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Genetic analysis of fibre traits in upland cotton (*Gossypium hirsutum* L.)

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ABSTRACT: A diallel set of ten parental lines of upland cotton was evaluated for lint yield, lint index, ginning outturn, 2.5 per cent span length, fibre strength, fibre fineness and maturity coefficient at the experimental area of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. Significant additive genetic variance was detected for lint index, ginning outturn, 2.5 per cent span length and fibre strength, whereas the dominance genetic variance was found to be highly significant for all the characters studied except for ginning outturn. Epistasis was found to be present only in the inheritance of fibre fineness. The gca and sca effects were highly significant for almost all the characters. The parent RS 2013 was the best combiner for lint yield and also a good combiner for fibre strength whereas GTSV 337 was the best combiner for fibre strength and good combiner for lint yield /plant and ginning outturn but it was poor combiner for fibre length, fibre fineness and maturity coefficient. For fibre quality traits, RS 2094 was found to be good combiner for all the fibre quality traits *viz.* ginning outturn, 2.5 per cent span length, fibre strength and maturity coefficient. Pusa 317 was observed to be the best combiner for fibre length and fibre fineness, and good combiner for fibre strength. The scope of utilizing these parental lines for simultaneous improvement of lint yield and fibre quality traits has been discussed.

Key words: Combining ability, genetic analysis, lint yield and quality, upland cotton (*Gossypium hirsutum* L.).

Cotton is an important cash crop of the world, and India ranks first in acreage. At present cotton accounts for 44 per cent of all the fibres used in the world. The cotton industry depends on lint yield and ultimately on the quality of cotton fibre. The lint yield which is a complex character directly depends on seed cotton yield and ginning outturn. Similarly, fibre quality depends upon 2.5 per cent span length, fibre strength, fibre fineness and maturity coefficient. Research efforts led to the improvement of fibre length from 22-23mm in early eighties to 28-30mm in the nineties in *hirsutum* cotton. Fibre strength is also an important property of cotton fibre, but till date more attention was given to fibre length as spinnability depends upon it. It affects the processing performance of fibre and finished product fabric. The yarn spun from varieties having poor strength will fetch less price in the market. With the advancement in spinning techniques, from ring spinning to open end spinning, more emphasis is being given to fibre strength along with other fibre properties. Work on improvement of fibre strength along with other fibre properties has been under taken by many advanced cotton growing countries. Significant genetic improvement in fibre strength has been made in USA with the development and release of genotypes like Tamcot Lotus, with 30.2g/tex fibre strength. Genotypes with high fibre strength are also available in the germplasm in India. The major problem encountered while improving these quality traits is the negative correlation between fibre length and fibre strength as well as fibre fineness and fibre strength.

Higher yield is always a desired trait in all the crops. More is the yield, better will be the returns to the farmers. To improve lint yield selection has to be made for higher seed cotton yield and better ginning outturn. It is well known that environment also plays a major role in their expression of these traits. To bring simultaneous improvement for lint yield and fibre quality traits it is very important to know the genetics of these traits. The present study was, therefore, under taken to know the genetics of fibre quality and yield, and the combining ability of the parental lines.

The present investigations were conducted at the experimental area of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. The experimental material consisted of ten reasonably homozygous parental lines namely GTSV 337, RS 2013, RS 2094, RS 2097, PIL 8-5, Pusa 317, F 1861, H 1126, CSH 1071 and CNH 13, and their forty five cross combinations (F_1s), excluding reciprocals *i.e.* half diallel set. These 45 crosses along with 10 parental lines were grown in a randomized complete block design with three replications during *kharif,* 2010. Plants were spaced 67.5cm between rows and 60cm within rows. All recommended package of practices were followed to raise the crop. Seed cotton was picked at the time of maturity. Twenty boll samples/entry were collected at the same time to estimate fibre traits *viz.,* lint index, ginning outturn, 2.5 per cent span length, fibre strength, fibre fineness and maturity coefficient. The analysis of variance for all the traits was performed to study the variation between parental lines and F_1 progenies. The analysis of gca and sca was performed. The estimates of variance for gca and sca and their effects were computed to Model I (fixed effect model) and method 2 (parents and one way hybrids). Genetic parameters were estimated.

