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Evaluation of Hirsutum Cotton Genotypes for Water Stress using Peg-6000 by Slanting Glass Plate Technique

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ABSTRACT

Laboratory experiment was conducted during 2016 at Agriculture Research Station, Crop physiology division, Dharwad, to screen cotton varieties to water stress condition for seed germination and seedling growth. Study consisted of 19 Gossypium hirsutum varieties with two checks. The genotypes were subjected to different osmotic potentials (0.0 MPa (0 bar), - 0.140 MPa (-1 bar) and -0.39 MPa (-3.9 bar)) by slanting glass plate technique. The genotypes were screened for percent seed germination, root length, shoot length and seedling vigour traits (seedling vigor index, shoot vigor index, and root vigor index) at 3rd, 7th and 12th day. Where, the germination percentage at different PEG-6000 concentrations is 87.6 %, 76.4 % and 19.0% and maximum germination per cent at higher PEG concentrations (20%) was 60% and at this concentration the shoot growth was completely inhibited in all the genotypes. As the PEG concentration increases there was a decrease in germination and increase in root to shoot ratio. The genotypes which found tolerant to the increased osmotic potential were Sahana, BS-37, LRA-5166, CCH-12-3 GBHV- 177, BS-39, GBHV-182, ARBH-1352, and the gneotypes RAH-806, TSH-4/115, CNH-1110, NDLH-1943, NDLH-1938, RAH-100 are less tolerant to different osmotic stress condition.

Key words: *Osmotic potential, Hirsutum cotton, PEG-6000, Water stress*

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. Cotton is cultivated in 70 countries of the world with the total coverage of 33.1 m ha, production of 116.6 m bales and a productivity of 76.6 kg lint ha^{-1}. India being the traditional home for cotton and cotton textiles, the cultivated area occupying about 11.8 m ha producing 35.2 m bales with the productivity of 504 kg lint ha^{-1}. In Karnataka, it is grown in an area of 6.12 lakh ha with a production of 20 lakh bales and productivity of 556 kg lint ha^{-1} [1]. Though, India has the largest area under cotton, it ranks third in production due to low productivity.

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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 since water is the primary component of actively growing plants ranging from 70–90% of plant fresh mass. 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.

The effect of water stress on growth, yield components and quality characters are widely different and severe. The turgor loss is the first effect of water stress that influences cell growth rate and its final volume. Cotton is one of the most important economic crops in world. It is grown in both dry land and irrigated areas. Among the abiotic stresses, water stress is recognized as the most devasting cause which limits the fiber yield and lint quality in cotton production. The flowering and boll development stage are the critical stages of irrigation that determines the yield in cotton. Short-duration water stress occurring during this stage significantly affects various physiological and biochemical characters in cotton plants, such as leaf expansion, photosynthesis, carbon and nitrogen metabolism and antioxidant metabolism.

The PEG was first time used as an inducer and identifier to screen and select drought resistant tobacco cell lines. Chinese researchers used to do cotton drought evaluation and identification by repeated drought induction method. It is still in the experimental stage to use PEG solution for the identification. PEG-6000 was used to establish a rapid and effective cotton-drought tolerance evaluation system for selection and breeding of the drought-tolerant cotton genotypes[7]. Earlier germination studies have been carried out with aqueous solutions of polyethyleneglycol-6000 (PEG-6000) and mannitol[5]. Laboratory assays simulating water stress circumstances have aided researchers for the identification of cultivars with an elevated level of resistance to such adverse conditions in other crops, such as maize[11]. Water stress induced by PEG, leads to decrease in the germination index and the morphological development of organs from young cotton plants and also reported that water absorption, retention and biomass gain were affected by water stress[6]. Performance of cotton genotypes for drought tolerance using PEG water stress at germination, bud-stage, cotyledon stage and real-leaf stage revealed that at 17% PEG-6000 treatment the seedlings growth rate showed inhibition. Physiological quality of cotton cultivar seeds were evaluated in laboratory by the simulation of water potentials with polyethyleneglycol-6000 (0.0; -0.2; -0.4; -0.6; -0.8; -1.0 MPa), at 25 ºC using germitest paper as substrate. The effect of water stress on seed viability and on plantlet vigor was severe at potentials below -0.4 MPa. Differential viability and vigor between cultivars were observed under the water stress levels with polyethyleneglycol-6000 [4]. Evaluation of the germination capacity of seeds is one of the most common methods used to determine the tolerance of plants to abiotic stresses[15]. PEG

