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Analysis of the process of anion uptake of intact maize plants

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on the growth of the shoots as well as on the roots, and as a result of this hormonal influences on the uptake are possible. It is quite unknown how far such influences exist e.g. on the secretion into the vessels, and in what way ions stored in the vacuoles are liberated and made available to the shoots also remains an unsolved problem.

As was admitted this scheme is speculative. It is given in order to obtain a preliminary review of the salt relations of the intact maize plants. At the same time it may serve not only to show how complex the uptake by intact plants may be, but also to illustrate that, except for the absorption problem in its strict sense, there remain many typical physiological problems concerning the salt uptake of higher plants.

V. SUMMARY

In all experiments sets of intact maize plants were used, high salt as well as low salt ones. As a rule the phosphate uptake was determined and occasionally the nitrate uptake. In some experiments the growth was determined by tracing the development of the shoots.

The starting point was the examination of the course of the uptake of phosphate and the growth in light and darkness. Initially the uptake increases in light, in particular with low salt material. But with an intensive illumination the uptake by high salt material also increases. After some days a constant level is attained. In darkness the uptake decreases. The extent to which this occurs with low salt material depends on the degree in which the plants have been turned into a high salt condition. This can be regulated experimentally by the use of various concentrations.

The growth of the shoot increases mostly only a little during the first days of an experiment. Afterwards it remains at a constant level but shows a typical day and night rhythm in spite of constant conditions. In darkness the growth drops. Generally uptake and growth progress parallel to each other, but there are exceptions.

It appeared from analysis of the plants, that a large amount of the phosphate absorbed is transferred to the shoot. With an extremely low salt condition the amounts present in the shoot and root are almost equal. If the plants are standing on a nutrient solution, a large part is transferred to the shoot.

In explanation of the behaviour observed, the uptake from the external solution was assumed to depend on a number of physiological factors: fixation by growth processes in root and shoot; accumulation in the vacuoles; secretion into the vessels; loss from the shoots. The importance of accumulation and secretion is obvious. The effect of the loss from the shoot (as far as it can be studied from a single experiment) could not be obtained.

On the other hand growth proved to be of primary importance. In order to show this, high nitrate, low phosphate plants were grown. By lack of phosphorus, growth was checked. Some nitrate absorption was possible but it soon came to a standstill, the plants coming in

a nitrate saturated condition as a result of the daily renewal of the solutions. By phosphate supply the synthetic processes could get started. This leads on the one hand to a renewed nitrate absorption, on the other hand to the promotion of the visible growth.

All processes mentioned are connected with metabolism. That is why sugar supply can be expected to have an influence. As a matter of fact carbon dioxide-free air proved to depress the uptake in the same way as does a dark treatment. The uptake could also be enhanced by the addition of glucose to the solution. At intensive illumination it does not occur. With low salt material a prolonged dark treatment may be necessary before a clear effect of the glucose addition is obtained. Hence it is not surprising that the uptake by low salt material is less sensitive to the changing of light and darkness, than is high salt material. Perhaps, this is mainly due to the accumulation in the vacuole being less sensitive to sugar supply, since much sugar has been stored in the vacuoles (osmoregulation).

Whether there is an effect of glucose addition or not, also depends on the external phosphate concentration. It was found, in accordance with the common concepts that the relation between concentration and uptake can be represented by an adsorption isotherm (Freundlich- or Langmuir curve). The well-known "saturation phenomenon" was also obtained. If the absorption activity of the plants increases, the uptake at a lower concentration is more enhanced than at a higher one. If glucose has an enhancing effect, then the higher the concentration the larger the effect.

To explain the regularities observed, the uptake of phosphate was assumed to start by becoming bound to some specific substance which is present in a limited amount. The preliminary data concerning the inhibition of the uptake by phloridzin also points to such a phosphorylation. Following on this initial binding the phosphate is translocated inwardly the symplasm of the roots. This translocation may be influenced by glucose. Langmuir's formula proves to be of primary importance in this concept. It renders a calculation of the theoretical "saturation" value possible. In nearly all cases where a maximum rate of the uptake was found, this appeared to be lower than this theoretical "saturation" value. This must be connected to a limiting influence of the consumption.

The significance of the metabolism for the phosphate uptake is obvious. However, experiments on the rapid loss of phosphate depending on the concentration of the medium, point to a large passive permeability. The significance of active and passive processes on the anion uptake was discussed in detail. It is emphasized that in general, the various principles, factors and processes important to the uptake, do not exclude one another. Nevertheless their quantitative meaning will depend on the certain known conditions e.g. low salt condition of the plants. Next to this the nature of the anion which is absorbed, particularly the extent to which it is taken up by the cytoplasm or the extent to which it is secreted into the vacuoles, is very important.