The Pharma Innovation Journal 2022; 11(12): 3155-3159

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 3155-3159

www.thepharmajournal.com
Received: 15-10-2022
Accepted: 23-11-2022

AK Choudhari
Department of Agriculture Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

MK Ghodke
Oilseed Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
AK Choudhari
Department of Agriculture Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Heterotic studies in sunflower (*Helianthus annuus* L.)

AK Choudhari and MK Ghodke

Abstract
Heterosis for seed yield and its attributing traits was studied in 54 crosses developed through LxT mating design involving 6 CMS lines and 9 testers. Analysis of variance revealed the presence of significant differences due to parents, crosses and parents vs crosses, indicating variability. The hybrids 17A x J/6, 17A x EC-623008, 17A X RHA-1-1 and 2A X RHA-1-1 were identified as best heterotic crosses for seed yield/plant and some of its component traits like, days to 50% flowering, days to maturity, head diameter, seed filling %, 100 seed weight and volume weight. For oil content, 2A X EC-623008 and 2A X RHA-1-1 recorded high heterotic effect. This study could prove useful in the development of new high-yielding sunflower hybrids.

Keywords: Heterotic studies, *Helianthus annuus* L., seed yield

Introduction
In India, Commercial cultivation of sunflower started in seventies with introduction of open pollinated populations from USSR and Canada. Low yielding genotypes and hybrids of sunflower are the major constraints of sunflower productivity due to which the area and production of sunflower is decreasing in past few years. To overcome this constraint breeders have center of attention towards production of hybrids through heterosis breeding, which become possible due to discovery of cytoplasmic male sterility by Leclercq (1969) [10] and fertility restoration system by Kinman (1970) [9].

The present investigation revealed extent of heterosis (relative heterosis and heterobeltiosis) observed within the available genetic variability of crosses for various characters studied. The main purpose of this study is to identify superior cross combination for seed yield as well as for oil content, which would be certainly helpful for evolving superior hybrids in future.

Material and Methods
Six CMS lines *viz*., CMS 234A, CMS 62A, CMS 243A, CMS 2A, ARM 249A and 17A and nine inbred lines *viz*., EC-623008, EC 601957, EC 601951, EC 623026, RHA-1-1, RHA-138-2, R-271-1, IR-1-1 and J/6 were planted during *kharif* 2015 at Oilseeds Research Station, Latur and crossing was performed in line x tester fashion to produce 54 hybrids. During *rabi*, 2016 and *kharif* 2017 the 54 hybrids along with their parents and three standard checks *viz*., LSFH-171, LSFH-35 and S-275 were evaluated in a Randomized Block Design replicated twice in four environments *viz*., E1- Latur *rabi* 2016, E2- Parbhani *rabi* 2016, E3- Latur *kharif* 2017 and E4- Parbhani *kharif* 2017. Observations were recorded for ten quantitative characters. Data obtained were subjected to line x tester analysis (Kempthorne, 1957) [8]. Heterosis was calculated as a percentage of increase or decrease in the F1 mean over its mid parent and better. The result of pooled analysis over locations is presented.

Results and Discussion
Pooled analysis of variance for ten sunflower traits is presented in Table 1. Revealed that mean sum of square due to genotypes found significant for all the characters in all four environments studied indicated presence of desirable amount of variation. Genotypes are further divided in to parents and crosses. Mean square component due to parents and crosses exhibited significant differences except seed filling % in E3 and E4 environments for crosses. Highly significant differences due to parents *vs* crosses were marked by all the traits studied except hull content in E2 and E3 environments indicated presence of heterosis in desirable direction. Significant variances due to genotypes, parents, crosses and parents vs. crosses were also reported by Dudhe *et al*., (2011) [6], Machikowa *et al*., (2011) [11] and Deengra *et al*., (2012) [4].

