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Original Research Article

GENOTYPIC VARIABILITY AND TRAIT ASSOCIATION IN COTTON (*GOSSYPIUM HIRSUTUM* L.) SEEDLINGS UNDER NORMAL AND DROUGHT CONDITIONS

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Abstract: *The genetic variability and correlation parameter studies for seedling traits viz; fresh root length, fresh shoot length, fresh shoot weight, dry shoot weight, tissue moisture percentage and root/shoot ratio in 40 accessions of cotton germplasm, including both local and exotic available at different research stations and institutes of Pakistan were carried out under greenhouse in the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during the year 2006. Sufficient genetic variability was observed for seedling characters like root length, shoot length, shoot fresh weight, shoot dry weight, tissue moisture percentage and root/shoot ratio under normal and water stress conditions. Based on rooting character and root/shoot ratio, three drought-tolerant cotton genotypes 149-F, BH-124 and DPL-26 and three drought susceptible VH-28, FH-945 and CIM-446 were selected. Correlation coefficients under normal conditions were greater than under drought stress, and the direction of correlations of seedling traits in most cases remained the same. Under normal (r = 0.72) and drought (r = 0.48) conditions, shoot length and root length, were positively correlated, indicating a corresponding increase in shoot length with an increase in root length and vice versa*.

Keywords: Genetic variability, correlation, seedling traits, drought, greenhouse

Introduction

Cotton (*Gossypium hirsutum* L.) is grown for fiber and seed worldwide; drought stress significantly reduces yield. Cotton plays an important role in the economy of Pakistan. It is a source of foreign exchange earnings and provides raw materials to our local textile industry. About 60% of the total foreign exchange is due to cotton, which is why it is called the backbone of our agrarian economy. The cotton area in Pakistan during 2012-13 was 2879 thousand hectares with lint production of 13.0 million bales and an average yield of 769Kg / ha. It accounts for 7.0 percent of the value added in agriculture and about 1.5 percent to GDP (Anonymous, 2012-13). Water is one of the most important factors in crop production.

Water shortage, the major factor limiting plant growth and crop productivity worldwide, is anticipated to increase with the spread of arid lands (Saranga et al., 2001). The scarcity of irrigation water is increasing in Pakistan and has reduced seed cotton yield per unit area. Water availability is decreasing, and demand for irrigation water is rising. Global environmental changes suggest a future increase in aridity in many parts of the earth (IPCC, 2001). Rainfed farming has already reduced crop yields, mainly due to water scarcity. Several studies have focused on modifying root systems to increase water use efficiency or determining the effects of plant growth regulators on cotton roots for increasing drought resistance (Pace et al., 1999). Root characteristics can be important in determining the response of plants to drought. Water deficit decreases shoot growth rate, plant height, and yield and affects root growth. However, root growth is less sensitive (McMicheal and Quisenberry, 1991). The variation within species allows the identification of the desired genotypes for the traits. Variability for drought tolerance in crops is not extensive, but genotypic responses to water stress do occur. The studies revealed that varieties/cultivars in each species differ from one another in their responses under water stress conditions, suggesting that drought tolerance in these species can be improved through breeding. The present study was carried out to introduce desirable genotypes for commercial cultivation and utilization in experiments for further research; a set of 40 genotypes of (*Gossypium hirsutum* L.) were used to study their root/shoot parameters under normal and water stress conditions (Abbas et al., 2015; Abbas et al., 2016; Ali et al., 2014; Ali et al., 2017). This research aimed to investigate the differences in these traits among various genotypes under both conditions

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and correlate these parameters to drought tolerance. This study will help understand genotypes' behavior under prevailing environmental conditions.

