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Genetic variability and associations of seed cotton yield, attributing traits and fiber quality parameters in *intra hirsutum* hybrids of upland cotton (*Gossypium hirsutum* L.)

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Abstract : Cotton is an important fibre crop worldwide. Yield and fibre quality are most important and complex traits as these are dependent on interaction of genetic architecture of plant and environment. Presence of genetic variability is the pre requisite for any crop improvement programme. The present study was aimed to investigate the degree of genetic variability, heritability, genetic advance and association of seed cotton yield, attributing traits, and fiber quality parameters among nineteen *intra hirsutum* hybrids of upland cotton (*Gossypium hirsutum* L.). The experiment was conducted in randomized block design (RBD) with three replications at the Research Area, Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agriculture University, Hisar, during *kharif* 2022. The genetic parameters for 16 yield components and fibre quality traits were analyzed. The phenotypic coefficient of variance (PCV) was slightly greater than genotypic coefficient of variance (GCV) indicating less influence of environment on the trait expression. High GCV and PCV were recorded for lint yield (20.0% and 23.6%) and seed cotton yield (20.0% and 23.0%). High heritability with high genetic advance as per cent of mean was reported for lint yield (69.6%, 34%), seed index (90.9%, 23.6%), plant/sq. m. (94.7%, 27.1%), number of boll /sq. m. (77.0%, 26.2), and seed cotton yield (70.6%, 33.5%). This suggested that genetic variance played a major role in the inheritance of these traits. Correlation coefficients revealed that seed cotton yield (SCY) exhibited significant and positive correlation with boll weight (0.67), boll number (0.441), lint yield (0.97), plant height (0.43), plant/ sq. m. (0.63), boll/ sq. m. (0.91), fibre fineness (0.39) and fibre strength (0.26). Thus, these findings suggested that direct selection based these traits would be quite effective to improve the yield and fiber quality in upland cotton.

Key words: Association, hybrid, quality, variability, yield attributing

Cotton, known as "White Gold," is a highly significant fiber and cash crop cultivated in over 60 countries (Jarwar *et al.*, 2018). Among the four cultivated species, *Gossypium. hirsutum* L. is the most prevalent, covering approximately 95 per cent of the global cotton production area due to its adaptability and high lint yield (Kumar *et al.*, 2021). This crop plays a crucial role in India's economy, providing employment to 4-5 crore individuals directly and indirectly, and serving as a valuable commodity for foreign exchange (Jangid *et al.*, 2019). Apart from being renowned for its fiber, cotton seeds contain 18 per cent oil (Abdullah *et al.*, 2016). The cotton plant exhibits significant genetic variation for various yield and quality traits, primarily due to its ease of hybridization through cross pollination (Joshi and Patil, 2018). Plant breeders aim to enhance both yield and fiber quality to meet the requirements of farmers and the textile industry. Lint yield can be deconstructed into several component traits, including boll weight, bolls/plant, seed index, lint index, seeds/boll, and locules/boll. However, the simultaneous improvement of yield and fiber quality is hindered by a negative association influenced by multiple QTLs and linkage drag (Gapare *et al.*, 2017; Kumar *et al.*, 2022).

Therefore, it is essential to assess the degree of variability, heritability, and genetic advancement to facilitate effective cotton breeding and the development of superior varieties and hybrids. Genetic variability indicates the feasibility of selection based on both phenotypic and genotypic factors. Thus, this study aims to investigate the genetic variability in upland cotton hybrids for 16 yield and attributing component traits, as well as fiber quality traits, while providing a detailed analysis of their heritable components to guide selection in breeding programs.

