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DEPENDENCE OF POTASSIUM UPTAKE OF RICE AND WHEAT SEEDLINGS ON TEMPERATURE, PRESENCE OF CALCIUMION AND ROOT LENGTH

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Abstract

A study was made of the effect of temperature on the K-ion uptakes of rice and spring wheat seedlings. The uptake studies were carried out in 10^{-3} M K(^{68}Rb)Cl solution in the presence and absence of Ca-ion and at different root lengths (ages). The experimental data indicated the following: the lower the temperature of the absorption solution, the higher the K-ion uptake anomaly of excised rice roots; no departure from the regular K-ion uptake was revealed by using wheat seedlings (roots) at different temperatures; the ion uptake anomaly may be strongly decreased by adding Ca-ion to the absorption solution; the Viets effect was observed for rice roots only above 15 °C, but for wheat already above 10 °C. Investigations with different rice root lengths (ages) show that the shorter (younger) the roots, the higher the K-ion uptake anomaly.

Introduction

Some investigations were made earlier to study the ion uptakes of thermophilic plants (ZSOLDOS, 1968; ZSOLDOS, 1972a). It was established that for certain thermophilic plants a chilling temperature may result in an anomalous K-ion uptake and efflux (ZSOLDOS, 1974). No departure from the regular ion uptake was revealed by using $H_2PO^-_4$, I^-, NO^-_3 and NH^+_4 ions (ZSOLDOS, 1972b).

Our earlier data suggested that cold-treatment of cold-sensitive plants, by changing the permeability of cell membranes, stimulated passive K-ion uptake. The anomalous ion uptake could be completely prevented by adding Ca-ion to the uptake solution. At the same time, at higher temperature Ca-ion is well known to stimulate certain ion uptakes (VIETS, 1944; MARSCHNER, 1971; WALLACE, 1971; ZSOLDOS, 1974). No, or only very small changes could be observed in the anomalous K-ion uptake if uncouplers of oxidative phosphorylation (e.g. 2.4-DNP) were employed (ZSOLDOS et al., 1968).

From our earlier data it seems that the mechanism of the initial K-ion uptake anomaly, at least for thermophilic plants, is rather complicated and somewhat different from that of other plants (ZSOLDOS and KARVALY, 1975). For this reason, further studies have been carried out in connection with the low-temperature effect. In this paper attention is paid to the investigation of the effects of low and high temperatures on the K-ion uptake. In the course of these investigations special attention was given to the temperature-dependence of the Viets effect. These studies were also extended to a comparison of K-ion uptakes in rice plant at different root lengths and temperatures.

Materials and Methods

Rice (*Oryza sativa* var. *japonica* cultivar Dunghan Shali) and spring wheat (*Triticum aestivum* cultivar Tobari 66) seedlings were grown in 5×10^{-4} M $CaSo_4$ solution under well-controlled conditions as described earlier (ZSOLDOS, 1972). 6—7 cm long roots of 7-day-old plants were excised and washed in distilled water for 10 minutes at room temperature. About 3 g of the root material was placed in 500 ml aerated, isotopically-labelled uptake solutions kept at different temperatures between 0 and 30 °C, for given periods of time.

The temperature of the absorption solution was constant within 1 °C during the incubation process. The pH of the uptake solution was adjusted to 6.4—6.5. No noticeable change in pH occurred during the experiments. The uptake studies were carried out in 10^{-3} M K(^{86}Rb)Cl solution. For technical reasons, ^{86}Rb was chosen as label for potassium. Before the systematic investigations, comparative studies were performed on the differences in behaviour of K-ion and Rb-ion during uptake (ZSOLDOS and KARVALY, 1975).

The root samples were removed from the uptake solution at different intervals and rinsed three times in distilled water for one minute at room temperature. The roots were then dried as described earlier and the activites of the samples were measured by scintillation counter (ZSOLDOS, 1972). Results are given in μM/g dry weight.

In the investigations of the K-ion uptakes of rice roots with different lengths (ages), intact roots with lengths of 4, 6 and 8 cm were used. To obtain roots suitable for our experimental purposes, rice was sown every one and a half days.

All experiments were repeated at least there times. Although the absolute values were not exactly the same for individual samples, the trends were identical, showing the effects to be due to sample.treatment and not to sample differences.

Results and Discussion

1. Investigation with rice roots

Fig. 1 shows the rate of K-ion uptake of excised rice roots at different temperatures and in the presence or absence of Ca-ion. It can be seen from the results that, as described in detail earlier, anomalous K-ion uptake is observable at lower temperature. This effect, however, could be strongly decreased by adding Ca-ion to the uptake solution (ZSOLDOS, 1972). At higher temperature, as can be seen from Fig. 1, the presence of Ca-ion in the absorption solution enhanced the uptake of K-ion, bringing about the well-known Viets effect.

These experimental results indicated that in the Viets effect there is a lower critical temperature, below which the Ca-ion inhibits the K-ion uptake. Our results showed that in rice seedlings the lower critical temperature of the Viets effect was ca. 14 °C. Below the critical temperature value, physiological or physical changes take place in the cell membrane, with resulting temperature injury.

In this connection we refer to the review by LYONS (1973), dealing in detail with the physiological manifestation of chilling injury. The investigations, carried out especially with the membranes of mitochondria, clearly showed that the membranes did undergo a physical-phase transition from a flexible liquid-crystalline to a solid-gel structure at 10 °C to 12 °C (LEVITT, 1972). It seems that these results are precisely correlated with the temperature below which injury occurred in the rice plant too.

