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Research Article

Combining ability of new parental lines for flowering, maturity and grain yield in *Rabi* Sorghum

Prabhakar [1*], M. Elangovan[2] And D. M. Bahadure [3]
[1]Centre on Rabi Sorghum (PDSR), Solapur-413006
[2,3]Directorate of Sorghum Research, Hyderabad- 500030
Email: prabhakar@sorghum.res.in

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Abstract
Combining ability studies involving five females and four males revealed the presence of significant differences due to lines, testers and line × testers, indicating the presence of variability. The estimates of variance components exhibited presence of additive gene action for days to flowering, maturity and grain yield studied. Considering the general combining ability effects of parents for days to flowering, maturity and grain yield, female SL-9B and males SLR-57 and SLR-30 were good general combiners for grain yield and the female SL-39B and male SLR-66 were good general combiners for earliness. The crosses 104B × SLR-30, SL-9B × SLR-57, SL-9B × SLR-30 and 104B × SLR-57 were identified promising for improving grain yield while crosses SL-19B x SLR-66, SL-9B x SLR-66 and SL-39B x SLR-57 have been selected for breeding forearliness.

Key words
Rabi sorghum, combining ability, heterosis.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the major crops for grain and fodder, which is widely grown in India under rainfed conditions. *Rabi* sorghum is grown over a total area of 5.6 million hectares (Dayakar Rao et.al.2010) mainly in the states of Maharashtra, Karnataka and Andhra Pradesh with average productivity of 719 kg/ha .In spite of such low productivity, *rabi* sorghum continues to be an important component of dryland farming in these states with fairly consistent area over many years. The low yields are mainly due to various abiotic (drought, nutrients, temperature, etc.,) and biotic (shoot fly, charcoal rot etc.) stresses. These stresses operate at various crop developmental stages. Hence, there is a need to develop new varieties with drought tolerance and early maturity suitable for rainfed situations.

Hybrid vigour and its commercial exploitation have paid rich dividends in *kharif* sorghum leading to quantum jump in sorghum production. However, the progress in *rabi* sorghum is limited and there is a need for critical studies on combining ability and heterosis involving diverse sources of germplasm and land races. The exploitation of heterosis by developing the hybrids is one of the quickest and simpler ways to improve productivity for grain as well as fodder yield with special reference to combining ability. This could be realized only when the male sterile and restorer lines having the seasonal adaptability and desired combining ability are identified and used in the development of *rabi* sorghum hybrids. To identify the desirable superior combiners for yield and its component, combining ability is frequently studied. The estimates of combining ability are useful to predict the relative performance of different lines in hybrid combinations. The information on the nature and magnitude of gene action is important in understanding the genetic potential of a population and decide the breeding procedure to be adopted in a given population. Line x tester analysis is a precise method for obtaining such information when a large number of parents are to be tested. Keeping these things in view, the present study involved a line x tester analysis in *rabi* sorghum to develop suitable new *rabi* sorghum hybrid parents.

Material and Methods

Five maintainer lines of *rabi* sorghum viz., 104B, SL-19B, SL-9B, SL-39B and SL-48B were crossed with 4 testers viz., SLR-57, SLR-66, SLR-30 and SLR-24. The parents were crossed in a line x tester mating design during *rabi* 2008-09. All the 20 crosses along with parents were grown in *rabi* 2009-10 in a randomized block design with two replications in the research farm of Centre on *Rabi* Sorghum (PDSR), Solapur. Each plot consisted of 4 rows of 4 meter length with a spacing of 45 x 15cm. Observations were recorded for three characters viz., days to flowering, days to maturity and grain yield per plant (g) on 10 randomly selected plants from each plot. Combining ability analysis was done following the method suggested by Kempthorne (1957). The F_1 hybrid performance was calculated as the estimate of heterosis over better parent (heterobeltosis) and the test of significance was done.

Results and Discussion

The analysis of variance for combining ability (Table 1) revealed the presence of significant differences due to lines, testers and lines x testers for all the characters studied indicating the existence of variability among parents and hybrids. The testers contributed a major share of variance for all the characters. The estimates of components of variance for gca were larger in magnitude than sca for all the characters indicating predominance of additive gene action. Similar results were reported by earlier workers (Nayeem and Bapat 1984, Madrap et.al. 1997 and Prabhakar 2002.)

