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RESEARCH ARTICLE

Heterosis studies in sunflower (*Helianthus annus* L.)

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SUMMARY

Five cytoplasmic male sterile lines and 10 testers were crossed in an L x T mating design to develop 50 sunflower hybrids. The hybrids and parents were evaluated during *Kharif*-2013. Highly significant differences existed among genotypes for all the traits studied. The highest magnitude of positive relative heterosis and heterobeltiosis for seed yield per plant was exhibited by the cross CMS-148 x SVR-467 followed by the crosses CMS-351 x SVR-467, CMS-107 x SVR-472 and CMS-107 x SVR-467. The hybrid CMS-148 x SVR-467 (21.19%) exhibited positive and significant heterosis for seed yield per plant over check Phule Raviraj. The heterosis for seed yield in hybrids was found to be mainly influenced by plant height, head diameter, number of seeds per head and 100 seed weight. The highest positive relative heterosis and heterobeltiosis for plant height was exhibited by the cross CMS-378 x SVR-490, whereas, for head diameter it was exhibited by the cross CMS-607 x CMS-467. The heterotic effect for number of seeds per head was more pronounced in cross CMS-607 x SVR-467 over both mid and better parents. The hybrid CMS-607 x SVR-496 recorded higher magnitude of heterosis for number of seeds per head over check Phule Raviraj. Highest significant and positive heterosis for 100 seed weight and protein content was exhibited by the hybrid CMS-607 x SVR-490 over mid parent, better parent and standard check Phule Raviraj.

Key Words : Sunflower, Heterosis, Seed yield

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Sunflower is an important oilseed crop in India and it ranks second to soybean among field crops grown for edible oil. The importance of hybrid cultivars in sunflower has increased recently because of their higher seed yield as compared with open pollinated varieties. Hybrids of sunflower are more stable, highly self fertile, with high yield performance and more uniform at maturity (Kaya and Atakisi, 2004). Resistance to diseases and Orobanche has also increased the importance of hybrid varieties. Availability of cytoplasmic male sterility has provided the desired means for the development of hybrids through heterosis breeding. Being cross pollinated crop, high heterosis for yield and its components has been reported by many researchers (Chaudhary and Anand, 1984; Khan *et al*., 2004; Kaya, 2005; Habib *et al*., 2006; Abdullah *et al*., 2010). However, heterosis does not appear in all hybrid combinations in F_1 generation. The occurrence of heterosis in sunflower hybrids is highly correlated with genetic divergence between the parental lines (Hladni *et al*., 2007). Moreover, high heterosis for seed yield and oil content is one of the driving forces behind the hybrid seed industry in cultivated sunflower (Cheres *et al*., 2000). Hence, the present investigation was undertaken to estimate the amount of heterosis in 50 hybrids obtained from genetically diverse five lines and 10 restorer testers.

MATERIAL AND METHODS

Five cytoplasmic sterile lines *viz.*, CMS-148, CMS-378, CMS-107, CMS-351 and CMS-607 and 10 tester restorer lines *viz.,* SVR-467, SVR-490, SVR-491, SVR-472, SVR-495, SVR-454, SVR-436, SVR-444, SVR-402 and SVR-496 were crossed in a line x tester mating design to obtain 50 cross combinations in *Rabi*-2012. The seed of 50 crosses and their 15 parents along with check Phule Raviraj were planted in a Randomized Block Design with three replications at Post Graduate Research Farm, College of Agriculture, Kolhapur in *Kharif* 2013. In lieu of male sterile lines (line A), their maintainer lines (line B) were used to eliminate the effect of male sterility for seed yield. The experimental unit consisted of three row plot of 0.60 m length with row-to-row and plant-to-plant distance of 60 cm and 30 cm, respectively. All the package of practices was followed for good crop growth. At the time flowering, five plants were randomly selected and tagged in each of the hybrids and parents in each replication. Observations were recorded on five randomly selected plants from each genotype in each replication at different growth stages of crop for the characters plant height, head diameter, number of seeds per head, 100 seed weight, seed yield per plant, and oil content.

