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APPRAISAL OF GROWTH PARAMETERS OF *GOSSYPIUM HIRSUTUM* HYBRIDS AND PARENTS UNDER SALINE ENVIRONMENT

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***Abstract:** Cotton "white gold" is grown in different climate regime and one of the most important commercial crops worldwide. The salinity is one of the biggest problems as it covers 7 % of land worldwide and it has been estimated that salinity affected areas are increasing at a rate of 10 % annually for various reasons. The identification of suitable cotton genotype for saline environment is the prime requirement and hence this experiment was laid out with twelve F1 hybrids and four parents at three different saline environments in RBD design during 2019-20. Dry biomass of plant, leaf dry weight and leaf area were estimated at 50 days after sowing (DAS) and 100 DAS. The results indicated that the total dry biomass, leaf dry weight and leaf area of cotton parents and hybrids at 50 DAS and 100 DAS were significantly reduced due to saline environment. The reduction in total dry biomass, leaf dry weight and leaf area of cotton parents and hybrids was 49.81 %, 54.98 % and 54.89 % at 50 DAS and 58.53 %, 51.20 % and 52.23 % at 100 DAS respectively. The genotypic variation was also found significant for all studied parameters. The significantly higher dry biomass in pooled was found in G. Cot 16 and GSHV 185 at 50 DAS and 100 DAS, respectively. The genotype G. Cot 16 and cross GSHV 185 x L 1384 showed significant higher leaf dry weight at 50 DAS and 100 DAS, respectively. Leaf area per plant was significantly higher in the crosses L 1384 x G. Cot 16 and GSHV 185 x L 1384 at 50 DAS and 100 DAS, respectively. The information generated in this study would be more useful to plan breeding strategy to develop salinity tolerant cotton variety for saline environment.*

Keyword: Cotton variety, Saline environment.

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INTRODUCTION

Cotton is popularly known as "white gold" and it is one of the most important economic crops worldwide. Cotton is produced in the major countries like USA, China, India, Pakistan, Uzbekistan, Turkey, Brazil, Greece, Argentina, Australia and Egypt. The diversity of cotton cultivars and cotton agro climatic zones in India is considerably larger when compared to other major cotton growing countries in the world. Salt-affected soils cover more than 7 % of the earth's land surface and represent a major limiting factor in crop production [1]. Soil salinity is becoming a serious threat to global agriculture. Currently, nearly 20 % of the world's cultivated area and nearly half of the world's irrigated lands are affected by salinity. It has been estimated that an approximate area of 7 million hectares of land is covered by saline soil in India [2]. About 7 Mha of land is salt affected in India of which 2.22 Mha is present in Gujarat state [3]. Plant growth and development processes such as seed germination, seedling growth, vegetative growth, flowering and fruiting are adversely affected by salinity, ultimately causing decreased economic yield and quality. It is believed that soil salinity affects plant growth and development by way of osmotic stress, injurious effects of toxic ions and the resulting nutrient imbalance [4]. It is generally believed that germination and young seedling stages are more sensitive to salinity stress than other stages [5]. Under salinity condition, salt-tolerant cotton varieties (*G. hirsutum* L.) had higher shoot biomass production than salt-sensitive varieties at the vegetative stage [6]. Salinity reduces the root and shoots growth significantly due to effect of different levels of NaCl [7]. The effects of salt stress on cotton biomass have shown that biomass can vary depending on growth stage, salt concentration and duration of salt treatment. Increased NaCl levels result in a significant decrease in root, shoot and leaf biomass in cotton [8]. The increased salinity also cause reduction in plant fresh weight (PFW) and plant dry weight (PDW), which consequently affect relative growth rate [10]. Salinity induces a marked reduction in dry matter gain in roots and shoots along with oxidative stress as indicated by the significant increase in malondialdehyde content [11]. Increased level of NaCl significantly reduces plant height, leaf area, fresh weight and dry weight [13]. Salinity induces reduction in the dry weight of leaves and roots and also root length [14]. The functional leaves, dry matter production and leaf area index are the main growth factor that directly affect grain yield [15]. Leaf area per plant of cotton genotypes progressively decreases with the increase in salinity level [9]. This decrease in leaf area may be attributed to the accumulation of Na^+ and other inorganic solutes as salt tolerant cultivar of cotton shows more tolerance to decrease in leaf area and accumulates less Na^+ compared to sensitive cultivar of cotton [10]. Sodium chloride stress adversely affects relative water content (RWC) and significantly reduces leaf dry weight. The present study was planned with an objective to study the effect of different saline environments on growth parameters of *Gossypium hirsutum* hybrids and parents at different stages.

