Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 1855-1560
Received: 06-11-2018
Accepted: 10-12-2018

Identification of drought tolerant cotton (*Gossypium hirsutum* L.) Genotypes by biophysical and physiological traits

Babu AG, Patil BC and Koti RV

Babu AG
Directorate of Research,
UHS, Bagalkot, Karnataka,
India

Patil BC
The Dean Agri. College of
Agriculture, Vijayapur, UAS,
Dharwad, Karnataka, India

Koti RV
College of Agriculture,
Vijayapur, UAS, Dharwad,
Karnataka, India

Abstract

Drought is the major ecological factors limiting crop production and food quality globally, especially in arid and semi-arid areas which affect the physiology of cotton and causes reduction in crop growth and yield. An experiment was conducted during 2011-12 *kharif* in relatively arid area at ARS Annigeri, Karnataka using 30 *Gossypium hirsutum* genotypes. The genotypes were critically evaluated for their performance for drought tolerance physiological traits and analyzed. There was significant difference between genotypes for SLW, leaf water potential, SPAD values, photosynthesis, stomatal conductance, transpiration rate, leaf temperature and seed cotton yield. The genotypes GIHV-218 followed by CNH-120MP, KH-155, ARB-9701, CPB-750, Sahana, RAH-101 and RAH-50 recorded significantly high values for drought tolerant traits and yield attributes. Hence these genotypes can be further utilized as parents to develop drought tolerant genotypes by breeding. The genotypes H-2076, H-1353 and KH-138 performed poor and are relatively drought susceptible.

Keywords: *Gossypium, hirsutum,* drought, water potential, photosynthesis, transpiration and yield

Introduction

Cotton (*Gossypium hirsutum* L.), the white gold is also known as king of fibre crops and is the main raw material for textile industry. It is the world's leading natural fibre crop. It is the most important global cash crop and controls economy of many nations. Cotton provides gainful employment to several million people in cultivation, trade, processing, manufacturing and marketing, sustaining directly or indirectly about 10 per cent of the population of India. Although cotton is considered to be a drought tolerant crop, its sensitivity varies greatly among genotypes (Naidu *et al.*, 1995) [6]. Water stress affects the growth and thereby limiting kapas yield and lint quality, necessitating the development of drought tolerant cultivars to get economic yield in water deficit areas.

Developing drought resistant crop plants is vital to meeting increased demand for agricultural products and mitigating the effects of an anticipated environmental shift towards greater aridity (Parry *et al.* 2005) [7]. The solution, however, requires comprehensive understanding of plant adaptive mechanisms and responses to water stress at their underlying physiological and genetic mechanism.

The development of stress resistant crops has been hindered by low heritability of complex traits such as yield by lack of knowledge of physiological parameters that reflect genetic potential for improved productivity under water deficit. Water stress commonly attributed to situations where the water loss exceeds sufficient absorption intensity causing a decrease in plant water content, turgor reduction and consequently, a decrease in cellular expansion and alterations of various essential physiological and biochemical processes that can effect growth and productivity (Pimentel, 2004) [8]. Twelve cotton genotypes were screened for drought tolerance using PEG-6000 at seedling stage and the results showed that the genotype BS-279, CNH-120MB, GIHV-218 and ARB-9701 were tolerant to the increased osmotic potential (Babu *et al.* 2014) [1].

A study was conducted to find out the Cotton (*Gossypium hirusutum* L.) varieties under pot culture technique (Gravimetric method) for drought tolerance as well as to study the effect of drought on fibre development and biochemical changes in Cotton. The results showed that soluble protein, total sugar, reducing sugar and non-reducing sugar reduced as per increasing the water stress levels and also increased in proline content and peroxidase activity was observed. The variety Bunny Bt showed the increase in values of proline content in leaves at different moisture levels compared to Anjali and Pratima (Shilpa bonde *et al.* 2016) [9].

Thus, the tolerance of cotton genotypes to water deficits has been the target for physiological and breeding studies on both the physiological, biochemical and the molecular levels. In this direction thirty *Gossypium hirsutum* genotypes have been screened for drought tolerance by physiological approaches and identified.

Correspondence
Patil BC
The Dean Agri. College of
Agriculture, Vijayapur, UAS,
Dharwad, Karnataka, India

Materials and Methods

An experiment was conducted at Agricultural Research Station, Annigeri Farm (ARS, Annigeri), UAS, Dharwad, Karnataka, India. The ARS Annigeri is more arid which receives less rainfall of average normal rainfall of 668.13 mm.

