J. Agric. Res. Technol., Special Issue (1) : 152-166 (2022) DOI: https://doi.org/10.56228/JART.2022.SP124

Study of Hetrosis in Sunflower (*Helianthus Annuus* L.)

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Abstract

The present investigation entitled "Heterosis studies in sunflower (Helianthus annuus L.) was undertaken to estimate the heterosis for seed yield and its components in sunflower. The 15 CMS lines and 5 restorer lines were crossed in line x tester model to produce 76 hybrids. The crosses were made at research area of Oilseed Section, Department of Genetics and Plant Breeding, CCS HAU, Hisar during the spring season of 2014. Hybrids and parents were evaluated under four different environments i.e. Summer 2014, last week of August (E1) and First week of Sept. (E2) and during spring 2015, i.e. first week of February (E3) and last week of February (E4). Data on five randomly selected plants from each genotype in each replication were recorded on different quantitative characters viz. plant height (cm), head diameter (cm), stem diameter (cm) days to 50% flowering, days to maturity, hundred seed weight (g), seed yield per plant (g), oil content (%), hull content (%), percent seed filling, germination (%), electrical conductivity (μScm^{-1} g^{-1}), viability (%), vigour index I, vigour index II, palmitic acid (%), stearic acid (%), oleic acid (%) and linoleic acid (%) in all the test environments. Hybrids CMS 207 A x HRHA 5-3, CMS 852 A x RHA 271, CMS 207 A x RHA 297, CMS 234 A x 6D-1 and CMS 207 A x 6D-1 were found better and superior for heterosis , seed yield and its contributing trait and also for oil content. The hybrids with good heterotic value could be directly used for heterosis breeding because of their dominant nature. The use of genotypes in hybridization from these results is likely to produce more heterotic combination in future.

Key word : Sunflower, Heterosis, Hybrid , Hybridization.

Sunflower is an important oilseed crop widely adopted and accepted for its high quality edible oil. It is grown over 23.28 million hectares in the world with 39.42 million ton production and 1690 kg per hectare productivity (Anonymous, 2016). Sunflower (Helianthus annuus L.) belongs to the genus Helianthus of the family Asteraceae, which includes 20 genera with 400 species. The cultivated sunflower is believed to have originated from wild Helianthus annuus in the south-western USA. The cultivation of sunflower in India started from 1972 after the introduction of Russian varieties such as Peredovick (EC 68414) and Armavirskii (EC 68415) and has acquired the status of an important commercial oilseed crop with greater spread across a number of agro - climatic and geographical regions. In India, Sunflower is known as "Surajmukhi" and it covers an area of 5.9 million hectare with production of 3.23 million ton and productivity of 736 kg/ha (Anonymous, 2016). Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu are considered as traditional sunflower growing states whereas, Punjab, Haryana, West Bengal and Uttar Pradesh are promising spring sunflower growing states. Sunflower is a rich source of good quality edible oil and it well fitted in our cropping pattern also. Sunflower, being a highly cross pollinated crop is ideally suited for exploitation of heterosis. The aim of breeding programme is to develop hybrids with high seed yield and oil yield potential having superior agronomic and economic advantages over varieties (high productivity, high oil content, uniformity, etc.). Hence, sunflower hybrid

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development is the main objective of breeding programme. Heterosis has been commercially exploited in sunflower and is expected to enhance productivity further.

Materials and Method

The experimental material consisted of 15 CMS (cytoplasmic male sterile) lines used as seed parents *viz.,* CMS 11A, CMS 17A, CMS 44A, CMSH 91A, CMS 103A, CMS 148A, CMS 207A, CMS 234A, CMS 302A, CMS 607A, CMS 852A, CMS ARG-2, CMS ARG-3, CMS ARG-6 and CMS DV-10 and five restorers (R line) used as a pollen parents namely 6D-1, HRHA 5-3, HRHA 4-2, RHA 297 and RHA 271 which were grown in paired rows and crossed in Line X Tester design to obtain 75 F1 hybrids, and there was a commercial check hybrid HSFH 848. Each CMS and restorer lines were grown in 2 rows of 4 meter length with a spacing of 45 cm x 30 cm.

Crossing Procedure : During the spring season of 2014, all the F_1"s were obtained by crossing the cytoplasmic male sterile lines with restorer lines. The cytoplasmic male sterile lines and restorer lines were sown in the field to affect crossing. At the time of flowering, all the heads in lines and testers were covered with muslin cloth bags to prevent open pollination. The pollen of the five restorer lines were collected separately in petridishes with the help of camel hairbrush during morning hours (7:00 to 11:00 AM) and pollinated to each of the cytoplasmic male sterile lines separately and the cloth bag was covered again after pollination. Pollination was done till all the florets in the capitulum showed sign of drying. The heads of all the resultant 75 hybrids were collected, dried and threshed. The well filled seeds from each cross were separated out for hybrid evaluation. The hybrid evaluation was conducted over 4 environments during 2014 -2015 i.e. Summer 2014 Last week of August (E1) and First week of September (E2) and during spring 2015, i.e. first week of February (E3) and last week of February (E4).

Results and Discussion

Heterosis of hybrids (F_1) over their respective better parents and standard check HSFH 848 was calculated for seed yield and its component traits and expressed in percentage. Over the environments (Table 1), the mean sum of squares, due to replications were found significant which emphasizes presence of enough variations in the environment. The mean sum of squares due to partitioning component parents, males, females, hybrids, location, hybrid x location, (parent vs. hybrid) x location were found significant for seed yield and its all component characters except electrical conductivity which was significant for male, female vs male and parents vs hybrids.

Plant height : Over the environments, the heterosis over better parent and standard check had positive and significant heterosis. The prominent hybrids over better parent were CMS 103 A x HRHA 5-3 (42.07%), CMSH 91 A x HRHA 4-2 (43.27%) and CMSH 91 A x HRHA 5-3 (40.72%) showed positive and significant heterosis and major hybrids over standard check were CMS 17 A x 6D-1 (27.34%), CMS 607 A x RHA 271 (26.60%) and CMS 302 A x RHA 297 (26.12%) showed positive and significant heterosis for this trait. In pooled analysis, heterosis over better parent ranged from 10.94% (CMS 852 A x HRHA 5-3) to 43.27% (CMSH 91 A x HRHA 4-2) and over standard check varied from 4.95% (CMS 23 x A x HRHA 4-2) to 32.88% (CMS 607 A x HRHA 5-3) for this trait. The results revealed that some experimental hybrids were taller/dwarf than standard check and these dwarf hybrids probably suit for mechanization and intercropping without much reduction in their yield levels. The results are supported by the findings of Shankara (1981), Govindaraju (1986) and Shivakumar (1989).

Table 1. Analysis of variance for plants and hybrids over the environments

Source	D.F.	PH (cm)	HD (cm)	SD (cm)	DF	DM	100 SW (g)	SY (g)	OC (%)	HC (%)	% SF
LOCATIONS	3	471553.80*	2403.26*	445.64*	2270.48*	587.32*	45.37*	18084.43*	1338.61*	2655.00*	9770.52*
REPL/LOC	8	352.51*	34.94*	2.62*	13.64*	5.19*	0.93	74.93*	42.37*	64.41*	55.78*
PARENTS	19	1031.16*	17.39*	1.69	27.43*	97.80*	2.75*	78.15*	72.69*	412.93*	1302.84*
FEMALES	14	1208.69*	13.82*	1.55	24.83*	96.10*	3.59*	71.36*	69.38*	504.18*	1625.01*
MALES	4	667.40*	20.80*	2.57*	42.63*	110.84*	0.28	90.30*	102.40*	176.00*	457.30*
FEMALE VS MALES	1	0.50	53.68*	0.07	2.89*	69.50*	0.84	124.46*	0.27	83.13*	174.53*
HYBRIDS	74	327.27*	11.69*	2.29*	27.65*	23.70*	2.78*	43.06*	3.67*	207.94*	379.03*
PAR VS HYB	1	165380.50*	4052.98*	1571.11*	30.06*	162.00*	1306.71*	38204.08*	0.13	39423.75*	194564.30*
PAR x LOC	57	182.13*	5.07*	1.13	4.61*	9.04*	1.37	36.73*	27.71*	42.88*	101.45*
FEMALE x LOC	42	163.81*	5.55*	1.22	4.72*	9.39*	1.07	26.73*	32.91*	37.07*	66.21*
MALE x LOC	12	278.79*	1.97	1.04	3.51*	8.05*	1.55	73.40*	15.18*	72.52*	120.87*
F VS M) x LOC	3	52.06*	10.68*	0.32	7.44*	8.11*	4.88*	30.05*	4.96*	5.72*	517.05*
HYBRIDS x LOC	222	262.93*	9.66*	2.39*	28.22*	20.57*	2.81*	30.92*	3.56*	131.21*	409.40*
(PAR VS HYB) x LOC	3	47674.67*	218.33*	39.37*	235.08*	201.01*	4.36*	1121.54*	4278.39*	167.75*	5611.38*
ERROR	752	18.90	1.95	0.50	3.47	1.69	0.74	5.31	2.57	18.20	11.20

