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ESTIMATION OF HETEROSIS FOR AGRONOMICALY IMPORTANT TRAITS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

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ABSTRACT

Forty two hybrids were tested using line × tester design involving three cytoplasmic male sterile lines and fourteen new restorer lines to study the magnitude and direction of heterosis over better parent and standard check at Main Agricultural Research Station,UAS Dharwad, during late *kharif* 2014. The study revealed that. different hybrids exhibited varied magnitude and direction of heterosis for different characters like days to 50 per cent flowering, days to maturity, plant height, head diameter, test weight, oil content, oil yield, seed yield per plant and seed yield per ha. The crosses CMS 853A × DSR-72, CMS 853A × DSR-115 and CMS 234A × DSR-90 were identified as potential hybrids with respect to majority of traits based on their performance and heterosis estimates. The values of heterobeltiosis ranged from -11.36 per cent (CMS-1030A x DSR-108) to 144.55 per cent (CMS-234A x DSR-90) and standard heterosis ranged from 20.82 per cent (CMS-853A x DSR-125) to 154.60 per cent (CMS-234A x DSR-90) over commercial check, SB-275 for seed yield per.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops of major economic importance. Due to its cross pollinated nature, it offers considerable scope for commercial exploitation of heterosis utilizing cytoplasmic male sterility and nuclear-restorer system (Gangappa *et al.*, 1997). Hybrids of sunflower are more stable, highly self-fertile, with high yield performance, and more uniform at maturity (Seetharam, 1979; Kaya and Atakisi, 2004). Thus, in recent past, the breeding emphasis has shifted from population breeding to heterosis breeding in a bid to meet the challenges and tremendous demand of sunflower oil in the market. High heterosis for yield and its components in sunflower, crops has been reported by many previous researchers (Chaudhary and Anand, 1984; Goksoy *et al.,* 2000; Khan *et al.,* 2004; Kaya, 2005). However, heterosis does not appear in all hybrid combinations of the F1 generation (Hladni *et al.,* 2007). Therefore to achieve the success in hybrid breeding is quite difficult and it takes some time. Hladni *et al.* (2007) reported that the occurrence of heterosis in sunflower hybrids is highly correlated with genetic distance between the parental lines.

The aim of this study was to estimate the amount of heterosis in forty two hybrids obtained from three CMS and fourteen restorer lines and to select hybrid with high level of heterosis. The present attempt has been taken to study heterosis for seed yield, yield components and oil content in sunflower.

MATERIALS AND METHODS

Three cytoplasmic male sterile (CMS) lines *viz.*, CMS 234A, CMS 853A and CMS 1030A were crossed with 14 new restorer lines, of which ten were recombinant R lines *viz.*, DSR-120, DSR-89, DSR-90, DSR-69, DSR-121, DSR-125, DSR-76, DSR-72, DSR-70, DSR-115 derived from [(CMS 4546 x DSF-2A) x TX 16R] and four were mutant lines *viz.*, DSR-83, DSR-93, DSR-112 and DSR-108 derived from EMS treatment of TX 16R seeds at 0.020 moles/dm^3 and 0.015moles/dm^3. Crosses were made in Line × Tester design to synthesize 42 hybrids. The parents and hybrids along with the checks *viz.*, SB-275, KBSH-53 and DSFH-3 were grown in a randomized block design with two replications. The experiment was conducted at Main Agricultural Research Station, Dharwad. Crossing was carried out during summer, 2014 and the evaluation of crosses and their parents was done during late *Kharif* 2014. Data for morphological characters was recorded on five randomly selected plants. Oil content was estimated wide line NMR. Heterosis was calculated over better parent and standard checks for seed yield, yield components and oil content. Heterosis was calculated as a percentage increase or decrease in the F_1 mean over its better parent and standard checks.

RESULTS AND DISCUSSION

The estimates of heterosis over better parent and standard check for nine characters are presented in Table 1. For days to 50 per cent flowering, better parent heterosis ranged from -19.44 per cent (CMS 234A x DSR-76) to 3.15 per cent (CMS 1030A x DSR-90). A total of 31 experimental hybrids recorded significant negative heterobeltiosis. However, the experimental hybrid, CMS 234A x DSR-89 registered the highest and

Table 1: Estimation of heterosis over better parent and standard checks for quantitative traits in sunflower

