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Heterosis for Seed Yield, its Components and Oil Content in Sunflower (*Helianthus annuus* L.)

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Abstract: *The experimental material was developed by crossing newly developed seven lines and eight testers in Line x Tester fashion during* Rabi 2013*. Parents, their fifty six hybrids along with standard check DRSH-1 were evaluated in randomized block design with three replications at Oilseed Research Unit, Dr. PDKV, Akola during* kharif *2014 to estimate the amount of per cent average heterosis, heterobeltiosis, standard heterosis for different characters in sunflower.*

The highest and significant average heterosis and heterobeltiosis for seed yield per plant was recorded by cross combination AKSF-12A x AKSF-8R (94.64% & 89.87%) followed by CMS-10A x PKV-105R (85.86% & 82.25%). The highest standard heterosis over check i.e. *DRSH-1 for seed yield per plant was recorded by AKSF-12A x RHA-138-2R (28.07%) followed by CMS-850A x RHA-138-2R (26.42%), CMS-234A x AKSF-6R (25.57%), CMS-243A x AKSF-8R (24.63%) and CMS-234A x RHA-138-2R (24.57%). From these five crosses, three crosses* viz.*, CMS-243A x AKSF-8R (6.18%), CMS-234A x RHA-138-2R (5.53%) and CMS-234A x AKSF-6R (3.51%) also recorded highly significant standard heterosis for oil content. On the basis of mean performance and heterosis, three crosses* viz.*, CMS-243A X AKSF-8R, CMS-234A X RHA 138-2R and CMS-234A x AKSF-6R are identified as promising crosses for seed yield as well as for oil content.*

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

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crop in the world. Sunflower is originated in the South-West United States-Mexico area (Heifer, 1955; Vranceanu and Stoenescu, 1979). Sunflower was introduced for commercial cultivation in India in 1969 from former USSR. 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. To conquer this constraint breeders have center of attention towards production of hybrids through heterosis breeding, which become possible due to discovery of cytoplasmic male sterility by Leclercq (1969) and fertility restoration system by Kinman (1970).

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 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 experimental material was consist of seven CMS lines *viz.*, CMS-243A, CMS-17A, AKSF-10-1A, AKSF-12A, CMS-234A, CMS-10A, CMS-850A and eight testers *viz.*, AKSF-6R, AKSF-14R, RHA-138-2R, 856R, AKSF-8R, PKV-105R, 189/1R, AKSF-12R and their 56 F_1's. The seven CMS lines were crossed with the eight restorers/testers in Line x Tester fashion during *rabi* 2013-14 and obtained sufficient cross seeds. The 56 F_1 crosses along with their 15

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parents were evaluated in Randomized Block Design (RBD) with three replications at the farm of Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra state, India) during *Kharif* 2014. 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 data was recorded on plant basis, from each genotype in each replication on 5 randomly selected plants and their average value was computed for ten quantitative traits *viz*., days to 50% flowering, days to maturity, plant height at harvest, head diameter (cm), hundred seed weight (g), volume weight (g/100ml), seed filling percentage, hull content (%), seed yield per plant (g) and oil content (%). Oil contends of all genotypes were determined by using NMR (nuclear magnetic resonance) machine. 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 carried out for the seed yield, its component characters and oil content is presented in Table 1. The mean sum of square due to treatments (genotypes) were highly significant for all the characters, indicating the presence of substantial genetic variability among the genotypes for all the characters under study. 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.

Character wise results of average heterosis (H_1), heterobeltiosis (H_2) and standard heterosis (H_3) observed in the 56 crosses 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 number of days required to 50 per cent of the plants in a genotype to flower is a definite indication of the duration of the genotype. Days to maturity is often closely correlated with days to flowering, although genetic differences in the period or duration required for flowering to maturity exists.

In the present study, for days to 50 per cent flowering heterosis over standard check (DRSH-1) was negative in direction for most of the hybrids indicating earliness of hybrids. The hybrid CMS-243A x 856R (-7.03%) and CMS-10A x 856R (-8.64%) had the highest significant negative mid parent heterotic value and better parent heterotic value respectively. The hybrids AKSF-10-1A x AKSF-8R, AKSF-12A x 856R, CMS-17A x PKV-105R and AKSF-12A x 189/1R recorded highest significant negative heterosis of 15.91 percent over the check.

Table 1
Analysis of variance for various characters

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	1.450	7.370	2.484	0.713	0.519	5.618	8.244	2.573	0.703	5.567
Treatments	70	17.925**	38.226**	1861.176**	25.078**	3.832**	64.754**	42.618**	43.779**	9.134**	342.922**
Parents	14	16.517**	28.936**	3400.680**	20.180**	2.616**	100.200**	23.707**	55.011**	7.320**	88.767**
Parents vs Crosses	1	71.512**	1278.591**	11089.145**	385.821**	74.053**	742.333**	672.228**	30.495**	45.179**	5668.680**
Crosses	55	17.309**	18.039**	1301.521**	19.765**	2.867**	43.392**	35.985**	41.162**	8.941**	310.784**
Male xFemale	42	11.061**	10.971**	793.65**	15.409**	2.199**	22.405**	30.695**	43.318**	6.025**	211.354**
Error	140	0.498	2.46	12.042	0.524	0.211	2.245	3.334	1.080	0.399	4.621