Pooled heterosis over mid parent and better parent exhibited by different cross combinations are presented in Tables 2. Out of fifty four crosses thirty eight and forty two crosses recorded significant negative heterotic effect over mid parent and better parent respectively for days to 50% flowering while, forty four and forty six crosses reported significant negative heterotic effect over mid parent and better parent for days to maturity. Crosses 2A X R-271-1, 249A X EC-601951 and 2A X EC-601951 recorded earliest among all. Similarly, negative heterosis for early flowering, and early maturity was reported by Chidambaram and Sundarsan (1990) [3] in sunflower. For head diameter fifty and forty three crosses marked with significant positive relative heterosis and heterobeltiosis respectively. Crosses 62A X RHA-138-2, 243A X RHA-138-2, 243A X EC-623008 stained with consistent significant positive heterotic effects over mid as well as over better parent. For seed filling % thirty six and eleven crosses found significant in desirable direction over mid and better parent. For hull content ten and thirteen crosses stained with significant negative heterosis over mid and better parents whereas, crosses 62A X IR-1-1, 249A X J/6, 249A XEC-601957 exhibited high negative heterotic effects on mid and better parent. Negative heterosis has been also reported by Amenla (1996) [2] for hull content. Regarding, 100 seed weight highest significant positive heterosis was marked by CMS234A X RHA-138-2 respective to mid and better parent followed by CMS62A X RHA-138-2, CMS249A X RHA-138-2 and CMS234A X EC-623008. For volume weight cross 243A X RHA-138-2 recorded high heterotic effects over mid parent and better parent respectively. Mohan Kumar (2002) [13] and Alone *et al.* (2003) [1] also reported positive heterosis for 100 seed weight and volume weight.

Regarding, seed yield/plant 44 and 49 crosses showed significant positive heterosis over mid and better parent whereas, 17A x J/6, 17A x EC-623008, 17A X RHA-1-1 and 2A X RHA-1-1 reported high significant heterotic effects over mid parent and better parent. Sawant *et al.* (2007) [14], Sujatha *et al.* (2009) [15], Masood *et al.* (2009) [12], Karasu *et al.* (2010) [7] and Usatov (2014) [16] in their respective studies have reported high levels of significant heterosis for seed yield. These hybrids also exhibited significant heterotic effects for days to 50% flowering, days to maturity, head diameter, seed filling %, 100 seed weight. For oil content eighteen and eight crosses reported high significant heterotic effects over mid parent as well as better parent whereas, 2A X EC-623008 and 2A X RHA-1-1 recorded high heterotic effect. Sujatha *et al.*, (2009) [15], Dudhe *et al.* (2009) [5] and Usatov (2014) [16] also reported significant heterosis for oil content.

Table 1: ANOVA for line x tester analysis in individual environments in sunflower