Sl. No.	Crosses	Heterosis (%) for 50 per cent flowering Better parent	SB-275	KBSH-53	DSFH-3	Heterosis (%) for days to maturity Better parent	SB-275	KBSH-53	DSFH-3	Heterosis (%) for plant height (cm) Better parent	SB-275	KBSH-53	DSFH-3
1	CMS-234A x DSR-83	-13.64 **	-3.06 **	-4.04 **	6.74**	-13.64 **	-3.06 **	-4.04 **	6.74**	3.15	18.42**	5.26	6.51
2	CMS-234A x DSR-120	-8.49 **	-1.02 **	-2.02 **	8.99**	-8.49 **	-1.02 **	-2.02 **	8.99**	16.56**	22.70**	9.06	10.36*
3	CMS-234A x DSR-89	-3.03 **	-2.04 **	-3.03 **	7.87**	-3.03 **	-2.04 **	-3.03 **	7.87**	5.64	17.11**	4.09	5.33
4	CMS-234A x DSR-90	-4.46 **	-1.53 **	-2.53 **	8.43**	-4.46 **	-1.53 **	-2.53 **	8.43**	16.92**	30.00**	15.56**	16.92**
5	CMS-234A x DSR-93	-4.90 **	-1.02 **	-2.02 **	8.99**	-4.90 **	-1.02 **	-2.02 **	8.99**	-1.38	17.43**	4.39	5.62
6	CMS-234A x DSR-69	-7.55 **	0	-1.01 **	10.11**	-7.55 **	0	-1.01 **	10.11**	-22.40**	-1.97	-12.87**	-11.83*
7	CMS-234A x DSR-121	0	1.02**	0	11.24**	0	1.02**	0	11.24**	-19.50**	5.92	-5.85	-4.73
8	CMS-234A x DSR-125	-8.57 **	-2.04 **	-3.03 **	7.87**	-8.57 **	-2.04 **	-3.03 **	7.87**	-2.69	6.91	-4.97	-3.85
9	CMS-234A x DSR-76	-15.45 **	-5.10 **	-6.06 **	4.49**	-15.45 **	-5.10 **	-6.06 **	4.49**	-4.53	10.86*	-1.46	-0.3
10	CMS-234A x DSR-112	-8.65 **	-3.06 **	-4.04 **	6.74**	-8.65 **	-3.06 **	-4.04 **	6.74**	-3.33	14.47**	1.75	2.96
11	CMS-234A x DSR-108	-7.25 **	-2.04 **	-3.03 **	7.87**	-7.25 **	-2.04 **	-3.03 **	7.87**	17.67**	16.12**	3.22	4.44
12	CMS-234A x DSR-72	-1.52 **	-1.02 **	-2.02 **	8.99**	-1.52 **	-1.02 **	-2.02 **	8.99**	-1.65	17.43**	4.39	5.62
13	CMS-234A x DSR-70	-9.09 **	-3.06 **	-4.04 **	6.74**	-9.09 **	-3.06 **	-4.04 **	6.74**	-4.69	0.33	-10.82*	-9.76*
14	CMS-234A x DSR-115	-6.40 **	-3.06 **	-4.04 **	6.74**	-6.40 **	-3.06 **	-4.04 **	6.74**	0.63	5.59	-6.14	-5.03
15	CMS-853A x DSR-83	-16.36 **	-6.12 **	-7.07 **	3.37**	-16.36 **	-6.12 **	-7.07 **	3.37**	-5.16	8.88	-3.22	-2.07
16	CMS-853A x DSR-120	-9.43 **	-2.04 **	-3.03 **	7.87**	-9.43 **	-2.04 **	-3.03 **	7.87**	-0.31	4.93	-6.73	-5.62
17	CMS-853A x DSR-89	-0.99 **	2.04**	1.01**	12.36**	-0.99 **	2.04**	1.01**	12.36**	-9.79*	0	-11.11*	-10.06*
18	CMS-853A x DSR-90	-4.95 **	-2.04 **	-3.03 **	7.87**	-4.95 **	-2.04 **	-3.03 **	7.87**	5.62	17.43**	4.39	5.62
19	CMS-853A x DSR-93	-2.94 **	1.02**	0	11.24**	-2.94 **	1.02**	0	11.24**	-20.99**	-5.92	-16.37**	-15.38**
