Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 2907-2914
Received: 22-03-2019
Accepted: 24-04-2019

HV Kalpande
Associate Professor, Department of Agricultural Botany, College of Agriculture VNMKV, Parbhani, Maharashtra, India

Ranjana Tiwari
Ph.D. Student, Department of Agricultural Botany, College of Agriculture VNMKV, Parbhani, Maharashtra, India

SV Kalyankar
Ph.D. Student, Department of Agricultural Botany, College of Agriculture VNMKV, Parbhani, Maharashtra, India

Correspondence
HV Kalpande
Associate Professor, Department of Agricultural Botany, College of Agriculture VNMKV, Parbhani, Maharashtra, India

Heterosis studies for yield, its component and grain mould resistance in sorghum genotype

HV Kalpande, Ranjana Tiwari and SV Kalyankar

Abstract
The present investigation entitled as “Genetics of Shootfly Resistance, Heterosis and Combining Ability in Sorghum (*Sorghum Bicolor* (L.) Moench)” was conducted in *kharif* 2015 at sorghum research station Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The second experiment was carried out to estimate the amount of heterosis and heterobeltiosis, the general and specific combining ability for selection of potential parents, crosses and to study important quantitative characters associated with grain mould resistance. In the present study, a set of 15 Parents (7 lines and 8 testers), 56 Hybrids and 3 checks were evaluated to study the inheritance of yield and grain mould resistance traits.
Crosses ICSA101 × KR125 (30.28), PMS71A × AKR456 (29.79), PMS74A × AKR456 (28.63), PMS232A × C43 (28.00) and PMS74A × KR125 (24.15) recorded significantly higher heterosis over standard checks for grain yield per plant. Similar trend was the trend in yield contributing characters and germination percentage. Highest significant negative heterobeltiosis over standard check SPH1641 was recorded by cross PMS74A × I26 (-37.79), ICSA101 × KR125 (-36.80) and PMS71A × AKR456 (-35.94) for threshed grade score and grain mould related characters.

Keywords: Heterosis studies, yield, component, grain mould resistance, sorghum genotype

Introduction
Sorghum (*Sorghum bicolor* (L.) Moench) is an important cereal crop in India. Sorghum belongs to natural order Poaceae, tribe Andropogenae, with ten pairs of chromosomes (2n=20) And considered to be of Ethiopian origin (Vavilov, 1935) [15].
Recent FAO statistics indicates a world production of 60 million tonnes of grain sorghum from 44 million hectare of land with productivity of 1238 kg/ ha (FAO stat 2016). Area under sorghum in India is 9.1 million hectare with 6.7 million tonnes of production and 783 kg productivity per hectare. Maharashtra which contributes about 49.14 per cent of area and 42.07 per cent production with an area of 28.58 lakh hectares, production of 25.07 lakh tonnes and productivity of 1971 kg/ha (Anonymous 2015) [2].
Grain mould constitutes one of the most important biological constraints to sorghum quality improvement and production. *Fusarium moniliforme* (Sheld), *Curvularia lunata* (Wakker) Boedijn and *Alternaria alternata* are most important fungi reported to effect the grain. This mould causes discoloration in grain. Fruiting structures of *Phoma sorghina* (Sacc.) and *Colletotrichum graminicola* (cesati) Wilson disfigure the pericarp. *Alternaria* spp. and *Cladosporium* spp. cause staining. *Dreschlera* spp. is also associated with diseased grains. In maharshtra, the most common grain mould in relative order of frequencies are *Curvularia lunata* (40-60%), *F. moniliforme* (15-20%). *Dreschlera* spp*; Phoma sorghina, Aspergellus* spp. (5-30%).
There was a variation in the percentage average loss within the groups of genotypes. It was 4.03 to 12.40 per cent in hybrids, 10.97 to 18.45 per cent in parents, 8.24 to 19.75 per cent in varieties and 3.33 to 6.90 per cent in IS lines respectively (Utikar *et al*., 1985[a]).
Reduction in germination, seed rot, seedling blight or reduced seedling growth may result due to pre-harvest infection of seeds by fungi. In most of the cases, avoidance or chemical control on farmer’s field is impracticable. Therefore, major research efforts have been focused on development of resistant cultivars.
Rain damaged grains fetches less value then normal grains and seed loses its viability. Line × tester analysis studies furnish useful information regarding the selection of suitable parents for effective hybridization programme (Sprague and Tatum, 1942) [12]. Heterosis or hybrid vigour is the increased or decreased vigour growth, fitness or yield of a hybrid over the parental values, resulting from the crossing of genetically unlike organisms.

The present investigation was carried out to obtain information on the following objectives

1. To identify various component characters associated with grain mould
2. To study the general and specific combining ability of the genotypes
3. To estimate the magnitude of heterosis for yield and yield parameters
4. To identify potential crosses for future crop improvement programme

Material and Methods

In *Rabi*, 2015 seven lines i.e. PMS28A, PMS74A, PMS71A, PMS98A, ICSA101A, PMS42A, PMS232A, were crossed with the eight testers i.e. I2, AKR456, KR191, KR196, KR125, C43, 9825REC and ICSR196. In *kharif* 2016 15 parents, 56 hybrids along with three checks i.e. CSH 25, SPH 1641 and CSH 16 were raised with 2 rows per treatment in randomized block design with 3 replications with a spacing 45 × 15 at sorghum research station vasantrao naik marathwada Krishi Vidyapeeth parbhani. Parbhani is located in the South-west part of Maharashtra, India, comes under agro-climatic zone-VII in the state. The site of experiment is located at 19° 16' N latitude, 67° 47' E longitude and 409 meter above the sea level. This region has Sub-tropical climate with extreme of summer and medium winter. The temperature falls down to as low as 12-14^{0}C during winter season especially in the month of December and January. The mercury rises up to 46-48^{0}C during summer. The average rainfall in this area is around 950 mm annually

Observation recorded were Grain yield per plant (gm), Fodder yield per plant (gm), Test weight (gm) Harvest index (%) field grade score (%), and germination (%)

The data recorded on the material generated as per Line x Tester model were subjected to analysis of variance as per the Line x Tester model given by Kempthorne (1957) [5]. Heterosis over better parent, Mid parent and over standard checks was estimated. as per the formula of Fonesca and Patterson (1968) [4].

Results

1) Heterosis, Heterobeltiosis and Economic Heterosis

The character wise results of heterosis and heterobeltiosis and economic heterosis are detailed below:

2) Grain yield (gm)

The positive heterosis for this trait is of interest to the breeder as it results in increase of yield. Heterosis in desired direction (positive significant) was exhibited by ten crosses out of fifty six crosses. Highest significant positive standard heterosis over mid parent was recorded by PMS232A × C43 (26.48) For Grain yield (gm), eight crosses recorded heterobeltiosis in desired (positive and significant) direction over better parent. Highest significant positive heterobeltiosis over better parent was recorded by cross ICSA101 × KR125 (30.28), PMS232A × C43 (23.86) Eight crosses recorded significant positive heterosis over standard check CSH25. Significantly highest positive heterosis over standard check CSH25 was recorded by cross ICSA101 × KR125 (27.87) Seven crosses showed significant positive heterosis over standard check SPH1641 among the fifty six crosses. Highest economic heterosis over this check recorded by cross ICSA101 × KR125 (17.51) Eight crosses recorded economic heterosis in desired direction (positively significant) over standard check CSH16 and significantly highest economic heterosis recorded by cross ICSA101 × KR125 (30.28). Boratkar (2010) reported similar results for grain yield in sorghum.