Material and methods

The present study was conducted in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, in 2006. The experimental material was selected from the local and exotic cotton germplasm at Pakistan's research stations and institutes. A set of 40 genotypes of (*Gossypium hirsutum* L.) were grown in greenhouse using a normal water supply and limited water conditions at the seedling stage in controlled light and temperature to provide the recommended environment for germination was maintained at 30ºC during day time and 25ºC during night time by using heaters. The plants were exposed to sunlight and supplemented with artificial light to provide a photoperiod of 14 hours. Seeds of the genotypes were sown in polythene bags (25x15cm) filled with silt @ 1250 grams per bag. The experiment was conducted using three replications. The treatments were arranged following a completely randomized design. After germination, all plants are watered and fertilized till the first true leaf's development. The plants in the control condition were watered regularly to keep the soil at field capacity (100% soil water saturation), while in another unit, water stress was imposed by withholding water. The effect of water stress was monitored visually and with a soil moisture meter (HH2 Theta Probe Type, Delta-T device, Cambridge, England). When the soil had 14 to 16% soil moisture content at the initial wilting stage, the stressed plants watered enough to relieve the sign wilting but not enough to reach field capacity. The experiment lasted 45 days until the third main stem leaf was fully expanded. The control and stressed plants were measured for the screening traits viz; fresh root length, fresh shoot length, fresh shoot weight, dry shoot weight, tissue moisture percentage and root/shoot ratio. Fresh root length of three plants of each entry was measured with the help of measuring tape in centimeters; data were averaged. Fresh shoot length was also measured in centimetres. Fresh shoot weight was taken of three plants of each genotype and weighed with the help of electronic balance, and their average was computed. Dry shoot weight of each of the three repeat plants was put in the oven (Gen. lab. Ltd. Windedness, England) at a controlled temperature of 70ºC for 48 hours for complete drying and shoot was weighed with the help of electronic balance and their averages were calculated. Tissue moisture percentage was calculated with the help of the following formula:

Tissue moisture % = (Shoot fresh weight-Shoot dry weight)/Shoot fresh weight

The root/shoot ratio was determined using the following formula:

Root/shoot ratio = (Root length/shoot length)x100

The analysis of variance was computed according to Steel *et al*., (1997).

Results and discussion

Agro-climatologically, Pakistan lies in the semiarid region of the world. Considering average river flow, depletion in the shortage capacity of reservoirs, precipitation patterns and groundwater recharge rate, Pakistan is likely to suffer from swear droughts in the times to come. Sustainability and improvement in cotton production are the major challenges to meet the upcoming threats of an increasing volume of world population, deterioration of arable land, depletion of water resources and environmental stresses, especially drought. For a successful breeding program, the existance of intraspecific variation for drought tolerance provides the scope for selection for its improvement. Seedling traits have been used to evaluate many genotypes for drought tolerance and play an important role in obtaining desirable crop stand, hence the endeavours of increasing cotton production have been made through developing improved seedling traits. Several different seedling traits have been suggested as important relative to drought tolerance. These include lateral and tap root weight, lateral root number and root/shoot ratio (Cook 1985; Pace *et al*., 1999). Root growth is an important and reliable indicator of the response of drought tolerant varieties (Basal et al., 2005). In the present study 45 days old seedlings of 40 accessions were examined. Many reports have been documented regarding the growth and response of cotton genotypes to moisture stress environment under greenhouse conditions (Quisenberry *et al*., 1981, Loffroy *et al*., 1983, Ball *et al*., 1994 and Pace *et al*., 1999) and in growth chamber (Genty et al., 1987; Nepo-muceno et al., 1998).

Genetic Variability

The mean squares and coefficient of variation for various cotton seedling traits in greenhouse under normal and drought conditions are presented in table-1. Variability was found in genotypes as indicated by the presence of highly significant genotypic differences for all the characters, i.e. root length, shoot fresh weight, shoot dry weight, root/shoot ratio, and tissue moisture percentage. These significant values allowed the data for further analysis. The mean performance of cotton genotypes is given in table-2a and table-2b.

