in 2 separate rootstock experiments is presented in this report.

Materials and Methods

The first experiment consists of adjacent plantings of virus-free, nucellar 'Valencia' sweet orange [*Citrus sinensis* (L.) Osb.] and 'Marsh' grapefruit (*C. paradisi* Macf.) (3). Each planting of the respective scion on 18 rootstocks was set in 1968 as a randomized complete-block design with 3 replications of 4-tree plots. The trees were spaced 10 x 15 ft or 290 trees/acre. The rootstocks (Table 1) were chosen for their previously exhibited dwarfing nature either as a rootstock or as an untested seedling.

Nearly all trees had formed into hedgerows by 1975. Thus, the trees were periodically hedged as needed with a hand-held pneumatic saw. Since 1978, the trees have been individually hedged each year and the fresh weight of the prunings recorded. The trees have also been topped at

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Table 1. Rootstocks included in 2 field experiments planted in 1968 and 1975, respectively.[z]

Rootstock	Abbreviation
1968 Experiment	
Rough lemon (*Citrus jambhiri* Lush.)	RL
Rubidoux trifoliate orange (*Poncirus trifoliata* Raf.)	Rub
Rusk citrange (*P. trifoliata* x *C. sinensis*)	RK
Koethen sweet orange x Rubidoux trifoliate orange	K x Rub
Rangpur lime (*C. limonia* Osb.) x Troyer citrange	R x T
Willits citrange	WC
Citrus sunki Hort. ex Tanaka x Swingle trifoliate orange	S x S
Rangpur lime x Shekwasha mandarin (*C. depressa* Hay.)	
Mandarin (*C. reticulata* Blanco)	
Shekwasha mandarin x rough lemon	
Savage citrange	
Sacaton citrumelo (*P. trifoliata* x *C. paradisi*)	
Ponkan mandarin	
Yutze pummelo (*C. grandis* (L.) Osb.)	
Ichang papeda (*C. ichangensis* Swing.)	
Ichang lemon (*C. ichangensis* x *C. grandis* (L.) Osb. Var?)	
Ichang pummelo (*C. ichangensis* x *C. grandis* (L.) Osb. Var?)[y]	
Glen citrangedin [(*Fortunella* sp. ? x *C. reticulata* var. austera Swing.) x (*C. sinensis* x *P. trifoliata*)]	
1975 Experiment	
Carrizo citrange	Car
Changsha mandarin	Cha
Flying Dragon trifoliate orange	FDT
Jacobsen trifoliate orange	Jac
Morton citrange	Mort
Rangpur lime x Troyer citrange	R x T
C. sunki x Swingle trifoliate orange	S x S
Swingle citrumelo	SwC
Uvalde citrange	UV
F-80-3 citrumelo	F3
F-80-8 citrumelo	F8
F-81-12 citrange	F12
F-81-13 citrange	F13
F-80-5 citrumelo	
F-80-6 citrumelo	
F-81-10 citrange	
F-81-14 citrumelo	
F-81-19 citrumelo	
Golden Ring mandarin	
Kadu Mal mandarin	
Kinokuni mandarin	
Murcott tangor	
Nova [*C. reticulata* x (*C. reticulata* x *C. paradisi*)]	
Tangelo, unnamed	
Tim Shan mandarin	
Citrumelo, unnamed	
Citrange, unnamed	
C. aurantifolia (Christm.) Swingle	

[z]Abbreviations are listed for only those rootstocks referred to in the text.
[y]Ichang pummelo is apparently a misidentified Ichang lemon seedling.

12 ft as necessary; however, topping has been required only in 1979 and 1980 for the most vigorous trees.

Canopy width and height were measured annually until a hedgerow had formed. Thereafter, calculation of tree volume was based upon the tree containment dimensions of in-row tree width (10 ft), tree width between rows (9 ft) and tree height.

