SALT-TOLERANCE IN DIFFERENT VARIETIES OF UPLAND COTTON *GOSSYPIUM HIRSUTUM* L.

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ABSTRACT: *In order to assess the salt tolerance in different varieties of upland cotton, nine varieties (Sadori-1, CRIS-34, SAU-1, Sindh-1, NIAB-78, Chandi-98, Shahbaz-95, Hari-Dost and Malmal) were evaluated against salinity (EC=5.6 dSm^{-1}) and the effects were compared with control (non-saline soil: EC=2.7 dSm^{-1}). With increasing soil salinity from 2.7 dSm^{-1} EC to 5.6 dSm^{-1} EC, the average cotton plant height was decreased from 139.25 to 109.11 cm, monopodial branches 1.92 to 1.42 plant^{-1}, sympodial branches 51.694 to 34.861 plant^{-1}, bolls 93.333 to 67.722 plant^{-1}, micronaire 4.62 to 4.22µg in^{-1}, seed cotton yield 63.544 g to 54.1333 g plant^{-1} and there was no effect of salinity on the G.O.T. Due to salinity, the sodium accumulation in cotton leaf increased from 43.60 to 70.64 m mhos L^{-1}, while K^+ accumulation was inversely affected and with increasing soil salinity, the leaf potassium accumulation decreased from 148.47 to 128.52 m mhos L^{-1}, Cl^- accumulation in cotton leaf was increased from 129.95 to 199.86 m mhos L^{-1}. The cotton genotypes responded to soil salinity variably for agronomic traits of cotton on the basis of yield plant^{-1}, genotype Chandi-98 ranked 1st producing seed cotton yield of 66.138 g plant^{-1}, with 144.25 cm plant height, 2.00 monopodial branches plant^{-1}, 53.13 sympodial branches plant^{-1}, 97.375 bolls plant^{-1}, 37.75 % G.O.T., 4.45µg in^{-1} micronaire, 59.82 m mhos L^{-1} leaf Na^+ accumulation, 130.26 m mhos L^{-1} leaf K^+ accumulation and 175.42 m mhos L^{-1} Cl^- concentration. The genotype Malmal ranked least producing seed cotton yield of 50.638 g plant^{-1}, with 92.38 cm plant height, 1.38 monopodial branches plant^{-1}, 36.38 sympodial branches plant^{-1}, 58.25 bolls plant^{-1}, 34.875% G.O.T., 4.45µg in^{-1} micronaire, highest leaf Na 66.71 m mhos L^{-1}, 138.85 m mhos L^{-1} leaf K^+ accumulation and 151.51 m mhos L^{-1} Cl^- concentration.*

Keywords: Cotton, varieties, salt tolerance, EC-levels, growth and seedcotton yield

INTRODUCTION

High salt concentrations in soils inhibiting crop development and yield are a numerous limitation to agriculture in arid regions. Irrigation through marginal class water is one of the main cause resulting in salt accumulation and reduction of agricultural productivity. Improving plant confrontation to salt, though not a ultimate solution, may provide yield constancy in continuation agriculture and limit salinization due to irrigation by reducing inputs [1]. Propagation for resistance to salinity in crops has frequently been partial by lack of dependable behavior for selection. Studies on adaptation to saline environments frequently point to limited ion accumulation and the synthesis of organic solutes as basic adaptation leading to salt resistance in glycophytes. Limited sodium uptake is a trait related to salinity acceptance in a number of crop plants [2] and [3]. In other crops, however, there is no clear correlation between salt tolerance and ion exclusion. In Upland cotton, early work by [4] found that salt tolerance appeared to be related to accumulation of Na+ and Cl in the shoot [5] Na+ accumulation was related to salt sensitivity. Surveying a collection of *G. hirsutum* cultivars for variability in the response to salinity, two genotypes were identified as showing differential growth under salt stress [6].

Salt resistance is the ability of a plant to survive and complete its life on saline environment that hold high concentrations of salt, mostly NaCl but sometimes also other salts including calcium salts and sulphates. Salt resistance of plants not just varies considerably amongst species but also between varieties [7]. Varietal differences in salt tolerance are intimately connected to the expansion of a plant [8].

