Pak. J. Agri. Sci.
27 (2) 193, 1990

IMPROVEMENT IN SALT TOLERANCE OF COTTON

A. Rauf, A. Razzaq, S. Muhammad & J. Akhtar
Department of Soil Science, University of Agriculture, Faisalabad

A pot experiment was conducted to evaluate the effects of presowing seed treatments on vegetative growth of cotton under saline conditions. Delinted cotton seeds were treated in 0.5 per cent solution/suspension of $ZnSO_4$, $CaSO_4$ and $CaCl_2$ for eight hours prior to sowing. Three salinity levels, i. e., 4, 8 and 12 dS m^{-1} were developed with NaCl salt while the soil as such (2.6 dS m^{-1}) was used as control. After 56 days of sowing the plants were uprooted. Seeds treated with 0.5% $CaSO_4$, $ZnSO_4$ and $CaCl_2$ produced 50, 37 and 17 per cent more biomass, respectively than control. After harvesting, the analysis of plants showed that calcium treatment enhanced the potassium selectivity against sodium which was almost doubled as compared to control.

INTRODUCTION

Excessive concentration of solube salts in the root zone is one of the major factors limiting cotton production and it was indicated that cotton seed yield on slightly salt affected soils was 41% lower than on normal soil (Qayyum and Malik, 1988). Cotton is quite sensitive to salt at germination and seedling stages but comparitively resistant there after (Bhatti and Rashid, 1980). Any technique which may ensure good seedling establishment under saline conditions would be highly desired. Presowing seed treatment is a promising technique which promotes the germination and plant growth under both normal and saline conditions (Henkel and Strogonov, 1961). Present study was undertaken to investigate the effects of some presowing seed treatments on salt tolerance of cotton.

MATERIALS AND METHODS

A pot experiment was conducted in the Department of Soil Science University of Agriculture, Faisalabad using sandy loam soil [ECe 2.6 dSm^{-1}, pH 7.9, SAR 4.6 $(mM/l)^{\frac{1}{2}}$] during 1989. Five kg of dried ground and sieved soil was filled in each plastic pot. Seeds of cotton var. NIAB–78 were soaked for eight hours in 0.5% solution/suspension each of $ZnSO_4$, $CaSO_4$ and $CaCl_2$ before sowing them into salinized pots. Canal water soaked seeds were used as control for presowing treatments. Seven seeds were sown in each pot and the seedlings were thinned to four after 10 days of germination.

Three salinity levels (ECe 4, 8 and 12 dSm^{-1}) were developed by adding NaCl while the soil as such was used as control. A basal dose of N and P (45–20 kg ha^{-1}) as urea and SSP was applied. Canal water was used for irrigation as and when needed. Pots were arranged according to Completely Randomized Design with factorial combination of treatments having three repeats.

At the end of eight weeks plants were uprooted carefully and fresh weight of shoot and root was noted and then dry weight was determined after oven drying at 60 C°. Comparison among treatments was made by Duncan's Multiple Range Test (Duncan, 1955).

Potassium versus sodium selectivity was calculated according to the following formula.

$$S_{K,\,Na} = \frac{K/Na \text{ in plant tissue}}{K/Na \text{ in soil extract}} \quad \text{(pitman 1976)}$$

RESULTS AND DISCUSSION

Plant growth

The length of shoots and roots decreased gradually with progressive increase in salinity (Table 1). Shoot lengths at EC 2.6 and 4 dS m^{-1} did not differ significantly; however at EC 8 and 12 dS m^{-1} reduction was 5 and 30 per cent respectively, as compared to control. Presowing seed treatments increased the shoot length at all salinity levels, and $CaSO_4$ gave the maximum mean shoot length (37.6 cm) followed by $CaCl_2$ (32.7 cm) and $ZnSO_4$ (31.5 cm). On an average, there was 52, 32 and 27 per cent increase in shoot length with $CaSO_4$, $CaCl_2$ and $ZnSO_4$ applications, respectively, as compared to control.

The maximum decrease of 21 per cent in root length occurred at EC 12 dS m^{-1} as compared to control; decrease at EC 8 was 18 per cent having non–significant differences with EC 12 but significant with control (EC 2.6) and EC 4 dSm^{-1}. On the other hand, presowing seed treatments had significant benefical effects on the root length. $CaSO_4$ gave the maximum root length followed by $ZnSO_4$ and $CaCl_2$. On an average, there was 70, 40 and 21 per cent increase in the root length with the application of $CaSO_4$, $ZnSO_4$ and $CaCl_2$ respectively, over the control.