has been used to establish a rapid and effective cotton-drought tolerance evaluation system for selection and breeding of the drought tolerant resources[13]. That osmotic adjustment using PEG-6000 in cotton could be used to evaluate the drought tolerance of cotton. This method is simple, fast and easily operated, could be used to evaluate the drought tolerance of cotton[3]. Hence in this direction by knowing the economic importance of cotton all over the India and of the factors which interfere in its cotton seed germination, the present study aimed to evaluate the effect of drought stress on the viability and vigor of cotton cultivar seeds in germination phase. Hence the objective of this paper is to evaluation and identification of twelve Indian cotton genotypes for drought tolerance using PEG 6000 as an osmotic stress inducer by slanting glass plate method.

This study was carried out in order to evaluate cotton varieties to drought stress and determine the best drought indices measures for increase and improvement of varieties yield in stress and non-stress condition. Also, this study was undertaken to assess the selection criteria for identifying drought tolerance in cotton varieties, so that suitable varieties can be recommended for cultivation in drought prone areas.

MATERIALS AND METHODS

The laboratory experiment was carried out in division of Crop Physiology, Agriculture Research Station, Dharwad, India to screen twenty one cotton verities 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 with National check (LRA–5166) and Local check (RAH – 100) and Sahana were used to assess their performance for drought tolerance during 2016. The genotypes were screened for tolerance to different osmotic stress conditions by slanting glass plate technique using different osmotic potentials of (0.0 MPa (0 bar), - 0.140 MPa (-1 bar) and -0.39 MPa (-3.9 bar)) by using Poly ethylene glycol-6000 (PEG-6000) at germination stage[3].

The concentrations of PEG-6000 required to obtain these values were determined by using the equation of Miche *et al.*[7]:

$$\Psi s = -(1.18\times10^{-2})\,C - (1.18\times10^{-4})\,C_2 + (2.67\times10^{-4})\,CT + (8.39\times10^{-7})\,C_2T$$

Where, Ψs=osmotic potential (bar)

C=concentration (g L^{-1} PEG-6000 in water)

T=temperature (^oC)

As a control, a solution with osmotic potential Ψs=0.0 MPa (0.0 bar) was used. The germination percentage, root length and shoot length parameters were recorded from all the germinated seedlings at 3rd, 7th and 12th days after imposing the treatments and the mean values are presented in tables.

The delinted seeds were initially disinfected with 0.1% $HgCl_2$ for 5 minutes. Six seeds were kept on top portion of the filter paper/glass plate at **3** cm spacing. The seeds were covered with a small strip of filter paper. Suitable holding material was used to avoid the fall of seeds in slanting position. Initially little quantity of respective prepared PEG solutions was added on to the small strip of filter paper which helps in adsorption of seeds on to filter paper firmly. Glass plate was inserted in polythene cover. The plate was transferred on the supporting wooden block in slanting position. 250 ml of corresponding concentrations (0%, 10% and 20%) of PEG-6000 osmotic solutions were added separately into the respective polythene cover carrying separate genotype seeds in slanting plate. The PEG solution moved upward and reached to the seeds by capillary movement through filter paper. Seedlings were allowed to grow under room temperature. Fresh PEG solutions were added in regular intervals of three days to maintain the level of solution. No need of

providing aeration to roots, since regularly exchange of fresh PEG solutions was done (Fig. 1).

Observations

Germination (%) -The seedlings emerged from PEG-6000 solutions were considered as germinated and observation was recorded at 3rd, 7th and 12th day and expressed in percentage.

***Root length (cm)* –** Germinated seedling roots in each replication were measured from collar region to the tip of the longest root at 3rd, 7th and 12th day was expressed in cm.

***Shoot length (cm)* -** The shoot length of above selected seedling was measured from collar region to tip of the shoot at 3rd, 7th and 12th day and was expressed in cm.

***Root: shoot ratio* -** The ratio of root length and the shoot length of each seedling selected above was calculated.

***Seedling vigour* -** Shoot and root vigour indices were calculated by multiplying shoot length or root length (at 12th day) in to germination percentage as described by [14].

