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Response of *Gossypium hirsutum* L. Hybrids to NaCl salinity at Seedling Stage

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ABSTRACT

The responses of 23 F_1 hybrids of *Gossypium hirsutum* L. were compared using zero and 300 mol m^{-3} concentration of NaCl. The salinity caused significant reduction in fresh shoot and root lengths. On the basis of relative shoot lengths hybrids Allepo-1 x BH-116, CIM-482 x Bambusa-49, MNH-563 x Carolina Queen, C-1996 x VH-37, and on the basis of root lengths Z-293 Glandless x NIAB Krishma, Lasani-9 x B-875, CIM-482 x Bambusa-49 were revealed to be the most tolerant to salinity, whilst hybrids BH-123 x Delcero and V-75-0412 x S-14 were susceptible to the effect of NaCl. The estimates of broad-sense heritability calculated on the basis of shoot length and root length data were 0.48 and 0.83, respectively in NaCl salinity. The data suggest that improvement in NaCl tolerance in Upland cotton may be possible exploiting variability through conventional breeding methods.

Key Words: Upland cotton; NaCl salinity; Heritability

INTRODUCTION

There are many biotic and abiotic factors which affect plant during growth and developmental phases, and have adverse effects on its performance. The presence of salts near root zone does not allow the plants to flourish and this may be one of the reasons of low yield of different crops in Pakistan. The problem of soil salinity is of frequent occurrence in irrigated areas of the world (Shannon, 1984) and in Pakistan due to the presence of salts of different species in the soil profile, about 6.3 x 10^6 ha of irrigated land has become salt affected to varying degrees (Malik & Shah, 1996).

Installation of tube wells and use of gypsum had proved to be effective in ameliorating the problem of salinity, but escalating costs of labour and energy, do not allow the running of the projects to continue. Therefore, the research workers suggested to bring genetic modifications in crop cultivars for successful growing under saline conditions, and this alternative is called genetic approach (Epestein, 1980; Shannon, 1984). Previous studies showed that varieties of rice (Moeljopawiro & Ikehashi, 1981; Ahmed *et al*. 2000) barley (Ayers, 1953), maize (Maas, 1983) and sorghum (Azhar & McNeilly, 1987; Azhar & Khan, 1997) differed from each other for their responses to salinity stress.

Cotton of *Gossypium hirsutum* L. is an important crop of the areas affected by salinity in Pakistan. Previous studies conducted on this aspect of cotton plant are few but these showed that genotypic variability for salinity tolerance in cotton was present (Randhawa, 1981; Ray *et al*., 1987; Khan *et al*., 1995; Zaidi, 1997; Azhar & Raza, 2000). The present work was done in order to collect more knowledge about salinity tolerance in *G. hirsutum* L.

MATERIALS AND METHODS

In the present investigations, the responses of 23 F_1 hybrids namely V-75-0412 x S14, Z-293 Glandless x NIAB Krishma, W-1105 x CIM-443, Lasani-9 x B-875, LH-72 x A-89/FM, MNH-564 x BH-124 Allepo-1 x BH-116, S-14 x B-622, VH-61 x Cocker-207, BH-36 x Pilose-3, BH-95 x CIM-243, BH-121 x 124-F, BH-123 x Delcero, BH-125 x A-618, BH-126 x AU-59, CIM-250 x NH-26-N, CIM-482 x Bambusa-49, CIM-536 x Carolina Queen, MNH-564 x BH-124, C-1800 x MR-73 (LCR_2, C-1802 x VH-28, C-1996 x VH-37, C-1997 x 30-M and C-2000 x Rode 8/4, were studied under zero and 300 mol m^{-3} concentration of NaCl. Seeds of all the hybrids were grown in polythene bags filled with a mixture of sand and clay in the ratio of 1:2. The Ece and pH of the growth media was 1.57dS m^{-1} and 8.60, respectively. The polythene bags in each repeat were arranged following completely randomized design, and there were three replications of the experiment. The seeds of each hybrid were dibbled in each bag under proper moisture conditions. One week after germination (at two leaved stage), first treatment of 50 mol m^{-3} NaCl solution was applied to 69 treatment bags. The concentration of NaCl in water was increased at the rate of 50 mol m^{-3}. The second dose of 100 mol m^{-3} NaCl was given one day after the first treatment, thus in this way progressive increases in solution were made, and the required level of 300 mol m^{-3} NaCl was achieved on 16th day after seeding. Three days after applying 300 mol m^{-3} NaCl solution to the seedlings, five plants were harvested in each replication, and the data on fresh shoot and root lengths were collected. Data were subjected to analysis of variance technique, and the response of 23 hybrids to salinity was compared using relative values of root and shoot growth i.e. indices of salt tolerance as suggested by Maas (1986). The indices of salt tolerance of hybrids were obtained using the following formula:

$$\text{Relative salt tolerance} = \frac{\text{mean performance of character in NaCl solution}}{\text{mean performance of character in control}} \times 100$$

Estimation of broad-sense heritability. Estimation of broad-sense heritability (h^2_{BS}) of the two plant characters assessed under 300 mol m^{-3} NaCl salinity and control were made following the formula given by Falconer (1981) based on the variance due to between hybrids and within-hybrids. The formula used to calculate the estimates of broad-sense heritability (h^2_{BS}) is given below:

$$h^2_{BS} = \frac{\text{Variance between genotypes}}{\text{Variance between genotypes + variance within genotypes}}$$

RESULTS AND DISCUSSION

The availability of variation in breeding population, and information on its heredity mechanism is essential to achieve rapid progress in a plant character through selection. In order to get such information about salinity tolerance in cotton, a sample of 23 F_1 hybrids differing in their genetic constitution were assessed following the method used by Azhar and Raza (2000). The responses of the hybrids to 300 mol m^{-3} NaCl salinity were compared on relative basis as suggested by Maas (1986). This method had been used previously for assessing salt tolerance in sorghum (Azhar & McNeilly, 1987; Azhar & Khan, 1997) and cotton (Zaidi, 1997).

