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Screening of hirsutum cotton genotypes for water stress tolerance in polybags

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Abstract
A polybag experiment was conducted with twenty one *hirsutum* cotton genotypes grown at three soil moisture (100, 50 and 25% field capacity) levels during 2014 at Crop physiology division, Agriculture Research Station, Hebballi farm, UAS, Dharwad to screen for water stress condition based on seedling growth and biochemical changes. Varying soil moisture stress was imposed from 21 days after sowing till 45 days. Then plants were extracted for recording observations. Results indicated that as stress level increases, the root length, root weight, lateral root number and leaf proline content increased whereas, chlorophyll content decreased. The shoot biomass decreased with increase in moisture stress, resulting in increased root to shoot ratio. However the degree of change varied with genotypes. The genotypes viz., Sahana, BS-37, LRA-5166, CCH-12-3, GBHV- 177, BS39, GBHV-182, ARBH-1352, which showed higher root weight, shoot weight, total dry matter, proline and chlorophyll content under higher moisture stress condition are proposed to be drought tolerant genotypes.

Keywords: leaf proline, chlorophyll, checks, root to shoot ratio

Introduction
Cotton (*Gossypium* spp.) "the silver fiber" is an important commercial crop of India, playing a significant role in Indian farming and industrial economy of country, by providing 65–70% of raw material for the textile industry of our country. India is the traditional home for cotton and cotton textiles, the cultivated area occupying about 11.8 mha producing 35.2 mbales with the productivity of 504 kg lint ha-1. In Karnataka, it is grown in an area of 0.61 mha with a production of 0.2 m bales and productivity of 556 kg lint ha-1 (Anonymous, 2016) [2]. Though, India has the largest area under cotton, it ranks third in production due to low productivity. The major reasons for low yield in India are biotic, abiotic, and technological problems. One of the major abiotic stresses affecting plant productivity is water stress resulting through drought which limits crop growth and productivity.

Water availability and quality affect the growth and physiological processes of all plants as water is the primary component of actively growing plants ranging from 70–90% of plant fresh mass (Babu, 2015) [3]. Due to its predominant role in plant nutrient transport, chemical and enzymatic reactions, cell expansion and transpiration, water stresses result in anatomical and morphological alterations as well as changes in physiological and biochemical processes affecting functions of the plants. Plant water deficits depend both on the supply of water to the soil and the evaporative demand of the atmosphere. In general, plant water stress is defined as the condition where a plant's water potential and turgor are decreased enough to inhibit normal plant function. The effect of water stress depends on the severity and duration of the stress, the growth stage at which stress is imposed and the genotype of the plant (Akram, 2011) [1]. Hence screening cotton genotypes for water stress tolerance and identifying associated morphological, biochemical traits is undertaken.

Materials and Methods
Polybag experiment consisted three water stress levels viz., control (100% field capacity), moderate stress (50% field capacity) and severe stress (25% field capacity), imposed after 21 days of sowing and maintained up to 45 days. Ninteen cotton varieties viz., TSH-04/115, GBHV-182, GBHV-177, PH-1060, CCH-12-3, GSHV-169, TCH-1777, SCS-1213, SCS-1062, AKH-09- 5, NDLH-1943, CNH- 1110, ARBH-1352, NDLH-1938, RAH- 806, BS-37, BS-39, and GJHV- 516 and three checks viz., LRA-5166 (National), RAH-100 (Zonal) and Sahana (Local) were used.

Three replications of treatment combinations were maintained to fit experimental design. The plants were extracted on 45th day from polybags for recording morphological observation viz., Shoot length (cm), root length (cm), number of secondary roots, shoot dry weight, leaf dry weight root dry weight were recorded. Root to shoot ratio was worked out. The leaf proline content was estimated by the method of Bates *et al*., (1973) [4] and chlorophyll content by using dimethyl sulfoxide (DMSO) as given by Shoaf and Loum (1976).

Results and Discussion

Shoot length of the cotton varieties under different field capacities and their mean values were calculated and presented in Table 1. Plant height could be considered an easy parameter to evaluate and compare different crop varieties for drought tolerance. Shoot length differed significantly with respect to moisture levels, genotypes and their interactions. Among the moisture levels, control recorded significantly higher shoot length (25.26 cm) which was followed by 50% and 25% of water supply (20.18 and 16.79 cm, respectively). There was a significant reduction in shoot length of all the varieties under drought stress. Among the genotypes BS-37 recorded (24.68 cm) which were on par with LRA-5166 and Sahana (24.26 and 23.86 cm, respectively) and which were followed by GBHV-177, CCH-12-3 and BS39 (22.52, 22.13 and 21.83 cm, respectively). The genotype RAH-806 recorded significantly lower shoot length (17.64 cm) was on par with the TSH-04/115 and GSHV-169 (17.77 and 17.64 cm, respectively) which was followed by CNH-1110 and RAH-100 (18.32 and 19.60 cm, respectively). This might be due to under moisture stress condition the plant increases the root length, root volume, root weight and lateral roots to absorb water form deeper surfaces, this caused decrease in shoot biomass. The decreased shoot length and leaves helps in reducing transpiration water loss from shoot surfaces. Shoots elongation significantly decreased by concentration of 2-8 MPa whereas no hypocotyl elongation was observed at concentration of 10 and 12 MPa and shoot elongation completely inhibited, it was in conformity with result observed by Tonin *et al*. (2000) [12].