20	CMS-853A x DSR-69	-5.66 **	2.04**	1.01**	12.36**	-5.66 **	2.04**	1.01**	12.36**	-21.09	-0.33	-11.40*	-10.36*
21	CMS-853A x DSR-121	2.48**	5.61**	4.55**	16.29**	2.48**	5.61**	4.55**	16.29**	-23.00**	1.32	-9.94*	-8.88
22	CMS-853A x DSR-125	-3.81 **	3.06**	2.02**	13.48**	-3.81 **	3.06**	2.02**	13.48**	-1.8	7.89	-4.09	-2.96
23	CMS-853A x DSR-76	-4.55 **	7.14**	6.06**	17.98**	-4.55 **	7.14**	6.06**	17.98**	-11.05*	3.29	-8.19	-7.1
24	CMS-853A x DSR-112	0	6.12**	5.05**	16.85**	0	6.12**	5.05**	16.85**	-11.39*	4.93	-6.73	-5.62
25	CMS-853A x DSR-108	-3.38 **	2.04**	1.01**	12.36**	-3.38 **	2.04**	1.01**	12.36**	7.33	5.92	-5.85	-4.73
26	CMS-853A x DSR-72	-0.5	2.55**	1.52**	12.92**	-0.5	2.55**	1.52**	12.92**	-7.16	10.86*	-1.46	-0.3
27	CMS-853A x DSR-70	-4.31 **	2.04**	1.01**	12.36**	-4.31 **	2.04**	1.01**	12.36**	0.63	5.92	-5.85	-4.73
28	CMS-853A x DSR-115	-3.45 **	0	-1.01 **	10.11**	-3.45 **	0	-1.01 **	10.11**	-3.45	1.32	-9.94*	-8.88
29	CMS-1030A x DSR-83	-8.18 **	3.06**	2.02**	13.48**	-8.18 **	3.06**	2.02**	13.48**	-7.74	5.92	-5.85	-4.73
30	CMS-1030A x DSR-120	-7.55 **	0	-1.01 **	10.11**	-7.55 **	0	-1.01 **	10.11**	-4.06	0.99	-10.23*	-9.17
31	CMS-1030A x DSR-89	-1.01 **	0	-1.01 **	10.11**	-1.01 **	0	-1.01 **	10.11**	-8.31	1.64	-9.65*	-8.58
32	CMS-1030A x DSR-90	-0.99 **	2.04 **	1.01**	12.36 **	-0.99 **	2.04 **	1.01**	12.36 **	-7.1	3.29	-8.19	-7.1
33	CMS-1030A x DSR-93	-0.98 **	3.06 **	2.02**	13.48 **	-0.98 **	3.06 **	2.02**	13.48 **	-11.88*	4.93	-6.73	-5.62
34	CMS-1030A x DSR-69	-1.89 **	6.12 **	5.05**	16.85 **	-1.89 **	6.12 **	5.05**	16.85 **	-11.72**	11.51*	-0.88	0.3
35	CMS-1030A x DSR-121	0	1.02 **	0	11.24 **	0	1.02 **	0	11.24 **	-21.50**	3.29	-8.19	-7.1
36	CMS-1030A x DSR-125	-5.71 **	1.02 **	0	11.24 **	-5.71 **	1.02 **	0	11.24 **	-4.19	5.26	-6.43	-5.33
37	CMS-1030A x DSR-76	-8.18 **	3.06 **	2.02**	13.48 **	-8.18 **	3.06 **	2.02**	13.48 **	-13.31**	0.66	-10.53 *	-9.47
38	CMS-1030A x DSR-112	0	6.12 **	5.05**	16.85 **	0	6.12 **	5.05**	16.85 **	-15.28**	0.33	-10.82 *	-9.76 *
39	CMS-1030A x DSR-108	2.42**	8.16 **	7.07**	19.10 **	2.42**	8.16 **	7.07**	19.10 **	14.00*	12.50*	0	1.18
40	CMS-1030A x DSR-72	2.02**	3.06 **	2.02**	13.48 **	2.02**	3.06 **	2.02**	13.48 **	-10.80*	6.51	-5.32	-4.2
41	CMS-1030A x DSR-70	-6.22 **	0	-1.01 **	10.11 **	-6.22 **	0	-1.01 **	10.11 **	3.13	8.55	-3.51	-2.37
42	CMS-1030A x DSR-115	-2.46 **	1.02 **	0	11.24 **	-2.46 **	1.02 **	0	11.24 **	-3.76	0.99	-10.23 *	-9.17

