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Genetic variability, correlation and path coefficient analysis for yield and its attributing traits in cotton (*Gossypium hirsutum* L.)

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ABSTRACT: In the present investigation, the genetic parameters *viz.,* genotypic and phenotypic variability, genotypic and phenotypic coefficient of variation, heritability, genetic advance and path coefficient were studied for seed cotton yield and its component traits in 15 diverse genotypes of cotton (*Gossypium hirsutum* L.). The analysis of variance revealed significant differences among the genotypes for all the characters studied. The high genotypic and phenotypic coefficient of variation observed for lint (kg/ha), seed cotton yield and monopodia/plant. High heritability coupled with high genetic advance as per cent of mean were exhibited by lint kg/ha, monopodia/plant and seed cotton yield. However, bolls/plant, GOT (%) and seed index recorded high heritability with moderate genetic advance. The characters plant stand, fibre length and plant height had low genetic advance as per cent of mean values and had moderate heritability indicating lesser proportion of genetic components in the total variability. Seed cotton yield was found positive and significantly correlated with monopodia, sympodia/plant, GOT (%), lint kg/ha and fibre length. Lint kg/ha exhibited the highest magnitude of direct effects on seed cotton yield, followed by fibre length, plant height, bolls and sympodia/plant.

Key words: Correlation, genetic variability, heritability, path coefficient analysis

Cotton (*Gossypium hirsutum* L.) plays a crucial role in the economy of India. It is the most important fiber and cash crop. India is second largest producer of cotton next to China with 22 per cent of world production and also the largest cotton growing country in the world with 103.10 lakh ha area (Annymous, 2012). In the year 2009, cotton area in Maharashtra was 35.03 lakh ha with production 63.00 lakh bales and productivity 306 kg/ha (Cotton Advisory Board. CICR, Nagpur).

The genetic information on broad sense heritability and genetic advance are very important to predict the behaviour of the parents to be utilized in breeding programme for selecting high yielding cultivars. The correlation analysis reflects correlated response of a particular character with its counterpart and provides a good index to predict the corresponding changes occurs in one character at the expanse of the proportionate change in the other. Simultaneously an attempt was made to study the direct and indirect effects of important yield components on seed cotton yield by path coefficient analysis. The results of this study might be capable in the selection criteria in further studies in order to increase the selection efficiency.

The experiment materials under investigation consisted of fifteen genotypes of cotton *viz.,* AKH 9916, AKH 017, AKH 28-2-2, AKH 0205, NH 630, NH 634, CNH 9, CNH 105, CNH 1105, CNH 1106, CIHS 97-10, RHC 0688, NH 615, AKH 8828 and PKV Rajat. The experiment was designed under randomized block design with three replications during *kharif,* 2009 at cotton research scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra. Each

entry was represented by four rows of 6m length spaced at 60 cm between rows and 30 cm within plants. The seeds were dibbled to ensure uniform plant population. All the recommended agronomic practices and plant protection measures were adopted to obtain healthy plants. The observations were recorded on randomly selected five plants for each genotype/ replication on eleven traits *viz.*, plant stand, days to first flowering, plant height, monopodia and sympodia/plant, GOT (%), lint (kg/ha), bolls/ plant, fibre length, seed index and seed cotton yield.

Number of plant counted after germination in the plot and final count were recorded at the time of harvesting. Number of days required from sowing to the date on which first flower of the plants flowered and average number of days to first flowering was calculated. The mean stem height was recorded in centimeter from the cotyledonary node up to the growing point at the time of maturity and the averages were worked out. Total numbers of vegetatively growing branches were counted on main stem of each selected plant at maturity and averages were calculated. Total number of boll bearing branches were recorded at maturity and averages were worked out. Bolls/plant from which seed cotton was picked during each picking was recorded and mean value for bolls/ plant was recorded. The seed cotton was ginned by hand gin and weight of lint was recorded on the balance with 0.1 per cent sensitivity and ginning percentage was calculated as the ratio of weight of lint to that of seed cotton expressed in percentage. Seed index was recorded by weighing 100 seeds of each genotype/plant/ replication and averaged. Seed cotton of well opened bolls was collected and fibre length of each genotype was recorded with the help of halo disc. The seed cotton obtained from five randomly selected plants was weighed separately and mean seed cotton yield was recorded.

