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Heteosis for grain yield and its contributing traits in sorghum (*Sorghum bicolor* (L.) Moench)

More Ambika, Deosarkar DB, Kalpande HV and Mehtre SP

Abstract
An experiment was conducted to assess the extent of heterosis in for grain yield and its contributing traits in sorghum (*Sorghum bicolor* (L.) Moench) crosses using line x tester mating design. Thirty hybrids derived from mating five testers with six lines in L x T design along with their parents and two checks *viz*., CSH 15 R and CSV 22 R were evaluated in Randomized Block Design with three replications. Observations were recorded on randomly selected 5 five plants in each replication for grain yield and its Contributing characters. Results evidenced the higher estimates of sca variances than the corresponding gca variances for the characters plant height, panicle length, panicle breadth, number of primaries per panicle, grain yield and fodder yield indicating non additive gene effects controlling the traits. Amongst 30 hybrids evaluated, three hybrids *viz.,* Phule Anuradha x PBMR 3, Phule Anuradha x PBMR 1 and ICSR 196 x PBMR 3 recorded lowest negative heterosis percentage for days to 50% flowering over standard hybrid check (CHS 15 R), varietal check (CSV 22 R) and better parent. Seven hybrids expressed significant superiority for heterobeltiosis and standard heterosis for grain yield, amongst which, CSV 29 R x PBMR 3, Parbhani Moti X PBMR 4, Phule Anuradha x PBMR 4, Parbhani Moti x PBMR 1 and MS 104B x PBMR 3 were top ranking. In addition to grain yield these crosses also performed better for panicle breadth, number of primary branches per panicle, 100 seed weight and harvest index. In addition the crosses; Parbhani Moti x PBMR 5, PMS 71B x PBMR 5, CSV 29R x PBMR 3, MS 104B x PBMR 3, ICSR 196 x PBMR 3 and Phule Anuradha x PBMR 3 possessed significantly desirable heterosis and *per se* performance for fodder yield per plant.

Keywords: Sorghum, heterosis, line x tester mating design

1. Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth major cereal crop of world following wheat, rice, maize and barley in terms of production and utilization. With its C4 photosynthetic pathway, it is adopted to a wide range of environmental conditions [16]. It has a multiple use as a food, fodder, fuel and fibre crops [13]. It is one among the climate resilient crops that can better adapt to climate change conditions [3, 17]. Hybrid vigour and its commercial exploitation have paid rich dividends in Kharif sorghum leading to quantum jump in sorghum production [8]. However, the progress in *rabi* sorghum is limited in spite of its more preference for consumption and animal feed due to the superior quality of fodder and grain as compared to *kharif* sorghum. Keeping in view the importance of sorghum under rainfed situation there is a need for critical studies on combining ability and heterosis for grain and fodder yield. In view of the above facts, present investigation was carried out to analysis extent of heterobeltiosis and economic heterosis in dual purpose sorghum [*Sorghum bicolor* (L.) Moench].

2. Materials and Methods
six lines *viz*., MS 104B, PMS 71B, ICSR 196, Parbhani Moti, CSV 29R and Phule Anuradha and five testers *viz.*, PBMR 1, PBMR 2, PBMR 3, PBMR 4 and PBMR 5 belonging to the different height, midrib colour and yield traits representing a fairly wide range of genetic diversity were crossed in a line x tester mating design for the development of experimental material to estimate combining ability. 30 F1s along with 12 parents and two checks *viz.*, CSH 15 R and CSV 22 R were evaluated at Sorghum Research Station, VNMKV, Parbhani during rabi 2018-19 in randomized block design with three replications. Both parents and F1 were raised each in two rows of 3 m length with a spacing of 45 cm x 15 cm. All the recommended practices were followed to raise good crop of *kharif* sorghum. The biometrical observations on grain yield and other related components *viz.,* days to 50 per cent flowering, plant height, panicle length, number of primaries per panicle, were recorded on randomly selected 5 five

plants in each replication for grain yield, fodder yield and yield contributing traits. Data was analyzed by the methods outlined by [12] using mean values of five random plants in each replication from all treatments to find out the significance of treatment effect. The heterosis effects in terms of per cent increase or decrease over superior parent (heterobeltiosis) and over standard check (economic heterosis) were measured for days to 50% flowering, plant height, test weight, grain yield per plant, fodder yield par plant, harvest index, field grade score and threshed grade score. The heterosis was calculated as per the procedure suggested by [4].

