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Heterotic capability of derived inbred lines for grain yield in Sorghum [*Sorghum bicolor* (L.) Moench]

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Abstract

An attempt was made to assess the heterotic capability of inbred lines in F_6 generation of a sorghum [*Sorghum bicolor* (L.) Moench] cross 3660 B × MR-750. Seventy-three inbred lines in F_6 generation were crossed to 296A, a well-known male sterile tester to develop 73 derived F_1s. The hybrids exhibited desirable transgressive segregation for grain yield and some hybrids were even better than commercial check (CSH 5) for their *per se* performance. This implied that lines with improved heterotic capability could be found in progenies from cross of two elite lines in sorghum.

Key words: Sorghum, inbreds, heterosis, grain yield

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench], an important staple food crop in many parts of the world has wider adaptability and high gain yield potential. Being an often cross-pollinated crop, it is amenable to breeding methods meant for both self and cross-pollinated crops. The commercial exploitation of heterosis through the use of cytoplasmic genetic male sterility made it possible to achieve high grain yield. Though sorghum production in India had registered marked improvement in eighties, in recent years, yield levels of hybrids appear to have reached stagnation. In an attempt to improve the yield levels of hybrids, the need for improvement of parental lines for their heterotic capability was also felt [1].

The selection of the best combination of inbreds for a good hybrid is the most resource taking task [2]. This is generally achieved through combining ability analysis to end up with few inbreds, which are subsequently test crossed to find the best combination. Since this involves time, labour, money etc., a simple and efficient way to breed a new hybrid is necessary. The Convergent improvement [3] that involves the reciprocal transfer of favourable alleles between two inbred lines has not been widely used even in maize programmes because of the difficulty in controlled transfer of alleles for traits like grain yield. According to Shull [4,5] inbred lines are used in production of hybrids. The breeding methods *viz.*, pedigree, back cross, recurrent selection etc., are used extensively to derive inbred lines. However, these approaches were not utilised to improve heterotic capability of parents as a trait in sorghum as done in pearl millet [1].

Hence the present study aimed to assess the heterotic capability of inbred lines derived from simple pedigree method unlike more complicated procedures like recurrent selection for specific combining ability (sca) to further enhance the level of heterosis in commercial hybrids.

Materials and methods

The material for this investigation consisted of F_6 generation inbreds of a sorghum cross 3660B x MR750. From this F_6 generation, random 73 inbreds were utilised to assess their heterotic capability when crossed with tester, 296A as compared to their parents, 3660B and MR750.

Production of derived F_1s (DF_1s): . Randomly chosen 73 F_6 inbred lines were used as males and crossed to 296A, a well-known male sterile tester (CMS line of 5 national hybrids CSH9, CSH10, CSH11, CSH12 and CSH13) to obtain corresponding 73 F_6 derived F_1s (F_6DF_1s). Two straight crosses involving parents, 3660B and MR-750 as males and 296A as female were made for comparing F_6 derived F_1s.

Evaluation of derived F_1s: All the derived 73 F_6F_1s and their male parents (F_7 generation), two parental straight crosses (296A x 3660B and 296A x MR750) along with commercial check, CSH-5 were evaluated during *Kharif* 1991 in randomised blocks with two replications. The seeds of each genotype were sown in 3m row with 45 cm x 15 cm spacing between the rows and plants, respectively. All recommended package of practices were followed to raise a good

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crop. Observations were recorded on ten random plants in each replication and mean values were calculated for each replication and subjected to analysis of variance. The heterosis values were calculated following standard procedures over male parent (heterobeltiosis), over better straight cross and over check, CSH5 (standard heterosis).

Results and discussion

Range, variance and mean grain yield: The range for grain Yield in the derived F_1 population of F_6 was higher as compared to that of the parental straight crosses and inbred male population (Table 1). A higher variance noticed in derived F_1 population as compared to that of straight crosses as well as inbred lines clearly revealed the release of variability for heterotic capability in the F_6 inbred lines.

