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RESPONSE OF COTTON CULTIVARS TO VARIOUS K^+ / Na^+ RATIOS DURING THEIR GROWTH IN SALINE CONDITIONS

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ABSTRACT

Four cotton cultivars differing in tolerance to stressed conditions were grown in solution culture at salt concentrations of 75,150 mol m^{-3} and control. The K^+/Na^+ ratios of 1:1, 1:2.5, 1:5,1:10 and 1:20 were maintained at each salinity level. At salt stress of 75 mol m^{-3}, the K^+ / Na^+ ratios of 1:2.5 and 1:20 produced significantly ($P \leq 0.05$) higher fresh matter yield as compared to other ratios. At salt stress of 150 mol m^{-3}, the yield differences due to external K^+ / Na^+ ratios were non significant. Higher shoot growth reduction was found at K^+/ Na^+ of 1:1 in both salinity levels. It is concluded that the K^+: Na^+ ratio of 1:2.5 (low salinity) and 1:10 (high salinity) had least inhibitory effect on the growth of cotton cultivars as compared to all other K^+/ Na^+ ratios. Performance of NIAB 78 and MNH 93 was superior to Ravi and D 9.

Key-words: Cotton cultuvars, salinity, K^+/ Na^+ ratios,

INTRODUCTION

Soil salinity and sodicity is one of the major and increasing problem in irrigated agriculture in Pakistan (Mahar *et al.*, 2003). Salinity decreases plant growth and yield to various degrees depending on plant species. Salinity level and ionic composition of the salts that contribute to it (Ashraf *et al.*, 2002).

Potassium is essential for the maintenance of turgor in growing plant cells (Wyn Jones *et al*., 1979). Salt affected soils widely differ in K^+/ Na^+ ratios and may affect plant growth due to K^+ - Na^+ interaction possibly resulting in an ion imbalance stress (Devitt *et al*., 1981). Role of potassium is particularly important for salt stressed nonhalophytes, since high external Na^+ concentrations can reduce K^+ accumulation and high cytoplasmic Na^+ / K^+ ratio is showing relationship with salt tolerance. (Aslam *et al*., 1990). In the present study, various K^+ / Na^+ ratios were prepared in saline substrates to study its effect on the growth and to establish relationship between K^+/ Na^+ ratios and salt tolerance of cotton cultivars

MATERIALS AND METHODS

Cotton cultivars were tested under laboratory conditions using acid delinted and water graded seeds of each cultivar and were sown in plastic coated galvanized irontrays (60x 30x 5 cm) filled with clean acid washed silica sand upto 4 cm depth.

Four cotton cultivars i.e. NIAB 78, MNH 93, D 9 and. Ravi at 2 leaves seedlings stage were transferred to 1 cm plugged holes in thermopal sheets floated over 15 liters aerated half strength Hoagland nutrient solution (Hoagland and Arnon, 1950) in plastic tubs. Three holes were used for each cultivar, where as each hole having one seedling. The experiment was laid out in Completely Randomized Design with three replications. Hoagland solution was made to full strength when the seedlings were established. The medium was salinized to final salinity levels of 75 and 150 mol m^{-3} in increments of 25 mol m^{-3} ($K^+ + Na^+$) $24h^{-1}$. The various K^+ / Na^+ ratios were 1:1, 1:2.5 1:5, 1:10 and 1:20 using KCl and NaCl salts as a source of potassium and sodium respectively. The solutions were changed every 2^{nd} day. After 15 days of salt stress fresh shoot and root were recorded.

RESULTS AND DISCUSSION

Different K^+: Na^+ ratios in the external medium affected fresh weight of cotton seedlings significantly at low salinity (75 mol m^{-3}) but at high salinity (150 ml m^{-3}), the differences in yield due to variation in external K^+ : Na^+ ratios were statistically non significant (Table 1). The average yield was lower at higher salinity, and control gave significantly ($P < 0.05$) greater yield than all the other treatments. At 75 mol m^{-3} $K^+ + Na^+$ cumulative fresh shoot yield (4 varieties) was significantly higher than K^+ : Na^+ ratios of 1:2.5 compared with all other ratios except the ratio 1:20. At high salinity (150 mol m^{-3}) relatively higher shoot fresh yields were found with the K^+ : Na^+ ratios of 1:10 and 1:20 which were not significantly different from other ratios, although, there was a definite tendency of increase in yield with increase in K^+: Na^+ ratios. It is worth noting that at both the salinity levels, the adverse effect of K^+: Na^+ ratio of 1:1 was greater than all the other K^+:Na^+ ratios studied. Varietal differences in shoot yield were significant. The comparatively tolerant varieties NIAB 78 and MNH 93 had significantly higher yield than the sensitive varieties D 9 and Ravi while these differed non-significantly from each other. In general, the cultivars K^+ : Na^+ ratios interaction was more pronounced in relatively salt tolerant cultivars. NIAB 78 produced significantly more fresh weight at K^+ :Na^+ ratios of 1:2.5 (75 mol m^{-3} Na^+ + K^+) and 1:10 (150 mol m^{-3} Na^+ + K^+) while MNH 93 had significantly more yield at K^+ : Na^+ ratio of 1:2.5 (low salinity) than all the other treatments. Similarly, cultivars D 9 produced the maximum yield at K^+ : Na^+ ratio of 1:2.5 (low salinity) which was significantly more than all other external K^+: Na^+ ratios except the ratios of 1:20 (low salinity).