Maximum shoot fresh weight was obtained at EC 4 dSm^{-1} and was about 2% more than the control. Increase in salinity decreased the shoot fresh weight by 8 and 45 per cent, respectively, at EC 8 and 12 dSm^{-1} compared to control. All the presowing seed treatments increased the fresh weight of shoot significantly. There was about 48, 31 and 13 per cent mean increase over control due to seed soaking in $CaSO_4$, $ZnSO_4$ and $CaCl_2$ solutions, respectively.

Table 1. Effect of presowing seed treatments on cotton at various salinity levels (Average of three repeats)

		EC_e levels (dSm^{-1})			
Treatments	2.6	4	8	12	Mean
		Shoot length (cm)			
Water	27.0	27.1	25.2	19.8	24.8 d
0.5% $ZnSO_4$	34.3	35.6	33.2	22.8	31.5 c
0.5% $CaSO_4$	40.0	41.2	40.4	29.0	37.6 a
0.5% $CaCl_2$	36.0	36.7	34.0	24.2	32.7 b
Average	34.3 a	35.1 a	33.2 b	23.9 c	
		Root length (cm)			
Water	22.8	21.6	18.3	16.3	19.7 c
0.5% $ZnSO_4$	30.5	33.0	23.0	24.3	27.7 b
0.5% $CaSO_4$	36.0	35.6	31.2	31.6	33.6 a

Table 1 continued

Treatments	2.6	4	8	12	Mean
	ECe levels (dSm^{-1})				
0.5% $CaCl_2$	25.6	27.3	21.8	20.6	23.8 b
Average	28.7 a	29.4 a	23.6 b	23.2 b	
	Shoot fresh weight (g pot^{-1})				
Water	35.5	35.8	30.7	16.4	29.6 d
0.5% $ZnSO_4$	43.5	45.6	41.3	25.5	38.9 b
0.5% $CaSO_4$	47.5	52.6	47.4	27.6	43.8 a
0.5% $CaCl_2$	40.4	37.2	34.9	22.1	33.6 c
Average	41.7 a	42.8 a	38.6 a	22.9 b	
	Root fresh weight (g pot^{-1})				
Water	2.4	2.7	2.0	1.2	2.1 c
0.5% $ZnSO_4$	4.6	5.3	4.4	3.8	4.5 a
0.5% $CaSO_4$	4.8	5.6	4.5	4.0	4.7 a
0.5% $CaCl_2$	4.3	5.2	3.4	2.7	3.9 b
Average	4.0 a	4.7 a	3.6 b	2.9c	
	Potassium contents (me $100g^{-1}$ DM)				
Water	17.3	14.8	12.1	10.7	13.7 d
0.5% $ZnSO_4$	18.2	15.0	13.1	11.7	14.5 c
0.5% $CASO_4$	22.7	19.5	16.8	15.7	18.6 a
0.5% $CaCl_2$	21.7	18.6	16.1	15.4	17.9 b
Average	20.0 a	17.0 b	14.5 c	13.4 d	
	Potassium selectivity over sodium				
Water	8.6	2.3	1.6	1.1	3.4 b
0.5% $ZnSO_4$	10.7	2.9	2.0	1.3	4.2 b
0.5% $CaSO_4$	19.5	5.3	4.0	2.7	7.9 a
0.5% $CaCl_2$	22.3	5.5	3.6	2.6	8.5 a
Average	15.3 a	4.0 b	2.8 c	1.9 c	

Mean followed by same letter (s) in rows and columns are statistically alike at 5% level of significance.

Increasing salinity decreased the root fresh weight significantly, however at EC 4 dSm^{-1} there was a slight increase over the control. On an average, the maximum reduction (28 per cent) was found at EC 12 as compared to control followed by EC 8 dSm^{-1}. The seed treatments improved the root growth resulting in higher fresh weight. It appears that the roots were relatively more benefited by the seed treatments than the shoots.

Potassium contents of shoot

There was a significant decrease in potassium contents of shoot with increasing salinity (Table 1). Maximum decrease (31 per cent) in potassium content was observed at EC 12 as compared to control. On the other hand, presowing treatments showed a pronounced effect on potassium contents and an increase of 36 and 31 per cent over control was observed where seed was treated with $CaSO_4$ and $CaCl_2$, respectively.

