INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2001/03–2–188–191
http://www.ijab.org

Salt Tolerance of Some Cotton Hybrids at Seedling Stage

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ABSTRACT

The studies were undertaken to investigate the response of 35 cotton hybrids at maximum salinity level of 0 and 250 mM NaCl with control for some important seedling traits i.e. dry shoot weight, dry root weight and root/shoot ratio. Indices of salt tolerance were estimated in absolute and relative terms. The hybrids Express x SLH-41, Express x MS-84, Express x CIM-109, Allepo-45 x SLS-1 and AUH-50 x SLH were identified as most tolerant to saline conditions. The different tolerance response of hybrids and high broad sense heritabilities suggest that rapid improvement in salinity tolerance seemed to be possible through selection pressure in early segregating populations.

Key Words: Cotton hybrid; Salt tolerance; Salinity

INTRODUCTION

Cotton being an important cash crop of Pakistan plays a distinguished role in energizing the economy of the country by fetching appreciable amount of foreign exchange annually. The cotton production of country is improving significantly but the yield per unit area is still lower than that of the other countries due to some biotic and abiotic factors. Amongst the abiotic factors, the presence of salt of different kinds in the root zone causes significant reduction in production (Shannon, 1984).

In this situation, where it is not possible to change the environment, the plant breeders are seeking to modify plants to suit such adverse soil conditions while maintaining the reliable yield. Clearly this strategy necessitates the study of variation controlling salt tolerance to facilitate the selection of tolerant plant material.

There is a wide degree of variation within specie in response to salinity but the proportion of genetic variation is desirable for improving the cotton plant. Systemic work to examine genetic variability within crops is still in its infancy (Srivastava & Jana, 1984), but the presence of inter-specific (Maas & Hoffman, 1977) and intra-specific (Rashid, 1986; Ashraf & McNeilly, 1988; Singh *et al.*, 1988) variation for salt tolerance is evident. The estimation of heritability has a great value in prediction of the effect in selection (Johnson *et al.*, 1955; Teran *et al.,* 1990).

Keeping in view above, the present study was conducted to assess the tolerance of cotton hybrids at seedling stage and to detect the heritability for salinity tolerance in *Gossypium hirsutum* L. The information so derived could play a significant role in the evolution of high yielding and salinity tolerant cotton varieties to a wide range of agro-ecological conditions.

MATERIALS AND METHODS

The experimental material used in this present studies was developed by crossing seven male parents *viz.,* SLH-41, MS-84, SLS-1, CIM-109, SLH-1, TH-14/83 and LA-17801 and five female parents viz. Express, Allepo-45, AUH, H-2918-2 and HG-142. The parents were field planted during the year 1998. The recommended agronomic practices were constantly employed for optimum growth. At flowering, the parents were crossed to get 35 hybrids. During emasculation and pollination, all necessary precautions were taken to avoid the contamination of genetic material.

Seeds were collected separately for each cross and grown in the polythene bags of measuring 6" x 8" filled with a mixture of sand and clay in the ratio 2:1. The electrical conductivity (0.92 ds m^{-1}) and pH (9) were determined prior to the start of experiment so that salt requirement for each of the treatment level could be measured accurately. The experiment was laid out following complete randomized design (CRD) with three replications for the treatment as well as control. One week after germination (at cotyledonary leaves stage) 50 mM NaCl solution was applied as a first increment to all the bags. Another dose of 50 mM NaCl solution was applied next day. In this way, the required level of 250 mM was achieved by applying 50 mM NaCl solution daily to the treatment bags. After 15 days of germination, the data were recorded using 10 plants in each replication for dry shoot weight (g), and dry root weight (g) and root/shoot ratio.

Salinity response of all the hybrids to increasing NaCl concentration was compared on the basis of their absolute and relative performances as suggested by Dewey (1960) and Maas (1986). The recorded data were subjected to analysis of variance technique (Steel & Torrie, 1980) to obtain level of significance among the genotypes. These genotypes were further analyzed for broad sense heritability as illustrated by Falconer (1981).