Shoot vigour index=Shoot length x germination %

Root length index = root length × germination %

Seedling vigour index = (root length + shoot length) × germination %

RESULTS AND DISCUSSION

Germination percentage (%)

The PEG concentration and genotypes are differed significantly with respect to germination percentage and shoot length was presented in table 1.

Experimental results showed that final germination percent of *hirsutum* varieties significantly affected by PEG 6000. The final germination per cent decreased by increasing osmotic potential. In distilled water (Control), percentage of seed germination was highest. As the concentration of PEG-6000increases seed germination is restricted. The seed germination percentage decreased as the PEG 6000 concentration increases from 0% to 20%. The PEG concentrations, genotypes and their interactions differed significantly with respect to germination percentage. Among the PEG concentrations, control (0.00 concentration) recorded significantly higher germination per cent (87.6), which was significantly differed with 10 % (76.4) and 20 % (19.0). Whereas the genotypes, Sahana recorded highest (86.7) germination percentage Followed by BS-37, LRA-5166, GBHV-177, CCH-12-3 and BS-39 the genotypes such as, RAH-806 recorded less germination per cent (20.0) followed by TSH-04/115, CNH-1110, NDLH-1943, NDLH-1938 and RAH-100. The genotype Sahana, BS-37, LRA-5166, ARBH-1357, BS-39 and CCH-12-3 are germinated well under all the PEG concentrations, hence these genotypes were considered as an osmotic stress tolerant. Results were conformity with[2] decreased seed germination is due to reduction in imbibitions of water by seeds which leads to a series of metabolic changes, including general reduction in hydrolysis and utilization of the seed reserve. Increase osmotic stress limit the mobilization of reserves in several species damages cellular machinery. Higher concentration of PEG is the lethal water potential for germination of cotton seeds, hence the germination was ceased[3,10].

Shoot length (cm)

The shoot length decreased with the increase in PEG-6000 concentrations from 0% to 20%. 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 Table 1 showed that different PEG concentrations and genotypes differed significantly with respect to shoot length at 3rd, 7th and 12th day. At 3rd day, among the PEG concentration, control recorded significantly higher (2.57 cm) shoot length than 10 per cent and 20 per cent of PEG

concentration (no shoot growth was observed). Among the genotypes, Sahana (4.60 cm) was recorded significantly higher shoot length which was followed by BS-37 (4.20 cm), LRA-5166 (4.00 cm), ARBH-1352 (3.20 cm) and BS-39 (3.30 cm) and significantly less shoot length was recorded by RAH-806 (0.45 cm) and TSH-04/115 (0.75 cm) was followed by RAH-100 (1.70 cm), NDLH-1938 (1.70 cm) and CNH-1110 (1.10 cm).

Whereas the PEG concentration at 7th day for shoot length was recorded significantly maximum in control (5.71 cm) followed by 10 per cent (2.58 cm) and less shoot length was recorded in 20 per cent (0.06 cm). Among the genotypes, Sahana recorded significantly higher shoot length (4.97 cm) which was followed by BS-37, LRA-5166, GBHV-177, CCH-12-3, and BS-39, (4.23, 4.15, 3.90, 3.77 and 3.68 cm, respectively). Whereas, lower shoot length was recorded by RAH-806 (0.52 cm) followed by TSH-04/115 (0.88 cm), CNH-1110 (1.17 cm), NDLH-1943 (1.27 cm), NDLH-1938 (1.67 cm) and RAH-100 (2.00 cm).

At 12th day under different PEG concentrations, the shoot length was recorded significantly highest in control (7.03 cm) followed by 10 per cent (3.31 cm) and less shoot length was recorded in 20 per cent (0.07 cm). The genotype Sahana recorded significantly higher shoot length (6.10 cm) which was followed by BS-37, LRA-5166, GBHV-177, CCH-12-3, BS-39 and ARBH-1352 (5.48, 5.11, 4.80, 4.65, 4.38 and 4.00 cm, respectively). Whereas, the genotype RAH-806 (0.57 cm) and TSH-04/115 (0.88 cm) followed by CNH-1110, NDLH-1943, NDLH-1938, GSHV-169 and RAH-100were recorded (1.57, 2.02, 2.45, 2.50 and 2.77 cm, respectively) significantly lower shoot length. 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 at concentration of 10 and 12 MPa and shoot elongation completely inhibited[3,11].