The second experiment is composed of adjacent plantings of virus-free 'Ruby' grapefruit and 'Pineapple' sweet orange on 28 rootstocks (Table 1), respectively. The trees were planted in 1975 at a spacing of 15 x 20 ft (145 trees/acre) using a randomized complete-block design with 4 replications of 2-tree plots. Tree width and height were measured in 1980.

Yield/plot was measured annually by volume in both experiments on the basis of the standard Florida field box. Yearly evaluation of juice quality was obtained from samples of 40 oranges or 20 grapefruit harvested from each plot. The last samples in the 1968 planting were taken during the 1978-1979 season. Yield/tree was compared to tree volume and land area/tree as measures of tree efficiency.

The site for each experiment is located near Lake Alfred and is representative of the central ridge citrus-growing region. The trees were managed according to standard cultural practices. The older planting was irrigated by traveling gun and the younger planting with a low volume, under-tree microjet-type system installed at the time of planting.

Results and Discussion

Rootstock had a significant effect on tree size in the 1968 planting (Table 2). Data are presented for the 4 most promising rootstocks plus 3 additional stocks, rough lemon (RL), Willits citrange (WC) and *C. sunki* x Swingle trifoliate orange (S x S) for comparison. Only 'Marsh' trees on RL had reached 12 ft in height at 12 years of age. These trees were topped the past 2 years, whereas trees on Rubidoux trifoliate (Rub), Koethen x Rubidoux (K x Rub) and Rangpur lime x Troyer citrange (R x T), although not statistically different in height, have not required topping. 'Marsh' trees on Rusk citrange (RK), as well as all the 'Valencia' trees, were smaller than those on RL.

Rootstock often affects tree size in a field trial; however, the objective here was to identify productive stock-scion combinations of reduced vigor suitable for higher density planting. Both 'Marsh' and 'Valencia' trees on WC and S x S were comparatively small while the Brix values of the fruit were the highest (Table 3). These apparent advantages, however, are lost when yield is examined (Table 2).

Table 2. Height, yield and production efficiency of closely spaced 12-year-old 'Marsh' grapefruit and 'Valencia' orange trees on selected rootstocks.[z]

Rootstock[y]	Tree height (ft)		Cumulative yield (boxes/tree)[x]		Fruiting efficiency[w] lb/ft³		Fruiting efficiency[w] lb/ft²	
	Marsh	Valencia	Marsh	Valencia	Marsh	Valencia	Marsh	Valencia
RL	12.0 a[v]	11.5 a	19.5 a	10.2 a	0.4 ab	0.2 a	5.1 ab	2.3 a
Rub	11.1 ab	9.8 b	12.6 b	8.7 ab	0.3 b	0.2 a	3.6 b	2.0 ab
RK	10.2 b	9.2 b	16.9 ab	7.4 b	0.4 ab	0.2 a	3.6 b	1.8 ab
K x R	11.1 ab	9.5 b	20.3 a	7.6 ab	0.6 a	0.2 a	6.2 a	2.2 a
R x T	11.1 ab	9.8 b	20.2 a	9.4 ab	0.5 a	0.2 a	5.9 a	2.2 a
WC	5.9 c	6.2 c	3.2 c	4.2 c	0.1 c	0.1 b	0.8 c	1.2 c
S x S	5.2 c	4.6 c	4.0 c	3.9 c	0.1 c	0.1 b	0.6 c	0.7 c

[z]Tree heights, and efficiency calculations, are based on 1979-1980 data.
[y]See Table 1 for the complete list of rootstocks.
[x]Data obtained from the 1973-1980 seasons; 'Valencia' yield data were not obtained in 1973-1974 nor 'Marsh' data in 1976-1977.
[w]Yield/ft³ of canopy volume and yield/ft² of ground area covered by the canopy.
[v]Mean separation within columns by Duncan's multiple range test, 5% level.

These trees were relatively unproductive particularly with the 'Marsh' scion. Their cumulative yield was only about 4 boxes/tree over 6 seasons. Yield ranged from 12.6 to 20.3 boxes/tree and from 7.4 to 10.2 boxes/tree for 'Marsh' and 'Valencia' trees, respectively, on the remaining rootstocks.

