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EFFECT OF APPLIED KINETIN ON UPTAKE AND TRANSPORT OF ^{22}NA AND ^{36}CL IN BEAN AND COTTON PLANTS

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1. INTRODUCTION

MULLER and LEOPOLD (1966) showed that kinetin induced transport of ^{32}P through the phloem. This transport occurred along the axis of vascular bundles independent of the water flow in the xylem and transport was blocked by metabolic inhibitors or by treatment of the stem with steam. Mass flow of ^{32}P through the phloem was initiated by a kinitin induced mobilizing centre which acted as a sink through changes of the osmotic potential. Transport of the radio-isotopes ^{86}Rb, ^{36}Cl, and ^{131}I was not affected by kinetin, but transport of ^{22}Na towards the kinetin-induced sink was enhanced.

MOTHES *et al.* (1961, 1964) stated that kinetin directly influences the movement and accumulation of ^{14}C-labelled amino acids in the leaf independent of any effect from kinetin-stimulated protein synthesis. KANNAN and MATHEW (1970) found that kinetin increased transport of Fe^{3+} from the primary leaf to the other parts of the plants. WITTWER *et al.* (1955, 1964, 1965) presented evidence that foliar absorption and translocation of ions depends on metabolism.

In this work the effect of applied kinetin on uptake and transport of ^{22}Na and ^{36}Cl was studied in order to determine a possible interaction between kinetin and salinity stress. ITAI *et al.* (1965, 1968) and VAADIA and ITAI (1968) found a reduced cytokinin activity in the root exudate of sunflower plants subjected to a water stress induced by gradual addition of NaCl to the medium. For this reason it was of interest to see whether applied kinetin could modify ion transport induced by salinity stress.

2. MATERIAL AND METHODS

Bean seeds (*Phaseolus vulgaris*, variety WIDUSA) were germinated in coarse

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sand. After 9 days the seedlings were transferred to HOAGLAND solution, with or without addition of kinetin. Plants were grown in a climate room at an air temperature of 20 °C, a relative humidity of 40 %, and a light intensity of 40.000 ergs/sec cm^2 (400–700 nm) for 12 hr a day.

The plants were grown for 3 days in different nutrient solutions containing kinetin in a concentration of 0.1, 0.5, or 1 mg/liter. Then the plants were again transferred, this time to a moderately saline solution (25 mM NaCl) containing ^{36}Cl (7.3 μC/liter). The plants were harvested after a period varying between 6 and 72 hr and Cl^- was extracted by boiling the plant tissue in water for 5 min. The water extract was evaporated and the residue bleached with a few drops of H_2O_2. The residue was dissolved in 2 ml methanol/water (1/1, v/v), was added to 10 ml of scintillation liquid, which consisted of a mixture of 800 ml dioxane, 160 ml ethylene glycol monoethyl ether, 48 g naphthalene, 9.6 g PPO, and 0.48 g POPOP. Activity of the samples was measured under refrigeration in a 'Nuclear Chicago' liquid scintillation counter.

Sodium was determined in a similar way as chloride. The saline solution contained ^{22}Na (2 μC/liter) or one of the leaves was fed ^{22}Na (0.1 μC) as a drop on the tip of a leaf. In the latter case transport from the leaf to the stem and roots was measured. The water extract of the plant tissue was evaporated and the radio-activity of the residue was measured with a conventional GEIGER-MÜLLER radiation counter.

In some experiments cotton plants (*Gossypium hirsutum*, variety 'Upland Long Staple') were grown as beans, except that the cotton seedlings were transferred to HOAGLAND solution after 15 days.

3. RESULTS AND DISCUSSION

1. *Effect of kinetin on transport of ^{22}Na, applied to the leaf tip.* When ^{22}Na is added as a drop to the leaf tip, the ion is absorbed by the leaf and transported to the stem. This transport of Na was greatly accelerated if the plants were previously grown for 3 days in a kinetin-enriched nutrient solution (Fig. 1). A fivefold increase in the rate of export of Na from the leaves in 6 hr was observed in plants grown in a solution of 0.1 mg/liter kinetin. Na-removal from the leaf was already complete in these plants within 6 hr. No significant differences were observed 6 hr, 48 or 72 hr after application.

