Minor Nutrients of Citrus

effects of phosphorus fertilization on the minor element nutrition of citrus studied with three types of soil series

Frank T. Bingham and James P. Martin

Accumulation of large phosphorus reserves in avocado and citrus soils will reduce the availability of zinc and copper in many California soils to the point of deficiency.

Many growers include applications of phosphorus in their soil management programs, but California citrus soils—depending upon the original status of the soil and subsequent management—may have deficient, adequate, or excessive available phosphorus.

The possible indiscriminate use of phosphorus prompted a program of studies to investigate the effects of excessive soil phosphorus on the minor element nutrition of citrus—copper, iron, manganese, and zinc—using greenhouse technique.

Soils of the Las Flores, Tierra, and Olivenhain series—all are common in the south coastal area of San Diego County—were selected for testing. To avoid fertilized soils, only uncultivated sites were sampled. The soils were placed in three-gallon crocks and treated with monocalcium phosphate in amounts equivalent to no treatment, as a check—0—76 pounds, 360 pounds, and 900 pounds of phosphorus—P—per acre 6".

In one experiment, Lisbon and Eureka lemons budded on Jochimsen grapefruit and Cleopatra mandarin roots were used to test the Olivenhain soil treated with the four levels of phosphorus. The lemon plants were grown six months, harvested, and analyzed.

In a later experiment, copper was added at the rate of 20 ppm—parts per million—copper to one half of each series of phosphorus treatments for the soils. The copper treatment was superimposed since a preliminary experiment demonstrated that copper was made unavailable by large applications of phosphorus. These three soils were cropped for five to six months with sour orange seedlings. At the conclusion of the experimental period, the seedlings were harvested and analyzed.

Lemon Scion-Rootstock

Under conditions of low phosphorus fertility, a large response in plant growth to an application of phosphorus—76 pounds P per acre to budded lemons on Olivenhain soil—occurred only with the Lisbon lemon. The Eureka exhibited a phosphorus response of less than 10% in growth; whereas the Lisbon's growth was increased 50% through fertilization.

Although the rootstock appeared to have no effect on scion growth at low levels of fertilization—under the conditions where large quantities of phosphorus were applied—the rootstock was particularly associated with scion performance. For example, as shown in the lower table on the next page, the Cleopatra mandarin root combination manifested poor growth at lower levels of phosphorus fertilization than the grapefruit root combination. As little as 360 pounds P per acre reduced growth of the Cleopatra mandarin root combinations 50%. Growth reduction of the grapefruit root was only apparent at the highest rate of phosphorus fertilization.

Mineral composition of the lemon tree foliage is especially useful in the interpretation of the growth depression brought about by excess phosphorus. The analysis given in the table, coupled with plant symptoms, shows that large applications of phosphorus have induced a copper deficiency. Each combination

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PESTICIDES

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milk, meats, and similar agricultural produce. It does not include foods that have been processed, fabricated, or manufactured by cooking, freezing, dehydrating, or milling.

Such processed foods will be considered acceptable where raw agricultural commodities—which bear residues exempted from the requirement of a tolerance or which are within the permitted tolerance—are used if *1*, the pesticide residues have been removed to the extent possible in good manufacturing practice and *2*, the concentration of the pesticide in the prepared or processed food sold to the consumer is not greater than the tolerance permitted on the raw agricultural commodity.

Use of pesticide chemicals in storage or transportation is as critical as their use in production of the raw agricultural commodity, and tolerance requirements for a processed food item are the same as for its basic ingredients.

Under the Miller Amendment, tolerances are established or exemptions granted without the necessity of public hearings. The manufacturer or other interested parties may petition for these. Reasonably short time intervals are prescribed for the processing of the petitions by the two governmental agencies involved. On the basis of the information and data accompanying the petition, the Department of Agriculture certifies as to the usefulness of the pesticide chemical for the uses specified and expresses an opinion as to whether the tolerances proposed by the petitioner reasonably reflect the amounts of residue likely to result when the pesticide chemical is used in the manners proposed.

The petition is then reviewed by the Food and Drug Administration of the Department of Health, Education, and Welfare, and its decision with regard to the establishment of a tolerance is announced. Decisions may be appealed to an Advisory Committee, and public hearings or even court reviews may be instituted.

Agriculturists must adhere strictly to the practices recommended for the use of pesticide chemicals. Otherwise, their shipments of produce may be confiscated upon crossing state lines.

The law as amended provides the grower or shipper with the means of controlling pesticide residues on raw agricultural commodities within legal limits without denying him the use of most of the essential pesticide chemicals. At the same time it assures maximum protection for the consuming public.

Several pesticide chemicals have already been exempted from the requirement of a tolerance. Others have built-in safety factors which prevent the retention of any residues, and a great many more—when used as recommended—result in residues below the tolerances now in effect as the result of the 1950 hearings or as the result of petitions submitted under the Miller Amendment.

G. E. Carman is Entomologist, University of California, Riverisde.

J. E. Swift is Extension Entomologist, University of California, Berkeley.

of scion-root manifests a marked reduction in leaf content of copper to the extent that severe copper deficiency occurred. Leaf levels were reduced to less than the four ppm copper concentration thought to be indicative of a possible deficiency. Also, typical symptoms of copper deficiency—gumming, yellow spots on leaves, leaf abscission—were observed in all treatments receiving 900 pounds per acre. The Cleopatra mandarin root combination was more sensitive to the phosphorus-induced copper deficiency. In this case, growth of the scion was materially reduced and severe copper deficiency symptoms were very evident where the soil received 360 pounds per acre. Generally, the phosphorus-induced copper deficiency was somewhat less in magnitude for the grapefruit root combinations, which is in accord with the uptake of copper.

