GENETIC DIVERSITY FOR YIELD AND RELATED TRAITS IN UPLAND COTTON GENOTYPES

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ABSTRACT:- An experiment to evaluate the genetic variability and yield potential in cotton cultivars was conducted at the Cotton Research Station, D.I.Khan, Pakistan, during 2013. The experiment was carried out in Randomized Complete Block design replicated four times. The genetic material comprised nine cotton cultivars viz., Gomal-93, SLH-373, BH-186, BH-172, CIM-573, CRIS-342, CIM-591, CIM-608 and DNH-105. Results depicted the significant ($P \leq 0.01$) differences for the investigated parameters. The genotype DNH-105 was the highest yielding genotype with seed yield of 2610.75 kg ha^{-1}, 42.3 bolls $plant^{-1}$, 3.57 g boll weight and 144.5 cm height in comparison to other eight genotypes. The cultivar Gomal-93 and SLH-373 also showed comparable yield and contributing parameters. The genetic variances of the studied parameters were higher in comparison to variances of environment and highly heritable in broad sense. These instant results suggest that these breeding materials have the room for further improvement and can be successfully utilized in future breeding programmes.

Key Words: Gossypium hirsutum; Seed Cotton Yield; Heritability; Genetic Potential; Pakistan.

INTRODUCTION

Hirsutum cotton contributes for approximately 90% of the world fiber production. Cotton is considered as multipurpose agricultural product and used in manufacturing of many products. It earns 45-60% foreign exchange. Along with fiber, it also provides 65-70% edible oil to the industry (Khan et al., 2010a, b; Statistica, 2014). Pakistan ranks 4th in cotton production and contribute 1.6% in GDP and 8% to the value added (Khan et al., 2009a, b;). Economy of Pakistan is largely reliant on production of upland cotton, with 1815 textile and ginning units supported by millions of laborers, farmers and traders, earning livelihoods directly or indirectly from this crop (Khan, 2013; Khan and Hassan, 2011). It is also termed as white gold due to its significance as cash and industrial crop. From the last two decades, the cotton production in the country is stagnant and low in comparison to world cotton producing countries (Khan and Hassan, 2011). The major production constraints include rain during cultivation, maximum fluctuation in temperature at the time of flowering and unsuitable technology (Khan et al., 2009a,

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b) and due to these factors during 2013-14, Cotton production stood at 12,769 thousand bales as compared to 13,031 thousand bales in 2012-13, and registered a decline of 2.0% (Pakistan Economic Survey, 2014).

As cotton is a sensitive crop and the performance of its cultivars varies with location as well as environmental conditions. Hence genetic potential and heritability of various genotypes in terms of performance for various morphological parameters is direly desirable for screening of high potential strains for breeding programme (Khan et al., 2010b). Knowledge of genetic potential of different cultivars and their heritability is of prime importance while breeders tackle the problem of low yield (Ahmad et al., 2008). According to Li et al. (2008) for obtaining superior genotypes proper exploitation of available germplasm in the form of hybridization and addition of new germplasm are necessary to create sufficient genetic variation. Variability in germplasm not only increase the chances of multiple resistance against biotic and abiotic stresses but also yield desirable combinations that can be utilized in future breeding programmes. Maximum heritability and genotypic differences suggests that the trait has the improvement opportunity through selection from segregating populations (Baloch, 2004; Khan et al., 2009b).

Different breeding procedures like introduction of exotic germplasm, hybridization and polyploidy can be used to obtain the desired genetic variability and the genotypes with diverse segregating populations (Esmail et al., 2008). Studies reported the development of cotton genotypes by hybridizing the distant parents (Punitha and Raveendran, 2004; Akter et al. 2009). The precise information on the nature and magnitude of genotypic variation depends upon the various procedures exploited for its estimation like characterization based on agronomical, morphological and physiological traits (Bajracharya et al., 2006). As the morphological traits of upland cotton cultivars revealed significant variability (Copur, 2006) and seed cotton yield have significant differences for first and last pick (Soomro et al., 2005). Keeping in view the importance of cotton as a major industrial crop, the study was carried out to estimate heritability and genetic potential in nine different upland cotton cultivars for yield related attributes in the agro-ecological environment of D.I.Khan.