The recorded data were subjected to analysis of variance according to Steel and Torrie (1980). Heterosis was calculated as a percentage of increase or decrease in the F_1 mean over its mid parent, better parent and standard check. Means and heterotic effects were tested by the least significant differences (LSD) test at the 0.05 and 0.01 levels.

RESULTS AND DISCUSSION

Analysis of variance for six sunflower traits is presented in Table 1. The variances due to females and males for all the traits were highly significant except for plant height, seed yield per plant and oil content in case of females. The variances due to female *vs* male, hybrids and parents *vs* hybrids were also highly significant for all the traits except plant height and head diameter for female *vs* male. The highly significant differences among the parents used in the study indicate diverse nature of experimental material.

The estimates of mid parent heterosis; better parent heterosis and standard heterosis for the traits under study are presented in Table 2. Among the 50 crosses, 45, 43 and one cross showed significant positive heterosis for plant height over mid parent, better parent and standard check, respectively. Maximum significant positive increase in plant height over mid parent was recorded in cross CMS-378 x SVR-490 (44.96%) followed by CMS-107 x SVR-454 (41.64%) and CMS-107 x SVR-436 (40.86%), whereas, heterobeltiosis for plant height was highest in cross CMS-378 x SVR-490 (43.84%) followed by CMS-607 x SVR-490 (39.23%) and CMS-

Table 1: Analysis of variance for different traits in sunflower (L x T mating design)

Source of variation	d.f.	Plant height (cm)	Head diameter (cm)	No. of seeds/head	100 seed weight (g)	Seed yield/ plant (g)	Oil content (%)
Replication	2	1704.60**	90.90**	7887.81**	0.87**	840.23**	0.29
Parent (P)	14	147.39*	7.40**	86696.12**	1.34**	26.01**	33.35**
Female (F)	4	4.21	9.00**	62386.20**	0.67**	10.38	0.75
Male (M)	9	216.45**	7.18**	75385.85**	1.75**	31.07**	6.21**
F vs M	1	98.55	2.99	285728.30**	0.40**	42.97*	407.98**
Hybrids (H)	49	344.93**	11.63**	69431.14**	9.13**	150.59**	34.12**
P vs H	1	29107.34**	369.61**	93078.24**	32.28**	2306.31**	49.74**
Error	128	73.51	0.87	1217.51	0.03	7.07	0.70

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Estimates of heterosis for five traits in sunflower hybrids

