Experiment No. 4, 1960.—This experiment was designed to test the effect of oil sprays on degreening when applications were made at different times during the summer. One plot was sprayed with parathion as a standard for comparison. Zineb was included in all sprays. The entire crop was picked January 15.

Results.—The effect of 1 per cent oil on degreening as well as final color was demonstrated by this experiment. Fruit from trees sprayed with parathion degreened in fewer hours and was more fully colored than fruit from any of the oil sprayed plots. After 48 hours in the degreening room there was more total shippable fruit from parathion sprayed plots than fruit held 72 hours from oil sprayed plots. There was no difference in color of fruit sprayed between July 1 and August 15, Table 6.

SUMMARY

The results of these experiments show that post-bloom and summer scalicides are necessary to consistently produce tangerines reasonably free of purple and chaff scale, the timing of the summer scalicide is not critical where a post-bloom scalicide has been applied, and 0.5 per cent oil plus organic phosphates are the most effective scalicides. Fruit produced following the low dosage oil sprays has as good color as parathion sprayed fruit and better than fruit sprayed with 1 per cent oil. Degreening is retarded as much with a single summer application of 1 per cent oil as with the addition of a post-bloom application.

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A NITROGEN RATE AND ARSENIC SPRAY EXPERIMENT ON MARSH GRAPEFRUIT IN THE INDIAN RIVER AREA

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Grapefruit in the Indian River area is most profitable to the grower when produced for the fresh fruit market. This generalization is more accurate in the Indian River area than in the Interior, due to the greater distance between groves and canneries. Production practices leading to high fresh fruit pack-out are therefore extremely important. In the State as a whole, about 65 per cent of the fruit run through packinghouses actually is shipped as fresh fruit (9). Small increases in pack-out have been calculated to result in very large increases in grower profit (2).

Quality is determined by a number of factors, including fertilizer practices and the use of arsenic sprays to reduce the acid content of the juice. It is generally believed that the effectiveness of arsenic applications is diminished by the use of high rates of nitrogen.

The purpose of this paper is to present results of a seven-year study of five rates of nitrogen and their interaction with arsenic sprays on the quality and yield of Marsh grapefruit.

METHODS

The experiment was conducted in a reasonably uniform block of trees in the grove of the Indian River Field Laboratory near Fort Pierce. Marsh grapefruit trees on sour orange rootstock had been planted in 1930 on single beds spaced 30 feet apart, with trees 25 feet apart on the beds. The cultural practices used in the grove were fairly typical of those used in the Indian River area and included sprinkle irrigation, a complete spray program, and mowing or infrequent light disking to control vegetation. The trees were also hedged as necessary to provide ready accessibility for cultural operations.

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About two-thirds of the experimental area was classified by the soil surveyors of the University of Florida Department of Soils[1] as Felda fine sand. The remainder was classified as Parkwood loamy fine sand, shallow-phase, or Sunniland fine sand. The soil pH in the individual treatments established ranged from 5.9 to 7.1 in samples taken in September 1955. Exchange capacity of soil samples taken from other experiments immediately adjacent to the nitrogen experiment ranged from 4 to 12 milliequivalents per 100 grams (3). Drainage of the experimental area was only fair, and a study made in this grove in 1953 showed that 75 per cent of the feeder roots were restricted to the upper 16 inches of soil (7).

The experimental area was divided into four blocks based on uniformity of soil within each block. Each block consisted of five, 6- to 9-tree plots, surrounded by buffer trees on all sides. Treatments were assigned to the individual plots at random within each block.

The five nitrogen rate treatments consisted of 0, 1, 2, 3, or 4 pounds of nitrogen per tree per year. All nitrogen fertilizer was distributed by hand to the entire area of the plot except that none was applied in the approximately 6-foot wide strip occupied by the water furrow. For the first year, the nitrogen was applied as ammonium nitrate in three equal applications. Due to difficulty in making uniform distribution of the small quantities of ammonium nitrate involved in such treatment, the schedule was changed for the last six years of the experiment to sodium nitrate equally divided in two applications per year. The first application was made in March 1954 and the treatments continued until after the harvest of the crop of fruit produced from the 1960 bloom.

In three of the six years reported here, arsenic was applied to one-half of the trees in each individual plot. In June 1955 and May 1956 the special spray contained 0.4

[1] The assistance of Ralph G. Leighty in making the soil survey is gratefully acknowledged.

