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INHERITANCE STUDIES AMONG INDIGENOUSLY EVOLVED HYBRIDS OF COTTON

Sajjad Ali Panhwar[1*], Shah Nawaz Mari[2], Mohammad Ameen Abro[2], Zahoor Ahmed Soomro[2], Nazeer Ali Panhwar[3], Ayaz Ali Soomro[4], Zaheer Ahmed Jatoi[1], Muhammad Tahir Jatoi[7], Muhammad Zahir Ahsan[5]. Abdul Razzaque Channa[6], Abdul Wahab Soomro[6] and Asghar Ali Rajper[2]

[1]*Department of Crop Genetics and Breeding, College of Tropical Crops, Hainan University, Haikou City, P.R China*
[2]*Department of Plant Breeding and Genetics Sindh Agriculture University Tando jam Hyderabad Sindh*
[3]*Shaheed Zulfiqar Ali Bhutto Agriculture College, Dorki Campus of S.A.U. Tando jam, Hyderabad Sindh, Pakistan*
[4]*Sindh Agriculture University, sub campus Umar Kot, Sindh, Pakistan*
[5]*Cotton Research Station, Sahiwal, Punjab, Pakistan*
[6]*Central Cotton Research Institute, Sakrand, Sindh, Pakistan*
[7]*College of Ecology and Environment, Hainan University, Haikou City, P.R China*

ABSTRACT

The experiment determining the variability and heritability in 17 genotypes of upland cotton were carried out in randomized complete block design with three replications during 2017-18. The hybrids manifested highly significant differences (P > 0.01 for all traits except lint index. The hybrids presented highest heritability, genetic advance, and selection index for all observed traits. Seed cotton yield per plant observed maximum phenotypic coefficient of variation (12.65%) followed by the plant height (5.36%). Higher value of phenotypic coefficient of variation than genotypic coefficient of variation indicated the influence of the environmental interaction in expression of traits. The highest GCV was exhibited in seed cotton yield followed by the Plant height, number of monopodia, and number of sympodia per plant and GOT%. Heritability was expressed remarkably high for staple length (92.45%) followed by monopodia per plant, sympodia per plant and seed index. Highest selection response was obtained in monopodia per plant, seed cotton yield and boll weight. High heritability with genetic advance suggested vigorous phenotypic selection in breeding program for batter improvement for above observed traits.

Keywords: Upland Cotton, F_1 Hybrids, Yield and Yield Components

INTRODUCTION

Gossypium Hirsutum L. plays a major role in boosting our national economy by earning huge amount of foreign exchange and that is why it is known as backbone of the economy of Pakistan (Khan *et al*., 2009). Cotton crop earns 45-60% foreign exchange which is depending upon the production and consumption. In addition to that it provides fibre for inland textile industry Khan *et al*., 2000). A great economic importance of cotton as a fibre crops, it shares in edible oil to the industry and feed (seed cake) for animals' consumption (Khan *et al*., 2003; Khan 2007). Apparently healthy cotton crop is a symbol of prosperity and strength for the nation. Pakistan occupies fourth position in terms of largest producer of cotton but yield per unit area is still lower due to various factors such as cotton leaf curl virus, pest attack, flood, rains as compared to other cotton growing countries (Khan *et al*., 2009a, 2009b). Cotton was cultivated 12% of the total cultivated in Pakistan during 2007-08, cotton crop was grown about 3.054 million hectares and production of seed cotton was 11.655 million bales with average seed cotton yield is 649 kg ha-1 (Makhdoom *et al.*, 2010).

Afiah and Ghoniem (2000), Khan (2003) and Ahmed *et al*. (2008) evaluated genetically diverse genotypes for yield and yield components and were found highly significant correlation which indicated improvement in yield components as a boll weight would have positive effect on seed cotton yield. Iqbal *et al*. (2003) and wang *et al*., (2004) studied genotypic correlation which was higher than the corresponding phenotypic correlation for the studied parameters and revealed that seed cotton yield per plant is significant and positively correlated with boll weight and bolls per plant. Rao and Mary (1996) and Meena *et al*. (2007) experimented on different upland cotton cultivars for yield and other economic characters and found significant variations for yield attributing traits which displayed positive effect on seed cotton yield. Arshad *et al*. (1993) and Soomro *et al*. (2008) also evaluated positive correlation for yield and its components including bolls per sympodia and sympodia per plant in upland cotton.

Heritability and genetic potential of different cultivars studied in the form of their expression for various morpho-yield traits and were earnestly needed for selection of parental lines for breeding program (Badr, 2003; Khan, 2003; Khan *et al*., 2010). Substantial genetic variance and high heritability estimates implied this character could be improved through selection from the segregating population (Baloch, 2004; Khan *et al*., 2000; Khan *et al*.,2009b). Hereditability estimates (narrow and broad sense) were analysed and found that high magnitude in intraspecific crosses of G. hirsutum comparative to G. barbadense crosses (Esmail, 2007; Khan *et al*., 2010). Genetic variability for seed cotton yield also studied by Terziev *et al*. (1996), Abouzaid *et al*. (1997), Khan (2003) and Khan *et al*., (2009a 2009b). Copur (2006) also determined yield and yield related components as well as other morphological traits of G. hirsutum cultivars and observed significant variations. Soomro *et al*. (2005) evaluated cotton yield in upland cotton cultivars and observed that the cultivars exhibiting significant differences for yield of first pick and last pick.

Consequently, the exploration and use of those genotypes with better genetic potential is continue prerequire for synthesis of physiologically efficient and genetically superior genotypes promising increased production per unit area under a given set of environmental condition.

The aiming of this research is to find out genetic mechanism of plant characters in terms of qualitative and quantitate traits in cotton crop. However, in the view of pivotal importance of cotton in the national economy, this study also helps to disclose the genetic variability and potential of different upland cotton cultivars for yield and yield attributes. Heritability, genetic, environmental, and phenotypic variances, expected response to selection and association of seed cotton yield with morphological and yield traits was also studied. Additionally, high productive and better fiber quality characters were elaborated.

