

Full Length Research Paper

Genetic variability, correlation and path analysis among different traits in *desi* cotton (*Gossypium arboreum* L.)

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Genetic variability, correlations and path coefficients were studied in *desi* (Indian) cotton (*Gossypium arboreum* L.) taking 20 phenotypically diverse genotypes along with two viz., PA- 402 and PA- 255, one NH-615 and one hybrid check NHH-44. A wide range of variation was found for almost all the characters. All the characters showed very small difference between genotypic coefficient of variation (GCV) and respective phenotypic coefficient of variation (PCV), indicated that all the characters were least affected by environment. The high heritability estimates coupled with high expected genetic advance were observed for number of monopodia plant⁻¹, number of sympodia plant⁻¹, plant height, number of bolls plant⁻¹, average boll weight, lint yield plant⁻¹, harvest index, oil content, seed cotton yield plant⁻¹, 2.5% span length and micronaire value indicating the presence of additive gene action and phenotypic selection may be more fruitful. The correlation studies revolved positive and significant genotypic and phenotypic correlation for most of the characters. Considering the association and path analysis, lint yield plant⁻¹, bolls plant⁻¹, ginning outturn, lint index, total biomass, number of sympodia plant⁻¹ and plant height had high positive effect on seed cotton yield plant⁻¹.

Key words: Genetic variability, correlation, path analysis, *Gossypium arboreum*.

INTRODUCTION

Cotton (*Gossypium* spp.) is an important fibre and cash crop of the country which provides lint as raw material to the textile industry (Perchival and Kohel, 1990). It plays a key role in Indian economy by earning more than 30% of foreign exchange (Patel et al., 2007). It is also known as "White Gold". It generates employment at various stages during cultivation, ginning, spinning and garment making. Out of four cultivated species of genus *Gossypium*, only two species, that is, *Gossypium hirsutum* and *Gossypium arboreum* are being mostly cultivated in Maharashtra,

India. In the last few years there has been a significant reduction in area of *G. arboreum* cotton across the country and particularly in Maharashtra because of lower productivity and inferior fibre properties as compared to tetraploid cotton in rain fed eco-system and non availability of Bt variety / hybrid.

Genetic cotton could be gained either through combination or exploitation of hybrid vigour. Therefore, more emphasis should be given to increase the seed cotton yield unit area⁻¹, by developing varieties with short

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structure, big boll size and medium to longer staple length with sustained yield in multiple environments. To achieve such desirable characteristics in a new variety, proper breeding strategies should be followed. The progress in breeding programme depends on magnitude of genetic variability present in breeding material. The existence of variability is essential for resistance of biotic and abiotic factor as well as for varietal adaptability. Selection is also effective when there is high degree of genetic variability among the individuals in a population. Correlation analysis measures the mutual relationship between various plant characters and determines the component character on which selection can be based for genetic improvement in yield.

Direction and magnitude of correlation between yield and yield contributing character must be considered for selecting the superior genotypes from diverse genetic population, but correlation does not provide information about direct and indirect effects of independent variables on dependent one, for this path coefficient analysis is essential. Path analysis splits correlation coefficient into measures of a direct and in direct effects. The present study on genetic variability, correlation and path analysis among different traits in *desi* (Indian) cotton was undertaken with the following objective viz., to study the performance of quality *arboreum* derived from breeding material and germplasm, the pattern of genetic variability, to estimate direct and indirect effects on seed cotton yield.

MATERIALS AND METHODS

Field trial was conducted during *Kharif* (monsoon) season of 2008 with twenty elite genotypes of *G. arboreum*, two *G. arboreum* checks and one *G. hirsutum* hybrid check were sown in Randomized Block Design in two replication along with a spacing of 60 × 30 cm between rows and plants, respectively at Cotton Research Station, Mehboob Baugh, Marathwada Agricultural University, Parbhani, Maharashtra, India. Recommend package practices for the region were followed.

Five competitive plants were randomly selected for recording data on days to 50% flowering, days to 50% boll bursting, monopodia plant⁻¹, sympodia plant⁻¹, bolls plant⁻¹, plant height (cm), boll weight (g boll⁻¹), seed cotton yield (g plant⁻¹), lint yield (g plant⁻¹), seed index, lint index, ginning outturn, harvest index, oil content, total biomass, 2.5% span length, micronaire value, fibre strength, uniformity ratio, maturity ratio, fibre elongation and short fibre index.

