Zinc-Deficient Crops

sweet corn, tomatoes, beans, and sugar beets used in tests for zinc deficiency

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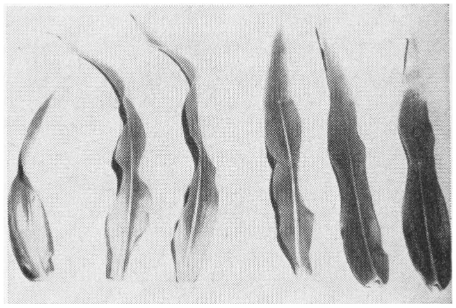
Zinc sprays produced marked yield increases in certain annual crops in so-called sick-spots in Yolo County in 1955.

Recently, annual crops have been shown to suffer from zinc deficiency, which is known to cause mottle-leaf of citrus and little-leaf of deciduous fruit trees. Crops in poor spots on Merritt Island, in Yolo County, have failed for many years to respond to any other fertilizers. However, soil treatments of zinc sulfate, in combination with other micro-element fertilizers—although showing some correction in preliminary tests in recent years—have had erratic results.

Greenhouse experiments were conducted at Davis in the winter of 1954–55. Sacramento loam soil from one of the known poor spots was used with sweet corn as the test crop as research in the State of Washington had indicated that corn is very sensitive to zinc deficiency. Because experience in correcting little-leaf disease in fruit trees has shown that many soils could render large quantities of zinc unavailable to the roots, foliar sprays—which avoid this fixation—were used to apply the zinc.

Incomplete correction of the deficiency was obtained with zinc sprays in initial tests. Foliar symptoms suggested manganese might also be deficient, and a subsequent test—using the same soil and the same crop—showed this to be true. The photograph at the lower left shows the comparative growth of sweet corn in this test. The average crop weights in grams per pot were: check, 121.5; one zinc spray, 194.5; one manganese spray, 213.6; one zinc plus one manganese spray, 266.8. Experiments with tomatoes, snap beans and lima beans gave similar results.

Influence of zinc and manganese sulfate sprays on the growth of sweet corn in zinc-deficient soil.



Left: Zinc-deficient sweet corn leaves. Right: Normal.

Zinc-deficiency symptoms of sweet corn are quite characteristic. Initial symptoms are a light interveinal chlorosis of the older leaves, which rapidly progresses to form a broad bleached stripe—six or more veins in width, between the midrib and leaf margin running from the base toward the tip of the older leaves. Typical zinc-deficient corn leaves are shown on the left in the photograph in column 2. Milo exhibits similar zinc-deficiency symptoms, and severe stunting of the plant often occurs. It was also observed in the greenhouse that tassels of severely zinc-deficient corn plants bore only aborted anthers that produced no pollen. In sand cultures—as shown in the illustration at the upper right—the silks of zinc-deficient corn plants were delayed in emergence until after all pollen had been shed; thus there was little or no pollination. This effect was observed in the field on numerous occasions during the summer.

Zinc-deficiency symptoms on snap and lima beans are alike. At first, small reddish-brown spots about the size of a pinhead appear on the primary leaves; then there is a slight interveinal yellowing in the older trifoliate leaves. Zinc-deficient tomatoes develop a faint interveinal yellowing in the younger leaves, sometimes followed by a slight bronzing of the upper leaf surface. In cases of severe deficiency, along the veins there are small elongated brownish spots which—when they enlarge—cause death of the leaf.

In the field—similar to what is often seen in manganese deficiency—zinc-deficient sugar beets showed stunting at an early age followed by interveinal yellowing of older leaves. Dead spots then developed along the leaf margins and between the veins, with eventual death of the leaf.

Left: Zinc-deficient sweet corn grown in sand culture. Note the absence of silks. Right: Normal sweet corn of the same experiment.

Zinc-deficient crops were observed in several locations near Clarksburg in 1955. The affected areas ranged from one to five acres in size and varied in severity, with transitory symptoms sometimes lasting only a few days. Similar symptoms were reported to be on vegetables in the Chino and Indio areas of southern California.

In field tests conducted in the Clarksburg area in 1955, correction of zinc-deficiency in sugar beets was best obtained by zinc sprays.

The Influence of Zinc and Manganese Sulfate and Chelate Sprays and Soil Applications on the Yield and Sugar Content of Sugar Beets

Treatment	Spray application: Yield tons/acre	Spray application: Sugar content % sucrose	Soil application: Yield tons/acre	Soil application: Sugar content % sucrose
Check	17.7	15.1	17.2	16.8
$ZnSO_4$	34.0	17.1	22.1	17.1
Zn Chelate	32.7	16.2	28.6	17.0
$MnSO_4$	19.2	15.8	18.6	16.8
Mn Chelate	20.5	16.6	22.1	18.1
$Zn+MnSO_4$	33.5	17.3	24.7	17.7
Zn+Mn Chelate	31.4	16.3	26.7	17.4
LSD (5%)	6.9	1.5	6.6	NS
(1%)	9.0	NS	8.6	NS

The zinc and manganese sprays—both as the sulfate and the chelate—were applied just after thinning, as 0.5% solutions. The rate—equivalent to about 100 gallons of solution per acre—was enough to cause the solution to drip from the leaves. Side-dressings were also applied at the same time. Zinc and manganese sulfate were applied at the rate of 50

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pounds per acre, and the chelates at 25 pounds per acre. As indicated in the above table, spray applications were more effective than soil applications, which is probably due to the fixing capacity of this particular soil for zinc. The data in the table also show that no yield increases were obtained by the use of manganese sprays or soil applications.