SOURCE	D.F.	GERM. (%)	EC (µS cm1g1)	VIAB. (%)	VI-1	VI-II	PALM. (%)	STER. (%)	OLEIC (%)	LINO. (%)
LOCATIONS	3	6707.42*	0.99	4465.76*	726135.00*	4540.15*	35.48*	284.37*	111499.70*	66843.22*
REPL/LOC	8	39.13*	0.01	61.81*	674804.00*	68.17*	26.95*	27.36*	215.79*	73.52*
PARENTS	19	1557.88*	0.76	1608.11*	3049624.00*	222.54*	3.66*	11.68*	75.31*	163.53*
FEMALES	14	1401.63*	0.22	1411.27*	4050480.00*	202.64*	3.97*	12.72*	81.72*	99.98*
MALES	4	2446.95*	2.16*	2669.80*	237296.00*	120.33*	1.56	10.11*	39.70*	48.78*
FEMALE VS MALES	1	188.84*	2.88*	117.25*	286986.00*	910.06*	7.71*	3.51*	127.93*	1512.28*
HYBRIDS	74	716.71*	0.36	664.11*	436387.00*	345.23*	12.36*	11.02*	141.95*	292.61*
PAR VS HYB	1	5783.38*	5.84*	13618.75*	31435570.00*	30711.53*	123.26*	19.34*	90.47*	10977.03*
PAR x LOC	57	21.36*	0.02	16.77*	2252955.00*	14.74*	1.70	1.30	68.27*	93.59*
FEMALE x LOC	42	22.16*	0.02	13.20*	29770200.00*	14.39*	1.23	0.99	75.47*	82.15*
MALE x LOC	12	10.38*	0.02	32.44*	6516088.00*	4.17*	2.68*	2.68*	28.96*	131.34*
(F VS M) x LOC	3	53.97*8	0.06	4.02*	8672208.00*	61.92*	4.43*	0.14	124.65*	102.88*
HYBRIDS x LOC	222	322.30*	0.22	307.68*	3414844.00*	202.05*	5.83*	8.54*	175.19*	196.72*
(PAR VS HYB) x LOC	3	5283.12*	0.58	4771.49*	8938517.00*	2272.59*	5.16*	9.33*	2181.01*	381.94*
ERROR	752	13.48	0.01	7.78	48929.00	15.72	0.36	0.20	3.87	3.99

PH-Plant height, HD-Head diameter, SD-Stem diameter, DF-days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield plant^{-1}, OC-Oil content, HC- Hull content, % SF-Percent seed filling, GERM.-Germination, EC-Electrical conductivity, VIAB.-Viability, VI I -Vigour index I, VI II-Vigour index II,PALM.-Palmitic acid, STER.-Stearic acid, OLEIC-Oleic acid, LINO.-Linolenic acid.

Head diameter : Over the environments (Table 1.1), the heterosis were positive and significant for all the hybrids. The major hybrids over better parent were CMS 207 A x RHA 297 (82.56%), CMS 17 A x HRHA 5-3 (75.95%) and ARG 6A x 6D-1(71.60%) and the prominent hybrids over standard check were CMS 17 A x HRHA 5-3 (37.99%), CMS 148 A x HRHA 4-2 (30.97%) and CMS 207 A x RHA 297 (29.72%) for this trait . Heterosis over all the environments ranged from 10.94% (CMS 852A X HRHA 5-3) to 43.27% (CMSH 91 A X HRHA 4-2) over better parent and 4.95% (CMS 234 A X HRHA 4-2) to 32.88% (CMS 607 A X HRHA 5-3) over standard check as presented in table 1.1. Positive heterotic effects have been reported by most of the researchers for this trait. Goksoy *et al*. (2000), Radhika *et al*. (2001), Phad *et al*. (2002), Alone *et al*. (2003) and Manivannan *et al*. (2005) reported significant positive heterosis, indicated positive influence of cytoplasmic sources on heterosis for head diameter.

Stem diameter : In pooled analysis, it was recorded (Table 1.1) that seventy five hybrids over better parent and seventy one hybrids over standard check showed positive and significant heterosis for stem diameter. The hybrids, CMS 148 A x HRHA 4-2 (106.55%), CMS 44 A x RHA 297 (80.93%) and CMS 234 A x RHA 271 (76.21%) showed positive and significant heterosis over better parent whereas, the hybrids CMS 44 A x RHA 297 (23.66%), CMS 17A x HRHA 5-3 (23.16%) and CMS 234 A x RHA 271 (21.77%) were found to be positive and significant heterosis over standard check. In pooled analysis, heterosis over better parent ranged from 36.53% (ARG 6A X RHA 271) to 106.55% (CMS 148 AX HRHA 4-2 and over standard check ranged from -6.66% (CMS 44 A X HRHA 4-2) to 23.16% (CMS 17-A X HRHA 5-3) as presented in Table1.1. The positive heterosis of moderate magnitude for stem girth was reported by Govindaraju *et al*. (1992) and Gangappa *et al*. (1997).

Days to 50% flowering : Over the environments, fifty three hybrids over better parent showed negative and significant heterosis per cent. The hybrids, CMS 148 A x HRHA 4-2 (-6.11%), CMS 302 A x 6D-1 (-4.56%) and ARG 2A x 6D-1 (-2.81%) were found to be negative and significant over better parent whereas, sixty eight hybrid over standard check showed significant heterosis per cent, whereas but the only one hybrid viz., CMS 302 A x 6D-1 (-1.45%) observed negative and significant heterosis over the standard check for early flowering. over all the environment the heterosis over better parent ranged from -6.11% (CMS 148 AX HRHA 4-2) to 10.71% (CMS 103 AX HRHA 5-3) and over standard check varied from 10.30% (DV 10 X HRHA 4-2) to -1.45% (CMS 302 A X 6D-1) for days to 50% flowering. The existence of both significant positive and negative heterotic effects over check suggests the presence of non-additive gene action for this trait. Giriraj *et al*. (1986), Gangappa *et al*. (1997), Radhika *et al*. (2001), Singh and Singh (2003) and Manivannan *et al*. (2005) have also reported heterosis for earliness in sunflower hybrids.

Days to maturity : Over the environments, fifty seven hybrids over better parent showed significant heterosis and three hybrids, namely, CMS 148 A x RHA 297 (-2.88%), CMS 103 A x RHA 271 (-2.08%) and CMS 103 A x HRHA 4-2 (-2.71%) exhibited negative and significant heterosis per cent, whereas, seventy three hybrids showed positive and significant heterosis per cent for early maturity over standard check. over all the environment the heterosis over better parent ranged from - 2.88% (CMS 148 A X RHA 297) to 10.82% (CMS 302 A X HRHA 5-3) and over standcheck varied from 0.96% (CMS 11 A X RHA 271) to 7.50% (CMS 302 A X HRHA 5-3) for this trait. Phad *et al*. (2002), Bajaj *et al*. (2003) and Alone *et al*. (2003) have also reported heterosis for early maturity in hybrids.

Table 1.1 Estimation of heterotic effects of hybrids for morphological characters and seed yield over the environments

Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP*	Check
CMS 11 A x 6D-1	16.82*	17.14*	19.54*	11.25*	60.49*	5.86*	-1.76*	1.80*	1.36*	1.15*	39.24*	15.41*	48.71*	5.97*
CMS 11 A x RHA 271	27.00*	20.06*	18.42*	10.20*	43.40*	-0.90	-1.19	2.39*	-1.12	0.96*	44.18*	19.51*	42.17*	13.97*
CMS 11 A x HRHA 4-2	28.17*	18.36*	21.16*	12.75*	66.97*	3.74*	-1.45	2.12*	1.11*	3.24*	42.42*	18.05*	67.348	19.25*
CMS 11 A x HRHA 5-3	33.75*	23.51*	34.03*	24.73*	63.84*	16.01*	4.17*	2.71*	5.21*	2.06*	45.61*	20.69*	76.46*	25.75*
CMS 11 A x RHA 297	25.89*	19.27*	18.53*	10.31*	56.74*	7.12*	3.47*	5.71*	0.93	3.05*	38.60*	14.88*	73.37*	23.55*
CMS 17-A x 6D-1	26.47*	27.34*	67.13*	28.37*	64.92*	12.25*	-0.36	3.52*	4.03*	3.81*	50.34*	13.70*	77.52*	25.23*
CMS 17-A x RHA 271	19.17*	19.99*	59.86*	22.79*	64.61*	13.76*	1.63*	6.78*	-0.75	2.38*	75.69*	34.16*	61.85*	29.74*
CMS 17 -A x HRHA 4-2	22.34*	23.18*	32.50*	13.43*	56.08*	6.24*	-1.16	4.71*	-1.56	2.04*	74.85*	24.13*	71.29*	20.83*
CMS 17 -A x HRHA 5-3	19.36*	20.17*	75.97*	37.99*	73.92*	23.16*	3.28*	1.84*	4.57*	1.43*	49.60*	15.01*	66.91*	17.74*
CMS 17 A x RHA 297	16.15*	16.94*	53.43*	17.85*	74.15*	19.02*	0.46	2.64*	-1.41	2.20*	39.15*	2.61*	72.03*	21.35*
CMS 44 A x 6D-1	19.25*	19.58*	49.33*	23.56*	71.89*	13.38*	-1.71*	2.11*	5.21*	2.83*	73.39*	31.12*	94.69*	21.91*
CMS 44 A x RHA 271	15.98*	13.26*	33.63*	10.57*	44.85*	0.10	-1.67*	2.59*	4.47*	2.11*	49.75*	14.35*	31.17*	5.15*
CMS 44 A x HRHA 4-2	14.72*	12.02*	31.05*	12.18*	55.83*	-6.66*	-0.51	3.80*	5.33*	2.94*	72.06*	22.14*	108.34*	30.45*
CMS 44 A x HRHA 5-3	23.15*	20.26*	55.45*	28.63*	66.84*	18.14*	3.35*	1.90*	4.57*	1.43*	61.28*	23.99*	76.85*	20.10*
CMS 44 A x RHA 297	23.51*	20.61*	47.92*	22.39*	80.93*	23.66*	1.14	3.33*	4.65*	2.28*	69.95*	25.31*	91.26*	23.81*
CMS 148 A x 6D-1	13.01*	13.31*	23.30*	7.58*	62.20*	6.99*	-1.73*	2.10*	3.86*	3.64*	44.16*	16.60*	57.83*	15.50*
CMS 148 A x RHA 271	18.92*	13.59*	36.68*	19.26*	65.52*	14.39*	-2.67*	2.26*	-0.43	2.71*	47.10*	18.98*	46.99*	17.83*
CMS 148 A x HRHA 4-2	26.78*	21.10*	50.10*	30.97*	106.55*	16.14*	-6.11*	0.55	-0.59	4.30*	53.63*	24.26*	70.57*	24.82*
CMS 148 A x HRHA 5-3	18.37*	13.07*	32.08*	15.25*	63.66*	15.89*	7.60*	6.09*	6.20*	3.02*	58.86*	28.48*	81.39*	32.74*
CMS 148 A x RHA 297	22.61*	17.11*	36.70*	19.28*	68.65*	15.26*	0.77	2.96*	-2.88*	0.97	52.98*	23.73*	79.26*	31.19*
CMSH 91 A x 6D-1	20.69*	21.02*	30.44*	26.94*	66.15*	14.64*	-0.59	3.28*	3.54*	3.33*	42.00*	19.11*	63.64*	31.89*
CMSH 91 A x RHA 271	25.16*	18.32*	20.29*	17.07*	70.41*	17.77*	-1.16	3.85*	4.78*	5.90*	41.06*	18.32*	45.85*	17.56*
CMSH 91 A x HRHA 4-2	43.27*	21.62*	28.57*	25.12*	73.60*	19.77*	-2.30*	4.23*	2.32*	3.41*	46.25*	22.68*	42.71*	15.02*
CMSH 91 A x HRHA 5-3	40.72*	21.07*	19.76*	16.55*	60.12*	13.38*	6.63*	5.13*	7.57*	4.34*	44.21*	20.96*	63.07*	31.43*
CMSH 91 A x RHA 297	16.64*	10.52*	23.90*	20.58*	65.97*	14.51*	0.59	2.77*	1.24*	2.32*	43.26*	20.16*	56.62*	26.23*
CMS 103 A x 6D-1	17.56*	17.88*	42.22*	15.12*	75.12*	15.51*	5.83*	8.56*	4.52*	4.30*	72.87*	30.73*	96.47*	22.52*
CMS 103 A x RHA 271	24.87*	18.04*	37.40*	11.22*	56.09*	7.87*	4.44*	7.14*	-2.08*	1.01	50.10*	14.62*	47.89*	18.55*
CMS 103 A x HRHA 4-2	39.53*	20.13*	38.88*	18.89*	73.15*	8.12*	3.35*	6.01*	-2.71*	2.08*	67.72*	22.28*	91.52*	19.43*
CMS 103 A x HRHA 5-3	42.07*	22.32*	34.83*	9.14*	45.26*	2.86*	10.71*	9.16*	5.98*	2.80*	67.98*	29.14*	77.43*	20.50*
CMS 103 A x RHA 297	23.36*	16.88*	21.19*	-1.90*	41.70*	-3.15*	1.54*	3.74*	1.48*	5.50*	68.70*	24.39*	74.61*	13.03*
CMS 234 A x 6D-1	23.48*	23.81*	41.95*	19.41*	60.30*	5.74*	0.24	1.55*	5.33*	4.07*	51.39*	14.48*	100.28*	21.63*
CMS 234 A x 6D-1	23.48*	23.81*	41.95*	19.41*	60.30*	5.74*	0.24	1.55*	5.33*	4.07*	51.39*	14.48*	100.28*	21.63*

Table 1.1 Contd

Hybrids	PH (cm)		HD (cm)		SD (cm)		DF		DM		100 SW (g)		SY (g)	
	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP	Check	BP*	Check
CMS 234A x RHA 271	27.11*	20.16*	34.85*	13.43*	76.21*	21.77*	4.01*	5.37*	5.63*	4.36*	49.40*	14.09*	42.76*	14.44*
CMS 234 A x HRHA 4-2	14.33*	4.95*	24.16*	6.29*	75.06*	7.62*	2.90*	4.25*	6.89*	5.61*	64.25*	16.60*	83.90*	11.68*
CMS 234 A x HRHA 5-3	27.78*	17.29*	29.05*	8.55*	53.57*	8.75*	4.33*	2.86*	9.01*	5.74*	58.88*	22.14*	61.63*	9.77*
CMS 234 A x RHA 297	24.11*	17.59*	36.39*	14.73*	54.90*	5.87*	-0.88	0.42	5.66*	4.39*	47.21*	8.54*	82.89*	18.39*
CMS 302 A x 6D-1	13.79*	14.10*	49.74*	13.30*	50.75*	12.13*	-4.56*	-1.45*	4.59*	4.38*	39.69*	5.64*	93.51*	16.33*
CMS 302 A x RHA 271	27.73*	24.84*	55.58*	17.72*	50.41*	11.88*	-2.63*	0.54	-0.56	2.30*	58.57*	21.09*	52.75*	22.45*
CMS 302 A x HRHA 4-2	18.98*	16.29*	42.52*	22.01*	54.79*	15.14*	-1.21	2.00*	-0.20	2.67*	53.50*	13.69*	111.18*	16.33*
CMS 302 A x HRHA 5-3	28.09*	25.19*	53.27*	20.19*	53.11*	13.88*	8.29*	6.77*	10.82*	7.50*	45.14*	11.58*	66.77*	13.26*
CMS 302 A x RHA 297	29.04*	26.12*	53.00*	15.77*	51.93*	13.01*	3.53*	5.77*	0.46	3.34*	54.22*	14.23*	85.01*	19.76*
CMS 607 A x 6D-1	17.73*	18.19*	36.48*	17.72*	68.48*	18.27*	9.02*	9.45*	7.31*	5.06*	46.21*	17.79*	50.28*	21.68*
CMS 607 A x RHA 271	26.11*	26.60*	46.42*	26.29*	62.41*	14.01*	3.14*	3.55*	4.09*	1.90*	47.03*	18.45*	46.66*	18.75*
CMS 607 A x HRHA 4-2	20.21*	20.68*	36.63*	17.85*	48.85*	4.49*	0.80	1.20	6.95*	4.71*	54.56*	24.52*	46.98*	19.01*
CMS 607 A x HRHA 5-3	32.36*	32.88*	30.75*	12.78*	50.39*	6.49*	4.69*	3.22*	9.46*	6.17*	25.06*	0.75	36.89*	10.84*
CMS 607 A x RHA 297	13.81*	14.26*	19.53*	3.10*	48.85*	4.49*	2.54*	2.95*	5.81*	3.60*	50.79*	21.49*	42.03*	15.00*
CMS 852 A x 6D -1	13.26*	17.48*	55.02*	10.44*	45.30*	-4.15*	1.30	1.59*	6.93*	6.70*	29.86*	15.54*	58.40*	16.66*
CMS 852 A x RHA 271	12.69*	16.88*	61.03*	17.85*	57.90*	9.12*	-1.21	-0.93	-0.98	2.15*	37.87*	22.67*	51.13*	21.15*
CMS 852 A x HRHA 4-2	17.25*	21.61*	27.34*	9.01*	73.09*	13.14*	-0.69	-0.41	1.37*	6.36*	43.51*	27.69*	52.73*	12.48*
CMS 852A x HRHA 5-3	10.94*	15.07*	23.71*	-2.99*	48.27*	4.99*	5.42*	3.94*	8.78*	5.52*	25.11*	11.32*	52.36*	12.20*
CMS 852 A x RHA 297	13.95*	18.19*	59.95*	13.95*	50.87*	3.11*	4.82*	5.11*	-1.52*	2.37*	17.10*	4.19*	51.12*	11.30*
ARG 2A x 6D-1	17.84*	18.16*	43.40*	18.63*	69.23*	11.63*	-2.81*	0.97	5.11*	4.89*	20.25*	15.68*	35.20*	16.17*
ARG 2A x RHA 271	28.65*	21.61*	47.13*	21.72*	61.71*	11.75*	1.72*	5.83*	-0.16	2.98*	28.89*	23.99*	33.80*	14.97*
ARG 2A x HRHA 4-2	37.97*	17.13*	31.90*	12.91*	63.09*	6.74*	3.00*	7.17*	0.66	4.92*	24.23*	19.51*	38.86*	19.32*
ARG 2A x HRHA 5-3	36.04*	17.04*	30.20*	7.71*	49.15*	5.62*	5.89*	4.40*	5.18*	2.03*	35.07*	29.94*	38.38*	18.90*
ARG 2A x RHA 297	24.83*	18.27*	24.55*	3.04*	47.57*	0.85*	2.85*	5.08*	0.35	4.32*	16.82*	12.38*	46.63*	25.99*
ARG 3A x 6D -1	12.30*	12.60*	35.65*	12.52*	60.96*	8.37*	2.15*	6.12*	4.56*	4.34*	50.03*	18.45*	59.71*	22.02*
ARG 3A x RHA 271	18.75*	12.26*	38.47*	14.86*	51.56*	4.74*	2.74*	7.95*	0.96	4.15*	62.74*	28.49*	42.31*	14.08*
ARG 3A x HRHA 4-2	33.74*	13.53*	25.98*	7.84*	48.68*	0.11	0.32	7.20*	-0.61	4.28*	35.31*	6.83*	46.39*	11.85*
ARG 3A x HRHA 5-3	29.90*	11.76*	39.41*	15.64*	50.04*	6.24*	9.68*	8.14*	6.18*	3.00*	38.48*	9.34*	53.34*	17.15*
ARG 3A x RHA 297	23.85*	17.35*	30.48*	8.23*	54.54*	5.62*	4.02*	6.28*	-0.53	3.40*	57.05*	23.99*	57.85*	20.60*
ARG 6A x 6D-1	11.89*	12.20*	71.60*	16.81*	36.86*	5.36*	-0.33	2.37*	3.27*	3.05*	71.47*	29.67*	70.82*	25.35*
ARG 6A x RHA 271	17.21*	13.23*	64.05*	20.06*	36.53*	5.12*	5.39*	8.25*	1.16*	4.35*	55.97*	19.11*	44.95*	16.20*
ARG 6A x HRHA 4-2	20.01*	15.92*	26.13*	7.97*	42.55*	9.75*	4.32*	7.15*	0.19	5.12*	68.90*	19.90*	54.20*	13.15*

