RESPONSE OF DIFFERENT COTTON (*GOSSYPIUM HIRSUTUM* L.) GENOTYPES AT VARIOUS SALINITY LEVELS

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ABSTRACT:- Keeping in view the salt stress threat in Pakistan, a hypothesis was developed that up to what level of salt, the cotton genotypes can survive so that it may provide the shelter for income from textile industry, as mainly the textile industry depends upon cotton production. High salinity levels hamper the boll formation in cotton genotypes as it reduces the yield. To verify this fact, study was carried out under natural conditions as pots experiment in soil at water testing laboratory, D.G. Khan during 2012-13. Six cotton genotypes (FH – 945, FH – 901, NIAB – 111, NIAB – 999, B – 630 and B – 622) were collected from Nuclear Institute for Agriculture and Biology (NIAB) and Ayub Agricultural Research Institute (AARI), Faisalabad. The plant height of NIAB-111 was more affected by soil salinity than that of other varieties. The number of bolls per plant also showed the similar fashion to salinity stress for all varieties. Maximum average weight of cotton boll was recorded in control practice as compared to salinity gradient treatments. Sodium (Na^+), Potassium (K^+) and Chloride (Cl^{-1}) contents in leaf sap were present more in salinity gradient treatment cotton genotypes as compared to farmer practice. Overall, findings revealed that higher to lower salinity levels did not suit to tested varieties. At optimum salinity stress level, all varieties performed optimally under salt conditions.

Key Words: Cell sap, Cotton genotypes, Salinity level

INTRODUCTION

Salinity is a major issue of soils in Pakistan like other arid and semi-arid regions; low rainfall and high evapotranspiration are mainly responsible for leaching and salts accumulation in crop root zone (Akhtar et al., 2010). Out of the total cultivable area of Pakistan about 6.67 m ha, land is salt affected, which is about 1/3rd in proportion (Khan et al., 2001). The low precipitation, high evapotranspiration and shallow water table enhanced the salts movements towards soil surface resulting in increased salinity level due to decrease in leaching (Alam and khan, 2000). The floods, canals, water logging and drains are major carrier for adding more salt stress to the normal fields (Munns 2002). In addition to this, major source for salinity is pumping out of the water through tube wells. About 60-70% water pumped by tube wells is from

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marginal to brackish range and its continuous utilization for irrigation or other purposes result in salinity or /sodicity (Chandio 2009).

Cotton (*Gossypium hirsutum* L.) is not only the cash crop but also the silver fiber of Pakistan (Khan, 2007). Cotton is considered as moderately salinity tolerant crop (Maas, 1986) but cotton yield is significantly reduced by salinity causing abnormal development and poor germination (Khan et al., 2001). Cotton seed yield has been reported to be reduced about 41% on soils affected by salts (Qayyum and Malik, 1988).

Salinity affects germination, growth as well as reproduction of a crop by changing its morphology and anatomy. The first detectable effect of salinity on cotton crop is the decline in total cotton leaf area (Bradford and Hsiao, 1983). Chlorides along with sodium are leading ions affecting the cotton crop (Meneguzzo et al., 2000). Presence of these ions mainly reduces the nutrient uptake by affecting its availability (Gratten and Grieve, 1992).

There is variation among crop species to tolerate salinity at different levels (Rehman et al., 2012). There is, likewise, a considerable difference among cotton cultivars for salinity tolerance (Choudhary et al., 2001; Ashraf, 2002). It would be essential to practice modern cotton genomic sources to increase salt tolerance level in cotton genotypes to minimize the adverse socio - economic effects on community due to low production (Basal et al., 2006).

Realizing the negative impact of salinity on the cotton production, we have tried to screen out the varieties that would have the capability to survive under salinity. A trial was conducted with the hypothesis to analyze the comparative response of different cotton genotypes against salinity gradient and their survival up to what salt stress levels.