3) Fodder yield per plant (gm)

Significant heterosis in desired direction (positive significant) for fodder yield per plant is desirable for this trait. Nine crosses recorded significant positive heterosis over mid parent. Highest significant positive standard heterosis over mid parent was recorded by cross PMS42A × KR125 (23.58) Six crosses recorded significant superior positive heterosis over better parent, which indicates the presence of heterobeltiosis in hybrids. The highest significant positive heterosis over better parent was recorded by cross PMS232A × C43 (18.88). Nine crosses recorded significant positive heterosis over standard check CSH25. Significantly highest positive heterosis over standard check CSH25 was recorded by cross ICSA101 × KR125 (28.77) followed by cross PMS7A × AKR456 (27.75). Seven crosses showed significant positive heterosis over standard check SPH1641 among the fifty six crosses. Highest economic heterosis over this check recorded by cross ICSA101 × KR125 (23.32). Heterosis in desired direction (positively significant) was exhibited by eleven crosses over standard check CSH16 and significantly highest economic heterosis recorded by cross ICSA101 × KR125 (29.05). these results are in conformity with the results of Chalawadi (2007).

4) Test weight (gm)

The positive heterosis for this trait is of interest to the breeder as it results in increase of yield parameter. Heterosis in desired direction (positive significant) was exhibited by eleven crosses out of fifty six crosses. Highest positive heterosis over mid parent was recorded by cross PMS71A × AKR456 (24.92). For Test weight (gm), six crosses recorded heterobeltiosis in desired (positive and significant) direction over better parent. Highest significant positive heterobeltiosis over better parent was recorded by cross PMS71A × AKR456 (22.85)

Six crosses recorded significant positive economic heterosis over standard check CSH25. Significantly highest positive economic heterosis over standard check CSH25 was recorded by cross ICSA101 × KR125 (21.00) Ten crosses showed significant positive heterosis over standard check SPH1641 among the fifty six crosses. Highest economic heterosis over this check recorded by cross ICSA101 × KR125 (29.99) Heterosis in desired direction (positively significant) was exhibited by six crosses over standard check CSH16 and significantly highest economic heterosis recorded by cross ICSA101 × KR125 (22.57). similar results were reported by Umakanth *et al.* (2003) [14].

5) Harvest index (%)

The positive heterosis for this trait is of interest to the breeder as it results increase in yield. Significant heterosis in desired direction (positive significant) for harvest index was desirable for this trait. Twelve crosses recorded significant positive heterosis over mid parent. Highest positive heterosis over mid parent was recorded by cross PMS71A × KR191 (34.53) Six crosses recorded significant superior positive heterosis over better parent, which indicates the presence of heterobeltiosis in hybrids. The highest significant positive heterosis over better parent was recorded by cross PMS71A × KR191 (26.58) Nineteen crosses recorded significant positive heterosis over standard check CSH25. Significantly highest positive heterosis over standard check CSH25 was recorded by cross ICSA101 × KR125 (37.22) Twenty seven crosses showed significant positive heterosis over standard check SPH1641 among the fifty six crosses. Highest economic heterosis over this check recorded by cross ICSA101 × KR125 (47.92) followed by PMS71A × KR191 (47.64). Economic heterosis in desired direction (positively significant) was exhibited by twenty six crosses over standard check CSH16 and significantly highest economic heterosis recorded by cross ICSA101 × KR125 (43.63). Swarnalata Kaul *et al.* (2003) [13] reported similar results for harvest index.

6) Field grade score

The negative heterosis for this trait is of interest to the breeder as it results in less grain mould incidence. Fourteen crosses recorded significant negative standard heterosis over mid parent. Highest negative standard heterosis over mid parent was recorded by cross PMS98A × 9825REC (-32.61) followed by cross PMS71A × AKR456 (-30.82). Twenty crosses recorded negative heterosis over better parent. The highest significant negative heterosis over better parent was recorded by cross PMS71A × I26 (-40.04) followed by cross PMS98A × 9825REC (-38.81). Five crosses recorded significant negative heterosis over standard check CSH25. Significantly highest negative economic heterosis over standard check CSH25 was recorded by cross ICSA101 × KR125 (-34.34) followed by cross PMS71A × AKR456 (-33.44). Six crosses recorded significantly negative heterosis over standard check SPH1641. Highest economic heterosis over this check recorded by cross ICSA101 × KR125 (-36.80) followed by cross PMS71A × AKR456 (-35.94). Heterosis in desired direction (negatively significant) was exhibited by seven crosses out of fifty six crosses. Significantly highest negative heterosis over standard check CSH16 was recorded by cross ICSA101 × KR125 (-38.39) followed by cross PMS71A × AKR456 (-37.55). Similar results were obtained by Prabhakar (2002) [7], Umakanth *et al*. (2002) Murumkar (2002).

7) Threshed grade score

The negative heterosis for this trait is of interest to the breeder as it results in less grain mould incidence. Heterosis over mid parent in desired direction (negatively significant) was exhibited by twelve crosses. Highest significant negative standard heterosis over mid parent was recorded by cross PMS71A × I26 (-30.74) followed by cross ICSA101 × I26 (-25.58). For Threshed grade score, out of fifty six crosses twenty two crosses recorded heterobeltiosis in desired (negatively significant) direction over better parent. Highest significant negative heterobeltiosis over better parent was recorded by PMS71A × I26 (-45.81) followed by cross ICSA101 × I26 (-40.76). Four crosses recorded significant negative economic heterosis over standard check CSH25. Significantly highest negative economic heterosis over standard check CSH25 was recorded by cross PMS71A × AKR456 (-25.00) followed by cross PMS74A × AKR456 (-20.32). Six crosses showed significant negative economic heterosis over check SPH1641 among the fifty six crosses. Highest economic heterosis over this check recorded by PMS71A × AKR456 (-27.84) followed by PMS74A × AKR456 (-23.33). Heterosis in desired direction (negatively significant) was exhibited by ten crosses over standard check CSH16 and significantly highest negative economic heterosis recorded by cross PMS71A × AKR456 (-29.70) and followed by cross PMS74A × AKR456 (-25.31). Similar results were obtained by Prabhakar, (2002) [7], Umakanth *et al.* (2002) Murumkar (2002).

8) Germination (%)

The positive heterosis for this trait is of interest to the breeder as it results higher plant stand and yield. Standard heterosis in desired direction (positive significant) was exhibited by thirteen crosses out of fifty six crosses, Significant highest of them having highest positive standard heterosis over mid parent was exhibited by cross PMS232A × C43 (24.02), PMS71A × AKR456 (23.62) and followed by cross ICSA101 × KR125 (22.97). For Germination (%) eleven crosses recorded significantly superior positive heterosis over better parent indicating the presence of heterobeltiosis in hybrids. The highest significant positive heterosis over better parent was recorded by cross PMS232A × C43 (23.00), PMS71A × AKR456 (22.90) and followed by cross ICSA101 × KR125 (19.93).Nine crosses recorded significant positive heterosis over standard check CSH25. Significantly highest positive heterosis over standard check CSH25 was recorded by cross PMS71A × AKR456 (21.52), ICSA101 × KR125 (20.31) followed by cross PMS74A × AKR456 (17.88). Eleven crosses showed significant positive heterosis over standard check SPH1641 among the fifty six crosses. Highest economic heterosis over this check recorded by cross PMS71A × AKR456 (26.26), ICSA101 × KR125 (25.00) followed by cross PMS74A × AKR456 (22.49). Heterosis in desired direction (positively significant) was exhibited by eleven crosses over standard check CSH16 and significantly highest economic heterosis recorded by cross PMS71A × AKR456 (27.59), ICSA101 × KR125 (26.42) and followed by cross PMS74A × AKR456 (23.87). Similar results were obtained by Patil and Padule (2000), Bhongle (2000), Thorat (2003) Somani and Indira (2000).

