



Studies on Heterosis and Combining ability for Yield Components in Grain Sorghum [*Sorghum bicolor* (L.) Moench]

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An experiment was conducted to estimate heterosis in 48 F1 hybrids of sorghum [*Sorghum bicolor* (L.) Moench] with respect to grain yield and its components using six lines and eight testers. The hybrids and their parents were evaluated to assess the combining ability and gene action governing the traits by using line x tester analysis at Directorate of Sorghum Research (DSR), Rajendranagar, Hyderabad during 2010-11. Non-additive gene action was predominant for all the traits under study. The line 234 A testers CB 111 and CB 119 emerged as good general combiners for yield and its component traits. Based on sca effects, three hybrids viz., 234 A x CB 127, 151 A x CB 126 and 3183 A x CB 119 were identified as promising for good specific combiners for grain yield per plant and other traits. The hybrid 3183 A x CB 119 recorded maximum grain yield with 84.22, 69.78 and 26.93 per cent heterosis over the mid parent, better parent and standard check respectively.

Key words: *Sorghum*, *Line x Tester analysis*, *Combining ability* and *Standard heterosis*

Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important cereal crop grown in the world and plays a very important role in providing nutrition to human race. It is a major cereal grown as dual purpose crop adapted to drought prone areas of the world. For improvement in such an important crop, the most important pre-requisite is the selection of suitable parents, which could combine well and produce desirable hybrids and segregants. In order to achieve this, Line x Tester analysis (Kempthorne, 1957) for combining ability was adopted to obtain information on nature and magnitude of gene action governing the traits of economic importance and also an attempt was made to estimate the heterosis in with respect to yield and its component traits under study.

Materials and Methods

The experimental material comprised of six male sterile lines viz., 234 A, 151 A, 3060 A, 3183 A, 339 A and 318 A which were crossed with eight testers viz., CB 110, CB 111, CB 119, CB 124, CB 126, CB 127, CB 128 and CB 129 to develop 48 hybrids during *rabi* 2010-11. These hybrids along with their parents and check CSH-16 were grown in randomized block design with three replications at Directorate of Sorghum Research, Rajendranagar, Hyderabad during *kharif* 2011. Observations were recorded on days to 50 per cent flowering, plant height (cm), panicle length (cm), panicle weight (g), number of primary branches/panicle, length of primary branch (cm), number of grains/primary branch, 100-seed weight (g), number of grains/panicle, starch content (%), protein content (%) and grain yield/plant (g).

The data was subjected to Line x Tester analysis developed by Kempthorne (1957).

Results and Discussion

The analysis of variance of combining ability for yield and its component traits (Table 1) revealed significant variation for all the traits under study. Variance due to parents was highly significant for all the traits except starch content, indicating good amount of genetic variability present among the parents. Variance due to crosses was also highly significant for all the traits studied. The lines were highly significant for all the traits except panicle weight and starch content in the grain. Variance due to testers was highly significant for all the traits except starch content and protein content in the grain. The interaction effects (lines x testers) were found to be significant for all the traits except panicle length and length of primary branch reveals the presence of significant variability in the material studied. The magnitude of variance due to SCA was higher than that of GCA revealed that non-additive gene action was predominant in the inheritance of grain yield and all its component traits (Table 1). Similar observations were also reported by Chaudhary *et al.* (2006) and Premalatha *et al.* (2006). Non-additive gene action for grain yield per plant in the present study was in accordance with the reports of Aruna *et al.* (2010) and Mahdy *et al.* (2011).

A perusal of results on *gca* effects (Table 2) revealed several good combiners for different traits studied but none of them was superior for all the traits. Among the lines, the live 234 A for panicle weight, number of primary branches per panicle and grain yield per plant, 151 A for earliness, number of

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Table 1. Analysis of variance for combining ability for yield and yield components in sorghum

Source	d.f	Days to 50% flower	Plant height (cm)	Panicle length (cm)	Panicle weight (g)	Number of primary branches/panicle	Length of primary branch (cm)	Number of grains/primary branch	100-seed weight (g)	Number of grains/panicle	Starch content in grain (%)	Protein content in grain (%)	Grain yield/plant (g)
Replications	2	6.40	126.13	6.42	125.52	77.16**	1.34	206.32*	0.046	31906.29	2.15	1.12	52.72
Treatments	61	39.52**	1748.3**	22.42**	1173.11**	221.18**	4.41**	1119.15**	0.38**	1389910.9**	23.96**	1.90**	911.44**
Crosses	47	17.81**	1508.2**	15.58**	949.79**	167.04**	2.54**	926.26**	0.31**	1303540.3**	28.65**	1.88**	724.56**
Line effect	5	63.90**	7338.8**	79.13**	1470.37	940.10**	11.63**	2107.15**	0.61**	1922380.3**	26.15	4.20*	1151.58*
Tester effect	7	35.86**	1969.2**	24.94**	2306.02**	196.62**	4.79**	2377.39**	0.89**	4713120.9**	22.99	2.71	1795.51**
L x T effect	35	7.61**	583.08*	4.63	604.17**	50.69**	0.79	467.34**	0.15**	533218.47*	30.13**	1.39**	449.36**
Error	122	3.99	119.92	5.88	287.30	13.40	0.66	51.86	0.05	326666.51	6.35	0.43	168.99
σ^2 gca		0.1623	14.729	0.1744	5.5027	1.8525	0.0278	7.3067	0.0025	12264.609	0.000	0.0079	4.3638
σ^2 sca		1.2095	154.38	-0.4194	105.6226	12.336	0.0433	138.4905	0.0323	68850.652	7.929	0.3183	93.457
σ^2 gca/ σ^2 sca		0.1341	0.0954	-0.4158	0.052	0.1501	0.6420	0.0527	0.0773	0.1781	0.000	0.0248	0.0466

* Significant at 5% level, ** Significant at 1% level

primary branches per panicle and starch content, primary branch, number of grains per primary branch
 3060 A for panicle length, panicle weight, length of and number of grains per panicle, 3183 A for earliness
Table 2. General combining ability (gca) effects for parents in respect of yield components in sorghum

