TABLE 3.--*Total* revenues to processors for selected citrus products allocated to the foodstore sector for 1970-71 season under alternative allocation models

Product	Actual 1970-71	Limited Supplies	Unlimited Supplies
	-----millions	of dollars----	
FCOJ	276	259	320
COJ	78	94	108
CSSOJ	30	32	45
TOTAL O.J.	384	385	473
CSSGJ	56	56	65
TOTAL	440	441	538

the FOB level. Thus, one would have to conclude that the available foodstore supplies were extremely well allocated with respect to maximization of FOB revenues. Since grower revenues are simply FOB revenues minus processing, pick and haul and tax costs, we could not expect grower revenues to have increased significantly from reallocation of the 1970-71 crop.

As the industry faces increased supplies in the future, it is interesting to see what additions to revenues can be expected. If orange supplies were such that product could be allocated to the foodstore sector to the point where total consumer expenditures are maximized, we could expect annual processor revenues for orange juice sold to the foodstore sector to reach 473 million dollars (Table 3, column 3). This represents an increase of 89 million dollars over receipts for the 1970-71 seasons. Most of the 89 million dollars would be passed back to the growers. Increased revenues from increased sales of canned grapefruit juice would be approximately 9 million dollars over 1970-71 values.

These figures are of interest in that they are somewhat more optimistic about the future than we had previously thought. Only a few years ago our research indicated that additional orange supplies would result in decreases in grower revenues. Now it looks like we can absorb additional supplies and realize increased returns at the same time. This is an enviable position to be in.

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SWEET ORANGE ROOTSTOCK IN EXPERIMENTAL TRIALS ON THE EAST COAST OF FLORIDA

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Abstract. **Information is presented on the performance of trees on sweet orange rootstock in 11 rootstock experiments ranging from 7 to 22 years of age in St. Lucie and Indian River Counties. Data on comparable trees on rough lemon and sour orange rootstocks are also given for 8 of the experiments. A number of different varieties of sweet orange were tested as rootstocks. In general, fruit yield and pounds of solids per tree on sweet orange were comparable to trees on sour orange but inferior to those on rough lemon. The survival record of trees on sweet orange is somewhat poorer than that of those on sour orange, but better than that of trees on rough lemon. Foot rot was of minor importance in these plantings.**

The ravages of young tree decline and sand hill decline, diseases which particularly affect trees on rough lemon rootstock have given great impetus to the search for new rootstocks for citrus in Florida. Sweet orange, although not really a *new* rootstock, is being considered as a practical substitute for rough lemon. Information is presented in this report on the performance, as rootstocks, of a number of varieties of sweet orange from 11 on-going experimental plantings ranging from 7 to 22 years of age. For purposes of comparison, data from trees on rough lemon and sour orange, where available, are also included.

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Materials and Methods

Most of the plantings reported here are in St. Lucie County but one is located in Indian River County. Tree-by-tree yield records and regular samplings for determination of fruit quality were taken annually for each site with the exception of 'Marsh' grapefruit experiment no. 1 for which no yield records were taken during 1970-71.

Canopy diameter measurements were made with a 30 foot telescoping fiberglass ruler during 1972. Trees were also rated for condition of health during 1972. Plantings on the property of private owners are fertilized, sprayed, and picked at the discretion of the owners. Table 1 provides information on scion variety, location, soil type, and budwood source for each of the *11 plantings.*

Tables 2, 3, and 4 also present data on the age of the planting and the average yield and average pounds of solids produced per tree for both the life of the experiment and for the 1971-72 season. These tables have figures on average canopy diameter of the trees and on a measure of productivity of the various types of trees for each 100 square feet of grove space occupied, called the "yield-area index." The canopy diameter squared is considered to be the grove space occupied by each category of tree. Finally, the tables show the number of trees originally planted in each group as well as trees missing and sick (in decline).

Table 1. Experiments Discussed In This Article

Scion	Experiment	Location of Planting County	Location of Planting Area	Soil Type	Budwood Source
Valencia orange (Tbl 2)	1	St. Lucie	Ag. Res. Center	Leon	Old line
	2	"	"	Parkwood	"
	3	"	"	Leon	"
	4	"	Cloud Grove	Felda	"
Ruby Red Gft. (Tbl 3)	1	St. Lucie	Ag. Res. Center	Leon	Old line
	2	"	"	Parkwood	"
	3	Indian River	Graves Bros	Felda	"
	4	St. Lucie	Ag. Res. Center	Leon	"
Marsh Gft. (Tbl 4)	1	St. Lucie	Shinn Road	Felda	Old line
	2	"	Allapattah Flats	Felda	Nucellar
Pineapple orange (Tbl 4)	1	St. Lucie	Shinn Road	Felda	Old line

