dere Grove—the actual work under Mrs. Stebbins' direction was done by an intelligent negro, an experienced "grove hand" not by a high-priced tree surgeon. There is no reason why such a job could not be done by a grove owner or any of his helpers who have had a little experience in propagation.

But it took a person of imagination and initiative like Mrs. Stebbins to forsake the textbook methods and devise a method that would work on old trees that had reached a size where they shaded out the ground almost completely. By planting the seedlings at some distance from the tree trunk a space could be chosen away from the main crown roots thus avoiding the sort of fatal competition that killed off the small seedlings planted close to the base of the trunk. To do this the seedlings used had to be tall and vigorous. Thus, we may owe Mrs. Stebbins a great debt of gratitude to have shown us the way, if ever we are forced to work over our old sour stock groves by the inarching method. Even if we escape the Tristeza menace the method has its application in many old groves suffering from footrot or senescence. A recent inspection of this famous old grove shows these inarched trees in a fairly thrifty condition carrying heavy crops of oranges.

The value and application of the effort that has been made by Drs. Swingle, Webber, Camp, and others to warn us against the serious danger almost at our door must depend entirely on the recognition and use by us of all available measures of protection. One of these measures would seem to be the suggested establishment of nursery grown seedlings of immune varieties immediately available for inarching if the strange disease should gain entrance to our shores. One would not need to wait until the disease actually invaded the grove or until immune seedling stocks could be grown. Better it would seem to be to start inarching at once as a measure of insurance against later disaster.

REPORT ON FERTILIZER EXPERIMENTS IN AN ORANGE GROVE IN THE EASTERN EVERGLADES

W. T. Forsee, Jr. and T.W. Young[1]

The Davie citrus area in which these experiments were located, lies on the eastern edge of the Florida Everglades about 10 miles southwest of Fort Lauderdale. The topography is essentially flat. Drainage is primarily by gravity through a series of lateral canals and two main outlet canals. The water table is held at an approximate average depth of three feet. The surface layer of the soil in most of the area originally consisted of a fibrous sawgrass (Everglades) peat from 18 to 24 inches deep. The citrus trees are planted on broad low ridges or beds built up from a mixture of the top soil and the underlying sand. Due to mixing with the sandy subsoil, oxidation of the organic soil and compaction, the mineral content of the surface layer has increased and the depth of the surface layer decreased in propor-

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tion to the rate of oxidation of the original peaty material.

The soil of the area selected for these experiments was a Davie fine sand, rather typical of that section. The experiments have been described in previous publications (5) (2). The trees, Lue Gim Gong variety, were set in 1929 and the experimental treatments started in 1934. The grove had received only very small amounts of fertilizer during the five-year interim between planting and establishment of the plots.

The experimental treatments initiated in March 1934, consisted of applying 16 different fertilizers with varying N-P-K ratios derived from various sources of base materials to triplicate plots. Only one application was made annually in the spring until 1942. Beginning at this time a second application was made in the fall. Occasional supplemental applications of minor elements were made uniformly over the plots. Yield data were taken each year from 1937 to 1945, inclusive. At the end of this period rooting across the middles between trees under different treatments was beginning to occur. This rendered the plots unsatisfactory for further investigations of this kind. Therefore, the experiments were terminated with the 1945 harvest.

The average yearly weight of fruit produced by each tree for the nine har-

TABLE 1

AVERAGE ANNUAL YIELD OF FRUIT PER TREE FOR THE NINE-YEAR PERIOD COVERED BY THE EXPERIMENT.

No.[1]	Treatment[4]	Average Yield lbs. per tree	Statistically[2] Equal at: 5%	1%
16	3-6-48 (muriate)[3]	285	a	a
7	3-6-24	283	a	a
14	3-6-12 (di-calcium phosphate)	270	a	ab
11	3-18-12 (rock phosphate)	269	a	ab
2	0-12-24[5]	267	a	ab
6	3-6-12	261	ab	ab
12	3-6-12 (colloidal phosphate)	259	ab	ab
13	3-6-12 (basic slag)	257	ab	ab
10	6-6-12	255	ab	ab
1	0-12-12[6]	249	ab	ab
9	3-12-24	248	ab	ab
8	3-12-12	225	bc	bc
5	6-0-12	186	cd	cd
4	3-0-12	160	d	d

[1]Treatment numbers are listed in the order of decreasing yields.

[2]Treatments followed by the same letters are statistically equal.

[3]For the first four years this treatment was a 3-6-12 with potassium carbonate as the potash source. During 1938, 39, 40 and 41 the treatment was a 3-6-24 using muriate. In 1942 the formula was increased to the 3-6-48.

[4]Unless otherwise indicated, P_2O_5 was derived from superphosphate, K_2O from sulfate of potash and N, 1/3 from castor pomace, 1/3 from nitrate of soda and 1/3 from amonium sulfate.

[5]Changed in 1939 from 0-0-12.