Parents	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle weight (g)	Number of primary branches/panicle	Length of primary branch (cm)	Number of grains/primary branch	100-seed weight (g)	Number of grains/panicle	Starch content in grain (%)	Protein content in grain (%)	Grain yield/plant (g)
Lines												
234 A	1.14**	-0.74	-1.28*	7.72*	3.66**	-0.07	-0.33	0.006	170.80	0.87	-0.55**	6.19*
151 A	-1.76**	-25.07**	0.97	-10.77**	8.51**	-0.22	-9.52**	-0.076	-377.79**	1.10*	-0.24	-10.92**
3060 A	1.98**	2.31	2.74**	8.58*	1.20	0.87**	9.41**	-0.062	397.81**	-0.80	-0.17	4.40
3183 A	-1.55**	1.89	-1.59**	0.03	-1.66*	-0.67**	-3.39*	0.11*	133.15	-0.70	0.14	2.36
339 A	1.21**	28.93**	-1.73**	1.75	-1.54*	-0.70**	-9.05**	0.24**	-169.65	-1.28*	0.17	4.22
318 A	-1.02*	-7.32**	0.88	-7.32*	-10.17**	0.80**	12.88**	-0.22**	-154.33	0.81	0.65**	-6.26*
S.Eg.±	0.4078	2.2354	0.4954	3.4599	0.7551	0.1666	1.4701	0.0498	116.666	0.5144	0.1349	2.653
S.Eg.g.±	0.5767	3.1613	0.7006	4.893	1.0679	0.2356	2.0791	0.0704	164.991	0.7275	0.1907	3.7527
Testers												
CB 110	-0.72	-4.82	-0.78	3.70	-4.15**	-0.16	5.53**	0.052	-9.47	1.48*	0.22	4.90
CB 111	-0.47	16.92**	1.67**	7.64	-0.05	-0.04	9.28**	-0.29**	611.52**	-0.30	-0.71**	6.29*
CB 119	2.01**	-7.86**	0.46	11.14**	-4.04**	0.85**	13.52**	-0.20**	424.52**	0.49	-0.22	9.94**
CB 124	-0.24	-1.58	-1.76**	2.81	3.46**	-0.62**	-2.45	-0.024	-35.15	0.29	-0.07	3.23
CB 126	-1.96**	16.32**	0.78	-3.96	1.94*	0.43*	0.87	0.17**	-277.40*	-0.85	-0.22	-2.83
CB 127	1.24**	-7.92**	0.98	-2.30	4.62**	0.39*	-2.58	0.006	-227.57	-0.09	0.42**	-4.92
CB 128	-1.28**	-6.35*	-0.22	-25.17**	0.54	-0.38*	-24.72**	0.41**	-960.96**	-2.10**	0.41**	-21.62**
CB 129	1.42**	-4.69	-1.14*	6.14	-2.31**	-0.46*	0.53	-0.119*	474.53**	1.08	0.17	5.01
S.Eg.±	0.4708	2.5812	0.5720	3.9952	0.8719	0.1924	1.6975	0.0575	134.715	0.5940	0.1557	3.064
S.Eg.g.±	0.6659	3.6504	0.8090	5.650	1.2331	0.2721	2.4007	0.0813	190.515	0.8401	0.2202	4.333

* Significant at 5% level, ** Significant at 1% level

and 100-seed weight, 339 A for plant height and 100-seed weight and the line 318 A for earliness, length of primary branch, number of grains per primary branch and protein content were found to be good general

Table 3. Specific combining ability (sca) effects of hybrids in respect of yield components in grain sorghum

Crosses	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle weight (g)	Number of primary branches/panicle	Length of primary branch (cm)	Number of grains/primary branch	100-seed weight (g)	Number of grains/panicle	Starch content in grain (%)	Protein content in grain (%)	Grain yield/plant (g)
234 A x CB 110	0.54	-10.39	0.39	-11.83	-3.81	0.41	-9.01*	-0.15	-127.69	-3.51*	0.86*	-10.53
234 A x CB 111	-0.84	-0.2	-0.06	1.22	1.81	-0.16	-12.30**	0.04	-428.03	0.82	-0.17	-1.58
234 A x CB 119	0.66	-3.75	-0.18	-8.28	1.29	-0.45	2.09	-0.14	7.83	-2.47	-0.38	-8.56
234 A x CB 124	0.19	-6.89	-2.68	-21.94*	-5.35*	0.02	5.86	0.02	-538.01	4.32**	-0.17	-13.19
234 A x CB 126	0.91	16.19*	1.29	5.16	2.50	-0.79	10.32*	0.22	-143.5	2.82	0.17	1.54
234 A x CB 127	-0.42	0.10	0.09	19.83*	-1.11	0.29	17.10**	0.07	996.66**	-2.68	-0.37	20.30**
234 A x CB 128	-2.23	9.53	1.21	15.45	6.80**	0.59	3.45	-0.05	58.85	3.67*	0.89*	8.67
234 A x CB 129	1.18	-4.58	-0.07	0.38	-2.14	0.08	-17.51**	-0.02	173.89	-2.97*	-0.82*	3.36
151 A x CB 110	-0.54	-8.08	0.24	8.08	3.95	1.19*	13.90**	-0.20	595.37	-1.01	0.64	3.59
151 A x CB 111	3.19**	-15.68*	0.38	-5.28	-3.68	-0.23	-9.66*	-0.14	-254.42	-5.46**	0.32	-6.79
151 A x CB 119	-1.16	-3.29	-1.94	-16.78	-3.79	-0.63	-10.04*	-0.09	-363.35	-0.57	-0.09	-14.77
151 A x CB 124	0.30	-4.77	-0.01	14.22	4.90*	-0.17	5.75	-0.27	691.92*	2.59	-0.65	11.59
151 A x CB 126	-1.31	8.18	0.63	23.33*	-0.22	0.34	15.99**	0.21	429.89	0.006	-0.88*	22.66**
151 A x CB 127	1.15	3.26	-0.43	-33.33**	-0.18	-0.77	-25.47**	0.12	-1017.02**	1.61	0.37	-24.90**
151 A x CB 128	-0.99	18.19**	0.98	12.54	-2.41	0.40	1.19	0.40**	21.33	0.48	-0.43	9.79
151 A x CB 129	-0.63	2.20	0.13	-2.78	1.45	-0.12	8.34*	-0.02	-103.71	2.35	0.72	-1.18
3060 A x CB 110	0.56	30.94**	-1.56	14.96	-6.21**	-0.79	12.13**	0.44**	-206.3	1.66	-0.42	10.59
3060 A x CB 111	-0.75	-4.66	-1.12	-5.97	-4.49*	0.15	-2.49	-0.14	232.96	1.61	-1.30**	-0.79
3060 A x CB 119	0.62	-13.34*	0.91	-20.81*	-0.58	0.06	6.10	-0.39**	-233.7	3.65*	-0.86*	-19.77**
3060 A x CB 124	0.29	-12.62*	1.41	6.18	9.50**	0.10	-12.71**	-0.16	494.7	1.75	0.34	5.59
3060 A x CB 126	-0.06	4.80	-1.53	-5.70	-1.52	0.49	-10.34*	0.07	331.75	-1.95	0.25	-1.00
3060 A x CB 127	-1.59	4.05	2.59	6.63	-5.20*	0.33	-5.25	0.16	-209.01	-2.24	0.58	2.76
3060 A x CB 128	0.59	-2.18	-1.32	2.50	4.49*	-0.22	-0.39	0.08	-415.48	-4.36**	0.58	2.79
3060 A x CB 129	0.34	-7.17	0.62	2.18	4.02	-0.13	12.96**	-0.05	5.08	-0.13	0.81*	-0.18
3183 A x CB 110	-1.75	-2.63	-0.15	-0.89	0.25	0.08	-5.52	0.12	-358.84	2.88	-0.08	1.63
3183 A x CB 111	-2.34*	13.28*	0.31	1.90	2.95	-0.17	15.69**	0.11	-31.71	-2.19	0.28	5.24

