Pak. j. life soc. sci. (2004), 2(2):109-111

Pakistan Journal of
Life and Social Sciences

Study of Distribution and Rate of Transport of Na^+ ion in Plant Tissues of Cotton Cultivars Differing in Salt Tolerance

Akhtar Nawaz Khan, R.H. Qureshi[1], and N.Ahmad[1]
Department of Soil Science, Faculty of Agriculture, Gomal University, D.I.Khan. Pakistan.
[1]Department of Soil Science, University of Agriculture, Fiasalabad, Pakistan

Abstract

Four cotton cultivars were studied at seedling stage in salinized nutrient growth medium upto 0, 75,150 and 250 mol m^{-3} NaCI salinity. After salinization, the seedlings were harvested one on day 3 and the other on day 17. The plant parts were analyzed for Na^+ contents. The tolerant cultivar NIAB 78 had significantly greater Na^+ concentration in stem than the sensitive D 9 and Ravi while the tolerant (NIAB 78) one maintained lower Na^+ concentration in leaf than the sensitive ones. It could be anatomical mechanism developed for the retention of low Na^+ concentrations in stem of tolerant cultivar (NIAB 78). J_{Na^+} of NIAB 78 higher than sensitive ones (D 9, Ravi) such a trend was related to demand for solutes set up by the growing plants for osmoregulation.

Key words: Rate of transport, Na, Cotton cultivars, Salt tolerance

Introduction

The reduction of plant growth under saline conditoins are due to toxic ions and low soil water potentials. The mechanisms of salt tolerance of cultivated crop species, that differ considerable in tolerance to salinity (Maas and Hoffman, 1977), range from restricted ion uptake and translocation into the shoot to structural metabolic changes that decrease salt injury (Maas and Nieman, 1978). Differences in salt tolerance occur not only between crop species but also between cultivars. The latter are attractive objects for studies on mechanisms of salt tolerance.

Varietal differences may be related with differences of ions especially Na^+ and / or CI^- retention in the root as well as with accumulation into the shoot (Abel and Mackenzie, 1964; Rathert and Doering, 1981). So, in the present study, four cotton cultivars of varying salt tolerance were studied to determine their Na^+ uptake under saline conditions.

Corresponding author: Akhtar Nawaz Khan,
Department of Soil Science, Faculty of Agriculture,
Gomal University, D.I. Khan. Pakistan

Materials and Methods

Seedlings 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. Later on, ½ Hoagland solution No.1 (Hoagland and Arnon 1950) was applied until seedlings were transplanted at 2 leaf stage. Cotton seedlings at 2 leaf stage were transferred to aerated to the 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 throughout day and night. After two days 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 (one on day 3 and the other on day 17 after salinization) to collect plant materials for analysis. Shoot, leaves, stem and root Na^+ contents were determined flame-photometrically on nitric acid extracts (Pitman. 1965). The rate of ion transport was determined according the formulae used by Salim and Pitman (1983).

$$J = (1/WR)\,(dM/dT) = M_1 - M_2 / WR \times \Delta T.$$

Where WR was the root weight and M was the amount of the ion in the plant tissue (umol per plant). The rate of ion transport was calculated as:

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

Where M_1, M_2 are the amounts of ion at harvest 1 and harvest 2, respectively.

Results and Discussion

Higher the salt concentration in the external solution, higher was the Na^+ concentration in plant leaves and stem (Table 1 and 2). Data also 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) while the tolerant cultivars had significantly greater Na^+ concentration 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 very rapid and was then somewhat stablized with only a small increase at 250 mol m^{-3} NaCI salinity; infact it decreased in the case of Ravi.

It is interesting to find that the tolerant cultivar NIAB 78 and moderate 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. At 250 mol m^{-3} NaCI, NIAB 78 had about 3 times greater J_{Na}^+ than the sensitive cultivar Ravi.

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 *Susbania aculeata* 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 greater 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. Never-the-less, Na^+ transport to leaves seems to be restricted more in the case of tolerant cultivars compared with the sensitive ones.

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

mol m^{-3} NaCI									
Variety	0 (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	0.542i	1.559eh	1770cg	1.754 dg	2.130 ac	1.07ab
D 9	0.143 jk	0.088k	0.802i	0.685i	1.327h	1.480gh	1.865bf	2.429 a	1.10 a
Ravi	0.128jk	0.076k	0.837i	0.644i	1.333h	1.512fh	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); H2 (17days) after salt stress
Means with different letters differ significantly according to Duncan's Multiple Range Test (P= 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 conditions.

mol m^{-3} NaCI									
Variety	0 (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	0.88lc	1.202b	1. 137b	1.400 a	0.71a
MNH 93	0.147h	0.048h	0.604eh	0.445fg	0.934c	1.171b	1.119b	1.413a	0.74a
D 9	0.155h	0.048h	0.397g	0.457fg	0.658e	0.705de	0.822cd	1.153b	0.55b
Ravi	0.175h	0.055h	0.429g	0.437g	0.686de	0.724de	0.949c	1.138b	0.57b
Mean	0.15e	0.05f	0.48d	0.44d	0.79c	0.95d	1.01b	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= 0.05)
Extra letters have been omitted except the first and the last ones to simplify the table.

Table 3: Rate of Sodium Transport (J_{Na+}) from root to shoot of cotton cultivars under saline conditions.

Variety	mol m^{-3} NaCI			
	0 (Control)	75	150	250
	H_2-H_1	H_2-H_1	H_2-H_1	H_2-H_1
	J_{Na}^+ from root to shoot (m 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.

References

Abel, G.H., and Mackenzia, A.J. Salt tolerant of soybeen varietes. (Glyline Max L. Merrill). during germination and later growth. Crop Sci., 1964. 4:157-161.

Hoagland, D.R., and Arnon, D.I. The water culture method for growing plants without soil. Calif. Agri. Exp. Stn., Cir., 347, pp:32. 1950.

Maas, E.V. and Hoffman, G.J. Salt tolerance current assessment. J. Irrig. Drainage Div. Am. Soc. Engg., 1977. 103: 115-134.

Maas, E.V., and Nieman, R.H. Physiology of plant tolerance to salinity. In: G.A. Jung (Ed.) Crop tolerance suboptimal land conditions. Amer. Soc. Agron. Pub.32 Chapter 13: pp: 277-299. 1978.

Pitman, M.G. Sodium and potassium uptake by seediangs of *Hordeum vulgare*. Aust. J. Biol. Sci., 1965.18: 10-24.

Pitman, M.G. Transport across the root and shoot/root interactions. In: R.C. Staples. G.H. Toenniessen. (Eds.) Salinity tolerance in plants, strategies for crop improvement. John Wiley and sons. pp: 93-123. 1984.

Rathert, G., and Doering, H.W. IV Ion-Specific salinity effects on amylases in leaves of bushbean and sugarbeet plants. J. Plant Nutr., 1981. 4: 261-277.

Salim, M., Aslam, Z., Sandhu, G.R. and Qureshi, R.H. Salt Tolerance studies on *Susbania aculeata*. Pak. J. Agri. Sci., 1979. XVI (3-4): 41-45.

Salim, M., and Pitman, M.G. Effects of salinity on ion uptake and growth of mungbean plants (*Viqna radiata* L.) Aust. J. Plant Physiol., 1983. 10: 395-407.