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SALT TOLERANCE OF TURFGRASS *Puccinellia distans*: II. IONIC INTERACTION IN THE ROOTS[1)]

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ABSTRACT

In this study, multi-compartment transport boxes were used to determine the mobility of ions in the execised roots. For measuring Na uptake, the concentrations of 1, 50 and 150 mM NaCl were used in the external medium, whilst Ca were 0 and 2.0 mM. The uptake of K was measured from 1.0 mM KCl in the presence of Na (0.50 and 150 mM) and Ca (0, 0.5 and 2.0 mM). In the present study, ^{22}Na and ^{86}Rb were used to label Na and K in the external medium, respectively.

Addition of Ca inhibited Na uptake in the roots exposed to 1.0 mM and 50 mM NaCl, thought Ca was relatively less effective in 150 mM. High concentrations of NaCl brought about the reduction of K uptake. Calcium, however, did not show any importance in recovering the uptake of K from the adverse effect of Na when the roots were exposed to 50 mM NaCl, thought stimulating effect of Ca was observed at 150 mM NaCl. The results revealed that the pattern of ionic interactions in Puccinellia distans differs much with that generally found in most of halophyte plants.

RINGKASAN

Pada penelitian ini, mobilitas ion pada potongan akar ditentukan dengan menggunakan *multi-compartment transpor box.* Untuk pengukuran serapan Na, konsentrasi NaCl pada medium adalah 1, 50 dan 150 mM, sedangkan konsentrasi Ca adalah 0 dan 2.0 mM. Serapan K diukur dari 1.0 mM KCl dengan perlakuan pemberian Na (0, 50 dan 150 mM) dan Ca (0 dan 2.0 mM). Untuk melabel Na dan K dipergunakan masing-masing ^{22}Na dan ^{86}Rb.

Pemberian Ca menghambat serapan Na pada kondisi 1.0 mM dan 50 mM NaCl, walaupun Ca tidak efektif lagi pada konsentrasi 150 mM NaCl. Serapan K menurun dengan meningkatnya konsentrasi NaCl pada larutan medium. Pemberian Ca kurang efektif dalam mengurangi pengaruh buruk Na terhadap serapan K pada saat akar diberi cekaman 50 mM NaCl, walaupun pengaruhnya terlihat pada konsentrasi 150 mM NaCl. Hasil menunjukkan bahwa pola interaksi ion pada akar *P. distans* sangat berbeda dengan pola yang umum ditemui pada kebanyakan tanaman halofita.

INTRODUCTION

Our previous work concerning the salt tolerance of turfgrass *Puccinellia distans* (Part I), a halophytic monocotyledon plant, revealed that its tolerance was apparently associated with exclusion of Na from the shoot. The result was in agreement with that previous postulated mechanism proposed by Gorham *et al.* (1989) and Austin (1984). However, the mechanism of tolerance of this halophytic monocotyledon in term of ionic interactions (Na, K, Ca) has not been elucidated.

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There are only few works addressing the phenomenon of salt tolerance at physiological basis of ionic interactions in halophytic monocotyledon plants (Greenway and Munns, 1980; Gorham *et al.*, 1985) as well as in halophytic dicotyledon (Flowers *et al.*, 1977; Jefferies, 1973; Sopandie, 1990; Sopandie *et al.*, 1990). Sopandie *et al.* (1990) revealed that halophytic dicotyledon *Salicornia virginica* has a spesific adaptation for K acquisition as one of its physiological competence in responding to salt stress, in which Ca involved substantially. The situation in halophytic monocotyledon may not be in complete agreement with the above picture drawn from general phenomenon in halophytic plants. The present study shows that there is quite difference between halophytic monocotyledon *P. distans* with the general mechanism of halophytic plants in term of ionic interactions (Na, K, and Ca).

MATERIALS AND METHODS

The roots of *Puccinellia distans* were excised from 2 month-old plants grown hydroponically in culture solution. The nutrient solution used was the same as described in previous work (Sopandie *et al.*, 1995) without the addition of NaCl. It this experiment, multi-compartment transport boxes (Fig. 1) were used to determine the mobility of ions (Fig. 2) in the excised roots. The detail of the methods has already been described in our previous work (Sopandie *et al.*, 1990).