MATERIALS AND METHODS

Plant material and experimental Design: The research work pertaining to study of genetic pattern of qualitative and quantitative traits of upland cotton, heritability (H2), genetic advance and correlation of seed cotton yield with other traits in upland cotton cultivars during 2017-18 under environmental condition of Sindh at botanical garden of Sindh Agriculture University Tandojam, Pakistan. Breeding material comprised of 17 different Gossypium hirsutum genotypes having broad genetic base and variation by date release, pedigree, seed cotton and fiber yield as well as fiber length. The parents were CRIS-134, CRIS-9, Sindh-1, Shahbaz, Qalandri, Chandi, Reshmim and 10 combination with F1 hybrid Viz, Sindh-1 X Shahbaz, Reshmi X Qalandri, CRIS-134 X Chandi, CRIS-134 X Reshmi, CRIS-134 X CRIS-9, Shahbaz X Sindh, Qalandri X Reshmi, Chandi X CRIS-134, Reshmi X CRIS-134, CRIS-9 X CRIS-134. Seeds were sown by manually during mid of May 2017 with intra- and inter row spacing of 30 and 75 cm, respectively in a randomized complete block design (RCBD) with three replications. Thinning was performed thrice after 10 and 15 days of germination when the plant height was 10 and 20 cm respectively to ensure single per plant. Each sub plot of cultivars having four rows with 8-meter length. All the recommended cultural practices and inputs including fertilizer, irrigation, hoeing and pest control were used in same amount for all the entries from sowing till harvesting, in order to maintain uniformity and minimize environmental variability to the maximum possible extent. Picking was completed during the month of November- December of single plant basis and ginning was performed with 17 saw-gins

The traits measurement and statistically analysis: The data were recorded individual plant basis before average for the following parameters.

Plant height (cm): Ten plants were selected randomly to calculate the average plant height at maturity, plant height from the surface of soil to the tip of the plant was measured in centimeters.

Sympodia per plant / Number of productive branches: Sympodia per plant of each labeled plants were counted prior to harvesting.

Monopodia per plant/ Number of non-productive branches: Monopodia per plants were counted from each tagged plant in the field before picking.

Bolls per plant: The total number of cotton bolls produced by the selected plants were counted and average number of bolls per plant was calculated by dividing the total number of bolls per plant to the total number of selected plants.

Boll weight (g): The average boll weight was calculated by dividing the seed cotton yield per plant to the number of bolls per plant.

$$\text{Average boll weight (g)} = \frac{\text{seed cotton yield per plant (g)}}{\text{Number of bolls per plant}}$$

Seed index (g): One hundred seeds were randomly counted from the embossed samples and the weight was recorded in grams by applying digital weighting scale in the laboratory.

Lint index (g): Lint produced by the 100 seeds was calculated by the formula.

$$\text{Lint index } = \frac{\text{seed index x GOT\%}}{100 - \text{GOT\%}}$$

Ginning outturn percentage (GOT%): Three seed cotton yield samples were collected form each replication to calculate the average ginning turnout percentage by using the following formula. The each plant was slected separately at random for seed cotton and the lint was weighted . Calculation the percentage of ginning exports by using the following formula.

$$\text{GOT}(\%) = \frac{\text{lint weight}}{\text{seedcotton weight}} \times 100$$

Seed cotton plant^{-1} (g): Ten plants were selected from each replication, picked separately and average seed cotton yield was considered by dividing the whole yield with ten. The genotype of each plant of seed cotton from each index plant was selected and weighted separately to record data (grams) of cotton yield per seed.

Staple length (mm): Staple length of each treatment was measured with the help of High-volume Instrument (HIV) installed at Cotton Research Institute Tandojam.

Statistical analysis: The data was subjected to analysis of variance (ANOVA) as described by the Steel and Terrie (1997). Genotypic and phenotypic Coefficient of variation as calculated as described by the Burton and Devane (1953), Broad Sense heritability was calculated using variance component method as formula given by the Breeze 1972. and genetic advance as per formula given by the Johnson *et al.*, 1956.

$$\text{Genotypic Variance(Vg)} = \frac{\text{Mean Square (MSG)} - \text{Mean Square (MSE)}}{3}$$

$$\text{Environmental Variance (Ve)} = \text{Mean Square (MSE)}$$

$$\text{Phenotypic Variance (Vp)} = \text{Genotypic Variance (Vg)} + \text{Environmental Variance (Ve)}$$

Genotypic, Phenotypic Coefficient of Variation was calculated as follows

$$\text{GCV (\%)} = \sqrt{\frac{\text{Vg}}{\text{Mean}} \times 100}$$

$$\text{PCV (\%)} = \sqrt{\frac{\text{Vp}}{\text{Mean}} \times 100}$$

Heritability was calculated as follows.

$$H(b) = \frac{Vg}{Vp}$$

The expected genetic advance was calculated as follows.

$$GA = K\sqrt{Vp}H^2$$

Where K at 20% selection intensity is 1.40
Genetic advance as percentage of mean was calculated as follows.

$$GA(\%) = \frac{GA}{Mean} \times 100$$

RESULTS AND DISCUSSION

The current research work was carried out to assess the inheritance pattern of yield and other genetic parameters of upland cotton. All observed traits exhibited highly significant differences at (P>0.01) for plant height, number of monopodial branches, number of sympodial branches, bolls per plant, boll weight, seed cotton yield per plant, seed index, ginning out turn and staple length. While lint index was non-significant (Table1). The parental crosses average performance shown in (Table2), which further indicated that the highest plant height was (155.30 cm) and minimum plant height (139.47cm) obtained from the cross Shahbaz x Sindh-I and by the parent Chandi respectively. A single stem branches per plant highest single stem branches per plant presented by Reshmi x CRIS 134 (1.10) and the least number of monopodia per plant (0.67) was displayed by parent Sindh-1. However, sympodia per plants observed in CRIS-134 x CRIS-9 (27.10) the least number of sympodia per plant (23.50) was displayed by parent Chandi.