Root length (cm)

Root length was increased with the increasing PEG-6000 concentrations up to 10% of PEG-6000 concentrations it declined thereafter. The increased root length might be due to under water stress the plant required more photosynthates for the growth of roots rather than shoots, helps in absorbing more water from deeper surfaces[3]. The data on root length (cm) of *hirsutum* varieties as influenced by the different concentration of PEG-6000 and their interactions are presented in Table 2. In general, root length increased 3rd, 7th and 12th day. The root length differed significantly with respect to PEG-6000 concentration of 10 per cent and 20 per cent. Root length was significantly maximum at control, followed by 10 and 20 per cent (5.21, 0.00 and 0.00 cm, respectively) at 3rd day, whereas the maximum root length was observed in 10 per cent followed by control and 20 per cent at 7th day (7.37, 6.58 and 0.83 cm, respectively) and 12th day (24.21, 9.83 and 0.96 cm, respectively).

The root length differed significantly with respect to genotypes at 3rd, 7th and 12th day. Genotypes, Sahana, BS-37, LRA-5166, GBHV-177, CCH-12-3, BS-39, ARBH-1352 and PH-1060 recorded significantly higher root length till to 12th day (18.69, 17.11, 16.49, 16.03, 15.28, 15.15, 13.73 and 13.31 cm, respectively) than genotypes, RAH-806, TSH-04/115, CNH-1110, NDLH-1943, NDLH-1938, RAH-100 and AKH-09-5 recorded significantly lowest root length (5.34, 5.72, 7.10, 7.40, 7.93, 8.40 and 9.45 cm, respectively). The root to shoot ratio was also differed significantly with respect to different

concentrations of PEG-6000, genotypes and their interactions. Among the PEG-6000 concentrations root to shoot ratio was found maximum in 10 per cent (6.37) which was followed by 20 per cent and control (1.33 and 2.05, respectively) among the genotypes NDLH-1943and BS-37 recorded (8.58 and 7.36, respectively) significantly higher root to shoot ratio followed by, , GBHV-177, LRA-5166and Sahana (7.26, 5.12 and 4.14, respectively). These results are agree with [8] in cowpea, [9] in pearl millet and [12] in *Brassica juncea* they affirmed that a moderate and low osmotic stress (PEG) showed faster radicel growth and Low osmotic stress (-2 and -4 MPa) improves the root length of the seedlings.

Indices

Seedling indices like seedling vigor index, shoot vigor index, and root vigor index are calculated at 12th day of different PEG concentrations as per the standard formulae by using germination per cent, shoot length and root length differed significantly with respect, PEG concentrations, genotypes and their interactions.

Seedling vigor index

The seedling vigour index decreased with the increase in PEG-6000 concentrations. As shown in Table 3, the PEG concentrations, genotypes and their interactions differ significantly with respect to seedling vigor index values. 10 per cent PEG concentration were recorded (2311.8) significantly higher seedling vigor index than control and 20 per cent (1535.3 and 39.25, respectively). The genotype, Sahana was recorded (2422.0) significantly higher seedling vigor index which was followed by BS-37, LRA-5166, GBHV-177, CCH-12-3 and BS-39 (2122.8, 2107.3, 2036.7, 1824.4 and 1790.8, respectively). Whereas, the genotype RAH-806 (87.0) records significantly less seedling vigor index followed by TSH-04/115, CNH-1110, NDLH-1943, NDLH-1938, RAH-100, (227.6, 499.9, 601.5, 718.9 and 832.8, respectively).

***Shoot vigor index* (SVI)**

It could be seen from the Table 3 that PEG concentrations, genotypes and their interactions differed significantly at 12th day after sowing with respect to Shoot vigor index**.** Among the PEG concentration, significantly higher shoot vigor index was recorded in control (638.7) than 10 per cent and 20 per cent (299.9 and 3.31, respectively). The genotype, Sahana was recorded (601.3) significantly higher seedling vigor index which was followed by BS-37, LRA-5166, GBHV-177, CCH-12-3 and BS-39 (544.2, 505.7, 477.0, 445.3 and 422.8 respectively). Whereas, the genotype RAH-806 (34.0) recorded significantly less seedling vigor index followed by TSH-04/115, CNH-1110, NDLH-1943, NDLH-1938, RAH-100, (59.2, 105.0, 155.3, 187.0 and 216.3, respectively).

