COMBINING ABILITY ESTIMATION FOR MORPHOLOGICAL AND YIELD CONTRIBUTING CHARACTERS IN *DESI* COTTON (*GOSSIPIUM ARBOREUM*)

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Abstract: In the present study six arboreum lines (PA-720, PA-08, PA-528, PA-532, PA-255 and PA-402) were crossed with four testers (AKA-7, GAM-162, Dwd-arb-10-1 and JLA-802) to obtain twenty four hybrids following line × tester design. The resultant twenty four hybrids along with their parents were evaluated in a randomized block design with three replications at Cotton Research Station, Mahboob Bagh Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2012-13. Observations were recorded on twelve parameters *viz.,* days to 50% flowering, days to 50% boll bursting, no. of sympodia per plant, no. of bolls per plant, no. of seeds per boll, boll weight, plant height, days to maturity, seed cotton yield per plant, lint yield per plant, seed index and oil content. The combining ability analysis indicated the presence of considerable variability in crosses for most of the traits under study. The lines *viz.,* PA-720, PA-08 and PA-532 and the tester AKA-7 was found the best general combiner. The crosses *viz.,* PA-528 × AKA-7, PA-528 × JLA-802 and PA-08 × AKA-7 showed significance of SCA effects for more number of traits so these can be used for future breeding programmes. The variance estimates due to GCA and SCA were highly significant for most of the characters. The magnitude of SCA variance was greater than GCA variance and more contribution of line × tester interaction to the total variability indicated the predominance of non additive gene action, so for improvement of these traits heterosis breeding is considered the more rewarding option.

Keywords: *Gossipium aboreum*, Seed, Cotton

INTRODUCTION

Cotton is an important commercial crop which accounts for 60% of total foreign exchange earnings through export of lint and value added cotton products (Eswari *et al.,* 2016). Cotton is also called as 'White Gold' or 'King of Apparel Fibre'. It is considered as most precious gift by nature to mankind as it provides clothing to all over the world. Other than fiber, it also provides edible oil which plays important role in country's economy. Cotton has four cultivated species, classified into new world cotton (*Gossypium hirsutum* L. and *Gossypium barbadense* L.) which are tetraploids (2n = 4x = 52) and old world cotton (*Gossypium herbaceum* L. and *Gossypium arboreum* L.) which are diploids (2n = 2x = 26). India is the native home of *G. arboreum* and there is wide climatic conditions in India which indicate the ample scope of crop improvement in India.

Fiber quality and seed cotton yield are two major objectives of cotton improvement programmes. Availability of variation among genotypes is important and it is controlled by strong genetic components. It is essential to identify superior parents for hybridization and crosses to increase the genetic variability. Combining ability helps in identification of superior genotypes, type of gene action and breeding procedures to be followed. The aim of this study was to estimate gene action and the type of inheritance for yield contributing traits which may be utilized in future breeding program of cotton.

MATERIAL AND METHOD

In the present study six arboreum lines (PA-720, PA-08, PA-528, PA-532, PA-255 and PA-402) were crossed with four testers (AKA-7, GAM-162, Dwd-arb-10-1 and JLA-802) to obtain twenty four hybrids following line × tester design. The L × T was performed according to Kempthorne (1957). The resultant twenty four hybrids along with their parents were evaluated in a randomized block design with three replications at Cotton Research Station, Mahboob Bagh Farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani during *kharif* 2012-13. Experiment was conducted by maintaining inter-row and intra-row spacing as 60cm and 30cm, respectively. Recommended cultivation practices and

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plant protection measures were adopted to raise a healthy crop.

Observations were recorded both as visual assessment and measurement on individual plants. Five competitive plants were selected randomly from each plot in each replication for recording observations on twelve parameters *viz.,* days to 50% flowering, days to 50% boll bursting, no. of sympodia per plant, no. of bolls per plant, no. of seeds per boll, boll weight, plant height, days to maturity, seed cotton yield per plant, lint yield per plant, seed index and oil content. All recorded datas were subjected to analysis of variance for testing the significance of treatments as suggested by Panse and Sukhatme, (1961). Combining ability analysis and the testing of significance of different genotypes was based on the procedure given by Kempthorne (1957).