[6]Changed in 1939 from 0-0-6.

vests is recorded in Table 1. The treatments are listed in the order of their decreasing yields along with columns showing those treatments that are statistically equal or different at the 5 percent and 1 percent points. Two of the treatments are not included in this discusion because they were changed during the course of the experiment and their yields have no bearing on the over-all results. The effects of treatment on yield may be evaluated from the standpoint of the three elements in the fertilizer that were varied, namely, nitrogen, phosphorus and potassium.

The rates of N in the fertilizers for the various treatments were 0, 3 and 6 percent, derived equally from nitrate of soda, sulfate of ammonia and castor pomace. The presence or absence of nitrogen in the fertilizer had no effect on yield as is evidenced by the fact that there is no statistical yield difference between treatments 2 and 9 or 1 and 8 (Table 1). The general condition of the trees in the no nitrogen treatments was equally as good as in any other treatment. The trees made good growth. Foliage was normal in size, color, density and total nitrogen content. There was no marked difference in the results obtained from the 3 percent and 6 percent nitrogen treatments where phosphate and potash were held constant. Under the conditions of this experiment, no beneficial results were obtained from nitrogen fertilization. Unpublished data from a nitrogen experiment operated four years in an adjoining grove substantiate these findings. In the latter case the plots were on soil ranging from about 14 to 50 percent organic matter. No increase in yield was secured over no nitrogen from light, medium or heavy nitrogen applications applied at various times throughout the year. This was just as true for the plots on the lowest soil organic matter content as those with the higher content.

Superphosphate was used in the various fertilizer treatments at the rates of 0, 6 and 12 percent. Rock phosphate was used at the rate of 18 percent and colloidal phosphate and basic slag at 6 percent, based on the approximate total P_2O_5 contents of the source materials. Phosphate treatment had a very decided effect upon yield (Table 1). The no

TABLE 2
EFFECT OF PHOSPHATE TREATMENT ON ACIDITY, RIND THICKNESS, PREHARVEST DROP OF FRUIT AND NUMBER OF CULLS

No.	Phosphorus Treatment	Citric Acid in Juice[1] Percent	Rind Thickness[1] mm	Preharvest Drop of Fruit[2] Percent	Culls[2] Percent
4	no P_2O_5	1.99	5.03	70	46
6	6% P_2O_5 (Super)	1.50	3.51	20	4
8	12% P_2O_5 (Super)	1.37	3.77	13	7
11	18% P_2O_5 (Rock)	—	—	14	5
12	6% P_2O_5 (Colloidal)	1.67	4.13	25	10
13	6% P_2O_5 (Basic slag)	—	—	27	9

[1]Samples collected 2/8/43.
[2]Average for the 1941, 1942 and 1943 harvest. Percentages calculated on the basis of the number of fruits harvested.

phosphate treatment show the lowest production rank for the nine years. Treatments 8 and 9 which received superphosphate at the highest rate during the entire period of the experiment ranked next to the no phosphate treatments, 4 and 5. This is perhaps due to the large amount of ammoniation on the high phosphate treatments which probably induced considerable early drop of green fruit. This factor will be discussed later. Yields from the slowly available sources of phosphate were all within the range of the best treatments. Dicalcium phosphate was probably more available than the other insoluble sources on this low pH soil. Rock phosphate was applied at three times the rate of the other materials. This may account for the fact that treatments 11 and 14 ranked higher in yield than treatments 12 and 13.

Treatments containing no phosphate or low amounts of available P_2O_5 produced fruit with a higher citric acid content and thicker rinds. Lack of phosphorus also induced a large amount of preharvest drop and the harvested fruit was soft and graded out a higher percentage of culls. These data are included in Table 2. Fruit from the no phosphate treatments was slightly smaller in size, had a rough, coarse texture, was somewhat elongated with a thick, wrinkled stem end and had a coarse structure with large juice sacks and a thick core. These differences with phosphate treatment have been discussed in detail in a previous report (2).

As early as 1941 ammoniation symptoms had become quite evident on treatments 8 and 9 which had received the heaviest superphosphate applications since the beginning of the experiment. The seriousness of this condition increased each year. In 1944 a nutritional

TABLE 3

THE EFFECT OF PHOSPHORUS TREATMENT UPON COPPER ASSIMILATION AS INDICATED BY LEAF AND FRUIT ANALYSES AND UPON THE INCIDENCE OF AMMONIATION IN THE FRUIT.

Phosphorus Treatment		Water Sol. P in Soil, lbs. per Acre	Copper, ppm[2,3]				Amoniation, percent	
Percent	Source		Soil[4]	Leaves[4,5]	Juice	Seed[4]	1944 Crop	1945 Crop[6]
none		4.2	185	9.6	0.57	10.5	0.4	0.12
6	Super	12.9	260	3.5	0.27	11.5	0.3	0.07
12	Super	34.0	263	1.9	0.15	3.4	24.0	0.05
18	Rock	13.5	—	3.6	—	—	0.1	0.00
6	Colloidal	6.3	—	7.7	—	—	0.1	0.01
6	Basic slag	7.6	—	7.1	—	—	0.1	0.04

[1]Based on total P_2O_5 content of source materials used.

