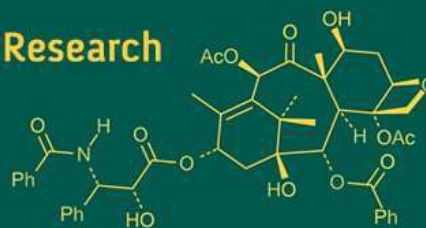
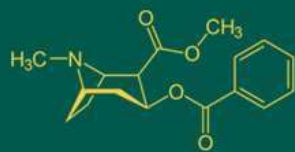


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Framing a cotton improvement program through genetic analysis and character association

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Abstract

This research study investigates genetic differences among cotton genotypes and how these differences impact on important traits like seed cotton yield and fiber quality. The analysis showed that there were significant genetic differences between the cotton genotypes for all the traits examined. Some genotypes, like CP 1512, G. Cot. 100 and KOP 3 showed promising results in terms of seed cotton yield. The study found that genetic factors played a major role in the traits of the cotton plants, meaning that the observed differences were mostly due to the plants' genetic makeup rather than environmental factors. Traits such as days to first picking, bolls per plant, and lint yield per plant showed high heritability, meaning they are strongly influenced by genetics, and thus simple selection could improve these traits over time. Among all traits studied viz. sympodia per plant, bolls per plant, lint yield per plant and ginning outturn showed highly significant and positive association with seed cotton yield per plant at both genotypic as well as phenotypic level, hence they were most important yield contributing characters for increasing the seed cotton yield. Path analysis revealed that lint index, bolls per plant, and lint yield per plant had positive effects on seed cotton yield. However, traits like days to 50% flowering, plant height, and boll weight had negative effects on seed cotton yield.

Keywords: *G. hirsutum*, genetic variance, co-efficient of variance, heritability, path co-efficient analysis, correlation

Introduction

Cotton is one of the most important fibre crop in the world also referred to as the "King of Fibre Crops." It supports several million jobs in agriculture, trade, manufacturing and processing. The four species of *Gossypium* that produce lint are *G. hirsutum*, *G. herbaceum*, *G. arboreum* and *G. barbadense* are all grown in India under a variety of agroclimatic conditions. Cotton cultivation and processing have been traced back to the ancient Indus valley civilization, which thrived in India some 5000 years ago, as evidenced by the discovery of the remains from Mohenjo-Daro and Harappa. The most prominent producers of cotton are China, India, United States, Brazil and Pakistan. Cotton is also described as the "White Gold". In terms of the botanical hierarchy, cotton is a member of the *Gossypieae* tribe and family of malvaceae, out of the eight known genera in this tribe, cotton is classified as *Gossypium*.

Cotton possesses a broad genetic diversity with the genus *Gossypium* and constitutes more than 50 species of which 7 are tetraploids and 43 are diploids. Out of those, only four are cultivated globally. *Gossypium arboreum*, *G. herbaceum*, *G. hirsutum* and *G. barbadense* are the four cultivated species of cotton that are raised in India. The first two species, *G. arboreum* and *G. herbaceum* are known as old world cottons, they are diploid ($2n = 2x = 26$) in nature and have A1 and A2 genomes, respectively. They are also known as Asian cottons because they are grown exclusively in Asia. The remaining two species, *G. hirsutum* and *G. barbadense* are tetraploid ($2n = 4x = 52$) in nature and are known as new world cottons. Tetraploid species *G. hirsutum* and *G. barbadense* account for 98% of global cotton production, while diploid species *G. arboreum* and *G. herbaceum* accounting for the remaining 2%.

Planning a successful breeding project will require careful consideration of the variability of the traits and their relationships to other variables that affect crop yield (Mary and Gopalan, 2006) ^[1]. Presence of variability in the population is foremost requirement for every crop development plan.

