aged from 8809 to 9002 pounds per acre.

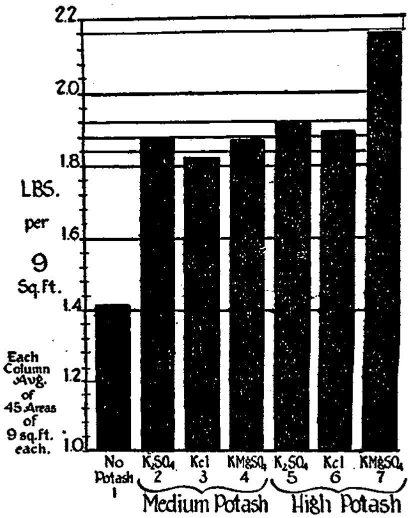
Summary

In an experiment with Valencia oranges, including several sources of potash and varying amounts, the trees which received no potash matured the fruit earlier. The percent of total solids of the juice was higher and the total acidity lower than oranges from trees fertilized with potash. The yields were less and the fruit smaller where no potash was used. The number of leaves were reduced and after three years the trees were not thrifty. Trees receiving potassium chloride gave higher yields and the fruit was larger than when potassium sulphate and potassium magnesium sulphate were used.

In an experiment with Parson Brown oranges, potash applied in the fall only, gave fruit of earlier maturity than potash applied in the spring and summer as well as in the fall. Fruit from the former treatment yielded juice of less acidity and less total solids. The yield and size of the fruit were not materially different.

Average Yield of Volunteer Cover Crop in Pounds per 9 sq. ft. as effected by No Potassium and various Sources and Amounts of Potassium over 1936-1939 Period.

GRAPH VII



THE EFFECT OF ZINC, IRON, MANGANESE AND MAGNESIUM APPLIED TO FRENCHED AND BRONZED ORANGE GROVES, ON THE VITAMIN C CONTENT OF ORANGES

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Introduction

The influence of frenching and bronzing of citrus foliage, attributed to a deficiency of one or more essential plant foods in the soil, on the vitamin C. content of oranges, and the effect of soil applications of zinc, manganese, and magnesium on the composition of the fruit were studied, and the results are reported in this paper. The data are from a few plots of extensive experiments conducted by the Division of Soil Fertility of the Bureau of Plant Industry on Nutritional problems of citrus soils.

In the season 1938-39 and 1939-40, fruit samples were obtained from some of these experiments, and the ascorbic acid content

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of juice from the fruit was determined. In sampling, it was important to observe several precautions in order to keep errors at a minimum. Fruit was taken from corresponding positions on the trees; samples to be compared were obtained at the same time, and a large enough sample was taken (usually 20 or more fruits) to smooth out individual fruit variations*. Comparative samples, too, were composed of fruit from the same bloom as far as it was possible to determine this factor. The vitamin was determined in the juice as quickly as practicable after it was expressed by hand. The actual determination was made on an aliquot taken from the composited juice, by titration, with freshly prepared 2.6 dichloro-benzenone indophenol solution, which had been previously standardized against pure ascorbie acid. (1)

Harding and Winston (3) have shown that the ascorbic acid content of oranges varies with variety, rootstock, and location of the fruit on the tree. Harding, Winston and Fisher (4) have found a general decrease in the ascorbic acid content of oranges during the growing season. Ijdo (5) found that a direct correlation existed between nitrogen and potash applications and the vitamin C content of spinach, but no fluctuations in the vitamin C content of the vegetables were noted when varying quantities of phosphoric acid, calcium or magnesium were applied.

Experiments on Seedling Oranges on Norfolk Fine Sand

An experiment on a seedling orange grove on Norfolk fine sand was made in which soil applications of iron sulfate and zinc sulfate were made in addition to the usual fertilizer applications of nitrogen, phosphorus, and potash, from 1933 to 1935. These treatments are outlined, together with the data in Tables 1 and 2, showing the effect of the iron, and zinc in overcoming the chlorosis of the foliage and the resultant effects on the vitamin C content of the orange juice.

Since 1935 the plots so treated have received no further applications of iron sulfate or zinc sulfate. All plots which were treated with zinc sulfate showed a marked decrease in amount of frenching, when a careful count was made in 1938. Plots receiving amendments of ferrous sulfate showed a sharp decrease in frenching when the rate of application was 4 pounds three times per year, but a much less marked decrease when the ferrous sulfate was applied at one fourth this rate.

The juice from plots treated with zinc sulfate, as shown in Table 2, contained significantly greater amounts of ascorbic acid, the average increase in this factor being about 15 percent greater than in the check plots. The oranges from the plots treated with ferrous sulfate yielded oranges which contained slightly higher levels of the vitamin, but not enough to be significant.

