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 semi-arid 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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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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