The analysis of variance for combining ability effects (Table 1) revealed highly significant variance due to gca and sca effects for all the traits under study. Further the gca/sca ratio for lint yield, lint index, 2.5 per cent span length and fibre fineness showed that gca effects were more important then sca effects indicating the importance of additive and additive x additive type of gene action. The results are in accordance with the findings of Patel *et al.,* (2009) for lint yield; Kaushik *et al.,* (2006) for lint index; Kaushik *et al* (2006) and Bhaskaran and Ravikesavan (2008) for 2.5 per cent span length; Bhaskaran and Ravikesavan (2008) for fibre fineness. Whereas, Pole *et al.,* (2008) and Deosarkar *et al.,* (2009) contradicted present findings and reported higher magnitude of sca variance for lint yield and fibre length. For ginning outturn and fibre strength, the sca effects seemed to be comparatively more important than the gca effects which corresponds to non additive effects, and the results are corroborative with the findings of Pole *et al.,* (2008) and Deosarkar *et al.,* (2009) for ginning outturn; and Ali *et al.,* (2008) for fibre strength, but contradicted the findings where gca effects were reported to be more important suggesting the pre poderance of additive gene

Table 1. Analysis of variance for combining ability effects for fibre traits in upland cotton.

Source of variation	d.f.	Mean sum of square						
		Lint yield (g)	Lint index (g)	Ginning outturn (%)	2.5 per cent span length (mm)	Fibre strength (g/tex)	Fibre fineness (Mic)	Maturity coefficient
gca	9	28.5214**	0.4093**	1.6906**	3.7109**	1.0306**	0.1531**	0.00008**
sca	45	10.6284**	0.1547**	1.8404**	1.4772**	1.4738**	0.1043**	0.00007**
Error	108	0.0825	0.0054	0.0733	0.0082	0.0103	0.0019	0.00001

*,** significance at 5 per cent and 1 per cent level of significance, respectively

effects by Bhaskaran and Ravikesavan (2008), Patel *et al.,* (2009) and Kannan *et al.,* (2013) for ginning outturn; Bhaskaran and Ravikesavan (2008) and Kannan *et al.,* (2013) for fibre strength; and Kannan *et al.,* (2013) for lint index, fibre length and fibre fineness.

Estimates of gca affects showed that the parent RS 2013 was the best general combiner for lint yield and also good combiner for fibre strength, whereas RS 2097 was the best general combiner for ginning outturn but poor combiner for lint yield (Table 2). For fibre traits, Pusa 317 was the best general combiner for 2.5 per cent span length and fibre fineness, whereas for fibre strength the best general combiner was GTSV 337 which was also good general combiner for lint yield, ginning outturn and fibre fineness. It can be concluded that by involving different parents with specific characters in a multiple cross, a base population having maximum genetic variation can be developed and the selection for the desirable recombinants can be made from that base population.

For lint yield and its component traits the best specific cross combination F 1861 x CSH 1071 was a good combiner for lint yield, lint index and ginning outturn as it showed highly significant mean squares for all these traits (Table 3). This cross combination was also good combiner for fibre fineness. RS 2013 x F 1861 also seemed to be the best cross combination as it was good specific combiner for lint yield, lint index and ginning outturn. Among other cross combinations PIL 8-5 x CNH 13 and F 1861 x H 1226 were good specific combiner for lint yield, lint index, ginning outturn and 2.5 per cent span length. Both RS 2013 x PIL 8-5 and GTSV 337 x RS 2094 were very good specific combiners for lint yield and maturity coefficient.

For fibre quality traits, the cross combination Pusa 317 x CNH 1071 was good specific combiner for ginning outturn, 2.5 per cent span length and fibre strength, which was also a good specific combiner for lint yield and lint index. For simultaneous improvement of lint yield and fibre quality traits it was observed that Pusa 317 x F 1861 was also a best combiner for lint yield along with two most important fibre quality traits as fibre length and fibre strength. RS 2013 x Pusa 317 was also observed to be a good specific cross combination for simultaneous improvement of lint yield and fibre quality traits as it showed highly significant mean squares for lint yield, lint index, fibre length and fibre

Table 2. General combining ability (gca) effects for fibre traits in upland cotton