It is crucial for plant breeders to gauge variability using factors such as heritability, genetic advance, genotypic coefficient of variation and phenotypic coefficient of variation. For a breeding effort to be successful in crops like cotton, understanding the variability using measures like genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) is crucial. The plant breeder can choose the best genotypes from varied populations by using the heritability estimates to determine the proportion of heritable components in variation. An important technique for bringing knowledge about the proper cause and effect relationships between yield and some yield components is correlation and path analysis (Khan *et al.*, 2003) [2]. It would be quite helpful in the indirect selection process for yield improvement to evaluate the strength of correlations between various features and yield. Path coefficient analysis offers a tool to measure the interactions between various yield components and show whether an influence has a direct impact on the yield or whether it takes an indirect route.

Materials and Methods

Thirty diverse cotton genotypes were taken into consideration for the undertaking the present experimental study. The genotypes were maintained at Regional Cotton Research Station, NAU, Bharuch and later on they were evaluated at College Farm, NAU, Bharuch during experimentation. All entries were evaluated in Randomized

Block Design (RBD) with three replications during *Kharif*-2023 at College Farm, College of Agriculture, NAU, Campus Bharuch. Twelve plants in each row were accommodated keeping 45 cm inter-plant distance while inter-row distance was kept 120 cm. All the cultural and recommended package of practices in vogue on the farm was followed. Five vigorous plants of each genotype were randomly selected and labeled from each replication for the various character listed below. Plot-based recording was performed for the two phenological characteristics, days to 50% flowering and first picking. The replication wise mean values were employed in statistical analysis. The statistical analyses like ANOVA, Genotypic, phenotypic and environmental variances, The genotypic and phenotypic coefficients of variation, Broad sense heritability Genetic advance as percent of mean, Correlation Coefficient Analysis, Path Coefficient Analysis were carried out by using INDOSTAT software package Version 8.1, developed in the year 2010.

Results and Discussion

The analysis of variance showed highly significant differences among genotypes for all the characters. This clearly revealed that an inherent genetic difference was present among the genotypes under the investigation for the studied traits. (Table 1). Similar outcomes were reported for all the traits under study by Mawblei *et al.* (2022) [3] and Patel *et al.* (2023) [4].

Table 1: Analysis of variance (mean sum of squares) for 15 different characters in cotton

Sr. No.	DF Characters	Mean Sum of Squares		
		Replications	Genotypes	Error
		2.00	29.00	58.00
1.	Days to 50% flowering	2.87	466.30**	2.18
2.	Days to first picking	15.74	501.09**	13.85
3.	Plant height	414.13	398.15**	87.83
4.	Monopodia per plant	0.018	1.84**	0.03
5.	Sympodia per plant	2.35	18.60**	1.31
6.	Bolls per plant	7.36	780.58**	20.21
7.	Boll weight	0.14	2.39**	0.05
8.	Seed cotton yield per plant	26.57	1261.05**	107.70
9.	Lint yield per plant	0.85	172.93**	6.16
10.	Ginning out turn	0.16	35.09**	1.53
11.	Seed index	0.55	8.39**	0.24
12.	Lint index	0.05	3.59**	0.11
13.	Upper half mean length	0.28	4.04**	1.06
14.	Fibre fineness	0.28	0.60**	0.09
15.	Fibre strength	1.94	4.89**	0.98
** Significant at 0.01 level of probability				

Based on *per se* performance, genotypes CP 1512 (144.66 g), G. Cot. 100 (137.71 g) and KOP₃ (124.66 g) were promising with respect to seed cotton yield per plant and some of the yield contributing traits. Genotype Daldran-6 had exceptionally high boll weight, fibre strength and coupled with less number of monopodial making it the most

distinct genotype among the 30 genotypes under investigation. For fibre quality parameters genotypes AC 738 (27.17 mm), G. Cot. 100(5.5 µg/inch), Daldran 6 (29.26 g/tex) had the maximum upper half mean length, fibre fineness and fibre strength respectively. (Table 2)

