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Na^+ DISTRIBUTION AND RATE OF TRANSPORT IN COTTON CULTIVARS UNDER SALINE CONDITIONS

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ABSTRACT

Four cotton cultivars were studied at seedling stage in salinized nutrient growth medium having 0, 75,150 and 250 mol m^{-3} NaCI salinity. After salinization, the seedlings were harvested after day 3 and the 2nd batch after 17 day. The plant parts were analyzed for Na^+ contents. The tolerant cultivar NIAB 78 accumulated significantly higher Na^+ concentration in stem than the sensitive D 9 and Ravi. NIAB 78 maintained lower Na^+ concentration in leaf than the sensitive ones. The reason of tolerance in NIAB 78 may be the maintenance of lower Na^+ accumulation in leaves than stem. Sodium transport (J_{Na^+}) of NIAB 78 was higher than D 9 and Ravi. Such a trend was related to the demand for solutes set up by the growing plants for osmoregulation.

Key words: Sodium distribution, cotton, salinity

INTRODUCTION

The reduction in plant growth under saline conditoins is related to the toxicity of ions present at higher concentration and low soil water potentials. The cultivated crop respond differently to salinity. (Maas and Hoffman, 1977). According to Maas and Nieman (1978) reported that the mechanism of salt tolerance is associated with restricted ion uptake and tronslocation with the plant bodies. Differences in salt tolerance occur not only between crop species but also between cultivars. Varietal differences may be related with differences of ions especially Na^+ and / or CI^- retention in the root as well as its with accumulation in the shoot (Abel and Mackenzie, 1964; Rathert and Doering, 1981). The objective of the present investigation is to explore the intra varietal variability and find suitable cultivar for salt affected soils.

MATERIALS AND METHODS

A laboratory experiment was conducted by growing four cotton cultivars in the half strength Hoagland solution. Seedlings of the cotton cultivar were raised in plastic coated iron trays (60 x 30 x 5 cm) filled with silica sand. For the first 3 days distilled water was applied and trays remained covered with percelian cloth. During the first 3 days the trays were irrigated with distilled water. After 3 day half strength Hoagland solution was applied till the transplantation (when the platn reach to 2 leaf stage). After attaining 2 leaves, the young seedling were transferred to aerated nutrient medium in plastic coated lined iron tanks (120 X 90 X 30 cm) covered with foam sheets having holes for holding plants supported on iron stands 90 cm above ground. The solution was aerated all the time (day and night). After seedling establishment, NaCI was added to the medium in increments of 25 mol m^{-3} per day to achieve the NaCI levels of 0, 75, 150 and 250 mol m^{-3}. The harvests were done first after day 3 and second on day 17 (after salinization) for Na^+ analysis.

The plants parts (shoot, leaves, stem and roots) were analyzed separately for Na^+ ion following Pitman (1965) digestion procedure.

The rate of ion transport was calculated according to the formula used by Salim and Pitman (1983) as follow:

$$\_\ J = \frac{M_2 - M_1}{W_2 - W_1} \times \frac{\log_e W_2 - \log_e W_1}{\Delta T}$$

Where

J= rate of ion transport from root to shoot per g root; M_2 = amount of ion (Na^+ m mol g^{-1} D.W) at harvest 2,
M_1 = amount of ion (Na^+ m mol g^{-1} D.W) at harvest 1; W_2 = weight of plant tissue (g) at harvest 2,
W_1 = weight of plant tissue (g) at harvest 1; Δ T= difference in time (days).

RESULTS AND DISCUSSION

The results (Table 1 and 2) showed that higher salt concentration in the external solution, higher was the Na^+ concentration in plant leaves and stem. It was also noted show that Na^+ concentration of different plant tissues varied with the period of growth; it increased significantly with increase in age of plants at higher salinity, but at control and at 75 mol m $^{-3}$ external salinity, it was lower at the time of second harvest than the first harvest.

The tolerant cultivar (NIAB, 78) had significantly lower leaf Na^+ concentration than the sensitive cultivars (D 9, Ravi). It was further noted that the tolerant cultivars had significantly ($P \leq 0.05$) higher Na^+ accumulation in stem than the sensitive cultivars, D 9 and Ravi. Rate of Na^+ transport from root to shoot, generally increased with increase in salt concentration in the root medium (Table 3).

The increase in the rate of Na^+ transport at low and moderate salinity was rapid initially and than somewhat stablized, while at higher salinity of 250 m mol m^{-3} NaCI salinity; there was a small increase. In case of Ravi, it in fact decreased.