3. Results and Discussion

Analysis of variance for yield and yield contributing characters revealed significant and appreciable differences among the parents, crosses and line verses testers for all the characters indicating the presence of sufficient variability among the parents (Table 1). Significant mean square differences for parents verses crosses for most of the characters except days to 50 per cent flowering showed presence of heterosis in desirable direction. The mean squares due to line x tester was significant for all the characters except for days to 50 per cent flowering indicating significant contribution of non-additive gene effects towards the variability (Table 1). These results are in agreement with those published earlier for days to 50 per cent flowering, plant height, panicle length and grain yield per plant [10], for days to 50 per cent flowering and grain yield per plant [21] and days to 50 per cent flowering, plant height, grain yield per plant and test weight [6]. Heterosis over better parent and standard checks CSH 15 R and CSV 22 R presented in table 2 revealed that amongst 30 hybrids evaluated, three hybrids *viz.*, Phule Anuradha x PBMR 3, Phule Anuradha x PBMR 3 and ICSR 196 x PBMR 3 recorded lowest negative heterosis percentage for days to 50% flowering over standard hybrid check (CHS 15 R), varietal check (CSV 22 R) and better parent indicating early flowering behaviour of these hybrids over checks and parents. A negative heterosis estimate for days to flowering is desirable because it implies that the crosses flowered earlier than the parents [2]. The high productivity of hybrids is the result of hybrid vigor or heterosis. Magnitude of heterosis for grain yield per plant was ranged from -26.11 (ICSR 196 x PBMR 2) to 55.29 per cent (MS 104B x PBMR 3) over better parent, -41.02 (ICSR 196 x PBMR 2) to 81.82% (CSV 29 R x PBMR 3) over hybrid check CSH 15R and -50.35 (ICSR 196 x PBMR 2) to 53.06 per cent (CSV 29 R x PBMR 3) over varietal check CSV 22 R. Among 30, eight crosses *viz.*, CSV 29R x PBMR 3, Parbhani Moti x PBMR 4, Phule Anuradha x PBMR 3, Parbhani Moti x PBMR 1, MS 104 B x PBMR 3, Parbhani Moti x PBMR 5, CSV 29R x PBMR 4 and CSV 29R x PBMR 5 expressed significant superiority for the grain yield regarding all three types of heterosis. Heterosis for grain yield was also obtained earlier by [9] for standard heterosis, [20, 2, 5] for heterobeltiosis, [15, 18] for relative heterosis, heterobeltiosis and standard heterosis.

Significant positive desirable heterosis was exhibited by crosses CSV 29 R x PBMR 2, ICSR 196 x PBMR 1 and PMS 71B x PBMR 1 for panicle length, Parbhani Moti x PBMR 3, Phule Anuradha x PBMR 3and Parbhani Moti x PBMR 5 for panicle breadth, Parbhani Moti x PBMR 1, Parbhani Moti x PBMR 4 and Phule Anuradha x PBMR 3 for number of primaries per panicle, CSV 29 R x PBMR 3, Parbhani Moti x PBMR 4 and Parbhani Moti x PBMR 1 for 100 seed weight. Most of the crosses with significant positive heterosis also expressed positive desirable heterosis for number of primaries, panicle length, panicle breadth, 100 seed weight and plant height. Heterosis for grain yield is the effect of simultaneous heterosis in more than one components of yield [11]. Heterosis for grain yield and its contributing traits *viz.*, panicle length, number of primaries, 100 seed weight and number of grains per panicle was also observed by [7, 11, 15]. For fodder yield, five crosses *viz.*, Parbhani Moti x PBMR 5, PMS 71 B x PBMR 5, CSV 29 R x PBMR 5, PMS 71 B x PBMR 3 and Phule Anuradha x PBMR 3 reported more than 30 per cent and 15 per cent fodder yield over standard checks CSH 15 R and CSV 22 R. while cross ICSR 196 x PBMR 1 recorded highest heterosis (44.62%) followed by MS 104B x PBMR 2 (25.46%), and PMS 71 B x PBMR 3 (25.44%). These hybrids also exhibited significantly high heterosis for plant height. Similar results were also obtained by [14, 19]. Crosses; CSV 29R x PBMR 3, Moti x PBMR 5 and Phule Anuradha x PBMR 3 potential for both grain and fodder yield are derived from the parents with high x high gca effects. Additive gene effects in these crosses could be exploited to produce superior segregants in segregating generations of these crosses to breed dual purpose high yielding varieties/hybrids.