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

Table 2
Heterosis (%) over mid-parent (MP), better-parent (BP) and standard check (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-243A X AKSF-6R	8.63 **	3.03 **	-3.39**	8.69 **	3.89 **	-2.97*
2	CMS-243A X AKSF-14R	14.56 **	9.70 **	2.85**	11.11 **	7.77 **	0.66
3	CMS-243A X RHA138-2R	-0.31	-3.03 **	-9.09**	7.33 **	3.53 **	-3.30**
4	CMS-243A X 856R	-7.03 **	-7.88 **	-13.62**	2.37 *	-0.71	-7.26**
5	CMS-243A X AKSF-8R	2.55 **	-2.42 *	-8.51**	5.80 **	3.18 *	-3.63**
6	CMS-243A X PKV-105R	6.41 **	0.61	-5.68**	9.85 **	6.36 **	-0.66
7	CMS-243A X 189/1R	-1.57	-4.85 **	-10.79**	3.05 **	1.41	-5.28**
8	CMS-243A X AKSF-12R	5.36 **	1.21	-5.10**	8.73 **	5.65 **	-1.32
9	CMS-17A X AKSF-6R	2.67 **	1.32	-12.50**	5.86 **	3.32 *	-7.59**
10	CMS-17A X AKSF-14R	14.85 **	14.47 **	-1.13	12.48 **	11.44 **	-0.33
11	CMS-17A X RHA138-2R	-3.25 **	-4.49 **	-15.33**	2.25	0.74	-9.90**
12	CMS-17A X 856R	-4.46 **	-7.41 **	-14.76**	1.68	0.74	-9.90**
13	CMS-17A X AKSF-8R	7.64 **	6.58 **	-7.94**	6.30 **	5.90 **	-5.28**
14	CMS-17A X PKV-105R	-1.00	-2.63 *	-15.91**	4.48 **	3.32 *	-7.59**
15	CMS-17A X 189/1R	2.61 **	1.95	-10.79**	5.69 **	5.11 **	-4.95**
16	CMS-17A X AKSF-12R	1.32	1.32	-12.50**	5.20 **	4.43 **	-6.60**
17	AKSF10-1A X AKSF-6R	12.24 **	11.49 **	-6.24**	11.80 **	11.58 **	-4.62**
18	AKSF10-1A X AKSF-14R	18.52 **	16.56 **	0.02	15.05 **	13.53 **	-0.33
19	AKSF10-1A X RHA138-2R	3.97 **	0.64	-10.79**	9.96 **	9.13 **	-5.28**
20	AKSF10-1A X 856R	6.49 **	1.23	-6.80**	10.48 **	9.02 **	-4.29**
21	AKSF10-1A X AKSF-8R	0.34	-0.67	-15.91**	6.06 **	4.09 **	-7.59**
22	AKSF10-1A X PKV-105R	9.22 **	8.84 **	-9.09**	9.92 **	8.68 **	-4.95**
23	AKSF10-1A X 189/1R	6.00 **	3.25 **	-9.65**	7.69 **	4.74 **	-5.28**
24	AKSF10-1A X AKSF-12R	0.00	-1.97	-15.33**	4.94 **	3.37 *	-8.91**
25	AKSF-12A X AKSF-6R	4.14 **	2.03	-14.20**	8.77 **	8.14 **	-7.92**
26	AKSF-12A X AKSF-14R	15.36 **	11.92 **	-3.97**	13.63 **	11.28 **	-2.31
27	AKSF-12A X RHA138-2R	2.68 **	-1.92	-13.06**	9.65 **	7.98 **	-6.27**
28	AKSF-12A X 856R	-2.63 **	-8.64 **	-15.91**	5.18 **	3.01 *	-9.57**
29	AKSF-12A X AKSF-8R	12.71 **	10.07 **	-6.80**	12.60 **	9.67 **	-2.64*
30	AKSF-12A X PKV-105R	10.73 **	8.84 **	-9.09**	11.54 **	9.43 **	-4.29**
31	AKSF-12A X 189/1R	0.00	-3.90 **	-15.91**	5.86 **	2.19	-7.59**
32	AKSF-12A X AKSF-12R	4.76 **	1.32	-12.50**	9.20 **	6.74 **	-5.94**
33	CMS-234A X AKSF-6R	0.65	-3.70 **	-11.35**	7.21 **	2.47	-4.29**
34	CMS-234A X AKSF-14R	2.24 *	-1.23	-9.09**	7.10 **	3.89 **	-2.97*
35	CMS-234A X RHA138-2R	-2.52 **	-4.32 **	-11.92**	3.30 **	-0.35	-6.93**
36	CMS-234A X 856R	-4.94 **	-4.94 **	-12.50**	2.73 *	-0.35	-6.93**
37	CMS-234A X AKSF-8R	0.32	-3.70 **	-11.35**	2.54 *	0.00	-6.60**
38	CMS-234A X PKV-105R	5.50 **	0.62	-7.38**	6.57 **	3.18 *	-3.63**
39	CMS-234A X 189/1R	-5.06 **	-7.41 **	-14.76**	0.18	-1.41	-7.92**
40	CMS-234A X AKSF-12R	-1.91 *	-4.94 **	-12.50**	3.27 **	0.35	-6.27**
41	CMS-10A X AKSF-6R	2.25 *	-2.45 *	-9.65**	6.81 **	1.75	-4.29**
42	CMS-10A X AKSF-14R	0.64	-3.07 **	-10.21**	5.63 **	2.11	-3.96**
43	CMS-10A X RHA138-2R	0.94	-1.23	-8.51**	6.57 **	2.46	-3.63**
44	CMS-10A X 856R	-5.23 **	-5.52 **	-12.50**	4.17 **	0.70	-5.28**

(*contd....Table 2*)

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)
45	CMS-10A X AKSF-8R	-0.64	-4.91 **	-11.92**	2.17	-0.70	-6.60**
46	CMS-10A X PKV-105R	-1.94 *	-6.75 **	-13.62**	2.55 *	-1.05	-6.93**
47	CMS-10A X 189/1R	-4.10 **	-6.75 **	-13.62**	0.18	-1.75	-7.59**
48	CMS-10A X AKSF-12R	-0.95	-4.29 **	-11.35**	3.62 **	0.35	-5.61**
49	CMS-850A X AKSF-6R	2.93 **	-0.63	-10.21**	8.99 **	5.43 **	-3.96**
50	CMS-850A X AKSF-14R	3.87 **	1.26	-8.51**	7.38 **	5.43 **	-3.96**
51	CMS-850A X RHA138-2R	2.22 *	1.26	-8.51**	6.12 **	3.62 **	-5.61**
52	CMS-850A X 856R	0.93	0.00	-7.94**	7.75 **	5.80 **	-3.63**
53	CMS-850A X AKSF-8R	-2.60 **	-5.66 **	-14.76**	2.39 *	1.09	-7.92**
54	CMS-850A X PKV-105R	7.19 **	3.14 **	-6.80**	9.43 **	7.25 **	-2.31
55	CMS-850A X 189/1R	2.24 *	0.63	-9.09**	4.73 **	4.35 **	-4.95**
56	CMS-850A X AKSF-12R	0.96	-1.26	-10.79**	7.18 **	5.43 **	-3.96**
	RANGE	-7.03 to 18.52	-8.64 to 16.56	-15.91 to 2.85	0.18 to 15.05	-1.75 to 13.53	-9.90 to 0.66
	SE(D)±	0.473	0.546	0.546	1.073	1.239	1.239
	CD 5%	0.9374	1.0824	1.0824	2.1258	2.4547	2.4547
	CD 1%	1.2399	1.4317	1.4317	2.8119	3.2468	3.2468

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 check (DRSH-1) for different characters in sunflower