A concentration of 1 mg/liter kinetin proved already to be supra-optimal, but also in this case practically all the Na applied to the leaf was removed after 2 or 3 days.

Further transport of Na from the stem to the roots was also higher in plants growing in a kinetin-enriched medium, though the effect was much less pronounced (Fig. 1).

In conclusion, export of Na applied to the leaves was greatly accelerated in plants which had been enriched in kinetin by exposure of the roots to a 0.1 mg/liter kinetin solution.

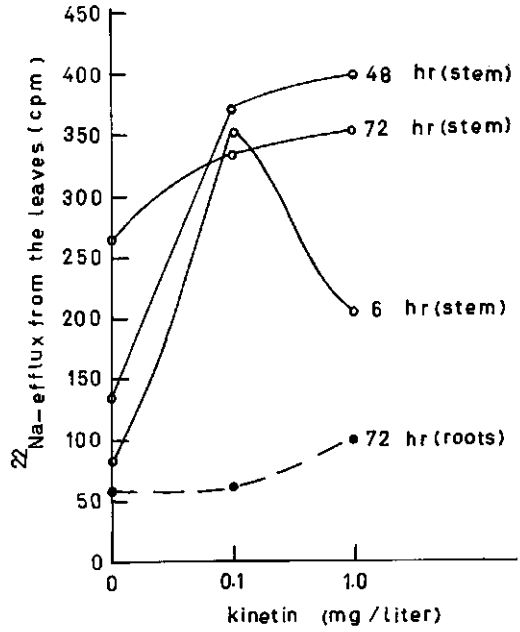

FIG. 1. Effect of kinetin on foliar application of ^{22}Na in bean plants. (A) ○—○ the quantity of ^{22}Na transported to the stem. (B) ●—● the quantity of ^{22}Na transported to the roots (cpm).

2. *Effect of kinetin on uptake and transport of ^{22}Na in bean and cotton plants.* Bean plants do not accumulate Na in the leaves (PEARSON, 1967). When the roots are cut, a greater quantity of Na is transported to the stem, petioles and even into the leaf blades. Uptake and translocation of Na was studied in intact bean plants and in plants with the root system removed just prior to the treatment with Na. No significant differences between the ^{22}Na distribution pattern of plants grown on solutions with different amounts of kinetin were observed. In the intact plants no accumulation of Na could be observed in the leaves, in agreement with PEARSON's results. So far, only an effect of kinetin was observed on efflux of Na from the leaves, while the influx could not be studied. For this reason further experiments were done with cotton, which is known to accumulate Na into the leaves.

Na-uptake by the roots, transport to the stem, and accumulation of Na into the leaves of cotton plants was affected by the kinetin treatment of the plants. After 24 hr a smaller amount of Na was present in the plants which had been grown in a medium with kinetin (Fig. 2). Na-uptake of the roots and Na-accumulation into the leaves was equal in plants grown without kinetin or in a 0.1 mg/l solution, while a considerable reduction in Na uptake and accumulation was observed in plants grown in kinetin solutions of higher concentrations (0.5 and 1 mg/liter).

3. *Effect of kinetin on uptake and transport of ^{36}Cl.* Cl-accumulation into the leaves of bean plants strongly depended on the pretreatment with kinetin. At 1 mg/liter kinetin it was reduced to 50% of the level of the plants which had not