Table 1.1 Contd

Hybrids	**PH (cm)**		**HD (cm)**		**SD (cm)**		**DF**		**DM**		**100 SW (g)**		**SY (g)**	
	BP	**Check**	**BP**	**Check**	**BP**	**Check**	**BP**	**Check**	**BP**	**Check**	**BP**	**Check**	**BP***	**Check**
ARG 6A x HRHA 5-3	19.51*	15.45*	39.52*	9.40*	37.35*	5.74*	9.46*	7.93*	7.86*	4.62*	37.58*	5.77*	54.33*	13.25*
ARG 6 A x RHA 297	16.31*	12.36*	67.76*	9.79*	45.16*	11.76*	4.51*	6.77*	1.22*	5.22*	57.95*	16.47*	70.80*	25.33*
DV 10 x 6D -1	20.72*	21.04*	41.79*	15.64*	73.03*	14.14*	3.33*	4.46*	5.97*	5.75*	57.85*	19.38*	52.90*	12.14*
DV 10 x RHA 271	25.68*	18.81*	35.10*	10.18*	51.92*	4.98*	5.14*	6.30*	2.07*	5.29*	62.89*	24.39*	42.01*	13.84*
DV 10 x HRHA 4-2	37.88*	20.25*	24.76*	6.80*	58.26*	3.36*	9.10*	10.30*	-0.45	4.45*	37.46*	-2.42*	46.56*	7.49*
DV 10 x HRHA 5-3	32.41*	15.48*	25.70*	2.52*	41.90*	0.48	6.95*	5.45*	8.16*	4.92*	32.94*	2.21*	55.45*	14.01*
DV -10 x RHA 297	15.25*	9.20*	32.23*	7.84*	46.65*	0.23	5.16*	6.31*	1.84*	5.87*	53.30*	13.03*	57.05*	15.18*
CMS 207 A x 6D -1	15.83*	16.14*	50.48*	6.93*	49.53*	1.48*	3.87*	7.92*	6.05*	5.83*	40.56*	6.30*	67.16*	18.45*
CMS 207 A x RHA 271	17.04*	13.60*	54.28*	12.91*	52.47*	5.36*	2.12*	7.30*	2.53*	5.76*	55.11*	18.45*	44.88*	16.14*
CMS 207 A x HRHA 4-2	21.84*	18.26*	39.33*	19.28*	67.81*	13.88*	-0.10	7.32*	1.64*	4.86*	58.30*	13.30*	61.88*	14.71*
CMS 207 A x HRHA 5-3	19.25*	15.75*	60.56*	25.90*	55.70*	10.25*	9.92*	8.38*	6.89*	3.68*	50.29*	15.54*	95.53*	38.55*
CMS 207 A x RHA 297	17.92*	14.46*	82.56*	29.72*	72.87*	18.14*	3.81*	6.06*	0.34	3.52*	63.86*	20.83*	82.52*	29.33*
SE	1.77	1.55	0.57	0.48	0.29	0.27	0.76	0.66	0.53	0.48	0.35	0.32	0.94	0.74
CDat5%	3.54	3.10	1.14	0.96	0.58	0.54	1.52	1.32	1.06	0.96	0.70	0.64	1.88	1.48

Hundred seed weight (g) : Over the environments, seventy five hybrids over better parent and seventy four hybrids over standard check showed positive and significant heterosis percent. The prominent hybrids over better parent were CMS 17 A x RHA 271 (75.69%), CMS 17 A x HRHA 4-2 (74.85%) and CMS 44 A x 6D-1 (73.39%) while the major hybrids over standard check were CMS 17 A x RHA 271(34.16%), CMS 44 A x 6D-1(31.12%) and CMS 103 A x 6D-1 (30.73%) for this trait. Over the environments (table 4.40) heterosis over better parent and standard check ranged from -16.82% (ARG 2A X RHA 297) to 75.69% (CMS 17-A X RHA 271) and -2.42% (DV 10 X HRHA 4-2) to 34.16% (CMS 17-A X RHA 271) respectively. Studies conducted by Sawant *et al*. (2007), Sujatha and Reedy (2009) have observed sufficient heterosis for this trait.

Seed yield plant^{-1} : In pooled analysis (Table 1.1), seventy five hybrids showed the positive and significant heterosis over both the parents i.e. over better parent and over standard check. The hybrids, CMS 302 A x HRHA 4-2 (111.18%), CMS 44 A x HRHA 4-2 (108.34%) and CMS 234 A x 6D-1 (100.28%) showed positive and significant heterosis percent over better parent whereas the hybrids, CMS 207 A x HRHA 5-3 (38.55%),CMS 148 A x HRHA 5-3 (32.74%) and CMSH 91 A x 6D-1 (31.89%) were observed to have positive and significant heterosis percent over standard check for this trait . over the environments heterosis over better parent varied from 31.17% (CMS 44 A X RHA 271) to 111.18% (CMS 302 A X HRHA 4-2) and over standard check from 5.15% (CMS 44 A X RHA 271) to 38.55% (CMS 207 A X HRHA 5-3). High degree of heterosis (more than 100 %) for seed yield was reported by Limbore *et al*. (1998) and Lande *et al* (1998) in sunflower. Naware (1999) noticed highest standard heterosis to the extent of 85.63 per cent in the hybrid 302 A x SS-56. Higher standard heterosis for seed yield plant^{-1} also have been reported by Habib *et al*. (2007) and Khan *et al*. (2008).

Oil content (%) : Over the environments, seventy five crosses over the better parent and sixty six crosses over standard check showed significant heterosis per cent. The hybrids, CMS 207 A x HRH A5-3 (8.67%), CMS 11 A x HRHA 5-3 (7.09%) and CMS 207 A x 6D-1 (6.90%) showed positive and significant heterosis over better parent whereas, the hybrids CMS 207 A x RHA 297 (6.52%), CMS 207 A x 6D-1 (6.63%) and CMS 17A x 6D-1 (5.28%) were observed to have positive and significant heterosis over the standard check for this trait. over all the environments heterosis ranged from -11.73% (CMS 234 A X HRHA 4-2) to 8.67% (CMS 207 A X HRHA 5-3) and from -0.44% (CMSH 91 A X RHA 297) to 6.63% (CMS 207 A X 6D -1) over better parent and standard check respectively, for oil content. A varying degree of negative heterosis for oil content was noticed over better parent and over standard check. Similar results were reported by several workers viz., Gill and Punia (1996), Harini (1992), Kumar *et al*. (1999) and Alone *et al*. (2003). Higher heterosis for oil content has earlier been reported by Devi *et al*. (2005), Kaya (2005a) and Sujatha and Reddy (2009).

Hull content (%) : Over the environments, seventy one hybrids over better parent and sixty eight hybrids over standard check showed negative and significant heterosis per cent. The results indicated that the heterosis over better parent was observed by the hybrids, CMS 148 A x HRHA 5-3 (-10.87%), CMS 148 A x 6D-1 (-7.03%) and CMS 148 A x RHA 297 (-4.83%) whereas the hybrids CMS 207 A x 6D-1 (-6.23%) and CMS 44 A x HRHA 5-3 (-4.30%) were found to be negative and significant heterosis over standard check for this trait. In pooled analysis, heterosis ranged from -10.87% (CMS 148 A X HRHA 5-3) to 75.08% (ARG 6A X 6D-1) and from -6.23% (CMS 207 A X 6D -1) to 33.52% (DV 10 X HRHA 4-2) over better parent and standard check respectively.

Percent seed filling : Over the environments, seventy four hybrids over better parent and seventy five hybrid over standard check showed positive and significant heterosis per cent. The hybrids, CMS 44A x 6D-1 (110.07%), ARG 3A x 6D-1 (107.40%) and ARG 6A x 6D-1 (102. 81%) were observed to have positive and significant heterosis over better parent and the hybrids ARG 6A x RHA 297 (61.69%), ARG 2A x 6D-1 (60.55%) and CMS 207 A x RHA 297 (58.96%) showed positive and significant heterosis over standard check for this trait. Over the environments, heterosis over better parent and standard check ranged from 1.63% (CMS 17 -A X HRHA 4-2) to 110.07% (CMS 44 A X 6D-1), 23.45% (CMS 607 A X RHA 297) 61.69% (ARG 6 A X RHA 297) respectively. Ahire *et al*. (1994) recorded highest heterosis in cross EC 42283 x EC 75270 and EC 73260 x EC 68414 for seed filled percent. Burali and Jadhav (2001) and Dudhe (2004) also reported the comparable results with present investigation.

Germination (%) : In pooled analysis, fifty five hybrids over better parent and seventy three hybrids over standard check showed significant heterosis per cent. The hybrids CMS 234 A x RHA 297 (65.21%), CMS 852 A x RHA 297 (20.36%) and ARG 2 A x RHA 297 (14.98%) showed positive and significant heterosis over better parent and the hybrids CMS 852 A x 6D-1 (40.45%), CMS 148 A x HRHA 4-2 (39.90%) and CMS 607 A x HRHA 4-2 (39.66%) were observed to have positive and significant heterosis over standard check for this trait. In pooled analysis, heterosis ranged from -28.80% (CMS 302 A X HRHA 4-2) to 65.21% (CMS 234 A X RHA 297) over better parent and from -5.30% (CMS 302 A X HRHA 4-2) to 40.45% (CMS 852 A X 6D -1) over standard check for this trait.