Hybrids	Plant height (cm)			Head diameter (cm)			No. of seeds/head		
	MP	BP	SC	MP	BP	SC	MP	BP	SC
CMS-148 x SVR-467	25.11**	20.33**	-2.29	75.77**	58.17**	6.53	109.74**	103.28**	-2.61
CMS-148 x SVR-490	20.95**	20.90**	-9.33*	44.69**	36.71**	-7.92	21.90**	8.53	-33.38**
CMS-148 x SVR-491	15.98**	13.99*	-11.48*	20.24**	16.27**	-16.15**	22.60**	1.58	-25.93**
CMS-148 x SVR-472	-1.93	-8.11	-21.16**	2.84	-2.29	-34.19**	91.04**	88.02**	-9.92**
CMS-148 x SVR-495	34.85**	33.90**	0.42	25.81**	25.02**	-14.72**	-8.77	-27.39**	-41.21**
CMS-148 x SVR-454	35.17**	29.58**	-2.82	46.58**	32.83**	-10.53*	8.23	7.26	-48.61**
CMS-148 x SVR-436	15.41**	14.46*	-14.16**	14.68**	9.46	-18.90**	-3.80	-24.06**	-37.14**
CMS-148 x SVR-444	17.94**	13.71*	-8.13	34.15**	26.52**	-3.85	2.50	-22.33**	-27.80**
CMS-148 x SVR-402	22.74**	21.98**	-7.37	2.67	-3.96	-25.71**	-33.12**	-49.67**	-52.26**
CMS-148 x SVR-496	10.52*	3.05	-10.63*	33.71**	29.44**	-6.88	-8.54	-28.08**	-39.82**
CMS-378 x SVR-467	2.27	-0.94	-19.56**	45.29**	23.17**	-4.61	31.53**	8.18	-24.58**
CMS-378 x SVR-490	44.96**	43.84**	9.45*	48.92**	32.07**	2.29	30.59**	22.79**	-14.40**
CMS-378 x SVR-491	8.37	7.28	-16.69**	9.68	5.90	-17.98**	-12.88**	-14.80**	-37.87**
CMS-378 x SVR-472	16.72**	10.12	-5.51	12.54*	0.32	-22.30**	10.35*	-8.11	-35.94**
CMS-378 x SVR-495	22.77**	21.03**	-7.91	14.82**	7.97	-16.38**	-10.02*	-16.28**	-32.22**
CMS-378 x SVR-454	33.46**	27.06**	-3.31	42.82**	21.86**	-5.62	20.95**	1.29	-29.39**
CMS-378 x SVR-436	29.54**	27.55**	-2.94	15.74**	13.23*	-12.30**	26.10**	16.15**	-3.85
CMS-378 x SVR-444	25.75**	22.10**	-1.36	7.77	6.76	-17.31**	54.32**	32.02**	25.51**
CMS-378 x SVR-402	35.22**	35.07**	2.79	-22.51**	-22.55**	-40.02**	-43.07**	-50.61**	-53.15**
CMS-378 x SVR-496	7.58	0.99	-12.42**	-9.01	-12.25*	-32.04**	-22.74**	-29.19**	-40.75**
CMS-107 x SVR-467	22.71**	18.91**	-3.44	46.36**	22.63**	-2.25	39.93**	17.12**	-21.87**
CMS-107 x SVR-490	36.31**	35.20**	2.98	25.03**	9.51	-12.70**	-7.59	-11.28*	-40.81**
CMS-107 x SVR-491	25.89**	24.69**	-3.18	32.23**	25.93**	0.38	-8.83*	-12.71**	-36.35**
CMS-107 x SVR-472	29.63**	22.35**	4.99	29.32**	13.84*	-9.26*	77.61**	50.57	0.44
CMS-107 x SVR-495	29.62**	27.72**	-2.72	13.75**	5.54	-15.87**	-20.36**	-27.37**	-41.20**
CMS-107 x SVR-454	41.64**	34.79**	2.67	22.64**	3.42	-17.56**	7.74	-8.13	-38.71**
CMS-107 x SVR-436	40.86**	38.63**	5.59	7.47	3.68	-17.35**	-21.87**	-29.46**	-41.60**
CMS-107 x SVR-444	34.83**	30.98**	5.82	17.36**	14.62**	-8.63	-10.58**	-23.21**	-28.62**
CMS-107 x SVR-402	26.58**	26.38**	-3.73	-3.86	-5.28	-24.50**	-28.34**	-38.97**	-42.11**
CMS-107 x SVR-496	23.67**	16.14**	0.72	17.83**	12.09*	-10.65*	-14.57**	-25.93**	-38.02**
CMS-351x SVR-467	32.79**	29.27**	4.97	48.14**	30.38**	-7.62	155.61**	120.54**	-0.85
CMS-351 x SVR-490	22.54**	20.96**	-6.98	25.31**	15.65*	18.06**	17.45**	-10.07	-44.80**
CMS-351 x SVR-491	29.87**	29.24**	0.36	28.99**	27.87**	-7.79	51.42**	9.58*	-20.09**
CMS-351 x SVR-472	28.72**	22.05**	4.72	12.13*	4.03	-26.29**	78.37**	51.90**	-29.53**
CMS-351 x SVR-495	26.80**	24.36**	-4.37	25.13**	22.80**	-12.99**	14.53**	-19.66**	-34.96**
CMS-351 x SVR-454	38.29**	31.01**	0.75	30.87**	15.97*	-17.83**	66.23**	40.73**	-33.78**
CMS-351 x SVR-436	35.30**	32.53**	1.92	15.58**	13.06*	-16.23**	-3.52	-32.75**	-44.33**
CMS-351 x SVR-444	22.79**	19.83**	-3.19	20.96**	16.87**	-11.18*	-14.59**	-42.31**	-46.37**
CMS-351 x SVR-402	31.50**	30.68**	0.49	6.31	1.85	-21.22**	-11.58*	-40.59**	-43.64**
CMS-351 x SVR-496	25.90**	18.77**	3.00	62.01**	60.97**	15.68**	36.86**	-4.89	-20.42**
CMS-607 x SVR-467	29.45**	24.63**	1.20	114.67**	113.06**	16.51**	167.92**	133.31**	4.90
CMS-607 x SVR-490	39.44**	39.23**	4.64	74.97**	67.32**	0.27	66.88**	28.76**	-20.96**
CMS-607 x SVR-491	31.61**	29.49**	0.55	30.78**	14.98*	-17.09**	31.69**	-4.04	-30.03**
CMS-607 x SVR-472	25.40**	17.62**	0.92	45.03**	37.92**	-16.38**	19.89*	2.95	-52.24**
CMS-607 x SVR-495	20.53**	19.56**	-10.15*	11.90	0.81	-31.24**	-40.87**	-58.26**	-66.20**
CMS-607 x SVR-454	22.72**	17.53**	-11.67*	61.53**	61.47**	-11.64**	67.15**	42.80**	-32.80**
CMS-607 x SVR-436	9.36	8.35	-18.57**	11.46	-3.14	-28.23**	-0.97	-30.54**	-42.50**
CMS-607 x SVR-444	30.65**	26.09**	1.87	34.18**	15.36**	-12.32**	9.30	-25.75**	-30.98**
CMS-607 x SVR-402	23.40**	22.76**	-6.78	19.73**	2.19	-20.95**	10.39*	-25.41**	-29.24**
CMS-607 x SVR-496	22.90**	14.70**	-0.53	44.65**	27.30**	-8.42	113.97**	49.62**	25.19**