Table 1: Percent heterosis over mid parent, better parent, and standard heterosis over checks

S. No.	Crosses	Grain Yield (gm)					Fodder Yield per plant (gm)				
		MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)	MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)
1.	PMS28A × I26	3.77	0.39	3.59	-4.81	5.54	-21.99**	-22.87 **	-27.62 **	-30.68 **	-27.46 **
2.	PMS28A × AKR456	5.15	0.58	6.27	-2.34	8.27	-15.74**	-21.84 **	-16.16 **	-19.71 **	-15.98 **
3.	PMS28A × KR191	-2.56	-3.91	-4.65	-12.38*	-2.85	-11.55**	-16.97 **	-13.19 **	-16.86 **	-13.00 *
4.	PMS28A × KR196	-7.99	-9.04	-12.24*	-19.36**	-10.59 *	1.99	-2.06	-2.40 **	-6.53	-2.19
5.	PMS28A × KR125	10.61 *	7.49	9.90	0.99	11.97 *	14.21**	6.10	13.43 **	8.63	13.68 **
6.	PMS28A × C43	3.04	2.64	-0.20	-8.30	1.67	-13.60**	-19.70 **	-14.23 **	-17.86 **	-14.04 **
7.	PMS28A × 9825REC	-42.80 **	-46.71**	-48.59 **	-52.76**	-47.62 **	-7.57	-11.63 *	-18.94 **	-22.37 **	-18.76 **
8.	PMS28A × ICSR196	-15.87 **	-25.75**	-28.37 **	-34.18**	-27.02 **	-34.33**	-38.92 **	-34.86 **	-37.62 **	-34.72 **
9.	PMS74A × I26	1.77	0.79	6.06	-2.54	8.06	-16.13**	-23.10 **	-13.46 **	-17.12 **	-13.27 **
10.	PMS74A × AKR456	19.74 **	19.49**	26.26 **	16.02**	28.63 **	15.78**	13.07 **	27.24 **	21.85 **	27.52 **

11.	PMS74A × KR191	1.14	-1.74	3.40	-4.98	5.35	-13.75**	-16.81 **	-6.37	-10.34 *	-6.17
12.	PMS74A × KR196	-36.19 **	-39.51**	-36.34 **	-41.50**	-35.14 **	-23.97**	-28.32 **	-19.33 **	-22.75 **	-19.16 **
13.	PMS74A × KR125	17.47 **	15.80**	21.86 **	11.98*	24.15 **	14.28**	11.42 *	25.39 **	20.08 **	25.66 **
14.	PMS74A × C43	-18.82 **	-21.91**	-17.82 **	-24.49**	-16.28 **	1.66	-0.93	11.49 *	6.77	11.74 *
15.	PMS74A × 9825REC	-18.18 **	-26.71**	-22.87 **	-29.13**	-21.42 **	-14.92**	-25.83 **	-16.53 **	-20.07 **	-16.35 **
16.	PMS74A × ICSR196	-45.13 **	-53.32**	-50.88 **	-54.86**	-49.95 **	-28.58**	-30.45 **	-21.74 **	-25.05 **	-21.56 **
17.	PMS71A × I26	13.85 **	10.21*	21.49 **	11.64*	23.77 **	14.07**	3.52	19.20 **	14.15 **	19.46 **
18.	PMS71A × AKR456	18.02 **	15.57**	27.39 **	17.07**	29.79 **	14.88**	10.95 *	27.75 **	22.34 **	28.03 **
19.	PMS71A × KR191	-30.69 **	-34.15**	-27.41 **	-33.30**	-26.05 **	-11.85**	-15.90 **	-3.16	-7.26	-2.95
20.	PMS71A × KR196	-0.46	-7.66	1.79	-6.47	3.70	5.13	-1.95	12.91 *	8.13	13.16 **
21.	PMS71A × KR125	-19.92 **	-22.82**	-14.93 **	-21.83**	-13.33 *	-25.95**	-28.60 **	-17.78 **	-21.27 **	-17.60 **
22.	PMS71A × C43	-24.74 **	-29.18**	-21.94 **	-28.27**	-20.47 **	-33.20**	-35.62 **	-25.86 **	-29.00 **	-25.70 **
23.	PMS71A × 9825REC	10.16 *	-3.30	6.59	-2.05	8.60	-16.27**	-27.71 **	-16.76 **	-20.29 **	-16.58 **
24.	PMS71A × ICSR196	-11.70 *	-26.29**	-18.75 **	-25.34**	-17.22 **	-18.77**	-21.77 **	-9.92 *	-13.73 **	-9.72
25.	PMS98A × I26	-39.01 **	-41.12**	-39.24 **	-44.17**	-38.10 **	-21.55**	-22.26 **	-27.05 **	-30.14 **	-26.89 **
26.	PMS98A × AKR456	1.34	-3.27	2.20	-6.08	4.13	-17.91**	-23.69 **	-18.15 **	-21.62 **	-17.97 **
27.	PMS98A × KR191	6.47	4.76	3.96	-4.47	5.92	-9.04*	-14.44 **	-10.55 *	-14.33 **	-10.35 *
28.	PMS98A × KR196	-49.51 **	-49.97**	-51.95 **	-55.84**	-51.04 **	-14.88**	-18.08 **	-18.37 **	-21.83 **	-18.19 **
29.	PMS98A × KR125	-29.52 **	-31.65**	-30.12 **	-35.79**	-28.81 **	-18.02**	-23.68 **	-18.41 **	-21.87 **	-18.23 **
30.	PMS98A × C43	6.40	5.76	2.83	-5.51	4.76	-14.33**	-20.21 **	-14.78 **	-18.39 **	-14.59 **
31.	PMS98A × 9825REC	-5.95	-12.19*	-15.67 **	-22.50**	-14.08 **	-1.49	-6.02	-13.41 **	-17.08 **	-13.22 **
32.	PMS98A × ICSR196	-38.80 **	-45.89**	-48.03 **	-52.24**	-47.05 **	-14.25**	-20.08 **	-14.77 **	-18.38 **	-14.58 **
33.	ICSA101 × I26	1.14	0.73	4.78	-3.72	6.75	-13.25**	-20.66 **	-10.22 *	-14.02 **	-10.02 *
34.	ICSA101 × AKR456	-5.24	-5.98	-0.66	-8.71	1.21	-20.33**	-22.41 **	-12.20 *	-15.92 **	-12.00 *
35.	ICSA101 × KR191	-27.80 **	-29.46**	-26.63 **	-32.58**	-25.25 **	-25.15**	-27.99 **	-18.51 **	-21.96 **	-18.33 **
36.	ICSA101 × KR196	8.53	3.45	7.61	-1.12	9.63	-17.46**	-22.39 **	-12.17 *	-15.89 **	-11.97 *
37.	ICSA101 × KR125	24.00 **	22.94**	27.87 **	17.51**	30.28 **	17.03**	13.79 **	28.77 **	23.32 **	29.05 **
38.	ICSA101 × C43	-26.10 **	-28.51**	-25.64 **	-31.66**	-24.24 **	-31.51**	-33.44 **	-24.68 **	-27.87 **	-24.51 **
39.	ICSA101 × 9825REC	-21.51 **	-29.33**	-26.49 **	-32.45**	-25.10 **	-14.30**	-25.47 **	-15.66 **	-19.23 **	-15.47 **
40.	ICSA101 × ICSR196	-23.54 **	-34.64**	-32.02 **	-37.53**	-30.74 **	-30.34**	-32.35 **	-23.44 **	-26.68 **	-23.27 **
41.	PMS42A × I26	-9.05 *	-10.94*	-8.10	-15.55**	-6.37	-4.56	-5.79	-9.25	-13.09 **	-9.05
42.	PMS42A × AKR456	-55.66 **	-57.08**	-54.65 **	-58.32**	-53.79 **	-20.43**	-24.48 **	-19.00 **	-22.43 **	-18.82 **
43.	PMS42A × KR191	14.18 **	13.99**	13.12 *	3.94	15.25 **	18.25**	13.60 **	18.77 **	13.74 **	19.04 **
44.	PMS42A × KR196	-5.57	-7.77	-8.79	-16.18**	-7.07	-7.73	-9.26	-9.58	-13.41 **	-9.38
45.	PMS42A × KR125	19.40 **	17.45**	20.08 **	10.35*	22.34 **	23.58**	17.47 **	25.58 **	20.26 **	25.85 **
46.	PMS42A × C43	-33.43 **	-33.99**	-34.72 **	-40.01**	-33.49 **	-21.96**	-25.79 **	-20.73 **	-24.09 **	-20.56 **
47.	PMS42A × 9825REC	-6.09	-13.50*	-14.45 **	-21.38**	-12.84 *	-1.54	-8.01	-11.39 *	-15.14 **	-11.19 *
48.	PMS42A × ICSR196	-13.26 *	-24.27**	-25.10 **	-31.17**	-23.69 **	-22.21**	-25.97 **	-21.05 *	-24.39 **	-20.88 **
49.	PMS232A × I26	2.54	1.67	4.91	-3.59	6.89	2.62	0.01	-1.12	-5.31	-0.90
50.	PMS232A × AKR456	3.28	1.21	6.94	-1.73	8.95	5.36	1.24	8.59	3.99	8.83
51.	PMS232A × KR191	-50.85 **	-51.38**	-50.68 **	-54.68**	-49.76 **	-1.68	-4.36	0.00	-4.24	0.22
52.	PMS232A × KR196	-20.20 **	-23.01**	-21.91 **	-28.24**	-20.44 **	-20.84**	-21.15 **	-21.43 **	-24.76 **	-21.25 **
53.	PMS232A × KR125	1.20	0.80	3.06	-5.30	5.00	-7.24	-10.73 *	-4.56	-8.61	-4.35
54.	PMS232A × C43	26.48 **	23.86**	25.64 **	15.45**	28.00 **	23.47**	18.88 **	26.97 **	21.59 **	27.25 **
55.	PMS232A × 9825REC	-19.21 **	-26.43**	-25.38 **	-31.43**	-23.97 **	-13.33**	-19.99 **	-20.89 **	-24.25 **	-20.72 **
56.	PMS232A × ICSR196	-36.17 **	-44.86**	-44.07 **	-48.61**	-43.02 **	-11.22**	-14.45 **	-8.77	-12.63 **	-8.57

