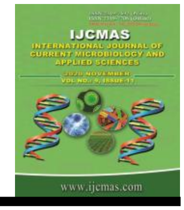
Int.J.Curr.Microbiol.App.Sci (2020) *9*(11): 846-863

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 11 (2020)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2020.911.102

Heterosis for Grain Yield and its Component Traits in Rabi Sorghum

A. S. Totre[1*], A. S. Jadhav[1], M. S. Shinde[2], N. S. Kute[3], U. S. Dalvi[2], R. S. Bhoge[4] and G. C. Shinde[1]

[1]Department of Agricultural Botany, [2]Sorghum Improvement Project, [3]Pulses Improvement, [4]Seed Testing Research Unit, Seed Cell, Project MPKV, Rahuri, (MS), India

**Corresponding author*

Keywords

Heterosis, L x T, Rabi Sorghum

Article Info

Accepted:
07 October 2020
Available Online:
10 November 2020

A B S T R A C T

The experiment was undertaken on Line x Tester analysis for, grain yield and its component traits in crosses of A and R lines of *rabi* sorghum at All India Co-ordinated Sorghum Improvement Project, M.P.K.V., Rahuri, during the year 2017-18 with objectives to study the heterosis of parents and hybrids. The four CMS lines (females), ten testers (males) and their forty F_1's hybrids were studied by using L x T design. Observations were recorded on eleven characters viz., Days to 50% flowering, Days to physiological maturity, seedling height at 14 DAE (cm), Plant height (cm), Grains per panicle (no.), Panicle weight (g), 1000 grain weight (g), Dry fodder weight (g), Dry matter content (g), Grain yield per plant (g) and Harvest index (%). Among the eleven characters studied, majority of the characters exhibited mid-parents as well as better parent heterosis along with standard heterosis in desirable direction in most of the hybrids, indicating the predominant role of non-fixable inter-allelic interactions and over dominance in the expression of heterosis in respect of all these traits. Among the hybrids RMS-2010-16A x RSV-2124, RMS-2010-24A x RSV-2124 and CMS-185A x RSV-2124, are identified as promising crosses.

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is cultivated as a major food crop in several countries in South Asia, Africa and Central America. It is fifth important cereal of the world after wheat, maize, rice and barley (Dillon *et al.*, 2007). Sorghum is believed to be originated in Africa and spread all over the world. Sorghum [*Sorghum bicolor* (L.) Moench] known as great millet and guinea corn in west Africa, kafir corn in South Africa, dura in Sudan, mtama in Eastern Africa, jowar in India and kaoliang in China (Purseglove, 1972).

Sorghum (*Sorghum bicolor* (L.) Moench) is unique in its adaptation to extreme environmental conditions. In India, there are two distinct growing season for sorghum i.e. rainy (*kharif*) and post rainy (*rabi*) seasons. Rabi sorghum is highly valued for consumption purpose due to the excellent quality of the grain, which matures during rain free cool climate. Hence, this grain fetches high market price, almost double that of *kharif* grain.

The discovery of cytoplasmic male sterile lines in sorghum facilitates the production of hybrids. Heterosis has been commercially exploited due to the availability of a stable and heritable CMS system to improve its productivity. Hence, the aim of the study was to evaluate the parents' genetic diversity and estimate percentage of heterosis of their F_1. Knowledge on the magnitude of heterosis for various characters is essential to locate better combinations to exploit them through heterosis breeding. Over dominance is attributed towards heterobeltiosis, while commercial superiority of the hybrid may be assessed by evaluating with a standard commercial check (Prakash *et al.,* 2010). With this point of views the hybrids generated in the present investigation were evaluated and selected on the basis of their standard heterosis.

Materials and Methods

The experimental material for the present study comprised of four male sterile lines, ten restorers, their resulting forty hybrids and one hybrid check CSH-15R. During *rabi* 2017- 18 four male sterile lines and ten restores were sown at Sorghum Improvement Project, M.P.K.V., Rahuri and these lines and testers were crossed in Line x Tester design to produce forty possible hybrids. The experiment was conducted during *rabi* 2018 by using fourteen parents, their forty hybrids along with one standard check CSH-15R at Sorghum Improvement Project, M.P.K.V., Rahuri. The observations were recorded on eleven characters viz., Days to 50% flowering, Days to physiological maturity, Seedling height at 14 DAE (cm), Plant height (cm), Grains per panicle (no.), Panicle weight (g), 1000 grain weight (g), Dry fodder weight (g), Dry matter content (g), Grain yield per plant (g) and Harvest Index (%). In the present investigation heterosis has been estimated over mid parent (Average / Relative heterosis) and better parent (heterobeltiosis) as per Fonesca and Patterson (1968).

Results and Discussion

The hybrids performed significantly better than the respective parents. Significant heterosis was observed for most of the studied characters. Average heterosis and heterobeltiosis in hybrids varied significantly and could be due to genetic diversity of parents used to generate the hybrids. This indicated the existence of vigor and development of hybrids. The analysis of variance and estimates of gca and sca variance are presented in Table 1 and 2. It was observed that, the mean squares due to lines, testers as well as lines vs tester interaction and hybrids were found significant for all the characters under studies except line, tester and line vs tester in days to 50% flowering. This suggested that the experimental material possessed considerable amount of variability for grain yield and all the component traits. Mean performance of parents, hybrids and standard check for grain yield per plant and its contributing characters in *rabi* sorghum are presented in Table 3. Higher values are desirable for all traits under study except for days to 50% flowering and days to maturity for which lower values are preferred.

The mean performance of hybrids for different traits studied were compared with the corresponding mid parent (MP), better parent (BP) and standard check hybrids (CSH-15R) and the differences are being expressed as per cent heterosis for grain yield, its components traits. In rabi sorghum, positive heterosis was desirable for all the characters studied except days to 50% flowering and days to maturity where negative heterosis is desirable. Character wise results of average heterosis (H_1) heterobeltiosis (H_2) and standard heterosis (H_3) observed in the forty crosses (Table 4).

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

Sources	DF	Days to 50% flowering	Days to physiological maturity	Seedling height at 14 DAE (cm)	Plant height (cm)	Grains per panicle (no.)	Panicle weight (g)	1000 grain weight (g)	Dry fodder weight (g)	Dry matter content (g)	Grain yield per plant (g)	Harvest index (%)
Replications	2	1.07	47.22**	8.58**	265.62	129953.71**	196.30	45.90**	30.27	2725.37**	33.81	17.34*
Treatments	53	13.40**	22.07**	8.80**	1546.37**	132943.91**	559.93**	41.66**	456.61**	1319.82**	155.51**	17.34**
Parents	13	3.03	16.76**	1.30	3540.38**	160844.19**	675.45**	71.50**	475.64**	1932.65**	236.12**	12.87**
Line	3	5.66	21.12*	0.74	686.84**	48218.65	2206.62**	4.30	58.43	249.98	62.76	24.06**
Testers	9	2.08	15.62**	1.61	606.72**	139852.04**	228.99	58.03**	99.35	1323.37**	167.11**	9.24
Line vs. Tester	1	3.65	14.00	0.16	38503.94**	687650.07**	100.15	394.40**	5113.96**	12464.15**	1377.26**	12.02
Parent vs. hybrid	1	80.55**	115.01**	82.64**	11360.11**	999520.58**	278.30	29.35**	2790.35**	12405.80**	186.77*	86.63**
Hybrids	39	15.14**	21.45**	9.41**	630.07**	101423.90**	528.64**	32.03**	390.43**	831.28**	127.84**	17.06**
Error	106	2.40	5.80	0.93	168.89	19771.94	167.83	2.81	92.52	237.04	31.25	4.92

