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Combining ability estimates and gene action for seed cotton yield, its components and fibre quality parameters in intraspecific crosses of upland cotton (*Gossypium hirsutum* L.)

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Abstract
The present study aimed to assess the general combining ability (GCA) of parental lines and the specific combining ability (SCA) of hybrids for seed cotton yield, its yield-contributing components, and fibre quality traits to facilitate the development of high-yielding cultivars with superior fibre attributes. A line × tester mating design was employed, involving four lines and twenty testers, to generate 80 hybrids. Analysis of variance revealed significant GCA and SCA effects for most traits, indicating the importance of both additive and non-additive genetic effects. Non-additive gene action was predominant for traits such as days to square initiation, number of monopods and sympods per plant, number of bolls per plant, plant height, boll weight, seed cotton yield, harvest index, 2.5% span length, fibre strength, and fibre fineness. Conversely, additive gene action was more prominent for days to maturity and ginning outturn. Among the female parents, PIL-138 exhibited strong general combining ability for number of sympods and bolls per plant, boll weight, seed cotton yield, and ginning outturn. PIL-139 showed good combining ability for fibre strength. RS 875 displayed significant negative GCA effects for earliness, monopods per plant, plant height, maturity duration, and fibre fineness-traits often desirable for specific breeding goals. Among testers, F-1040 showed good GCA for number of bolls, boll weight, sympods per plant, and seed cotton yield. EC676017 was favorable for monopods per plant and plant height, while RC-8 contributed to early square initiation. PIL-136 was a desirable tester for harvest index and ginning outturn. Notably, EC676015 was identified as an excellent general combiner for all fibre quality traits.
Hybrids showing high positive and significant SCA effects for seed yield included RS 875 × RC-85, RS 875 × PIL-135, and LH 900 × RC 240. For fibre traits, the combinations PIL-138 × EC676018, PIL-138 × EC676026, and PIL-139 × RC-85 were found to be promising based on their significant SCA effects. These results provide valuable insights for selecting superior parental lines and hybrid combinations in cotton breeding programs aimed at improving yield and fibre quality.

Keywords: Cotton, general and specific combining ability, line × tester analysis, additive gene action

Introduction
Cotton, often referred to as the "King of Fibre," is one of the most significant economic crops globally, serving as the primary source of natural fibre for the textile industry. Upland cotton (*Gossypium hirsutum* L.) accounts for approximately 95% of global cotton production. In India, cotton plays a pivotal role in the agricultural economy, contributing substantially to national income and foreign exchange earnings (Alkuddsi *et al*., 2013) [1].
With advancements in spinning technologies and the expanding range of cotton applications, the improvement of fibre quality has become a top priority in cotton breeding programs (Liang *et al*., 2013) [11]. Breeding new cultivars with both high yield and superior fibre quality is now the central objective for cotton breeder's worldwide (Ashokkumar *et al*., 2010) [2].
In Punjab, cotton is the third most important crop and is cultivated over an area of approximately 5.05 lakh hectares. However, all the currently recommended varieties and hybrids in the state possess only medium fibre quality. Despite decades of breeding efforts, there has been limited progress in enhancing fibre traits.

Furthermore, cotton yields have stagnated over the past decade, possibly due to a narrow genetic base initially constrained by polyploidization and domestication bottlenecks and later exacerbated by the overuse of elite germplasm in breeding programs. These programs have typically captured only a small portion of the existing genetic variation (Brubaker *et al*., 1999) [3].

To overcome this genetic stagnation, the use of exotic germplasm has emerged as a valuable strategy. Introducing new alleles-particularly those associated with high fibre strength-from foreign genetic resources, such as accessions from the United States, holds promise for cotton improvement. Selecting the right parental lines is the cornerstone of any successful breeding program. Estimating the general combining ability (GCA) of germplasm lines for lint yield and fibre quality helps identify parents capable of contributing to simultaneous genetic improvement of these traits.