***Root vigor index* (RVI)**

The results obtained with respect to Root vigor index at 12th day (Table 3) indicated that PEG concentrations, genotypes and their interaction differed significantly. Among the PEG concentration, 10 per cent were recorded significantly higher root vigor index (2011.8) than control and 20 per cent (896.5 and 36.0, respectively). The genotype, Sahana was recorded (1820.7) significantly higher seedling vigor index which was followed by BS-37, LRA-5166, GBHV-177, CCH-12-3 and BS-39 (1660.7, 1601.7, 1559.7, 1379.0 and 1368.0, respectively). Whereas, the genotype RAH-806 (53.0) recorded significantly less seedling vigor index followed by TSH-04/115, CNH-1110, NDLH-1943, NDLH-1938 and RAH-100, (168.5, 395.0, 446.2, 531.9 and 616.4, respectively).

Table 1: Effect of different concentration of PEG on germination percentage and shoot length of *hirsutum* cotton varieties at 3rd, 7th and 12th day of the slanting glass plate technique

Genotypes	Germination (%)				Shoot length (cm)											
					At 3rd day				At 7th day				At 12th day			
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean
TSH-04/115	67.0	20.0	0.0	29.0	0.75	0.00	0.00	0.25	2.65	0.00	0.00	0.88	2.65	0.00	0.00	0.88
GBHV-182	93.0	90.0	20.0	67.7	3.15	0.00	0.00	1.05	6.20	3.15	0.00	3.12	7.35	4.35	0.00	3.90
GBHV-177	100.0	100.0	40.0	80.0	3.65	0.00	0.00	1.22	7.15	4.45	0.10	3.90	8.75	5.50	0.15	4.80
PH-1060	93.0	90.0	20.0	67.7	3.15	0.00	0.00	1.05	6.65	3.40	0.00	3.35	7.45	4.45	0.00	3.97
CCH-12-3	100.0	90.0	30.0	73.3	3.30	0.00	0.00	1.10	6.85	4.40	0.05	3.77	8.65	5.20	0.10	4.65
GSHV-169	93.0	85.0	10.0	62.7	1.45	0.00	0.00	0.48	6.00	0.80	0.00	2.27	6.00	1.50	0.00	2.50
TCH-1777	87.0	80.0	10.0	59.0	2.78	0.00	0.00	0.93	5.95	2.45	0.00	2.80	7.20	3.60	0.00	3.60
SCS-1213	87.0	90.0	10.0	62.3	2.80	0.00	0.00	0.93	6.00	2.80	0.00	2.93	7.20	3.95	0.00	3.72
SCS-1062	87.0	80.0	10.0	59.0	2.30	0.00	0.00	0.77	5.75	2.30	0.00	2.68	7.15	3.15	0.00	3.43
AKH-09-5	80.0	80.0	10.0	56.7	2.20	0.00	0.00	0.73	5.65	2.10	0.00	2.58	6.85	2.65	0.00	3.17
NDLH-1943	80.0	50.0	0.0	43.3	1.45	0.00	0.00	0.48	3.50	0.30	0.00	1.27	5.45	0.60	0.00	2.02
CNH-1110	67.0	50.0	0.0	39.0	1.10	0.00	0.00	0.37	3.50	0.00	0.00	1.17	4.70	0.00	0.00	1.57
ARBH-1352	93.0	90.0	20.0	67.7	3.20	0.00	0.00	1.07	6.70	3.60	0.00	3.43	7.50	4.50	0.00	4.00
NDLH-1938	80.0	60.0	10.0	50.0	1.70	0.00	0.00	0.57	4.20	0.80	0.00	1.67	6.00	1.35	0.00	2.45
RAH-806	60.0	0.0	0.0	20.0	0.45	0.00	0.00	0.15	1.55	0.00	0.00	0.52	1.70	0.00	0.00	0.57
BS-37	100.0	100.0	50.0	83.3	4.20	0.00	0.00	1.40	7.45	5.10	0.15	4.23	10.25	6.00	0.20	5.48
BS-39	100.0	90.0	30.0	73.3	3.20	0.00	0.00	1.07	6.75	4.25	0.05	3.68	8.50	4.65	0.00	4.38
GJHV-516	93.0	90.0	20.0	67.7	2.90	0.00	0.00	0.97	6.15	3.00	0.00	3.05	7.25	4.00	0.00	3.75
Sahana	100.0	100.0	60.0	86.7	4.60	0.00	0.00	1.53	8.95	5.35	0.60	4.97	10.90	6.75	0.65	6.13
LRA-5166(NC)	100.0	100.0	40.0	80.0	4.00	0.00	0.00	1.33	7.35	4.90	0.20	4.15	9.25	5.80	0.29	5.11
RAH-100 (LC)	80.0	70.0	10.0	53.3	1.70	0.00	0.00	0.57	5.00	1.00	0.00	2.00	6.80	1.50	0.00	2.77
Mean	87.6	76.4	19.0		2.57	0.00	0.00		5.71	2.58	0.06		7.03	3.31	0.07	
	C	G	C x G		C	G	C x G		C	G	C x G		C	G	C x G	
S.Em±	1.24	0.47	2.15		0.011	0.004	0.020		0.021	0.008	0.036		0.023	0.009	0.040	
CD @5%	4.67	1.76	8.08		0.043	0.016	0.075		0.078	0.029	0.135		0.086	0.033	0.150	