Statistical analysis: All the recorded data were subjected to analysis of variance (ANOVA). For each trait the genotypic and phenotypic variances, broad sense heritability (h^2) and expected response to selection (Re) were further estimated from the ANOVA mean squares. Genotypic and phenotypic correlation coefficients were estimated by the method proposed.

Mean performance : Mean values (Table 1) for the plant stand was ranged from 72.00 (AKH 28-2-2, NH 630, CNH 1105, CIHS 97-10 and RHC 0688) to 76.00 (AKH 017). In respect of days to first flowering the range was observed from 50 days to 55 days. The genotype CNH 105 (50 days) was found early in flowering. In case of plant height, maximum plant height was observed by CNH 105 (96 cm) followed by AKH 9916 (94 cm) and NH 634 (92 cm). For the character monopodia/plant, the nine genotypes had recorded lowest monopodia/plant (01). The sympodia/plant was ranged from 12 (CNH 105) to 19 (AKH 017 and AKH 28-2-2). In respect of fibre characters, the highest GOT (%) was recorded by CIHS 97-10 (44 %) while the range was from 32 to 44 per cent. The highest value for lint kg/ha was exhibited by NH 630 (651 kg/ ha). For bolls/plant, the genotype AKH 9916 (20) had recorded highest bolls/plant. The mean range (23 to 28 mm) was observed for fibre length. The genotypes AKH 017, AKH 0205, NH 630, NH 634 and NH 615 had recorded maximum (28 mm) fibre length. The values of seed index among genotypes were ranged from 7.00 to 8.50 g. The mean seed cotton yield among genotypes was ranged from CNH 1105 (513 kg) to NH 630 (2234 kg). The highest seed cotton yield was

Table 1. Mean performance of genotypes for various characters of cotton

Sr No.	Genotypes	Plant stand	Days to first flower	Plant height (cm)	Mono-podia/ plant	Sym-podia/ plant	GOT (%)	Lint (kg/ha)	Bolls/ plant	Fibre length (mm)	Seed index	Seed cotton yield/ ha
1	AKH 9916	73	55	94	01	16	40	206	20	25	7	743
2	AKH 017	76	51	88	01	19	38	203	12	28	8	772
3	AKH 28-2-2	72	52	88	02	19	39	244	14	25	8	900
4	AKH 0205	74	52	89	01	14	40	210	13	28	7	756
5	NH 630	72	52	85	02	16	42	651	16	28	7	2234
6	NH 634	75	55	92	02	18	41	351	17	28	7	1233
7	CNH 9	73	51	84	02	14	33	173	18	23	8.5	756
8	CNH 105	74	50	96	01	12	39	194	18	24	8	715
9	CNH 1105	72	54	82	01	13	34	121	11	26	8.5	513
10	CNH 1106	74	52	89	01	15	36	183	13	25	8.5	731
11	CIHS 97-10	72	52	91	01	14	44	205	13	26	7	673
12	RHC 0688	72	53	89	01	18	32	214	13	24	8.5	963
13	NH 615 (C)	75	55	81	01	15	38	413	16	28	8	1566
14	AKH 8828 (C)	74	55	81	02	15	39	273	12	25	8	1010
15	PKV Rajat	74	55	90	02	17	41	310	13	23	7	1086
SE +		0.84	0.83	2.53	0.09	0.93	1.24	17.43	0.81	1.05	0.26	101.19
CD (p=0.05)		2.44	2.40	7.35	0.27	2.71	3.59	50.49	2.35	3.04	0.77	293.14

recorded by NH 630 (2234 kg) followed by NH 615 (1566 kg) and NH 634 (1233 kg).

