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National Academy of Agricultural Science (NAAS) Rating : 3.03

Heterosis for yield, its components and oil content in sunflower (*Helianthus annuus* L.).

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Abstract: *Fifty hybrids were tested using line x tester design involving five cytoplasmic male sterile lines and ten fertility restorer lines during* rabi *2014, using Randomized block design with three replications at the field of Oilseed Research Unit, Dr. PDKV, Akola. The hybrids and parents were evaluated during* kharif *2015 to estimate extent of heterosis in sunflower genotypes. Highly significant differences existed among genotypes, parents and parents vs crosses indicating the presence of heterosis for recorded traits. The highest standard heterosis over best check* i.e. *DRSH-1 for seed yield per plant was recorded by AKSF-6-1A X AKSF 14R (29.75%) followed by AKSF-10-1A X AKSF 14R (28.56%). The crosses CMS 137-12A X PKV-105R (8.15%), AKSF-6-1A X AKSF 6R (7.95%), CMS 607A x 3/147R (7.62%), CMS 137-12A X 3/147R (7.57%), AKSF-10-1A X AKSF 6R (7.41%), CMS 137-12A X 856R (7.20%) and CMS 137-12A X AKSF-14R (6.42%) recorded the significant positive standard heterosis for oil content over DRSH-1. On the basis of mean performance and average heterosis, heterobeltiosis and standard heterosis, the crosses* viz., *AKSF-6-1A X AKSF 14R, AKSF-10-1A X AKSF 14R, AKSF-10-1A X RHA 138-2, AKSF-10-1A X MRHA-1R and CMS 137-12A X AKSF-14R were identified as promising crosses.*

Keywords: *Heterosis, Heterobeltiosis, Line x Tester and Standard heterosis.*

INTRODUCTION

Heterosis or hybrid vigor, describes the superiority performance in terms of vigor, size, yield, speed of development, fertility and resistance to disease and to insect pests, of an F_1 hybrid over its homozygous parental inbred line (Shull *et al.* [19], 1914). Different genetic models have been supposed to explain heterosis, comprising, dominance, over dominance, and epistasis (Birchler *et al.* [3], 2003). Sunflower (*Helianthus annuus* L.) is grown worldwide, mostly as a source of vegetable oil and proteins. Low yielding genotypes and hybrids of sunflower are the major constraints of sunflower productivity due to which the area and production of sunflower is decreasing in past few years. Hence, the main objectives of sunflower breeding programs are the development of productive F_1 hybrids with high seed and oil yield. In sunflower, being the cross-pollinated crop, heterosis can be exploited for better seed yield and other yield components. The discovery of cytoplasmic male sterility (Lecklereq [13], 1966) in France and fertility restoration (Kinman [12], 1970) in America has provided the desired means for the development of hybrids through heterosis breeding. Sunflower hybrids exhibit varied magnitude and direction of heterosis for different characteristics (Gangappa *et al.* [7], 1997). Standard heterosis for plant height, heterobeltiosis for days to 50% flowering, days to maturity and seed yield can be exploited effectively (Kandhola *et al.* [10], 1995). The present investigation revealed extent of heterosis (average heterosis, heterobeltiosis and standard heterosis) observed within the available genetic variability of crosses for various characters studied. The main purpose of this study is to identify superior cross

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combination for seed yield as well as for oil content, which would be certainly helpful for evolving superior hybrids in future.

MATERIAL AND METHODS

The present field study was carried out at field of Oilseed Research Unit, Dr. PDKV, Akola. Crossing work was done in *rabi* 2014 and evaluation of parents and F_1's was taken up in *kharif* 2015, resultant 50 crosses and one check were sown in a simple Randomized Block Design with three replications for evaluation in line x tester fashion. Each entry was sown in one row of 4.5 m length in each replication. The inter and intra-row spacing was 60 cm and 30 cm, respectively. All the standard agronomic and plant protection measures were used. The materials used and methods followed during the course of the investigation are presented below. The parent materials for the present study consisted of five cytoplasmic male sterile lines *viz.*, CMS-137-12A, PET89-1A, CMS-607A, AKSF-10-1A and AKSF-6-1A and ten restorer lines *viz.*, AKSF-6R, RHA-138-2R, 856R, AKSF-14R, MRHA-1R, 3/147R, AKSF-12R, AK-1R, 298R and PKV-105R were used in the investigation. The following observations of ten different quantitative characters were recorded: viz., days to 50 percent flowering, days to maturity, plant height, head diameter, 100 seed weight, volume weight, seed filling percentage, hull percent, oil content and seed yield per plant. Oil content of all genotypes were determined by using NMR (nuclear magnetic resonance) machine at Instrumental cell, Oilseed Research Unit, Dr. PDKV, Akola. Heterosis was calculated over mid parent, better parent and standard check (DRSH-1) for seed yield, its components and oil content.

RESULT AND DISCUSSION

The analysis of variance for various characters under study is presented in Table 1. The variation among treatments was highly significant for all of the characters. The mean sum of square due to parents (lines & testers), Male (testers) x Female (lines), crosses and parents vs crosses were also found highly significant for all the characters studied. This indicates presence of substantial genetic variability for the characters studied.

The percentage of average heterosis (H_1), heterobeltiosis (H_2) and standard heterosis (H_3) for the characters studied is given in Table 2. In sunflower, positive heterosis is desirable for all the characters studied except days to 50% flowering, days to maturity, plant height and hull content, where negative heterosis is desirable.

The present estimation of heterosis for different characters is study under Table 2. For days to 50 per cent flowering, average heterosis ranged -10.23 (PET-89-1A X AKSF-14R) to 5.63 per cent (AKSF-10-1A X PKV-105R). For better parent heterosis ranged from -15.68 (CMS137-12A X AKSF-14R) to 4.97 per cent (AKSF-10-1A X PKV-105R). A total of 41 hybrids recorded significant negative standard heterosis. The highest significant negative standard heterosis was recorded by cross CMS-607A X AK-1R (-14.45%) followed by PET-89-1 X AK-1R (-12.72%) The present findings are in agreement with earlier investigations by Kandhola *et. al.* [10], 1995, Kumar *et al.* [11], (2001) and Phad *et al.* [16], (2002) and Venkata and Nadaf [21] (2013) have also reported earliness in sunflower hybrids.

