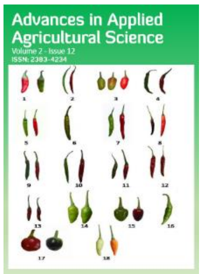
Advances in Applied Agricultural Sciences

Volume 02 (2014), Issue 12, 73-80

Journal homepage: www.aaasjournal.org



Research Article

Association Analysis of Yield and Fiber Traits in Advance Pakistani Upland Cotton Cultivars (*Gossypium hirsutum* L.)

Abdul Wahid Baloch [1], Javed Hussain Sahito [1], M. Ali [1], Ghulam Asghar Baloch [2], Saifullah Abro [3], Siraj Ahmed Channa [1], Abdul Majeed Baloch [1], Ghulam Hussain Baloch and Gul Muhammad Baloch [1]*

[1] *Sindh Agriculture University, Tandojam, Pakistan.*

[2] *2Agriculture Research Institute, Quetta, Pakistan.*

[3] *Nuclear Institute of Agriculture, Tandojam, Pakistan.*

ARTICLE INFO

Article history:

Received: July 07, 2014
Revised: September 21, 2014
Accepted: October 06, 2014
Available online December 23, 2014

Keywords:
Correlation analysis
Fiber and yield traits
Upland cotton

[*] Corresponding Author;
E. Mail:
balochabdulwahid@yahoo.com

ABSTRACT

The present study was conducted to estimate correlation and regression between yield and fiber characters in eight commercially grown cultivars of cotton genotypes during kharif 2012. The mean squares from analysis of variance showed that genotypes differed significantly for majority of the traits studied. This shows the presence of genetic variability for various major characters in the studied materials. The correlation coefficient (r) indicated that sympodial branches plant^{-1}(bolls plant^{-1} and boll weight were significantly and positively correlated with seed cotton yield plant^{-1}. The higher correlations coefficients of yield components with seed cotton yield also suggested that yield components can reliably be used as indirect selection criteria to improve seed cotton yield plant^{-1}. However, negatively significant correlation was found between micronaire value and seed cotton yield plant^{-1}, suggesting that care must be given to micronaire value while seed cotton yield is being improved. The regression coefficient (b) revealed that a unit increase in monopodial branches plant^{-1}, sympodial branches plant^{-1}, bolls plant^{-1} and boll weight caused a substantial increase in seed cotton yield plant^{-1}. The coefficient of determination (r^2) further suggested that larger portion of total variability in seed cotton yield plant^{-1} was attributable to traits such as sympodial branches plant^{-1}, bolls plant^{-1} and boll weight. Correlation and regression coefficient analysis suggested that sympodial branches plant^{-1} and bolls plant^{-1} were the most important yield components traits and could be exploited as selection criteria for further improvement of cotton genotypes.

Cotton crop plays a vital role in enhancing our country's economy since it is a major source of earning foreign exchange, therefore, it has been considered as the backbone of the economy of Pakistan. It is known as white gold due to its importance as cash and industrial crop. Besides its fiber, it also produces edible oil and cotton seed cake for human and animal consumption, respectively. Keeping in view the future needs of the country, the research on cotton needs to be versatile and accelerated to produce better genotypes which can adjust in diverse agro–ecological conditions of the country. It is in keen interest of plant breeder to recognize the extent of relationship between yield and its various components which will assist in selecting plants of desirable traits.