The leaf content of zinc also was somewhat reduced by the phosphorus applications. Large applications of phosphorus were associated with a decrease of leaf zinc of approximately 25%. Furthermore, the concentrations were reduced to the extent that a mild zinc deficiency was likely.

In later experiments with other soils, zinc deficiency patterns were apparent in certain treatments receiving large applications of phosphorus. Extremely severe zinc deficiency has been induced in the field as a result of applying large quantities of phosphorus. Analysis of the foliage of trees from the Irvine test plots reveals that, in addition to zinc, the copper values are extremely low—which coincides with the results from the greenhouse experiments.

The uptake of iron appears to be unhampered by phosphorus fertilization. Possibly manganese is slightly increased. No iron or manganese deficiency patterns were evident.

Sour Orange Seedling

The second experiment was conducted with additional soils treated with phosphorus and with copper applied at the rate of 20 ppm copper on a dry soil basis. Sour orange seedlings were used in these experiments.

In the case of all three soils—Olivenhain, Las Flores, and Tierra—the seedlings responded favorably to a nominal application of phosphorus. In general, plant growth was increased 50% by fertilizing the soil.

In their native state, these soils are deficient in phosphorus and if cropped, would benefit from phosphorus fertilization. However, large applications of phosphorus induced poor growth which was apparently due primarily to copper and, to some extent, zinc deficiencies. Although copper was added, heavy applications of phosphorus caused a reduction in the leaf content of copper. The reduction, in the case of the copper-treated soils, was not to the extent that severe copper deficiency occurred. Comparison of the treated and untreated copper soils showed that the reduction in growth caused by phosphorus was modified considerably by the copper application.

The copper response demonstrates that copper is one of the nutrients primarily limiting growth where large quantities of phosphorus have been used. Copper applications to the sandy Las Flores soils caused the greatest increase in leaf copper concentrations.

Similar to the previous experiment, zinc was adversely affected by heavy phosphorus applications. A mild pattern of zinc deficiency was apparent in some treatments. Manganese and iron were not antagonized by phosphorus.

The two experiments show the possible danger which may arise from the indiscriminate use of phosphorus-containing materials.

The lemon experiment demonstrated that the lemon reacts differently to excess phosphorus, depending upon the rootstock. Therefore, the scion-rootstock combination is also an important factor in the minor element nutrition of citrus.

The research program is being extended to a number of different soils with the objective of developing—in addition to an understanding of the problem—means of determining by soil analysis an excessive accumulation of soil phosphorus.

Frank T. Bingham is Assistant Chemist, University of California, Riverside.

James P. Martin is Associate Chemist, University of California, Riverside.

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Effect of Phosphorus Fertilization on the Growth and Micronutrient Composition of Sour Orange Seedlings Grown in Soils With and Without Copper Sulfate Addition

Soil series	Treatment	Minus copper: Shoot weight	Minus copper: Leaf composition P	Cu	Fe	Mn	Zn	Plus copper: Shoot weight	Plus copper: Leaf composition P	Cu	Fe	Mn	Zn
	Lbs. P/acre	grams	%	ppm	ppm	ppm	ppm	grams	%	ppm	ppm	ppm	ppm
Olivenhain	0	16	0.10	11.0	54	20	20	17	0.10	14.0	54	20	19
	76	30	0.20	8.0	52	22	22	29	0.20	13.0	52	28	22
	360	22	0.24	6.2	44	25	23	22	0.24	9.0	48	22	19
	900	9	0.38	3.8	68	28	15	20	0.24	4.0	38	22	12
Las Flores	0	12	0.06	15.0	58	16	28	13	0.06	18.0	46	24	23
	76	20	0.24	8.0	48	24	25	28	0.19	14.0	47	23	21
	360	16	0.33	3.4	52	28	18	29	0.27	12.0	59	36	18
	900	12	0.38	3.0	64	39	20	20	0.27	10.0	60	47	22
La Tierra	0	25	0.06	13.0	56	18	23	27	0.08	10.0	60	23	25
	76	34	0.18	12.0	64	26	24	38	0.21	10.0	62	23	34
	360	36	0.28	5.5	60	32	14	37	0.23	5.0	58	26	22
	900	25	0.31	3.0	92	69	18	41	0.26	4.5	56	38	15

Shoot Weight and Mineral Leaf Composition of Budded Lemons Grown in Olivenhain Soil Fertilized with 0; 76; 360; and 900 Lbs. P/Acre

Treatment: Scion-Root	Lbs. P/acre	Plant shoot weight	Leaf Composition: P	Cu	Fe	Mn	Zn
		Grams	%	ppm	ppm	ppm	ppm
Lisbon L. x Cleo. M.* ...	0	25	0.10	5.8	83	46	20
" " ...	76	33	0.18	7.0	102	53	19
" " ...	360	19	0.21	3.6	115	43	15
" " ...	900	18	0.29	2.0	98	39	13
Lisbon L. x J. Grft.** ...	0	23	0.12	6.4	93	28	24
" " ...	76	36	0.18	5.8	83	30	20
" " ...	360	33	0.23	3.2	96	36	14
" " ...	900	26	0.23	2.2	115	54	15
Eureka L. x Cleo. M.* ...	0	29	0.10	7.2	110	29	26
" " ...	76	31	0.18	5.2	127	29	23
" " ...	360	22	0.22	2.4	125	38	19
" " ...	900	20	0.26	2.2	112	47	15
Eureka L. x J. Grft.** ...	0	26	0.11	6.2	96	33	22
" " ...	76	29	0.18	5.8	102	32	23
" " ...	360	30	0.17	3.0	126	39	20
" " ...	900	26	0.26	3.6	96	42	16

* Cleopatra Mandarin. ** Jochimsen Grapefruit.