The line × tester mating design (Kempthorne, 1957) [6] provides a systematic framework for identifying suitable parental combinations. This approach not only helps estimate GCA and specific combining ability (SCA) but also sheds light on the underlying genetic control of important traits, guiding the formulation of effective breeding strategies.

The present study was therefore conducted to evaluate the GCA and SCA of exotic and locally available cotton genotypes for seed cotton yield, its yield components, and fibre quality traits, with the goal of identifying superior parents and cross combinations for future breeding programs.

Material and Methods

An experiment was conducted at the experimental field of the Department of Plant Breeding and Genetics, Punjab Agricultural University during *Kharif* 2010 and *Kharif* 2011. The breeding material consisted of four females *viz.* PIL-138, PIL-139, LH 900 and RS 875 and twenty testers including eight exotic accessions *viz.* EC676023, EC676021, EC676015, EC676017, EC676018, EC676022, EC676014, EC676026 and twelve indigenous lines namely PIL-138, PIL-139, PIL-137, RC-85, RC-8, PIL-8, PIL-8H, CIM240, RC 240, F-1040, IL-92, RC-79. The females were crossed with males in lines × tester mating design to develop eighty crosses during *Kharif*, 2010.

The seeds of the parental lines and their corresponding 80 F_1 hybrids were sown during the *Kharif* season of 2011 using a randomized complete block design (RCBD) with three replications. Each plot consisted of a 6-meter row, with a spacing of 75 cm between rows and 60 cm between plants. Three seeds were dibbled per hill to ensure uniform germination, and later thinned to retain one healthy seedling per hill.

Observations were recorded on five competitive plants per genotype in each replication for 13 traits: days to square initiation, number of monopods per plant, number of sympods per plant, number of bolls per plant, plant height (cm), days to maturity, boll weight (g), seed cotton yield per plant (g), harvest index (%), ginning outturn (%), 2.5% span length (mm), fibre strength (g/tex), and fibre fineness (µg/inch).

The mean values for each trait across replications were subjected to analysis of variance (ANOVA) as per the method of Panse and Sukhatme (1964). Line × tester analysis, following the method proposed by Kempthorne (1957) [6], was conducted to estimate General Combining Ability (GCA) effects of the parents and Specific Combining Ability (SCA) effects of the hybrids for the traits under investigation.

Results and Discussion

Analysis of variance

The 24 parental lines and 80 hybrids evaluated in this study exhibited significant variation for all the yield components and fibre quality traits analyzed (Tables 1 & 2), indicating the presence of substantial genetic variability within the experimental material. Analysis of variance revealed that the mean squares for parents vs. hybrids were significant for all characters except boll weight, suggesting the presence of average heterosis in most traits (Table 1).

Further, line × tester analysis (Table 2) showed highly significant mean squares for lines, testers, and line × tester interactions across all traits, confirming differential combining ability among the genotypes. Notably, the magnitude of specific combining ability (SCA) effects was greater than that of general combining ability (GCA) effects for most traits, including days to square initiation, number of monopods and sympods per plant, number of bolls per plant, plant height, boll weight, seed cotton yield, harvest index, 2.5% span length, fibre strength, and fibre fineness. This indicates a predominance of non-additive gene action in the inheritance of these traits. However, for days to maturity and ginning outturn, additive gene action was more prominent, as evidenced by higher GCA effects.

These findings suggest that high performance in yield components and fibre quality traits did not always align within the same genotypes, reflecting independent genetic control of these parameters. The GCA/SCA ratios and degree of dominance further supported the predominance of non-additive gene action for most traits. These results are consistent with previous studies reporting non-additive gene effects for number of bolls, boll weight, and seed cotton yield (Ashokkumar *et al*., 2010) [2], although other studies have highlighted the role of both additive and non-additive effects (Kumaresan *et al*., 1999) [9].

