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Studies on genetic variability, direct and indirect effect for seed cotton yield, its contributing characters and fibre properties in upland cotton

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ABSTRACT: The experimental work comprising of genetic variability, heritability and genetic advance as well as correlation and path analysis study for 16 traits in thirty four genotypes of cotton (*Gossypium hirsutum* L.) was carried out during winter 2017 at (TNAU) Research Farm of Cotton Research Station, Srivilliputtur. The genotypic differences were significant for all the traits. The variability studies indicated that high estimate of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for monopodia/plant and high heritability and high genetic advance was observed for lint index and bundle strength The correlation study revealed that lint yield had highly significant and positive correlation with plant height, sympodia/plant, bolls/plant, boll weight and uniformity index and significant association with seed index. Path analysis revealed that uniformity index exhibited maximum positive direct effects on lint yield followed by seed index, bolls/plant, and also uniformity index exhibited significant and positive indirect effect on lint yield *via* plant height, sympodia/plant, bolls/plant, boll weight, seed index and lint index. Hence selection for these traits would be quite effective to improve the lint yield yield.

Key words: Association analysis, cotton, heritability, lint yield

Cotton (*Gossypium* spp.), is the world's most utilized natural textile fibre and global textile industry depends largely on natural fibre. Majority of plant trichomes are multi-cellular, but *Gossypium* spp. produce unicellular seed trichomes known as fibre, making cotton the leading cash crop with significant economic and social impact on Indian economy (Boopathi *et al.,* 2011). Improving cotton fibre quality and lint yield remains challenging for cotton breeders. The success of any breeding programme depends on the spectrum of genetic variability present in the population. The major target of cotton breeding in the world has been to improve fibre yield and quality. Remarkable advances in cotton yield and quality improvement has been recorded by conventional and molecular approaches in the last few decades. Yield potential is reportedly plateau due to complex and antagonistic genetic relationship among the cultivated species. For instance, continuous incorporation of genes and selection from the same breeding stock of cultivated species has resulted in narrow genetic base for most of the elite types which is a major bottleneck for cotton breeding, cultivation and production. Selection changes the genetic structure of population due to preservation of superior alleles and discarding the undesirable alleles (Budak *et al.*, 2004). Often the selection is based solely on phenotypic expression which is often misleading because of the influence of environment. Therefore, information on phenotypic, genotypic and environmental variability is of great importance for effective selection. However, genotypic coefficient of variation does not give an exact idea on the total heritable variation. According to Magadum *et al.* (2012), the relative amount of heritable variation could be assessed by heritability. To account for the proportion of phenotypic variance attributable to genetic variance, heritability will have to be estimated. This is vital as it also provides the basis for effective selection. Magadum *et al.,* (2012) also pointed out that genetic variability along with heritability of a character will indicate the possibility and extent to which improvement is feasible through selection on phenotypic basis. Heritability value alone may not provide clear predictability of the breeding value (Mishra *et al.,* 2015). Hence, combination with genetic advance over means is more effective and reliable in predicting the resultant effect of selection (Ramanjinappa *et al.*, 2011). In the presence of high amount of genetic variability, knowledge on heritability and genetic advance helps the breeder to exercise selection on the desired characters to achieve the objective quickly. Therefore, for improvement of target trait in any crop, it is necessary to have full information on the variability, heritability and genetic advance. Further, efficiency of selection in any breeding programme mainly depends upon the knowledge of association of the characters. Phenotypic correlation indicated the extent of the relation between two characters while genotypic correlation provides an estimate of inherent association between the genes controlling them. The cause for negative effect of the trait is very essential for formulating selection indices by path analysis (Rao, *et al.,* 2001; Kaushik, *et al.,* 2003; Gururajan and Sunder, 2004; Gite *et al.,* 2006). Hence the present study was planned to assess the variability, correlation and path analysis for various yield and yield contributing characters in a set of genotypes. Such information may be fruitful in formulating efficient selection programme for synthesis and development of new cotton genotypes with improved yield and its contributing traits.