Table 2 : Contd……..

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Hybrids	100 seed weight (g)			Seed yield/plant (g)			Oil content (%)		
	MP	BP	SC	MP	BP	SC	MP	BP	SC
CMS-148 x SVR-467	61.43**	60.68**	63.12**	137.86**	133.75**	21.19**	17.99**	7.82**	15.47**
CMS-148 x SVR-490	63.90**	58.12**	60.52**	49.17**	39.65**	-19.86**	7.53**	-2.03	5.63**
CMS-148 x SVR-491	38.67**	38.18**	40.27**	87.44**	74.55**	1.30	17.89**	7.99**	15.04**
CMS-148 x SVR-472	31.19**	19.23**	21.04**	77.48**	73.88**	-12.96*	8.62**	-2.86	9.18**
CMS-148 x SVR-495	-1.15	-3.34	2.68	14.92	9.84	-39.69**	8.13**	-3.92*	9.58**
CMS-148 x SVR-454	49.25**	41.38**	43.53**	3.08	1.34	-47.50**	2.66	-5.91**	0.13
CMS-148 x SVR-436	-13.56**	-24.45**	2.53	55.52**	36.43**	-9.48	-11.46**	-20.05**	-12.08**
CMS-148 x SVR-444	11.56**	-1.00	0.51	38.50**	23.45**	-21.05**	5.22**	-2.77	1.62
CMS-148 x SVR-402	-42.12**	-42.74**	-41.87**	-2.91	-19.31**	-39.00**	-14.13**	-24.77**	-11.35**
CMS-148 x SVR-496	-10.24**	-16.32**	-1.74	41.93**	33.08**	-23.89**	-1.95	-10.11**	-4.42*
CMS-378 x SVR-467	41.21**	25.38**	26.10**	58.60**	46.66**	-10.49	-5.49**	-13.14**	-6.98**
CMS-378 x SVR-490	68.96**	54.33**	45.63**	58.19**	53.47**	-6.33	11.15**	1.84	9.80**
CMS-378 x SVR-491	13.95**	1.08	1.88	51.70**	47.97**	-9.69	3.03	-5.08**	1.11
CMS-378 x SVR-472	74.05**	68.82**	40.13**	19.10*	6.41	-35.06**	-11.12**	-20.07**	-10.16**
CMS-378 x SVR-495	33.44**	15.72**	22.92**	7.56	2.16	-37.65**	-5.66**	-15.71**	-3.86
CMS-378 x SVR-454	48.27**	37.82**	25.16**	35.64**	25.39**	-23.47**	6.09**	-2.22	4.05*
CMS-378 x SVR-436	-7.24*	-26.96**	-0.87	3.94	-0.22	-33.80**	-7.55**	-16.05**	-7.68**
CMS-378 x SVR-444	0.97	0.55	-20.90**	65.34**	61.57**	3.32	18.30**	9.95**	14.91**
CMS-378 x SVR-402	-35.43**	-42.36**	-42.73**	16.61*	5.37	-20.34**	-0.37	-12.24**	3.41
CMS-378 x SVR-496	1.00	-15.95**	-1.30	-10.42	-13.24	-47.05**	-10.14**	-17.14**	-11.90**
CMS-107 x SVR-467	65.30**	65.06**	66.02**	106.67**	103.34**	5.42	14.74**	6.54**	14.11**
CMS-107 x SVR-490	11.96**	105.7**	106.3**	40.66**	31.82**	-24.36**	0.37	-7.09**	0.18
CMS-107 x SVR-491	-1.55	-1.79	-1.01	55.83**	45.27**	-15.69**	-0.05	-6.96**	-0.89
CMS-107 x SVR-472	-15.19**	-22.49**	-22.27	109.60**	105.12**	2.91	11.75**	1.50	14.09**