The experiment was conducted during the *kharif* 2022 at the Cotton Research Area, CCS Haryana Agriculture University, Hisar. The experimental material consisted of 19 *intra hirsutum* hybrids of upland cotton (*Gossypium hirsutum* L.) (Table 1). The hybrids were sown in a randomized block design (RBD) with three replications. Each genotype was assigned to a four row plot, with each row spaced 67.5 cm apart and plant to plant distance of 30 cm within the row. The following traits were recorded for analysis: boll weight (g), bolls/plant, ginning outturn (%), seed index (g), lint yield (kg/ha), plant height (cm), monopodia, plant/sq.m., boll/ sq. m., lint index (g), sympods/plant, fibre length, uniformity index (%), fiber fineness (µ/inch), fibre strength (g/tex) and seed cotton yield (q/ha). The data obtained from the experiment was subjected to analysis of variance (ANOVA) following the standard procedure suggested by Fisher (1925). Genotypic and phenotypic coefficients of variation were estimated based on the genotypic and phenotypic variances, as suggested by Burton and Devane (1953). The coefficients of variation were categorized into three groups: Low (0-10%), Moderate (11-20%), and High (>20%), according to the method proposed by Shiva Subramanian and Menon (1973). The heritability in broad sense, which indicates the proportion of phenotypic variance attributed to genotypic variance, was calculated as a percentage. The heritability values were classified into three groups: Low (<30%), Moderate (30-60%), and High (>60%), following the classification. Genetic advance was calculated using the formula provided by Johnson *et al.*, (1955). The values were also categorized as Low (0-10%), Moderate (11-20%), and High (>20%). Correlation coefficients between different pairs of traits were estimated at phenotypic (r(p)) level using the formulas given by Al-Jibouri *et al.*, (1958). Path coefficient analysis, based on the formula given by Wright (1921) was performed. This analysis involves solving a set of 'p' simultaneous equations to obtain the path coefficients. IN DOST AT and R software were used for these calculations. Overall, the study followed a rigorous experimental design and employed statistical analyses to explore the relationships between various traits in upland cotton genotypes.

The analysis of variance revealed highly significant (P<1) differences for all the traits

Table 1: List of intra hirsutum hybrids of upland cotton used in the study

Sr. No.	Name of hybrid	Sr. No.	Name of hybrid
1.	KCH 9377 BG II	11	C 9316 BG II
2.	ACH-911-2 BGII	12	US 51 BG II (ZC 2)
3.	US 712 BGII	13	KCH 9388 BG II
4.	C 9317 BG II	14	ACH-944-2 BGII
5.	HYCH - 1278	15	DACH 45N45 BG II
6.	CT006 BGII	16	ARCH 1010 BG II
7.	RCH 773 BG II (ZC 1)	17	DC5418 BGII
8.	ARCH 1006 BG II	18	DACH 47N47 BG II
9.	BIO 6275 BGII	19	BIO 6635 BGII
10.	CT003 BGII		

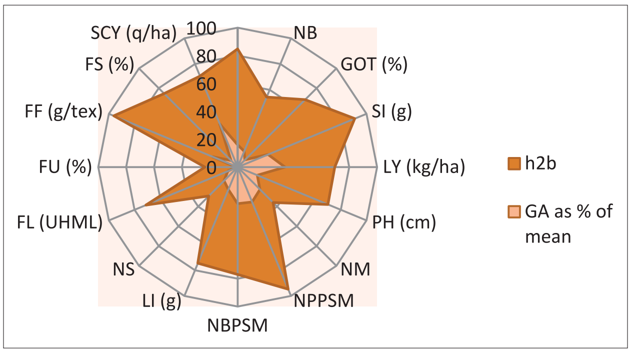

Fig. 1. Estimates of genotypic and phenotypic coefficient of variation for different characters in Intra-hirsutum hybrids of upland cotton

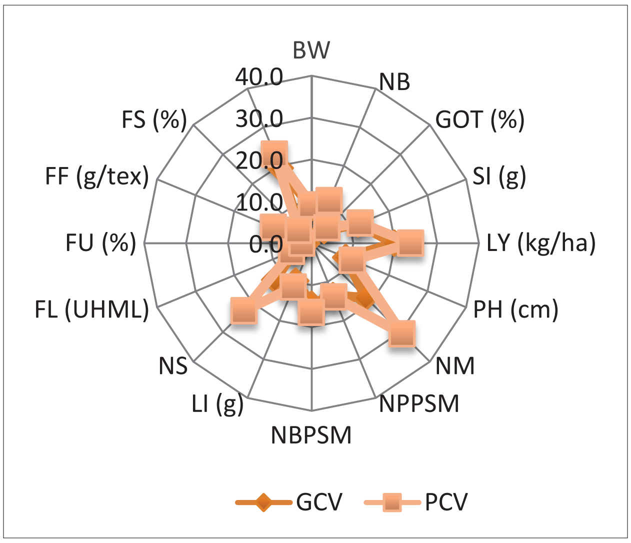

Fig. 2. Estimates of heritability and genetic advance as per cent of for different characters in Intra-hirsutum hybrids of upland cotton

except uniformity index. It revealed that adequate variability was present in the material under study for seed cotton yield and its contributing traits as well as fibre quality traits except uniformity index (%). These findings are in concordance with Nikhil *et al.*, (2018), Sahar *et al.*, (2021), Ishaq *et al.*, (2021) and Nawaz *et al.*,(2019).

