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Screening of cotton (*Gossypium hirsutum* L.) genotypes for drought tolerance

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Abstract
The experiment entitled "screening the cotton (*Gossypium hirsutum* L.) Genotypes for drought tolerance" was conducted at Department of Biochemistry, Main Cotton Research Station, Navsari Agricultural University, Surat. Twelve genotypes were selected for screening in drought tolerance. Seeds were grown in pots filled with sand culture for 15 days. The seedling was subjected to control and 10 % PEG-6000 treatment for 48 hour and control was taken without PEG treatment. Samples were analyzed for relative water content, membrane stability index, proline, chlorophyll stability index and molecular diversity using molecular markers. Two genotypes GSHV-172 and GISV-272 showed highest relative water content (70.36 and 72.31 %) in PEG treatment and (95.83 and 95.71 %) respectively in control while membrane stability index was found (73.03 and 66.49 %) in GSHV-172 and GISV-272 respectively in PEG treated samples. Proline contend was found higher in same genotype. Two genotypes GSHV-172 and GISV-272 showed highest Chlorophyll stability index compared to other genotypes. So based on biochemical parameters GSHV-172 and GISV-272 found drought tolerant genotype, rest of genotypes were moderately tolerance to drought susceptible. Total twelve RAPD were amplified to generate the 86 fragments and obtained 71 polymorphic bends. The percent polymorphism obtained for RAPD primers were ranked from 25 % to 100 %. The cluster analysis showed the highest similarity 94 % was observed between GISV-272 and GSHV-172 while, the lowest similarity 77 % was observed between Surat dwarf and GSHV-01/13387.

Keywords: Relative water content, Membrane stability index, RAPD

Introduction
Cotton is an important industrial crop which in popularly known as "white gold" and the "king of fiber". This commercial crop with unique industrial properties and major source of high-quality natural fiber and edible oil, cotton enjoys great demand across the globe. (Wendel *et al*., 2016) [16] The cotton (*Gossypium hirsutum* L.), an important fibre crop, is grown throughout India under both rainfed and irrigated conditions on an area of 9.5 million ha (Yang *et al*., 2014) [37]. India has the largest land area under cotton cultivation and is the second largest producer of cotton in the world (Singh, Kairon, 2013) [29]. It includes approximately 50 species distributed worldwide. Among these 50, two diploid (*G. arboreum* and *G. herbaceum*) and two tetraploid (*G. hirsutum* and *G. barbadense*) species are under cultivation in tropical and sub-tropical environmental conditions. Four species are under commercial cultivation *G. herbaceum* L. (2n=26), *G. arboretum* L. (2n=26), *G. hirsutum* L. (2n=52) and G. *barbandense* L. (2n=52). Improving drought tolerance is complex for researchers because, under drought, the plant itself adopts various strategies to combat stress depending on the level of water stress, the length of time to which the plant is subjected to water stress and the genotypes of plant species. (Boutree *et al*, 2010) [9] Examination of biochemical characters under stress condition is helpful to know the adaptations mechanism against the harsher environment (Prajapat *et al*., 2018) [23].

Drought is commonly defined as the absence of adequate moisture for a plant to grow normally and complete its life cycle (Bartels, Sunkar, 2005) [5]. Drought is one of the most critical abiotic stresses that limit crop growth and productivity worldwide. Drought is considered a multidimensional stress that leads to changes in the physiological, morphological, ecological, biochemical and molecular characteristics of plants. (Hasan *et al*., 2018) [15]. The symptoms of drought stress also vary with the plant species, developmental stages, growth conditions, and environmental factors (Arbona *et al*, 2013, Bhargava *et al*., 2013) [4, 7].