RESULT AND DISCUSSION

Combining ability is defined as the ability of parents or cultivars to combine amongst each other or capability of transmission of favourable genes during the process of hybridization. Combining ability is of two types. Specific combining ability is the deviation in the performance of hybrids from the expected productivity. It occurs due to the genes with dominance or epistatic effect and non-fixable. On the other hand, general combining ability is the average performance of a line in a series of crosses. It occurs due to additive genes and is fixable (Sprague and Tatum, 1942). The higher magnitude of SCA than GCA indicates the preponderance of dominant genes (Desphande and Baig, 2003).

The combining ability analysis indicated the presence of considerable variability in crosses for most of the traits under study (Table-1). The female lines exhibited significant differences for the characters *viz.,* number of bolls per plant and lint yield per plant. Testers did not show significant difference for any character. L × T interaction was significant for all the characters except no. of sympodia per plant, no. of seeds/boll and days to maturity.

Estimation of GCA and SCA Effects- The GCA and SCA effects were worked out for all the traits which were presented in table-3 and table-4, respectively and discussed as under-

Days to 50% flowering and 50% boll bursting- The line PA-08 and the tester GMA-162 showed significant negative GCA effect for days to 50 percent flowering (-1.83 and -1.27, respectively) and days to 50% boll bursting (-2.18 and -1.81, respectively) which is in the desirable direction.

None of the crosses showed significant SCA effect for days to 50% flowering but crosses *viz.,* PA-402 × Dwd-arb-10-01 (-2.056), PA-255 × GAM-162 (-1.722) and PA-255 × Dwd-arb-10-01 (-1.417) showed desirable negative SCA effect.

No. of sympodia per plant-Among parents, the line PA-532 (2.00) and the tester AKA-7 (1.54) showed the highest positive GCA effect. The cross PA-528 × Dwd-arb-10-01 (3.911), PA-402 × JLA-802 (2.961) and PA-720 × AKA-7 (2.378) showed non-significant but positive SCA effect.

Number of bolls/plant- PA-720 (1.81) and PA-08 (1.63) were the highest performing lines while AKA-7 (0.79) and Dwd-arb-10-1 (0.75) were the highest performing testers for bolls per plant. The cross PA-402 × JLA-802 (3.786) and PA-528 × AKA-7 (2.331) performed highest significant SCA value for number of bolls per plant.

No. of seeds/boll- None of the lines and tester was found with significant and positive GCA effect. None of the cross showed significantly positive SCA effect but positive SCA effects were shown by the cross PA-08 × AKA-7 (1.328) and PA-528 × Dwd-arb-10-1 (1.011).

Boll weight (g)- The line PA-532 (0.10) showed the positive and significant GCA while, the tester AKA-7 (0.08) showed the positive and significantGCA for boll weight.The crosses *viz.,* PA-402 × JLA-802 (0.149), PA-255 × JLA-802 (0.147) and PA-528 × AKA-7 (0.132) showed significant positive SCA effect in desirable direction.

Plant height (cm)- Among parents, the lines *viz.,* PA-532 (4.26) and PA-08 (4.07) showed significant and positive GCA effect while, only one tester AKA-7 (4.66) manifested positive GCA effect for plant height. The line PA-402 (-11.14) showed the highest negative GCA effect for plant height. It is suggested to use these parents in breeding programmes for development of plant height. PA-532 × AKA-7 (21.596) and PA-528 × JLA-802 (11.607) showed highest significant positive SCA effect and the crosses *viz.,* PA-08 × Dwd-arb-10-1 (-16.538) and PA-402 × AKA-7 (-11.154) showed highest significant negative SCA effect. These crosses can be used in different breeding programmes for tallness or dwarfness.

Days to maturity- None of the line and none of the tester performed significantly in desirable direction. Only one cross, PA-08 × AKA-7 (-5.708) showed desirable SCA effect in negative direction.

Seed cotton yield per plant- The lines PA-720 (3.11) and PA-532 (2.86) and the testers Dwd-arb-10-1 (3.84) and AKA-7 (3.54) were with significant and positive GCA effect for seed cotton yield. It

indicates that these parents are good general combiners for the respective trait. A total seven crosses performed significant SCA effect in positive direction. Highest performing cross were PA-528 × AKA-7 (10.083), PA-255 × AKA-7 (7.200) and PA-08 × AKA-7 (6.239).