Table 1: Cont....................

Sl. No.	Crosses	Heterosis (%) for head diameter (cm)				Heterosis (%) for test weight (g/100 seeds)				Heterosis (%) for oil content (%)			
		Better parent	SB-275	KBSH-53	DSFH-3	Better parent	SB-275	KBSH-53	DSFH-3	Better parent	SB-275	KBSH-53	DSFH-3
1	CMS-234A x DSR-83	-19.41**	5.6	-7.55	-12.81*	1.51	35.93**	16.53*	-9.34	-4.69	-11.71*	-9.21	-8.34
2	CMS-234A x DSR-120	-16.38**	3.45	-9.43	-14.59**	66.81**	75.12**	50.13**	16.80**	-7.94	-14.71*	-12.30*	-11.47*
3	CMS-234A x DSR-89	9.86	34.48**	17.74**	11.03*	106.42**	70.14**	45.87**	13.49**	-4.1	-11.16*	-8.64	-7.78
4	CMS-234A x DSR-90	97.24**	53.88**	34.72**	27.05**	58.50**	81.18**	55.33**	20.85**	2.88	-4.69	-1.99	-1.06
5	CMS-234A x DSR-93	39.66**	7.76	-5.66	-11.03*	24.17**	39.04**	19.20**	-7.26	7.97	0.02	2.86	3.83
6	CMS-234A x DSR-69	21.74**	20.69**	5.66	-0.36	86.25**	70.61**	46.27**	13.80**	1.92	-5.58	-2.91	-1.99
7	CMS-234A x DSR-121	81.25**	25.00**	9.43	3.2	-4.89	30.02**	11.47	-13.28**	2.77	-4.79	-2.09	-1.16
8	CMS-234A x DSR-125	9.52	-0.86	-13.21*	-18.15**	60.94**	32.66**	13.73*	-11.51*	-2	-9.21	-6.64	-5.75
9	CMS-234A x DSR-76	-8.7	-9.48	-20.75**	-25.27**	54.72**	27.53**	9.33	-14.94**	2.91	-4.67	-1.97	-1.04
10	CMS-234A x DSR-112	31.60**	31.03**	14.72*	8.19	123.39**	99.07**	70.67**	32.78**	-27.25 **	-32.61**	-30.70**	-30.04**
11	CMS-234A x DSR-108	23.32**	34.48**	17.74**	11.03*	88.08**	69.36**	45.20**	12.97**	4.93	-2.79	-0.04	0.91
12	CMS-234A x DSR-72	16.48**	31.03**	14.72*	8.19	85.52**	73.41**	48.67**	15.66**	-4.65	-5.53	-2.86	-1.93
13	CMS-234A x DSR-70	8.7	-3.02	-15.09*	-19.93**	95.33**	95.02**	67.20**	30.08**	0.76	-6.65	-4.01	-3.1
14	CMS-234A x DSR-115	56.38**	26.72**	10.94	4.63	50.15**	60.19**	37.33**	6.85	5.4	-2.35	0.41	1.37
15	CMS-853A x DSR-83	-11.18*	16.38*	1.89	-3.91	7.2	43.55**	23.07**	-4.25	2.95	-11.06*	-8.54	-7.67
16	CMS-853A x DSR-120	8.01	33.62**	16.98**	10.32	27.85**	34.21**	15.07*	-10.48*	3.13	-6.94	-4.31	-3.4
17	CMS-853A x DSR-89	9.86	34.48**	17.74**	11.03*	34.31**	35.77**	16.40*	-9.44	1.17	-12.44*	-9.96	-9.1
18	CMS-853A x DSR-90	89.13**	50.00**	31.32**	23.84**	36.60**	56.14**	33.87**	4.15	8.01	-5.71	-3.04	-2.12
19	CMS-853A x DSR-93	80.43**	43.10**	25.28**	18.15**	73.47**	94.25**	66.53**	29.56**	2.02	-11.86*	-9.37	-8.51