The analysis of genotypic and phenotypic coefficient of variance was calculated according to Burton (1952). Heritability (Broad sense) was done by the methods of Allard (1960). The correlation coefficients were calculated according to Johnson et al (1955) whereas path coefficient analysis as described by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance revealed highly significant differences among genotypes for all the characters

indicating considerable amount of genetic variation present in the material. High magnitude of variation in the experimental material was reflected by high values of mean and range for almost all the characters.

Range of variation on the basis of mean was more for the characteristics viz., seed cotton yield plant⁻¹, days to 50% flowering, days to 50% boll bursting, number of sympodia, plant height, number of bolls plant⁻¹, lint yield plant⁻¹, seed index and lint index, ginning outturn oil content, 2.5% span length, fibre strength and uniformity ratio. Similar results were reported by Nageshwara et al (2001), Neelam and potdukhe (2002), Phundan et al. (2004), Ghumber et al. (2005) and Kumari and Subbramma (2006).

Genetic variability

The estimates of genetic parameters like genotypic variance (σ^2_p), phenotypic variance (σ^2_g), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense), genetic advance (GA) and expected genetic advance (EGA) are presented in Table 1.

Variance components and coefficient of variation

The values of phenotypic variance were more than the genotypic variance for all the characters. High genotypic and phenotypic variances were observed for the characters seed yield plant⁻¹, number of bolls plant⁻¹, plant height and days to 50% flowering. Low genotypic and phenotypic variances were observed for the characters of number of monopodia (0.01 and 0.02), Earliness index (0.001 and 0.002), average boll weight (0.051 and 0.068), Harvest index 0.012 and 0.014), maturity ratio (0.0004 and 0.0005) as well as fibre elongation (0.011 and 0.021), fibre strength (0.535, 0.670), micronaire value (0.280, 0.399), lint index (0.249, 0.350) and seed index (0.353, 0.53) and short fibre index.

In present investigation through the phenotypic coefficient of variations were greater than genotypic coefficient of variations. The differences between them were of lower magnitude, that is, they were more or less close to each other. This indicates that there is small effect of environment on characters and selection may be effective. Sambamurty et al. (2004) and Gumber et al. (2005) also reported greater PCV values than GCV values for all the characters.

High estimates of genotypic and phenotypic coefficient of variation were observed for number of sympodia, number of monopodia, number of bolls plant⁻¹, plant height, average boll weight, seed cotton yield plant⁻¹, lint yield plant⁻¹, harvest index, total biomass, maturity ratio, short fibre index and 2.5% span length and fibre elongation. Kumari and Subbramma (2006) reported

Table 1. Parameters of genetic variability for yield and yield contributing characters of cotton.

S/N	Characters	Range	General mean	GV (%)	PV (%)	GCV (%)	PCV (%)	Heritability (%)	Genetic advance	EGA (%)
1	Days to 50% flowering	69.00-78.25	72.92	6.73	7.59	3.56	3.78	88.70	5.03	6.90
2	Days to 50% boll bursting	107.60-113.75	110.71	2.79	3.07	1.51	1.58	90.80	3.28	2.96
3	Number of monopodia	1.10-1.60	1.29	0.01	0.02	9.45	10.91	75.00	0.25	19.38
4	Number of sympodia	9.80-21.60	15.88	15.19	16.02	24.54	25.20	94.80	7.81	49.24
5	Earliness index	0.77-0.88	0.83	0.001	0.002	3.02	4.61	42.90	0.03	4.08
6	Plant height	120.40-202.40	163.50	200.0	250.70	8.63	9.67	80.00	29.89	18.26
7	Number of bolls plant ⁻¹	8.50-20.00	14.76	13.95	14.96	25.30	26.20	93.20	7.43	50.34
8	Average boll weight	2.01-2.63	2.30	0.05	0.07	9.86	11.37	75.00	0.40	17.62
9	Seed cotton yield	16.88-35.66	29.69	75.64	131.20	29.67	38.57	60.70	13.49	45.03
10	Lint yield plant ⁻¹	7.14-12.97	10.90	8.51	9.00	26.84	27.51	95.10	5.88	53.94
11	Seed index	5.80-8.34	6.93	0.35	0.53	8.56	10.47	66.80	1.00	14.42
12	Lint index	3.45-4.47	4.16	0.25	0.35	11.99	14.22	22.43	0.93	22.44
13	Ginning outturn	33.61-39.87	37.71	1.66	2.50	3.41	4.19	66.50	20.16	5.74
14	Harvest index	0.16-0.55	0.36	0.01	0.01	30.96	32.25	92.10	0.22	61.02
15	Oil content	14.90-19.50	17.39	1.60	1.69	7.27	7.49	94.19	2.52	14.54
16	Total biomass	23.80-120.40	57.45	830.49	852.80	50.16	50.49	97.30	5.47	10.00
17	2.5% span length	26.20-27.70	27.24	4.17	4.97	7.49	9.19	80.04	3.22	11.83
18	Micronaire value	4.40-6.00	5.22	0.28	0.39	10.15	12.11	70.20	0.91	17.52
19	Fibre strength	17.50-20.50	19.27	0.54	0.67	3.80	4.25	79.00	1.34	6.99
20	Uniformity ratio	48.00-53.00	50.66	1.97	3.00	2.79	3.42	65.70	2.34	4.63
21	Maturity ratio	0.81-0.86	0.84	0.001	0.002	2.05	2.35	79.40	0.03	3.69
22	Fibre elongation	5.80-6.20	5.90	0.01	0.02	1.78	2.47	51.90	0.15	2.64
23	Short fibre index	7.60-11.80	9.55	1.59	1.65	13.10	13.44	94.90	2.61	26.29