In sunflower early to medium duration hybrids are preferred and in the present study as the check DRSH-1 is late in maturity, the standard heterosis ranged from -13.27 per cent to 0.68 per cent. AKSF-6-1A X RHA-138-2R (-13.27%) followed by AKSF-6-1A x 856R (-11.90%) and AKSF-6-1A x AK-1R (-9.86%). Out of 50 crosses, 34 crosses recorded highly significant negative heterosis over check, DRSH-1 indicating the early maturity in hybrids. The hybrid AKSF-6-1A X RHA-138-2R (-12.82% & -14.72%), AKSF-6-1A x 856R (-8.32% & -9.44%) had the highest significant negative mid parent heterotic value and better parent heterotic value respectively. Kandhola *et al*. [10], (1995) and Phad *et al*. [16], (2002) also reported earliness in hybrids.

For the plant height, AKSF-6-1A X RHA-138-2R (-13.82%) exhibited highest negative average heterosis, followed by AKSF-6-1A x 3/147R (-8.10%) and CMS-607A x 3/147R (-6.06%). The cross AKSF-6-1A X RHA-138-2R (-14.29%) exhibited highest negative heterobeltiosis followed by CMS 137-12A X 298R (-13.07%). As the check DRSH-1 is tall in growth habit the maximum negative standard heterosis for plant height were found in crosses CMS

Table 1
Analysis of variance

Sources of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	100 seed weight (g)	Volume weight (g/100ml)	Seed filling (%)	Hull content (%)	Oil content (%)	Seed yield per plant (g)
		1	2	3	4	5	6	7	8	9	10
Replications	2	3.174	5.421	43.172	8.178	0.167	5.579	2.467	5.630	1.928	14.665
Treatments	64	17.964**	27.742**	726.035**	45.566**	5.383**	43.392**	55.357**	17.630**	8.831**	276.656**
Parents	14	25.381**	30.895**	418.012**	30.047**	4.482**	32.014**	53.079**	17.558**	11.120**	66.674**
Parents vs Crosses	1	30.586**	19.645**	11101.789**	1507.110*	168.569**	637.190**	776.267**	50.863**	137.322**	7760.448**
Crosses	49	15.588**	27.007**	602.291**	20.172**	2.310**	34.525**	41.295**	16.972**	5.555**	183.920**
Error	128	0.987	1.634	24.249	2.739	0.174	1.651	5.279	1.946	1.575	5.175

Note: * Significant at 5% level of significance

** Significant at 1% level of significance

137-12A X 298R (-33.65%) followed by AKSF-6-1A X RHA-138-2R (-32.24%) and PET-89-1A x AKSF-14R (-31.71%).

Average heterosis for head diameter ranged from 0.99 to 85.53%. Out of 50 crosses the cross i.e. AKSF-10-1A X AK-1R (85.53%) followed by AKSF-10-1A X PKV-105R (80.04%) and CMS-607A X RHA-138-2R (79.12%) show the maximum significant average heterosis. Out of 50 hybrids, maximum significant positive heterobeltiosis was exhibited by AKSF-10-1A X AK-1R (62.99%) followed by AKSF-10-1A X PKV-105R (61.61%) and CMS-607A X RHA-138-2R (55.85%). Standard heterosis ranged from -40.07 to 26.86 per cent over check DRSH-1. Cross CMS-607A X RHA-138-2R (26.86%) exhibited maximum positive standard heterosis followed by cross CMS 137-12A X AKSF-14R (25.67%) and CMS 137-12A X RHA-138-2R (20.08%). Radhika *et al*. [17], (2001) and Habib *et al.* [8], (2006) reported positive heterosis for head diameter.

The cross PET-89-1A x AKSF-12R (136.11%) exhibited maximum positive average heterosis for 100 seed weight followed by AKSF-10-1A x AKSF-12R (110.98%). The maximum significant positive heterobeltiosis is recorded by cross PET-89-1A x 856R (94.18%) followed by the cross PET-89-1A x AKSF-12R (79.93%). Standard heterosis over best check DRSH-1 ranged from -39.69 to 21.36 per cent. The cross AKSF-10-1A x AKSF-6R (21.36%) recorded maximum standard heterosis, followed by the cross PET-89-1A x 856R (19.82%). Gangappa *et al.* [7], (1997), Radhika *et al.* [17], (2001) and Halaswamy *et al.* [9], (2003) reported a highly significant genetic difference among inbred lines for 100 seed weight, which are comparable with present experimental findings. For the trait volume weight, total of 39 hybrids recorded significant positive heterosis over the mid parent and 28 hybrids had significant positive heterosis over the check DRSH-1. The crosses CMS-137-12A X AK-1R (23.27 per cent) recorded highest useful heterosis followed by CMS-137-12A X MRHA-1R (21.74 per cent). These observations support the reports of Sawargaonkar and Ghodke [18] (2008) and Chandra *et al*. [4], (2013).

For the percentage of filled seeds per head having maximum significant positive average heterosis recorded in CMS 137-12A x AKSF-6R (19.68%) followed by PET-89-1A x AKSF-6R (19.67%). The maximum positive heterobeltiosis observed in the cross CMS 137-12A x AKSF-6R (19.68%) followed by CMS 137-12A x AKSF-12R (17.43%). The crosses CMS-607A X 3/147R (9.62%) followed by cross CMS-607A X AK-1R (9.13%) exhibited maximum positive standard heterosis for this trait. Similar reports on significant positive heterosis have also been reported, Dudhe *et al*. [5], (2004) and Chandra *et al*. [4], (2013).

For hull content highest significant negative average heterosis was recorded by the cross CMS 137-12A X 298R (-28.98 per cent) followed by CMS

Table 2
Heterosis (%) over mid-parent (MP), better-parent (BP) and standard checks (DRSH-1) for different characters in sunflower