Comparison of the data in Tables 2 and 3 emphasizes several factors that are meaningful in evaluating size-controlling rootstocks for possible use in higher density plantings. First, it's important to recognize that the objective stated above is not reached with small tree size per se. Small, less vigorous trees may be conveniently spaced close together, require little, if any, pruning, and be easier to harvest; but, these characteristics are not meaningful if the trees are not productive.

Trees on Rub, RK, R x T and K x R were larger than those on WC and S x S, but, also more productive and efficient. This second factor, efficiency or yield/unit of canopy volume or ground surface area, is necessary in order for small trees to equal or surpass the production/acre of more vigorous, comparably spaced trees. For example, 'Marsh' trees on R x T and K x R had numerically higher cumulative yields and efficiency values than those on RL. This means that the smaller trees on the former stocks produced as much, or more, fruit on an individual tree basis than the larger RL-rooted trees.

The final point concerns the performance of the trees on RL. Trees on this rootstock are normally productive but may not be suitable for use in closely spaced plantings because of excessive vigor. Nevertheless, the 'Valencia' trees on RL were the most productive and the 'Marsh' trees were also among the best yielding ones. This suggests that such combinations should not be arbitrarily dismissed for use in higher density plantings (5). However, the RL-rooted trees are tall and the fresh weight of regrowth removed after each annual hedging has been significantly larger than that for trees on the other stocks (data not presented). Furthermore, the bearing zone of the trees on RL has gradually shifted toward the top of the tree. Perhaps with proper management such trees will have a limited role in higher density plantings; but, smaller, efficient, productive trees have a greater potential. When the production, efficiency and juice quality data were combined, calculations of pounds-solids/acre reveal that trees on Rub, RK, K x Rub and K x T have the greatest overall potential.

The effect of rootstock was also evident in the 5-year-old 'Ruby' grapefruit and 'Pineapple' orange plantings. Despite the young age of the trees, there were marked influences on tree height, yield and fruit quality (Table 4). Trees on Carrizo citrange (Car), a commercial Florida rootstock included for comparison, were tall ('Ruby' — 6.0 ft; 'Pineapple' — 6.6 ft) as were the trees on the other citrange and citrumelo rootstocks. Trees on the remaining stocks were all only 4.6 ft, or less, in height. The smallest trees were those on Flying Dragon trifoliate (FDT) and R x T.

The yield and quality of the fruit for the majority of these trees would not have precluded commercial harvest. Both scions were the most productive (1.5 boxes/tree) on 2 citranges, F13 and Morton, while the yield/tree was generally about 0.5 to 1.0 box for the small trees. Differences in fruit weight were small for 'Pineapple.' Juice content varied from a high of 60.5% [Changsha mandarin (Cha)] to 55.7% (F13) among the oranges and from 57.8% (R x T) to 51.8% (S x S) among the grapefruit. The Brix values for 'Pineapple' fruit were higher for nearly all rootstocks as compared to Car; however, for 'Ruby' grapefruit, the juice of the fruit from trees on Car had one of the higher Brix values.

Any assessment of rootstock potential at this time would be inappropriate because of the young age of the trees. However, certain characteristics of several of the rootstocks should be noted. Flying Dragon trifoliate orange, for example, may be a true dwarfing rootstock (2). Its behavior to date corroborates this description and suggests that trees on trifoliate orange can be successfully grown in the well-drained sandy soils of central Florida. Trees on Morton citrange were not small, but, their performance was superior to those on Carrizo. Trees on R x T tended to have small fruit and were not as productive as desired. This may be the result of their very precocious bearing habit. They set as many as 20 fruit/tree during the second year after planting. Thus, heavy, early fruiting reduced the vegetative growth of the tree resulting in small, weak-appearing trees in some instances. This potential disadvantage may be overcome as the trees in the older planting have grown and fruited satisfactorily. A substantial change in performance with age may also be responsible for the differences among the trees on S x S. Trees on this stock are characterized by small size and fruit of unusually high soluble solids and acid content. Trees in the younger planting appear to be normal and healthy; however, those in the 1968 planting have an unhealthy appearance due, perhaps, to the development of a delayed incompatibility and/or the effects of tristeza. 'Valencia' trees on S x S vary in their susceptibility to tristeza (1), and perhaps, their horticultural performance.