Sr. No.	Crosses	Plant Height (cm) 3			Headdiameter (cm) 4		
		$MP(H_1)$	$BP(H_2)$	$Check(H_3)$	$MP(H_1)$	$BP(H_2)$	Check (H_3)
1	CMS-243A X AKSF-6R	-6.63 **	-17.10 **	-9.41 **	11.19 **	-1.26	9.99**
2	CMS-243A X AKSF-14R	23.68 **	-1.70	7.43 **	33.68 **	9.69 **	22.20**
3	CMS-243A X RHA138-2R	21.18 **	0.50	9.83 **	10.67 **	-0.65	10.65**
4	CMS-243A X 856R	-0.58	-14.29 **	-6.33 **	17.01 **	7.24 *	19.43**
5	CMS-243A X AKSF-8R	4.57 **	-9.03 **	-0.59	12.41 **	-3.26	7.76*
6	CMS-243A X PKV-105R	5.80 **	-6.64 **	2.03	11.06 **	-0.54	10.77**
7	CMS-243A X 189/1R	-11.11 **	-18.85 **	-11.32 **	27.56 **	10.95 **	23.59**
8	CMS-243A X AKSF-12R	-11.61 **	-24.32 **	-17.30 **	-7.82 *	-25.06 **	-16.55**
9	CMS-17A X AKSF-6R	25.05 **	-6.82 **	-21.01 **	70.48 **	41.48 **	22.32**
10	CMS-17A X AKSF-14R	65.53 **	36.15 **	-12.28 **	56.90 **	41.12 **	0.78
11	CMS-17A X RHA138-2R	3.01	-18.76 **	-41.52 **	13.52 **	-6.70	-17.33**
12	CMS-17A X 856R	12.06 **	-14.55 **	-32.36 **	14.70 **	-7.39 *	-14.08**
13	CMS-17A X AKSF-8R	13.41 **	-14.14 **	-30.59 **	9.84 *	-6.09	-24.55**
14	CMS-17A X PKV-105R	74.65 **	30.74 **	9.28 **	78.34 **	46.88 **	29.42**
15	CMS-17A X 189/1R	27.09 **	-7.19 **	-16.24 **	34.94 **	14.20 **	-5.96
16	CMS-17A X AKSF-12R	12.86 **	-13.44 **	-32.62 **	67.66 **	52.42 **	6.26
17	AKSF10-1A X AKSF-6R	0.80	-2.99	-17.76 **	30.42 **	27.95 **	14.98**
18	AKSF10-1A X AKSF-14R	10.43 **	0.59	-21.14 **	9.65 **	-1.61	-11.61**
19	AKSF10-1A X RHA138-2R	14.25 **	9.58 **	-14.09 **	11.91 **	11.14 **	-0.12

(*contd....Table 2*)

Sr. No.	Crosses	Plant Height (cm) 3			Headdiameter (cm) 4		
		$MP(H_1)$	$BP(H_2)$	$Check(H_3)$	$MP(H_1)$	$BP(H_2)$	$Check (H_3)$
20	AKSF10-1A X 856R	1.02	0.53	-20.42 **	9.82 **	8.08 *	0.30
21	AKSF10-1A X AKSF-8R	-19.87 **	-21.09 **	-36.20 **	44.71 **	37.05 **	23.16**
22	AKSF10-1A X PKV-105R	5.23 **	1.96	-14.77 **	28.33 **	27.10 **	14.20**
23	AKSF10-1A X 189/1R	-21.19 **	-26.36 **	-33.54 **	13.75 **	9.02 *	-2.05
24	AKSF10-1A X AKSF-12R	-4.51 **	-4.84 *	-25.40 **	25.94 **	11.83 **	0.48
25	AKSF-12A X AKSF-6R	10.42 **	5.48 **	-10.59 **	2.11	1.99	-11.61**
26	AKSF-12A X AKSF-14R	25.33 **	14.98 **	-11.27 **	26.90 **	15.74 **	0.30
27	AKSF-12A X RHA138-2R	33.52 **	29.03 **	-0.42	34.68 **	33.18 **	17.99**
28	AKSF-12A X 856R	-18.16 **	-19.19 **	-36.03 **	17.51 **	13.62 **	5.42
29	AKSF-12A X AKSF-8R	17.06 **	14.41 **	-7.51 **	-13.76 **	-16.90 **	-27.98**
30	AKSF-12A X PKV-105R	16.90 **	12.42 **	-6.03 **	3.42	2.55	-9.63**
31	AKSF-12A X 189/1R	-16.78 **	-22.81 **	-30.34 **	0.53	-1.94	-15.04**
32	AKSF-12A X AKSF-12R	-12.79 **	-13.17 **	-32.41 **	24.63 **	12.45 **	-2.59
33	CMS-234A X AKSF-6R	48.56 **	17.72 **	-0.21	69.96 **	41.76 **	22.56**
34	CMS-234A X AKSF-14R	41.08 **	24.82 **	-19.58 **	41.12 **	27.64 **	-8.84**
35	CMS-234A X RHA138-2R	58.35 **	33.70 **	-3.76 *	61.41 **	33.32 **	18.11**
36	CMS-234A X 856R	28.35 **	4.37 *	-17.38 **	24.11 **	0.69	-6.56*
37	CMS-234A X AKSF-8R	27.47 **	2.82	-16.88 **	26.29 **	8.54 *	-12.82**
38	CMS-234A X PKV-105R	38.66 **	10.45 **	-7.68 **	28.02 **	5.96	-6.62*
39	CMS-234A X 189/1R	27.11 **	-1.53	-11.14 **	29.38 **	10.06 *	-9.33**
40	CMS-234A X AKSF-12R	18.61 **	-2.93	-24.43 **	36.56 **	24.86 **	-12.94**
41	CMS-10A X AKSF-6R	14.53 **	-18.37 **	-30.80 **	4.35	-10.86 **	-22.92**
42	CMS-10A X AKSF-14R	22.08 **	-4.78 *	-38.65 **	40.19 **	30.22 **	-7.04*
43	CMS-10A X RHA138-2R	11.68 **	-16.18 **	-39.66 **	6.96	-9.55 *	-19.86**
44	CMS-10A X 856R	60.01 **	16.47 **	-7.81 **	25.42 **	4.11	-3.43
45	CMS-10A X AKSF-8R	39.52 **	0.89	-18.44 **	16.20 **	2.40	-17.75**
46	CMS-10A X PKV-105R	22.00 **	-12.67 **	-27.00 **	1.18	-14.25 **	-24.43**
47	CMS-10A X 189/1R	-0.93	-30.66 **	-37.43 **	5.24	-8.25 *	-24.43**
48	CMS-10A X AKSF-12R	12.59 **	-17.62 **	-35.86 **	22.57 **	15.13 **	-19.74**
49	CMS-850A X AKSF-6R	39.15 **	-1.54	-16.54 **	29.10 **	9.42 *	-5.42
50	CMS-850A X AKSF-14R	68.57 **	30.32 **	-16.03 **	64.37 **	51.35 **	8.06*
51	CMS-850A X RHA138-2R	73.15 **	28.90 **	-7.22 **	54.73 **	29.83 **	15.04**
52	CMS-850A X 856R	52.25 **	9.97 **	-12.95 **	54.50 **	27.28 **	18.11**
53	CMS-850A X AKSF-8R	22.55 **	-12.06 **	-28.90 **	17.57 **	2.75	-17.45**
54	CMS-850A X PKV-105R	28.45 **	-8.73 **	-23.71 **	35.48 **	13.93 **	0.42
55	CMS-850A X 189/1R	30.86 **	-9.06 **	-17.93 **	8.18 *	-6.45	-22.92**
56	CMS-850A X AKSF-12R	15.34 **	-16.26 **	-34.81 **	69.22 **	57.54 **	9.81**
	RANGE	-21.19 to 74.65	-30.66 to 36.15	-41.52 to 9.83	-13.76 to 78.34	-25.06 to 57.54	-27.97 to 29.42
	SE(D)±	2.111	2.438	2.438	0.4737	0.547	0.547
	CD 5%	4.1843	4.8316	4.8316	0.9388	1.0841	1.0841
	CD 1%	5.5346	6.3908	6.3908	1.2418	1.4339	1.4339