MATERIAL AND METHODS

The field experiment was conducted under three different locations for different saline environment during 2019-20. The first location was Surat at Main Cotton Research Station (MCRS), Navasari Agricultural University, Surat, which is situated in South Gujarat at a cross point of 21° - 172 N latitude and 72° – 802 E longitude at elevation of 11.34 meters above the mean sea level and is about 18 Kilometers away from the Arabian sea shore. The second location was Danti at Coastal Soil Salinity Research Station (CSSRS), Navsari Agricultural University, Danti-Umbharat. CSSRS is situated in South Gujarat at a cross point of 21° 032 N latitude and 72° 732 E longitude at an elevation of 2.5 m above mean sea level on the western coastal belt of India. The third location was Dumas at Farmer's field that is located at the cross point of 21° 092 N latitude and 72° 722 E longitude at an elevation of 2.5 m above mean sea level on the western coastal belt of India. The aerial distance between the locations of Surat to Dumas, Dumas to Danti and Danti to Surat are 10.89, 7.32 and 16.41 Km, respectively. Plant material for this study comprised of four parent genotypes viz. two tolerant genotypes (G.Cot.16, GSHV 185) and two susceptible genotypes (L 1384 and TCH 1777), which were selected on the basis of AICCIP 2016-17 data [16]. The crossing of these parents was carried out in full diallel fashion to obtain twelve hybrids during 2018-19. All genotypes (parents and hybrids) were evaluated in randomized block design (RBD) with three replications at above three different saline environments i.e. Surat ($EC_{2.5}$-0.47 dSm^{-1}), Danti ($EC_{2.5}$- 4.17 dSm^{-1}) and Dumas ($EC_{2.5}$- 4.79 dSm^{-1}). Surat environment was considered as normal location whereas, Danti and Dumas was considered as saline affected environment for this study. Selection of saline environment was based on EC of the soil as described by Maas and Hoffman [17]. The total dry biomass and leaf dry weight were measured from five randomly selected plants from each plot and average value was taken for statistical analysis and interpretation. The leaf area was calculated based on leaf weight according to the method describe by Watson [18].

RESULT AND DISCUSSION

Total dry biomass: The result for total dry biomass at 50 DAS and 100 DAS for cotton hybrids and parents grown under different environments are presented in figures 1 and 2, respectively. The results showed that total dry biomass was significantly (at $p < 0.05$ %) differing amongst the hybrids and parents. Total dry biomass significantly decreased when plants were grown under the saline environment over normal environment. Under saline environment, at Danti, mean total dry biomass at 50 DAS was 8.93 g ranging from 7.83 g (G. Cot 16 x L 1384) to 10.45 g (G. Cot 16) and at Dumas mean total dry biomass at 50 DAS was 9.00 g ranging from 7.51 g (G. Cot 16 x L 1384) to 10.73 g (G. Cot 16), while under normal condition mean total dry biomass at 50 DAS was 17.89 g ranging from 15.26 g (L 1384 x GSHV 185) to 19.93 g (GSHV 185 x L 1384). Pooled mean total dry biomass at 50 DAS amongst hybrids and parents was significantly higher in G. Cot 16 which was followed by GSHV 185 and GSHV 185 x L 1384, while significantly lower biomass was observed in G. Cot 16 x L 1384 which was at par with L 1384 x GSHV 185, L 1384 x TCH 1777 and G. Cot 16 x GSHV 185. The interaction of genotypes and growing condition for dry biomass at 50 DAS was non significant, which indicated that all the hybrids and parents responded similarly to salinity stress under different locations. All the genotypes showed significant reduction due to salinity. In terms of per cent decrease under stress condition, it was lower in hybrids TCH 1777 x GSHV 185 (42.19 %) and GSHV 185 x G. Cot 16 (44.82 %) and higher in genotypes L 1384 (55.06 %) and L 1384 x TCH 1777 (53.64 %). Under saline environment, at Danti, mean total dry biomass at 100 DAS was 24.50 g ranging from 20.17g (L 1384) to 29.61g (GSHV 185 x G. Cot 16) and at Dumas mean total dry biomass at 100 DAS was 24.63g ranging from 20.97g (G. Cot 16 x L 1384) to 30.26g (GSHV 185 x G. Cot 16), while under normal environment the mean total dry biomass at 100 DAS was 59.44g ranging from 52.57g (L 1384 x GSHV 185) to 68.26 g (GSHV 185 x L 1384). Pooled mean total dry biomass at 100 DAS amongst hybrids and parents was significantly higher in GSHV 185 which was at par with GSHV 185 x G. Cot 16 and GSHV 185 x L 1384, while significantly lower total dry biomass was observed in TCH 1777 x G. Cot 16 which was at par with G. Cot 16 x L 1384 and TCH 1777 and three other hybrids. The interaction of genotypes and growing condition for total dry biomass at 100 DAS was significant, which indicated that all the hybrids and parents responded differently at different locations. All the genotypes showed significant reduction due to salinity. In terms of per cent decrease under stress condition, it was lower in hybrids TCH 1777 x GSHV 185 (49.73 %) and GSHV 185 x G. Cot 16 (51.53 %) and higher in genotypes L 1384 (64.81 %) and L 1384 x TCH 1777 (63.62 %). Total dry biomass reduced less vigorously in tolerant parents and their hybrids as compared to susceptible parents and their hybrids. The reduction in total dry biomass due to salinity was higher in susceptible genotypes, whereas it was lower in tolerant genotypes. The effect of salinity stress on cotton can vary depending on growth stage, salt concentration and duration of salt treatment. Increased NaCl levels result in a significant decrease in root, shoot and leaf biomass in cotton [8]. The present investigation showed that the reduction in total dry biomass of cotton plant was significant due to saline environment as compared to normal environment. Among the parents and hybrid, GSHV 185 x G. Cot 16 and TCH 1777 x GSHV 185 showed significantly lower reduction in total dry biomass, however L 1384 and L 1384 x TCH 1777 showed significantly higher reduction in total dry biomass at 50 and 100 DAS due to saline condition. Earlier researchers have reported 60 to 75 % reduction in total dry biomass in cotton at 200 mM NaCl concentration [10], while 14.44 %, 18.33 %, and 31.6 % reduction in total dry biomass in cotton at 50, 75 and 100 mM NaCl, respectively has also been reported earlier [12]. Salt sensitive, moderately salt tolerant and salt tolerant cotton genotypes could be earlier discriminated based on total dry biomass production and reduction ratios of cotton genotypes under salt stress conditions [9].

