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Salt Tolerance of Nine *Gossypium hirsutum* L. Varieties to NaCl Salinity at Early Stage of Plant Development

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ABSTRACT

Responses of nine different genotypes of *Gossypium hirsutum* L. to 5 NaCl concentrations viz. 0, 75, 100, 125 and 150 mM, were compared at seedling stage. Application of NaCl solutions caused significant reduction in shoot and root lengths of all the genotypes, but the effect was more pronounced on roots. Based upon indices of salt tolerance calculated using root length data, two genotypes, Delcerro and VH-57 appeared to be the most tolerant to NaCl salinity. The estimates of broad sense heritability are high and ranged 0.82-0.89. These estimates suggest that further improvement in NaCl tolerance in the species may be possible exploiting the variability in root length.

Key Words: *Gossypium hirsutum* L; Salt tolerance; Root length; Heritability

INTRODUCTION

The presence of excess salts in the soils of arid and semi-arid regions is the most serious problem limiting crop production. It has been reported that 6.2×10^6 ha of arable land of Pakistan had been affected by the accumulation of salts to varying degrees (Govt. of Pakistan, 2000). To reclaim these derelict lands various reclamation projects, for example, Salinity Control and Reclamation Project (SCARP) were adopted by the government but these approaches were not continued due to increasing cost of labour and energy. In addition, use of gypsum was recommended as soil amendment. When it is not feasible to harness the environments, development of salt tolerant varieties is a sure and cost effective means of tackling the problem, and this approach is called biological approach (Shannon, 1984).

Although the work on improvement in salt tolerance of crop plants was initiated long ago, the work done on rice (Moelijopwiro & Ikehashi, 1981), maize (Maas, 1983), sorghum (Azhar & McNeilly, 1987, 1988; Azhar & Khan, 1997), cotton (Azhar & Raza, 2000), triticale, wheat, rye and barley (Salim, 1991) increased the interests of the breeders in recent years and they speeded up their efforts to develop plants having enhanced salt tolerance, through selection and breeding.

Amongst other crops, cotton is the most important crop of Pakistan, and is grown in canal irrigated areas affected by varying concentrations of salts. The previous work on studying the potential of the cotton species for improving salt tolerance is not much. There are a few reports available which show that intraspecific genotypic variability does exist in *G. hirsutum* L. (Ray, 1987; Khan *et al.*, 1995, Azhar & Raza, 2000). The present work was carried out in order to study the responses of some lines/varieties of *Gossypium hirsutum* L. to NaCl salinity during early stage of plant development.

MATERIALS AND METHODS

In the present investigations, responses of nine varieties/lines of *Gossypium hirsutum* L. namely VH-57, BP-52NC-63, MS-84, Delcerro, Coker-30, MS-95, RH-112, Arhugoe 4-73-3 and B-765 were compared at 0, 75, 100, 125 and 150 mM NaCl concentrations in the growing medium. Seven seeds of each entry were sown in polythene bags filled with a mixture of sand and soil in the ratio of 2:1. The pH, ECe, and saturation percentage of the medium were 7.90, 0.70 and 26.20%, respectively. Forty five bags in each replication were arranged in a completely randomized design with three replications. Anhydrous NaCl was dissolved in distilled water to develop the desired levels of salinity. Application of each NaCl treatment was completed in two equal doses; the first half was applied 15 days after the emergence of seeds and the second half 3 days after the application of first treatment.

One month after planting the seeds, five seedlings of each genotype in each replication were taken as an experimental unit and data on fresh shoot lengths and root lengths were recorded. The data were subjected to analysis of variance technique in order to determine whether the genotypic differences were significant. The responses of nine genotypes based upon shoot and root lengths measured in salinity were compared with that measured in control treatment, called relative salt tolerance of Maas (1986).

Estimation of broad-sense heritability. Estimates of broad-sense heritability ($h^2_{B.S}$) of shoot length and root length were made based on the variances due to between the accessions and within the accessions. (Falconer and Mackey, 1996). The formula is given below:-

$$h^2{}_{BS} = \frac{Variance\ between\ accessions}{Variance\ between\ accessions + Varience\ within\ accessions}$$

RESULTS AND DISCUSSION

Development of salinity tolerance in a plant species like *hirsutum* may be possible if significant amount of genetic variation in salinity tolerance is available. Mean squares obtained from ordinary analysis of variance using absolute values showed that the nine genotypes were significantly different ($P \leq 0.01$) from each other for their root and shoot length (Table I). There were significant differences among the five NaCl levels, ($P \leq 0.01$) and significant interaction component (S x G) indicated that all the genotypes responded differently to salinity regimes. The responses of nine genotypes based upon the two characters were compared as suggested by Maas (1986), and the relative values are given in (Table II). Although application of NaCl salinity had affected the growth of all the genotypes adversely, the effect on some of the genotypes was more pronounced than the others.