In saline soil, Na^+, K^+ and Cl^- are the leading ions disturbing plant growth. Under these situation the performance of some vital nutrients may also be decreased [9] and plant life may experience dietetic disorders. It is now evident that some plant genus can bear high salinity [10] (Glenn, *et al.*, 1996 and [11]. Significant differences in temperament have also been reported amongst svarieties of different species including, wheat [12], [13], and Cotton [14], [15]. The discrepancy performance of plant species may be obliging for utilization of these soils by surviving fairly tolerant genotypes. A improved osmotic modification, a lower Na^+/K^+ ratio and a lower Cl^- absorption were create in the leaves of NIAB-78 followed by MNH-93. This contributed towards for better expansion performance under saline conditions [14]. N [16] Ali *et al.* found that NIAB-999 and CIM-707 produced utmost stable yield as compared to S-12 showing tolerance to salinity. [17] experimentally observed that major differences between genotypes with observe to growth and salinity resistance [18] suggested with the intention of salt acceptance in the species may be enhanced additional by select the plants have longer roots from the segregating generations in salinized media. [19] observed that there were no momentous differences in the levels of Cl^- build up between genotypes and postulate to facilitate the upper tolerance in Z407 was the result of several traits such as a higher Na^+ uptake and water content. [20] concluded that solution culture assortment approach can be obliging for the screening of cotton genotypes for salt tolerance. [21] concluded that Delta Opal, Golden West, and Deltapine 50 are salt sensitive Sahin-2000, Nazilli M 503 and TAM94L-25 are Salt-tolerant, while rest of the cotton genotypes are considered as moderately salt-tolerant. [22] exposed that proline build up and chlorophyll concentrations are not important to be used as precise indicators to distinguish the sensitivity of cotton cultivars to salinity. Considering the significance of the aspect under investigation, the study was performed to evaluate salt acceptance in dissimilar varieties of cotton.

MATERIALS AND METHODS

The experiment was laid out in a four simulated Randomized Complete Block Design (RCBD) in a plot size of 5.0 m x 4.50 m (22.5 m^2), to assess the salt tolerance in different varieties of upland cotton, nine varieties (Sadori-1, CRIS-34, SAU-1, Sindh-1, NIAB-78, Chandi-98, Shahbaz-95, Hari-Dost and Malmal) were evaluated against salinity (EC=5.6 dSm^{-1}) and the effects were compared with control (non-saline soil: EC=2.7 dSm^{-1}). The crop was managed in accordance with the recommended package of production technologies for cotton.

Soil Analysis: Soil was analysed experimentally for physico-chemical properties, before sowing including soil texture (by hydrometer), Organic matter using Walkley-Black method, pH, Electrical conductivity (EC dS m^{-1}) by using digital meter, Soluble cations (Na^+ and K^+, Cl^- by titration) and Sodium adsorption ratio (SAR) was calculated as:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

The agronomic observations were recorded according to the standard procedures; while fiber quality was determined in the laboratory using method included in the laboratory manual for lint quality determination.

Ion analysis: The concentration of ions (Na^+, Ca^{2+}, Mg^{2+}) was determined in $meql^{-1}$. Leaf petioles from each treatment were secured at the time of maturity. The samples were processed and analysed for Na^+, K^+ and Cl^- concentration using method of [5].

Data Collection and Interpretation: The agronomic character were calculated in the field, whilst for G.O.T. and micron ire the cotton samples from each tagged plant were brought to the laboratory for qualitative analysis. The data consequently collected were subjected to statistical analysis using Analysis of variance technique and Least Significant Test (LSD) to determination the superiority of treatment by means of Computer Software.

RESULTS AND DISCUSSION

Plant height (cm)

Table-1 revealed that the plants in high salinity soil were significantly shorter (20.08%) than those grown in non-saline plots. The difference between genotypes was also significant ($P<0.05$). Over both salt treatments, plants of genotype Malmal were significantly ($P<0.05$) shorter than rest of the genotypes tested; whereas, the plants of genotypes Chandi and Hari-dost were significantly taller plants than all than other genotypes. Moreover, the interaction of salinity x variety was also significant ($P<0.05$).

Monopodial branches plant^{-1}

Results of Table-2 shows that the cotton plants sown in plots with high salinity levels had markedly lesser number of monopodial branches plant^{-1} and caused 26.04 percent reduction in the monopodial branches as compared to the cotton genotypes grown in plots with permissible salinity level (control). The differences in the number of monopodial branches plant^{-1} between genotypes were significant ($P<0.05$). Averaged over salt-treatments, the lowest number of monopodial branches plant^{-1} (1.25) was determined in cotton genotype Shahbaz-95; whereas the plants of genotypes Haridost, Chandi-98 and Sindh-1 had respectively greater number of monopodial branches plant^{-1} as compared to rest of the genotypes tested.