Note: C_1: 0.0 MPa (0 bar) C_2: - 0.140 MPa (-1 bar) C_3: -0.39 MPa (-3.9 bar)

Table 2: Effect of different concentration of PEG on root length and root to shoot ratio of *hirsutum* cotton varieties at 3rd, 7th and 12th day of the slanting glass plate technique

Genotypes	Root length (cm)												Root to shoot ratio			
	At 3rd day				At 7th day				At 12th day							
	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C_1	C_2	C_3	Mean	C1	C2	C3	Mean
TSH-04/115	3.10	0.00	0.00	1.03	2.30	1.30	0.00	1.20	3.45	13.71	0.00	5.72	1.30	0.00	0.00	0.43
GBHV-182	5.60	0.00	0.00	1.87	7.60	8.10	0.80	5.50	9.45	26.78	0.85	12.36	1.29	6.16	0.00	2.48
GBHV-177	6.70	0.00	0.00	2.23	10.10	9.10	1.90	7.03	13.25	32.68	2.15	16.03	1.51	5.94	14.33	7.26
PH-1060	6.00	0.00	0.00	2.00	7.60	8.20	1.00	5.60	10.25	28.54	1.15	13.31	1.38	6.41	0.00	2.60
CCH-12-3	6.50	0.00	0.00	2.17	8.20	8.80	1.80	6.27	13.15	30.69	2.00	15.28	1.52	5.90	0.00	2.47
GSHV-169	4.35	0.00	0.00	1.45	6.40	8.20	0.00	4.87	8.60	26.37	0.00	11.66	0.00	0.00	0.00	0.00
TCH-1777	5.00	0.00	0.00	1.67	7.20	6.80	0.20	4.73	9.05	21.71	0.28	10.35	1.26	6.03	0.00	2.43
SCS-1213	5.10	0.00	0.00	1.70	7.20	7.20	0.40	4.93	9.15	24.06	0.50	11.24	1.27	6.09	0.00	2.45
SCS-1062	4.50	0.00	0.00	1.50	6.80	6.10	0.20	4.37	9.00	21.16	0.35	10.17	1.26	6.72	0.00	2.66
AKH-09-5	4.40	0.00	0.00	1.47	6.80	5.40	0.00	4.07	8.65	19.69	0.00	9.45	1.26	7.43	0.00	2.90
NDLH-1943	4.10	0.00	0.00	1.37	5.70	3.30	0.00	3.00	7.60	14.61	0.00	7.40	1.39	24.35	0.00	8.58
CNH-1110	3.80	0.00	0.00	1.27	5.40	1.90	0.00	2.43	7.05	14.25	0.00	7.10	1.50	0.00	0.00	0.50
ARBH-1352	6.10	0.00	0.00	2.03	7.60	8.20	1.10	5.63	11.10	28.83	1.25	13.73	1.48	6.41	0.00	2.63
NDLH-1938	4.10	0.00	0.00	1.37	6.40	3.80	0.00	3.40	8.45	15.33	0.00	7.93	1.41	11.36	0.00	4.25
RAH-806	1.70	0.00	0.00	0.57	1.80	0.00	0.00	0.60	2.65	13.38	0.00	5.34	1.56	0.00	0.00	0.52
BS-37	7.30	0.00	0.00	2.43	10.70	9.70	2.60	7.67	13.95	34.37	3.00	17.11	1.36	5.73	15.00	7.36
BS-39	6.30	0.00	0.00	2.10	7.80	8.70	1.70	6.07	13.05	30.45	1.95	15.15	1.54	6.55	0.00	2.69
GJHV-516	5.30	0.00	0.00	1.77	7.50	7.60	0.50	5.20	9.25	26.37	0.65	12.09	1.28	6.59	0.00	2.62
Sahana	8.20	0.00	0.00	2.73	14.30	12.00	3.10	9.80	17.20	35.23	3.65	18.69	1.58	5.22	5.62	4.14
LRA-5166(NC)	6.90	0.00	0.00	2.30	10.50	9.50	2.10	7.37	13.50	33.61	2.35	16.49	1.46	5.79	8.10	5.12
RAH-100 (LC)	4.30	0.00	0.00	1.43	6.80	4.30	0.00	3.70	8.60	16.59	0.00	8.40	1.26	11.06	0.00	4.11
Mean	5.21	0.00	0.00		7.37	6.58	0.83		9.83	24.21	0.96		1.33	6.37	2.05	
	C	G	C x G		C	G	C x G		C	G	C x G		C	G	C x G	
S.Em±	0.017	0.007	0.030		0.022	0.008	0.038		0.039	0.015	0.067		0.027	0.010	0.048	
CD @5%	0.066	0.025	0.114		0.083	0.031	0.144		0.146	0.055	0.253		0.103	0.039	0.179	