Genotypic coefficient variance and phenotypic coefficient variance : The analysis of variance revealed significant differences among the genotypes for all the characters studied indicating presence of high degree of variability. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) showed wide variation for the characters studied (Table 2). Similar results were reported by Neelam and Potdukhe (2002), Roy (2006), Kaushik and Kapoor (2006), Kale *et al.,* (2007) and Sakthi *et al.,* (2007), Khan *et al.,* (2009) and Soomro *et al.,* (2010) for seed cotton yield. The estimates of GCV ranged from 1.351 to 49.08. The highest GCV estimated for the character lint kg/ha (49.08) followed by seed cotton yield (43.23), monopodia/plant (35.60) and bolls/plant (17.24). At the same time the estimates of PCV ranged from 2.40 to 50.40. The maximum PCV was recorded for lint kg/ha (50.40) followed by seed cotton yield (46.81), monopodia/plant (37.42) and bolls/plant (19.74). Soomro *et al.,* (2005) observed significant differences for bolls per plant, yield and other yield attributes. Taohua and Haipeng (2006), Meena *et al.,* (2007) and Ahmad *et al.,* (2008) reported varied values for bolls per plant. Khan *et al.,* (2009) observed the highest phenotypic and genotypic variances for plant height and seed cotton yield/plant. Efrem *et al.,* (2010) and Bolek *et al.* (2010) reported significant genetic variability among cultivars for seed cotton yield. High estimates of phenotypic and genotypic coefficient of variation were observed for the characters number of bolls, lint yield/plant and seed cotton yield (Elango *et al.,* 2012). Presence of high GCV values as an indicator of genetic variability for seed cotton yield and overall great influence of environment on traits under study were in accordance with

Table 2. Variability parameters in cotton

Characters	Range	**Mean**	Variance		Coefficient of variation		Heritab-ilitybs (%)	Genetic advance	G.A. as per cent of mean
			Geno typic	Phen-otypic	Geno-typic	Phen-otypic			
Plant stand	72.00 to 76.00	**73.46**	0.98	3.11	1.35	2.40	31.70	1.47	2.00
Days to first flower	50.00 to 55.00	**52.93**	2.37	4.44	2.91	3.98	53.40	2.97	5.61
Plant height (cm)	81.00 to 96.00	**87.93**	14.33	33.67	4.30	6.59	42.60	6.52	7.41
Monopodia/ plant	01.00 to 02.00	**1.40**	0.24	0.27	35.60	37.42	90.50	1.25	89.41
Sympodia/ plant	12.00 to 19.00	**15.66**	3.79	6.41	12.42	16.17	59.10	3.95	25.21
GOT (%)	32.00 to 44.00	**38.40**	9.85	14.48	8.17	9.91	68.10	6.83	17.81
Lint (kg/ha)	121.00 to 651.00	**263.40**	16717.84	17629.38	49.08	50.40	94.80	332.40	126.19
Bolls/ plant	11.00 to 20.00	**14.64**	6.37	8.35	17.24	19.74	76.30	5.82	39.77
Fibre length (mm)	23.00 to 28.00	**25.73**	2.38	5.71	6.00	9.28	41.80	2.63	10.24
Seed index	07.00 to 08.00	**7.73**	0.35	0.56	7.67	9.74	61.80	1.23	15.91
Seed cotton yield/ha	513.33 to 2234.00	**977.11**	178485.10	209205.00	43.23	46.81	85.30	1030.19	105.43

findings of Asad *et al.,* (2002), Khan (2003), Killi *et al.,* (2005) and Ganensan and Reveendran (2007). The moderate to least amount of variations were observed for bolls and sympodia/ plant, GOT (%), seed index, fibre length, plant height, days to first flowering and plant stand.