The development of cultivars having tolerance to various biotic and a-biotic stresses, possessing better fiber quality and greater yield potential are the primary goals of a cotton breeder. Seed cotton yield is correlated to its components and the components are correlated among themselves and that correlation might be due to developmental (Adams &Grafius, 1971) or genetical factors (Tang, 1992). The yield components in cotton crop are developed in a sequence, where yield is the end result. Therefore, developmental relationship might play a key role in the association of yield and yield contributing characters. The correlation analysis offers a good index to envisage the corresponding change which happens in one character at the expense of the proportionate change in the other (Ahmad *et al*., 2008). Fiber fineness was positively associated with seed cotton weight and negatively associated with a number of sympodial branches, number of mature bolls, plant height, fiber length and fiber strength (Killi *et al.*, 2005). Ekinci *et al.,* (2010) reported a positive correlation of number of monopodial branches plant^{-1}with single boll weight, bolls plant^{-1} and sympodial branchesplant^{-1}. Fiber length was significantly and positively associated with fiber strength and fiber elongation (Ashokkumar & Ravikesavan, 2010; Malagouda *et al.,* 2014). Regarding correlation studies, Farooq *et al.,* (2014) reported that seed cotton yieldplant^{-1}had positive correlation with bolls plant^{-1}, plant height, boll weight, staple length and strength, earliness index and GOT%. Erande *et al.,* (2014), studied different cotton species and reported that lint yield plant^{-1}, bolls plant^{-1}, GOT%, lint index, total biomass, sympodia plant^{-1}and plant height had positive association with seed cotton yield plant^{-1}. For a concurrent selection of yield and fiber quality traits, knowledge about correlation of both kinds of traits is a prerequisite. The current study was planned to investigate the genetic potential of different advance cotton cultivars and relationship of seed cotton yield with different fiber and yield related traits.

Materials and Methods

The field experiment was conducted at the experimental farm of Nuclear Institute of Agriculture, Tandojam, during Kharif season 2012, in order to find out the correlation and regression analysis between yield and fiber traits in commercially grown cultivars of cotton genotypes. The experimental design was laid out in Randomized Complete Block Design (RCBD) with four replications. The experimental materials consisted of eight commercially grown cotton cultivars viz., IR-03, IR-1524, IR-3701, Sadori, Sindh-1, CIM-598, CRIS-342 and NIAB-846. Row to row space was kept at 75cm and plant to plant distance was 30 cm. All the recommended agronomic practices and plant protection measures were applied to obtain healthy plants. Observations were recorded on five randomly selected plants of each cultivar in each replication for plant height (cm), monopodial branches plant^{-1}, sympodial branches plant^{-1}, bolls plant^{-1}, boll weight (gm), seed cotton yield plant^{-1}(gm), ginning outtern (GOT%), staple length (mm), seed index (100 seed weight, gm) and micronaire value (µg/inch). The analysis of variance was worked out after Steel & Torrie (1980) whereas, correlation coefficients (r) were determined according to statistical methods suggested by Raghavrao (1983).

Results and Discussion

Analysis of variance and mean performance of cotton genotypes

Results showed that genotypes differed highly significantly (P ≤0.01) for plant height, monopodial branches plant^{-1}, sympodial branches plant^{-1}, bolls plant^{-1}, boll weight, and micronaire value, whereas seed cotton yield plant^{-1}and GOT% was significant at P ≤0.05 level, while staple length and seed index were non-significant. This shows the presence of considerable genetic variability among the genotypes for further evaluation and use of the genotypes in breeding experiment (Table 1).

Table 1. *Mean squares from analysis of variances for various traits in upland cottoncultivars.*

Traits	Mean squares		
	Replication DF= 03	**Cultivars DF=7**	**Error DF=21**
Plant height	25.803	432.517**	3.147
Monopodial branches plant^{-1}	0.03792	0.45268**	0.03220
Sympodial branches plant^{-1}	3.6283	29.4650**	2.3760
Bolls plant^{-1}	22.331	148.767**	11.810
Boll weight	0.00208	0.35693**	0.00304
Seed cotton yield plant^{-1}	215.64	1160.07*	141.01
Ginning outtern percentage	1.46947	3.08607*	1.47173
Staple length	0.91917	1.06857^{NS}	1.04083
Seed index	0.05115	0.58924^{NS}	0.13615
Micronaire value	0.00015	0.65523**	0.00058

