Sodium in Lemon Tree Collapse

analyses show high sodium concentrations in the roots of collapsing trees are result of tree condition, not the cause

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An answer to whether high concentrations of sodium found in roots of lemon trees severely affected by decline—collapse—were the cause or the result of the tree's condition was the objective of a series of analyses of root and soil samples.

Thirty-six healthy trees were selected in a block of six-year-old Cascade Eureka lemon trees on grapefruit rootstock growing in a Yolo loam soil, near Goleta, in Santa Barbara County. Some of the trees in the block were collapsing.

All 36 trees appeared to be healthy when a root sample was taken from each in February 1954. Root samples were taken again from the same trees in August 1954. By that time a number of the sampled trees were severely affected by collapse and all trees were rated for collapse.

The samples consisted of roots 1/8″ to 1/2″ in diameter. After they were washed, the bark was removed so there might be separate samples of root bark and root wood. All samples were analyzed for sodium and several of the nutrient elements, so any abnormality in the relationship of one element to another might be detected.

Soil samples were taken from several locations in the 36-tree plot and analyses made to get information regarding the uniformity of the soil in terms of its content of nutrient elements as well as sodium and other salts. A separate soil sample was taken from the 0″–12″, 12″–24″, 24″–36″, and the 36″–48″ soil layers. The first set of soil samples was taken in May 1954 when the trees still appeared to be healthy. Similar samples were taken in October after some trees were severely affected by collapse.

The irrigation water used on the orchard was also sampled and analyzed. It was found to be good water, reasonably low in content of total salts as well as in percentage of sodium.

Concentrations of sodium in root-bark samples from the 36 trees are shown in the graph below. In February 1954, while the trees were still in good condition, the concentration of sodium in the root bark was relatively low. Although the trees varied considerably in this respect, no values approached the 0.3% and 0.4% sodium concentrations previously found in the root bark of severely declined trees. In August 1954 sodium concentrations in the root bark of some of the 36 trees were very much higher than in the previous February, and most of the trees showing large increases in sodium concentrations were those affected by collapse. In only one instance—tree 5, row 21—was sodium concentration above 0.15% found in a tree that appeared to be normal and healthy.

The other elements for which analyses were made were potassium, calcium, phosphorus, nitrogen, magnesium, sulfur, and chloride. In most of the trees

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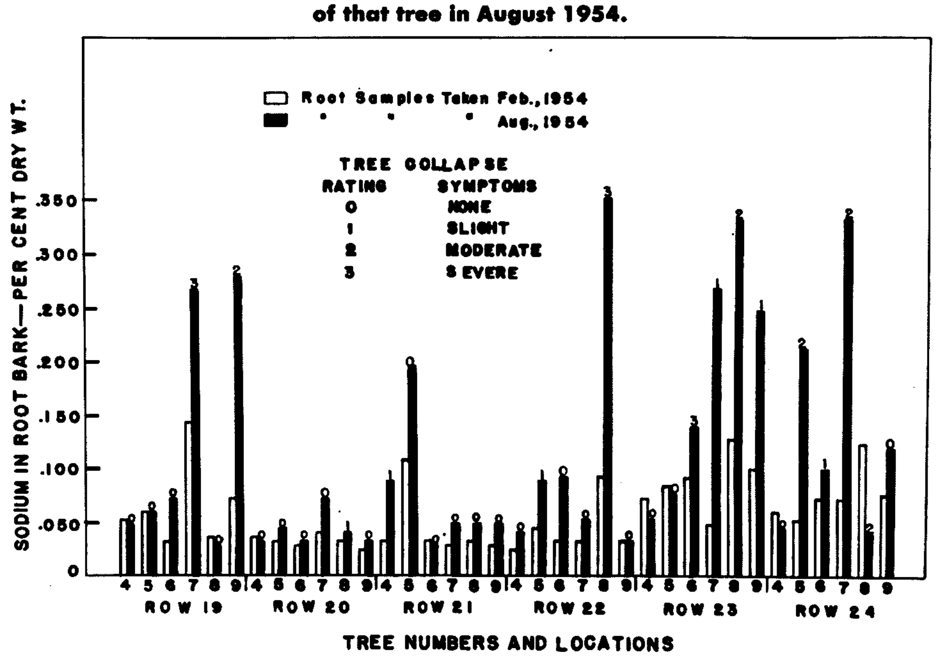
Lemon Tree Collapse Symptoms

Rating	Classification	Description
0	None	Tree normal in appearance
1	Slight	Growth reduced; foliage sparse or yellowish on part of tree
2	Moderate	Growth reduced; foliage sparse and yellowish throughout tree
3	Severe	No new growth; foliage sparse and yellowish throughout tree; some leaves wilted
4	Very severe	Same as 3, but all leaves wilted

Changes in Collapse Rating of Cascade Eureka Lemon Trees on Grapefruit Rootstocks, During a Six Months' Period—February to August—and Associated Changes in Saturation Extract of Soil of Different Depths on Two Sampling Dates—May and October—in 1954

Tree No.	Collapse rating Feb.	Collapse rating Aug.	Soil depth inch	Electrical conductance K x 10³ at 25° C May	Electrical conductance Oct.	Sodium (% of total cations) May	Sodium Oct.
6 (row 23)	0	3	0–12	1.04	0.88	19	26
			12–24	0.47	0.82	45	45
			24–36	0.81	1.11	48	45
			36–48	0.91	1.52	52	55
7 (row 19)	0	3	0–12	0.63	0.74	25	22
			12–24	0.39	0.54	51	48
			24–36	0.51	0.66	54	58
			36–48	0.60	0.74	51	59
8 (row 22)	0	3	0–12	0.74	0.54	23	23
			12–24	0.40	0.42	40	47
			24–36	0.45	0.50	49	56
			36–48	0.37	0.54	46	46

Sodium concentrations in root-bark samples from 36 Cascade Eureka lemon trees on grapefruit rootstock before, February 1954—unshaded bars indicate relatively low concentrations of sodium—and after, August 1954, some trees exhibited collapse symptoms. Number above solid bar indicates the collapse rating of that tree in August 1954.



