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RESEARCH PAPER

Heterosis and combining ability studies for yield and its components in desi cotton (*Gossypium arboreum* L.)

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Abstract: The present investigation was carried out in order to study the general and specific combining ability effects for seed cotton yield and its attributes in diploid cotton (*G. arboreum* L.). A set of 19 genotypes, including 16 lines and three testers, 48 crosses and four checks were grown under rainfed conditions during *kharif* 2015 at Botanical garden, Agriculture College, Dharwad, University of Agricultural Sciences, Dharwad. The hybrids were generated using Line × Tester design. Analysis of variance showed significant differences among parents and hybrids for maximum characters indicating presence of genetic variability. The ratio of variance due to GCA to that of SCA was less than one for all the characters indicating preponderance of non additive gene effects in the inheritance of characters. None of the lines showed significant positive *gca* effects for yield but line*, G. arb* 205 for number of bolls per plant and the line*, G.arb* 59 for boll weight recorded significant positive *gca* effects. Two crosses *G. arb* 52 × *G. arb* 147 and *G. arb* 106 × *G. arb* 151 registered significant and positive sca effects along with significant and positive standard heterosis for seed cotton yield and majority of yield components.

Key words: Combining ability, Gene effects, Line, Tester

Introduction

Cotton, the king of fiber, is one of the most momentous and important cash crops having profound influence on economics and social affairs of the country. It is also called "White Gold" due to its global importance in agriculture as well as industrial economy. In world, cotton is growing in an area of 33.1 million hectares producing 118 million bales with a productivity of 766 kg/ha (USDA).In India, the crop is being grown in an area of 12.65 million hectares producing 400 lakh bales with a productivity of 537 kg/ha. In Karnataka cotton is being grown in an area of 7.60 lakh hectares with a production and productivity of 26.9 lakh bales and 626 kg/ha respectively (Anon., 2016).

The success of the hybridization is largely dependent on the correct selection of parents. Estimates of genetic variation and combining ability are useful in determining the breeding value of some populations and the appropriate procedures to use in a breeding program. Combining ability describes the breeding value of parental lines to produce hybrids. Sprague & Tatum (1942) used the term general combining ability (GCA) to designate the average performance of a line in hybrid combinations and used the terms specific combining ability (SCA) to define those cases in which certain combinations do relatively better or worse than expected on the basis of the average performance of the lines involved. He stated that gca effects were due to additive type of gene action but sca effects were due to genes which are non-additive (dominant and epistatic) type of gene action. It is useful in selection of desirable parents to generate potential hybrids with a reasonable level of stability (Ashok kumar and Ravikesavan, 2008). Hence present investigation was carried out to estimate the general and specific combining ability effects of *desi* cotton hybrids.

Material and methods

The present study which comprised of *G. anamolum* introgressed lines of *G. arboreum* × *G.arboreum* cotton hybrids was carried out under rainfed conditions during *kharif* 2015 at Botanical garden, Agriculture College, University of Agricultural Sciences, Dharwad.The experimental material includes 16 *G. arboreum* lines*, viz., G. arb* 190, *G. arb* 193*, G. arb* 196*, G. arb* 197, *G. arb* 199, *G. arb* 200*, G. arb* 201*, G. arb* 205, *G. arb* 161, *G. arb* 157*, G. arb* 52, *G. arb* 106*, G. arb* 111*, G. arb* 108*, G. arb* 59, *G. arb* 42 and three *G. arboreum testers, G. arb* 147*, G. arb* 149, *G. arb* 151 and 48 *G. arboreum* × *G. arboreum* crosses and four checks, DDhC-11, Jayadhar, DLSa-17 and AKA-235.

A complete set of 71 genotypes was evaluated in a randomized block design replicated twice. Each plot consisted of single row of 5 m length spaced at 90cm apart with plant to plant distance of 30 cm. All the recommended agronomical practices and plant protection measures were followed as and when required to raise a good crop of cotton. Observations were recorded for plant height (cm), number of monopodia per plant, number of sympodia per plant, number of locules per boll, number of bolls per plant, boll weight (g), seed cotton yield (kg/ha), ginning outturn (%), seed index, lint index and halo length (mm). Data were recorded on five random competitive plants from each entry from two replications and mean of five plants was taken for further analysis.