The diallel analysis of total dry biomass at 50 and 100 DAS showed that the effect of general combining ability (GCA) and specific combining ability (SCA) was significant (Table 1), which suggest that the both

Fig 1: Total dry biomass at 50 DAS of cotton hybrids and parents under different saline environments

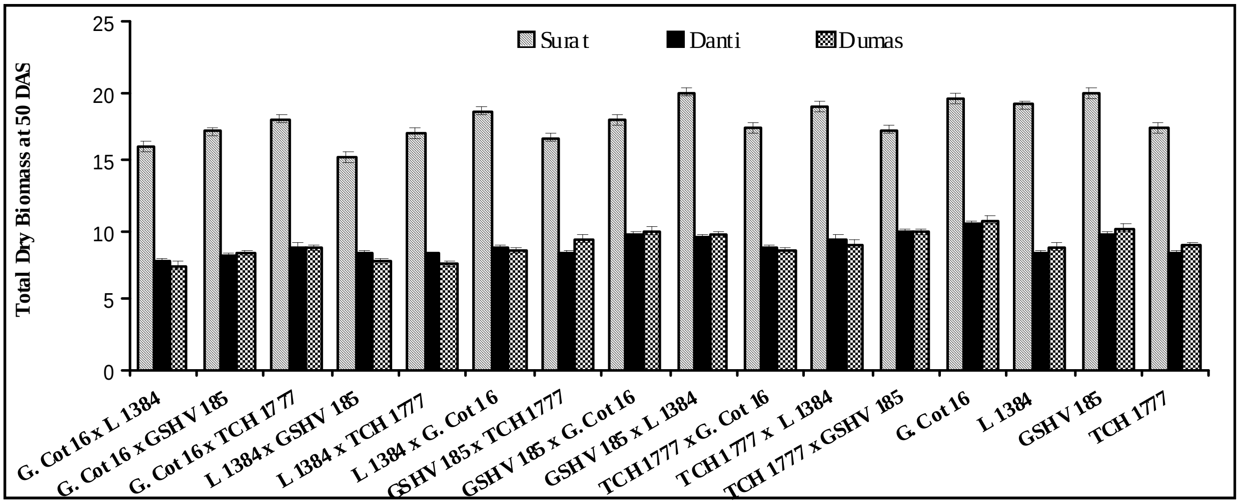


Fig 2: Total dry biomass at 100 DAS of cotton hybrids and parents under different saline environments