Table 1. The effect of nitrogen rate on yield and fruit quality of Marsh grapefruit over a six-crop period, 1955-1961.

	Pounds Nitrogen per Tree per Year					Statistical Significance[a]
	0	1	2	3	4	
Yield, boxes per tree	4.94	7.02	9.66	8.99	8.43	**
Juice quality						
Soluble solids, °Brix	9.67	9.63	9.19	9.44	9.69	**
Percent acid	1.35	1.31	1.32	1.36	1.44	**
Ratio, Brix to acid	7.23	7.41	7.04	7.06	6.98	N.S.
Percent juice content	44.7	48.2	49.0	48.9	48.6	**
External quality						
Fruit size, grams per fruit[b]	516.	533.	535.	492.	478.	*
Percent green fruit[c]	36.9	46.2	74.9	76.9	79.9	**
Percent coarse fruit[d]	26.7	26.8	26.6	35.4	31.8	N.S.
Percent, longitudinal of transverse diameter[c]	91.5	92.3	91.5	92.6	93.0	N.S.

[a] ** = Significant at 1% level. * = Significant at 5% level. N.S. = Not significant at 5% level.

[b] Five-year average. No data on this point collected 1957-58.

[c] Average of 1955-56, and 1956-57 crops.

[d] Averages of Dec. 1955, Dec. 1956, and Feb. 1959.

pound lead arsenate per 100 gallons. In 1957 no arsenic spray was used, but data were taken on the same half plots to measure residual effect from the prior two years. In May 1958 the same half plots received a spray containing only 0.2 pound lead arsenate per 100 gallons.

Potassium and magnesium were applied as double sulfate of potash magnesia in either two or three applications per year, using a fertilizer distributor. During the first year, the grove received three applications totaling 30 pounds per tree (6.6 lb. K_2O and 5.4 lb. MgO). The next two years, a total of 37 pounds per tree per year (8.1 lb. K_2O and 6.7 lb. MgO) was applied in two equal annual applications. The last three years of the experiment, the annual rate was gradually reduced, averaging 11.2 pounds per tree (2.5 lb. K_2O and 2.0 lb. MgO). The rates used in the first two years of the experiment were intentionally high compared with normal grove fertilization since difficulty was anticipated in maintaining adequate potassium level at high nitrogen rates.

Occasional zinc spray application completed the fertility program.

An over-all application of 1,100 pounds of dolomite per acre was made at the beginning of the experiment and an additional 20 pounds per tree was applied to the plots found to be acid in the surface soil. Subsequently the plots found to be low in surface soil pH were individually treated with dolomite in appropriate amounts on June 11, 1956.

Systematic field observations of the condition of the trees were made at least once per year. Spring flush leaves were sampled in July of each year and analyzed for inorganic elements. Yield was obtained at the time of commercial harvest of the crop, which generally was in late winter each year. Fruit quality determinations were made primarily in December on random samples of fruit.

Results

Yield.—Yield of the trees is given in Table 1. The natural fertility of this soil is indicated by an average production of 4.94 boxes of fruit per year without nitrogen application. Maximum yield was obtained from application of 2 pounds of nitrogen per tree per year. This production was obtained at a nitrogen expenditure of 0.21 pound of N per actual box of fruit produced. Nitrogen applications higher than 2 pounds per tree per year resulted in decrease in fruit production.

Internal Fruit Quality. — All fruit quality data are given in Table 1. The application of 2 pounds of nitrogen per tree per year resulted in lowest levels of soluble solids in the juice. Both lower and higher rates resulted in higher soluble solids.

Acidity of the juice was decreased by the first increment of nitrogen, but was increased by further increments. Juice content was notably low on the no-nitrogen treatment, but was about the same for the other four treatments.

External Fruit Quality.—Fruit size was variously determined as the proportion of fruit smaller than a given size as measured on the tree, the average diameter of the fruit in samples picked for fruit quality determinations, and as average weight of the fruit sampled for fruit quality determinations (Table 1). Judged by all methods of measurement, there was a slight tendency for fruit size to decrease with increasing rate of application of nitrogen.