GV = Genotypic variance, PV = Phenotypic variance, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, EGA = Expected genetic advance.

that the estimates of GCV and PCV were high for number of boll, seed cotton yield plant⁻¹ (g), fibre properties viz., 2.5% span length and micronaire values.

The lowest genotypic and phenotypic coefficients of variation were observed for days to 50% flowering and boll bursting, uniformity ratio, fibre elongation ginning outturn and oil content. Similar finding were reported by Sumathi and Nadarajan (1996) for days to 50% flowering and

ginning percentage and Gumber et al. (2005) for ginning percentage.

Heritability and genetic advance

Heritability estimate for characters under study is given in Table 1. Heritability values are useful in predicting the expected progress to be achieved through the process of selection. Genetic

coefficient of variation along with heritability estimate provides a reliable estimate of the amount of genetic advance to be expected through phenotypic selection (Wright, 1921).

Heritability ranged from 42.90% for Earliness index to 97.30% for total biomass. According to Singh (2001) heritability values greater than 80% are very high, values from 60 to 79% are moderately high and values from 40 to 59% are low. Accordingly, characters like days to 50%

Table 2a. Genotypic correlation between yield and its components in cotton.

Character	Days to 50% flowering	Days to 50% boll bursting	Number of monopodia	Number of sympodia	Earliness index	Plant height (c.m)	Number of bolls plant ⁻¹	Average boll weight (g)	Lint yield plant ⁻¹ (g)	Seed index (g)	Lint index (g)	Ginning outturn (%)
Days to 50% flowering	1.00	0.199	-0.257	0.312	0.333	0.943**	0.459*	0.044	0.024	0.760**	-0.199	0.045
Days to 50% boll bursting		1.000	-0.089	0.061	0.559**	0.380	0.400*	0.286	0.117	0.475*	0.630**	0.088
Number of monopodia			1.000	0.731**	0.241	0.190	0.402*	0.521**	0.859**	0.529**	-0.417*	0.277
Number of sympodia				1.000	0.336	0.089	0.375	0.374	0.471*	0.014	-0.469	0.430*
Earliness index					1.000	0.852**	0.390	-0.161	-0.022	0.476*	-0.124	0.169
Plant height						1.000	0.638*	-0.015	0.314	0.966**	0.201	0.035
Number of bolls plant ⁻¹							1.000	0.422*	0.096	0.501**	0.049	0.366
Average boll weight								1.000	0.619**	0.098	0.360	0.008
Lint yield plant ⁻¹									1.000	0.389*	0.010	0.044
Seed index										1.000	0.224	0.472*
Lint index											1.00	0.431*
Ginning outturn												1.000

*, ** significant at 5 and 1% probability levels respectively.

flowering (88.70%), number of monopodia (75.00%), number of sympodia (94.80%), plant height (80.00%), number of bolls plant⁻¹ (93.20%), average boll weight (75.20%), lint yield plant⁻¹ (95.10%), harvest index (92.10%) and seed cotton yield (60.70%) had very high and moderately high heritability. This indicates that selection will be the best step for selecting genotypes having traits with very high and moderately high heritability. This is because there would be a close correspondence between the accessions and the phenotype due to relative small contribution of the environment to the total variability. These results are in conformity with the results reported by Deshmukh et al. (1999), Rao and Raddy (2001) and Kapoor and Kaushik (2003).