**= Significant at 0.01 *p* value; *= Significant at 0.05 *p* value; NS= Non-Significant

The data presented in Table 2 exposed that the variety NIAB-846 produced the tallest plants (134.55 cm) followed by Sindh-1 (132.30 cms) whereas the cultivar Sadori had the shortest plants of 102.15 cm as compared to the rest of the genotypes. For monopodial branches plant^{-1}, CRIS-342 produced maximum number of monopodial branches plant^{-1} (1.30), however, the variety IR-1524 ranked second (1.20) whereas IR-3701 produced the lowest number of monopodial branches plant^{-1} (0.33). For sympodial branches plant^{-1}, CRIS-342 showed the highest number of sympodial branches plant^{-1} (17.85) followed by Sadori (17.20), whereas IR-03 expressed the lowest number of sympodial branches plant^{-1} (12.05). Regarding bolls plant^{-1}, the variety CRIS-342 formed maximum number of bolls plant^{-1} (34.40.) whereas lowest numbers were obtained from CIM-598 (18.85). The cultivar CRIS-342gave maximum boll weight (3.75gms) while the lowest was observed in variety Sindh-1 (2.87gms). Considering seed cotton yield plant^{-1}, the variety CRIS-342 produced higher (106.32 gms) whereas, variety Sindh-1 produced the lowest value for seed cotton yield plant^{-1} (69.47 gms). In respect to GOT%, it ranged from 39.21% (CIM-598) to 37.12% (Sindh-1). In case of staple length, the maximum staple length was obtained from variety NIAB-846 (28.47 mm) while the lowest from IR-03 (26.950 mm). With respect to seed index, the variety IR-1524 produced maximum seed index (7.52gms) whereas, CIM-598 gave the lowest seed index (6.50gms). Considering the micronaire value, IR-03gave best micronaire value (4.94 µg/inch), however, the variety CRIS-342showed the lowest (4.03µg/inch). All in all, the variety CRIS-342 displayed better performance in five out of ten quantitative and qualitative traits.

Genetic parameters

In the present research, various multigenic characters of

Table 2. *Mean performance of cotton genotypes for various quantitative and qualitative traits.*

Genotypes	PH (cm)	MBP	SBP	BP	BW (gms)	SCYP (gms)	GOT (%)	SL (mm)	SI (gm)	MIC (µg/inch)
IR-03	124.55	0.85	12.05	20.70	3.02	92.92	38.41	26.95	7.15	4.94
IR-1524	129.15	1.20	16.75	32.60	3.07	99.93	37.72	28.45	7.52	4.60
IR-3701	119.25	0.33	15.90	30.35	2.90	85.37	37.32	27.52	6.55	4.92
Sadori	102.15	0.70	17.20	33.20	3.15	104.83	38.20	28.20	7.27	4.09
Sindh-1	132.30	0.75	14.65	23.85	2.87	69.47	37.12	27.60	6.87	4.59
CIM-598	116.80	0.55	10.35	18.85	3.47	69.90	39.21	27.75	6.50	4.04
CRIS-342	119.25	1.30	17.85	34.40	3.75	106.32	39.01	27.75	7.00	4.03
NIAB -846	134.55	0.85	12.75	24.00	3.10	83.39	37.65	28.47	7.45	4.90
LSD (5%)	2.60	0.26	2.26	5.05	0.08	17.46	1.78	1.50	0.54	0.03

PH=Plant Height; MBP=Monopodial branches plant^{-1}; SBP= Sympodial branches plant^{-1}; BP= Bolls plant^{-1}; BW= Boll weight; SCYP= Seed cotton yield plant^{-1}; GOT= Ginning outtern; SL= Staple length; SI= Seed index; MIC= Micronaire value

Table 3. *Correlation (r) and regression coefficients (b) of various traits in cotton cultivars.*