Table 1.(Mean squares (ANOVA) of different quantitative and qualitative parameters in upland cotton.

Source of variation	D.F	Plant Height	Monopodia per plants	Sympodia per plant	Bolls per plant	Boll weight	Seed cotton yield/plant	Seed index	Lint index	G.O.T%	Staple length
Replication	2	11.48	0.08	0.45	1.21	0.01	7.61	0.02	0.06	1.00	0.05
Genotypes	16	90.25**	0.04**	5.72**	7.70 **	0.22**	561.98**	0.52**	0.45NS	10.10**	3.40**
Error	32	5.49	0.03	1.09	2.71	0.01	35.80	0.02	0.16	0.50	0.09
Total	50										

****** = Highly significant at 0.01 level of probability; **NS** = Non-significant

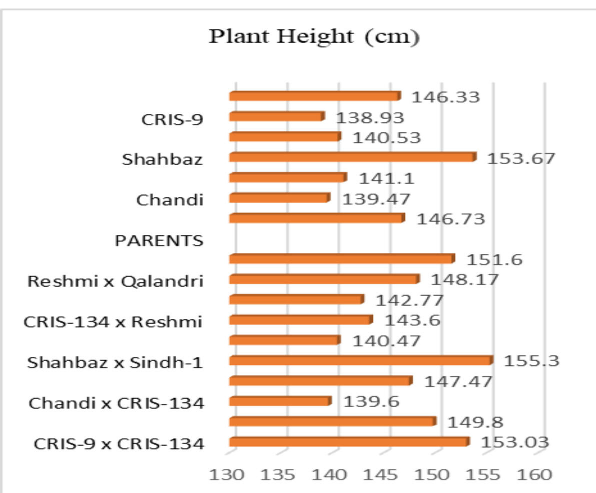

Fig. 1. The mean values of plant height for cross combinations and parents.

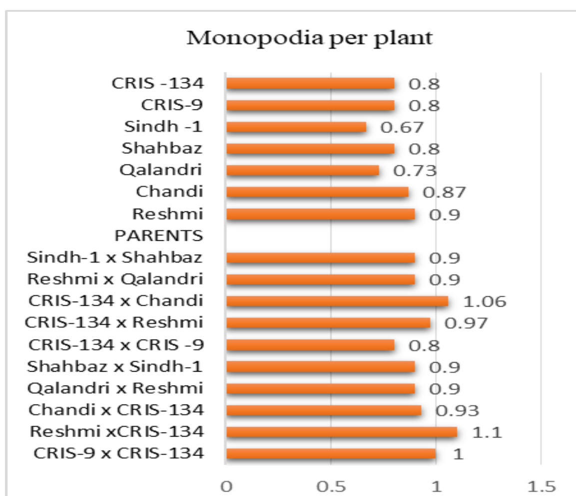

Fig. 2. The mean values of monopodia per plant for cross combinations and parents.

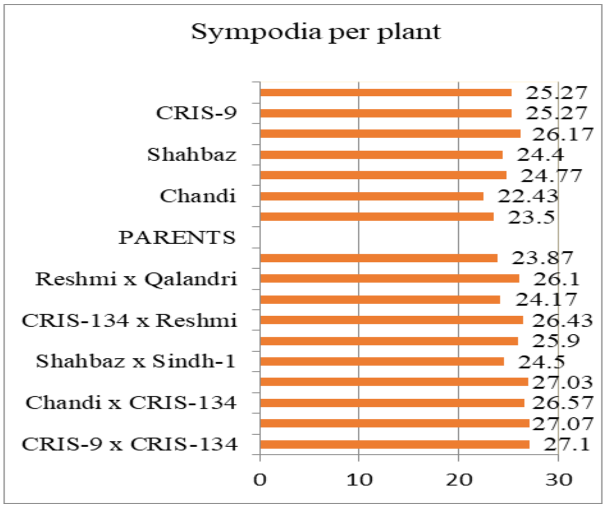

Fig.3. Mean values of sympodia per plant for cross combinations and parents.

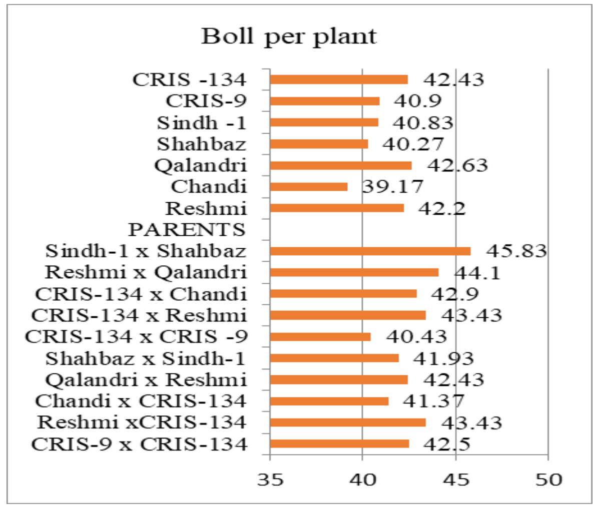

Fig.4. The mean values of bolls per plant for cross combinations and parents.

