GENETIC VARIABILITY AND CORRELATION ANALYSIS IN UPLAND COTTON

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ABSTRACT

The study was carried out to determine the genetic variability, correlation and regression coefficient of the seed cotton yield with various morphological and yield contributing traits in five upland cotton cultivars. The cultivars viz; CIM-473, CIM-496, CIM-499, CIM-506 and CIM-707 were sown in a randomized complete block (RCB) design with four replications at NWFP Agricultural University, Peshawar, Pakistan during May 2005. All the genotypes revealed highly significant differences ($P \leq 0.01$) for monopodia and sympodia per plant, bolls per plant and seeds per boll, while the plant height, first internode length, boll weight and seed cotton yield per plant manifested significant variations among the cultivars. Boll per sympodia was having non-significant differences in mean values. All the parameters manifested positive correlation with seed cotton yield except monopodia per plant and first internode length. Cultivar CIM-499 performed well by having better boll set, early maturity and increased seed cotton yield, while other four cultivars were having statistically at par seed cotton yield. During future breeding programme the yield related traits may also be kept in mind during making selection as they were the major attributes of the seed cotton yield.

Key Words: Correlation, Genetic variability, Gossypium hirsutum, Mean performance, Regression coefficient

Citation: Ahmad, W., N.U. Khan, M.R. Khalil, A. Parveen, U. Aimen, M. Saeed, Samiullah, and S.A. Shah. 2008. Genetic variability and correlation analysis in upland cotton. Sarhad J. Agric. 24(4): 573-580.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) plays a pivotal role in the economy of Pakistan. It is the most important fiber, industrial and cash crop, grown over 12% of the total cultivated area. Of the total foreign exchange earnings, cotton contributes about 60% through the export of raw cotton and its byproducts. The crop also provides raw material to local industry which includes over 500 textiles mills, 335 ginning factories and 5000 oil expelling units. Besides its textile industry use, it also provides food in the form of edible oil and cotton seed cake as animal feed. Its contribution in oil production is obvious from the fact that it contributes 60-70% to the local production of edible oil (Khan, 2003). In Pakistan during 2006-07 the total grown area was 3.072 million hectares and the seed cotton production was 13.00 million bales and the national average yield was 720 kg ha^{-1} (Anonymous, 2007). Our per unit seed cotton yield is still low as compared to other cotton growing countries. Seed cotton yield being a complex character, is the product of interplay between its components coupled with varying environmental conditions. A thorough knowledge about the nature, mean performance, extent of relationship and correlation of yield with various agronomic characters is indispensable for breeder to tackle the problem of yield increase successfully.

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. Suinaga *et al.* (2006), Taohua and Haipeng (2006), Khan *et al.* (2007) and Meena *et al.* (2007) studied the stability and adaptability of *Gossypium hirsutum* cultivars and observed varied values for different agronomic, morphological and yield related traits. Genetic variability and positive correlation were observed for seed cotton yield and yield components in *Gossypium hirsutum* (Iqbal *et al.* 2003 and Wang *et al.* 2004). Arshad *et al.* (1993) also executed mean performance and positive correlation of seed cotton yield with yield components in *hirsutum* cultivars. Khan *et al.* (1999) and Khan (2003) studied upland cotton genotypes and found high genetic variability for yield, and yield components. Khan *et al.* (2000) studied the earliness and agronomic characteristics of upland cotton cultivars using correlation and found that monopodia had a negative direct effect on yield. Jost and Cothren (2000) and Badr (2003) also evaluated the cotton cultivars for earliness and other yield contributing traits and observed varied performance. DeGui *et al.* (2003) studied the effects of genetic transformation on the yield and yield components and concluded that higher yields of cultivars were mainly caused by higher number of bolls per plant. The present research was accomplished to study the genetic potential of different cotton cultivars and relationship of seed cotton yield with different yield related and morphological traits under the climatic conditions of Peshawar valley, Pakistan.

MATERIALS AND METHODS

An experiment to study the performance and association of seed cotton yield with yield components and morphological traits in five upland cotton genotypes was carried out at NWFP Agricultural University Peshawar, Pakistan during 2005. Breeding material comprised of five different *Gossypium hirsutum* genotypes i.e. CIM-473, CIM-496, CIM-499, CIM-506 and CIM-707 varied by pedigree, time of release (Table I) seed cotton yield, its components and fibre quality traits. The cultivars were sown in a randomized complete block (RCB) design with four replications during mid of May, 2005. The rows and plants spacing was of 75 and 30 cm, respectively. Thinning was made after fifteen days of germination for keeping only single plant per hill.