The water regimes, genotypes and their interactions differed significantly with respect to root length presented in Table 1. In general water stress results in thinning of the roots, because of reduced the air space between cells of xylem vessels and increases the tap root length. Among the water regimes, 100% field capacity recorded significantly higher root length (20.57 cm), which was followed by (18.01 cm) 50% field capacity and the lower root length was observed under 25% field capacity (16.57 cm). Among the genotypes BS-37 recorded (24.57 cm) higher root length which was followed by LRA5166, Sahana, GBHV-177, CCH-12-3 and BS-39 (23.65, 22.68, 21.27, 20.87 and 20.16 cm, respectively) and the genotype RAH-806 recorded significantly lower root length (13.95 cm) was on par with the TSH-04/115, GSHV-169, CNH-1110 and RAH-100 (14.39, 13.07, 15.09 and 16.75 cm). This was due to the root traits play a major role in water stress tolerance under terminal water stress environments. In terms of root architecture, both more prolific root systems extracting more of the water in upper soil layers and longer root systems extracting soil moisture from deeper soil layers are important for maintaining yield under terminal water stress. Maruti and Katageri, (2015) [6] reported that the genotypes such as IC 359963 (2.25), RDT 17 (5.1%) and CPD 446 (4.1%) recorded significantly thinner roots than Sahana (4.9%) in both normal and water stress condition, also significantly increases their primary root length.

Data on number of secondary roots is presented in the Table 1 were differed significantly with respect to moisture levels, genotypes and their interactions. The genotypes Sahana recorded significantly higher secondary roots (44.17) which were followed by BS-37, LRA-5166, GBHV-177 and CCH-12-3 (41.33, 41.08, 37.83 and 36.83, respectively). The genotype RAH-806 recorded significantly lower secondary root (16.00) was followed by TSH- 04/115, RAH-100 and GSHV-169 (19.00, 20.33 and 23.83, respectively). Among the different waterregimes 50% field capacity recorded significantly higher number of secondary roots (36.86), which was followed by control (29.81) where as 25% field capacity recorded significantly (25.19) lower number of secondary roots. It was observed from the experiment that slight increase in stress condition increases secondary root numbers but severs stress condition decrease secondary root number and similar results are reported by Maruti and Katageri (2015) [6].

Moisture levels, genotypes and their interactions differed significantly with respect to root to shoot ratio (Table 1). The genotypes BS-37 recorded significantly higher (1.023) root to shoot ratio which was on par with LRA-5166, Sahana, GBHV-177, CCH-12-3 and BS-39(0.997, 0.966, 0.960, 0.960 and 0.938, respectively). The genotype GSHV-169 recorded significantly lower root to shoot ratio (0.746) was on par with the RAH-806 and TSH- 04/115 (0.797 and 0.815, respectively) and followed by CNH-1110, NDLH-1938 and RAH-100 (0.836, 0.853 and 0.862, respectively). Among the moisture levels 25% field capacity recorded significantly higher root to shoot ratio (0.980), which was followed by 50% field capacity (0.887) where as 100% field capacity (0.811) recorded significantly lower root to shoot ratio. Mc Michael and Quisenberry (1991) [7] in cotton and Ogbonnaya *et al*. (2003) [8] in cowpea reported that the water stress tolerant genotypes had higher root to shoot ratio than susceptible ones.

The results obtained on total dry matter accumulation and its distribution on leaf, stem and root dry weight during the growth as influenced by different field capacities, genotypes and their interactions are presented in Table 2. With respect to stem dry weight, different water regimes, genotypes and their interactions differed significantly. Among the field capacities, 100% recorded significantly higher stem dry weight (0.950 g) which was followed by 50% and 25% of water supply (0.760 and 0.630 g respectively). Among the genotypes BS-37 recorded (0.940 g) which was on par with LRA-5166 and Sahana (0.924 and 0.910 g, respectively) and which was followed by CCH-12-3, GBHV-177, BS-39 and GBHV-182 (0.880, 0.875, 0.873 and 0.868 g respectively). The genotype GSHV169 recorded significantly lower stem dry weight (0.477 g) which was followed by RAH-806 and TSH-04/115 (0.514 and 0.586 g, respectively).