Green fruit color was so strongly enhanced by high nitrogen rates as to be obvious in the field. This characteristic was measured in a variety of ways, but all methods showed this trend. In Table 1 is shown the percentage of green fruit as determined in the laboratory by comparing all fruits from a large sample picked for fruit quality determination against an individual grapefruit selected to have a moderately good color break but still showing an unsatisfactory degree of degreening for the fresh fruit market. The proportion of green fruit increased drastically between the no-nitrogen and 2-pound rate but above this rate very little further increase in green color occurred.

Coarseness of fruit was measured by examining the fruit individually in the laboratory. Only a very slight coarsening of fruit, evidenced by wrinkling around the stem-end or development of a "shoulder" around the stem was observed to occur as a result of high nitrogen application. There was a pronounced difference between successive years in degree of coarseness.

The fruit were also examined for flatness and these data are reported as the per cent that the longitudinal diameter was of the transverse diameter. Only a very slight de-

crease in flatness was found to occur as a result of increasing nitrogen applications.

Tree Appearance.—In mid-July 1954, four months after the beginning of differential fertilization, visible differences in tree appearance were noted. Trees receiving no nitrogen were both lighter green and thinner in foliage than were trees receiving nitrogen. By June 1955, the tree appearance had become stabilized. Thereafter, the foliage of many of the trees receiving no nitrogen was very thin and yellow. Some trees receiving 1 pound of nitrogen per year also had thin yellow foliage. Trees receiving 2 pounds of nitrogen per tree per year had good foliage density, but were usually only dull green in foliage color. During the entire course of the experiment, there was little difference in the dark green and dense foliage condition of trees receiving 3 or 4 pounds of nitrogen per year.

In addition to severe nitrogen deficiency, some trees in the no-nitrogen and 1-pound plots showed symptoms of molybdenum deficiency (yellow-spot).

Leaf Analysis.—The six-year (1955 to 1960) average mineral analysis of spring flush leaves sampled from non-fruiting twigs in July is given in Table 2. Compared with commercial groves in the Indian River area, nitrogen in leaves ranged from very low to only a moderate level. This result was predictable since low leaf nitrogen was found to be weakly correlated with high leaf calcium in a survey of Indian River grapefruit groves (6). Nitrogen levels in all the plots varied upward or downward from year to year, and the nitrogen rates affected the nitrogen content of the leaves to different degrees in different years. In statistical terms, the effects were 1) very highly significant differences among years, and 2) interaction between treatments and years. Magnesium was found to increase with increased nitrogen application. Potassium declined drastically with nitrogen increase in spite of K_2O-to-N ratios not lower than 1.9 to 1 in the fertilizer program the first three years of the experiment. Phosphorous declined slightly with increase in nitrogen. The effect of treatment on calcium content of leaves was of doubtful significance. All these results are similar to those reported previously (5, 8).

Effect of Arsenic Applications.—In three of the six years reported here, arsenic was applied to one-half of the trees in each individual plot. Data on the fruit produced are given in Table 3. The only practically important or statistically significant change due to arsenic was the decrease in acidity of the juice with consequent increase in the ratio of soluble solids to acidity. Data are presented also for 1957-58, a year during which no arsenic was

Table 2. The average effect of nitrogen rate on leaf analysis over a six-year period.

	Pounds Nitrogen per Tree per Year					Statistical Significance[a]
	0	1	2	3	4	
Nitrogen, percent	1.70	1.93	2.13	2.18	2.25	**
Phosphorus, percent	0.130	0.124	0.123	0.120	0.118	**
Potassium, percent	2.14	1.79	1.66	1.47	1.38	**
Calcium, percent	4.68	4.85	4.87	5.12	4.82	*
Magnesium, percent	0.245	0.294	0.284	0.310	0.33	**

[a] * = Differences statistically significant at 5% level; ** = significant at 1%.

applied. No significant residual effect from two years of previous arsenic applications was noted. In 1958-59, the very low rate of 0.2 pound per 100 gallons had a much less pronounced but still significant effect upon the acidity and the soluble solids-to-acid ratio of the juice. These results suggest that arsenic may be somewhat more effective on Indian River Marsh grapefruit trees than on Interior Florida Marsh trees (1, 4).

In no individual case in any of the three years of arsenic sprays was there found to be a statistically significant interaction between nitrogen rate and arsenic effect on any fruit characteristic. Therefore it was demonstrated that the effect of arsenic was the same at all nitrogen levels employed.