Sr.No	Crosses	Days to 50% Flowering 1			Days to Maturity 2		
		$MP(H_1)$	$BP(H_2)$	$Check(H_3)$	$MP(H_1)$	$BP(H_2)$	$Check\ (H_3)$
1	CMS 137-12A X AKSF-6R	-1.88	-2.48	-9.25 **	3.68 **	3.14 **	0.68
2	CMS 137-12A X RHA138-2R	-5.67 **	-9.20 **	-8.67 **	-2.57 **	-5.02 **	-3.40 **
3	CMS 137-12A X 856R	-3.14 *	-4.35 **	-10.98 **	3.02 **	2.11	-1.36
4	CMS 137-12A X AKSF-14R	-9.83 **	-15.68 **	-9.83 **	-4.92 **	-8.20 **	-4.76 **
5	CMS 137-12A X MRHA -1R	-5.56 **	-6.13 **	-11.56 **	3.41 **	1.41	-2.04
6	CMS 137-12A X 3/147R	-5.26 **	-5.56 **	-11.56 **	2.33 *	0.35	-3.06 **
7	CMS 137-12A X AKSF-12R	-2.24	-4.97 **	-11.56 **	-1.08	-3.17 **	-6.46 **
8	CMS 137-12A X AK-1R	-4.13 **	-6.21 **	-12.72 **	-0.18	-1.76	-5.10 **
9	CMS 137-12A X 298R	-4.40 **	-5.59 **	-12.14 **	1.05	0.35	-1.7
10	CMS 137-12A X PKV-105R	1.86	1.86	-5.20 **	0.35	0	-3.40 **
11	PET 89-1A X AKSF-6R	3.68 **	1.2	-2.31	-6.07 **	-6.55 **	-7.82 **
12	PET 89-1A X RHA138-2R	-4.40 **	-6.32 **	-5.78 **	-1.19	-2.68 *	-1.02
13	PET 89-1A X 856R	-4.94 **	-7.78 **	-10.98 **	1.93 *	0	-1.36
14	PET 89-1A X AKSF-14R	-10.23 **	-14.59 **	-8.67 **	-6.55 **	-8.85 **	-5.44 **
15	PET 89-1A X MRHA -1R	0	-1.2	-4.62 **	1.24	-1.72	-3.06 **
16	PET 89-1A X 3/147R	0.3	-1.2	-4.62 **	2.31 *	-0.69	-2.04
17	PET 89-1A X AKSF-12R	-1.57	-5.99 **	-9.25 **	2.49 *	-0.69	-2.04
18	PET 89-1A X AK-1R	-5.92 **	-9.58 **	-12.72 **	-0.88	-3.45 **	-4.76 **
19	PET 89-1A X 298R	0.62	-2.4	-5.78 **	-2.42 *	-2.76 *	-4.08 **
20	PET 89-1A X PKV-105R	3.05 *	1.2	-2.31	-1.05	-2.41 *	-3.74 **
21	CMS- 607A X AKSF-6R	1.5	-2.87 *	-2.31	0.86	0	-0.68
22	CMS- 607A X RHA138-2R	0.57	0.57	1.16	-5.58 **	-6.69 **	-5.10 **
23	CMS- 607A X 856R	5.14 **	0	0.58	-0.53	-2.74 *	-3.40 **
24	CMS- 607A X AKSF-14R	-5.29 **	-8.11 **	-1.73	-4.52 **	-6.56 **	-3.06 **
25	CMS- 607A X MRHA -1R	-6.82 **	-9.77 **	-9.25 **	1.59	-1.71	-2.38 *
26	CMS- 607A X 3/147R	0	-3.45 *	-2.89 *	2.65 **	-0.68	-1.36
27	CMS- 607A X AKSF-12R	-6.13 **	-12.07 **	-11.56 **	1.77	-1.71	-2.38 *
28	CMS- 607A X AK-1R	-9.76 **	-14.94 **	-14.45 **	-0.18	-3.08 **	-3.74 **
29	CMS- 607A X 298R	-5.74 **	-10.34 **	-9.83 **	-3.10 **	-3.77 **	-4.42 **
30	CMS- 607A X PKV-105R	1.49	-2.3	-1.73	-1.05	-2.74 *	-3.40 **
31	AKSF-10-1A X AKSF-6R	1.26	1.26	-6.94 **	0.7	-0.35	-2.72 *
32	AKSF-10-1A X RHA138-2R	0.9	-3.45 *	-2.89 *	0.34	-2.68 *	-1.02
33	AKSF-10-1A X 856R	-1.27	-1.89	-9.83 **	3.93 **	3.56 **	-1.02
34	AKSF-10-1A X AKSF-14R	-3.49 **	-10.27 **	-4.05 **	-1.37	-5.25 **	-1.7
35	AKSF-10-1A X MRHA -1R	-2.48	-3.68 *	-9.25 **	4.69 **	3.20 **	-1.36
36	AKSF-10-1A X 3/147R	-0.31	-1.23	-7.51 **	1.44	0	-4.42 **
37	AKSF-10-1A X AKSF-12R	-2.89 *	-5.03 **	-12.72 **	3.44 **	1.78	-2.72 *
38	AKSF-10-1A X AK-1R	0.32	-1.26	-9.25 **	4.68 **	3.56 **	-1.02
39	AKSF-10-1A X 298R	3.80 **	3.14 *	-5.20 **	2.28 *	1.04	-1.02
40	AKSF-10-1A X PKV-105R	5.63 **	4.97 **	-2.31	-0.18	-0.35	-4.42 **
41	AKSF-6-1A X AKSF-6R	-0.31	-0.63	-8.09 **	-5.41 **	-5.57 **	-7.82 **
42	AKSF-6-1A X RHA138-2R	-4.19 **	-8.05 **	-7.51 **	-12.82 **	-14.72 **	-13.27 **
43	AKSF-6-1A X 856R	-4.10 **	-5.00 **	-12.14 **	-8.32 **	-9.44 **	-11.90 **
44	AKSF-6-1A X AKSF-14R	-4.35 **	-10.81 **	-4.62 **	-3.89 **	-6.89 **	-3.40 **
45	AKSF-6-1A X MRHA -1R	-3.41 *	-4.29 **	-9.83 **	1.25	-1.05	-3.74 **
46	AKSF-6-1A X 3/147R	-3.73 **	-4.32 **	-10.40 **	-0.89	-3.15 **	-5.78 **
47	AKSF-6-1A X AKSF-12R	1.92	-0.63	-8.09 **	-4.66 **	-6.99 **	-9.52 **
48	AKSF-6-1A X AK-1R	-1.27	-3.13 *	-10.40 **	-5.53 **	-7.34 **	-9.86 **
49	AKSF-6-1A X 298R	4.10 **	3.13 *	-4.62 **	-7.32 **	-7.64 **	-9.52 **
50	AKSF-6-1A X PKV-105R	5.30 **	4.97 **	-2.31	-6.34 **	-6.99 **	-9.52 **
	RANGE	-10.23 to 5.63	-15.68 to 4.97	-14.45 to 1.16	-12.82 to 4.69	-14.72 to 3.56	-13.27 to 0.68
	SE(D)±	0.7024	0.8111	0.8111	0.9039	1.0437	1.0437
	CD 5%	1.394	1.6096	1.6096	1.7937	2.0712	2.0712
	CD 1%	1.8453	2.1307	2.1307	2.3745	2.7418	2.7418

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

Cont......Table 2
Heterosis (%) over mid-parent (MP), better-parent (BP) and standard checks (DRSH-1) for different characters in sunflower