Table 1: Analysis of variance for yield and yield contributing traits.

Source of variation	D.F.	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Panicle breadth (cm)	No. of Primaries /panicle	Grain yield/plant (g)	100 seed weight (g)	Fodder yield/plant (g)	Harvest Index (%)
Replications	2	6.106	9.732	7.429	0.066	12.15	4.59	0.020	4.425	1.048
Treatments	40	41.821**	2229.05**	25.479**	1.167**	267.05**	263.63**	0.777**	681.713**	52.577**
Parents	10	56.933**	3106.67**	27.936**	1.164**	191.60**	164.81**	0.697**	531.139**	60.973**
Line	5	46.989**	4015.12**	37.429**	1.634**	146.80**	83.89**	0.912**	688.780**	3.680
Testers	4	41.767**	2649.76**	10.852*	0.826**	113.48**	63.01**	0.328**	456.258**	30.469**
Lines vs Tester	1	167.322**	392.04**	48.804**	0.170	728.08**	976.66**	1.103**	42.462	469.450**
Parents vs Crosses	1	0.429	10259.8**	73.680**	0.339*	360.83**	1855.89**	1.207**	6385.86**	92.937**
Crosses	29	38.037**	1649.51**	22.969**	1.197**	289.84**	242.80**	0.790**	536.940**	48.291**
Error	80	5.464	39.854	3.246	0.063	8.76	7.65	0.029	15.686	2.435

Table 2: Estimation of heterobeltiosis (BP) and economic heterosis (EP) over hybrid check CSH 15 R and Varietal Check CSV 22R for yield and yield contributing traits.

Sr. No.	Genotypes	Days to 50% flowering			Plant height (cm)			Panicle length (cm)		
		BP	CSH 15 R	CSV 22 R	BP	CSH 15 R	CSV 22 R	BP	CSH 15 R	CSV 22 R
1	MS 104B x PBMR 1	-3.93	-0.45	-3.51	22.11**	-4.21	-16.05**	3.7	-11.15	-4.93
2	MS 104B x PBMR 2	0.44	4.07	0.88	34**	7.94**	-5.4*	19.53**	2.42	9.58
3	MS 104 B x PBMR 3	-0.92	-2.26	-5.26*	14.73**	13.61**	-0.43	0.65	-13.76*	-7.73
4	MS 104B x PBMR 4	-5.6*	-0.9	-3.95	-4.49	0	-12.36**	-9.37	-22.35**	-16.92*