All the cultural practices were carried out as per recommended package for cotton production and the crop grown under uniform conditions to minimize environmental variability to the maximum possible extent. Each variety got four rows of 8 m length and data were recorded on central two rows. At maturity ten plants were randomly selected from two central rows and were labeled for data collection and the border rows were discarded. Picking was done during November and December 2005. The data were recorded on plant height, monopodia per plant (vegetative branches), sympodia per plant (fruiting branches), first internode length, bolls per sympodia, bolls per plant, boll weight (g), seeds per boll and seed cotton yield per plant (g).

Data on plant height was recorded from the base of plant to the tip of the plant. Data on monopodia and sympodia were taken by counting the number of vegetative and fruiting branches. About first internode length, the data were collected by measuring distance from the basal node to the second node. Effective and mature opened bolls per sympodia and bolls per plant were counted. Boll weight was recorded by picking 10 mature bolls from every labeled plant and formulates the average value. In the same way, the seed per boll counted and recorded the average value. Seed cotton yield was recorded by weighing the seed cotton obtained from all picked bolls from selected plants and then take average per plant.

All the data were subjected to analysis of variance (ANOVA) and LSD through Mstatc computer programme to compare the mean differences, and simple correlation (r) and regression coefficient which were also studied. Table IV shows correlation between seed cotton yield and morphological and yield related traits. Regression analysis is shown in Table IV, where all the morphological and yield contributing traits were regressed on seed cotton yield per plant. R^2 shows the dependency of Y (dependent variable) upon X (independent variable), while regression coefficient β shows that a unit change in X variable will bring change in Y variable.

Table I. ***Pedigree and other relevant information of upland cotton cultivars used during 2005***

Cultivars	Pedigree / Parentage	Year of Release	Centre
CIM-473	CIM-402 x LRA 5166	2002	Central Cotton Research Institute (CCRI) Multan, Pakistan
CIM-496	CIM-425 x 755-6/93 (1993)	2005	-do-
CIM-499	CIM-433 x 755-6/93 (1992)	2003	-do-
CIM-506	CIM-360 x CP-15/2 (1993)	2004	-do-
CIM-707	CIM-243 x 738-6/93 (1993)	2004	-do-

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences ($P \leq 0.01$) for monopodia per plant, sympodia per plant, bolls per plant and seeds peer boll, while the plant height, first internode length, boll weight and seed cotton yield per plant manifested only significant variations among the cultivars. The trait boll per sympodia was having non-significant differences in mean values.

Plant Height

Highest and statistically at par plant height (Table II) was recorded in CIM-470 (111 cm) and CIM-496 (106 cm). While other three cultivars (CIM-506, CIM-499 and CIM-707) showed at par medium plant height (90.0 to 93.0 cm). Significant and positive correlation (r=0.694) was noted among seed cotton yield and plant height (Table IV), which showed that selection for plant height can be effective in breeding for seed cotton yield when it is paired with good set of sympodia per plant. Non-significant values were observed for plant height, when it was regressed on seed cotton yield. The coefficient of determination R^2 was 0.481, while the regression coefficient was -3.223 (Fig. 1 and Table IV). Plant height is very important trait and has close association with bolls per plant (if no lodging occurred) and has ultimate positive effect on seed cotton yield. Almost all the cultivars showed medium plant height with significant mean differences. Results also revealed that bolls per plant is also varietal trait and not entirely dependent on plant height, but plant height contribution can not be ignored.