RESULTS AND DISCUSSION

Analysis of variance indicated significant differences among parents and F_1 progenies for these four characters i.e. dry shoot weight, dry root weight (g) and root/shoot ratio (Table I). Indices of absolute and relative salt tolerance of all the hybrids for these seedling traits is presented in Table IIa and IIb, respectively. An examination of Table IIIa, IIIb showed that results for all the traits under study in both the salinity levels were highly significant among all the hybrids. Table IV indicates the components of variance and broad sense heritability of salt tolerance at two salinity levels.

Dry shoot weight. Data on absolute and relative values present in Table IIa and IIb showed differing responses of hybrids to increasing NaCl levels and hybrids differed from each other even under non stress condition and under highest NaCl concentration i.e. 250 mM. The response of some hybrids were less affected ranging from 0.050 to 0.082 g (Allepo-45 x LA17801 and HG142 x LA17801) in contrast to the response of remaining hybrids ranging from 0.025 to 0.049 g (Express x CIM-109 and H-2918-2 x TH-14/83). The responses of all the hybrids were compared in relative terms (Table IIb). The data revealed that most of the hybrids showed high degree of tolerance ranging from 56.68 to 97.04 (H-2918-2 x LA-17801 and Express x SLS-1). Table IV showed the estimation of broad sense heritability ($h^2_{B.S}$), which was greater in control (0.99947) than treatment (0.6351).

Table I. Mean square values of the characters

SOV	d.f.	Dry shoot weight	Dry root weight	Root/ Shoot ratio
Hybrid	34	0.00083	0.00465	0.00790
Treatment	1	0.01263	0.01127	0.011875
Hybrid x treatment	34	0.000135	0.00042	0.001166
Error	140	0.000312	0.000004	0.000211

Table IIIa. Mean squares values for control

SOV	d.f.	Dry shoot weight	Dry Root weight	Root/ Shoot ratio
Hybrid	34	0.000574	0.00324	0.0059398
Error	70	0.000001	0.0000056	0.0000089

Table IIIb. Mean squares values for treatment

SOV	d.f.	Dry shoot weight	Dry root weight	Root/ Shoot ratio
Hybrid	34	0.000388	0.001831	0.003112
Error	70	0.000065	0.0000036	0.000414

Table IIa. Indices of absolute tolerance for control and treatment

Sr. No.	Hybrids	Dry Shoot Weight		Dry Root Weight		Root/ Shoot ratio	
		Treatment	Control	Treatment	Control	Treatment	Control
1	Express x SLH-41	0.0604	0.0782	0.0416	0.1186	0.0704	0.1516
2	Express x MS-84	0.0487	0.0580	0.1033	0.1534	0.1669	0.2640
3	Express x SLS-1	0.0568	0.0586	0.0380	0.0827	0.0702	0.1409
4	Express x CIM-109	0.0256	0.0556	0.0393	0.0703	0.0770	0.1248
5	Express x SLH-1	0.0547	0.0615	0.0340	0.0877	0.0627	0.1423
6	Express x TH-14/83	0.0554	0.0691	0.0427	0.0740	0.0775	0.1070
7	Express x LA-17801	0.0636	0.0841	0.0370	0.0790	0.0583	0.0938
8	Allepo-45 x SLH-41	0.0737	0.0875	0.0500	0.1163	0.0681	0.1328
9	Allepo-45 x MS-84	0.0572	0.0745	0.0330	0.0633	0.0585	0.0848
10	Allepo-45 x SLS-1	0.0490	0.0862	0.0430	0.0810	0.0884	1.0938
11	Allepo-45 x CIM-109	0.0665	0.0890	0.0453	0.1220	0.0684	0.1369
12	Allepo-45 x SLH-1	0.0590	0.0670	0.0407	0.0927	0.0689	0.1382
13	Allepo-45 x TH-14/83	0.0559	0.0690	0.0420	0.0607	0.0761	0.0879
14	Allepo-45 x LA-17801	0.0504	0.0814	0.0503	0.0903	0.0999	0.1109
15	AUH x SLH-41	0.0417	0.0497	0.0313	0.0727	0.0753	0.1461
16	AUH x MS-84	0.0812	0.0923	0.1207	0.1890	0.1490	0.2046
17	AUH x SLS-1	0.0818	0.0930	0.0740	0.1010	0.0912	0.1087
18	AUH x CIM-109	0.0619	0.0915	0.0423	0.0750	0.0687	0.0182
19	AUH x SLH-1	0.0602	0.0786	0.0407	0.1187	0.0685	0.1508
20	AUH x TH-14/83	0.0537	0.0580	0.1037	0.1553	0.1975	0.2675
21	AUH x LA-17801	0.0438	0.0586	0.0367	0.0823	0.0843	0.1451
22	H-2918-2 x SLH-41	0.0463	0.0557	0.0367	0.0720	0.0798	0.1290
23	H-2918-2 x MS-84	0.0582	0.0617	0.0307	0.0890	0.0534	0.1441
24	H-2918-2 x SLS-1	0.0625	0.0694	0.0417	0.0750	0.0768	0.1084
25	H-2918-2 x CIM-109	0.0637	0.0840	0.0350	0.0800	0.0551	0.0940
26	H-2918-2 x SLH-1	0.0702	0.0875	0.0510	0.1177	0.0726	0.1343
27	H-2918-2 x TH-14/83	0.0497	0.0745	0.0300	0.0653	0.0667	0.0874
28	H-2918-2 x LA-17801	0.0487	0.0860	0.0430	0.0810	0.0888	0.0941
29	HG-142 x SLH-41	0.0671	0.0892	0.0047	0.1230	0.0678	0.1378
30	HG-142 x MS-84	0.0602	0.0671	0.0407	0.0923	0.0679	0.1374
31	HG-142 x SLS-1	0.0515	0.0692	0.0430	0.0620	0.0828	0.0895
32	HG-142 x CIM-109	0.0492	0.0816	0.0503	0.0900	0.1010	0.1102
33	HG-142 x SLH-1	0.0394	0.0492	0.0303	0.0733	0.0778	0.1489
34	HG-142 x TH-14/83	0.0811	0.0921	0.1223	0.1870	0.1513	0.2029
35	HG-142 x LA-17801	0.0825	0.0927	0.0733	0.1030	0.0894	0.1110

