Research Paper

Genotypic characterization of cotton (*Gossypium Hirsutum* L.) for Physiological attributes associated with water stress Tolerance.

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Abstract: Drought has an impact on agricultural growth and development, which significantly reduces output and degrades produce quality. Fifty cotton genotypes were tested in the field for performance under artificially produced water deficit stress conditions. In 2015, sowing was carried out in the first week of May with two sets of every genotype in each replication. While the other set continued to be stressed by a water shortage, one set was regularly irrigated. The crop was allowed to grow for a duration of four weeks. Data on various physiological markers related to different genotypes' resistance to water stress were gathered. The findings showed that under normal and stressful conditions, the genotypes differed significantly (p 0.01) in a number of physiological variables e.g. relative water content, cell damage, leaf water potential, excised leaf water loss, osmotic potential, and stomatal conductance. For the several variables examined, very significant interactions (p0.01) were also found between genotypes and water stress. The genotypes include (Include nutshell results indicating susceptible and tolerant varieties)

Keywords: Cotton; physiological traits; drought tolerance; Genotypes; Pakistan

1. Introduction

Cotton is globally well known as the most valuable agricultural as well as industrial produce. Cotton and its related businesses are sharing a lot to the economic development and employment generation of both developed as well as developing countries. In Pakistan about 40% of the labour force is engaged in cotton production chain from farm to its finished products. Cotton generates 8% of the GDP and 50% of foreign exchange earnings for Pakistan. When plants are subjected to the stress of drought, it causes widespread disruption of their defense mechanisms on both the cellular and molecular levels. As a result of water deficit, turgor pressure decreases, which has knock-on effects on cell growth rate, leaf development, stem elongation, and stomatal diameter. As a result of altered carbohydrate metabolism [1-4], photosynthesis is slowed or halted in drought-stricken plants, hastening the process of fruit shedding. Without irrigation, regular precipitation is essential for the optimal growth and development of cotton plants[5,6].

Stomatal closure, the rate of water loss through excised leaves, and abscisic acid (ABA) buildup have all been linked by researchers to drought resistance in plants. It has been shown that high stomatal conductance can be used as a selection criterion for excellent yields in irrigated crops produced in hot regions [7]. Cotton plants under water stress showed a significant reduction in stomatal area when the rate of CO2 adjustment was measured [8].

There is a close correlation between cotton genotypes' physiological features associated with drought resistance and yield indices. For instance, in drought conditions, the photosynthetic rate, which greatly declines with the application of water stress, can be employed successfully for germplasm screening [9]. Regular screening of developing germplasm is required for greater adaptability and sustainable production because germplasm with genetic variability may respond differently under normal and water deficiency situations. In order to assess advanced cotton genotypes for drought resistance traits in field settings, the following research were carried out.

2. Materials and Methods

On the basis of leaf water potential, two irrigation levels were maintained while fifty genotypes were examined in the field. In water shortage stress (T1), the top limit of leaf water potential () was kept at 2.4+0.2 MPa while the upper limit of was maintained at -1.6+0.2 MPa for normal irrigation (T0). When the leaf water potential reached the predetermined limit, the crop was irrigated. A total of 750 mm of water was applied to a typical irrigated crop, whereas only 300 mm was used to relieve water deficiency stress. In both treatments, the initial irrigation was applied at the time of planting, and successive irrigations were applied based on the leaf water potential. The experiment was set up using a split plot arrangement and a randomized complete block design. The sub plots were designated for genotypes, whereas the major plots were allotted for irrigation water levels. All cotton genotypes' seeds were planted with a gap of 75 cm between adjacent rows and 30 cm between individual plants. In accordance with Pettigrew's 2004 experiment, soil between two rows was covered with polythene sheet during the months of July and August to reduce the impact of any anticipated rainfall. In order to evaluate the genotypic responses to water scarcity, data on 10 plants from each genotype were collected for all replications on Relative water content, Excised leaf water loss, Cell injury, Leaf water potential and Osmotic potential. The mean and mean variance of all genotypes and cultivars were calculated statistically from the data. The LSD was estimated with a 0.05% probability.