Significant mean squares for fresh shoot lengths and fresh root lengths showed significant differences in the two seedling characters measured between the hybrids and NaCl treatments (Table I). The significant interaction component hybrids x salinity indicated that shoots and roots of the hybrids responded differently to 300 mol m^{-3} NaCl salinity.

Table I. Mean squares of 23 F_1 hybrids in control and NaCl salinity

Source of variance	Degrees of freedom	Fresh shoot length	Fresh shoot length
Salinity level (S)	1	443.097**	390.735**
Hybrids (H)	22	4.581**	58.799**
H x S	22	0.549*	1.577*
Error	92	0.323	0.918

The indices of salt tolerance showed that salinity had adverse effect of on shoot length and root length of all the hybrids (Table II). The comparison of indices of salt tolerance based upon fresh shoot length revealed that some of the hybrids were more tolerant than the others. Comparison of indices of salt tolerance based upon shoot length data showed that hybrids Allepo-1 x BH-116 (78.71%), CIM-482 x Bambusa-49 (78.62%), MNH-563 x Carolina Queen (77.45%), C-1996 x VH-37 (76.31%), CIM-250 x NH-26-N (75.21%) and Z-293 Glandless x NIAB Krishma (74.95%) appeared to be the most tolerant to salinity. In contrast, shoot length of BH-123 x Delcero, BH-121 x 124-F, BH-126 x A-618 and LH-72 x A-89/FM were significantly affected by salinity and produced only 59.32, 63.47, 64.11 and 66.23%, respectively compared with those in control treatments and thus may be regarded as susceptible to salinity. Remaining hybrids may be considered as moderately tolerant to salinity.

Table II. Indices of salt tolerance based upon fresh shoot and root length of 23 F_1 hybrids of *Gossypium hirsutum* L.

Hybrids	Fresh shoot length	Fresh root length
V-75-0412 x S-14	68.51	49.93
Z-293 Glandless x NIAB Krishma	74.95	83.21
W-1105 x CIM-443	71.14	77.21
L asani-9 x B-875	69.68	83.03
LH-72 x A-89/FM	66.24	80.17
Allepo-1 x BH-116	78.71	67.19
S-14 x B-622	73.99	72.78
VH-61 x Cocker-207	71.67	81.02
BH-36 x Pilose-3	68.70	79.74
BH-95 x CIM-243	67.14	77.99
BH-121 x 124-F	63.47	75.84
BH-123 x Delcero	59.32	79.13
BH-125 x A-618	64.12	68.17
BH-126 x AU-59	69.39	68.01
CIM-250 x NH-26-N	75.21	69.37
CIM-482 x Bambusa-49	78.62	84.90
MNH-536 x Carolina Queen	77.45	73.91
MNH-564 x BH-124	73.56	77.73
C-1800 x MR-73 (LCR_2)	69.49	71.62
C-1802 x VH-28	69.49	71.71
C-1996 x VH-37	76.31	74.19
C-1997 x 30-M	67.94	78.57
C-2000 x Rode-8/4	70.54	70.42
	$Cd_1 = 7.76$	$Cd_1 = 11.1$
	$Cd_2 = 6.46$	$Cd_2 = 9.24$

The root lengths of some of the hybrids were markedly reduced under 300 mol m^{-3} NaCl salinity. The roots of CIM-482 x Bambusa-49, Z-293 Glandless x NIAB Krishma, Lasani-9 x B-875, VH-61 x Cocker-207 and LH-72 x A-89/FM were less affected under stress condition, and produced 84.90, 83.21, 83.03, 81.02 and 80.17% root lengths of the control, respectively; and thus may be categorized as the most tolerant to salinity. However, root lengths of V-75-0412 x S-14 was affected seriously and produced only 49.23% compared with the root lengths measured in untreated bags.

The estimates of broadsense heritability of shoot and root lengths measured under 300 mol m-3 NaCl and control are given in Table III. The estimates of shoot length in control and salinity were 0.41 and 0.48, respectively, and these estimates based upon root lengths were 0.93 and 0.83, respectively. The previous estimates about broad-sense heritability for salinity tolerance in other crops varied from species to species e.g. in seven grass and four forage species, these ranged 0.25 to 0.79 and 0.31 to 0.62, respectively (Ashraf *et al*., 1986a,b), in sorghum 0.38 to 0.78 (Azhar & McNeilly, 1988; 1989). The estimates of broad sense heretability calculated here generally agreed to those reported previously, and suggested that the variation in the two seedling characters measured in the hybrids was genetically controlled. Thus variation in salinity tolerance in *G. hirsutum* L. may be exploited further through hybridization if it involved a significant additive component in its inheritance.

Table III. Components of variances and broad-sense heritabilities of salt tolerance in 23 F_1 *Gossypium hirsutum* L. hybrid for shoot and root lengths in control and NaCl salinity

Component	Characters	Control	NaCl
$V_P=\sigma^2_b+\sigma^2_w$	Shoot length	1.452	1.934
	root length	12.478	12.206
$V_G=\sigma^2_b$	Shoot length	0.598	0.933
	root length	11.658	10.176
$h^2_{BS}=V_G/V_P$	Shoot length	0.410	0.482
	root length	0.934	0.833

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