As compared to mean yield of straight crosses, F_6DF_1s had higher (16%) mean yield. About 55% of the F_6DF_1s exhibited superiority over better straight cross (296A x MR-750) and 20% of the total crosses had significant heterosis. This clearly depicts the extent of transgressive segregation occurring for heterotic capability for grain yield in desirable direction. Comparison of the performance of F_6DF_1s with male parents revealed that the overall mean of F_6 derived F_1s was 55 percent higher than the inbred males (now in F_7 generation) (Table 1). Nearly 77 percent of the derived F_1s exhibited superiority over their respective male parents indicating the level of heterobeltiosis occurring for *per se* yielding ability (Table 3).

Table 1. Mean, range and variance in F_6 derived F_1 population for grain yield in sorghum

	F_6DF_1s	Male (in F_7)	Straight crosses*	CSH5 (check)
Mean (g)	59.42	38.24	51.36	62.39
Range (g)				
From	34.43	21.50	43.69	-
To	93.88	73.57	59.03	
Variance	161.47	97.00	117.65	

*296A x 3660B, 296A x MR750

Heterotic capability of F_6 inbred lines: Heterotic capability of F_6 inbred lines was reflected in the *per se* performance and standard heterosis of the hybrids (Table 2). As compared to the parental straight crosses, 296A x 3660B and 296A x MR750, significant increase in grain yield was exhibited by 20% of the F_6DF_1s (Table 3). The overall mean heterosis of crosses with significant heterosis was high (31% over better straight cross) (Table 2). Though the performance of two straight crosses was inferior to commercial check (CSH-5), 9 F_6 derived hybrids were significantly superior over CSH5 (Table 2). This indicated that some F_6 inbreds had an improvement in their heterotic capability

Table 2. *Per se* performance and heterosis of best crosses involving F_6 inbred lines for grain yield in sorghum

S. No.	Cross	*Per se*		% Heterosis	
		Mean of F_6DF_1s (g)	Mean of Male (in F_7 (g))	Over better straight cross#	Over check (CSH5)
1	296A x F_6-104	93.88	36.00	59.03**	50.47**
2	296A x F_6-8	84.38	31.57	42.94**	35.25**
3	296A x F_6-66	83.63	62.13	41.61**	34.04**
4	296A x F_6-13	77.40	59.33	31.11**	24.06**
5	296A x F_6-127	76.50	51.00	29.59**	22.62*
6	296A x F_6-30	76.20	37.43	29.08**	22.13*
7	296A x F_6-105	75.13	37.00	27.27**	20.42*
8	296A x F_6-82	75.00	33.78	27.05**	20.21*
9	296A x F_6-22	74.57	41	26.32**	19.52*
10	296A x F_6-157	74.20	31.29	25.70*	18.93
11	296A x F_6-101	74.20	36.38	25.70*	18.93
12	296A x F_6-135	73.44	49.88	24.41*	17.71
13	296A x F_6-67	72.71	36.50	23.17*	16.54
14	296A x F_6-139	72.00	37.83	21.97*	15.40
15	296A x F_6-92	71.13	26.30	20.50*	14.01
	Mean			30.36	23.34
	Straight crosses				
16	296A x 3660B	43.69	30	–25.98**	–29.97*
17	296A x MR750#	59.03	35	-	–5.38
18	CSH5 (Check)	62.39	-	-	-
	CD (5%)	11.95	-	-	-
	CD (1%)	15.65	-	-	-

#Better straight Cross (296 A x MR 750); *,**: Significant at 5 and 1 per cent, respectively

compared to their parental lines during genetic recombination process. These lines appear to have accumulated more number of such genes, which impart genetic diversity to their genetic constitution relative to that of their parents. Thus, the recombination between the two parents *viz.*, 3660B and MR750 had generated inbreds with improved heterotic capability, which have the potentiality to produce superior commercial hybrids. Burton [1] also reported that lines with improved heterotic capability could be found in populations from cross of two elite lines in pearl millet.