Sr. No.	Genotypes		d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed filling %	Hull content (%)	100 seed weight (gm)	Volume weight (gm)	Seed yield/plant(gm)	Oil content (%)
1	Replications	E1	1	0.87	0.87	22.29	0.27	1.51	0.11	0.02	0.18	4.02	1.28
		E2	1	0.02	0.72	68.44	0.84	6.15	2.93	0.29	3.93	5.16	1.36
		E3	1	0.46	0.18	1.60	0.09	14.98	0.32	0.70	1.04	0.76	0.65
		E4	1	1.85	5.28	2.82	0.46	105.62	2.06	0.05	7.40	7.40	1.88
2	Genotypes	E1	68	17.06**	14.58**	822.97**	11.29**	142.94**	22.05**	1.47**	34.67**	195.06**	10.68**
		E2	68	30.37**	25.51**	1090.06**	10.26**	76.79**	25.58**	1.55**	40.97**	255.06**	9.15**
		E3	68	13.42**	14.43**	1139.57**	10.98**	97.33*	22.24**	1.06**	26.14**	138.03**	19.04**
		E4	68	10.33**	8.63**	818.01**	20.53**	89.31*	25.69**	2.47**	38.80**	349.55**	15.42**
3	Parents	E1	14	14.53**	17.96**	428.55**	4.87**	142.51**	14.71**	0.90**	41.52**	56.42**	16.58**
		E2	14	12.65**	26.67**	547.91**	3.90*	143.10**	9.37**	1.29**	63.43**	66.38**	20.64**
		E3	14	14.27**	17.96**	814.36**	5.79**	126.66*	22.66**	1.52**	58.58**	70.77**	23.16**
		E4	14	22.69**	8.72**	508.57**	15.51**	11.69*	15.36**	1.84**	32.41**	94.20**	22.35**
4	Crosses	E1	53	15.13**	9.96**	284.26**	7.10**	125.69**	23.94**	1.41**	27.23**	165.43**	8.83**
		E2	53	31.58**	21.88**	737.18**	6.55**	57.27*	30.23**	1.04**	32.61**	217.74**	5.39**
		E3	53	12.82**	13.36**	299.65**	5.83**	79.04	22.44**	0.80*	16.15**	124.18**	15.25**
		E4	53	6.40**	6.06*	649.15**	18.74**	61.92	28.40**	1.81**	27.27**	271.70**	7.70**
5	Parents vs. Cross	E1	1	154.89**	211.82**	34896.43**	323.49**	1063.19**	24.57*	12.74**	333.46**	3706.44**	26.02**
		E2	1	214.18**	201.76**	27383.07**	295.63**	183.20*	6.17	31.87**	169.73**	4874.57**	47.03**
		E3	1	33.28**	23.65**	50208.31**	356.56**	655.90**	5.82	8.74**	101.17**	1813.52**	162.18**
		E4	1	45.28**	143.71**	14099.87**	185.54**	1228.01**	26.47*	51.37**	738.71**	8050.33**	327.62**
7	Error	E1	68	1.49	1.20	26.04	0.94	2.69	2.46	0.28	1.89	1.70	0.56
		E2	68	1.95	1.95	22.69	1.72	26.69	2.49	0.42	4.69	3.71	0.66
		E3	68	1.52	1.71	5.36	1.75	54.33	1.74	0.48	4.54	2.17	0.76
		E4	68	1.98	2.76	29.85	0.69	43.83	2.51	0.31	9.47	4.28	0.86

*, ** Significant at 5 % and 1 % level, respectively

Table 2: Pooled heterosis over midparent (MP) and better parent (BP)