The range for a genotypic and phenotypic coefficient of variation for different economically important traits was represented in Fig. 1. In the present study, PCV is slightly greater than the GCV for all the characters indicating that there is little influence of environment in the expression of these traits. Low GCV and PCV were recorded for boll weight (8.4%, 9.1%), ginning outturn (4.3%, 5.2%), fibre length (4.3%, 5.1%), fibre strength (3.7%, 4.3%) and fibre fineness (9.6%, 9.8%), respectively. This suggests that there is less span for the improvement of these traits. Low GCV and moderate PCV were observed for/boll/plant (8.1%, 11.00%), plant height (8.8%, 10.59%) and lint index (9.7%, 11.3%), indicating that these traits were more influenced by environments. Moderate GCV and PCV was found for seed index (12.03%, 12.61%), plant/sq. m. (14.5%, 16.5%) and boll/sq. m. (14.5%, 16.5%). These findings were in accord with Rao *et al.*, (2021), Gnanasekaran *et al.*, (2020), Bhatti *et al.*, (2020) and Manonmani, *et al.*, (2019). High GCV and PCV were recorded for lint yield (20.0%, 23.6%) and seed cotton yield *i.e.* 20 and 23 per cent respectively (Fig. 1). This suggested that genetic variance played a major role in the inheritance of these traits. A similar results was reported by Khokhar *et al.*, (2017), Sahar *et al.*, (2021) and Rao *et al.*, (2021).

The high heritability estimate coupled with high genetic advance as a per cent of mean was recorded for the seed index (90.9%, 23.6%), lint yield (69.6%, 34.0%), plant/sq. m. (94.7%, 27.1%), boll/sq. m. (77.0%, 26.2%) and seed cotton yield (70.6%, 33.5%) (Fig. 2). This indicates that heritability is due to additive gene action and hence direct selection will be profitable in these traits. Previous studies by Sahar *et al.*, (2021), Abro *et al.*, (2021), Nandhini *et al.*, (2019), Nikhil *et al.*, (2018) and Shao *et al.*, (2016) documented similar results. Higher heritability with medium genetic advance was found for boll weight (84.7%, 15.9%), plant height (70.10 %, 15.29 %), lint index (74.60 %, 17.39 %) and fibre strength (96.1%, 19.5%). High heritability with a low response to selection was observed for ginning outturn (68.42%, 7.3%), fibre length (71.1%, 7.5%), and fibre strength (74.5%, 6.6%) (Fig. 2). This is indicative of non additive gene action thus, heritability may be due to the influence of environment rather than genotype and selection for the such trait will not

Table 2: Correlation coefficients among various traits in *intra hirsutum* hybrids of upland cotton

Trait	BW	NB	GOT	SI	LY	PH	NM	NPSM	NBSM	LI	NS	FL	UI	FF	FS	SCY
BW	1															
NB	0.009	1														
GOT	-0.062	0.130	1													
SI	0.272*	0.081	-0.449**	1												
LY	0.647**	0.452**	0.137	-0.045	1											
PH	0.090	0.105	-0.01	-0.272*	0.449**	1										
NM	0.286*	-0.384**	0.095	-0.045	0.156	-0.099	1									
NPSM	0.432**	-0.307*	-0.261	-0.062	0.592**	0.483**	0.372**	1								
NBSM	0.430**	0.379**	-0.159	-0.007	0.886**	0.533**	0.107	0.762**	1							
LI	0.210	0.176	0.181	0.793**	0.007	-0.332*	0.017	-0.270*	-0.142	1						
NS	-0.101	0.049	0.091	-0.324*	0.133	0.173	-0.005	0.144	0.171	-0.281*	1					
FL	0.164	0.293*	-0.427**	0.337*	0.228	0.346**	-0.263*	0.145	0.336*	0.071	-0.113	1				
UI	-0.065	-0.028	-0.082	0.228	-0.010	-0.034	0.066	0.085	0.057	0.200	-0.216	0.150	1			
FF	0.554**	-0.026	0.044	0.220	0.380**	0.275*	0.039	0.268*	0.241	0.256	0.027	0.141	0.080	1		
FS	0.359**	0.253	-0.385**	0.434**	0.166	0.044	-0.276*	-0.033	0.140	0.190	-0.283*	0.575**	0.156	0.166	1	
SCY	0.676**	0.441**	-0.088	0.077	0.973**	0.439**	0.126	0.635**	0.918**	-0.010	0.118	0.332*	0.009	0.392**	0.266*	1