Table 1. Effect of soil application of Iron Sulphate and Zinc Sulphate on Recovery of Orange Trees Affected with Chlorosis, (Frenching).
(Seedling Oranges on Norfolk Fine Sand).

Plot Treatments in Addition to N-P-K 1933 to 1935	No. of Leaves Affected with Chlorosis in 1938
	Percent
None	39.6
Iron Sulphate, 4 lbs. per tree three times annually	1.9
Iron Sulphate, 1 lb. per tree three times annually	21.4
Zinc Sulphate (Average of varying quantities)	1.7

Soil applications of zinc were made at varying levels, and different methods of application, but since the differences in the vitamin content of fruit from the various zinc treated plots were not sufficiently great to be evaluated as separate factors, they were grouped under two headings to correspond with the number of check plots. The first group was composed of plots receiving annually 5 pounds and 10 pounds of zinc sulfate broadcast; the

*Analyses of varience (2) were made of all data, probability differences at the 1 per cent level being considered highly significant; at the 5 percent level of sufficient significance to indicate definite trends.

second group received 10 pounds of zinc sulfate in a trench around the tree, and 10 pounds of zinc sulfate per year, in three applications of 3 1-3 pounds each. Since the mean difference between the vitamin content of fruit from each group of zinc treatments, and that of the check plots is highly significant, it can be stated that the increase can be attributed to the use of zinc sulfate, regardless of amount or number of applications within the limits outlined by the experiment. By contrast, application of ferrous sulfate was not successful in producing a significant increase in the vitamin content of fruit from plots so treated.

Experiments With Parson Brown Oranges On Blanton Fine Sand

The influence of soil applications of magnesium and manganese on the vitamin C content of Parson Brown oranges affected with bronzing was studied. The trees are 25 years old, and the experiment was inaugurated in 1935, at which time bronzing was severe and general over the entire grove. The data showing the effect of the soil applications on recovery of the trees from bronzing are given in Table 3, and the influence of the treatments on the vitamin C content of the orange juice is shown in Table 4. Treatments are outlined in the Tables. A series of plots was treated with soil applications of dolomitic limestone, others calcined magnesium sulfate. The results of these two groups are treated as a unit in presenting the data in this paper. Another series of plots received manganese

Table 2. Effect of Soil Applications of Iron Sulphate and Zinc Sulphate on Vitamin C Content of Oranges from Chlorotic (Frenched) Trees.
(Seedling Oranges on Norfolk Fine Sand).

Plot Treatments In Addition to N-P-K 1933-1935	Vitamin C Content of Juice — Milligrams per Milliliter	
	1938-1939	1939-1940
None (Block 1) /a	.577	.516
None (Block 2) /a	.527	.456
Iron Sulphate (Block 1), /b 4 lbs. per tree, 3 times per year	.532	.505
Iron Sulphate (Block 2), /b 1 lb. per tree, 3 times per year	.588	.505
Zinc Sulphate, (Block 1), /c 5 lbs. per tree, annually, broadcast	.635	.635
Zinc Sulphate, (Block 2), /c 10 lbs. per tree annually, broadcast.	.572	.578
Zinc Sulphate, (Block 1), /d 10 lbs. per tree annually, in trench.	.641	.537
Zinc Sulphate, (Block 2), /d 3.3 lbs. per tree broadcast 3 times per year.	.604	.525

a/ Means of untreated plots = .519: Difference between means = .000.
b/ Means of Iron Sulphate plots = .533: Difference between means = .014.
c/ Means of Zinc Sulphate plots = .605: Difference between means = .086.
d/ Means of Zinc Sulphate plots = .577: Difference between means = .058.
Least significant difference: P.01 = .057.
c and d are highly significant at 1 percent level.

Table 3. Effect of Soil Applications of Dolomitic Limestone, Magnesium and Manganese on Recovery of Orange Trees Affected with Bronzing.
(Parson Brown Oranges on Blanton Fine Sand).

Plot Treatment in Addition to N-P-K 1935 to 1938	Leaves Showing Bronzed Condition in 1938
	Percent /a
None	37.0
Dolomitic Limestone 18 lbs. Annually or Calcined Magnesium Sulfate, 12 lbs. annually	20.9
Dolomitic Limestone, 18 lbs. annually or Calcined Magnesium Sulfate, 12 lbs. annually, + Manganese Sulphate, 6 lbs. annually	17.5

/a Average of 5 replications

sulfate in addition to dolomitic limestone and calcined magnesium sulfate. These likewise are treated as a unit.