Table 3. (Continued) Estimates of specific combining ability (sca) effects of hybrids in respect of yield components in grain sorghum

Crosses	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle weight (g)	Number of primary branches/panicle	Length of primary branch (cm)	Number of grains/primary branch	100-seed weight (g)	Number of grains/panicle	Starch content in grain (%)	Protein content in grain (%)	Grain yield/plant (g)
3183 A x CB 119	0.76	7.73	0.49	29.40**	1.95	0.32	14.29**	0.30*	248.22	-0.69	0.62	29.15**
3183 A x CB 124	-1.90	11.52	0.92	2.74	-2.29	-0.11	-6.52	0.17	-282.63	-5.69**	-0.41	2.30
3183 A x CB 126	-0.19	-15.78*	-0.85	-21.14*	-2.86	-0.18	-7.21	-0.32*	-350.79	-0.44	-0.64	-18.29*
3183 A x CB 127	2.94*	-6.2	-0.75	7.85	5.47*	0.80	-7.21	-0.19	275.98	1.99	-0.23	0.46
3183 A x CB 128	2.99*	-9.17	1.22	-16.93	-1.44	-0.24	0.59	-0.34	510.9	4.78**	0.13	-12.03
3183 A x CB 129	-0.51	1.23	-1.19	-2.92	-4.04	-0.48	-4.10	0.14	-11.12	-0.63	0.32	-8.47
339 A x CB 110	1.81	0.65	1.57	-5.53	0.40	-0.20	1.22	-0.19	-70.37	3.73*	-0.24	-2.56
339 A x CB 111	-0.04	1.57	0.58	1.52	2.74	-0.17	7.48	0.01	-42.43	2.85	0.78*	-2.94
339 A x CB 119	0.73	18.69**	-0.57	15.35	1.76	-0.07	-12.07**	0.14	510.69	-3.50*	0.58	14.4
339 A x CB 124	1.19	8.75	0.12	-7.64	-3.67	0.17	-10.77*	0.1	-389.29	-3.92**	0.25	-10.56
339 A x CB 126	-0.29	-25.15**	-0.22	-3.20	0.64	0.41	-5.13	-0.31*	-11.85	-1.11	-0.33	-3.24
339 A x CB 127	-0.49	5.09	0.07	1.80	0.49	-0.64	21.72**	0.22	-17.21	2.52	0.05	4.60
339 A x CB 128	-2.96*	-31.48**	-2.37	-12.99	-0.80	-0.08	-12.75**	0.001	-187.21	-1.21	-1.41**	-11.36
339 A x CB 129	0.05	21.86**	0.80	10.68	-1.56	0.59	10.31*	0.02	207.68	0.65	-0.36	11.66
318 A x CB 110	-0.61	-10.48	-0.50	-4.78	5.41*	-0.68	-12.72**	-0.01	167.84	-3.75*	-0.76*	-2.73
318 A x CB 111	0.79	5.50	-0.09	6.60	0.66	0.60	1.28	0.12	523.64	2.37	0.07	6.87
318 A x CB 119	-1.62	-6.04	1.27	1.10	-0.63	0.77	-0.36	0.17	-169.68	3.59*	0.13	-0.44
318 A x CB 124	-0.09	4.01	0.24	6.43	-3.08	-0.01	18.40**	0.14	23.32	0.94	0.65	4.26
318 A x CB 126	0.95	11.76	0.69	1.55	1.46	-0.26	-3.62	0.12	-255.5	0.68	0.75*	-1.66
318 A x CB 127	-1.58	-6.31	-1.57	-2.78	0.52	-0.02	-0.88	-0.39**	-29.39	-1.20	-0.40	-3.23
318 A x CB 128	2.60*	15.11*	0.27	-0.57	-6.63**	-0.44	7.90	-0.09	11.6	-3.36*	0.23	2.12
318 A x CB 129	-0.43	-13.54*	-0.31	-7.56	2.28	0.06	-9.99*	-0.06	-271.83	0.73	-0.68	-5.18
S.E.S _k ±	1.1533	6.3226	1.4012	9.7862	2.1357	0.4713	4.1581	0.1409	329.983	1.4551	0.3814	7.505
S.E.S _k S _k ±	1.5257	8.364	1.8536	12.9459	2.8253	0.6235	5.5007	0.1864	436.526	1.9249	0.5046	9.928
S.E.S _k S _k ±	1.631	8.9415	1.9815	13.8397	3.0204	0.6665	5.8804	0.1992	466.666	2.0578	0.5394	10.614

* Significant at 5% level, ** Significant at 1% level

combiners which may be utilized as potential parents in future hybrid development programme.

Likewise, among the testers, CB 110 for number of grains per primary branch and starch content, CB 111 for plant height, panicle length, number of grains per primary branch, number of grains per panicle and grain yield per plant, the testers CB 119 for panicle weight, length of primary branch, number of grains per primary branch, number of grains per panicle and grain yield per plant, CB 126 and CB 128 for earliness and 100-seed weight and the testers CB 127 and CB 128 for protein content can be utilized in population improvement to develop high yielding varieties since they possess high *per se* performance with significant *gca* effects for the respective traits.

An overall picture of *sca* effects revealed that none of the hybrids were found to be superior for all the traits studied (Table 3). Three hybrids *viz.*, 234 A x CB 127, 154 A x CB 126 and 3183 A x CB 119 were identified as promising for good specific combiners for grain yield per plant, panicle weight and number of in turn, these hybrids also exhibited high mean performance and high heterosis for most of the traits. Therefore, these hybrids were recommended for heterosis breeding.

Relationship between *sca* effects of hybrids and *gca* effects of parents are helpful to understand the type of interaction between parents and the breeding procedure to be used. The hybrids, 234 A x CB 127 and 3183 A x CB 119 which recorded significant *sca* effects for grain yield per plant were found to involve high x low and low x high combinations in terms the respective parental *gca* effects indicating the presence of additive x dominance type of gene interaction. Thus, it can be concluded that both inter

and intra allelic interactions were involved in the expression of these traits. The other hybrid 151 A x CB 126 involving parents with poor *gca* and with higher *sca* effects might be due to high complementarity between the parents.

