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Genetic Diversity and Association Analysis in Upland Cotton Cultivars

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Abstract
An experiment to find out the genetic diversity, correlation and regression coefficient of seed cotton yield with different qualitative and yield related morphological attributes in eight upland cotton cultivars was carried out at Cotton Research Station, Dera Ismail Khan, Pakistan during April 2015. The cultivars viz; Cris-342, Cris-134, Cris-129, Gomal-93, Israr Shaheed, SLH-317, DNH-57 and CIM-573 were sown in a randomized complete block (RCB) design having three replications. All the cultivars revealed highly significant ($P \leq 0.01$) differences for seed cotton yield whereas boll weight, number of bolls plant^{-1}, sympodial Internodal length and number of fruiting position on sympodia depicted significant ($P \leq 0.05$) differences while plant height, length of sympodia and height of first sympodia were having non-significant differences in mean values. The Pearson's correlation coefficient (r) were significant, positive and highest between seed cotton yield and plant height (0.702), number of bolls plant^{-1} (0.813) and boll weight (0.775). Regression analysis revealed that plant height (R^2= 0.493), boll weight (R^2=0.60) and number of bolls plant^{-1} (R^2=0.661) significantly ($P \leq 0.05$) contributed in the seed cotton yield. The information generated hence may be utilized for hybridization between genotypes for the creation of genetic variability in cotton.
Keywords: correlation, genetic diversity, hirsutum, regression coefficient

INTRODUCTION
Cotton is of great importance and the textile industries have taken the outstanding position in Pakistan. Cotton being an often cross pollinated crop is the main source of raw material in textile and one of the leading cash crop of our country (Khan *et al*., 2009). This crop has an economic value in terms of its share in more than half of the total export materials for Pakistan (Rahman *et al*., 2012). Being a fiber, cash and industrial crop cotton also have a pivotal role in edible oil and seed cake for the animal feed (Khan *et al*., 2008). Pakistan is the fourth largest producer of cotton and Punjab and Sindh provinces are the major cotton belt of this region. But due to high infestation of leaf curl viruses and high insect pest situations these areas are highly under pressure (Ahmad *et al*., 2008). Therefore cultivation of this crop in some plain areas of the D.I.Khan (KPK) and Baluchistan provinces are remarkably boosting the crop yield (Khan, 2003).

For sustainability and better productivity of cotton crop, genetic diversity is a crucial constituent upon which future of cotton breeding depends and its effective exploitation can be used in future cotton breeding program (Ullah *et al*., 2006). For getting better-quality genotypes proper exploitation of available germplasm and addition of new germplasm for the creation of sufficient genetic diversity is of greater importance (Li *et al*., 2008). To estimate the level of genetic diversity various breeding approaches like polyploidy, hybridization and introduction of the exotic germplasm can be used (Brown-Guedira *et al*., 2000). One of the utmost value of the genetic diversity within and among the genotypes is that it can be used to enhance the probability of enviable combinations which can be used in a breeding program. However, this diversity is too much important to increase the resistance against various abiotic and biotic stresses (Van Esbroeck and Bowman, 1998).

Correlation analysis help plant breeder to produce talented genotypes with high yield and excellent fiber qualities. Correlation analysis provides a good indicator to calculate the consequent change which occurs in one trait at the level of proportionate change in the other (Ahmad *et al*., 2008). The correlation analysis also reflects correlated response of a particular character with its counterpart and also provides a good index to predict the corresponding change which occurs in one character at the expanse of the proportionate change in the other. It also reflects associated reply of a particular trait with its complement.

Seed cotton yield is a complex character which is less influenced by the environment and direct selection for this trait is not often effective. Therefore, it is necessary to evaluate the association of this trait with other yield attributing traits (Joshi *et al*., 2006). To evaluate and select promising genotypes the information about association of traits is very important.

The present research work was therefore carried out to identify and asses the diversity among the cotton cultivar and to study the relationship of seed cotton yield with other yield attributing traits under the agroclimatic condition of Dera Ismail Khan (KPK) Pakistan.

