Pak. j. life soc. sci. (2004), 2(2):97-98

Pakistan Journal of
Life and Social Sciences

Effect of External K^+/Na^+ Ratios on Growth of Cotton in Salt Stressed Conditions

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Abstract

Four cotton cultivars were grown in solution culture at salt concentrations of 75,150 mol m^{-3} apart from control, 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^+ of 1:2.5 and 1:20 produced significantly greater fresh weight 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. The maximum adverse effect on the shoot growth of cotton was found at K^+/ Na^+ of 1:1 in both salinity levels. Performance of NAIB 78 and MNH 93 was superior, to Ravi and D 9.

Key words: External K^+/Na^+ ratios, Cotton growth, Salt stress conditions

Introduction

Potassium is important for the generation of turgor in growing plant cells (Wyn *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 of cotton cultivar and to establish relationship between this parameter and salt tolerance of cotton cultivars.

Materials and Methods

Seedlings of four cotton cultivars i.e. NIAB 78, MNH 93, D 9 and. Ravi at 2 leaves 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.

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Three holes were used for each cultivar, each hole having one seedling. The experiment was laid out in Completely Randomized Design. 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. The solutions were changed every 2nd 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). As expected, the average yield was lower at higher salinity, and control gave significantly greater yield than all the other treatments. At high salinity (150 mol m^{-3} Na^++ K^+) the 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 (Table 1). 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. 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, the cultivars D 9 and Ravi also 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).

The various K^+ :Na^+ ratios affected on fresh root growth significantly, and this effect was dependent on the level of salinity (Table 2).At 75 mol m^{-3} Na^+ + K^+, 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 growth took place at the K^+: Na^+ ratio of 1:1.

A plant response 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, 1984) 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} K^+: Na^+), the K^+ + Na^+ ratio 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.

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

Variety	Control	75 mol m^{-3} (K^+ + Na^+)					150 mol m^{-3} (K^+ + Na^+)-					Mean
		K^+: Na^+ ratios										
		1:1	1:2.5	1:5	1:10	1:20	1:1	1:2.5	1:5	1:10	1:20	
NAIB 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 at seedling growth stage.

Variety	Control	75 mol m^{-3} (K^+ + Na^+)					150 mol m^{-3} (K^+ + Na^+)-					Mean
		K^+: Na^+ ratios										
		1:1	1:2.5	1:5	1:10	1:20	1:1	1:2.5	1:5	1:10	1:20	
NAIB 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 b	0.29 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.

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