*significant at 5%, **significant at 1% BW: Boll Weight (g), NB: Number of bolls per plant, GOT: Ginning Out Turn (%), SI : Seed Index (g), LY: Lint Yield (kg/ha), PH: Plant Height (cm), NM: No. of Monopodia, NPSM: No. of Plant per square meter, NBSM: No. of boll per square meter, LI: Lint Index (g), NS: No. of sympods per plant, FL: Fibre length (UHML), UI: Uniformity index (%) , FF: Fiber fineness (μ/inch), FS: Fibre strength (g/tax) and SCY: Seed cotton yield (q/ha)

Table 3: Path coefficient analysis for yield attributing and fibre quality traits in *intra hirsutum* hybrids of upland cotton

Traits	BW	NB	GOT	SI	LY	PH	NM	NPSM	NBSM	LI	NS	FL	UI	FF	FS	SCY
BW	0.089	-0.016	0.012	0.048	0.601	-0.006	-0.011	0.105	-0.066	-0.033	-0.010	-0.006	0.001	0.022	-0.021	0.709
NB	-0.008	0.194	-0.015	0.010	0.218	-0.012	0.017	-0.089	-0.020	-0.015	-0.025	-0.008	0.003	-0.001	-0.016	0.235
GOT	-0.006	0.016	-0.181	-0.088	0.025	0.002	0.001	-0.069	0.041	0.003	0.007	0.014	0.007	0.001	0.027	-0.201
SI	0.027	0.012	0.099	0.160	-0.076	0.011	-0.001	-0.018	0.007	-0.103	-0.028	-0.009	-0.005	0.009	-0.023	0.063
LY	0.061	0.048	-0.005	-0.014	0.873	-0.031	-0.007	0.161	-0.131	0.016	-0.005	-0.006	0.002	0.016	-0.007	0.973
PH	0.012	0.053	0.007	-0.042	0.628	-0.043	0.008	0.134	-0.115	0.043	0.030	-0.010	-0.001	0.012	-0.004	0.713
NM	0.041	-0.140	0.005	0.008	0.249	0.014	-0.024	0.147	-0.044	-0.002	-0.017	0.011	-0.002	0.000	0.012	0.259
NPSM	0.041	-0.076	0.055	-0.013	0.620	-0.025	-0.015	0.228	-0.124	0.038	0.015	-0.004	-0.001	0.010	0.004	0.753
NBSM	0.041	0.027	0.051	-0.008	0.791	-0.034	-0.007	0.195	-0.145	0.033	0.002	-0.008	0.000	0.010	-0.004	0.943
LI	0.024	0.024	0.005	0.136	-0.117	0.015	0.000	-0.072	0.039	-0.121	-0.031	-0.001	-0.002	0.010	-0.010	-0.100
NS	-0.021	-0.110	-0.027	-0.104	-0.099	-0.029	0.009	0.078	-0.005	0.085	0.043	0.004	0.002	-0.002	0.013	-0.163
FL	0.026	0.076	0.133	0.072	0.272	-0.021	0.013	0.043	-0.061	-0.008	-0.009	-0.020	-0.001	0.005	-0.038	0.482
UI	-0.010	-0.056	0.113	0.065	-0.156	-0.004	-0.004	0.026	0.006	-0.016	-0.009	-0.001	-0.012	0.009	-0.007	-0.055
FF	0.054	-0.006	-0.003	0.039	0.392	-0.015	0.000	0.065	-0.042	-0.035	-0.003	-0.003	-0.003	0.035	-0.011	0.465
FS	0.039	0.065	0.101	0.077	0.128	-0.004	0.006	-0.020	-0.013	-0.024	-0.012	-0.015	-0.002	0.008	-0.048	0.286

Residual effect: 0.009; BW: Boll Weight (g), NB: Number of bolls per plant, GOT: Ginning Out Turn (%), SI : Seed Index (g), LY: Lint Yield (kg/ha), PH: Plant Height (cm), NM: No. of Monopodia, NPSM: No. of Plant per square meter, NBSM: No. of boll per square meter,LI: Lint Index (g), NS: No. of sympods per plant, FL: Fibre length (UHML), UI: Uniformity index (%) , FF: Fiber fineness (μ/inch), FS: Fibre strength (g/tax) and SCY: Seed Cotton Yield (q/ha) be rewarding. Similar findings were recorded by Hafiz *et al.*, (2013), Dhivya *et al.*, (2014) and Reddy *et al.*, (2019). In their studies, ginning outturn and seed index recorded high heritability with moderate genetic advance as per cent of mean indicating that variations for these characters is due to interaction of both additive and non-additive genetic factors.