Drought stress inhibits plant growth and development (Wang *et al*., 2003) [35] but enables root length proliferation to acquire water from the deep soil and tolerate the stress (Hufstetler *et al*., 2007, Afshari, *et al*., 2011) [17, 2]. The root/shoot ratio also increases, indicating water acclimatization and enhanced tolerance (Kumar *et al*. 2010, Sumartini *et al*., 2013) [19, 31]. Decreased shoot length is observed due to the blockage of vascular tissue vessels and a reduction in cell elongation (Abdalla *et al*., 2007) [1]. Generally, drought symptoms are mostly observed in the leaves of plants showing loss of turgor, drooping, wilting, etiolation, yellowing, and premature downfall (Akhtar, Nazir., 2013, Sapeta *et al*., 2013) [3, 27]. The photosynthetic rate was found to decrease under drought conditions in different plant species (Chen *et al*., 2010) [10]. Plants grown under drought conditions have lower stomatal conductance, reduced CO_2 fixation, and decreased photosynthesis, which result in reduced growth and yield of plants. Severe drought stress also inhibits the photosynthesis of plants by causing changes in the chlorophyll content and damaging the photosynthetic apparatus (Dalton *et al*., 1998) [11]. Drought is an abiotic stress, it has drastic effect on plant growth and crop productivity (Quisenberry *et al*., 1985) [24].

The entire cotton plant has the potential to be a source of valuable compounds, such as terpenes, phenolics, fatty acids, lipids, carbohydrates, and proteins (Shakhidoyatov *et al*., 1997, Perveen, *et al*., 2001) [28, 22]. These compounds, which are distributed in seeds, bolls, calyx, leaves, stalks, stems, and roots of the plant (Hu *et al*., 2011, Haleem *et al*., 2014) [16, 14] play functional biological roles in humans and animals (Essien *et al*., 2011, Sánchez-Muñoz *et al*., 2012, Rogerio *et al*., 2009) [13, 26, 25].

Material and Methods

The investigation on “screening the cotton (*Gossypium hirsutum* L.) Genotypes for drought tolerance” was carried out at the Department of Biochemistry, Main Cotton Research Station, Navsari Agricultural University, Surat. The statistical design used for the study was completely randomized design. The experiment was carried out with twelve cotton genotypes using CRD design.

Geographical features: Geographically, Surat is located at a cross point of 20°12’ N latitude and 72°52’ E longitudes with an altitude of near at 12 (11.34) meters above the mean sea level in South of Gujarat. The place is located at near Science Center, Surat Municipal Corporation, Athwa lines, Surat.

The 12 cotton genotypes seeds were grown for 15 days in sand culture with 10 plants for each genotype. Four kg of soil, peat and sand in the ratio 1:1:1 was filled in 5 kg capacity pots during *Kharif* (June- September 2020). After 15 days, the plants were uprooted and dipped in 10 % PEG-6000 for 48 hours. After 48 hour the leaf samples were taken out and used for physiological and biochemical parameters from control and PEG treated condition. Molecular analysis was done from 15 days old genotypes.

Table 1: Genotypes Treatment

V1 – G Cot 10	V5 - GSHV-180	V9 - BC-68-2
V2 - G.Cot.100	V6 - G.Cot.16	V10 - American nectariless
V3 -GISV- 272	V7 - LRA-5166	V11 - Surat dwarf
V4 - GSHV-172	V8 - G.N.Cot.22	V12 - GSHV-01/13387

ANOVA was carried out to test difference in treatment using completely randomized design with three repetitions. Data were analyzed using OPSTAT (O.P. Sheoran Programmer, Computer Section, CCS HAU, Hisar) statistic software. The critical difference (CD) among the variances was calculated at $p \leq 0.05$. The molecular data were analyzed using unweight pair group method using arithmetic average (UPGMA) method by NTSYS-pc version 2.02.

Table 2: Observation recorded

Sr. No	Parameter	Reference
1	Relative water content (%)	Turner (1986) [33]
2	Membrane stability index (%)	Martineau *et al*., (1979) [20]
3	Proline (µg g^{-1})	Bates *et al*. (1973) [6].
4	Chlorophyll Stability (%)	Sibasubramanian (1992) [30]
5	Molecular Diversity using molecular marker	Botstein *et al*., (1980) [8] and Doyle and Doyle (1987) [12]

Results and Discussion

The data presented in Table 3 indicate that due to drought stress, there was decline in normal condition. The Relative water content, MSI percentage, Proline and Chlorophyll stability index was recorded at 15 days after sowing from control and 48-hour PEG Treated condition. Genotype GSHV-172 and GISV-272 showed significantly higher among all genotypes under control and PEG treated condition. Techawongstin *et al*. (1993) [32] reported a similar phenomenon in water-stressed hot pepper. Results in total dysfunction and it is generally accepted that the maintenance of integrity and stability of membranes under drought stress is a major component of drought tolerance in plants (Vaidya *et al*. 2015) [34]. Iqbal *et al*. (2016) [18] who reported that, the accumulation of proline in drought tolerant and drought susceptible cultivars has revealed the significance of this osmolyte. Proline content has been shown to accumulate upon desiccation in leaves of many plant species. It has been suggested by Jones *et al*. 1980. The Same result was revealed by the Patil *et al*. (2011) [21] as Chlorophyll stability index.