20	CMS-853A x DSR-69	52.17**	50.86**	32.08**	24.56**	28.00**	29.39**	10.93	-13.69**	9.88	-5.07	-2.38	-1.45
21	CMS-853A x DSR-121	30.43**	3.45	-9.43	-14.59**	4.1	42.30**	22.00**	-5.08	-0.21	-13.79*	-11.35*	-10.51
22	CMS-853A x DSR-125	33.33**	20.69**	5.66	-0.36	2.77	3.89	-10.93	-30.71**	9.67	-5.25	-2.57	-1.64
23	CMS-853A x DSR-76	15.65*	14.66*	0.38	-5.34	11.08	12.29	-3.73	-25.10**	-2.44	-11.21*	-8.69	-7.83
24	CMS-853A x DSR-112	25.54**	25.00**	9.43	3.2	40.31**	41.84**	21.60**	-5.39	6.53	-7.97	-5.36	-4.46
25	CMS-853A x DSR-108	1.98	11.21	-2.64	-8.19	69.54**	71.38**	46.93**	14.32**	-0.23	-13.80*	-11.36*	-10.52
26	CMS-853A x DSR-72	49.43**	68.10**	47.17**	38.79**	50.15**	51.79**	30.13**	1.24	-6.29	-7.16	-4.53	-3.63
27	CMS-853A x DSR-70	71.01**	52.59**	33.58**	25.98**	34.46**	35.93***	16.53*	-9.34	0.66	-13.03	-10.57	-9.72
28	CMS-853A x DSR-115	88.83**	53.02**	33.96**	26.33**	47.38**	57.23**	34.80**	4.88	8.61	-6.16	-3.51	-2.59
29	CMS-1030A x DSR-83	-15.46**	10.78	-3.02	-8.54	8.13	44.79**	24.13**	-3.42	0.85	-6.31	-3.66	-2.74
30	CMS-1030A x DSR-120	-9.41	12.07	-1.89	-7.47	73.19**	81.80**	55.87**	21.27**	5.32	-2.16	0.61	1.57
31	CMS-1030A x DSR-89	-0.35	21.98**	6.79	0.71	97.17**	94.71**	66.93**	29.88**	-11.56	-17.84**	-15.52**	-14.72*
32	CMS-1030A x DSR-90	63.54**	27.59**	11.70*	5.34	15.92*	32.50**	13.60*	-11.62*	5.24	-2.23	0.54	1.49
33	CMS-1030A x DSR-93	51.96**	17.24*	2.64	-3.2	37.50**	53.97**	32.00**	2.7	-1.39	-8.39	-5.8	-4.91
34	CMS-1030A x DSR-69	26.96**	25.86**	10.19	3.91	59.53**	57.54**	35.07**	5.08	5.86	-1.66	1.13	2.09
35	CMS-1030A x DSR-121	90.91**	26.72**	10.94	4.63	-4.44	30.64**	12	-12.86*	1.32	-5.87	-3.21	-2.29
36	CMS-1030A x DSR-125	47.62**	33.62**	16.98**	10.32	39.69**	37.95**	18.27**	-7.99	-0.64	-7.7	-5.09	-4.19
37	CMS-1030A x DSR-76	21.30**	20.26**	5.28	-0.71	3.46	2.18	-12.40*	-31.85**	6.94	-0.66	2.15	3.12
38	CMS-1030A x DSR-112	24.68**	24.14**	8.68	2.49	29.13**	27.53**	9.33	-14.94**	-0.9	-7.94	-5.34	-4.44
39	CMS-1030A x DSR-108	-17.00 **	-9.48	-20.75**	-25.27 **	44.41**	42.61**	22.27**	-4.88	2.56	-4.73	-2.03	-1.1
40	CMS-1030A x DSR-72	8.81	22.41**	7.17	1.07	11.34	9.95	-5.73	-26.66**	2.8	1.85	4.73	5.73
41	CMS-1030A x DSR-70	23.67**	10.34	-3.4	-8.9	63.86**	63.61**	40.27**	9.13	-1.98	-8.94	-6.36	-5.47
42	CMS-1030A x DSR-115	78.19**	44.40**	26.42**	19.22**	2.33	9.18	-6.4	-27.18**	5.77	-1.74	1.04	2