Climatic condition at ARS, Annigeri

During the experiment period in the year 2011 the rainfall during July, August, September, October and November was 68.1, 185.2, 34.5, 101 mm and rainy days were 8, 11, 4, 9, 0, 0, 0 and 0 days respectively. Cotton crop experienced moisture stress in the month of September, November and onwards. As total rainfall of 34.5 mm in September and there was no rainfall was received during October month onwards was coincided with critical water requirement of cotton (Table 1, Fig. 1)

Table 1: Mean monthly meteorological data of ARS, Annigeri

Month	Rainfall (mm)				Temperature (^{0}C)						Relative humidity (%)		
					Maximum			Minimum					
	2011-12	Normal 1976-2010	Deviation (mm)	No. of rainy days	2011-12	Normal 1976-2010	Deviation	2011-12	1976-2010	Deviation	2011-12	Normal 1976-2010	Deviation
April	103.2	36.49	66.7	8	36.86	37.58	-0.72	23.34	21.00	2.34	79.10	73.42	5.68
May	103.3	62.30	41.0	7	36.50	36.63	-0.13	22.10	20.87	1.23	76.80	75.17	1.63
June	41.1	98.80	-57.7	6	29.70	34.54	-4.87	20.40	20.75	-0.35	87.00	84.06	2.94
July	68.1	77.38	-9.3	8	29.10	28.98	0.12	20.10	20.55	-0.45	87.70	87.01	0.69
August	185.2	83.83	101.4	11	28.90	28.49	0.41	19.50	20.25	-0.75	88.90	92.26	-3.36
September	34.5	153.33	-118.8	4	29.40	30.10	-0.70	19.90	20.01	-0.11	86.80	88.33	-1.53
October	101.0	103.31	-2.3	9	30.70	31.66	-0.96	20.00	19.61	0.39	83.50	86.68	-3.18
November	0.00	34.24	-34.2	0	28.60	30.44	-1.84	18.80	16.46	2.34	77.60	85.48	-7.88
December	0.00	4.33	-4.3	0	29.50	29.15	0.35	17.10	15.12	1.98	78.40	82.50	-4.10
January	0.00	1.59	-1.6	0	28.90	29.75	-0.85	17.60	14.27	3.33	67.90	77.38	-9.48
February	0.00	0.29	-0.3	0	33.30	32.74	0.56	21.40	16.36	5.04	79.70	68.45	11.25
March	0.00	12.24	-12.2	0	36.60	35.22	1.38	21.40	19.63	1.77	68.20	74.09	-5.89
Total	636.4	668.1	-31.7	53									

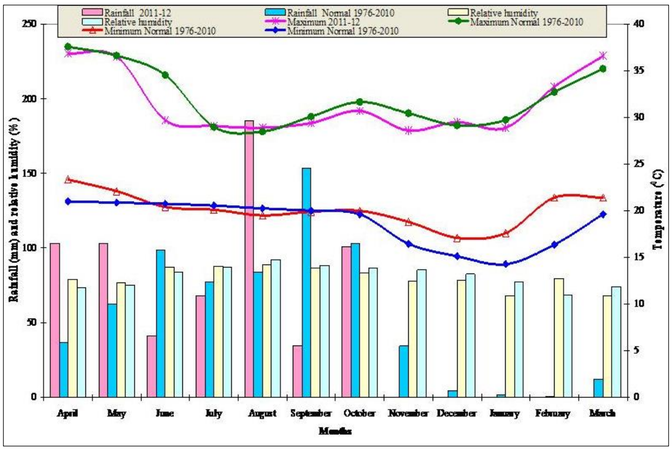

Fig 1: Mean monthly meteorological data at ARS Annigeri

Cotton genotypes

The experimental material consisted of thirty upland cotton (*G. hirsutum* L.) cultivars selected on the basis of putative differences in yield under drought conditions. Seeds of the cultivars were obtained from Agricultural Research Station, Dharwad and Cotton research stations located at different ecological regions of India. The experiment was conducted at ARS Annigeri, using 30 genotypes.

Experimental design and cultural practices

Thirty cotton cultivars were evaluated under rained condition in the field during 2011-12 at the ARS, Annigeri research station. The experimental plot was laid out in RBD design with three replications. Cotton seeds were delinted with sulfuric acid and soaked in water for 12 h before planting. Sowing was done during the month of June with a spacing of 90 cm × 20 cm. Commercial chemical fertilizer was applied at the rate of 100:50:50 kg/ha of N:P_2O_5:K_2O. 50% N was applied at the time of seedbed preparation. Plant population was maintained at four plants/m^2 by hand-thinning 25 days after germination. The plots were inter-cultured twice after sowing and further maintained weed free by hand weeding. The plant protection measures were taken throughout the crop growth period as per recommended schedule. The remaining 50 per cent of the N was given in two split doses at 30 DAS and 45 DAS.

Measurement of physiological attributes

Five plants from each replication was selected randomly and tagged for recording various observations on growth and physiological observations. Measurement of physiological parameters *viz.* rate of photosynthesis, conductance, transpiration and leaf temperature was determined with a LICOR-6400 Photosynthesis system. All physiological measurements were performed between 1000 and 1200 h at PARX1500 mmolm^{-2} s^{-1} during cloud-free days. The youngest fully expanded main stem leaf exposed to direct sunlight was used to determine the gas exchange parameters. The Chlorophyll content was measured using SPAD meter which directly gives SPAD values. The leaf water potential was measured using pressure bomb apparatus. Seed cotton was hand-picked from all the plots and was sun-dried for one day after removing trash and dry carpels before weighing. The data was analysed in DMRT (Duncan Multiple Range Test) statistical analysis method.