Cotton breeders are mostly interested in short stature plants due to lodging threat and suitable also for mechanical picking, but it is observed that plant height is positively correlated with bolls per plant and seed cotton yield (Khan 2003). Khan *et al.* (1999) also reported significant genetic variability for plant height and was found positively correlated with sympodia, bolls per plant and seed cotton yield if lodging didn't occur. Meena *et al.* (2007) studied the stability and adaptability of *hirsutum* cultivars and observed varied values for plant height and other yield components. Arshad *et al.* (1993) and Suinaga *et al.* (2006) also evaluated upland cotton varieties and concluded that plant height was positively correlated with seed cotton yield and bolls per plant. Khan (2003), Soomro *et al.* (2005) and Taohua and Haipeng (2006) observed positive correlation between plant height and seed cotton yield and their studies further revealed that characters such as plant height contributed 70% of the total variability for seed cotton yield. Therefore, it is concluded that in cotton crop, plant height is desirable if no lodging occurred. The contradictory views of past researchers about the said trait might be due to genotypic and environmental differences and may be due to different genetic background of the cultivars used in different environmental conditions.

Monopodia per Plant

Minimum and statistically at par vegetative branches per plant (0.15) was recorded in CIM-499 and CIM-707 (Table II) and were found also at par with cultivar CIM-473 (0.25). The highest monopodia per plant was recorded in CIM-506 (0.75). Significant and negative correlation (r=-0.056) was observed between seed cotton yield and monopodia per plant (Table IV). When monopodia per plant were regressed on seed cotton yield, highly significant value of coefficient of determination R^2 was 0.232, while the regression coefficient was -22.680 (Fig. 2 and Table IV). Monopodia is negatively correlated with seed cotton yield and the slight trend of negative correlation between them revealed that during selection of genotypes having less monopodia may lead to an increase in seed cotton yield. Khan *et al.* (2000 and 2003) and Iqbal *et al.* (2003) also studied the earliness and agronomic characteristics of upland cotton cultivars using correlation and found that monopodia per plant had a direct negative effect on yield.

Table II. ***Mean performance of plant height, sympodia/plant, monopodia/plant, and first Internode length of upland cotton during 2005***

Cultivars	Plant height (cm)	Monopodia/ Plant	Sympodia/ Plant	First internode length (cm)
CIM-473	111.0 a	0.25 bc	37.33 ab	2.03 a
CIM-496	106.0 a	0.30 b	40.33 a	2.35 a
CIM-499	91.7 b	0.15 c	35.00 bc	2.00 a
CIM-506	90.0 b	0.75 a	32.33 c	2.33 a
CIM-707	93.0 b	0.15 c	38.67 ab	1.43 b
CV (%)	6.5	15.63	6.98	13.47

Sympodia per Plant

Maximum sympodia per plant (40.33) were observed in CIM-496. It was found statistically at par with two other cultivars CIM-707 and CIM-473 ranged from 37.33 to 38.67 (Table II). Cultivar CIM-506 showed the minimum sympodia per plant i.e. 32.33. Significant and positive correlation (r=0.945) was noticed for sympodia per plant with seed cotton yield (Table IV). When sympodia per plant were regressed on seed cotton yield, the coefficient of determination R^2 was 0.893, while the regression coefficient was -2.576 (Fig. 3 and Table IV). Results enunciated that a unit increase in the number of sympodia will lead to a matching increase in the seed cotton yield. The plant type characteristics played an important role in the correlation with plant height and number of sympodia, and attention should be paid to the selection of plant type characteristics in breeding. Positive correlation of sympodia with seed cotton yield and significant variation for the said trait was observed (Arshad *et al.* 1993, Sultan *et al.* 1999 and Khan *et al.* 2000).

First Internode Length

In cotton, earliness can be studied with different ways like days to first square, first flowering, open boll and first internode length. Minimum first internode length (1.43 cm) was observed in CIM-707, while other four cultivars were statistically at par and having 2.00 to 2.35 cm first internode length (Table II). Significant and negative correlation (r=-0.188) was observed with seed cotton yield (Table IV).

Table III. ***Mean performance of bolls/sympodia, bolls per plant, boll weight, seeds/boll and seed cotton yield plant^{-1} of upland cotton during 2005***

Cultivars	Bolls/ sympodia	Bolls/plant	Boll weight (g)	Seeds/boll	Seed cotton yield (g/plant)
CIM-473	1.42	20 abc	3.61 b	27.67 ab	53 b
CIM-496	1.46	21 ab	3.61 b	27.33 ab	50 b
CIM-499	1.45	23 a	3.18 c	32.33 a	57 a
CIM-506	1.42	17 c	3.75 a	31.33 a	51 b
CIM-707	1.40	19 bc	3.58 b	23.00 b	52 b
CV (%)	7.48	12.15	1.96	10.18	3.51

When the data of first internode length were regressed on seed cotton yield, the coefficient of determination R^2 was 0.035, while the regression coefficient was 51.607 (Fig. 4 and Table IV). It is also concluded that CIM-707 was noticed as early maturing cultivar by having short first internode's length and can easily be set in cropping system. The same findings manifested by Jost and Cothren (2000), Badr (2003) and Iqbal *et al.* (2003) who studied the earliness.