MATERIALS AND METHOD

Breeding Material and Experimental Design

The experiment was conducted at Cotton Research Station, D.I.Khan during the cotton cropping season 2013. The experimental material comprised Gomal-93, SLH-373, BH-186, BH-172, CIM-573, CRIS-342, CIM-591, CIM-608 and DNH-105. The seed of these cultivars were hand sown on May 10, 2013 in randomized complete block design (RCBD) having four replications. Each subplot has four 10m long rows, with plant to plant and row to row distance of 30 and 75 cm, respectively. To ensure single plant per hill, thinning was performed after 20 days of germination. The recommended cultural practices and standard plant protection measures were applied to all the entries so as to reduce the environmental variations. Picking was performed on single plant basis in November- December, 2014.

Data Recording and Analysis

At maturity, ten plants were randomly selected from central two rows to reduce the border effect. The data on plant height, number of bolls plant^{-1}, boll weight and seed cotton yield (kg ha^{-1}) was recorded. The data recorded were subjected to analysis of variance (ANOVA) technique (Steel and Torrie, 1980). The means were further compared by using the least significant difference (LSD) test at 5% level of probability. Broad sense heritability (H^2) was estimated as suggested by Burton (1951) on entry mean basis.

$H^2 = Vg/Vp$

$Vg = M_2 - M_1/r$

$Vp = Vg + Ve/r$

where,

M_2 = Genotypic mean squares

M_1 = Error mean squares

R = Replication

RESULTS AND DISCUSSION

The ANOVA depicted significant (P≤ 0.01) differences for height of plant, number of bolls, boll weight and seed cotton yield (Table 1).

Table 1. Mean squares and coefficient of variation for different parameters of cotton during 2014

Parameter	Mean squares		CV%
	Genotypes	Error	
Plant height (cm)	587.937**	72.32	6.97
Bolls plant	115.889**	11.105	10.43
Boll weight (g)	0.395**	0.0311	5.54
Seed cotton yield(kg ha^{-1})	877400**	14094	6.57

*** Significant at 1% level of probability,*
CV = Coefficient of variation

Plant Height

Mean squares of plant height showed highly significant differences. The plant height ranged from 112.00 to 144.25 cm among the cotton cultivars (Table 2). Maximum height (144.25 cm) was recorded in DNH-105 which was statistically at par

Table 2. Genetic variability for plant height, number of bolls plant^{-1}, boll weight and yield of upland cotton during 2014

Genotype	Plant height (cm)	Bolls/plant	Boll weight (g)	Seed cotton yield (kg ha^{-1})
Gomal-93	140.00^{a}	39.00^{a}	3.50^{ab}	2497.25^{a}
SLH-317	125.00^{b}	30.50^{bc}	3.13^{cd}	2097.50^{b}
BH-186	113.75^{bc}	27.00^{c}	3.15^{cd}	1475.00^{c}
BH-172	119.50^{bc}	26.35^{c}	2.95^{d}	1503.25^{c}
CIM-573	113.00^{bc}	30.45^{bc}	3.17^{cd}	1480.70^{c}
CRIS-342	113.25^{bc}	29.25^{bc}	2.52^{e}	1491.50^{c}
CIM-591	112.00^{ac}	33.25^{b}	3.35^{abc}	1495.00^{c}
CIM-608	118.00^{bc}	29.55^{bc}	3.3^{bc}	1601.75^{c}
DNH-105	144.25^{a}	42.30^{a}	3.57^{b}	2610.75^{a}
$LSD_{0.05}$	12.41	4.86	0.26	173.26

Means followed by same letter do not differ significantly at P<0.05.