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table.2 Estimates of combining ability in *rabi* sorghum

Estimates	Days to 50% flowering	Days to physiological maturity	Seedling height at 14 DAE (cm)	Plant height (cm)	Grains per panicle (no.)	Panicle weight (g)	1000 grain weight (g)	Dry fodder weight (g)	Dry matter content (g)	Grain yield per plant (g)	Harvest index (%)
σ^2_{gca}	1.8042**	2.1592**	0.6555*	105.4407**	3606.7121	8.2268	3.1135	41.9674**	25.7846	3.1187	0.8453*
σ^2_{sca}	2.4902**	2.7510**	2.8027**	10.4999	23175.9934**	127.39**	5.0730	65.4107**	195.0548**	32.2124**	3.4655**
σ^2_A	3.6084	4.3185	1.3109	210.88	7213.4242	16.4536	6.2270	83.9348	79.0161	6.2375	1.6906
σ^2_D	2.4902	2.7510	2.8027	10.4999	23175.9934	127.3987	5.0730	65.4107	195.0548	32.2124	3.4655
σ^2_A / σ^2_D	1.4490	1.5698	0.4677	20.08	0.3112	0.1292	1.2275	1.2832	0.2644	0.1936	0.4878

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table.3 Mean performance of parents and hybrids for grain yield and its contributing characters in *rabi* sorghum

Sr. No.	Name of parents/ crosses	Days to 50 % flowering	Days to physiological maturity	Seedling height at 14 DAE	Plant height (cm)	Grains per panicle	Panicle weight (g)	1000 gain weight (g)	Dry fodder weight (g)	Dry matter content (g)	Grain yield per plant (g)	Harvest index (%)
	Female (lines)											
1.	RMS2010-10A	67.46	108.76	23.60	188.60	1622	94.83	25.00	71.46	178.13	49.52	27.77
2.	RMS2010-16A	66.13	107.53	23.40	188.20	1534	129.83	24.66	64.50	170.06	47.22	27.92
3.	RMS2010-24A	69.40	113.66	22.83	159.80	1500	69.36	25.33	75.06	159.80	43.66	27.30
4.	CMS-185A	67.06	109.66	24.03	165.13	1320	76.00	27.33	69.36	179.73	39.02	22.02
	Lines Mean	**67.51**	**109.90**	**23.465**	**175.43**	**1494**	**92.505**	**25.58**	**70.095**	**171.93**	**44.855**	**26.25**
	Male (Testers)											
5.	RSV 2015	66.0	108.13	24.00	235.67	2042	112.80	34.67	95.49	216.73	65.67	30.32
6.	RSV 2121	66.47	107.13	23.10	254.00	2005	104.67	34.67	105.13	247.47	65.99	28.08
7.	RSV 2138	67.93	109.27	22.93	259.13	2180	102.06	38.33	95.70	242.13	69.80	28.89
8.	RS 585	66.60	106.80	23.97	219.73	1693	97.36	29.33	86.06	195.06	55.87	28.77
9.	RSV 1996	67.13	109.33	23.90	241.93	1642	97.80	32.00	90.06	187.47	53.18	28.30
10.	RSV 1850	67.00	110.27	24.77	222.90	1641	91.97	25.67	93.13	215.10	56.24	25.96
11.	RSV 1837	67.53	107.73	23.43	239.30	1699	90.26	36.67	90.36	208.73	57.08	26.96
12.	RSV 2124	65.30	105.63	22.30	254.20	1705	91.00	30.00	94.47	202.36	54.27	26.74
13.	PSR 34	66.73	108.13	23.27	238.03	1537	85.87	26.33	92.13	186.46	45.45	24.39
14.	CSV 26	67.93	113.87	24.36	259.67	1628	85.47	36.00	102.70	199.13	51.80	25.97
	Testers Mean	**66.85**	**108.62**	**23.60**	**242.45**	**1777**	**95.93**	**32.37**	**94.523**	**210.06**	**57.53**	**27.43**
	Hybrids											
15.	2010-10A x RSV2015	67.60	109.46	24.73	241.03	1566	113.73	35.66	66.33	179.16	56.40	31.59
16.	2010-10A x RSV 2121	66.70	107.53	23.93	236.33	1579	85.66	28.33	70.00	184.16	60.13	35.58
17.	2010-10A x RSV 2138	67.26	109.00	24.06	243.26	1630	99.36	31.66	89.33	192.06	59.62	31.07
18.	2010-10A x RSV 585	67.13	109.13	27.86	221.66	1403	74.83	30.33	78.00	173.40	46.37	27.20
19.	2010-10A x RSV 1996	65.53	106.73	25.73	199.23	1466	88.63	30.33	81.33	157.40	50.59	31.85

20.	2010-10A x RSV 1850	62.00	104.33	30.66	208.20	1445	88.66	31.33	70.33	168.13	48.36	28.62
21.	2010-10A x RSV 1837	66.10	108.46	26.06	218.40	1624	90.80	38.33	93.53	196.80	57.65	29.69
22.	2010-10A x RSV 2124	66.00	107.40	25.60	211.13	1231	83.73	28.33	64.60	162.40	40.51	25.30
23.	2010-10A x PSR 34	65.86	106.93	25.93	214.26	1504	104.00	29.33	82.60	167.06	50.52	30.65
24.	2010-10A x CSV 26	69.80	111.20	28.26	215.93	1511	109.80	32.33	82.80	199.46	58.54	29.20
25.	2010-16A x RSV 2015	62.90	103.30	26.96	207.06	1473	81.93	36.00	86.13	168.70	43.24	25.68
26.	2010-16A x RSV 2121	64.13	105.13	26.50	197.76	1549	98.00	29.33	89.80	176.40	49.12	27.78
27.	2010-16A x RSV 2015	67.40	108.66	23.70	204.60	1616	96.23	32.33	77.80	167.13	51.63	29.59
28.	2010-16A x RSV 2138	67.40	108.46	23.90	197.00	1376	76.73	28.00	80.86	183.06	49.83	28.29
29.	2010-16A x RS 585	65.60	107.40	22.93	192.73	1394	75.73	29.00	86.06	164.73	45.41	27.72
30.	2010-16A x RSV 1996	67.66	109.53	25.46	188.96	1515	89.13	37.66	70.83	161.66	49.36	30.60
31.	2010-16A x RSV 1837	67.33	109.53	28.20	210.66	1638	105.40	32.66	83.13	190.13	55.48	29.33
32.	2010-16A x RSV 2124	66.80	109.00	23.20	204.46	2150	125.30	34.33	97.80	236.13	70.48	30.33
33.	2010-16A x PSR 34	62.60	105.53	25.53	210.33	1376	87.46	30.66	91.80	190.40	50.20	26.53
34.	2010-16A x CSV 26	65.66	106.33	27.03	209.86	1518	83.50	29.66	120.46	213.13	50.69	23.74
35.	2010-24A x RSV 2015	64.26	104.40	26.36	191.33	1882	111.83	35.00	73.66	183.83	60.63	32.82
36.	2010-24A x RSV 2121	64.13	105.13	24.73	189.46	1337	76.66	27.00	71.80	178.16	47.01	26.40
37.	2010-24A x RSV 2138	64.60	105.73	25.76	204.83	1532	89.40	30.00	70.06	190.66	56.06	29.68
38.	2010-24A x RS 585	66.20	107.53	24.56	192.56	1619	89.83	28.33	77.80	188.13	54.48	28.85
39.	2010-24A x RSV 1996	68.86	113.13	26.03	187.80	1341	103.73	26.00	60.46	162.80	45.34	28.00
40.	2010-24A x RSV 1850	69.13	112.63	24.10	189.83	1465	77.40	30.33	61.40	154.73	46.52	29.66