MATERIALS AND METHODS

Experimental location and plant material

An experiment to find out the genetic diversity, performance and association of seed cotton yield with various qualitative and yield related morphological attributes in eight upland cotton cultivars was carried out at Cotton Research Station, D.I.Khan (situated at 31º49′ N latitude and 70º55′ E longitude), Pakistan during April 2015. The cotton cultivars comprised of Cris-342, Cris-134, Cris-129, Gomal-93, Israr Shaheed, SLH-317, DNH-57 and CIM-573 were investigated during the course of study.

Experimental layout and crop management

The cultivars were hand sown in a randomized complete block (RCB) design having three replications during mid of April 2015. The row × plant spacing was 75 × 30 cm respectively. Planting was done in a 4 row plot with 10 m length having plot size of 40 m^2. Seeds were planted in hills and each hill received 5 seeds which were irrigated immediately. To ensure single plant per hill, thinning was performed after 20 days of germination. In this experiment, 60 kg ha^{-1} of P_2O_5 as single super phosphate and 50 kg ha^{-1} of nitrogen as urea were applied prior to sowing, 50 kg ha^{-1} nitrogen as urea used at the flowering stage and 50 kg ha^{-1} at boll formation stage. Picking was done 130 days and 150 days after planting. All the cultural practices were performed as recommended.

Recording of observations and statistical analysis

Data on number of bolls $plant^{-1}$, boll weight (g), plant height (cm), seed cotton yield (kg ha^{-1}), sympodial length (cm), number of fruiting position at sympodia and sympodial intermodal length (cm) were recorded. The data recorded were subjected to analysis of variance technique appropriate for RCB design as suggested by Steel *et al*., 1997. To determine the statistical differences in means the least significant difference (LSD) test at 5% level of probability was used when the F value was significant. For this purpose, MSTAT-C (Freed *et al*., 1989) statistical package was utilized. Microsoft Excel 2013 was used for correlation and regression coefficient analysis (Steel *et al*., 1997). Person's Correlation coefficient was calculated to determine the correlation among various parameters and seed cotton yield whereas regression analysis was performed for estimations of seed cotton yield due to other parameters.

RESULTS

Plant height (cm)

The mean values pertaining to plant height depicted non-significant differences among the cotton cultivars (Table 1). Maximum plant height of 152 cm was recorded for cultivar SLH-317 followed by cultivar DNH-57 (149.33 cm) and Israr Shaheed (148.67 cm) (Table 2). Minimum plant height of 124 cm was recorded for cultivar Cris-134. The correlation analysis revealed that plant height also had significant positive correlation (r=0.702) with seed cotton yield. The coefficient of determination (r^2=0.493) revealed that 49.3% of total variation in seed cotton yield was induced by plant height. The regression coefficient (b=31.3) determined that with a unit increase in plant height, a proportional increase of 31.3 g in seed cotton yield could be expected (Table 3, Fig. 1).

Length of Sympodia (cm)

The mean square values pertaining to length of sympodia showed non-significant variation among the various cultivars (Table 1). However maximum sympodial length (57.13cm) was recorded for cultivar Cris-134 (Table 2). Correlation analysis revealed that there was non-significant positive (r=0.136) association among length of sympodia and seed cotton yield (Table 3). Similarly regression analysis also revealed non-significant explanation (R^2=0.018) of seed cotton yield by length of sympodia (Table 3, Fig. 2).

Number of fruiting position

Statistically significant ($P \leq 0.05$) variation was found for number of fruiting positions for various cultivars (Table 1). Maximum (11.27) fruiting positions were found in the cultivar Cris-134 which was at par with Cris-342 and Israr Shaheed (Table 2). Minimum numbers of fruiting positions were found in the cultivar Cris-129 (7.53) which was at par with CIM-573 (7.60) (Table 2). Correlation analysis revealed non-significant negative correlation (r=-0.815) among number of fruiting position and seed cotton yield (Table 3). The regression analysis also revealed least explanation (R^2=0.034) of seed cotton yield by the independent variable i.e. number of fruiting position (Table 3, Fig. 3).