Table 1.2 Effects of heterosis for oil content and viability over the environments

Hybrids	**OC (%)**		**HC (%)**		**% SF**		**GERM. (%)**		**EC (μScm1g1)**		**VIAB. (%)**	
	BP	**CHK**	**BP**	**CHK**	**BP**	**CHK**	**BP**	**CHK**	**BP**	**CHK**	**BP**	**CHK**
CMS 11 A x 6D-1	0.74	0.49	20.46*	3.35*	45.30*	46.07*	5.32*	33.51*	-45.66*	-49.09*	10.11*	48.15*
CMS 11 A x RHA 271	5.07*	3.56*	22.38*	12.65*	48.32*	49.11*	-0.26	33.63*	-52.04*	-55.05*	5.72*	53.55*
CMS 11 A x HRHA 4-2	-10.07*	2.94*	19.33*	7.08*	50.83*	51.63*	1.34	26.00*	-20.90*	-25.88*	0.51	35.23*
CMS 11 A x HRHA 5-3	7.09*	1.15*	7.40*	-0.23	43.52*	44.29*	12.55*	38.75*	-53.19*	-56.14*	13.66*	52.92*
CMS 11 A x RHA 297	-1.78*	3.62*	36.28*	16.92*	54.90*	55.72*	10.56*	36.29*	-65.38*	-48.12*	8.79*	46.38*
CMS 17-A x 6D-1	5.55*	5.28*	14.04*	18.43*	19.88*	49.00*	9.90*	39.32*	-49.67*	-54.67*	16.28*	54.38*
CMS 17-A x RHA 271	1.67*	1.39*	-2.82	0.93	12.29*	39.56*	-23.35*	2.70	24.78*	12.43*	-23.73*	10.77*
CMS 17 –A x HRHA 4-2	-9.74*	3.31*	-1.37	2.42	1.63	26.31*	0.97	25.54*	-14.89*	-23.33*	4.25*	36.46*
CMS 17 -A x HRHA 5-3	2.29*	2.01*	0.92	4.80*	22.26*	51.96*	7.89*	33.60*	-41.41*	-47.18*	11.44*	43.70*
CMS 17 A x RHA 297	-4.23*	1.04	4.78*	8.82*	18.28*	47.01*	8.52*	34.38*	-67.80*	-51.73*	15.84*	48.58*
CMS 44 A x 6D-1	-0.98	1.53*	57.64*	14.55*	110.07*	51.62*	9.86*	39.27*	-46.99*	-54.26*	13.65*	51.42*
CMS 44 A x RHA 271	1.48*	4.04*	15.67*	6.47*	67.27*	53.44*	1.92	36.55*	-39.39*	-47.71*	3.90*	50.90*
CMS 44 A x HRHA 4-2	-11.17*	1.68*	13.45*	1.81	58.27*	53.56*	9.92*	37.80*	-28.26*	-38.10*	13.59*	51.34*
CMS 44 A x HRHA 5-3	0.27	2.81*	3.02	-4.30*	41.93*	36.70*	6.02*	32.91*	-42.11*	-50.03*	10.37*	47.05*
CMS 44 A x RHA 297	-3.22*	2.10*	30.86*	5.89*	93.57*	58.32*	-4.01*	20.33*	-46.70*	-20.09*	1.38	35.07*
CMS 148 A x 6D-1	-7.09*	2.06*	-7.03*	1.18	28.77*	42.07*	3.21	38.94*	-46.65*	-48.59*	9.96*	55.65*
CMS 148 A x RHA 271	-7.35*	1.77*	-3.57*	4.95*	33.92*	47.76*	-9.16*	22.29*	-55.08*	-56.70*	-7.18*	34.81*
CMS 148 A x HRHA 4-2	-11.61*	1.17*	15.84*	26.07*	37.93*	52.18*	3.92*	39.90*	-50.30*	-52.12*	6.86*	51.26*
CMS 148 A x HRHA 5-3	-7.81*	1.26*	-10.87*	-2.99	33.84*	47.66*	-6.57*	25.77*	-30.49*	-33.02*	-1.16	39.90*
CMS 148 A x RHA 297	-6.63*	2.56*	-4.83*	3.58*	17.08*	29.17*	-26.03*	-0.42	-36.64*	-4.99*	-21.92*	10.52*
CMSH 91 A x 6D-1	4.32*	4.82*	20.67*	0.89	27.19*	34.30*	5.68*	34.91*	-22.21*	-40.01*	8.70*	44.31*
CMSH 91 A x RHA 271	2.76*	3.25*	21.73*	12.04*	36.79*	44.43*	-7.63*	23.75*	-22.84*	-40.45*	-8.11*	33.45*
CMSH 91 A x HRHA 4-2	-10.86*	2.03*	33.71*	19.99*	38.95*	46.71*	3.37	31.96*	-11.80*	-31.93*	13.19*	48.17*
CMSH 91 A x HRHA 5-3	0.82	1.30*	22.21*	13.53*	46.06*	54.22*	4.74*	33.71*	-35.41*	-50.18*	8.47*	40.96*
CMSH 91 A x RHA 297	-5.63*	-0.44	34.03*	12.07*	38.27*	46.00*	-3.71*	22.92*	-42.00*	-13.04*	3.44*	34.42*
CMS 103 A x 6D-1	-5.33*	-0.09	48.97*	16.38*	37.30*	41.92*	2.33	33.11*	-18.78*	-36.02*	8.71*	52.01*
CMS 103 A x RHA 271	-1.37*	4.09*	33.18*	22.58*	43.49*	48.32*	3.54	38.71*	-9.83*	-29.00*	5.12*	52.67*
CMS 103 A x HRHA 4-2	-10.86*	2.03*	31.90*	18.36*	46.56*	51.49*	3.54	34.68*	-21.14*	-37.90*	5.63*	47.72*
CMS 103 A x HRHA 5-3	-4.07*	1.24*	18.18*	9.79*	29.09*	33.43*	-27.09*	-5.16*	55.10*	22.12*	-24.90*	5.01*
CMS 103 A x RHA 297	-3.75*	1.57*	32.13*	6.92*	20.20*	24.25*	-1.90	27.60*	-52.12*	-28.23*	0.91	41.11*
CMS 234 A x 6D-1	1.93*	1.68*	53.42*	21.21*	29.52*	34.89*	-17.68*	4.35*	2.59*	27.91*	-15.52*	12.16*
CMS 234A x RHA 271	1.09	0.22	31.80*	21.31*	27.11*	32.38*	-0.55	33.24*	-49.33*	-36.81*	0.00	45.23*
CMS 234 A x HRHA 4-2	-11.73*	1.04	37.54*	23.42*	48.45*	54.61*	9.51*	36.16*	-47.29*	-34.31*	12.78*	47.63*
CMS 234 A x HRHA 5-3	1.62*	0.75	28.39*	19.27*	48.35*	54.50*	8.69*	33.75*	-42.89*	-28.79*	15.30*	48.69*
CMS 234 A x RHA 297	-4.10*	1.17*	41.63*	14.61*	40.85*	46.69*	65.21*	33.44*	-65.51*	-48.27*	83.65*	46.75*
CMS 302 A x 6D-1	-5.11*	1.86*	67.64*	21.81*	89.21*	54.45*	0.20	33.27*	-40.95*	-50.18*	6.76*	48.00*
CMS 302 A x RHA 271	-3.24*	3.87*	39.09*	28.02*	54.18*	41.42*	-5.53*	26.57*	-3.60*	-18.63*	-5.88*	36.69*
CMS 302 A x HRHA 4-2	-9.61*	3.47*	43.79*	29.04*	33.22*	29.25*	-28.80*	-5.30*	10.90*	-6.35*	-21.60*	8.68*
CMS 302 A x HRHA 5-3	-4.37*	2.65*	31.03*	21.72*	34.04*	29.11*	-0.63	32.17*	-27.84*	-39.10*	4.36*	44.67*
CMS 302 A x RHA 297	-4.02*	3.03*	59.46*	29.04*	90.95*	56.17*	1.61	35.15*	-54.21*	-31.35*	6.84*	48.11*
CMS 607 A x 6D-1	-7.38*	1.39*	28.98*	19.94*	72.118	38.86*	-17.49*	4.59*	7.21*	23.77*	-15.00*	12.84*
CMS 607 A x RHA 271	-5.52*	3.43*	34.81*	25.36*	44.14*	32.22*	0.78	35.01*	-46.65*	-38.43*	2.51*	48.88*
CMS 607 A x HRHA 4-2	-10.73*	2.19*	28.13*	19.14*	59.21*	54.48*	12.33*	39.66*	-52.76*	-45.45*	17.68*	54.04*
CMS 607 A x HRHA 5-3	-6.77*	2.06*	32.89*	23.57*	38.40*	33.30*	-5.10*	16.79*	-30.11*	-19.30*	-0.45	28.38*
CMS 607 A x RHA 297	-6.95*	1.86*	21.36*	12.86*	50.93*	23.45*	-11.31*	-3.25*	-34.16*	-1.32*	-0.79	5.93*

Electrical conductivity : Over the environments (Table 1.2), seventy three hybrids over better parent and seventy five hybrids over standard check showed negative and significant heterosis percent. The heterosis over better parent were observed by the hybrids CMS 17 A x RHA 297 (-67.80%), CMS 234 A x RHA 297 (-65.51%) and CMS 11A x RHA 297 (-65.38%) and the hybrids CMS 148 A x RHA 271 (-56.70%), CMS 11 A x HRHA 5-3 (-56.14%) and CMS 11 A x RHA 271 (-55.05%) were found to be negative and significant heterosis over standard check HSFH 848 for this trait. Over all the environments, heterosis ranged from -67.80% (CMS 17 A X RHA 297) to 55.10% (CMS 103 A X HRHA 5-3) and from -56.70% (CMS 148 AX RHA 271) to 279% (CMS 234 A X 6D-1) over better parent and over standard check respectively.