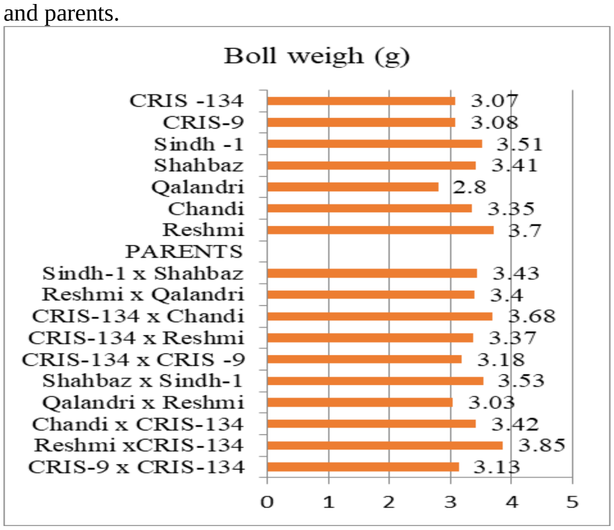

Fig.5. The mean values of boll weight for cross combinations and parents.

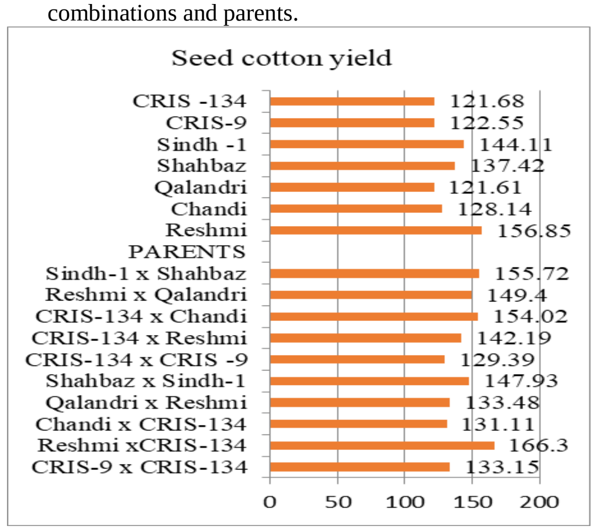

Fig.6. The mean values of Seed cotton yield for cross combinations and parents.

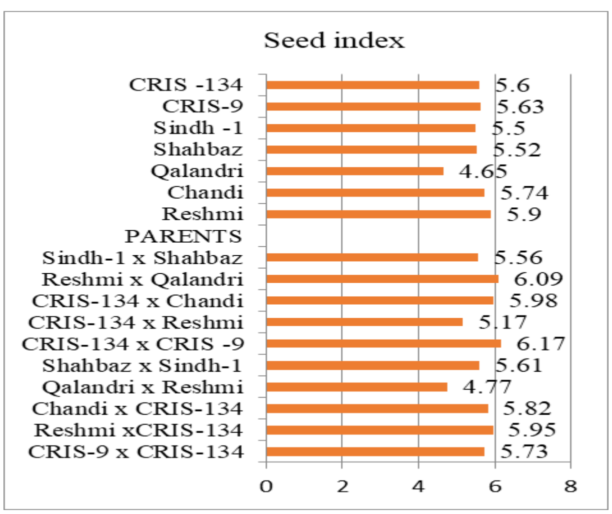

Fig.7.The mean values of Seed index for cross combinations and parents.

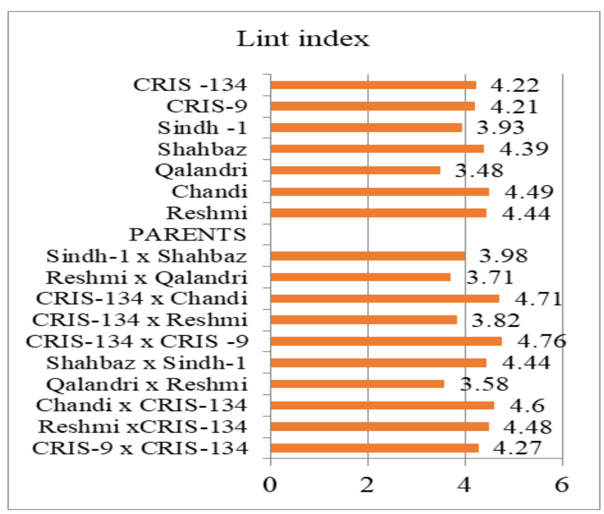

Fig.8.The mean values of Lint index for cross combinations and parents

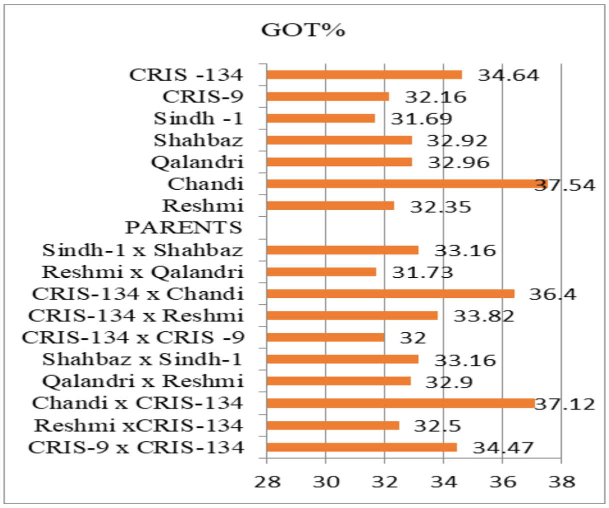

Fig. 9. The mean values of GOT% for cross combinations and parents.

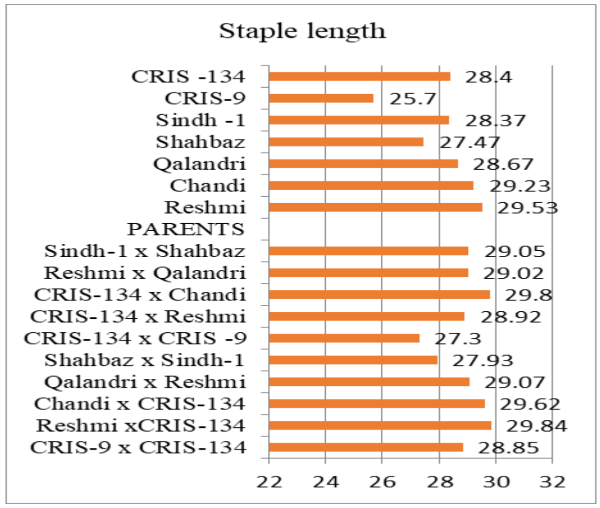

Fig.10. The mean values of staple length for cross combinations and parents.