The hybrid 339 A x CB 119 had non-significant *sca* effects for grain yield with high mean performance which involved good general combiners can be utilized in isolating promising segregants at later generations for the desirable genes of the parents. The hybrids, 3183 A x CB 111 and 339 A x CB 128 recorded significant negative *sca* effects for days to 50% flowering. Highest positive significant *sca* for plant height was recorded by the hybrid 3060 A x CB 110 followed by 339 A x CB 129. The hybrid 234 A x CB 127 was superior for four traits as evidenced by *sca* panicle weight, number of grains per primary branch, number of grains per panicle and grain yield per plant. The hybrid 234 A x CB 128 was superior for number of primary branches per panicle, starch and protein content.

Six hybrids *viz.*, 234 A x CB 124, 234 A x CB 128, 3060 A x CB 119, 3183 A x CB 128, 339 A x CB 110 and 318 A x CB 119 were found to be superior for starch content, whereas five hybrids *viz.*, 234 A x CB 110, 234 A x CB 128, 3060 A x CB 129, 339 A x CB 111 and 318 A x CB 126 were found to be superior for protein content.

The estimates of three types of heterosis revealed significant positive heterosis over mid and better parent and standard check for grain yield and yield components in majority of the crosses (Table 4).

The hybrid 3183 A x CB 119 exhibited superior heterotic expression either of three heterosis, namely relative heterosis, heterobeltiosis, standard heterosis

for grain yield per plant and number of grains per primary branch and good specific combiner for these traits (Table 5). This hybrid recorded maximum grain yield with 84.22, 69.78 and 26.93 per cent heterosis over the mid parent, better parent and standard check, respectively. All three types of heterosis for this trait were reported by Premalatha *et al.* (2006). Standard heterosis for this trait reported by Mahmoud and Ahmed (2010) and Makanda *et al.* (2010). It also showed higher mean performance for grain yield per plant and number of grains per primary branch may be further exploited in multilocation evaluation before releasing for cultivation.

The hybrids *viz.*, 234 A x CB 126, 3060 A x CB 110, 3183 A x CB 119 and 339 A x CB 129 were tall and high yielding compared to parents. Better parent heterosis for plant height was reported by El-Mottaleb and Asran (2004), and El-Dardeer *et al.* (2011). Almost all hybrids showed significant negative

heterosis except few *viz.*, 151 A x CB 111, 151 A x CB 127, 3183 A x CB 127, 339 A x CB 110, 339 A x CB 124 and 318 A x CB 128. Similarly, all hybrids showed significant negative heterobeltiosis for days to 50% flowering except two, 3060 A x CB 110 and 339 A x CB 110. The results of heterosis for earliness were in accordance with the findings of Kenga *et al.* (2005) and Premalatha *et al.* (2006).

For number of primary branches per panicle, hybrids were found to be superior than the check CSH-16. For panicle weight, significant positive heterosis and heterobeltiosis was exhibited by nine hybrids but none of them were found to be superior than the check. Both mid parent heterosis and better parent heterosis for panicle weight was reported by Sharma and Sharma (2006). The hybrid 3060 A x CB 127 recorded significant positive standard heterosis for panicle length.

For number of grains per primary branch, as

Table 4. Relative Heterosis (RH), Heterobeltiosis (HB) and Standard Heterosis (SH) for days to 50% flowering, plant height, panicle length and panicle weight