Sympodial branches plant^{-1}

The cotton crop sown in plots with high salinity level showed marked reduction in the number of sympodial branches plant^{-1} (32.56%) as compared to the cotton genotypes grown in control plots. The differences in the number of sympodial branches plant^{-1} between genotypes were significant ($P<0.05$). Averaged over salt-treatments, the lowest number of sympodial branches plant^{-1} (34.50) was noted in cotton genotype SAU-1; whereas Haridost, Chandi-98 and Sadori had more sympodial branches plant^{-1} than rest of the genotypes examined (Table-3).

Bolls plant^{-1}

Table-4 explains that the cotton genotypes sown in saline plots resulted considerable reduction (27.44%) in the number of bolls plant^{-1} when compared with the cotton genotypes grown in control plots. The differences in the number of bolls plant^{-1} between genotypes were significant ($P<0.05$) and the on average of salt-treatments, the lowest number of bolls plant^{-1} (58.25) was found in cotton genotype Malmal; whereas the plants of genotypes Chandi-98, Haridost and Niab-78 had higher number of bolls plant^{-1}, respectively as compared to other genotypes. The treatment interaction indicated that the interaction of salinity and genotypes was also statistically significant ($P<0.05$); and it was noted that under saline conditions, genotype Sadori had lowest number of bolls plant^{-1} than all other tested genotypes; while genotype Chandi-98 resulted highest number of bolls plant^{-1}.

G.O.T. (%)

Table-5 revealed that cotton genotypes sown in saline plots showed no adverse effect on G.O.T. percentage when compared with those grown in control plots. The differences in the G.O.T. between genotypes were non-significant ($P>0.05$) and on average of salt-treatments, relatively lower G.O.T. (34.875%) was found in cotton genotype Malmal; whereas the G.O.T. in genotypes SAU-1, Shahbaz-95 and Sadori-1 was relatively higher as compared to other genotypes. The treatment of salinity and genotypes was also statistically non-significant ($P>0.05$); and it was noted that under saline conditions, genotype Malmal and Sindh-1 had lower G.O.T. than other tested genotypes; while G.O.T. percentage in genotype SAU-1 and Haridost was higher than rest of the genotypes. The results clearly indicate that none of the cotton genotypes showed to be influenced by the salinity in regards to their G.O.T. percentage is concerned; even in some genotypes the G.O.T. in saline plots was higher than the control plots.

Micronaire (μg in^{-1})

Micronnaire of genotypes (Table-6) sown in saline plots was adversely affected by soil salinity when compared with those grown in control plots and 8.62 percent reduction in micronnaire in saline plots was recorded over control plots. The micronnaire in control plots was 4.62μg in^{-1} as compared to 4.22 μg in^{-1} in control plots. The differences in the micronaire between genotypes were also significant ($P<0.05$) and on average of salt-treatments, lowest micronaire (4.25μg in^{-1}) was noted in cotton genotype Malmal; whereas the micronaire in genotypes Haridost and Sadori-1 was higher as compared to other genotypes. The interface of salinity and genotypes was also statistically significant ($P<0.05$); and it was noted that under saline conditions, genotypes Cris-34 and Malmal had lower micronaire than other tested genotypes; while micronaire in genotype Haridost was higher than rest of the genotypes. The results clearly suggested that all the cotton genotypes were adversely affected for micronaire.

Seed cotton yield (g plant^{-1})

Table-7 explains the results that cotton crop sown in plots with saline soil resulted in a considerable reduction (14.81%) in the seed cotton yield plant^{-1} (54.1333 g) as compared to those in grown in control plots (63.544 g). The differences in the seed cotton yield plant^{-1} between genotypes were also significant ($P<0.05$). Averaged over salt-treatments, the lowest seed cotton yield plant^{-1} (50.638 g) was noted in cotton genotype Malmal; whereas the plants of genotypes Chandi-98 and Haridost, had higher seed cotton yield plant^{-1}, respectively as compared to rest of the genotypes tested. Seed cotton yield plant^{-1} under saline conditions, for genotypes Sadori-1 (49.525 g), Cris-134 (50.625 g) and Malmal (50.625 g) was in lower side; while genotype Chandi-98 (61.175 g) produced higher seed cotton yield plant^{-1} than other test genotypes.