Heritability study : High heritability along with high genetic advance as percent of mean in characters suggested that the genotypic variations for such characters are probably due to high additive genetic effects whereas environmental effects had least effect on such characters. High heritability coupled with high genetic advance as per cent of mean were observed for lint kg/ha (94.80 %), monopodia/ plant (90.50 %) and seed cotton yield (85.30 %). Thus selection would be more effective for improvement for these characters. Boll/plant (76.30 %), GOT (%) (68.10%) and seed index (61.80%) recorded high heritability with moderate genetic advance as per cent of mean indicating variations for such characters is due to interaction of both additive and non additive genetic factors. The characters plant height (42.60 %), fibre length (41.80%) and plant stand (31.70 %) had low genetic advance as per cent of mean values and had moderate heritability indicating lesser proportion of genetic components in the total variability. High genetic advance along with high heritability was observed in balls/plant and seed cotton yield by Roy (2006). Seed cotton yield/plant, seed index and bolls/plant (Khan *et al.,* 2009). High heritability and genetic advance were observed for the traits *viz.,* bolls/plant, boll weight, lint yield/plant and seed cotton yield (Elango *et al.,* 2012).

Genotypic and phenotypic correlation coefficient : In general, genotypic correlations had higher magnitude than corresponding phenotypic correlations for all the characters under study (Table 3). This indicated that there was inherent association among the characters. Seed cotton yield was found significant positively associated with monopodia and sympodia/plant, GOT (%), lint kg/ha and fibre length at genotypic level, indicating that these attributes are predominant and may contribute considerably towards higher seed cotton yield. However, plant height and seed index showed negative correlation. Among yield components, plant stand registered positive and significant

association with fibre length at genotypic level. Similarly, plant height revealed positive and significant correlations with GOT (%) and bolls/plant at genotypic level. Monopodia/plant had significant and positive association with sympodia/plant at genotypic level and lint kg/ha at both levels. Conversely the GOT (%) had positive and significant association with lint kg/ha and fibre length at genotypic and phenotypic levels, while the character lint kg/ha had positive and significant association with fibre length and negative correlation with seed index at both levels. Bolls/plant and fibre length showed negative and significant correlations with seed index at genotypic level. The phenotypic correlation coefficients for three traits *viz.,* monopodia/plant, lint kg/ha. and fibre length had revealed positive and significant association with seed cotton yield per plant. These findings are accordance with Ahmad *et al.,* (2008), Tamilselvam *et al.,* (2013) and Yanal *et al.,* (2013).