Similar tests on tomatoes in nearby spots did not materially correct the deficiency troubles—either because the tomatoes did not readily absorb the zinc through the leaves or because some other deficiency existed.

Tests on field corn using spray application indicated much the same response as was found in greenhouse tests. The yields per acre were 121 bushels for zinc sulfate sprays, 12.6 bushels for manganese sulfate sprays, 108 bushels for zinc and manganese sulfate together, and 16.3 bushels for the check. It is apparent that manganese treatments failed to increase yields as they did in the greenhouse.

These tests indicate that foliar sprays may be more efficient than soil applications—in some crops—in correcting certain micro-nutrient deficiencies. The soil can therefore be eliminated as an interfering factor in the absorption of these nutrients. Four pounds of zinc sulfate per acre applied as a foliar spray produced greater yields of sugar beets than did fifty pounds side-dressed. Inasmuch as zinc sulfate is rather expensive, this means that sizable savings in material can be realized. Zinc chelate—because it complexes the zinc inside a large organic molecule which breaks down slowly in the soil, releasing the zinc—was superior to zinc sulfate for soil application. When used in a spray, however, zinc chelate did not appear to correct the deficiency as well as zinc sulfate.

The many factors affecting the absorption of zinc by various crops are being studied.

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because the establishment of adequate stands without disturbing the sod eliminates the hazard of erosion, and stock are able to graze the fields during wet weather with less deterioration of the stand and soil structure than when a seedbed is prepared.

At the time the 1953 sample areas were hand harvested, the forage was separated as rose clover, crimson clover, subclover, and resident annuals. The latter group consisted mainly of broad leaf filaree—*Erodium botrys* Bertol.—wild oats—*Avena fatua* L.—and soft chess—*Bromus mollis* L. In the four fields sampled, the fertilizer increased the proportion of seeded legumes in the forage at the expense of the resident annuals.

Under conditions of low fertility, rose clover was the dominant legume in all four fields. In Fields Nos. *2*, *3*, and *5*, the percentage of rose clover was further increased by fertilization at the expense of the resident annuals. Fertilization increased the proportion of crimson clover in all fields except Field No. *3* where the proportion remained unchanged, but still increased in absolute production since total forage increased. In Field No. *4*, crimson clover became dominant with fertilization because this seed mixture contained twice as much crimson clover as rose clover. Crimson clover did not make a very strong initial showing in Field No. *5* where no seedbed was prepared.

Subclover was present in minor amounts, irrespective of fertilization, in Fields Nos. *3*, *4*, and *5*. The difference in growth habit between the prostrate subclover and the upright rose and crimson clovers placed the subclover at a disadvantage under the management program in those fields involving deferred grazing and seed harvesting. In Field No. *2*—subjected to moderate spring grazing—subclover made more of a showing where fertilized.

An additional series of samples was harvested on May 17–20, 1954, from sites comparable to the 1953 series. Yields of forage were again markedly increased by the phosphorus fertilizer even though no reapplication was made during this season except on Field No. *5*, which received 300 pounds per acre of single superphosphate in 1953 in addition to the initial 150 pounds applied in 1952. Forage production was much improved in Field No. *5* over that of the previous year. Although seeded in sod, Field No. *5* was fully as productive in the second year as Field No. *4*, seeded at the same time but on a prepared seedbed.

Yields on the fertilized strips on Fields Nos. *3* and *4* were less than in 1953, since both were grazed early in 1954 and the harvested samples were a measure of recovery. Grazing on Fields Nos. *2* and *5* was deferred for dry feed in 1954.

The botanical composition data for 1954 are not quite as accurate as those for 1953 since the samples dried somewhat before the separations could be completed, and some shattering resulted. However, several trends are evident. Crimson clover was reduced in Fields Nos. *2* and *3* and remained substantially unchanged on the fertilized areas of Fields Nos. *4* and *5*. This seems to be related to the age of the stand. Rose

Effect of Phosphorus Fertilization on the Botanical Composition of Forage on Range Seeded with Annual Clovers

Field and treatment	Botanical Composition: Harvested May 22–27 1953				Harvested May 17–20 1954			
	Rose clover	Crimson clover	Subclover	Resident annuals	Rose clover	Crimson clover	Subclover	Resident annuals
Seeded and Fertilized, Fall 1951			%			%		
Field No. 2								
Check	16	3	5	76	35	0	1	64
200 lbs/A superphosphate	44	20	10	26	62	0	13	25
Field No. 3								
Check	61	22	2	15	44	4	0	52
200 lbs/A superphosphate	68	22	1	9	57	12	0	31
Seeded and Fertilized, Fall 1952								
Field No. 4								
Check	28	16	5	51	31	8	12	49
150 lbs/A treble superphosphate	26	59	4	11	8	58	6	28
Field No. 5								
Check	22	4	2	72	69	2	1	28
150 lbs/A superphosphate*	36	9	2	53	71	12	0	17

* Additional 300 lbs/A of superphosphate applied in fall, 1953.