The research experiment was conducted at Tamil Nadu Agricultural University Research Farm of Cotton Research Station, Srivilliputtur, during the winter 2017. The mean maximum and minimum temperature of this region is 37.2˚C to 25.5˚C and an annual rainfall is 818.8 mm. The experimental site is located at 9” 5'N latitude, 77” 6'E longitudes and an altitude of 137.92m above mean sea level. The crop has grown in sandy clay loam soil texture with pH of 8.2. The experimental material comprised of thirty four improved *G.hirsutum* cultures received from various research institutes under AICRP on cotton. Thirty four cotton cultures were raised in a randomized block design with three replications. Two rows per each entry were sown at a spacing of 90x45cm. Standard procedure for field maintenance was adhered to; basic agronomic practices like irrigation, fertilizer application, weeds and pest control were practiced. Data were recorded from five selected plants in each entry for twelve characters *viz.,* Days to first flowering (DFF), Days to fifty per cent flowering (DFPF), Plant height (PH), Monopodia/plant (M/P), Sympodia/plant (Sy/P), Bolls/plant (B/P), Boll weight (BW), Seed index (SI), Lint index (LI), Ginning percentage (GP), Upper Half Mean Length (UHML), Bundle strength (BS), Fibre fineness (FF), Uniformity index (UI), Seed cotton yield (kg/ha) (SCY) and Lint yield (kg/ha) (LY). Seed cotton was pooled from the sampled plants, ginned and the lint obtained was evaluated for fibre quality characters estimation using High Volume Instrument 900 classic. Mean data were subjected to genetic variability, correlation and path analysis. Information on the nature and magnitude of variability for both quantitative and qualitative traits in any crop species plays a vital role in formulating an effective breeding programme and its success. Superior genotypes can be isolated by selection if considerable genetic variation exists within the population. The success in breeding programme for economic traits, which are controlled by polygenes and highly influenced by environment, depends on nature and magnitude of their genotypic variability. It is therefore essential to partition the overall variability into heritable and non-heritable components. Knowledge on the magnitude of heritability coupled with nature and extent of variability, association, direct and indirect effect of yield attributing traits in the breeding material gives an idea for effective genetic improvement through selection.

Analysis of variance revealed significant differences among all genotypes for all the traits. Estimates of genetic variability (Table 1 and Fig. 1.) revealed high estimate of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for monopodia/plant (53.10 and 27.58%) whereas, moderate estimates of PCV and GCV were estimated for traits like bundle strength (11.05 and 11.05%), uniformity index (18.79 and 16.13%) and lint yield (17.69 and 15.77%). Moderate PCV and low GCV was observed the traits like bolls/plant (10.81 and 8.34) and seed index (10.17 and 7.67%). Days to first flowering (3.11 and 2.57%), days to fifty per cent flowering (2.42 and 1.69%), plant height (7.12 and 6.72%), sympodia/plant (7.86 and 5.27%), boll weight (9.59% and 6.34%), lint index ((9.70 and 8.77%), ginning percentage (5.70 and 3.65%), seed cotton yield (7.42 and 7.42%), upper half men length (8.77%, 8.77), fibre fineness (1.05 and 1.05%) exhibited low PCV and GCV indicated that these characters were highly influenced by environmental factors. The phenotypic co- efficient of variation which measures total variation was found to be greater than genotypic coefficient of variation for all the characters except upper half mean length, bundle strength and fibre fineness, indicated some degree of environmental influence on the traits. Selection for improvement of such traits may sometimes be misleading. These findings were also supported by Santoshkumar *et al.,* (2012), Pujer *et. al.,* 2014, Sunayana *et al.,* 2017, Gnanasekaran *et al.,* 2018 and Praveen Sampath Kumar *et al.,* (2019).

The estimates of high heritability value was noticed for days to first flowering (68.70%), plant height (88.90%), lint index (81.72%), seed cotton yield (99.89%), upper half mean length (100.0%), bundle strength (100.0%), fibre fineness (100.0%), uniformity index (73.65%) and lint yield (79.48). These findings were in accordance with previous reports by Gnanasekaran