Sr. No.	Crosses	Plant Height (cm) 3			Head diameter (cm) 4		
		MP(H_1)	BP(H_2)	Check(H_3)	MP(H_1)	BP(H_2)	Check (H_3)
1	CMS 137-12A X AKSF-6R	1.57	-7.83 **	-26.15 **	27.53 **	25.50 **	17.43 **
2	CMS 137-12A X RHA138-2R	17.01 **	7.36 **	-16.04 **	38.30 **	29.31 **	20.98 **
3	CMS 137-12A X 856R	38.87 **	34.93 **	-11.89 **	44.44 **	19.77 **	12.06 *
4	CMS 137-12A X AKSF-14R	14.40 **	5.55 *	-18.45 **	35.18 **	34.31 **	25.67 **
5	CMS 137-12A X MRHA -1R	26.15 **	20.41 **	-13.50 **	22.10 **	11.03	3.88
6	CMS 137-12A X 3/147R	18.76 **	11.10 **	-16.71 **	17.64 **	16.91 *	9.38
7	CMS 137-12A X AKSF-12R	15.89 **	14.51 **	-23.41 **	36.90 **	13.49 *	6.19
8	CMS 137-12A X AK-1R	5.83 *	3.22	-29.10 **	28.19 **	2.21	-4.37
9	CMS 137-12A X 298R	-6.30 *	-13.07 **	-33.65 **	6.82	0.02	-6.42
10	CMS 137-12A X PKV-105R	20.12 **	14.71 **	-17.67 **	34.08 **	8.92	1.91
11	PET 89-1A X AKSF-6R	20.40 **	6.63 *	-14.57 **	29.37 **	29.07 **	17.47 **
12	PET 89-1A X RHA138-2R	13.25 **	1.37	-20.73 **	18.82 **	12.54	2.43
13	PET 89-1A X 856R	44.76 **	44.53 **	-10.69 **	51.43 **	26.96 **	15.56 *
14	PET 89-1A X AKSF-14R	-1.78	-11.61 **	-31.71 **	11.35 *	10.53	2.1
15	PET 89-1A X MRHA -1R	2.71	-4.47	-31.37 **	32.43 **	21.94 **	10.98
16	PET 89-1A X 3/147R	12.30 **	2.44	-23.21 **	14.37 *	13.52 *	4.89
17	PET 89-1A X AKSF-12R	20.29 **	15.72 **	-22.60 **	34.16 **	12.46	2.36
18	PET 89-1A X AK-1R	18.62 **	12.67 **	-22.60 **	34.87 **	8.66	-1.1
19	PET 89-1A X 298R	26.81 **	14.74 **	-12.43 **	37.77 **	30.68 **	18.94 **
20	PET 89-1A X PKV-105R	28.02 **	19.12 **	-14.50 **	50.85 **	23.86 **	12.73 *
21	CMS- 607A X AKSF-6R	12.43 **	7.80 **	-13.63 **	24.72 **	3.83	-5.93
22	CMS- 607A X RHA138-2R	24.27 **	20.55 **	-5.73 **	79.12 **	55.85 **	26.86 **
23	CMS- 607A X 856R	18.83 **	9.20 **	-19.72 **	38.11 **	36.59 **	-15.86 **
24	CMS- 607A X AKSF-14R	11.19 **	8.49 **	-16.18 **	52.36 **	25.87 **	16.26 **
25	CMS- 607A X MRHA -1R	12.97 **	11.69 **	-17.89 **	43.90 **	28.54 **	-1.55
26	CMS- 607A X 3/147R	-6.06 *	-6.97 *	-30.26 **	36.68 **	12.9	4.31
27	CMS- 607A X AKSF-12R	-0.43	-4.92	-30.10 **	57.00 **	55.31 **	-4.37
28	CMS- 607A X AK-1R	3.77	0.36	-26.22 **	59.91 **	53.79 **	-7.35
29	CMS- 607A X 298R	14.83 **	12.72 **	-13.97 **	32.06 **	14.75 *	-6.31
30	CMS- 607A X PKV-105R	-4.7	-5.83 *	-30.77 **	0.99	-0.52	-40.07 **
31	AKSF-10-1A X AKSF-6R	9.24 **	-1.5	-21.09 **	34.13 **	21.47 **	10.05
32	AKSF-10-1A X RHA138-2R	24.26 **	13.27 **	-11.42 **	49.01 **	41.78 **	15.41 *
33	AKSF-10-1A X 856R	31.40 **	28.57 **	-17.25 **	65.35 **	51.96 **	11.69
34	AKSF-10-1A X AKSF-14R	27.07 **	16.46 **	-10.02 **	31.13 **	17.73 **	8.75
35	AKSF-10-1A X MRHA -1R	27.02 **	20.41 **	-13.50 **	42.69 **	39.81 **	7.08
36	AKSF-10-1A X 3/147R	36.34 **	26.70 **	-5.02 *	41.33 **	26.88 **	17.23 **
37	AKSF-10-1A X AKSF-12R	25.69 **	23.32 **	-17.51 **	61.20 **	48.12 **	8.86
38	AKSF-10-1A X AK-1R	30.56 **	26.45 **	-13.14 **	85.53 **	62.99 **	19.79 **
39	AKSF-10-1A X 298R	19.35 **	10.00 **	-16.04 **	51.12 **	43.58 **	17.23 **
40	AKSF-10-1A X PKV-105R	41.38 **	34.08 **	-3.77	80.04 **	61.61 **	18.78 **
41	AKSF-6-1A X AKSF-6R	1.04	0.36	-19.59 **	17.86 **	13.72 *	3.03
42	AKSF-6-1A X RHA138-2R	-13.82 **	-14.29 **	-32.24 **	24.72 **	22.62 **	3.29
43	AKSF-6-1A X 856R	4.73	-6.83 *	-26.35 **	33.80 **	15.82 *	-2.44
44	AKSF-6-1A X AKSF-14R	13.54 **	12.25 **	-11.27 **	24.04 **	18.58 **	9.53
45	AKSF-6-1A X MRHA -1R	11.46 **	6.38 *	-15.91 **	23.07 **	17.48 *	-1.04
46	AKSF-6-1A X 3/147R	-8.10 **	-10.47 **	-29.23 **	12.62 *	7.65	-0.54
47	AKSF-6-1A X AKSF-12R	5.34 *	-2.77	-23.14 **	54.53 **	33.74 **	12.66 *
48	AKSF-6-1A X AK-1R	12.39 **	5.03	-16.98 **	56.92 **	30.28 **	9.74
49*	AKSF-6-1A X 298R	4.80 *	2.99	-18.59 **	18.07 **	16.26 *	-2.07
50	AKSF-6-1A X PKV-105R	18.53 **	13.07 **	-10.62 **	61.56 **	36.83 **	15.26 *
	RANGE	-13.82 to 44.76	-14.29 to 44.53	-33.65 to -3.77	0.99 to 85.53	-0.52 to 62.99	-40.07 to 26.86
	SE(D)±	3.482	4.0207	4.0207	1.1703	1.3514	1.3514
	CD 5%	6.9099	7.9788	7.9788	2.3225	2.6818	2.6818
	CD 1%	9.1469	10.5619	10.5619	3.0744	3.55	3.55