Sympodial Internodal Length (cm)

Mean Square table showed significant ($P \leq 0.05$) differences among various cultivars for sympodial intermodal length (Table 1). Maximum (5.38 cm) sympodial intermodal length recorded for cultivar Cris-134 whereas minimum (4.006 cm) sympodial intermodal length was observed for cultivar Cris-129 (Table 2). Sympodial intermodal length showed non-significant positive (r=0.316) correlation with seed cotton yield (Table 3). Similarly coefficient of determination (0.094) also showed least explanation of seed cotton yield by sympodial intermodal length (Table 3, Fig.).

Number of bolls plant^{-1}

Statistically significant (P≤0.05) variation was found among various cultivars for number of bolls plant^{-1} (Table 1). Maximum (42.76) number of bolls plant^{-1} was found in the cultivar Israr Shaheed which was at par with DNH-57 (38.00) and Cris-342 (36.00). Minimum number of bolls plant^{-1} was found in the cultivar Cris-129 (Table 2). Correlation analysis revealed that there was significant (P≤0.05) positive correlation among number of bolls plant^{-1} and seed cotton yield (Table 3). Similarly 66.1% of variation in seed cotton yield was been explained by the linear effect of number of bolls plant^{-1}. Further it can be inferred from the results that with unit increase in number of bolls plant^{-1} there will be an increase of 112.598 gm in seed cotton yield (Table 3, Fig.).

Boll weight (g)

Results of Table 1 exhibits that there was significant (P≤0.05) variation among various cultivars regarding boll weight (Table 1). Maximum (2.96 gm) boll weight was recorded for cultivar Israr Shaheed which was at par with cultivar DNH-57 (2.88 g) (Table 2). Minimum (2.21 g) boll weight was recorded for cultivar Cris-342. The correlation analysis showed that there was significant (P≤0.05) positive correlation (r=0.775) among boll weight (g) and seed cotton yield (Table 3). Regression analysis also revealed high explanation (R^2=0.60) of seed cotton yield by the linear effect of boll weight and it was found that with unit increase of boll weight there will be a linear increase of 1612.471 g seed cotton yield (Table 3, Fig.).

Seed cotton yield (kg ha^{-1})

Various cotton cultivars depicted highly significant (P≤0.01) differences regarding seed cotton yield (Table 1). Maximum seed cotton yield of 3544.4 kg ha^{-1} was recorded for cultivar Israr Shaheed followed by DNH-57 (3411.1 kg ha^{-1}). Minimum (1933.3 kg ha^{-1}) seed cotton yield was recorded for cultivar Cris-342. The Pearson's correlation coefficient (r) were significant, positive and highest between seed cotton yield and plant height (0.702), number of bolls plant^{-1} (0.813) and boll weight (0.775). Similarly regression analysis revealed that plant height (R^2= 0.493), boll weight (R^2=0.60) and number of bolls plant^{-1} (R^2=0.661) significantly (P≤0.05) contributed in the seed cotton yield.

DISCUSSIONS

Cotton has the most complex structure among major field crops, and its performance can be influenced by multidirectional interactions of hereditary and ecological factors. Study of the genuine relationship between the performance of cotton seed and related traits uncover its significance in cotton breeding programs. Seed cotton yield and yield contributing traits that are not under the immediate control of a solitary gene, therefore, the improved characteristics of the components lead to a corresponding improvement in performance. For understanding the mechanism of affiliation, i.e. a cause-effect provides the premise for formulating selection criteria suitable in breeding programs based on yield components for the rational improvement of performance and components.

From the instant results it can be inferred that however mean differences among various cultivars didn't fluctuate yet plant height significantly contributed in seed cotton yield. It is also fact that breeder usually lean towards medium stature plants to circumvent lodging and observe good mechanical picking but its contribution in improvement of yield cannot be degraded if lodging doesn't occur as reported by Ahmad *et al*., (2008). They further reported that plant height contributed 48.1% in seed cotton yield which affirms our results. Likewise Arshad *et al*. (1993), Suinaga *et al*. (2006), Khan (2003) and Soomro *et al*. (2005) also reported positive correlation of plant height and seed cotton yield in upland cotton cultivars. Our results are in contradiction with that of Hussian *et al*. (2000) who reported that plant height contributes just 13.24% in seed cotton yield which might be because of environmental and other factors.

