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Effect of External Sodium Chloride Salinity on Ionic Composition of Leaves of Cotton Cultivars I. Cell Sap, Sodium and Potassium

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ABSTRACT

This study was conducted to observe the effect of external sodium chloride salinity on cell sap, sodium and potassium of leaves of cotton cultivars. This experiment was conducted in hydroponic system in growth tanks. Four cotton cultivars i.e. two sensitive (D 9 and Ravi) and two relatively tolerant cultivars (NAIB 78 and MNH 93) were grown under salt stress of 0, 75. 150, 250 mol m^{-3} NaCI for two weeks. The individual leaves were collected and grouped into expanding (Young: leaf 1+ leaf 2) and expanded (Old: leaf 3+ leaf 4) to assess the salt tolerance of cotton cultivars based on cell sap Na^+, K^+ and $Na^+ + K^+$ concentrations. The tolerant cultivars had lower concentration of Na^+ and $Na^+ + K^+$ in leaves than the sensitive ones.

Key Words: Salinity; Ionic composition; Cotton

INTRODUCTION

The reduced growth and the ultimate death of a plant in saline environments is related to a number of factors including a build-up of ions in the cytoplasm of leaf and root cells that inhibits metabolic processes or to a build-up of ions in the cell walls of the leaves (Oertli, 1968; Greenway & Munns. 1980).

Ion entering the shoot may be involved in complex interaction with growth rate or they may be compartmentalized on tissue (leaf to leaf). Intercellular and intracellular basis and gradients in salt concentration from leaf to leaf are often reported for nonhalophytes exposed to salinity (Flower *et. al*., 1977).

The mature leaves of some species become severely injured at high NaCI levels in medium (Bernstein, 1971). Varietal comparisons within certain species indicate that this injury results from a very high $CI^-$and/or Na^+ concentration in these leaves (Bernstein, 1975; Lauchli & Wieneke, 1979; Greenway & Munns, 1980)

This study was conducted to observe the effect of external sodium chloride salinity on cell sap, sodium and potassium of leaves of cotton cultivars.

MATERIALS AND METHODS

This experiment was conducted in hydroponic system in iron growth tanks. Four cultivars i.e., two sensitive (D 9 and Ravi) and two relatively tolerant cultivars (NAIB 78 and MNH 93) were included for comparison. Cotton seedlings were germinated in silica sand in iron trays (60 x 30 x 5 cm).

Two leaves seedlings were transferred to aerated half strength Hoaglands solution in iron tanks (120 x 90 X 30 cm) covered with foam sheets having holes for holding plants. The solutions were aerated using an air compressor. The medium was changed to full strength Hoagland solution after establishment of the seedlings. Nutrient solution were salinized in increments of 50 mol m^{-3} per day upto the final salinity levels (0, 75, 150 and 250 mol m^{-3} NaCI) which were maintained for the rest of the growth period (2 weeks). The average temperature was 33^0C and average relative humidity was 52%. The experiment was laid out in Completely Randomized Design. Two weeks after imposing salt stress, plants were harvested and separated into root and leaves. Fresh leaves were washed with distilled water and blotted with tissue paper before storage. The leaves were grouped into expanding (Young : leaf 1+ leave 2) and expanded (Old : leaf 3 + leaf 4) groups for comparisons. The cell sap was used for the determination of Na^+ and K^+.

RESULTS AND DISCUSSION

Data presented in Table I indicate that cotton maintained lower sap Na^+ concentration in the younger leaves than fully expanded older leaves and the differences were statistically significant at all the salinity levels (except control). The tolerant cultivars had a significantly lower Na^+ concentration in leaf sap than the sensitive cultivars. However, it is interesting to find that even the sensitive cultivars exhibited such a character rather more strongly. This type of differentiation was more pronounced at low salinity ($Na^{+\ young}$: $Na^+{}_{old}{}^{1:2}$) than at the high salinity ($Na^+{}_{young}$: $Na^+{}_{old}{}^{1:1.1}$)

The distribution pattern of sap K^+ in various leaves was opposite to that of Na^+ and younger leaves had significantly greater K^+ concentration than the older leaves in salinity treatment (Table II). These differences were more pronounced at higher salinity as the ratio (K^+_{young}: K^+_{old}) increased with the increase in external salinity. It is notable that the sensitive cultivar had significantly greater sap K^+ than the tolerant ones. Such a tendency is contradictory to the trends observed in other crops such as wheat (Chauhan *et al*., 1980) and Barley (Wyn Jones & Storey, 1978b). It is interesting to find that even in the control treatment the sensitive cultivars had significantly more sap K^+ than the tolerant ones. However, Pitman (1972) reported that this difference was due to translocation of K^+ in the phloem from older to younger leaves.