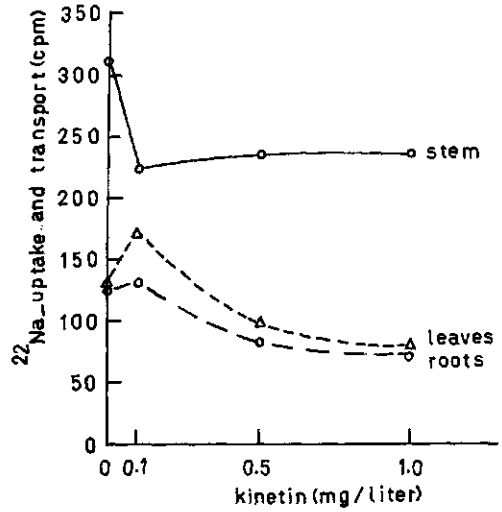

FIG. 2. Effect of kinetin on ^{22}Na uptake and transport in cotton plants. ○—○ stem, △---△ leaves ○---○ roots.

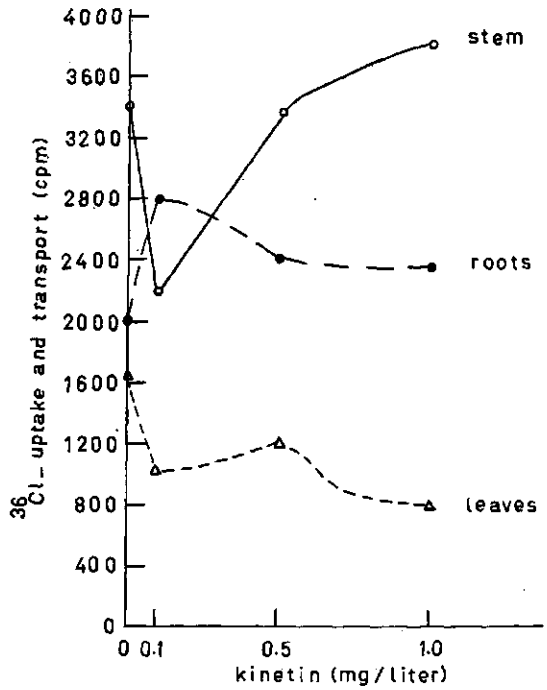

FIG. 3. Effect of kinetin on ^{36}Cl uptake in bean plants. ○—○ stem, ●---● roots △---△ leaves.

received any kinetin in the nutrient solution (Fig. 3). Cl-uptake of the roots was slightly increased by the application of kinetin, *viz.* 20 to 30%. The action of kinetin in this way resembles the effect of glycerophosphoryl choline and of lecithin (KUIPER, 1969). Application of these lipids also resulted in an increased

Cl-uptake of the roots with a concomittant decrease of this ion in the leaf tissue. Cl-transport into the stem was intermediate between the patterns of roots and leaves. At 0.1 mg/liter kinetin a reduction in Cl was observed, while at higher concentrations an increase was observed.

4. *Discussion.* Evidently, the distribution patterns of Na and Cl are affected by the pretreatment of the plants, that is if they were exposed to kinetin in the nutrient solution. Na-efflux from bean leaves was greatly stimulated by kinetin. Kinetin decreased uptake, transport, and accumulation of Na into the leaves of cotton plants. Finally, it decreased Cl-accumulation into bean leaves. These reductions in the Na and Cl transport clearly could alleviate the salinity stress to plants by NaCl in the root solution.

ITAI *et al*, (1965, 1938) and VAADIA and ITAI (1968) observed a reduced cytokinin activity upon exposure of plants to salinity stress. The reduction in activity is accompanied by increased flows of Na and Cl into the plants. The results indicate that endogeneous kinetin is an important factor in regulation of the transport and accumulation of Na and Cl in plants under conditions of salinity stress.

SUMMARY

Application of kinetin to the roots of bean plants stimulated the transport of ^{22}Na applied to the leaf tip from the leaf to the stem and roots. When the roots of cotton plants were exposed to salinity stress (25 mM NaCl), kinetin application decreased transport of ^{22}Na to the stem and leaves. When bean plants were exposed to salinity stress, kinetin application to the roots reduced ^{36}Cl transport to the leaves. These results suggest that endogenous kinetin is of importance in regulation of Na- and Cl-transport in plants under conditions of salinity stress.

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