Sr. No.	Genotypes	Days to 50% flowering		Daya to maturity		Plant height (cm)		Head diameter (cm)		Seed filling %	
		MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1	234A x EC-623008	-5.93**	-6.27 **	-4.81**	-4.99 **	28.59**	19.33**	16.94**	14.56**	12.18**	7.29*
2	234A X EC-601957	-4.10**	-4.46 **	-2.58**	-2.96 **	31.04**	18.60**	4.14	-2.11	5.07	1.96
3	234A X EC-601951	-2.62**	-3.35 **	-2.13**	-2.44 **	16.48**	10.11**	9.59**	5.10	-1.22	-2.44
4	234A X EC-623026	-2.98**	-3.16 **	0.06	-1.03	23.29**	16.15**	23.60**	13.81**	7.91*	5.08
5	234A X RHA-1-1	-5.29**	-5.38 **	-3.21**	-3.45 **	12.80**	11.52**	28.60**	19.55**	0.09	-2.62
6	234A X RHA-138-2	-6.52**	-8.83 **	-3.74**	-5.12 **	19.96**	15.67**	24.10**	13.80**	7.04*	3.10
7	234A X R-271-1	-4.19**	-6.51 **	-2.74**	-4.24 **	13.47**	13.30**	9.02*	5.10	8.88**	6.74
8	234A X IR-1-1	-4.22**	-5.43 **	-1.86**	-2.05 **	17.76**	16.25**	17.33**	8.00*	13.80**	12.29**
9	234A X J/6	-5.06**	-7.57 **	-5.14**	-6.27 **	18.99**	11.27**	10.16**	5.66	9.80**	6.60
10	62A x EC-623008	-3.57**	-4.19 **	-1.28*	-1.28	25.81**	15.23**	28.17**	19.10**	9.24**	8.48*
11	62A X EC-601957	0.09	-1.28	0.97	0.38	31.62**	17.62**	35.22**	30.89**	6.90*	6.04
12	62A X EC-601951	-1.76*	-3.46 **	-1.42*	-1.92 **	21.47**	13.31**	16.64**	10.64*	9.56**	6.76*
13	62A X EC-623026	-4.52**	-5.65 **	-1.04	-2.30 **	26.44**	17.54**	55.69**	54.02**	7.34*	6.09
14	62A X RHA-1-1	-5.70**	-6.56 **	-3.52**	-3.58 **	18.53**	15.54**	55.37**	52.15**	11.56	10.36**
15	62A X RHA-138-2	-5.65**	-7.07 **	-3.16**	-4.37 **	23.85**	17.80**	64.40**	63.37**	6.19*	6.14
16	62A X R-271-1	-5.00**	-8.20 **	-1.76**	-3.46 **	17.17**	15.35**	33.06**	25.58**	11.14**	9.12**
17	62A X IR-1-1	-5.54**	-5.80 **	-2.05**	-2.05 **	21.13**	17.92**	47.90**	46.38**	6.53*	3.91
18	62A X J/6	-4.92**	-6.51 **	-2.66**	-3.64 **	22.21**	12.79**	35.73**	28.74**	10.37**	9.42
19	243A X EC-623008	1.44	-1.22	-2.07**	-4.17 **	28.21**	20.54**	45.79**	40.22**	22.22**	7.57*
20	243A X EC-601957	0.18	-3.15 **	-3.02**	-5.64 **	39.97**	28.30**	39.03**	28.40**	20.85**	7.77*
21	243A X EC-601951	-4.36**	-7.87 **	-5.98**	-8.46 **	15.27**	10.43**	13.68**	7.08	13.05**	2.44
22	243A X EC-623026	-1.81*	-4.90 **	-2.47**	-5.76 **	36.64**	30.45**	51.13**	36.80**	6.57	-4.67
23	243A X RHA-1-1	-0.81	-3.67 **	-1.75**	-3.80 **	13.02**	12.74**	37.63**	25.74**	14.88**	2.70
24	243A X RHA-138-2	-7.56**	-8.04 **	-7.11**	-7.97 **	23.44**	20.66**	57.64**	42.11**	11.78**	-0.99
25	243A X R-271-1	0.37	-4.90 **	-2.17**	-5.88 **	28.01**	26.41**	22.38**	15.86**	13.50**	2.15
26	243A X IR-1-1	-4.80**	-6.47 **	-5.45**	-7.48 **	32.11**	31.97**	47.57**	33.52**	5.90	-4.12
27	243A X J/6	-3.51**	-3.85 **	-1.67**	-2.82 **	26.14**	19.52**	35.04**	27.20**	5.78	-5.62
28	2A X EC-623008	-5.05**	-5.48 **	-3.73**	-4.23 **	36.73**	32.71**	20.69**	17.51**	10.04**	0.56
29	2A X EC-601957	-6.20**	-7.31 **	-4.21**	-4.27 **	32.40**	25.17**	26.74**	18.44**	9.01**	1.00
30	2A X EC-601951	-5.48**	-6.95 **	-5.30**	-5.30**	19.57**	18.34**	0.41	-4.28	6.70*	0.53
31	2A X EC-623026	-5.63**	-6.58 **	-0.78**	-1.55**	24.28**	22.56**	19.77**	9.66*	12.60**	4.67
32	2A X RHA-1-1	-4.60**	-5.30 **	-2.77**	-3.32**	29.45	24.97**	44.60**	33.65**	14.90**	6.73
33	2A X RHA-138-2	-7.10**	-8.66 **	-4.45**	-6.12**	25.12	23.83**	27.69**	16.43**	6.75*	-1.79
34	2A X R-271-1	-8.03**	-10.97 **	-3.21**	-4.40**	15.83	10.74**	6.72	2.25	10.85**	3.70
35	2A X IR-1-1	-7.37**	-7.79 **	-2.96**	-3.46**	25.45	21.27**	24.12**	13.59**	13.56**	6.90
36	2A X J/6	-3.68**	-5.46 **	-0.51**	-2.01**	26.32	23.60**	18.89**	13.34**	14.64**	6.27
37	249A X EC-623008	4.95**	4.38 **	0.00	-1.97**	28.24	14.85**	10.26**	5.53	3.46	-2.20
38	249A XEC-601957	0.00	-1.28	-2.84**	-5.29**	29.11	12.89**	21.30**	11.50**	7.58*	3.15
39	249A X EC-601951	-6.68**	-8.21 **	-7.19**	-9.47**	13.80	3.74*	6.69	0.01	11.04**	8.35*
40	249A X EC-623026	0.00	-1.09	-2.92**	-6.03**	26.35	14.80**	17.00**	5.41	4.02	0.09
41	249A X RHA-1-1	-2.85**	-3.65 **	-4.08**	-5.90**	21.83	15.93**	28.50**	16.86**	10.45**	6.20
42	249A X RHA-138-2	-2.87**	-4.42 **	-4.83**	-5.54**	24.98	16.11**	25.24**	12.38**	3.73	-1.26
43	249A X R-271-1	1.70*	-1.64	-2.36**	-5.90**	19.09	14.42**	8.29*	2.03	9.07**	5.64
44	249A X IR-1-1	-2.55**	-2.90 **	-4.14**	-6.03**	19.18	13.25**	27.15**	14.52**	12.93**	10.09**
45	249A X J/6	0.18	-1.58	-0.99	-1.97**	23.15	11.10**	17.17**	9.83**	9.11**	4.68
46	17A X EC-623008	-2.13**	-2.40 **	-2.94**	-3.07**	35.58	31.02**	35.83**	28.27**	-4.49	-5.87
47	17A X EC-601957	2.33**	1.86*	0.19	-0.51	38.96**	30.81**	21.49**	19.60**	4.31	4.28
48	17A X EC-601951	-0.09	-0.93	-1.54*	-2.17**	28.78**	26.88**	28.66**	24.07**	-2.85	-4.61
49	17A X EC-623026	-0.65	-0.93	1.68**	0.26	36.42**	33.93**	35.07**	34.21**	-5.72	-6.09
50	17A X RHA-1-1	-0.37	-0.37	-0.19	-0.26	25.10**	21.30**	37.25**	36.71**	8.85**	8.51*
51	17A X RHA-138-21	-2.08 **	-4.42**	-2.15**	-3.25**	21.13**	20.43**	39.03**	37.52**	2.50	1.75
52	17A X R-271-1	0.10	-2.41**	0.59	-1.28	25.56**	20.57**	20.99**	16.07**	5.23	4.11
53	17A X IR-1-1	-1.37	-2.54**	-0.51	-0.64	20.87**	17.36**	22.55**	21.72**	7.78*	5.93
54	17A X J/6	-4.07 **	-6.51**	-1.90**	-2.76**	32.17**	28.75**	14.74**	10.64*	-2.37	-2.45
	S.E	1.21	1.39	0.51	0.68	2.04	2.35	0.46	0.53	2.35	2.71
	CD@5%	2.42	2.80	1.17	1.35	4.02	4.64	0.92	1.05	4.64	5.36