The genotypes were evaluated for drought tolerance for biophysical and physiological traits and the results were as follows.

Results and Discussion

Traditional plant breeding efforts aim to improve drought tolerance in crop species using solely yield *per se* have met only with limited success. Yield is a complex trait and is end product of various developmental and physiological processes. Therefore, the heritability of yield, particularly under drought, is low which hampers the progress in improving yield and its stability under water stress conditions. Moreover, large genotype x environment interaction for yield under drought is another major reason for slow progress. Indirect selection for secondary physiological traits exhibiting high correlation with yield may complement empirical breeding efforts to improve drought tolerance in crop plants (Cooper, 1999) [2].

Taking into consideration the historic data on performance of cotton, we chose ARS Annigeri as drought prone environment for the study. Measurement of physiological attributes *viz*. specific leaf weight, water potential, SPAD values, leaf water potential and gas exchange parameters at all growth stages was measured at 60DAS, 90DAS, and 125DAS Whereas. There was a significant genotypic difference among the genotypes at for physiological traits were noticed.

1. Specific leaf weight (mg/cm^2)

In general, SLW increased as the growth of the crop advanced its growth. The mean SLW values of the cotton genotypes grown at ARS Annigeri at 60 DAS, 90 DAS and 125 DAS were 7.7 mg/cm^2, 8.4 mg/cm^2, 8.9 mg/cm^2 respectively. The results indicated that significant differences among the genotypes for SLW recorded at all the stages *i.e*., 60 DAS, 90 DAS and 125 DAS (Table 2). At 60 DAS, the genotypes GIHV-218 (8.5 mg/cm^2) and CPD-750 (8.5 mg/cm^2) recorded significantly higher SLW over other genotypes, however, these were on par with ARB-9701 (8.4 mg/cm^2), Sahana (8.4 mg/cm^2), BS-30 (8.4 mg/cm^2), BS-279 (8.3 mg/cm^2), ARB-8908 (8.2 mg/cm^2), GJHV-477 (8.2 mg/cm^2) and CNH-120MB (8.1 mg/cm^2); followed by GSHV-97/13 (8 mg/cm^2) and F-2228 (7.9 mg/cm^2). While, L-761 (6.9 mg/cm^2) showed least SLW over all other the genotypes and was on par with CPD-168 (7 mg/cm^2), L-763 (7 mg/cm^2), RAH-30 (7.1 mg/cm^2), LH-2076 (7.1 mg/cm^2), RAS-299-1 (7.2 mg/cm^2), KH-138 (7.2 mg/cm^2), F-1861 (7.2 mg/cm^2), KH-134 (7.3 mg/cm^2) and CPD-446 (7.3 mg/cm^2).

At 90 DAS the genotypes CPD-750 (9.7 mg/cm^2) and GIHV-218 (9.6 mg/cm^2) recorded significantly higher SLW over other genotypes and were on par with Sahana (9.5 mg/cm^2) and ARB-9701 (9.4 mg/cm^2); followed by BS-279 (9.2 mg/cm^2), BS-30 (9.2 mg/cm^2), ARB-8908 (9.0 mg/cm^2) and GJHV-477 (7.6 mg/cm^2). While L-761(7.3 mg/cm^2) and L-763 (7.3 mg/cm^2) showed least SLW and was on par with CPD-168 (7.4 mg/cm^2), RAH-30 (7.5 mg/cm^2), F-1861 (7.6 mg/cm^2) and LH-2076 (7.6 mg/cm^2). At 125 DAS, the genotype CPD-750 (10.2 mg/cm^2) recorded significantly higher SLW over other genotypes and was on par with GIHV-218 (10.1 mg/cm^2), Sahana (10.0 mg/cm^2) and ARB-9701 (9.8 mg/cm^2); followed by BS-279 (9.7 mg/cm^2), BS-30 (9.7 mg/cm^2), ARB-8908 (9.6 mg/cm^2), CNH-120MB (9.4 mg/cm^2) and GJHV-477 (9.4 mg/cm^2). While, L-761 (7.6 mg/cm^2) and L-763 (7.7 mg/cm^2) showed least SLW and was on par with CPD-168 (7.9 mg/cm^2) and RAH-30 (8.0 mg/cm^2) (Table 2).

Higher productivity of cotton was largely influenced and controlled by high specific leaf weight, which are efficient in carbon exchange rate (photosynthesis) and also keep the leaves photo synthetically active for a period of up to 70 days and contribute to high biomass (Kudachikar and Janagoudar, 1999) [4].