Table 1: Cont....................

Sl. No.	Crosses	Heterosis (%) for oil yield (kg/ha)				Heterosis (%) for seed yield per plant (g)				Heterosis (%) for seed yield (kg/ha)			
		Better parent	SB-275	KBSH-53	DSFH-3	Better parent	SB-275	KBSH-53	DSFH-3	Better parent	SB-275	KBSH-53	DSFH-3
1	CMS-234A x DSR-83	73.14**	51.66**	32.74*	7.98	76.00**	81.68**	41.44**	21.58**	81.92**	71.72**	46.29**	17.86*
2	CMS-234A x DSR-120	42.94*	25.21	9.59	-10.85	46.29**	51.00**	17.56**	1.05	55.43**	46.72**	24.99**	0.7
3	CMS-234A x DSR-89	113.41**	86.94**	63.61**	33.10**	120.11**	127.21**	76.89**	52.05**	119.70**	110.25**	79.12**	44.31**
4	CMS-234A x DSR-90	145.35**	114.92**	88.10**	53.02**	144.55**	154.60**	98.21**	70.38**	139.47**	126.04**	92.56**	55.15**
5	CMS-234A x DSR-93	74.11**	64.48**	43.96**	17.11	63.04**	88.36**	46.64**	26.05**	43.35**	64.21**	39.90**	12.71
6	CMS-234A x DSR-69	39.69*	37.37*	20.23	-2.19	27.92**	69.09**	31.64**	13.16**	21.79*	45.69**	24.12**	0
7	CMS-234A x DSR-121	99.02**	74.33**	52.58**	24.13*	89.34**	98.98**	54.91**	33.16**	78.61**	83.14**	56.02**	25.71**
8	CMS-234A x DSR-125	21.71	29.96	13.74	-7.47	47.55**	85.67**	44.54**	24.25**	14.15	42.84**	21.69*	-1.96
9	CMS-234A x DSR-76	49.08**	30.59	14.29	-7.02	41.05**	55.72**	21.23**	4.21	44.05**	36.92**	16.65	-6.02
10	CMS-234A x DSR-112	31.11	23.46	8.05	-12.09	27.28**	49.55**	16.42**	0.08	65.17**	83.19**	56.07**	25.74**
11	CMS-234A x DSR-108	43.00**	66.92**	46.09**	18.85	-7.48*	33.82**	4.18	10.45**	24.25**	71.61**	46.19**	17.79*
12	CMS-234A x DSR-72	51.20**	65.23**	44.61**	17.65	67.23**	89.07**	47.19**	26.53**	58.38**	74.58**	48.73**	19.83**
13	CMS-234A x DSR-70	37.97*	26.76	10.94	-9.75	58.55**	86.30**	45.03**	24.67**	19.61*	35.57**	15.49	-6.95
14	CMS-234A x DSR-115	76.47**	71.71**	50.28**	22.26	10.34**	33.43**	3.87	10.71**	52.93**	75.80**	49.77**	20.67**
15	CMS-853A x DSR-83	41.02**	49.09**	30.48*	6.15	47.25**	80.95**	40.87**	21.09**	36.91**	67.48**	42.68**	14.95*
16	CMS-853A x DSR-120	52.33**	61.04**	40.95**	14.66	31.33**	61.38**	25.64**	8.00**	41.77**	73.42**	47.74**	19.03*
17	CMS-853A x DSR-89	59.78**	68.92**	47.84**	20.27	24.51**	53.01**	19.12**	2.39	56.69**	91.67**	63.29**	31.56**
18	CMS-853A x DSR-90	86.72**	97.41**	72.77**	40.56**	88.48**	131.62**	80.32**	55.00**	70.83**	108.97**	78.03**	43.43**
19	CMS-853A x DSR-93	66.10**	75.61**	53.69**	25.03*	64.48**	102.12**	57.35**	35.26**	62.80**	99.15**	69.66**	36.69**
20	CMS-853A x DSR-69	64.44**	73.85**	52.15**	23.78*	45.95**	92.92**	50.19**	29.11**	49.59**	82.99**	55.89**	25.60**
21	CMS-853A x DSR-121	29.58	36.99*	19.9	-2.46	44.83**	77.98**	38.56**	19.11**	28.66**	57.38**	34.08**	8.02
22	CMS-853A x DSR-125	-8.12	-1.89	-14.13	-30.14*	-3.98	20.82**	-5.94	-19.14**	-17.08*	3.76	-11.6	-28.78**
23	CMS-853A x DSR-76	0.79	6.56	-6.74	-24.13*	7.57*	32.19**	2.91	11.54**	-2.21	19.63	1.91	-17.89*
24	CMS-853A x DSR-112	10.56	16.89	2.3	-16.78	12.37**	38.08**	7.50*	-7.59*	3.9	27.10*	8.28	-12.76
25	CMS-853A x DSR-108	11.15	29.74	13.55	-7.62	29.46**	87.24**	45.77**	25.30**	8.56	49.94**	27.74**	2.92
26	CMS-853A x DSR-72	93.61**	111.58**	85.18**	50.65**	98.45**	143.87**	89.85**	63.20**	85.80**	127.29**	93.63**	56.01**
27	CMS-853A x DSR-70	-7.77	-2.49	-14.66	30.57**	2.8	26.33**	-1.65	15.46**	-8.32	12.15	-4.46	23.02**
28	CMS-853A x DSR-115	101.94**	113.49**	86.85**	52.01**	101.68**	147.84**	92.94**	65.86**	85.72**	127.19**	93.54**	55.94**
29	CMS-1030A x DSR-83	17.66	13.91	-0.31	-18.9	25.39**	33.70**	4.09	10.53**	16.67	21.50*	3.5	-16.61*
30	CMS-1030A x DSR-120	36.21*	31.86	15.41	-6.11	39.33**	48.56**	15.66**	-0.58	29.24**	34.58**	14.65	-7.63
31	CMS-1030A x DSR-89	21.57	17.69	3	-16.2	47.08**	56.82**	22.09**	4.95	37.13**	42.80**	21.66*	-1.98
32	CMS-1030A x DSR-90	76.39**	70.77**	49.45**	21.59	83.96**	96.15 **	52.70**	31.26**	67.75**	74.68**	48.81**	19.90**
33	CMS-1030A x DSR-93	27.32	23.26	7.87	-12.24	31.04**	51.40 **	17.86**	1.32	17.48	34.58**	14.65	-7.63
34	CMS-1030A x DSR-69	55.16**	52.58**	33.54*	8.64	30.89**	73.02 **	34.70**	15.79**	29.77**	55.24**	32.25**	6.55
35	CMS-1030A x DSR-121	39.20*	34.76*	17.94	-4.05	45.23**	54.86 **	20.56**	3.63	37.13**	42.80**	21.66*	-1.98
36	CMS-1030A x DSR-125	32.51*	41.49*	23.83	0.74	18.75**	49.43 **	16.33**	0	22.49**	53.27**	30.57**	5.2
37	CMS-1030A x DSR-76	51.96**	47.12**	28.76*	4.75	41.05**	55.72 **	21.23**	4.21	42.16**	48.04**	26.11**	1.61
38	CMS-1030A x DSR-112	28.65	24.55	9.01	-11.32	24.70**	46.52 **	14.07**	-1.95	22.01*	35.33**	15.29	-7.11
39	CMS-1030A x DSR-108	-0.43	16.22	1.72	-17.25	-11.36 **	28.20 **	-0.2	-14.21	-11.76	21.87*	3.82	-16.35*
40	CMS-1030A x DSR-72	26.39	38.12*	20.89	-1.66	31.18 **	48.31 **	15.46**	-0.75	22.77*	35.33**	15.29	-7.11
41	CMS-1030A x DSR-70	23.97	20.01	5.03	-14.55	22.59 **	44.04 **	12.14**	-3.61	15.43	30.84**	11.46	-10.19
42	CMS-1030A x DSR-115	70.22**	65.63**	44.96**	17.93	38.62 **	67.62 **	30.49**	12.17**	46.34**	68.22**	43.31**	15.47*