Lint yield per plant- PA-08 (9.58) and PA-528 (5.04) were significant and positive performing lines and no tester performed significant GCA effect in desirable direction. Only one cross PA-720 × GAM-162 (7.454) exhibited significant positive SCA effect.

Seed index- The line PA-720 (0.25) and the tester GAM-162 (0.38) showed significant positive GCA among parents. The crosses, PA-528 × JLA-802 (0.860) and PA-08 × AKA-7 (0.602) showed significant SCA effect in desirable direction.

Oil content- Highest significant GCA performance among parents was shown by one line PA-402 (0.50) and one tester JLA-802 (0.60) which can be used in breeding programmes targeted for oil improvement. Two crosses performed significant positive SCA effect for oil yield. These crosses are PA-08 × JLA-802 (1.545) and PA-528 × AKA-7 (0.805). The above all characters are in agreement with earlier results, observed by Karademr and Gencer (2010), Dhamaynthi (2011), Nadagundi *et al.,* (2011), Jatoi *et al.,* (2011), Mendez-Natera *et al.,* (2012) and DaiGang *et al.,* (2012).

Most of the significant SCA effects observed in the present investigation were resulted by a combination of low general combiner parents. Both the parents (PA 402 × Dwd-arb-10-1; PA-255 × AKA-7; PA-255 × Dwd-arb-10-1)were poor general combiner but, their progeny performed significant SCA effect for earliness (days to 50% flowering and days to 50% boll bursting). Similar performance exhibited by the parental combination *viz.,* PA-528 × Dwd-arb-10-1 and PA-402 × JLA-802 for number of sympodia per plant; PA-402 × JLA-802 and PA-528 × AKA-7 for number of bolls per plant; PA-08 × AKA-7 and PA-528 × Dwd-arb-10-1 for number of seeds per boll; PA-255 × JLA-802 and PA-402 × JLA-802 for boll weight; PA-528 × JLA-802 for plant height; PA-255 × JLA-802 and PA-255 × GAM-162 for seed cotton yield; PA-720 × GAM-162 for lint yield; PA-528 × JLA-802 for seed index and PA-528 × AKA-7 for oil content. These results indicate that for production of valuable hybrid for specific trait, it is not necessary that any one parent should possess higher GCA value. Similar pattern of combination was also observed by Patel *et al.,*(1997), Imran *et al.,* (2012) and Ali *et al.,* (2016) for various characters.The

combination of low × high or high × low was also observed. It is performed by the parents, PA-720 × AKA-7 for number of sympodia per plant; PA-528 × AKA-7 for boll weight; PA-08 × GAM-162 and PA-532 × Dwd-arb-10-1 for plant height; PA-255 × AKA-7 for seed cotton yield; PA-08 × JLA-802 for oil content. The high × high general combiner also resulted in the higher SCA effect and it was observed for the crosses *viz.,* PA-08 × AKA-7 for days to maturity; PA-532 × AKA-7 for plant height; PA-528 × AKA-7 and PA-08 × AKA-7 for seed cotton yield.

Contribution of parents and their interaction
The estimates of variance due to general combining ability (GCA), variance due to specific combining ability (SCA), GCA and SCA ratio were worked out for different characters and presented in Table-2. The variance estimates due to GCA and SCA were highly significant for most of the characters except no. of seeds per boll (Ali *et al.,* 2016), days to maturity and seed index. It is indicating the importance of both additive and non-additive gene actions. The magnitude of SCA variance was greater than GCA variance for all the traits which indicates prevalence of non-additive gene action. Similar results also reported by Neelima *et al.* (2004), Kiani *et al.* (2007), Preetha and Raveendran (2008) and Pole *et al.* (2008). The ratio of variances of GCA and SCA (<1) indicated the prevalence of non-additive gene action. Similar results were reported by Azhar *et al.,* (2007), Tang and Xiao (2013), Nimbalakar *et al.,* (2014), Ali *et al.,* (2015) and Patel and Choudhary (2015). Contribution of L × T interaction, to the total variability was higher for most of the characters except no. of bolls per plant and lint yield per plant where contribution of lines was higher. Similarly, if we compare the role of lines and testers, contribution of tester was more for the traits *viz.,* days to 50% flowering, days to 50% boll bursting, days to maturity, seed cotton yield per plant, seed index and oil content while, the traits *viz.,* no. of sympodia per plant, no. of bolls per plant, no. of seeds per boll, boll weight, plant height and lint yield per plant exhibited more contribution of lines. Relatively more contribution of line × tester interaction also indicates the predominance of non additive gene action (Samreen *et al.,* 2008). For improvement in traits under non-additive genetic control, heterosis breeding is considered the more rewarding option (Imran *et al.*, 2012; Ali *et al.*, 2015) or other breeding methodologies like bi-parental mating, recurrent selection and diallel selective mating can be used (Prasad *et al.,* 2016).