2. SPAD Values (Chlorophyll content)

In general, the SPAD values are increased with the age crop up to 90-110 DAS and it was reduced after 125DAS. The mean SPAD values of the cotton genotypes grown at ARS Annigeri it was 29.6, 35.1 and 28.1 at 60 DAS, 90 DAS and 125 DAS respectively. The results indicated that significant difference among the genotypes for SPAD values at all the crop stages *i.e*., 60 DAS, 90 DAS and 125 DAS (Table 2). At 60 DAS the genotypes GIHV-218 (34.4) recorded significantly higher SPAD value over other genotypes, and was on par with BS-279 (34.1), CNH-120MB (34.1), KH-155 (34.0), ARB-9701 (34.0), CPD-750 (32.6), Sahana (32.4), GSHV-01/26 (32.2), RAH-101 (32.1), GJHV-477 (32.0), CPD-231 (31.8), BS-30 (31.3), ARB-8908 (31.3) and RAH-30 (31.2). While, LH-2076 (24.0) showed least SPAD value among the genotypes, followed by L-761 (24.4) this was on par with H-1353 (25.0), KH-138 (25.4), F-1861 (25.7), KH-134 (25.8), F-2228 (26.2), L-763 (26.3), CPD-446 (26.6), GSHV-97/13 (27.2) and RAS-299-1 (27.3).

At 90 DAS, there was significant difference among genotypes for SPAD values observed. The genotype CNH-120MB (40.7) showed significantly higher SPAD values over other genotypes, however, this was on par with BS-279 (40.6), KH-155 (39.7), ARB-9701 (39.0), CPD-750 (38.6), Sahana (38.2) and GSHV-01/26 (38.1). While, LH-2076 (27.3) showed significantly less SPAD values and was on par with L-761 (29.2) and H-1353 (29.9).

At 125 DAS, there was significant difference among genotypes for SPAD values observed. The genotype GIHV-218 (36.1) showed significantly higher SPAD values over other genotypes, however, this was on par with CNH-120MB (35.3) followed by BS-279 (33.2), KH-155 (32.3), ARB-9701 (31.6), CPD-750 (31.2), Sahana (31.1), GSHV-01/26 (30.7) and RAH-101 (30.3). While, LH-2076 (20.4) showed significantly less SPAD values and was on par with L-761 (22.4) and H-1353 (23.1) (Table 2). These results are in agreement with the finding of Krasichkova *et al.* (1989) [3].

3. Water potential (-MPa)

The present study the water potential status was generally increased as the age crop growth up to 125 DAS and it was reduced at 125DAS. The mean leaf water potential values of the genotypes grown at ARS Annigeri were -1.17 MPa, -1.46 MPa and -2.44 MPa at 60 DAS, 90 DAS and 125 DAS respectively (Table 2). The results indicated that significant difference among the genotypes for water potential values at different stages *i.e*., 60 DAS, 90 DAS and 125 DAS. At 60 DAS, the genotypes GIHV-218 (-0.84 MPa), CNH-120MB (-0.87 MPa), KH-155 (-0.87 MPa), BS-279 (-0.87 MPa) and ARB-9701 (-0.89 MPa) was maintained significantly higher water potential status over other genotypes, followed by CPD-750 (-0.96 MPa) and Sahana (-0.97 MPa). While, LH-2076 (-1.45 MPa), L-761 (-1.44 MPa), H-1353 (-1.42 MPa), KH-138 (-1.42 MPa) and F-1861 (-1.42 MPa) maintained significantly lower water potential status among the genotypes followed by KH-134 (1.40 MPa).

At 90 DAS, the genotype GIHV-218 (-1.15 MPa) was maintained significantly higher water potential status over other genotypes; however, this was on par CNH-120MB (-1.17 MPa), BS-279 (-1.18 MPa), KH-155 (-1.19 MPa) and ARB-9701 (-1.20 MPa) followed by CPD-750 (-1.23 MPa), Sahana (-1.28 MPa), GSHV-01/26 (-1.32 MPa) and RAH-101 (-1.35 MPa). While, LH-2076 (-1.75 MPa), L-761 (-1.74 MPa), H-1353 (-1.73 MPa) and KH-138 (-1.72 MPa) maintained significantly lower water potential status among the genotypes followed by F-1861 (-1.69 MPa) and KH-134 (-1.68 MPa). At 125 DAS the genotypes GIHV-218 (-1.84 MPa) maintained significantly higher water potential status over other genotypes, followed by CNH-120MB (-1.93 MPa), however, this was on par with BS-279 (-1.98 MPa) and KH-155 (-1.99 MPa) followed by ARB-9701 (-2.04 MPa). While, LH-2076 (-2.94 MPa), L-761 (-2.93 MPa), H-1353 (-2.92 MPa), KH-138 (-2.92 MPa) and F-1861 (-2.90 MPa) maintained significantly lower water potential status among the genotypes followed by KH-134 (-2.82 MPa) (Table 2).

4. Biophysical characters

4.1 Rate of Photosynthesis (µ mol $CO_2/m^2/sec$)

In general the rate of photosynthesis was significantly differed among the genotypes (Fig 2). The mean photosynthesis rate of the genotypes was 25.5 µ mol $CO_2/m^2/s$. There was significant difference among cotton genotypes for rate of photosynthesis recorded at 90 DAS. Among the cotton genotypes GIHV-218 (29.4) recorded significantly highest photosynthesis rate over other genotypes followed by BS-279 (28.3) and CNH-120MB (28.3) however, these were on par with KH-155 (27.8). While the least photosynthesis rate recorded in LH-2076 (19.2) followed by L-761 (20.1), H-1353 (23.0), KH-138 (23.3), F-1861 (23.4) and KH-134 (23.6) (Fig 2). These results are in conformity with the results of Landiver *et al.*,(1988) [5] who found the lint yield could be increased by increasing photosynthetic rate to the extent that can remain photo synthetically active up to 70 DAS of their age.