Similarly, non-additive gene action has been emphasized in the inheritance of seed cotton yield (Kumar *et al*., 2014), while fibre strength and micronaire have been attributed to additive gene action, and fibre length to non-additive gene action (Lukange *et al*., 2007) [14]. Ashokkumar *et al*. (2010) [2] also noted a significant role of non-additive gene effects in the inheritance of fibre quality traits, supporting the present findings.

The magnitude of GCA variances were higher than SCA variance for days to maturity (Simon *et al.*, 2013) [18] and ginning outturn (Jatoi *et al.*, 2011) [4] indicating the importance of additive gene action for these characters. The results of this study would suggest that heterosis breeding was suitable for all the characters including fibre properties except ginning outturn and days to maturity. The non-additive gene actions are also important for varietal adaptability.

General combining ability analysis

Combining ability analysis provides valuable insights for selecting suitable parents based on the performance of their hybrids, and plays a crucial role in heterosis breeding. In the present study, the lines PIL-138 and RS875, along with

testers F-1040 and EC676015, emerged as the best general combiners, exhibiting significant GCA effects for the majority of yield-related and fibre quality traits (Table 3).

Among the lines, PIL-138 consistently demonstrated strong general combining ability for key yield attributes, including number of sympods per plant, number of bolls per plant, boll weight, seed cotton yield per plant, and ginning outturn. Similarly, the tester F-1040 ranked highest for number of bolls per plant, boll weight, and number of sympods per plant, making it a strong general combiner for seed cotton yield and its component traits. Additionally, RC-85 was also identified as a superior male parent for seed cotton yield.

For other traits, RS875 emerged as the best general combiner for early square initiation, reduced plant height, lower monopod number, earlier maturity, and superior 2.5% span length, making it a valuable female parent for these traits. The line PIL-139 was identified as the best general combiner for fibre strength and fibre fineness, whereas LH900 was noted for its strong GCA effects on harvest index.

In terms of testers for fibre quality traits, EC676015 was identified as the best general combiner for 2.5% span length, and a good general combiner for fibre strength and fibre fineness. PIL-8 and EC676018 were identified as top general combiners for fibre fineness and fibre strength, respectively.

Other notable general combiners included:-

- EC676017 for number of monopods per plant and plant height
- RC-8 for early square initiation
- PIL-136 for harvest index and ginning outturn
- EC676021 for earliness (days to maturity)

Overall, PIL-138 and F-1040 stand out as valuable sources of favorable alleles for improving seed cotton yield and its contributing traits, while RS875, PIL-139, and EC676015 offer strong potential for enhancing fibre quality characteristics.

Specific combining ability analysis

Based on the SCA effects presented in Table 4, most of the hybrid combinations exhibiting high SCA values resulted from crosses between geographically diverse parents. This observation aligns with the findings of Joshi and Dhawan (1966) [5], who reported high SCA effects in hybrids derived from genetically diverse parental lines.

Analysis of specific combining ability revealed significant variation across the 80 hybrids evaluated. A total of:

- 8 hybrids exhibited significant negative SCA effects for days to square initiation,
- 9 hybrids for plant height,
- 29 hybrids for days to maturity,
- 5 hybrids for number of monopods per plant, and
- 22 hybrids for fibre fineness, suggesting potential for earliness, compact plant architecture, and finer fibre traits.

Conversely, a significant number of hybrids showed positive SCA effects, indicating favorable contributions for yield and fibre traits:

- 9 hybrids for number of sympods per plant,
- 17 hybrids for number of bolls per plant,
- 10 hybrids for boll weight,
- 26 hybrids for seed cotton yield per plant,
- 12 hybrids for harvest index,
- 3 hybrids for ginning outturn,
- 30 hybrids for 2.5% span length, and
- 26 hybrids for fibre strength.

Among the top-performing hybrids with significant positive SCA effects for seed cotton yield, the most promising combinations were:

- RS 875 × RC-85,
- RS 875 × PIL-135,
- LH 900 × RC-240,
- RS 875 × EC676017, and
- LH 900 × EC676023.