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

Cont......Table 2
Heterosis (%) over mid-parent (MP), better-parent (BP) and standard checks (DRSH-1) for different characters in sunflower

Sr.No	Crosses	100 seed weight (g) 5			Volume weight (g/100ml) 6		
		MP(H_1)	BP(H_2)	Check(H_3)	MP(H_1)	BP(H_2)	Check (H_3)
1	CMS 137-12A X AKSF-6R	26.15 **	25.84 **	1.23	10.55 **	6.24 *	7.42 **
2	CMS 137-12A X RHA138-2R	28.97 **	25.57 **	1.01	6.05 *	3.5	1.36
3	CMS 137-12A X 856R	26.88 **	9.79	-11.68 *	21.10 **	15.08 **	7.29 *
4	CMS 137-12A X AKSF-14R	18.12 **	15.13 **	-2.45	10.13 **	1.71	11.94 **
5	CMS 137-12A X MRHA -1R	-12.64 **	-18.00 **	-24.81 **	26.58 **	22.80 **	21.74 **
6	CMS 137-12A X 3/147R	50.64 **	31.01 **	5.38	19.42 **	13.99 **	6.27 *
7	CMS 137-12A X AKSF-12R	81.37 **	27.15 **	2.28	29.65 **	29.16 **	20.41 **
8	CMS 137-12A X AK-1R	47.02 **	17.46 **	-5.51	22.06 **	13.35 **	23.27 **
9	CMS 137-12A X 298R	36.15 **	20.78 **	-2.84	21.11 **	16.94 **	9.01 **
10	CMS 137-12A X PKV-105R	39.18 **	24.37 **	0.04	0.5	-6.39 *	1.14
11	PET 89-1A X AKSF-6R	35.17 **	19.68 **	-4.2	21.46 **	13.65 **	14.92 **
12	PET 89-1A X RHA138-2R	62.49 **	47.04 **	12.04 **	29.15 **	22.68 **	20.14 **
13	PET 89-1A X 856R	98.91 **	94.18 **	19.82 **	33.99 **	30.83 **	15.28 **
14	PET 89-1A X AKSF-14R	22.95 **	6.25	-9.98 *	0.59	-9.44 **	-0.33
15	PET 89-1A X MRHA -1R	16.46 **	-2.58	-10.68 *	22.35 **	15.54 **	14.55 **
16	PET 89-1A X 3/147R	67.06 **	64.04 **	1.23	38.98 **	36.34 **	20.13 **
17	PET 89-1A X AKSF-12R	136.11 **	79.93 **	11.03 *	3.58	1.12	-6.45 *
18	PET 89-1A X AK-1R	100.72 **	78.58 **	10.20 *	22.41 **	10.80 **	20.49 **
19	PET 89-1A X 298R	32.02 **	31.41 **	-18.16 **	31.67 **	30.68 **	15.15 **
20	PET 89-1A X PKV-105R	51.28 **	49.34 **	-5.43	12.33 **	1.97	10.17 **
21	CMS- 607A X AKSF-6R	29.70 **	22.83 **	9.98 *	11.68 **	8.21 **	9.41 **
22	CMS- 607A X RHA138-2R	14.81 **	6.26	-4.86	12.85 **	11.06 **	8.76 **
23	CMS- 607A X 856R	-8.53	-24.24 **	-32.17 **	8.84 **	2.6	-2.71
24	CMS- 607A X AKSF-14R	18.78 **	15.59 **	3.5	17.82 **	9.67 **	20.70 **
25	CMS- 607A X MRHA -1R	11.86 **	10.55 *	1.36	3.03	0.79	-0.08
26	CMS- 607A X 3/147R	34.45 **	11.88 *	0.18	32.87 **	25.81 **	19.30 **
27	CMS- 607A X AKSF-12R	46.57 **	-0.24	-10.68 *	16.87 **	15.45 **	9.47 **
28	CMS- 607A X AK-1R	49.63 **	15.00 **	2.98	1.66	-4.85	3.48
29	CMS- 607A X 298R	29.61 **	9.87	-1.62	10.73 **	6.05 *	0.56
30	CMS- 607A X PKV-105R	33.52 **	13.98 **	2.06	6.00 *	-0.48	7.52 **
31	AKSF-10-1A X AKSF-6R	66.55 **	51.61 **	21.36 **	17.87 **	10.29 **	11.52 **
32	AKSF-10-1A X RHA138-2R	57.93 **	47.04 **	12.04 **	12.64 **	6.99 *	4.77
33	AKSF-10-1A X 856R	54.01 **	45.90 **	-4.16	13.39 **	10.72 **	-2.44
34	AKSF-10-1A X AKSF-14R	12.19 *	-0.41	-15.62 **	8.71 **	-2.13	7.72 **
35	AKSF-10-1A X MRHA -1R	20.69 **	3.58	-5.03	7.31 **	1.34	0.47
36	AKSF-10-1A X 3/147R	57.55 **	50.10 **	-1.4	11.75 **	9.62 **	-3.41
37	AKSF-10-1A X AKSF-12R	110.98 **	57.43 **	3.41	26.54 **	23.52 **	14.28 **
38	AKSF-10-1A X AK-1R	69.31 **	46.64 **	-3.68	-5.19 *	-14.19 **	-6.68 *
39	AKSF-10-1A X 298R	56.70 **	52.63 **	0.26	6.68 *	5.89	-6.70 *
40	AKSF-10-1A X PKV-105R	61.33 **	58.43 **	4.07	-0.44	-9.63 **	-2.36
41	AKSF-6-1A X AKSF-6R	31.12 **	23.95 **	-0.79	11.06 **	7.08 *	8.27 **
42	AKSF-6-1A X RHA138-2R	51.16 **	46.30 **	11.47 *	6.75 **	4.54	2.37
43	AKSF-6-1A X 856R	45.63 **	32.84 **	-5.3	19.63 **	13.31 **	6.38 *
44	AKSF-6-1A X AKSF-14R	25.22 **	15.29 **	-2.32	-0.26	-7.60 **	1.7
45	AKSF-6-1A X MRHA -1R	-25.99 **	-34.22 **	-39.69 **	-11.55 **	-13.90 **	-14.64 **
46	AKSF-6-1A X 3/147R	42.70 **	30.88 **	-6.7	10.06 **	4.72	-1.69
47	AKSF-6-1A X AKSF-12R	51.35 **	10.01	-21.58 **	1.45	0.71	-5.45
48	AKSF-6-1A X AK-1R	66.72 **	39.59 **	-0.48	3.96	-3.15	5.33
49	AKSF-6-1A X 298R	41.61 **	32.66 **	-5.43	9.11 **	5	-1.43
50	AKSF-6-1A X PKV-105R	30.23 **	22.96 **	-12.34 **	9.03 **	1.89	10.08 **
	RANGE	-25.99 to 136.11	- 34.22 to 94.18	-39.69 to 21.36	-11.55 to 38.98	-14.19 to 36.34	-14.64 to 23.27
	SE(D)±	0.2951	0.3408	0.3408	0.9085	1.049	1.049
	CD 5%	0.5856	0.6762	0.6762	1.8028	2.0817	2.0817
	CD 1%	0.7752	0.8951	0.8951	2.3865	2.7556	2.7556