Na^+ concentration (m mhos L^{-1})

The results of Table-8 shows that sodium (**Na^{+})** concentration in leaves of all cotton genotypes augmented with increasing level of salinity. The Na^+ in plants sown in saline plots was higher (70.64 m mhos L^{-1}) than those in control plots (43.60 m mhos L^{-1}) showing an increase of 62.01 percent as compared to control plots. The differences in the leaf Na^+ concentration between genotypes were also significant ($P<0.05$). Averaged over salt-treatments, the lowest leaf Na^+ concentration (50.34 m mhos L^{-1}) was determined in cotton genotype Sindh-1; whereas the leaf Na^+ concentration was higher in genotypes Malmal (66.71 m mhos L^{-1}) and Haridost (64.61 m mhos L^{-1}) as compared to rest of the genotypes evaluated. The effect of interaction of salinity levels and genotypes was also significant ($P<0.05$); and the leaf Na^+ concentration under saline conditions was higher for genotypes Chandi-98 (83.25 m mhos L^{-1}), Malmal (79.82 m mhos L^{-1}) and Haridost (77.81 m mhos L^{-1}) was higher than other genotypes; while leaf Na^+ concentration was lower (60.50 m mhos L^{-1}) in genotype Niab-78 than other genotypes.

K^+ concentration (m mhos L^{-1})

Table-9 explains the Potassium (K^{+}) concentration in leaves of all cotton genotypes decreased with rising level of salinity. The leaf K^+ concentration in plots with saline soil was lower (128.52 m mhos L^{-1}) than those in control plots (148.47 m mhos L^{-1}) showing a decrease of 13.43 percent over control plots. The varietal effect on the leaf K^+ concentration of cotton was also significant ($P<0.05$); and over average of salinity levels, the lowest leaf K^+ concentration (126.54 m mhos L^{-1}) was determined in genotype Sindh-1; whereas the leaf K^+ concentration was higher in Niab-78 (154.55 m mhos L^{-1}) and Shahbaz-95 (149.18 m mhos L^{-1}) as compared to rest of the genotypes.

Cl^- concentration (m mhos L^{-1})

Table-10 shows that results that the leaf for Chlorine (Cl^-) concentration of all cotton genotypes augmented with increasing soil salinity. The leaf Cl^- concentration in saline soil was higher (199.86 m mhos L^{-1}) than control (129.32 m mhos L^{-1}) showing an increase of 54.54% over control. The varietal effect on the leaf Cl^- concentration of cotton was also significant ($P<0.05$); and on average of salinity levels, the lowest leaf Cl^- concentration (151.51 m mhos L^{-1}) was determined in genotype Malmal; whereas the leaf Cl^- was higher in Sadori-1 (179.32 m mhos L^{-1}) and Chandi-98 (175.42 m mhos L^{-1}) than all other genotypes. Regardless of genotypes, the leaf Cl^- concentration in cotton increased significantly under saline conditions when compared with the control.

Soil analysis

The experimental soil was analyzed (Table-11) for its various physico-chemical properties which included pH, EC, ESP, SAR and OM at 0-20, 20-40.and 40-60 depth. The data on these soil characteristics are consolidated in Table-11. The results indicated that soil at all depths were heavy in texture (clay loam), saline in one plot (EC>5.6 dSm^{-1}), non-saline in another plot (EC <2.7 dS m^{-1}), alkaline in reaction and poor in organic mater. The data further indicated that with increasing the soil depth, the organic matter content of the soil reduced; while in saline soil at surface layer, the organic matter was alarmingly least. Although, the change in pH was negligible at all soil depths in saline and control plots; EC was markedly higher in saline plots as compared to control. No considerable change in soil depths in saline and control plots was observed in case of ESP and SAR.