[2]Copper analyses were made spectrographically by Mr. T. C. Erwin of the Florida Agricultural Experiment Station, Soils Department, Gainesville.

[3]Numbers recorded are averages of all samples analyzed from each labeled P_2O_5 group.

[4]Oven-dry basis.

[5]Average for two sets of samples representing old and new growth.

[6]Nutritional sprays, including copper, were used for this crop.

spray program including copper was initiated on the entire grove. This practically eliminated ammoniation from the 1945 crop (Table 3).

Since ammoniation is a symptom of copper deficiency, evidence is rather conclusive that the higher amounts of available phosphorus in the soil had interfered with copper assimilation by the trees. The extent and relation of copper deficiency symptoms as evidenced by ammoniation to phosphate treatment in this set of plots has been mentioned by Forsee and Allison (3). Copper analyses made on soil, leaf and fruit samples from certain treatments representing various levels of phosphorus supplied from soluble and insoluble sources are recorded in Table 3 along with the percent ammoniation.

The soil analyses for total copper indicate that the trees on the phosphate treated plots had excess to as much or more copper than those on the plots receiving no phosphorus. However, as the superphosphate treatment increased the assimilation of copper decreased as is evidenced by the copper contents of the leaves, juice and seeds. Leaf samples from the collodial and basic slag treatments show copper values intermediate between the no phosphate and the percent superphosphate treatments while samples from the rock phosphate treatment show copper values approximately the same as the 6 percent superphosphate treatments. This correlates with the water soluble phosphorus contents of the soil (Table 3) and indicates that copper assimilation by the tree is inversely proportional to the amount of active phosphorus in the soil.

In studying soils from rather widely different parts of Florida, Jamison (4) found little difference, by laboratory methods, in the fixation of copper in the presence and absence of superphosphate. In lysimeter experiments on virgin Norfolk fine sand Erwin (1) found that copper in the plant was decreased and copper in the leachate was increased as the phosphorus in the soil was increased up to a certain level. Beyond this level of phosphorus the leaching of copper was depressed. While the data included in Table 3 and the experiments of Erwin (1) definitely indicate that soil applications of soluble phosphorus influence copper assimilation, this influence may be indirect and due to some factor other than straight fixation of copper by phosphate.

At the conclusion of the experiment the trees on the no phosphate plots were smaller and showed much less vegetative growth than the other treatments. The foliage was smaller with a somewhat narrow and stunted appearance. The small amount of phosphate carried by the castor pomace used as a portion of the nitrogen source in the mixed fertilizer and cross rooting between plots probably prevented the appearance of more serious phosphate deficiency symptoms.

Potash treatments during most of the experiment were 12 and 24 percent derived from the sulfate and 48 percent derived from muriate. As shown in Table 1, the two highest average yields were from treatments 1 and 7 (48 and 24 percent K_2O, respectively). These two treatments were consistently good producers throughout the entire period of the experiment. However, where nitrogen and phosphorus were held constant, the differences in yield with respect to potash were not statistically significant. The 48 percent potash treatment produced a relatively high percentage of large, coarse fruits that were somewhat wrinkled and green, particularly around the stem end. Many were slightly misshapen. There was no difference between the various potash treatments with respect to tree growth or appearance so far as could be determined from observation.

The results of this eleven-year experiment may be summed up briefly. On most Davie soils (15 percent organic matter or over) nitrogen is not normally a necessary fertilizer ingredient. Phosphate fertilization is essential to satisfactory production over a prolonged period. The insoluble sources of phosphate may be used if applied at appropriate rates. A moderate amount of superphosphate (equivalent to about 1.2 pounds of P_2O_5 per tree per year on mature trees) gives good results and is safer to use than larger amounts. The level at which potash would become a limiting factor in production is below 2.4 pounds of K_2O per tree per year. It is doubtful that rates of application much above this would prove profitable. Muriate of potash is no more toxic or in any way inferior to other sources of potash.

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A PROGRESS REPORT ON PHOSPHATE FERTILIZER TRIALS WITH ORANGES IN FLORIDA

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There is little published evidence on the effect of phosphate fertilization on citrus production and fruit quality in Florida, although it has been common practice to use mixed fertilizers rich in phosphate almost since the beginning of the Florida industry. Forsee and Neller (10) have reported yield and growth responses of oranges to various phosphatic materials on the organic soils of the eastern Everglades, but there are no recent published data for the sandy mineral soils on which most of the Florida citrus plantings are made.

The purpose of this paper is to present a progress report on two long-term field experiments. Four levels of phosphate fertilization on oranges are compared in

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