Table 1.2 Contd.

Hybrids	OC (%)		HC (%)		% SF		GERM. (%)		EC (µScm1g1)		VIAB. (%)	
	BP	CHK	BP	CHK	BP	CHK	BP	CHK	BP	CHK	BP	CHK
CMS 852 A x 6D -1	0.81	1.24*	44.46*	11.18*	78.56*	29.46*	10.79*	40.45*	-50.22*	-34.99*	14.25*	51.68*
CMS 852 A x RHA 271	0.39	0.82	26.08*	16.06*	69.66*	55.63*	0.43	34.55*	-50.00*	-34.67*	1.86	47.93*
CMS 852 A x HRHA 4-2	-11.44*	1.37*	37.44*	23.34*	55.55*	50.92*	7.78*	34.01*	-49.25*	-33.73*	10.36*	44.47*
CMS 852A x HRHA 5-3	1.67*	2.10*	35.77*	26.12*	52.61*	46.99*	4.46*	28.54*	-31.71*	-10.78*	9.65*	41.40*
CMS 852 A x RHA 297	-0.98	4.46*	51.50*	22.59*	71.85*	40.55*	20.36*	27.17*	-40.82*	-11.28*	21.05*	34.43*
ARG 2A x 6D-1	-8.97*	-0.09	36.79*	25.94*	77.84*	60.55*	9.69*	39.05*	-37.37*	-42.22*	16.17*	54.23*
ARG 2A x RHA 271	-6.27*	2.87*	37.14*	26.26*	45.00*	33.01*	-22.51*	3.82*	18.26*	9.08*	-21.27*	14.34*
ARG 2A x HRHA 4-2	-9.34*	3.78*	36.08*	25.28*	31.82*	27.89*	2.98	28.04*	-4.35*	-11.75*	7.78*	41.09*
ARG 2A x HRHA 5-3	-5.99*	3.18*	35.49*	25.87*	53.75*	48.08*	2.77	26.46*	-36.94*	-41.83*	8.82*	40.33*
ARG 2A x RHA 297	-4.72*	4.58*	34.00*	23.37*	59.61*	44.10*	14.98*	33.86*	-60.09*	-40.19*	19.71*	41.08*
ARG 3A x 6D -1	0.68	2.32*	44.04*	7.57*	107.40*	56.08*	6.87*	35.47*	-23.55*	-32.90*	10.19*	46.28*
ARG 3A x RHA 271	1.55*	3.20*	26.80*	16.72*	60.55*	47.27*	-9.10*	21.79*	6.25*	-6.79*	-9.41*	31.56*
ARG 3A x HRHA 4-2	-10.24*	2.74*	24.88*	12.06*	51.43*	46.92*	1.71	28.02*	-45.65*	-52.35*	3.68*	36.84*
ARG 3A x HRHA 5-3	0.61	2.25*	26.48*	17.49*	62.23*	56.26*	7.36*	35.13*	-42.19*	-49.29*	9.91*	45.07*
ARG 3A x RHA 297	-5.03*	0.20	37.82*	11.53*	93.92*	58.61*	4.57*	31.63*	-64.40*	-46.65*	6.57*	40.66*
ARG 6A x 6D-1	-3.58*	3.14*	75.08*	27.21*	102.81*	46.38*	-9.28*	22.41*	-41.47*	-43.18*	-10.39*	29.28*
ARG 6A x RHA 271	-5.44*	1.15*	38.73*	27.69*	64.56*	50.95*	2.02	37.65*	-41.98*	-43.71*	-1.15	43.57*
ARG 6A x HRHA 4-2	-8.27*	4.99*	32.44*	18.85*	47.80*	43.40*	-5.02*	28.16*	-40.26*	-42.01*	-4.42*	37.90*
ARG 6A x HRHA 5-3	-2.80*	3.98*	20.75*	12.17*	60.44*	54.53*	2.83	38.75*	-34.81*	-36.72*	4.32*	50.51*
ARG 6 A x RHA 297	-5.01*	1.61*	53.70*	24.38*	97.69*	61.69*	3.10*	39.12*	-61.53*	-42.30*	3.60*	49.47*
DV 10 x 6D -1	2.74*	3.828*	39.80*	28.41*	31.10*	33.58*	-5.41*	23.91*	-34.23*	-40.39*	-5.84*	31.53*
DV 10 x RHA 271	1.43*	2.50*	35.67*	24.88*	45.92*	48.68*	-4.38*	28.10*	-42.66*	-48.00*	-5.01*	37.96*
DV 10 x HRHA 4-2	-10.61*	2.32*	45.36*	33.52*	37.14*	39.73*	-2.19	28.12*	-47.62*	-52.50*	-0.87	38.48*
DV 10 x HRHA 5-3	0.78	1.83*	38.06*	28.26*	48.17*	50.98*	-6.20*	22.87*	-21.81*	-29.11*	-5.62*	31.84*
DV -10 x RHA 297	-1.38*	4.04*	31.35*	20.65*	48.71*	51.52*	-10.41*	17.35*	-24.43*	13.28*	-8.64*	27.62*
CMS 207 A x 6D -1	6.90*	6.63*	8.58*	-6.23*	35.40*	41.46*	4.53*	32.51*	-36.45*	-34.78*	4.88*	39.24*
CMS 207 A x RHA 271	5.27*	3.76*	27.37*	17.24*	48.72*	55.37*	-9.84*	20.79*	-19.37*	-17.24*	-8.02*	33.59*
CMS 207 A x HRHA 4-2	-9.70	3.36*	30.28*	16.90*	43.31*	49.72*	1.23	25.86*	-31.01*	-29.23*	4.86*	37.26*
CMS 207 A x HRHA 5-3	8.67*	4.02*	33.37*	23.90*	50.61*	57.34*	12.16*	38.02*	-33.30*	-31.58*	14.71*	47.93*
CMS 207 A x RHA 297	0.97	6.52*	35.92*	17.39*	52.15*	58.96*	14.46*	36.22*	-41.61*	-12.46*	24.20*	52.61*
SE	0.65	0.56	1.74	1.66	1.37	1.28	1.50	1.45	0.03	0.03	1.14	1.05
CDat5%	1.31	1.12	3.48	3.32	2.74	2.56	3.00	2.90	0.06	0.06	2.28	2.10

CHK = Check

Viability (%) : Over the environments, sixty five hybrids over better parent and seventy five hybrid over standard check showed positive and significant heterosis per cent. The results indicated that the heterosis over better parent were observed by the hybrids CMS 234 A x HRHA 5-3 (83.65%), CMS 852 A x RHA 297 (21.05%) and CMS 207 A x RHA 271 (24.20%) exhibited positive and significant heterosis and the hybrids, CMS 148 A x 6D-1 (55.65%), ARG 2A x 6D-1 (54.23%) and CMS 607 A x HRHA 4-2 (54.04%) were found to be positive and significant heterosis over standard check HSFH 848 for this trait. In pooled analysis, heterosis ranged from -24.90% (CMS 103 AX HRHA 5-3) to 83.65% (CMS 234 A X RHA 297) over better parent and from 5.93% (CMS 607 A X RHA 297) to 55.65% (CMS 148 A X 6D-1) over standard check Vigour index –I. Over the environments, the hybrids CMS 302 A x RHA 297 (45.84), CMS 11 A x HRHA 5-3 (42.67) and CMS 11 A x RHA 297 (41.71) were found to be positive and significant heterosis over better parent however, the hybrids, CMS 11 A x HRHA 5-3 (39.99), CMS 11 A x RHA 297 (38.78) and CMS 302 A x RHA 271 (38.68) were observed to have positive and significant heterosis over standard check for this trait. Over the environments, heterosis over better parent ranged from -42.39% (ARG 3A X RHA 271) to 46.87% (CMS 11 A X RHA 297) and over standard check -5.25% (CMS 148 A X RHA 297) to 39.99% (CMS 11 A X HRHA 5-3).

Vigour index-II : In pooled analysis, seventy two hybrids over better parent and sixty four hybrid over standard check showed positive and significant heterosis per cent. The results indicated that the heterosis over better parent were observed by the hybrids CMS 234 A x HRHA 4-2 (149.07%), CMS 234 A x RHA 297 (141.29%) and CMS 852 A x HRHA 4-2 (122.91%) and heterosis over standard check HSFH 848 by hybrids, CMS 103 A x 6D-1 (34.06%), CMS 103 A x RHA 271 (31.09%),CMS 148A x 6D-1 (29.05%) were found to be positive and significant heterosis for seedling vigour index II. Over all the environments, heterosis ranged from -3.44% (CMS 148 A X RHA 297) to 149.07% (CMS 234 A X HRHA 4-2) and from -34.82% (ARG 2A X HRHA 5-3) to 34.06% (CMS 103 A X 6D-1) over better parent and over standard check respectively.

