Characterization of the Plant Factor in the Cation Requirement and Contents of Plants

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Although advances in our knowledge of the mineral nutrition of plants have been made, we are unable to explain satisfactorily the mechanism whereby two different plant species, growing under the same soil conditions, absorb cations in different amounts and proportions. We are somewhat more certain as to the factors responsible for differences in the mineral content of one plant species when grown on different soils. Differences in the first category are associated with the metabolic activities of plants; the second are associated with concentrations, activities, and distribution of cations in the soil. Thus we encounter a host of variables which render it difficult to isolate soil effects and physiological effects. While it is possible to measure many of the soil properties which may affect the cation content of plants, we have no satisfactory method whereby the plant differences contributing to this can be measured. We speak of them in general terms such as metabolic or respiratory activity, "feeding power", Ca requirements, and so forth. An attempt has been made recently, therefore, to formulate some means by which different plant species may be characterized from the standpoint of their proportionate uptake of cations and their cation content (6)\(^3\). Further studies pertaining to this plant factor have been made and are being considered in this paper.

EXPERIMENTAL

Cotton and soybeans were grown side by side in rows in large terra cotta tanks outdoors in a Portsmouth fine sandy loam. The exchangeable Ca ranged from 3 to 64% saturation. The tanks were seeded on May 24 and harvested on August 22, 1947. Three replications were used. The dry weights were then taken and the plants were analyzed for Ca, Mg, and K, following conventional procedures. Exchange properties of the soil were determined according to a procedure described elsewhere (4).

In a greenhouse experiment six species of plants (turnips, cotton, soybeans, cowpeas, oats, and wheat) were grown in a bentonite-sand mixture contained in 1 liter percolator cylinders. Only one level of Ca was used. The plants were seeded on March 24 and harvested on April 26, 1948. Four replications were used. The plants were analyzed for Ca, Mg, and K.

RESULTS AND DISCUSSION

The dry weight and cation content of cotton and soybeans grown on the Portsmouth soil are given in Table 1. The results show that cotton requires a very much higher degree of Ca saturation for optimum growth than soybeans. Cotton takes in its Ca mostly at the lower levels of Ca, whereas soybeans increase but slightly. Magnesium and K in both species of plants decreased with increasing degree of Ca saturation, except at the higher levels in soybeans. The Ca content in cotton to obtain Ca at the low level of Ca saturation had little effect on the cation content. The Ca content in soybeans increased but slightly. Magnesium and K in both species of plants decreased with increasing degree of Ca saturation. For the same soil treatments the Ca content in cotton was doubled when the Ca in the soil was increased from 3 to 64% saturation. For the same soil treatments the Ca content in soybeans decreased but slightly. Magnesium and K in both species of plants decreased with increasing degree of Ca saturation, except at the higher levels in soybeans. The Ca content in cotton to obtain Ca at the low level of Ca saturation had little effect on the cation content.

Irrespective of the exact mechanism by which cations are absorbed by the plant, it seems rather that H ions are involved in the mobilization of exchangeable cations. In fact, Vageler (seen in Science, page 124) classified plant species on the basis of their H ion producing capacity. Conceivably, the higher the concentration of H ions the greater the mobilization of cations and the greater the proportion of cations that are held more tightly absorbed by the soil colloid. Ca, for example, is held more tightly than K. Hence, if the concentration of H ions is greater in the zone at the root surface-soil colloid interface, it will be dominated by K ions, with relatively fewer H ions present. With progressively higher concentrations of H ions the total release of cations will increase, and relatively more Ca ions will take part in this equilibrium. This is in agreement with the results between cotton and soybeans shown in Table 1. It is likewise in agreement with chemical release data presented previously (6).

Further data pertaining to the probable role of H ions in the mobilization of cations as reflected by plant position are shown in Table 2. The plant species are arranged in decreasing order of their Ca content. If the species are arranged in this manner, there is a tendency for cotton to fall in the same order also. With respect to Ca absorption, a major differentiation can be made only between cotton and the other plant species. By taking Ca absorption into account, a definite decrease in the same order is indicated. On the basis of these results it is assumed that turnips, for example, have a greater ability to mobilize Ca into the plant than has cotton or wheat.

To obtain a measure of the relative ability of different species to mobilize Ca into the plant, it is desirable to take into account the total contents of cations in the plant, as well as the amount of Ca in the plant. The plant differences contributing to this can be measured. We speak of them in general terms such as metabolic or respiratory activity, "feeding power", Ca requirements, and so forth. An attempt has been made recently, therefore, to formulate some means by which different plant species may be characterized from the standpoint of their proportionate uptake of cations and their cation content (6)\(^3\). Further studies pertaining to this plant factor have been made and are being considered in this paper.