Table 2: Mean performance of cotton genotypes for 15 different characters

Sr. No.	Accessions	Days to 50% flowering	Days to first picking	Plant height (cm)	Monopodia per plant	Sympodia per plant	Bolls per plant	Boll weight (g)	Seed cotton yield per plant (g)
1.	Ac-738	54.66	90.33	132.50	4.43	16.14	29.39	2.41	71.75
2.	Bhagaya	90.66	119.67	152.84	4.62	18.04	58.28	3.32	89.54
3.	Bc-68-2	86.66	116.67	138.29	3.47	17.05	52.21	3.76	83.84
4.	Bhv-19	67.00	94.67	165.00	4.37	18.93	61.46	3.50	92.34
5.	Bhv-76	72.66	104.67	153.48	2.45	11.86	24.09	2.47	64.27
6.	Bhv-97	84.00	113.67	151.32	4.77	17.32	54.83	3.48	84.97
7.	C-1622	62.66	92.67	159.01	3.47	18.22	59.72	3.59	91.79
8.	CAK-2160	58.33	88.00	152.45	2.70	20.02	64.73	4.60	98.24
9.	CAK-NS-15	90.33	129.33	156.31	4.67	13.32	26.64	3.24	66.76
10.	Coher-310	87.33	117.67	131.62	3.20	21.14	74.09	3.79	121.99
11.	CP-1512	89.33	121.00	120.82	4.39	22.12	80.78	2.41	144.67
12.	Daldran-6	63.00	91.33	151.32	2.32	20.95	72.17	5.55	120.15
13.	Deviraj	66.66	96.67	146.05	4.45	20.94	70.58	3.64	114.46
14.	G.Cot.-100	63.00	94.67	135.16	4.52	21.40	80.59	2.44	137.31
15.	H.128	58.66	90.00	143.52	3.64	16.72	49.46	3.75	78.15
16.	H-654-C	61.33	94.67	150.08	2.37	19.45	64.11	3.56	95.94
17.	IAA3932	57.66	87.67	145.52	2.52	18.22	58.87	4.48	92.82
18.	KOP-3	60.66	93.33	139.85	3.26	22.35	75.53	3.47	124.66
19.	LH-299	67.66	96.00	165.06	4.25	19.49	64.54	5.54	97.92
20.	LH-223-357	56.66	88.00	141.86	3.32	20.26	64.87	3.37	100.82
21.	LH-223-358	74.00	104.00	119.58	3.35	16.31	33.13	4.71	72.42
22.	LRK-516	91.33	127.00	145.99	3.76	19.42	63.58	3.69	95.94
23.	Mahalaxmi	83.66	114.33	143.39	2.42	17.19	52.37	4.40	84.06
24.	Mav-28	57.33	86.67	131.77	4.42	16.61	37.5	3.50	75.48
25.	ND-9	87.33	116.67	137.55	4.40	20.42	65.30	2.31	103.35
26.	SRT-5 locks	81.33	110.00	154.86	3.45	15.74	28.65	2.33	67.82
27.	SS Visnu	61.66	93.33	137.51	2.85	20.13	68.01	2.15	110.47
28.	Surat dwarf	65.66	96.00	129.42	3.49	19.02	62.58	3.68	95.45
29.	9/33/5056	74.33	105.67	152.72	3.22	20.44	66.20	2.68	104.78
30.	G N Cot.-26	63.66	97.00	146.39	3.59	20.85	69.46	3.39	113.18
	Mean	71.31	102.37	144.37	3.60	18.67	57.79	3.50	96.51
	Range	54.66-91.33	86.67-129.33	119.5-165.06	2.32-4.77	11.8-22.35	24.09-80.78	2.15-5.55	64.2-144.67
	S. Em.±	0.85	2.15	5.41	0.11	0.66	2.60	0.14	5.99
	CD at 5%	2.42	6.08	15.32	0.31	1.88	7.35	0.39	16.96
	CV%	2.07	3.64	6.49	5.20	6.15	7.78	6.86	10.75