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 check (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-243A X AKSF-6R	35.13 **	30.12 **	45.28 **	7.76 **	6.02 *	11.11**
2	CMS-243A X AKSF-14R	54.68 **	43.33 **	48.17 **	22.23 **	14.75 **	20.27**
3	CMS-243A X RHA138-2R	7.77	-0.11	20.95 **	-5.20 *	-5.73 *	-0.07
4	CMS-243A X 856R	46.03 **	45.93 **	50.86 **	7.27 **	1.50	6.37*
5	CMS-243A X AKSF-8R	32.18 **	17.20 *	21.16 **	8.24 **	0.61	5.45
6	CMS-243A X PKV-105R	36.62 **	32.27 **	46.04 **	-5.91 *	-14.34 **	-10.21**
7	CMS-243A X 189/1R	20.86 **	11.13	36.94 **	-10.21 **	-16.51 **	-12.50**
8	CMS-243A X AKSF-12R	7.59	-4.60	-1.38	-11.91 **	-13.78 **	-9.62**
9	CMS-17A X AKSF-6R	60.68 **	26.11 **	40.80 **	20.09 **	0.25	1.66
10	CMS-17A X AKSF-14R	107.54 **	78.59 **	57.55 **	35.21 **	17.51 **	8.08**
11	CMS-17A X RHA138-2R	49.93 **	14.34 *	38.46 **	6.05 *	-13.00 **	-7.79**
12	CMS-17A X 856R	44.57 **	16.82 *	20.61 **	23.32 **	6.42 *	-0.46
13	CMS-17A X AKSF-8R	104.51 **	83.62 **	46.80 **	27.86 **	12.15 **	0.98
14	CMS-17A X PKV-105R	68.71 **	32.96 **	46.80 **	24.07 **	10.99 **	-4.52
15	CMS-17A X 189/1R	63.78 **	24.16 **	53.00 **	26.84 **	11.21 **	0.22
16	CMS-17A X AKSF-12R	15.60	3.79	-17.02 *	-3.36	-18.99 **	-18.68**
17	AKSF10-1A X AKSF-6R	37.27 **	26.98 **	41.76 **	6.24 *	-6.85 *	-5.52**
18	AKSF10-1A X AKSF-14R	13.59	9.59	4.00	16.03 **	6.22	-2.30
19	AKSF10-1A X RHA138-2R	44.22 **	28.63 **	55.75 **	2.90	-11.45 **	-6.15*
20	AKSF10-1A X 856R	33.63 **	28.24 **	32.39 **	15.51 **	4.95	-1.83
21	AKSF10-1A X AKSF-8R	40.88 **	29.77 **	23.16 **	25.56 **	16.08 **	4.49
22	AKSF10-1A X PKV-105R	-1.85	-8.74	0.76	14.12 **	7.76 *	-7.30*
23	AKSF10-1A X 189/1R	16.97 **	3.52	27.57 **	4.04	-3.86	-13.36**
24	AKSF10-1A X AKSF-12R	34.02 **	23.46 **	17.16 *	10.94 **	-2.29	-1.93
25	AKSF-12A X AKSF-6R	27.37 **	18.64 **	32.46 **	15.30 **	-4.66	-3.32
26	AKSF-12A X AKSF-14R	25.17 **	19.89 *	15.51 *	34.51 **	15.73 **	6.45*
27	AKSF-12A X RHA138-2R	8.91	-2.22	18.40 *	19.47 **	-2.90	2.91
28	AKSF-12A X 856R	19.48 **	15.49 *	19.23 *	37.76 **	17.70 **	10.09**
29	AKSF-12A X AKSF-8R	44.64 **	32.33 **	27.50 **	26.95 **	10.22 **	-0.78
30	AKSF-12A X PKV-105R	6.00	-0.75	9.58	30.51 **	15.55 **	-0.59
31	AKSF-12A X 189/1R	-16.70 **	-25.78 **	-8.55	-0.92	-14.01 **	-22.52**
32	AKSF-12A X AKSF-12R	21.19 **	10.87	6.82	2.46	-14.93 **	-14.63**
33	CMS-234A X AKSF-6R	24.79 **	8.15	20.74 **	18.53 **	3.99	5.47
34	CMS-234A X AKSF-14R	62.07 **	56.25 **	37.84 **	31.58 **	20.53 **	10.87**
35	CMS-234A X RHA138-2R	44.52 **	21.12 **	46.66 **	23.11 **	6.00 *	12.36**
36	CMS-234A X 856R	52.49 **	36.72 **	41.14 **	29.99 **	18.17 **	10.53**
37	CMS-234A X AKSF-8R	6.47	5.22	-13.85	7.03 *	-0.99	-10.87**
38	CMS-234A X PKV-105R	1.08	-11.99	-2.83	14.80 **	8.46 *	-6.69*
39	CMS-234A X 189/1R	14.25 *	-4.92	17.16 *	3.61	-4.19	-13.68**
40	CMS-234A X AKSF-12R	36.46 **	34.85 **	10.41	9.86 **	-3.19	-2.83
41	CMS-10A X AKSF-6R	21.23 **	-6.23	4.69	15.37 **	-3.76	-2.39
42	CMS-10A X AKSF-14R	37.12 **	16.02	2.34	7.82 *	-6.37	-13.87**
43	CMS-10A X RHA138-2R	43.78 **	8.14	30.94 **	8.03 **	-11.44 **	-6.13*
44	CMS-10A X 856R	84.06 **	46.46 **	51.21 **	27.18 **	9.67 **	2.59
45	CMS-10A X AKSF-8R	108.21 **	83.62 **	46.80 **	17.61 **	3.07	-7.20*

