ON THE RESORPTION OF UREA BY THE ROOT SYSTEM OF THE HIGHER PLANTS

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In the present paper some results of studies on the resorption of urea by the root system of the higher plants and on its nutrient value as a nitrogen source will be reported in a summarized form. As plant materials, seedlings of *Zea Mays* (starch corn, Sapporo eight lines) and *Glycine Soja* were employed. In the case of the ordinary water culture, the seed was germinated in sawdust watered with tap-water, and when the roots two or three inches the long seedlings were transferred to a water-culture solution of the following composition:

Urea ($CO(NH_2)_2$)	0.360 gm
Calcium chloride ($CaCl_2 . 2H_2O$)	0.089 gm
Potassium biphosphate (KH_2PO_4)	0.250 gm
Magnesium sulphate ($Mg\ SO_4 . 7H_2O$)	0.250 gm
Potassium chloride (KCl)	0.120 gm
Ferric chloride ($FeCl_3$. 2%)	3 drops
Distilled water	1000 c.c.

pH=4.6

This culture solutions contains urea and calcium chloride instead of calcium nitrate as nitrogen and calcium sources. The amount of nitrogen in urea, is equivalent to that in the ordinary Knop's solution, but the amount of calcium was much lessened in order to prevent precipitation, which is due to the formation of either calcium sulphate or calcium phosphate. Experiments were conducted by the method of the ordinary water culture and sterile water culture. At the beginning and the end of experiments, the total amount of urea in the culture solution was determined, and the difference between these two determinations was regarded as the amount of urea resorbed by the root system of the plants. For the estimation of urea, the micro-Kjeldahl method for ammonia was used, combined with hydrolysis with aid of urease. The amount of free ammonia decreased or increased in the culture solution during the course of the experiment was calculated. From the result of the experiments, it was recognized that the more urea there was contained in the culture solution, the

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more it was resorbed by the root system of the culture seedlings. But when the concentration of urea in the culture solution was very high, the growth of the seedlings in the solution was injured and various phenomena of injury to the seedlings were found, although the amount of urea resorbed by the seedlings was larger than that in the case of the low concentration.

In the case of water culture of *Zea Mays*, the most favourable concentration of urea in the solution was 0.006 mol, 0.36 gram of urea in one litre of water, although the concentration of urea in the culture solution was more or less varied according to the species of plants used, stage of the growth of plants, and other cultural conditions. The resorption of urea by the root of seedlings was influenced by the amount of other salts in addition to urea contained in the culture solution; that is, when the experiments were carried out using the above described culture solution which contains various described culture solutions various amounts of calcium chloride and potassium chloride besides urea, the amount of urea resorbed by the seedling roots was very much lessened by increasing the calcium chloride. On the contrary, with the solution containing potassium chloride to the amount of 0.002 mol, the amount of urea resorbed by seedling roots was the maximum, but when the concentration of potassium chloride in the culture solution was higher or lower than the above mentioned the amount of urea resorbed was decreased. Probably, this phenomenon may be caused as the result of the special ionic effects of K. and Ca on the permeability of the protoplasm of plants.

The hydrogen ion concentration in the culture solution played a role in the resorption of urea by the root of seedlings. The amount of urea resorbed per gram of dry weight of the root of *Zea Mays* was large at pH 5.6–6.4 and on the more acid side than this pH value, but the amount decreased at pH 6.8–7.8 and on the alkaline side.

The occurrence and amount of urease in the plants also influenced the degree of the resorption of urea by the seedling roots. It is very probable that as the cotyledon part of soy-bean contains a large amount of urease, the existense of this cotyledon accelerates the resorption of urea by the root, and also that the amount of urea resorbed by the same materials is very small, when the cotyledons are cut off at the beginning of experiments. The amount of urea resorbed by the root of soy-bean was very much influenced by photosynthesis. When the seedlings of soy-bean cultivated in the urea culture solution were transferred into tap-water, the amount of urea resorbed by the seedlings in the dark was inferior to that in the light, but the amount of free ammonia excreted into the tap-water by the root in the dark was superior to that in the light.

Such results indicate clearly that the influence of light on the resorption of urea and on the utilization of ammonia absorbed by root must be taken into consideration. In general, light is important, because seedlings can form protein from the product of photosynthesis together with the nitrogen-source absorbed from culture solutions. The seedlings in the dark can not sythesize protein, and the resorbed urea or ammonia can not be utilized. Such an accumulation of urea and ammonia hinders the further resorption of these substances, cosequently this caused the excretion of ammonia into the culture solution from the seedling roots. The urease in the plants has influence upon the resorption of urea by the seedling roots, but also acts on the transportation and utilization of urea resorbed in the plants.

Occurrence of a very small amount of urease was ascertained in the part of embryo and scutellum in the seedlings of *Zea Mays*, but in other parts such an occurrence could not be found. On the contrary, the occurrence of the urease was proved in every part of soy-bean, especially in the cotyledon. By the method of FOSSE using xanthydrol as reagent, it was ascertained that young seedlings of *Zea Mays* resorbed urea as itself and this urea resorbed was transported in the plants as urea or as ureïdes, which may be derived from urea, a part of which appeared in the drops of guttation. As every part of soy-bean contains a comparatively large amount of urease, it is very probable that the urea resorbed by the root of soy-bean was changed immediately by urease in the plants.

In the water culture of *Zea Mays* in culture solution or in tap-water, the excretion of urease from the root of seedlings was not recognized.

Under natural conditions, urea is decomposed into ammonia by the decomposing action of urobacteria in the soil and the ammonia thus formed is absorbed by the root, and it can be resorbed as itself too. In this case, if the urease occurs in the plants, it is probable that the resorbed urea is decomposed immediately into ammonia in the plant body, which can be available for protein synthesis as a nitrogen source.

When the concentration of urea in the culture solution is very high, a large amount of urea is decomposed into ammonia in a comparatively short time, and then the reaction of the culture solution become less acidic or more alkaline than at the beginning. Concequently in turn the growth of seedlings may be affected by this change of reaction. Such a secondary unfavorable change of reaction in the culture solution containing urea in the course of culture, and the high concentration of urea, which causes accumulation of urea and ammonia in the plant body, act injuliously on the growth of plants.