Table.2. Phenotypic, Genotypic, phenotypic coefficient variation, genotypic coefficient variation, Heritability% and Genetic advance.

Trait	Mean	Range	CV	Phenotypic Variance	Genotypic Variance	PCV	GCV	Heritability (%)	Genetic Advance	GA% of mean
Plant Height	117.5	57.8-128.3	11.5	33.74	28.25	5.36	4.90	83.73	6.81	5.80
Monopodia per plant	2.2	1.0 - 2.9	8.7	0.36	0.34	4.08	3.91	91.81	0.78	35.38
Sympodia per plant	16.7	11.6 - 23.4	12.3	2.63	1.54	3.97	3.03	58.60	1.33	7.97
Bolls per plant	38.8	31.6 - 42.5	9.4	3.70	1.99	3.09	2.27	53.86	1.45	3.74
Boll weight	2.9	2.2 – 3.9	11.1	0.08	0.07	1.66	1.55	87.50	0.35	11.95
Seed cotton Yield	131.9	109.2 – 205.4	9.2	211.19	175.39	12.65	11.53	83.04	16.89	12.81
Seed index	6.7	5.6 – 7.9	10.3	0.19	0.17	1.67	1.58	89.29	0.54	8.06
Lint Index	3.7	2.6 – 4.8	11.5	0.26	0.09	2.63	1.62	37.67	0.27	7.22
GOT %	38.6	35.7 – 40.6	10.6	3.70	3.2	3.09	2.88	86.49	2.33	6.03
Staple Length	26.6	25.6 – 29.8	9.9	1.19	1.11	2.12	2.04	92.45	1.41	5.31

The mean square analysis of variance showed highly significant ($P<0.01$)variations among cotton genotypes for plant height (cm), monopodia per plant, sympodial per plant, boll weight (g), seed cotton yield (g), seed index, lint index, GOT% and staple length (mm) except indicating the presence of preferable genetic variability (Table.1). The data is further subjected for the estimation of phenotypic variance (PV), genotypic variance (GV), phenotypic coefficient variation (PCV), genotypic coefficient variation (GCV) heritability (H2) and genetic advance (GA) were presented in (Table 2).

Genotypes mean performance

Plant height: Plant height is especially important and has close association with bolls per plant and it has also ultimately positive effect on seed cotton yield. Parental lines and cross combinations mean performance for plant height varied from (138.93- 153.67cm) and (139.60 -155.30 cm) respectively, (Fig.1). The parents Shahbaz (153.67 cm) exhibited maximum plant height followed by CRIS -9 (138.93 cm) and Reshmi (146.73 cm). However, Chandi

(139.47 cm) observed least plant height followed CRIS-9 (138.93- 153.67 cm). The results of F1 hybrid Shahbaz x Sindh-1 (155.30 cm) and CRIS-9 x CRIS-134 (153.03 cm) was observed maximum plant height. However, CRIS-134 x CRIS -9 (140.47 cm) and CRIS-134 x Chandi (142.77 cm) confirmed least plant height. Results revealed that the bolls per plant is varietal trait and not entirely dependent on plant height, but plant height influence cannot be disregarded.

Plant Breeders are enthusiast to investigate short stature plants due to lodging threat and found it is also easy in picking by machine and as well as manual (Khan *et al*., 2003). However, Chen *et al*. (1991) studied that Gossypium hirsutum cultivars, the plant height and sympodiamypodia were significantly correlated with each other and negatively correlated with first picking. There was genetic variability for plant height among different cotton cultivars and that plant height was positively correlated to bolls per plant and seed cotton yield if lodging does not occur. Khan (2003), Taohua and Haipeng (2006), Meena *et al*. (2007) and Ahmed *et al*. (2008) experimented that the stability and adaptability of Gossypium hirsutum cultivars observed varied values for plant height and other yield components. Chen and Zhao (1991) observed plant height and character of plant types and found closed correlated with yield contributes. However, Plant type characteristics are playing an important role in the correlation with plant height and sumpodia and concluded that consideration should be paid to the selection of plant type characteristics in breeding program. Arshad *et al*., (1993) evaluated upland upland cultivars and concluded that plant height is positively correlated with yield and boll number. Tyagi (1994a & b) and Sambamurthy (1999) noticed positive correlation between plant height and yield and their study further exhibited that the plant height also contributed 70% of the total variability for the seed cotton yield. Therefore, it was concluded that in crop cotton crop, plant height is most desirable if no longer lodging occurs. The contradictory views of plant researchers about the above said traits might be due to genotypic and environmental variations and may be due to different genetic background of the breeding material could be under various environmental conditions. Therefore, it was concluded that plant height is desirable trait if lodging does not occur. The different contradictory theories have been reported in previous studies showed that plant height varies due to genotypic variation and different genetic background of breeding material.