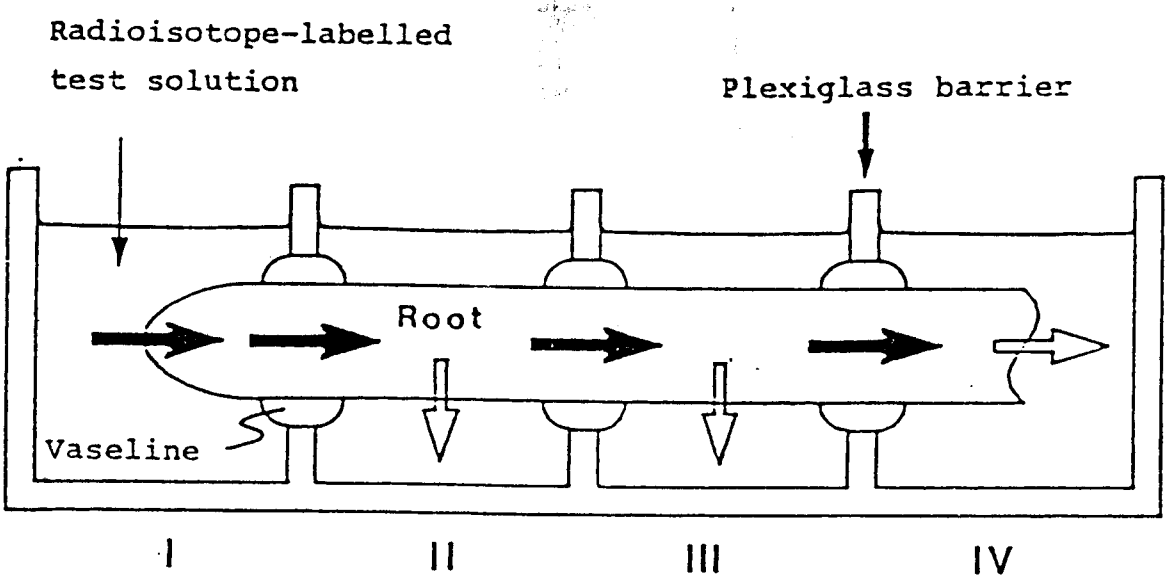

Fig. 1. Schematic representation of multi-compartment transport box. *Black arrows* show diagrammatically the absorption and translocation of ions in a plant root, and *white arrows* show the efflux of ions from a plant root. I, II, III, IV: positions of each compartment.

For measuring Na uptake, the concentrations of 1, 50, and 150 mM NaCl were used in the external medium, whilst CaCl2 were 0 and 2.0 mM. The uptake of K was measured from 1.0 mM KCl in the presence of Na (0, 50 and 150 mM) and Ca (0, 0.5 and 2.0 mM) in the uptake media. In the present study, ^{22}Na and ^{86}Rb were used to label Na and K in the external medium, respectively. The uptake and transport of ions in excised roots were determined by the methods described in previous work (Sopandie *et al.*, 1990). On referring to the distribution pattern of ion in an excised root described in Fig. 1 and 2, therefore, the results in the present study will be discussed.

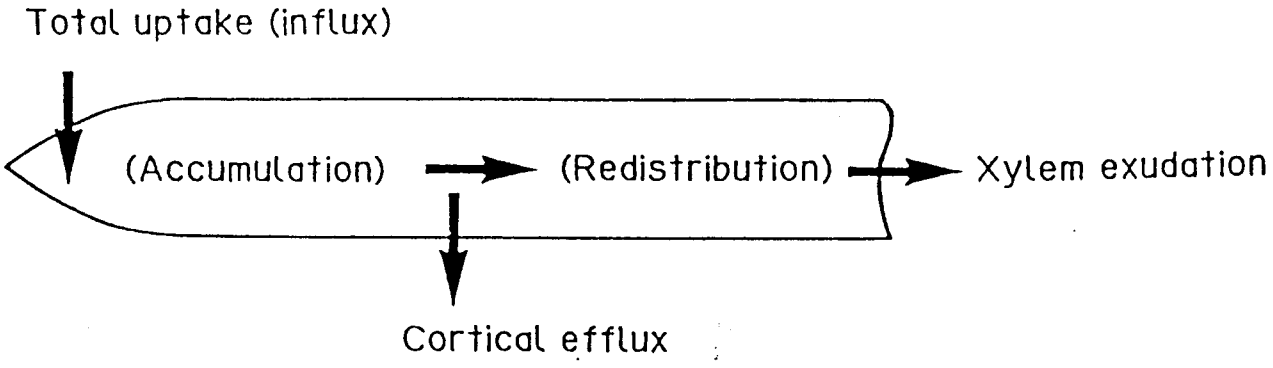

Fig. 2. Schematic representation of the absorption and distribution of ions in excised roots.