4.2 Leaf temperature (^{o}C)

The leaf temperature was significantly differed among the genotypes (Fig 2). The mean leaf temperature was 31.0 ^{o}C. There was significant difference among cotton genotypes for leaf temperature recorded. There was no significant difference among genotypes for leaf temperature. Among the genotypes GIHV-218 (30.3^{0}C) maintained lowest leaf temperature followed by BS-279 (30.4^{0}C), CNH-120MB (30.4^{0}C), ARB-9701 (30.5^{0}C), KH-155 (30.5^{0}C), Sahana (30.6^{0}C), CPD-750 (30.6^{0}C), GSHV-01/26 (30.7^{0}C) and RAH-101 (30.7^{0}C). While LH-2076 (31.9^{0}C) maintained highest leaf temperature followed by L-761 (31.8^{0}C), H-1353 (31.7^{0}C), KH-138 (31.7^{0}C), F-1861 (31.6^{0}C), F-2228 (31.5^{0}C) and KH-134 (31.5^{0}C) (Fig 2).

4.3 Stomatal Conductance (µ mol $CO_2/m^2/sec$)

Stomatal conductance was significantly differed among the genotypes (Fig 3). The mean stomatal conductance of genotypes was 0.23 µ mol $CO_2/m^2/s$. At 90 DAS, there was significant difference among cotton genotypes for stomatal conductance. Among the genotypes GIHV-218 (0.32) recorded significantly highest stomatal conductance over other genotypes and was on par with BS-279 (0.31), CNH-120MB (0.31), KH-155 (0.30) and ARB-9701 (0.29); followed by CPD-750 (0.28). Whereas the least stomatal conductance was recorded in LH-2076 (0.16), H-1353 (0.16) and L-761 (0.16) however, these were on par with KH-134 (0.17), F-2228 (0.17), CPD-446 (0.18), KH-138 (0.18), L-763 (0.18), F-1861 (0.19) and GSHV-97/13 (0.19) (Fig 3). These results are in conformity with the results of Lopez *et al.*, (1993) were also of the opinion that both transpiration and conductance are important from the point of water uptakes by plants. By this we can found that transpiration was associated with higher yield.

4.4 Rate of transpiration (mmol $H_2O/m^2/sec$)

The rate of transpiration was significantly differed among the genotypes (Fig 3). The mean rate of transpiration of genotypes was 2.9 µ mol $H_2O/m^2/sec$. There was significant difference among genotypes for rate of transpiration. At 90 DAS, there was significant difference among genotypes for rate of transpiration. Among the cotton genotypes GIHV-218 (3.8) recorded significantly highest rate of transpiration, however, this was on par with BS-279 (3.7) and CNH-120MB (3.7) followed by KH-155 (3.5), ARB-9701 (3.4), CPD-750 (3.4), Sahana (3.3), GJHV-477 (3.3) and GSHV-01/26 (3.3). The least rate of transpiration was recorded in L-761 (2.0) and was on par with H-1353 (2.1) and LH-2076 (2.2) (Fig 3).

5. Seed cotton yield (kg/ha)

The data on seed cotton yield was significantly differed among the genotypes (Fig 4). The mean seed cotton yield was 1616 kg/ha. There was significant difference among genotypes for seed cotton yield. Among the genotypes GIHV-218 (2180 kg/ha), CNH-120MB (2172 kg/ha) and BS-279 (2164 kg/ha) recorded highest seed cotton yield, however, which, were on par with KH-155 (2128 kg/ha) and ARB-9701 (2093 kg/ha), followed by CPD-750 (2029 kg/ha). While LH-2076 had recorded lowest (1171 kg/ha) and was on par with L-761 (1187 kg/ha), H-1353 (1198 kg/ha), KH-138 (1213 kg/ha), F-1861 (1239 kg/ha) and KH-134 (1288 kg/ha) (Fig 4). The low yield could be due to these genotypes having lower SPAD value, low photosynthetic rate, lower conductance, high leaf temperature and low maintenance leaf water potential compare to other genotypes. These results are in agreement with ARAÚJO *et al.*, 2003, where they subjected genetically equivalent cotton plant populations to water deficits, show reductions in yield of up to 50% if compared to those that have been irrigated.

Conclusion

There was significant genotypic variation among the cotton genotypes for physiological traits observed. The genotypes GIHV-218, CNH-120MB, KH-155, ARB-9701, CPD-750, Sahana, RAH-101 and RAH-30 performed better under arid condition by expressing highest drought tolerant physiological attributes, along with yield performance; hence these genotypes are drought tolerant cultivars and can be used further for breeding programme for drought tolerance. These genotypes performed well in physiological traits *viz.* Specific leaf weight, SPAD value, higher photosynthetic rate, higher conductance, higher transpiration rate, low leaf temperature and higher leaf water potential compared to other genotypes. Whereas the genotypes LH-2076, L-761, H-1353 and KH-138 performed least under drought stress by expressing poor physiological and yield traits for drought, hence these genotypes are drought susceptible.