Similarly sympodial branch (fruiting branch) on which the bolls are set on cotton plant; contributes directly towards seed cotton yield. It is believed that unit increase or decrease in the number of bolls will affect seed cotton yield which largely relies upon this important trait. Thus, plant breeders and researchers recommend that sympodial branches do serve as a decent model for selecting high yielding cotton varieties. Longer sympodial branches found in the present study are in consonance with that of Jatoi *et al*. (2012) who also reported variation among various cultivars with respect to length of sympodia (cm).

Number of bolls plant^{-1} is also the major yield contributing component with a solid association with seed cotton yield. The present results demonstrated that number of boll plant^{-1}has prime role in improvement of seed cotton and can readily affect seed cotton yield in high degree. Differences among various cultivars represent that amid breeding process high number of bolls plant^{-1} cultivars ought to be preferred to obtain high seed cotton yield cultivars. Hussian *et al*. (2000) revealed a positive correlation of seed cotton yield with number of bolls plant^{-1}. Present results are also in consonance with those obtained by Rauf *et al*. (2004) who observed that bolls plant^{-1} expressed maximum positive direct impact on seed cotton yield plant^{-1}.

The instant results suggest that boll weight (gm) has a direct influence on seed cotton yield because as the boll weight increases, the yield also increases. The present results are similar to those of Taohua and Haipeng

(2006) and Meena *et al*. (2007) who evaluated different hirsutum varieties for yield and other economic characters and observed noteworthy variations for boll weight and showed a positive effect on seed cotton yield. Therefore, it was concluded that boll weight is an important yield component and should be considered while breeding for seed cotton yield. Similar to present results, Khadijah *et al*. (2010) and Baloch *et al*. (2014) also reported positive correlation of boll weight with seed cotton yield.

From the instant study it can be concluded there was clear variation in seed cotton yield with change in cultivar which might be due to genetic makeup. Similar results was also reported by Baloch (2014) that there was highly significant differences among various cultivars regarding seed cotton yield (kg ha^{-1}). Present results are in consonance with those of Jatoi (2007), Panhwar (2007) and Baloch and Veesar (2007) who reported variation in various cultivars regarding seed cotton yield. Our results are also in conformity with that of sahito *et al*. (2016) who also reported significant positive correlation of seed cotton yield with other quantitative and qualitative traits in upland cotton cultivars.

CONCLUSIONS

The analysis of variance revealed significant differences among the genotypes for Boll weight, Number of bolls, sympodial internodal length, seed cotton yield and number of fruiting positions. Based on the mean performance, cultivar Is.Shaheed performed very well in terms of seed cotton yield, bolls plant^{-1} and boll weight, hence this cultivar may be preferred for hybridization and selection programme to develop new promising cotton varieties.

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Table 1 Mean squares of various parameters

Source of variation	**Degree of Freedom**	**Length of Sympodia (cm)**	**No. Fruiting Position**	**Seed Cotton Yield (kg ha^{-1})**	**Sympodial Internodal Length (cm)**	**No. of bolls plant^{-1}**	**Boll weight (g)**	**Plant height (cm)**
Rep	**2**	159.50	9.48	31157	0.362	2.67	0.011	191.37
Varieties	**7**	177.66ns	4.95*	940926**	0.455*	49.83*	0.217*	473.05ns
Error	**14**	28.425	1.52	3962	0.138	18.43	0.008	42.85
CV%	**-**	12.22	13.92	2.22	7.73	12.29	3.67	4.85

Table 2 Mean performance

Varieties	**Length of Sympodia (cm)**	**No. Fruiting Position**	**Seed Cotton Yield (kg ha^{-1})**	**Sympodial Internodal Length (cm)**	**No. of bolls plant^{-1}**	**Boll weight (g)**	**Plant height (cm)**
Cris-342	47.20	10.07 ab	1933.3 h	4.79 ab	36.00 abc	2.21 d	125.00
Cris-134	57.13	11.27 a	2711.1 f	5.38 a	31.13 bc	2.38 bc	124.00
Cris-129	29.73	7.53 c	2177.8 g	4.006 c	30.13 c	2.45 bc	126.67
Gomal-93	43.33	8.47 bc	2822.2 e	4.90 ab	34.27 bc	2.50 b	125.00
Is.Shaheed	46.40	9.27 abc	3544.4 a	4.81 ab	42.76 a	2.96 a	148.67
SLH-317	43.60	8.20 bc	2966.7 d	5.05 ab	32.40 bc	2.31 cd	152.00
DNH-57	41.93	8.40 bc	3411.1 b	4.83 ab	38.00 ab	2.88 a	149.33
CIM-573	39.67	7.60 c	3122.2 c	4.64 bc	34.80 bc	2.43 bc	129.33
$LSD_{0.05}$	NS	2.15	110.22	0.65	7.51	0.16	NS