Table 1. Analysis of variance for combining Ability for different characters including parents

Source	d.f.	Days to 50% flowering	Days to 50% boll bursting	No. of sympodia/ plant	No. of boll/ plant	No. of seed / boll	Boll Weight (g)	Plant height (cm)	Days to maturity	Seed cotton yield/ plant	Lint yield / plant	Seed index	Oil content (%)
Replications	2	1.098	8.009	9.026	0.871	2.503	0.001	63.965	12.127	112.384	31.735	0.015	0.166
Crosses	23	9.971**	18.753**	19.058**	15.386**	2.069	0.042**	356.190**	26.782	157.179**	182.804**	1.058**	2.288**
Females	5	10.433	17.247	23.980	34.263*	1.308	0.054	389.708	17.980	81.970	441.521*	0.559	1.421
Males	3	18.00	35.421	29.438	14.424	1.175	0.070	228.813	38.458	362.297	92.496	1.2524	2.980
M x F	15	8.211*	15.921*	15.342	9.287**	2.501	0.033**	370.494**	27.380	141.224**	114.62**	1.186**	2.440**
Error	66	3.582	8.373	7.915	2.152	2.916	0.010	48.107	23.076	7.020	29.565	0.164	0.386

Table 2. Variances for General and Specific Combining Ability and Percent contribution of lines, testers and LxT for morphological characters in cotton

Sr.no.	Character	δ² GCA	δ²SCA	δ²GCA / δ²SCA	Percent contributions of		
					Lines	Testers	LxT
1.	**Days to 50 % flowering**	0.7089*	1.5427*	0.4595	22.74	23.54	53.70
2.	**Days to 50% boll bursting**	1.1974*	2.5160*	0.4759	19.99	24.63	55.36
3.	**No. of sympodia/ plant**	1.2529*	2.4755*	0.5061	27.35	20.14	52.15
4.	**No. of boll/ plant**	1.4794**	2.3781**	0.6221	48.40	12.22	39.36
5.	**No. of seed / boll**	-0.1116	-0.1384	0.8069	13.74	7.40	78.84
6.	**Boll Weight (g)**	0.0035*	0.0075**	0.4627	27.75	21.70	50.54

7.	**Plant height (cm)**	17.4103	107.4622**	0.1620	23.78	8.37	67.83
8.	**Days to maturity**	0.3428	1.4345	0.2390	14.59	18.73	66.67
9.	**Seed cotton yield/ plant**	14.3409*	44.7347**	0.3206	11.33	30.06	58.59
10.	**Lint yield / plant**	15.8296**	28.3538**	0.5583	52.50	6.59	40.89
11.	**Seed index**	0.0494	0.3404	0.1452	11.48	15.43	73.07
12.	**Oil content (%)**	0.1210	0.6842**	0.1768	13.50	16.98	69.50