41.	2010-24A x RSV 1837	66.93	108.80	25.80	211.80	1440	92.00	28.00	75.73	176.06	50.29	28.75
42.	2010-24A x RSV 2124	65.60	107.60	25.80	195.03	1753	95.00	29.66	82.73	187.50	61.03	32.48
43.	2010-24A x PSR 34	64.53	105.60	24.60	208.13	1318	88.00	27.66	69.70	164.06	46.06	28.15
44.	2010-24A x CSV 26	69.40	111.80	23.00	202.53	1241	82.00	29.33	66.13	154.80	44.07	28.70
45.	CMS 185A x RSV 2015	62.06	101.86	26.50	204.86	1473	104.86	37.33	56.93	152.13	44.88	29.56
46.	CMS 185A x RSV 2121	61.66	102.70	26.13	192.76	1727	107.60	37.33	78.80	188.06	54.74	29.18
47.	CMS 185A x RSV 2138	63.26	105.46	23.13	213.40	1579	99.53	34.00	82.06	183.13	56.46	30.88
48.	CMS 185A x RS 585	62.26	104.40	25.26	188.66	1372	91.40	33.33	74.60	185.80	46.99	25.14
49.	CMS 185A x RSV 1996	62.06	103.50	24.16	190.76	1230	71.06	32.33	76.13	179.40	44.72	25.07
50.	CMS 185A x RSV 1850	63.00	105.23	22.80	175.46	1641	100.33	33.33	80.73	193.70	57.51	30.16
51.	CMS 185A x RSV 1837	64.46	106.23	22.63	195.73	1576	74.56	34.00	76.20	168.13	50.18	29.88
52.	CMS 185A x RSV 2124	66.80	108.53	23.53	193.26	1805	113.66	32.00	72.80	192.46	59.36	30.78
53.	CMS 185A x PSR 34	62.66	103.53	23.46	198.13	1272	76.26	27.66	77.70	175.13	40.52	23.14
54.	CMS 185A x CSV 26	64.20	105.96	23.06	208.60	1512	74.53	27.66	74.03	177.80	47.48	26.09
55.	**CSH 15R (Ch)**	**65.33**	**107.10**	**23.56**	**213.26**	**1517**	**91.86**	**29.66**	**78.13**	**185.73**	**51.99**	**27.79**
	Hybrid mean (HM)	**65.43**	**107.06**	**25.19**	**204.19**	**1517**	**91.95**	**31.39**	**78.07**	**179.19**	**51.46**	**28.84**
	General mean (GM)	**65.84**	**107.56**	**24.74**	**209.22**	**1562**	**92.71**	**31.12**	**80.48**	**184.40**	**52.09**	**28.32**
	SE ±	0.89	1.38	0.55	7.48	80.53	7.43	0.96	5.54	8.85	3.22	1.27
	CD at 5 %	2.49	3.87	1.56	20.96	225.74	20.84	2.69	15.55	24.82	9.02	3.57
	CD at 1%	3.30	5.12	2.06	27.73	298.62	25.57	3.56	20.57	32.83	11.94	4.72

Table.4 Heterosis (%) over mid-parent (MP), better-parent (BP) and standard check (CSH-15R) for different characters in *rabi* sorghum

Sr. No.	Crosses	Days to 50% flowering			Days to physiological maturity			Seedling height at 14 DAE (cm)		
		1			2			3		
		MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1.	2010-10A x RSV 2015	1.30	2.42	3.74	0.94	1.23	2.21	3.92	3.06	4.95
2.	2010-10A x RSV 2121	-0.40	0.35	2.09	-0.39	0.37	0.40	2.50	1.41	1.56
3.	2010-10A x RSV 2138	-0.64	-0.30	2.96	-0.02	0.21	1.77	3.44	1.98	2.12
4.	2010-10A x RSV 585	0.15	0.80	2.76	1.25	2.18	1.90	17.17**	16.27**	18.25**
5.	2010-10A x RSV 1996	-2.63	-2.38	0.31	-2.12	-1.87	-0.34	8.35**	7.67*	9.19**
6.	2010-10A x RSV 1850	-7.78**	-7.46**	-5.10*	-4.73**	-4.08*	-2.58	26.81**	23.82**	30.13**
7.	2010-10A x RSV 1837	-2.07	-2.03	1.17	0.20	0.68	1.28	10.84**	10.45**	10.61**
8.	2010-10A x RSV 2124	-0.58	1.07	1.02	0.19	1.67	0.28	11.55**	8.47*	8.63*
9.	2010-10A x PSR 34	-1.84	-1.30	0.82	-1.40	-1.11	-0.16	10.67**	9.89**	10.04**
10.	2010-10A x CSV 26	3.10	3.46	6.84**	-0.10	2.24	3.83*	17.86**	16.01**	19.94**
11.	2010-16A x RSV 2015	-4.79**	-4.70*	-3.72	-4.20**	-3.94*	-3.55	13.78**	12.36**	14.43**
12.	2010-16A x RSV 2121	-3.27	-3.02	-1.84	-2.05	-1.87	-1.84	13.98**	13.25**	12.45**
13.	2010-16A x RSV 2015	0.55	1.92	3.16	0.25	1.05	1.46	2.30	1.28	0.57
14.	2010-16A x RSV 2138	1.56	1.92	3.16	1.21	1.56	1.28	0.91	-0.28	1.41
15.	2010-16A x RS 585	-1.55	-0.81	0.41	-0.95	-0.12	0.28	-3.03	-4.04	-2.69
16.	2010-16A x RSV 1996	1.65	2.32	3.57	0.58	1.86	2.27	5.74**	2.83	8.06*
17.	2010-16A x RSV 1837	0.75	1.81	3.06	1.77	1.86	2.27	20.43**	20.34**	19.66**
18.	2010-16A x RSV 2124	1.65	2.30	2.24	2.27	3.19	1.77	1.53	-0.85	-1.56
19.	2010-16A x PSR 34	-5.77**	-5.34**	-4.18*	-2.13	-1.86	-1.46	9.43**	9.12**	8.35*
20.	2010-16A x CSV 26	-2.04	-0.71	0.51	-3.94*	-1.12	-0.72	13.19**	10.94**	14.71**