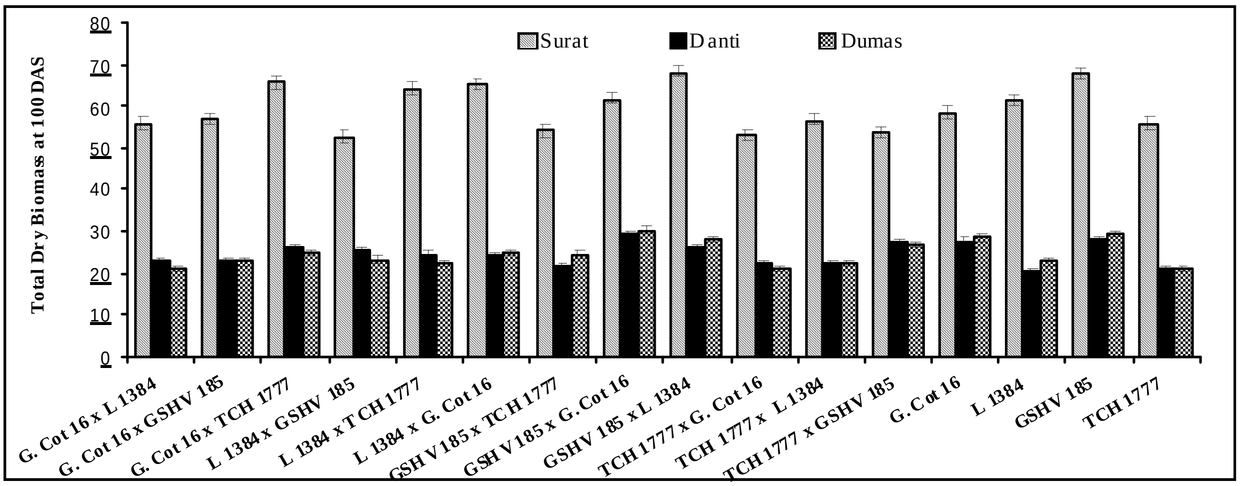


Fig 3: Leaf dry weight per plant at 50 DAS of cotton hybrids and parents under different saline environments

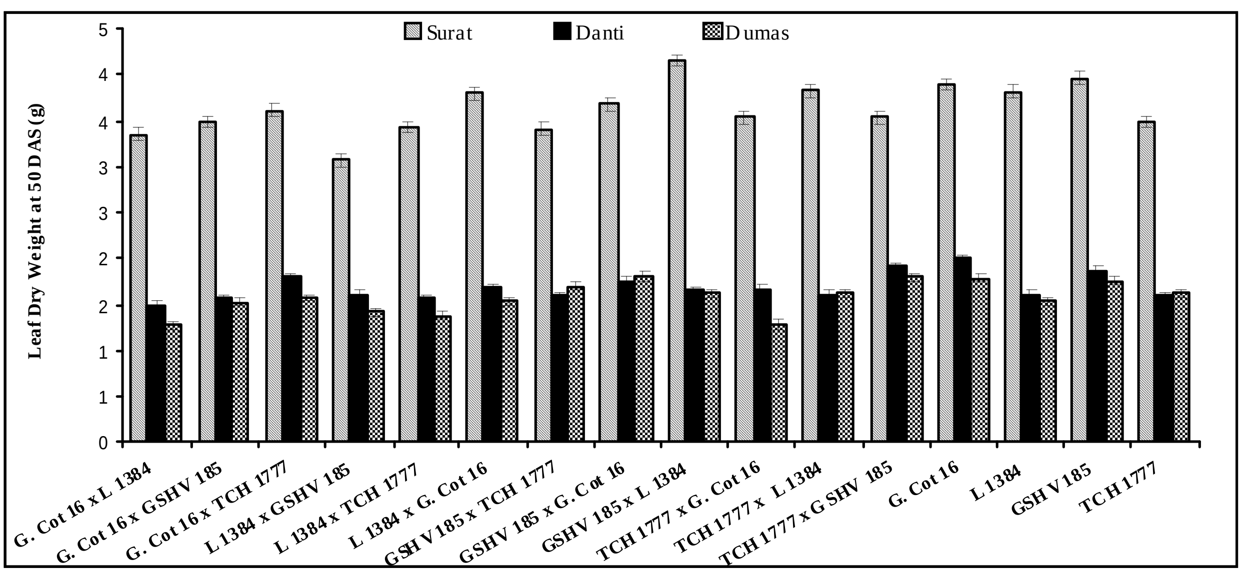


Table 1: Mean squares of diallel analysis of variance of data for different growth characters. *, **, *** = Significant at 0.05, 0.01 and 0.001 levels, respectively. NS = non significant.

