

Original Research Article

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Heterotic Studies on Yield and its Component Traits in Sunflower Hybrids

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ABSTRACT

The experiment was conducted at college of Agriculture, Vijayapur to study heterotic performance of 40 sunflower hybrids over the checks (Standard heterosis) during *khari*2018. The experiment consisted of 8 testers and 5 lines used in line x tester fashion to produce 40 hybrid combinations. These 40 hybrid combinations were studied for heterosis performance over two checks KBSH-53 and Cauvery Champ respectively. All the hybrid combinations showed negative heterosis for days to 50 % flowering over checks indicating earliness over both the checks. Among them The crosses CMS 7-1-1 A × DSR-37 and CMS-1030A × DSR-13 exhibited highest negative values of -25 per cent over KBSH-53 and -28 percent over cauvery champ. Similarly for plant height, all the combinations shown positive heterosis indicating tallness dominant over checks used. The crosses CMS 7-1-1 A ×DSR-37 and CMS-853A × DSR-19 recorded highest positive heterosis of 25.68 percent heterosis over KBSH-53 and 28.25 heterosis percent over cauvery champ with respect to yield (kg ha⁻¹). Similarly the cross CMS-853A ×DSR-19 exhibited maximum heterotic per cent of 22 and 25 percent over KBSH-53 and cauvery champ respectively for oil content.

Keywords

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Introduction

Sunflower (*Helianthus annuus* L.) is the most important oilseed crop after soybean in the world, belonging to Asteraceae/ Compositae family originated from temperate North America and has high content of unsaturated fatty acids and lacks cholesterol, thus there is a high oil benefits from it with a desirable quality. It is a diploid crop with an haploid genome size of about 3000 Mb with diploid

chromosome number $2n=34$ (Darvishzadeh *et al.*, 2010). Sunflower has been successfully cultivated over a widely scattered geographical area across the world. It is a highly cross pollinated crop, which can be adapted to a various environmental conditions having high yield potential. Due to its photo insensitiveness it can be grown in all seasons and can be taken in various inter and sequence cropping systems. Due to its moderate requirements and high oil quality,

its acreage has been increased in both developing and developed countries.

However, the average productivity of crop is a major concern in India, which is less than half the world's average yield due to its cultivation under rainfed situation. Hence Heterosis the most important contributions towards improvisation in agriculture with respect to yield. Since farmers mainly prefer hybrids to cultivate in larger areas, this heterosis exploitation is best suited for increase in the yield of the crop. However, the EC 68414 (Peredovik), EC 68415 (Armaviriski, 3497) and Morden (Cermianka-66) are the open pollinated varieties through which the commercial cultivation of sunflower started in our country.

The importance of hybrids especially in sunflower has been increasing now a days because of its higher seed yield capacity when compared with other cross-pollinated varieties in the world. Hybrids are more stable, highly self-fertile, with high yielding ability and more uniformity at maturity.

Drought and disease tolerance breeding has gained its importance in obtaining hybrid varieties. The heterotic performance of a hybrid combination (showing superiority when compared to their parents) mainly depends upon the combining abilities of parents used.

Scientists reported that heterotic hybrids have been obtained by crossing inbred CMS female and restorer lines having high GCA (General Combining Ability) and SCA (Specific Combining Ability) values. This higher GCA variance refers to additive gene action depicting breeding value of the particular line, while higher SCA variance indicates the greater role of non-additive gene action, which is of great importance in heterosis breeding (Shabbir *et al.*, 2016).

Materials and Methods

The 40 hybrids along with checks (KBSH-53 and cauvery champ) were evaluated in field condition during *kharif*, 2018 in randomised block design with two replications at college of Agriculture Vijayapura. Two rows of each hybrid were sown with a spacing of 60 cm × 30 cm and row length of 4 m. All the recommended package of practices were followed to raise a good crop. Protective irrigation was given for three times during the cropping period. Per cent heterosis of the derived F₁ over checks KBSH-53 and Cauvery Champ was considered for calculating standard heterosis for all the characters. Heterosis for each trait was computed by using the following formulae

Per cent heterosis over standard check hybrid (CH)=

$$\frac{F_1 - CH}{CH} \times 100$$

The observations were recorded from five randomly tagged plants in each hybrid from both the replication. The following observations were recorded *viz.*, days to 50 per cent flowering, days to maturity, relative chlorophyll content using SPAD chlorophyll meter at 45 DAS, relative chlorophyll content using SPAD chlorophyll meter at 60 DAS, head diameter, seed yield per plant, test weight, seed yield per hectare and oil content respectively. The analysis was carried out using windostat software.