Results

Eight of the experiments covered in the tables contain trees on sour orange and rough lemon rootstocks as well as on sweet orange so production on the 3 rootstocks can be compared directly. In 7 of these experiments, trees on rough lemon have outyielded those on both sweet orange and sour orange in both boxes of fruit

Table 2. Performance of 'Valencia' Orange Trees on Sweet Orange Rootstock Compared with Trees on Rough Lemon and Sour Orange Stocks

			Average Production Per Tree								
			For Life of Expmt.		1971-72				Number of Trees		
Expt.	Age (Yrs.)	Rootstock	Yield (Boxes)	Lbs. of Solids	Yield (Boxes)	Lbs. of Solids	Average Canopy Diameter (Ft.)	Yield-Area Index(z)	Planted	Dead	Sick(y)
1	22	Rough lemon	2.1	12.6	2.1	14.8	17.5	0.7	14	1	4
		Sour orange	1.3	9.1	1.2	8.9	15.1	0.6	14	0	0
		Parson Brown	1.5	9.9	1.2	8.3	16.2	0.6	14	0	2
2	22	Rough lemon	3.1	17.3	3.2	21.5	18.1	0.9	8	0	1
		Sour orange	2.2	14.2	1.9	14.8	17.0	0.8	6	0	0
		Parson Brown	2.0	13.1	2.0	15.1	18.1	0.6	9	0	0
3	16	No R.L. or S.O.	-	-	-	-	-	-	-	-	-
		Sweet orange	1.5	9.9	0.9	7.0	15.1	0.7	6	0	0
		Bessie	1.5	10.5	2.0	15.5	15.4	0.6	6	0	0
		Brazilian	1.4	9.2	0.9	6.7	14.8	0.6	6	0	0
		Hamlin	1.3	9.0	1.6	12.4	14.8	0.6	6	0	2
		Mme. Vinous	1.3	9.0	1.1	8.7	14.9	0.6	6	0	1
		Valencia	1.2	8.0	1.5	11.2	14.4	0.6	6	0	1
4	12	Rough lemon	1.5	9.9	1.6	11.9	12.4	1.0	10	0	6
		Sour orange	1.1	7.8	1.6	11.7	12.5	0.7	10	0	0
		Pineapple	1.3	8.7	1.6	11.1	13.6	0.7	10	0	0

(z). Yield-area index is the average yield per 100 square feet of tree-space area as determined by this formula: yield-area index = y/a where y = average annual yield (in boxes) and a = (canopy diameter)^2/100.

(y). Trees in definite decline; those rated 1 or higher on this scale: 0 = healthy to 3 almost dead.

Table 3. Performance of Ruby Red Grapefruit Trees on Sweet Orange Rootstock Compared With Trees on Rough lemon and Sour Orange Stocks

			Average Production Per Tree								
			For Life of Expmt.		1971-72				Number of Trees		
Expt.	Age (Yrs.)	Rootstock	Yield (Boxes)	Lbs. of Solids	Yield (Boxes)	Lbs. of Solids	Average Canopy Diameter (Ft.)	Yield-Area Index$^{(z)}$	Planted	Dead	Sick$^{(y)}$
1	22	Rough lemon	3.4	13.6	3.9	16.2	18.1	1.0	14	0	8
		Sour orange	3.0	13.8	3.7	17.9	16.2	1.1	14	0	1
		Parson Brown	2.8	11.9	2.6	12.5	18.4	0.8	14	1	4
2	22	Rough lemon	5.4	20.8	5.0	22.8	22.3	1.1	6	0	1
		Sour orange	4.3	18.9	5.6	26.9	20.2	1.1	6	0	0
		Parson Brown	4.2	18.1	4.0	19.4	19.5	1.1	6	0	2
3	17	Sour orange	5.1	24.8	9.0	47.9	18.4	1.5	6	0	0
		Bessie	5.3	24.1	9.9	50.7	19.1	1.5	6	0	0
		Brazilian	5.2	24.6	8.5	43.7	18.0	1.6	6	0	0
		Hamlin	4.9	24.0	7.6	38.8	18.6	1.4	6	0	0
		Homosassa	5.8	27.0	8.8	45.8	18.7	1.7	6	0	0
		Mme. Vinous	4.4	20.7	7.8	37.1	18.3	1.3	6	0	0
		Pineapple	5.9	28.0	8.5	43.6	18.8	1.7	6	0	0
		Swt. Seedling	4.7	22.7	7.4	38.7	18.1	1.4	6	0	0
		Swt. Seville	3.3	15.4	5.3	26.5	16.7	1.2	6	0	0
		Valencia	5.5	26.1	9.4	48.3	18.8	1.6	6	0	0
4	16	Swt. orange	3.3	14.5	2.1	10.2	19.0	0.9	4	0	0
		Valencia	3.5	15.3	4.1	19.2	18.2	1.0	4	0	0

