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Combining ability analysis in sorghum *(Sorghum bicolor* L. (Moench)) for yield and its attributing traits

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Abstract : In the present study, information on the magnitude of combining ability was obtained for grain yield and its components following diallel analysis excluding reciprocals involving ten elite genotypes of sorghum. The 45 F_1s, 10 parents and one standard check were tested in randomized block design with three replications at Navsari Agricultural University, Waghai. Analysis of variance revealed presence of considerable variability among genotypes. Combining ability analysis revealed importance of both additive and non additive variances in the expression of various traits. Additive gene action was predominant for grain yield and its related traits. The *per se* performance of parents for various traits in general was associated with high GCA effects. Similarly close association between hybrid performance and SCA effects was observed. Parents SR 1718, SR 1571, SR 770 and SPV 1022 were observed as good general combiners for yield and its attributing traits. While in respect of hybrids, crosses SR 770 x SPV 1022, GMRP 9 x SR 1571, SR 833 x GMRP 27 and SR 833 x GMRP 9 had exhibited higher SCA effects with higher mean values. The parents with good GCA offer the best possibilities of exploitation for the development of improved lines with enhanced yielding ability. The crosses with high SCA which had at least one parent with high GCA could be successfully exploited for varietal improvement. Recurrent reciprocal selection may be useful to handle such materials.

Keywords : Sorghum, GCA, SCA, heterosis, yield improvement.

Introduction

Sorghum *(Sorghum bicolor* (L.) Moench) is an important rainfed crop. It provides staple food for the people. It is the primary necessity for the breeder to make choice of elite parents for hybridization to improve yield. Combining ability analysis is the main tool for choice of parents as well as understanding of the nature of gene action. So, information on relative importance of general and specific combining ability is of immense use in the development of an efficient breeding programme. The present study was therefore conducted to estimate the general and specific combining abilities of parents and hybrids, respectively.

Materials and methods

Ten homozygous lines of grain sorghum were used as parents in this hybridization programme. The lines were SR 770, SR 833,

Table 1. Analysis of variance for combining ability in sorghum for yield and its attributing traits (Waghai)

Source of variation	d.f.	Plant height (cm)	Flat leaf area (sq.cm)	Panicle length (cm)	Primaries per panicle	Grain yield/ plant (g)	Test weight (g)
Replications	2	155.751	5.478	0.253	10.841	18.372	0.034
Genotypes	54	2585.724 **	6591.962**	25.062**	106.717**	533.151 **	0.314**
Parents	9	2845.717**	6086.273**	44.057**	105.420**	738.171**	0.445**
Hybrids	44	2301.972 **	6823.256 **	21.700 "	105.646 **	494.000**	0.287**
Parents vs hybrids	1	12731.122	966.207	2.096	165.502	410.375	0.291
GCA	9	1174.924**	5717.505 **	25.951**	77.010 **	418.767**	0.197
SCA	45	799.305 **	1493.284 **	4.832**	27.285 **	129.506**	0.086
Error	108	170.550	100.455	1.529	5.588	5.245	0.020
$\sigma^2 g$		83.698	468.688	2.030	5.952	34.460	0.014
$\sigma^2 s$		628.755	1392.829	3.300	21.697	124.262	0.066
SEm±		1.761	1.351	0.166	0.318	3.238	

* - Significant at 5% and ** = Significant at 1%

SPV 1388, SPV 1022, CSV 15,GMRP9, GMRP27, SR 1571, SR 1718 and GJ 38.

The crossing programme was adopted using diallel mating design excluding reciprocals at Main Sorghum Research Station, Navsari Agricultural University, Surat. The parental lines and their resultant 45 F_1s were evaluated with GJ 41 as standard check at Hill Millet Research Station, Waghai. The trial was conducted in a RBD with three replications. The recommended agricultural practices were adopted to raise the crop. The observations recorded were plant height (cm), flag leaf area (sq. cm), panicle length (cm), primaries per panicle, grain yield per plant (g) and test weight (g). Analysis of data for general and specific combining ability was carried out following Griffing's (1956) Method II, Mode I (Fixed model).