Bolls per Sympodia

Data regarding bolls per sympodia showed non-significant differences among the five cultivars, however, highest bolls per sympodia (1.46) were observed in CIM-496, followed by CIM-499 with 1.45 bolls per sympodia (Table III). Minimum bolls per sympodia were observed in CIM-707 (1.40). Significant and positive correlation (r=0.718) was observed of the said trait with seed cotton yield (Table IV). Highly significant values were observed when bolls per sympodia were regressed on seed cotton yield. The coefficient of determination R^2 was 0.516, while the regression coefficient was -28. 855 (Fig. 4 and Table IV). The cultivars having maximum number of bolls per sympodia also showed increased seed cotton yield as being a yield contributing trait. Morphological traits like sympodia, plays an important role in cotton crop and those fruiting branches which bear cotton bolls also manage the bolls number and seed cotton yield in cotton plant. Both traits sympodia and bolls per sympodia were found mostly positively correlated with seed cotton yield (Khan, 2000 & 2003). Therefore, the cultivars having maximum number of bolls per sympodia also showed increased seed cotton yield. The said trait has a significant impact on the seed cotton yield, and the breeders should think about it while breeding for seed cotton yield.

Table IV. Correlation and regression coefficient between seed cotton yield, its components and morphological traits of upland cotton during 2005

Parameter	Correlation Coefficient	Regression		
		Coefficient	R^2	Slope (β)
Plant height	0.694	0.515	0.481	-3.223
Monopodia/plant	-0.056	-3.766	0.003	43.106
Sympodia/plant	0.945	1.307	0.893	2.576
First internode length	-0.188	-4.770	0.035	51.607
Bolls/sympodia	0.718	49.528	0.516	-28.855
Bolls/plant	0.908	2.286	0.824	6.612
Boll weight	0.482	19.046	0.232	-22.680
Seeds/boll	0.237	0.639	0.056	24.346

Afiah and Ghoneim (2000) worked out that all the yield traits showed either significant positive or negative association with bolls per sympodia / plant, as bolls per plant has direct effect from bolls per sympodia. Same genetic variability and correlation for bolls per sympodia was also authenticated by Arshad *et al.* (1993) who studied the effect of agronomic characteristics on seed cotton yield in *Gossypium hirsutum* and correlation among plant type characteristics. Plant type character like sympodia was primarily correlated with yield components. Sultan *et al.* (1999), Iqbal *et al.* (2003) and Wang *et al.* (2004) also evaluated upland cotton varieties and observed positive correlation of bolls per sympodia with seed cotton yield. Studies also revealed that there was an antagonistic association between boll number and boll weight and both traits had strong direct effect on seed cotton yield. It is concluded that attention should be paid to the selection of plant type characteristics in cotton breeding.

Bolls per Plant

Maximum number of bolls per plant (23) was picked in CIM-499, however, it was found statistically at par with cultivars CIM-496 (21) and CIM-473 (20). Cultivar CIM-506 (17) showed minimum bolls per plant (Table III). Significant and positive correlation (r=0.908) were observed between bolls per plant and seed cotton yield (Table IV). Non-significant values were observed for bolls per plant when it was regressed on seed cotton yield. The coefficient of determination R^2 was 0.824, while the regression coefficient was 6.612 (Fig 6 and Table IV).