Crosses	Days to 50% flowering			Plant height			Panicle length			Panicle weight		
	RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
234 A x CB 110	-4.62*	-5.31*	3.70	4.47	-3.34	-16.30**	17.98*	11.31	-10.95	30.09*	26.09	-11.00
234 A x CB 111	-7.66	-9.64**	1.90	6.04	-0.37	-1.87	16.09*	1.51	-3.81	22.02*	5.56	2.05
234 A x CB 119	-5.97**	-11.51**	8.25**	8.65	-1.46	-14.67**	18.43*	9.56	-8.57	24.51*	13.39	-2.56
234 A x CB 124	-5.53**	-7.27**	3.92	1.59	0.17	-13.25**	5.39	5.03	-25.48**	5.00	-2.78	-19.44
234 A x CB 126	-7.73**	-10.13**	2.33	15.35**	9.73*	5.27	15.69*	-0.36	-2.14	35.74**	35.25*	-3.84
234 A x CB 127	-5.24**	-7.87**	5.29*	5.38	0.52	-12.95**	20.18*	9.70	-5.71	33.86**	18.38	8.70
234 A x CB 128	-8.78**	-8.82**	-1.59	14.42**	6.26	-7.98	20.55*	10.66	-6.07	24.37	24.37	-12.21
234 A x CB 129	-6.02**	-11.52**	8.15**	8.64	-0.24	-13.61**	22.03*	21.31*	-13.93	46.54**	42.03**	0.26
151 A x CB 110	-6.60**	-11.11**	-2.65	4.65	0.15	-26.24**	19.92*	19.13*	-3.42	64.60**	36.00	-9.91
151 A x CB 111	-2.04	-8.05**	3.70	-3.32	-18.62**	-19.85**	20.38**	11.68	5.83	18.46	-14.29	-17.14
151 A x CB 119	-8.94**	-17.65**	0.74	8.20	5.77	-25.45**	13.31	11.70	-6.79	18.81	-10.71	-23.27*
151 A x CB 124	-5.72**	-11.24**	-0.53	1.27	-8.87	-23.28**	21.60**	13.66	-7.86	49.29**	13.58	-5.88
151 A x CB 126	-11.49**	-17.29**	-5.82*	11.07*	-5.49	-9.34*	15.54*	5.45	3.57	67.79**	34.898	-4.09
151 A x CB 127	-3.23	-9.72**	3.17	6.19	-1.44	-22.52**	20.28**	16.86*	0.45	-20.45	-41.50**	-46.29**
151 A x CB 128	-7.37**	-11.19**	-4.23	20.00**	14.40**	-15.06**	21.95**	19.21*	1.19	25.39	1.09	-28.64**
151 A x CB 129	-9.00**	-17.66**	0.63	12.288	8.32	-21.54**	25.51**	17.03	-5.12	52.80**	26.25	-16.37
3060 A x CB 110	-4.29**	-4.52	5.08	35.76**	30.99**	3.77	5.74	-5.81	-3.57	67.70**	66.41**	10.23
3060 A x CB 111	-7.21**	-8.33**	3.39	9.83*	-0.92	-2.41	8.33	4.30	6.79	20.06	0.53	-2.81
3060 A x CB 119	-5.74**	-10.47**	9.52**	10.06*	3.99	-17.62**	18.13**	7.21	9.76	17.09	2.98	-11.51
3060 A x CB 124	-5.10*	-5.95*	5.40	4.70	1.61	-14.46**	19.83**	1.16	3.57	38.86**	24.07	2.81
3060 A x CB 126	-8.79**	-10.32**	2.12	15.91**	5.81	1.51	1.84	-0.23	2.14	29.83*	24.46	-11.51
3060 A x CB 127	-6.60**	-8.33**	4.76	14.31**	13.88**	-9.79*	24.91**	14.88*	17.62*	26.38*	8.08	-0.77
3060 A x CB 128	-4.32*	-5.29*	4.23	14.82**	11.22*	-11.90**	6.04	-3.02	-0.71	15.63	11.23	-21.48*
3060 A x CB 129	-6.88**	-11.52**	8.15**	14.20**	9.32	-13.40**	19.39**	0.58	2.98	55.64**	54.44**	2.30
3183 A x CB 110	-11.32**	-12.56**	-4.23	18.47**	16.93**	-11.60**	5.94	4.49	-14.05	38.80**	38.13*	-8.50
3183 A x CB 111	-13.12**	-15.55**	-4.76	21.11**	7.03	5.42	8.94	1.76	-3.57	19.15	0.00	-3.32
3183 A x CB 119	-8.97**	-14.88**	4.13	25.57**	21.31**	-8.28*	11.93	11.13	-7.26	58.99**	40.18**	20.46
3183 A x CB 124	-11.86**	-14.07**	-3.70	20.49**	14.35**	-3.73	13.02	4.92	-13.69	26.10*	12.96	-6.39
3183 A x CB 126	-12.58**	-15.43**	-3.70	7.29	-4.08	-7.98	-1.32	-9.33	-10.95	2.53	-1.44	-29.92**
3183 A x CB 127	-3.64	-6.94**	6.35*	10.74*	8.62	-14.61**	7.15	4.85	-9.88	18.93	1.95	-6.39
3183 A x CB 128	-4.40*	-5.00*	2.43	13.13**	12.11*	-15.24**	11.11	9.40	-7.14	-16.24	-19.2	-42.97**
3183 A x CB 129	-11.52**	-17.23**	1.16	21.87**	19.32**	-9.79*	6.25	-1.59	-19.05**	39.28**	38.61*	-8.18
339 A x CB 110	-2.44	-3.38	5.82*	26.14**	15.70**	2.11	16.40*	14.58	-8.33	30.47*	26.45	-10.74
339 A x CB 111	-6.19**	-8.42**	3.28	20.32**	14.07**	12.35**	12.51	2.26	-3.10	16.82	1.06	-2.30
339 A x CB 119	-5.57**	-11.33**	8.47**	37.19**	23.38**	8.89*	9.91	5.99	-11.55	41.83**	29.17*	11.00
339 A x CB 124	-3.76	-5.76*	5.61*	24.37**	21.50**	7.23	12.15	7.07	-17.02*	13.33	4.94	-13.04
339 A x CB 126	-9.13**	-11.71**	0.53	8.59*	4.24	0.00	3.39	-7.52	-9.17	20.22	19.78	-14.83
339 A x CB 127	-5.01*	-7.87**	5.29*	23.10**	16.38**	2.71	13.33	7.76	-7.38	11.18	-1.67	-9.72
339 A x CB 128	-9.54**	-9.72**	-2.65	6.95	-1.54	-13.10**	-2.05	-6.31	-20.48**	-13.04	-13.04	-38.62**
339 A x CB 129	-7.28**	-12.90**	6.46*	39.08**	26.62**	11.75**	18.71*	13.06	-12.38	51.40**	46.74**	3.58
318 A x CB 110	-6.53**	-10.14**	-1.59	8.24	6.95	-19.31**	11.17	5.93	-6.43	20.45	16.13	-17.14
318 A x CB 111	-5.48*	-10.39**	1.06	12.38**	-0.76	-2.26	13.39*	9.55	3.81	12.63	-2.12	-5.37
318 A x CB 119	-9.43**	-17.30**	1.16	11.46*	7.78	-18.67**	21.55**	18.19*	4.40	18.37	8.33	-6.91
318 A x CB 124	-6.16**	-10.76**	0.00	11.13*	5.37	-11.30**	16.82*	5.01	-7.24	17.74	9.57	-9.21
318 A x CB 126	-7.93**	-13.10**	-1.06	17.05**	4.55	0.30	10.91	5.33	3.45	14.9	14.7	-18.16
318 A x CB 127	-7.13**	-12.50**	0.00	5.38	3.26	-18.83**	10.25	8.76	-3.93	-2.19	-13.09	-20.2
318 A x CB 128	-1.72	-4.81*	2.65	22.33**	21.36**	-8.43*	13.54	11.32	-1.67	-9.91	-10.39	-36.06**
318 A x CB 129	-8.53**	-16.45**	2.12	7.33	5.19	-20.63**	17.36*	5.26	-7.02	20.07	15.77	-17.39

* Significant at 5% level, ** Significant at 1% level

Table 4. (Continued) Relative Heterosis (RH), Heterobeltiosis (HB) and Standard Heterosis (SH) for number of primary branches per panicle, length of primary branch, number of grains per primary branch and 100-seed weight