(*contd....Table 2*)

Sr. No	Crosses	100 seed weight (g) 5			Volume weight (g/100ml) 6		
		$MP(H_1)$	$BP(H_2)$	$Check(H_3)$	$MP(H_1)$	$BP(H_2)$	$Check (H_3)$
46	CMS-10A X PKV-105R	48.07 **	14.98 *	26.95 **	28.90 **	15.22 **	-0.88
47	CMS-10A X 189/1R	7.78	-19.41 **	-0.69	-0.22	-12.58 **	-21.22**
48	CMS-10A X AKSF-12R	69.50 **	49.48 **	19.50 **	2.41	-14.22 **	-13.89**
49	CMS-850A X AKSF-6R	19.91 **	1.11	12.89	8.54 **	-7.97 **	-6.67*
50	CMS-850A X AKSF-14R	44.57 **	35.08 **	19.16 *	30.07 **	14.92 **	5.71
51	CMS-850A X RHA138-2R	22.69 **	0.17	21.30 **	17.80 **	-1.89	3.98
52	CMS-850A X 856R	38.54 **	20.69 **	24.60 **	28.83 **	13.00 **	5.69
53	CMS-850A X AKSF-8R	10.04	7.76	-13.85	22.34 **	9.11 **	-1.76
54	CMS-850A X PKV-105R	-10.83	-24.47 **	-16.61 *	16.59 **	6.10	-8.72**
55	CMS-850A X 189/1R	19.31 **	-3.24	19.23 *	8.83 **	-2.98	-12.58**
56	CMS-850A X AKSF-12R	25.35 **	22.76 *	-1.86	-7.86 *	-21.54 **	-21.25**
	RANGE	-16.70 to 108.21	-25.78 to 83.62	-17.02 to 57.55	-11.91 to 37.76	-21.54 to 20.53	-22.51 to 20.27
	SE(D)±	0.3087	0.3565	0.3565	1.0511	1.2137	1.2137
	CD 5%	0.6118	0.7064	0.7064	2.0831	2.4053	2.4053
	CD 1%	0.8092	0.9344	0.9344	2.7553	3.1815	3.1815

Note: * Significant at 5% level of significan ** Significant at 1% level of significanc

Cont...Table 2.,Heterosis (%) over mid-parent (MP), better-parent (BP) and standard check (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-243A X AKSF-6R	12.63 **	7.73 **	10.13**	-5.40 *	-16.62 **	6.40*
2	CMS-243A X AKSF-14R	-1.48	-3.38	-1.21	-4.47	-13.10 **	10.87**
3	CMS-243A X RHA138-2R	8.12 **	2.90	5.20*	-32.84 **	-37.46 **	-20.19**
4	CMS-243A X 856R	8.87 **	6.76 **	9.16**	3.90	-2.24	24.73**
5	CMS-243A X AKSF-8R	6.57 **	5.80 **	8.16**	-22.29 **	-30.33 **	-11.11**
6	CMS-243A X PKV-105R	0.00	-0.48	2.73	-12.80 **	-20.93 **	0.89
7	CMS-243A X 189/1R	3.23	0.48	2.73	-7.27 **	-13.86 **	9.91**
8	CMS-243A X AKSF-12R	7.35 **	5.80 **	8.16**	-22.33 **	-33.69 **	-15.38**
9	CMS-17A X AKSF-6R	14.44 **	13.54 **	7.68**	-7.38 **	-15.96 **	0.38
10	CMS-17A X AKSF-14R	4.86 *	3.02	1.24	-9.02 **	-14.70 **	1.89
11	CMS-17A X RHA138-2R	8.71 **	7.29 **	1.75	-0.83	-4.73	13.79**
12	CMS-17A X 856R	9.46 **	7.54 **	5.69**	-15.19 **	-17.65 **	-1.65
13	CMS-17A X AKSF-8R	11.11 **	7.84 **	8.65**	4.81	-3.19	15.62**
14	CMS-17A X PKV-105R	11.72 **	7.18 **	10.64**	-13.84 **	-19.48 **	-3.82
15	CMS-17A X 189/1R	15.98 **	14.80 **	11.13**	-15.92 **	-19.42 **	-3.75
16	CMS-17A X AKSF-12R	-1.27	-3.48	-4.18	-0.98	-13.07 **	3.82
17	AKSF10-1A X AKSF-6R	15.36 **	13.23 **	5.69**	-17.90 **	-22.78 **	-14.72**
18	AKSF10-1A X AKSF-14R	18.11 **	13.07 **	11.13**	-14.81 **	-17.09 **	-8.43**
19	AKSF10-1A X RHA138-2R	24.12 **	22.46 **	13.10**	-26.85 **	-26.98 **	-19.37**
20	AKSF10-1A X 856R	4.99 *	0.50	-1.21	-19.92 **	-20.66 **	-10.73**

(*contd....Table 2*)