Table 3: Relative water content (%), Membrane stability index (%) Proline (µg g^{-1}) Chlorophyll stability index (%) of different genotypes under control and PEG treated condition

Sr. No	Genotypes	Relative water content (%)		Membrane stability index (%)		Proline (µg g^{-1})		Chlorophyll stability index (%)
		Control condition	PEG treated condition	Control condition	PEG treated Condition	Control condition	PEG treated condition	
V_1	G. Cot.10	89.48	49.52	62.90	51.56	0.50	1.28	65.81
V_2	G. Cot.100	93.10	51.18	66.77	58.06	0.73	3.32	71.36
V_3	GISV-272	95.71	72.31	91.07	66.49	0.86	4.18	83.43
V_4	GSHV-172	95.83	70.36	92.07	73.03	0.91	4.06	86.76
V_5	GSHV-180	94.02	52.80	83.36	52.75	0.62	2.44	79.98
V_6	G. Cot.16	92.54	53.79	87.79	62.93	0.67	3.76	80.28
V_7	LRA-5166	95.04	53.66	81.48	52.71	0.62	3.86	76.34
V_8	G.N. Cot.22	95.20	62.57	89.40	53.49	0.65	1.98	74.96
V_9	BC-68-2	90.34	49.80	54.09	50.62	0.61	1.29	65.31

V_{10}	American nectariless	90.96	58.01	75.43	51.16	0.70	2.30	80.56
V_{11}	Surat dwarf	92.54	64.89	77.23	57.26	0.69	2.09	78.34
V_{12}	GSHV-01/13387	94.59	53.05	77.44	54.98	0.69	2.98	79.88
S.E.M		0.96	0.60	0.55	0.33	0.01	0.03	1.471
CD at $p \leq 0.05$		2.83	1.76	1.60	0.97	0.04	0.08	0.708
CV%		1.79	1.80	1.21	1.01	3.50	1.66	1.128

Polymorphism as detected by RAPD analysis

The Table 4 percent polymorphism obtained for RAPD primer were ranged from 25 % to 100% with an average value of 82.55 % per primer. The polymorphism information content (PIC) values for RAPD marker from 0.08-0.50. The performance of individual primer to amplify genomic DNA of 12 cotton genotypes is discussed as under.

OPB-07: Out of which 7 fragments were polymorphic and 1 fragment were monomorphic having 87.50 % polymorphism and PIC value 0.47

OPM-07: Out of which 3 fragments were polymorphic and 0 fragment were monomorphic having 100.00 % polymorphism and PIC value 0.50

Sr. No.	Genotypes	Relative water content (%)		Membrane stability index (%)		Proline (µg g^{-1})		Chlorophyll stability index (%)
		Control condition	PEG treated condition	Control condition	PEG treated Condition	Control condition	PEG treated condition	
V_1	G. Cot.10	89.48	49.52	62.90	51.56	0.50	1.28	65.81
V_2	G. Cot.100	93.10	51.18	66.77	58.06	0.73	3.32	71.36
V_3	GISV-272	95.71	72.31	91.07	66.49	0.86	4.18	83.43
V_4	GSHV-172	95.83	70.36	92.07	73.03	0.91	4.06	86.76
V_5	GSHV-180	94.02	52.80	83.36	52.75	0.62	2.44	79.98
V_6	G. Cot.16	92.54	53.79	87.79	62.93	0.67	3.76	80.28
V_7	LRA-5166	95.04	53.66	81.48	52.71	0.62	3.86	76.34
V_8	G.N. Cot.22	95.20	62.57	89.40	53.49	0.65	1.98	74.96
V_9	BC-68-2	90.34	49.80	54.09	50.62	0.61	1.29	65.31
V_{10}	American nectariless	90.96	58.01	75.43	51.16	0.70	2.30	80.56
V_{11}	Surat dwarf	92.54	64.89	77.23	57.26	0.69	2.09	78.34
V_{12}	GSHV-01/13387	94.59	53.05	77.44	54.98	0.69	2.98	79.88
SEm		0.96	0.60	0.55	0.33	0.01	0.03	1.471
CD at $p \leq 0.05$		2.83	1.76	1.60	0.97	0.04	0.08	0.708
CV %		1.79	1.80	1.21	1.01	3.50	1.66	1.128