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

Cont......Table 2
Heterosis (%) over mid-parent (MP), better-parent (BP) and standard checks (DRSH-1) for different characters in sunflower

Sr.No	Crosses	Seed filling (%) 7			Hull content (%) 8		
		$MP(H_1)$	$BP(H_2)$	$Check(H_3)$	$MP(H_1)$	$BP(H_2)$	$Check\ (H_3)$
1	CMS 137-12A X AKSF-6R	19.68 **	19.68 **	8.17 **	-15.22 **	-26.74 **	-12.08 *
2	CMS 137-12A X RHA138-2R	14.14 **	10.45 **	6.73 *	-4.89	-15.98 **	0.83
3	CMS 137-12A X 856R	8.99 **	6.38 *	-3.85	-22.04 **	-27.69 **	-13.23 **
4	CMS 137-12A X AKSF-14R	-0.51	-4.85	-5.77 *	-8.65 *	-18.12 **	-1.74
5	CMS 137-12A X MRHA -1R	10.58 **	10.00 **	0.48	-8.39 *	-17.51 **	-1.01
6	CMS 137-12A X 3/147R	12.14 **	9.05 **	4.33	-8.09 *	-21.68 **	-6.01
7	CMS 137-12A X AKSF-12R	17.43 **	16.49 **	5.29	-5.37	-14.86 **	2.17
8	CMS 137-12A X AK-1R	9.14 **	7.98 **	-2.4	-14.10 **	-19.89 **	-3.87
9	CMS 137-12A X 298R	8.40 **	6.38 *	-3.85	-28.98 **	-31.28 **	-17.53 **
10	CMS 137-12A X PKV-105R	4.86	0.99	-1.44	-25.98 **	-32.15 **	-18.57 **
11	PET 89-1A X AKSF-6R	19.67 **	16.49 **	5.29	12.11 **	8.03	1.84
12	PET 89-1A X RHA138-2R	15.04 **	8.46 **	4.81	-6.83	-7.94	-13.21 **
13	PET 89-1A X 856R	10.36 **	10.06 **	-5.29	-10.17 *	-13.81 **	-11.57 *
14	PET 89-1A X AKSF-14R	5.73 *	-1.46	-2.4	-9.78 *	-10.18 *	-14.55 **
15	PET 89-1A X MRHA -1R	10.87 **	7.37 *	-1.92	-16.05 **	-16.85 **	-20.09 **
16	PET 89-1A X 3/147R	4.51	-1.01	-5.29	10.52 *	4.8	-1.2
17	PET 89-1A X AKSF-12R	7.99 **	5.95	-5.77 *	0.34	-0.53	-4.56
18	PET 89-1A X AK-1R	8.29 **	6.52 *	-5.77 *	-15.89 **	-19.76 **	-16.70 **
19	PET 89-1A X 298R	13.65 **	12.71 **	-1.92	3.63	-4.66	7
20	PET 89-1A X PKV-105R	9.19 **	2.46	0	5.9	2.87	2.87
21	CMS- 607A X AKSF-6R	-4.5	-9.91 **	-8.17 **	-6.13	-16.11 **	-6.86
22	CMS- 607A X RHA138-2R	-9.93 **	-12.26 **	-10.58 **	-3.25	-11.53 **	-1.78
23	CMS- 607A X 856R	12.53 **	3.77	5.77 *	-8.05 *	-11.54 **	-1.79
24	CMS- 607A X AKSF-14R	-4.78 *	-6.13 *	-4.33	1.65	-5.62	4.78
25	CMS- 607A X MRHA -1R	10.95 **	5.19	7.21 **	9.43 *	2.08	13.34 **
26	CMS- 607A X 3/147R	10.95 **	7.55 **	9.62 **	20.99 **	6.55	18.30 **
27	CMS- 607A X AKSF-12R	2.27	-4.25	-2.4	0.38	-6.44	3.88
28	CMS- 607A X AK-1R	14.65 **	7.08 **	9.13 **	-17.29 **	-19.98 **	-11.15 *
29	CMS- 607A X 298R	11.45 **	3.3	5.29	-15.38 **	-15.83 **	-5.53
30	CMS- 607A X PKV-105R	-2.17	-4.25	-2.4	-3.78	-8.55 *	1.53
31	AKSF-10-1A X AKSF-6R	-0.51	-3.96	-6.73 *	-13.22 **	-20.07 **	-17.03 **
32	AKSF-10-1A X RHA138-2R	-1.74	-1.98	-4.81	-12.26 **	-17.24 **	-14.09 **
33	AKSF-10-1A X 856R	1.84	-3.96	-6.73 *	-24.41 **	-24.85 **	-21.99 **
34	AKSF-10-1A X AKSF-14R	0.98	0	-0.96	8.21 *	3.69	7.64
35	AKSF-10-1A X MRHA -1R	3.57	0.5	-2.4	0.16	-3.55	0.12
36	AKSF-10-1A X 3/147R	10.72 **	9.90 **	6.73 *	-0.49	-9.74 *	-6.3
37	AKSF-10-1A X AKSF-12R	5.94 *	1.49	-1.44	-7.35	-10.86 *	-7.46
38	AKSF-10-1A X AK-1R	8.29 **	3.47	0.48	6.57	6.57	10.63 *
39	AKSF-10-1A X 298R	9.14 **	3.47	0.48	-20.27 **	-23.26 **	-13.87 **
40	AKSF-10-1A X PKV-105R	5.19 *	4.93	2.4	-13.21 **	-14.81 **	-11.56 *
41	AKSF-6-1A X AKSF-6R	11.55 **	3.65	9.13 **	15.45 **	3.08	14.69 **
42	AKSF-6-1A X RHA138-2R	7.62 **	3.2	8.65 **	-11.19 **	-18.87 **	-9.73 *
43	AKSF-6-1A X 856R	3.02	-6.39 *	-1.44	-14.13 **	-17.48 **	-8.19
44	AKSF-6-1A X AKSF-14R	0.71	-2.28	2.88	8.33 *	0.48	11.79 *
45	AKSF-6-1A X MRHA -1R	3.18	-3.65	1.44	0.36	-6.47	4.06
46	AKSF-6-1A X 3/147R	-2.39	-6.85 **	-1.92	7.29	-5.6	5.03
47	AKSF-6-1A X AKSF-12R	7.43 **	-0.91	4.33	-3.9	-10.51 *	-0.44
48	AKSF-6-1A X AK-1R	-3.23	-10.96 **	-6.25 *	-11.65 **	-14.60 **	-4.99
49	AKSF-6-1A X 298R	5.50 *	-3.65	1.44	-21.58 **	-21.92 **	-12.37 **
50	AKSF-6-1A X PKV-105R	7.58 **	3.65	9.13 **	-18.67 **	-22.78 **	-14.09 **
	RANGE	-9.93 to 19.68	-12.26 to 19.68	-10.58 to 9.62	-28.98 to 20.99	-32.15 to 8.03	-21.99 to 18.30
	SE(D)±	1.6247	1.876	1.876	0.9865	1.1391	1.1391
	CD 5%	3.2241	3.7229	3.7229	1.9577	2.2606	2.2606
	CD 1%	4.2679	4.9281	4.9281	2.5915	2.9924	2.9924