Crosses	Number of primary branches per panicle			Length of primary branch			Number of grains per primary branch			100-seed weight		
	RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
234 A x CB 110	-6.04	-23.78**	-6.65	18.27*	10.93	-13.44*	14.91*	-11.74*	2.01	10.04	9.75	-17.60**
234 A x CB 111	2.43	-12.33**	7.37	14.92	10.14	-17.89**	-2.55	-30.95**	2.53	9.76	4.16	-22.20**
234 A x CB 119	-0.14	-17.65**	0.86	13.35	1.19	-11.95	37.88**	5.47	23.32**	8.4	0.66	-24.82**
234 A x CB 124	-3.32	-16.63**	2.11	16.3	14.65	-21.64**	46.40**	24.79**	9.71	0.41	-10.42	-14.70*
234 A x CB 126	-8.39**	-9.18*	11.24*	-17.65**	-36.75**	-19.38**	35.92**	5.47	18.39**	37.48**	30.01**	-2.89
234 A x CB 127	1.37	-10.27**	9.89*	20.02**	9.42	-9.17	30.52**	-2.43	22.10**	15.00*	12.59	-12.23*
234 A x CB 128	1.69	-5.76	15.42**	18.73*	12.17	-13.81*	10.52	-5.27	-17.83**	19.68**	12	-4.03
234 A x CB 129	-3.71	-19.66**	-1.6	25.35**	17.77	-19.51**	27.36**	16.58	-13.05*	13.34	8.46	-18.99**
151 A x CB 110	22.86**	5.88	11.53**	30.54**	18.76*	-7.32	36.02**	1.51	17.33**	5.32	4.38	-21.63**
151 A x CB 111	10.57**	1.04	6.43	15.39	7.19	-20.09**	-7.29	-35.87**	-4.78	-0.63	-5.12	-30.03**
151 A x CB 119	8.74*	-4.58	0.51	12.43	-2.47	-15.13*	14.48*	-14.89**	-0.48	7.75	0.64	-25.78**
151 A x CB 124	27.65**	17.61**	23.88**	14.97	12.84	-25.06**	37.14**	12.98	-0.68	-12.36*	-22.24**	-25.96**
151 A x CB 126	1.28	-5.04	14.30**	-5.7	-29.19**	-9.75	35.32**	1.98	14.47*	34.22**	27.70**	-5.83
151 A x CB 127	18.42**	12.24**	18.22**	7.54	-4.81	-20.98**	-29.33**	-48.59**	-35.66**	14.43*	11.34	-13.21*
151 A x CB 128	4.01	3.6	9.13*	17.73*	7.86	-17.12**	-3.41	-20.01**	-30.61**	34.33**	24.97**	7.09
151 A x CB 129	18.11**	4.97	10.57*	24.06**	20.30*	-23.06**	60.50**	41.51**	5.54	10.82	6.7	-21.31**
3060 A x CB 110	-4.03	-16.76**	-13.64**	-5.69	-16.16*	-15.89*	28.80**	18.08**	36.48**	45.36**	30.41**	-2.09
3060 A x CB 111	-0.75	-8.68*	-5.26	7.94	-5.92	-5.62	1.59	-16.24**	24.36**	10.97	4.81	-29.70**
3060 A x CB 119	3.25	-8.80*	-5.38	9.24	2.00	2.33	30.04**	18.60**	38.66**	6.1	2.47	-34.40**
3060 A x CB 124	24.65**	15.65**	19.98**	6.01	-11.91	-11.63	8.38	3.64	-0.15	0.38	-18.38**	-22.28**
3060 A x CB 126	-9.07**	-15.35**	1.89	-10.15*	-19.72**	2.33	1.84	-5.38	6.21	43.46**	35.97**	-9.47
3060 A x CB 127	1.43	-3.17	0.46	9.58	0.13	0.45	-2.45	-13.67*	8.03	28.37**	13.28	-11.69*
3060 A x CB 128	4.24	3.86	8.55	-1.33	-12.88*	-12.6	-3.04	-7.87	-11.24	34.80**	14.31*	-2.05
3060 A x CB 129	11.77**	0.00	3.75	9.24	-12.67	-12.39	54.26**	36.84**	31.83**	22.19**	14.48	-21.87**
3183 A x CB 110	11.51*	4.07	-8.45	5.24	-0.66	-22.48**	-1.68	-11.33*	2.49	22.85**	21.12**	-6.42
3183 A x CB 111	15.73**	15.21**	1.34	5.82	2.08	-23.90**	8.01	-12.20**	30.36**	14.89*	7.31	-17.08**
3183 A x CB 119	12.40**	7.02	-5.86	14.82*	3.12	-10.27	27.26**	14.19*	33.51**	29.58**	18.47*	-8.46
3183 A x CB 124	11.86**	11.36*	-1.15	4.83	2.66	-28.88**	2.28	-0.46	-7.53	7.51	-2.63	-7.28
3183 A x CB 126	-8.00*	-20.38**	-4.16	-17.98**	-36.70**	-19.32**	-6.99	-15.00*	-4.59	16.65*	8.58	-16.10**
3183 A x CB 127	22.57**	18.43**	11.72**	18.09*	8.33	-10.08	-16.03**	-26.84**	-8.45	6.63	6.16	-17.24**
3183 A x CB 128	-0.39	-8.27*	-4.13	-1.24	-6.09	-27.84**	-15.87*	-18.65**	-24.43**	11.11	5.65	-9.47
3183 A x CB 129	3.61	0.03	-12.01**	6.87	-0.23	-30.88**	17.63*	6.03	-1.5	22.69**	15.54*	-10.73
339 A x CB 110	8.29	-1.75	-8.07	3.32	-4.55	-25.52**	10.79	-10.28	3.7	7.18	-1.28	-11.99*
339 A x CB 111	11.99**	8.16	1.20	7.90	1.82	-24.10**	4.38	-22.63**	14.88*	7.47	-5.84	-16.05**
339 A x CB 119	8.66*	0.51	-5.96	11.85	-1.56	-14.34*	3.71	-16.38**	-2.23	18.31**	1.63	-9.39
339 A x CB 124	6.43	3.70	-2.98	11.11	10.89	-26.36**	2.05	-7.40	-18.59**	2.78	-0.5	-5.25
339 A x CB 126	-5.52	-16.04**	1.06	-10.91	-32.34**	-13.76*	-0.57	-18.56**	-8.59	12.93	-1.37	-12.06*
339 A x CB 127	11.45**	11.00*	4.71	1.34	-8.95	-24.42**	19.45**	-6.09	17.52**	18.57**	11.13	-0.93
339 A x CB 128	-2.11	-7.24	-3.05	2.73	-4.41	-26.55**	-31.36**	-37.34**	-45.65**	19.59**	17.26*	4.55
339 A x CB 129	4.57	-1.95	-8.26	25.59**	19.82*	-20.74**	48.10**	45.17**	8.27	13.63*	0.31	-10.57
318 A x CB 110	23.62**	13.77*	-13.28**	-5.15	-15.57*	-15.57*	-7.72	-12.36*	12.62	11.94	6.4	-20.11**
318 A x CB 111	13.43**	-1.60	-14.22**	12.29	-2.00	-2.00	-4.37	-10.81*	32.43**	9.13	8.67	-26.49**
318 A x CB 119	8.85	-1.73	-21.84**	15.99**	8.46	8.46	10.27*	5.31	35.32**	18.08*	14.91	-22.27**
318 A x CB 124	11.82*	-3.73	-14.55**	3.80	-13.63*	-13.63*	27.94**	7.73	38.43**	0.83	-13.77*	-17.89**
318 A x CB 126	-2.6	-25.38**	-10.18*	-17.13**	-26.05**	-5.75	-2.33	-8.50	17.57**	30.12**	29.10**	-12.67*
318 A x CB 127	16.56**	-2.14	-7.68	5.05	-3.88	-3.88	-7.92	-9.13	16.77*	-7.65	-13.76	-32.77**
318 A x CB 128	-9.69*	-27.16**	-23.87**	-4.37	-15.44*	-15.44*	-5.34	-20.72**	1.88	15.00*	2.89	-11.83*
318 A x CB 129	16.26**	3.61	-15.15**	10.82	-11.3	-11.3	8.41	-14.34**	10.08	7.83	7.35	-26.73**

* Significant at 5% level, ** Significant at 1% level

Table 4. (Continued) Relative Heterosis (RH), Heterobeltiosis (HB) and Standard Heterosis (SH) for number of grains per panicle, starch content in the grain, protein content in the grain and grain yield per plant