Results and Discussion

The analysis of variance for combining ability for yield and its attributing traits are presented in Table 1. The ANOVA revealed significant varietal differences for genotypes, parents and hybrids for all the characters studied which was the indication of existence of sufficient variability among genotypes. The variances due to general combining ability and specific combining ability were highly significant for all the traits under evaluation except test weight, which suggested that both additive and non additive variances were important in the inheritance of the characters under study. Similar findings had been reported by Patel *et al.* (1990), Amsalu and Bapat (1990), Mehtre and Borikar (1992), Senthil and Palanisamy (1994), Pillai *et al.* (1995), Naik (1996), Bhadouriya and Saxena (1997), Chhimpi (1998), Bhavsar and Borikar (2002) and Rafiq *et al.* (2002).

Table 2. Estimates of GCA effects of parents for yield and its attributing traits (Waghai)

S. No.	Parents	Plant height (cm)	Flag leaf area (sq.cm)	Panicle length (cm)	Primaries per panicle	Grain yield/ plant (g)	Test weight (g)
1	SR 770	1.264 (165.33)	33.082 (206.97)**	-0.148 (21.10)	0.803 (41.60)	4.753 (45.30)**	0.108 (2.8)**
2	SR833	1.984 (151.00)	1.723(158.83)	-1.962(17.00)**	0.462(44.80)	-4.483(15.03)**	-0.051(2.5)
3	SPV 1388	8.309(200.36)*	-15.202(186.90)**	-2.037(19.90)**	-4.955 (33.00)**	-5.722(27.60)**	-0.033(2.7)
4	SPV 1022	2.242(205.00)	16.623(184.20)**	-0.137 (20.20)	0.978 (49.10)	5.786 (57.20)**	0.058 (3.0)
5	CSV 15	8.048 (228.33)*	-31.641 (112.20)**	-0.593 (21.33)	0.378 (43.80)	-4.389 (40.20)**	-0.200 (2.4)**
6	GMRP 9	12.498 (248.67)**	-8.421 (091.80)**	1.916 (27.67)**	-0.722 (39.20)	1.269 (30.30)*	0.042 (2.1)
7	GMRP27	-5.869(222.00)	-4.166 (082.40)	1.160 (27.60)**	1.728 (50.20)**	0.611 (18.20)	-0.017(1-8)
8	SR 1571	3.884 (202.67)	19.568 (166.30)**	1.977 (26.33)**	3.462 (53.30)**	9.211 (55.50)**	0.225 (3.0)**
9	SR 1718	-14.241 (183.00)**	18.134 (199.50)**	0.946 (27.30)**	1.528 (48.50)*	2.578 (53.70)**	0.050 (2.3)
10	GJ38	-18.119 (168.00)**	-29.702 (131.43)**	-1.121 (23.00)**	-3.663 (45.80)**	-9.614 (21.30)**	-0.183 (2.6)**
	S.E.(g_i)±	3.576	2.745	0.339	0.647	0.627	0.039
	S.E.(g_i-g_j)±	5.331	13.571	1.674	0.965	0.934	0.116
	Parental Mean	197.430	152.053	23.14	44.931	36.130	2.521

* = Significant at 5% and ** = Significant at 1%

Figures in parenthesis indicated the mean performance of parents

The GCA variances were higher as compared to SCA variances for all the characters. These types of result suggested the preponderance of additive gene action for yield and its attributes. The results were in agreement with the earlier results of Poor and Rezai (1997), Shakoor and Qureshi (1999), Patil (2000), Ravindrababu *et al.* (2001), Gaikwad *et al.* (2002) and Tiwari *et al.* (2003). Due to high magnitude of additive gene action, direct selection might be effective in the improvement of the traits under study.

The estimates of general combining ability effects are presented in Table 2. For plant height, the GCA values of the parents ranged from -18.119 (GJ 38) to 12.498 (GMRP 9). Two parents *viz.,* GJ 38 (-18.119) and SR 1718 (-14.241) exhibited significant, negative and higher GCA effects which was in desired direction indicating that these two parents were found good general combiners for dwarfness.