At low salinity (75 mol m^{-3}), the K^+ /Na^+ ratios of 1:2.5 was least inhibitory effect on the growth of cotton cultivars as compared to all others K^+ :Na^+ ratios. At this salinity (75 mol m^{-3}), the effect of treatments on fresh shoot yield of various K^+ /Na^+ ratios varied, the fresh shoot yield was diminished with ratio of 1:1 indicating a toxic effect of higher concentration of K^+ in the root medium as suggested by Lauchli and Epstein (1984).

The effect of various K^+ :Na^+ ratios on fresh root yield was significant and this effect was dependent on the level of salinity (Table 2). At 75 mol m^{-3} salinity, the maximum cumulative fresh root weights were produced with K^+ : Na^+ ratio of 1:2.5 while at the high salinity, the ratio of 1:10 was the least harmful. In general, there was an increasing trend in root yield with decreasing K^+: Na^+ ratio except in the case of K^+: Na^+ ratio of 1:20 at the high salinity. At both the salinities, the minimum root yield took place at the K^+: Na^+ ratio of 1:1.

Table 1. Effect of various K^+ : Na^+ ratios in the external solution on the shoot fresh yield (g plant $^{-1}$) of cotton cultivars.

		75 mol m^{-3} (K^+ + Na^+)					150 mol m^{-3} (K^+ + Na^+) — K^+: Na^+ ratios					
Variety	Control	1:1	1:2.5	1:5	1:10	1:20	1:1	1:2.5	1:5	1:10	1:20	Mean
NIAB 78	5.82ab	3.05df	4.15 c	2.95dg	2.93 dg	3.19 de	2.51 dk	2,54 dj	2.73dh	4.25c	3.42cd	3.41 a
MNH 93	6.41 a	2.40 dl	4.18 c	2.93 dg	2.70 di	3.18 de	2.33 el	2.53 dj	2.34 el	2.59 dj	2.99 df	3.14 a
D 9	5.36 b	1.75hm	3.27 de	1.19 n	1.39 lm	3.09 df	1.50km	1.30 m	1.98 gm	1.82 hm	1.83 hm	2.23 b
Ravi	5.69 ab	1.96 gm	2.61 dj	1.69 im	1.51 km	3.16 df	1.59 jm	1.75 hm	1.86 hm	1.96 gm	2.15 fm	2.36 b
Mean	5.82 a	2.29 d	3.55 b	2.19 d	2.13 d	3.16 bc	1.98 d	2.03 d	2.23d	2.66 cd	2.60 cd	

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 Effect of various K^+ : Na^+ ratios in the external solution on the the fresh root yield (g plant $^{-1}$) of cotton cultivars.

		75 mol m^{-3} (K^+ + Na^+)					150 mol m^{-3} (K^+ + Na^+) — K^+: Na^+ ratios					
Variety	Control	1:1	1:2.5	1:5	1:10	1:20	1:1	1:2.5	1:5	1:10	1:20	Mean
NIAB 78	1.22 ab	0.58 ch	0.73cd	0.65 cg	0.90bc	0.70ce	0.35eh	0.68 cf	0.68 cf	1.04 ab	0.58 ch	0.74 a
MNH 93	1.25 a	0.32 eh	0.50 dh	0.54 ch	0.63 ch	0.52 dh	0.26 h	0.36 dh	0.37 dh	0.43 dh	0.50 dh	0.52 b
D 9	1.23 ab	0.48 dh	0.60 ch	0.35 eh	0.37 dh	0.57 ch	0.27 gh	0.31 fh	0.34 eh	0.45 dh	0.48 dh	0.50 b
Ravi	1.20 ab	0.31 fh	0.59 ch	0.52 dh	0.35 eh	0.59 ch	0.28 gh	0.47 dh	0.46 dh	0.48dh	0.40 dh	0.51 b
Mean	1.23 a	0.42 bc	0.61 b	0.52 bc	0.56 b	0.59 b0	.29 c	0.45 bc	0.46 bc	0.60 b	0.49 bc	

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.

Plant responses to salinity has been reviewed by different researchers in the past (Maas and Nieman, 1978, Green way and Munns, 1980 and Poljakoff-Mayber, 1982). Cotton is considered to be fairly salt tolerant (Maas, 1986) but varietal differences have also been reported (Lauchli and Stelter, 1982). Results revealed an interesting pattern of the effect of external K^+: Na^+ ratios on the fresh shoot yield of cotton. At low salinity (75 mol m^{-3}), the $K^{+:}$

Na^+ ratio of 1:2.5 followed by 1:20 produced significantly greater yield than all other ratios while at higher salinity (150 mol m^{-3} $K^+ + Na^+$) the overall differences in yield due to external K^+: Na^+ ratios were non significant. Perhaps, at this high salinity, specific ion toxicity was masked by osmatic effects. However, the tolerant cultivar NIAB 78 showed significantly greater shoot fresh yields at high salinity with K^+: Na^+ of 1:10 than the sensitive ones. Data on the root yield was some what similar to those of shoot yield. In general, non specific effects of salinity were dominant at high salinity as various K^+: Na^+ ratio did not differ significantly from one another in respect of their effect on fresh shoot yields of cotton. However, specific toxicity of Cl^- could not be ruled out even at the high salinity. At low salinity, various K^+: Na^+ ratios showed significant differences but it is difficult to partition the specific effects in this case as the effect of decreasing K^+: Na^+ was nonlinear with an apparent enhanced toxicity at the ratios 1:1, 1:5 and 1:10. Greater toxicity of KCl than NaCl was also reported in sorghum bicolor (Weimberg *et al*., 1982), mung bean plants (Salim and Pitman, 1983) and Lucerne (Smith and Struckmeyer, 1977).

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