The estimates of gca effects of lines and testers along with their *per se* performance are presented in Table-2. Among the lines SL-39B and 104B showed good general combining ability for days to flowering. The line SL-39B also exhibited highly significant gca in desirable direction for days to maturity. However, it showed negative gca effect for grain yield per plant. The line 104B and SL-19B were bad combiners for days to maturity since they showed significant gca effects in non-desirable direction. In testers, SLR-66 was the best general combiner for days to flowering and maturity and bad combiner for grain yield per plant. The line SL-9B was the best general combiner for grain yield per plant. The testers namely SLR-57 and SLR-30 were the best general combiners for grain yield per plant. The tester SLR-24 was the poor combiner for grain yield per plant. Thus, considering the gca effects of parents, line SL-9B and testers SLR-57 and SLR-30 were good general combiners for grain yield per plant and the line SL-39B and tester SLR-66 were good general combiner for earliness (days to flowering and maturity). The gca effects of parents and their *per se* performance indicated that the parent showing high mean performance also showed high general combining ability for grain yield per plant. Like wise, the line SL-39B and tester SLR-66 which flowered and matured earlier than the rest showed the best general combining ability for earliness. Similar trend was reported by earlier workers (Prabhakar 2002, Pathak and Sanghi 1988, Patil and Bapat 1991 and Patil and Mistry 1997.) This suggests that in addition to gca effects, per se performance could also be considered as a criterion to select the parents in future breeding programme.

The mean performance, heterosis and specific combining ability effects of top ranking eight crosses with gca effects of their parents for grain yield per plant are presented in Table 3. The crosses which showed significant sca effect along with higher heterosis and *per se* performance were 104B x SLR-30, SL-9B x SLR-57, SL-9B x SLR-30 and 104 B x SLR-57. High heterotic crosses showed significant sca effects with higher *per se* performance. It was noticed that the crosses 104B x SLR-57 and 104B x SLR-30 which showed the highest sca effects had one parent with negative and other parent with positive gca effects. However, both the parents had positive gca effects for the crosses SL-9B x SLR-30 and SL-9B x SLR-57. Under such situation if additive genetic system is present in good combiner and complementary one in another acting in the same direction to maximize the expression of desirable attributes, then such crosses are expected to throw transgressive segregants in future generation. The findings suggested that it is very important to consider the heterosis, gca of the parents involved and per se performance of the crosses while selecting the best cross combinations. Thus, the combinations of poor x high or high x high combiners could result into the hybrids with high performance depending on the *per se* performance of the parents concerned. It is observed that the line SL-9B and testers SLR-57 and SLR-30 which were the best general combiners for grain yield per plant were involved in the crosses having higher sca effects. These crosses can be directly used in the breeding programme for improvement of grain yield.

The mean performance, heterosis, sca effects of crosses and gca effects of parents for top ranking 8 crosses for days to flowering are given in Table 4. The crosses selected for earliness based on significant sca effects and heterosis in the desirable direction along with per se performance were SL-19B x SLR-66, SL-9B x SLR-66 and SL-39B x SLR-57. The crosses showed high heterosis in the desirable direction with significant sca effects and higher per se performance. Here also, the crosses which showed earliness had gca effects of one parent in the desirable direction. The line SL-39B and tester SLR-66 which were the best combiners for earliness were involved in the selected crosses. It is necessary to select crosses based on heterosis and per se performance in addition to significant sca effects. These crosses can be directly used in breeding for earliness in *rabi* sorghum. Breeding for early *rabi* sorghum varieties and hybrids assumes great significance in view of the crop grown under rainfed condition. It would help to overcome the terminal moisture stress. The present investigation clearly indicated the importance of gca effects of parents and *per se* performance during choice of parents and consideration of heterosis and *per se* performance in addition to sca effects of crosses while selecting the best hybrid combinations. The parents SL-9B, SLR-30 and SLR-57 can be directly used for breeding for high yield and the parents SLR-66 and SL-39B for breeding for early varieties and hybrids in *rabi* sorghum.