Genotypes	Lint yield (g)	Lint index (g)	Ginning outturn (%)	2.5 per cent span length	Fibre strength (g/tex) (mm)	Fibre fineness (Mic)	Maturity coefficient
GTSV 337	**1.6013****	-0.0044	**0.4683****	-0.6072**	**0.6239****	-0.0300*	-0.0001
RS 2013	2.7774**	-0.0961**	-0.3206**	-0.4072**	0.1628**	0.0006	-0.0003
RS 2094	-1.8198**	-0.1711**	0.2628**	0.2817**	0.0794**	0.1644**	0.0049**
RS 2097	-2.5059**	0.1761**	**0.4850****	**0.6878****	-0.0983**	0.0978**	0.0011
PIL 8-5	-0.6559**	0.3678**	0.3739**	0.5039**	-0.0956**	-0.0189	-0.0012
PUSA 317	0.5152**	0.1150**	-0.4122**	**0.8900****	**0.2128****	**-0.2300****	-0.0045**
F 1861	0.3080**	0.0678**	0.0906**	-0.5156**	-0.4789**	0.1228**	0.0033**
H 1226	0.6136**	-0.2378**	-0.2094**	-0.1128**	-0.1733**	0.0006	-0.0003
CSH 1071	-0.4753**	-0.1544**	-0.4344**	-0.6267**	-0.1206**	-0.0133	-0.0012
CNH 13	-0.3587**	-0.0628**	-0.3039**	-0.73.9**	-0.1122**	-0.0939**	-0.0017
S.E. $_{(m)}$	0.0786	0.0202	0.0742	0.0248	0.278	0.012	0.0001
S.E. $_{(d)}$	0.1172	0.0300	0.1106	0.369	0.415	0.018	0.0001

*,** significance at 5% and 1% level of significance, respectively

strength. On the basis of gca effects it can be concluded that RS 2013 can be used in cross combinations with Pusa 317, GTSV 337 and RS 2094 for simultaneous improvement in yield and fibre quality traits through recurrent selection.

The genetic analysis revealed that additive component of variance was significant for lint index, ginning outturn, 2.5 per cent span length and fibre strength (Table 4), indicating that the improvement of these characters can be made easily by following simple selection procedures. The results are corroborative with the findings of Kaushik *et al.,* (2006), Khan and Hassan (2011), Kannan *et al.,* (2013) and Raza *et al.,* (2013) for ginning outturn; Kaushik *et al.*, (2006), Ali *et al.,* (2008, 2009), Rehman and Malik (2008), Channa *et al.,* (2013), Kannan *et al.,* (2013), Raza *et al.,* (2013), Rasheed *et al.,* (2014) and Song *et al.,* (2015) for 2.5 per cent span length; Ali *et al.,* (2008, 2009), Rehman and Malik (2008), Kannan *et al.,* (2013), Raza *et al.,* (2013), Rasheed *et al.,* (2014) and Song *et al.,* (2015) for fibre strength; and Ali *et al.,* (2008), Channa *et al.,* (2013), Kannan *et al.,* (2013), Raza *et al.,* (2013), Rasheed *et al.,* (2014) and Song *et al.,* (2015) for fibre fineness. While the dominance component was highly significant for almost all the characters under study except for ginning outturn, which are in accordance with the results of Song *et al.,* (2015) who reported the involvement of dominant genetic effects in the inheritance of fibre length, strength and fineness. Partial dominance was reported by Raza *et al.,* (2013) for ginning outturn, 2.5 per cent span length and fibre strength. Rasheed *et al.,* (2014) also revealed that fibre length, strength and fineness were controlled by additive gene action with partial dominance while ginning outturn by over dominance type of gene effects. The significance of dominance component suggested that heterosis breeding and/or recurrent selection procedures can be followed for simultaneous improvement of yield and quality traits in cotton. Further the significance of h^2 (overall heterosis) for fibre fineness and maturity coefficient revealed that substantial improvement for these characters can be made through the development of hybrids. Epistasis is also involved in the inheritance of fibre fineness. The involvement of both dominance and epistatic effects in the inheritance of fibre fineness suggested that improvement for this trait can be achieved by following reciprocal recurrent selection procedures.

From the present investigations it was observed that the parental lines used in the study showed considerable variation for yield and fibre quality traits. The parental lines were genetically diverse especially for seed cotton yield, fibre length, fibre strength and fibre fineness. Such lines can, therefore, be used to recombine the characters for developing varieties with higher yield and good quality fibre. The prevalence of dominance genetic variation for almost all the characters under study showed that heterosis breeding can be used as a tool to develop new cross combinations/hybrids with higher yield and superior fibre quality. GTSV 337 was the best combiner for fibre strength which is the most important component of fibre quality these days and good combiner for lint yield /plant and ginning outturn but it was poor combiner for fibre length, fibre fineness and maturity coefficient. Similarly, RS 2013 was the best general combiner for lint yield but poor combiner for ginning outturn, 2.5 per cent span length, fibre fineness and maturity coefficient. On the other hand, Pusa 317 was best general combiner for 2.5 per cent span length and fibre fineness, and also good general combiner for lint index and fibre strength, but poor general combiner for ginning outturn. Another parent RS 2094 was a good general combiner for ginning outturn, 2.5 per cent span length, fibre strength and maturity coefficient, but it was poor general combiner for lint yield and lint index. It, thus, appeared that these parental lines can be involved