Results and Discussion

Heterosis is the superiority of F₁ over the mid parent, better parent or standard check in either direction, *i.e* it may be positive or negative heterosis. The present study included heterosis over standard checks (Hayes *et al.*, 1956). Heterosis is the driving force globally for acceptance of sunflower as a major oilseed crop with its high potential for enhancing the productivity.

Table.1 Standard heterosis (%) over the check (KBSH-53 and Cauvery champ) for SPAD at 45 DAS and SPAD at 60 DAS in sunflower

SI No	Crosses	SPAD at 45 DAS			SPAD at 60 DAS		
		F ₁ mean	% heterosis over		F ₁ mean	% heterosis over	
			KBSH 53	C Champ		KBSH 53	C Champ
1	CMS 21A × DSR-13	37.73	0.72	1.70	32.73	0.83	1.96
2	CMS 21A × DSR19	36.56	-2.40	-1.46	31.56	-2.77	-1.68
3	CMS 21A × DSR 23	38.03	1.52	2.51	33.03	1.76	2.90
4	CMS 21A × DSR 35	38.82	3.63	4.64	33.82	4.19	5.36
5	CMS 21A × DSR 37	43.94	17.30 *	18.44 *	39.94	23.04 *	24.42 **
6	CMS 21A × DSR 66	36.04	-3.79	-2.86	31.04	-4.37	-3.30
7	CMS 21A × DSR-107	38.92	3.90	4.91	33.92	4.50	5.67
8	CMS 21A × DSR-132	41.33	10.33	11.40	40.33	24.25**	25.64 **
9	CMS-1030A × DSR-13	38.15	1.83	2.82	33.14	2.11	3.26
10	CMS-1030A × DSR-19	36.87	-1.58	-0.62	31.87	-1.82	-0.72
11	CMS-1030A × DSR-23	30.92	-17.4 *	-16.66 *	25.92	-20.15*	-19.25 *
12	CMS-1030A × DSR-35	32.49	-13.27	-12.43	33.49	3.17	4.33
13	CMS-1030A × DSR-37	41.77	11.51	12.59	38.27	17.90 *	19.22 *
14	CMS-1030A × DSR-66	42.61	13.75	14.85 *	37.61	15.87	17.17 *
15	CMS-1030A × DSR-107	41.79	11.56	12.64	36.79	13.34	14.61
16	CMS-1030A × DSR-132	41.53	10.86	11.94	36.53	12.54	13.80
17	4546 × DSF 2A × DSR13	34.83	-7.02	-6.12	29.83	-8.10	-7.07
18	4546 × DSF 2A × DSR19	36.33	-3.02	-2.08	31.33	-3.48	-2.40
19	4546 × DSF 2A × DSR23	32.07	-14.3*	-13.56	29.07	-10.44	-9.44
20	4546 × DSF 2A × DSR35	39.63	5.79	6.82	34.63	6.69	7.88
21	4546 × DSF 2A × DSR37	40.11	7.07	8.11	38.11	17.41	18.72 *
22	4546 × DSF 2A × DSR66	40.26	7.47	8.52	35.26	8.63	9.84
23	4546 × DSF 2A × DSR107	38.53	2.86	3.85	33.53	3.30	4.45
24	4546 × DSF 2A × DSR132	40.40	7.84	8.88	44.75	37.86**	39.41 **
25	CMS 7-1-1 A × DSR-13	35.98	-3.95	-3.02	30.98	-4.56	-3.49
26	CMS 7-1-1 A × DSR-19	39.44	5.29	6.31	34.44	6.10	7.29
27	CMS 7-1-1 A × DSR-23	37.43	-0.08	0.89	32.43	-0.09	7.29
28	CMS 7-1-1 A × DSR-35	37.80	0.91	1.89	45.2	39.25**	40.81 **
29	CMS 7-1-1 A × DSR-37	36.63	-2.22	-1.27	45.85	41.25**	42.83 **
30	CMS 7-1-1 A × DSR-66	39.03	4.19	5.20	34.03	4.84	6.01
31	CMS 7-1-1 A × DSR-107	38.22	2.03	3.02	33.22	2.34	3.49
32	CMS 7-1-1 A × DSR-132	36.46	-2.67	-1.73	34.96	7.70	8.91
33	CMS-853A × DSR-13	39.53	5.53	6.55	34.53	6.38	7.57
34	CMS-853A × DSR-19	41.78	11.53	12.61	45.18	39.19**	40.75 **
35	CMS-853A × DSR-23	39.02	4.16	5.18	45	38.63**	40.19 **
36	CMS-853A × DSR-35	38.78	3.52	4.53	33.78	4.07	5.23
37	CMS-853A × DSR-37	37.58	0.32	1.29	32.58	0.37	1.50
38	CMS-853A × DSR-66	40.18	7.26	8.30	35.18	8.38	9.60
39	CMS-853A × DSR-107	44.53	18.87 *	20.03 **	34.53	6.38	7.57
40	CMS-853A × DSR-132	35.43	-5.42	-4.50	30.43	-6.25	-5.20
C1	KBSH-53	37.46			32.46		
C2	Cauvery champ	37.10			32.10		