Fig. 1-8 ***Graphical presentation of correlation and regression coefficient of different yield and morphological traits of upland cotton during 2005***

Fig. 1 ***Plant height***

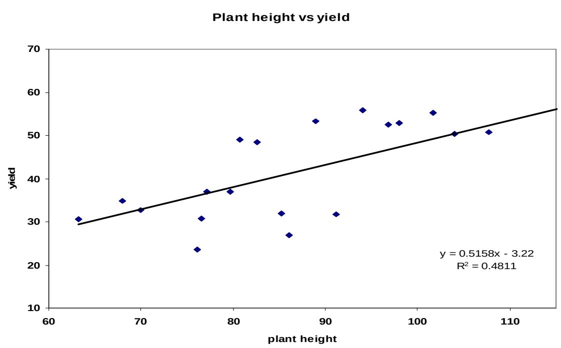


Fig. 2 ***Monopodia per plant***

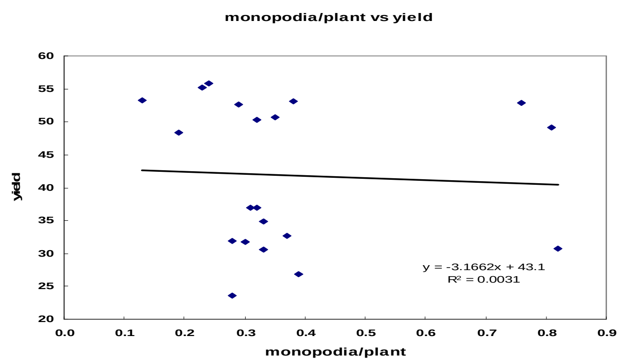


Fig. 3 ***Sympodia per plant***

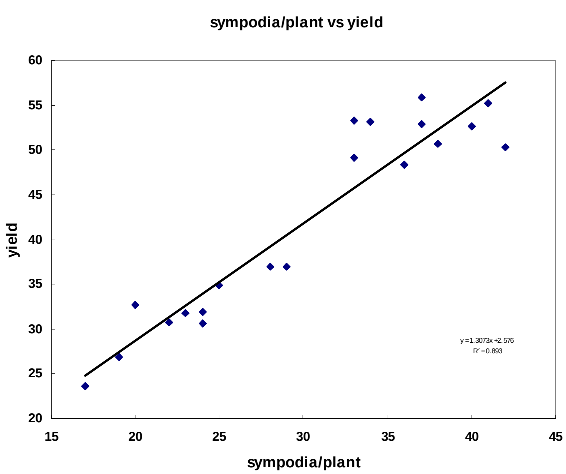


Fig. 4 ***First Internode Length***

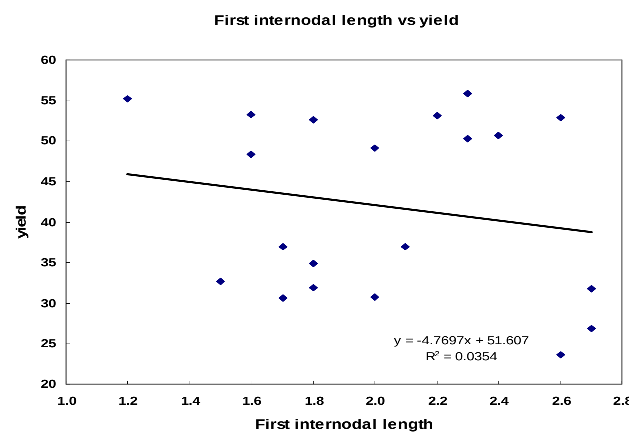


Fig. 5 ***Bolls per sympodia***

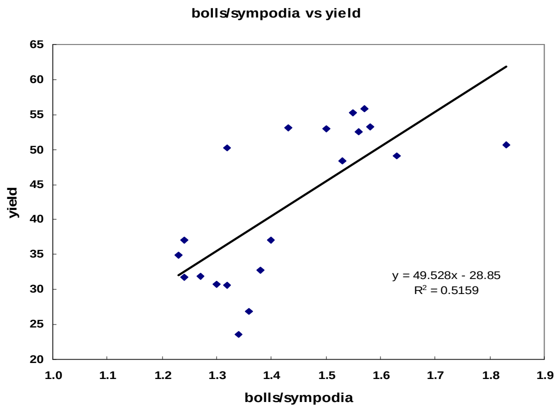


Fig 6 ***Bolls per plant***

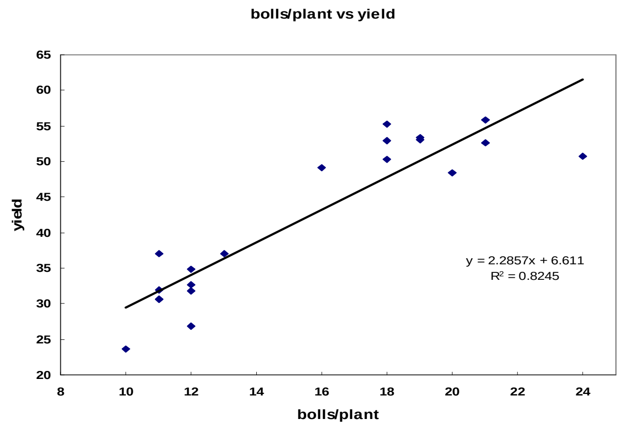


Fig. 7 ***Boll weight***

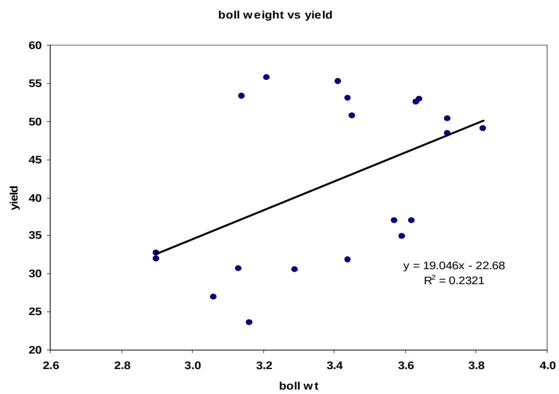
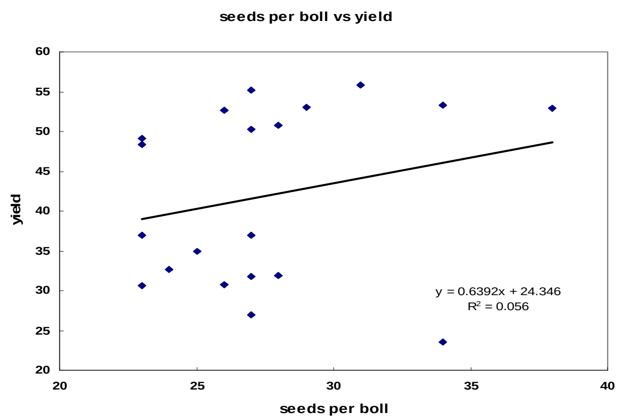


Fig. 8 ***Seeds per boll***



The “r” value and “R^2” values suggested that bolls per plant is the most important character and can readily affect the seed cotton yield in a large extent. Bolls per plant is the major independent yield component and plays principal role and have a direct influence in management of seed cotton yield. Thus variability for this trait among different cultivars is a good sign and selection in the breeding material for high boll number will have a significant effect on the seed cotton yield. Suinaga *et al.* (2006) and Meena *et al.* (2007) also evaluated the *Gossypium hirsutum* cultivars and hybrids, and observed varied values for bolls per plant. Soomro *et al.* (2005) and Copur (2006) also compared the yield and yield components of cotton cultivars and showed significant differences for these traits. DeGui *et al.* (2003) also revealed the effects of genetic transformation on the yield and yield components. The higher lint yields of cultivars were mainly caused by higher number of bolls per plant. They recommended selection for large bolls with high yields in cotton crop. Khan *et al.