Table IIb. Indices of relative salt tolerance for seedling traits

Sr. No.	Hybrids	Dry Shoot Weight	Dry Root Weight	Root/Shoot ratio
1.	Express x SLH-41	77.17	35.11	46.44
2.	Express x MS-84	83.86	67.39	63.21
3.	Express x SLS-1	97.04	45.96	49.81
4.	Express x CIM-109	94.66	55.92	61.68
5.	Express x SLH-1	88.84	38.78	44.03
6.	Express x TH-14/83	80.23	57.65	72.42
7.	Express x LA-17801	75.63	46.83	62.09
8.	Allepo-45 x SLH-41	84.19	42.97	51.24
9.	Allepo-45 x MS-84	76.78	52.10	68.87
10.	Allepo-45 x SLS-1	56.87	53.08	94.17
11.	Allepo-45 x CIM-109	74.66	37.88	49.97
12.	Allepo-45 x SLH-1	88.01	43.88	49.86
13.	Allepo-45 x TH-14/83	81.07	69.23	86.57
14.	Allepo-45 x LA-17801	61.99	55.71	90.02
15.	AUH x SLH-41	83.98	43.11	51.52
16.	AUH x MS-84	87.94	63.84	72.83
17.	AUH x SLS-1	87.99	73.26	83.87
18.	AUH x CIM-109	67.60	56.44	83.91
19.	AUH x SLH-1	76.55	34.26	45.41
20.	AUH x TH-14/83	92.59	66.73	73.84
21.	AUH x LA-17801	74.70	44.53	58.10
22.	H-2918-2 x SLH-41	83.02	50.92	61.84
23.	H-2918-2 x MS-84	94.33	34.45	37.05
24.	H-2918-2 x SLS-1	90.01	55.55	70.87
25.	H-2918-2 x CIM-109	75.84	43.75	58.58
26.	H-2918-2 x SLH-1	80.20	43.34	54.04
27.	H-2918-2 x TH-14/83	66.77	51.02	76.61
28.	H-2918-2 x LA-17801	56.68	53.08	94.36
29.	HG-142 x SLH-41	75.29	37.94	50.61
30.	HG-142 x MS-84	89.72	44.04	49.41
31.	HG-142 x SLS-1	74.38	69.35	92.51
32.	HG-142 x CIM-109	60.26	55.92	91.62
33.	HG-142 x SLH-1	80.16	41.36	52.27
34.	HG-142 x TH-14/83	88.06	65.41	74.54
35.	HG-142 x LA-17801	89.00	71.19	80.54