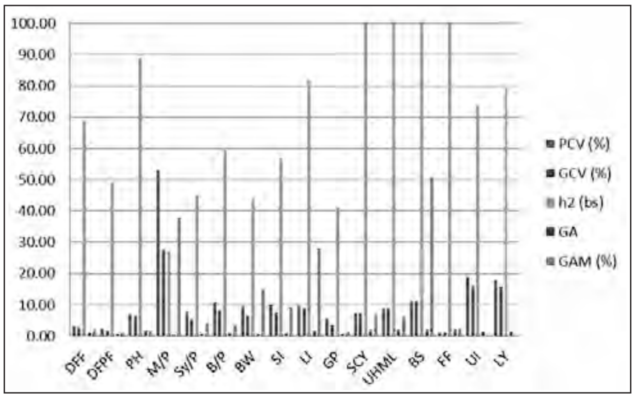

Fig. 1 : Genetic components of variance for variouis traits

Table 1. Genetic components of variance for various traits

Traits	PCV	GCV	h2	GA	GAM
DFF	3.11	2.57	68.70	1.17	2.17
DFPF	2.42	1.69	49.19	0.71	1.22
PH	7.12	6.72	88.90	1.73	1.65
M/P	53.10	27.58	26.97	0.29	37.93
Sy/P	7.86	5.27	44.91	0.62	4.26
B/P	10.81	8.34	59.55	0.95	3.70
BW	9.59	6.34	43.81	0.60	15.02
SI	10.17	7.67	56.96	0.89	9.22
LI	9.70	8.77	81.72	1.52	28.03
GP	5.70	3.65	41.07	0.54	1.50
SCY	7.42	7.42	99.89	2.06	7.16
UHML	8.77	8.77	100.00	2.06	6.37
BS	11.05	11.05	100.00	2.06	51.00
FF	1.05	1.05	100.00	2.06	2.49
UI	18.79	16.13	73.65	1.30	0.17
LY	17.69	15.77	79.48	1.46	0.07

Table 2. Genotypic correlations for various economic traits

Traits	DFF	DFPF	PH	M/P	Sy/P	B/P	BW	SI	LI	GP	SCY	UHML	BS	FF	UI	LY
DFF	1.000	0.969**	-0.119	0.362*	-0.090	-0.119	0.023	0.302	0.122	-0.205	0.116	0.228	-0.079	0.156	-0.205	-0.160
DFPF		1.000	-0.321	0.256	-0.239	-0.449**	-0.087	0.143	-0.023	-0.222	0.049	0.162	-0.181	0.068	-0.405*	-0.362*
PH			1.000	-0.251	0.915**	0.801**	0.409*	0.193	-0.003	-0.274	0.032	0.018	0.238	0.056	0.595**	0.673**
M/P				1.000	-0.373*	0.011	0.079	0.389*	0.209	-0.176	0.000	-0.023	0.049	-0.083	-0.035	-0.011
Sy/P					1.000	0.655**	0.655**	0.388*	0.226	-0.182	0.119	0.015	0.208	0.104	0.500**	0.561**
B/P						1.000	0.528**	0.177	0.081	-0.108	-0.053	0.049	0.203	0.000	0.778**	0.815**
BW							1.000	0.631**	0.548**	-0.004	0.139	0.472**	0.230	0.147	0.530**	0.544**
SI								1.000	0.751**	-0.155	0.529**	0.610**	0.149	0.500**	0.298	0.333*
LI									1.000	0.535**	0.216	0.359*	0.300	0.243	0.376*	0.250
GP										1.000	-0.339*	-0.239	0.263	-0.263	0.157	-0.075
SCY											1.000	0.705**	-0.090	0.927**	-0.191	-0.116
UHML												1.000	0.026	0.774**	0.102	0.155
BS													1.000	0.003	0.033	-0.028
FF														1.000	-0.115	-0.062
UI															1.000	0.973**
LY																1.000

* Significant at 5% level;** Significant at 1% level

Table 3. Direct effects (diagonal) and indirect effects (off diagonal) of economic traits on seed cotton yield at genotypic level