The individual and/or relative performance of any of the stock-scion combinations included in these experiments may change as additional observations are obtained. At the present, though, several rootstocks, particularly R x T, K x Rub, Rub, RK, FDT, and Cha, appear to be promising candidates for closely spaced plantings.

Table 3. Juice quality of fruit from 12-year-old closely spaced 'Marsh' grapefruit and 'Valencia' orange trees on selected rootstocks.[z]

Rootstock[y]	Juice content (%)		Brix		Acid (%)		Brix/acid ratio		Soluble solids/acre (lb)[x]	
	Marsh	Valencia	Marsh	Valencia	Marsh	Valencia	Marsh	Valencia	Marsh	Valencia
RL	46.6 c[w]	57.6 bc	8.7 c	11.1 d	1.38 a	.73 c	6.3 c	15.3 c	5498	3836
Rub	53.3 b	59.4 ab	10.1 b	12.7 bc	1.31 ab	.79 b	7.7 b	16.2 b	4859	4092
RK	56.3 a	61.1 a	10.2 b	13.4 b	1.23 b	.79 b	8.3 a	17.1 a	5179	3900
K x R	53.6 ab	58.6 ab	9.7 b	13.4 b	1.24 b	.78 bc	7.8 ab	17.4 a	7864	5051
R x T	54.6 ab	58.6 ab	9.3 bc	12.3 c	1.26 b	.76 bc	7.4 b	16.0 bc	7608	4092
WC	51.6 b	56.8 bc	11.0 a	14.1 ab	1.36 a	.82 ab	8.1 a	17.3 a	703	1534
S x S	54.2 ab	55.1 c	11.4 a	15.0 a	1.40 a	.86 a	8.2 a	17.5 a	511	831

[z]Data are the mean of the 1975-1976 and 1978-1979 seasons. Fruit weight data not presented because of the absence of statistically significant differences.
[y]See Table 1 for complete list of rootstocks.
[x]Based on 1978-1979 data. Calculations are for a uniform, one-acre planting of each respective stock-scion combination.
[w]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 4. Height, yield and juice quality of 5-year-old 'Ruby' grapefruit and 'Pineapple' orange trees on selected rootstocks.[z]