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Contid…

Sr. No.	Crosses	Days to 50% flowering			Days to physiological maturity			Seedling height at 14 DAE (cm)		
		1			2			3		
		MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
21.	2010-24A x RSV 2015	-5.07**	-2.63	-1.63	-5.86**	-3.45	-2.52	12.60**	9.86**	11.88**
22.	2010-24A x RSV 2121	-5.59**	-3.51	-1.84	-4.77**	-1.87	-1.84	7.69*	7.07*	4.95
23.	2010-24A x RSV 2138	-5.92**	-4.91*	-1.12	-5.14**	-3.23	-1.28	12.60**	12.35**	9.34**
24.	2010-24A x RS 585	-2.65	-0.60	1.33	-2.45	0.69	0.40	4.99	2.50	4.24
25.	2010-24A x RSV 1996	0.88	2.58	5.41**	1.46	3.48	5.63**	11.41**	8.93**	10.47**
26.	2010-24A x RSV 1850	1.37	3.18	5.82**	0.60	2.15	5.17**	1.26	-2.69	2.26
27.	2010-24A x RSV 1837	-2.24	-0.89	2.45	-1.72	0.99	1.59	11.53**	10.10**	9.48**
28.	2010-24A x RSV 2124	-2.60	0.46	0.41	-1.87	1.86	0.47	14.33**	12.99**	9.48**
29.	2010-24A x PSR 34	-5.19*	-3.30	-1.22	-4.78**	-2.34	-1.40	6.72	5.73	4.38
30.	2010-24A x CSV 26	1.07	2.16	6.22**	-1.73	-1.64	4.39*	-2.54	-5.61	-2.40
31.	CMS 185A x RSV 2015	-6.71**	-5.96**	-5.00*	-6.46**	-5.80**	-4.89**	10.34**	10.26**	12.45**
32.	CMS 185A x RSV 2121	-7.64**	-7.22**	-5.61**	-5.26**	-4.14**	-4.11*	10.89**	8.74**	10.89**
33.	CMS 185A x RSV 2138	-6.27**	-5.67**	-3.16	-3.65*	-3.48	-1.53	-1.49	-3.74	-1.84
34.	CMS 185A x RS 585	-6.83**	-6.51**	-4.69*	-3.54**	-2.25	-2.52	5.28	5.13	7.21*
35.	CMS 185A x RSV 1996	-7.50**	-7.46**	-5.00*	-5.48**	-5.34**	-3.36	0.83	0.55	2.55
36.	CMS 185A x RSV 1850	-6.02**	-5.97**	-3.57	-4.30**	-4.04*	-1.74	-6.56*	-7.94*	-3.25
37.	CMS 185A x RSV 1837	-4.21*	-3.88*	-1.33	-2.27	-1.39	-0.81	-4.63	-5.83	-3.96
38.	CMS 185A x RSV 2124	0.93	2.30	2.24	0.82	2.75	1.34	1.58	-2.08	-0.14
39.	CMS 185A x PSR 34	-6.33**	-6.09**	-4.08*	-4.93**	-4.25*	-3.33	-0.78	-2.36	-0.42
40	CMS 185A x CSV 26	-4.89**	-4.27*	-1.73	-5.19**	-3.37	-1.06	-4.68	-5.34	-2.12
	S.E. (Sij) ±	1.097	1.27	1.27	1.70	1.96	1.96	0.68	0.78	0.78

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Contid…

Sr. No.	Crosses	Plant height (cm)			Grains per panicles (no.)			Panicle weight (g)		
		4			5			6		
		MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1.	2010-10A x RSV 2015	13.62**	2.28	13.02*	-14.51**	-23.31**	2.89	9.55	0.83	23.80*
2.	2010-10A x RSV 2121	6.79	-6.96	10.82*	-12.93*	-21.26**	3.72	-14.12	-18.15	-6.75
3.	2010-10A x RSV 2138	8.67*	-6.12	14.07**	-14.25**	-25.22**	7.06	0.93	-2.65	8.16
4.	2010-10A x RSV 585	8.57	0.88	3.94	-15.33*	-17.11*	-7.83	-22.13**	-23.14*	-18.54
5.	2010-10A x RSV 1996	-7.45	-17.65**	-6.58	-10.11	-10.66	-3.66	-7.98	-9.37	-3.52
6.	2010-10A x RSV 1850	1.19	-6.59	-2.38	-11.42	-11.95	-5.06	-5.07	-6.50	-3.48
7.	2010-10A x RSV 1837	2.08	-8.73	2.41	-2.16	-4.38	6.70	-1.89	-4.25	-1.16
8.	2010-10A x RSV 2124	-4.64	-16.94**	-1.00	-25.99**	-27.81**	-19.12*	-9.88	-11.70	-8.85
9.	2010-10A x PSR 34	0.45	-9.98	0.47	-4.79	-7.27	-1.22	15.11	9.67	13.21
10.	2010-10A x CSV 26	-3.66	-16.84**	1.25	-6.97	-7.15	-0.71	21.80*	15.78	19.52
11.	2010-16A x RSV 2015	-2.30	-12.14**	-2.91	-17.63**	-27.87**	-3.23	-32.46**	-36.89**	-10.81
12.	2010-16A x RSV 2121	-10.55*	-22.14**	-7.27	-12.49*	-22.76**	1.73	-16.42*	-24.52**	6.68
13.	2010-16A x RSV 2015	-8.52*	-21.04**	-4.06	-12.96*	-25.84**	6.18	-17.00*	-25.88**	4.75
14.	2010-16A x RSV 2138	-3.42	-10.35	-7.63	-14.72*	-18.71**	-9.61	-32.45**	-40.90**	-16.47
15.	2010-16A x RS 585	-10.38*	-20.34**	-9.63	-12.18	-15.05*	-8.39	-33.46**	-41.67**	-17.56
16.	2010-16A x RSV 1996	-8.07	-15.22**	-11.39*	-4.59	-7.70	-0.48	-19.63*	-31.35**	-2.98
17.	2010-16A x RSV 1837	-1.44	-11.97**	-1.22	1.33	-3.57	7.60	-4.23	-18.82*	14.73
18.	2010-16A x RSV 2124	-7.56	-19.56**	-4.13	32.71**	26.05**	41.22**	13.48	-3.49	36.39**
19.	2010-16A x PSR 34	-1.31	-11.64**	-1.38	-10.39	-10.47	-9.59	-18.90*	-32.63**	-4.79
20.	2010-16A x CSV 26	-6.28	-19.18**	-1.59	-4.00	-6.75	-0.29	-22.43*	-35.69**	-9.11