Root dry weight reflects the amount of photosynthates diverted towards the roots. It is more important than fresh weight to identify the water stress tolerance, because the fresh root weight involves varying amount of water hold in the root biomass. According to Rezaeieh and Eivazi (2012) [10], root dry weight was the best indicator and easiest typical trait to determine the water stress tolerance of maize. Pace *et al*. (1999) [9]; Dewi (2009) [5] reported, that the water stress tolerant cultivars are maintained higher root dry weight and also record the higher number of secondary roots and tap root length in water stress condition. The result with respect to root dry weight is presented in Table 2. Where root dry weight differed significantly with respect to water regimes, genotypes and their interactions. The 100% field capacity recorded significantly higher root dry weight (0.478 g), which was followed by 50% field capacity (0.419 g) and the lower root dry weight was observed under 25% field capacity (0.387 g). Among the genotypes BS-37 recorded (0.595 g) higher root dry weight which was followed by LRA-5166, Sahana, GBHV177, CCH-12-3 and BS-39 (0.573, 0.564, 0.520, 0.528 and 0.518 g, respectively) and the genotype GSHV-169 recorded significantly lower shoot length (0.219 cm) was on par with RAH-806 (0.228 cm) which was followed by TSH-04/115, CNH1110 and RAH-100 (0.262, 0.285 and 0.364 cm, respectively). Increase in root dry weight may be due to higher primary root length, higher secondary root number and thicker roots and higher primary root length under water stress condition. It indicates that such genotypes have greater flexibility to adjust with the changing moisture level during crop growth stage but higher decreased root dry weight under drought condition as compared to the normal condition was due to decreasing primary root length, secondary root number and higher thinning of roots (Maruti and Katageri, 2015) [6].

Significant differences were observed for root to shoot ratio between genotype, water regimes and interaction effects (Table 2). The genotypes BS-37 recorded significantly higher (0.65) root to shoot ratio which was on par with LRA-5166 and Sahana (0.63 and 0.63, respectively) and followed by GBHV177, CCH-12-3 and BS-39 (0.60, 0.61 and 0.58, respectively). Whereas, the genotype RAH-806 recorded significantly lower root to shoot ratio (0.45) which was on par with the TSH04/115 and GSHV-169 (0.45 and 0.46, respectively) followed by CNH-1110 and RAH-100 (0.47 and 0.48, respectively). Among the different water regimes 25% field capacity recorded significantly higher root to shoot ratio (0.60), which was followed by 50% field capacity (0.54) where as 100% field capacity (0.49) recorded significantly lower root to shoot ratio.

The results obtained on leaf dry weight and total dry weight differed significantly with respect to water regimes, genotypes and their interaction are presented in Table 3. Present investigation revealed that the reduction in stem dry weight, leaf dry weight and total biomass as increased in the stress levels from 100 to 25% field capacity. The 100% field capacity recorded higher leaf dry weight and total dry weight (1.037 and 1.989 g, respectively) followed by 50% field capacity (0.829 and 1.589 g, respectively). Significantly lower leaf dry weight and total dry weight (0.700 and 1.334 g, respectively) was recorded under 25% field capacity. The genotypes BS-37 recorded significantly higher leaf dry weight and total dry weight (1.077 and 2.017 g, respectively) which was on par with LRA-5166 (1.024 and 1.948 g, respectively) and Sahana (1.011 and 1.921 g, respectively) and followed by GBHV-177 (0.962 and 1.836 g, respectively), CCH-12-3 (0.965 and 1.528g, respectively) and BS-39 (0.952 and 1.825 g, respectively). The genotype RAH-806 recorded significantly lower leaf dry weight and total dry weight (0.595 and 1.109 g, respectively) was followed by TSH- 04/115 (0.651 and 1.237 g, respectively), GSHV-169 (0.544 and 1.021 g), CNH-1110 (0.670 and 1.286 g, respectively) and RAH-100 (0.846 and 1.613 g, respectively). This study showed that the rapid decrease in plant biomass from 100% to 25% field capacity i.e., both in stress condition and among the genotypes, is mainly because of reduction in photosynthetic activity and other metabolic reaction because of drought condition (Rezaeieh and Eivazi, 2012) [10]. That mean changes occured due to stress condition was adoptive mechanism which uses most of its energy to accumulation of osmoregulants, activation of most of oxidative enzymes and also accumulation and translocation of assimilates to stem and root.

Significant differences were observed for proline and total chlorophyll content between genotype, water regimes and interaction effects (Table 3). Proline is a major osmoregulent, it is produced in larger amount under stress as compared to the normal conditions (Unyayar *et al*., 2004) [13]. Drought stress condition increases the proline content in the leaves. The proline was found higher in 25% field capacity (71.80 mg g-1 fr. Wt.) was followed by 50% field capacity (63.61 mg g-1 fr. Wt.) and lower proline content (46.61 mg g-1 fr. Wt.) was observed under 100% field capacity. Among the genotypes CCH-12-3 (70.46 mg g-1 fr. Wt.) and LRA-5166 recorded (69.93 mg g-1 fr. Wt.) significantly maximum proline content which was on par with the Sahana and (68.37 mg g-1 fr. Wt.) and followed by GBHV-182, GBHV-177, BS-37 and BS-39. Whereas lower proline content was recorded by GSHV-169 (49.29 mg g-1 fr. Wt.) followed by RAH-806, TSH-04/115 and RAH-100 (51.51, 54.24 and 56.96 mg g-1 fr. Wt., respectively). By measuring the chlorophyll content of a plant tissue, a reliable estimate of photosynthetic rate in green tissue of plants can be estimated. The genotype CCH-12-3 and Sahana recorded significantly higher total chlorophyll content (4.296 and 4.146 mg g-1 fr. Wt.) which was followed by BS-39 and LRA-5166 (3.914 and 3.745 mg g-1 fr. Wt., respectively) and lower total chlorophyll content was observed in RAH-100 (2.064 mg g-1 fr. Wt.) followed by TSH-04/115 and NDLH-1943 (2.350 and 2.353 mg g fr. Wt. -1, respectively).