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

Table 2: Percent heterosis over mid parent, better parent, and standard heterosis over checks

S. No.	Crosses	Test Weight (gm)					Harvest Index (%)				
		MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)	MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)
1.	PMS28A × I26	14.00 **	6.26	2.18	9.77 *	3.50	-0.38	-1.98	-1.20	6.50	3.42
2.	PMS28A × AKR456	1.19	0.79	-2.30	4.95	-1.04	-3.94	-10.09	3.93	12.04	8.79
3.	PMS28A × KR191	-1.65	-5.95	-0.90	6.46	0.39	8.19	5.30	6.13	14.41	11.10
4.	PMS28A × KR196	8.52	-2.53	-6.27	0.69	-5.06	-7.89	-10.12	-4.79	2.63	-0.34
5.	PMS28A × KR125	-1.69	-4.06	-3.07	4.13	-1.82	-11.92 *	-18.66**	-3.21	4.33	1.31
6.	PMS28A × C43	-5.71	-6.99	-8.07	-1.24	-6.87	-11.45	-16.86**	-4.54	2.91	-0.07
7.	PMS28A × 9825REC	-10.92 **	-11.45*	-13.83 **	-7.43	-12.71**	-7.71	-9.48	-5.12	2.28	-0.68
8.	PMS28A × ICSR196	6.46	2.00	-1.92	5.36	-0.65	9.41	7.81	11.94	20.67**	17.18*
9.	PMS74A × I26	11.96 **	5.14	-0.51	6.88	0.78	13.28 *	6.07	18.57 *	27.82**	24.12**
10.	PMS74A × AKR456	23.13 **	21.66**	17.93 **	26.69 **	19.46**	14.37 *	12.49*	30.03 **	40.17**	36.12**
11.	PMS74A × KR191	4.61	-0.73	4.61	12.38 **	5.97	13.11 *	4.83	17.18 *	26.32**	22.66**
12.	PMS74A × KR196	14.58 **	3.65	-1.92	5.36	-0.65	8.09	5.26	17.66 *	26.84**	23.17**
13.	PMS74A × KR125	17.80 **	14.07**	15.24 **	23.80 **	16.73**	6.37	3.15	22.73 **	32.30**	28.47**
14.	PMS74A × C43	-0.99	-3.11	-4.23	2.89	-2.98	12.72 *	11.22	27.71 **	37.67**	33.69**
15.	PMS74A × 9825REC	-0.20	-1.58	-4.23	2.89	-2.98	-4.84	-7.81	3.06	11.09	7.88
16.	PMS74A × ICSR196	-1.89	-5.28	-10.37 *	-3.71	-9.21*	10.37	6.44	18.99 **	28.26**	24.55**