** Significance at 5% * Significance at 1 %

Table.2 Standard heterosis (%) over the check (KBSH-53 and Cauvery champ) for days to 50 % flowering and days to maturity in sunflower

SI No	Crosses	Days to 50 % flowering			Days to maturity		
		F ₁ mean	% heterosis over		F ₁ mean	% heterosis over	
			KBSH-53	C. Champ		KBSH-53	C. Champ
1	CMS 21A × DSR-13	65	-9.72 **	-13.33 **	97	-9.35 *	-19.83 **
2	CMS 21A × DSR19	57	-20.83 **	-24.00 **	96	-10.28 *	-20.66 **
3	CMS 21A × DSR 23	58	-19.44 **	-22.67 **	96	-10.28 *	-20.66 **
4	CMS 21A × DSR 35	56	-22.22 **	-25.33 **	99	-7.48	-18.18 **
5	CMS 21A × DSR 37	55	-23.61 **	-26.67 **	93	-13.08 **	-23.14 **
6	CMS 21A × DSR 66	59	-18.75 **	-22.00 **	95	-11.21 **	-21.49 **
7	CMS 21A × DSR-107	60	-16.67 **	-20.00 **	104	-2.80	-14.05 **
8	CMS 21A × DSR-132	55	-23.61 **	-26.67 **	97	-9.35 *	-19.83 **
9	CMS-1030A × DSR-13	54	-25.00 **	-28.00 **	97	-9.35 *	-19.83 **
10	CMS-1030A × DSR-19	60	-16.67 **	-20.00 **	99	-7.48	-18.18 **
11	CMS-1030A × DSR-23	66	-9.03 *	-12.67 **	100	-6.54	-17.36**
12	CMS-1030A × DSR-35	56	-22.22 **	-25.33 **	104	-2.80	-14.05 **
13	CMS-1030A × DSR-37	57	-20.83 **	-24.00 **	105	-1.87	-13.22 **
14	CMS-1030A × DSR-66	61	-15.28 **	-18.67 **	107	0.00	-11.57 **
15	CMS-1030A × DSR-107	58	-20.14 **	-23.33 **	93	-13.08 **	-23.14 **
16	CMS-1030A × DSR-132	57	-20.83 **	-24.00 **	97	-9.35 *	-19.83 **
17	4546 × DSF 2A × DSR13	63	-13.19 **	-16.67 **	102	-4.67	-15.70 **
18	4546 × DSF 2A × DSR19	65	-10.42 **	-14.00 **	90	-15.89 **	-25.62 **
19	4546 × DSF 2A × DSR23	61	-15.97 **	-19.33 **	98	-8.41 *	-19.01 **
20	4546 × DSF 2A × DSR35	60	-16.67 **	-20.00 **	107	0.00	-11.57 **
21	4546 × DSF 2A × DSR37	60	-16.67 **	-20.00 **	105	-1.87	-13.22 **
22	4546 × DSF 2A × DSR66	67	-6.94 *	-10.67 **	95	-11.21 **	-21.49 **
23	4546 × DSF 2A × DSR107	57	-21.53 **	-24.67 **	96	-10.28 *	-20.66 **
24	4546 × DSF 2A × DSR132	56	-22.22 **	-25.33 **	97	-9.35 *	-19.83 **
25	CMS 7-1-1 A × DSR-13	65	-10.42 **	-14.00 **	98	-8.41 *	-19.01 **
26	CMS 7-1-1 A × DSR-19	56	-22.92 **	-26.00 **	101	-5.61	-16.53 **
27	CMS 7-1-1 A × DSR-23	55	-24.31 **	-27.33 **	99	-7.94	-18.60 **
28	CMS 7-1-1 A × DSR-35	59	-18.06 **	-21.33 **	99	-7.48	-18.18 **
29	CMS 7-1-1 A × DSR-37	54	-25.00 **	-28.00 **	103	-3.74	-14.88 **
30	CMS 7-1-1 A × DSR-66	55	-24.31 **	-27.33 **	92	-14.02**	-23.97 **
31	CMS 7-1-1 A × DSR-107	57	-21.53 **	-24.67 **	96	-10.28 *	-20.66 **
32	CMS 7-1-1 A × DSR-132	55	-23.61 **	-26.67 **	93	-13.08**	-23.14 **
33	CMS-853A × DSR-13	56	-22.92 **	-26.00 **	97	-9.35 *	-19.83 **
34	CMS-853A × DSR-19	58	-19.44 **	-22.67 **	96	-10.28 *	-20.66 **
35	CMS-853A × DSR-23	58	-19.44 **	-22.67 **	99	-7.48	-18.18 **
36	CMS-853A × DSR-35	57	-21.53 **	-24.67 **	101	-5.61	-16.53 **
37	CMS-853A × DSR-37	56	-22.22 **	-25.33 **	97	-9.35 *	-19.83 **
38	CMS-853A × DSR-66	58	-19.44 **	-22.67 **	99	-7.48	-18.18 **
39	CMS-853A × DSR-107	55	-24.31 **	-27.33 **	100	-6.54	-17.36 **
40	CMS-853A × DSR-132	58	-20.14 **	-23.33 **	92	-14.02**	-23.97 **
C1	KBSH-53	72			107		
C2	Cauvery champ	75			121		