The estimates of GCA effects for flag leaf area revealed that out of nine, only four parents recorded positive and significant GCA effects. The parents were SR 770, SR 1571, SR 1718 and SPY 1022. Besides highest GCA effects parent SR 770 also ranked first for mean performance for the trait. For panicle length, highly positive and significant GCA effects were noticed in case of SR 1571. GMRP 9 and GMRP 27. The parents with higher GCA effects also performed well in respect of mean performance. In case of

Table 3A. Details of top ten crosses in respect of combining ability effects for yield and its attributing traits (Waghai)

S.No.	Plant height (cm)			Flag leaf area (Sq.cm)		
	Cross	SCA effects	Mean	Cross	SCA effects	Mean
1	GMRP9xSR 1718	63.720**	171.00	SR770xSPV1022	84.108 **	291.00
2	CSV 15 x GMRP 27	56.309**	124.67	GMRP9xSR1571	72.567 **	240.90
3	GMRP9xSR 1571	53.178**	197.00	SR 833 x GMRP 27	63.789 **	218.53
4	SPV 1022xGJ38	50.920**	112.00	SPV 1388 x GMRP 27	63.447 **	201.27
5	SPV 1022 xSR 1718	48.797**	118.00	SR 770 x GMRP 27	58.364 **	244.47
6	SPV 1388 x CiJ 38	40.653*	128.33	CSV 15xGJ38	46.556 **	142.40
7	CSV 15xSR 1571	26.728	164.00	SR833xSR 1571	43.122 * *	221.60
S	SPV 1022 x GMRP 27	22.170	153.00	SR770xSR 1718	37.497 **	245.90
9	CSV 15 x GMRP 9	20.342	179.00	SR833xGMRP9	33.711 *	184.20
10	SR 1571 xSR 1718	-18.439	150.00	SPV 1022 xSR 1571	32.622 *	226.00
	S.E. $(S_{ij})\pm$	10.784			8.270	
	S.E.$(S_{ij} - S_{jk})\pm$	17.683			13.571	
	Mean of F_1		174.656			158.327

* = Significant at 5% and ** = Significant at 1%

primaries per panicle, the parents SR 1571, GMRP 27 and SR 1718 registered higher and significant GCA effects accompanied with high mean.

Looking to the most important character *i.e.* grain yield per plant, the parents SR 1571, SPV 1022, SR 770 and SR 1718 exhibited significant and higher GCA effects with high grain yield per plant. The result suggested that the parents with high GCA effects were also observed top ranker for yield and its attributing traits. The results were in agreement with Wadikar *el al.* (2006). For test weight, parents SR 1571 and SR 770 were observed good general combiners with high test weight.

Considering the overall performance in respect of GCA effects, parents SR 1718, SR 1571, SR 770 and SPV 1022 were observed good general combiners for yield and its attributing traits with high *per se* performance. So, these lines can be used as parents for yield improving breeding programme.

Details of top ten crosses in respect of specific combining ability effects for yield and its attributing traits are presented in Table 3 Looking to the results for plant height only one F_1 *i.e.* SR 1571 x SR 1718 had exhibited negative SCA effect but it was non significant. While in case of flag leaf area highest and significant SCA effect was exhibited by the cross SR

Table 3B. Details of top ten crosses in respect of combining ability effects for yield and its attributing traits (Waghai)

S.No.	Panicle length (cm)			Primaries per panicle		
	Cross	SCA effects	Mean	Cross	SCA effects	Mean
1	GMRP9xSR 1571	4.037*	30.83	CSV 15xGMRP9	9.738**	52.20
2	CSV 15xGJ38	3.642*	24.83	SR770xSPV 1022	9.613**	54.20
3	SR770xSPV 1022	2.681	25.30	CSV 15xGJ38	5.880	45.40
4	SR770xGMRP27	2.417	26.33	SR833xSR 1571	5.571	52.30
5	SR 833x(jMRP9	2.142	25.00	SPV 1388 x CSV 15	4.871	43.10
6	SPV 1388 xSPV 1022	2.104	22.83	GMRP27xG.l38	4.730	45.60
7	SR833xGMRP27	2.098	24.20	GMRP9xSR1571	4.655	50.20
8	SPV 1388 x CSV 15	2.059	22.33	SR770xSR 1718	4.563	49.70
9	SR770xGJ38	1.698	23.33	SR833xSR 1718	4.005	48.80
10	SPV 1388 xSR 1571	1.490	24.33			
	S.E. $(S_{ij})\pm$	1.021			1.952	
	S.E.$(S_{ij} - S_{jk})\pm$	1.674			3.200	
	Mean of F_1		22.85			42.33

* - Significant at 5% and ** = Significant at 1%

770 X SPV 1022 accompanied with high mean followed by GMRP 9 x SR 1571, SR833 x GMRP 27, SPV 1388 x GMRP 27 and SR 770 x GMRP 27.