OPM-13: Out of which 7 fragments were polymorphic and 0 fragment were monomorphic having 100.00 % polymorphism and PIC value 0.41.

OPM-19: Out of which 1 fragment were polymorphic and 3 fragments were monomorphic having 25.00 % polymorphism and PIC value 0.08

OPM-20: Out of which 9 fragments were polymorphic and 0 fragments were monomorphic having 100.00% polymorphism and PIC value 0.50.

OPX-13: Out of which 3 fragments were polymorphic and 5 fragments were monomorphic having 37.50 % polymorphism and PIC value 0.19.

OPC-11: Out of which 4 fragments were polymorphic and 4 fragments were monomorphic having 50.00 % polymorphism and PIC value 0.41.

OPJ-05: Out of which 10 fragments were polymorphic and 0 fragments were monomorphic having 100.00 % polymorphism and PIC value 0.50.

OPJ-19: Out of which 9 fragments were polymorphic and 0 fragments were monomorphic having 100.00 % polymorphism and PIC value 0.44.

OPA-01: Out of which 4 fragments were polymorphic and 0 fragments were monomorphic having 100.00 % polymorphism and PIC value 0.50.

OPC-20: Out of which 11 fragments were polymorphic and 0 fragments were monomorphic having 100.00 % polymorphism and PIC value 0.47.

OPC-07: Out of which 3 fragments were polymorphic and 2 fragments were monomorphic having 60.00 % polymorphism and PIC value 0.15.

Table 4: Size, number of amplified bands, percent polymorphism and PIC obtained by RAPD primers.

Sr. No	Name of primers	Total number of bands	Number of Monomorphic Bands	Number of Polymorphic Bands	Percent Polymorphism	PIC Value
1	OPB-07	8	1	7	87.50	0.47
2	OPM-07	3	0	3	100.00	0.50
3	OPM-13	7	0	7	100.00	0.41
4	OPM-19	4	3	1	25.00	0.08
5	OPM-20	9	0	9	100.00	0.50
6	OPX-13	8	5	3	37.50	0.19
7	OPC-11	8	4	4	50.00	0.41
8	OPJ-05	10	0	10	100.00	0.50

9	OPJ-19	9	0	9	100.00	0.44
10	OPA-01	4	0	4	100.00	0.50
11	OPC-20	11	0	11	100.00	0.47
12	OPC-07	5	2	3	60.00	0.15
		86	15	71	82.55	4.62

Table 5: Genetic similarity coefficient between the cotton genotypes based on the RAPD data

Genotypes	G Cot 10	G Cot 100	GISV-272	GSHV-172	GSHV-180	G Cot 16	LRA-5166	GN Cot 22	BC-68-2	AN	SD	GSHV-01/13387
G. Cot.10	1.00											
G. Cot.100	0.85	1.00										
GISV-272	0.83	0.87	1.00									
GSHV-172	0.78	0.83	0.94	1.00								
GSHV-180	0.77	0.84	0.84	0.81	1.00							
G. Cot.16	0.74	0.79	0.85	0.81	0.84	1.00						
LRA-5166	0.81	0.82	0.81	0.77	0.79	0.81	1.00					
G.N. Cot.22	0.61	0.57	0.54	0.51	0.56	0.60	0.67	1.00				
BC-68-2	0.70	0.70	0.64	0.61	0.71	0.76	0.79	0.69	1.00			
AN	0.83	0.83	0.88	0.83	0.78	0.85	0.79	0.51	0.70	1.00		
SD	0.67	0.65	0.65	0.63	0.55	0.63	0.63	0.60	0.69	0.65	1.00	
GSHV-01/13387	0.67	0.63	0.61	0.61	0.50	0.50	0.63	0.57	0.56	0.60	0.77	1.00