Palmitic acid (%) : Over the environments, the heterosis over better parent were observed by the hybrids CMS 207 A x HRHA 4-2 (82.53%), DV 10 x RHA 271 (45.28%) and CMS 207 A x RHA 297 (37.84%) showed positive and significant heterosis whereas the heterosis over standard check were observed by the hybrids CMS 207 A x HRHA 4-2 (82.15%), ARG 6A x RHA 271 (39.91%) and DV 10 x RHA 271 (38.53%) showed positive and significant heterosis pooled analysis, heterosis ranged from -14.64 (CMS 302 A X HRHA 5-3) to 82.53% (CMS 207 A X HRHA 4-2) over better parent and -12.45% (CMS 44 A X RHA 297) to 82.15% (CMS 207 A X HRHA 4-2) over standard check. Heterosis for palmitic acid has been recorded by Lokendrakumar *et al*. (1998), Singh *et al*. (2002) and Giriraj and Nagaraj (2003).

Stearic acid (%) : In pooled analysis (Table 1.3), it was recorded that the heterosis over better parent were observed by the hybrids CMS 234 A x RHA 297 (66.35%), CMS 607 A x 6D-1 (51.05%) and CMS 103 A x RHA 297 (49.34%) whereas the heterosis over standard check were observed by the hybrids, ARG 2A x RHA 271 (101.07%), ARG 3A x RHA 297 (85.52%) and CMS 234A x RHA 297 (84.23%) showed positive and significant heterosis for this trait. over better parent and heterosis varied from -12.47% (CMS 207 A X HRHA 4-2) to 101.07% (ARG 2A X RHA 271) over standard check. The similar results were observed by

Tabel 1.3 Estimation of heterosis effects for seedling vigour and linoleic acid over the environments

Hybrids	**VG I**		**VG II**		**PALM. (%)**		**STER. (%)**		**OLEIC (%)**		**LINO. (%)**	
	BP	**CHK**	**BP**	**CHK**	**BP**	**CHK**	**BP**	**CHK**	**BP**	**CHK**	**BP**	**CHK**
CMS 11 A x 6D-1	31.17	30.39*	68.57*	5.90*	-9.26*	-9.71*	2.00*	19.23*	5.05*	46.22*	10.08*	39.29*
CMS 11 A x RHA 271	22.02	28.80	69.20*	6.29*	8.77*	0.07	-19.97*	-6.45*	-11.48*	31.86*	15.02*	45.54*
CMS 11 A x HRHA 4-2	16.71	22.87	44.82*	-9.02*	2.77*	-2.55*	16.87*	42.63*	-14.88*	16.96*	21.20*	53.36*
CMS 11 A x HRHA 5-3	42.67*	39.99*	51.70*	-4.70*	2.00*	-6.17*	-22.14*	26.53*	1.69*	34.81*	9.90*	39.06*
CMS 11 A x RHA 297	41.71*	38.78*	57.24*	-1.22	-7.07*	-12.06*	-0.41*	16.42*	-11.56*	27.25*	16.18*	47.01*
CMS 17-A x 6D-1	25.90	30.71*	55.30*	-2.91	-9.79*	-10.24*	-1.53*	36.17*	8.30*	50.75*	17.83*	28.08*
CMS 17-A x RHA 271	5.04	12.88	39.51*	-12.79*	7.32*	-6.43*	-23.42*	5.90*	-4.78*	41.85*	29.01*	40.23*
CMS 17 -A x HRHA 4-2	10.60	13.31	54.33*	-3.52*	2.64*	-2.68*	2.80*	42.16*	5.14*	44.47*	8.76*	18.22*
CMS 17 -A x HRHA 5-3	13.30	19.29	58.47*	-0.93	13.50*	-1.71*	-32.16*	10.25*	-4.26*	26.91*	42.13*	57.83*
CMS 17 A x RHA 297	22.88	27.41	81.61*	13.53*	-5.14*	-10.24*	1.28*	40.06*	-15.58*	21.47*	43.97*	56.49*
CMS 44 A x 6D-1	38.24	27.38	84.88*	10.57*	-3.59*	-4.08*	25.52*	38.98*	6.94*	48.86*	-3.78*	23.11*
CMS 44 A x RHA 271	8.55	16.72	66.79*	1.40	2.47*	-10.66*	20.30*	26.92*	-16.90*	23.79*	19.52*	52.91*
CMS 44 A x HRHA 4-2	20.63	26.99	55.17*	-7.20*	0.01	-5.17*	-1.10*	20.70*	-2.34*	34.18*	1.25	29.54*
CMS 44 A x HRHA 5-3	39.87	29.14	46.07*	-12.65*	6.63*	-7.66*	-21.49*	27.59*	-7.26*	27.43*	21.28*	55.17*
CMS 44 A x RHA 297	26.32	13.82	36.21*	-18.54*	-7.47*	-12.45*	15.16*	23.19*	-3.30*	39.14*	15.12*	47.29*
CMS 148 A x 6D-1	17.27	23.93	87.27*	29.05*	-6.09*	-6.56*	-12.30*	16.11*	0.27	40.60*	13.10*	40.23*
CMS 148 A x RHA 271	-0.65	4.87	42.70*	-1.66	-0.03	-5.29*	-17.20*	9.62*	-4.11*	42.84*	-8.93*	12.90*
CMS 148 A x HRHA 4-2	11.89	20.60	42.16*	-2.04	-2.59*	-7.64*	-20.11*	5.76*	-23.11*	7.81*	18.21*	46.56*
CMS 148 A x HRHA 5-3	5.81	11.34	31.22*	-9.57*	4.80*	-0.71*	-12.34*	42.47*	-12.57*	22.59*	15.13*	42.74*
CMS 148 A x RHA 297	-10.81	-5.25	-3.44	-33.46*	-1.17*	-6.37*	-6.80*	23.38*	-2.80*	39.86*	12.79*	39.84*
CMSH 91 A x 6D-1	28.71	21.50	7.49	-25.14*	1.97*	4.34*	45.19*	60.76*	-0.56	38.42*	11.19*	44.06*
CMSH 91 A x RHA 271	2.11	10.57	25.26*	-12.76*	-3.87*	-1.63*	26.16*	32.72*	-14.45*	27.43*	18.07*	52.98*
CMSH 91 A x HRHA 4-2	9.85	14.21	46.89*	2.30	-1.53*	0.75*	16.89*	42.65*	18.11*	62.28*	-24.21*	-1.81*
CMSH 91 A x HRHA 5-3	34.33	26.01	76.30*	22.78*	8.65*	11.17*	-20.77*	28.75*	6.24*	40.83*	22.94*	59.28*
CMSH 91 A x RHA 297	11.00	9.45	67.55*	16.69*	-1.47*	0.82*	8.64*	16.22*	-6.29*	34.84*	8.93*	41.13*
CMS 103 A x 6D-1	40.98*	29.31	66.85*	34.06*	5.21*	4.68*	30.27*	44.24*	-5.08*	32.13*	16.57*	45.44*
CMS 103 A x RHA 271	20.56	29.46	63.16*	31.09*	8.03*	2.54*	19.60*	29.06*	-13.44*	28.95*	14.76*	43.17*
CMS 103 A x HRHA 4-2	15.91	19.14	42.67*	14.63*	10.07*	4.48*	18.43*	44.53*	-10.28*	23.27*	12.47*	40.32*
CMS 103 A x HRHA 5-3	22.67	15.11	32.36*	6.35*	16.77*	10.84*	-17.65*	33.82*	-6.08*	24.50*	9.08*	36.09*
CMS 103 A x RHA 297	19.81	12.24	17.31*	-5.74*	22.80*	16.56*	49.34*	61.15*	-1.08	42.34*	-15.90*	4.92*
CMS 234 A x 6D-1	19.38	8.22	68.33*	-7.33*	-2.81*	-1.62*	45.45*	61.08*	-6.88*	29.62*	8.99*	15.95*
CMS 234A x RHA 271	9.87	19.38	79.96*	9.41*	9.65*	10.99*	11.46*	23.43*	-8.55*	36.22*	23.35*	31.22*
CMS 234 A x HRHA 4-2	22.43	25.95	149.07*	10.72*	13.86*	15.25*	14.10*	39.25*	23.11*	69.16*	20.51*	28.21*
CMS 234 A x HRHA 5-3	21.05	12.86	83.36*	-4.08*	15.15*	16.56*	-32.04*	10.44*	14.60*	51.91*	26.07*	40.00*
CMS 234 A x RHA 297	33.31	22.39	141.29*	6.60*	11.24*	12.60*	66.35*	84.23*	10.72*	59.32*	32.04*	43.29*
CMS 302 A x 6D-1	24.59	18.72	36.42*	-9.53*	-4.25*	10.89*	10.22*	63.94*	7.61*	49.79*	42.47*	54.86*
CMS 302 A x RHA 271	26.36	38.68*	34.50*	-10.80*	5.45*	22.13*	20.80*	79.67*	-0.57	48.11*	14.77*	24.75*
CMS 302 A x HRHA 4-2	19.94	21.70	17.28*	-22.22*	-3.66*	11.58*	-12.15*	30.66*	1.43	39.37*	22.14*	32.77*
CMS 302 A x HRHA 5-3	28.02	21.80	32.04*	-12.43*	-14.64*	-1.14*	-24.49*	22.71*	-8.29*	23.48*	28.78*	43.01*
CMS 302 A x RHA 297	45.84*	32.85*	36.40*	-9.53*	-2.05*	13.44*	-37.64*	-7.26*	4.87*	50.90*	36.37*	48.23*
CMS 607 A x 6D-1	19.28	27.15	34.70*	-25.84*	19.09*	18.50*	51.05*	74.51*	-8.13*	31.40*	17.50*	36.40*
CMS 607 A x RHA 271	9.08	16.37	37.62*	-16.33*	18.81*	13.39*	14.32*	32.07*	-20.10*	19.01*	22.62*	42.34*
CMS 607 A x HRHA 4-2	12.24	16.70	79.30*	-20.30*	31.03*	25.06*	33.53*	62.96*	4.82*	49.91*	-1.69*	14.13*
CMS 607 A x HRHA 5-3	8.23	16.45	53.21*	-19.84*	14.29*	9.08*	-29.36*	14.80*	0.01	43.04*	10.48*	28.25*
CMS 607 A x RHA 297	4.95	9.70	92.45*	-23.07*	19.26*	13.82*	37.87*	59.29*	8.87*	56.65*	-11.54*	2.69*

Lokendrakumar *et al*. (1998) and Singh *et al*. (2002). CMS 234 A x HRHA 4-2 (23.11%), CMSH 91 A x HRHA 4-2 (18.11%) and CMS 234 A x HRHA 5-3 (14.60%) had positive and significant heterosis whereas seventy five hybrids over standard check had positive and significant heterosis. The hybrids CMS 234 A x HRHA 4-2 (69.16%), CMSH 91 A x HRHA 4-2 (62.28%) and ARG 2A x 6D-1 (61.64%) were found to be positive and significant heterosis for this trait.