3. Results

Pooled analysis of variance was applied to the data collected for all physiological characteristics under both normal and stressful settings. Cotton genotypes examined under normal and stress conditions indicated extremely significant differences (P 0.01), according to the mean square for pooled analysis of variance (Table 1). For all of the characteristics, very significant results (P 0.01) were shown for the genotype x environment interaction.

3.1 Relative water content (RWC).

50 accessions measured under controlled and drought conditions showed differences in relative water content, and relative water content was also significantly lower under stressful conditions. CIM-591, BH-176 and MPS-11displayed the highest relative water content under controlled conditions (Table 2). MS-64 , Cooker-315 and GS-444 displayed the same minimal relative water content. The entries with the lowest relative water content were GS-444, CRIS-510, and Cooker-315 with average values of 32.53, 34.87, and 45.63 8 respectively. At drought conditions, the highest value was demonstrated by MPS-11 (59.63), BH-176 (58.97), Karishma (54.97), and DPL-45 (54.63). Based on the grand mean of the relative water content under normal and drought conditions, the range was 42.63 to 70.30.

Table-1 **Analysis of variance (Mean squares) for physiological parameters.**

Source of variation	**Degrees of freedom**	**Mean squares**				
		RWC	**Excised leaf water loss**	**Cell injury**	**Leaf water potential**	**Osmotic potential**
Replication	2	3.880^{NS}	0.00510^{NS}	1.110^{NS}	0.813	0.000012
Treatment (T)	1	58688.05**	14.24412**	35154.19**	1600.830**	0.570462**
Genotype (G)	49	167.44**	0.57059**	202.18**	8.637**	0.006871**
T x G	49	69.18**	0.17472**	101.46**	5.442**	0.001818**
Error	198	5.02	0.00821	2.69	0.948	0.000096
Total	299					

NS = Non-significant (P>0.05); * = Significant (P<0.05); ** = Highly significant (P<0.01)

3.2 Excised Leaf Water Loss

Fifty accessions measured for excised leaf water loss under controlled and drought circumstances varied from one another, and excised leaf water loss was also significantly lower under stress. Maximum excised leaf water loss under controlled conditions was demonstrated by the strains BH-176, Cyto-62 and Tree Cotton with average values of 2.63, 2.60 and 2.57 respectively. The least amount of excised leaf water loss was shown by the GS-444 (0.83), B-452, and Cooker-315 varieties (0.87). The entries with the highest average values of excised leaf water loss during drought conditions were BH-176 (1.77), Cyto-62, Tree cotton, MPS-11 Stoneville (1.50), and Stoneville (1.40). The entries with the lowest average values were MS-64, Cooker-315 and Cooker-312 which had average values of 0.53, 0.63, and 0.67 respectively. Extracted leaf water loss ranged from 0.73 to 2.05 based on the grand mean calculated from normal and drought conditions (Table 2).

3.3 Cell injury

Fifty accessions assessed for cell injury under controlled and drought circumstances varied from one another, and relative cell injury was also noticeably decreased under stress. Maximum cell injury was demonstrated by MS-64 under controlled conditions, followed by Sun-2 and GS-444, with average values of 42.87, 39.17, and 38.87, respectively (Table 2). BH-176 (21.40), DPL-45 (21.77), Tree cotton (22.33), CIM-608 (22.37), and Cyto-62 all showed similar low levels of cell damage (22.57). The entries with the highest values of cell injury in drought conditions were MS-64 (67.40), GS-444 (66.37), and Cooker-315 (65.83), whereas the entries with the lowest values were Tree cotton (31.90), Cyto-62, and (36.87). MPS-11 (38.37), BH-176(36.93)and DPL-45 (39.60)., Based on the grand mean from both normal and drought conditions, the range of cell injury was 27.12 to 55.13. (Table 2).