17.	PMS71A × I26	23.82 **	16.80**	9.48 *	17.61 **	10.89*	24.64 **	18.52**	28.23 **	38.23**	34.23**
18.	PMS71A × AKR456	24.92 **	22.85**	19.08 **	27.92 **	20.62**	4.61	1.26	17.06 *	26.19**	22.54**
19.	PMS71A × KR191	-7.27	-12.39**	-7.68	-0.83	-6.49	34.53 **	26.58**	36.96 **	47.64**	43.36**
20.	PMS71A × KR196	6.62	-3.14	-9.22 *	-2.48	-8.04	-3.93	-4.94	2.85	10.87	7.66
21.	PMS71A × KR125	-0.07	-3.68	-2.69	4.54	-1.43	-1.23	-5.70	12.20	20.95**	17.45*
22.	PMS71A × C43	1.46	-1.17	-2.30	4.95	-1.04	-6.63	-9.32	4.12	12.24	8.99
23.	PMS71A × 9825REC	-1.47	-3.29	-5.89	1.10	-4.67	-18.24 **	-19.52**	-12.92	-6.13	-8.85
24.	PMS71A × ICSR196	0.28	-2.73	-8.83 *	-2.06	-7.65	-4.88	-6.80	0.84	8.71	5.56
25.	PMS98A × I26	-10.79 **	-24.16**	-9.99 *	-3.30	-8.82*	-10.47	-12.33	-14.47 *	-7.80	-10.47
26.	PMS98A × AKR456	-11.64 **	-19.74**	-4.74	2.34	-3.50	13.61 *	2.75	18.78 *	28.04**	24.33**
27.	PMS98A × KR191	-14.97 **	-19.74**	-4.74	2.34	-3.50	22.20 **	20.98**	15.43 *	24.43**	20.83**
28.	PMS98A × KR196	-5.84	-22.55**	-8.07	-1.24	-6.87	-17.26 **	-22.11**	-17.49 *	-11.06	-13.63
29.	PMS98A × KR125	-19.81 **	-25.78**	-11.91 **	-5.36	-10.77*	-7.45	-17.36**	-1.67	6.00	2.93
30.	PMS98A × C43	-10.89 **	-18.34**	-3.07	4.13	-1.82	-16.59 **	-24.33**	-13.11	-6.33	-9.05
31.	PMS98A × 9825REC	-17.72 **	-25.13**	-11.14	-4.54	-9.99*	-24.26 **	-28.34**	-24.90 **	-19.04*	-21.38**
32.	PMS98A × ICSR196	-14.80 **	-25.78**	-11.91 **	-5.36	-10.77*	18.50 **	12.61	16.92 *	26.04**	22.39**
33.	ICSA101 × I26	-5.32	-12.24**	-14.60 **	-8.25	-13.49**	-9.06	-17.40**	-1.31	6.39	3.31
34.	ICSA101 × AKR456	-1.91	-2.11	-4.74	2.34	-3.50	-3.98	-5.54	12.87	21.67**	18.15*
35.	ICSA101 × KR191	-5.50	-9.11*	-4.23	2.89	-2.98	14.18 *	2.67	22.68 **	32.25**	28.42**
36.	ICSA101 × KR196	14.43 **	2.24	-0.51	6.88	0.78	-19.69 **	-24.25**	-9.48	-2.43	-5.25
37.	ICSA101 × KR125	22.01 **	19.77**	21.00 **	29.99 **	22.57**	15.08 **	14.84*	37.22 **	47.92**	43.63**
38.	ICSA101 × C43	-7.05	-7.77	-8.83 *	-2.06	-7.65	-2.56	-4.46	14.16	23.06**	19.50*
39.	ICSA101 × 9825REC	2.24	2.24	-0.51	6.88	0.78	-8.20	-13.83*	2.96	10.98	7.77
40.	ICSA101 × ICSR196	-0.14	-4.87	-7.43	-0.55	-6.23	-7.52	-13.57*	3.26	11.32	8.09
41.	PMS42A × I26	13.31 **	8.96	-1.92	5.36	-0.65	2.90	0.35	3.01	11.04	7.82
42.	PMS42A × AKR456	-2.05	-5.55	-8.45	-1.65	-7.26	7.76	1.72	17.59 *	26.76**	23.09**
43.	PMS42A × KR191	4.98	-2.67	2.56	10.18 *	3.89	26.94 **	22.46**	25.70 **	35.51**	31.58**
44.	PMS42A × KR196	5.76	-2.13	-11.91 **	-5.36	-10.77*	1.39	-0.18	5.74	13.98	10.68
45.	PMS42A × KR125	6.17	0.38	1.41	8.94	2.72	4.18	-2.97	15.45 *	24.45**	20.85**
46.	PMS42A × C43	-0.75	-5.18	-6.27	0.69	-5.06	-3.14	-8.27	5.33	13.54	10.25
47.	PMS42A × 9825REC	-1.85	-5.53	-8.07	-1.24	-6.87	-8.78	-9.72	-5.38	2.00	-0.95
48.	PMS42A × ICSR196	-10.28 *	-11.24*	-20.10 **	-14.17 **	-19.07**	1.91	1.32	5.21	13.41	10.13
49.	PMS232A × I26	11.09	4.93	-1.92	5.36	-0.65	7.70	4.78	8.09	16.52*	13.15
50.	PMS232A × AKR456	7.73	5.81	2.56	10.18 *	3.89	-4.10	-9.26	4.90	13.08	9.80
51.	PMS232A × KR191	-9.47 *	-14.58**	-9.99 *	-3.30	-8.82*	0.13	-3.63	-0.58	7.17	4.06
52.	PMS232A × KR196	8.13	-1.64	-8.07	-1.24	-6.87	8.01	6.60	12.92	21.73**	18.20*
53.	PMS232A × KR125	4.28	0.38	1.41	8.94	2.72	1.57	-5.18	12.82	21.62**	18.09*
54.	PMS232A × C43	20.64 **	17.36**	16.01 **	24.62 **	17.51**	15.24 **	9.38	25.60 **	35.40**	31.47**
55.	PMS232A × 9825REC	-3.62	-5.53	-8.07	-1.24	-6.87	6.16	5.33	10.40	19.00*	15.56*
56.	PMS232A × ICSR196	5.92	2.88	-3.84	3.30	-2.59	-6.17	-6.47	-2.89	4.69	1.65

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

Table 3: Percent heterosis over mid parent, better parent, and standard heterosis over checks

S. No.	Crosses	Field Grade Score					Threshed Grade Score				
		MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)	MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)
1.	PMS28A × I26	-5.02	-15.60 **	26.64**	21.89**	18.83**	-7.40	-29.62 **	18.81 *	14.32 *	11.36
2.	PMS28A × AKR456	6.88	-2.77	13.38	9.12	6.38	40.86 **	31.60 **	33.03 **	28.00 **	24.69 **
3.	PMS28A × KR191	-13.54 *	-14.24 *	0.00	-3.76	-6.17	28.52 **	15.38 *	27.34 **	22.53 **	19.36 **
4.	PMS28A × KR196	6.69	0.00	33.33**	28.33**	25.10**	17.63 **	-3.65	32.53 **	27.51 **	24.22 **
5.	PMS28A × KR125	-13.49 *	-24.00 **	-11.37	-14.70*	-16.84*	-3.06	-5.52	-12.63	-15.93 *	-18.10 **
6.	PMS28A × C43	13.83 *	8.60	26.64**	21.89**	18.83**	7.75	2.22	0.00	-3.78	-6.27
7.	PMS28A × 9825REC	33.36 **	25.00 **	66.67**	60.41**	56.38**	17.49 **	0.00	25.00 **	20.27 **	17.16 *
8.	PMS28A × ICSR196	77.36**	71.51 **	100.00**	92.49**	87.66**	54.18 **	38.60 **	52.51 **	46.74 **	42.95 **
9.	PMS74A × I26	-12.52*	-28.90 **	6.69	2.68	0.10	-22.92 **	-37.79 **	5.02	1.05	-1.57
10.	PMS74A × AKR456	-16.77*	-17.50 *	-21.18**	-24.14**	-26.05**	-22.17 **	-23.15 **	-20.32 **	-23.33 **	-25.31 **
11.	PMS74A × KR191	**27.85****	16.23 *	33.33**	28.33**	25.10**	**23.83** **	20.08 **	32.53 **	27.51 **	24.22 **
12.	PMS74A × KR196	-0.20	-14.97 **	13.38	9.12	6.38	-10.85 *	-21.82 **	7.53	3.46	0.78
13.	PMS74A × KR125	-12.36	-14.96	-20.18**	-23.18**	-25.10**	-7.84	-12.82	-9.62	-13.03	-15.28 *
14.	PMS74A × C43	26.79**	19.58 **	26.64**	21.89**	18.83**	24.07 **	20.56 **	25.00 **	20.27 **	17.16 *
15.	PMS74A × 9825REC	52.60**	30.02 **	73.36**	66.85**	62.66**	20.29 **	10.03	37.54 **	32.34 **	28.92 **
16.	PMS74A × ICSR196	57.78**	46.88 **	59.98**	53.97**	50.10**	16.98 **	13.60 *	25.00 **	20.27 **	17.16 *
17.	PMS71A × I26	-27.13**	-40.04 **	-10.03	-13.41	-15.59*	-30.74 **	-45.81 **	-8.53	-11.99	-14.26 *
18.	PMS71A × AKR456	-30.82**	-31.30 **	-33.44**	-35.94**	-37.55**	-23.63 **	-25.81 **	-25.00 **	-27.84 **	-29.70 **
19.	PMS71A × KR191	64.17**	51.41 **	73.69**	67.17**	62.97**	33.74 **	24.62 **	37.54 **	32.34 **	28.92 **
20.	PMS71A × KR196	-13.12*	-25.00 **	0.00	-3.76	-6.17	-0.75	-15.99 **	15.55 *	11.18	8.31
21.	PMS71A × KR125	79.29**	71.35 **	66.00**	59.76**	55.75**	59.75 **	57.37 **	50.00	44.33 **	40.60 **
22.	PMS71A × C43	-1.37	-5.58	0.00	-3.76	-6.17	16.54 *	15.04 *	12.54	8.29	5.49