Characters combinations	Correlation coefficient (r)	Coefficient of determination (r2)	Regression coefficient (b)
Plant height v/s monopodial branches plant $^{-1}$	0.226^{NS}	0.051	0.008
Plant height v/s sympodial branches plant $^{-1}$	-0.254 ^{NS}	0.065	-0.074
Plant height v/s bolls plant^{-1}	-0.266 ^{NS}	0.071	-0.174
Plant height v/s seed cotton yield plant^{-1}	-0.286 ^{NS}	0.082	-0.550
Plant height v/s micronaire value	0.616*	0.379	0.023
Monopodial v/s sympodial branches plant $^{-1}$	0.238 ^{NS}	0.057	1.956
Monopodial v/s bolls plant^{-1}	0.257 ^{NS}	0.066	4.757
Monopodial v/s boll weight	0.033 ^{NS}	0.001	0.027
Monopodial v/s seed cotton yield plant^{-1}	0.316 ^{NS}	0.100	0.171
Monopodial v/s GOT%	-0.310 ^{NS}	0.134	-1.387
Monopodial v/s seed index	0.390*	0.152	0.523
Sympodial v/s bollsplant^{-1}	0.952**	0.902	2.146
Sympodial v/s boll weight	-0.502*	0.252	-0.050
Sympodial v/s seed cotton yield plant $^{-1}$	0.863**	0.745	5.719
bollsplant^{-1}v/s boll weight	-0.385*	0.148	-0.017
bollsplant^{-1}v/s seed cotton yield plant $^{-1}$	0.944**	0.891	2.776
bollsplant^{-1}v/s seed index	0.184 ^{NS}	0.034	0.013
bollsplant^{-1}v/s micronaire value	-0.239 ^{NS}	0.057	-0.014
boll weight v/s seed cotton yield plant $^{-1}$	0.587*	0.346	5.280
boll weight v/s GOT%	0.343*	0.118	1.604
boll weight v/s staple length	0.106 ^{NS}	0.011	0.338
boll weight v/s micronaire value	-0.362*	0.131	-0.482
seed cotton yield plant $^{-1}$v/s staple length	0.253 ^{NS}	0.064	0.012
seed cotton yield plant $^{-1}$v/s seed index	0.201 ^{NS}	0.040	0.005
seed cotton yield plant $^{-1}$v/s micronaire	-0.374*	0.140	-0.007
GOT% v/s staple length	0.096 ^{NS}	0.009	0.066
GOT% v/s seed index	-0.183 ^{NS}	0.033	-0.065
staple length v/s seed index	0.420*	0.176	0.217
seed index v/s micronaire value	0.153 ^{NS}	0.023	0.123

**= Significant at 0.01 *p* value; *= Significant at 0.05 *p* value; NS= Non-Significant eight commercially grown cultivars were studied in order to evaluate genetic potential and also to get better understanding of interrelationship of various quantitative and qualitative traits in cotton genotypes so as to improve the important traits in future breeding programs.

The results are given in Table-3 which shows that plant height had positive and significant relationship with micronaire value (r=0.616*) and this association between plant height and fiber finness indicates that increase in plant height will cause correspondingly increase in fiber finness. It is known fact that increase micronaire value will result in course fiber which is undesirable in cotton breeding for quality traits so cotton breeder must be careful while selecting the genotypes for fiber traits. Similar results were also obtained by Salahuddin *et al.,* (2010b) and Rao & Gopinath (2013) in their respective studies. However, plant height was negatively correlated with micronaire value was reported in previous studies of (Ashokkumar & Ravikesavan, 2010). The plant height was negatively correlated with sympodial branches plant^{-1} (r=-0.254), bolls plant^{-1} (r=-0.266) and seed cotton yield plant^{-1} (r=-0.286). From above results, it is understood that the tallest plants may produce adverse effects on yield related traits and, as a consequences, yield can be decreased to some extent. In cotton, medium-tall plants with production capacity of setting maximum number of bolls which is the ultimate result for obtaining higher yields are more desirable. The coefficient of determination (r^2) revealed that 8.20% of total variability in seed cotton yield plant^{-1} was due to its association with plant height. The regression coefficient (b) indicated that a unit increase in plant height will reduce 0.550% gms of seed cotton yield plant^{-1}.