MATERIALS AND METHOD

Experiment Description

A pot study was initiated under natural conditions in soil at water testing laboratory, D.G. Khan during the year 2012-13. Six cotton genotypes namely FH-945, FH-901, NIAB-111, NIAB-999, B-630 and B-622 were provided by Nuclear Institute of Agriculture and Biology (NIAB) and Ayub Agriculture Research Institute, (AARI), Faisalabad for screening against the salinity gradient. These genotypes were subjected to various treatments i.e. T_1 (Control), T_2 (EC_e = 7.5 dS m^{-1}) and T_3 (saline soil having EC_e 15 dS m^{-1}). Ten Kg of air dried soil was filed in plastic pots (27 cm in diameter), previously passed through a 2 mm sieve and then analyzed for pre-requisite physiochemical characters like $EC_{e,}$ pH, SAR and textural class (Table-1). Five plants of each cultivar were transplanted into these labeled pots and replicated thrice. The required salt concentrations were determined by quadratic equation and desired salinity levels, such as 0.96, 7.5 and 15 dS m^{-1} were developed prior to filling the soil in pots by mixing the calculated amount of NaCl salt in soil. Sulphuric acid @ 100 ml kg^{-1} of seed was used for delinting of seed and gentle stirring was done to remove fuzz. A basal dose of NPK fertilizers was applied @ 175, 85 and 60 kg per ha respectively. Full dose of P and K and 1/3rd urea was applied at sowing time, while the remaining N was added 30 and 40 days after sowing. Physico-chemical characteristics of the soil under study site were pH 7.70, ECe 2.5 dS m^{-1}, SAR 5.8 ($mmol_c$ $kg^{-1})^{1/2}$, textural class was sandy clay loam.

Plant Harvesting and their Physico-Chemical analysis

Physical parameters like plant height (cm/plant), no. of bolls per plant, monopodial branches per plant, and sympodial branches per plant and seed cotton (g/pot) were recorded to analyze the salinity threat to cotton. Fully extended younger leaves were collected, washed with distilled water, blotted and stored in the 1.5 cm^3 Eppendorf tubes at freezing temperature for chemical analysis. The cell sap was extracted from the stored leaved (Gorham et al., 1985). Tissues sap was collected in other Eppendorf tubes by Gilson pipettes and centrifuges at 6500 rpm for 10 min. The supernatant sap was collected and used for ionic analysis. Sodium (Na^+) and, Potassium (K^+) was estimated by using Sherwood-410 flame photometer while Chlorides (Cl^-) were determined by using Sherwood-296 chloride analyzer directly calibrated to $mgL^{-1.}$

Statistical Analysis

Complete Randomized Design (CRD) in factorial experiment was adopted in this study. The data obtained from this study was pooled and analyzed statistically using SPSS program (Volkan et al., 1980).

RESULTS AND DISCUSSION

Plant Height

The data pertaining to the impact of salinity on plant height of all six genotypes was elucidated in (Table 1). The results revealed a significant reduction in plant height with increasing levels of salinity. In general, higher average plant height (51.8 cm) was in the control treatment, while it decreased linearly down to 40.4 cm. Comparing to all genotypes, B – 622 gained maximum plant height (63.6 cm), while NIAB - 111 significantly produced the lowest plant height (45.6 cm) under normal field condition (control practice). However, these both genotypes showed the similar trend at 7.5 dS m^{-1}. Therefore, at very higher salinity level (15 dS m^{-1}), NIAB-999 produced a significantly higher plant height (44.7 cm) than that of other genotypes and NIAB -111 produced minimum plant height (35.9 cm) due to the very high toxic impact of osmolutes. It is obvious from the results that B-622 performed better under the salt stress environment as compared to all other genotypes. Actually, plant height decreased all the cotton genotypes due to intrusion of toxic ions by salinity, especially Na^+ which retarded and reduced the growth and development process of plants. Another apparent cause of reduction in plant height with rising level of salinity may be compacted leaf area (Curtis and Lauchli, 1985), leaf expansion and final leaf area (Jafri

Table 1. Effect of salinity on plant height (cm)