Discussion

This experiment has shown that fruit of most acceptable fresh fruit quality is produced from trees receiving low amounts of nitrogen, but that yield would be limited by low nitrogen rate. Fruit quality was depressed but yield was increased by increasing nitrogen to a rate of 2 pounds per tree. Beyond this rate, no beneficial effect on either yield or any individual fruit quality factor was obtained except a slight increase in soluble solids in the juice. In fact, a detrimental effect on fruit size as well as yield of the trees was indicated.

The optimum rate of application of nitrogen for trees growing under the conditions of this experiment would therefore appear to be not more than 2 pounds per tree per year, and in view of the requirements of the fresh fruit market, the practical optimum would be possibly somewhat less than 2 pounds. At the tree spacing used, this amounts to 116 pounds of nitrogen per acre per year, or 0.21 pound of N per actual box of fruit picked. The figure of 2 pounds N per tree per year corre-

Table 3. The effect of arsenic sprays on yield, and on fruit quality in December.

	Avg. of 1955-6 & 1956-7		1957-8		1958-9	
	Arsenic Spray Application					
	+[a]	-	Residual Effect[b]	Check	+[c]	-
Yield, boxes per tree	12.0[d]	11.8[d]	6.03	6.16	8.00	8.66
Brix, degrees	9.51	9.48	9.52	9.37	9.69	9.59
Acid, percent	1.21	1.41	1.26	1.27	1.45	1.56
Ratio, Brix to acid	7.90	6.75	7.59	7.40	6.69	6.17
Juice percent by weight	46.8	46.8	51.0	50.9	48.0	47.8
Grams per fruit	514.	528.			464.	462.

[a] Sprayed once each year in May or June with 0.4 lb. lead arsenate per 100 gal.

[b] No arsenic application on this crop, but plots sampled as in previous two years.

[c] Sprayed in May with 0.2 lb. lead arsenate per 100 gal.

[d] 1956-57 crop only.

sponds well with results of an experiment carried out in an Indian River Valencia orange grove with similar soil (5).

There exists no entirely satisfactory method of leaf, soil, or fruit analysis by which the nitrogen status of a tree may be satisfactorily determined. The nitrogen status of citrus trees in soils such as used in this experiment is heavily dependent upon weather conditions. It is suggested that Indian River growers compare their current nitrogen programs, for grapefruit groves on soils similar to the one used in this experiment, with the 116-pound figure found to be optimum on this site. If a distributor throwing fertilizer into the water furrow is used, proportionate increase in rate should be considered. Observations on foliage, fruit color, and tree condition will thereafter be the best guide to further adjustment of the nitrogen program in each specific grove. Optimum fresh fruit quality was obtained from trees having only moderate green leaf color, and not those intensely green.

SUMMARY

An experiment concerning the nitrogen fertilization of Marsh grapefruit trees on a hammock soil in the Indian River area was conducted over a seven-year period. The optimum rate of nitrogen under the conditions of the experiment appeared to be approximately 116 pounds per acre per year.

Arsenic was found to be equally effective at all nitrogen rates used in the experiment.

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RECENT DEVELOPMENTS IN PRUNING CITRUS

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Pruning of deciduous fruit trees is a common horticultural practice. However, until recently very little pruning of citrus, other than sprouting or dead wood removal, has been practiced in this country. There has been little research in Florida relative to the responses of mature bearing citrus trees to pruning.

Early work in California by Hodgson (2) with young mature trees indicated pruning to be of dubious value, but he conceded that pruning might be useful in rejuvenating old trees. During the past decade, hedging and topping of lemons and oranges in California have been reported (3, 4) highly beneficial and are becoming a common practice. Rather severe pruning has been intensively practiced on citrus in Spain for many years. Bowman (1) reports that research in Australia showed a favorable response with lemons and mandarins to thinning-out pruning and that citrus trees were successfully rejuvenated by cutting back entire trees to limbs about two inches in diameter.

As Florida plantings have become crowded, as the cost of land has skyrocketed, and as harvest labor has become scarce, the need to investigate the influence of pruning on rejuvenating old trees and on facilitating management and harvesting has become not only apparent but imperative.

The development of the hedging machine by Prosser (6) served as an immediate solution for facilitating grove management and, as pointed by Norris (5), hedging possibly increases yield and external quality of some varieties. However, more research is needed to substantiate this.

In 1958, comprehensive research was initi-

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