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Contid…

Sr. No.	Crosses	Plant height (cm)			Grains per panicles			Panicle weight (g)		
		4			5			6		
		MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
21.	2010-24A x RSV 2015	-3.42	-18.81**	-10.28*	6.26	-7.85	23.64**	22.78*	-0.86	21.73
22.	2010-24A x RSV 2121	-8.43	-25.41**	-11.16*	-23.70**	-33.31**	-12.15	-11.89	-26.75**	-16.55
23.	2010-24A x RSV 2138	-2.21	-20.95**	-3.95	-16.70**	-29.69**	0.67	4.30	-12.41	-2.69
24.	2010-24A x RS 585	1.48	-12.36**	-9.71	1.44	-4.34	6.37	7.76	-7.74	-2.21
25.	2010-24A x RSV 1996	-6.51	-22.38**	-11.94*	-14.65*	-18.33*	-11.93	24.11*	6.07	12.92
26.	2010-24A x RSV 1850	-0.79	-14.83**	-10.99*	-6.70	-10.72	-3.73	-4.05	-15.84	-15.75
27.	2010-24A x RSV 1837	6.14	-11.49	-0.69	-9.93	-15.19*	-5.37	15.26	1.92	0.15
28.	2010-24A x RSV 2124	-5.78	-23.28**	-8.55	9.38	2.80	15.16**	18.48	4.40	3.41
29.	2010-24A x PSR 34	4.63	-12.56**	-2.41	-13.23*	-14.28	-13.43	13.38	2.48	-4.21
30.	2010-24A x CSV 26	-3.43	-22.00**	-5.03	-20.61**	-23.72**	-18.44*	5.92	-4.06	-10.74
31.	CMS 185A x RSV 2015	2.23	-13.07**	-3.94	-12.36*	-27.85**	-3.20	11.09	-7.03	14.15
32.	CMS 185A x RSV 2121	-8.02	-24.11**	-9.61	3.85	-13.89*	13.42	19.11	2.80	17.13
33.	CMS 185A x RSV 2138	0.60	-17.65**	0.06	-9.78	-27.57**	3.70	11.79	-2.48	8.35
34.	CMS 185A x RS 585	-1.96	-14.14**	-11.53*	-8.91	-18.94**	-9.86	5.44	-6.13	0.51
35.	CMS 185A x RSV 1996	-6.27	-21.15**	-10.55*	-16.95**	-25.09**	-19.22*	-18.22	-27.33*	-22.64
36.	CMS 185A x RSV 1850	-9.56*	-21.28**	-17.72**	10.84	-0.01	7.82	19.47	9.10	9.22
37.	CMS 185A x RSV 1837	-3.21	-18.21**	-8.22	4.42	-7.21	3.54	-10.30	-17.39	-18.83
38.	CMS 185A x RSV 2124	-7.82	-23.97**	-9.38	19.32**	5.84	18.58*	36.13**	24.91*	23.73*
39.	CMS 185A x PSR 34	-1.71	-16.76**	-7.10	-10.97	-17.26*	-16.45*	-5.77	-11.18	-16.98
40	CMS 185A x CSV 26	-1.79	-19.76**	-2.19	2.61	-7.09	0.65	-7.68	-12.80	-18.87
	S.E. (Sij) ±	9.18	10.61	10.61	94.42	114.80	114.80	9.16	10.57	10.57

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Contid…

Sr. No.	Crosses	1000 grain weight (g)			Dry fodder weight (g)			Dry matter content (g)		
		7			8			9		
		MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1.	2010-10A x RSV 2015	19.55**	2.88	20.22**	-20.54*	-30.54**	-15.10	-9.25	-17.33**	-3.54
2.	2010-10A x RSV 2121	-5.03	-18.27**	-4.49	-20.72**	-33.42**	-10.41	-13.46*	-25.58**	-0.84
3.	2010-10A x RSV 2138	0.0	-17.39**	6.74	6.88	-6.65	14.33	-8.60	-20.68**	3.41
4.	2010-10A x RSV 585	11.66**	3.41	2.25	0.97	-9.37	-0.17	-7.07	-11.11	-6.64
5.	2010-10A x RSV 1996	6.43	-5.21	2.25	0.70	-9.70	4.10	-13.89*	-16.04*	-15.25
6.	2010-10A x RSV 1850	23.68**	22.08**	5.62	-14.54	-24.48**	-9.98	-14.49*	-21.83**	-9.48
7.	2010-10A x RSV 1837	24.32**	4.55	29.21**	15.59	3.50	19.71	1.74	-5.72	5.96
8.	2010-10A x RSV 2124	3.03	-5.56	-4.49	-22.14**	-31.62**	-17.32	-14.64*	-19.75**	-12.56
9.	2010-10A x PSR 34	14.29**	11.39*	-1.12	0.98	-10.35	5.72	-8.36	-10.40	-10.05
10.	2010-10A x CSV 26	6.01	-10.19**	8.99	-4.92	-19.38	5.97	5.74	0.17	7.39
11.	2010-16A x RSV 2015	21.35**	3.85	21.35**	7.67	-9.80	10.24	-12.77	-22.16**	-9.17
12.	2010-16A x RSV 2121	-1.12	-15.38**	-1.12	5.88	-14.58	14.93	-15.50	-28.72**	-5.03
13.	2010-16A x RSV 2015	2.65	-15.65**	8.99	-2.87	-18.70	-0.43	-18.91**	-30.97**	-10.01
14.	2010-16A x RSV 2138	3.70	-4.55	-5.62	7.42	-6.04	3.50	0.27	-6.15	-1.44
15.	2010-16A x RS 585	2.35	-9.38*	-2.25	11.37	-4.44	10.15	-7.85	-12.13	-11.31
16.	2010-16A x RSV 1996	49.67**	46.75**	26.97**	-10.13	-23.94**	-9.34	-16.05**	-24.84**	-12.96
17.	2010-16A x RSV 1837	6.52	-10.91**	10.11*	7.36	-8.00	6.40	0.39	-8.91	2.37
18.	2010-16A x RSV 2124	25.61**	14.44**	15.73**	23.04**	3.53	25.17*	26.81**	16.69**	27.14**
19.	2010-16A x PSR 34	20.26**	16.46**	3.37	17.22	-0.36	17.49	6.81	2.11	2.51
20.	2010-16A x CSV 26	-2.20	-17.59**	0.00	44.10**	17.30*	54.18**	15.46*	7.03	14.75*

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Contid…

Sr. No.	Crosses	1000 grain weight (g)			Dry fodder weight (g)			Dry matter content (g)		
		7			8			9		
		MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
21.	2010-24A x RSV 2015	16.67**	0.96	17.98**	-13.62	-22.86**	-5.72	-2.35	-15.18*	-1.02
22.	2010-24A x RSV 2121	-10.00*	-22.12**	-8.99	-20.31**	-31.71**	-8.11	-12.51*	-28.00**	-4.07
23.	2010-24A x RSV 2138	-5.76	-21.74**	1.12	-17.94*	-26.79**	-10.32	-5.13	-21.26**	2.66
24.	2010-24A x RS 585	3.66	-3.41	-4.49	-3.43	-9.60	-0.43	6.03	-3.55	1.29
25.	2010-24A x RSV 1996	-9.30*	-18.75**	-12.36**	-26.77	-32.86**	-22.61	-6.24	-13.16	-12.35
26.	2010-24A x RSV 1850	18.95**	18.18**	2.25	-26.99	-34.07**	-21.42	-17.45**	-28.06**	-16.69*
27.	2010-24A x RSV 1837	-9.68*	-23.64**	-5.62	-8.44	-16.19	-3.07	-4.45	-15.65*	-5.20
28.	2010-24A x RSV 2124	7.23	-1.11	0.00	-2.40	-12.42	5.89	3.54	-7.35	0.95
29.	2010-24A x PSR 34	7.10	5.06	-6.74	-16.63*	-24.35**	-10.79	-5.24	-12.01	-11.67
30.	2010-24A x CSV 26	-4.35	-18.52**	-1.12	-25.60**	-35.61**	-15.36	-13.74*	-22.26**	-16.65*
31.	185A x RSV 2015	20.43**	7.69	25.84**	-30.93**	-40.38**	-27.13**	-23.26**	-29.81**	-18.09**
32.	185A x RSV 2121	20.43**	7.69	25.84**	-9.68	-25.05**	0.85	-11.95*	-24.00**	1.26
33.	185A x RSV 2138	3.55	-11.30**	14.61**	-0.57	-14.25	5.03	-13.18*	-24.37**	-1.40
34.	185A x RS 585	17.65**	13.64**	12.36**	-4.01	-13.32	-4.52	-0.85	-4.75	0.04
35.	185A x RSV 1996	8.99*	1.04	8.99	-4.50	-15.47	-2.56	-2.29	-4.30	-3.41
36.	185A x RSV 1850	25.79**	21.95**	12.36**	-0.64	-13.31	3.33	-1.88	-9.95	4.29
37.	185A x RSV 1837	6.25	-7.27	14.61**	-4.59	-15.68	-2.47	-13.44*	-19.45**	-9.48
38.	185A x RSV 2124	11.63**	6.67	7.87	-11.13	-22.94**	-6.83	0.74	-4.89	3.63
39.	185A x PSR 34	3.11	1.22	-6.74	-3.78	-15.67	-0.55	-4.35	-6.08	-5.71
40	185A x CSV 26	-12.63**	-23.15**	-6.74	-13.95	-27.91**	-5.25	-6.14	-10.71	-4.27
	S.E. (Sij) ±	1.18	1.36	1.36	6.80	7.85	7.85	10.88	12.57	12.57