The range of genetic advance as percent of mean was from 2.64% for fibre elongation to 61.02% for harvest index. High heritability estimates coupled with high expected genetic

advance were observed for the characters number of sympodia, plant height, number of monopodia, number of boll plant⁻¹ average boll weight, harvest index, oil content, total biomass, fibre strength, short fibre index, seed cotton yield plant⁻¹, lint yield plant⁻¹, lint index, harvest index, 2.5% span length and micronaire value indicating additive gene action. Kapoor and Kasushik (2003) reported highest heritability coupled with highest expected genetic advance for number of bolls plant⁻¹, seed cotton yield plant⁻¹ and boll weight. High heritability estimates coupled with low expected genetic advance were observed for days to 50% flowering, days to 50% boll bursting, ginning percentage, maturity ratio indicating non additive gene action. Similar result were reported by Rao and Raddy (2001) for days to 50% flowering (Neelam and Potdukhe, 2002; Sambamurthy et al., 2004; Kumari and Subramamma, 2006). Low heritability estimates

coupled with low expected genetic advance were observed for the characters like earliness index and fibre elongation.

Association among characters

Estimates of correlation coefficient measures the degree of relationship between pairs of characters are presented in Tables 2a, b and 3a, b. Computation of correlation between yield and yield contributing characters of considerable importance in plant selection. In the present study, the genotypic and phenotypic correlations of seed cotton yield with number of monopodia, number of sympodia, earliness index, plant height, number of bolls plant⁻¹, average boll weight and lint yield plant⁻¹ were positive and significant indicating the increase in seed cotton yield is mainly because of increase in one or more of the above characters.

Table 2b. Genotypic correlation between yield and its components in cotton.

Character	Harvest index	Oil content	Total biomass	2.5% Span length	Micronaire value 10 ⁻⁶ /inch	Fibre strength	Uniformity ratio	Maturity ratio	Fibre elongation	Short fibre index	Seed cotton yield
Days to 50% flowering	0.284	0.114	-0.184	-0.164	0.124	-0.226	0.144	0.154	-0.188	0.087	0.296
Days to 50% bollbursting	0.407*	-0.147	-0.393*	-0.248	-0.173	-0.227	-0.032	-0.020	-0.169	0.089	0.309
Number of monopodia	-0.325	-0.209	0.780**	0.343	-0.849**	-0.236	-0.680	-0.801**	-0.679**	0.477*	0.499**
Number of sympodia	-0.123	-0.134	0.480	-0.290	-0.318	0.023	0.219	-0.295	-0.535**	0.605**	0.425*
Earliness index	-0.565**	-0.284	-0.392	0.150	0.236	-0.032	0.023	0.220	-0.278	0.301	0.461*
Plant height	0.227	0.126	0.044	0.233	0.045	-0.352	0.162	0.079	0.056	0.173	0.480*
Number of bolls plant ⁻¹	0.379	0.062	0.048	0.118	-0.311	-0.359	-0.165	-0.310	-0.269	0.320	0.783**
Average boll weight	0.009	0.387*	0.353	0.368	-0.436*	-0.203	-0.295	-0.454*	-0.253	0.170	0.631**
Lint yield plant ⁻¹	0.056	0.134	0.276	0.275	-0.579**	-0.018	-0.519**	-0.674**	-0.298	0.169	0.419*
Seed index	-0.371**	0.029	-0.491**	-0.230	0.220	-0.537**	0.078	0.130	-0.398*	0.167	0.333
Lint index	-0.224	0.620**	-0.259	0.885**	0.129	-0.365	-0.130	-0.028	-0.042	0.219	0.189
Ginning outturn	0.776**	-0.168	0.162	-0.105	0.697**	0.217	0.270	-0.436*	-0.413	0.396*	0.703**
Harvest index	1.000	0.204	-0.200	0.026	-0.077	-0.329	0.350	0.059	-0.229	-0.071	0.379
Oil content		1.000	-0.185	0.347	0.128	-0.213	-0.007	-0.097	-0.081	-0.194	0.342
Total biomass			1.000	-0.093	-0.514**	0.288	-0.327	-0.464*	-0.160	0.334	0.149
2.5% span length				1.000	-0.559**	0.576**	-0.935**	-0.358	0.283	-0.699**	0.447*
Micronaire value					1.000	0.239	0.729**	0.929**	0.679**	-0.712**	-0.932**
Fibre strength						1.000	0.497**	0.368	0.786**	-0.286	-0.547**
Uniformity ratio							1.000	0.726**	0.658**	-0.693**	-0.643**
Maturity ratio								1.000	0.774**	-0.572**	-0.912**
Fibre elongation									1.000	-0.937**	-0.761**
Short fibre index										1.000	0.622**