Root Length

Regarding the mean values of root length measured under normal water condition experiment, it is evident that 40 genotypes differed from each other and ranged from 14.03cm for FH-950 to 5.43cm for FVH-53. Under drought conditions, root lengths were markedly reduced, ranging from 12.63cm for FH-950 to 3.73cm for CIM-496. Data on root length revealed that accessions have different responses to the two moisture conditions. Genotypes FH-950 and FH-925

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had the tallest root length under the control condition, measuring 14.03 and 14.00 cm, respectively; FH-950 gave maximum length under drought conditions. In contrast, genotypes FVH-53, CIM-496 and BH-147 had shorter root lengths under control, measuring 5.43, 7.80 and 7.97cm, respectively, whilst under stress conditions, CIM-496 developed shorter root length. Based on the least reduction in root length under drought conditions, the cotton genotypes 149-F (4.15% loss), MNH-552 (4.27% loss), BH-124 (4.39% loss) and S-14 (4.70% loss), these genotypes are rated as drought tolerant. In contrast, the genotypes VH-28, FH-945 and CIM-446 showed varied responses to the two moisture conditions, e.g. root length of these genotypes were 9.07, 9.40 and 13.0cm respectively, under normal conditions, whilst under drought conditions these measured 5.40, 6.00, and 8.40cm respectively. Due to drastic root length conditions in drought conditions, these genotypes may be rated as drought susceptible.

Shoot Length

The mean performance of various genotypes of cotton for shoot length under normal and drought conditions is represented in Table-2a. In this parameter, genotypes appeared to respond differently to non stress and stressed conditions. The shoot length under normal conditions ranged from 28.33cm for OKRA-659 to 13.87cm for BH-147. Shoot length under drought conditions was markedly reduced and varied from 22.13cm for MNH-147 to 7.03cm for CIM-496, and similar differences were recorded among other genotypes. Cotton genotypes OKRA-659, CIM-446 and MNH-147 had the longest shoot length under control, each measuring 28.33, 27.50 and 26.47cm, against shoot length of BH-147, which was only 13.87cm. Under stress conditions MNH-147 and MNH-129 had the longest shoot length i.e. 22.13 and 19.57cm, against shoot length of CIM-496, which was only 7.03cm in the genotypes.

Shoot Fresh Weight

The mean of various genotypes for the expression of shoot fresh weight (table-2a) under normal conditions ranged from 6.31g to 1.84g, while in drought conditions, it ranged from 4.91g to 0.94g. The genotype 4-F, MNH-147, MNH-129 under normal conditions exhibited the highest means, 6.31g, 6.00g, 5.98g and S-12, MNH-786, COKER 4601 had the lowest shoot fresh weight, 1.84g, 2.09g, 2.20g. The genotype MNH-147 followed by CIM-446 and 199-F under drought conditions, had the highest shoot fresh weight 4.91g, 3.50g, 3.48g and CIM-496, DPL-26, NIAB-999 had the least shoot fresh weight, 0.94g, 1.26g, 1.31g respectively.

Shoot Dry Weight

Table-2b indicates the means of all forty cotton genotypes for shoot dry weight. This table indicated that the mean ranged from 0.99g to 0.32g and 0.85g to 0.16g, under normal and drought conditions, respectively. Under normal moisture conditions experiment, genotypes MNH-147, CIM-446, VH-141 showed the highest mean 0.99g, o.91g, 0.83g and were significantly different from the genotype CIM-496, CIM-448, S-14 which had the lowest 0.32g, 0.38g, 0.39g mean while under drought condition experiment, the genotype MNH-147, CIM-446, MNH-129 showed the highest mean value 0.85g, 0.79g, 0.72g and the genotype 149-F, CIM-496, CIM-448 had the lowest value for shoot dry weight, 0.16g, 0.19g, 0.20g.

Tissue Moisture Percentage

Mean highest tissue moisture percentage was produced by genotype MNH-129 (92.02g), followed by BH-124 (91.90g), NIAB-KARISHMA (90.85g) and the lowest number was observed in cotton genotype MNH-786 (71.30g), FH-900 (80.18g), BH-160 (80.90g) under normal moisture condition experiment. Whereas under drought condition, the cotton genotype 149-F (92.01g) followed by BH-124 (91.54g) and DPL-26 (90.42g) at the highest tissue moisture percentage. While the genotype VH-28 (74.77g) followed by FH-945 (76.79g) and CIM-446 (77.40g) had the lowest tissue moisture percentage.