The higher significant SCA effects for panicle length were registered by only two F_1s *i.e.* GMRP 9 x SR 1571 and CSV 15 x GJ 38 with higher mean. While for primaries per panicle the crosses CSV 15 x GMRP 9 and SR 770 x SPV 1022 were observed promising in respect of SCA effects as well as mean performance.

For grain yield per plant cross CSV 15 x GJ 38 exhibited significantly highest SCA effect followed by GMRP 27 x GJ 38, SR 833 x GMRP 27, SPV 1388 x GMRP 27 and SR 833 x GMRP 9. In case of grain yield per plant the highest SCA effect was not associated with the highest mean. Considering the test weight, only three crosses *viz.,* SR 770 x SPV 1022, SR 833 x GMRP 27 and SR 833 x GMRP 9 were noticed significantly superior with higher mean.

Looking to the overall performance for SCA effects, crosses SR 770 x SPV 1022, GMRP 9 x SR 1571, SR 833 x GMRP 27 and SR 833 x GMRP 9 had exhibited higher SCA effects accompanied with higher mean. So these hybrids could be subjected to evaluate for further generation for yield improving programme.

Table 3C. Details of top ten crosses in respect of combining ability effects for yield and its attributing traits (Waghai)

S.No.	Grain yield / plant (g)			Test weight (g)		
	Cross	SCA effects	Mean	Cross	SCA effects	Mean
1	CSV 15xGJ38	20.824 **	46.30	SR770xSPV 1022	0.524**	3.3
2	GMRP 27x0.1 38	18.424 **	48.90	SR 833 x GMRP 27	0.458*	3.0
-i	SR833xGMRP27	17.193 **	52.80	SR 833 x GMRP 9	0.399*	3.0
4	SPV 1388 x GMRP 27	15.732 **	50.10	CSV 15 x GMRP 27	0.308	2.7
5	SR833xGMRP9	15.035 **	51.30	GMRP9xSR 1738	0.299	3.0
6	SR770xSPV 1022	14.282 **	64,30	GMRP27xGJ38	0.291	2.7
7	GMRP9xSR 1571	13.841 **	63.80	SPV 1388 x GMRP 27	0.241	2.S
8	SR833xSR 1571	13.293 **	57.50	GMRP9 x GJ38	0.233	2.7
9	SR833xGJ38	8.818 **	34.20	SR1718xGJ38	0.224	2.7
				GMRP9xSR 1571		3.1
10	GMRP9xSR 1718	8.174 **	51.50	SR 770 x GMRP 27	0.199	2.9
	S.E. $(S_{ij})\pm$	2.109			0.117	
	S.E.$(S_{ij} - S_{jk})\pm$	3.105			0.191	
	Mean of F_1		40.22			2.63

* = Significant at 5% and ** = Significant at 1%

Results of present study suggested that high magnitude of GCA, contribute additive gene action or additive x additive interaction effects and represent fixable portion of genetic variance. In view of this, parents SR 1718, SR 1571. SR 770 and SPV 1022 offered the best possibilities of exploitation for the development of improved lines with enhanced yielding ability. It is suggested that population involving these lines in a multiple crossing programme may be developed for isolating desirable recombinations. Further the lines showing good general combining ability for respective component may be utilized in component breeding for effective improvement in particular component, ultimately seeking improvement in yield itself.

The crosses showing high SCA effects involving either both or at least *one* good general combiner, it could be successfully exploited for varietal improvement and expected to produce stable performing transgressive segregants carrying fixable gene effect. The high x low GCA crosses through complementary interaction exhibited high SCA effect. Reciprocal recurrent selection might be useful to handle such materials.

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