Source of Variation	DF	Total Dry Biomass		Leaf Dry Weight		Leaf Area	
		50 DAS	100 DAS	50 DAS	100 DAS	50 DAS	100 DAS
Replication	2	1.14	1.10	0.45	5.65	487.56	680.93
Genotypes	15	2.54***	30.10***	0.08***	0.68*	3727.55**	24522.07***
GCA	3	1.66*	45.06***	0.06*	0.81*	2710.64 NS	34810.56***
SCA	6	2.11***	8.96**	0.05**	0.46 NS	1967.77 NS	27963.26***
Reciprocals	6	3.42***	43.76***	0.11***	0.84*	5996.18**	15931.18***
Error	30	0.41	1.78	0.02	0.26	1269.06	1781.68

additive and non additive gene effects were responsible for the inheritance of this character. Further, the reciprocal effect was significant for total dry biomass at 50 and 100 DAS in studied genotypes, which indicated the importance of this trait during selection for the male and female parents. Under saline environment, mean total dry biomass of hybrids having a tolerant genotype as female parent was significantly higher than susceptible hybrids, where susceptible female was used as a parent.

Leaf Dry weight: The result for leaf dry weight at 50 DAS and 100 DAS for cotton hybrids and parents grown under different environments are presented in fig. 3 and fig. 4. The result showed that leaf dry weight was significantly (at $p < 0.05$ %) differing amongst the hybrids and parents. The leaf dry weight significantly decreased when plants were grown under the stress environment over normal environment. Under saline environment, at Danti, mean leaf dry weight at 50 DAS was 1.68g ranging from 1.50g (G. Cot 16 x L 1384) to 2.00g (G. Cot 16) and at Dumas mean leaf dry weight at 50 DAS was 1.57g ranging from 1.27g (G. Cot 16 x L 1384) to 1.81g (GSHV 185 x G. Cot 16), while under normal environment at Surat mean leaf dry weight at 50 DAS was 3.63g ranging from 3.07g (L 1384 x GSHV 185) to 4.16g (GSHV 185 x L 1384). Pooled mean leaf dry weight at 50 DAS amongst hybrids and parents was significantly higher in G. Cot 16 (2.56g), which was at par with GSHV 185 (2.53g) and GSHV 185 x L 1384 (2.48g) and two other hybrids, while significantly lower leaf weight was observed in L 1384 x GSHV 185 (2.03g), which was at par with G. Cot 16 x L 1384 (2.04 g), L 1384 x TCH 1777 (2.12g) and three other hybrids. The interaction of genotypes and growing condition for leaf dry weight at 50 DAS was significant, which indicated that all the hybrids and parents responded differently to different locations. All genotypes showed significant reduction due to salinity. In terms of per cent decrease under stress condition, it was lower in hybrids TCH 1777 x GSHV 185 (47.55 %) and L 1384 x GSHV 185 (50.81 %) and higher in genotypes GSHV 185 x L 1384 (60.67 %) and L 1384 (58.82 %). Under saline environment, at Danti, mean leaf dry weight at 100 DAS was 5.53 g ranging from 4.34g (TCH 1777) to 6.51g (GSHV 185 x G. Cot 16) and at Dumas mean leaf dry weight at 100 DAS was 4.40g ranging from 3.63g (TCH 1777) to 5.43g (GSHV 185 x L 1384), while under normal environment at Surat mean leaf dry weight at 100 DAS was 10.29g ranging from 8.42 g (L 1384 x GSHV 185) to 12.11 g (GSHV 185 x L 1384). Pooled mean leaf dry weight at 100 DAS amongst hybrids and parents was significantly higher in GSHV 185 x L 1384 (7.88g) which was at par with G. Cot 16 (7.13 g) and TCH 1777 x GSHV 185 (7.12), while significantly lower leaf dry weight was observed in TCH 1777 (6.03g) which was at par with L 1384 x G. Cot 16 (6.25g) and L 1384 x GSHV 185 (6.27g) and four other hybrids. The interaction of genotypes and growing condition for leaf dry weight at 100 DAS was significant, which indicated that all the hybrids and parents responded differently at different locations. All the genotypes showed significant reduction due to salinity. In terms of per cent decrease under stress condition, it was lower in hybrids GSHV 185 x G. Cot 16 (34.35 %) and L 1384 x GSHV 185 (38.18 %) and higher in genotypes L 1384 (61.20 %) and TCH 1777 (60.60 %). Leaf dry weight of plants at 50 and 100 DAS showed higher reduction in susceptible parents and their hybrids as compared to tolerant parents and susceptible parents and their hybrids. Similar results were reported in cotton by earlier workers [8,13-14].