It is concluded that the shoot length, root length, root to shoot ratio, leaf proline content, total chlorophyll content and dry weight summarized that, genotypes *viz*., Sahana, BS-37, LRA-5166, CCH-12-3 GBHV- 177, BS-39, GBHV-182, ARBH-1352 were found to be drought tolerant at lower field capacities of 25 and 50%.

Table 1: Effect of moisture stress on shoot length, root length, number of secondary root and root to shoot ratio of *hirsutum* cotton genotypes at 45 DAS grown in poly bags

Genotypes	Shoot length (cm)				Root length (cm)				Number of secondary roots				Root to shoot ratio (length basis)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
TSH-04/115	20.95^{j-n}	18.20^{p-s}	14.16^{v}	17.77^{g}	16.21^{r-y}	14.70^{x-z}	12.25^{z}	14.39^{kl}	17.50^{uv}	23.50^{q-s}	16.00^{uv}	19.00^{i}	0.77^{m-p}	0.81^{l-p}	0.87^{h-m}	0.82^{ij}
GBHV-182	25.68^{c-e}	21.33^{i-k}	17.60^{p-s}	21.54^{bc}	21.07^{e-g}	18.62^{i-o}	17.89^{l-r}	19.19^{d-f}	34.00^{i-k}	36.75^{e-i}	26.00^{pq}	32.25^{cd}	0.82^{k-o}	0.87^{h-m}	1.02^{a-f}	0.90^{d-g}
GBHV-177	22.81^{g-j}	16.71^{s-u}	15.22^{uv}	18.25^{fg}	19.20^{h-o}	16.53^{q-x}	15.95^{s-z}	17.23^{h}	31.19^{k-n}	33.62^{k-n}	27.14^{o-q}	30.65^{d}	0.84^{i-o}	0.90^{g-n}	1.02^{a-f}	0.90^{d-h}
PH-1060	25.67^{c-e}	21.45^{h-k}	17.24^{p-s}	21.45^{bc}	21.23^{e-g}	18.73^{i-o}	17.53^{n-u}	19.16^{d-f}	25.00^{qr}	36.00^{g-i}	26.50^{o-q}	29.17^{e}	0.83^{j-o}	0.87^{h-m}	1.02^{a-f}	0.91^{c-f}
CCH-12-3	23.31^{e-}	17.33^{p-s}	15.12^{uv}	18.59^{e}	19.60^{g-}	17.14^{o-v}	15.86^{s-z}	17.53^{gh}	31.50^{k-}	34.44^{k}	26.88^{o-}	30.94^{d}	0.84^{i-o}	0.83^{j-o}	0.88^{h-n}	0.84^{c-f}