Sr. No.	Accessions	Lint yield per plant (g)	Ginning out turn (%)	Seed index (g)	Lint index (g)	Upper half mean length (mm)	Fibre fineness (µg/inch)	Fibre strength (g/tex)
1.	Ac-738	31.44	28.84	6.25	2.53	27.17	4.47	28.80
2.	Bhagaya	36.73	28.28	7.06	2.08	23.93	5.03	28.70
3.	Bc-68-2	35.09	31.88	8.63	3.94	25.20	5.40	27.60
4.	Bhv-19	39.25	30.57	13.37	5.89	24.93	5.37	29.03
5.	Bhv-76	22.97	22.75	9.49	3.74	25.27	4.27	27.60
6.	Bhv-97	34.68	29.17	8.52	3.51	24.53	4.60	26.60
7.	C-1622	39.34	23.88	8.43	2.64	25.63	4.57	25.83
8.	CAK-2160	42.48	33.41	9.44	4.74	23.07	4.67	25.47
9.	CAK-NS-15	29.61	27.61	7.29	2.78	22.43	5.37	26.70
10.	Coher-310	46.30	33.46	9.42	4.74	27.00	4.33	28.40
11.	CP-1512	65.21	35.09	6.61	3.26	25.20	4.93	28.27
12.	Daldran-6	45.14	35.01	8.41	4.53	24.40	4.60	29.27
13.	Deviraj	42.48	33.82	13.55	6.93	24.30	4.57	24.43
14.	G.Cot.-100	47.76	34.11	8.85	4.59	24.63	5.50	27.27
15.	H.128	35.01	33.00	7.76	4.20	26.47	5.27	27.10
16.	H-654-C	37.36	27.42	7.42	2.80	24.23	5.33	26.40
17.	IAA3932	35.94	26.56	7.70	2.78	25.50	3.53	26.43
18.	KOP-3	46.58	28.37	8.11	3.14	25.33	5.33	25.80
19.	LH-299	41.98	30.56	7.41	3.26	25.97	4.80	27.47
20.	LH-223-357	43.30	31.37	7.50	3.51	25.63	4.47	26.83
21.	LH-223-358	33.09	27.28	6.78	2.54	25.53	4.50	25.93
22.	LRK-516	38.36	29.22	7.92	3.27	25.36	4.50	28.70
23.	Mahalaxmi	35.15	34.27	7.63	3.98	23.43	5.23	26.63
24.	Mav-28	32.74	26.02	8.41	2.95	26.43	4.53	26.80
25.	ND-9	43.29	29.22	8.49	3.51	23.40	5.37	25.13
26.	SRT-5 locks	30.24	30.95	7.46	3.35	24.47	4.97	28.37
27.	SS Visnu	43.71	25.89	6.18	2.16	24.23	4.77	25.87
28.	Surat dwarf	39.00	25.00	7.72	2.58	26.30	4.78	27.67
29.	9/33/5056	43.06	27.77	7.53	2.90	25.70	4.80	26.67
30.	G N Cot.-26	43.37	32.69	9.68	4.70	26.53	4.33	29.00
	Mean	39.35	29.78	8.30	3.58	25.07	4.80	27.15
	Range	22.97-65.21	22.75-35.09	6.18-13.55	2.08-6.93	22.43-27.17	3.53-5.50	24.43-29.27
	S. Em.	1.43	0.72	0.29	0.20	0.60	0.18	0.57
	CD at 5%	4.06	2.03	0.81	0.56	1.69	0.50	1.62
	CV%	6.31	4.16	5.98	9.62	4.12	6.34	3.65

Estimation of genotypic and phenotypic variance indicated high contribution of genotypic variance into phenotypic variance for all characters, which specify that variability

present in the genotypes was mainly due to genetic constitution and it was less affected by environment.

Table 3: The estimates of genotypic (σ^2_g), phenotypic variance (σ^2_p) and other genetic parameters for different characters in cotton