Note: C_1: 0.0 MPa (0 bar) C_2: - 0.140 MPa (-1 bar) C_3: -0.39 MPa (-3.9 bar)

Table 3: Table 1: Effect of different concentration of PEG on Seedling vigor index (SeVI), Shoot vigor index (SVI) and Root vigor index (RVI) of *hirsutum* cotton varieties

Genotypes	SeVI				SVI				RVI			
	C1	C2	C3	Mean	C1	C2	C3	Mean	C1	C2	C3	Mean
TSH-04/115	408.7	274.2	0.0	227.6	177.6	0.0	0.0	59.2	231.2	274.2	0.0	168.5
GBHV-182	1562.4	2801.7	17.0	1460.4	683.6	391.5	0.0	358.4	878.9	2410.2	17.0	1102.0
GBHV-177	2200.0	3818.0	92.0	2036.7	875.0	550.0	6.0	477.0	1325.0	3268.0	86.0	1559.7
PH-1060	1646.1	2969.1	23.0	1546.1	692.9	400.5	0.0	364.5	953.3	2568.6	23.0	1181.6
CCH-12-3	2180.0	3230.1	63.0	1824.4	865.0	468.0	3.0	445.3	1315.0	2762.1	60.0	1379.0
GSHV-169	1357.8	2369.0	0.0	1242.3	558.0	127.5	0.0	228.5	799.8	2241.5	0.0	1013.8
TCH-1777	1413.8	2024.8	2.8	1147.1	626.4	288.0	0.0	304.8	787.4	1736.8	2.8	842.3
SCS-1213	1422.5	2520.9	5.0	1316.1	626.4	355.5	0.0	327.3	796.1	2165.4	5.0	988.8
SCS-1062	1405.1	1944.8	3.5	1117.8	622.1	252.0	0.0	291.4	783.0	1692.8	3.5	826.4
AKH-09-5	1240.0	1787.2	0.0	1009.1	548.0	212.0	0.0	253.3	692.0	1575.2	0.0	755.7
NDLH-1943	1044.0	760.5	0.0	601.5	436.0	30.0	0.0	155.3	608.0	730.5	0.0	446.2
CNH-1110	787.3	712.5	0.0	499.9	314.9	0.0	0.0	105.0	472.4	712.5	0.0	395.0
ARBH-1352	1729.8	2999.7	25.0	1584.8	697.5	405.0	0.0	367.5	1032.3	2594.7	25.0	1217.3
NDLH-1938	1156.0	1000.8	0.0	718.9	480.0	81.0	0.0	187.0	676.0	919.8	0.0	531.9
RAH-806	261.0	0.0	0.0	87.0	102.0	0.0	0.0	34.0	159.0	0.0	0.0	53.0
BS-37	2420.0	4037.0	160.0	2205.7	1025.0	600.0	10.0	545.0	1395.0	3437.0	150.0	1660.7
BS-39	2155.0	3159.0	58.5	1790.8	850.0	418.5	0.0	422.8	1305.0	2740.5	58.5	1368.0
GJHV-516	1534.5	2733.3	13.0	1426.9	674.3	360.0	0.0	344.8	860.3	2373.3	13.0	1082.2
Sahana	2810.0	4198.0	258.0	2422.0	1090.0	675.0	39.0	601.3	1720.0	3523.0	219.0	1820.7
LRA-5166(NC)	2275.0	3941.0	105.6	2107.2	925.0	580.0	11.6	505.5	1350.0	3361.0	94.0	1601.7
RAH-100 (LC)	1232.0	1266.3	0.0	832.8	544.0	105.0	0.0	216.3	688.0	1161.3	0.0	616.4
Mean	1535.28	2311.80	39.35		638.74	299.98	3.31		896.54	2011.83	36.04	
	C	G	C x G		C	G	C x G		C	G	C x G	
S.Em±	0.38	0.14	0.66		0.20	0.08	0.35		0.37	0.14	0.63	
CD @5%	1.44	0.54	2.49		0.77	0.29	1.33		1.38	0.52	2.38	