DISCUSSION

The electrical conductivity exceeds from 4 dS m^{-1} of extract from water-saturated, root-associated is to be considered as saline or salt affected soil. The main cause for the irrigated areas is the development of surplus ions in the upper soil profiles [23]. Increased salinity has an inverse relationship with stomatal conductance and net photosynthetic rate [24], leading to reduced photo-assimilation and dry matter production. The effect of salinity on soil physico-chemical properties, leaf ionic accumulation and agronomic performance of cotton was significant ($P<0.05$). With increasing soil salinity from 2.7 dSm^{-1} EC to 5.6 dSm^{-1} EC, the average cotton plant height was decreased from 139.25 to 109.11 cm, monopodial branches 1.92 to 1.42 $plant^{-1}$, sympodial branches 51.694 to 34.861 $plant^{-1}$, bolls 93.333 to 67.722 $plant^{-1}$, micronaire 4.62 to 4.22µg in^{-1}, seed cotton yield 63.544 g to 54.1333 g $plant^{-1}$ and there was no effect of salinity on the G.O.T. Due to salinity, the sodium accumulation in cotton leaf increased from 43.60 to 70.64 m mhos L^{-1}, while K^+ accumulation was inversely affected and with increasing soil salinity, the leaf potassium accumulation decreased from 148.47 to 128.52 m mhos L^{-1}, Cl^- accumulation in cotton leaf was increased from 129.95 to 199.86 m mhos L^{-1}. The cotton genotypes responded to soil salinity variably for agronomic traits of cotton and on the basis of seed cotton yield $plant^{-1}$, genotype Chandi-98 ranked 1st producing seed cotton yield of 66.138 g $plant^{-1}$, with 144.25 cm plant height, 2.00 monopodial branches $plant^{-1}$, 53.13 sympodial branches $plant^{-1}$, 97.375 bolls $plant^{-1}$, 37.75 % G.O.T., 4.45µg in^{-1} micronaire, 59.82 m mhos L^{-1} leaf Na^+ accumulation, 130.26 m mhos L^{-1} leaf K^+ accumulation and 175.42 m mhos L^{-1} Cl^- concentration. The genotype Malmal ranked least for all these parameters. However, Malmal proved to be tolerant to salinity and showed no adverse effect on its seed cotton yield under salinity conditions when compared with control; while Sadori-1 was found to be more sensitive to salinity so far seed cotton yield is concerned as compared to rest of the genotypes. These results are further supported by many research workers. Their results showed that sodium concentration in leaves of all cotton genotypes improved with rising level of salinity. The utmost sodium concentration was observed in saline treatment when compared to control. [20] reported that NIAB-111 had the greatest sodium concentration in leaf sap while FH-938 had the minimum and SLH-257 was proved intermediate. In our results similar results was seen when the genotypes differed significantly for leaf ionic accumulation. Na^+ being a monovalent is extremely effectual for osmotic adjustment [25]. A significant reduction in potassium concentration in leaves of cotton genotypes was observed by [20] in saline soil as compared to control, where high sodium concentration displaced calcium from the plasma lemma resultant in loss of membrane integrity and efflux of cytosolic potassium, hence potassium concentrations in leaves decreased. Potassium concentration in leaves may be attributed to potassium selectivity for absorption. The ability of cotton genotypes to maintain a low chloride concentration may be an important reason for their salt tolerance. It is assumed that successful osmotic adjustment and a batter ionic balance regarding Na^+, K^+ and Cl^- in salt tolerant varieties contributed towards their better growth performance under saline conditions. At salinity there was a significant reduction in K^+: Na^+ ratio when compared to control. SLH-257 and FH-938 showed maximum K^+: Na^+ ratio and their results were non significant while Niab-111 showed minimum K^+: Na+ ratio. K+: Na+ ratio selectivity is an important criterion of salt tolerance because tolerant varieties maintain high K+: Na+ ratio [5]. The above findings from the past researches are well in accordance with the results obtained in the present study. However, results further concluded that genotype Cyhandi-98 proved to be high yielding when compared with rest of the genotypes; while Malmal proved to be tolerant to salinity and showed no adverse effect on its seed cotton yield under salinity conditions when compared with control. [16] found that NIAB-999 and CIM-707 showed tolerance to salinity; while [17] observed significant differences among genotypes with regard to growth and salinity tolerance. [18] and [19] observed no significant differences in Cl^- accumulation for genotypes and higher tolerance in genotypes was the result of higher Na^+ uptake and water content; while [20] and [21] reported that different cotton varieties had varied ionic accumulation in plants.