Root/Shoot ratio

The mean highest root/shoot ratio was produced by genotypes BH-118, BH-124 and MNH-552, ranging 0.75g, 0.73g and 0.71g, respectively, while lower ratios was observed in genotypes FVH-53, FH-945 and OKRA 659 having values 0.38, 0.41 and 0.43g under normal water condition. Under drought stress condition, the differential responses of genotypes to water stress for root/shoot ratio is obvious from their values (table-2b). Genotype 149-F is the most tolerant with ratio of 1.14 followed by BH-124 and DPL-26 with values of 1.00 and 0.97, respectively. In contrast, the most sensitive genotype found was VH-28 with ratio of 0.40 and is closely followed by FH-945 and CIM-446 with values of 0.43 and 0.44, respectively. The response of accessions to water stress conditions have been compared with those measured under non stress conditions. Water stress tolerance cannot be attributed to a genotype because of its superiority for a single trait; therefore, many different parameters must be evaluated (Al-Hamdani and Barger, 2003; Aaliya et al., 2016; Batool et al., 2023; Rehman et al., 2017; Zafar et al., 2022). Root growth is an important and reliable indicator of the response of drought-tolerant varieties (Ball *et al*., 1994; Pace *et al*., 1999; Basel *et al*., 2005), and therefore this trait was also examined at the seedling stage because root length is less sensitive than shoot length according to Malik *et al* (1979), McMicheael and Quiesenberry (1991), and Ball *et al*., (1994).

The data showed sufficient genetic variability (table-1) for seedling characters like root length, shoot length, shoot fresh weight, shoot dry weight, tissue moisture percentage and root/shoot ratio under

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normal and water stress conditions. These results follow Singh et al., (1985) and McMicheael and Quiesenberry (1991). Water stress markedly reduced all the seedling traits except root/shoot ratio, which further increased. It indicated that selection for higher root/shoot ratio would be beneficial for selecting drought-resistant genotypes and is a reliable indicator of water stress tolerance. Reason for increased root/shoot ratio under water stress may be due to the limited supply of water and nutrients to the shoot and some hormonal messages induced in roots when they counter drought stress (Sharp and Davis, 1985; Misra, 1990 and 1994). An increase in root-to-shoot ratio under drought conditions was related to ABA content of roots and shoots. A possible reason for the decrease in the mean value of other seedling traits is the deficiency of water that slowed the physiological process. Similar adverse effects of water stress on seedling traits have been noted in previous studies (Loffroy *et al*., 1983, Ball *et al*., 1994; Pace *et al*., 1999; Pettigrew, 2004; Basel *et al*., 2005; Hafeez et al., 2021; Iqbal et al., 2022; Puspito et al., 2015). Based on rooting character and root/shoot ratio, three drought-tolerant cotton genotypes 149-F, BH-124 and DPL-26 and three drought susceptible VH-28, FH-945 and CIM-446 were selected. According to Hurd (1976), root mass under drought conditions is important in drought resistance breeding.

Correlation Coefficients

Correlation of root length with other traits

Under normal condition root length showed a significant positive correlation with other characters namely shoot length, shoot fresh weight, shoot dry weight, root/shoot ratio except tissue moisture percentage which showed non significance. The highly significant correlation coefficient condition of root length was found with shoot length. Under drought stress root length had developed a significant positive correlation with shoot length, shoot fresh weight and root/shoot ratio, while showing non significant positive relationship with shoot dry weight and tissue moisture percentage. A strong correlation of root length was found with root/shoot ratio under drought condition.

Correlation of shoot length with other traits

Shoot length significantly correlated with all other seedling characters except tissue moisture percentage. Correlation of shoot length was significant with shoot fresh weight, shoot dry weight and tissue moisture percentage whereas with root/shoot ratio was significant. The strongest positive correlation of shoot length was found between shoot fresh and shoot dry weights. Under drought, the correlation of shoot length was significantly positive with shoot fresh weight and shoot dry weight, whereas root/shoot ratio and tissue moisture percentage were negative. The strongly negative, nonsignificant correlation was found with root/shoot ratio.