Table 3. Specific combining ability (sca) effects for fibre traits in upland cotton

Cross	Lint yield (g)	Lint index (g)	Ginning outturn (%)	2.5 per cent span length	Fibre strength (g/tex) (mm)	Fibre fineness (Mic)	Maturity coefficient
GTSV337xRS2013	-1.4943**	-0.0316	1.0874**	-0.2904**	0.8121**	0.0816*	-0.0003
GTSV337xRS2094	3.8029**	0.0101	1.0707**	-1.1793**	-0.6712**	0.4510**	0.0144**
GTSV337xRS2097	-0.1776	0.6295**	2.1818**	-1.5321**	1.7732**	0.0843*	0.005
GTSV337xPIL8-5	-0.7610**	0.0045	-2.8737**	0.2651**	2.5705**	0.0677	0.0039
GTSV337xPusa317	-7.4121**	-0.3093**	-0.5876**	-0.0543	-0.2712**	-0.6212**	-0.0128**
GTSV337xF1861	2.4085**	-0.1955**	1.3763	-0.6154**	0.1538*	-0.374**	-0.0072*
GTSV337xH1226	-1.1637**	0.0434	-2.1904**	0.2487**	-0.3518**	0.3816**	0.0064*
GTSV337Xcsh1071	-1.4082**	-0.1066	-0.2321	0.1957**	0.9288**	0.0621	0.0039
GTSV337xCNH13	1.2418**	0.2684**	-0.5626*	-0.7904**	1.1538**	-0.224**	-0.0056
RS2013 x RS2094	2.6268**	-0.0982	-0.8071**	-0.1460*	1.0899**	0.2538**	0.0014
RS2013 x RS2097	1.4463**	-0.4121**	0.6374**	-0.0321	-0.9657**	-0.3129**	-0.0014
RS2013 x PIL8-5	4.3629**	0.1962**	-1.4515**	-2.4015**	0.1982*	0.5371**	0.0175**
RS2013 x Pusa317	2.6252**	0.3490**	-0.2687	0.6457**	0.7232**	0.2184**	-0.0058
RS2013 x F1861	3.6657**	0.6129**	1.1652**	0.0846	-0.8518**	-0.4379**	-0.0103**
RS2013 x H1226	0.9268**	-0.2649**	-0.3682	-0.1849*	-0.3907**	-0.2823**	-0.0067*
RS2013 x CSH1071	-2.6510**	-0.6149**	-1.2765**	-1.6710**	-0.0434	-0.0351	0.0008
RS2013 x CNH13	-3.2343**	0.3934**	1.7596**	-1.0904**	-0.0518	0.1788**	0.0114**
RS2094 x RS2097	1.4435**	-0.6371**	-0.4126	-0.3543**	-0.3157**	-0.2101**	-0.0067*
RS2094 x PIL8-5	-2.2398**	-0.0621	0.4652*	0.3763**	-0.5851**	-0.1934**	-0.0044
RS2094 x Pusa317	-4.0110**	-0.2760**	-1.0154**	-1.8432**	-0.8934**	-0.0823*	-0.0011
RS2094 x F1861	-3.1371**	0.1712**	-0.3515	0.6624**	-0.6018**	-0.0684	0.0011
RS2094 x H1226	-4.2426**	0.5101**	-0.2182	0.3596**	-0.3073**	0.2538**	0.0014
RS2094 x CSH1071	-1.6537**	0.3601**	0.1735	1.9735**	-0.8601**	0.301**	0.0022
RS2094 x CNH13	-2.7704**	-0.9316**	0.9429**	0.8207**	-0.2018*	-0.2851**	-0.0072*
RS2097 x PIL8-5	-0.9871**	-0.3427**	-0.7237**	-0.3432**	-2.4073**	-0.0601	-0.0039
RS2097 x Pusa317	-2.4915**	1.0768**	1.8624**	0.2707**	0.951**	0.1510**	0.0061
RS2097 x F1861	-3.5176**	-0.3760**	-0.9737**	-2.4237**	-0.724**	0.1982**	-0.0050
RS2097 x H1226	-0.9899**	-0.1750**	-0.3071	1.3068**	0.3705**	-0.0795*	-0.0047
RS2097 x CSH1071	-1.4010**	-0.5871**	-3.7487**	0.2874**	-2.0823**	-0.0657	0.0028
RS2097 x CNH13	-1.6510**	-0.0788	-0.5793**	1.7013**	0.4093**	-0.0184	-0.0067*
PIL8-5 x Pusa317	-4.2082**	0.5149**	-0.5598*	0.2346**	-1.8518**	-0.1323**	-0.0050
PIL8-5 x F1861	-4.6676**	-0.2343**	-0.8293**	-0.1265	0.7066**	-0.0518	0.0072*
PIL8-5 x H1226	1.2935**	0.0379	1.2374**	-0.1626*	-0.9323**	0.0371	-0.0025
PIL8-5 x CSH1071	-2.5510**	0.1879**	0.3290	0.2179**	1.4149**	-0.7823**	-0.0183**
PIL8-5 x CNH13	4.8324**	0.1962**	0.8985**	1.6985**	-0.0934	-0.2684**	-0.0111
Pusa317 x F1861	2.9279**	0.0518	0.4235	1.0207**	1.3649**	0.1260**	0.0072*
Pusa317 x H1226	4.4552**	-0.3093**	-1.7098**	1.1179**	-0.6407**	-0.1518**	-0.0092**
Pusa317 x CSH1071	3.6113**	0.3073**	1.9151**	1.8651**	1.0066**	0.1955**	0.005
Pusa317 x CNH13	2.6613**	0.2823**	0.1179	-0.4876**	0.4649**	-0.224**	-0.0078*
F 1861 x H1226	2.0963**	0.3712**	1.3207**	0.3568**	-0.4823**	0.0288	0.0031
F 1861 x CSH1071	3.7518**	0.5212**	2.2790**	-1.196**	-1.5018**	0.1427**	0.0006
F 1861 x CNH13	0.4685*	-0.0705	-1.9182**	2.1179**	0.2899**	0.0899*	0.0044
H 1226 x CSH1071	0.7463**	-0.1066	1.1457**	-0.9654**	-0.3073**	-0.8684**	-0.0158**
H 1226 x CNH13	-3.3704**	-0.0649	0.0485*	-0.7848**	-0.7157**	0.3121**	0.0081
CSH1071 x CNH13	3.5518**	0.0851	0.1402	-1.071**	-1.0351**	0.0927**	0.0022
S.E. $_{(m)}$	0.2371	0.0608	0.2236	0.0748	0.0839	0.0513	0.0030
S.E. $_{(d)}$	0.1172	0.0950	0.3496	0.1169	0.1311	0.0574	0.0049