** Significance at 5% * Significance at 1 %

Table.3 Standard heterosis (%) over the check (KBSH-53 and Cauvery champ) for plant height and head diameter in sunflower

Sl. No	Crosses	Plant height (cm)			Head diameter (cm)		
		F ₁ mean	% heterosis over		F ₁ mean	% heterosis over	
			KBSH-53	C. Champ		KBSH-53	C. Champ
1	CMS 21A × DSR-13	112.20	47.83 **	40.78**	6.49	13.07	10.19
2	CMS 21A × DSR19	103.40	36.23 **	29.74 **	6.25	8.89	6.11
3	CMS 21A × DSR 23	88.20	16.21 *	10.66	6.58	14.63	11.71
4	CMS 21A × DSR 35	104.00	37.02 **	30.49 **	6.30	9.76	6.96
5	CMS 21A × DSR 37	112.60	48.35 **	41.28 **	7.70	34.15 **	30.73 **
6	CMS 21A × DSR 66	128.60	69.43 **	61.36 **	7.57	31.88 **	28.52 **
7	CMS 21A × DSR-107	126.50	66.67 **	58.72 **	6.80	18.47 *	15.45
8	CMS 21A × DSR-132	114.80	51.25 **	44.04 **	5.76	0.35	-2.21
9	CMS-1030A × DSR-13	120.90	59.29 **	51.69 **	6.25	8.89	6.11
10	CMS-1030A × DSR-19	124.40	63.90 **	56.09 **	7.06	23.00 *	19.86 *
11	CMS-1030A × DSR-23	127.80	68.38 **	60.35 **	6.23	8.54	5.77
12	CMS-1030A × DSR-35	132.40	74.44 **	66.12 **	7.51	30.84 **	27.50 **
13	CMS-1030A × DSR-37	169.10	122.79**	112.17 **	9.10	58.54 **	54.50 **
14	CMS-1030A × DSR-66	104.60	37.81 **	31.24 **	7.27	26.66 **	23.43 *
15	CMS-1030A × DSR-107	110.40	45.45 **	38.52 **	7.76	35.19 **	31.75 **
16	CMS-1030A × DSR-132	125.00	64.69 **	56.84 **	7.90	37.63 **	34.13 **
17	4546 × DSF 2A × DSR-13	108.60	43.08 **	36.26 **	6.80	18.47 *	15.45
18	4546 × DSF 2A × DSR-19	102.50	35.05 **	28.61 **	7.02	22.30 *	19.19 *
19	4546 × DSF 2A × DSR-23	96.60	27.27 **	21.20 **	6.82	18.82 *	15.79
20	4546 × DSF 2A × DSR-35	97.00	27.80 **	21.71 **	7.46	29.97 **	26.66 **