The diallel analysis of leaf dry weight showed that the effect of GCA and SCA was significant at 50 DAS (Table 1), which suggest that the both additive and non additive gene effects were responsible for the inheritance of this character. Further, the reciprocal effect was significant for leaf dry weight

Fig 4: Leaf dry weight per plant at 100 DAS of cotton hybrids and parents under different saline environments

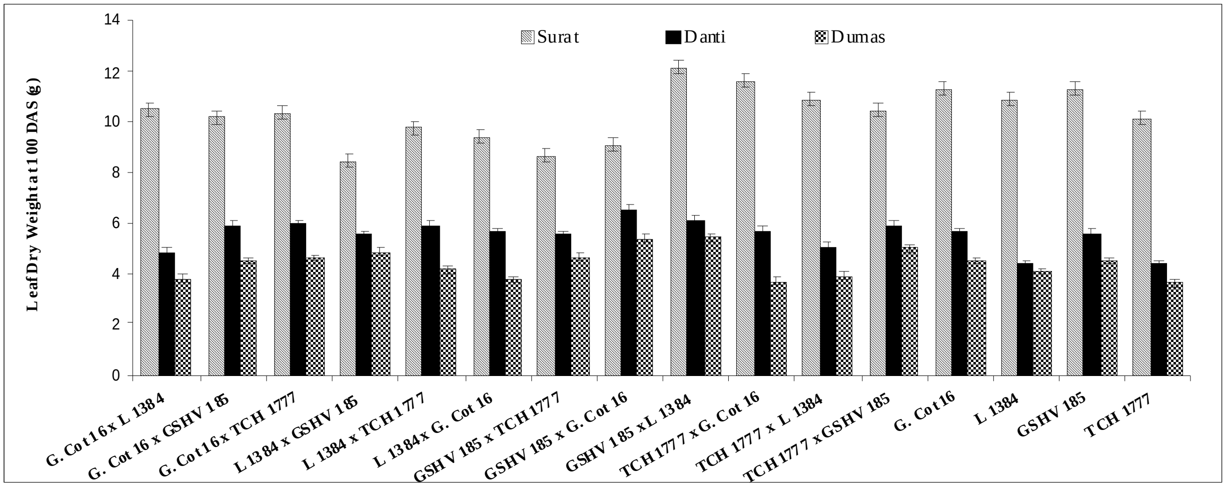


Fig 5: Leaf area per plant at 50 DAS of cotton hybrids and parents under different saline environments