5	MS 104B x PBMR 5	-4.82*	7.24**	3.95	5.31*	12.48**	-1.42	12.76	-3.38	3.38
6	PMS 71 B x PBMR 1	-5.24*	-1.81	-4.82	5.24*	-12.16**	-23.01**	7.94	9.01	16.64*
7	PMS 71 B x PBMR 2	-3.06	0.45	-2.63	11.65**	-6.81**	-18.32**	-5.43	-4.49	2.19
8	PMS 71B x PBMR 3	-3.13	-1.81	-4.82	19.64**	18.48**	3.84	-20.02**	-19.22**	-13.57*
9	PMS 71 B x PBMR 4	-3.02	1.81	-1.32	-14.4**	-10.37**	-21.45**	0.17	1.17	8.24
10	PMS 71 B x PBMR 5	-2.01	10.41**	7.02**	8.95**	16.37**	1.99	2.15	3.17	10.39
11	ICSR 196 x PBMR 1	-6.55*	-3.17	-6.14*	7.49*	-13.94**	-24.57**	4.13	11.87	19.7**
12	ICSR 196 x PBMR 2	-2.62**	0.9	-2.19	4.43	-15.88**	-26.28**	-6.14	0.84	7.89
13	ICSR 196 x PBMR 3	-4.59	-5.88*	-8.77**	10.47**	9.4**	-4.12	-1.34	6	13.42
14	ICSR 196 x PBMR 4	-3.45	1.36	-1.75	6.81**	11.83**	-1.99	-27.39**	-21.99**	-16.53*
15	ICSR 196 x PBMR 5	-6.43**	5.43*	2.19	-0.46	6.32*	-6.82**	-18.26**	-12.18	-6.04
16	Parbhani Moti x PBMR 1	-4.37	-0.9	-3.95	-4.35	3.4	-9.38**	-2.47	-20.22**	-14.63*
17	Parbhani Moti x PBMR 2	-2.62	0.9	-2.19	1.65	9.89**	-3.69	16.42*	-8.76	-2.37
18	Parbhani Moti x PBMR 3	-3.95	-0.9	-3.95	-1.5	6.48*	-6.68**	13.21	-3.24	3.53
19	Parbhani Moti x PBMR 4	-0.86	4.07	0.88	5.4*	13.94**	-0.14	6.17	-22.02**	-16.57*
20	Parbhani Moti x PBMR 5	-2.41	9.95**	6.58*	11.69**	20.75**	5.82**	-13.93	-30.69**	-25.84*
21	CSV 29 R x PBMR 1	-5.65*	-1.81	-4.82	-8.59**	6.97**	-6.25**	-11.37	-16.75**	-10.92
22	CSV 29 R x PBMR 2	-5.22*	-1.36	-4.39	-0.97	15.88**	1.56	19.51**	12.25	20.11**
23	CSV 29 R x PBMR 3	0.43	4.52	1.32	-2.35	14.26**	0.14	11.59	4.82	12.15
24	CSV 29 R x PBMR 4	-1.72	3.17	0	-5.26*	10.86**	-2.84	-14.83**	-20**	-14.41*
25	CSV 29 R x PBMR 5	0	12.67**	9.21**	-3.19	13.29**	-0.71	1.41	-4.75	1.92
26	Phule Anuradha x PBMR 1	-10.04**	-6.79*	-9.65**	-33.53**	-25.12**	-34.38**	12.08	-8.32	-1.9
27	Phule Anuradha x PBMR 2	-4.37	-0.9	-3.95	-8.06**	3.57	-9.23**	6.19	-16.78	-10.95
28	Phule Anuradha x PBMR 3	-6.88*	-8.14**	-10.96**	-4.75*	7.29**	-5.97**	-1.86	-16.12*	-10.25
29	Phule Anuradha x PBMR4	-3.88	0.9	-2.19	-7.48**	4.21	-8.66**	7.19	-25.36**	20.14**
30	Phule Anuradha x PBMR 5	-7.23**	4.52	1.32	1.87	14.75**	0.57	8.1	-12.95*	-6.86
	Min.	-10.04	-8.14	-10.96	-33.53	-25.12	-34.38	-23.08	-27.39	-30.69
	Max.	0.44	12.67	9.21	22.11	20.15	5.82	21.05	19.53	12.25
	SE (d)	1.91	1.90	1.91	5.13	5.13	4.76	0.50	0.52	0.47

*and ** Significant at 5% and 1% level respectivel

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Table 3: Estimation of heterobeltiosis (BP) and economic heterosis (EP) for yield and yield contributing traits.