Table 2: Genotypic difference for SPAD, SLW (mg.cm^{-2}) and water Potential (-bars) in Cotton genotypes at 60DAS, 90DAS and 125DAS

Sl. No	Genotypes	SPAD Values			SLW (mg.cm^{-2})			Water potential (- MPa)		
		60DAS	90DAS	125DAS	60DAS	90DAS	125DAS	60DAS	90DAS	125DAS
1	GSHV-97/13	27.2 ef	32.7 i-n	26.0 k-o	8.0 b-e	8.8 d-f	9.3 e-g	1.28 c-e	1.58 d-f	2.68 de
2	CPD-446	26.6 ef	32.4 i-n	25.6 k-o	7.3 h-k	7.9 i-k	8.3 i-l	1.28 c-e	1.59 d-f	2.71 cd
3	KH-155	34.0 a-c	39.7 a-c	32.3 cd	7.8 d-g	8.7 d-f	9.2 fg	0.87 l	1.19 rs	1.99 no
4	RAH-101	32.1 a-c	37.7 b-g	30.3 c-h	7.6 e-h	8.7 d-f	9.3 e-g	1.05 j	1.35 no	2.15 kl
5	Sahana	32.4 a-c	38.2 a-e	31.1 c-f	8.4 ab	9.5 ab	10.0 a-c	0.97 k	1.28 pq	2.11 k-m
6	F-1861	25.7 ef	31.1 l-o	24.4 m-p	7.2 h-k	7.6 k-m	8.2 j-l	1.42 a	1.69 ab	2.90 a
7	RAS-299-1	27.3 ef	33.0 i-m	26.2 j-n	7.2 h-k	7.7 j-l	8.3 i-l	1.27 de	1.56e-g	2.65 de
8	BS-30	31.3 a-c	36.7 d-h	29.3 d-j	8.4 ab	9.2 bc	9.7 b-e	1.12 i	1.41 k-n	2.29 ij
9	RCR-4	30.9 bc	35.2 f-i	28.4 f-k	7.4 g-j	8.0 h-j	8.6 h-j	1.16 g-i	1.47 i-k	2.41 h
10	L-761	24.4 ef	29.2 op	22.4 pq	6.9 k	7.3 m	7.6 m	1.44 a	1.74 a	2.93 a

11	GJHV-358	30.6 cd	34.6 h-k	27.8 g-l	7.4 g-j	8.3 gh	8.7 hi	1.20 fg	1.49 hi	2.54 fg
12	CPD731	27.5 e	33.6 i-l	26.8 i-n	7.8 d-g	8.7 d-f	9.2 fg	1.23 ef	1.54 f-h	2.61 ef
13	F-2228	26.2 ef	32.0 k-o	25.2 l-p	7.9 c-f	8.7 d-f	9.3 e-g	1.34 bc	1.64b-d	2.80 b
14	GSHV-01/26	32.2 a-c	38.1 a-f	30.7 c-g	7.6 e-h	8.6 e-g	9.2 fg	1.04 j	1.32 op	2.12 kl
15	CPD-750	32.6 a-c	38.6 a-d	31.2 c-f	8.5 a	9.7 a	10.2 a	0.96 k	1.23 qr	2.09 lm
16	CPD431	27.8 de	34.2 h-k	27.4 h-m	7.5 f-i	8.6 e-g	9.2 fg	1.22 e-g	1.51 g-i	2.56 fg
17	CPD-168	30.6 cd	35.0 g-j	28.2 f-l	7.0 jk	7.4 lm	7.9 lm	1.19 f-h	1.48 h-j	2.51 g
18	ARB-8908	31.3 a-c	35.4 e-i	28.6 e-k	8.2 a-d	9.0 cd	9.6 c-f	1.13 hi	1.42 j-m	2.35 hi
19	H-1353	25.0 ef	29.9 n-p	23.1 o-q	7.4 g-j	8.1 hi	8.7 hi	1.42 a	1.73 a	2.92 a
20	LH-2076	24.0 f	27.3 p	20.4 q	7.1 i-k	7.6 k-m	8.2 j-l	1.45 a	1.75 a	2.94 a
21	KH-138	25.4 ef	30.6 m-o	23.9 n-p	7.2 h-k	7.7 j-l	8.2 j-l	1.42 a	1.72 a	2.92 a
22	CNH120MB	34.1 ab	40.7 a	35.3 ab	8.1 a-d	8.8 d-f	9.4 d-g	0.87 l	1.17 rs	1.93 o
23	RAH-30	31.2 a-c	35.3 e-i	28.5 e-k	7.1 i-k	7.5 lm	8.0 k-m	1.16 g-i	1.45 i-l	2.38 h
24	GIHV-218	34.4 a	43.5 h-k	36.1 a	8.5 a	9.6 a	10.1 ab	0.84 l	1.15 s	1.84 p
25	L-763	26.3 ef	32.2 j-n	25.5 k-o	7.0 jk	7.3 m	7.7 m	1.33 cd	1.62 c-e	2.76 bc
26	BS-279	34.1 ab	40.6 ab	33.2 bc	8.3 a-c	9.2 bc	9.7 b-e	0.87 l	1.18 rs	1.98 no
27	KH-134	25.8 ef	31.8 k-o	25.1 l-p	7.3 h-k	8.0 h-j	8.4 i-k	1.40 ab	1.68a-c	2.82 b
28	CPD-231	31.8 a-c	36.8 c-h	29.3 d-j	7.5 f-i	8.5 fg	9.0 gh	1.10 ij	1.39 l-n	2.27 j
29	GJHV-477	32.0 a-c	37.0 c-h	29.4 d-i	8.2 a-d	8.9 c-e	9.4 d-g	1.05 j	1.36m-o	2.18 k
30	ARB-9701	34.0 a-c	39.0 a-d	31.6	8.4 ab	9.4 ab	9.8 a-d	0.89 l	1.20 rs	2.04 mn
Mean		35.5	29.6	35.1	28.1	7.7	8.4	8.9	1.17	1.46
SEm +		0.28	1.01	0.89	0.93	0.14	0.11	0.14	0.022	0.022

