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Genetic variability, correlation and path analysis for seed cotton yield improvement in upland cotton (*Gossypium hirsutum* L.)

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Abstract
The present study was undertaken for estimation of genetic variability, genotypic correlation and path analysis in parents, F_1's of 4 (lines) × 8 (testers) and one check hybrid (Bunny) in intra-specific crosses of cotton (*Gossypium hirsutum* L.). High PCV and GCV recorded for number of monopodia and single plant yield. High heritability coupled with high genetic advance recorded for most of the characters except for uniformity ratio and bundle strength. Very high direct effect was observed in days to first flowering, number of monopodia, number of bolls per plant and number of sympodia on single plant yield. Aassociation analysis revealed that single plant yield exhibited significant positive correlation with days to first flowering, number of sympodia, number of bolls, boll weight, internode length, number of nodes, seed index, lint index, ginning out turn and fibre fineness and hence selection for these characters will help in selecting genotypes with high yield.

Keywords: Upland cotton, variability, correlation, path analysis, seed cotton yield

Introduction
Cotton (*Gossypium* spp.), commonly called as 'White Gold' that plays a vital role in the country's economic growth by providing substantial employment and making significant contributions to export earnings. The success of any breeding programme depends upon the quantum of genetic variability present in the population. Wider range of variability helps in selecting a desirable genotype. Therefore, for successful improvement of any crop, it is necessary to have knowledge of variability present in the available genetic material. Substantial genetic variances and high heritability estimates implied that characters could be improved through selection from segregating populations (Baloch, 2004) [4]. High genetic advance coupled with high heritability estimates offers a most effective response to selection (Larik *et al.*, 1997) [10]. In order to enhance the yield potential of the cotton varieties, an understanding on relationship among different characters is more important (McCarty *et al.* 2008) [12]. Knowledge on the extent of association between yield components and fibre quality traits conferring seed cotton yield would be very helpful in deciding the traits that contribute for high yield. The magnitude of relationship between various plant characters is measured by correlation coefficient analysis that determines the component characters on which selection can be made for improvement in seed cotton yield and fibre quality. Selection based on association analysis is ineffective; hence path coefficient analysis helps in partitioning the observed correlation coefficient into components of direct and indirect effects and provides better insight of character relationship. The main objective was to study the variability, correlation and path analysis of various yield and yield attributing characters.

Materials and methods
The present investigation study of evaluation of intraspecific hybrids of upland cotton (*Gossypium hirsutum* L.) was carried out during winter 2016-17 in the experimental field of Department of Cotton, Centre for Plant Breeding and Genetics (CPBG), Tamil Nadu Agricultural University (TNAU), Coimbatore under irrigated condition. Thirty two intra-hirsutum hybrids were developed through line x tester method involving 4 lines (TSH 0499, TSH 04/115, BGDS 1063 and ARBC 19) as female parents and eight testers (MCU 7, MCU 13, CO 14, SVPR 4, KC 3, Surabhi, TCH 1777, TCH 1819) as male parents. It was carried out using randomized block design replicated twice each in two rows of 10 m length with a spacing of 90 x 60 cm. Five plants at random were taken in each entry and data on days to first flowering, plant height, number of monopodia, number of sympodia,

number of bolls per plant, boll weight, internode length, number of nodes per plant, seed index, lint index, single plant yield, ginning outturn, 2.5 per cent span length, bundle strength, uniformity ratio, elongation percentage and fibre fineness were recorded. The analysis of variance was carried out following Panse and Sukhatme (1985) [13]. Genotypic correlation coefficients were further partitioned into direct and indirect effects by path analysis as suggested by Dewey and Lu (1959) [6].

Results and discussion

Variability studies

Estimation of genetic variability showed that there was close correspondence between phenotypic and genotypic variance for days to first flowering, plant height, number of monopodia, number of sympodia, number of bolls per plant, boll weight, single plant yield, internode length, number of nodes per plant, seed index, lint index, ginning out turn, uniformity ratio, bundle strength, fibre fineness and 2.5 per cent span length indicating less environmental influence. Elongation percentage showed higher difference indicating the influence of environment on its performance among genotypes. Low PCV and GCV observed for days to first flowering, plant height, ginning out turn, 2.5 per cent span length, uniformity ratio and bundle strength. Moderate PCV and GCV recorded for number of sympodia, number of bolls per plant, boll weight, internode length, number of nodes per plant, seed index, lint index and fibre fineness. High PCV and GCV identified for number of monopodia and single plant yield. Moderate PCV and low GCV observed for elongation percentage (Table 1).