Dry root weight. The value of absolute salt tolerance for this trait (Table IIa) revealed differing responses of the hybrids to increasing NaCl salinity. The hybrids Allepo-45 x SLH-41 and HG-142 x TH-14/83 were less affected by the given salinity ranging from 0.0500 to 0.1233 g while the hybrids which were more sensitive to salinity level for this trait ranged from 0.0330 to 0.0453 g (HG-142 x SLH-1 and Allepo-45 x CIM-109). On the basis of relative salt tolerance, the hybrid HG-142 x SLS-1 (69.345) showed maximum degree of tolerance while the hybrid AUH x SLH-1 (34.269) was less tolerant. The components of variance and broad sense heritability ($h^2_{B.S}$) for two salinity levels (Table IV) showed that heritability for the dry root weight was less in saline condition (0.9941) than the control (0.9948).

Table IV. Broad sense heritability for two salinity levels

COV	Dry Shoot Weight		Dry Root Weight		Root/Shoot ratio	
	T	C	T	C	T	C
V_g	0.00011	0.00019	0.00061	0.00107	0.00095	0.00197
V_P	0.00017	0.00019	0.00064	0.00108	0.0013	0.0019
$h^2_{B.S}$	0.635	0.959	0.947	0.986	0.686	0.995

COV= Components of variance; T=Treatment; C=Control

Root/shoot ratio. Table IIa and IIb showed that the responses of some of the hybrids were markedly different from each other and produced high root/shoot ratio ranging from 0.0704 to 0.1975 (Express x SLH-41 and AUH x TH-14/83). While remainder produced low fresh shoot weight ranging from 0.0530 to 0.0702 (H-2918-2 x MS-84 and Express x SLS-1). On the basis of indices of relative salt tolerance, some of the crosses appeared to be more tolerant as compared to others ranging from 37.057 to 76.612 (H-2918-2 x MS-84 and H-2918-2 x TH-14/83). The broad sense heritability ($h^2_{B.S}$) for the root/shoot ratio was lower in treatment (0.6862) than the control (0.9950).

The data assessed both in absolute and relative terms were presented in Table IIa and IIb in respect of dry shoot weight, dry shoot weight and root/shoot ratio. All the hybrids showed a wide degree of responses at maximum salinity level ranging from more tolerance to susceptible. On the basis of absolute salt tolerance with increase salinity level, a retarded growth of all the characters was examined. This retarded growth of hybrids could be attributed to the toxic effect of NaCl and low water potential in the shooting medium. However, the differences among hybrids were greater which suggested that each hybrid had different potential to respond to toxic effect of NaCl in soil culture. Some hybrids operated to be most tolerant to sudden stress of NaCl salinity and the effect was found gradually increasing on manifestation of the characters. It was observed during the experimentation and measurement of characters that growth of the roots was more severely affected due to salinity stress as compared to shoots, as previously has been reported in sorghum by Ratanadilok *et al*. (1978) and Levitt (1980).

The heritability of any given character refers only to the offspring examined under the particular experimental conditions (Falconer & Mackay, 1996) and therefore variability is estimation of heritability is to be expected. Such variation would seem likely to occur with increased stress, because different genes may contribute to the same trait in different environments (Richards, 1978; Rumbaugh *et al.,* 1984). The broad sense heritabilities that were estimated ranged from moderate to very high (0.631-0.991). Previously, broad sense heritabilities for salinity tolerance in other crop species showed considerable differences. These were 0.5 in alfalfa (Allen *et al*., 1985) , in seven grass and four forage species ranged from 0.23-0.77 and 0.31-0.62, respectively. The broad sense heritabilities in sorghum ranged from 0.38-0.78 (Azhar & McNeilly, 1987; Ashraf , 1994). Based upon this data, it is suggested that significant advance in salinity tolerance may be possible using high selection pressure.

The results revealed differing tolerance of the hybrids and consequently existence of variation in salt tolerance in *Gossypium hirsutum* L. Estimation of broad sense heritability ($h^2_{B.S}$) for salt tolerance is appreciably high suggesting that selection would be very useful in the early segregating generations for further strengthening the cotton breeding programme for salinity tolerance.

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(Received 23 December 2000; Accepted 15 March 2001)