Sr. No	Crosses	Seed filling (%) 7			Hull content (%) 8		
		$MP(H_1)$	$BP(H_2)$	$Check(H_3)$	$MP(H_1)$	$BP(H_2)$	$Check (H_3)$
21	AKSF10-1A X AKSF-8R	12.95 **	6.86 **	7.68**	0.16	-4.03	5.99
22	AKSF10-1A X PKV-105R	5.88 **	-0.96	2.24	-11.90 **	-14.55 **	-5.61
23	AKSF10-1A X 189/1R	4.23 *	0.51	-2.70	-6.42 *	-6.83 *	2.89
24	AKSF10-1A X AKSF-12R	16.97 **	11.44 **	10.64**	1.41	-7.85 **	1.79
25	AKSF-12A X AKSF-6R	9.09 **	7.94 **	0.76	-23.55 **	-24.19 **	-26.21**
26	AKSF-12A X AKSF-14R	7.29 **	3.52	1.75	-8.02 **	-11.91 **	-7.91**
27	AKSF-12A X RHA138-2R	14.52 **	13.90 **	5.20*	-3.27	-9.58 **	-0.48
28	AKSF-12A X 856R	8.33 **	4.52 *	2.73	0.61	-6.92 *	4.75
29	AKSF-12A X AKSF-8R	14.65 **	9.31 **	10.13**	-16.04 **	-18.33 **	-17.34**
30	AKSF-12A X PKV-105R	4.06 *	-1.91	1.24	-6.97 *	-10.60 **	-7.19**
31	AKSF-12A X 189/1R	9.19 **	6.12 **	2.73	-1.24	-7.46 *	1.31
32	AKSF-12A X AKSF-12R	12.95 **	8.46 **	7.68**	0.88	-1.97	-6.19
33	CMS-234A X AKSF-6R	1.57	0.52	-4.18	19.57 **	6.27	3.41
34	CMS-234A X AKSF-14R	-0.51	-2.01	-3.69	31.43 **	13.28 **	18.40**
35	CMS-234A X RHA138-2R	11.05 **	9.33 **	4.21*	2.33	-13.65 **	-4.99
36	CMS-234A X 856R	5.10 **	3.52	1.75	-4.52	-20.16 **	-10.15**
37	CMS-234A X AKSF-8R	5.79 **	2.94	3.72	1.35	-11.43 **	-10.35**
38	CMS-234A X PKV-105R	2.49	-1.44	1.75	12.37 **	-2.86	0.83
39	CMS-234A X 189/1R	1.80	1.02	-2.21	-13.77 **	-27.08 **	-20.16**
40	CMS-234A X AKSF-12R	-2.54	-4.48 *	-5.17*	-7.12 *	-14.64 **	-22.94**
41	CMS-10A X AKSF-6R	7.98 **	7.41 **	0.27	-12.14 **	-14.02 **	-16.34**
42	CMS-10A X AKSF-14R	6.74 **	3.52	1.75	-7.77 **	-12.79 **	-8.84**
43	CMS-10A X RHA138-2R	19.25 **	19.25 **	10.13**	2.39	-5.47	4.02
44	CMS-10A X 856R	7.77 **	4.52 *	2.73	20.52 **	10.15 **	23.94**
45	CMS-10A X AKSF-8R	-2.30	-6.37 **	-5.66**	0.47	-3.52	-2.37
46	CMS-10A X PKV-105R	5.56 **	0.00	3.23	20.59 **	14.40 **	18.75**
47	CMS-10A X 189/1R	12.27 **	9.69 **	6.19**	1.92	-5.68 *	3.27
48	CMS-10A X AKSF-12R	1.03	-2.49	-3.20	38.87 **	36.73 **	27.38**
49	CMS-850A X AKSF-6R	3.06	-0.49	-0.24	45.79 **	28.16 **	24.73**
50	CMS-850A X AKSF-14R	2.99	1.97	2.24	15.67 **	-1.35	3.13
51	CMS-850A X RHA138-2R	-2.56	-6.40 **	-6.16**	14.42 **	-4.44	5.16
52	CMS-850A X 856R	1.99	0.99	1.24	6.57 *	-11.78 **	-0.72
53	CMS-850A X AKSF-8R	0.74	0.49	1.24	-6.12 *	-18.84 **	-17.85**
54	CMS-850A X PKV-105R	2.91	1.44	4.71*	-3.44	-17.41 **	-14.28**
55	CMS-850A X 189/1R	-6.27 **	-7.88 **	-7.65**	7.80 **	-9.78 **	-1.24
56	CMS-850A X AKSF-12R	-3.96 *	-4.43 *	-4.18	5.94	-3.75	-13.11**
	RANGE	-6.27 to 24.12	-7.88 to 22.46	-7.64 to 13.10	-32.84 to 45.79	-37.46 to 36.73	-26.21 to 27.38
	SE(D)±	1.2511	1.4446	1.4446	0.7852	0.9067	0.9067
	CD 5%	2.4793	2.8628	2.8628	1.5561	1.7969	1.7969
	CD 1%	3.2794	3.7867	3.7867	2.0583	2.3767	2.3767