Genotypes	Control	Ece 7.5 dSm^{-1}	Ece 7.5 dSm^{-1}	Mean
FH-945	46.6^{e}	42.9^{fgh}	40.3^{hij}	43.3^{C}
FH-901	49.5^{d}	42.4^{ghi}	39.9^{ij}	43.9^{C}
NIAB-111	45.6^{ef}	42.3^{ghi}	35.9^{k}	41.3^{B}
B-630	46.3^{e}	43.0^{fgh}	28.8^{j}	42.7^{CD}
B-622	63.6^{a}	56.2^{b}	42.8^{fghi}	54.2^{A}
NIAB-999	54.9^{a}	52.2^{b}	44.7^{c}	50.6^{B}
Mean	51.8^{A}	46.5^{B}	40.4^{C}	

Means with similar letters are non significant at p< 0.05 and Ahmad, 1994). Saline conditions may reduced the process of photosynthesis, dry matter accumulation and ultimate growth (Ahmad et al., 2003).

Number of Bolls per Plant

The investigations with respect to boll numbers plant^{-1} were depicted in (Table 2). Significant impact of salt stress on cotton plant was decreased boll numbers plant^{-1} with increasing levels of salinity. In general, maximum average boll numbers plant^{-1} (6.1) was produced by control treatment, while the minimum number of bolls per plant (4.3) was found at the high salt stress level. Under normal field condition, genotype B – 630 produced maximum number of bolls (9.6/plant) while NIAB - 111 had produced the minimum bolls (4.4/plant). Therefore, at 7.5 dSm^{-1} electrolytic content, maximum number of bolls (8.2/plant^{-1}) were produced in B-630 as compared to all other genotypes, while the minimum number of bolls (4.4/plant^{-1}) were recorded in B -622 and FH – 945. However, at very high salt stress (15 dSm^{-1}), cotton genotype B-630 produced the maximum number of bolls (6.0 /plant) as compared to all others and the minimum was recorded in FH-901 (3.0/plant). It was evident from the investigations that salinity decreased the boll numbers plant^{-1} significantly as compared to normal field conditions. Saline conditions may reduce the process of photosynthesis, dry matter accumulation and ultimate growth (Ahmad et al., 2003).

Table 2. Effect of salinity on number of bolls per plant.

Genotypes	Control	Ece 7.5 dS m^{-1}	Ece 7.5 dS m^{-1}	Mean
FH -945	5.6^{de}	4.4^{defg}	5.6^{de}	5.1^{BC}
FH -901	6.0^{cd}	5.0^{efgh}	3.0^{h}	4.5^{CD}
NIAB -111	4.4^{efgh}	4.8^{defg}	3.4^{gh}	4.2^{D}
B -630	9.6^{a}	8.2^{b}	6.0^{cd}	7.9^{A}
B -622	5.6^{cd}	4.4^{defg}	3.2^{efgh}	4.7^{CD}
NIAB -999	7.2^{be}	5.6^{de}	3.8^{fgh}	5.5^{B}
Mean	6.1^{A}	5.6^{B}	4.3^{B}	

Means with similar letters are non significant at p< 0.05 significantly

Seed cotton yield (g

Yield is an essential and integral constituent for the sustainability of agriculture, as well as for country and farmer's economy. In this study, the data regarding seed cotton yield shown in (Table 3) significantly differed among all treatments. In general trend, maximum boll weight (5.8 g) was found in control treatment, while the boll weight (4.2 g) decreased significantly in both salinity levels (7.5 dSm^{-1} and 15 dSm$^{-1)}$. Under nor-mal field condition (control treatment) B-630 gave the maximum (7.6 g) and FH-901 gave the lowest yield (4.0 g). Other varieties including FH-945, NIAB-111, NIAB-999 and B-622 pro-duced the intermediate yield. The genotype B-630 produced the maximum (6.0 g)

Table 3. Effect of soil salinity on seed cotton yield (g) of different cotton genotypes.