*, ** significant at 5 and 1% probability levels respectively.

Similar results were reported by Rajarathinam et al. (1993), Mandloi et al. (1998) and Gumber et al. (2005) for numbers of bolls plant and boll weight and Ahuja and Kumar (2001) for number of bolls plant⁻¹ and plant height. Rao and Mary (1996) reported positive and significant correlation for seed cotton yield plant⁻¹ with seed index, lint index, harvest index and ginning outturn (%), Patel et al. (2003) reported positive correlation of seed index seed cotton yield with seed oil percent. Plant height exhibited positive and significant

association with number of bolls plant⁻¹, lint yield and seed cotton yield plant⁻¹. The significant and positive correlation of number of sympodia plant⁻¹ with number of bolls plant⁻¹ and boll weight indicates the possibility of increase in seed cotton yield through the simultaneous improvement of these characters. The number of bolls plant⁻¹ showed significant positive correlation with boll weight. The results indicate that the direct selection procedure to increase number of bolls plant⁻¹ would help full for increasing boll weight.

The character average boll weight showed significant positive correlation with seed cotton yield.

The Earliness index (Bartlett's index) exhibited negative non significant correlation with average boll weight at both genotypic and phenotypic levels. The results are in accordance with the studies conducted by Carvalho et al. (1994). The fibre quality parameters viz., micronaire value, fibre strength, uniformity ratio exhibited negative correlation with seed cotton yield plant⁻¹, whereas

Table 3a. Phenotypic correlation between yield and its components in cotton.

Character	Days to 50% flowering	Days to 50% boll bursting	Number of monopodia	Number of sympodia	Earliness index	Plant height (c.m)	Number of bolls plant ⁻¹	Average boll weight (g)	Lint yield plant ⁻¹ (g)	Seed index (g)	Lint index (g)	Ginning outturn (%)
Days to 50% flowering	1.000	0.189	-0.177	0.271	0.236	0.471*	0.407*	0.007	0.012	0.545**	-0.108	0.042
Days to 50% boll bursting		1.000	-0.076	-0.046	0.349	0.252	0.379	0.247	0.110	0.358	0.369	0.059
Number of monopodia			1.000	0.441*	-0.048	-0.176	0.397*	0.400*	0.507**	-0.285	-0.265	0.402*
Number of sympodia				1.000	0.194	0.410*	0.391*	0.308	0.460*	0.034	-0.252	0.390*
Earliness index					1.000	0.423*	0.160	-0.033	0.565**	0.395*	-0.086	0.125
Plant height						1.000	0.456*	0.037	0.145	0.482*	-0.134	0.028
Number of bolls plant ⁻¹							1.000	0.449*	0.080	0.432*	0.016	0.241
Average boll weight								1.000	0.492**	0.085	0.233	0.036
Lint yield plant ⁻¹									1.000	0.315	0.105	0.071
Seed index										1.000	0.205	0.021
Lint index											1.000	0.027
Ginning outturn												1.000

*, ** significant at 5 and 1% probability levels respectively.

the trait 2.5% span length showed positive correlation with seed cotton yield plant⁻¹. Similar results were obtained by Rajarathinam et al. (1993), Rao et al. (2001) and Sharma (2005).

In present study, significant and positive genotypic and phenotypic correlation was observed between numbers of bolls plant⁻¹, number of monopodia and sympodia plant⁻¹, boll weight and plant height with seed cotton yield plant⁻¹, which is considerable significant to breeder because component breeding would be very effective under such situation. Selection for all these traits might be helpful in evolving high yielding varieties of *desi* (Indian) cotton.