When magnesium and manganese together were applied as a soil amendment, a greater amount of vitamin C was found in the fruit, the significance being at the 5 per cent level. Application of a source of magnesium without manganese produced an increase in all but one instance. These data indicate a very definite trend in the vitamin levels of fruit from the treated plots. It should be pointed out that this experiment had been in progress for only two years at the time when the samples were taken, and the deficiency symptoms, while definitely decreased, were not entirely alleviated. The increase in the ascorbic acid content of fruit from the treated plot is very consistent with the decrease in percentage of bronzed leaves. The trends, therefore, which are apparent at the end of two years of corrective treatment, indicate that after more time has elapsed, greater and more significant differences may be expected.

Discussion of Results

It is reasonable to assume that when citrus leaves are abnormal in appearance, due to a deficiency in the soil of a nutrient element, oranges from the trees will be abnormal in some of their characteristics. It has been shown, in the data presented herein, that oranges from "frenched trees" and from "bronz-

Table 4. Effect of Soil Applications of Dolomitic Limestone, Magnesium, and Manganese on Vitamin C Content of Orange Juice from Fruit of Trees Affected with Bronzing. (Parson Brown Oranges on Blanton Fine Sand).

Replicate Block No.	Treatment in Addition to N-P-K 1935-1938	Vitamin C Content of Juice of 1938 Fruit Milligrams per Milliliter
1a	None	.54
2a	None	.55
3a	None	.52
4a	None	.53
5a	None	.50/a
1b	Calcined Magnesium Sulphate, 4 lbs. per tree 3 times per year	.54
2b	Dolomitic Limestone, 6 lbs. per tree, 3 times per year	.58
3b	Calcined Magnesium Sulphate, 12 lbs. per tree, 1 application per year	.56
4b	Dolomitic Limestone, 18 lbs. per tree, 1 application per year	.55
5b	Dolomitic Limestone, 36 lbs. per tree, applied once in two years	.52/b
1c	Same as treatment 1b + Manganese Sulphate, 6 lbs. per year	.61
2c	Same as treatment 2b + Manganese Sulphate, 6 lbs. per year	.58
3c	Same as treatment 3b + Manganese Sulphate, 6 lbs. per year	.55
4c	Same as treatment 4b + Manganese Sulphate, 6 lbs. per year	.56
5c	Same as treatment 5b + Manganese Sulphate, 6 lbs. per year	.52/c

a/ Means of untreated plots = .528: Difference between means = .000
b/ Means of Dolomitic Limestone & Calcined Magnesium Sulphate Plots = .550: Difference between means = .022
c/ Means of Dolomitic Limestone & Calcined Magnesium Sulphate + Manganese Sulphate Plots = .564: Difference between means = .036. Least significant mean difference P.05 = .036.
c is significant at 5 percent level.

ed trees" yield juice containing subnormal amounts of ascorbic acid. It has further been shown, that after the proper remedial measures have been adopted, namely restoration to the soil of zinc in the first instance, and magnesium in the second, after an interval of time, the vitamin C content of the fruit is restored to what might be considered a normal level.

It is worthy of emphasis, however, to consider that the malnutrition effected a decrease in the vitamin C content of the fruit, and that restoration of the proper elements to the tree has enabled it to function in a more normal manner, resulting in a higher amount of vitamin C in the fruit.

Soil applications of sources of magnesium or zinc to groves which did not exhibit the leaf symptoms characteristic of deficiencies of these elements failed to cause any significant increase in the ascorbic acid content of fruit from such treated plots. In a series of "spot tests" involving soil applications of boron, barium, manganese, and iron to trees having apparently normal foliage, when fruit from such plots was analyzed for its vitamin C content, no differences (neither increases nor decreases) were noted, which could be attributed to the soil treatments.

The authors have observed an apparent "lag" in recovery of the vitamin content of the fruit; usually no significant increases in this substance are obtained until at least the second year after corrective treatments are begun. Where a definite trend in vitamin content of fruit is observed at the termination of the second year, it is reasonable to expect the results to have greater significance the following year.

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SOME EFFECTS OF SOILS AND FERTILIZERS ON FRUIT COMPOSITION

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The problem of the wide variation in the quality of Florida citrus fruit has been recognized and discussed for many years. The general opinion here and in the markets would indicate that fruit produced on the heavier type soils is superior to that grown on the lighter sandy type soils. Very little attention appears to have been given the variation in composition of fruit grown under these two widely different conditions. Indeed, a better understanding of the variation in fruit composition should lead to more intelligent treatment of the problem from the standpoint of fruit quality. Although the magnitude of variation in composition of citrus soils is very great, the influence of this variation is greater on foliage than on fruit composition; however, this does not preclude the possibility that small differences in fruit composition are significant in determining fruit quality and maturity.

There are a great many factors beyond our control which produce either good or bad effects in fruit quality. However, those factors