Monopodial branches is also an important trait since it bears fruiting branches on main cotton plant, hence contribute indirectly towards seed cotton yield. The results from correlation of monopodial branches plant^{-1}indicated non-significantly positive association with sympodial branches plant^{-1} (r=0.238^{NS}), bolls plant^{-1} (r=0.257^{NS}), boll weight (r=0.033^{NS}) and seed cotton yield plant^{-1} (r=0.316^{NS}) which revealed that increase in one character will not cause any significant change in another trait. Our results are similar to those obtained by Iqbal *et al.,* (2006), Kalpande *et al.,* (2008) and Yahaya *et al.,* (2013). However, monopodial branches plant^{-1}established significant and positive association with seed index (0.390*) revealed that increase in monompodial braches plant^{-1} will correspondingly increase seed index. The coefficient of determination (r^2) determined that monopodial branches plant^{-1} was responsible for 10.0% variation in seed cotton yield plant^{-1}. The regression coefficient (b) indicated that a unit increase in monopodial branches plant^{-1} resulted into corresponding increase of 0.171 gms in seed cotton yield plant^{-1}. Sympodial branches plant^{-1} is one of the major quantitative traits and is considered as fruiting branches which bears bolls in cotton plant, hence contribute directly towards seed cotton yield. For that reason, plant breeders and researchers are interested to maximize sympodial branches plant^{-1} which does serve as good criterion for selecting high yielding cotton cultivars. In the present research work, it is evident that sympodial branches plant^{-1}were highly significantly and positively correlated with bolls plant^{-1} (r=0.952**) and seed cotton yield plant^{-1} (r=0.863**). It shows that a unit increase in sympodial branches plant^{-1} resulted into a proportional increase in bolls plant^{-1} and seed cotton yield plant^{-1}, however, negative association with boll weight (r=-0.502*) indicated that increase in sympodial branches plant^{-1} will decrease the boll size. The results reported by Abbas *et al.,* (2013) and Farooq *et al.,* (2013) were in accordance with our findings. The coefficient of determination (r^2) revealed 74.50% variation in the seed cotton yield plant^{-1}, due to its relationship with sympodial branches plant^{-1}. Regression coefficient (b) exhibited that a unit increase in sympodial branches plant^{-1} resulted into a proportional increase of 5.719 gms in seed cotton yield plant^{-1}.

Bolls plant^{-1} is the major yield contributing factor having strong correlation with seed cotton yield. Considering the improvement of this vital trait, it has generally been observed that an increase in boll number in cotton plant will ultimately increase the seed cotton yield. The results shown in the Table-3 indicates positive association of bolls plant^{-1} with seed cotton yield plant^{-1} (r=0.944**), yet showed negative correlation with boll weight (r=-0.385*). These associations indicated that increase in number of bolls plant^{-1} will cause markedly increase in seed cotton yield while its increase will simultaneously cause negative impact on boll weight by reducing the boll size. It seems that cotton production could be improved by the increase in number of bolls plant^{-1}. These results are in accordance with the findings of Islam *et al.,* (2013) and Vinodhana *et al.,* (2013). The coefficient of determination (r^2) revealed 89.1% of the total variation in seed cotton yield plant^{-1}attributable to the variation in bolls plant^{-1}. The regression coefficient (b) indicated that for a unit increase in bolls plant^{-1}, there would be a relative increase of 2.776 gms in seed cotton yield plant^{-1}. The correlation results indicated that boll weight made positive and significant association with seed cotton yield plant^{-1} (r=0.587*) and GOT% (r=0.343*) but negatively significant correlation with micronaire value (r=-0.362*). These correlations results indicated that an increase in boll weight will considerably increase seed cotton yield^{-1} and GOT%. Yet, its significantly negative correlation with micronaire value suggested that increase in boll weight may cause adverse effect on micronaire value. The positive relationship between boll weight and seed cotton yield have been reported by Rao & Gopinath (2013) and Pujer *et al.,* (2014). The coefficient of determination (r^2) determined that boll weight was responsible for 34.6% variation in seed cotton yield plant^{-1}. The regression coefficient (b=) suggested that a unit increase in boll weight resulted into corresponding increase of 5.280 gms in seed cotton yield plant^{-1}.