Sr. No.	Characters	Variance components		GCV (%)	PCV (%)	h^2_b (%)	GA % Mean
		σ^2_g	σ^2_p				
1.	Days to 50% flowering	154.70	155.43	17.44	17.48	99.53	35.84
2.	Days to first picking	162.41	167.03	12.44	12.62	97.23	25.28
3.	Plant height	103.43	132.71	7.04	7.97	77.94	12.81
4.	Monopodia per plant	0.60	0.61	21.52	21.73	98.09	43.92
5.	Sympodia per plant	5.76	6.20	12.85	13.33	92.91	25.52
6.	Bolls per plant	253.45	260.19	27.54	27.91	97.41	56.01
7.	Boll weight	0.77	0.79	25.15	25.46	97.58	51.18
8.	Seed cotton yield per plant	384.45	420.35	20.31	21.24	91.46	40.02
9.	Lint yield per plant	55.59	57.64	18.94	19.29	96.43	38.32
10.	Ginning out turn	11.18	11.69	11.22	11.48	95.62	22.62
11.	Seed index	2.71	2.79	19.85	20.15	97.07	40.30
12.	Lint index	1.15	1.19	30.02	30.53	96.69	60.81
13.	Upper half mean length	0.99	1.34	3.97	4.63	73.65	7.02
14.	Fibre fineness	0.17	0.20	8.63	9.37	84.75	16.37
15.	Fibre strength	1.30	1.63	4.20	4.70	79.95	7.74
σ^2_g : Genotypic variance, σ^2_p : Phenotypic variance, GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, h^2_b : Broad sense heritability, GA % mean: Genetic advance as percent of mean							

The estimates of genotypic and phenotypic variances revealed that the characters *viz.*, days 50 % flowering, days to first picking, monopodia per plant, sympodia per plant, bolls per plant, boll weight, seed cotton yield per plant, lint yield per plant, ginning out turn, seed index, lint index, upper half mean length, fibre fineness and fibre strength showed larger contribution of genotypic variance to total variance and also expressed high magnitude of heritability, which indicated less influence of environmental factors on expression of these characters (Table 3) Extent of variability in the experimental material was high for monopodia per plant, bolls per plant, boll weight, seed cotton yield and lint index indicated by high estimates of GCV, while rest of the characters had low to moderate GCV estimates. Similar results was reported by Patel *et al.* (2023) [4]

Broad sense heritability ranged from 73.65 percent for upper half mean length to 99.53 percent for days to 50% flowering. The estimates of genetic advance as percent of mean were high coupled with high heritability for days to first picking, monopodia per plant, sympodia per plant, bolls per plant, boll weight, seed cotton yield per plant, lint yield per plant, ginning out turn, seed index and lint index, indicating the predominance of additive gene action in the inheritance of these traits. Hence, simple selection would be effective for genetic improvement of the said characters in desired direction. High heritability coupled with moderate genetic advance as percent of mean was observed for plant height and fiber fineness indicating the involvement of both additive and non-additive gene effects in control of this character. Only two character, upper half mean length and fibre strength, had high heritability coupled with low genetic advance as a percent of mean. This clearly indicated the existence of non-additive gene action in the expression of these traits. (Table 3). Present findings are confirmed by the reports of Jeyaraj *et al.* (2023) [5], Krishnan *et al.* (2023) [6] and Sagar *et al.* (2023) [7].

Based on correlation studies, the estimates of correlation coefficient revealed that three characters *viz.*, sympodia per plant, bolls per plant, lint yield per plant and ginning outturn showed highly significant and positive association with seed cotton yield per plant at both genotypic as well as phenotypic level, hence were most important yield contributing characters for increasing the seed cotton yield. (Fig. 1) As a result, there is an opportunity of increasing seed cotton yield per plant while improving these component traits through a selection process. Similar results were obtained by Jeyaraj *et al.* (2023) [5], Patel *et al.* (2023) [4], Sanmugapriya *et al.* (2023) [8], Selvaraj *et al.* (2023) [9], Vanda *et al.* (2023) [10].

It was further noticed that genotypic correlations were higher in magnitude than phenotypic correlations for majority traits, indicating strong and inherent association between two characters.