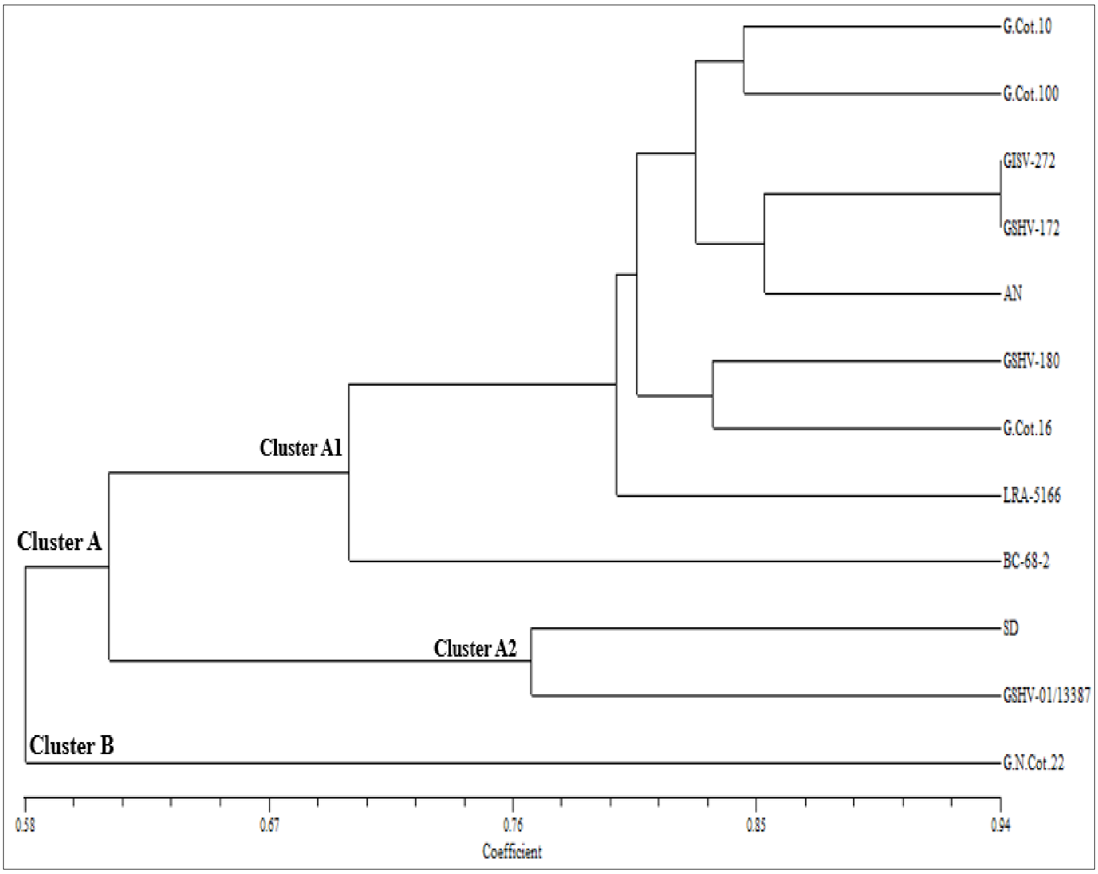

Fig 1: Dendrogram depicting the genetic relationship among 12 cotton genotypes based on RAPD data

Genetic similarity
Genetic similarity was determined under Table 5 for each pair of 12 populations which revealed that the genetic similarity was minimum 0.50 and maximum 0.94.

Conclusion
Based on biochemical observation among twelve cotton genotypes, Genotypes GSHV-172 and GISV-272 showed highest relative water content, membrane stability index, and proline and chlorophyll stability index compared to other genotypes. Eighty-six fragment and seventy one polymorphic bands were obtained using 12 RAPD primers. The cluster analysis showed the highest similarity 94% between GISV-272 and GSHV-172 belong to same cluster. From biochemical observation genotypes GSHV-172 and GISV-272 were found drought tolerant which having similar cluster in Dendrogram and highest genetic similarity.