For fibre quality traits, hybrids such as:

- PIL-138 × EC676018,
- PIL-138 × EC676026,
- PIL-139 × RC-85,
- LH 900 × PIL-8, and
- LH 900 × IL-92, demonstrated desirable SCA effects for 2.5% span length, fibre strength, and fibre fineness.

When genetic variation arises from additive gene effects, selection from segregating populations is an effective strategy for identifying plants with a desirable combination of traits. In contrast, when non-additive gene action predominates, as indicated for many traits in this study, heterosis breeding becomes a more suitable approach for exploiting hybrid vigor and improving cotton yield and quality.

Table 1: Analysis of variance for mean squares for different traits in *intra hirsutum* crosse

Source of variation	D.F	Mean sum of squares												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Replicates	2	19.423	10.149**	74.607**	873.988**	4584.904**	4.654	2.979**	20,023.74**	6.736	1.971	0.328	0.401	0.026
Parents	23	15.841	1.585**	64.877**	211.874**	437.620**	164.812**	0.594**	3429.774**	386.167**	8.123**	7.121**	38.327**	1.252**
Lines	3	33.223	1.000**	54.528**	42.750**	74.305	351.858**	0.608**	1332.111**	1401.790**	39.591**	5.672**	3.887**	1.943**
Testers	19	13.272	1.723**	66.368**	220.648**	461.821**	116.283**	0.600**	3816.57**	245.863**	2.975	1.759**	24.748**	0.574**
Lines vs testers	1	12.488	0.711**	67.600**	552.545**	1067.742**	525.719**	0.441**	2373.653**	5.075	11.525*	113.344**	399.639**	12.063**
Parents vs hybrids	1	660.250**	20.646**	494.176**	2858.308**	9060.496**	13242.00**	22.833	102.412**	587.632**	115.234**	2.961**	34.647**	5.346**
Hybrids	79	61.841**	0.323**	13.062**	125.103**	707.571	220.279**	0.292**	2373.653**	173.656**	9.877**	3.239**	7.774**	0.534**
Error	206	19.831	0.087	3.307	7.022	90.694	1.704	0.065	202.429	32.244	2.415	0.118	0.157	0.012

Source of variation	D.F	Mean sum of squares												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Lines	3	196.606**	1.768**	46.722**	426.739**	4557.872**	2857.200**	1.065**	7596.423**	383.159**	104.258**	1.832**	29.767**	4.989**
Testers	19	93.847**	0.474**	20.408**	237.724**	1248.180**	195.509**	0.339**	6387.799**	247.778**	12.366**	5.532**	8.751**	0.692**
Lines X testers	57	44.079**	0.197**	8.842**	71.687**	324.720**	89.750**	0.236**	1269.572**	137.922**	4.079**	2.549**	6.291**	0.247**
Error	206	19.831	0.087	3.307	7.022	90.694	1.704	0.065	193.712	32.244	2.415	0.118	0.167	0.012
Estimates of genetic components														
σ^2 Females		2.542	0.026	0.631	5.918	70.553	46.124	0.014	105.272	4.087	1.670	-0.012	0.543	0.079
σ^2 Males		4.147	0.023	0.964	13.836	76.955	8.813	0.009	427.413	9.155	0.691	0.249	0.238	0.037
σ^2 Female x Males (*sca*)		8.083	0.037	1.845	21.555	78.009	29.349	0.057	358.62	35.226	0.555	0.811	2.041	0.078
σ^2 *gca*		2.810	0.026	0.687	7.237	71.620	39.906	0.013	158.959	4.932	1.506	0.031	0.36	0.072
σ^2 *gca*/σ^2 *sca*		0.348	0.701	0.372	0.336	0.918	1.360	0.227	0.443	0.140	2.716	0.039	0.176	0.918
DD $(2VD/VA)^{1/2}$		1.696	1.193	1.639	1.726	1.044	0.858	2.094	1.502	2.673	0.607	5.115	2.381	1.041