21	4546 × DSF 2A × DSR-37	77.20	1.71	-3.14	6.95	21.08 *	18.00
22	4546 × DSF 2A × DSR-66	84.60	11.46	6.15	5.72	-0.35	-2.89
23	4546 × DSF 2A ×DSR-107	90.60	19.37 *	13.68	6.07	5.75	3.06
24	4546 × DSF 2A ×DSR-132	107.20	41.24 **	34.50 **	9.01	56.97**	52.97 **
25	CMS 7-1-1 A × DSR-13	92.80	22.27 **	16.44 *	6.67	16.20	13.24
26	CMS 7-1-1 A × DSR-19	98.00	29.12 **	22.96 **	8.06	40.42 **	36.84 **
27	CMS 7-1-1 A × DSR-23	91.10	20.03 *	14.30	7.94	38.33 **	34.80 **
28	CMS 7-1-1 A × DSR-35	91.10	20.03 *	14.30	9.20	60.37**	56.28 **
29	CMS 7-1-1 A × DSR-37	114.10	50.33 **	43.16 **	9.42	64.11**	59.93 **
30	CMS 7-1-1 A × DSR-66	89.10	17.39 *	11.79	6.44	12.20	9.34
31	CMS 7-1-1 A × DSR-107	105.60	39.13 **	32.50 **	8.21	43.03 **	39.39 **
32	CMS 7-1-1 A × DSR-132	140.70	85.38 **	76.54 **	7.36	28.22 **	24.96 **
33	CMS-853A × DSR-13	129.10	70.09 **	61.98 **	9.46	64.81 **	60.61 **
34	CMS-853A × DSR-19	125.90	65.88 **	57.97 **	9.47	65.07**	60.87 **
35	CMS-853A × DSR-23	123.40	62.58 **	54.83 **	9.70	68.99**	64.69 **
36	CMS-853A × DSR-35	121.40	59.95 **	52.32 **	8.05	40.24 **	36.67 **
37	CMS-853A × DSR-37	124.90	64.56 **	56.71 **	8.72	51.92 **	48.05 **
38	CMS-853A × DSR-66	120.00	58.10 **	50.56 **	9.56	66.55 **	62.31 **
39	CMS-853A × DSR-107	110.70	45.85 **	38.90 **	10.19	77.53 **	73.01 **
40	CMS-853A × DSR-132	129.80	71.01 **	62.86 **	10.13	76.48 **	71.99 **
C1	KBSH-53	75.90			5.74		
C2	Cauvery champ	79.70			5.89		

** Significance at 5% * Significance at 1 %

Table.4 Standard heterosis (%) over the check (KBSH-53 and Cauvery champ) for test weight and yield ha⁻¹ in sunflower