Sr. No	**Genotypes**	**Panicle breadth (cm)**			**No. of Primaries/panicle**			**Grain yield/plant(g)**		
		BP	**CSH15 R**	**CSV22 R**	**BP**	**CSH15 R**	**CSV22 R**	**BP**	**CSH 15 R**	**CSV 22 R**
1	MS 104B x PBMR 1	-6.07	-5.07	-21.89**	-22.72**	-17.78**	-29.52**	-24.08**	-31.16**	-42.05**
2	MS 104B x PBMR 2	13.95	12.2**	-7.68*	3.39	10*	-5.71	31.5**	19.23**	0.38
3	MS 104 B x PBMR 3	1.04	23.07**	1.26	10.7**	17.78**	0.95	55.29**	40.8**	18.54**
4	MS 104B x PBMR 4	-16.11**	-3.47	-20.57**	-13.58**	-8.06	-21.19**	6.97	-3.01	-18.35**
5	MS 104B x PBMR 5	-2.76	14.93**	-5.43	-10.18**	-4.44	-18.1**	-17.21*	-24.94**	-36.81**
6	PMS 71 B x PBMR 1	3.21	11.53	-8.23*	11.05**	14.44**	-1.9	28.41**	28.82**	8.45
7	PMS 71 B x PBMR 2	-1.17	6.8	-12.12**	-8.36*	-5.56	-19.05**	-4.21	-3.9	-19.1**
8	PMS 71B x PBMR 3	9.63	33.53**	9.87	9.16*	12.5**	-3.57	14.56*	14.93*	-3.25
9	PMS 71 B x PBMR 4	-4.98	9.33*	-10.04**	-5.93	-3.06	-16.9**	-19.73**	-19.47**	-32.21**
10	PMS 71 B x PBMR 5	4.68	23.73**	1.81	0.81	3.89	-10.95**	6.97	7.32	-9.66
11	ICSR 196 x PBMR 1	-6.01	-0.87	-18.43**	1.65	2.5	-12.14**	43.84**	14.82*	-3.34
12	ICSR 196 x PBMR 2	16.18	22.53**	0.82	-18.43**	-25**	-35.71**	-26.11**	-41.02**	-50.35**
13	ICSR 196 x PBMR 3	-5.31	15.33**	-5.1	13.71**	10.56*	-5.24	43.79**	24.94**	5.18
14	ICSR 196 x PBMR 4	1.91	17.27	-3.51	-15.41**	-22.22**	-33.33**	27.25**	1.57	-14.49*
15	ICSR 196 x PBMR 5	-15.34**	0.07	-17.66**	11.18*	2.22	-12.38**	18.47*	-5.43	-20.39**
16	Parbhani Moti x PBMR 1	-7.62	28.47**	5.7	12.83**	29.44**	10.95**	24.08**	43.91**	21.15**
17	Parbhani Moti x PBMR 2	-20.23**	10.93*	-8.72*	-19.13**	-7.22	-20.48**	2.36	18.71*	-0.06
18	Parbhani Moti x PBMR 3	1.68	41.4**	16.35**	0.24	15**	-1.43	9.07	26.5**	6.49
19	Parbhani Moti x PBMR 4	-18.84**	12.87**	-7.13*	11.38**	27.78**	9.52**	34.16**	55.6**	30.99**
20	Parbhani Moti x PBMR 5	-0.34	38.6**	14.04**	5.57	21.11**	3.81	21.39**	40.79**	18.53**
21	CSV 29 R x PBMR 1	-3.55	17.73**	-3.13	-19.72**	-2.78	-16.67**	-11.37*	10.98	-6.57
22	CSV 29 R x PBMR 2	-18.95**	-1.07	-18.6**	-3.21	17.22**	0.48	7.11	34.12**	12.91*
23	CSV 29 R x PBMR 3	0.05	22.13**	0.49	5.05	27.22**	9.05*	45.2**	81.82**	53.06**
24	CSV 29 R x PBMR 4	0.49	22.67**	0.93	-14.68**	3.33	-11.43**	9.74	37.42**	15.68*
25	CSV 29 R x PBMR 5	-2.95	18.47**	-2.52	9.17**	32.22**	13.33**	12.22*	40.52**	18.3**
26	Phule Anuradha x PBMR 1	-6.32	3.8	-14.59**	-27.27**	-26.67**	-37.14**	9.39	13.61	-4.36
27	Phule Anuradha x PBMR 2	-0.9	9.8*	-9.65*	-2.4	-9.44*	-22.38**	-19.38**	-16.27*	-29.51**
28	Phule Anuradha x PBMR 3	8.87	32.6**	9.11*	26.86**	23.33**	5.71	38.79**	44.14**	21.34**
29	Phule Anuradha x PBMR4	-2.49	12.2**	-7.68*	0	-7.22	-20.48**	-18.21**	-15.06*	-28.49**
30	Phule Anuradha x PBMR 5	-20.25**	-5.73	-22.44**	5.39	-2.22	-16.19**	-9.03	-5.53	-20.47**
	Min.	-20.25	-5.73	-22.44	-21.27	-26.67	-37.14	-26.11	-41.02	-50.35
	Max.	16.18	33.33	16.35	26.86	32.22	13.33	55.29	81.82	53.06
	SE (d)	0.2056	0.2056	0.2056	2.4167	2.4167	2.4167	2.2580	2.2580	2.2580

*and ** Significant at 5% and 1% level respectively

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Table 4: Estimation of heterobeltiosis (BP) and economic heterosis (EP) for yield and yield contributing traits.