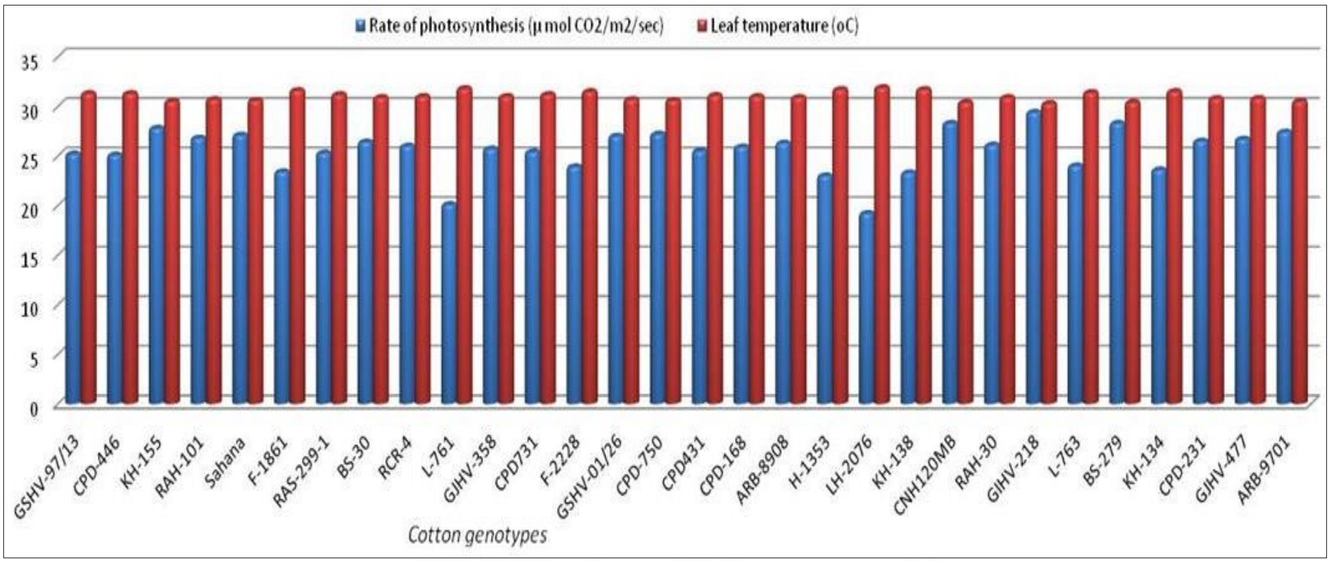

Fig 2: Genotypic difference for Rate of photosynthesis (µ mol $CO_2/m^2/sec$) and leaf temperature (^0C)