3.4. Leaf water potential

The leaf water potential of 50 accessions measured in controlled and drought circumstances varied from one another, and the leaf water potential in stressed conditions was also significantly decreased. Under controlled conditions, Tree cotton, Stoneville, BH-176 (-17.00) and DNH-105 (-17.33) (Table 2). NIAB-112, CIM-473 and AC-307 all displayed the same minimal leaf water potential (-22.760). Tree cotton and Cyto-62 both showed the highest value of -22.00 followed by DPL-45 (22.33) andBH-176 (23.00) under the drought conditions. GS-444, MS-64 (-27.33) and Cooker-315 had the entries with the lowest leaf water potential values. Based on the grand mean of the normal and drought conditions, the range of the leaf's water potential was -24.84 to -22.78.

3.5. Osmotic potential

Fifty accessions were also assessed for osmotic potential under controlled and drought circumstances varied from one another, and osmotic potential was also noticeably lower under stress conditions. The entries with the highest values of osmotic potential under controlled conditions were BH-176, DPL-145 and Tree cotton with the value of -0.15 followed by Cyto-62 and MPS-11 with the value of -0.16 while the entries with the lowest values (0.28) were PB-38, cocker-15, MS-64, and IUB-2011 (Table 3). At times of drought, BH-176 demonstrated the highest osmotic potential (-0.20) followed by Cyto-62 and DPL-45 with average values of -0.25 and -0.26 respectively. Cooker-315 (-0.380), MS-64 (-0.365) and CIM-43 all displayed the same minimal osmotic potential (-0.355). The range of the osmotic potential was -0.33 to -0.18 based on the grand mean that was determined from normal and drought conditions.

Table-2 Means values of Physiological parameters under normal and drought conditions.

Genotypes	Relative water contents			Excised leaf water loss			Cell injury			Leaf water potential			Osmotic potential		
	*N	**D	Mean	*N	**D	Mean	*N	**D	Mean	*N	**D	Mean	*N	**D	Mean
DNH-105	73.97	41.30	57.64	1.47	1.30	1.39	34.03	61.80	47.92	-17.03	-25.03	-21.03	-0.20	-0.30	-0.25
CRIS-533	74.63	43.30	58.97	1.12	0.87	1.00	23.77	65.80	44.79	-22.03	-26.03	-24.03	-0.20	-0.34	-0.27
MPS-27	77.30	47.97	62.64	1.07	0.83	0.95	29.10	55.57	42.34	-20.37	-24.37	-22.37	-0.18	-0.29	-0.24
CIM-506	72.97	48.97	60.97	1.40	1.00	1.20	29.43	56.83	43.13	-18.70	-25.03	-21.87	-0.22	-0.35	-0.28
TH-112/05	75.63	52.30	63.97	1.60	1.07	1.34	35.70	63.97	49.84	-21.70	-25.37	-23.54	-0.22	-0.28	-0.25
PB-896	76.63	45.63	61.13	1.13	0.80	0.97	26.07	58.30	42.19	-22.03	-23.70	-22.87	-0.21	-0.29	-0.25
Sun-2	74.63	46.30	60.47	1.57	1.30	1.44	39.17	57.13	48.15	-19.70	-25.03	-22.37	-0.20	-0.28	-0.24
CIM-573	76.63	48.63	62.63	2.17	1.13	1.65	33.17	61.37	47.27	-17.70	-25.70	-21.70	-0.18	-0.34	-0.26
BH-176	81.30	58.97	70.14	2.33	1.77	2.05	21.40	39.60	30.50	-16.70	-22.70	-19.70	-0.15	-0.20	-0.18
CIM-591	83.30	51.30	67.30	1.40	1.03	1.22	37.17	62.03	49.60	-21.70	-23.70	-22.70	-0.22	-0.33	-0.28
NIA-80	75.63	49.63	62.63	1.13	0.90	1.02	31.87	48.43	40.15	-21.70	-24.37	-23.04	-0.22	-0.34	-0.28
CRIS-510	74.97	34.97	54.97	1.14	0.90	1.02	35.27	49.60	42.44	-21.70	-24.70	-23.20	-0.22	-0.28	-0.25
VH-300	76.30	41.30	58.80	1.17	1.03	1.10	29.40	51.97	40.69	-20.70	-25.70	-23.20	-0.20	-0.29	-0.25
GS-444	63.63	32.63	48.13	0.83	0.73	0.78	38.67	66.37	52.52	-21.70	-26.70	-24.20	-0.26	-0.36	-0.31
CIM-124	76.63	46.30	61.47	1.23	0.83	1.03	33.27	56.03	44.65	-19.03	-24.37	-21.70	-0.22	-0.34	-0.28
DPL-45	80.63	54.63	67.63	2.17	1.30	1.74	21.77	36.93	29.35	-19.03	-22.03	-20.53	-0.15	-0.26	-0.21
NIAB-112	78.63	52.63	65.63	1.30	0.73	1.02	38.53	49.27	43.90	-22.37	-24.03	-23.20	-0.25	-0.33	-0.29
CIM-608	77.63	50.30	63.97	1.63	1.10	1.37	22.37	53.97	38.17	-18.70	-25.03	-21.87	-0.25	-0.27	-0.26
IUB-2011	78.30	41.63	59.97	1.13	0.97	1.05	27.83	55.33	41.58	-19.70	-25.70	-22.70	-0.28	-0.27	-0.28