Crosses	Number of grains per panicle			Starch content in the grain			Protein content in the grain			Grain yield per plant		
	RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
234 A x CB 110	22.73	20.08	5.87	-2.87	-5.04	-6.15*	7.61	4.67	5	34.62**	29.91*	-11.93
234 A x CB 111	8.13	-8.18	15.92	0.72	-1.26	-2.42	-6.97	-8.81	-13.52**	22.89*	7.74	-3.06
234 A x CB 119	13.14	-5.22	23.72	-3.58	-4.97	-6.08*	-12.21**	-17.57**	-10.94*	32.89**	26.69	-5.28
234 A x CB 124	4.56	4.54	-7.79	7.20**	4.82	3.59	-8.65*	-14.03**	-7.58	14.22	6	-16.05
234 A x CB 126	8.73	7.48	-3.02	4.01	0.89	-0.29	-0.62	-0.66	-5.7	42.65**	35.98*	-7.82
234 A x CB 127	32.66*	17.5	34.28*	-5.16	-6.15*	-7.25*	-6.15	-11.98*	-4.69	37.22**	20.49	8.02
234 A x CB 128	7.43	-7.11	-18.1	0.93	0.3	-0.88	5.83	-0.36	7.03	24.57	19.63	-18.9
234 A x CB 129	52.40**	48.01**	30.49*	-4.18	-4.84	-5.96	-10.80*	-14.78**	-11.25*	56.86**	49.53**	1.37
151 A x CB 110	58.82**	31.99	11.34	0.14	-3.14	-2.15	2.81	0.22	5.86	60.12**	35.18*	-14.78
151 A x CB 111	14.41	-17.49	4.17	-9.47**	-12.19**	-11.29**	-4.45	-11.02*	-6.02	14.96	-14.79	-23.34*
151 A x CB 119	1.83	-27.30*	-5.11	-1.5	-3.95	-2.97	-11.44**	-12.44**	-5.39	22.79	-2.97	-27.46**
151 A x CB 124	57.66**	28.75	13.56	3.75	0.36	1.39	-14.81**	-15.55**	-9.22	48.84**	15.2	-8.77
151 A x CB 126	33.84	8.35	-2.24	-1.07	-5.05	-4.08	-12.97**	-17.38**	-12.73*	83.08**	56.19**	-4.01
151 A x CB 127	-36.56*	-52.77**	-46.03**	0.51	-1.62	-0.61	-1.68	-2.89	5.16	-26.67*	-45.58**	-51.21**
151 A x CB 128	5.74	-1.2	-36.47*	-4.54	-6.16*	-5.2	-8.54*	-9.31	-2.58	24.55	5.58	-34.11**
151 A x CB 129	50.57**	25.89	4.6	2.97	1.16	2.2	1.15	0.44	6.09	54.08**	31.44	-19.22
3060 A x CB 110	24.95	19.42	10.52	4.62	4.4	-1.03	-0.72	-3.82	-3.52	71.43**	68.84**	6.44
3060 A x CB 111	31.40**	13.86	43.75**	1.49	1.41	-3.71	-14.26**	-15.61**	-20.63**	28.30*	7.75	-3.06
3060 A x CB 119	10.51	-5.57	23.27	5.29	4.63	0.44	-12.87**	-18.51**	-11.95*	21.21	10.17	-17.64

3060 A x CB 124	45.72**	42.30**	31.69*	2.9	2.7	-2.64	0	-6.25	0.78	42.66**	26.40*	0.1
3060 A x CB 126	30.21*	28.57	18.99	-3.83	-4.79	-9.74**	4.26	3.79	-1.48	43.67**	43.30**	-11.93
3060 A x CB 127	0.18	-9.34	3.6	-5.05	-6.01	-9.06**	6.56	-0.43	7.81	18.91	0	-10.35
3060 A x CB 128	-5.46	-19.88	-25.86	-11.75**	-13.01**	-15.12**	6.86	0.22	7.66	19.49	18.27	-26.19*
3060 A x CB 129	50.68**	42.97**	32.32*	-0.4	-1.76	-4.25	8.55	3.3	7.58	57.11**	56.70**	-3.7
3183 A x CB 110	8.32	1.96	-2.55	5.4	3.95	0.91	1.9	1.47	2.66	52.26**	52.26**	-4.01
3183 A x CB 111	14.65	0.72	27.18	-5.38	-6.42*	-9.16**	1.18	-3.86	-2.73	31.68**	11.97	0.74
3183 A x CB 119	15.06	-0.35	30.08*	-2.4	-2.94	-5.79	0.37	-2.82	5	84.22**	69.78**	26.93**
3183 A x CB 124	7.77	3.62	-0.97	-9.56**	-10.79**	-13.41**	-7.3	-10.03*	-3.28	33.63**	20	-4.96
3183 A x CB 126	-3.87	-6.56	-10.7	-2.51	-4.6	-7.40*	-5.02	-7.95	-6.88	11.96	10.55	-30.31**
3183 A x CB 127	5.32	-3.3	10.51	0.39	0.23	-2.71	-1.53	-4.76	3.13	12.03	-4.59	-14.47
3183 A x CB 128	18.7	-0.72	-5.12	1.14	0.88	-1.56	1.95	-1.02	6.33	-7.88	-8.34	-42.22**
3183 A x CB 129	38.27**	29.24	23.52	-2.16	-2.36	-4.84	3.2	1.73	5.94	38.93**	37.19*	-13.52
339 A x CB 110	22.55	14.98	-3	5.65*	4.06	1.29	-4.77	-10.04*	1.48	46.90**	45.10**	-6.23
339 A x CB 111	17.23	-7.06	17.34	1.3	0.05	-2.61	0.31	-9.35*	2.27	22.54*	5.28	-5.28
339 A x CB 119	26.00*	-1.32	28.81	-7.69**	-8.33**	-10.77**	-4.92	-6.93	5	64.55**	53.39**	14.68
339 A x CB 124	6.32	-2.27	-13.8	-7.88**	-9.26**	-11.67**	-6.24	-8.45	3.28	17.62	6.8	-15.42
339 A x CB 126	10.17	0.23	-9.57	-4.57	-6.75*	-9.23**	-1.17	-9.0*	2.66	36.06**	32.72*	-14.23
339 A x CB 127	-2.42	-19.64	-8.17	0.18	-0.13	-2.78	-4.03	-5.96	6.09	18.28	1.77	-8.77
339 A x CB 128	-8.11	-14.1	-36.49*	-8.90**	-9.01**	-11.21**	-16.28**	-18.28**	-7.81	-5.24	-6.86	-39.81**
339 A x CB 129	53.96**	45.49*	20.88	-1.24	-1.31	-3.81	-7.96	-11.50*	-0.16	70.35**	66.18**	7.39
318 A x CB 110	19.41	14.8	4.94	-3.91	-6.59*	-6.59*	-5.78	-11.49*	1.03	36.79**	32.66*	-16.37
318 A x CB 111	24.56*	7.37	35.56*	2.34	-0.24	-0.24	-2.47	-12.32**	0.08	26.11*	4.58	-5.91
318 A x CB 119	-2.71	-17.29	7.97	4.81	2.71	2.71	-5.27	-7.8	5.23	35.22**	21.19	-9.4
318 A x CB 124	10.91	8.96	-0.39	1.36	-1.47	-1.47	0.67	-2.26	11.56*	28.15*	12	-11.3
318 A x CB 126	-8.3	-8.9	-16.72	0.04	-3.52	-3.52	6.28	-2.67	11.09*	28.08*	25.77	-22.70*
318 A x CB 127	-10.62	-19.56	-8.07	-3.61	-5.18	-5.18	-4.39	-6.84	6.33	-0.85	-17.67*	-26.19*
318 A x CB 128	-9.8	-23.18	-29.78	-10.20**	-11.28**	-11.28**	1.27	-1.71	12.19*	3.65	1.02	-36.96**
318 A x CB 129	21.87	16.32	6.33	0.66	-0.62	-0.62	-7.16	-11.23*	1.33	34.91**	32.47	-18.59