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References

1. Abdalla MM, El-Khoshiban NH. The influence of water stress on growth relative water content, photosynthetic pigments, some metabolic and hormonal contents of two Triticum Aestivum cultivars. Journal of Applied Science Research. 2007;3(12):2062-2074.
2. Afshari RT, Angoshtari1 R, Kalantari S. Effects of light and different plant growth regulators on induction of callus growth in rapeseed (*Brassica napus* L.) genotypes. Plant Omics Journal. 2011 Mar;4(2):60-67.
3. Akhtar I, Nazir N. Effect of waterlogging and drought stress in plants. International Journal of Water Research and Environment Science. 2013;2(2):34-40.
4. Arbona V, Manzi M, De Ollas C, Gómez-Cadenas A. Metabolomics as a tool to investigate abiotic stress tolerance in plants. International Journal of Molecular Science. 2013 Mar 1;14(3):4885-4911.
5. Bartels D, Sunkar R. Drought and salt tolerance in plants. Critical reviews in plant sciences. 2005 Feb 23;24(1):23-58.
6. Bates LS, Waldren RP, Teare ID. Rapid determination of free proline for water stress studies. Plant soil. 1973 Aug;39(1):205-207.
7. Bhargava S, Sawant K. Drought stress adaptation: Metabolic adjustment and regulation of gene expression. Plant Breeding. 2013 Feb;132(1):21-32.
8. Botstein D, White RL, Skolnick M, Davis RW. Construction of a genetic linkage map in man using restriction fragment length polymorphisms. The American Journal Human Genetics. 1980 May;32(3):314-331.
9. Boutree T Akhkha A, Al-Shoaibi A, Alhejeli AM. Effect of water stress on growth and water use efficiency (WUE) of some wheat cultivars (*Triticum durum*) grown in Saudi Arabia. Journal of Taibah University Science. 2010 Jan 1;3(1):39-48.
10. Chen F, Wang F, Wu FB, Mao WH, Zhang GP, Zhou MX. Modulation of exogenous glutathione in antioxidant defense system against Cd stress in the two barley genotypes differing in Cd tolerance. Plant Physiology and Biochemistry. 2010 Aug 1;48(8):663-672.
11. Dalton DA, Joyner SL, Becana M, Iturbe-Ormaetxe I, Chatfield JM. Antioxidant defenses in the peripheral cell layers of legume root nodules. Plant Physiology. 1998 Jan 1;116(1):37-43.
12. Doyle JJ, Doyle JL. Isolation of DNA from fresh plant tissue. Focus. 1987;12:13-15.
13. Essien EE, Aboaba SO, Ogunwande IA. Constituents and antimicrobial properties of the leaf essential oil of *Gossypium barbadense* (Linn.). Journal of Medicinal Plant Research. 2011 Mar 4;5(5):702-705.
14. Haleem N, Arshad M, Shahid M, Tahir MA. Synthesis of carboxymethyl cellulose from waste of cotton ginning industry. Carbohydr. Polym. 2014;113:249-255.
15. Hasan MM, Fanglu M, Prodhan ZH, Li F, Shen H, Chen Y, Wang X. Molecular and Physio-Biochemical Characterization of Cotton Species for Assessing Drought Stress Tolerance. International Journal of Molecular Science. 2018 Sep 6;19(9):26-36.
16. Hu G, Houston NL, Pathak D, Schmidt L, Thelen JJ, Wendel JF. Genomically biased accumulation of seed storage proteins in allopolyploid cotton. Genetics. 2011 Nov 1;189(3):1103-1115.
17. Hufstetler VE, Boerma R, Carter TEJ, Earl HJ. Genotypic variation for three physiological traits affecting drought tolerance in soybean. Crop Science. 2007 Jan;47(1):25-35.
18. Iqbal MJ, Maqsood ZA, Manzoor A, Hassan M, Jamil A. SSR markers associated with Proline in drought tolerant wheat germplasm. Applied Biochemistry and Biotechnology. 2016 Mar;178(5):1042-1052.