(z), (y) - See footnotes under Table 1.

and pounds of solids produced during the life of the planting. Only in 'Marsh' grapefruit experiment no. 2 do trees on sweet orange equal those on rough lemon in average yield and exceed them in pounds of solids produced. On the other hand the longtime production record of trees on sweet orange rootstocks is slightly greater than that of trees on sour orange.

Trees on different varieties of sweet orange have usually performed about the same in comparable plantings.

When production on the different rootstocks for the 1971-72 season is compared, trees on rough lemon are less outstanding than they appear over the life of the experiment. Trees on rough lemon were highest in yield and pounds

Table 4. Performance of 'Marsh' Grapefruit and 'Pineapple' Orange Trees on Sweet Orange Rootstock Compared With Trees on Rough Lemon and Sour Orange Stocks

			Average Production Per Tree								
			For Life of Expmt.		1971-72				Number of Trees		
Expt.	Age (Yrs.)	Rootstock	Yield (Boxes)	Lbs. of Solids	Yield (Boxes)	Lbs. of Solids	Average Canopy Diameter (Ft.)	Yield-Area Index$^{(z)}$	Planted	Dead	Sick$^{(y)}$
		Marsh Grapefruit									
1	12	Rough lemon	6.6	24.3	11.6	48.1	16.7	2.4	10	0	1
		Sour orange	4.0	16.6	8.4	35.9	15.2	1.7	10	0	0
		Pineapple	4.0	16.6	8.7	36.0	16.7	1.4	10	0	0
2	7	Rough lemon	4.4	15.7	7.2	26.9	13.7	2.3	24	0	1
		Sour orange	3.9	16.2	7.2	31.3	14.1	2.0	24	0	0
		Hamlin	4.4	17.8	7.9	32.9	15.2	1.9	24	0	1
		Pineapple Orange									
1	12	Rough lemon	3.3	17.9	3.2	19.3	13.5	1.8	10	0	4
		Sour orange	2.2	12.9	3.5	21.9	12.3	1.5	10	0	0
		Pineapple	2.4	14.5	3.6	22.9	13.2	1.4	10	0	0

(z), (y). See footnotes under Table 1.

of solids in only 4 of the 8 experiments; in the remaining experiments trees on either sweet or sour orange were highest or, in one case, all were at the same level.

Trees on sweet orange are somewhat smaller in canopy diameter than comparable trees on rough lemon rootstock in the plantings under study, but trees on sweet orange rootstock are almost always larger than those on sour orange.

The situation is quite different when trees are compared for efficiency in fruit production as measured by the yield-area index. Here trees on rough lemon are outstanding followed by those on sour orange rootstock. Data in Tables 2, 3 and 4 show that trees on sweet orange stocks are lowest in yield-area index.

Only two of all the trees originally set out in the 11 plantings are now dead but a relatively high proportion of the trees on rough lemon rootstock are now in definite decline. In two cases (Table 2, Expt. 4 and Table 3, Expt. 1) more than half the trees on rough lemon show such decline symptoms. The cause of decline of rough lemon is diagnosed as blight or young tree decline in almost every case. An appreciable proportion of the trees on sweet orange is also in decline in 3 plantings, a decline judged to result from *root rot* rather than blight. Foot rot lesions are present at the base of the 2 trees on sweet orange listed as in decline in Table 3, Expt. 2, but the lesions are too small to account for the stage of decline of the trees and it appears that root rot is involved also.

Decline symptoms are insignificant for trees on sour orange rootstock.

Discussion and Conclusions

In the preceding section an attempt has been made to summarize observations on the performance of trees on sweet orange rootstock in 11 rootstock plantings. Average yield per tree on sweet orange stock was seen to be slightly more than that obtained from trees on sour orange. Tree survival in good condition on sweet orange rootstock was better than on rough lemon although inferior to that of trees on sour orange. These results suggest that sweet orange rootstock can be a reasonable alternative to the more commonly used rough lemon and sour orange.

Previous comparative studies in Central Florida (3, 4), coastal California (1), and South Africa (6) also indicated that sweet orange compared well with most other stocks even though it is not usually the most productive of a series of stocks. An earlier more detailed study of the four 22-year old experiments described here (2), also showed good performance by trees on sweet orange rootstock.