Yield is considered as the most important trait which is mandatory to raise the yield production to its high level as it plays a critical role in strengthening the socio-economic conditions of the growers and country too. The correlation results revealed that seed cotton yield established significant and negative association with micronaire value (r=-0.374*) suggested that care must be given to micronaire value while improving seed cotton yield. Our results are similar to those obtained by Pujer *et al.,* (2014). GOT% is a complex trait which is controlled by many genes and is mostly affected by the dynamic changes of environment. Primarily, it depends on lint weight that creates direct effect on GOT%. Production plant^{-1} and per unit area can be improved by selecting the genotypes having high ginning outturn. The results are shown in the Table-3, showing that GOT% made positive but non-significant correlation with staple length (r=0.096^{NS}); while non-significant and negative with seed index (r=-0.183^{NS}). These results indicated that increase or decrease in one trait will not result any significant change in another trait, these results are in agreement with those of Dinakaran *et al.,* (2012).

Among the fiber quality parameters of cotton, fiber length has been secured a distinct position since it is more useful for textile mills in yarn manufacturing. The results found in the present study indicated that there had been significant and positive relationship between staple length and seed index (r=0.420*). Based on the obtained results, it could be inferred that significant progress could be achieved in improving staple length with no adverse impact on other important traits. Magadum *et al.,* (2012), Vinodhana *et al.,* (2013) and Pujer *et al.,* (2014), during their studies related to correlation between staple length and seed index in cotton, found the results which were in complete accordance to the results reported in this study. The coefficient of determination (r^2) indicated that 6.40 of total variability in seed cotton yield plant^{-1} was due to its association with staple length; while regression coefficient (b) showed that a unit increase in staple length will result in an increase of 0.012 gms in seed cotton yield plant^{-1}. Moreover, the correlation between seed index and micronaire value was positive but non-significant (r=0.153^{NS}), it implies that association between these two important traits is silent. The coefficient of determination (r^2) explained that 4.00% of total variability in seed cotton yield plant^{-1} was due to its association with seed index; while regression coefficient (b) described that a unit increase in seed index will result in an increase of 0.005 gms in seed cotton yield plant^{-1}.

Acknowledgements

The authors wish to acknowledge to the Director, Nuclear Institute of Agriculture, Tandojam for providing facilities in the experimental field and laboratory to carry out the present research work.

References

1. Abbas H G, Mahmood A & Qurban A. (2013). Genetic variability, heritability, genetic advance and correlation studies in cotton (*Gossypium hirsutum* L.). International Research Journal of Microbiology. 4(6): 156-161.
2. Adams M W & Grafius J E. (1971). Yield component compensation-alternate interpretations. Crop Science. 11: 33-35.
3. Ahmad W, Khan N U, Khalil M R, Parveen A, Aimen U, Saeed M, Samiullah & Shah S A. (2008). Genetic variability and correlation analysis in upland cotton.Sarhad Journal of Agriculture. 24(4): 573-580.
4. Ashokkumar, K. & R. Ravikesavan, (2010).Genetic studies for Correlation and Path analysis for seed oil, Yield and fibre quality traits in upland cotton (*G. hirsutum*. L). Australian Journal of Basic and Applied Sciences. 4(11): 5496-5499.
5. Dinakaran E, Thirumeni S & Paramasivam K. (2012).Yield and fiber quality components analysis in upland cotton (*Gossypium hirsutum* L.) under salinity. Annals of Biological Research. 3(8): 3910-3915.
6. Ekinci R, Basbag S & Gencer O. (2010). Path coefficient analysis between seed cotton yield and some characters in cotton (*Gossypium hirsutum* L.).Journal of Environmental Biology. 31(5): 861-864.
7. Erande C S, Kalpande H V, Deosarkar D B, Chavan S K, Patil V S, Deshmukh J D, Chinchane V N, Kumar A, Dey U & Puttawar M R. (2014). Genetic variability, correlation and path analysis among different traits in desi cotton (*Gossypium hirsutum* L.). African Jouranl of Agricultural Research. 9(29): 2278-2286.
8. Farooq J, Anwar M, Riaz M, A. Farooq, Mahmood A, Shahid M T H, Rafiq M S & Ilahi F. (2014). Correlation and path coefficient analysis of earliness, fiber quality and yield contributing traits in cotton (*Gossypium hirsutum* L.).The Journal of Animal & Plant Sciences. 24(3): 781-790.
9. Farooq J, Anwar M, Riaz M, Mahmood A, Farooq A, Iqbal M S & Iqbal M S. (2013). Association and path analysis of earliness, yield and fiber related traits under cotton leaf curl virus (CLCuV) intensive conditions in *Gossypium hirsutum* L. Plant Knowledge Journal. 2(1): 43-50.
10. Iqbal M, Hayat K, Sohail R, Khan A, Sadiq A & Islam N.