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Table 1.Analysis of variance for combining ability for characters in rabi sorghum

Source	df	Days to flowering	Days to maturity	Grain yield per plant (g)
Replications	1	0.406	1.600	172.219
Crosses	19	21.916**	78.605**	234.867**
Testers	3	97.80**	248.167**	820.756**
Lines	4	14.280**	122.438**	231.273**
Lines x Tester	12	5.820*	21.604*	97.926*
Error	19	1.185	4.126	28.646
Estimation of variance components				
Lines		0.93	12.60	4.16
Testers		9.19	22.60	82.28
gca		5.525	18.189	47.565
sca		1.816	8.739	34.640

* and ** significant at 5 and 1 per cent, respectively .

Table 2.General combining ability effects and *per se* performance of lines and testers for characters in *rabi* sorghum

	Days to flowering		Days to maturity		Grain yield per plant (g)	
	gca	*Per se*	gca	Per se	gca	*Per se*
Lines						
104B	- 1.800**	79.0	4.250**	126.0	-2.025	45.0
SL-19B	0.700	76.0	2.375**	121.5	0.225	55.5
SL-9B	0.950*	76.5	1.125* -	121.0	6.725**	60.5
SL-39B	-0.925*	72.5	6.000**	118.0	-3.900*	50.0
SL-48B	1.075*	76.5	0.500	120.0	-1.025	55.5
Testers					6.475**	
SLR-57	0.700	76.0	1.550	121.0	-6.925**	49.0
SLR-66	- 4.400**	71.5	-7.050**	114.0	9.875**	51.0
SLR-30	3.000**	77.0	4.650**	123.5	-9.425**	56.5
SLR-24	0.700	77.5	0.850	120.0		43.5
					1.693	
S.E. for Lines	0.268	--	0.642	--	1.466	--
S.E. for Testers	0.405	--	0.556	--		--

* and ** significant at 5 and 1 per cent, respectively.

Table 3. Mean performance, heterosis and sca effects of top ranking eight crosses with gca of their parents for grain yield per plant (g).

Sl No	Crosses	*Per se*	Heterobeltosis (%)	sca	gca of parents	
					P_1	P 2
1.	SL-9B x SLR-57	89.0	47.1**	6.723**	6.725**	6.475**
2.	SL-9B x SLR-30	87.0	43.8*	1.375*	6.725**	9.875**
3.	104B x SLR-30	86.0	52.2**	9.625**	-2.025	9.875**
4.	SL-19B x SLR-30	77.0	36.2*	-2.125*	0.225	9.875**
5.	104B x SLR-57	76.0	55.1**	2.525*	-2.025	6.475**
6.	SL-39B x SLR-30	73.0	29.2	-2.000	-3.900*	9.875**
7.	SL-39B x SLR-66	71.5	45.9*	-0.100	-3.900*	6.475**
8.	SL-48B x SLR-57	71.5	45.9*	-2.975*	-1.025	6.475**

* and ** significant of 5 and 1 per cent, respectively.

Table 4.Mean performance, heterosis and sca effects of top ranking eight crosses with gca effects of their parents for days to flowering.

Sl No	Crosses	*Per se*	heterobeltosis (%)	sca	gca of parent	
					P_1	P_2
1.	SL-19B x SLR-66	71.0	-6.5**	-1.600**	0.700	-4.400**
2.	SL-9B x SLR-66	71.0	-7.2**	-1.850**	0.950*	-4.400**
3.	SL-39B x SLR-66	71.0	-2.0	0.025	-0.925*	-4.400**
4.	104 B x SLR-66	71.5	-9.5**	1.400*	-1.800**	-4.400**
5.	SL-39B x SLR-57	74.0	-2.6*	-2.075**	-0.925*	0.700
6.	104B x SLR-57	75.0	-5.1**	-0.200	-1.800**	0.700
7.	SL-48B x SLR-66	75.0	-2.0	2.025**	-1.075*	-4.400**
8.	104B x SLR-30	75.5	-4.4*	-0.200	-1.800**	3.000

* and ** significant of 5 and 1 per cent, respectively.