RESULTS

Effect of Ca in Na uptake

The effect of Ca on Na uptake on excised roots of P. distans is presented in Fig. 3. At two levels of Ca (0 and 2.0 mM), the uptake of Na increased as the concentration of NaCl in the medium was increased. Addition of 2.0 mM Ca inhibited Na uptake in the roots exposed to 1.0 mM and 50 mM NaCl, thought Ca was relatively less effective in 150 mM. Calcium showed a little effect on the translocation of Na along the roots, i. e. cortical efflux, redistribution and exudation. These results indicate that Ca had less interference on Na uptake in P. distans, as compared to that in barley and *Salicornia* (Sopandie *et al.*, 1990).

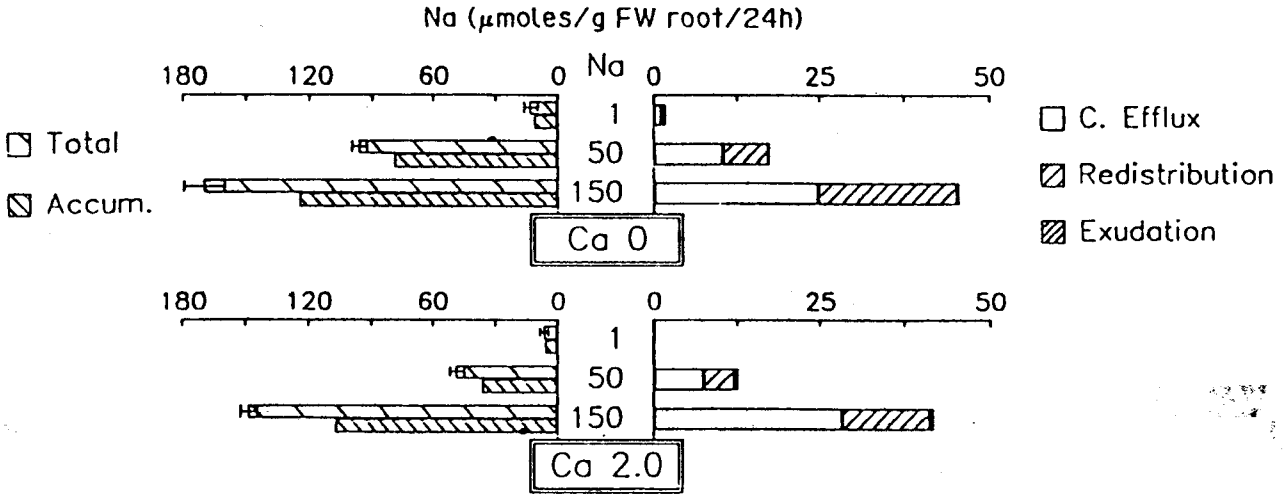

Fig. 3. Effect of Ca on the absorption and translocation of Na in excised *Puccinellia distans* roots. Bars (⊢—⊣) denote SD.