Sr. No.	Genotypes	100 Seed weight (g)			Fodder yield/plant (g)		
		BP	CSH 15 R	CSV 22 R	BP	CSH 15 R	CSV 22 R
1	MS 104B x PBMR 1	-4.06	-10.47*	-24.01**	18.59**	0.15	-13.1**
2	MS 104B x PBMR 2	2.83	1.22	-14.08**	25.46**	19.51**	3.7
3	MS 104 B x PBMR 3	17.78**	23.94**	5.2	21.47**	30.33**	13.08**
4	MS 104B x PBMR 4	-6.22	-2.56	-17.3**	-8.37*	-10.99**	-22.77**
5	MS 104B x PBMR 5	0.6	-6.12	-20.32**	1.88	22.38**	6.18*
6	PMS 71 B x PBMR 1	5.45	1.34	-13.99**	8.04*	6.12	-7.92*
7	PMS 71 B x PBMR 2	-5.77	-7.24	-21.27**	2.69	0.86	-12.48**
8	PMS 71B x PBMR 3	-15.03 **	-10.58*	-24.1**	25.44**	34.58**	16.77**
9	PMS 71 B x PBMR 4	-1.29	2.56	-12.95**	16.74**	14.67**	-0.51
10	PMS 71 B x PBMR 5	4.75	0.67	-14.56**	14.58**	37.63**	19.41**
11	ICSR 196 x PBMR 1	15.21**	-1.34	-16.26**	44.62**	22.14**	5.97
12	ICSR 196 x PBMR 2	-13.12 **	-14.48**	-27.41**	-2.91	-7.51*	-19.75**
13	ICSR 196 x PBMR 3	-3.49	1.56	-13.8**	15.9**	24.34**	7.89*
14	ICSR 196 x PBMR 4	-22.72 **	-19.71**	-31.85**	-5.44	-8.15*	-20.3**
15	ICSR 196 x PBMR 5	20.16**	2.9	-12.67**	-15.08**	2	-11.5**
16	Parbhani Moti x PBMR 1	-12.75 **	17.37**	-0.38	13.26**	22.71**	6.47*
17	Parbhani Moti x PBMR 2	-4.8	28.06**	8.7*	4.22	12.92*	-2.02
18	Parbhani Moti x PBMR 3	4.64	40.76**	19.47**	6.24*	15.11**	-0.12
19	Parbhani Moti x PBMR 4	-0.33	34.08**	13.8**	13.64**	23.12**	6.83*
20	Parbhani Moti x PBMR 5	-2.9	30.62**	10.87**	18.27**	42.06**	23.26**
21	CSV 29 R x PBMR 1	1.03	19.82**	1.7	-4.6	14.87**	-0.33
22	CSV 29 R x PBMR 2	-3.47	14.48**	-2.84	-9.15**	9.39*	-5.08
23	CSV 29 R x PBMR 3	14.27**	35.52**	15.03**	8.78**	30.98**	13.65**
24	CSV 29 R x PBMR 4	2.54	21.6**	3.21	2.53	23.45**	7.11*
25	CSV 29 R x PBMR 5	7.42	27.39**	8.13*	12.83**	35.85**	17.87**
26	Phule Anuradha x PBMR 1	-32.48 **	-23.39**	-34.97**	2.01	7.07*	-7.1*
27	Phule Anuradha x PBMR 2	-1.67	11.58*	-5.29	19.67**	25.62**	8.99**
28	Phule Anuradha x PBMR 3	4.32	18.37**	0.47	24.08**	33.12**	15.5**
29	Phule Anuradha x PBMR 4	-3.63	9.35	-7.18	-3.14	1.67	-11.7**
30	Phule Anuradha x PBMR 5	3.73	17.71**	-0.09	9.83**	31.92**	14.47**
	Min.	-32.48	-23.39	-34.96	-15.08	-10.99	-22.77
	Max.	20.16	40.76	19.47	44.62	42.06	23.26
	SE (d)	0.1410	0.1410	0.1410	3.2338	3.2338	3.2338

4. Conclusion

On the basis of *per se* performance, significant desirable sca effects and all three types of heterosis, six F_1 hybrids *viz.*, MS 104B x Bmr 7-4-1, MS 104B x Bmr 7-8-1, PMS 71 B x Bmr 7-4-1, Parbhani Moti x Bmr 7-2-2, Phule Anuradha x Bmr 7-4-1 and ICSR 196 x Bmr 7-4-1 identified as potential crosses for grain yield, fodder yield and its contributing traits. Heterosis breeding might be exploited directly in these crosses with the provision of male sterility followed by multi location trials.

5. Conflict of interest

The authors confirm that there are no known conflicts of interest associated with publication of this paper.

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