	g				m				n	-n	q	e				
GSHV-169	20.63^{k-o}	18.28^{h-k}	14.00^{v}	17.64^{g}	14.66^{x-z}	13.52^{z}	11.03^{z}	13.07^{m}	18.50^{tu}	35.50^{g-i}	17.50^{uv}	23.83^{g}	0.71^{p}	0.74^{op}	0.79^{m-p}	0.75^{k}
TCH-1777	23.97^{e-g}	19.06^{k-o}	17.50^{p-s}	20.18^{de}	19.60^{g-m}	16.42^{q-x}	17.15^{o-v}	17.72^{gh}	31.50^{k-n}	40.50^{b-d}	16.00^{uv}	29.33^{e}	0.82^{k-o}	0.86^{h-m}	0.98^{b-g}	0.89^{d-h}
SCS-1213	24.26^{e-g}	21.16^{p-r}	18.04^{p-s}	21.15^{cd}	19.85^{f-l}	18.28^{k-q}	17.74^{m-s}	18.62^{fg}	31.50^{k-n}	40.00^{b-e}	30.00^{mn}	33.83^{c}	0.82^{k-o}	0.86^{h-m}	0.98^{b-g}	0.89^{d-h}
SCS-1062	23.43^{f-h}	19.27^{n-q}	17.00^{q-t}	19.90^{e}	19.11^{h-o}	16.17^{r-y}	16.66^{p-w}	17.31^{h}	30.50^{l-n}	40.00^{b-e}	26.00^{pq}	32.17^{cd}	0.82^{k-o}	0.84^{i-o}	0.98^{b-g}	0.88^{e-h}
AKH-09-5	23.32^{f-i}	19.10^{j-l}	16.13^{s-u}	19.52^{e}	18.87^{i-o}	15.93^{s-z}	15.68^{u-z}	16.83^{hi}	30.00^{mn}	40.00^{b-e}	25.00^{qr}	31.67^{d}	0.81^{l-p}	0.83^{j-o}	0.97^{c-g}	0.87^{e-i}
NDLH-1943	24.10^{e-g}	18.53^{l-p}	15.00^{uv}	19.21^{ef}	18.83^{i-o}	15.19^{w-z}	13.97^{z}	16.00^{ij}	22.50^{rs}	31.50^{k-n}	25.00^{qr}	26.33^{f}	0.78^{m-p}	0.82^{k-o}	0.93^{e-j}	0.84^{h-j}
CNH-1110	22.73^{g-j}	18.42^{m-q}	13.80^{v}	18.32^{fg}	17.60^{n-t}	14.95^{w-z}	12.74^{z}	15.10^{jk}	29.00^{m-p}	39.50^{c-f}	29.50^{m-o}	32.67^{cd}	0.77^{m-p}	0.81^{l-p}	0.92^{f-k}	0.84^{h-j}
ARBH-1352	26.26^{b-d}	21.62^{p-r}	17.47^{p-s}	21.78^{bc}	21.76^{d-f}	19.35^{g-n}	18.01^{k-r}	19.71^{de}	29.00^{m-p}	30.50^{l-n}	16.50^{uv}	25.33^{fg}	0.83^{j-o}	0.90^{g-l}	1.03^{a-e}	0.92^{c-e}
NDLH-1938	24.02^{e-g}	18.68^{o-r}	15.12^{t-v}	19.27^{ef}	19.08^{h-o}	15.44^{v-z}	14.21^{z}	16.24^{i}	22.00^{rs}	26.50^{o-q}	16.00^{uv}	21.50^{h}	0.79^{m-p}	0.83^{j-o}	0.94^{e-i}	0.85^{g-j}
RAH-806	20.70^{j-o}	18.11^{p-s}	14.11^{v}	17.64^{g}	15.52^{a}	14.31^{yz}	12.01^{z}	13.95^{lm}	15.00^{vw}	21.00st	12.00^{w}	16.00^{j}	0.75^{n-p}	0.79^{m-p}	0.85^{h-n}	0.80^{jk}
BS-37	32.82^{a}	22.34^{g-k}	18.90^{n-q}	24.69^{a}	28.09^{a}	24.73^{b}	20.89^{e-h}	24.57^{a}	39.50^{c-f}	48.00^{a}	36.50^{f-i}	41.33^{a}	0.86^{h-m}	1.11^{a}	1.11^{a}	1.02^{a}
BS-39	26.87^{bc}	21.17^{j-l}	17.43^{p-s}	21.82^{bc}	22.54^{c-e}	19.93^{f-k}	18.01^{k-r}	20.16^{cd}	35.00^{h-j}	43.00^{b}	30.50^{l-n}	36.17^{b}	0.84^{i-o}	0.94^{e-i}	1.03^{a-e}	0.94^{cd}
GJHV-516	24.85^{d-f}	21.11^{j-m}	17.96^{p-s}	21.31^{c}	20.34^{f-j}	18.38^{j-p}	17.89^{l-r}	18.87^{ef}	28.50^{n-p}	38.50^{c-g}	29.50^{m-o}	32.17^{cd}	0.82^{k-o}	0.87^{h-m}	1.00^{b-g}	0.90^{d-g}
LRA-5166 (NC)	31.22^{a}	22.63^{g-k}	18.92^{n-q}	24.26^{a}	26.54^{a}	24.01^{bc}	20.41^{f-i}	23.65^{a}	41.00^{bc}	47.75^{a}	34.50^{h-k}	41.08^{a}	0.85^{h-n}	1.06^{a-c}	1.08^{ab}	1.00^{ab}
RAH-100 (ZC)	23.38^{f-h}	18.86^{o-q}	16.56^{r-u}	19.60^{e}	18.87^{i-o}	15.71^{t-z}	15.68^{u-z}	16.75^{hi}	24.00^{q-s}	22.00^{rs}	15.00^{vw}	20.33^{hi}	0.81^{l-p}	0.83^{j-o}	0.95^{d-h}	0.86^{f-i}
Sahana (LC)	29.61^{a}	23.15^{a}	18.83^{a}	23.86^{a}	25.17^{a}	23.10^{a}	19.78^{a}	22.68^{a}	46.00^{a}	51.00^{a}	35.50^{a}	44.17^{a}	0.850^{a}	0.998^{a}	1.051^{a}	0.96^{a}
Mean	24.55	19.67	16.36		19.93	17.40	16.08		28.33	35.43	24.10		0.79	0.86	0.96	
	S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %	
F	0.28		1.04		0.26		0.97		0.46		1.74		0.01		0.05	
G	0.11		0.40		0.10		0.37		0.18		0.68		0.01		0.02	
F x G	0.48		1.81		0.44		1.67		0.80		3.02		0.02		0.09	

Note: F: Field capacity, G: Genotypes, F1: 100 % field capacity, F2: 50 % field capacity, F3: 25 % field capacity

Table 2: Effect of moisture stress on stem dry weight, root dry weight and rot to shoot ratio of *hirsutum* cotton genotypes at 45 DAS grown in poly bags

