

Sulfur in Fertilizer Programs

long-term studies of influence of sulfur on navel orange production indicate no improvement in yield

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Most of the Washington navel orange production in California is on neutral to slightly alkaline soils.

Results with citrus suggest that the hydrogen or hydroxyl ion concentration between a pH—relative acidity-alkalinity, with pH7 as neutral—of 4.0—acidity—and 9.0—alkalinity—is of little importance in itself. However, in this range, solubility effects are primarily involved, and it has been suggested that if California citrus soils could be made slightly acid, beneficial results would accrue.

In an attempt to determine the influence of increased soil acidity on navel orange production, a series of treatments designed to increase soil acidity were included in a long-term fertilizer experiment at the University of California Citrus Experiment Station.

The first experiment was started on 10-year-old trees. The basic treatment during the first four years consisted of an annual application of one pound of nitrogen—N—with half of it from manure, and one pound each of phosphorus—P205—and potassium—K20—per tree. In the subsequent years, three pounds of N—from manure—and three pounds each of P205 and K20 were applied annually.

Yield of Washington Navel Oranges, as Related to Sulfur Applications. Figures Are Pounds of Fruit Per Tree Per Year.

Period	Treatment					L.S.D.** at 5%
	7 (+S)	14 (-S)	24 (+S)	21 (-S)	L.S.D.** at 5%	
1936-39	134	117	127*	118*	27*	27*
1940-43	220	206	164	203	37	37
1944-47	202	197	159	185	38	38
1948-51	181	160	149	181	39	39

* Before the addition of sulfur.

** To show a difference between treatments, the difference in yields must be greater than these figures.

In addition, one lot of trees received sulfur. Sulfur was broadcast annually in small amounts over the years. The total quantity applied during the years of the experiment was 80 pounds per tree, or 7,200 pounds per acre.

The second experiment was on trees then 22 years old. These trees received three pounds of N per tree annually from calcium nitrate. One lot of trees also received sulfur. Sulfur was broadcast in small amounts annually. The total applied was 50 pounds per tree, or 4,500 pounds per acre. Winter cover crops were grown in all plots of both experiments.

Soil Reaction

The sulfur treatments resulted in a gradual acidification of the soil throughout the rooting zone and show lowering of the pH of the 6"-12" zone. Acidification in depth occurred slowly. The reduction in pH was much slower in the first experiment than in the second. This difference was probably due to the buffering effect of the organic matter added as manure in the first experiment. The organic matter added maintained good soil structure, but in the second experiment—where no organic matter was added—there has been a marked breakdown in soil structure related to the increased acidity. In the first experiment, it was not until after a period of 16 years that any effect was measurable at the three-foot level. In the second experiment, effects of the sulfur on pH at the three-foot level were measurable after five years.

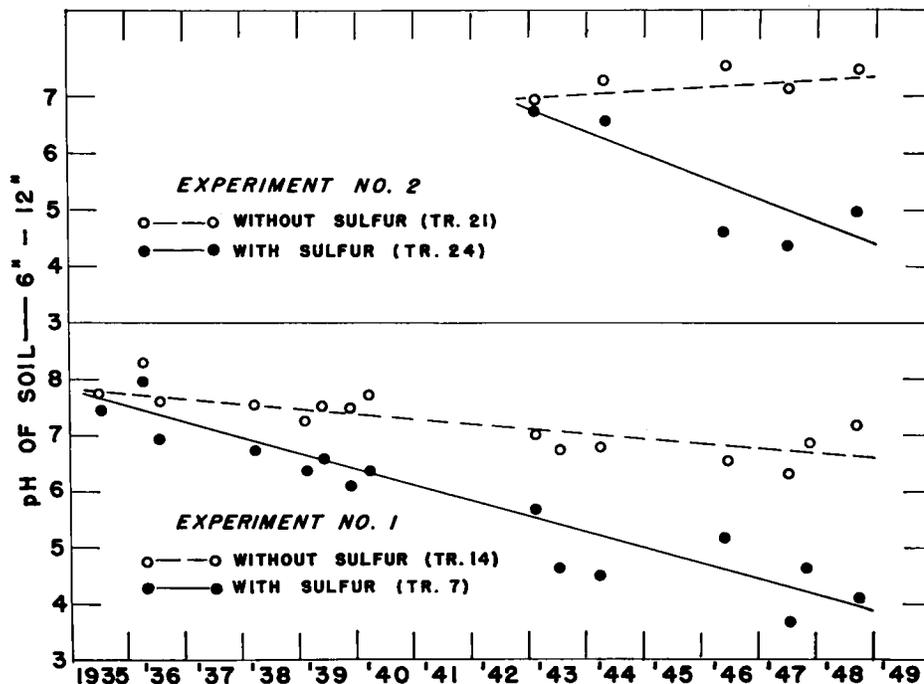
In the first experiment, the soil acidity increased to a depth of three feet in 21 years and to the same depth in 11 years in the second experiment. There is also more total salts, particularly in the surface, in the acidified soils.

Leaf Composition

To determine if soil acidification had produced changes in the mineral composition of the leaves, leaf samples were analyzed. There appeared to be no marked differences in leaf composition brought about by the application of sulfur. There were small differences but they were within the range of normal nutrition and are considered to be of no importance.

Observations in the field show slightly

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VALENCIA

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on June 23, 1952, were: 1,056, 1,219, 1,654, 1,638, 2,215, 2,027, 1,121, and 1,183 grams for cultures Nos. one to eight. The fruit measurements of the Keen sour orange rootstocks showed: 2.24; 2.29; 2.36; 2.26, on Brazilian sour orange rootstock; 2.35; 2.44; 2.50; and 2.26 inches average diameter for cultures Nos. one to eight.