Monopodia per plant: Growth pattern of monopodial branches arises from the main stem and observed indirect fruit. Maximum monopodia per plant were notice during vegetative growth, due its reproductive growth stage became delayed. Breeders mostly prefer early maturity and least monopodia per plant in cotton. The vegetative branches per plant ranged 0.67 - 0.90 and 0.80-1.10 for parental lines and F1 hybrids among parents. However, lowest monopodia per plant recorded in Sindh-1(0.67) followed by Reshmi (0.90), while maximum monopodial branches were found by Reshmi (0.90) followed by Sindh -1 (0.67). The F1 cross combinations, CRIS-134 x CRIS-9 (0.80), Reshmi x Qalandri (0.90) and Sindh-1 x Shahbaz (0.90) all showed minimum number of monopodial branches, respectively (Fig.2). Previous study showed that Gossypium hirsutum cultivar viz., CIM-506 found maximum seed cotton yield plant-1, sympodia plant-1, however cultivar CIM0707 and CIM-554 showed considerably high yield contributing traits and seed cotton yield (Batool *et al.*, 2010). Khan (2009) studied Gossypium hirsutum cultivars CIM-499, CIM-473, CIM-496 and CIM-506, results showed that high genetic potential revealing that plant height (137.30 to 155.30 cm), bolls sympodia-1 (2.28 to 3.31), bolls plant-1 (14.00 to 25.95) boll weight (3.07 to 4.16 g), locules boll-1 (4.30 to 4.48) and seed cotton yield (1200 to 2450 kg ha-1). The heritability broad sense has been observed for the trait's days to first flowering (0.96), plant height (0.95), monopodia plant-1(0.88), sympodia plant-1 (0.89, boll weight (0.97) and seed cotton yield plant-1(0.91), while first internode length expressed low heritability (0.36) (Batool *et al.*, 2010). Tyagi *et al*. (1996), khan (2003) and Ahmed *et al*., (2008) observed similar results and indicated variability for monopodia per plant. Monopodia per plant were mostly noticed negatively correlated with seed cotton yield in several research literatures, that's why breeder are interested in mower number monopodia per plant. Results suggested that mostly genotypes observed low number of monopodia per plant and possesses higher seed cotton yield. Therefore, in breeding program for higher yield should be preferred to less vegetative branches per plant.

Sympodia per plant: The fruiting branches per plant calculated from 22.43 - 26.17 for parental line and 23.87 - 27.10 for F1 hybrids. The maximum sympodia per plant exhibited in Sindh -1 (26.17) followed by Chandi (22.43). The lowest number of sympodia per plant was observed by Chandi (22.43) and Reshmi (23.50). The F1 hybrid combination CRIS-9 x CRIS-134 (27.10) and Reshmi x CRIS-134 (27.07) were found maximum sympodia per plant, while Sindh-1 x Shahbaz (23.87) displayed least number of sympodia per plant, respectively (Fig.3). Sundas *et al*., (2010), khan (2009) found that CIM-506 had maximum sympodia per plant approximately (16.93), However it was observed statistically at per with three other cultivars viz., CIM-707, CIM-554 and SLH-284 having 15.17 to 15.97 sympodia per plant. Tyagi *et al*. (1996) and Khan *et al*. (2000, 2007a 2009a) noticed the same results and were indicating variability among upland cotton genotypes for this particular trait. Sympodia per plant have direct influence on seed cotton yield and several previous research indicated positive association of fruiting branches with the seed cotton yield. Meanwhile, more attention should be paid to the selection of plant type characteristics in cotton breeding program.

Bolls per plant: Bolls per plant were picked twice, mean value recorded from 42.43- 42.63 among all genotypes (Fig.4). Maximum number of bolls were observed in Qalandri (42.63) followed by CRIS -134 (42.43). However, Chandi (39.17) and Shahbaz (40.27) presented least number of bolls per plant. The new cross combinations, Sindh-1 x Shahbaz (45.83), Reshmi x Qalandri (44.10), CRIS-134 x Reshmi (43.43) and CRIS-134 x Chandi (42.90) displayed maximum bolls per plant. Cook and El-Zik (1993) found that cotton cultivars are differed significantly for bolls production. The results were the like the findings of khan (2003) who also have reported variable number of bolls per plant. The heritability was found greater magnitude with expected response to selection, along with positive correlation with yield, it showed major portion of the traits was controlled by genetic variance and playing a crucial role. Taohua and Haipeng (2006), Meena *et al*. (2007) and Ahmed *et al*. (2008) also studied *G. hirsutum* cultivars and observed variation in terms of boll per plant. Soomro *et al. (*2005) examine the yield and yield components of commercial cotton cultivars (CRIS-5A, CRIS-134, CRIS-9, CIM-496, CIM0-499 and CIM-506) and observed significant differences for bolls per plant. Rao and Mary (1996) compared different *G. hirsutum* cultivars for yield and various economic traits and observed dissimilarity for number of bolls and indicated positive genotypic correlation of bolls per plant with yield. Zhang *et al*. (2003) also evaluated the effect of genetic transformation of yield and bolls per plant of cotton cultivars, it was found that higher lint yield of cotton cultivars was mainly due to higher number of bolls per plant and lint percentage. Iqbal *et al*. (2003) observed positive association between stability variance for yield and the estimated of genotypic components for bolls set which indicated boll set was the main contributor towards increasing of see cotton yield. Results revealed that bolls per plant has greater emphasis in cotton improvement program, as it contributes significantly. Therefore, selection should be made on the bases of maximum number bolls per plant and high lint percentage for breeding cotton with high seed cotton and lint yields.

Boll weight: Boll weight recorded among all the parents were ranged from 3.51-3.70 (Fig.5). The highest boll weight was found by Reshmi (3.70) followed by Sindh -1 (3.51). However, minimum weight of bolls was presented by Qalandri (2.80) and CRIS -134(3.07g), respectively. However, among F1 cross combinations Reshmi x CRIS-134 (3.85) and CRIS-134 x Chandi (3.68g) observed maximum boll weight followed by Shahbaz x Sindh-1 (3.53g). Sundas *et al*. (2010), Khan (2009) observed maximum boll weight in three cultivars viz., CIM-707, SLH-284 and CIM-554 with ranging of 3.04 to 3.83 g, whereas four other cultivars (CIM-499, CIM-506, CIM-446 and CIM-573) exhibited lowest boll weight. In the contrast Terziey *et al*. (1996) and Abouzaid *et al*. (1997), Ahmed *et al*. (2008) and khan et al., 2009 obtained different results to proportion and variation for boll weight in relation to seed cotton cultivars. Suinaga *et al.* (2006), Taohua and Haipeng (2006), Khan *et al.* (2007) and Meena *et al*. (2007) did research on performance of cotton cultivars and observed varied values for boll weight. Khan (2003) also studied different G. hirsutum cultivars for yield and other economic traits and noticed significant variations for boll weight and indicated positive effect on the seed cotton yield. Boll weight is also an important yield contributing character and has direct effect on seed cotton yield. During selection of the genotype, consideration should be paid to boll weight.