*, **-significant at 5 per cent and 1 per cent level, respectively

DD = Degree of dominance

1. Days to square initiation, 2. Number of monopods per plant, 3. Number of sympods per plant, 4. Number of bolls per plant, 5. Plant height (cm), 6. Days to maturity, 7. Boll weight (g), 8. Seed cotton yield per plant (g), 9. Harvert Index (%), 10. Ginning outturn (%), 11. 2.5% Span length (mm), 12. Fiber strength (g/tex), 13. Fiber fineness (µg/inch)

Sr. No.	Parents	1	2	3	4	5	6	7	8	9	10	11	12	13
Lines														
1	PIL-138	0.2	0.24**	0.85**	3.78**	11.57**	4.95**	0.17**	16.58**	-0.40	-0.57*	0.08	-0.19**	0.24**
2	PIL-139	1.1*	-0.01	0.63**	-1.25**	1.87	6.77**	0.04	-6.62**	-3.28**	-1.59**	-0.16**	1.16**	-0.42**
3	LH 900	1.32*	-0.07*	-0.48*	-0.2	-0.63	-4.5**	-0.09**	-7.36**	2.60**	1.17**	-0.13**	-0.31**	0.11**
4	RS 875	-2.62**	-0.16**	-0.99**	-2.33**	-7.01**	-7.23**	-0.12**	-2.60	1.00	0.99**	0.21**	-0.66**	0.07**
SE		0.50	0.03	0.20	0.30	1.06	0.15	0.03	0.01	0.63	0.17	0.04	0.04	0.01
CD 5%		0.98	0.06	0.40	0.58	2.09	0.29	0.06	0.01	1.24	0.34	0.08	0.09	0.02
CD 1%		1.28	0.09	0.52	0.76	2.75	0.38	0.07	0.03	1.64	0.45	0.10	0.11	0.03
Testers														
1	PIL-138	-2.87*	0.01	-1.49**	1.99**	0.15	1.84**	0.14	13.14**	1.77	1.2**	0.57**	-0.02	-0.13**
2	PIL-139	0.05	0.01	1.22*	0.97	6.40**	3.34**	0.22**	22.15**	7.58**	1.51**	0.78**	0.03	-0.04
3	PIL-137	-3.03*	-0.06	0.65	0.20	-3.51	2.50**	-0.13	6.06	-3.18*	2.16**	-0.01	0.05	-0.03
4	RC85	3.47**	0.26**	0.83	3.58**	2.74	2.34**	-0.15*	48.76**	1.48	0.63	-0.20*	-0.89**	0.06
5	RC-8	-5.70**	0.05	0.24	-0.95	1.82	0.59	-0.12	-3.11	-1.29	-1.19**	0.01	-1.76**	-0.10**