Table 3. Estimates of General Combining Ability (GCA) for Lines and Testers

Parents	Days to 50% flowering	Days to 50% boll bursting	No. of sympodia / plant	No. of boll/ plant	No. of seed / boll	Boll Weight (g)	Plant height (cm)	Days to maturity	Seed cotton yield/ plant	Lint yield / plant	Seed index	Oil content (%)
Lines												
PA-720	0.75	1.23	-1.13	1.81**	-0.185	0.04	1.48	-1.06	3.11**	-6.24**	0.25*	-0.34
PA-08	-1.83**	-2.18*	1.40	1.63**	-0.056	-0.03	4.07*	-0.90	-1.91*	9.58**	-0.24*	-0.33
PA-528	0.00	-0.18	-0.28	-0.98*	-0.306	-0.00	1.12	0.68	-0.15	5.04**	-0.01	-0.06
PA-532	0.50	0.23	2.00*	0.53	-0.256	0.10**	4.26*	0.84	2.86**	-3.34*	0.11	0.30
PA-255	0.33	0.90	-0.40	-2.63**	0.511	-0.07**	0.19	1.68	-0.40	-1.13	-0.26*	-0.06
PA-402	0.25	-0.01	-1.58	-0.35	0.292	-0.03	-11.14**	-1.23	-3.51**	-3.89*	0.15	0.50**
S.E.(Gi)	0.546	0.835	0.8122	0.4235	0.4930	0.0294	2.0022	1.3868	0.7649	1.569	0.1171	0.1796
S.E.(Gi-Gj)	0.772	1.181	1.1486	0.5990	0.6972	0.0416	2.8316	1.9612	1.0817	2.219	0.1656	0.2539
CD @5%	1.099	1.681	1.6348	0.8525	0.9924	0.0592	4.0303	2.7914	1.5396	3.159	0.2357	0.3614

CD @1%	1.468	2.244	2.1823	1.1380	1.3248	0.0791	5.3800	3.7262	2.0553	4.217	0.3146	0.4825
Testers												
AKA-7	0.05	0.34	1.54*	0.79*	-0.094	0.08**	4.66**	-0.79	3.54**	2.32	-0.08	-0.19
GMA-162	-1.27**	-1.81*	0.55	-0.79*	0.306	-0.07**	0.87	-1.62	-2.20**	-0.42	0.38**	0.23
Dwd-arb-10-1	1.16*	1.56*	-0.98	0.75*	0.083	0.00	-2.33	0.87	3.84**	1.04	-0.22*	-0.17
JLA-802	0.05	-0.90	-1.11	-0.75*	-0.294	-0.01	-1.99	1.54	-5.38**	-2.95	-0.07	0.60**
S.E.(Gi)	0.446	0.682	0.6631	0.3458	0.4026	0.0240	1.6348	1.1323	0.6245	1.281	0.0956	0.1466
S.E.(Gi-Gj)	0.631	0.964	0.9378	0.4891	0.5693	0.0340	2.3120	1.6013	0.8832	1.812	0.1352	0.2073
CD @5%	0.898	1.681	1.3348	0.6961	0.8103	0.0484	3.2907	2.2791	1.2571	2.579	0.1924	0.2951
CD @1%	1.198	2.244	1.7819	0.9292	1.0817	0.0646	4.3928	3.0424	1.6781	3.443	0.2569	0.3939

Table 4. Estimates of specific combining ability (SCA) for yield contributing characters

Hybrids	Days to 50% flowering	Days to 50% boll bursting	No. of sympodia/ plant	No. of boll/ plant	No. of seed / boll	Boll Weight (g)	Plant height (cm)	Days to maturity	Seed cotton yield/ plant	Lint yield / plant	Seed index	Oil content (%)
PA-720 x JLA-802	0.194	-0.847	1.989	0.475	0.744	-0.050	-10.218*	3.125	-7.528**	-6.879*	0.063	0.035
PA-528 x AKA-7	-0.806	-0.681	0.111	2.331**	-0.589	0.132*	-9.096*	-3.042	10.083**	5.387	0.212	0.805*
PA-08 x GAM-162	-1.583	-1.069	-0.011	-0.558	-0.833	-0.013	9.476*	-2.208	4.172**	0.770	0.177	0.722
PA-532 x Dwd-arb-10-1	2.194	2.597	-2.089	-2.247*	0.678	-0.069	9.837*	2.125	-6.728**	0.721	-0.453	-1.562**
PA-255 x JLA 802	-0.889	-1.431	-1.278	0.858	-1.056	0.147*	1.390	-0.042	5.372**	1.256	0.153	-0.903*
PA-402 x AKA-7	0.111	0.069	-3.356*	0.114	-0.656	-0.072	-11.154**	-0.208	-4.483**	2.698	0.212	0.058
PA-720 x GAM 162	1.667	2.014	0.722	-0.308	0.700	-0.153*	5.851	0.625	-0.394	7.454*	-0.739**	0.224
PA-528 x Dwd-	-0.889	-0.653	3.911	-0.664	1.011	0.078	3.913	-0.375	-0.494	-11.408**	0.374	0.621