* (1999) evaluated the *hirsutum* cultivars and observed significant variations for number of bolls per plant and showed positive effect on seed cotton yield. Boll set is the main contributor towards increase in seed cotton yield. Results also revealed that bolls per plant should receive greater emphasis in cotton improvement as it contributes significantly.

Boll Weight

Among the five cultivars, the highest boll weight (3.75 g) was observed in CIM-506. It was followed by CIM-473, CIM-496 and CIM-707 ranged from 3.58 to 3.61 g. Minimum boll weight (3.18 g) was manifested by CIM-499 (Table III). Significant and positive correlation (r=0.482) was noticed between boll weight and seed cotton yield (Table IV). Non-significant values were observed for boll weight, when it was regressed on seed cotton yield. The coefficient of determination R^2 was 0.23, while the regression coefficient was -22.68 (Fig. 7 and Table IV). Boll weight is the second major yield component after bolls per plant and have a greater contribution in enhancement of seed cotton yield. Khan (2003) and Copur (2006) also obtained similar proportion and variation for boll weight in relation to seed cotton yield. Taohua and Haipeng (2006) and Meena *et al.* (2007) evaluated different *hirsutum* varieties for yield and other economic characters and observed significant variations for boll weight and showed positive effect on seed cotton yield. Results also revealed that the boll weight following the bolls per plant had positive effect on seed cotton yield. Seed cotton yield was significantly and positively correlated with boll weight and number of bolls per plant. Therefore, it is concluded that boll weight is an important yield component and should be kept in mind while breeding for seed cotton yield.