In the present study, a comparison of heterosis (over male-parent) was made among all the 73 hybrids involving male sterile 296A and 73 F_6 inbreds (Table 3). The range of heterosis was very high (-13.46 to 170.46%) with 42% of the crosses showing low heterosis (<50%), 36 % hybrids showing medium heterosis (50 -100 %) while 22 % of the hybrids exhibited very high heterosis (>100%). The mean heterosis shown by low, medium and high heterotic groups was 24%, 72% and 127% respectively. As the performance of hybrids depended upon the heterotic capability of the parents involved, the differences in the superiority of hybrids (heterosis over respective male parents) can be attributed to the differences shown by the new inbred lines for their ability to impart hybrid vigour to their offsprings when combined with a given tester 296A. Heterosis ($\Sigma\, dy^2$) is a function of differences in gene

Table 3. Range, mean of heterosis (for grain yield) over male parent among F_6DF_1s

Group	Magnitude of heterosis	No. of hybrids	% of total crosses	Mean heterosis (%) of group	Range (%)	Hybrids with F_6 parents (296A x F_6)
Low	<50%	31	42	24	−13.46-50	10, **13***, 23, 31*, 32, 37*, 57, **66***, 70, 72*, 73, 76, 79, 81*, 83*, 85*, 86*, 90, 94, 95, 102, 106, 113, 116, 120, **127***, 128*, **135***, 140*, 148, 158*
Medium	50-100%	26	36	72	50.48 - 99.21	6*, 16*, 17*, 18*, **22***, 27*, 42*, 47*, 50*, 51*, 52*, 53*, 64*, **67***, 87*, 96,*, 99*, 111*, 112*, 124*, 129*, **139***, 143*, 144*, 151*, 153*
High	>100%	16	22	127	101.36 - 170.46	7*, **8***, 21*, 25*, **30***, 55*, 44*, 62*, 68*, **82***, **92***, **101***, **104***, **105***, 121*, **157***
Over all	-	73	100	63.67	−13.46 - 170.46	

*Hybrids with these parents are significantly superior over their respective male parent (56 hybrids)
1. Hybrids with parents in block letters showed significant superiority over CSH5 (9 hybrids)
2. Hybrids with parents underlined were significantly superior over the better straight cross (15 hybrids)

frequencies (y^2) and dominance deviations at different loci between parents [6]. Since the parents are homozygous, the difference of gene frequency between them is either nil (0) or maximum (1). The heterosis then is the sum of the deviations *d* of those loci that have different alleles in the two lines. The amount of heterosis is some thing specific to each particular cross. The genes by which two lines differ will not be the same for all the pairs of lines, so different pairs of lines will have different values of ($\Sigma\, dy^2$) and will show different amounts of heterosis [6]. In the study it is observed that some of the inbred lines *viz.*, F_6-8 (167.78%), F_6-44 (147.81%), F_6-62 (105.58%), F_6-92 (170.46%), F_6-104 (160.78%), F_6-105 (102.51%) gave hybrids with 296A which are highly heterotic than other inbred lines *viz.*, F_6-32 (-5.49%), F_6-57 (8.95%), F_6-70 (8.65%), F_6-95 (5.22%) which expressed comparatively very less heterosis. A high level of heterosis in a cross indicates that the parents are genetically more diverse than those crosses, which show little or no heterosis [6, 7]. Thus, the chance of obtaining superior hybrid combinations increases with the increase in genetic distance between the CMS line and restorers. In the present study, since the female parent is common, the differences seen in the expression of heterosis is a reflection of the differences in the contribution of $\Sigma\, dy^2$ by different male parents to heterosis. Thus the male parents varied in their contribution to the heterosis values shown by them. Increased genetic diversity among the progenies of sorghum cross from a given tester as compared to the parents was also reported by earlier studies [8,9].

Thus the present study indicated the possibility of deriving inbred lines with improved heterotic capability from an elite sorghum cross. A large number of potential F_6 inbreds have been identified to further elevate the hybrid vigour of sorghum hybrids. Improving heterotic capability of sorghum lines followed in the study through pedigree method is very simple unlike complicated recurrent selection procedures for improving specific combining ability (sca) and this may be followed to effectively derive the lines with high heterotic potential.

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