(2006). Correlation and path coefficient analysis for earliness and yield traits in cotton. Asian Journal of Plant Sciences. 5(2): 341-344.

11. Islam M K, Akhteruzzaman M & Sharmin D. (2013). Multivariate and genetic component analysis of new cotton (*Gossypium hirsutuml*.) genotypes. Bangladesh Journal of Progressive Science and Technology. 11(2): 185-190.
12. Kalpande H V, Bhale S D, Kale U V, Deshmukh J D, Gite V K & Kakde S S. (2008). Genetic variability and correlation studies in F3 generation of cotton (*Gossypium hirsutum* L). International Journal of Plant Sciences.3:(1) 94-97.
13. Killi F, Efe L & Mustafayev S. (2005).Genetic and environmental variability in yield, yield components and lint quality traits of cotton. International Journal of Agriculture and Biology.7:1007-1010.
14. Magadum S, Banerjee U, Ravikesavan R, Thiyagu K, Boopathi N M & Rajarathinam S. (2012). Association analysis of yield and fiber quality characters in interspecific population of cotton (*Gossypium spp*.).Journal of Crop Science and Biotechnology. 15(3): 239-243.
15. Malagouda P, Khadi B M, Basamma K & KatageriI S. (2014). Genetic variability and correlation analysis for fiberquality traits in diploid cotton (*Gossypium spp*). American-Eurasian Journal of Agriculture & Environmental Science. 14 (5): 392-395.
16. Pujer S, Siwach S S, Deshmukh J, Sangwan R S & Sangwan O. (2014). Genetic variability, correlation, and path analysis in upland cotton (*Gossypium hirsutum* L.). Electronic Journal of Plant Breeding. 5(2): 284-289.
17. Raghavrao D. (1983) Design of Experiments. Statistical Techniques in Agricultural and Biological Research. Oxford and IBH Publishing Company, New Delhi.
18. Rao P J M & Gopinath M. (2013). Association analysis of Yield and Fiber quality Characters in upland cotton (*Gossypium hirsutum* L.). Australian Journal of Basic and Applied Sciences. 7(8): 787-790.
19. Salahuddin S, Abro S, Kandhro M M, Salahuddin L & Laghari S. (2010b). Correlation analysis of seed cotton yield with some quantitative traits in upland cotton (*Gossypium hirsutum* L.)Pakistan Journal of Botany. 2(6): 3799-3805.
20. Steel R G D & Torrie J H. (1980).Principles and Procedures of Statistics. Second Edition, New York: McGraw-Hill.
21. Tang B. (1992). Evaluation of F2 hybrids of host plant resistant germplasms and cotton cultivars for yield and fiber qualities: Heterosis, combining ability, stability and potential for commercial uses. Ph.D Dissertation submitted to Mississippi State University, Mississippi, USA.
22. Vinodhana N K, Gunasekaran M & Vindhiyavarman P. (2013). Genetic studies of variability, correlation and path analysis in cotton genotypes. International Journal of Pure & Applied Bioscience. 1(5): 6-10.
23. Yahaya A I, Ado S G, Ishiyaku M F, Onu I & Usman A. (2013). Agronomic performance of commercial cotton genotypes and their relation to leaf roller infestation. Production Agriculture and Technology. 9(1): 98-104.