Seeds per Boll

Highest and statistically at par seeds per boll were obtained in CIM-499 and CIM-506 (32.33, 31.33), respectively (Table III). These cultivars were also comparable with CIM-473 (27.67) and CIM- 496 (27.33). Minimum seeds per boll (23.00) were observed in CIM-707. Significant and positive correlation (r=0.237) was noticed between seeds per boll and seed cotton yield (Table IV). Non-significant values were observed for seeds per boll, when it was regressed on seed cotton yield. The coefficient of determination R^2 was 0.056, while the regression coefficient was 24.346 (Fig 8 and Table IV). Results revealed that seeds per boll can positively affect the seed cotton yield through increase in boll weight.

Seed per boll is an important yield component and manage boll weight, seed cotton yield, lint yield and cottonseed oil content. Seeds per boll by having close correlation with seed cotton yield, contributes also to seed cotton yield through addition to boll weight. Thus cultivars having high seeds per boll have relatively good yield potential in comparison with cultivars have less number of seeds per boll. Iqbal *et al.* (2003), Khan (2003) and Wang *et al.* (2004) derived information on genetic variability and positive correlation between seeds per bolls and seed cotton yield. Correlation also showed positive associations between seed cotton yield and all other yield traits including seeds per boll.

Seed Cotton Yield per Plant (g)

Highest seed cotton yield (57 g) was observed in CIM-499. It was followed by four other cultivars having statistically at par seed cotton yield ranged from 50 to 53 g per plant (Table III). The promising cultivar (CIM-499) which having maximum yield, also showed more number of bolls sympodia/plant, seed per boll, and medium type of plant height, sympodia per plant and boll weight, first internode length, and less number of monopodia. Due to medium length of first internode length, the said variety was also found early maturing, which can be readily fitted in cropping system. Seed cotton yield is an ultimate goal in growing cotton besides lint % (GOT). Same genetic variability for seed cotton yield was also reported by Arshad *et al.* (1993). Badr (2003) and Copur (2006) determined the yield and yield components of *Gossypium hirsutum* cultivars and observed significant differences. Soomro *et al.* (2005) also studied the seed cotton yield in upland cotton cultivars and found that cultivars showed significant differences. Iqbal *et al.* (2003) and Khan *et al.* (2000 and 2007) evaluated some strains of *Gossypium hirsutum* and mentioned positive association between variances for yield and boll set, which indicated that boll set is the main contributor to seed cotton yield. Afiah and Ghoneim (2000) also mentioned that seed cotton yield was positively correlated with number of sympodia, bolls per plant, boll weight and lint yield.

CONCLUSION AND RECOMMENDATION

All the parameters manifested positive correlation with seed cotton yield except monopodia per plant and first internode length. Results revealed that the cultivar CIM-499 performed well having better boll set, early maturity and increased seed cotton yield. All the cultivars showed high variability for sympodia, monopodia, boll weight, bolls and seed cotton yield per plant, which can be exploited in future breeding programs. Seed cotton yield showed strong and positive association as well as strong dependency upon yield contributing traits i.e. boll weight, bolls per plant, number of sympodia and bolls per sympodia. Thus during future breeding programme these parameters also kept in mind during making selection as they were the major attributes of the seed cotton yield.

On the basis of present findings, it is suggested that while breeding for higher seed cotton yield:

i. Selection for higher number of sympodia, bolls per plant, bolls per sympodia, plant height and high boll weight should be practiced, as these were found to be positively correlated and affecting the seed cotton yield.
ii. Higher monopodia should be discouraged as these were found to be causing decline in seed cotton yield.
iii. The cultivars having early maturity should be adopted in the Peshawar valley to fit readily in cropping system.

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