PB-38	72.63	40.63	56.63	1.20	1.00	1.10	33.57	48.27	40.92	-20.37	-26.03	-23.20	-0.28	-0.34	-0.31
CIM-534	77.63	41.63	59.63	1.03	1.00	1.02	28.17	60.50	44.34	-21.37	-23.37	-22.37	-0.20	-0.35	-0.28
CIM-612	76.30	48.63	62.47	1.67	0.93	1.30	30.43	49.43	39.93	-22.03	-23.03	-22.53	-0.20	-0.28	-0.24
CIM-473	77.30	53.30	65.30	1.13	0.80	0.97	29.47	55.17	42.32	-22.37	-23.37	-22.87	-0.19	-0.28	-0.24
L-229-29-71	71.97	48.30	60.14	1.20	0.97	1.09	32.77	51.27	42.02	-21.70	-24.70	-23.20	-0.23	-0.28	-0.26
B-452	73.30	49.97	61.64	0.87	1.20	1.04	32.50	41.37	36.94	-18.70	-26.03	-22.37	-0.24	-0.28	-0.26
Stone ville-603	71.97	47.63	59.80	1.27	1.40	1.34	31.33	52.50	41.92	-16.70	-25.03	-20.87	-0.20	-0.33	-0.27
Tree Cotton	79.30	52.97	66.14	2.27	1.50	1.89	22.33	31.90	27.12	-16.70	-21.70	-19.20	-0.15	-0.27	-0.21
BP-52	71.63	48.63	60.13	1.17	0.97	1.07	30.10	48.03	39.07	-19.37	-25.37	-22.37	-0.19	-0.27	-0.23
Cooker-312	74.97	51.97	63.47	1.33	0.67	1.00	35.57	55.77	45.67	-21.70	-25.70	-23.70	-0.22	-0.34	-0.28
RA-31-21	72.63	40.97	56.80	1.60	0.77	1.19	26.47	55.50	40.99	-19.70	-24.03	-21.87	-0.26	-0.36	-0.31
MS-64	44.30	40.97	42.64	0.93	0.53	0.73	42.87	67.40	55.14	-22.03	-26.70	-24.37	-0.28	-0.38	-0.33
CIM-84	73.97	42.63	58.30	1.13	0.73	0.93	27.97	51.60	39.79	-22.03	-24.03	-23.03	-0.25	-0.27	-0.26
AC-307	75.63	42.30	58.97	1.23	0.83	1.03	37.33	45.90	41.62	-22.37	-24.70	-23.54	-0.26	-0.34	-0.30
NIAB-78	72.97	50.63	61.80	1.20	0.97	1.09	33.00	60.67	46.84	-21.70	-26.03	-23.87	-0.27	-0.33	-0.30
GH-11-9-75	77.97	44.63	61.30	2.00	0.83	1.42	31.90	60.30	46.10	-19.03	-26.03	-22.53	-0.26	-0.33	-0.29
CIM-86	73.97	40.97	57.47	1.10	0.77	0.94	26.37	43.13	34.75	-21.70	-26.37	-24.04	-0.23	-0.35	-0.29
CIM-43	79.30	41.63	60.47	1.10	0.83	0.97	36.90	42.17	39.54	-20.70	-25.03	-22.87	-0.25	-0.37	-0.31
Karishma	76.30	54.97	65.64	1.03	1.03	1.03	36.07	42.37	39.22	-19.03	-25.37	-22.20	-0.20	-0.27	-0.24
Cyto-62	80.63	47.30	63.97	2.30	1.50	1.90	22.57	36.87	29.72	-17.70	-21.70	-19.70	-0.16	-0.25	-0.21
CRIS-134	79.63	42.63	61.13	1.93	0.80	1.37	34.47	52.90	43.69	-19.70	-25.37	-22.54	-0.25	-0.34	-0.30
VS-212	76.30	52.30	64.30	1.40	1.20	1.30	26.13	61.73	43.93	-20.37	-24.70	-22.54	-0.23	-0.27	-0.25
MPS-11	80.97	59.63	70.30	2.23	1.50	1.87	26.23	38.37	32.30	-17.70	-22.70	-20.20	-0.16	-0.26	-0.21
ME-115	73.63	47.30	60.47	1.23	0.90	1.07	28.00	62.97	45.49	-18.03	-25.70	-21.87	-0.25	-0.33	-0.29
CIM-57	78.30	43.63	60.97	1.00	0.73	0.87	30.37	52.47	41.42	-20.37	-26.37	-23.37	-0.21	-0.28	-0.25
F-14	71.97	45.30	58.64	1.17	0.77	0.97	30.37	51.43	40.90	-20.70	-25.03	-22.87	-0.26	-0.33	-0.29
S-71	74.97	45.63	60.30	1.17	0.73	0.95	32.27	44.50	38.39	-21.70	-24.37	-23.04	-0.20	-0.32	-0.26
CIM-496	74.97	44.97	59.97	2.07	0.83	1.45	22.77	45.13	33.95	-21.70	-24.37	-23.04	-0.27	-0.33	-0.30
Cooker-315	45.63	40.30	42.97	0.87	0.63	0.75	35.70	65.83	50.77	-21.70	-27.37	-24.54	-0.28	-0.39	-0.33
SLH-41	77.97	46.97	62.47	1.83	1.10	1.47	30.40	56.47	43.44	-18.37	-24.70	-21.54	-0.27	-0.34	-0.31
CRIS-9	70.97	42.63	56.80	2.00	0.83	1.42	37.37	50.00	43.69	-18.70	-25.03	-21.87	-0.23	-0.27	-0.25