Traits	DFF	DFPF	PH	M/P	Sy/P	B/P	BW	SI	LI	GP	SCY	UHML	BS	FF	UI	LY
DFF	-0.030	0.038	0.002	-0.011	-0.001	-0.005	0.000	0.072	-0.032	0.011	0.004	0.003	0.000	-0.010	-0.203	-0.160
DFPF	-0.029	0.039	0.005	-0.008	-0.003	-0.020	0.001	0.034	0.006	0.012	0.002	0.002	0.000	-0.004	-0.400	-0.362*
PH	0.004	-0.013	-0.016	0.007	0.010	0.035	-0.003	0.046	0.001	0.015	0.001	0.000	0.000	-0.004	0.588	0.673**
M/P	-0.011	0.010	0.004	-0.029	-0.004	0.001	-0.001	0.093	-0.054	0.010	0.000	0.000	0.000	0.005	-0.034	-0.011
Sy/P	0.003	-0.009	-0.014	0.011	0.011	0.029	-0.005	0.093	-0.059	0.010	0.005	0.000	0.000	-0.007	0.494	0.561**
B/P	0.004	-0.018	-0.013	0.000	0.007	0.044	-0.004	0.042	-0.021	0.006	-0.002	0.001	0.000	0.000	0.769	0.815**
BW	-0.001	-0.003	-0.006	-0.002	0.007	0.023	-0.008	0.151	-0.143	0.000	0.005	0.006	0.000	-0.009	0.524	0.544**
SI	-0.009	0.006	-0.003	-0.011	0.004	0.008	-0.005	0.239	-0.195	0.009	0.020	0.008	0.000	-0.032	0.295	0.333*
LI	-0.004	-0.001	0.000	-0.006	0.003	0.004	-0.004	0.180	-0.260	-0.030	0.008	0.004	0.000	-0.015	0.372	0.250
GP	0.006	-0.009	0.004	0.005	-0.002	-0.005	0.000	-0.037	-0.139	-0.055	-0.013	-0.003	0.000	0.017	0.156	-0.075
SCY	-0.003	0.002	-0.001	0.000	0.001	-0.002	-0.001	0.127	-0.056	0.019	0.038	0.009	0.000	-0.059	-0.189	-0.116
UHML	-0.007	0.006	0.000	0.001	0.000	0.002	-0.004	0.146	-0.093	0.013	0.027	0.012	0.000	-0.049	0.100	0.155
BS	0.002	-0.007	-0.004	-0.001	0.002	0.009	-0.002	0.036	-0.078	-0.015	-0.003	0.000	0.000	0.000	0.033	-0.028
FF	-0.005	0.003	-0.001	0.002	0.001	0.000	-0.001	0.120	-0.063	0.015	0.035	0.010	0.000	-0.063	-0.114	-0.062
UI	0.006	-0.016	-0.009	0.001	0.006	0.034	-0.004	0.071	-0.098	-0.009	-0.007	0.001	0.000	0.007	0.989	0.973**

Residual Effect: 0.0088

et al., (2018) and Praveen Sampath Kumar *et al.,* (2019) for plant height, seed cotton yield, upper half mean length, and bundle strength and Sunayana *et al.,* (2017) for days to first flowering and lint index.

High heritability and high genetic advance over the mean was observed for lint index (81.72 and 28.03%) and bundle strength (100.0 and 51.00%) indicated that most likely the heritability is due to additive gene effect and improvement of these traits can be made through direct phenotypic selection. Similar result was reported by Santoshkumar *et al.,* (2012). The traits days to first flowering (68.70 and 2.17%), plant height (88.90 and 1.65%), seed cotton yield (99.89 and 7.16%), upper half mean length (100.0 and 6.37%), fibre fineness (100.0 and 2.49%), uniformity index (73.65 and 0.17%) and lint yield (79.48 and 0.07%) had high heritability accompanied by low genetic advance indicated the effect of non additive gene action and hence heterosis breeding may be rewarding for these traits. Similar results were reported by Gnanasekaran *et al.,* (2018) for plant height, and Pujer *et al.,* (2014) for uniformity index, Santoshkumar *et al.,* (2012) for days to first flowering, plant height, seed cotton yield and upper half mean length.

The genotypic correlation co-efficient between yield and its components were presented in Table 2. Lint yield had highly significant and positive correlation with characters *viz.,* plant height (0.673), sympodia/plant (0.561), bolls/plant (0.815), boll weight (0.544) and uniformity index (0.973) and significant and positive correlation with seed index (0.333). It indicated that increase in one trait will simultaneously increase in the other. Lint yield/plant was having significant but negative association with days to fifty per cent flowering (-0.362) and having non-significant association with days to first flowering (-0.160), monopodia/plant (-0.011), lint index (0.250), ginning percentage (-0.075), seed cotton yield (-0.116), upper half mean length (0.155), bundle strength (-0.028) and fibre fineness (-0.062). Such positive association of lint yield with these traits was also observed by Sunayana *et al.,* (2017) for plant height, boll/plant, boll weight, seed index and negative non significant ginning percentage. Efrem *et al.*, (2014) reported the significant and positive correlation for plant height, bolls/plant and boll weight. Hence, plant height, sympodia/plant, bolls/ plant, boll weight and seed index had significant positive association with lint yield indicating the existence of true relationship among these characters and their exploitation in selection programmes.