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 check (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-243A X AKSF-6R	4.65 **	3.92 **	1.75	36.59 **	34.44 **	5.09
2	CMS-243A X AKSF-14R	11.88 **	8.82 **	5.08**	57.70 **	57.32 **	19.68**
3	CMS-243A X RHA138-2R	3.89 **	0.83	3.46**	50.46 **	41.67 **	21.45**
4	CMS-243A X 856R	2.02	1.49	-0.97	43.72 **	34.91 **	16.40**
5	CMS-243A X AKSF-8R	6.85 **	3.91 **	6.18**	82.57 **	64.64 **	24.63**
6	CMS-243A X PKV-105R	8.59 **	5.64 **	2.02	14.77 **	-0.42	-24.61**
7	CMS-243A X 189/1R	6.20 **	4.23 **	0.65	53.59 **	51.51 **	17.89**
8	CMS-243A X AKSF-12R	3.53 **	0.71	-2.75	18.78 **	11.33 *	-15.73**
9	CMS-17A X AKSF-6R	-5.66 **	-6.34 **	-6.94**	59.73 **	40.62 **	9.92**
10	CMS-17A X AKSF-14R	3.87 **	-0.35	-1.00	64.48 **	46.52 **	11.47**
11	CMS-17A X RHA138-2R	2.81 **	1.19	3.82	10.90 **	-6.09	-19.50**
12	CMS-17A X 856R	2.97 **	2.06	1.39	49.88 **	26.59 **	9.22**
13	CMS-17A X AKSF-8R	-3.28 **	-4.61 **	-2.54*	6.79	5.59	-35.77**
14	CMS-17A X PKV-105R	8.70 **	4.30 **	3.61**	78.77 **	73.06 **	2.90
15	CMS-17A X 189/1R	5.47 **	2.08	1.41	27.07 **	12.08 **	-12.78**
16	CMS-17A X AKSF-12R	-1.69	-5.69 **	-6.29**	7.15	1.69	-32.66**
17	AKSF10-1A X AKSF-6R	0.32	0.24	-1.68	35.46 **	29.35 **	1.11
18	AKSF10-1A X AKSF-14R	3.79 **	0.20	-1.73	20.30 **	16.38 **	-11.47**
19	AKSF10-1A X RHA138-2R	-3.60 **	-5.72 **	-3.27**	53.28 **	40.22 **	20.20**
20	AKSF10-1A X 856R	-0.05	-0.3	-2.23	31.62 **	20.05 **	3.58
21	AKSF10-1A X AKSF-8R	-0.29	-2.29	-0.16	36.50 **	26.63 **	-9.94
22	AKSF10-1A X PKV-105R	3.96 **	0.37	-1.55	55.46 **	38.57 **	-1.45
23	AKSF10-1A X 189/1R	1.43	-1.21	-3.12*	0.46	-3.86	-25.19**
24	AKSF10-1A X AKSF-12R	3.87 **	0.28	-1.65	15.48 **	11.49 *	-20.72**
25	AKSF-12A X AKSF-6R	9.46 **	5.09 **	2.91*	60.43 **	46.30 **	14.35**
26	AKSF-12A X AKSF-14R	8.96 **	8.25 **	-1.18	31.05 **	20.98 **	-7.95*
27	AKSF-12A X RHA138-2R	-0.11	-6.19 **	-3.75**	70.64 **	49.40 **	28.07**
28	AKSF-12A X 856R	8.36 **	4.20 **	1.70	-17.28 **	-27.77 **	-37.67**
29	AKSF-12A X AKSF-8R	4.54 **	-1.63	0.50	94.64 **	89.27 **	21.87**
30	AKSF-12A X PKV-105R	14.29 **	13.54 **	3.67**	63.58 **	52.50 **	-1.81
31	AKSF-12A X 189/1R	-0.05	-1.59	-8.51**	-3.66	-11.97 **	-31.49**
32	AKSF-12A X AKSF-12R	3.81 **	3.14 *	-5.84**	21.59 **	19.92 **	-20.60**
33	CMS-234A X AKSF-6R	7.17 **	5.70 **	3.51**	80.81 **	60.65 **	25.57**
34	CMS-234A X AKSF-14R	12.51 **	10.18 **	4.92**	31.36 **	18.12 **	-10.14**
35	CMS-234A X RHA138-2R	6.68 **	2.85 *	5.53**	70.10 **	45.31 **	24.57**
36	CMS-234A X 856R	2.66 *	1.42	-1.02	-15.93 **	-28.37 **	-38.19**
37	CMS-234A X AKSF-8R	-3.08 **	-6.37 **	-4.35**	38.12 **	38.01 **	-16.04**
38	CMS-234A X PKV-105R	4.05 **	1.91	-2.96*	14.31 **	9.54	-33.48**
39	CMS-234A X 189/1R	2.66 *	1.44	-3.40**	21.46 **	8.13	-15.86**
40	CMS-234A X AKSF-12R	4.49 **	2.33	-2.54*	47.53 **	41.43 **	-6.36
41	CMS-10A X AKSF-6R	-0.07	-3.14 *	-5.16**	27.52 **	7.40	-16.04**

(*contd....Table 2*)

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)
42	CMS-10A X AKSF-14R	-0.20	-0.54	-8.59**	37.87 **	17.42 **	-10.68**
43	CMS-10A X RHA138-2R	-3.61 **	-8.63 **	-6.26**	28.52 **	4.37	-10.54**
44	CMS-10A X 856R	5.23 **	2.16	-0.29	27.18 **	3.03	-11.11**
45	CMS-10A X AKSF-8R	6.40 **	1.05	3.25**	40.52 **	32.06 **	-19.66**
46	CMS-10A X PKV-105R	4.85 **	4.51 **	-3.95**	85.86 **	82.25 **	1.45
47	CMS-10A X 189/1R	-9.67 **	-10.19 **	-16.50**	-5.79	-20.51 **	-38.15**
48	CMS-10A X AKSF-12R	-0.88	-1.22	-9.22**	3.33	-6.59	-38.15**
49	CMS-850A X AKSF-6R	-6.68 **	-6.71 **	-8.59**	68.60 **	46.56 **	14.55**
50	CMS-850A X AKSF-14R	10.18 **	6.42 **	4.27**	64.40 **	44.58 **	10.00**
51	CMS-850A X RHA138-2R	-0.58	-2.82 *	-0.29	76.25 **	47.47 **	26.42**
52	CMS-850A X 856R	3.87 **	3.66 **	1.57	33.19 **	11.15 **	-4.10
53	CMS-850A X AKSF-8R	4.32 **	2.18	4.40**	29.83 **	26.53 **	-23.02**
54	CMS-850A X PKV-105R	6.96 **	3.31 **	1.23	59.34 **	56.49 **	-9.66**
55	CMS-850A X 189/1R	1.03	-1.55	-3.54**	-3.97	-16.36 **	-34.91**
56	CMS-850A X AKSF-12R	-1.86	-5.21 **	-7.12**	5.19	-1.54	-34.81**
	RANGE	-9.67 to 14.29	-10.19 to 13.54	-16.50 to 6.18	-17.28 to 94.64	-28.37 to 89.27	-38.19 to 28.07
	SE(D)±	0.4077	0.4708	0.4708	1.4985	1.7303	1.7303
	CD 5%	0.808	0.9329	0.9329	2.9696	3.429	3.429
	CD 1%	1.0687	1.234	1.234	3.9279	4.5356	4.5356

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

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 -9.90 to 0.66 per cent. The crosses CMS17A x RHA-138-2R (-9.90%) and CMS 17A x 856R (-9.90%) showed highest negative standard heterosis followed by cross AKSF-12A x 856R (-9.57%) and AKSF-10-1A x AKSF-12R (-8.91%). Out of 56 crosses, 48 crosses recorded highly significant negative heterosis over check DRSH-1, indicating the early maturity in hybrids. Kandhola *et al*. (1995) and Phad *et al*. (2002) also reported earliness in hybrids. For the plant height, the cross AKSF-10-1A x 189/1R (-21.19%) exhibited highest negative average heterosis, followed by AKSF-10-1A x AKSF-8R (-19.87%) and AKSF-12A x 856R (-18.16%). Out of 56 crosses, 28 crosses recorded significant negative heterobeltiosis in desirable direction for this trait. As the check DRSH-1 is tall in growth habit the maximum negative standard heterosis for plant height were found in crosses CMS-17A x RHA-138-2R (-41.52%) followed by CMS-10A x RHA-138-2R (-39.66%) and CMS-10A x AKSF-14R (-38.65%).