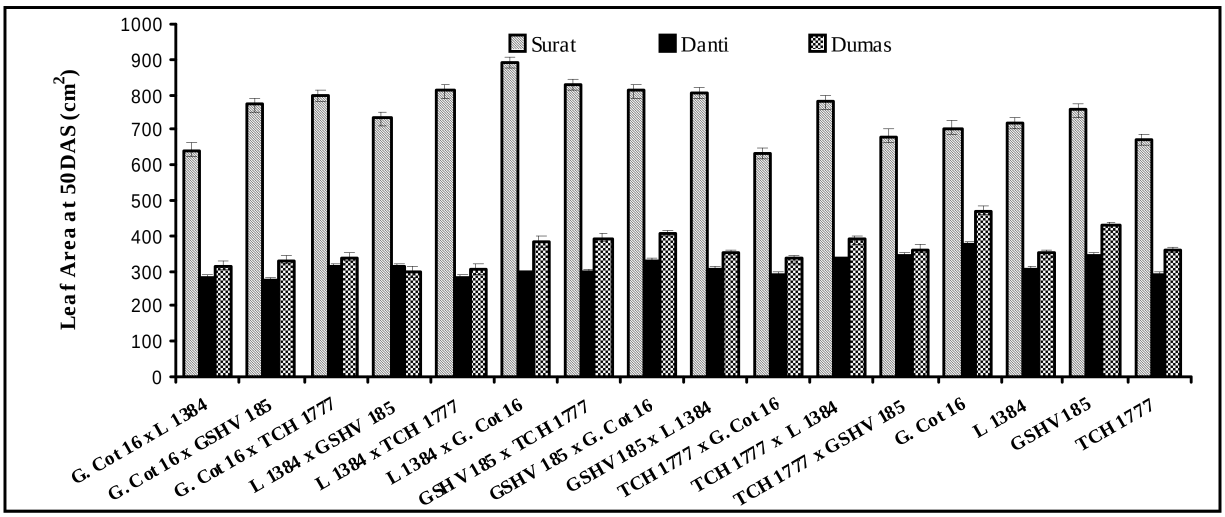
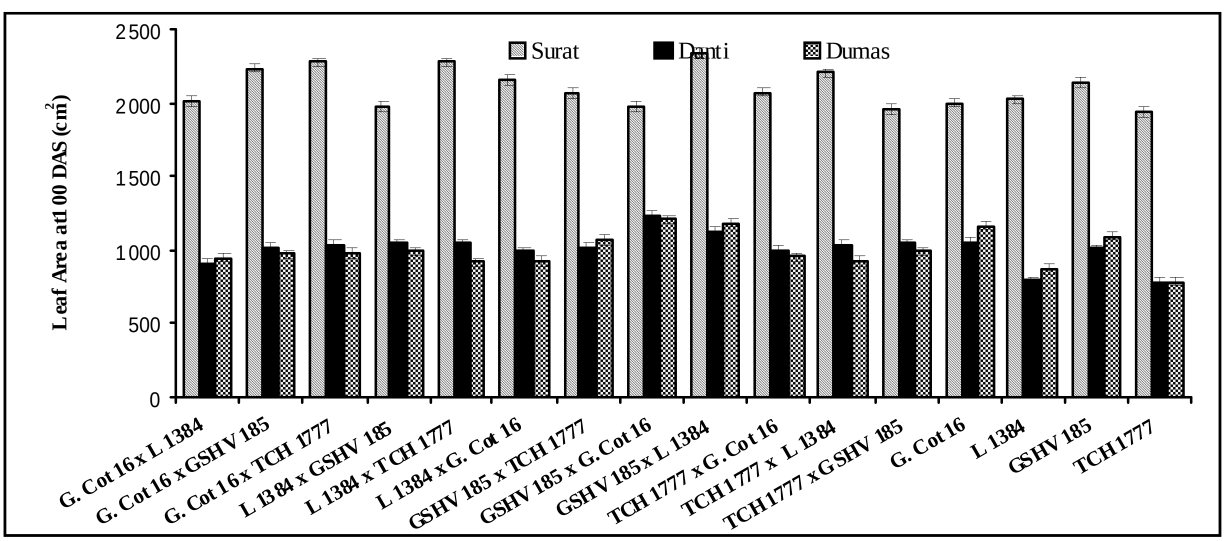


Fig 6: Leaf area per plant at 100 DAS of cotton hybrids and parents under different saline environments



of plant in studied genotypes, which indicated the importance of this trait for selection of the male and female parents. Under saline condition, leaf dry weight was higher in the hybrids which have female parent as tolerant genotype.