23.	PMS71A × 9825REC	21.65**	5.02	40.02**	34.76**	31.38**	7.86	-4.95	18.81 *	14.32 *	11.36
24.	PMS71A × ICSR196	66.09**	56.91 **	70.90**	64.48**	60.36**	36.32 **	27.20 **	39.97 **	34.67 **	31.19 **
25.	PMS98A × I26	-25.53**	-28.58 **	16.72*	12.34	9.52	-15.94 **	-23.72 **	28.76 **	23.89 **	20.69 **
26.	PMS98A × AKR456	18.38**	-6.21	53.29**	47.53**	43.83**	8.62	-5.78	29.60 **	24.70 **	21.47 **
27.	PMS98A × KR191	-18.48**	-30.63 **	13.38	9.12	6.38	-9.21	-18.18 **	12.54	8.29	5.49
28.	PMS98A × KR196	-19.76**	-27.15 **	19.06*	14.59*	11.72	-23.28 **	-23.28 **	5.52	1.53	-1.10
29.	PMS98A × KR125	11.25*	-14.32 **	40.02**	34.76**	31.38**	-2.14	-18.18 **	12.54	8.29	5.49
30.	PMS98A × C43	-3.39	-20.40 **	30.10**	25.21**	22.07**	1.95	-12.77 *	19.98 **	15.45 *	12.46
31.	PMS98A × 9825REC	-32.61**	-38.81 **	0.00	-3.76	-6.17	-0.96	-5.47	30.02 **	25.10 **	21.87 **
32.	PMS98A × ICSR196	41.96**	18.28 **	93.31**	86.05**	81.38**	17.12 **	5.41	44.98 **	39.50 **	35.89 **
33.	ICSA101 × I26	-2.92	-22.21 **	16.72*	12.34	9.52	-25.58 **	-40.76 **	0.00	-3.78	-6.27
34.	ICSA101 × AKR456	93.65**	88.45 **	80.04**	73.28**	68.93**	49.25 **	48.39 **	50.00 **	44.33 **	40.60 **
35.	ICSA101 × KR191	38.70**	24.00 **	42.25**	36.91**	33.47**	15.47 *	10.00	21.40 **	16.81 *	13.79 *
36.	ICSA101 × KR196	19.18**	0.00	33.33**	28.33**	25.10**	-11.13 *	-23.28 **	5.52	1.53	-1.10
37.	ICSA101 × KR125	-26.51**	-27.37 **	-34.34**	-36.80**	-38.39**	-13.34 *	-16.57 *	-16.64 *	-19.79 **	-21.87 **
38.	ICSA101 × C43	96.93**	82.53 **	93.31**	86.05**	81.38**	37.08 **	35.65 **	35.54 **	30.41 **	27.04 **
39.	ICSA101 × 9825REC	13.20*	-5.02	26.64**	21.89**	18.83**	-6.17	-15.59 **	5.52	1.53	-1.10
40.	ICSA101 × ICSR196	100.67**	83.62 **	100.00**	92.49**	87.66**	51.73 **	44.76 **	59.28 **	53.26 **	49.29 **
41.	PMS42A × I26	2.19	-13.30 **	30.10**	25.21**	22.07**	-9.47 *	-26.10 **	24.75 **	20.03 **	16.93 *
42.	PMS42A × AKR456	126.52**	116.74 **	126.64**	118.13**	112.66**	41.51 **	37.74 **	47.07 **	41.51 **	37.85 **
43.	PMS42A × KR191	-20.69**	-24.20 **	-13.04	-16.31*	-18.41**	-19.45 **	-20.76 **	-12.54	-15.85 *	-18.03 **
44.	PMS42A × KR196	96.16**	75.00 **	133.33**	124.57**	118.93**	50.31 **	33.50 **	83.61 **	76.67 **	72.10 **
45.	PMS42A × KR125	-6.36	-13.65	-9.70	-13.09	-15.27*	-7.93	-14.10 *	-8.28	-11.75	-14.03 *
46.	PMS42A × C43	26.69**	25.89 **	33.33**	28.33**	25.10**	29.87 **	24.43 **	32.86 **	27.84 **	24.53 **
47.	PMS42A × 9825REC	62.51**	44.98 **	93.31**	86.05**	81.38**	26.05 **	16.86 **	46.07 **	40.55 **	36.91 **
48.	PMS42A × ICSR196	56.14**	53.02 **	66.67**	60.41**	56.38**	29.81 **	27.89 **	40.72 **	35.40 **	31.90 **
49.	PMS232A × I26	54.34**	28.83 **	93.31**	86.05**	81.38**	4.80	-17.24 **	39.72 **	34.43 **	30.96 **
50.	PMS232A × AKR456	7.74	5.11	5.57	1.61	-0.94	-11.98	-13.40	-12.46	-15.77 *	-17.95 **
51.	PMS232A × KR191	72.64**	61.90 **	85.73**	78.76**	74.27**	55.90 **	47.05 **	62.29 **	56.15 **	52.12 **
52.	PMS232A × KR196	128.14**	100.00 **	166.67**	156.65**	150.21**	56.59 **	33.98 **	84.28 **	77.31 **	72.73 **
53.	PMS232A × KR125	76.61**	65.93 **	66.67**	60.41**	56.38**	39.46 **	35.64 **	32.69 **	27.67 **	24.37 **
54.	PMS232A × C43	-22.64**	-24.63 **	-20.18**	-23.18**	-25.10**	-16.75 *	-16.75 *	-18.56 *	-21.64 **	-23.67 **
55.	PMS232A × 9825REC	25.51**	10.03	46.71**	41.20**	37.66**	-9.04	-18.93 **	1.34	-2.49	-5.02
56.	PMS232A × ICSR196	27.37**	22.42 **	33.33**	28.33**	25.10**	16.01 **	9.57	20.57 **	16.01 *	13.01