Genotypes	Shoot dry weight (g plant^{-1})				Root dry weight (g plant^{-1})				Root to shoot ratio (dry weight basis)			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
TSH-04/115	1.50^{q-w}	1.25^{z}	0.95^{z}	1.24^{g}	0.30^{t-w}	0.27^{w-y}	0.22^{z}	0.26^{k}	0.20^{kl}	0.21^{jk}	0.23^{h-k}	0.21^{g}
GBHV-182	2.12^{c-e}	1.77^{i-n}	1.49^{q-x}	1.79^{bc}	0.55^{de}	0.48^{f-j}	0.46^{h-k}	0.50^{de}	0.26^{e-h}	0.27^{d-g}	0.31^{a-c}	0.28^{b}
GBHV-177	1.85^{i-j}	1.36^{v-z}	1.26^{yz}	1.49^{f}	0.47^{g-k}	0.40^{m-p}	0.39^{k-n}	0.42^{g}	0.25^{f-i}	0.30^{a-d}	0.31^{a-c}	0.29^{ab}
PH-1060	2.12^{c-e}	1.77^{i-n}	1.42^{u-z}	1.77^{bc}	0.57^{cd}	0.50^{f-h}	0.47^{g-k}	0.51^{cd}	0.27^{d-g}	0.28^{c-f}	0.33^{a}	0.29^{ab}
CCH-12-3	1.92^{f-h}	1.45^{l-w}	1.28^{y-z}	1.55^{f}	0.50^{e}	0.43^{k-n}	0.40^{m-p}	0.44^{f}	0.26^{e-h}	0.30^{a-d}	0.31^{a-c}	0.29^{ab}
GSHV-169	1.23^{z}	1.04^{z}	0.80^{z}	1.02^{i}	0.25^{x-z}	0.23^{yz}	0.19^{z}	0.22^{l}	0.20^{kl}	0.22^{i-k}	0.23^{h-k}	0.22^{fg}
TCH-1777	1.99^{e-g}	1.57^{o-u}	1.44^{t-z}	1.67^{de}	0.46^{h-k}	0.39^{n-p}	0.41^{l-o}	0.42^{g}	0.23^{h-k}	0.25^{f-i}	0.28^{c-f}	0.25^{cd}
SCS-1213	2.02^{d-f}	1.72^{j-o}	1.48^{r-y}	1.74^{cd}	0.48^{f-j}	0.44^{j-m}	0.43^{k-n}	0.45^{f}	0.24^{g-j}	0.26^{e-h}	0.29^{b-e}	0.26^{c}
SCS-1062	1.94^{f-h}	1.65^{l-q}	1.40^{v-z}	1.66^{de}	0.43^{k-n}	0.37^{o-r}	0.38^{o-q}	0.39^{h}	0.22^{i-k}	0.22^{i-k}	0.27^{d-g}	0.24^{de}
AKH-09-5	1.90^{f-i}	1.60^{o-t}	1.32^{yz}	1.61^{e}	0.43^{k-n}	0.36^{p-s}	0.36^{p-s}	0.38^{hi}	0.23^{h-k}	0.23^{h-k}	0.27^{d-g}	0.24^{de}
NDLH-1943	1.80^{h-l}	1.39^{v-z}	1.12^{z}	1.44^{f}	0.40^{m-p}	0.32^{s-v}	0.29^{u-w}	0.34^{j}	0.22^{i-k}	0.23^{h-k}	0.26^{e-h}	0.24^{de}
CNH-1110	1.60^{o-t}	1.30^{z}	0.96^{z}	1.29^{g}	0.33^{r-u}	0.28^{v-x}	0.24^{x-z}	0.28^{k}	0.21^{jk}	0.22^{i-k}	0.25^{f-i}	0.23^{ef}
ARBH-1352	2.16^{b-d}	1.82^{h-k}	1.45^{s-z}	1.81^{bc}	0.57^{cd}	0.51^{fg}	0.47^{g-k}	0.52^{cd}	0.26^{e-h}	0.28^{c-f}	0.33^{a}	0.29^{ab}
NDLH-1938	1.88^{f-j}	1.50^{q-w}	1.18^{z}	1.52^{f}	0.41^{l-o}	0.33^{r-u}	0.31^{t-w}	0.35^{j}	0.22^{i-k}	0.22^{i-k}	0.26^{e-h}	0.23^{ef}
RAH-806	1.38^{w-z}	1.09^{z}	0.86^{z}	1.11^{h}	0.25^{x-z}	0.23^{yz}	0.20^{z}	0.23^{l}	0.18^{l}	0.21^{jk}	0.23^{h-k}	0.21^{g}
BS-37	2.59^{a}	1.84^{g-j}	1.63^{m-r}	2.02^{a}	0.68^{a}	0.60^{c}	0.51^{fg}	0.60^{a}	0.26^{e-h}	0.33^{a}	0.31^{a-c}	0.30^{a}
BS-39	2.25^{bc}	1.78^{h-m}	1.44^{t-z}	1.82^{bc}	0.58^{cd}	0.51^{fg}	0.46^{h-k}	0.52^{cd}	0.26^{e-h}	0.29^{b-e}	0.32^{ab}	0.29^{ab}
GJHV-516	2.03^{d-f}	1.67^{k-p}	1.47^{r-y}	1.73^{cd}	0.52^{ef}	0.47^{g-k}	0.45^{i-l}	0.48^{e}	0.25^{f-i}	0.28^{c-f}	0.31^{a-c}	0.28^{b}
LRA-5166 (NC)	2.45^{a}	1.78^{h-m}	1.61^{n-s}	1.95^{a}	0.64^{b}	0.58^{fcd}	0.49^{b}	0.57^{b}	0.26^{e-h}	0.33^{a}	0.31^{a-c}	0.30^{a}
RAH-100 (ZC)	1.88^{f-j}	1.63^{m-r}	1.33^{x-z}	1.61^{e}	0.41^{l-o}	0.34^{q-t}	0.34^{j}	0.36^{ij}	0.22^{i-k}	0.21^{jk}	0.26^{e-h}	0.23^{ef}
Sahana (LC)	1.13^{a}	0.88^{a}	0.72^{a}	**0.91**^{a}	0.626^{a}	0.574^{a}	0.492^{a}	**0.564**	0.55^{a}	0.65^{a}	0.69^{a}	**0.63**^{a}
Mean	1.93	1.55	1.29		0.46	0.40	0.37		0.23	0.26	0.28	
	S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %	
F	0.02		0.08		0.01		0.02		0.00		0.01	
G	0.01		0.03		0.00		0.01		0.00		0.01	
F x G	0.04		0.14		0.01		0.04		0.01		0.03	