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Contid…

Sr. No.	Crosses	Grain yield per plant (g)			Harvest index (%)		
		10			11		
		MP (H1)	BP (H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1.	2010-10A x RSV 2015	-2.07	-14.11*	8.49	8.76	4.18	13.69*
2.	2010-10A x RSV 2121	4.12	-8.87	15.66	16.67**	16.03*	17.24**
3.	2010-10A x RSV 2138	0.07	-14.58*	14.67	9.68	7.56	11.81
4.	2010-10A x RSV 585	-12.00	-17.00*	-10.82	-3.78	-5.46	-2.12
5.	2010-10A x RSV 1996	-1.48	-4.88	-2.69	13.61*	12.53	14.62*
6.	2010-10A x RSV 1850	-8.55	-14.02	-6.99	6.56	3.08	3.01
7.	2010-10A x RSV 1837	8.16	0.99	10.89	8.51	6.93	6.85
8.	2010-10A x RSV 2124	21.93**	-25.34**	-22.08**	-7.18	-8.89	-8.96
9.	2010-10A x PSR 34	6.40	11.16	-2.83	17.54**	10.38	10.30
10.	2010-10A x CSV 26	15.55	13.01	12.59	8.66	5.15	5.07
11.	2010-16A x RSV 2015	-23.40	-34.16**	-16.84	-11.83*	-15.32*	-7.59
12.	2010-16A x RSV 2121	-13.23	-25.56**	-5.53	-0.77	-1.04	-0.01
13.	2010-16A x RSV 2015	-11.76	-26.03**	-0.69	4.16	2.42	6.48
14.	2010-16A x RSV 2138	-3.32	-10.80	-4.15	-0.18	-1.65	1.82
15.	2010-16A x RS 585	-9.55	-14.62	-12.66	-1.41	-2.07	-0.25
16.	2010-16A x RSV 1996	-4.58	-12.23	-5.05	13.57*	9.57	10.11
17.	2010-16A x RSV 1837	6.37	-2.81	6.71	6.89	5.04	5.55
18.	2010-16A x RSV 2124	38.89**	29.88**	35.56**	10.97	8.63	9.16
19.	2010-16A x PSR 34	8.35	6.31	-3.44	1.45	-4.98	-4.51
20.	2010-16A x CSV 26	2.38	-2.14	-2.50	-11.89*	-14.97*	-14.55*
21.	2010-24A x RSV 2015	10.91	-7.67	16.62	13.91*	8.22	18.10**
22.	2010-24A x RSV 2121	-14.25	-28.75**	-9.58	-4.66	-5.98	-5.00

23.	2010-24A x RSV 2138	-1.18	-19.68**	7.83	5.65	2.75	6.81
24.	2010-24A x RS 585	9.48	-2.47	4.80	2.93	0.30	3.84
25.	2010-24A x RSV 1996	-6.37	-14.75	-12.80	0.71	-1.08	0.76
26.	2010-24A x RSV 1850	-6.87	-17.28**	-10.51	11.40	8.67	6.75
27.	2010-24A x RSV 1837	-0.17	-11.90	-3.27	5.98	5.32	3.47
28.	2010-24A x RSV 2124	24.64**	12.47	17.39	20.19**	18.97**	16.88*
29.	2010-24A x PSR 34	3.39	1.36	-11.40	8.93	3.13	1.31
30.	2010-24A x CSV 26	-7.67	-14.92	-15.23	7.75	5.13	3.27
31.	CMS 185A x RSV 2015	-14.27	-31.66**	-13.68	12.95*	-2.51	6.39
32.	CMS 185A x RSV 2121	4.25	-17.04*	5.28	16.50*	3.94	5.03
33.	CMS 185A x RSV 2138	3.76	-19.11**	8.59	21.30**	6.89	11.12
34.	CMS 185A x RS 585	-0.96	-15.88	-9.62	-1.02	-12.62*	-9.54
35.	CMS 185A x RSV 1996	-3.01	-15.92	-13.99	-0.37	-11.42	-9.78
36.	CMS 185A x RSV 1850	20.73*	2.25	10.62	25.73**	16.20*	8.55
37.	CMS 185A x RSV 1837	4.42	-12.10	-3.49	21.99**	10.83	7.52
38.	CMS 185A x RSV 2124	27.27**	9.40	14.18	26.22**	15.08*	10.76
39.	CMS 185A x PSR 34	-4.06	-10.84	-22.07**	-0.27	-5.10	-16.71*
40	CMS 185A x CSV 26	4.55	-8.34	-8.68	8.72	0.46	-6.11
	S.E. (Sij) ±	3.95	4.57	4.57	1.57	1.81	1.81

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Days to 50% flowering standard heterosis ranged from -5.61 to -4.08 per cent over check CSH-15R (Table 4). The cross CMS-185A x RSV-2121 (-5.61 %) exhibits highest negative standard heterosis followed by cross RMS-2010-10A x RSV-1850 (-5.10), CMS-185A x RSV-2015 (-5.00) and CMS-185A x RSV1996 (-5.00). Out forty hybrids, seven hybrids, were showed significant negative standard heterosis over the check CSH-15R. These results are in line with the earlier results of Prabhakar (2001), Kulkarni and Patil (2004), Umakant *et al.,* (2006), Gite *et al.,* (2015), Kalpande *et al.,* (2015) and Iyanar and Gopalan (2016).

The magnitude of heterosis over mid parent was -3.54 per cent (CMS-185A x RS-585) to -6.46 per cent (CMS-185A x RSV-2015) for days to physiological maturity. The range of heterobeltiosis was from -3.94 per cent (RMS-2010-16A x RSV-2015) to -5.80 per cent (CMS-185A x RSV-2015). The standard heterosis ranged from 5.63 to -4.89 per cent. The crosses CMS-185A x RSV-2015 (-4.89%) and CMS-185A x RSV-2121 (-4.11%) were showed highest negative standard heterosis. Similar results recorded by Prabhakar (2001), Umakant *et al.,* (2006), Gite *et al.,* (2015), Kalpande *et al.,* (2015) and Prasad B *et al.,* (2018).