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

Table 4: Percent heterosis over mid parent, better parent, and standard heterosis over checks

S. No.	Crosses	Yield					Germination (%)				
		MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)	MP	BP	SH1 (CSH25)	SH2 (SPH1641)	SH3 (CSH16)
1.	PMS28A × I26	3.77	0.39	3.59	-4.81	5.54	0.62	-1.09	-3.09	0.69	1.83
2.	PMS28A × AKR456	5.15	0.58	6.27	-2.34	8.27	-16.69**	-16.80 **	-18.49 **	-15.30 **	-14.35 **
3.	PMS28A × KR191	-2.56	-3.91	-4.65	-12.38*	-2.85	4.41	1.92	-0.14	3.76	4.93
4.	PMS28A × KR196	-7.99	-9.04	-12.24*	-19.36**	-10.59 *	-3.96	-11.78 *	-13.56 **	-10.19 *	-9.17
5.	PMS28A × KR125	10.61 *	7.49	9.90	0.99	11.97 *	9.61*	8.33	8.67	12.91 **	14.19 **
6.	PMS28A × C43	3.04	2.64	-0.20	-8.30	1.67	-1.24	-3.36	-5.32	-1.62	-0.51
7.	PMS28A × 9825REC	-42.80 **	-46.71**	-48.59 **	-52.76**	-47.62 **	-15.12**	-16.59 **	-18.28 **	-15.09 **	-14.13 **
8.	PMS28A × ICSR196	-15.87 **	-25.75**	-28.37 **	-34.18**	-27.02 **	-33.71**	-34.85 **	-36.16 **	-33.67 **	-32.92 **
9.	PMS74A × I26	1.77	0.79	6.06	-2.54	8.06	1.54	0.18	-2.57	1.23	2.37
10.	PMS74A × AKR456	19.74 **	19.49**	26.26 **	16.02**	28.63 **	20.93**	20.64 **	17.88 **	22.49 **	23.87 **
11.	PMS74A × KR191	1.14	-1.74	3.40	-4.98	5.35	-11.81**	-13.61 **	-15.98 **	-12.70 **	-11.71 *
12.	PMS74A × KR196	-36.19 **	-39.51**	-36.34 **	-41.50**	-35.14 **	5.45	-2.80	-5.47	-1.78	-0.67
13.	PMS74A × KR125	17.47 **	15.80**	21.86 **	11.98*	24.15 **	16.86**	15.08 **	15.43 **	19.94 **	21.30 **
14.	PMS74A × C43	-18.82 **	-21.91**	-17.82 **	-24.49**	-16.28 **	-13.47**	-15.02 **	-17.35 **	-14.13 **	-13.16 **
15.	PMS74A × 9825REC	-18.18 **	-26.71**	-22.87 **	-29.13**	-21.42 **	-16.91**	-18.05 **	-20.31 **	-17.19 **	-16.26 **
16.	PMS74A × ICSR196	-45.13 **	-53.32**	-50.88 **	-54.86**	-49.95 **	-8.50*	-9.74 *	-12.22 **	-8.79	-7.76
17.	PMS71A × I26	13.85 **	10.21*	21.49 **	11.64*	23.77 **	13.40**	10.98 *	9.73 *	14.02 **	15.30 **
18.	PMS71A × AKR456	18.02 **	15.57**	27.39 **	17.07**	29.79 **	23.62**	22.90 **	21.52 **	26.26 **	27.69 **
19.	PMS71A × KR191	-30.69 **	-34.15**	-27.41 **	-33.30**	-26.05 **	-9.78	-12.33 **	-13.31 **	-9.93 *	-8.91
20.	PMS71A × KR196	-0.46	-7.66	1.79	-6.47	3.70	5.36	-3.61	-4.69	-0.97	0.15
21.	PMS71A × KR125	-19.92 **	-22.82**	-14.93 **	-21.83**	-13.33 *	-31.35**	-31.84 **	-31.62 **	-28.95 **	-28.15 **
22.	PMS71A × C43	-24.74 **	-29.18**	-21.94 **	-28.27**	-20.47 **	-6.75	-9.16 *	-10.18 *	-6.67	-5.61
23.	PMS71A × 9825REC	10.16 *	-3.30	6.59	-2.05	8.60	-8.52*	-10.51 *	-11.51 *	-8.06	-7.02
24.	PMS71A × ICSR196	-11.70 *	-26.29**	-18.75 **	-25.34**	-17.22 **	-17.82**	-19.59 **	-20.49 **	-17.38 **	-16.45 **
25.	PMS98A × I26	-39.01 **	-41.12**	-39.24 **	-44.17**	-38.10 **	11.57**	10.96 *	5.03	9.13	10.36 *
26.	PMS98A × AKR456	1.34	-3.27	2.20	-6.08	4.13	1.19	-0.93	-3.20	0.58	1.72
27.	PMS98A × KR191	6.47	4.76	3.96	-4.47	5.92	-15.72**	-15.86 **	-21.23 **	-18.15 **	-17.23 **
28.	PMS98A × KR196	-49.51 **	-49.97**	-51.95 **	-55.84**	-51.04 **	14.50**	7.41	0.56	4.49	5.67