19. Kumar N, Nandwal AS, Devi S, Sharma KD, Yadav A, Waldia RS Root characteristics, plant water status and CO_2 exchange in relation to drought tolerance in chickpea. E Journal ICRISAT Org. 2010;8:5.
20. Martineau PM, Williams JH, Speght JE. Temperature tolerance in soybeans-II. Evaluation of segregating population for membrane thermo-stability. Crop Science. 1979 Jan;19(1):79-81.
21. Patil MD, Biradar DP, Patil VC, Janagouda BS. Response of Cotton Genotypes to Drought Mitigation Practices. American Eurasian Journal of Agricultural and Environmental Science. 2011;11(3):360-364.
22. Perveen SS, Qaisrani TM, Siddiqui F, Perveen R, Naqvi SHM. Cotton plant volatiles and insect's behavior. Pakistan Journal of Biological Science. 2001;4:554-558.
23. Prajapat P, Singh D, Tripathi S, Patel K, Abbas H, Patel P. Effect of water stress on ant oxidative enzymes and glycine betaine content in drought susceptible cotton (*Gossypium hirsutum* L.) genotypes. Indian Journal of Biochemistry and Biophysics. 2018;55(3):198-204.
24. Quisenberry JE, Wendt CW, Berlin JD, McMichael BL. Potential for using leaf turgidity to select drought tolerance in cotton. Crop Science. 1985 Mar;25(2):294-299.
25. Rogerio AP, Andrade EL, Leite DFP, Figueiredo CP, Calixto JB. Preventive and therapeutic anti-inflammatory properties of the sesquiterpene α-humulene in experimental airways allergic inflammation. Br. Journal of Pharmacology. 2009 Oct;158(4):1074-1087.
26. Sánchez-Muñoz BA, Aguilar MI, King-Díaz B, Rivero JF, Lotina-Hennsen B. The sesquiterpene β-caryophyllene and caryophyllene oxide isolated from Senecio salignus act as phytogrowth and photosynthesis inhibitors. Molecules. 2012 Feb 6;17(2):1437.
27. Sapeta H, Costa M, Lourenc T, Marocod J, Van der Linde P, Oliveiraa MM. Drought stress response in Jatropha curcas: Growth and physiology. Environment Exportation and Botany. 2013 Jan 1;85:76-84.
28. Shakhidoyatov KM, Rashkes AM, Khidyrova NK. Components of cotton plant leaves, their functional role and biological activity. Chemical and Natural Compound. 1997 Nov;33(6):605-616.
29. Singh P, Kairon MS. Cotton Varieties and Hybrids, CICR technical bulletin no, 2013, 13.
30. Sivasubramanian K. Chlorophyll stability index: methods for determining drought Hardness of Acacia species. Nitrogen Fixing Tree Research Reports. 1992;10:111-112.
31. Sumartini S, Emy S, Sri M, Dan A. Screening of Cotton line (*Gossypium hirsutum* L.) tolerance to drought at germination stage with PEG-6000. Journal Littri. 2013;3:139-146.
32. Techawongstin S, Nawata E, Shigenaga S. Recovery in physiological characteristics from sudden and gradual water stress in hot-peppers. In Kuo (Ed.), Adaptations of

Food Crops to Temperature and Water Stress; c1993. p. 140-147.
33. Turner NC. Crop water deficit: A decade of progress. Advance in Agronomy. 1986;39:1-51
34. Vaidya S, Vanaja M, Lakshmi NJ, Sowmya P, Anitha Y, Sathish P. Variability in drought stress induced responses of groundnut (*Arachis hypogaea* L.) Genotypes. Biochem. Physiol. 2015;4(1):149. DOI: 10.4172/2168-9652.1000149.
35. Wang W, Vinocur B, Altman A. Plant responses to drought, salinity and extreme temperatures: Towards genetic engineering for stress tolerance. Planta. 2003 Nov;218(1):1-4.
36. Wendel JF, Brubaker C, Alvarez I, Cronn R, Stewart JM. Evolution and natural histry of the cotton genus. In Genetics and genomics of cotton (Springer, New your); c2016. p. 3.
37. Yang F, Du M, Tian X, Eneji AE, Duan L, Li Z. Plant growth regulation enhanced potassium uptake and use efficiency in cotton. Field Crops Research. 2014 Jul 1;163:109-118.