The trend of Na^+ + K^+ (Table III) was similar to that for Na^+ (Table I). The tolerant cultivars exhibited significantly lesser Na^+ + K^+ levels compared with the sensitive cultivars and a greater accumulation in order leaves than the younger ones. This was in agreement with Salim and Pitmans (1983) who have shown that the level of Na^+ + K^+ was related to the salt tolerance in Mungbean Plants.

Results clearly show that there was a definite gradient in the accumulation of various ions of leaves of different ages. Na^+ accumulated to a much greater extent in the older than in the younger leaves. K^+ concentration on the other hand showed the opposite trend in salinity treatment, where

Table I. Na^+ Contents (m mol Kg^{-1}) of Leaf Cell Sap of Various Cotton Cultivars Grown at Different Salinity Levels

	mol m^{-3} NaCI								
Variety	**O(Control)**		**75**		**150**		**250**		**Mean**
	Young	**Old**	**Young**	**Old**	**Young**	**Old**	**Young**	**Old**	
	leaves								
NAIB 78	9 q	11q	30pq	70 op	131 mn	286 gj	314 eh	329 eg	148c
MNH 93	7 q	12 q	29pg	78 op	187 l	259 ij	355 de	408 bc	167b
D 9	9q	12q	110no	172lm	238jk	345df	411bc	470a	221a
Ravi	11q	16q	132mn	273hj	204kl	303fi	385cd	450ab	222a
Mean	9g	13g	75f	148e	190d	298c	366b	414 b	

Young (Expanding) and Old (Expanded) leaves
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 II. K^{-1} Contents (m mol Kg^{-1}) of Leaf Cell Sap of Various Cotton Cultivars Grown at Different Salinity Levels

	mol m^{-3} NaCI								
Variety	**O(Control)**		**75**		**150**		**250**		**Mean**
	Young	**Old**	**Young**	**Old**	**Young**	**Old**	**Young**	**Old**	
	Leaves								
NAIB 78	147 dg	169d	128fj	124fj	121 gj	53 pq	93 kn	42 q	110 b
MNH 93	128 fj	169 b	145dh	139ei	113ik	58oq	90 kn	45 pq	111b
D 9	163de	233b	140 ei	117hk	128hj	83lo	106jm	71np	130 a
Ravi	197 c	262 a	150 df	114ik	127fj	81 mo	109 jl	67nq	138a
Mean	159 b	208a	141c	124 d	122d	69f	100 e	56 g	

Young (Expanding) and Old (Expanded) leaves
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 III. Na^+ + K^+ Contents (m mol Kg^{-1}) of leaf cell sap of various cotton cultivars grown at different salinity levels

	mol m^{-3} NaCI								
Variety	**O (Control)**		**75**		**150**		**250**		**Mean**
	Young	**Old**	**Young**	**Old**	**Young**	**Old**	**Young**	**Old**	
	Leaves								
NAIB 78	156 no	180mo	158mo	194 lo	252 jl	339 fh	407 ce	371 dg	257d
MNH 93	135o	181 mo	174mo	217 ml	300 hj	317 gi	445 bc	453 bc	278 c
D 9	172 mo	245 jl	250 jl	289hk	366 eg	428 cd	517 a	541a	351b
Ravi	208 ln	278 ik	282 hk	387df	331fi	384 df	449ab	533a	357 a
Mean	168f	221e	216 e	272 d	312 c	367 b	455a	471a	

Young (Expanding) and Old (Expanded) leaves
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.

older leaves had significantly lower K^+ concentration than the younger leaves. Differential accumulation of Na^+ and K^+ in leaves of different ages has also been reported earlier in rice (Yeo & Flowers, 1982), barley (Greenway, 1962b), Beans (Salim & Pitman, 1983; Imamul Haq & Larher 1985).

Varietal differences with respect to Na^+ and $Na^+ + K^+$ concentration were clearly evidenced that the tolerant cultivars accumulated relatively less of these ions than the sensitive cultivars (Table I & III).A similar trend was also reported by Lauchli and Stelter (1982). However, there was no relationship between K^+ concentration (Table II) and salt tolerance of different cotton cultivars.

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