Table I. Mean squares from analysis of variance of nine genotypes grown in control and four NaCl salinity levels

Source of variation	df	Shoot length	Root length
Salinity levels (S)	4	51.74**	39.75**
Genotypes (G)	8	44.14**	21.95**
S x G	32	3.11**	2.02**
Errors	90		

Indices of salt tolerance for shoot length revealed that in high concentration of NaCl, (150 mM) the accessions namely, BP-52NC-63 and Coker-30 measuring 98% and 88% shoot length appeared to be the most tolerant accessions. When comparisons were made using mean indices, the two accessions with mean values, 91.9% and 92.2% respectively, expressed better salt tolerance than RH-112, Arhugoe 4-73-3 and VH-57 which produced 89.1%, 89.1% and 87.5% mean shoot lengths in salinity as compared with that in control. In this respect, genotype Delcerro which produced only 79.2% mean shoot length showed poor salt tolerance.

The indices of salt tolerance based upon root length data under 150 mM NaCl level showed that, VH-57 and Delcerro with 84.7% and 83.3% indices were found to be the most salt tolerant genotypes and based upon mean indices, again these two accessions were better than the others ((Table II). Coker-30 and Arhugoe-4-73-3 which measured only about 69% mean root length showed poor salt tolerance. Similar differing responses of *Gossypium hirsutum* genotypes to NaCl salinity had been reported in previous studies (Azhar & Raza, 2000; Noor *et al*., 2001; Akhtar & Azhar, 2001).

The data revealed that root lengths of the nine genotypes were affected more seriously than their shoot lengths suggesting the sensitivity of root length to NaCl salinity, which is according to the studies of Levitt (1980) and Okusanya & Ungar (1984). It had been reported that under severe stresses growth and production of cytokinins in roots were immediately stopped (Bottger, 1978). Thus root length is a reliable indicator of salt tolerance of a plant species. The research workers had been able to distinguish salt tolerant and non-tolerant plants of a number of species using root length, for example, grasses (Leim *et al.*, 1985) and sorghum (Azhar & McNeilly, 1987). Thus based upon root length measured in the present studies, two genotypes/varieties VH-57 and Delcerro may be regarded as more salt tolerant than the others.

The estimates of broad-sense heritability calculated using root length data were high i.e. 0.87 and 0.82 under 125 and 150 mM NaCl salinity, respectively (Table III).

Table II. Indices of salt tolerance of nine genotypes measured in five NaCl levels

Genotypes	Shoot length					Root length				
	75mM	100mM	125mM	150mM	Mean	75mM	100mM	125mM	150mM	Mean
VH-57	97.3	90.5	87.8	74.3	87.5	84.7	79.7	81.4	84.7	82.6
BP-52 NC-63	90.7	92.7	86.0	98.0	91.9	64.0	88.9	74.1	57.4	71.3
MS-84	90.3	88.8	81.3	76.1	84.1	85.7	69.0	76.2	69.0	75.0
Delcerro	85.1	84.5	68.6	78.4	79.2	90.7	87.0	88.9	83.3	87.5
Coker-30	95.6	91.6	93.5	88.3	92.2	82.8	76.6	53.1	62.5	68.8
MS-95	90.6	84.5	81.2	73.5	82.5	87.9	87.9	69.0	60.3	76.3
RH-112	97.8	87.7	88.4	84.1	89.1	80.0	76.3	68.8	60.0	71.3
Arhugoe 4-73-3	88.0	82.4	93.7	82.3	89.1	75.7	60.8	77.0	63.5	69.3
B-765	90.5	82.9	86.9	83.5	85.9	92.5	76.1	70.1	52.2	72.2

Table III. Components of variance and broad-sense heritabilities of salt tolerance in nine *G. hirsutum* L. genotypes for shoot and root lengths in control and four NaCl salinity levels

Components	Characters	Control	75mM	100mM	125mM	150mM
$V_p = \sigma^2 b + \sigma^2 w$	Shoot length	10.29	5.29	5.65	4.05	7.09
	Root length	3.51	3.24	1.80	1.98	1.48
$V_g = \sigma^2 b$	Shoot length	11.18	5.72	6.38	4.79	0.55
	Root length	3.93	3.82	2.11	2.26	1.80
$h^2_{B.S} = V_G/V_P$	Shoot length	0.92	0.92	0.88	0.84	0.83
	Root length	0.89	0.85	0.85	0.87	0.82

Similar magnitude of heritability for salinity tolerance in *G. hirsutum* L. had been reported by Azhar and Raza (2000), Akhtar and Azhar (2001), Noor *et al*. (2001). These estimates of heriltability are inflated and therefore, must be interpreted with care as suggested by Falconer and Mackey (1996*).* The pattern of responses of nine genotypes suggest that significant amount of variation in *hirsutum sp*. for salt tolerance exists and possibility of brining further improvement, through selection and breeding is present if the variability is affected by a significant additive component.

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