Correlation of shoot fresh weight with other traits

Shoot fresh weight showed positive and significant correlation with shoot dry weight and tissue moisture percentage, while it showed negative non significant with root/shoot ratio under normal conditions. Under drought condition experiment, the shoot fresh weight showed highly significant positive correlation with shoot dry weight while it showed a significant negative correlation with root/shoot ratio and non significantly positive correlation with tissue moisture percentage.

Correlation of shoot dry weight with other traits

Under normal conditions shoot dry weight showed a significant correlation with tissue moisture percentage whilst nonsignificant negative correlation with root/shoot ratio. Shoot dry weight had a highly significant negative correlation with root/shoot ratio and tissue moisture percentage under drought conditions.

Correlation of root/shoot ratio with other traits

Root/shoot ratio showed a negative correlation with shoot length, shoot fresh weight, shoot dry weight and tissue moisture percentage and has a positive correlation with root length under normal and drought conditions. Root/shoot ratio strongly correlated with root length under drought stress conditions.

Correlation of tissue moisture percentage with other traits

Tissue moisture percentage had positive significant correlation with shoot length and shoot fresh weight while it had negative correlation with shoot dry weight under both environments and with root/shoot ratio under normal water condition. Under water stress condition the tissue moisture percentage non-significant positively correlation with root length, shoot fresh weight and root/shoot ratio, while there is a negative correlation with shoot length and shoot dry weight. Correlation coefficients under normal conditions were greater than under drought stress, and the direction of correlations of seedling traits in most cases remained the same. The low magnitude of correlation could be due to low modifying effects of environment on the characters. Root length under normal and drought conditions positively correlated with shoot length. Fresh shoot weight showed significant positive correlation with shoot length and root length. Dry shoot weight positively correlated with fresh shoot weight, shoot length and root length but negative with root/shoot ratio and tissue moisture percentage. Root/shoot ratio showed almost negative relationship for all other characters except root length under both conditions. Nonsignificant negative and positive correlation was observed between tissue moisture percentage and root/shoot ratio under both conditions. A negative association of root/shoot ratio and tissue moisture percentage might be due to the balanced compensation of either trait. Under normal conditions, shoot length and root length were

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positively correlated, indicating a corresponding increase in shoot length with an increase in root length and vice versa. Under normal conditions when water is not a limiting factor, a well-developed rooting system is necessary to absorb water and nutrients for the growing shoot and anchor the plant. The development of such correlation favors the plant's final productivity. Correlation among seedling traits under drought conditions indicated that under water deficient condition, root will tend to go deeper in the soil to explore water as a consequence root/shoot length will be increased. Increased root length is a good indicator for drought resistance.

Conclusion

It is concluded that drought resistant and susceptible genotypes can be evaluated at seedling traits to save the time. Based on rooting character, three drought tolerant cotton genotypes 149-F, BH-124 and DPL-26 and three drought susceptible VH-28, FH-945 and CIM-446 were selected. These genotypes can be used in further breeding programs to study gene action, combining ability studies. The resistant varieties can also be used directly under drought conditions. The traits like root/shoot ratio and tissue moisture percentage should be desirable selection criteria.

Conflict of interest

The authors declared the absence of a conflict of interest.

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Table-1 Mean squares and coefficient of variation (CV %) for various cotton seedling traits in greenhouse under normal and drought conditions.

Sr. No.	Character	Under Normal Replication (df:2)	Genotypes (df:39)	Error (df:78)	CV%	Under Drought Replication (df:2)	Genotypes (df:39)	Error (df:78)	CV%
1	Root length	0.058	12.759**	0.036	1.70	0.072	14.815**	0.147	4.03
2	Shoot length	0.085	44.982**	0.297	2.80	0.240	31.532**	0.229	3.53
3	Shoot fresh weight	0.039	4.633**	0.017	3.23	0.007	2.112**	0.002	3.84
4	Shoot dry weight	0.001	0.075**	0.000	3.16	0.001	0.083**	0.001	6.22
5	Root/shoot ratio	0.000	0.021**	0.000	3.23	0.003	0.091**	0.001	5.18
6	Tissue moisture percentage	0.292	48.828**	0.378	0.72	0.627	47.646**	0.605	0.92