Sl. No	Crosses	Test weight (g)			Yield ha ⁻¹ (kg)		
		F ₁ mean	% Heterosis over		F ₁ Mean	% Heterosis over	
			KBSH -53	C. Champ		KBSH -53	C. Champ
1	CMS 21A × DSR-13	3.34	-4.30	-3.75	446.15	-10.17	-8.30
2	CMS 21A × DSR19	3.38	-3.15	-2.59	388.46	-21.75	-20.16
3	CMS 21A × DSR 23	3.65	4.58	5.19	513.46	3.42	5.53
4	CMS 21A × DSR 35	3.57	2.29	2.88	512.31	3.42	5.30
5	CMS 21A × DSR 37	3.77	8.02	8.65	479.23	-3.52	-1.50
6	CMS 21A × DSR 66	3.83	9.74	10.37	479.23	-3.52	-1.50
7	CMS 21A × DSR-107	3.89	11.46	12.10	502.31	1.11	3.24
8	CMS 21A × DSR-132	3.39	-2.87	-2.31	477.35	-3.83	-1.89
9	CMS-1030A × DSR-13	4.03	15.47	16.14	471.54	-5.04	-3.08
10	CMS-1030A × DSR-19	3.73	6.88	7.49	511.54	3.02	5.14
11	CMS-1030A × DSR-23	4.24	21.49 *	22.19 *	494.23	-0.50	1.58
12	CMS-1030A × DSR-35	3.91	12.03	12.68	559.62	12.69	15.02
13	CMS-1030A × DSR-37	4.06	16.33	17.00	561.54	13.09	15.42
14	CMS-1030A × DSR-66	3.57	2.29	2.88	417.31	-15.91	-14.23
15	CMS-1030A × DSR-107	3.51	0.57	1.15	511.54	3.02	5.14
16	CMS-1030A × DSR-132	3.81	9.17	9.80	390.38	-21.35	-19.76
17	4546 × DSF 2A × DSR-13	3.71	6.30	6.92	351.92	-29.10 *	-27.67 *
18	4546 × DSF 2A × DSR-19	3.10	-11.17	-10.66	378.85	-23.67	-22.13 *
19	4546 × DSF 2A × DSR-23	3.21	-8.02	-7.49	398.08	-19.84	-18.18
20	4546 × DSF 2A × DSR-35	3.19	-8.60	-8.07	353.85	-28.70 *	-27.27 *
21	4546 × DSF 2A × DSR-37	3.37	-3.44	-2.88	319.23	-35.75**	-34.39 **
22	4546 × DSF 2A × DSR-66	3.54	1.43	2.02	384.62	-22.56	-20.95
23	4546 × DSF 2A × DSR-107	3.50	0.29	0.86	305.77	-38.47**	-37.15 **
24	4546 × DSF 2A × DSR-132	4.62	32.38**	33.14**	607.50	22.36**	24.86 *
25	CMS 7-1-1 A × DSR-13	4.01	14.90	15.56	503.85	1.51	3.56
26	CMS 7-1-1 A × DSR-19	3.45	-1.15	-0.58	574.92	15.81	18.17
27	CMS 7-1-1 A × DSR-23	3.92	12.32	12.97	542.31	9.26	11.46
28	CMS 7-1-1 A × DSR-35	4.51	29.23**	29.97**	618.50	24.57**	27.12 *
29	CMS 7-1-1 A × DSR-37	4.77	36.82**	37.46**	624.00	25.68**	28.25 *
30	CMS 7-1-1 A × DSR-66	3.24	-7.16	-6.63	528.85	6.55	8.70
31	CMS 7-1-1 A × DSR-107	3.55	1.72	2.31	563.46	13.49	15.81
32	CMS 7-1-1 A × DSR-132	3.69	5.73	6.34	571.15	15.01	17.39
33	CMS-853A × DSR-13	3.80	8.88	9.51	398.08	-19.84	-18.18
34	CMS-853A × DSR-19	4.40	26.07**	26.80 **	624.00	25.68 *	28.25*
35	CMS-853A × DSR-23	4.46	27.94**	28.53 **	619.00	24.67 *	27.23*
36	CMS-853A × DSR-35	4.04	15.76	16.43	415.77	-16.31	-14.55
37	CMS-853A × DSR-37	3.62	3.72	4.32	557.69	12.39	14.62
38	CMS-853A × DSR-66	3.74	7.16	7.78	519.23	4.53	6.72
39	CMS-853A × DSR-107	3.77	8.02	8.65	353.85	-28.70 *	-27.27 *
40	CMS-853A × DSR-132	3.72	6.59	7.20	542.31	9.16	11.46
C1	KBSH-53	3.29			496.50		
C2	Cauvery champ	3.47			486.50		

Table.5 Standard heterosis (%) over the check (KBSH-53 and Cauvery champ) for Oil content and oil yield in sunflower