Results and discussion

The results of the analysis of variance for combining ability are presented in Table 1. Mean sum of squares were found to be significant for all the traits studied except for number of locules per boll and boll weight indicating the presence of

Table 1. ANOVA for combining ability for various characters in *G. arboreum* × *G. arboreum* cotton crosses

Source of variation	d.f.	Plant height (cm)	Number of monopodia/ plant	Number of sympodia/ plant	Number of locules	Number of bolls/ plant	Boll weight (g)	Seed cotton yield (kg/ha)	Ginning outturn (%)	Seed index	Lint index	Halo length (mm)
						Mean sum of squares						
Replications	1	1481.296**	0.082	0.003	0.027	5.792	0.02	1938.787	0.712	0.492	0.21	7.566
Lines (L)	15	394.461	0.369*	6.651	0.093	27.307	0.131	69077.8	20.833**	0.74	0.956*	0.203**
Testers (T)	2	143.966	0.005	14.761*	0.093	75.003	0.075	98812.53	8.836	0.106	0.442	39.274
Hybrids	47	529.302**	0.221**	5.559*	0.106	36.354**	0.117	67245.95	11.934**	0.818 **	0.615**	27.583**
Line × Tester Effect	30	622.411**	0.161**	4.399	0.114	38.3**	0.112	64225.59*	7.692**	0.904 **	0.456**	15.493**
Error	47	164.022	0.049	3.346	0.072	15.107	0.082	45098.22	3.366	0.158	0.125	2.478
σ^2gca		6.199	0.008	0.4	0.002	1.985	0.001	2104.829	0.611	0.014	0.03	1.162
σ^2sca		235.494	0.06	0.651	0.026	12.432	0.018	10136.09	2.234	0.369	0.167	2.245
σ^2gca/σ^2sca		0.026	0.133	0.614	0.077	0.160	0.056	0.208	0.274	0.038	0.180	0.518

Table 2. Estimation of general combining ability (*gca*) effects of parents (lines and testers) for various characters in cotton

Sl. No.	Genotypes	Plant height (cm)	Number of monopodia/ plant	Number of sympodia/ plant	Number of locules	Number of bolls/ plant	Boll weight (g)	Seed cotton yield (kg/ha)	Ginning outturn (%)(g)	Seed index	Lint index	Halo length (mm)
	Lines											
1.	*G. arb* 190	-4.974	-0.2*	-0.184	0.229*	-2.611	-0.117	4.74	-1.102	-0.25	-0.282	1.545*
2.	*G. arb* 193	8.793	0.167*	1.416	0.196	2.223	0.098	132.62	0.464	-0.182	-0.047	-4.735**
3.	*G. arb* 196	6.659	-0.067	-0.351	-0.038	-2.327	-0.240 *	-85.833	-1.317	-0.224	-0.313*	1.267*
4.	*G. arb* 197	-7.941	-0.033	-1.268	0.096	1.049	0.003	48.93	-0.157	-0.02	-0.067	1.822**
5.	*G. arb* 199	0.843	0.067	-1.751 *	0.096	-2.086	-0.049	-133.943	0.846	0.298	0.247	2.6**
6.	*G. arb* 200	8.309	0.6**	1.366	-0.037	-0.552	-0.085	-55.92	-0.469	0.16	-0.017	3.267**
7.	*G. arb* 201	9.059	0.233**	0.566	-0.104	-2.502	0.025	-131.17	-3.582**	-0.227	-0.617**	-0.51
8.	*G. arb* 205	13.859**	-0.033	0.716	-0.037	3.0494*	0.116	80.49	2.48**	0.573**	0.673**	-0.121
9.	*G. arb* 161	-9.857	0.367**	-0.384	-0.004	0.339	0.038	8.147	-0.402	0.043	-0.063	3.879**
10.	*G. arb* 157	0.476	-0.333**	-1.534 *	-0.071	-2.427	-0.285 *	-193.790 *	-2.12**	0.218	-0.242	2.769**
11.	*G. arb* 52	-8.624	0.067	-0.084	-0.104	0.448	0.038	29.254	-2.237**	-0.514**	-0.557**	0.21
12.	*G. arb* 106	-1.091	-0.267**	1.166	0.163	2.473	0.026	144.16	0.013	0.125	0.11	-1.233*
13.	*G. arb* 111	3.226	-0.167*	0.482	-0.204	2.923	0.118	119.464	2.103**	-0.552**	0.003	-1.843**
14.	*G. arb* 108	-14.924 **	0	-1.384	-0.071	-2.044	-0.137	-112.14	1.391	-0.107	0.2	-6.953**
15.	*G.arb* 59	-5.024	-0.2*	1.016	-0.138	2.173	0.268*	28.034	3.551**	0.746	0.942**	-1.231*
16.	*G.arb* 42	1.209	-0.2*	0.216	0.029	-0.127	0.185	116.957	0.538	-0.087	0.027	-0.733
	S.Em±	5.02	0.090	0.718	0.1008	1.496	0.112	85.58	0.733	0.165	0.144	0.599
	C.D. at 5%	10.106	0.167	1.445	0.204	3.01	0.227	172.185	1.475	0.334	1.186	10.106
	Testers											
1.	*G. arb*147	-2.449	-0.004	-0.519	0.01	-1.096	-0.034	-43.117	-0.523	-0.044	-0.1	-0.913**
2.	*G. arb* 149	1.195	-0.01	-0.25	-0.058	-0.654	-0.021	-19.595	-0.004	-0.02	-0.029	1.232**
3.	*G. arb* 151	1.254	0.015	0.769*	0.048	1.74**	0.055	62.712	0.528	0.065	0.129*	-0.319
	S.Em±	2.71	0.035	0.310	0.0436	0.648	0.048	37.06	0.317	0.071	0.063	0.255
	C.D. at 5%	4.376	0.072	0.626	0.088	1.304	0.098	74.558	0.638	0.145	0.514	4.376