arb-10-1												
PA-08 x JLA-802	-1.056	-1.764	1.539	0.475	-0.939	0.097	-4.326	-2.958	1.672	5.888	-0.580*	1.545**
PA-532 x AKA -7	2.611*	3.403*	0.194	-0.469	0.061	-0.025	21.596**	1.875	-6.717**	-6.646*	-0.017	-0.325
PA-255 x GAM -162	0.500	0.681	-0.394	-0.492	0.950	0.013	-9.456*	1.708	4.772**	-1.170	0.128	-1.158**
PA-402 x Dwd-arb-10-1	-2.056	-2.319	-1.339	0.486	-0.072	-0.085	-7.804	-0.625	0.272	1.928	0.468	-0.062
PA-528 x JLA 802	-1.222	-1.514	0.122	1.558	-0.256	-0.022	11.607**	2.208	4.389**	-1.935	0.860**	0.778*
PA-720 x AKA-7	-0.222	-1.014	2.378	-1.586	0.011	-0.047	0.996	0.375	-6.267**	5.294	-0.838**	-0.373
PA-528 x GAM-162	1.667	2.597	1.056	1.258	-0.167	0.064	3.935	1.542	-1.178	-5.674	-0.153	-0.766*
PA-08 x Dwd-arb-10-1	-0.222	-0.069	-3.556*	-1.231	0.411	0.005	-16.538**	-4.125	3.056	2.315	0.131	0.361
PA-532 x JLA 802	1.278	2.153	0.056	-1.942*	0.178	-0.019	7.674	3.375	-10.144**	4.711	-1.098**	-0.775*
PA-255 x AKA-7	-1.722	-2.014	0.378	0.981	0.444	0.043	-4.604	-2.125	7.200**	-0.320	0.285	0.175
PA-402 x GAM -162	-0.833	-1.736	0.544	1.092	0.133	0.054	-5.665	-1.958	2.022	-5.331	0.433	0.542
PA-720 x Dwd-arb-10-1	1.278	1.597	0.111	-0.131	-0.756	-0.078	2.596	0.708	0.922	0.941	0.380	0.058
PA-08 x AKA-7	1.694	3.403*	-2.428	-1.425	1.328	-0.152*	-6.126	-5.708*	6.239**	-3.040	0.602*	-0.680
PA-532 x GAM-162	0.028	0.236	0.294	-1.369	0.728	-0.031	2.263	3.125	0.183	-6.414*	0.145	-0.340
PA-255 x Dwd-arb-10-1	-1.417	-2.486	-0.828	-0.992	-0.783	0.034	-4.132	0.292	-9.394**	3.941	0.153	0.437
PA-402 x JLA-802	-0.306	-1.153	2.961	3.786**	-1.272	0.149*	7.996	2.292	2.972	5.503	-0.900**	0.583
S.E. ±	1.092	1.670	1.624	0.8471	0.9860	0.0589	4.0045	2.7735	1.5298	3.1393	0.2342	0.3591

CONCLUSION

The identification of cross combinations having high mean performance, high heterosis, and desirable SCA effects with stability over environments is of immense value in breeding programme. The female parents *viz.,* PA-720, PA-08 and PA-532 exhibited highest GCA for different traits and among male parents, AKA-7 was found the best general combiner for most of the traits. It indicates that these lines and tester, being good general combiner, can be used as donor parent for desirable genes for the respective traits. The crosses *viz.,* PA-528 × AKA-7, PA-528 × JLA-802 and PA-08 × AKA-7 showed significance of SCA effects for more number of traits so these can be used for future breeding programmes for exploiting the potential. The variance estimates due to GCA and SCA were highly significant for most of the characters. The magnitude of SCA variance was greater than GCA variance and more contribution of line × tester interaction to the total variability indicated the predominance of non-additive gene action, so for improvement of these traits heterosis breeding is considered the more rewarding option.

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