High heritability coupled with high genetic advance were observed for characters *viz.*, number of monopodial branches per plant, number of sympodia, number of bolls per plant, boll weight, single plant yield, internode length, number of nodes per plant, seed index, lint index and fibre fineness. High heritability coupled with low genetic advance were noticed for characters *viz.*, days to first flowering, plant height, ginning out turn, 2.5 per cent span length, uniformity ratio, bundle strength and elongation percentage. Low PCV and GCV for plant height were reported by Dahiphale *et al.* (2015) [5] and Reddy *et al*. (2015) [16]. Moderate PCV and GCV for number of sympodial branches per plant was reported by Dhivya *et al*. (2014) [7] and Dahiphale *et al*. (2015) [5]. Moderate PCV and GCV for boll weight by Vineela (2013) [19]. Moderate PCV and GCV for number of bolls per plant was reported by Vineela (2013) [19], Dhivya *et al*. (2014) [7], Dahiphale *et al*. (2015) [5] and Reddy *et al*. (2015) [16]. Moderate PCV and GCV for lint index was reported Dhivya *et al*. (2014) [7] and Reddy *et al*. (2015) [16]. High PCV and GCV for seed cotton yield was reported by Dinakaran *et al*. (2012) [8], Vinodhana *et al*. (2013) [20] and Dahiphale *et al*. (2015) [5] High heritability coupled with high genetic advance as per cent of mean for number of bolls was reported by Abbas *et al.* (2013) [1], Vinodhana *et al*. (2013) [20], Dahiphale *et al*. (2015) [5] and Reddy *et al*. (2015) [16]. High heritability coupled with high genetic advance as per cent of mean for number of sympodial branches per plant was reported by Vineela (2013) [19], Abbas *et al*. (2013) [1] and Dhivya *et al*. (2014) [7]. High heritability coupled with high genetic advance as per cent of mean for boll weight was reported by Dinakaran *et al*. (2012) [8] and Vineela (2013) [19]. High heritability coupled with low genetic advance as per cent of mean for elongation percentage was reported by Reddy *et al*. (2015) [16].

Table 1: Components of variance for yield and fibre quality traits

Characters	PCV (%)	GCV (%)	Heritability (%)	GAM (%)
Days to first flowering	4.40	3.93	79.72	7.22
Plant height	9.77	9.46	93.75	18.86
Number of monopodial branches per plant	34.13	27.45	64.69	45.48
Number of sympodial branches per plant	14.59	12.65	75.14	22.59
Number of bolls per plant	18.70	17.84	90.98	35.05
Boll weight	13.72	12.08	77.57	21.92
Single plant yield	23.87	23.05	93.28	45.86
Internode length	14.99	14.02	87.56	27.03
Number of nodes per plant	14.49	11.87	67.06	20.02
Seed index	13.63	13.36	96.04	26.96
Lint index	11.37	10.92	92.11	21.58
Ginning out turn	6.63	5.19	61.14	8.35
2.5 per cent span length	5.75	4.96	74.18	8.79
Uniformity ratio	4.65	3.55	58.18	5.57
Bundle strength	6.93	4.76	47.14	6.73
Elongation percentage	10.46	9.72	86.46	18.62
Fibre fineness	12.63	11.41	81.55	21.22

