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Effect of Seed Pre-treatments on Germination and Growth of Cotton *(Gossypium hirsutum* L.*)* Under Saline Conditions

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Abstract: Effect of 10 pre-soaking seed treatments on cotton germination, seedling length and weight at salinity levels of 1.5, 5,10,15, 22 and 30 dS m^{-1} was studied under laboratory conditions. Significantly higher germination, seedling length and seedling weight of cotton was found at $S_{1.5}$ and S_5 salinity levels. Significant reduction in seed germination, seedling length and seedling weight of cotton was observed with linear increase in salinity. Minimum seedling length and weight was found at 30 ds m^{-1}. The decrease in germination and seedling weight at 10, 15, 22 and 30 ds m^{-1} was 11, 22,44 and 84 and was 6, 19, 34 and 44 % respectively. Like salinity, pre-soaking had a significant positive effect on germination, seedling length and weight. Soaking of seeds in 15 ml concentrated sulphuric acid for 10 minutes and then dipped in 15 meq/L calcium sulphate for 2 hours (T_9) was best of all treatments followed by T_4 (seed soaked in 20 ml concentrated sulphuric acid for 10 minutes) and T_8 (seeds soaked in 15 meq/L calcium sulphate for 2 hours) indicating that various soaking treatments helped in mitigating the hazardous effects of salinity. Values recorded with respect to germination, seedling length and weight were minimum in control (dry sowing).

Key words: Germination, soil salinity, soaking, cotton, gypsum.

Introduction

Soil salinization is a major menace of irrigated agriculture in arid and semi-arid regions. In Pakistan, about 6.3 million hectare of land is affected by salinity and sodicity (GOP, 1996-97) and this menace is increasing at a formidable rate of 0.2 to 0.4 % annually (Ishaque, 1982). Apart from chemical and mechanical means to combat this menace, a plausible approach could be the development of salt resistant varieties (Qureshi and Barrett-Lennard, 1998).

Cotton is an important cash crop grown on an area of 3149 ha in the Indus valley (GOP, 1996). Although, it is fairly a salt tolerant crop (Gupta *et al.*, 1995) but due to its sensitivity at germination (Malik and Makhdum, 1987), crop stand and yield is affected. Qureshi and Barrett-Lennard (1998) stated graphing relationship between the relative yield of cotton and soil salinity and categorized it as tolerant to salinity. It has been claimed in earlier studies (Yasin *et al.*, 1995) that pre-soaking seed treatments stimulate the germination and plant growth under saline conditions. Selvaraj and Kesavan (1989) showed that soaking of cotton seeds in 100 ml concentrated sulphuric acid for 15 minutes gave higher germination (80.8 %) than other treatments (71-76.7 %). Therefore, any treatment which ensures good germination and subsequent seedling establishment under saline conditions would be highly desirable. In view of these facts, the present study was undertaken to investigate the effects of presowing seed treatments on germination and subsequent growth of cotton under saline conditions.

Materials and Methods

In a preliminary experiment carried out at University of Agriculture, Faisalabad, during 1985, several presoaking seed treatments were tested for their effect on cotton seed germination. Out of these, ten promising treatments were selected to test germination under saline conditions (Table 1). Salt solutions having electrical conductivity levels viz., Control (EC 1.5 dS m^{-1}), 5, 10,15, 22 and 30 dS m^{-1}, designated as $S_{1.5}$, S_5, S_{15}, S_{22} and S_{30} were prepared using salts of NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$ in ratio of 7:9:3:1 respectively in half strength Hoagland and Amon's solution (1950). Seed germination experiment was conducted in six plastic coated metal trays (45x35x5 cm^3) filled with sand up to 4 cm soil depth. As described earlier, 6 salinity levels were developed in separate trays. In each tray, ten rows of thirty seeds of cotton NIAB-78 variety that had been soaked already in different solutions of promising seed treatments (Table 1) were sown 2 cm deep in sand trays. The solutions were renewed daily to overcome variations in salinity. The trays were kept at room temperature (±25 °C) for two weeks until seeds had germinated.

Germination of seeds was recorded daily for two weeks. After two weeks, the experiment was terminated and length and dry weight of five randomly selected seedlings in each treatment was recorded. Data were subjected to statistical analysis according to completely randomized design with factorial arrangement. Comparison among treatments and salinity levels was done by Duncan's Multiple Range tests (Steel and Torrie, 1980)

Results and Discussion

The results of ten promising presowing seed treatments selected have been discussed under the following sub headings.

Seed germination: Various seed soaking treatments and salinity levels had significant effect on germination (Table 2). Seed germination decreased significantly with increasing salinity.