Chlorine in Plant Nutrition

experiments with plants in nutrient solutions establish chlorine as a micronutrient essential to plant growth

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A severe nutritional deficiency disease occurred in tomato plants growing in experimental cultures after chlorine was removed from the nutrient solutions.

Although the major portion of subsequent investigations with chlorine was with tomato, other species—particularly lettuce and cabbage—also have shown acute nutritional disturbances within a few weeks after transplanting seedlings to culture solutions lacking chlorine. Therefore, the studies of chlorine nutrition as revealed by the tomato plant are believed to have general implications for plant nutrition.

The nutritional disease in its severe state resulted in the yellowing of the leaves—chlorosis—and finally death—necrosis—of leaf tissue itself. Growth was exceedingly restricted and plants would not set fruit. Additions of chlorine as chloride to the culture solutions prevented the disease, and severely chlorine-deficient plants resumed growth after chlorine was supplied.

The experiments were well enough controlled so that the addition of one micromol of chloride ion per plant was accurately manifested by a delay of symptoms for an additional week beyond the one required for symptoms to appear in plants grown on the low halide purified cultures. At these latter levels, the addition of 10 micromols of bromide ion per plant delayed part but not all of the symptoms. Neither iodide nor fluoride ions appeared to be of consequence, with the role of iodine being very difficult to assess because of its toxicity.

From the experimental observations it was concluded that chlorine is a nutrient element—certainly the natural halide—and that it is to be classed with the micronutrient elements. It also appears certain that bromine can complement chlorine as a plant nutrient, which at the moment is reminiscent of the sparing effect of sodium for potassium. The possibility of some higher amount of bromine being able to completely supplant chlorine must remain open for further investigation, but at the moment this possibility seems remote.

Because chloride-deficient plants can be produced and chemical analyses can be made of them, it is possible to make positive statements of their agronomic requirements and to express them in practical terms. Dried tomato plants suffering from chlorine deficiency have about 200 parts of chlorine per million parts of dry weight. The concentration is not greatly different for the stems, roots, or leaves. Thus for each ton of dry tomato plant produced, a minimum of 200 grams of chlorine would be required.

Exclusive of plant functions, it is a fact of soil chemistry that chloride ion acts like nitrate in many respects. Nitrate is highly mobile in soils and is easily leached away—particularly under conditions of high rainfall—and this characteristic becomes a matter of concern for practical problems of nitrogen fertilization. Neither nitrate nor chloride ions are fixed by soil colloids. Actually both of them are repelled, a phenomenon referred to as negative absorption. As a result, it would be expected that soils leached with completely salt-free water could retain their chlorine or nitrate nitrogen for only a relatively short period of time. There are several natural agencies responsible for replacing nitrogen to the soil, and most of the soil nitrogen is extracted from the atmospheric reservoir by electrical storms, and free living or symbiotic micro-organisms. With chlorine, some other method must be responsible.

On the basis of chlorine being a micro nutrient element, it is assumed that soil chlorine must be continuously resupplied to soils. Otherwise, higher green plants such as the tomato would not survive.

It seems clear that the atmosphere—as a natural distributing agency—transports large quantities of chlorine, originating from the ocean, to be deposited on soils with rain and snow, and carried back to the ocean by rivers.

The chlorine content of rain water is known to be highly variable. It is greater near the seacoast and lessens rapidly inland. Also, there are differences between rains in the same area. Therefore, there is the possibility that some rains could have too little chlorine to meet optimal needs for plant growth.

An important question—which may not be answered for some time to come—is whether there are actually land areas where chlorine is sufficiently limiting to be of economic importance in plant growth, or whether as a natural condition the distribution of chlorine by the atmosphere will always provide adequate chlorine.

Chlorine has been regarded as an element frequently accumulating in undesirable quantities—particularly in semiarid regions—so its removal to the seas along with other excess salts constituted a problem. However, there might be other agricultural areas, where chlorine additions would be of benefit to crops because of less than an adequate supply from natural sources.

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SODIUM

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that had high concentrations of sodium in the root bark in August, the concentration of chloride was also higher and the concentration of potassium was lower than in the previous February. However, these differences were not so large or so consistent as the differences in sodium concentrations.

There were no changes in concentrations of calcium, phosphorus, nitrogen, magnesium, and sulfur which were associated with changes in condition of the trees. The sodium concentrations in the root wood samples were also much greater in the August samples than in those taken in February but the concentrations were not so high as in the root bark.

The analyses of soil samples taken from the 36-tree plot are presented in the table on page 4. The total amount of salt in the soil was low in all samples. The conductance values of the saturation extracts in most cases were less than 1.0 millimhos per centimeter. Previous studies have shown excellent growth and production of citrus in soils having salinity levels of this low amount.

When the May 1954 soil samples were taken, the adjacent trees appeared to be healthy. However, as indicated by the August ratings, the same trees had developed severe symptoms of collapse be-

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