CMS-107 x SVR-495	18.98**	15.66**	22.85**	22.75*	17.46**	-35.51**	-18.16**	-26.15**	-15.77**
CMS-107 x SVR-454	4.50	-0.43	-0.14	2.53	0.91	-47.72**	-12.80**	-18.79**	-13.58**
CMS-107 x SVR-436	4.96	-8.74**	23.86**	-5.25	-16.80*	-44.80**	-14.79**	-21.84**	-14.04**
CMS-107 x SVR-444	32.93**	18.60**	18.94**	15.16	2.76	-34.29**	-9.66**	-15.16**	-11.33**
CMS-107 x SVR-402	-40.46**	-40.74**	-40.56**	-16.90*	-30.88**	-47.74**	-12.74**	-22.38**	-8.54**
CMS-107 x SVR-496	52.57**	41.44**	66.09**	37.97**	29.50**	-25.94**	-9.31**	-15.51**	-10.16**
CMS-351x SVR-467	19.36**	18.39**	21.04**	126.49**	121.06**	20.38**	14.49**	6.53**	14.10**
CMS-351 x SVR-490	39.61**	34.23**	37.27**	31.09**	27.74**	-26.70**	-6.77**	-13.52**	-6.76**
CMS-351 x SVR-491	20.23**	19.38**	22.05**	63.14**	58.11**	-8.24	6.96**	-0.23	6.28**
CMS-351 x SVR-472	6.09	-3.89	-1.74	15.34	8.53	-40.90**	-11.01**	-19.00**	-8.96**
CMS-351 x SVR-495	-3.50	-5.31	0.58	54.84**	54.21**	-15.34**	0.78	-8.87**	3.94
CMS-351 x SVR-454	7.04*	1.06	3.33	-0.93	-3.33	-47.36**	-3.85*	-10.26**	-4.50*
CMS-351 x SVR-436	-31.75**	-40.17**	-18.80**	9.27	-0.52	-34.00**	-11.87**	-18.98**	-10.90**
CMS-351 x SVR-444	13.27**	0.21	2.46	-16.76*	-22.94**	-50.72**	-5.89**	-11.43**	-7.43**
CMS-351 x SVR-402	43.04**	41.02**	44.18**	7.71	-7.35	-29.96**	-13.61**	-23.00**	-9.27**
CMS-351 x SVR-496	90.32**	78.02**	109.0**	47.11**	43.59**	-17.88**	1.50	-5.24**	0.76
CMS-607 x SVR-467	88.36**	87.35**	88.43**	98.42**	95.98**	1.60	17.44**	8.33**	16.02**
CMS-607 x SVR-490	117.5**	111.9**	110.9**	67.74**	57.78**	-9.46	21.06**	11.33**	20.03**
CMS-607 x SVR-491	25.05**	24.25**	25.23**	56.19**	46.14**	-15.18**	3.32	-4.46*	1.78
CMS-607 x SVR-472	-13.23**	-20.42**	-20.82**	36.63**	33.20**	-32.64**	-8.37**	-17.31**	-7.05**
CMS-607 x SVR-495	-22.95	-25.39**	-20.75**	-2.22	-6.08	-48.43**	-11.07**	-20.26**	-9.05**
CMS-607 x SVR-454	92.48**	84.08**	83.15**	68.11**	66.10**	-13.94*	5.24**	-2.63	3.61
CMS-607 x SVR-436	-14.36	-25.79**	0.72	22.52**	7.96	-28.38**	-9.89**	-17.87**	-9.68**
CMS-607 x SVR-444	30.76**	17.08**	16.49**	42.92**	27.97**	-18.17**	4.41*	-2.60	1.80
CMS-607 x SVR-402	-20.15**	-20.20**	20.61**	21.98**	1.79	-23.05**	-10.38**	-20.78**	-6.65**
CMS-607 x SVR-496	-7.40**	-14.47**	0.43	66.14**	56.53**	-10.48	14.99**	6.42**	13.16**