Association studies

Genotypic correlation for single plant yield showed positively and highly significant correlation with days to first flowering (0.50), number of sympodia (0.59), number of bolls per plant (0.79), boll weight (0.36), seed index (0.70), lint index (0.60), number of nodes per plant (0.55), ginning out turn (0.35) and fibre fineness (0.66). Positive but non-significant correlation with single plant yield was estimated for plant height (0.30), uniformity ratio (0.12) and 2.5 per cent span length (0.31). Similarly, non-significant negative correlation was obtained for number of monopodia (-0.04), bundle strength (-0.07) and elongation percentage (-0.26). The correlation results revealed that single plant yield established highly positive significant association with nine characters *viz.*, days to first flowering, number of sympodial branches per plant, number of bolls per plant, boll weight, internode length, number of nodes per plant, seed index, lint index, ginning out turn and fibre fineness (Table 2). Similar results for positive correlation between yield and fibre quality related traits were already reported by Agaudo *et al*. (2008), Do-Thi-Haan *et al*. (2008), Reddy and Reddy (2008) [15], Tamilselvam *et al*. (2013) [18], Magadum *et al*. (2012) [11] and Salahuddin *et al*. (2010) [17]. Inter correlation among the important component traits is considered trait is also essential in order to decide upon which

trait is to be given weightage while exercising selection. The inter correlation of days to first flowering with number of monopodial branches per plant, number of bolls per plant, number of nodes per plant and 2.5 per cent span length showed highly positive association. Plant height showed positively and highly significant correlation with number of sympodial branches per plant, number of nodes per plant and uniformity ratio.

Number of monopodial branches per plant showed positively and highly significant correlation with 2.5 per cent span length.Number of sympodial branches per plant showed positively and highly significant correlation with number of bolls per plant, boll weight, number of nodes per plant, seed index and fibre fineness. Number of bolls per plant showed positively and highly significant correlation with number of nodes per plant, seed index, lint index and fibre fineness. Boll weight showed positively and highly significant correlation with internode length, number of nodes per plant, lint index and fibre fineness. 2.5 per cent span length showed positively and highly significant correlation with bundle strength. Uniformity ratio showed positively and highly significant correlation with fibre fineness. Bundle strength showed significant negative correlation with elongation percentage and fibre fineness. Elongation percentage showed negative correlation with fibre fineness.

Table 2: Genotypic correlation coefficients between single plant yield with yield components and fibre quality traits

	DFF	PH	NM	NS	NB	BW	IL	NN	SI	LI	GOT	SL	UR	STR	EP	MIC	SPY
DFF	1.00	0.08	0.60**	0.18	0.51**	0.25	-0.07	0.41*	0.22	0.16	-0.15	0.50**	-0.33	0.30	-0.33	-0.05	0.50**
PH		1.00	0.03	0.74**	0.33	0.20	-0.03	0.75**	0.29	0.08	-0.43*	0.11	0.37*	0.13	-0.21	0.32	0.30
NM			1.00	-0.13	0.27	-0.20	-0.41*	0.19	-0.04	0.01	-0.35*	0.51**	-0.38*	0.07	-0.13	-0.41*	-0.04
NS				1.00	0.66**	0.33*	0.03	0.92**	0.62**	0.33	-0.26	0.16	0.32	0.10	-0.34*	0.60**	0.59**
NB					1.00	0.25	0.31	0.76**	0.61**	0.43*	0.01	0.33	0.07	0.04	-0.16	0.47**	0.79**
BW						1.00	0.35*	0.42*	0.33	0.45**	-0.01	0.15	0.13	-0.23	-0.36*	0.76**	0.71**
IL							1.00	-0.01	0.03	0.04	0.11	-0.31	0.11	-0.30	0.12	0.43*	0.36*
NN								1.00	0.63**	0.35	-0.53**	0.38*	0.15	0.07	-0.41*	0.58**	0.70**
SI									1.00	0.49**	0.08	0.34*	-0.09	-0.01	-0.42*	0.53**	0.60**
LI										1.00	0.49**	0.55**	-0.07	0.24	-0.27	0.36*	0.55**
GOT											1.00	0.01	-0.01	0.02	0.14	0.15	0.35*
SL												1.00	-0.40*	0.60**	-0.61**	-0.18	0.31
UR													1.00	0.02	0.19	0.39*	0.12
STR														1.00	-0.53**	-0.38*	-0.07
EP															1.00	-0.08	-0.26
MIC																1.00	0.66**
SPY																	1.00

*Significant (5% level) **Significant (1% level)

Association studies of single plant yield with other yield and quality traits were represented in Table 3. A residual effect of 0.26 indicates high contribution towards variability in single plant yield by the characters chosen for study. Days to first flowering, number of monopodia, number of bolls per plant and number of sympodia showed very high direct effect on single plant yield. High direct effect on single plant yield was contributed by internode length, seed index, 2.5 per cent span length, uniformity ratio and elongation percentage. Lint index and ginning out turn showed moderate direct effect and plant height, number of nodes per plant, bundle strength and fibre fineness had negative direct effect on yield.