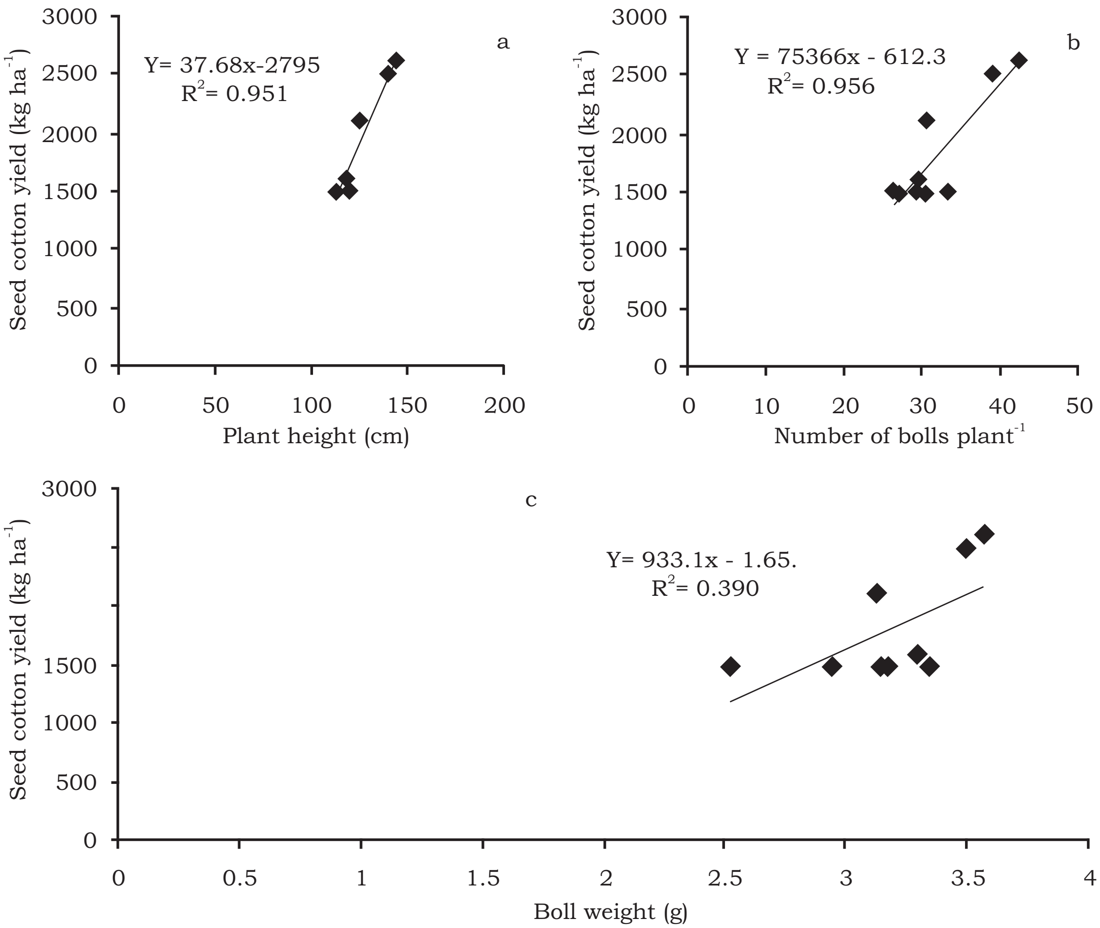

Figure 1. Association between (a) seed cotton yield and plant height, (b) seed cotton yield and number of bolls plant^{-1} and (c) seed cotton yield and boll weight in non-bt cotton cultivars

with Gomal-93 (140 cm). Minimum plant height was recorded in CIM-591. Genetic variances (128.90) were greater than environmental variances (72.32) and heritability estimate was also high (0.87). The highest coefficient of determination (R^2=0.951) between seed cotton yield and plant height was also observed (Figure 1) showing that seed cotton yield is directly influenced with increase in plant height. Although dwarf plants are desired on account of threat due to lodging, but it has also been investigated in various studies that in the absence of lodging plant height are positively associated along with number of bolls plant^{-1} and yield (Khan et al., 2009a). Similarly, Suinaga et al. (2006) and Meena et al. (2007) also recorded different values for height and other yield contributing traits.

Bolls Plant^{-1}

The data pertaining to bolls plant^{-1} depicted highly significant differences among genotypes. Bolls plant^{-1} ranged from 26.35 to 42.30. Highest bolls plant^{-1} (42.30) was

Table 3. Variance components for Genetic, environmental and phenotypic attributes and broad sense heritability (bs) for different parameters of cotton during 2014

Parameter	Genetic variance	Environmental variance	Phenotypic variance	Heritability
Plant height	128.900	72.3200	146.980	0.87
Bolls plant^{-1}	26.190	11.1050	28.960	0.90
Boll weight	0.091	0.0311	0.098	0.92
Seed cotton yield (kg ha^{-1})	215826.500	14094.0000	219350.000	0.98