Note: C_1: 0.0 MPa (0 bar) C_2: - 0.140 MPa (-1 bar) C_3: -0.39 MPa (-3.9 bar)

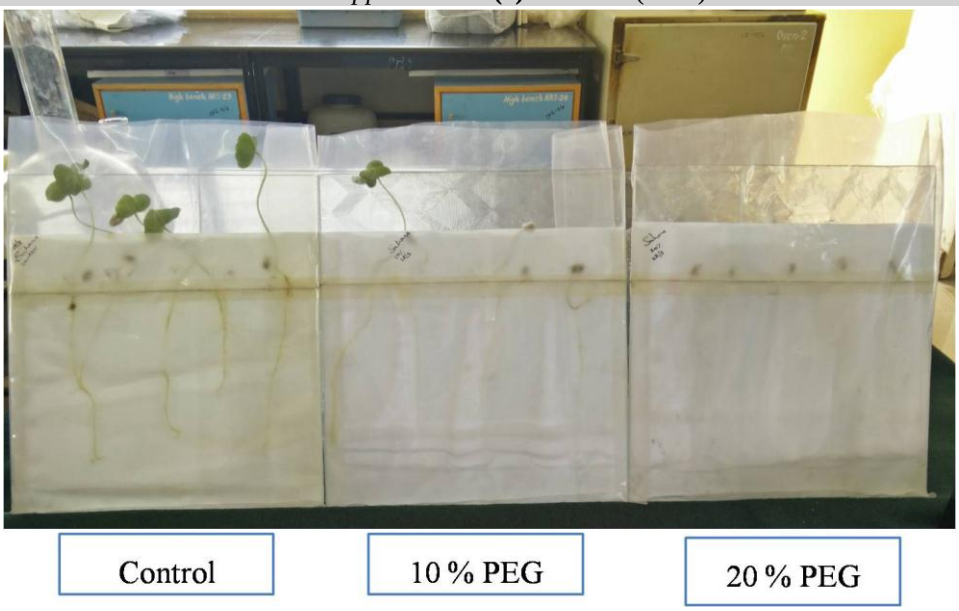

Fig. 1

Fig. 2

CONCLUSION

It is concluded that the laboratory experiment was to study the germination studies of 21 cotton varieties were evaluated to identify tolerant genotypes under different osmotic potential by using PEG-6000 *viz*, 0.00MPa, -0.140 MPa (-1 bar) and -0.39 MPa (-3.9 bar) in a slanting plate technique was to identify tolerant varieties. Among the varieties, Sahana, LRA-5166 and RAH-100 were used as a national and local check, respectively. The germination percentage, shoot length, Root length and seedling vigour were recorded at different time intervals. All these observations indicates Sahana, BS-37, LRA-5166, CCH-12-3 GBHV- 177, BS-39, GBHV-182, ARBH-1352 were found to be tolerant at osmotic potential of -0.39 MPa than -0.14 MPa.

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