Similar results were reported by Agaudo *et al*. (2008), Do-Thi-Haan *et al*. (2008), Reddy and Reddy (2008) [15], Salahuddin *et al*. (2010) [17], Magadum *et al*. (2012) [11], Tamilselvam *et al*. (2013) [18], Rao and Gopinath (2013) [14] and Reddy *et al*. (2015) [16]. In contrary, Abdullah *et al*. (2016) [2] was reported negative inter correlation among various yield and fibre quality traits.

Table 3: Path coefficients between single plant yield with yield components and fibre quality traits

	DFF	PH	NM	NS	NB	BW	IL	NN	SI	LI	GOT	SL	UR	STR	EP	MIC	SPY
DFF	1.703	-0.017	0.667	0.291	-0.687	0.004	-0.071	-0.328	0.156	0.037	-0.036	0.376	-0.310	-0.116	-0.131	0.011	0.505
PH	0.135	-0.213	0.035	1.194	-0.447	0.003	-0.030	-0.604	0.208	0.018	-0.105	0.083	0.349	-0.052	-0.085	-0.067	0.298
NM	1.025	-0.007	1.108	-0.214	-0.364	-0.003	-0.399	-0.150	-0.025	0.001	-0.086	0.384	-0.359	-0.028	-0.052	0.086	-0.039
NS	0.306	-0.157	-0.147	1.618	-0.882	0.005	0.027	-0.742	0.437	0.073	-0.064	0.118	0.304	-0.040	-0.133	-0.127	0.591
NB	0.873	-0.071	0.301	1.064	-1.341	0.003	0.304	-0.613	0.435	0.095	-0.001	0.245	0.064	-0.014	-0.063	-0.098	0.793
BW	0.432	-0.044	-0.227	0.533	-0.330	0.014	0.345	-0.341	0.232	0.100	-0.002	0.111	0.120	0.088	-0.143	-0.159	0.711
IL	-0.124	0.007	-0.454	0.045	-0.418	0.005	0.975	0.008	0.018	0.009	0.027	-0.234	0.101	0.118	0.048	-0.090	0.355
NN	0.695	-0.160	0.207	1.495	-1.023	0.006	-0.010	-0.803	0.447	0.078	-0.129	0.286	0.142	-0.028	-0.161	-0.123	0.702
SI	0.375	-0.063	-0.040	0.998	-0.822	0.004	0.025	-0.507	0.709	0.109	0.020	0.252	-0.087	0.003	-0.167	-0.112	0.597
LI	0.281	-0.018	0.003	0.533	-0.577	0.006	0.040	-0.283	0.350	0.222	0.119	0.410	-0.069	-0.092	-0.108	-0.075	0.546
GOT	-0.247	0.091	-0.392	-0.425	0.005	0.000	0.108	0.425	0.057	0.108	0.244	0.003	-0.008	-0.007	0.057	-0.032	0.000
SL	0.858	-0.024	0.570	0.256	-0.440	0.002	-0.305	-0.308	0.239	0.122	0.001	0.746	-0.380	-0.231	-0.241	0.037	0.311
UR	-0.559	-0.079	-0.421	0.520	-0.090	0.002	0.104	-0.121	-0.065	-0.016	-0.002	-0.300	0.945	-0.007	0.077	-0.082	0.115
STR	0.510	-0.028	0.081	0.168	-0.048	-0.003	-0.297	-0.057	-0.005	0.052	0.004	0.444	0.018	-0.389	-0.210	0.079	-0.071
EP	-0.566	0.046	-0.147	-0.545	0.214	-0.005	0.118	0.327	-0.299	-0.060	0.035	-0.454	0.183	0.206	0.395	0.017	-0.261
MIC	-0.087	-0.068	-0.455	0.975	-0.626	0.010	0.419	-0.469	0.378	0.079	0.037	-0.132	0.371	0.146	-0.033	-0.210	0.657

*Significant (5% level) **Significant (1% level)

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