Note: F: Field capacity G: Genotypes F_1: 100 % field capacity F_2: 50 % field capacity F_3: 25 % field capacity

Table 3. Effect of moisture stress on leaf dry weight, total dry matter and biochemical parameters at 45 DAS in *hirsutum* cotton genotypes grown in poly bags

Genotypes	Leaf dry weight (g plant^{-1})				Total dry matter (g plant^{-1})				Proline (µg g fr. wt.$^{-1}$)				Total chlorophyll (mg g fr. wt.$^{-1}$)			
	F_1	**F_2**	**F_3**	**Mean**	**F_1**	**F_2**	**F_3**	**Mean**	**F_1**	**F_2**	**F_3**	**Mean**	**F_1**	**F_2**	**F_3**	**Mean**
TSH-04/115	0.81^{n-q}	0.65^{t-v}	0.49^{xy}	0.65^{l}	1.80^{q-u}	1.52^{w-z}	1.18^{z}	1.50^{g}	22.25^{u-y}	30.36^{o-s}	36.89^{e-l}	29.83^{cd}	2.44^{jk}	1.49^{w-z}	1.35^{yz}	1.76^{h}
GBHV-182	1.08^{de}	0.91^{h-l}	0.78^{o-r}	0.92^{d-g}	2.67^{b-d}	2.25^{g-j}	1.96^{l-r}	2.29^{bc}	33.31^{l-q}	36.40^{e-l}	39.18^{b-f}	36.30^{b}	2.93^{d-f}	1.94^{n-q}	1.83^{p-s}	2.23^{e}
GBHV-177	0.96^{g-j}	0.71^{r-t}	0.67^{s-z}	0.78^{k}	2.86^{b}	2.17^{h-l}	2.03^{k-p}	2.35^{b}	22.65^{u-w}	30.44^{o-s}	34.13^{s-o}	29.07^{c-d}	2.24^{j-l}	2.28^{j-l}	1.81^{o-r}	2.11^{e-f}
PH-1060	1.09^{de}	0.91^{h-l}	0.73^{q-t}	0.91^{e-h}	2.69^{b-d}	2.27^{g-j}	1.89^{p-s}	2.28^{bc}	29.01^{r-t}	36.46^{e-l}	39.23^{b-f}	34.90^{b}	2.84^{e-h}	2.03^{n-p}	1.85^{o-s}	2.24^{e}
CCH-12-3	0.99^{f-h}	0.76^{o-r}	0.68^{s-v}	0.81^{j}	2.87^{b}	2.24^{g-j}	2.01^{k-q}	2.37^{b}	31.10^{n-s}	31.49^{n-s}	35.07^{f-m}	32.55^{j-q}	2.74^{h-i}	2.13^{n-o}	1.67^{s-w}	2.18^{e-f}
GSHV-169	0.68^{s-u}	0.54^{wx}	0.42^{y}	0.54^{n}	1.48^{x-z}	1.26^{z}	0.98^{z}	1.24^{h}	18.58^{y}	28.69^{r-t}	34.05^{i-p}	27.11^{e}	3.65^{a}	1.43^{w-z}	1.31^{z}	2.13^{ef}
TCH-1777	1.05^{d-f}	0.82^{m-p}	0.75^{p-s}	0.87^{h-j}	2.45^{e-g}	1.96^{l-r}	1.85^{p-t}	2.09^{de}	22.40^{u-y}	34.90^{g-n}	38.64^{b-g}	31.98^{c}	2.33^{kl}	1.84^{o-s}	1.72^{r-v}	1.97^{g}
SCS-1213	1.06^{d-f}	0.88^{i-n}	0.77^{o-r}	0.90^{f-h}	2.50^{d-f}	2.16^{h-l}	1.91^{o-s}	2.19^{cd}	28.76^{r-t}	35.37^{f-m}	38.65^{b-g}	34.26^{b}	2.78^{f-h}	1.84^{o-s}	1.76^{q-t}	2.13^{ef}
SCS-1062	1.02^{e-g}	0.89^{i-n}	0.74^{p-s}	0.88^{g-j}	2.37^{e-h}	2.02^{k-p}	1.78^{r-v}	2.06^{e}	22.81^{u-w}	34.66^{g-n}	38.33^{b-h}	31.93^{c}	3.00^{c-e}	1.73^{q-u}	1.57^{t-x}	2.10^{f}
AKH-09-5	0.98^{f-h}	0.85^{k-o}	0.68^{s-u}	0.84^{j}	2.33^{f-i}	1.96^{l-r}	1.68^{t-x}	1.99^{e}	19.23^{w-y}	34.27^{h-o}	38.26^{b-h}	30.58^{c}	3.12^{cd}	1.71^{r-v}	1.53^{u-y}	2.12^{ef}