Leaf Area: The result of leaf area per plant at 50 DAS and 100 DAS for cotton hybrids and parents grown under different environments are presented in fig. 5 and fig. 6 respectively. The result showed that leaf area was significantly (at $p < 0.05$ %) differing amongst the hybrids and parents. The leaf area significantly decreased when plants were grown under the stress environment over normal environment. Under saline environment, at Danti, mean leaf area at 50 DAS was 309.83 cm^2 ranging from 271.99 cm^2 (G. Cot 16 x GSHV 185) to 376.37 cm^2 (G. Cot 16) and at Dumas mean leaf area at 50 DAS was 362.67 cm^2 ranging from 295.79 cm^2 (L 1384 x GSHV 185) to 470.42 cm^2 (G. Cot 16), while under normal environment at Surat mean leaf area at 50 DAS was 751.13 cm^2 ranging from 631.30 cm^2 (TCH 1777 x G. Cot 16) to 892.09 cm^2 (L 1384 x G. Cot 16). Pooled mean leaf area at 50 DAS amongst hybrids and parents was significantly higher in L 1384 x G. Cot 16 (522.97 cm^2), which was at par with G. Cot 16 (517.76 cm^2) and GSHV 185 x L 1384 (514.47 cm^2) and five other hybrids, while significantly lower leaf area was observed in G. Cot 16 x L 1384 (412.20 cm^2), which was and at par with TCH 1777 x G. Cot 16 (418.57 cm^2), TCH 1777 (438.48 cm^2) and five other hybrids. The interaction of genotypes and growing condition for leaf area at 50 DAS was significant, which indicated that all the hybrids and parents responded differently to different locations. All genotypes showed significant reduction due to salinity. In terms of per cent decrease under stress condition, it was lower in hybrids G. Cot 16 (40.07 %) and GSHV 185 (48.86 %) and higher in genotypes L 1384 x TCH 1777 (63.86 %) and L 1384 x G. Cot 16 (62.07 %). Under saline environment, at Danti, mean leaf area at 100 DAS was 1011.10 cm^2 ranging from 786.95 cm^2 (TCH 1777) to 1228.79 cm^2 (GSHV 185 x G. Cot 16) and at Dumas mean leaf area at 100 DAS was 999.20 cm^2 ranging from 786.44 cm^2 (TCH 1777) to 1208.01 cm^2 (GSHV 185 x L 1384), while under normal environment at Surat mean leaf area at 100 DAS was 2109.11 cm^2 ranging from 1943.88 cm^2 (L 1384 x GSHV 185) to 2345.73 cm^2 (GSHV 185 x L 1384). Pooled mean leaf area at 100 DAS amongst hybrids and parents was significantly higher in GSHV 185 x L 1384 (1549.67 cm^2), which was followed by GSHV 185 x G. Cot 16 (1474.54 cm^2) and G. Cot 16 x TCH 1777 (1434.95 cm^2), while significantly lower leaf area was observed in TCH 1777 (1173.43 cm^2), which was at par with L 1384 (1232.24 cm^2). The interaction of genotypes and growing condition for leaf area at 100 DAS was significant, which indicated that all the hybrids and parents responded differently at different locations. All the genotypes showed significant reduction due to salinity. In terms of per cent decrease under stress condition, it was lower in hybrid GSHV 185 x G. Cot 16 (38.68 %) and genotype G. Cot 16 (44.51 %) and higher in genotypes TCH 1777 (59.45 %) and L 1384 (58.95 %). Leaf area per plant reduced less vigorously in tolerant parents and their hybrids as compared to susceptible parents and their hybrids. The reduction in leaf area due to salinity was higher in susceptible genotypes, whereas it was lower in tolerant genotypes. The similar observation was also recorded in cotton [9-10,18] and in rice [20]. The reduction in leaf area under high salinity levels due to turgescence reduction resulting from salt stress, which can lead to inhibition of cell division and expansion [21]. Compared with the control, the NaCl treatment significantly reduced plant height, leaf area, fresh weight and dry weight and suggested that genotypes with larger leaf area have a greater response to NaCl treatment than those with smaller leaf areas [13].

The diallel analysis of leaf area per plant at 100 DAS showed that the effect of GCA and SCA was significant (Table 1), which suggest that both additive and non additive gene effects were responsible for the inheritance of this character. Further, the reciprocal effect was significant for leaf area per plant in studied genotypes, which indicated the importance of this trait for the selection of male and female parents. Under saline condition, mean leaf area of hybrids having GSHV 185 as a tolerant female parent was significantly higher than susceptible hybrids. Similar results were also concluded and reported for the number of bolls, boll weight, seed cotton yield, harvest index, span length and fiber fineness [22] and for biochemical parameters [23]. Researcher worked on cotton for the characters like cell membrane thermo stability, excise leaf water loss, relative water contents, chlorophyll contents, plant height and number of sympodia for genetic transmission. They found that GCA effects of parents and SCA effects of crosses were highly affected by abiotic stress environment. Degree of dominance revealed that all parameters were highly influenced by non-additive gene action under different water regimes [24]. Both additive and non additive gene action were important in the expression of biomass recovery, water use efficiency, total leaf area, transpiration and yield per plant in cotton. The GCA and SCA variances under varied condition indicated the influence of growing conditions on various characters [25].

CONCLUSION

Total dry biomass, leaf dry weight and leaf area of cotton parents and hybrids at 50 DAS and 100 DAS were significantly reduced due to saline environment. The reduction in total dry biomass, leaf dry weight and leaf area of cotton parents and hybrids was 49.81 %, 54.98 % and 54.89 % at 50 DAS, while 58.53 %, 51.20 % and 52.23 % at 100 DAS, respectively. The genotypic variation was also found significant for all studied parameters. Significantly higher dry biomass in pooled was found in G. Cot 16 and GSHV 185 at 50 DAS and 100 DAS, respectively. The genotype G. Cot 16 and GSHV 185 x L 1384 showed significantly higher leaf dry weight at 50 DAS and 100 DAS, respectively. Leaf area per plant was significantly higher in L 1384 x G. Cot 16 and GSHV 185 x L 1384 at 50 DAS and 100 DAS, respectively. The information generated in this study will be helpful for cotton breeders for genetic improvement of cotton genotypes.

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