Table 3. Estimation of specific combining ability (*sca*) effects for various characters in *G. arboreum* × *G. arboreum*

Crosses	Plant height (cm)	Number of monopodia/ plant	Number of sympodia/ plant	Number of locules	Number of bolls/ plant	Boll weight (g)	Seed cotton yield/ ha (kg)	Ginning outturn (%)g)	Seed index	(Lint index	Halo length (mm)
*G. arb*190 × *G. arb*147	-17.651*	0.138	1.819	-0.11	4.829	0.044	79.54	1.817	0.958**	0.709**	-0.088
*G. arb*190 × *G. ar*b149	-20.645*	-0.056	-2.4	0.058	-6.263 *	0.041	-70.252	0.282	-0.401	-0.138	0.101
*G. arb*190 × *G. arb*151	38.296**	-0.081	0.581	0.052	1.434	-0.085	-9.288	-2.099	-0.557	-0.571*	-0.012
*G. arb*193 × *G. arb*147	-7.368	-0.329 *	-1.681	0.023	-6.454 *	-0.111	-123.25	-0.6	0.454	0.134	-0.143
*G. arb*193 × *G. arb*149	1.139	0.177	1.55	-0.108	5.904	0.076*	135.718	0.031	0.395	0.227	-1.454
*G. arb*193 × *G. arb*151	6.229	0.152	0.131	0.085	0.551	0.035	-12.468	0.569	-0.850 **	-0.361	1.598
*G. arb*196 × *G. arb*147	20.466*	0.004	1.485	0.156	4.296	0.193	155.774	-0.383	-0.129	-0.095	0.525
*G. arb*196 × *G. arb*149	-16.228	-0.09	-2.333	-0.275	-3.096	-0.326	-112.999	0.387	-0.008	0.054	3.044**
*G. arb*196 × *G. arb*151	-4.238	0.085	0.848	0.119	-1.199	0.133	-42.775	-0.004	0.137	0.041	-3.569**
*G. arb*197 × *G. arb*147	11.266	-0.329*	0.952	0.023	5.469*	0.219	169.731	0.257	0.433	0.254	2.135*
*G. arb*197 × *G. arb*149	-19.528*	-0.123	-1.517	-0.008	-6.493 *	-0.119	-120.652	-1.538	0.404	-0.013	0.489
*G. arb*197 × *G. arb*151	8.262	0.452**	0.565	-0.015	1.024	-0.1	-49.078	1.281	-0.837**	-0.241	-2.624*
*G. arb*199 × *G. arb*147	-4.918	-0.029	-0.565	0.223	-1.496	-0.249	-91.886	0.148	0.429	0.225	-3.308**
*G. arb*199 × *G. arb*149	3.789	-0.123	0.917	0.092	3.962	0.098	182.351	-1.696	-0.005	-0.236	2.046
*G. arb*199 × *G. arb*151	1.129	0.152	-0.352	-0.315	-2.466	0.151	-90.465	1.547	-0.425	0.011	1.263
*G. arb*200 × *G. arb*147	-9.484	0.437**	1.019	-0.144	1.796	0.043	-62.66	3.218*	-0.362	0.294	-2.645*
*G. arb*200 × *G. arb*149	-15.928	-0.156	-0.5	-0.175	3.929	0.374	204.988	-0.301	0.819**	0.357	-1.621
*G. arb*200 × *G. arb*151	25.413**	-0.281	-0.519	0.319	-5.724 *	-0.417 *	-142.328	-2.918 *	-0.457	-0.651 *	4.266**
*G. arb*201 × *G. arb*147	1.866	0.104	-0.281	0.023	0.321	0.223	50.51	-0.653	-0.341	-0.196	1.637
*G. arb*201 × *G. arb*149	4.872	0.21	1.25	-0.008	-1.646	-0.156	-83.202	1.412	0.505	0.407	-1.179
*G. arb*201 × *G. arb*151	-6.738	-0.315*	-0.969	-0.015	1.326	-0.067	32.692	-0.759	-0.165	-0.211	-0.458
*G. arb*205 × *G. arb*147	-4.734	-0.329*	0.069	0.356*	2.349	0.091	108.63	-1.948	0.169	-0.251	2.913**
*G. arb*205 × *G. arb*149	29.672**	-0.023	-1.4	-0.275	-6.273 *	-0.117	-329.472 *	1.157	-0.65*	-0.148	-0.567
*G. arb*205 × *G. arb*151	-24.938**	0.352*	1.331	-0.081	3.924	0.026	220.842	0.791	0.48	0.399	-2.346*
*G. arb*161 × *G. arb*147	16.682	-0.029	0.619	0.223	1.429	0.064	72.874	0.412	-0.226	-0.04	3.578**
*G. arb*161 × *G. arb*149	15.739	0.177	0	-0.108	-0.013	0.011	-34.469	-0.048	-0.44	-0.191	2.438*
*G. arb*161 × *G. arb*151	-32.421**	-0.148	-0.619	-0.115	-1.416	-0.075	-38.405	-0.364	0.665*	0.231	-6.016**

Contd...