Table-2a Means of seedling traits of cotton genotypes under normal and drought condition in glass house

Sr.No.	Genotypes	Root length(cm)		Shoot length(cm)		Root/shoot ratio	
		Normal	Drought	Normal	Drought	Normal	Drought
1	MNH-786	10.90	8.87	16.43	12.00	0.66	0.74
2	MNH-93	10.03	8.23	17.53	11.47	0.57	0.72
3	MNH-552	12.50	11.97	17.70	12.77	0.71	0.94
4	MNH-554	12.10	10.12	21.77	15.63	0.56	0.65
5	VH-28	9.07	5.40	18.17	13.40	0.50	0.40
6	CIM-240	11.10	10.37	16.67	12.17	0.67	0.85
7	149-F	12.87	12.33	21.30	10.80	0.60	1.14
8	4F	9.00	6.50	19.80	14.07	0.45	0.46
9	NIAB-999	11.80	10.87	19.40	11.40	0.61	0.95
10	NIAB-KARISHMA	12.37	11.07	18.97	12.77	0.65	0.87
11	FH-900	12.97	11.03	23.80	19.00	0.55	0.58
12	FH-950	14.03	12.63	23.20	16.10	0.60	0.79
13	FH-925	14.00	12.57	22.03	13.20	0.64	0.95
14	CIM-446	13.00	8.40	27.50	18.93	0.47	0.44

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15	BH-160	12.67	10.73	19.53	14.63	0.65	0.73
16	VH-141	12.97	12.17	23.57	15.97	0.55	0.76
17	VH-144	13.60	12.00	26.37	15.67	0.52	0.77
18	CIM-1100	12.03	10.80	20.90	17.10	0.58	0.63
19	DPL-26	9.03	8.23	14.53	8.47	0.62	0.97
20	S-14	9.93	9.47	17.67	12.43	0.56	0.76
21	S-12	8.40	7.90	13.90	9.10	0.60	0.87
22	BH-124	10.63	10.17	14.63	10.17	0.73	1.00
23	FH-945	9.40	6.00	22.80	14.03	0.41	0.43
24	CIM-473	11.00	10.20	17.97	15.97	0.61	0.64
25	BH-147	7.97	7.23	13.87	12.60	0.57	0.57
26	CIM-496	7.80	3.73	16.33	7.03	0.48	0.53
27	FVH-53	5.43	5.00	14.30	9.43	0.38	0.53
28	FH-901	8.03	7.40	14.33	10.67	0.56	0.70
29	BH-118	12.97	12.00	17.20	13.77	0.75	0.87
30	BH-36	8.13	7.30	16.70	10.97	0.49	0.66
31	BH-116	10.87	9.07	17.97	10.40	0.61	0.87
32	CIM-448	11.20	8.90	18.57	11.03	0.60	0.81
33	COKER-4601	10.57	8.90	18.40	13.03	0.57	0.68
34	MNH-147	13.97	11.37	26.47	22.13	0.53	0.51
35	OKRA-659	12.07	9.90	28.33	16.37	0.43	0.61
36	DIXI-KING	10.93	9.87	17.87	12.83	0.61	0.77
37	VH-54	12.70	9.03	21.30	17.70	0.60	0.51
38	MNH-129	13.23	12.10	23.63	19.57	0.56	0.62
39	199-F	13.00	11.13	22.67	14.80	0.57	0.75
40	SLH-257	10.90	9.70	15.97	12.90	0.68	0.75

Table-2b Means of seedling traits of cotton genotypes under normal and drought condition in glass house