2. Investigation with wheat roots

The K-ion uptakes at different temperatures are depicted in Fig. 2. The experimental results on wheat roots indicated primarily that no departure from the regular

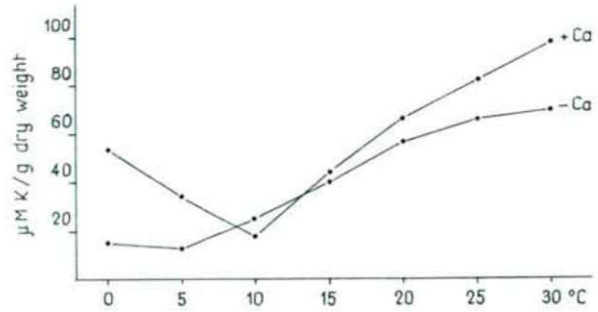

Fig. 1. K-ion uptake by excised rice from 10^{-3}M KCl solution at different temperatures in the presence and absence of 10^{-3}M $CaCl_2$. Uptake time: 60 minutes.

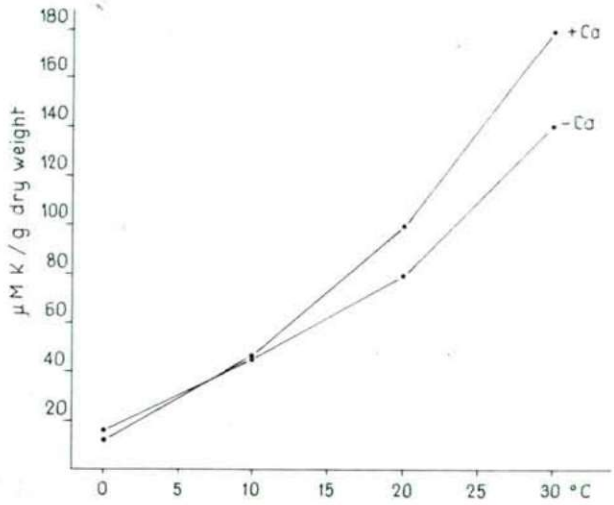

Fig. 2. K-ion uptake by excised spring wheat roots from 10^{-3}M KCl solution at different temperatures in the presence and absence of 10^{-3}M $CaCl_2$. Uptake time: 60 minutes.

ion uptake was revealed by using K-ion at different temperatures. It can also be stated that the lower critical temperature range of the Viets effect is considerably different from that found for rice seedlings.

The results showed that the lower critical temperature of wheat roots was ca. 10 °C. In our opinion comparison of these data with the results obtained with rice seedlings, helps to explain better the Viets effect, not satisfactorily cleared up at present (WALLACE, 1971).

3. Investigation with rice seedlings of different root lengths

From our earlier scattered obsservations the conclusion was drawn, that the root lengths of thermophilic plants may influence the K-ion uptake anomaly. As the problem is of great importance from a methodological point of view, we have

carried out some investigations in this direction. The results are demonstrated in Fig. 3. From the graphs it is easy to see that the K-ion uptake anomaly with the 4 cm long roots is strikingly higher than those with 6 or 8 cm long roots. At 21 °C, on the other hand, where it is well known that no uptake anomaly is experienced, there is practically no difference in the ion uptake of roots of different lengths.

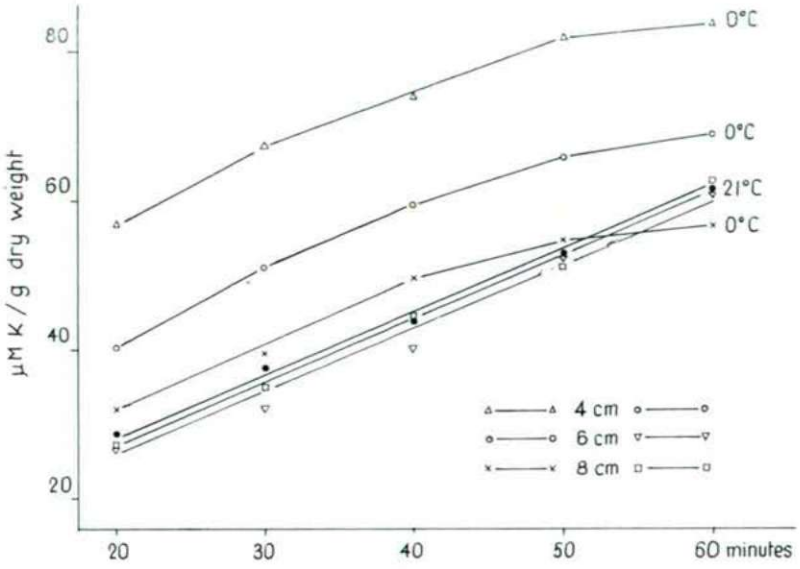

Fig. 3. K-ion uptake by excised rice roots from 10^{-3}M KCl solution at different temperatures and root lengths.

From the above results it is obvious that in the investigation of the ion uptake of thermophilic plants one must take into consideration the fact that the extent of the uptake anomaly is strongly influenced by the length of the roots. Failing this, chiefly when we screen the cold-resistance of different varieties of thermophilic plants, we may obtain faulty results. The experimental data also indicate the need for further investigations of the K-ion uptake anomaly of root segments. These are now in progress.

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