* and ** indicate significance of values at P=0.05 and 0.01, respectively

107 x SVR-436 (38.63%). Three crosses *viz*., CMS-378 x SVR-490 (9.45%), CMS-107 x SVR-444 (5.82%) and CMS-107 x SVR-436 (5.59%) exhibited significant positive heterosis over standard check Phule Raviraj. Heterosis for tallness in sunflower has also been reported by Ahire *et al*.(1994); Habib *et al*. (2006) and Sujatha and Reddy (2009).

Larger head size is a desired character to effect more yield in sunflower crop. Out of 50 hybrids, 39 and 31 hybrids exhibited significant positive relative heterosis and heterobeltiosis, respectively for head diameter. While none of the hybrid exhibited significant positive heterosis over check Phule Raviraj. The higher magnitude of significant positive relative heterosis was observed in the cross CMS-607 x SVR-467 (114.67%) followed by CMS-148 x SVR-467 (75.77%) and CMS-607 x SVR-490 (74.97%) for head diameter, while maximum positive heterobeltiosis for head diameter was found in cross CMS-607 x SVR-467 (113.06%) followed by CMS-607 x SVR-490 (67.32%) and CMS-607x SVR-454 (61.47%). Ahire *et al*. (1994), Gangappa *et al*. (1997), Gill *et al*. (1998), Habib *et al*. (2006) and Sujatha and Reddy (2009) also found high positive heterosis for head diameter.