Sr.No.	Genotypes	Shoot fresh weight(g)		Shoot dry weight(g)		Tissue moisture %	
		Normal	Drought	Normal	Drought	Normal	Drought
1	MNH-786	2.09	1.71	0.60	0.29	71.30	82.87
2	MNH-93	3.80	1.95	0.47	0.31	87.67	84.09
3	MNH-552	5.67	2.93	0.63	0.48	88.85	83.69
4	MNH-554	3.49	2.40	0.63	0.44	82.09	81.80
5	VH-28	4.30	2.28	0.43	0.31	84.09	74.77
6	CIM-240	3.81	2.54	0.52	0.31	86.40	87.76
7	149-F	3.39	1.96	0.41	0.16	87.99	92.01
8	4F	6.31	2.69	0.59	0.28	90.63	89.71
9	NIAB-999	3.67	1.31	0.41	0.22	88.89	83.60
10	NIAB-KARISHMA	4.39	2.10	0.40	0.30	90.85	85.89
11	FH-900	2.41	1.26	0.48	0.21	80.18	83.11
12	FH-950	4.22	2.82	0.40	0.31	90.54	88.85
13	FH-925	5.13	2.17	0.48	0.31	90.64	85.87
14	CIM-446	5.98	3.50	0.91	0.79	84.72	77.40
15	BH-160	3.78	2.65	0.72	0.52	80.90	80.49
16	VH-141	5.59	2.68	0.83	0.36	85.13	86.43
17	VH-144	5.83	2.92	0.77	0.48	86.82	83.43
18	CIM-1100	4.91	2.45	0.62	0.32	87.45	86.85
19	DPL-26	2.41	1.26	0.42	0.27	86.54	90.42
20	S-14	2.46	1.39	0.39	0.25	83.99	82.02
21	S-12	1.84	1.80	0.32	0.23	82.76	87.00
22	BH-124	3.80	1.95	0.49	0.29	91.90	91.54
23	FH-945	4.80	2.40	0.53	0.42	86.53	76.79
24	CIM-473	4.00	1.92	0.42	0.31	89.44	84.13
25	BH-147	3.97	2.33	0.61	0.47	84.64	79.83
26	CIM-496	2.49	0.94	0.32	0.19	87.14	80.30
27	FVH-53	3.03	1.96	0.52	0.33	82.45	83.40
28	FH-901	4.30	2.28	0.70	0.34	83.67	84.91

29	BH-118	3.17	2.07	0.50	0.28	84.15	86.37
30	BH-36	3.10	2.12	0.57	0.28	81.58	86.65
31	BH-116	4.26	1.40	0.43	0.28	89.89	79.92
32	CIM-448	3.39	1.96	0.38	0.20	89.27	86.73
33	COKER-4601	2.20	1.93	0.38	0.19	82.85	89.96
34	MNH-147	6.00	4.91	0.99	0.85	83.56	82.62
35	OKRA-659	3.99	2.41	0.57	0.51	85.70	79.00
36	DIXI-KING	4.81	2.41	0.52	0.38	89.27	84.40
37	VH-54	5.02	3.21	0.73	0.63	85.50	80.51
38	MNH-129	5.98	3.50	0.49	0.72	92.02	83.90
39	199-F	4.34	3.48	0.75	0.65	82.63	81.27
40	SLH-257	3.08	2.50	0.57	0.43	81.58	82.76

Table-3 Cotton genotypes with their stress status

Sr.No.	Genotype	Root/shoot ratio	Remarks
1	149-F	1.14	Drought tolerant
2	BH-124	1.00	Drought tolerant
3	DPL-26	0.97	Drought tolerant
4	VH-28	0.40	Drought susceptible
5	FH-945	0.43	Drought susceptible
6	CIM-446	0.44	Drought susceptible

Table-4 Correlation among seedling traits

Character	Shoot length	Shoot fresh weight	Shoot dry weight	Root/shoot ratio	Tissue moisture percentage
Root length (N)	0.72**	0.47**	0.36**	0.37**	0.23NS
Root length (D)	0.48**	0.29*	0.25NS	0.55**	0.09NS
Shoot length (N)		0.60**	0.44**	-0.37**	0.30*
Shoot length (D)		0.79**	0.73**	-0.45**	-0.03NS
Shoot fresh weight (N)			0.58**	-0.19NS	0.56**
Shoot fresh weight (D)			0.81**	-0.41**	0.11NS
Shoot dry weight (N)				-0.13NS	-0.29*
Shoot dry weight (D)				-0.40**	-0.46**
Root/shoot ratio (N)					-0.09NS
Root/shoot ratio (D)					0.12NS

*,**=Significant and highly significant, respectively
NS= Non-significant

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