*,** significance at 5 per cent and 1 per cent level of significance, respectively

Table 4. Genetic components of variance for fibre traits in upland cotton.

Genetic components	Lint yield (g)	Lint index (g)	Ginning outturn (%)	2.5 per cent span length	Fibre strength (g/tex) (mm)	Fibre fineness (Mic)	Maturity coefficient
D	5.1476±4.995	0.2232*±0.081	1.8603*±0.729	1.3733*±0.502	1.1505*±0.774	0.0322±0.049	0.00001±0.00002
H_1	49.9126**±10.526	0.6733**±0.172	1.7815±1.554	7.3125**±1.068	7.8423**±1.648	0.4353**±0.104	0.00025**±0.00006
H_2	38.1487**±8.946	0.5709**±0.146	6.8702**±1.321	5.1517**±0.908	4.7833**±1.40	0.3717**±0.089	0.00022**±0.00005
F	4.5939±11.409	0.1909±0.186	2.3621±1.684	1.9672**±1.157	3.5202±1.786	0.0309±0.113	0.00001±0.00006
E	0.0825±1.491	0.0054±0.024	0.0734±0.220	0.0082±0.151	0.0103±0.233	0.0020±0.015	0.00001±0.000008
h^2	2.0698±5.988	0.0115±0.098	0.0540±0.884	0.1442±0.607	0.5601±0.937	0.1627*±0.059	0.00007*±0.00003
$(H_1/D)^{1/2}$	-	1.7376	-	2.3075	-	-	-
$H_2/4H_1$	0.1911	0.2119	-	0.1761	0.1525	0.2135	0.2138
t^2	1.7769	2.2739	0.6951	0.322	0.3959	5.7229*	1.1728

*,** significance at 5 per cent and 1 per cent level of significance, respectively

in a complex cross to develop a single base population having all the relevant genes. Such a population is expected to carry usefully genetic variation for all yield and fibre quality traits. It is possible that simultaneous improvement for yield and quality characters can be made through recurrent selection or even through hybrid breeding by involving specific parental lines like RS 2013, RS 2094, Pusa 317 in a cross. The significance of additive component of variation for lint index, ginning outturn, 2.5 per cent span length and fibre strength revealed that the improvement for these characters can be achieved through simple recurrent selection procedures.

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