Genotypes	Control	Ece 7.5 dS m^{-1}	Ece 7.5 dS m^{-1}	Mean
FH -945	5.4^{bcde}	4.8^{cdef}	4.2^{efg}	4.8^{CD}
FH -901	6.0^{bc}	5.4^{bcde}	4.4^{efg}	5.3^{BC}
NIAB -111	4.0^{defg}	4.2^{efg}	3.8^{fg}	4.2^{D}
B -630	7.6^{a}	6.4^{b}	5.0^{cdef}	6.3^{A}
B -622	6.6^{ab}	5.8^{bcd}	4.6^{defg}	5.7^{B}
NIAB -999	4.6^{defg}	4.4^{efg}	3.4^{g}	4.1^{D}
Mean	5.8^{A}	5.2^{B}	4.2^{C}	

Means with similar letters are non significant at p< 0.05 statistically. cotton genotypes.

and FH – 901 prod-uced the minimum yield (3.0 g) at medium salt stress (7.5 dSm^{-1}) level. Similarly, B – 630 also produced the maximum yield (4.6 g), while NIAB – 999 produced the minimum yield (2.3 g) at 15 dSm^{-1}. The remaining cotton genotypes including FH-945, NIAB-111, FH-901 and B-622 did not differ at this level. The results showed that all the treatments showed significant difference among each other and at the higher salinity level, the salinity had a significant impact on the yield component. This might be due to retarded growth associated with the shrinkage of cell, reduction in chlorophyll contents, tissues differentiation (Ashraf et al., 2005; Khan et al., 2009).

Sodium (Na^+) Concentration ($molm^{-3}$) in Leaf Sap

Data presented in the (Table 4) reflects the increased concentration of sodium in leaf sap of each cotton genotypes with rising level of salinity. Generally, maximum average sodium content was observed in saline conditions as compared normal (control) field condition. The genotype B-630 accumulated more Na+ ionic content as compared to all other genotypes and minimum by FH 901at. Similar results were obtained at salinity 7.5 dS m^{-1}, however, at very high salt stress (15 dS m-1), NIAB-111 had maximum sodium concentration (43.4 $molm^{-3}$) as compared to others. Generally, maximum average sodium content was observed in saline conditions as compared to normal (control) field condition. It is evident from the above results that with rising levels of salinity, the sodium concentration increased in leaves of each cotton genotypes. Finally, statistical data regarding the sodium concentration in leaf sap of each cotton genotypes at salinity level shows that sodium contents have a significant positive relation with salinity level (Santa-Maria & Epstein, 2001). Moreover, this increase in sodium concentration could be due to uptake of sodium ion to create an osmotic pressure as sodium being monovalent is very helpful for osmotic adjustment (Gorham et al., 1985).

Table 4. Effect of salinity on sodium concentration (mol m-3) in lea sap of different cotton genotypes.

Genotypes	Control	Ec_e 7.5 dSm^{-1}	Ec_e 7.5 dSm^{-1}	Mean
FH -945	26.8^{e}	42.0^{c}	59.8^{ab}	42.9^{AB}
FH -901	22.4^{e}	44.6^{c}	55.8^{b}	40.8^{B}
NIAB -111	23.7^{e}	44.6^{c}	51.9^{a}	43.4^{AB}
B 630	33.5^{d}	43.8^{c}	56.7^{ab}	44.7^{A}
B -622	26.8^{e}	45.1^{c}	58.5^{ab}	43.5^{AB}
NIAB -999	24.3^{e}	43.8^{c}	59.8^{ab}	42.6^{AB}
Mean	26.3^{C}	44.0^{B}	58.7^{A}	

Means with similar letters are non significant at p< 0.05 statistically

Potassium (k^+) Concentration ($molm^{-3}$) in Leaf Sap

The data regarding potassium (K^+) ion content in the leaf sap is given in table 5. Results showed that potassium concentration in leaves decreased significantly with increasing level of salinity. In general, more K^+ concentration in leaves was available in control treatment while it was available minimum under both saline conditions. Comparison of all genotypes for K^+ concentration in leaves showed that it was present maximum in FH-901 leaves (193.2 $molm^{-3}$) as compared to all other genotypes while it was minimum in NIAB-999 leaves (154.1 $molm^{-3}$) in

Table 5. Effect of salinity on potassium concentration (mol m^{-3}) in leaf sap of different cotton genotypes