Number of seeds per head is also an effective trait contributing to seed yield and thus, positive heterosis for this trait is desirable. Among the 50 hybrids, 26, 15 and one hybrid exhibited significantly positive heterosis over mid parent, better parent and check Phule Raviraj, respectively. Maximum significant increase in number of seeds per head over mid parent was recorded in cross CMS-607 x SVR-467 (167.92%) followed by CMS-351 x SVR-467 (155.61%), CMS-607 x SVR-496 (113.97%) and CMS-148 x SVR-467 (109.74%). The hybrid CMS-607 x SVR-467 (133.31%) showed highest significant positive heterobeltiosis followed by the crosses CMS-351 x SVR-467 (120.54%) and CMS-148 x SVR-467 (103.28%). The only one hybrid CMS-607 x SVR-496 (25.19%) recorded the highest magnitude of significant positive heterosis over check Phule Raviraj. The positive heterosis for number of seeds per head was also reported by Ahire *et al*. (1994), Limbore *et al*. (1999) and Habib *et al*. (2006).

More the weight of 100 seeds, more will be the seed yield. Hence, heavier weight of 100 seeds is a desirable trait for successful hybrid development in sunflower. The significant positive heterosis for 100 seed weight was found in 29, 25 and 26 crosses over mid parent, better parent and check Phule Raviraj, respectively. The cross CMS-607 x SVR-496 (117.53%) displayed highest significant positive mid parent heterosis for 100 seed weight followed by the crosses CMS-107 x SVR-490 (111.96%), CMS-607 x SVR-454 (92.48%) and CMS-351x SVR-496 (90.32%). Maximum positive and significant heterobeltiosis for 100 seed weight was observed in the crosses CMS-607 x SVR-490 (111.92%) and CMS-107 x SVR-490 (105.70%). The highest percentage of heterosis over check Phule Raviraj was recorded in the cross CMS-607 x SVR-490 (110.85%) followed by the crosses CMS-351 x SVR-496 (109.04%) and CMS-107 x SVR-490 (106.29%). High mid parent heterosis for 100 seed weight was also recorded by Gangappa *et al*. (1997), Sassikumar and Gopalan (1999) and Habib *et al*. (2006) and heterobeltiosis by Habib *et al*. (2006).

Out of 50 hybrids, 34, 29 and one hybrid exhibited significant positive heterosis for seed yield per plant over mid parent, better parent and check Phule Raviraj, respectively. The magnitude of mid parent heterosis was higher in cross CMS-148 x SVR-467 (137.86%) followed by the crosses CMS-351 x SVR-467(126.49%), CMS-107 x SVR-472 (109.60%) and CMS-107 x SVR-467 (106.67). Heterobeltiosis was of greater magnitude in the cross CMS-148 x SVR-467 (133.75%) followed by the crosses CMS-351 x SVR-467 (121.06%) CMS-107 x SVR-472 (105.12%) and CMS-107 x SVR-467 (103.34%). Single hybrid CMS-148 x SVR-467 (21.19%) exhibited positive and significant heterosis over check Phule Raviraj. Heterosis for seed yield was also reported by earlier researchers (Singh *et al*., 1984; Giriraj *et al*., 1986; Khan *et al*., 2004; Kaya, 2005; Ahire *et al*., 1994 and Karasu *et al*., 2010).

Higher oil content is commercially important trait of sunflower and hence positive heterosis is important. Positive and significant heterosis for oil content was observed in 18, 8 and 15 crosses over mid parent, better parent and check Phule Raviraj, respectively. Higher magnitude significant and positive mid parent heterosis for oil content was found in the hybrids CMS-607 x SVR-490 (21.06%) and CMS-378 x SVR-444 (18.30%). Heterobeltiosis for oil content was more pronounced in the hybrid CMS-607 x SVR-490 (11.33%) which was followed by CMS-378 x SVR-444 (9.95%) and CMS-607 x SVR-467(8.33%). Highly significant and positive heterosis over check Phule Raviraj was found in the hybrids CMS-607 x SVR-490 (20.03%) and CMS-607 x SVR-467(16.02%). Similar heterotic effects were also reported by earlier research workers (Rather and Sandha, 1999; Nehru, 2000 and Habib *et al*., 2000).

Therefore, it can be concluded that the hybrid CMS-148 x SVR-467 can be exploited for seed yield and the hybrids CMS-607 x SVR-490 and CMS-607 x SVR-467 for better oil content on commercial basis.

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