6	PIL-8	-3.78*	-0.17*	1.00	1.36*	2.32	-1.33**	0.25**	22.83**	8.52**	0.25	0.89**	0.26*	-0.52**
7	PIL-8H	-2.62*	-0.26**	0.37	-0.85	1.32	4.92**	0.14	14.19**	2.9	0.87*	-0.11	0.13	0.23**
8	CIM240	0.30	0.03	1.21*	2.90**	9.40**	2.42**	0.18*	17.08**	6.35**	0.36	-0.07	-0.80**	0.09**
9	RC 240	1.72	0.01	1.21*	6.45**	16.74**	1.59**	-0.06	-7.98*	-11.28**	0.42	0.42**	0.74**	-0.10**
10	F-1040	-0.45	0.43**	2.85**	7.31**	24.82**	7.42**	0.22**	29.31**	-0.23	-0.40	0.69**	1.59**	0.07*
11	IL-92	-2.03	0.22**	0.11	6.17**	9.65**	3.34**	-0.02	27.44**	3.00	-1.21**	-0.79**	0.06	-0.07*
12	RC-79	-0.62	0.03	-1.16*	-2.26**	-6.01*	3.92**	-0.08	-16.13**	-0.03	-0.25	-0.16	-0.6**	-0.15**
13	EC676023	-0.20	0.30	-0.25	2.30**	-0.60	-5.75**	0.01	-12.41**	0.49	-0.39	-0.79**	-0.97**	0.48**
14	EC676021	2.40	-0.24**	-1.79**	-5.85**	-10.01**	-6.5**	-0.23**	-24.91**	-5.29**	-1.67**	0.28**	1.17**	0.03
15	EC676015	-0.20	-0.08	-0.10	-3.49**	-12.01**	-5.08**	-0.15*	-11.00**	0.45	-0.54	0.98**	1.26**	-0.16**
16	EC676017	0.55	-0.39**	-2.67**	-8.32**	-18.01**	-4.58**	-0.20	-20.77**	-2.14	0.06	-1.27**	0.51**	-0.3**
17	EC676018	2.3	0.05	0.09	-2.09**	-5.51	-5.25**	0.27**	-26.40**	-1.12	-1.41**	-0.62**	0.71**	0.54**
18	EC676022	2.47*	-0.09	-1.77**	-6.35**	-11.6**	-2.33**	-0.17*	-26.29**	-0.88	-0.99*	-0.53**	-0.03	0.06
19	EC676014	5.88**	-0.10	-0.55	-5.90**	-7.51**	-3.5**	-0.15*	-28.49**	-3.52*	0.04	0.91**	-0.63**	0.12**
20	EC676026	2.3	0.03	-0.01	2.85**	-0.6	0.09	0.02	-23.47**	-3.58*	0.56	0.92**	-0.79**	-0.02
SE		1.25	0.08	0.51	0.75	2.68	0.37	0.07	3.92	1.60	0.44	0.10	0.11	0.03
CD 5%		2.46	0.16	1.00	1.46	5.25	0.72	0.14	7.68	3.13	0.86	0.19	0.22	0.06
CD 1%		3.23	0.21	1.32	1.92	6.91	0.95	0.18	10.10	4.12	1.13	0.25	0.29	0.08