Genotypes	Control	Ec$_e$ 7.5 dSm^{-1}	Ec$_e$ 7.5 dSm^{-1}	Mean
FH -945	203.8^{ab}	189.4^{a-d}	173.3^{b-e}	188.8^{A}
FH -901	220.6^{a}	186.2^{a-e}	172.9^{b-e}	193.2^{A}
NIAB -111	201.0^{ab}	180.9^{b-e}	169.7^{b-e}	183.9^{A}
B -630	200.6^{a-c}	170.5^{b-e}	166.5^{b-e}	179.2^{A}
B -622	197.0^{a-c}	189.0^{a-d}	164.8^{b-e}	183.5^{A}
NIAB -999	153.6^{d}	147.3^{e}	160.8^{b-e}	154.1^{B}
Mean	196.1^{A}	177.2^{B}	167.9^{C}	

Means with similar letters are non significant at p< 0.05 statistically

Table 6. Effect of salinity on chloride concentration (mol m^{-3}) in leaf sap of different cotton genotypes

Genotypes	Control	Ec$_e$ 7.5 dSm^{-1}	Ec$_e$ 7.5 dSm^{-1}	Mean
FH -945	50.4^{f}	126.3^{c}	189.6^{b}	122.1^{C}
FH -901	50.7^{f}	122.0^{c}	192.7^{b}	121.9^{C}
NIAB -111	69.3^{de}	136.6^{c}	221.1^{a}	142.3^{A}
B -630	77.7^{d}	137.2^{c}	227.1^{a}	143.9^{A}
B -622	60.8^{ef}	137.2^{c}	116.0^{a}	138.0^{AB}
NIAB -999	51.4^{f}	125.1^{c}	118.0^{a}	131.4^{B}
Mean	60.1^{C}	130.8^{B}	109.1^{A}	

Means with similar letters are non significant at p< 0.05 statistically.

control treatment. Medium level salinity (7.5 dSm^{-1}) resulted in maximum K^+ concentration in FH-945 leavesand the minimum in NIAB-999. There was significant reduction in leaf sap potassium as compared to control treatment at 15 dSm^{-1} which confirmed the results of Aslam and Muhammad (1972) regarding the effect of salinity on potassium concentration in different cotton genotypes. They also reported that less potassium was available in cotton genotypes under marginal land environmental conditions. Hence, our investigations responded similarly like to other mentioned findings.

Chloride (Cl^-) Concentration (mol m^{-3}) in Leaf Sap

The data regarding to chloride (Cl^-) concentration is shown in Table 6. The results depicted that the Cl^- contents in leaf sap of all cotton genotypes increased linearly with increasing level of salinity. Overall, more Cl^- contents were found in saline treatments and remained in lower strength in control. The comparison of all cotton genotypes indicted that maximum chloride concentration was found in leaves of B-630 (143.9 molm^{-3}), while it was the minimum in FH-945 (121.9 molm^{-3}). At control treatment, maximum sodium concentration was present in B-630 leaves, while it was found minimum in FH-901 leaves. The investigations showed that Cl^- contents in leaf sap of all cotton genotypes increased linearly with increasing level of salinity. The comparison of all cotton genotypes indicted that maximum chloride concentration was found in leaves of B-630 while it was less was in FH-945. At control treatment, maximum Cl^- concentration was present in B-630 leaves while it was found minimum in FH-901 leaves. It was pointed out that chloride contents had a significant impact by retarding the growth of various crop plants like wheat and cotton along with deteriorating the soil quality attribute (Khan et al., 2001).

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S.No	Author Name	Contribution to the paper
1.	Mr. Muhammad Bilal	Conceived the idea, Data Collection and Write, Introduction
2.	Mr. Zafar Abbas	Statistical analysis, Methodology and reference
3.	Mr. Ijaz Ahmad	Overall management of the article
4.	Mr. Muhammad Aslam	Wrote Abstract
5.	Mr. Muhammad Ijaz	Experimental work
6.	Dr. Adnan Shakeel	Data entry in and prepared data sheet for statistical analysis
7.	Mr. Mushtaq Ahmad	Technical input
8.	Mr. Kashif Bashir	Result and Discussion

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