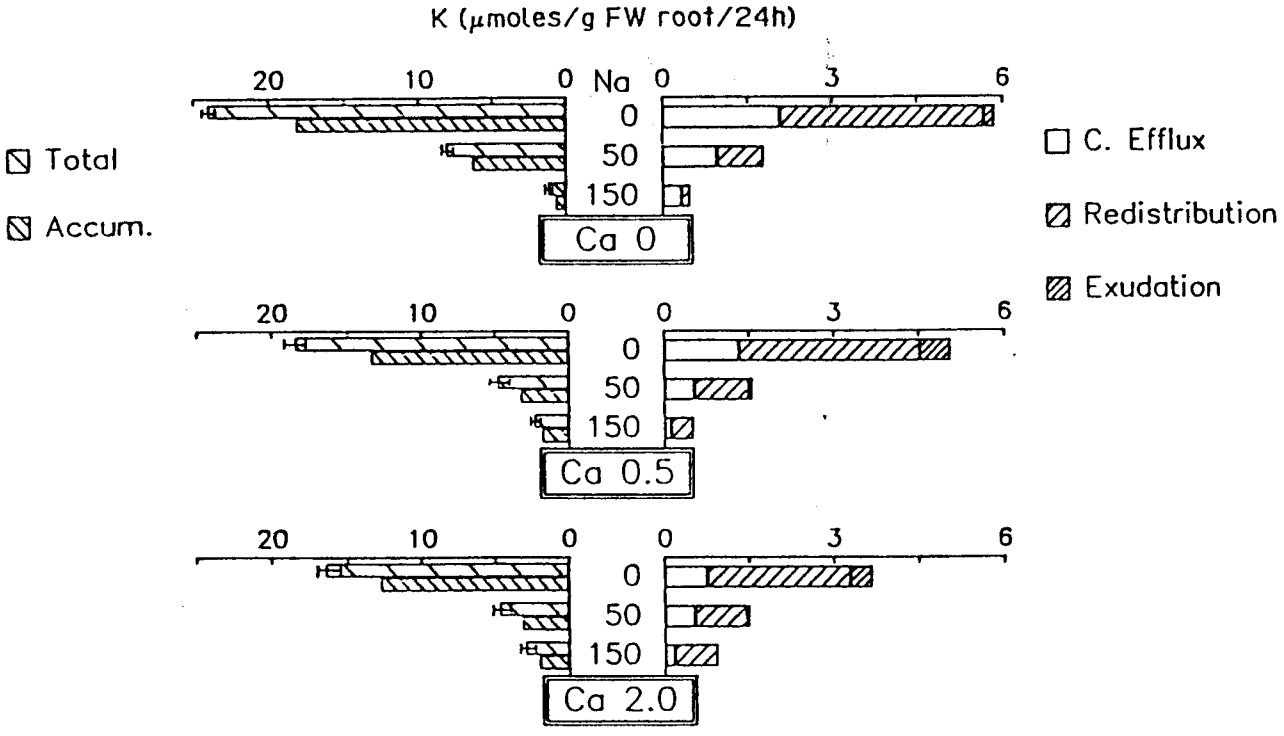

Fig. 4. Effects of Na and Ca on the absorption and translocation of K in excised *Puccinellia distans* roots. Bars (⊢—⊣) denote SD.

Effects of Na and Ca on K uptake

Figure 4 shows the interactions among Na, Ca and K in excised roots of P. distants. When the roots were exposed to an uptake medium lacking Ca, high concentrations of Na conciderably inhibited the absorption and translocations of K, as shown by the decrease of all parameters of transport (accumulation, cortical efflux, redistribution and exudation). Calcium (0.5 and 2.0 mM), however, did not show any importance in recovering the uptake of K from the adverse effect of Na when the roots were exposed to 50 mM NaCl, thought as stimulating effect of Ca was observed at 150 mM NaCl. Concerning the effect of Ca on K uptake under salt-stress condition, it indicates that the results in *Puccinellia distans* were found to be somewhat different with that observed in barley and *Salicornia virginica* (Sopandie *et al.*, 1990). Unlike *S. virginica*, this halophytic monocotyledon P. *distans* showed a quite different pattern of K uptake in the presence of Na. It was evidenced that in P. *distans* the uptake of K was basically similar to that of glycophytes, as shown that K uptake was decreased by high concentrations of Na in all concentrations of Ca (Sopandie *et al.*, 1990).

DISCUSSION

The purpose of this experiment was to study the salt tolerance of turfgrass P. *distans* in the term of ionic interactions (Ca, Na and K) in excised roots. The results show that the pattern of ionic interaction in excised roots of P. *distans* differs much with that generally found in halophytes (Flowers *et al.*, 1977) or glycophytes (Greenway and Munns, 1980; Gorham *et al.*, 1985; Sopandie, 1990; Sopandie *et al.*, 1990). It has been indicated that the interference of Ca on Na uptake in the roots of P. distans was small. Moreover, the role of Ca in recovering K uptake from the adverse effect of Na seems to be unclear. Several works revealed that in most glycophytes (Kawasaki *et al.*, 1978a and 1978b; Greenway and Munns; 1980; Sopandie, 1990; Sopandie *et al.*, 1990 and 1995) or halophytes plants (Flowers *et al.*, 1977; Jefferies, 1973; Sopandie et al., 1989, Sopandie, 1990; Sopandie *et al.*, 1990a and 1990b), Ca had an important role in the inhibition of Na absorption and in mitigating the adverse effect of Na on K uptake. Thus, it might suggest that Ca has less importance in the selective mechanism on the absorption of monovalent cations in the roots of *Puccinelllia distans*. There was a significant different in the pattern of K uptake between halophytic monocotyledon P. *distans* and that of dicotyledon Salicornia virginica. It has been shown in Sopandie et al. (1990) that S. virginica appears to have an ability to respond salt stress by regulating high potassium nutrition in the presence of Ca. This evidence, however, was not found in *P. distans.* Judging from the results, it suggests that P. *distans* has the pattern of K uptake which principally similar to that of glycophytes. These findings indicate that different groups of plants might employ different strategies in coping with salinity.

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