Considering inter-correlation among the yield contributing traits studied, plant height exhibited significant and positive correlation with bolls/plant, boll weight and uniformity index whereas sympodia/plant showed significant positive association with bolls/plant, boll weight, seed index and uniformity index. Bolls/plant registered a positive and significant correlation with boll weight and uniformity index were as boll weight showed significant positive association with seed index, lint index, upper half mean length and uniformity index. Seed index exhibited positive significant correlation with lint index, seed cotton yield, upper half mean length and fibre fineness. These results clearly indicated that selection for any one of these traits lead to concurrent improvement of other traits as well as seed cotton yield and lint yield. Among the fibre quality traits, upper half mean length had significant positive association with fibre fineness. The association between yield components and fibre parameters revealed significant positive association of plant height, sympodia/plant, bolls/plant and seed index with fibre fineness; boll weight and seed index with upper half mean length indicated that these important yield contributing traits were good indicators of fibre properties improvement. Negative correlations between yield and quality traits were observed and make the selection procedure difficult where both the parameters have to be developed simultaneously but in the present study significant positive correlation was observed between the yields contributing traits and some important fibre properties indicated that simultaneously improvement of both can be possible.

The genotypic correlation co-efficient of lint yield with other yield contributing traits were further partitioned into direct and indirect effects and the results were presented in Table 3. The component of residual effect of path analysis in yield was 0.0088. Uniformity index (0.989) exhibited maximum positive direct effects on lint yield followed by seed index (0.239) which has moderate direct effects whereas bolls/plant (0.044), days to fifty per cent flowering (0.039), seed cotton yield (0.038) upper half mean length (0.012) and sympodia/plant (0.011) exhibited low to negligible levels of direct effect on lint yield. Negative and moderate direct effect was observed in case of lint index (-0.260) whereas fibre fineness (-0.063), ginning percentage (-0.055), days to first flower (-0.030), monopodia/plant (-0.029), plant height (-0.019) and boll weight (-0.004) which exhibited low to negligible negative direct effect on lint yield. Thus, these studies revealed that, the traits which had positive and direct effect on lint yield should be given due to emphasis for making selection for high yielding genotypes. In the present study, uniformity index exhibited significant and positive indirect effect on lint yield via plant height (0.588), sympodia/plant (0.494), bolls/plant (0.769), boll weight (0.524), seed index (0.295) and lint index (0.372). Sympodia/plant exhibited positive indirect effect on lint yield via bolls/plant (0.029) and seed index (0.093). Bolls/plant exhibited positive indirect effect on lint yield via seed index (0.042) while boll weight exhibited positive indirect effect on lint yield via bolls/plant (0.023) and seed index (0.151) which indicated that selection of one character would help to simultaneous improvement of the related traits.

CONCLUSION

High estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) for monopodia/plant. High heritability and genetic advance was observed for lint index and bundle strength indicated that most likely the heritability is due to additive gene effect and improvement of these traits can be made through direct phenotypic selection. Lint yield had highly significant and positive correlation with characters *viz.,* plant height, sympodia/plant, bolls/plant, boll weight and uniformity index and significant with seed index. Significant positive association of plant height, sympodia/plant, bolls/plant and seed index with fibre fineness, boll weight and seed index with upper half mean length indicated that these important yield contributing traits were good indicators of fibre properties improvement. Uniformity index exhibited maximum positive direct effects on lint yield and also exhibited significant and positive indirect effect on lint yield via plant height, sympodia/plant, bolls/plant, boll weight, seed index and lint index. Heritability, correlation and direct and indirect effect estimates vary for different traits with variation in genetic material. Hence, present study about heritability, correlations and direct and indirect effect estimation 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 to device suitable breeding methodologies for simultaneous improvement of both yield and quality parameters involving three way crosses, modified back crosses or recurrent selection.

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