*G. arb*157 × *G. arb*147	-16.851	-0.129	-1.181	-0.21	-2.954	-0.232	-132.08	0.168	-0.531	-0.201	0.358
*G. arb*157 × *G. arb*149	22.455*	-0.123	2.6*	0.258	4.104	0.394*	174.918	-0.421	0.77*	0.297	-0.622
*G. arb*157 × *G. arb*151	-5.604	0.252	-1.419	-0.048	-1.149	-0.162	-42.838	0.252	-0.24	-0.096	0.264
*G. arb*52 × *G. arb*147	15.599	0.171	1.769	0.423*	3.171	0.234	325.027*	1.657	0.466	0.434	-0.753
*G. arb*52 × *G. arb*149	-8.195	-0.323*	-0.2	-0.308	-1.946	-0.054	-136.565	-0.293	0.407	0.137	-0.899
*G. arb*52 × *G. arb*151	-7.404	0.152	-1.569	-0.115	-1.224	-0.18	-188.462	-1.364	-0.873**	-0.571 *	1.653
*G. arb*106 × *G. arb*147	0.516	0.204	-1.581	-0.144	-3.154	-0.199	-182.86	-1.278	-0.602*	-0.533 *	-0.64
*G. arb*106 × *G. arb*149	2.672	0.01	0.5	0.225	-1.296	-0.227	-68.712	-2.173	-0.376	-0.524 *	0.544
*G. arb*106 × *G. arb*151	-3.187	-0.215	1.081	-0.081	4.451	0.426*	251.572*	3.451**	0.978**	1.057**	0.096
*G. arb*111 × *G. arb*147	-10.351	-0.296*	-1.498	-0.277	-4.804	-0.011	-247.633	-0.143	-0.051	-0.031	-0.365
*G. arb*111 × *G. arb*149	6.755	0.41**	1.233	0.192	5.054	0.051	132.915	0.977	-0.32	-0.018	0.824
*G. arb*111 × *G. arb*151	3.596	-0.115	0.265	0.085	-0.249	-0.04	114.718	-0.834	0.37	0.049	-0.459
*G. arb*108 × *G. arb*147	7.799	0.338*	-0.331	-0.11	-4.388	-0.306	-69.95	-4.377 **	-0.901**	-1.038**	-3.585**
*G. arb*108 × *G. arb*149	-10.045	-0.056	0.2	0.058	1.97	-0.009	60.618	3.409**	-0.295	0.326	1.434
*G. arb*108 × *G. arb*151	2.246	-0.281	0.131	0.052	2.417	0.315	9.332	0.968	1.195**	0.712**	2.151*
*G. arb*59 × *G. arb*147	-0.051	0.138	0.719	-0.044	1.946	0.109	148.907	-0.822	0.376	0.035	-1.142
*G. arb*59 × *G. arb*149	2.305	0.244	0.3	0.225	2.054	0.046	20.495	0.934	-0.618*	-0.156	-4.122**
*G. arb*59 × *G. arb*151	-2.254	-0.381*	-1.019	-0.181	-3.999	-0.155	-169.402	-0.112	0.242	0.121	5.264**
*G. arb*42 × *G. arb*147	-2.784	-0.062	-1.331	-0.410 *	-2.354	-0.112	-200.676	2.527	-0.146	0.3	1.525
*G. arb*42 × *G. arb*149	1.172	-0.156	-0.2	0.158	0.054	-0.086	44.321	-2.123	-0.19	-0.381	-0.456
*G. arb*42 × *G. arb*151	1.613	0.219	1.531	0.252	2.301	0.198	156.355	-0.404	0.335	0.081	-1.069
S.Em±	9.05	0.156	1.29	0.189	2.75	0.20	150.16	1.29	0.28	0.250	1.110
C.D. at 5%	17.505	0.289	2.504	0.354	5.214	0.394	298.232	2.554	0.579	0.497	2.055

*, ** : Significant at 5% and 1% level of probability