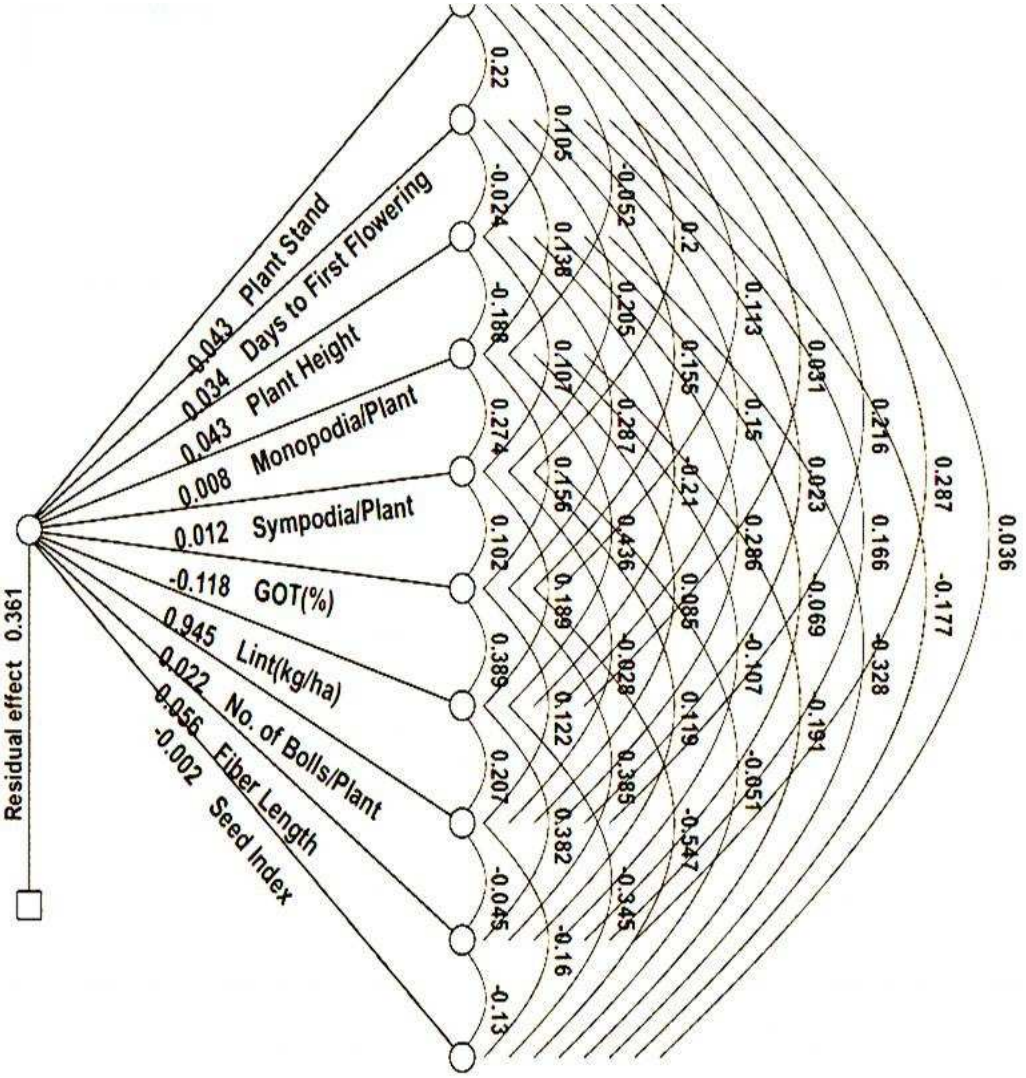

Fig 1. Path coefficient diagram showing direct and indirect effects of attributing traits on seed cotton yield

Table 3. Genotypic and phenotypic correlation coefficient in cotton for different traits.

Characters		Plant stand	Days to first flower	Plant height (cm)	Mono-podia/ plant	Sym-podia/ plant	GOT (%)	Lint (kg/ha)	Bolls/ plant	Fibre length (mm)	Seed index	Seed cotton yield
Plant stand	G	1.00	-0.0249	-0.0158	-0.1246	0.1195	0.1253	-0.0049	-0.0709	0.4346**	-0.1557	0.0167
	P	1.00	0.2201	0.1051	-0.0520	0.2002	0.1134	0.0312	0.2162	0.2868	0.0358	0.0076
Days to first flower	G		1.00	-0.0249	0.2355	0.1983	0.1018	0.2515	-0.0921	-0.0080	-0.3465*	0.2547
	P		1.00	-0.0237	0.1379	0.2050	0.1549	0.1497	0.0232	0.1663	-0.1767	0.1604
Plant height(cm)	G			1.00	-0.2804	0.0488	0.4130**	-0.2451	0.5179**	-0.3260*	-0.5045**	-0.3838**
	P			1.00	-0.1876	0.1066	0.2870	-0.2102	0.2864	-0.0690	-0.3281*	-0.1918
Monopodia/ plant	G				1.00	0.3646**	0.2154	0.4655**	0.1306	-0.2472	-0.1986	0.4631**
	P				1.00	0.2741	0.1563	0.4362**	0.0848	-0.1066	-0.1911	0.4005**
Sympodia/ plant	G					1.00	0.0070	0.2629	-0.1490	0.1892	-0.1743	0.2961*
	P					1.00	0.1022	0.1888	-0.0275	0.1188	-0.0511	0.1899
GOT (%)	G						1.00	0.4916**	0.1330	0.3815**	-1.1267	0.3438*
	P						1.00	0.3892**	0.1225	0.3847**	-0.5470**	0.2910
Lint (kg/ha)	G							1.00	0.2184	0.5215**	-0.5208**	1.0238**
	P							1.00	0.2074	0.3823**	-0.3452*	0.9266**
Bolls/ plant	G								1.00	-0.1269	-0.3071*	0.2146
	P								1.00	-0.0455	-0.1603	0.2052
Fibre length(mm)	G									1.00	-0.5822**	0.4782**