Path analysis

In order to know the specific forces in building up of the total correlation, it is essential to resort to path coefficient analysis (Table 4a, b). It was

observed that genotypic level of analysis was more important as a plant breeder viewpoint so more emphasis was placed on path coefficient analysis at genetic level. At genotypic level, lint yield plant⁻¹ (0.877), number of bolls plant⁻¹ (0.767). Similar findings were reported by Gururajan (2000), and Alther and Singh (2003). Seed index (0.747), ginning outturn (0.513), plant height (0.371), lint index (0.364) and total biomass exerted highest direct effect on seed cotton yield. Whereas, weak positive indirect effects were observed for the characters of days to 50% boll bursting (0.182), number of sympodia plant⁻¹ (0.153), average boll weight (0.118), 2.5% span length (0.257), uniformity ratio (0.148), maturity ratio (0.152), fibre elongation (0.130) and negative indirect effects were showed by the traits days to 50% flowering, number of monopodia, harvest index, fibre strength, earliness index and oil content with seed cotton yield. The fibre quality characteristics viz., short fibre index, 2.5% span

length, micronaire value, maturity ratio and uniformity ratio exhibited direct effect on seed cotton yield plant⁻¹, while fibre strength showed negative in direct effects. Similar results were reported by Rajarathinam et al. (1993), Rao et al. (2001) and Ekinici et al. (2010).

The path analysis studies revealed that, the traits which had positive direct effects on seed cotton yield should be given due to emphasis for making selection for high yielding genotypes in *desi* (Indian) cotton.

Irum et al. (2011) noticed that the genotypes exhibited a wide range of variability for all the characters except shoot length. Moderate to high heritability estimates were found for all characters. All the seedling traits showed positive and significant correlation with cotton yield both at genotypic and phenotypic level. Path coefficient analysis showed that root length had the highest and positive direct effect on cotton yield.

Positive direct effects were produced by shoot

Table 3b. Phenotypic correlation between yield and its components in cotton.

Character	Harvest index	Oil content	Total biomass	2.5% span length	Micronaire value 10 ⁻⁶ /inch	Fibre strength	Uniformity ratio	Maturity ratio	Fibre elongation	Short fibre index	Seed cotton yield
Days to 50% flowering	0.262	0.092	-0.174	-0.096	0.057	-0.185	0.033	0.154	-0.134	0.057	0.239
Days to 50% boll bursting	0.379	-0.174	-0.368	-0.01	-0.143	-0.186	0.009	0.016	-0.157	0.068	0.232
Number of monopodia	-0.239	-0.171	0.521**	0.03	-0.534	-0.164	-0.361	-0.534**	-0.162	0.336	0.222
Number of sympodia	0.133	-0.14	0.461*	-0.424*	-0.433	-0.043	0.176	-0.345	-0.426*	0.562**	0.387*
Earliness index	-0.372	-0.152	-0.26	0.399	0.05	-0.122	0.019	0.064	0.017	0.168	0.456*
Plant height	0.085	0.005	0.008	0.124	0.025	-0.202	0.014	0.021	0.277	0.125	0.469*
Number of bolls plant ⁻¹	0.369	0.038	0.041	0.044	-0.385	-0.317	-0.109	-0.256	-0.396*	0.317	0.570**
Average boll weight	0.034	0.389*	0.324	0.099	-0.460*	-0.189	-0.255	-0.364	-0.181	0.145	0.419*
Lint yield plant ⁻¹	0.043	0.139	0.258	0.124	-0.479*	-0.113	-0.385	-0.551**	-0.244	0.156	0.393*
Seed index	-0.463*	0.022	-0.411*	-0.176	0.142	-0.435*	0.02	0.142	-0.511**	0.146	0.203
Lint index	-0.396	0.388*	-0.405	0.025	0.062	-0.144	0.029	-0.002	0.02	0.128	0.24
Ginning outturn	0.142	-0.073	-0.107	-0.065	0.454	0.078	0.083	-0.461*	-0.278	0.345	0.588**
Harvest index	1	-0.188	-0.799**	0.038	-0.037	-0.468*	0.095	0.126	-0.123	-0.076	0.273
Oil content		1	-0.181	0.153	0.133	-0.185	-0.018	-0.112	-0.016	-0.172	0.223
Total biomass			1	-0.056	-0.403	0.253	-0.276	-0.434*	-0.123	0.331	0.123
2.5% span length				1	-0.498*	0.125	-0.075	-0.032	0.285	-0.263	0.438*
Micronaire value					1	0.17	0.611**	0.672**	0.445**	-0.542**	-0.588**
Fibre strength						1	0.466*	0.271	0.402*	-0.226	-0.465
Uniformity ratio							1	0.610*	0.451*	-0.538**	-0.414*
Maturity ratio								1	0.543*	-0.530**	-0.510**
Fibre elongation									1	-0.677**	-0.436*
Short fibre index										1	0.467*

*, ** significant at 5 and 1% probability levels respectively.