variability among hybrids and their parents.σ^2*gca*/σ^2sca was smaller than one for all characters studied which indicated predominance of non-additive gene action (dominant or epistasis) for these characters. These results were in accordance with earlier findings of Basal *et al.* (2011), Suryakumar *et al.* (2012), Alkuddsi *et al*. (2013).

The estimated general combining ability effects of lines and testers (Table 2) revealed significant differences among the parents. The line*, G. arb* 106 showed significant positive *gca* effects and found to be good general combiner for seed cotton yield, the line *G. arb* 205 was emerged as good general combiner for plant height, number of bolls per plant, ginning outturn, seed index and lint index. Among testers *G. arb* 151 exhibited significant positive *gca* effects for number of sympodia per plant, number of bolls per plant and lint index. Similar findings were made by Alkuddsi *et al.* (2013), Suryakumar *et al*. (2014), Patel *et al.* (2014) and Sawarkar *et al.* (2014).

The cross, *G. arb* 106 × *G. arb* 151 exhibited significant positive sca effects for seed cotton yield, boll weight, ginning outturn, seed index and lint index, the cross also exhibited significant heterosis for seed cotton yield (kg/ha) over DDhC-11 and Jayadhar. Similarly the cross, *G. arb* 52 × *G. arb* 147 recorded significant positive *sca* effects for seed cotton yield it also showed significant positive hetrosis over Jayadhar. The cross*, G. arb* 157 × *G. arb* 149 recorded significant positive *sca* effects for plant height, number of sympodia per plant, boll weight and seed index. The results indicated the predominance of non- additive gene action in the inheritance of these characters (Table 3). These results are in agreement with the findings of Saravanan and Koodalingam (2011), Nakum *et al.* (2014), Patel *et al*. (2014), Sawarkar *et al.* (2014) and Solanki *et al*. (2014).

Thus the parental genotypes showing significant positive *gca* effects for various traits can be further utilized in development of high yielding varieties and the crosses exhibiting significant positive *sca* effects for different traits could be exploited in heterosis breeding.

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