Table 3 Correlation coefficient (r), coefficient of determination (r^2), regression coefficient (b)and their significance for seed cotton yield and other quantitative traits in *GossypiumhirsutumL.*

Traits	**r**	**R^2**	**Intercept**	**b**
Plant Height	0.702*	0.493	-1389.377	31.300*
Boll Weight	0.775*	0.60	-1221.268	1612.471*
No of Bolls/Plant	0.813*	0.661	-1094.954	112.598*
No. of Fruiting position	-0.815	0.034	3551.357	-80.819NS
SympodialInternodal length	0.316	0.094	723.679	439.956NS
Length of Sympodia	0.136	0.018	2405.644	9.867NS
Sympodial branch angle	-0.534	0.286	8656.861	-103.403NS

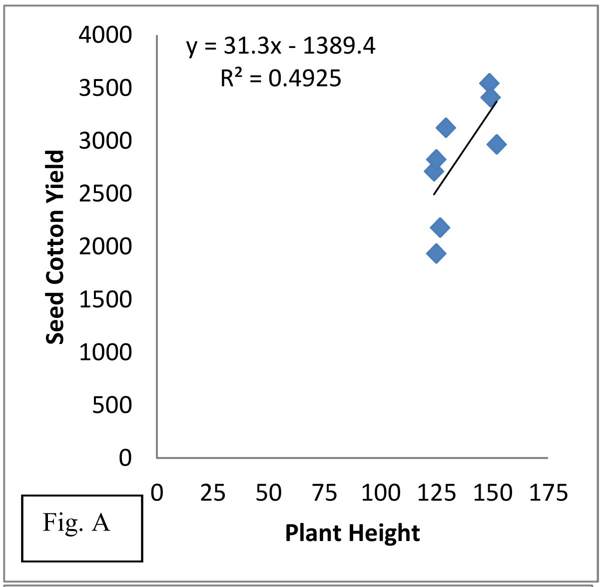


Fig. A

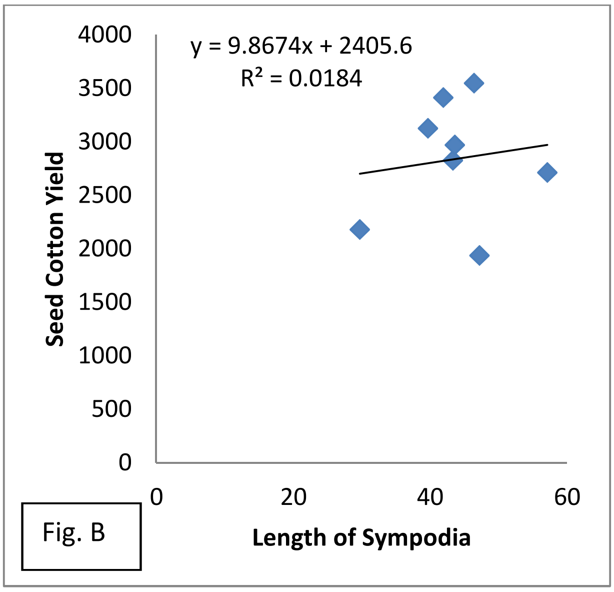
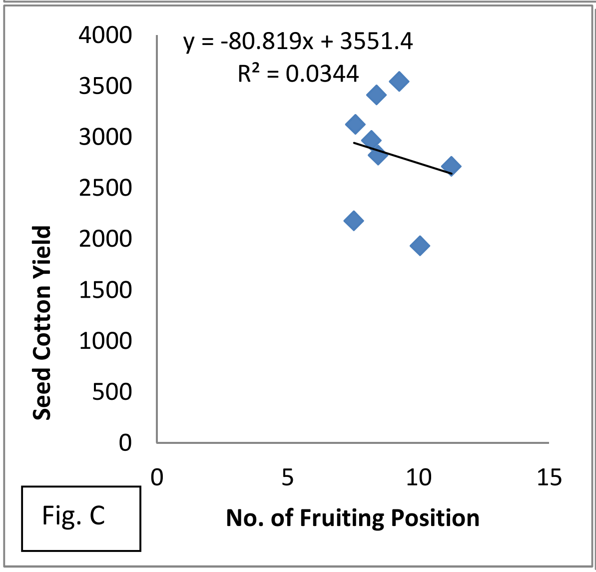