Oleic acid (%) : Over the environments, it was recorded that sixty five hybrids over better parent had significant heterosis. The cross combination Over all the environments, heterosis ranged -58.03% (CMS 207 A X HRHA 4-2) to 66.35% (CMS 234 A X RHA

Tabel 1.3 Contd.

Hybrids	VG I		VG II		PALM. (%)		STER. (%)		OLEIC (%)		LINO. (%)	
	BP	CHK	BP	CHK	BP	CHK	BP	CHK	BP	CHK	BP	CHK
CMS 852 A x 6D -1	25.01	23.53	64.72*	-9.32*	5.70*	8.36*	37.73*	65.82*	-15.79*	17.22*	6.54*	24.96*
CMS 852 A x RHA 271	5.32	12.81	59.90*	-2.78	25.84*	29.00*	7.26*	29.15*	-5.99*	40.04*	20.26*	41.06*
CMS 852 A x HRHA 4-2	14.11	18.39	122.91*	15.04*	6.19*	8.86*	-3.51*	17.76*	-3.58*	33.73*	17.80*	38.17*
CMS 852A x HRHA 5-3	18.75	14.82	99.14*	4.18*	8.37*	11.09*	-8.78*	48.25*	10.28*	52.96*	16.96*	37.18*
CMS 852 A x RHA 297	16.77	15.85	87.45*	-3.26*	1.22*	3.76*	29.13*	55.48*	-4.71*	37.11*	25.07*	46.70*
ARG 2A x 6D-1	16.95	18.36	22.41*	-24.26*	3.48*	7.91*	27.00*	70.15*	11.84*	61.64*	9.11*	38.16*
ARG 2A x RHA 271	4.84	13.41	6.02*	-34.40*	9.06*	13.72*	50.08*	101.07*	-4.22*	42.67*	17.42*	48.67*
ARG 2A x HRHA 4-2	14.38	18.38	30.54*	-19.22*	2.55*	6.93*	-10.73*	19.60*	7.48*	55.34*	-0.29	26.25*
ARG 2A x HRHA 5-3	7.73	10.67	5.35*	-34.82*	8.64*	13.29*	-25.58*	20.95*	-10.67*	29.10*	27.77*	61.78*
ARG 2A x RHA 297	21.78	25.50	28.17*	-20.70*	23.15*	28.42*	33.53*	78.90*	4.42*	50.91*	14.93*	45.52*
ARG 3A x 6D -1	32.15	20.31	10.72*	-14.47*	4.08*	15.06*	5.87*	37.83*	-6.40*	39.97*	-8.95*	16.54*
ARG 3A x RHA 271	2.70	9.95	13.45*	-12.36*	19.03*	31.60*	34.39*	74.95*	-9.05*	36.02*	-3.61*	23.37*
ARG 3A x HRHA 4-2	10.68	17.06	1.09	-21.91*	13.82*	25.84*	18.23*	53.92*	0.77	50.69*	-12.70*	11.73*
ARG 3A x HRHA 5-3	40.35*	30.52*	10.54*	-14.60*	-2.69*	7.58*	9.42*	77.81*	-9.63*	35.15*	9.89*	40.66*
ARG 3A x RHA 297	30.44	20.75	13.81*	-12.08*	7.37*	18.71*	42.51*	85.52*	-4.20*	43.26*	21.39*	55.37*
ARG 6A x 6D-1	7.63	10.90	30.77*	0.13	6.98*	13.67*	-4.83*	41.91*	-3.78*	37.67*	17.81*	48.75*
ARG 6A x RHA 271	11.62	20.53	18.95*	-8.92*	31.67*	39.91*	2.57*	52.96*	0.02	48.99*	3.59*	30.80*
ARG 6A x HRHA 4-2	20.95	25.18	26.36*	-3.25*	6.74*	13.42*	-23.81*	13.62*	6.21*	51.98*	8.92*	37.53*
ARG 6A x HRHA 5-3	19.13	21.62	50.17*	14.98*	26.24*	34.14*	-13.36*	40.79*	-0.75	42.01*	-0.54	25.59*
ARG 6 A x RHA 297	6.80	13.14	45.26*	11.23*	-5.18*	0.75*	-26.18*	10.09*	-8.85*	31.15*	14.82*	44.98*
DV 10 x 6D -1	14.65	18.99	62.10*	-5.24*	10.50*	9.95*	1.86*	12.78*	-3.31*	34.59*	17.42*	46.90*
DV 10 x RHA 271	8.95	16.39	35.75*	-17.46*	45.28*	38.53*	1.07*	10.46*	-1.72*	46.40*	0.81	26.11*
DV 10 x HRHA 4-2	13.88	17.95	66.07*	-2.92	30.83*	24.76*	17.99*	44.00*	-7.21*	27.49*	16.71*	46.00*
DV 10 x HRHA 5-3	6.26	12.13	43.62*	-16.04*	16.76*	11.34*	-14.36*	39.17*	0.98	33.86*	16.21*	45.38*
DV -10 x RHA 297	3.15	7.71	34.60*	-21.32*	24.17*	18.40*	2.71*	12.26*	-8.58*	31.55*	26.83*	58.67*
CMS 207 A x 6D -1	26.67	14.53	33.54*	-18.92*	28.45*	28.19*	-47.90*	8.67*	-13.14*	20.91*	26.07*	42.71*
CMS 207 A x RHA 271	-2.52	5.94	70.06*	3.40*	25.18*	24.92*	-57.18*	-10.68*	-7.65*	37.57*	17.03*	32.48*
CMS 207 A x HRHA 4-2	10.16	14.37	61.79*	-1.78	82.53*	82.15*	-58.03*	-12.47*	2.71*	41.12*	19.19*	34.92*
CMS 207 A x HRHA 5-3	34.01	26.30	92.65*	16.96*	-0.13	-0.33	-48.03*	8.40*	5.93*	42.60*	28.92*	45.93*
CMS 207 A x RHA 297	38.49	26.37	72.27*	4.59*	37.84*	37.56*	-42.39*	20.16*	1.06	45.42*	29.23*	46.29*
SE	21.00	18.00	1.62	1.52	0.24	0.21	0.18	0.17	0.80	0.77	0.82	0.76
CD at 5%	40.00	30.02	3.24	3.04	0.49	0.42	0.37	0.34	1.61	1.54	1.63	1.52

PH-Plant height, HD-Head diameter, SD-Stem diameter, DF-days to flowering, DM- days to maturity,100 Seed weight, SY- Seed yield plant^{-1}, OC-Oil content, HC-Hull content, % SF-Percent seed filling, GERM.-Germination, EC-Electrical conductivity, VIAB.-Viability, VI I-Vigour index I, VI II- Vigour index II,PALM.-Palmitic acid, STER.-Stearic acid, OLEIC-Oleic acid, LINO. - Linolenic acid.

297) In pooled analysis, heterosis over better parent ranged from -23.11% (CMS 148 A X HRHA 4-2) to 23.11% (CMS 234 A X HRHA 4-2) and over standard check heterosis varied from 7.81% (CMS 148 A X HRHA 4-2) to 69.16% (CMS 234 A X HRHA 4-2). Significant heterosis for oleic acid has been reported by Skoric *et al*. (1978), Baldani *et al*. (1991), Shekar *et al*. (1998), Singh *et al*. (1999) and Giriraj and Nagaraj (2003) in various studies.

Linoleic acid (%) : Over the environments (table 1.3), seventy one hybrids over better parent and seventy five hybrids over standard check had positive and significant heterosis per cent. The major hybrids over better parent were CMS 17 A x RHA 297 (43.97%), CMS 302 A x 6D-1 (42.47%) and CMS17 A x HRHA 4-2 (42.13%) and the prominent hybrids over standard check were CMSH 91 A x HRHA 5-3(59.28%), DV 10 x RHA 297 (58.67%) and CMS 17 A x HRHA 5-3 (57.83%) showed positive and significant heterosis for this trait. Heterosis for this trait has been reported earlier by Lokendrakumar *et al*. (1998), Rather *et al*. (1999), Singh *et al*. (1999) and Giriraj and Nagaraj (2003). The fatty acid biosynthesis pathway shows the formation of palmitic acid-stearic acid-oleic acid-linoleic acid in which oleic acid is the precursor of linoleic, the unsaturated fatty acid as it is formed in subsequent pathway. Correlation between oleic and linoleic acid has been found to be negative and highly significant (Singh *et al*. 2002). Due to such association among these traits, as oleic acid increases linoleic acid decreases. Similar result were reported by Giriraj *et al*. (1986),Goksoy *et al*. (2000) Nehru *et al*. (2000), Seetharam *et al*. (2001), Gill and Sheoran (2002), Khan *et al*. (2004), Goksoy and Turan (2004), Kaya (2005a), Khan *et al*. (2008), Karasu *et al*. (2010) and Deshmukh *et al* (2016).

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