The illustration of Valencia orange fruit shows a comparison of the fruit sizes obtained in three of the cultures—Nos. one, six, and eight. The two fruits—shown to the left—from culture No. 1, the culture solution of which contained no calcium and high magnesium, averaged 70 grams fresh weight per fruit; the two fruits—center—from culture No. 6, the culture solution of which contained 82 ppm calcium and 144 ppm magnesium, averaged 172 grams fresh

weight per fruit; whereas the two fruits—shown to the right—from culture No. 8, the culture solution of which contained high calcium and no magnesium, averaged 64 grams fresh weight per fruit.

The improvement in the root system as calcium in the nutrient solution was increased is seen in the illustration showing the root systems. The depressing effect on the fruit size and on the root condition of very low calcium or magnesium values is clearly shown by the illustrations.

As the calcium in the nutrient solution increased and the magnesium decreased, the fresh weight of the peel as a percentage of the fresh weight of the whole fruit—Keen sour orange rootstocks—shows changes: 35.06; 35.73; 29.24; 30.76, on Brazilian sour orange rootstock; 29.37; 29.92; 27.52; and 29.88% for cultures Nos. one to eight. The fruits from cultures Nos. one and two—those that received a nutrient solution low in

calcium and high in magnesium—had the largest percentages of peel, and some of the fruit of culture No. one—no calcium, high magnesium—were somewhat misshapen and the peel pebbly. The fresh weight of the pulp of an average fruit from cultures Nos. one—lowest calcium, highest magnesium—to eight—highest calcium, lowest magnesium—was: 59.5, 59.9, 94.6, 76.8, 81.3, 87.4, 101.5, and 72.2 grams. Except for culture No. 3 and culture No. 8—highest calcium, no magnesium—a decrease in magnesium and an increase in calcium in the nutrient solution was accompanied by an increase in the fresh weight of the fruit pulp.

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ALKALI

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in several plots failed to germinate, but where the crop did germinate and come through the soil, it usually died before making but a slight growth.

Of the plants mentioned, yellow-blossom sweet clover, tall wheatgrass, and Lemons alkaligrass proved the most rapid in obtaining stands. The alfalfa and alta fescue—although somewhat slower in starting—eventually did a better job of growing than the others, the one exception being tall wheatgrass.

The first year, spotty stands of all five named plants were obtained on the 4-, 8-, and 16-ton gypsum plots. A sparse selection of plants appeared on the 2-ton gypsum plot and no plants germinated on the sulfur or check plots. The first year the plots were watered nine times and by the end of the season the rate of water penetration in the 4-, 8-, and 16-ton gypsum plots was very rapid and the rate of the 2-ton gypsum plot had increased appreciably. The sulfur and check plots had only a very slow water penetration rate, resulting in increased evaporation losses.

During the second season, the plots were all reseeded to Ladak alfalfa. Excellent stands were obtained in all gypsum-treated plots, but a stand could apparently not be obtained in the sulfur or check plots. Although the growth was slower in the 2-ton gypsum plot, a good stand was obtained, and during the third year the alfalfa growth on the 2-ton gypsum plots was as vigorous as the others. But even after three years of leaching on seven different plots, the sulfur applications up to 3,000 pounds per acre show no appreciable benefit. Gypsum

and sulfuric acid appear to be much more economical than sulfur.

Field tests indicate that slick spots will respond more rapidly to applications of sulfuric acid than to equivalent amounts of calcium applied in the form of gypsum. Slick spots should be diked and leached several times prior to planting; otherwise, suitable forage-type cover cannot be obtained.

The table on page 10 shows results of the applications of gypsum and soil sulfur. Two growing seasons occurred between the tests. The figures show that the pH—relative acidity-alkalinity—was reduced considerably by the gypsum applications, and subsequent leaching of the salts is shown by the reduction of conductance values. This is particularly true in the 4- and 8-ton gypsum treatments and to a lesser degree in the 2-ton gypsum application.

On the check plots the salinity increased. This was apparently due to the accumulation of salts from the evaporated irrigation water. All gypsum treatments reduced the per cent soluble and exchangeable sodium, while the untreated plots showed evidence of the per cent sodium increasing.

Little effective reclamation was accomplished by the sulfur treatment. The pH values were lowered very slightly and the salinity reduced a little. No reduction was observed in either the exchangeable or soluble sodium of the soil. Practically no plant growth was obtained, even after three seasons on plots receiving the sulfur treatment, as shown in the illustration on page 10.

The tabulated figures are merely an indication of reclamation. In no instance has reclamation been possible in one year. Generally, at least two years are

needed, and on the worst alkali soils, up to five or six years may be needed. Reclamation is only possible if there are adequate drains so that the salts can be removed by leaching.

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SULFUR

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less manganese deficiency symptoms on the leaves where sulfur has been added, but again this difference is of doubtful commercial importance.

Fruit Production

The final measure of any possible benefit from such treatments, as applied in these experiments, is their influence on yields. The tabulated yields—in four-year periods—show that the acidification of the soil by the use of sulfur in these experiments had no effect on fruit production.

Sulfur has other agricultural uses—such as in the reclamation of alkali soils—but where other nutrients are not limiting and where soil structure has not been greatly affected, the use of sulfur to increase soil acidity has been of no benefit in these experiments.

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