Fig. B



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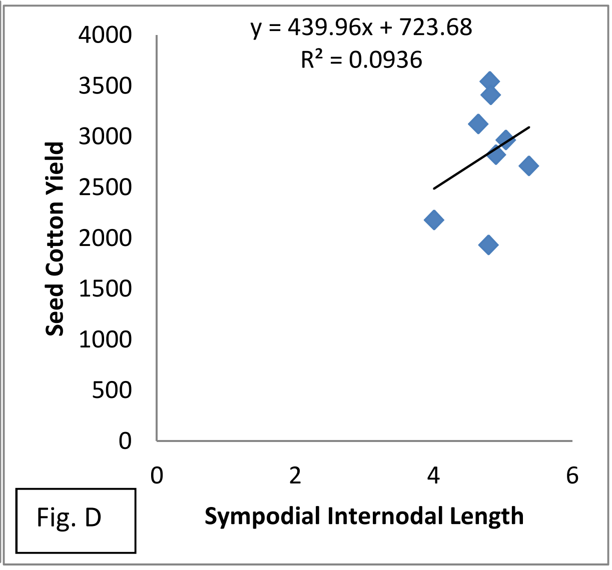

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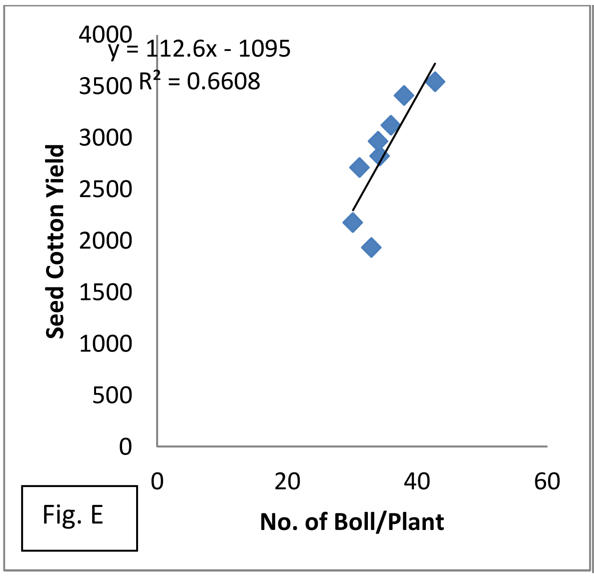

Fig. E

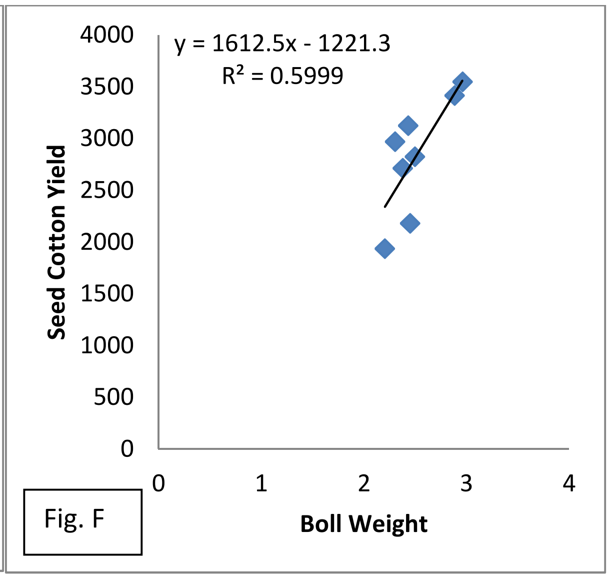

Fig. F