negative standard heterosis. The existence of both significant positive and negative heterotic effects over parents and checks suggests the presence of non-additive gene action for this trait as also indicated by earlier investigations by Kandhola, *et al.,* 1995. For days to maturity, the range of heterosis was from -16.36 per cent (CMS 853A x DSR-83) to 2.48 per cent (CMS 853A x DSR-121). The hybrid CMS 853A x DSR-83 recorded highest and negative standard heterosis over all hybrids. Similar reports were made byAlone, *et al.*, 2003 and Bajaj, *et al.*, 2003 who have reported early maturity in hybrids.

Heterosis in negative direction was considered desirable for plant height for easy in harvesting and less prone for lodging. The hybrid, CMS 853A x DSR-121 recorded significant negative heterosis over better parent (-23.00) and standard checks indicated that these hybrids were dwarf compared to better parent and checks. Longanathan and Gopalan, 2006 reported both positive and negative heterosis for plant height, while only negative heterosis has been reported by Phad, *et al.,* 2002. As many as 27 hybrids recorded significant positive heterobeltosis for head diameter. The heterosis over better parent ranged from -19.41 per cent (CMS 234A x DSR-83) to 97.24 per cent (CMS 234A x DSR-90) and hybrids CMS 853A x DSR-93, CMS 234A x DSR-69 and CMS 853A x DSR-69 recorded higher negative standard heterosis.

Test weight (gm) is an important yield component trait in sunflower. The heterosis for this trait ranged from -4.89 per cent (CMS 234A x DSR-121) to 123.39 per cent (CMS 234A x DSR-112). Among 42 hybrids, 30 hybrids recorded significant positive heterosis. The hybrids CMS 234A x DSR-112, CMS 234A x DSR-70 and CMS 853A x DSR-93 recorded higher heterosis over better parent and commercial checks as also reported earlier by Goksoy, *et al.,* 1977.

For seed yield per plant (g/plant), the heterosis over better parent ranged from -11.36 per cent (CMS 1030A x DSR-108) to 144.55 per cent (CMS 234A x DSR-90). Among hybrids tested, 39 hybrids recorded significant positive heterosis. For seed yield (kg/ha), the range of heterobeltosis was from -17.08 per cent (CMS 853A x DSR-125) to 139.47 per cent (CMS 234A x DSR-90). The hybrids, CMS 853A x DSR-72 (127.29 %), CMS 853A x DSR-115 (127.19 %) and CMS 234A x DSR-90 (126.04 %) recorded higher heterosis over better parent and commercial checks The results are in agreement with Gangappa *et al.,* 1997, Madrap and Makne, 1993, Kandhola,