SI No	Crosses	Oil content (%)			Oil yield (kg ha ⁻¹)		
		F ₁ mean	% Heterosis over		F ₁ Mean	% Heterosis over	
			KBSH-53	C Champ		KBSH -53	C. Champ
1	CMS 21A × DSR-13	35.50	-4.52	-2.07	158.82	-13.84	-9.41
2	CMS 21A × DSR19	36.11	-2.88	-0.39	140.23	-23.93	-20.02
3	CMS 21A × DSR 23	40.61	9.23	12.03*	209.44	13.63	19.47
4	CMS 21A × DSR 35	39.73	6.87	9.62	203.46	10.38	16.06
5	CMS 21A × DSR 37	41.35	11.22	14.07*	198.56	7.73	13.26
6	CMS 21A × DSR 66	36.46	-1.92	0.59	175.14	-4.99	-0.10
7	CMS 21A × DSR-107	35.91	-3.42	-0.94	180.34	-2.15	2.89
8	CMS 21A × DSR-132	40.44	8.77	11.56	192.85	4.62	10.00
9	CMS-1030A × DSR-13	41.60	11.90*	14.77 *	196.82	6.78	12.27
10	CMS-1030A × DSR-19	41.12	10.60	13.44 *	210.50	14.20	20.07
11	CMS-1030A × DSR-23	40.14	7.95	10.73	198.09	7.47	12.99
12	CMS-1030A × DSR-35	43.40	16.73**	19.73 **	242.68	31.66**	38.43 **
13	CMS-1030A × DSR-37	37.75	1.53	4.14	211.28	14.62	20.51
14	CMS-1030A × DSR-66	38.47	3.48	6.14	159.04	-13.72	-9.28
15	CMS-1030A × DSR-107	40.00	7.59	10.35	205.04	11.24	16.96
16	CMS-1030A × DSR-132	37.16	-0.04	2.52	144.82	-21.44	-17.40
17	4546 × DSF 2A × DSR-13	36.12	-2.85	-0.36	128.17	-30.47*	-26.89 *
18	4546 × DSF 2A × DSR-19	34.43	-7.38	-5.01	130.67	-29.11*	-25.47
19	4546 × DSF 2A × DSR-23	40.09	7.84	10.61	161.00	-12.65	-8.16
20	4546 × DSF 2A × DSR-35	36.20	-2.62	-0.12	127.49	-30.84	-27.28 *
21	4546 × DSF 2A × DSR-37	39.32	5.76	8.47	125.91	-31.69*	-28.18 *
22	4546 × DSF 2A × DSR-66	32.00	-13.92	-11.71 **	123.18	-33.17*	-29.74 *
23	4546 × DSF 2A ×DSR-107	39.78	7.01	9.75	121.99	-33.82*	-30.42 *
24	4546 × DSF 2A ×DSR-132	43.50	17.01**	20.02 **	264.83	43.67**	51.06 **
25	CMS 7-1-1 A × DSR-13	38.36	3.19	5.84	193.37	4.90	10.30
26	CMS 7-1-1 A × DSR-19	43.05	15.8**	18.78 **	247.84	34.46**	41.37 **
27	CMS 7-1-1 A × DSR-23	43.34	16.58**	19.58 **	234.97	27.48**	34.03 *
28	CMS 7-1-1 A × DSR-35	44.37	19.35**	22.42 **	274.06	48.68**	56.33 **
29	CMS 7-1-1 A × DSR-37	44.00	18.35**	21.40 **	275.53	48.93**	56.59 **
30	CMS 7-1-1 A × DSR-66	38.83	4.45	7.13	204.58	10.99	16.69
31	CMS 7-1-1 A × DSR-107	41.29	11.07	13.92 *	232.67	26.22*	32.72 *
32	CMS 7-1-1 A × DSR-132	39.87	7.25	10.00	227.95	23.66	30.02 *
33	CMS-853A × DSR-13	38.84	4.47	7.15	153.98	-16.46	-12.17
34	CMS-853A × DSR-19	45.57	22.58 **	25.73 **	284.70	54.45**	62.39 **
35	CMS-853A × DSR-23	45.07	21.24 **	24.35 **	278.95	51.33**	59.12 **
36	CMS-853A × DSR-35	40.81	9.76	12.58 *	168.67	-8.50	-3.79
37	CMS-853A × DSR-37	39.39	5.96	8.68	219.67	19.17	25.30
38	CMS-853A × DSR-66	36.44	-1.98	0.54	189.25	2.67	7.95
39	CMS-853A × DSR-107	30.69	-17.44	-15.33 *	107.54	-41.66**	-38.66 **
40	CMS-853A × DSR-132	34.56	-7.03	-4.65	187.21	1.56	6.78
C1	KBSH-53	37.17			184.33		
C2	Cauvery champ	36.24			175.31		