*N= Normal **D=drought

4. Discussion

This study determines the genotypes of plants that can withstand drought by noting their physiological characteristics under both normal and stressful conditions. In this investigation, three sensitive genotypes (GS-444, Cooker-315, and MS-64) and five tolerant genotypes (BH-176, MPS-11, DPL-45, Tree cotton, and Cyto-62 were found based on physiological factors. The entries with the highest relative water content at the time of the drought were MPS-11, BH-176, Karishma, and DPL-45, whereas the entries with the lowest relative water content were GS-444, CRIS-510, and Cooker-315. Water loss from excised leaf 205 was significantly decreased under stressful conditions. The entries with the highest values of excised leaf water loss during drought conditions were BH-176, Cyto-62, Tree cotton, MPS-11 , and Stoneville, whereas the entries with the lowest values were MS-64, Cooker-315, Cooker-312, and GS-444. Relative water content is a measuring trait, and plants with high relative water contents can survive in low water situations, as [10] predicted in their experiment and in their final results. Similar studies on cotton were undertaken by [11,12] both found that excised leaf water loss was a major characteristic that could be used to reliably assign genotypes for drought tolerance in numerous crops, including cotton. Additionally, the stress state significantly reduced relative cell damage. In a drought situation, the entries with the highest values of cell injury were MS-64, GS-444, and Cooker-315, whereas the entries with the lowest values were Tree cotton and Cyto-62. The entries with the lowest values, DPL-45, MPS-11 and BH-176 were drought-tolerant. Entries processing better relative root length and subsequently more tolerant to drought were those with less cell injury, and vice versa. Results from [13] are likewise comparable.

Conflicts of Interest:

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article.

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