CONCLUSIONS

1. Soil physico-chemical properties and leaf ionic (Na^+,K^+,Cl^- accumulation) were significantly ($P<0.05$) affected by soil EC level.
2. The effect of salinity on agronomic performance of cotton was significant ($P<0.05$)
3. Cotton genotype Chandi-98 proved to be high yielding and Malmal yielded lwoest.
4. Malmal proved to be tolerant to salinity.
5. Genotype Sadori-1 was found to be more sensitive to salinity than other genotypes

.Table-1 Plant height (cm) of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m^{-1})		Mean
	2.7	5.6	
Sadori-1	144.50	110.25	127.38bc
Cris-34	134.00	125.00	129.50b
SAU-1	131.00	81.50	106.25e
Sindh-1	143.00	92.25	117.63d
Naib-78	135.75	124.25	130.25b
Chandi-98	152.75	135.75	144.25a
Shahbaz	135.5	110.00	122.75cd
Hari-dost	159.0	135.50	147.25a
Mal-mal	117.75	87.00	92.38f
Average	139.25	111.28	(20.08%)

Significance level	Salinity	Variety	Salinity x variety
SED	1.26	2.68	3.79
LSD	3.377**	7.164**	10.132**

Table-2 Monopodial branches $plant^{-1}$ of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m^{-1})		Mean
	2.7	5.6	
Sadori-1	1.50	1.25	1.37b
Cris-34	2.00	1.50	1.75ab
SAU-1	1.50	1.25	1.38b
Sindh-1	2.75	1.25	2.00a
Naib-78	2.00	1.50	1.75ab
Chandi-98	2.25	1.75	2.00a
Shahbaz	1.25	1.25	1.25b
Hari-dost	2.25	2.00	2.13a
Mal-mal	1.75	1.00	1.38b
Average	1.92 a	1.42 b	(26.04%)

Significance	Salinity	Variety	Salinity x

level			variety
SED	0.14	0.30	0.42
LSD	0.28*	0.69*	NS

Table-3 Number of sympodial branches of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m-1)		Mean
	2.7	5.6	
Sadori-1	67.25	30.75	49.00 a
Cris-34	36.00	36.25	36.13 c
SAU-1	40.75	28.25	34.50 c
Sindh-1	56.50	28.00	42.25 b
Naib-78	53.50	36.75	45.13 b
Chandi-98	60.00	46.25	53.13 a
Shahbaz	49.75	25.00	37.38 c
Hari-dost	69.50	41.75	55.63 a
Mal-mal	32.00	40.75	36.38 c
Average	51.69a	34.86b	(32.56%)

Significance level	Salinity	Variety	Salinity x variety
SED	1.27	2.71	3.65
LSD	3.417**	7.249**	10.253**

Table-4 Number of bolls plant^{-1} of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m-1)		Mean
	2.7	5.6	
Sadori-1	99.25	41.25	70.250 c
Cris-34	83.00	73.25	78.125 b
SAU-1	84.74	64.75	74.750 c
Sindh-1	106.50	61.00	83.750 b
Naib-78	100.25	84.50	92.375 a
Chandi-98	100.75	94.00	97.375 a
Shahbaz	94.75	53.25	74.000 c
Hari-dost	100.75	91.00	95.875 a
Mal-mal	70.00	46.50	58.250 d
Average	93.333 a	67.722 b	(27.44%)

Significance level	Salinity	Variety	Salinity x variety
SED	1.54	3.27	4.63
LSD	4.123**	8.75**	12.37**

Table-5 GOT% of various cotton genotypes as affected by different salinity levels

Variety	Salinity levels (EC dS m^{-1})		Mean
	2.7	5.6	
Sadori-1	37.250	38.750	38.000
Cris-34	37.250	36.250	36.750
SAU-1	38.750	42.000	40.375
Sindh-1	36.000	35.750	35.875
Naib-78	37.500	37.250	37.375
Chandi-98	37.500	38.000	37.750
Shahbaz	41.250	38.000	39.625
Hari-dost	35.750	39.000	37.375
Mal-mal	34.000	35.750	34.875
Average	37.250	37.861	-

Significance level	Salinity	Variety	Salinity x variety
SED	1.123	2.38	3.37
LSD	NS	NS	NS

Table-6 Micronaire (µg in^{-1}) of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m^{-1})		Mean
	2.7	5.6	
Sadori-1	4.80	4.20	4.50 a
Cris-34	4.40	4.10	4.25 d
SAU-1	4.50	4.20	4.35 c
Sindh-1	4.60	4.30	4.45 b
Naib-78	4.70	4.20	4.45 b
Chandi-98	4.60	4.30	4.45 b
Shahbaz	4.70	4.40	4.55 a
Hari-dost	4.60	4.10	4.35 c
Mal-mal	4.70	4.20	4.45 b
Average	4.62 a	4.22 b	(8.62%)