The path coefficient analysis revealed that highest positive direct effect on seed cotton yield was registered by lint index (0.719) followed by bolls per plant (0.474), lint yield per plant (0.445), days to first picking (0.190) and sympodia per plant (0.140). Remaining characters *viz.*, days to 50% flowering, plant height, boll weight, ginning out turn, seed index, upper half mean length and fibre fineness exerted direct negative effect on seed cotton yield per plant. (Fig. 2) lint index and bolls per plant could be considered as major yield components and should be given due weightage while exercising selection for improvement in terms of seed cotton yield as they had high positive direct effect as well as positive correlation with seed cotton yield. Similar results were obtained by Gauswami *et al.* (2021) [11], Mawblei *et al.* (2022) [3], Selvaraj *et al.* (2023) [9], Vanda *et al.* (2023) [10]. The residual effect was observed low (0.204) indicating there was no considerable effect *via* such traits which are not considered under investigation. (Fig 2.)

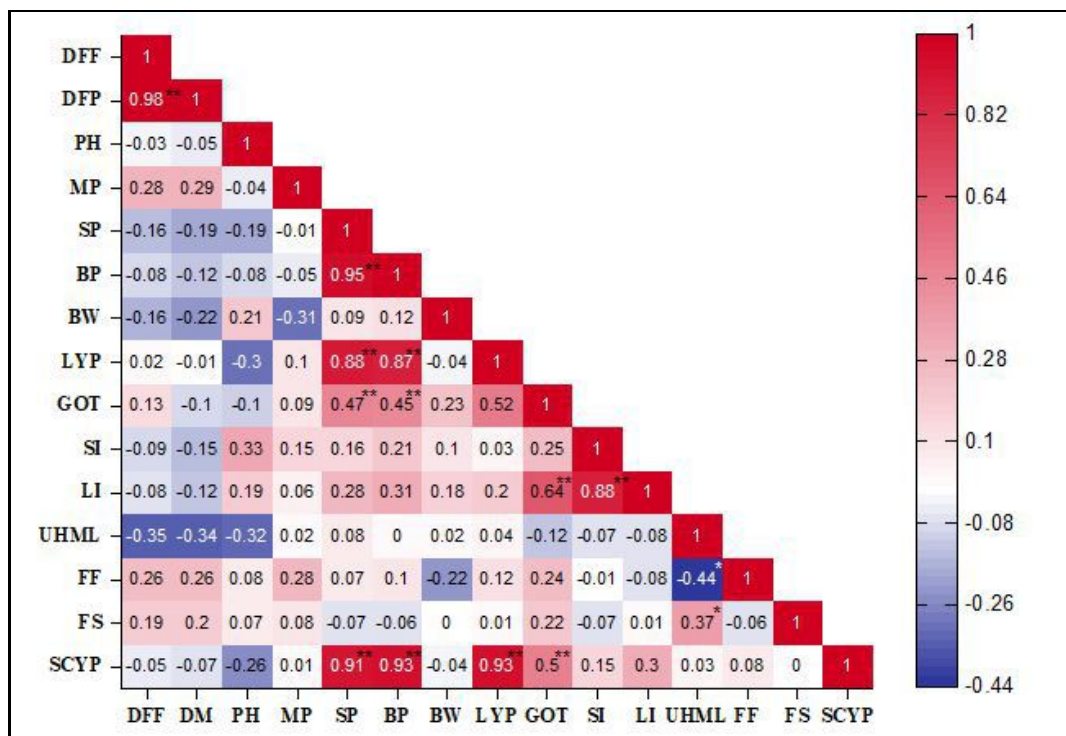
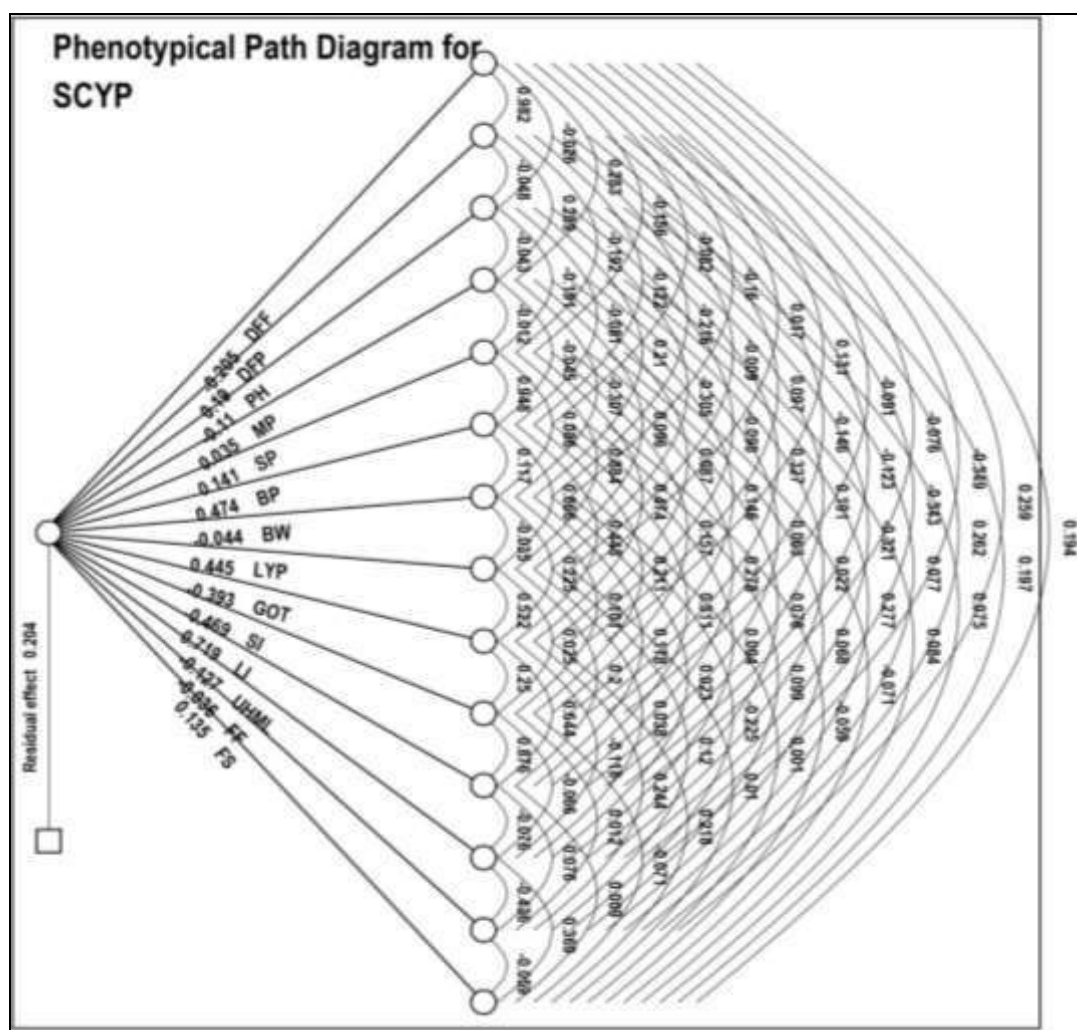