Vg = genetic variance, Ve = environmental variance and Vp = phenotypic variance

recorded in DNH-105 which was statistically at par with Gomal-93 (Table 2). Minimum bolls plant^{-1} was recorded in genotype BH-172. The genetic and environmental variances were 26.19 and 11.105, respectively. The heritability estimates for bolls plant^{-1} was also higher (Table 3). The coefficient of determination between boll weight and seed cotton yield was recorded to be R^2=0.756 (Figure 1) showing that bolls plant^{-1} has positive direct association with yield. Ahmad et al. (2008) also obtained similar results for boll number. Khan (2003) and Khan et al. (2007a; b) also investigated various *G. hirsutum* cultivars for yield parameters and recorded significant differences for bolls number and weight and contributed significant variation and direct relation with seed cotton yield.

Boll Weight

Among investigated genotypes weight of boll ranged from 2.52 to 3.57 g (Table 2). The highest and statistically at par boll weight was recorded in DNH-105, Gomal-93 (3.50g) and CIM-591 (3.35g. Minimum boll weight (2.52 g) was recorded in CRIS-342. The remaining genotypes showed intermediate boll weight. Along with high heritability (0.92), the genetic variances were also higher than environmental variances showing the potential of genotypes to enhance boll weight which is the second main contributor to seed cotton yield after boll numbers. The coefficient of determination between boll weight and seed cotton yield was R^2= 0.390 (Figure 1). Ahmad et al. (2008) and Khan et al. (2009a) also observed the same proportion and variation regarding boll weight in association with seed cotton yield in various genotypes of cotton.

Seed Cotton Yield (kg ha^{-1})

The mean values pertaining to yield depicted significant ($P \leq 0.01$) variation among the cultivars. Seed cotton yield among the genotypes ranged from 1475.00 to 2610.75 kg ha^{-1} (Table 2). The maximum yield of 2610.75 kg ha^{-1} was observed in DNH-105 that was statistically similar with Gomal-93 (24970.25 kg ha^{-1}). These genotypes were followed by SLH-373 (2097.5 kg ha^{-1}). The lowest yield of 1475 kg ha^{-1} was noted in genotype BH-186 having low boll numbers, weight and plant height (Table 2). The genotypic and environmental variations for seed cotton yield were 215826.5 and 14094, respectively. The broad sense heritability estimates for seed cotton yield was higher (0.98). Results on seed cotton yield revealed that it was mostly controlled by genetic variance due to its greater value and higher heritability and selection in these genotypes will be more effective. Khan et al. (2009a; b; 2010a; b); Copur (2006) and Soomro et al. (2005) also found significant differences for seed cotton yield in upland cotton genotypes.

The study revealed that DNH-105 was the most promising genotype considering yield, bolls plant^{-1}, boll weight and plant height. The genotype Gomal-93 also depicted reasonable yield and its related parameters. All the studied traits were highly heritable and less environmental influence was observed. Thus the present breeding material can be successfully utilized for future breeding programme.

LITERATURE CITED

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

Akter, A., M. Hasan, A. Paul, M. Mutlib and M. Hossain. 2009. Selection of parent for improvement of restorer line in rice (*Oryza sativa* L.). SAARC J. Agric. 7: 43-50.

Bajracharya, J., K. Steele, D. Jarvis, B. Sthapit and J. Witcombe. 2006. Rice landrace diversity in Nepal: Variability of agro-morphological traits and SSR markers in landraces from a high-altitude site. Field Crops Res. 95(2): 327-335.

Baloch, M.J. 2004. Genetic variability and heritibility estimates of some polygenic traits in upland cotton. Pakistan J. Sci. Indust. Res. 47(6): 451-454.

Burton, G.W. 1951. Quantitative inheritance in pearl millet (*Pennisetum glaucum*). Agron. J 43(9): 409-417.

Copur, O. 2006. Determination of yield and yield components of some cotton cultivars in semi arid conditions. Pakistan J. Biol. Sci. 9(14): 2572-2578.

Esmail, R., J. Zhang and A. Abdel-Hamid. 2008. Genetic diversity in elite cotton germplasm lines using field performance and RAPD markers. World J. Agric. Sci. 4(3): 369-375.