Foot rot on sweet orange stock is usually mentioned as the first objection to its use. It is therefore of special interest that foot rot has been such a minor problem in the 11 rootstock experiments reported here. This should not be interpreted as implying that foot rot will always be a small problem in Florida since the susceptibility of trees on sweet orange is too well documented (5) to be questioned and instances of serious damage by foot rot in some commercial blocks on sweet orange are well known. While much is being learned about foot rot, it remains a sporadic disease whose incidence still cannot be predicted accurately. Nevertheless, with reasonable care, foot rot is more likely to be of minor importance than of major importance in new blocks on sweet orange rootstock.

Sweet orange rootstock has some advantages which have not yet been mentioned. Trees on the stock are tolerant of tristeza and appear much less likely to be affected by blight and young tree decline than trees on rough lemon. A number of successful commercial blocks on sweet orange stock are known in Florida. Sweet orange rootstock also tends to promote high quality in fruit on its budded scions.

Nevertheless, some other characteristics of trees on sweet orange are negative and should not be ignored. Sweet orange seedlings and budded trees on sweet orange are often difficult to handle in the nursery and in the young grove, mainly because the danger of foot rot is greater with young trees. Experience has also demonstrated that trees on sweet orange rootstock usually wilt sooner than trees on most other rootstocks under conditions of low soil moisture. The data on yield-area index revealed, in the plantings studied, that trees on sweet orange rootstock were less efficient fruit producers than trees on either rough lemon or sour orange.

Sweet orange clearly cannot be considered a perfect rootstock but there is no reason to believe that a perfect rootstock exists. Even if a stock could be found which has no present disease or quality problems, horticultural history suggests that difficulties would appear eventually. The periodic appearance of new citrus problems leaves growers with no real alternative to a program of diversification of rootstocks. Diversification can give a measure of security which cannot be provided by any one or two rootstocks.

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EIGHT YEARS OF ROOT INJURY FROM WATER TABLE FLUCTUATIONS

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Abstract. **A grove in Manatee County has been under observation and study because it was one of the first sites where hydrogen sulfide was detected in the root zone during periods of flooding. The periphery of an old pond site in the center of the grove became plugged with iron sulfide restricting flow to ditches. Root kill during periods of flooding correlated with detectable sulfide levels. Hydrogen sulfide was also present above the water table in fragments of palmetto roots and where iron sulfide had been deposited on organic matter in the old pond area. Attempts to improve deep rooting by mixed soil columns indicated that root growth was profuse in columns of alkaline slag gravel and sand. Tree size correlated with rooting depth. Over the 8-year period, drainage per se did not eliminate all root growth problems. Light sandy subsoils in certain blocks acted as physical barriers to root growth and low subsoil pH seemed to restrict deep rooting.**

A 50-acre 12-year-old orange grove on sour orange rootstock in Manatee County has been under long-term observation and study because of root damage associated with flooding. The grove was one of the first sites where toxic hydrogen sulfide was detected in the root zone. The site apparently had been used for vegetable crops prior to grove development as indicated by 150 lb. per acre of copper in the top soil. A 3-acre area, where the soil exhibited particularly poor drainage characteristics (6), was found to be an old pond site based upon soil borings and aerial photographs. The single bedded grove had ditches that were supposed to be 4 ft. deep spaced 320 ft. apart. From 1965 to 1972, ditch depths were shallow—averaging only 3 ft. because of erosion and lack of maintenance. Soil type was predominantly Immokalee fine sand.

The primary purpose for this long-term study was to measure and evaluate hydrogen sulfide as a citrus root toxicant; however, it became apparent that other growth inhibiting factors, not eliminated by drainage, were also present.

Attempts were made to reduce the level of hydrogen sulfide by eliminating sulfates from the fertilizer and by soil applications and injections of sodium nitrate and lime. In laboratory studies (5, 7), nitrates inhibited the production of hydrogen sulfide and liming reduced the destruction of roots during flooding. Fluctuations of the water table, root growth, and characteristics of the soil environment were recorded in an effort to evaluate growth of the trees.

Methods

In 1964, 4-tree plots with 6 replicates for each soil treatment were selected near the poorly drained old pond area of the grove. The study involved 5 nitrate and lime treatments applied in 6 applications from April to September. Treatments and applications for the year were: 1) solutions of sodium nitrate, equivalent to 400 lb. of N per acre, pressure injected through bayonet nozzles to a depth of 2 ft. into the subsoil, 2) hydrated lime, equivalent to 3 tons per acre, injected as a slurry to 2 ft., 3) lime equivalent to 1 ton per acre plus sodium nitrate equivalent to 400 lb. per acre injected to 2 ft.,

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