Table 2: Heterosis of top three hybrids for different characters in sunflower

Character	Desirable crosses	Per se performance			Per cent heterosis				
		Females	Males	F_1	MP	BP	KBSH-53	KBSH-44	SB-275
Days to 50% flowering	CMS 234x DSR-89	60	64	61.5	-9.68**	-12.50**	-15.15**	-12.50**	-5.08**
	CMS 1030Ax DSR-112	63.5	63	59.5	-11.20**	-12.88**	-12.88**	-10.16**	-2.54**
	CMS 234Ax DSR-76	60	72	58	-12.12**	-19.44**	-12.12**	-9.38**	-1.69
Days to maturity	CMS 853Ax DSR-83	101	110	92	-12.80**	-16.36**	-6.12**	-7.07**	3.37**
	CMS 234Ax DSR-76	92	110	93	-7.92**	-15.45**	-5.10**	-6.06**	4.49**
	CMS 234Ax DSR-83	92	110	95	-5.94**	-13.64**	-3.06**	-4.04**	6.74**
Plant height (cm)	CMS 853Ax DSR-93	130	181	143	-8.04	-20.99**	-5.92	-16.37**	-15.38**
	CMS 234Ax DSR-69	114	192	149	-2.61	-22.40**	-1.97	-12.87**	-11.83**
	CMS 853Ax DSR-89	130	168.5	152	1.84	-9.79*	0	-11.11*	-10.06*
Head diameter (cm)	CMS 853Ax DSR-72	9.2	13.05	19.5	75.28**	49.43**	68.10**	47.17**	38.79**
	CMS 234Ax DSR-90	8	9.05	15.6	109.38**	97.24**	53.88**	34.72**	27.05**
	CMS 853Ax DSR-115	9.2	9.4	17.75	90.86**	88.83**	53.02**	33.96**	26.33**
Test weight (g/100 seeds)	CMS 234Ax DSR-112	2.65	4.4	4.18	8.19	123.39**	99.07**	70.67**	32.78**
	CMS 234Ax DSR-70	2.65	3.21	6.27	-19.93**	95.33**	95.02**	67.20**	30.08**
	CMS 1030Ax DSR-89	3.175	2.47	6.26	0.71	97.17**	94.71**	66.93**	29.88**
Volume weight (g/cc)	CMS 853Ax DSR-72	25.5	25.65	35.9	31.62**	23.58**	34.46**	57.80**	50.21**
	CMS 1030Ax DSR-83	29.75	26	35.75	28.25**	20.17**	33.90**	57.17**	49.58**
	CMS 1030Ax DSR-72	29.75	29.05	35.15	19.56**	18.15**	31.65**	54.51**	47.07**
Oil content (%)	CMS 1030Ax DSR-70	38.14	33.25	37.38	4.74	2.8	1.85	4.73	5.73
	CMS 234Ax DSR-93	38.03	33.86	41.06	8.09	7.97	0.02	2.86	3.83
	CMS 1030Ax DSR-76	38.14	37.36	40.78	3.65	6.94	-0.66	2.15	3.12
Seed yield per plant (g)	CMS 234Ax DSR-90	26.25	26.48	64.75	145.60**	144.55**	154.60**	98.21**	70.38**
	CMS 853Ax DSR-72	31.25	28.75	62.02	106.72**	98.45**	143.87**	89.85**	63.20**
	CMS 853Ax DSR-115	32.25	30.75	63.03	103.31**	101.68**	147.84**	92.94**	65.86**
Seed yield (kg/ha)	CMS 853Ax DSR-72	1110.96	1001.08	2052.824	95.47**	85.80**	127.29**	93.63**	56.01**
	CMS 853Ax DSR-115	1110.96857	1043.98	2063.27	91.49**	85.72**	127.19**	93.54**	55.94**
	CMS 234Ax DSR-90	.25	869.14	1586.42	140.60**	139.47**	126.04**	92.56**	55.15**
Alternaria leaf blight PDI at 60 DAS	CMS 1030Ax DSR-121	35.22	23.23	17.22	-41.09**	-51.12**	-61.20**	-58.83**	-62.28**
	CMS 234Ax DSR-108	48.19	33.89	18.41	-55.14**	-61.80**	-58.50**	-55.97**	-59.66**
	CMS 234Ax DSR-121	48.19	23.23	19.47	-45.48**	-59.60**	-56.11**	-53.43**	-57.34**
Alternaria leaf blight PDI at 75 DAS	CMS 853Ax DSR-90	67.31	39.94	27.68	-48.38**	-58.87**	-43.22**	-52.17**	-49.09**
	CMS 853Ax DSR-69	67.31	52.24	31.87	-46.70**	-52.66**	-34.64**	-44.95**	-41.41**
	CMS 853Ax DSR-120	67.31	47.81	33.82	-41.26**	-49.77**	-30.64**	-41.58**	-37.82**

et al., 1995, Radhika, *et al.,* 2001 and Loganathan and Gopalan, 2006.

The magnitude of heterosis over mid parent for oil content ranged from -27.25 per cent (CMS 234A x DSR-112) to 9.88 per cent (CMS 853A x DSR-69). Among all hybrids, CMS 853A x DSR-69 recorded higher positive heterosis over better parent. Similar results were reported by several workers *viz.*, Naresh, *et al.,* 1996, Gill and Punia, 1996 and Alone, *et al.*, 2003. Most of the hybrids recorded positive heterosis over mid parent indicating non-additive gene action for oil yield. None of the hybrids recorded significant positive standard heterosis for this trait.

Heterosis recorded by top three hybrids for yield and its component traits are presented given in Table 2. Among all hybrids, CMS 853A x DSR-72, CMS 853Ax DSR-115and CMS 234Ax DSR-90 performed better with respect to seed yield, head diameter and other yield component traits. Among the 48 hybrids, some are fertile, some are partial fertile and some are sterile. So the partially fertile lines need to be improved by employing them in biparental mating and selection schemes. The potential hybrids identified *viz.,* CMS 853A x DSR-72, CMS 853A x DSR-115and CMS 234A x DSR-90could be tested on large scale over environments to assess their real potential and adaptability across different agroclimatic zones and seasons (late *kharif* and rabi).

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