Potassium selectivity versus sodium

Increasing salinity levels decreased the potassium selectivity versus sodium drastically, even slight increase in salinity over the control decreased potassium selectivity tremandously. The decrease at EC 4, 8 and 12 dSm^{-1} was 74, 82 and 87 per cent respectively compared to control. Presowing seed treatments improved potassium uptake from the soil by plants and there was 30 and 49 per cent increase with $CaSO_4$ and $CaCl_2$, respectively as compared to control.

Reduction in shoot length under saline conditions is eventually due to the excess of salts which modify the metablic activities of cell wall causing deposition of various materials which limit the cell wall elasticity and consequently the turgor pressure efficiency in cell enlargement (Aceves–N, *et al.*, 1975). In addition to this, decline in enzymes' activity with increasing salinity has been reported to be associated with change in osmotic potential of soil due to higher salt concentration, specific ion toxicity and salting out effect of solube salts on enzyms' proteins (Ahmad and Khan, 1988). However increase in salt tolerance of calcium treated cotton seed may be attributed to calcium, which is absorbed during the treatment phase and counteracts the harmful effects of sodium (Chaudhri and Rajput, 1966). The beneficial effect of calcium on root growth of cotton in saline environment may be due to maintenance of potassium sodium selectively and adequate calcium status in the root (Kent and Lauchli, 1985). However, a greater response in growth with $CaSO_4$ than $CaCl_2$ could also be related to the less toxicity of associated anions i. e. SO_4 than Cl (Bhatti et al., 1981). The improvement in potassium selectivity is might be due to the fact that calcium is maximally effective in maintaining the integrity of selective absorption mechanism (Epstein, 1961). Also, calcium reduces the efflux of cytosolic potassium and retards the entry of sodium by maintaining the cation selectivity of membrane (Cramer *et al.*, 1986).

REFERENCES

Aceves–N. E., L. H. Stolzy and G. R. Mehuys. 1975. Effect of soil osmotic potential produced with two salt species on plant water potential, growth and grain yield of wheat. Plant Soil 42: 619–627.

Ahmed, I. and K. M. Khan 1988. Studies on enzyme's activity in normal and saline soils. Pak. J. Agric. Res. 9: 506–508.

Bhatti, A. S., G. Sarwar and M. Tahir. 1981. Response of corn to micronutrients (Zn and Cu) on a saline soil. II. Effects of presowing seed treatment. PP. 91–96. In Proc., Workshop/Seminar on Membrane Biophysics and Salt Tolerance in Plants. March 11–21, 1978, Faisalabad. Pakistan.

Bhatti, H. M. and M. Rashid. 1980. Role of soil factors in cotton production. A review. The Pak. Cottons 24 : 183–192.

Chaudhri, I.I. and B. A. Rajput. 1966. Investigations on salt resistance in cotton. Pak. J. Sci. Indust. Res. 9 : 260–264.

Cramer, G. A., A. Lauchli and V. S. Polito. 1986. Displacement of Ca^{++} by Na^{+} from the plasmalemma of root cells. A primary reponse to salt stress. Plant physiol.79:207–211.

Duncan, D. B. 1955. Multiple Range and Multiple F Tests. Biomatrics 11:1–42.

Epstein, E. 1961. The essential role of calcium in selective cation transport by plant cell. plant physiol. 36: 437–444.

Henkel, P. A. and B. P. Strogonov. 1961. Physiology of plants consuming saline water. PP. 145–151 . Proc. Tehran Symp. Salinity Prob. Aridzone, UNESCO, Paris.

Kent, L. M. and A. Lauchli. 1985. Germination and seedling growth of cotton; salinity–calcium interactions. Plant, Cell and Environment, 8:155–159.

Pitman, M. G. 1976. Ion uptake by plant roots. P. 95–128. In U. Liittge and M. G. Pitman (eds.) Transport in plants II. Part B. Tissue and Organs. Encyclopedia of Plant Physiology, New Series, Vol. 2 Spring–Verlag, Berlin.

Qayyum, M. A. and M. D. Malik. 1988. Farm production losses in salt affected soils. PP. 356–364. Proc. First National Congress on Soil Science, Lahore. Oct. 6–8, 1985, Managing Soil Resources.