29.	PMS98A × KR125	-29.52 **	-31.65**	-30.12 **	-35.79**	-28.81 **	-8.79	-11.83 *	-11.56 *	-8.11	-7.07
30.	PMS98A × C43	6.40	5.76	2.83	-5.51	4.76	-4.05	-4.12	-10.10 *	-6.59	-5.53
31.	PMS98A × 9825REC	-5.95	-12.19*	-15.67 **	-22.50**	-14.08 **	-11.54**	-11.99	-16.76 **	-13.51 **	-12.53 **
32.	PMS98A × ICSR196	-38.80 **	-45.89**	-48.03 **	-52.24**	-47.05 **	-15.14**	-15.59 **	-20.13 **	-17.01 **	-16.08 **
33.	ICSA101 × I26	1.14	0.73	4.78	-3.72	6.75	11.29**	10.88 *	5.73	9.86 *	11.10 *
34.	ICSA101 × AKR456	-5.24	-5.98	-0.66	-8.71	1.21	-29.88**	-30.73 **	-32.31 **	-29.67 **	-28.87 **
35.	ICSA101 × KR191	-27.80 **	-29.46**	-26.63 **	-32.58**	-25.25 **	-13.35**	-14.28 **	-18.27 **	-15.07 **	-14.11 **
36.	ICSA101 × KR196	8.53	3.45	7.61	-1.12	9.63	-1.73	-8.60	-12.84 **	-9.44 *	-8.42
37.	ICSA101 × KR125	24.00 **	22.94**	27.87 **	17.51**	30.28 **	22.97**	19.93 **	20.31 **	25.00 **	26.42 **
38.	ICSA101 × C43	-26.10 **	-28.51**	-25.64 **	-31.66**	-24.24 **	0.82	-0.02	-4.66	-0.94	0.18
39.	ICSA101 × 9825REC	-21.51 **	-29.33**	-26.49 **	-32.45**	-25.10 **	-7.56	-7.94	-12.22 **	-8.79	-7.76
40.	ICSA101 × ICSR196	-23.54 **	-34.64**	-32.02 **	-37.53**	-30.74 **	-39.93**	-40.16 **	-42.94 **	-40.71 **	-40.04 **
41.	PMS42A × I26	-9.05 *	-10.94*	-8.10	-15.55**	-6.37	-16.69**	-18.21 **	-19.66 **	-16.52 **	-15.58 **
42.	PMS42A × AKR456	-55.66 **	-57.08**	-54.65 **	-58.32**	-53.79 **	-43.73**	-43.87 **	-44.87 **	-42.71 **	-42.07 **
43.	PMS42A × KR191	14.18 **	13.99**	13.12 *	3.94	15.25 **	17.38**	14.44 **	12.41 **	16.80 **	18.12 **
44.	PMS42A × KR196	-5.57	-7.77	-8.79	-16.18**	-7.07	-38.59**	-43.65 **	-44.65 **	-42.49 **	-41.84 **
45.	PMS42A × KR125	19.40 **	17.45**	20.08 **	10.35*	22.34 **	10.82**	9.67 *	10.01 *	14.31 **	15.60 **
46.	PMS42A × C43	-33.43 **	-33.99**	-34.72 **	-40.01**	-33.49 **	-9.94*	-11.99 *	-13.55 **	-10.17	-9.16
47.	PMS42A × 9825REC	-6.09	-13.50*	-14.45 **	-21.38**	-12.84 *	-27.93**	-29.27 **	-30.52 **	-27.81 **	-26.99 **
48.	PMS42A × ICSR196	-13.26 *	-24.27**	-25.10 **	-31.17**	-23.69 **	-23.43**	-24.83 **	-26.17 **	-23.28 **	-22.42 **
49.	PMS232A × I26	2.54	1.67	4.91	-3.59	6.89	-20.53**	-20.82 **	-24.50 **	-21.56 **	-20.67 **
50.	PMS232A × AKR456	3.28	1.21	6.94	-1.73	8.95	13.32**	11.95 *	9.39 *	13.66 **	14.95 **
51.	PMS232A × KR191	-50.85 **	-51.38**	-50.68 **	-54.68**	-49.76 **	-21.79**	-22.63 **	-26.23 **	-23.35 **	-22.49 **
52.	PMS232A × KR196	-20.20 **	-23.01**	-21.91 **	-28.24**	-20.44 **	-39.62**	-43.84 **	-46.45 **	-44.36 **	-43.73 **
53.	PMS232A × KR125	1.20	0.80	3.06	-5.30	5.00	-32.41**	-34.08 **	-33.88 **	-31.30 **	-30.52 **
54.	PMS232A × C43	26.48 **	23.86**	25.64 **	15.45**	28.00 **	24.02**	23.00 **	17.27 **	21.85 **	23.23 **
55.	PMS232A × 9825REC	-19.21 **	-26.43**	-25.38 **	-31.43**	-23.97 **	-9.70*	-10.06 *	-14.25 **	-10.90 *	-9.89 *
56.	PMS232A × ICSR196	-36.17 **	-44.86**	-44.07 **	-48.61**	-43.02 **	-13.35**	-13.68 **	-17.70 **	-14.48	-13.52 **

Summery and Conclusion

In general, crosses (hybrids) were early in maturity and high yielding compared to the parents, which is desirable and may be exploited for development of high yielding hybrids. The parent ICSA101, KR125, PMS71A, AKR456, PMS74A, PMS232A and C43 recorded significant higher Grain yield (gm), Fodder yield per plant (gm), Field grade score, Threshed grade score, and Germination (%).

Amongst the hybrids ICSA101 × KR125, PMS71A × AKR456, PMS74A × AKR456 and PMS232A × C43 exhibited significantly higher Grain yield (gm), Fodder yield per plant (gm), Field grade score, Threshed grade score, and Germination (%).Out of fifty six crosses, ICSA101 × KR125 (47.97 gm) and PMS71A × AKR456 (47.79 gm) exhibited significant highest grain yield followed by cross PMS74A × AKR456 (47.36 gm) and PMS232A × C43 (46.13 gm). Similar is the trend in yield contributing characters. These crosses also recorded significantly less grain mould attack.

Crosses ICSA101 × KR125 (30.28), PMS71A × AKR456 (29.79), PMS74A × AKR456 (28.63), PMS232A × C43 (28.00) and PMS74A × KR125 (24.15) recorded significantly higher heterosis over standard checks for grain yield per plant. Similar trend followed in yield contributing characters and germination percentage. Highest significant negative heterobeltiosis over standard check SPH1641 was recorded by PMS74A × I26 (-37.79), ICSA101 × KR125 (-36.80) and PMS71A × AKR456 (35.94) for threshed grade score and grain mould related characters. The crosses ICSA101 × KR125, PMS71A × AKR456, PMS74A × AKR456 and PMS232A × C43 were found as best specific combiner for yield per plant and other yield contributing characters and exhibited highest positive significant heterosis over better parents and standard checks.

References

1. Anonymous. Economic survey 2014-15. Directorate of Economics and Statistics. Department of Agriculture and Cooperation, Government of India, 2014.
2. Anonymous. Economic survey of Maharashtra 2015-16. Directorate of Economics and Statistics. Planning Department, Government of Maharashtra, 2015.
3. Chaudhary SB, Narkhede BN. Line × tester analysis in rabi sorghum hybrids. Journal of Soils and crops. 2004; 14(1):209-210.
4. Fonseca S, Patterson P. Hybrid vigor in a seven parent diallel crosses in common winter wheat. Crop Science, 1968; 8:85-88.
5. Kempthrone O. An introduction to genetic statistics, 1957.
6. Mohammed MI. Line × tester analysis across locations and years in sudanese × exotic lines of forage sorghum. Journal of Plant Breeding and Crop Science. 2009; 1(9):311-319.
7. Prabhakar B. Combining ability studies in rabi sorghum (*Sorghum bicolor* (L.) Moench). Annals of Agricultural Research. 2002; 23(3):500-502.
8. Prakash R, Ganesamurthy K, Nirmalakumari A, Nagarajan P. Combining ability for fodder yield and its components in Sorghum (*Sorghum bicolor* L.). Electronic Journal of Plant Breeding. 2010; 1(2):124-128.
9. Prakash R, Ganesamurthy K, Nirmalakumari A, Nagarajan P. Combining ability for fodder yield and its components in Sorghum (*Sorghum bicolor* L.). Electronic Journal of Plant Breeding. 2010; 1(2):124-128.
10. Premalatha N, Kumaravadivel N, Veerabadhiran P. Heterosis and combining ability for grain yield and its components in sorghum [*Sorghum bicolor* (L.) Moench]. Indian Journal of Genetics. 2006; 66(2):123-126.
11. Rafiq SM, Thete RY, Madhusudhana R, Umakanth AV. Combining ability studies for grain yield and its components in post rainy season sorghum grown in medium deep and shallow soil. International Sorghum and Millets News Letter. 2002; 43:33-37.
12. Sprague CF, Tatum LA. General and specific combining ability effects in single crosses of corn. Journal of Agronomy. 1942; 34:923-932.

13. Swarnalata K, Rafiq KS, Singh K. Heterobeltiosis and combining ability for grain yield components in post rainy season sorghum. International Sorghum and Millets News Letter. 2003; 44:21-23.
14. Umakanth AV, Madhusudan R, Latha KM, Swarnalata K, Rana BS. Heterosis studies for yield and its component in rabi sorghum (*Sorghum bicolor* (L.) Moench). Indian Journal of Genetetics. 2003; 63(2):159-161.
15. Vavilov NI. The origin, variation, immunity and breeding of cultivated, 1935.