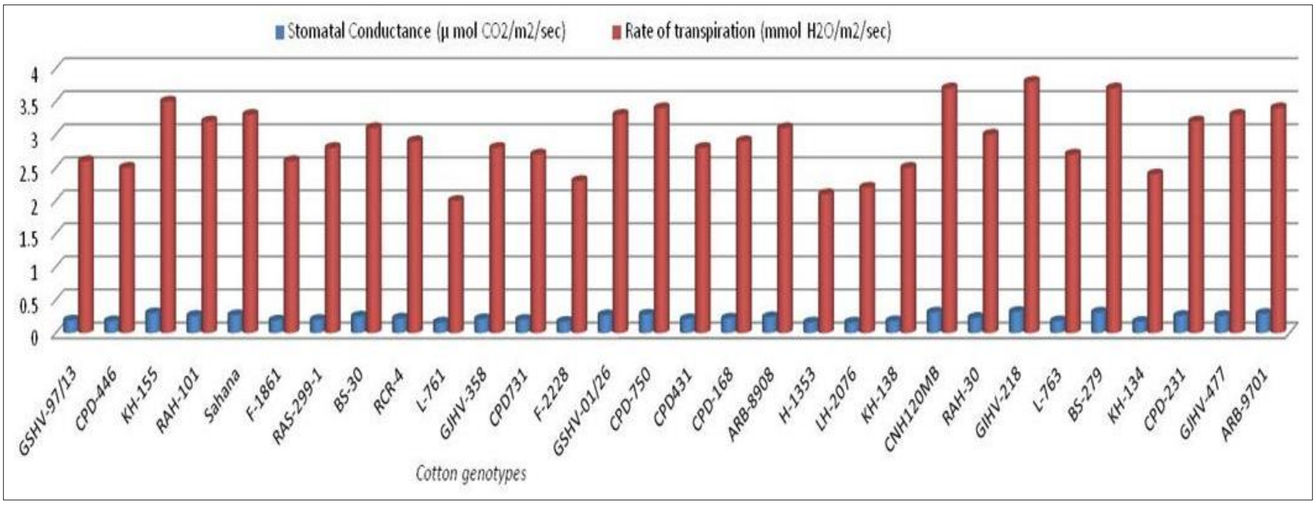

Fig 3: Genotypic difference for stomatal conductance (µ mol $CO_2/m^2/sec$) and, Rate of transpiration (mmol $H_2O/m^2/sec$)

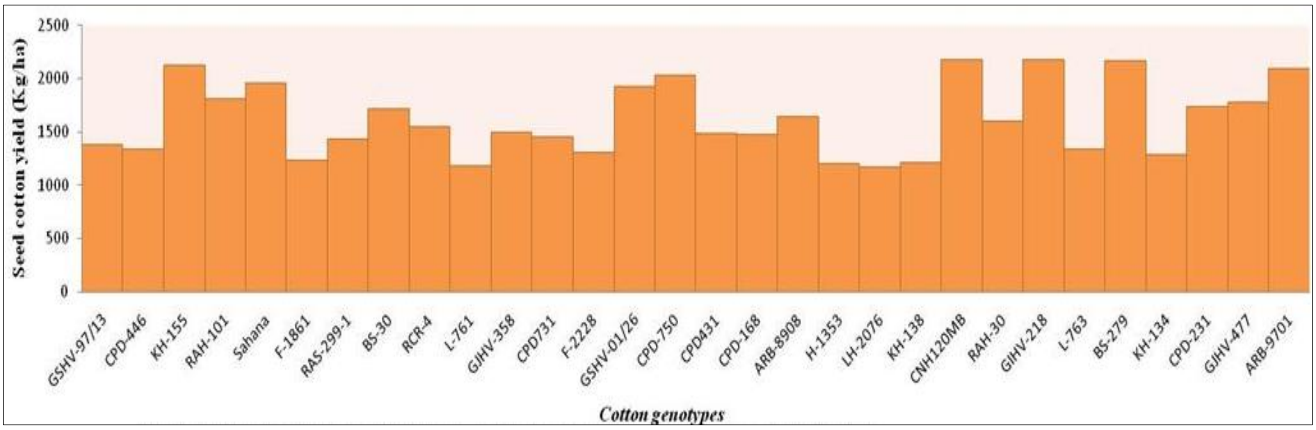

Fig 4: Genotypic difference of different cotton genotypes for seed cotton yield (Kg/ha)

Consent: It is no applicable.
Ethical Approval: It is no applicable.
Competing Interests: Authors have declared that no competing interests exist.

References

1. Babu AG, Patil BC, Pawar KN. Evaluation of Cotton genotypes for drought tolerance using peg-6000 water stress by slanting glass plate technique. The Bioscan. 2014; 9(2):1419-1424.
2. Cooper M. Concept and strategies for plant adaptation research in rainfed lowland rice. Field Crops Res. 1999; 64:13-34.
3. Krasichkova GU, Asoeva LM, Giller Yu E, Sanginov BS. Photosynthetic system of *G. barbadense* at the early stages of development. Doklady Vsesovuznoi Ordena trodovogo krasnogo Znameni Akademii sel skokhozya irtvennykh nauk Imne V.I. Lenina. 1989; 12:9-11.
4. Kudachikar, Janagoudar. Physiological analysis of hirsutum cotton for higher productivity under rainfed conditions. Madras agricultural journal. 1999; 86:10-13.
5. Landiver JA, Baker DN, Hodges HF. Leaf area index development and yield of cotton cultivars differing in maturities. Proc. of Belt. Cot. Prod. Res. Conf. 3-8th June, New Orleans, Lovisiana, USA, 1988.
6. Naidu P, Cameron DF, Konduri SV. Improving drought tolerance of cotton by glycine betaine applicaton and selection. Proc. of the 9th Australian Agron. Conf, 1995, 1-5.
7. Parry MAJ, Flexas J, Medrano H. Prospects for crop production under drought: Research priorities and future directions. Ann. Appl. Biol., 2005; 147(3):211-226.
8. Pimentel. The relation of plant with water. ufruralirjedur, Seropedica, 2004, 192.
9. Shilpa bonde, Chandrasekhar CN, Pusadkar PP. Study of biochemical changes in cotton genotypes at squaring stage under water stress conditions, The Ecoscan. 2016; 10(1&2):117-120.