Head diameter is an important yield contributing character attracting attention of the workers for better head size. Among the 56 hybrids CMS-17A x PKV-105R (78.34 & 29.42%) recorded highest significant positive heterosis over mid parent and standard check. As many as 33 hybrids recorded positive heterosis over better parent indicating that it is possible to combine better head size compared to commercial hybrids. Dutta *et al*. (2011) and Venkata and Nadaf (2013) reported significant positive heterosis for head diameter.

The 100 seed weight of a genotype serves as an indicator of seed yield as it is an important character contributing to yield. In the present investigation, most of the hybrids recorded positive heterosis over mid parent and better parent. Among 56 hybrids AKSF-10A x AKSF-8R (108.21 & 83.62%) recorded maximum significant positive heterosis over mid parent and better parent, whereas, CMS17A x AKSF-14R (57.55%) recorded highest standard heterosis. In general, the hybrid combinations with CMS 17A as female parents recorded the highest positive heterosis for 100 seed weight. These observations are in conformity with the reports of Patil *et al.* (2007), Sawargaonkar and Ghodke (2008) and Venkata and Nadaf (2013).

For the trait volume weight, total of 43 hybrids recorded significant positive heterosis over the mid parent and nine hybrids had significant positive heterosis over the check DRSH-1. The crosses CMS-243A x AKSF-14R (20.27%) and CMS-234A x RHA-138-2R (12.36%) recorded high standard heterosis for this trait. These observations support the reports of Patil *et al*. (2007), Sawargaonkar and Ghodke (2008) and Chandra *et al*.(2013).

The cross AKSF-10-1A x RHA-138-2R has recorded highest highly significant heterosis over mid (24.12%), better parent (22.46%) and standard check (13.01%) for seed filling percentage. The hybrids with RHA-138-2R as male parent resulted in higher seed filling per cent. Similar reports on significant positive heterosis have also been reported by Patil *et al*. (2007) and Dutta *et al*. (2011).

Negative association between hull content and oil content is well known in sunflower. For hull content majority of the hybrids (32) exhibited negative heterosis over the mid parent. The highest negative significant mid parent heterosis (- 32.84%) and better parent heterosis (37.46%) recorded by the hybrid CMS-243A x RHA-138-2R. The highest negative standard heterosis was recorded by the crosses AKSF-12A x AKSF-6R (-26.21%), followed by the cross CMS-234A x AKSF-12R (-22.94%).

For oil content, considerable amount of heterosis is observed in the present investigation, total of 35 hybrids exhibited significant positive average heterosis. The cross AKSF-12A x PKV-105R (14.29%) exhibited highest significant average heterosis for oil content, followed by CMS-234A x AKSF-14R (12.51%) and CMS-243A x AKSF-14R (11.88%) and these crosses also exhibited highest significant heterosis over better parents. As the oil content of DRSH-1 is generally high, the highest standard heterosis in desirable direction was recorded in the cross CMS-243A x AKSF-8R (6.18%), followed by cross CMS-234A x RHA-138-2R (5.53%) and CMS-243A x AKSF-14R (5.08%). Lande *et al.* (1998), Neelima *et al*. (2009) and Chandra *et al.* (2013) also noted heterosis for oil content in sunflower.

For the trait seed yield per plant, the results of heterosis over mid parent indicated prevalence of heterosis to an extent of 94.64 per cent and majority

Table 3
Mean yield performance and heterosis promising crosses

Crosses	*Mean seed yield / plant*	*Heterosis (%) for seed yield* H_1	H_2	H_3	*Significant H_3 for other characters*	*Oil content (%)*
AKSF-12A X RHA138-2R	64.42**	70.64 **	49.40 **	28.07**	1,2,4,5,7	36.75
CMS-850A X RHA138-2R	63.59**	76.25 **	47.47 **	26.42**	1,2,3,4,5	38.07
CMS-234A X AKSF-6R	63.16**	80.81 **	60.65 **	25.57**	1,2,4,5,7,9	39.52**
CMS-243A X AKSF-8R	62.69**	82.57 **	64.64 **	24.63**	1,2,4,5,7,8,9	40.54**
CMS -234A X RHA138-2R	62.66**	70.10 **	45.31 **	24.57**	1,2,3,4,5,6,9	40.29**

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

H_1 - Average heterosis ; H_2 - Heterobeltiosis; H_3 - Standard heterosis over DRSH-1

1) Days to 50% Flowering	2) days to Maturity	3) Plant height
4) Head diameter	5) 100 seed weight	6) Volume weight
7) Seed filling percentage	8) Hull content	9) Oil content.

of the crosses were observed to be positive and significant in their expression. The cross AKSF-12A x AKSF-8R recorded the highest heterosis of 94.94 per cent which is followed by CMS-10A x PKV-105R with 85.86 per cent and CMS-243A X AKSF-8R with 82.57 per cent. The cross AKSF-12A x AKSF-8R (89.27%) recorded highest significant positive heterosis over better parent, followed by CMS-10A x PKV-105R (82.25%). The prevalence of substantial magnitude of heterosis for seed yield over better parents has also been reported by Dutta *et al.* (2011). The standard heterosis over check hybrid DRSH-1 ranged from -38.19 per cent (CMS-234A x 856R) to 28.07 per cent (AKSF-12A x RHA-138-2R). A total of 17 hybrids recorded positive significant heterosis over DRSH-1. The highest significant standard heterosis recorded in the cross, AKSF-12A x RHA-138-2R (28.07%), followed by cross CMS-850A x RHA-138-2R (26.42%) and CMS-234A x AKSF-6R (25.57%). The standard heterosis involving RHA-138-2R, AKSF-8R and AKSF-14R as male parents was appreciably high than those involving other tester parents. Among female parents, crosses involving CMS-243A and CMS-234A recorded higher heterosis over the checks followed by CMS-850A. Similar results about the higher standard heterosis for seed yield per plant were also reported by Kalpande *et al*. (2004), Neelima *et al*. (2009) and Ventaka and Nadaf (2013).

On the basis of mean seed yield performance, heterosis, heterobeltiosis, standard heterosis (Table 3), the crosses AKSF-12A x RHA-138-2R, CMS-850A x RHA-138-2R, CMS-234A x AKSF-6R, CMS-243A x AKSF-8R and CMS-234A x RHA-138-2R are identified as promising crosses for seed yield. Out of these five promising crosses three crosses *viz.*, CMS-243A x AKSF-8R, CMS-234A x RHA-138-2R and CMS-234A x AKSF-6R are identified as promising crosses for seed yield as well as oil content and thus, these crosses needs further evaluation in preliminary or multilocation hybrid trials for further commercial exploitation.

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