Table 4a. Direct and indirect (Genotypic) effects of 22 causal variables on seed cotton yield.

Character	Days to 50% flowering	Days to 50% boll bursting	Number of monopodia	Number of sympodia	Earliness index	Plant height (cm)	Number of bolls plant ⁻¹	Average boll weight (g)	Fibre elongation	Short fibre index (g)	Lint index	Ginning outturn
Days to 50% flowering	-0.101	0.036	-0.038	0.359	-0.148	0.350	0.352	-0.005	-0.020	-0.568	0.072	0.036
Days to 50% boll bursting	0.020	0.182	0.013	0.070	0.249	-0.141	-0.306	-0.033	0.103	0.355	0.229	0.071
Number of monopodia	0.026	0.016	-0.150	0.843	-0.107	-0.070	0.308	0.061	0.784	-0.395	0.151	0.225
Number of sympodia	-0.032	0.011	0.110	0.153	-0.149	-0.032	-0.287	-0.044	0.413	0.010	0.170	-0.349
Earliness index	-0.034	0.101	0.036	0.387	-0.445	0.316	-0.222	-0.019	0.018	-0.355	0.045	0.137
Plant height	0.096	0.069	0.028	0.102	-0.379	0.371	-0.489	-0.001	0.275	0.722	0.218	-0.028
Number of bolls plant ⁻¹	0.047	0.072	0.060	0.432	-0.129	-0.236	0.767	-0.050	0.084	-0.374	0.017	-0.297
Average boll weight	0.004	-0.052	-0.078	-0.431	0.071	0.005	0.324	0.118	-0.542	0.073	-0.130	-0.006
Lint yield plant ⁻¹	0.002	0.021	0.135	0.543	-0.009	-0.116	-0.073	-0.073	0.877	0.291	-0.003	-0.035
Seed index	0.077	0.086	-0.079	0.016	0.212	-0.358	0.384	0.011	0.341	0.747	81.000	0.139
Lint index	-0.020	0.144	0.062	-0.200	0.055	0.223	0.037	0.042	0.008	0.167	0.364	0.025
Ginning outturn	-0.005	-0.016	-0.042	-0.495	-0.075	0.001	0.280	-0.001	-0.038	0.128	-0.011	0.513

Table 4a. Contd.

Harvest index	0.029	0.074	0.049	-0.141	-0.251	-0.084	-0.290	-0.001	0.049	-0.426	0.277	0.143
Oil content	0.001	0.026	-0.031	-0.154	0.126	-0.046	-0.047	0.046	0.117	0.021	-0.189	-0.136
Total biomass	-0.019	-0.710	-0.117	-0.553	0.174	0.016	0.036	0.042	0.241	-0.367	0.240	0.131
2.5% span length	-0.017	0.045	-0.051	-0.911	-0.512	0.860	0.090	0.043	0.241	0.172	-0.322	0.041
Micronaire value	-0.013	0.031	-0.031	-0.597	0.105	-0.016	-0.392	-0.051	-0.507	-0.164	0.047	0.567

Table 4b. Direct and indirect (Genotypic) effects of 22 causal variables on seed cotton yield.