Average heterosis for seedling height at 14 DAE ranged from -6.56 to 26.81 per cent (Table 4). The cross RMS-2010-10A x RSV-1850 (26.81%) exhibited highest positive average heterosis followed by RMS-2010-16A x RSV-1837 (20.43%) and RMS-2010-10A x CSV-26 (17.86%). Heterobeltiosis ranged from -7.94 per cent (CMS-185A x RSV-1850) to 23.82 per cent (RMS-2010-10A x RSV-1850) (Table 4). As the check CSH-15R is tall in growth habit the standard heterosis for Seedling height at 14 DAE ranged from 7.21 to 30.13 per cent over check CSH-15R (Table 4). Twenty one crosses showed standard heterosis in desirable direction. Maximum positive heterosis was found in crosses RMS-2010-10A x RSV-1850 (30.13%) followed by RMS-2010-10A x CSV-26 (19.94%) and RMS-2010-16A x RSV-1837 (19.66%) while minimum positive standard heterosis was observed in CMS-185A x RS-585 (7.21%).

Out of forty hybrids, two hybrids recorded significant average heterosis in positive direction for plant height (cm). The heterosis over better parent ranged from -25.41 per cent (RMS-2010-24A x RSV-2121) to - 11.97 per cent (RMS-2010-16A x RSV-1837). Out of forty crosses, none of the cross exhibited positive and significant heterobeltiosis for this trait.

The range of standard heterosis over the check CSH-15R was -17.72 per cent (CMS-185A x RSV-1850) to 14.07 per cent (RMS-2010-24A x RSV2138). Out of 40 crosses, three crosses exhibited positive and significant standard heterosis for this trait. Maximum positive heterosis was found in crosses RMS-2010-10A x RSV-2138 (14.07%) followed by RMS-2010-10A x RSV-2015 (13.02%) and RMS-2010-10A x RSV-2121 (10.82%). The similar results were earlier reported by Prabhakar (2001), Prakash *et al.,* (2010), Gite *et al.,* (2015), Kalpande *et al.,* (2015) and Kumar and shrotria (2016).

Out of forty hybrids, two hybrids recorded significant average heterosis in positive direction for grains per panicle (no.). The heterosis over better parent ranged from -33.31 per cent (RMS-2010-24A x RSV-2121) to 26.05 per cent (RMS-2010-16A x RSV-2124). Out of forty crosses, only one of the cross exhibited positive and significant heterobeltiosis for this trait.

The range of standard heterosis over the check CSH-15R was -19.22 per cent (CMS-

185 x RSV-1996) to 41.22 per cent (RMS-2010-216A x RSV2124). Out of forty crosses, four crosses exhibited positive and significant standard heterosis for this trait. Maximum positive heterosis was found in crosses RMS-2010-216A x RSV-2124 (41.22%) followed by RMS-2010-24A x RSV-2015 (23.64%) and CMS-185A x RSV-2124 (18.58%). Similar finding was recorded by Laxman (2001).

Average heterosis for panicle weight ranged from -33.46 to 36.13 per cent. The cross CMS185A x RSV-2124 (36.13%) exhibited highest positive average heterosis followed by RMS-2010- 24A x RSV-1996 (24.11%) and RMS-2010-24A x RSV-2015 (22.78%). Heterobeltiosis ranged from -41.67 per cent (RMS-2010-16A x RS-585) to 24.91 per cent (CMS-185A x RSV-2124) (Table 4). Out of forty crosses, only one cross show highest significant positive heterobeltiosis in desirable direction for this trait. Standard heterosis over check hybrid CSH-15R ranged from 23.73 per cent (CMS-185A x RSV-2124 to 36.39 per cent (RMS-2010-16A x RSV-2124). Three crosses showed standard heterosis in desirable direction. The highest significant standard heterosis recorded in the cross, RMS-2010-16A x RSV-2124 (36.39%), followed by cross RMS-2010-10A x RSV2015 (23.80%) and CMS-185A x RSV-2124 (23.73%) (Table 4). Similar findings reported by Gite *et al.,* (2015), Prasad B *et al.,* (2018) and Khadi *et al.,* (2018).

The magnitude of heterosis over mid parent was 11.63 per cent (CMS-185A x RSV-2124) to 49.67 per cent (RMS-2010-16A x RSV-1996) for 1000 grain weight (g). The cross RMS-2010-16A x RSV-1996 (49.67%) 71 exhibited highest positive average heterosis followed by CMS-185A x RSV-1850 (25.79%) and RMS-2010-10A x RSV-1837 (24.32%). The range of heterobeltiosis was from -23.64 per cent (RMS-2010-24A x RSV-1837) to 46.75 per cent (RMS-2010-16A x RSV-1996). Out of forty crosses, seven crosses show highest significant positive heterobeltiosis in desirable direction for this traits. The standard heterosis ranged from -12.36 per cent to 29.21 per cent. The RMS-2010-24A x RSV-1837 (29.21%), RMS-2010-16A x RSV-1996 (26.97%), and CMS-185A x RSV-2015 (25.84%) were showed highest positive standard heterosis. Out of forty crosses, thirteen crosses show highest significant positive standard heterosis in desirable direction for this trait. Similar result recorded by Prabhakar (2001), Umakant *et al.,* (2006), Gite *et al.,* (2015) and Kalpande *et al.,* (2015),

Out of forty hybrids, two hybrids recorded significant average heterosis in positive direction for dry fodder weight (g). The heterosis over better parent ranged from -40.38 per cent (CMS-185A x RSV-2015) to 17.30 per cent (RMS-2010-216A x CSV-26). Out of forty crosses, only one of the cross exhibited positive and significant heterobeltiosis for this trait. The range of standard heterosis over the check CSH-15R was -27.13 per cent (CMS-185 x RSV-2015) to 54.18 per cent (RMS-2010-16A x CSV-26).

Out of forty crosses, two crosses exhibited positive and significant standard heterosis for this trait. Maximum positive heterosis was found in crosses RMS-2010-216A x CSV-26 (54.18%) followed by RMS-2010-16A x RSV-2124 (25.17%) respectively. Similar result reported by Prakash *et al.,* (2010) and Kumar and shrotria (2016).

Average heterosis for dry matter content ranged from -23.26 to 26.81 per cent. The cross RMS-2010-16A x RSV-2124 (26.81%) exhibited highest positive average heterosis followed by RMS-2010-16A x CSV-26 (15.46%). Heterobeltiosis ranged from -30.97

(RMS-2010-16A x RSV2015) to 16.69 per cent (RMS-2010-16A x RSV-2124) (Table 4). Out of forty crosses, only one cross show highest significant positive heterobeltiosis in desirable direction for this trait. Standard heterosis over check hybrid CSH-15R ranged from -18.09 per cent (CMS-185A x RSV-2015) to 27.14 per cent (RMS-2010-16A x RSV-2124). Two crosses showed standard heterosis in desirable direction. The highest significant standard heterosis recorded in the cross, RMS-2010-16A x RSV2124 (27.14%), followed by cross RMS-2010-16A x CSV-26 (14.75%), (Table 4). Similar finding was reported by Akabari *et al.,* (2012).