many as 18 hybrids showed significant positive standard heterosis ranged from 14.47 per cent (151 A x CB 126) to 38.66 per cent (3060 A x CB 119). For number of grains per panicle, seven hybrids viz.,

Table 5. Best crosses on the basis of sca effects, heterobeltiosis and standard heterosis for different characters in sorghum

Characters	Good specific combiners	sca effect	gca status of parents	Best crosses	Heterobeltiosis (%)	Standard heterosis (%)
Days to 50% flowering	3183 A x CB 111	-2.34*	H x L	151 A x CB 126	-17.29**	-5.82*
	339 A x CB 128	-2.96*	L x H	3183 A x CB 111	-15.55**	-4.76
	234 A x CB 126	16.19*	L x H			
Plant height	151 A x CB 128	18.19**	L x L			
	3060 A x CB 110	30.94**	L x L	339 A x CB 111	14.07**	12.35**
	3183 A x CB 111	13.28*	L x H	339 A x CB 119	23.38**	8.89*
	339 A x CB 119	18.69**	H x L	339 A x CB 129	26.62**	11.75**
	339 A x CB 129	21.86**	H x L			
Panicle length	318 A x CB 128	15.11*	L x L	3060 A x CB 127	14.88*	17.62*
	234 A x CB 127	19.83*	H x L			
Panicle weight	151 A x CB 126	23.33*	L x L	3183 A x CB 119	40.18**	20.46
	3183 A x CB 119	29.40**	L x H			
	234 A x CB 128	6.80**	H x L			
No. of primary branches/ panicle	151 A x CB 124	4.90*	H x H	234 A x CB 128	-5.76	15.42**
	3060 A x CB 124	9.50**	L x H	151 A x CB 124	17.61**	23.88**
	3060 A x CB 128	4.49*	L x L	151 A x CB 127	12.24**	18.22**
	3183 A x CB 127	5.47*	L x H	3060 A x CB 124	15.65**	19.98**
	318 A x CB 110	5.41*	L x L	3183 A x CB 127	18.43**	11.72**
	151 A x CB 110	1.19*	L x L			
Length of primary branch	234 A x CB 126	10.32*	L x L	234 A x CB 126	5.47	18.39**
	234 A x CB 127	17.10**	L x L	234 A x CB 127	-2.43	22.10**
	151 A x CB 110	13.90**	L x H	151 A x CB 110	1.51	17.33**
	151 A x CB 126	15.99**	L x L	151 A x CB 126	1.98	14.47*
	151 A x CB 129	8.34*	L x L	151 A x CB 126	1.98	14.47*
	3060 A x CB 110	12.13**	H x H	3060 A x CB 110	18.08**	36.48**
	3060 A x CB 129	12.96**	H x L	3060 A x CB 119	18.60**	38.66**
	3183 A x CB 111	15.69**	L x H	3060 A x CB 129	36.84**	31.83**
	3183 A x CB 119	14.29**	L x H	3183 A x CB 111	-12.20**	30.36**
	339 A x CB 127	21.72**	L x L	3183 A x CB 119	14.19*	33.51**
	339 A x CB 129	10.31*	L x L	318 A x CB 119	5.31	35.32**
	318 A x CB 124	18.40**	H x L	318 A x CB 124	7.73	38.43**
100-seed weight	151 A x CB 128	0.40**	L x H			
	3060 A x CB 110	0.44**	L x L			
	3183 A x CB 119	0.30*	H x L			

				234 A x CB 127	17.50	34.28*
				234 A x CB 129	48.01**	30.49*
No. of grains/ panicle	234 A x CB 127	996.66**	L x L	3060 A x CB 111	13.86	43.75**
	151 A x CB 124	691.92*	L x L	3060 A x CB 124	42.30**	31.69*
				3060 A x CB 129	42.97**	32.32*
				318 A x CB 111	7.37	35.56*
Starch content	234 A x CB 124	4.32**	L x L			
	234 A x CB 128	3.67*	L x L			
	3060 A x CB 119	3.65*	L x L			
	3183 A x CB 128	4.78**	L x L			
	339 A x CB 110	3.73*	L x H			
	318 A x CB 119	3.59*	L x L			
Protein content	234 A x CB 110	0.86*	L x L			
	234 A x CB 128	0.89*	L x H	318 A x CB 124	-2.26	11.56*
	3060 A x CB 129	0.81*	L x L	318 A x CB 126	-2.67	11.09*
	339 A x CB 111	0.78*	L x L	318 A x CB 128	-1.71	12.19*
	318 A x CB 126	0.75*	H x L			
Grain yield/ plant	234 A x CB 127	20.30**	H x L			
	151 A x CB 126	22.66**	L x L	3183 A x CB 119	69.78**	26.93**
	3183 A x CB 119	29.15**	L x H			

* Significant at 5% level, ** Significant at 1% level

234 A x CB 127, 234 A x CB 129, 3060 A x CB 111, 3060 A x CB 124, 3060 A x CB 129, 3060 A x CB 119 and 318 A x CB 111 showed significant positive standard heterosis. None of the hybrids exhibited significant positive heterobeltiosis and standard heterosis for starch content. Three hybrids, 318 A x CB 124, 318 A x CB 126 and 318 A x CB 128 were superior than the standard check with regards to protein content in the grain. Several hybrids exhibiting good specific combining ability and significant positive standard heterosis for the respective traits (Table 5).

Among the lines the live, 3060 A performed well for many traits studied like panicle length, panicle weight, length of primary branch, number of grains per primary branch and number of grains per panicle. Among the testers, CB 119 performed well for grain yield per plant, panicle weight, length of primary branch, number of grains per primary branch and number of grains per panicle grains per primary branch and number of grains per panicle. For grain yield per plant the hybrids 234 A x CB 127 and 3183 A x CB 119 were found to involve parent with high x low and low x high *gca* effects indicating the role of non-additive gene action (Table 5).

The hybrids that exhibited heterosis for grain yield can be effectively exploited in a sorghum improvement programme.

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