NDLH-1943	0.93^{h-k}	0.72^{r-t}	0.58^{vw}	0.74^{k}	2.20^{h-k}	1.72^{s-w}	1.42^{yz}	1.78^{f}	22.54^{u-x}	33.46^{k-q}	37.48^{e-k}	31.16^{c}	2.35^{j-l}	1.54^{u-y}	1.41^{x-z}	1.76^{h}
CNH-1110	0.84^{l-o}	0.68^{s-u}	0.49^{xy}	0.67^{l}	1.93^{m-s}	1.59^{v-y}	1.19^{z}	1.57^{g}	19.87^{v-y}	32.33^{m-r}	37.05^{e-l}	29.75^{cd}	2.99^{c-e}	1.51^{v-z}	1.39^{x-z}	1.96^{g}
ARBH-1352	1.11^{cd}	0.95^{g-j}	0.75^{p-s}	0.94^{c-f}	2.73^{bc}	2.32^{f-j}	1.92^{n-s}	2.32^{b}	25.62^{tu}	36.51^{e-l}	40.16^{b-e}	34.10^{b}	2.69^{hi}	2.05^{m-o}	1.87^{o-r}	2.20^{ef}
NDLH-1938	0.95^{g-j}	0.78^{o-r}	0.60^{u-w}	0.77^{k}	2.29^{f-j}	1.83^{p-u}	1.49^{x-z}	1.87^{f}	22.44^{u-y}	33.59^{j-q}	37.65^{d-j}	31.23^{c}	2.35^{j-l}	1.64^{s-w}	1.43^{w-z}	1.80^{h}
RAH-806	0.78^{o-r}	0.56^{wx}	0.45^{y}	0.60^{m}	1.63^{u-x}	1.33^{z}	1.05^{z}	1.34^{h}	18.67^{xy}	30.22^{p-s}	36.11^{e-m}	28.33^{de}	2.70^{hi}	1.46^{w-z}	1.35^{yz}	1.84^{h}
BS-37	1.34^{a}	0.98^{f-h}	0.91^{h-l}	1.08^{a}	3.27^{a}	2.43^{e-g}	2.13^{i-n}	2.61^{a}	23.72^{uv}	38.56^{b-g}	46.07^{a}	36.11^{b}	2.54^{ij}	3.35^{b}	2.92^{d-g}	2.94^{a}
BS-39	1.18^{bc}	0.94^{g-j}	0.74^{p-s}	0.95^{c-e}	2.83^{b}	2.30^{f-j}	1.91^{o-s}	2.34^{b}	27.76^{st}	36.96^{e-l}	41.62^{b-d}	35.45^{b}	2.72^{g-i}	2.66^{hi}	1.88^{n-r}	2.42^{d}
GJHV-516	1.06^{d-f}	0.85^{k-o}	0.77^{o-r}	0.89^{g-i}	2.55^{c-e}	2.14^{i-m}	1.92^{n-s}	2.20^{cd}	29.72^{q-s}	36.29^{e-m}	38.79^{b-g}	34.93^{b}	2.95^{c-f}	1.90^{n-r}	1.80^{q-s}	2.22^{e}
LRA-5166 NC)	1.27^{a}	0.92^{h-l}	0.89^{i-n}	1.02^{b}	3.10^{a}	2.36^{e-h}	2.11^{j-o}	2.52^{a}	31.03^{n-s}	38.32^{b-h}	46.03^{a}	38.46^{a}	3.05^{cd}	3.14^{c}	2.24^{k-m}	2.81^{b}
RAH-100 (ZC)	0.96^{g-i}	0.89^{i-n}	0.68^{s-u}	0.85^{ij}	2.28^{g-j}	1.97^{l-r}	1.67^{t-x}	1.98^{e}	21.98^{u-y}	34.25^{h-o}	37.76^{c-i}	31.33^{c}	1.57^{t-x}	1.64^{s-w}	1.44^{w-z}	1.55^{i}
Sahana (LC)	1.245^{a}	0.920^{a}	0.868^{a}	1.011^{a}	2.374^{a}	1.803^{a}	1.586^{a}	1.921^{a}	57.00^{a}	69.18^{a}	78.92^{a}	68.37^{a}	4.056^{a}	4.640^{a}	3.741^{a}	4.146^{a}
Mean	1.01	0.81	0.68		2.44	1.99	1.70		24.67	34.18	38.56		2.70	1.97	1.71	
	S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %		S.Em. ±		L.S.D. @ 5 %	
F	0.01		0.04		0.03		0.11		0.53		2.01		0.03		0.11	
G	0.00		0.02		0.01		0.04		0.21		0.78		0.01		0.04	
F x G	0.02		0.08		0.05		0.18		0.93		3.49		0.05		0.19	

Note: F: Field capacity G: Genotypes F1: 100 % field capacity F2: 50 % field capacity F3: 25 % field capacity

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