The magnitude of heterosis over mid-parent for grain yield per plant ranged from 21.93 per cent (RMS-2010-10A x RSV-2124) to 38.89 per cent (RMS-2010-16A x RSV-2124). A total of four hybrids recorded significant positive heterosis over mid parent. The cross RMS-2010-16A x RSV2124 (38.89%) exhibited highest significant average heterosis followed by CMS-185 x RSV-2015 72 (27.27%) and RMS-2010-24A x RSV-2124 (24.64%) (Table 4). The range in heterobeltiosis varied from -31.66 per cent (CMS-185 x RSV-2015) to 29.88 per cent (RMS-2010-16A x RSV-2124). A only one hybrid recorded significant positive heterosis over better parent. The cross RMS-2010-16A x RSV-2124 (29.88%) exhibited highest significant heterosis over better parent. The range of heterosis over standard checks, CSH-15R was from -22.08 per cent (RMS-2010-10A x RSV-2124) to 35.56 per cent (RMS-2010-16A x RSV-2124).

Among forty hybrids, only one hybrid recorded positive significant heterosis over CSH-15R. The highest standard heterosis in desirable direction was recorded in the cross RMS-2010-16A x RSV-2124 (35.56%), (Table 4). The similar results were earlier reported by Prabhakar (2001), Kulkarni and Patil (2004), Umakant *et al.,* (2006). Gite *et al.,* (2015), Kalpande *et al.,* (2015), Khadi *et al.,* (2018) and Prasad *et al.,* (2018).

A total of twelve hybrids recorded significant positive heterosis over mid parent for Harvest index (%). The magnitude of heterosis over mid-parent for harvest index ranged from -11.89 per cent (RMS-2010- 16A x CSV-26) to 26.22 per cent (CMS-185A x RSV-2124). The heterosis over better parent ranged from -15.32 per cent (RMS-2010-16A x RSV-2015) to 18.97 per cent (RMS-2010-24A x RSV2124). Out of forty crosses, four crosses exhibited positive and significant heterobeltiosis for this trait. The range of standard heterosis over the check CSH-15R was -16.71 per cent (CMS-185 x RSV-PSR-34) to 18.10 per cent (RMS-2010-24A x RSV-2015). Out of forty crosses, five crosses exhibited positive and significant standard heterosis for this trait. Maximum positive heterosis was found in crosses RMS-2010-24A x RSV-2015 (18.10%) followed by RMS-2010-10A x RSV-2121 (17.24%) and RMS-2010-24A x RSV-2124 (16.88%) respectively. Similar finding was reported by Jadhav and Deshmukh (2017).

In conclusions the heterosis studies indicated that expression of relative heterosis, heterobeltosis and standard heterosis in several crosses for most of the characters in both desirable direction as well as undesirable direction. Four crosses were shown significant positive heterosis over standard check CSH-15R for the traits days to 50% flowering, days to physiological maturity, grains per panicle, panicle weight, dry fodder weight.

The cross RMS-2010-16A x RSV-2124 show significant standard heterosis over check CSH-15R for grain yield per plant. Thus there is need of cytoplasm diversification and use of diverse parents in *rabi* sorghum for hybrids development.

Acknowledgement

The Authors are sincerely grateful to Department of Agriculture Botany and All India Coordinated Sorghum Improvement Project, Mahatma Phule Krushi Vidyapeeth Rahuri, for providing necessary facilities for complete research work.

References

Akabari, V.R., Parmar, H.P., Niranjana, M. and Nakarani, D.B. (2012). Heterosis and combining ability for green fodder yield and its contributing traits in forage sorghum [*Sorghum bicolor* (l.) moench]. *Forage Res.*, 38(3): 156-163.

Dillon, S.L., Shapter, F.M., Henry, R.J., Cordeiro, G., Izquierdo, L. and Slade, L.L. 2007. Domestication to crop improvement: genetic resources for sorghum and saccharum (Andropogoneae). Ann. Bot. (Lond.) 100: 975-989.

Fonseca, A. and Patterson. F.L. 1968. Hybrid vigour in a seven parent diallel cross in common winter wheat (*T. aestivum* L.). *Crop Sci.,* 8: 85-88.

Gite, A.G., Kute, N.S. and Patil, V.R. (2015). Heterosis studies for yield and its components traits *rabi* sorghum (*Sorghum bicolor* L. Moench). *J. of Global Biosci.*, 4(8): 3207-3219.

Iyanar, K. and Gopalan, A. (2006). Heterosis In relation to per se and sca effects in grain sorghum {*Sorghum bicolor* (l.) moench}. *Indian J. Agric. Res.*, 40(2): 109-113.

Jadhav, R.R. and Deshmukh, D.T. (2017). Heterosis and combining ability studies in sorghum (*Sorghum bicolor* (L.) Moench) over the environments. *Int. J. Curr. Microbiol. Ap. Sci.*, 6(10): 3058-3064.

Kalpande, V.V., Ghorade, R.B., Nair, B., Kahate, N.S. and Gunjal, S.M. (2015) Heterosis studies for grain yield and yield components in post rainy sorghum. *Plant Archives.*, 15(1): 177-180.

Khadi, P.S., Biradar, B.D. and Pattanashetti, S.K. (2018). Heterosis studies for yield and yield components in *rabi* sorghum [*Sorghum bicolor* (L.) Moench]. *J. Farm Sci.*, 31(3): 342-343.

Kulkarni, V. and Patil, M.S. (2004). Heterosis Studies in Sorghum. *Karnataka J. Agri. Sci.*, 17(3): 458-459.

Kumar, P. and Shrotria, P.K. (2016). Combining ability and heterosis studies for yield and component traits in forage sorghum (*Sorghum bicolor* L. Moench). *Green Farming.*, 7(1):1-7.

Laxman., S. (2001). Studies on heterosis and combining ability in sorghum (*Sorghum bicolor* L. Moench) through Line x Tester Analysis. *J. Res. Angrau.*, 29(4): 12-17.

Prabhakar (2001). Heterosis in rabi sorghum (*Sorghum bicolor* (L.) Moench). *Indian J. Genet.*, 61(4): 364-365.

Prakash, R., Ganesamurthy, K., Nirmalakumari, A. and Nagarajan, P. (2010). Heterosis for fodder yield in sorghum (*Sorghum bicolor* L. Moench). Electronic J. of Plant Breed., 1(3): 319-327.

Prasad B, H. V., Biradar, B.D. and Verma, L.K. (2018). Estimation of heterosis among B x B, B x R and R x R crosses of *rabi* sorghum. *Bull. Env. Pharmacol. Life Sci.*, 7(1): 14-20.

Purseglove, J.W. 1972. *Sorghum bicolor* (L.) Monech, in Tropical crops. Monocotyledons, longman group limited, London, pp. 261-287.

Umakanth, A.V., Rao, S.S. and Kuriakose, S.V. (2006). Heterosis in landrace hybrids of post-rainy sorghum {*Sorghum bicolor* (l.) moench}. *Indian J. Agric. Res.*, 40 (2): 147-150.

How to cite this article:

Totre, A. S., A.S. Jadhav, M. S. Shinde, N. S. Kute, U. S. Dalvi, R. S. Bhoge and Shinde, G. C. 2020. Heterosis for Grain Yield and its Component Traits in Rabi Sorghum. *Int.J.Curr.Microbiol.App.Sci.* 9(11): 846-863. doi: https://doi.org/10.20546/ijcmas.2020.911.102