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

Cont......Table 2
Heterosis (%) over mid-parent (MP), better-parent (BP) and standard checks (DRSH-1) for different characters in sunflower

Sr. No.	Crosses	Oil content (%) 9			Seed Yield /plant 10		
		$MP(H_1)$	$BP(H_2)$	$Check(H_3)$	$MP(H_1)$	$BP(H_2)$	$Check\ (H_3)$
1	CMS 137-12A X AKSF-6R	7.61 **	0.37	0.42	25.95 **	20.29 **	-8.32 *
2	CMS 137-12A X RHA138-2R	16.40 **	15.87 **	1.24	70.17 **	64.54 **	22.23 **
3	CMS 137-12A X 856R	21.33 **	18.39 **	7.20 **	72.96 **	70.26 **	21.92 **
4	CMS 137-12A X AKSF-14R	14.55 **	7.26*	6.42 *	59.49 **	44.55 **	23.39 **
5	CMS 137-12A X MRHA -1R	12.54 **	9.69 **	0.04	69.35 **	68.74 **	17.90 **
6	CMS 137-12A X 3/147R	15.04 **	7.09 *	7.57 **	75.12 **	73.83 **	20.59 **
7	CMS 137-12A X AKSF-12R	11.50 **	7.53 *	0.24	82.30 **	58.27 **	9.79 *
8	CMS 137-12A X AK-1R	7.18 **	1.97	-2.19	58.85 **	37.18 **	-4.84
9	CMS 137-12A X 298R	13.36 **	9.05 **	2.2	65.22 **	52.23 **	5.61
10	CMS 137-12A X PKV-105R	16.47 **	9.08 **	8.15 **	53.84 **	42.53 **	-1.13
11	PET 89-1A X AKSF-6R	4.62	-1.48	-1.44	14.13 **	8.91	-16.99 **
12	PET 89-1A X RHA138-2R	7.95 **	7.33 *	-5.13	46.58 **	41.60 **	5.19
13	PET 89-1A X 856R	8.62 **	7.32 *	-2.81	46.76 **	44.33 **	3.35
14	PET 89-1A X AKSF-14R	3.6	-2.06	-2.82	-12.02 *	-20.33 **	-31.99 **
15	PET 89-1A X MRHA -1R	6.17 *	4.53	-4.66	7.84	7.35	-24.99 **
16	PET 89-1A X 3/147R	8.14 **	1.65	2.11	19.57 **	18.81 **	-17.74 **
17	PET 89-1A X AKSF-12R	2.18	-0.47	-7.21 **	33.49 **	15.99 **	-19.69 **
18	PET 89-1A X AK-1R	2.1	-1.91	-5.92 *	63.22 **	41.06 **	-2.33
19	PET 89-1A X 298R	6.96 **	3.92	-2.61	55.69 **	43.57 **	-0.6
20	PET 89-1A X PKV-105R	3.73	-1.9	-2.74	32.94 **	23.27 **	-14.65 **
21	CMS- 607A X AKSF-6R	-2.86	-5.01	-4.97	22.46 **	0.34	-23.52 **
22	CMS- 607A X RHA138-2R	10.98 **	6.20 *	1.54	47.50 **	22.09 **	-9.31 *
23	CMS- 607A X 856R	0.08	-2.57	-6.84 *	31.99 **	10.87	-20.61 **
24	CMS- 607A X AKSF-14R	1.98	0.12	-0.65	42.00 **	11.50 *	-4.82
25	CMS- 607A X MRHA -1R	4.52	2.11	-2.37	35.87 **	15.28 *	-19.45 **
26	CMS- 607A X 3/147R	14.36 **	7.14 *	7.62 **	57.61 **	34.94 **	-7.77
27	CMS- 607A X AKSF-12R	-1.65	-2.88	-7.14 **	54.34 **	50.72 **	-23.01 **
28	CMS- 607A X AK-1R	3.71	3.55	-0.68	84.48 **	81.28 **	-8.56 *
29	CMS- 607A X 298R	3.97	2.94	-1.57	18.91 **	8.98	-36.29 **
30	CMS- 607A X PKV-105R	0.77	-1.02	-1.87	31.22 **	19.60 **	-29.23 **
31	AKSF-10-1A X AKSF-6R	14.01 **	7.38 *	7.41 **	27.19 **	20.15 **	-8.43 *
32	AKSF-10-1A X RHA138-2R	10.29 **	9.64 **	-3.05	75.75 **	68.04 **	24.83 **
33	AKSF-10-1A X 856R	3.88	2.65	-7.04 **	52.77 **	48.67 **	6.46
34	AKSF-10-1A X AKSF-14R	3.74	-1.91	-2.67	67.91 **	50.61 **	28.56 **
35	AKSF-10-1A X MRHA -1R	11.32 **	9.62 **	-0.02	79.62 **	76.91 **	23.61 **
36	AKSF-10-1A X 3/147R	2.69	-3.46	-3.03	54.44 **	53.78 **	5.11
37	AKSF-10-1A X AKSF-12R	11.02 **	8.16 **	0.84	88.17 **	65.00 **	11.82 **
38	AKSF-10-1A X AK-1R	-1.23	-5.09	-8.96 **	59.88 **	39.44 **	-5.5
39	AKSF-10-1A X 298R	7.21 **	4.18	-2.37	81.07 **	68.63 **	14.28 **
40	AKSF-10-1A X PKV-105R	6.70 **	0.93	0.06	60.25 **	50.08 **	1.71
41	AKSF-6-1A X AKSF-6R	15.24 **	7.90 *	7.95 **	40.60 **	38.56 **	5.61
42	AKSF-6-1A X RHA138-2R	9.49 **	9.46 **	-4.36	62.50 **	62.20 **	20.49 **
43	AKSF-6-1A X 856R	8.42 **	6.48 *	-3.57	59.00 **	56.42 **	15.76 **
44	AKSF-6-1A X AKSF-14R	8.78 **	2.25	1.46	62.83 **	52.00 **	29.75 **
45	AKSF-6-1A X MRHA -1R	2.62	0.44	-8.39 **	3.04	0.16	-25.87 **
46	AKSF-6-1A X 3/147R	3.84	-2.94	-2.51	39.24 **	33.92 **	-0.89
47	AKSF-6-1A X AKSF-12R	5.56 *	2.22	-4.71	93.14 **	63.22 **	20.80 **
48	AKSF-6-1A X AK-1R	5.44 *	0.72	-3.39	66.14 **	39.68 **	3.38
49	AKSF-6-1A X 298R	6.70 *	3.06	-3.41	50.99 **	35.13 **	0.01
50	AKSF-6-1A X PKV-105R	8.76 **	2.28	1.4	67.50 **	50.71 **	11.54 **
	RANGE	-2.86 to 21.33	-5.09 to 18.39	-8.96 to 8.15	-12.02 to 93.14	-20.33 to 81.28	-36.29 to 29.75
	SE(D)±	0.8875	1.0248	1.0248	1.6086	1.8574	1.8574
	CD 5%	1.7611	2.0336	2.0336	3.1921	3.6859	3.6859
	CD 1%	2.3313	2.6919	2.6919	4.2255	4.8792	4.8792