Character	Harvest index	Oil content	Total biomass	2.5% span length	Micronaire value 10 ⁻⁶ /inch	Fibre strength	Uniformity ratio	Maturity ratio	Fibre elongation	Short fibre index	Seed cotton yield
Days to 50% flowering	0.311	0.043	-0.164	0.043	0.111	0.263	0.150	-0.023	0.025	0.029	0.239
Days to 50% boll bursting	-0.446	-0.056	-0.351	0.064	-0.155	-0.263	0.033	0.003	0.021	0.030	0.232
Number of monopodia	-0.357	-0.080	0.697	0.088	0.765	0.274	0.713	0.122	0.088	0.016	0.222
Number of sympodia	0.135	0.051	0.429	-0.203	-0.467	0.026	0.229	0.060	0.069	0.208	0.387*
Earliness index	-0.620	-0.108	-0.351	0.296	-0.213	0.037	0.023	-0.033	0.036	0.103	0.456*
Plant height	-0.249	0.048	-0.039	0.060	-0.040	0.409	0.169	-0.012	-0.007	0.059	0.469*
Number of bolls plant ⁻¹	-0.415	0.023	0.042	0.030	-0.460	-0.417	0.172	0.047	0.061	0.111	0.570**
Average boll weight	0.009	0.147	0.316	0.094	-0.393	0.235	-0.309	0.069	0.033	0.058	0.419*
Lint yield plant ⁻¹	0.062	0.051	0.246	0.070	-0.521	0.208	-0.543	0.103	0.038	0.058	0.419*
Seed index	0.628	0.011	-0.436	-0.059	0.198	0.624	-0.081	-0.019	0.051	0.057	0.203
Lint index	0.685	0.198	-0.590	-0.228	0.116	0.424	-0.136	0.004	-0.005	-0.075	0.24
Ginning outturn	-0.193	0.064	0.144	-0.130	0.628	-0.252	0.283	0.066	0.053	0.129	0.588**
Harvest index	-0.098	0.078	-0.715	0.006	0.069	0.615	0.068	-0.008	0.029	-0.024	0.273
Oil content	0.224	-0.382	-0.165	-0.089	0.115	0.247	-0.006	0.014	0.010	-0.066	0.223
Total biomass	-0.878	-0.070	0.494	0.023	-0.463	0.334	0.343	0.070	0.020	0.118	0.213
2.5% span length	-0.029	0.132	-0.083	0.257	0.503	-0.321	-0.980	0.054	-0.036	-0.240	0.438*
Micronaire value	0.084	-0.048	0.460	-0.144	0.301	0.278	0.764	-0.142	-0.088	-0.245	-0.588**
Fibre strength	-0.581	0.081	0.257	0.071	-0.251	-0.162	-0.521	-0.056	-0.102	-0.098	-0.465
Uniformity ratio	-0.071	0.003	-0.292	-0.240	0.657	0.578	0.148	-0.111	-0.085	-0.238	-0.414*
Maturity ratio	0.064	-0.360	-0.414	0.092	0.837	0.428	-0.761	0.152	-0.100	-0.196	-0.510**
Fibre elongation	-0.251	-0.300	-0.143	-0.073	0.612	0.914	-0.690	-0.118	0.130	-0.322	-0.436*
Short fibre index	-0.077	-0.070	0.307	0.180	-0.642	-0.332	0.726	0.087	0.122	0.344	0.467*

*, ** significant at 5 and 1% probability levels respectively.

length, root length, shoot/root length ratio, shoot weight and root weight, while shoot/root weight ratio had negative direct effects. Salahuddin et al.

(2010) recorded that highly significant positive correlation ($r = 0.567$) was displayed by sympodial cotton yield was greatly influenced by sympodial

branches. The coefficient of determination ($r^2 = 0.321$) revealed 32.1% variation in the seed cotton yield plant⁻¹ due to its relationship with sympodial

branches plant⁻¹. Regression coefficient ($b = 5.66$) showed that a unit increase in sympodial branches plant⁻¹ resulted into a proportional increase of 5.66 gm in seed cotton yield plant⁻¹, whereas bolls plant⁻¹ exhibited strong positive association with seed cotton yield ($r = 0.959$). The coefficient of determination ($r^2 = 0.92$) revealed 92% of the total variation in seed cotton yield attributable to the variation in number of bolls plant⁻¹. The regression coefficient ($b = 3.37$) indicated that for a unit increase in bolls plant⁻¹, there would be a proportional increase of 3.37 gm in seed cotton yield plant⁻¹. Boll weight displayed a highly significant positive correlation ($r = 0.597$) with seed cotton yield plant⁻¹.

The result of genetic variability, character association and path coefficient analysis confirmed that the characters number of monopodia and sympodia plant⁻¹, plant height, number of bolls plant⁻¹, average boll weight, lint yield plant⁻¹ and span length were important in respect of genetic variability, correlation and path coefficient analysis. The greater variability in these characters would give a prime scope for the development of high yielding through selection in the segregating generation.

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