Germination of seed at $S_{1.5}$ (26.95) and S_5 (26.42) was statistically at par, but were significantly higher than all other salinity levels. The reduction in germination at S_{10}, S_{15}, S_{22} and S_{30} salinity levels was 11, 22, 44 and 84 % respectively over control (81.5 %). The gradual reduction in germination with linear increase in salinity was in line with the results of Gupta *et al.* (1995). Adverse effects due to salinity on germination were also observed by Yasin *et al.* (1995) and Ashiq *et al.* (1988). The comparison among various presowing seed treatment means showed that all treatments increased seed germination over control. Out of 30 seeds sown, seed germination was maximum in T_9 (23.00) treatment followed by T_4 (22.7) and T_8 (22.3) with the minimum being in control (15.3). Beneficial effects of seed soaking in calcium salts had

Table 1: Various presowing seed treatments used for germination

S.NO	Description
T_1	Control (Dry seed sowing)
T_2	Soaking seeds in distilled water
T_3	Seeds treated with 10 ml conc. Sulphuric acid for 10 minutes
T_4	Seeds treated with 20 ml conc. Sulphuric acid for 10 minutes
T_5	Seeds treated with 50 ml conc. Sulphuric acid for 30 minutes
T_6	Seeds treated with 50 ml conc. Sulphuric acid for 60 minutes
T_7	Seeds soaked in 10 meq/L calcium sulphate for 2 hours
T_8	Seeds soaked in 20 meq/L calcium sulphate for 2 hours
T_9	Seeds treated with 15 ml conc. Sulphuric acid for 10 minutes and then soaked in 15 meq/L calcium sulphate for 2 hours.
T_{10}	Seeds treated with 50 ml 50% dilute sulphuric acid for 10 minutes and then soaked in 15 meq/L calcium sulphate for 2 hours

Table 2: Effect of presowing seed treatments on germination of cotton at various salinity levels.

Treatment	Salinity levels (dS m^{-1})						
	1.5	5	10	15	22	30	Mean
T_1	22.75	21.25	19.25	16.50	12.00	-	15.29f
T_2	23.75	22.75	21.50	18.25	14.00	3.50	17.29e
T_3	28.50	27.00	25.50	20.75	16.50	7.50	20.95b
T_4	28.75	28.75	27.00	23.75	18.50	9.25	22.66a
T_5	26.75	25.50	22.25	21.00	15.50	-	18.50d
T_6	26.50	27.00	23.75	19.50	13.25	-	18.33de
T_7	27.25	27.25	24.25	22.25	12.25	4.50	19.70c
T_8	28.75	28.76	26.00	24.00	19.00	7.00	22.25a
T_9	28.25	28.76	26.50	23.75	20.75	10.00	23.00a
T_{10}	28.25	27.25	23.50	18.75	13.50	2.00	18.88cd
Means	26.95a	26.42a	23.95b (11)*	21.08 (22)	15.50d (44)	4.38e (84)	

Mean values followed by same letters are non significant at 5% levels of significance.
* Values in parenthesis are percent reduction in seed germination over control ($S_{1.5}$)

Table 3: Effect of presowing seed treatments on seedling length (cm) at various salinity levels.

Treatment	Salinity levels (dS m^{-1})						
	1.5	5	10	15	22	30	Mean
T_1	11.37	11.07	9.90	8.53	6.38	-	7.87c
T_2	11.56	10.53	10.24	8.72	6.41	3.84	8.55ab
T_3	11.66	11.18	10.27	8.82	6.81	3.79	8.76a
T_4	11.79	11.41	10.85	8.61	6.98	3.73	8.93a
T_5	11.42	10.83	10.06	8.30	6.28	-	7.81bc
T_6	11.27	11.17	9.93	8.51	6.39	-	7.88bc
T_7	11.79	11.39	10.50	8.68	6.89	3.40	8.76a
T_8	11.89	11.56	10.51	8.83	6.74	4.25	8.96a
T_9	11.47	11.37	10.67	8.59	6.28	4.60	9.04a
T_{10}	11.34	11.15	10.14	8.47	6.24	4.12	8.57a
Means	11.55a	11.16a	10.31b	8.61c	6.64d	2.79e	

Mean values followed by same letters are non significant at 5% levels of significance.

Table 4: Effect of presowing seed treatments on seedling dry weight (g) at various salinity levels.