Fig 1: Pearson correlation coefficients among various characters and seed cotton yield.



where DFF = Days to 50% flowering, DFP = Days to first picking, PH = Plant height, MP = Monopodia per plant, SP = Sympodia per plant, BP = Bolls per plant, BW = Boll weight, LYP = Lint yield per plant, GOT = Ginning out turn, SI = Seed index, LI = Lint index, UHML = Upper half mean length, FF = Fibre fineness, FS = Fibre strength, SCYP = Seed cotton yield per plant.

Fig 2: Path diagram for 15 traits in cotton.

Conclusion

The findings of present experiment led to the conclusion that isolation of genotypes with higher seed cotton yield along with good quality is possible amongst the genotypes studied. The characters viz. days to 50% flowering, days to first picking, monopodia per plant, sympodia per plant, bolls per plant, boll weight, seed cotton yield per plant, lint yield per plant, ginning out turn, seed index and lint index displayed sufficient variability, high heritability and high genetic advance. Hence, these characters were mainly governed by additive gene action and could be improved by selection.

The correlation study revealed the importance of characters sympodia per plant, bolls per plant lint yield per plant and ginning outturn for enhancing seed cotton yield. Further, path coefficient analysis discovered that lint index and bolls per plant could be considered as major yield components and should be given due weightage while exercising selection because of their high positive direct effect.

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