Seed cotton yield per plan: Seed cotton yield varied from 121.61 -156.85g for parental lines and 129.39-166.30g for cross combinations among all parents (Fig.6). Maximum seed cotton yield revealed by genotype Reshmi (156.85g) followed by Sindh -1(144.11g). However, lowest seed cotton yield was observed in Qalandri (121.61g). The F1 hybrid Reshmi xCRIS-134 (166.30g) displayed maximum. Seed cotton yield followed by Sindh-1 x Shahbaz (155.72g) and CRIS-134 x Chandi (154.02). Seed cotton yield was mainly controlled by genetic variance due to its greater values and in presence of high heritability (Sundas *et al*., 2010). Genetic variability for seed cotton yield was reported by Terziev *et al*. (1994), Abouzaid *et al*. (1997) and Khan *et al*. (2010). Copur (2006) and Khan *et al*. 2009a also determined the yield and yield components of G. Hirsutum cultivars and it was observed significantly differences. Soomro *et al*. (2005) evaluated the seed cotton yield in upland cotton cultivars and observed that cultivars manifested significant differences for yield of First and last picking. Khan (2003) and Khan *et al*. (2000, 2007a, 2007b) also studied different G. hirsutum cultivars for yield traits and found significant variations for boll par plant and boll weight that contribute significantly and carrying positive effect on seed cotton yield. Results revealed that the seed cotton yield is mainly controlled by genetic variation due to it higher values and presence of high heritability. There are no any other recommendations in the said genotypes for further improvement in seed cotton yield.

Seed Index: Seed index assorted from 4.65-5.90 for parental lines and 4.77– 6.17 for F1 hybrids, among all the parents (Fig.7). The maximum seed index exhibited by genotypes Reshmi (5.90) followed by Chandi (5.74). However, minimum seed index was displayed by Qalandri (4.65). Highest seed index observed by F1 hybrid CRIS-134 x CRIS-9 (6.17) followed by Reshmi x Qalandri (6.09) and CRIS-134 x Chandi (5.98). Dani (1991) evaluated the mean performance of G. hirsutum for the seed index and noticed significant variations among cultivars for seed index. Suinage *et al*. (2006), Taohua and Haipeng (2006) and Meena *et al*. (2007) evaluated the yield capacity of G. hirsutum cultivars and detected variations in seed index. Hassan *et al.* (2005) evaluated the performance of Egyptian cotton cultivars and indicated positive and significant correlation between seed index and seed cotton yield. Abouzaid *et al*. (1997) and Iqbal *et al*. (2003) conducted study on *G. hirsutum* for seed index yield and other yield related parameters and observed that yield contributes in a varied significantly between cultivars and Iqbal *et al*. (2003) mentioned in their studies conducted on G. hirsutum for seed index, yield and other yield related traits and observed that yield attributes also varied significantly between cultivars. The inconsistent views of past researchers about the said trait might be due to genotypic and environmental differences and due to diverse genetic background of the breeding material used in various environmental conditions.

Lint Index: On average lint index ranged from 3.93 – 4.49 (Fig.8). Maximum lint index was obtained in parental line by Chandi (4.49) and lowest recorded by sindh-1(3.93) respectively. The highest lint index for cross combination noticed in CRIS-134 x Chandi (4.71) and minimum lint index were recorded in Qalandri x Reshmi (3.58). Rao and Mary (1996), Afiah and Ghoneim (2000) observed that the genetic variability was high for the yield components including lint index and yield. Positive association between these two parameters lint index and yield suggesting that lint index leads to increase seed cotton yield and lint percentage. Suinaga *et al*. (2006), Taohua and Haipeng (2006) and Meena *et al*. (2007) evaluated the performance of Gossypium hirsutum and observed variation for lint index. Abouzaid *et al*. (1997) and Iqbal *et al*. (2003) also preferred that G. Hirsutum cultivars which varied significantly for lint index and other yield related traits.

Lint percentage (GOT%): lint percentage is the vital trait and possess major output after ginning the seed cotton, as cotton is mainly for the purpose of lint (fibres) and cotton seed oil is extracted as by-product. Parental lines and cross combinations mean performance for GOT% ranged from 31.69-37.54 and 31.73-37.12 respectively (Fig.9). The parents, Chandi (37.54) displayed maximum GOT% followed by CRIS -134(34.64) and Qalandri (32.96). The least GOT% was recorded in Sindh -1(31.69) followed by CRIS-9(32.16). Among F1 hybrids it was observed that, CRIS-134 x Chandi (36.40) and Chandi x CRIS-134 (37.12) showed maximum GOT%. However, lowest GOT% was observed in Reshmi x Qalandri (31.73) and CRIS-134 x CRIS -9 (32.00). Arshad *et al.* (1993) and Iqbal *et al*. (2003) also reported that agronomic characteristic of upland cotton cultivars using correlation and mentioned that GOT % had negative effect on seed cotton yield. Afiah and Ghoneim (2000) studied phenotypic and genotypic correlation and displayed that lint yield trait was major contributor to yield and followed by lint percentage and boll weight. Taohua and Haipeng (2006) and Meena *et al.* (2007) investigated the stability and adaptability of G. Hirsutum and observed different values for lint percentage. Cook and El-Zik (1993) obtained other results for the cultivars were differed significantly for lint yield. Reid *et al*. (1989) also studied the fibre yield of promising cultivars in all major Australian cotton growing areas and it was revealed that highest rate of genetic gain in lint yield. Khan *et al*. (2009a) measured bolls per plant in upland cotton and found most important effect on lint yield. The unpredictable finding and different observation of previous studies suggested that traits might have genotypic and environmental differences. Therefore, it is suggested that to breed cotton cultivars with higher lint yield based on synchronous selection of more bolls per plant.