Treatment	Salinity levels (dS m^{-1})						
	1.5	5	10	15	22	30	Mean
T_1	0.170	0.152	0.130	0.123	0.098	-	0.112ef
T_2	0.174	0.160	0.144	0.135	0.105	0.081	0.132abcd
T_3	0.176	0.180	0.142	0.112	0.096	0.073	0.130bcde
T_4	0.198	0.184	0.156	0.138	0.107	0.098	0.147ab
T_5	0.167	0.161	0.135	0.105	0.088	-	0.109f
T_6	0.173	0.172	0.145	0.100	0.104	-	0.115def
T_7	0.191	0.183	0.152	0.107	0.019	0.082	0.134abcd
T_8	0.188	0.170	0.169	0.141	0.111	0.076	0.142abc
T_9	0.213	0.196	0.166	0.143	0.116	0.083	0.153a
T_{10}	0.173	0.155	0.130	0.102	0.106	0.069	0.122cdef
Means	0.182a	0.171a (6)*	0.147b (19)	0.120c (34)	0.102d (44)	0.056e (69)	

Mean values followed by same letters are non significant at 5% levels of significance.
* Values in parenthesis are percent reduction in seedling dry weight over control ($S_{1.5}$)

also been observed in earlier studies (Misra and Sen, 1981; Selvaraj and Kesavan, 1989) The treatments behaved differently at various levels of salinity. The germination differences between treatments were small at low salinity

levels but became large at higher salinity levels. Maximum germination at S_5 was observed when seeds were treated either with 20 meq/L calcium sulphate for 2 hours (T_8) or with 20 ml concentrated sulphuric acid for 10 minutes (T_4) or by their combination (T_9). The performance of T_9 and T_8 at each salinity level was better. However, there was gradual reduction in germination with increasing salinity in each treatment. This reduction might be due to the decreased osmotic potential which reduces water imbibition in seed during germination (Shanon *et al.*, 1994), The accumulation of toxic ions like sodium and chloride in cytoplasm may also damage the enzymes and organelles (Lauchli and Epstein, 1990) leading to poor germination. Poor germination in each treatment at S_{30} was recorded. In T_2, T_5 and T_6 treatment, there was no seed germination at S_{30} salinity. Every seed soaking treatment had beneficial effects on germination. Even small amount of calcium absorbed during treatment phase counteracted the harmful effect of sodium on germination (Shannon and Francois, 1977). The results are also supported by the idea that calcium absorbed during pre-soaking increased the seed calcium concentration in seeds thus increasing stability of protoplasm membrane (Cramer *et al.*, 1987).

Length of seedling: Perusal of the data indicated that increase in salinity decreased the seedling length significantly (Table 3). On the average, seedling length in $S_{1.5}$ (11.6 cm) and S_5 (11.2 cm) treatments was statistically similar but was significantly higher than other salinity levels.

Minimum shoot length (2.79 cm) was observed at S_{30}. The reduction in seedling length in S_{30} might be attributed to nutritional disorder or delayed germination due to higher osmotic pressure (Chaudhry *et al.*, 1989). Toxicity due to ions on metabolism may be another reason for reduction in seedling length. Data pertaining to various presowing seed treatments (Table 3) showed that seedling length increased significantly at all treatments over control. The maximum average seedling length (9.04 cm) was observed for T_9 which was statistically similar to T_8, T_4, T_3, T_7, T_{10} and T_2 treatments. Significantly smaller seedling length was observed in control and T_5 treatments. Treatments T_9 and T_8 were better than all others at 30 dS m^{-1} salinity. In general, presowing seed treatments at different salinity levels enhanced the seedling length. On the average, seedling length in T_8, T_9 and T_4 was relatively greater at all salinity levels. This indicates that seed soaking treatments help in improving growth by overcoming the hazardous effects of salinity. Bhatti *et al.* (1978) attributed it to physiological changes occurring in plants. Similar effect of presowing seed treatments on seedling growth had been reported by Yasin *et al.* (1995).

Dry weight of seedling: Seedling weight as affected by various salinity levels is given in Table 4. The analysis of variance indicated that presoaking seed treatments and different salinity levels had significant effect on seedling weight. Seedling weight in $S_{1.5}$ and S_5 (low salinity) was statistically similar but these values were higher than those obtained at other salinity levels.

Minimum weight (0.056 g) was recorded at 30 dS m^{-1} salinity. A reduction in seedling weight of 69, 44, 34, 19 and 6 % over control was observed for S_{30}, S_{22}, S_{15}, S_{10} and S_5 treatments respectively. The probable cause of this reduction at higher salinity levels could be the toxic effect of added salts or physiological scarcity of water with increasing solute suction of saline media (Rhoades and Loveday, 1990).

Unlike salinity, various presoaking seed treatments (Table 4) significantly increased the dry weight of seedlings. Maximum increase in seedling weight (36.6%) over control was observed in T_9 treatment. However, seedling weight decreased in all treatments with increasing salinity, being minimum at S_{30}. According to Strogonov (1964), presowing seed treatments induced marked changes in the physiology of embryo causing increased resistance. Similar increase in dry weight of seedling with calcium salts was reported by Bhatti *et al.* (1978) and Yasin *et al.* (1995). From the above discussion, it can be inferred that all soaking treatments improved the germination of cotton seeds.

However, for better results, soaking of seeds in 15 ml concentrated sulphuric acid for 10 minutes followed by dipping in calcium sulphate (15 meq/L) for 2 hours is recommended.

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