Rootstock[y]	Tree height (ft)	Yield (boxes/tree)	Weight/fruit (lb)	Juice content (%)	Brix	Acid (%)	Brix/acid *ratio*
			Pineapple orange				
Car	6.6 abc[x]	0.8 abc	.39 n.s.	57.9 ab	13.0 cde	.74 cde	16.9 cd
Cha	3.9 fg	0.5 bcde	.32	60.5 a	15.1 ab	.78 bc	19.3 a
F3	7.3 a	1.2 ab	.41	57.5 ab	12.2 e	.74 cde	16.5 d
F8	5.6 cd	1.5 a	.31	57.7 ab	14.2 abcd	.86 a	16.7 d
F12	5.6 cd	0.6 abcd	.39	57.5 ab	13.7 bcde	.76 cd	18.1 abc
F13	6.2 bcd	1.5 a	.42	55.7 b	12.5 e	.72 de	17.5 bcd
FDT	3.2 g	0.6 abcd	.30	57.3 b	15.6 a	.84 ab	18.5 ab
Mort	5.7 cd	1.5 a	.35	58.5 ab	14.1 abcd	.78 bc	19.3 a
R x T	3.7 fg	0.4 bcde	.33	57.4 b	14.2 abcd	.78 bc	18.3 ab
S x S	4.5 ef	0.6 abcd	.34	58.7 ab	14.5 abc	.78 bc	18.7 ab
UV	4.2 f	0.7 abc	.45	58.6 ab	12.6 cd	.71 e	17.7 bcd
Jac[w]	5.4	0.6	.36	57.6	13.5	.77	17.6
SwC[w]	5.8	0.6	.41	58.0	12.4	.75	16.5
			Ruby grapefruit				
Car	6.0 ab	0.9 abcd	0.86 abc	54.7 abcd	9.3 abc	1.03 cd	9.0 ab
Cha	5.3 abcd	0.5 defg	0.79 bc	56.1 ab	8.9 abc	1.01 cde	8.8 ab
F3	6.6 a	1.3 ab	0.84 abc	56.0 ab	8.6 c	1.02 cde	8.5 b
F8	6.2 ab	1.0 abc	0.92 abc	53.4 bcd	8.5 c	1.01 cde	8.5 b
F12	5.4 abc	0.7 cdef	0.82 bc	52.8 cd	9.5 abc	1.07 bc	8.8 ab
F13	5.8 ab	1.8 a	0.96 ab	52.8 cd	8.5 c	0.95 e	8.9 ab
FDT	4.0 cd	0.8 bcde	0.80 bc	53.7 bcd	9.8 ab	1.04 cd	9.5 a
Mort	5.9 ab	1.8 a	1.06 a	53.6 bcd	8.8 bc	1.02 cde	8.7 ab
R x T	3.8 d	0.8 bcde	0.70 v	57.8 a	9.1 abc	0.97 de	9.4 a
S x S	4.6 bcd	0.9 bcd	0.80 bc	51.8 d	10.0 a	1.11 a	9.0 ab
UV	6.0 ab	0.7 cdef	0.96 ab	52.8 cd	8.9 abc	1.09 ab	8.3 b
Jac	3.8 d	0.6 defg	0.75 bc	55.9 abc	9.5 abc	1.03 cd	9.2 a
SwC	6.1 ab	1.0 abc	0.96 ab	55.0 abc	9.1 abc	1.00 cde	9.1 ab

[z]Based on data from the 1979-1980 season.
[y]See Table 1 for the complete list of rootstocks.
[x]Mean separation within columns by Duncan's multiple range test, 5% level; n.s. = not significant.
[w]Not included in the statistical analysis.

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THE EFFECT OF ADDITIVES ON THE EFFICIENCY OF ABSCISSION-INDUCING CHEMICALS ON 'VALENCIA' ORANGES IN FLORIDA

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Additional index words. Acti-Aid, Pik-Off, Release, Sweep surfactants, buffers, urea, ethephon, CGA 15281, *Citrus sinensis.*

Abstract. **During the past 6 years, several chemicals, buffers, surfactants and ethylene-generating chemicals have been added to Acti-Aid,[1] Release and Pik-Off, and to combinations of these to increase loosening of 'Valencia' oranges [Citrus sinensis (L.) Osb.] grown on the ridge and on the Merritt Island citrus-growing areas of Florida. Most of the additives did not increase abscission chemical activity; however, ethephon and CGA 15281 did increase ethylene in the fruit the first day and fruit loosening after 3 days, but excessive defoliation occurred. Calcium chloride ($CaCl_2$) added to reduce the amount of defoliation reduced the fruit loosening caused by ethephon and CGA 15281. Urea caused increased damage to the rind with abscission chemicals, and generated more ethylene, but not enough to increase 'Valencia' fruit loosening during the nonresponsive period. Triton X-100 and Chevron X-77 were equally effective and consistently increased the effectiveness of abscission-inducing chemicals when compared to other surfactants. Sweep was inconsistent and carboxymethyl cellulose (CMC) was ineffective in prolonging ethylene generation *and in increasing* fruit loosening.**

[1]Mention of a trademark, warranty, proprietary product, or vendor does not constitute a guarantee by the U.S. Department of Agriculture and does not imply its approval to the exclusion of other products or vendors that may also be suitable.