Table 4. Path coefficient analysis showing direct and indirect effects of ten casual variables on seed cotton yield

Characters	Plant stand	Days to first flower	Plant height (cm)	Mono-podia/ plant	Sym-podia/ plant	GOT (%)	Lint kg/ha	Bolls/ plant	Fibre length (mm)	Seed index	Seed cotton yield
Plant stand	**-0.0433**	-0.0095	-0.0045	0.0022	-0.0087	-0.0049	-0.0013	-0.0094	-0.0124	-0.0015	0.0076
Days to first flower	0.0074	**0.0338**	-0.0008	0.0047	0.0069	0.0052	0.0051	0.0008	0.0056	-0.0060	0.1604
Plant height (cm)	0.0045	-0.0010	**0.0432**	-0.0081	0.0046	0.0124	-0.0091	0.0124	-0.0030	-0.0142	-0.1918
Monopodia/ plant	-0.0004	0.0011	-0.0015	**0.0081**	0.0022	0.0013	0.0036	0.0007	-0.0009	-0.0016	0.4005
Sympodia/ plant	0.0024	0.0025	0.0013	0.0034	**0.0122**	0.0013	0.0023	-0.0003	0.0015	-0.0006	0.1899
GOT (%)	-0.0133	-0.0182	-0.0237	-0.0184	-0.0120	**-0.1176**	-0.0458	-0.0144	-0.0452	0.0643	0.2910
Lint (kg/ha)	0.0295	0.1415	-0.1987	0.4123	0.1784	0.3679	**0.9452**	0.1960	0.3614	-0.3263	0.9266
Bolls/ plant	0.0047	0.0005	0.0062	0.0018	-0.0006	0.0026	0.0045	**0.0216**	-0.0010	-0.0035	0.2052
Fibre length (mm)	0.0161	0.0094	-0.0039	-0.0060	0.0067	0.0216	0.0215	-0.0026	**0.0563**	-0.0073	0.3625
Seed index	-0.0001	0.0004	0.0007	0.0004	0.0001	0.0012	0.0007	0.0003	0.0003	**-0.0022**	-0.2987

Figures in bold letters indicate the direct effects, ***Residual effect=*** *0.3613*

Path coefficient analysis : Seed cotton yield is a complex character exhibits low heritability. On the other hands, it is affected by interactive effects of various traits. Moreover, ancillary characters are being less influenced by environmental fluctuations than the seed cotton yield, thus selection will be more effective based on these traits than seed cotton yield. Hence, path coefficient analysis was carried out to estimate the direct and indirect effects of various component traits for recommending a reliable selection criterion. In the present investigation, lint kg/ha (0.9452) exhibited the highest magnitude of direct effects on seed cotton yield, followed by fibre length (0.0563) and plant height (0.0432) in Table 4 and Fig 1. These results were in agreement with Thanki and Sawargaonkar (2010).