** Significance at 5% * Significance at 1 %

Table.6 Promising hybrids with maximum seed yield and its component traits in sunflower

Traits	CMS 853A × DSR-19	CMS 7-1-1 A × DSR-37	CMS 853A × DSR-23	CMS 7-1-1 A × DSR-35	4546 × DSF 2A × DSR-132	KBSH-53 (check)	Cauvery champ (check)
SPAD at 45 DAS	41.78	36.63	39.02	37.80	40.40	37.46	37.10
SPAD at 60 DAS	45.18	45.85	45.00	45.20	44.75	32.46	32.10
DFF	58.00	54.00	58.00	59.00	56.00	72.00	75.00
DM	96.00	103.00	99.00	99.00	97.00	107.00	121.00
PH (cm)	125.90	114.10	123.40	91.10	107.20	75.9	79.70
HD (cm)	9.47	9.42	9.70	9.20	9.01	5.74	5.89
TW (g)	4.40	4.77	4.46	4.51	4.62	3.49	3.47
YI ha⁻¹ (kg)	624.00	624.00	619.00	618.50	607.50	496.5	486.53
OC (%)	45.57	44.00	45.07	44.37	43.50	37.17	36.24
OY(kg ha⁻¹)	284.70	275.53	278.95	274.06	264.83	184.33	175.31

DFF- Days to 50% flowering, DM- Days to maturity, PH- Plant height, HD-Head diameter , TW- Test weight, YI/ha- Seed yield per hectare, OC- Oil content, OY- Oil yield

Figure.1 Performance of top three hybrids compared to checks



CMS 7-1-1A x DSR-37



CMS 853A x DSR-19



CMS 853A x DSR-13



KBSH-53



Cauvery champ

The nature and magnitude of heterosis is important for heterosis breeding. The variance due to additive and non additive gene actions are important considerations for identification of best heterotic combination with its magnitude of expression for yield and its related traits. The commercialization of hybrids began with the release of first ever sunflower hybrid, BSH-1 in 1980 (Seetharam, 1981) for commercial utilization.

The standard heterosis percentage estimated for different traits studied are depicted under Table 1 to Table 5. The top five hybrids with maximum productivity is depicted in Table 6. The picture showing top three hybrid performance is shown in Figure 1

Heterosis in the negative direction is desired with respect to days to flowering, since it is closely related with days to maturity even though there is a genetic difference from flowering to maturity. Thus negative value indicates the earliness over the standard check used. The crosses CMS 7-1-1 A × DSR-37 and CMS-1030A × DSR-13 exhibited highest negative values of -25 percent over KBSH-53 and -28 percent over cauvery champ. The similar report of earliness in sunflower hybrids shown by Radhika *et al.* (2001), and Saleem (2011)

The plant height is one of the important contributor towards the yield related trait which was reported by Manivannan *et al.*(2005) and Shakuntala (2014). All the combinations except 4546A × DSF-2A × DSR-37 and 4546A × DSF-2A × DSR-66 exhibited significant positive heterosis over KBSH-53

Similarly for head diameter, the hybrid combinations involved both positive and negative heterotic values. Out of 40 hybrids, 29 hybrids exhibited significant positive heterosis over KBSH-53 and 25 hybrids

exhibited significant positive heterosis over Cauvery champ. The hybrid CMS-853A × DSR-107 recorded highest heterotic percent of 77 and 73 percent over KBSH-53 and cauvery champ respectively. Asif (2010), Keerthi (2010), Shakuntala (2014) reported negative heterosis for head diameter.

The crosses CMS 7-1-1 A ×DSR-37 and CMS-853A × DSR-19 recorded highest positive heterosis of 25.68 percent heterosis over KBSH-53 and 28.25 heterosis percent over cauvery champ for yield per ha. In sunflower, Similar results with heterosis in both the direction for seed yield per ha was reported by Madrap and Makne (1993) and Seetharam *et al.* (2001). CMS-853A ×DSR-19 exhibited maximum heterotic per cent of 22 and 25 percent over KBSH-53 and cauvery champ respectively. Similar results were reported by several workers *viz.*,Shivaraju (1984) and Alone *et al.* (2003).

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