*, **-significant at 5 per cent and 1 per cent level respectively

1. Days to square initiation, 2. Number of monopods per plant, 3. Number of sympods per plant, 4. Number of bolls per plant, 5. Plant height (cm), 6. Days to maturity, 7. Boll weight (g), 8. Seed cotton yield per plant (g), 9. Harvert Index (%), 10. Ginning outturn (%), 11. 2.5% Span length (mm), 12. Fiber strength (g/tex), 13. Fiber fineness (µg/inch)

Table 2: Top five crosses of SCA effects for seed cotton yield, its components and fiber quality traits

Sr. No.	Traits	No of hybrids with desirable significant SCA	Range of SCA effects	Top ranking hybrids	SCA effects
1	Days to Square Initiation	8	-7.62** to 8.38**	PIL-138 X CIM240	-7.62**
				PIL-139 X PIL-135	-6.68**
				LH 900 X EC676023	-6.23**
				PIL-139 X EC676021	-5.35*
				LH 900 X EC676017	-5.32*
2	Number of Monopods per Plant	5	-0.80** to 0.51	PIL-139 X RC85	-0.80**
				RS 875 X RC 240	-0.36*
				LH 900 X EC676018	-0.33*

				LH 900 X PIL-135	-0.29*
				LH 900 X EC676022	-0.29*
3	Number of Sympods per Plant	9	-1.86 to 3.22**	PIL-139 X PIL-137	3.22**
				PIL-139 X EC676015	2.56**
				PIL-139 X PIL-8H	2.53**
				PIL-138 X PIL-136	2.46**
				LH 900 X RC 240	2.36**
4	Number of bolls per plant	17	-10.58** to 11.41**	PIL-138 X IL-92	11.41**
				PIL-139 X PIL-135	10.43**
				PIL-139 X EC676026	9.86**
				PIL-138 X EC676023	7.72**
				LH 900 X RC 240	7.45**
5	Plant height (cm)	9	-20.79** to 20.93**	PIL-139 X EC676014	-20.79**
				RS 875 X EC676026	-20.15**
				LH 900 X RC-79	-18.65**
				PIL-138 X CIM240	-15.74**
				PIL-138 X PIL-137	-14.49**
6	Days to Maturity	29	-9.59** to 9.33**	LH 900 X EC676026	-9.59**
				PIL-138 X PIL-137	-8.45**
				PIL-138 X PIL-136	-7.95**
				PIL-138 X PIL-135	-7.45**
				LH 900 X EC676017	-6.92**
7	Bollweight (g)	10	-0.65** to 0.49**	LH 900 X RC 240	0.49**
				RS 875 X EC676015	0.48**
				PIL-139 X PIL-137	0.43**
				RS 875 X RC-8	0.38**
				PIL-139 X EC676021	0.37**

*, **-significant at 5 per cent and 1 per cent level respectively

Sr. No.	Traits	No of hybrids with desirable significant SCA	Range of SCA effects	Top ranking hybrids	SCA effects
8	Seed cotton yield per plant(g)	26	-30.54** to-42.37**	RS 875 X RC85	42.37**
				RS 875 X PIL-135	39.67**
				LH 900 X RC 240	39.35**
				RS 875 X EC676017	34.97**
				LH 900 X EC676023	29.81**
9	Harvest Index (%)	12	-13.81 to 17.59**	RS 875 X F-1040	17.59**
				RS 875 X EC676026	13.02**
				PIL-138 X RC 240	12.70**
				RS 875 X EC676015	10.80**
				PIL-139 X EC676018	9.55**
10	Ginning outurn (%)	4	-2.29** to 3.37**	PIL-139 X EC676026	3.37**
				PIL-139 X PIL-8H	1.83*
				RS 875 X EC676022	1.82*
				PIL-139 X RC-8	1.73*
11	2.5% Span length (mm)	30	-2.25** to 1.92**	LH 900 X IL-92	1.92**
				PIL-139 X EC676017	1.53**
				PIL-138 X PIL-136	1.34**
				RS 875 X EC676014	1.17**
				RS 875 X RC-8	0.99**
12	Fiber Strength(g/tex)	26	-4.76 to 3.74**	PIL-138 X EC676018	3.74**
				RS 875 X EC676026	2.34**
				RS 875 X PIL-8H	2.22**
				LH 900 X RC-79	2.07**
				PIL-139 X PIL-137	1.96**
13	Fiber fineness (µg/inch)	22	-0.61** to 0.50**	PIL-139 X RC85	-0.61**
				PIL-138 X EC676026	-0.58**
				PIL-139 X RC 240	-0.55**
				PIL-138 X PIL-136	-0.47**
				PIL-138 X EC676014	-0.46**

*, **-significant at 5 per cent and 1 per cent level respectively

Conclusion

The present investigation demonstrated significant genetic variability among parents and their hybrids for yield components and fibre quality traits, highlighting the potential for genetic improvement in upland cotton. The predominance of non-additive gene action for most traits-including seed cotton yield, number of bolls per plant, boll weight, and fibre quality parameters-suggests that heterosis breeding can be effectively utilized to enhance productivity and fibre characteristics. Lines such as PIL-138 and RS 875, and testers like F-1040 and EC676015, emerged as superior general combiners for multiple traits and can serve as valuable parental lines in breeding programs. Several hybrids, notably RS 875 × RC-85, LH 900 × RC-240, and PIL-138 × EC676018, displayed high specific combining ability and desirable trait combinations, indicating their potential for direct exploitation or use in further selection programs. This study reinforces the usefulness of line × tester analysis for identifying promising parental combinations and understanding gene action governing key agronomic and fibre traits. The integration of elite and exotic germplasm with diverse genetic backgrounds offers a viable strategy to break the existing yield plateau and

achieve simultaneous improvement in yield and fibre quality in cotton.

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