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

137-12A X PKV-105R (-25.98 per cent). The cross CMS 137-12A X PKV-105R (-32.15 per cent) followed by CMS 137-12A X 298R (-31.28 per cent) reported highest significant negative heterobeltiosis for hull content. The cross AKSF-10-1A X 856R (-21.99 per cent) followed by PET-89-1A X MRHA-1R (-20.09 per cent) exhibited highest negative standard heterosis. Most of the crosses showed significant negative heterosis for this trait.

Oil content is also an equally important character along with seed yield per plant in sunflower. In pooled analysis, the observed average heterosis range of hybrid was from -2.86 to 21.33 per cent, the crosses CMS 137-12A X 856R (21.33 per cent) registered highest heterosis followed by CMS 137-12A X PKV-105R (16.47 per cent) and CMS 137-12A X RHA-138-2R (16.40 per cent). For heterobeltiosis heterosis ranged from -5.09 to 18.39 per cent. CMS 137-12A X 856R (18.39 per cent) exhibited highest positive significant heterobeltiosis followed by CMS 137-12A X RHA-138-2R (15.87 per cent) and CMS 137-12A X MRHA-1R (9.69 per cent). Standard heterosis over check DRSH-1 ranged from -8.96 to 8.15 per cent. Seven crosses *viz.*, CMS 137-12A X PKV-105R (8.15 per cent) followed by AKSF-6-1A X AKSF-6R (7.95 per cent), CMS-607A X 3/147R (7.62 per cent), CMS 137-12A X 3/147R (7.57%), AKSF-10-1A X AKSF 6R (7.41%), CMS 137-12A X 856R (7.20%) and CMS 137-12A X AKSF-14R (6.42%)recorded the significant positive standard heterosis over DRSH-1. Nehru *et al.* [15], (2000) and Dudhe [5], (2004) noted highest heterosis and heterobeltiosis for seed yield and oil content per cent.

For seed yield (kg/plant), the range of average heterosis from -12.02 to 93.14 per cent. Out of 50 crosses, the highest positive average heterosis was recorded the AKSF-6-1A X AKSF-12R (93.14 per cent) followed by AKSF-10-1A X AKSF-12R (88.17 per cent), CMS-607A X AK-1R (84.48 per cent). The heterobeltiosis for this trait was ranged from -20.33 to 81.28 per cent. Maximum significant positive heterobeltiosis was found in crossCMS-607A X AK-1R (81.28 per cent) followed by AKSF-10-1A X MRHA-1R (76.91 per cent) and CMS 137-12A X 3/147R (73.83 per cent). The range of standard heterosis over DRSH-1 was found to be -36.29 to 29.75 per cent. AKSF-6-1A X AKSF-14R (29.75 per cent) recorded highest useful heterosis followed by AKSF-10-1A X AKSF-14R (28.56 per cent), AKSF-10-1A X RHA-138-2R (24.83 per cent) and AKSF-10-1A X MRHA-1R (23.61 per cent). Comparable types of results were reported by Madrap and Makne [14] (1993), Nehru e*t al.* [15] (2000), Phad *et al.* [16] (2002), Singh and Singh [20] (2003), Vishwanath [22] (2003), Dudhe [5] (2004), Ahmad *et al.* [1] (2005), Anwar *et al.* [2] (2006) and Dutta *et al.* [6], (2011).

CONCLUSION

In this study cytoplasmic male sterile lines and restorer were used as parents and line x tester analysis was used as an appropriate method for the estimation of average heterosis, heterobeltiosis and standard heterosis.

The significant average heterosis, heterobeltiosis and standard heterosis has been observed for yield and yield contributing characters in many crosses. Ten crosses viz., AKSF-6-1A X AKSF-14R, AKSF-10-1A X AKSF-14R, AKSF-10-1A X RHA138-2R, AKSF-10-1A X MRHA -1R, CMS 137-12A X AKSF-14R, CMS 137-12A X RHA-138-2R, CMS 137-12A X 856R, AKSF-6-1A X AKSF-12R, CMS 137-12A X 3/147R and AKSF-6-1A X RHA-138-2R recorded the highly significant standard heterosis over best check DRSH-1 for yield and most of the yield contributing traits. Seven crosses *viz.*, CMS 137-12A X PKV-105R (8.15 per cent) followed by AKSF-6-1A X AKSF-6R (7.95 per cent), CMS-607A X 3/147R (7.62 per cent), CMS 137-12A X 3/147R (7.57%), AKSF-10-1A X AKSF 6R (7.41%), CMS 137-12A X 856R (7.20%) and CMS 137-12A X AKSF-14R (6.42%) recorded the significant positive standard heterosis over DRSH-1. Considering the mean performance of crosses, average heterosis, heterobeltiosis and standard heterosis of crosses for seed yield and oil content, three crosses *viz.*, CMS 137-12A X AKSF-14R, CMS 137-12A X 856R and CMS 137-12A X 3/147R are identified as promising crosses and these crosses may be need to further evaluation for commercial exploitation.

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