Medium heritability with medium genetic advance as per cent of mean was found for bolls/plant (54.30%, 12.31%) while, low heritability with high genetic advance as per cent of mean was found for monopods (35.9 %, 22.6%). Low heritability with low genetic advance as per cent of mean was found for fibre uniformity (23.4%, 1.1%) but low heritability with medium genetic advance as per cent of mean was found for sympods (29.30%, 13.7%) suggesting the environmental influence on the trait and selection is highly ineffective. Similarly, Subalakhshmi *et al.*, (2022) recorded that the traits *viz.*, days to first boll bursting (56.33 %, 5.99%), locules/boll (38%, 2.91%), fibre fineness (32.96%, 7.52 %), and uniformity index (47.33 %, 1.01 %) had moderate heritability with low genetic advance as per cent of mean while, low heritability (27.98%) with a low response to selection (1.74%) was recorded for elongation percentage suggesting the environmental influence on the trait and selection is highly ineffective.

Seed cotton yield (SCY) exhibited significant and positive correlation with boll weight (0.67), boll number (0.441), lint yield (0.97), plant height (0.43), plant/sq.m. (0.63), boll/sq.m. (0.91), fibre fineness (0.39) and fibre strength (0.26) (Table 2). Boll weight is significantly positive correlation with seed index (0.27), lint yield (0.64), monopods (0.28), plant/sq.m. (0.42), boll/sq.m. (0.43), fibre fineness (0.55) and fibre strength (0.35). Boll number with were significantly correlated lint yield, fibre length and seed cotton yield. Similar results were observed by Magadum *et al.*, (2012). Therefore, a rational increase in yield is therefore possible through simultaneous selection for component characters under hybridization programmes as the majority of significant morphological parameters were showing a strong positive association with seed cotton yield/plant.

Fibre length exhibited significant and positive correlation with bolls (0.29), seed index (0.33), plant height (0.34), bolls /sq.m. (0.33), fibre strength (0.57) and seed cotton yield (0.33) while significant negative correlated with ginning outturn (-0.42) and monopods (-0.26) (Table 2). Fibre strength had negative and significant association with ginning outturn (-0.38), monopods (-0.27) and sympods (-0.28) whereas, it had postive association with boll weight (0.35), seed index (0.43) and fibre length (0.57). These results confirmed the findings of Angadi *et al.*, (2016) and Irfan *et al.*, (2018). Tulasi *et al.*, (2014) and Nisar *et al.*, (2022) and also reported significant and negative association with fibre fineness.

The estimation of direct and indirect effects of different yield attributing traits and fibre quality traits on seed cotton yield/plant was worked out through path analysis (Table 3). Among the studied traits, lint yield (0.873) had highest positive direct effect on seed cotton yield by followed by plant /sq.m. (0.22), bolls/plant (0.19) and boll weight (0.08),whereas, ginning outturn (-0.18) had negative direct effect on seed cotton yield followed by boll/sq.m. (-0.14) and lint index (-0.12). Hence these traits should be considered important for improvement in the seed cotton yield/plant as theses directly contributed towards seed cotton yield. Similar results were observed by Dahiphale and Deshmukh *et al.*, (2018), Reddy *et al.*, (2019), Mudhalvan *et al.*, (2021).

CONCLUSION

The results indicated that correlation, direct and indirect effect estimates vary for different traits due to variation in genetic material based on yield component traits and fibre quality parameters. Hence, correlations, direct and indirect effect estimates would provide useful information for planning a successful breeding programme if the genetic material is grouped for yield and fibre quality characters and also it is essential for selection of suitable breeding methodologies for simultaneous improvement of both yield and fibre quality parameters. The seed cotton yield/plant had shown strong and positive association as well as high positive direct effects on boll weight, boll, plant/sq.m., boll /sq.m., fibre fineness and fibre strength. Thus, in future breeding programmes, these parameters should be given priority while making selection for seed cotton yield improvement.

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