Significance level	Salinity	Variety	Salinity x variety
SED	0.0302	0.0429	0.0607
LSD	0.0405**	0.0860**	0.1216**

Table-7 Seedcotton yield (g plant^{-1}) of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m-1)		Mean
	2.7	5.6	
Sadori-1	70.400	49.825	60.113 b
Cris-34	57.900	50.625	54.263 d
SAU-1	58.650	53.000	55.825 c
Sindh-1	68.900	51.025	59.963 b
Naib-78	61.475	59.600	60.538 b
Chandi-98	71.100	61.175	66.138 a
Shahbaz	60.400	52.675	56.538 c
Hari-dost	72.425	58.650	65.538 a
Mal-mal	50.650	50.625	50.638 e
Average	63.544 a	54.1333 b	

Significance level	Salinity	Variety	Salinity x variety
SED	0.27	0.58	0.83
LSD	0.738**	1.565**	2.214**

Table-8 Na+ concentration (m mhos L^{-1}) of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m-1)		Mean
	2.7	5.6	
Sadori-1	41.22	66.22	53.72 f
Cris-34	44.26	71.40	57.83 d
SAU-1	39.60	65.70	52.65 f
Sindh-1	39.95	60.72	50.34 g
Naib-78	43.62	60.50	52.06 f
Chandi-98	36.40	83.25	59.83 c
Shahbaz	42.36	70.40	56.38 e
Hari-dost	51.40	77.81	64.61 b
Mal-mal	53.60	79.82	66.71 a
Average	43.60 b	70.64 a	(62.01%)

Significance level	Salinity	Variety	Salinity x variety
SED	0.2445	0.5186	0.7334
LSD	0.4902**	1.0398**	1.4705**

Table-9 K^+ concentration (m mhos L^{-1}) of cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m-1)		Mean
	2.7	5.6	
Sadori-1	141.36	120.21	130.79 f
Cris-34	155.88	134.60	145.24 c

SAU-1	138.42	119.22	128.82 g
Sindh-1	136.90	116.18	126.54 h
Naib-78	164.65	144.44	154.55 a
Chandi-98	139.20	121.31	130.26 f
Shahbaz	159.23	139.12	149.18 b
Hari-dost	152.22	132.33	142.28 d
Mal-mal	148.40	129.29	138.85 e
Average	148.47 a	128.52 b	

Significance level	Salinity	Variety	Salinity x variety
SED	0.2292	0.4862	0.6876
LSD	0.4595**	0.9748**	1.3785**

Table-10 Leaf Cl^- (m mhos L^{-1}) in cotton genotypes as affected by salinity levels

Variety	Salinity levels (EC dS m^{-1})		Mean
	2.7	5.6	
Sadori-1	142.40	216.23	179.32 a
Cris-34	132.81	202.16	167.49 c
SAU-1	123.35	196.12	159.74 d
Sindh-1	119.13	189.63	154.38 e
Naib-78	134.18	201.22	167.70 c
Chandi-98	139.60	211.23	175.42 b
Shahbaz	129.21	204.14	166.68 c
Hari-dost	126.27	191.92	159.10 d
Mal-mal	116.95	186.06	151.51 e
Average	129.32 b	199.86 a	

Significance level	Salinity	Variety	Salinity x variety
SED	0.9237	1.9294	2.7710
LSD	1.8518**	3.9283**	5.5554**

Table-11 Physico-chemical properties of site (before sowing)

Soil property	Depth (cm)					
	0-20		20-40		40-60	
	EC 2.7 dSm^{-1}	EC 5.6 dSm^{-1}	EC 2.7 dSm^{-1}	EC 5.6 dSm^{-1}	EC 2.7 dSm^{-1}	EC 5.6 dSm^{-1}
pH	7.9	8.12	7.5	7.52	7.4	7.37
EC	3.5	5.60	2.55	4.42	1.65	3.47
ESP	5.98	4.63	6.75	5.44	8.55	5.03
SAR	4.81	4.11	5.32	4.19	6.51	4.51
OM%	1.04	0.11	0.93	0.88	0.81	0.75

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