Staple length: The breeder's emphasis to improve the fibre quality because this trait is most important and having remarkably advantage in textile industry. Staple length varied from 25.70-29.53 among the calculated date which showed Reshmi (29.53mm) possess highest value for staple length, while CRIS-9 (25.70 mm) exhibited least staple length. However, the maximum staple length among parents was evaluated in Reshmi (29.53mm) and Chandi (29.23mm) while CRIS-9 (25.70mm) presented lowest fibre length. Results of single cross combinations showed that Reshmi-134 (29.84mm) presented highest fibre length followed by Chandi x CRIS-134 (29.62 mm). However, the lowest staple length displayed by CRIS-134 x CRIS -9 (27.30 mm) (Fig. 10). Irfanullah *et al*. (1994) and Islam *et al*., (2001) studied on fibre fitness, however their reports are similar to Ahmed and Azhar (2000), Hendawy *et al*. (1999) and Ali *et al*. (2008a) was not satisfied with the present findings. Ali *et al*. (2008a) observed the data which is similar to the Hassan *et al.* (2010), they studied fibre strength. However, fiber uniformity was under the control of additive gene effect according to Liu and Han (1998), Ali *et al*. (2008a). Khan *et al*. (1999) reported that parents having good general combining ability for a character which are expected to high yielding of cotton hybrid and it was authentically investigated when CIM-707 was crossed with different parents which possess high staple length, fibre strength and uniformity respectively. In the contrary Patel *et al*., (1997) suggested that it is not necessary that the parents possess good general combining ability for hybrid production, however it was observed time that few parents present poor GCA might be combine well to produce good hybrids in case of FH-1000x DPL-2775 for fibre uniformity.

Genotypic and phenotypic variation:

The phenotypic, genotypic coefficient, heritability % and genetic advance variance showed variation in every developmental stage and economical traits were recorded in (Table 2). The estimates ranged from 1.0% to 205.4% and 2.9% to 109.2 % respectively. The maximum GV and PV effects were found in Seed cotton Yield 109.2%, 205.4% followed by plant height 57.8%, 128.3%, respectively. Bolls per plant were 31.6%, 42.5%, however GOT% observed 35.7%, 40.6% respectively, The Staple length were found 25.6%, 29.8%, and in case of sympodia per plant was 11.6%, 23.4%. Seed index 5.6%, 7.9%, respectively. The smallest GV and PV were found for monopodial per plan 1.0%, 2.9% and 2.2 %, 3.9% for boll weight displayed least GV and PV values recommended that breeder should choose best germplasm for genetic variability in breeding populations. The Genotypic and phenotypic variation was premier for Seed cotton Yield 205.4% followed by plant height (128.3cm) and number of bolls (42.5g), it was suggested that these traits have considered genotypic and phenotypic variances.

Heritability (H2) estimates, genetic variance (σ2g) and phenotypic variance (σ2p) were presented in (Table 2). The genetic variance (175.39) was almost equal to phenotypic variance (211.19) for Seed cotton Yield resulted in high broad sense heritability (83.04%) Although genetic advance was 16.89. Therefore, maximum heritability % were associated with maximum genetic variance (175.39). The monopodia branch genotypic (0.34) and phenotypic (0.36) variance were equal suggesting preferable amount of variability with maximum heritability% (91.81%) joined with more amount of response to selection (0.84). The inheritance of monopodial branches ware remained less affected by genetic variance (0.34). Hence, in the inheritance of monopodial branches the genetic variance performed important role and even as intensive selection in the early generation will decrease the vegetative branches maximum heritability% (58.60) and genetic advance (1.33) were recorded for fruiting branches. Genotypic variance (1.54) observed less compared to genotypic (175.39) and phenotypic variance ((211.19). Maximum heritability and response to selection clarify sympodial branches were under the influence of genetic variance and early selection can made reasonable improvement. However, seed cotton yields genotypic variance (175.39) was least than phenotypic variance (211.19) and heritability% (58.60%) was observed for sympodial branches. For boll weight the maximum genetic variance recorded (0.07) it is very close associated with phenotypic variance (0.08) while results showed maximum heritability (87.50). The genotypic variance (1.99) was lower to phenotypic variance (3.70) for Bolls per plant the genetic variance (1.99) is mostly closets with phenotypic variance (3.70) maximum heritability (53.86) was recorded by bolls per plant. The genotypic variance (0.17) less than phenotypic variance (0.19) observed by seed index and highest heritability showed (89.29) by lint index genotypic variance (0.09) was lower to phenotypic variance (0.26) hence higher heritability (37.67) estimates and lint index is considerably control by genotypic factors. The genotypic variance (3.2) almost close to phenotypic variance (3.70) and heritability recorded (86.49) for GOT%. For staple length the genotypic variance was low (1.11) even than phenotypic variance (1.19) and highest heritability displayed (92.45). The highest heritability was recorded among all parameters as compare to staple length.

CONCLUSION

Present investigation pertaining maximum heritability estimates were reported for staple length, sympodial per plant, boll weight, seed cotton yield and bolls per plant. However, least heritability was recorded for staple length and number of Monopodia per plant. The genetic variance is most significance estimates variation among many traits resulted in genetic factors influence except lint index. However, maximum heritability estimated by seed cotton yield and yield contributing traits were almost found genetically, while lowest genetic variance and phenotypic variance were controlled by additive gene action. Further, results recommended phenotypical selection for improvement of said traits except lint index. Eventually, taken together, this work describes quantitative and qualitative characteristics of upland cotton and F1 hybrid, and discovered the best genotypes as cause the effect of performance. These results not only provide the better understanding of mechanism of cotton, but also provides valuable genetic material for breeding high yielding varieties.

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