It is interesting to find that the tolerant cultivar NIAB 78 and moderately tolerant MNH 93 had higher rate of Na^+ transport (J_{Na}^+) than the sensitive cultivars D- 9 and Ravi at different salt concentrations in the growth medium (Table 3). At 250 mol m^{-3} NaCI, NIAB 78 had about 3 times greater J_{Na}^+ than the sensitive cultivar Ravi.

Table 1. Sodium concentration in leaves of cotton cultivars at different harvests under saline condition.

---mol m^{-3} NaCI---									
Variety	O (Control)		75		150		250	Mean	
		H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
Sodium Concentration (m mol g^{-1} D.W).									
NAIB 78	0.082k	0.055k	0.658i	0.461ij	1.204 h	1.745 dg	1.483gh	1.958bd	0.96b
MNH 93	0.089k	0.053k	0.684i	0.512i	1.559eh	1770cg	1.754 dg	2.130a	1.07 ab
D 9	0.143 jk	0.088k	0.802i	0.685i	1.327b	1.480gh	1.865bf	2.429 a	1.10a
Ravi	0.128jk	0.076k	0.837i	0.644i	1.333h	1.512th	1.929be	2.563a	1.13a
Mean	0.111f	0.068f	0.745d	0.576e	1.356e	1.627b	1.758b	2.270a	

Harvesting time: H_1 (3days), H_2 (17days) after salt stress
Means with different letters differ significantly according to Duncan's Multiple Range Test ($P \leq 0.05$)
Extra letters have been omitted except the first and the last ones to simplify the Table.

Table 2 Sodium concentration in stem of cotton cultivars at different harvests under saline condition.

---mol m^{-3} NaCI---									
Variety	O (Control)		75		150		250	Mean	
		H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
Sodium Concentration (m mol g^{-1} D.W).									
NAIB 78	0.124h	0.046h	0.489fg	0.427g	0.88le	1.202b	1. 137b	1.400 a	0.71a
MNH 93	0.147h	0.048h	0.604eh	0.445fg	0.934e	1.171b	1.119b	1.413a	0.74a
D 9	0.155h	0.048h	0.397g	0.457fg	0.658e	0.705dc	0.822cd	1.153b	0.55b
Ravi	0.175h	0.055h	0.429g	0.437g	0.686de	0.724de	0.949e	1.138b	0.57b
Mean	0.15e	0.05f	0.48d	0.44d	0.79c	0.95d	1.1b	1.28a	

Harvesting time: H_1 (3days) H_2 (17days) after salt stress
Means with different letters differ significantly according to Duncan's Multiple Range Test ($P \leq 0.05$)
Extra letters have been omitted except the first and the last ones to simplify the Table.

Table 3. Rate of Sodium Transport (JNa^+) from root to shoot of cotton cultivars under saline condition.

	---------- mol m^{-3} NaCI ----------			
Variety	O (Control)	75	150	250
	H_1 - H_2	H_1 - H_2	H_1 - H_2	H_1 - H_2
$J_{Na}{}^+$ from root to shoot (u mol g^{-1} D.W).h^{-1}				
NAIB 78	0.289	1.770	3.791	3.879
MNH 93	0.333	1.553	3.104	3.314
D 9	0.195	1.037	1.808	1.989
Ravi	0.219	1.071	2.457	1.408
Mean	0.259	1.358	2.790	2.648

Harvesting time: H_1 (3days) H_2 (17days) after salt stress.

Significantly greater Na^+ concentration in stem of the tolerant cultivar NIAB 78 compared with the sensitive cultivars indicates that NIAB 78 had an anatomical mechanism developed for the retention of Na^+ in stem, thus maintaining a low Na^+ concentration in the physiological more active organs i.e. leaves. Such a mechanism was suggested earlier in some leguminous plants like Sesbania aculeate by Salim *et al*. (1979).

Rates of Na^+ transport ($J_{Na}{}^+$) from root to shoot increased with increase in external salinity upto 150 mol m^{-3} NaCI while at 250 mol m^{-3} NaCI salinity, these rates did not increase further. According to Pitman (1984) such a trend was related to "demand" for solutes set up by the growing plants for osmoregulation. $J_{Na}{}^+$ of the tolerant cultivars were significantly higher than the sensitive cultivars especially at the highest salinity which indicated a relatively poorer control of the tolerant cultivars over Na^+ uptake at the root plasmalemma level. Alternatively, higher transpiration rates and greater "demand" for solutes for osmoregulation in the case of tolerant cultivars (with more biomass) could enhance the transport rates. Nevertheless, Na^+ transport to leaves seems to be restricted more in the case of tolerant cultivars compared with the sensitive ones.

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