Khan, N. and G. Hassan. 2011. Genetic effects on morphological and yield traits in cotton (*Gossypium hirsutum* L.). Spanish J. Agric. Res. 9(2): 460-472.

Khan, N.U. 2003. Genetic analysis, combining ability and heterotic studies for yield, its components, fibre and oil quality traits in upland cotton (*G. hirsutum* L.). PhD Dissert Sindh. Agric. Univ. Tandojam, Pakistan.

Khan, N.U. 2013. Diallel analysis of cotton leaf curl virus (CLCuV) disease, earliness, yield and fiber traits under CLCuV infestation in upland cotton. Austr. J. Crop. Sci. 7(12): 1955-1966.

Khan, N.U., H. Basal and G. Hassan. 2010a. Cottonseed oil and yield assessment via economic heterosis and heritability in intraspecific cotton populations. Afr. J.

Biotechnol. 9(44): 7418-7428.

Khan, N.U., G. Hassan, K.B. Marwat, Farhatullah, M.B. Kumbhar, A. Parveen, Umm-E-Aiman, M.Z. Khan and Z.A. Soomro. 2009a. Diallel analysis of some quantitive traits in *Gossypium hirsutum* L. Pakistan J. Bot. 4(6): 3009-3022.

Khan, N.U., G. Hassan, K.B. Marwat, S.B. Farhatullah, K. Makhdoom, I. Khan, I. Khan and W. Ahmad. 2009b. Genetic variability and heritability in upland cotton. Pak. J. Bot 41(4): 1695-1705b.

Khan, N.U., G. Hassan, M.B. Kumbhar, S. Kang, I. Khan and A. Parveen. 2007a. Heterosis and inbreeding depression and mean performance in segregation generations in upland cotton. Eur. J. Scien: res. 17(4): 531-546.

Khan, N.U., H.U. Khan, K. Usman, H.U. Khan and S. Alam. 2007b. Performance of selected cotton cultivar for yield and fibre related parameters. Sarhad Journal of Agriculture. 23(2): 257.

Khan, N.U., K.B. Marwat, G. Hassan, S. Batool, Farhatullah, K. Makhdoom, W. Ahmad and H. Khan. 2010b. Genetic variation and heritability for cotton seed, fiber and oil traits in *Gossypium hirsutum* L. Pakistan J. Bot. 42(1): 615-625.

Li, Z., X. Wang, Y. Zhang, G. Zhang, L. Wu, J. Chi and Z. Ma. 2008. Assessment of genetic diversity in glandless cotton germplasm resources by using agronomic traits and molecular markers. Frontiers Agric. in China 2(3): 245-252.

Meena, R., D. Monga and R. Kumar. 2007. Undescriptive cotton cultivars of north zone: An evaluation. J. Cotton Res. and Develop. 21(1): 21-23.

Pakistan Economic Survey. 2014. Highlights of Pakistan Economic Survey 2013-14. Available at (finance.gov.pk/survey/chapters_14/Highlights_ES_201314.pdf).

Punitha, D. and T. Raveendran. 2004. DNA fingerprinting studies in coloured cotton genotypes. Plant Breeding, 123(1): 101-103.

Soomro, A., R. Kakar, H. Ali and S. Abid. 2005. Comparison of yield and its components in some commercial cotton varieties. Indus J. Plant Sci. 4: 545-552.

Statistica. 2014. World's 10 leading cotton producing countries in 2013/2014. (Available at http://www.statista.com/statistics/263055/cotton-production-world-wide-by-top-countries/).

Steel, R. and J. Torrie. 1980. Principles and procedures of statistics. A biological approach. McGraw-Hill Book Co., New York.

Suinaga, F.A., C.S. Bastos and L.E.P. Rangel. 2006. Phenotypic adaptability and stability of cotton cultivars in the Mato Gross State, Brazil. Pesquisa Agropecuária Tropical 36(3): 145.

AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Dr. Kalim Ullah	Conceived the idea, Results and Discussion
2.	Mr. Zahid Usman	Overall management of the article,

		Conclusion
3.	Mr. Niamatullah Khan	Methodology, Data collection
4.	Mr. Rehmat Ullah	Data analysis
5.	Mr. Fazal Yazdan Saleem	Technical Input at every step
6.	Mr. Shahid Iqbal Khattak	Introduction
7.	Mr. Muhammad Ali	References

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