Plant stand had positive correlation with seed cotton yield (rg =0.0076). Its direct effect was negative with low magnitude (-0.0433). This character showed negative indirect effects except for monopodia/plant (0.0022). Positive direct effect was found in days to first flower (0.338), whereas it had positive association (rg = 0.1604) with seed cotton yield. Positive indirect effects were noticed for plant stand (0.0074), monopodia/plant (0.0047), sympodia/plant (0.0069), GOT (%) (0.0052), lint kg/ha (0.0051), bolls/plant (0.0008) and fibre length (0.0056). Negative association was noticed for plant height (-0.1918) with seed cotton yield and it revealed positive direct effect (0.0432), this character indirectly contributed to the seed cotton yield *via* positive path values of plant stand (0.0045), sympodia/plant (0.0046), GOT (%) (0.0124) and bolls/plant (0.0124). The trait monopodia/plant showed significant and positive correlation (0.4005) with seed cotton yield, its direct effect was also registered positive with low path values (0.0081). This character indirectly contributed mainly *via* days to first flower (0.0011), sympodia/plant (0.0022), GOT (%) (0.0013), Lint (kg/ ha) (0.0036) and bolls/plant (0.0007) towards seed cotton yield. The results are in accordance with Afiah and Ghoneim (2000), Shazia Salahuddin *et al.,* (2010) and Alkuddsi *et al.,* (2013). Sympodia/plant revealed positive association (0.1899) with seed cotton yield/plant. It had positive direct effect (0.0122) on seed cotton yield. This character indirectly influenced to the seed cotton yield via plant stand (0.0024), days to first flowering (0.0025), plant height (0.0013), monopodia/plant (0.0034), GOT (%) (0.0013), lint kg / ha (0.0023) and fibre length (0.0015) Similar findings were obtained by Alkuddsi *et al.,* (2013) which shown positive association with seed cotton yield. The character GOT (%) showed positive and significant correlation (0.2910) with seed cotton yield/plant, while it had negative direct effect (-0.1176) on seed cotton yield, this character indirectly contributed positive effect *via* seed index (0.0643). Similarly Iqbal *et al.,* (2003) and Elango Dinakaran *et al.,* (2012) studied agronomic characteristics of upland cotton cultivars using correlation and mentioned that GOT (%) had a negative direct effect on seed cotton yield. Positive direct effect was found in lint kg/ha (0.9452), whereas it had positive association (rg = 0.9266) with seed cotton yield. Positive indirect effects were noticed for plant stand (0.0295), days to first flowering (0.1415), monopodia/plant (0.4123), sympodia/plant (0.1784), GOT (%) (0.3679), bolls/plant (0.1960) and fibre length (0.3614). Similar findings were obtained by Murthy *et al.,* (2005) and Elango Dinakaran *et al.,* (2012). Positive association was noticed for bolls/plant (0.2052) with seed cotton yield and it revealed positive direct effect

(0.0216). This character indirectly contributed to the seed cotton yield *via* positive path values of plant stand (0.0047), days to first flowering (0.0005), plant height (0.0062), monopodia/plant (0.0018), GOT (%) (0.0026) and lint (kg/ha) (0.0045). These results are agreement with Joshi *et al.,* (2006) and Vinodhana *et* al., (2013). Fibre length showed significant and positive correlation (0.3625) with seed cotton yield. Its direct effect was also registered positive path value (0.0563). This character indirectly contributed mainly via plant stand (0.0161), days to first flower (0.0094), sympodia/plant (0.0067), GOT (%) (0.0216)and lint kg/ ha (0.0215) towards seed cotton yield. Similarly Vinodhana *et al.,* (2013) reported fibre length influenced the seed cotton yield positively through sympodia and ginning percentage. Negative association was noticed for seed index (-0.2987) with seed cotton yield and it revealed negative direct effect (-0.0022). This character indirectly contributed to the seed cotton yield *via* positive path values of days to first flowering (0.0004), plant height (0.0007), monopodia/plant (0.0004), sympodia/ plant (0.0001), GOT (%) (0.0012), lint (kg/ha) (0.0007), bolls/plant (0.0003) and fibre length (0.0003). Similar findings were obtained by Alkuddsi *et al.,* (2013)

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