Sr. No.	Genotypes	Hull content (%)		100 seed weight (gm)		Volume weight (gm)		Seed yield/plant(gm)		Oil content (%)	
		MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1	234A x EC-623008	-0.12	-1.33	40.88**	31.70**	11.56**	9.81**	110.73**	88.17**	-21.90 **	-26.47 **
2	234A X EC-601957	-7.77**	-12.71**	21.55**	20.48**	15.14**	6.69*	53.66**	35.84**	-8.19 *	-10.43 *
3	234A X EC-601951	2.39	1.40	25.80**	23.51**	8.26**	-1.76	34.08**	9.30*	4.10	3.78
4	234A X EC-623026	-4.69	-8.36**	37.92**	33.19**	11.64**	8.44**	39.57**	35.80**	6.82	4.05
5	234A X RHA-1-1	-5.81*	-6.13*	29.94**	27.62**	6.02*	5.96	41.75**	41.49**	6.30	1.51
6	234A X RHA-138-2	13.37**	9.19**	57.42**	45.81**	21.33**	7.68*	59.79**	57.79**	0.64	-0.28
7	234A X R-271-1	1.24	-0.55	23.54**	12.50*	11.88**	10.07**	40.42**	36.59**	1.63	1.26
8	234A X IR-1-1	-4.09	-7.50**	38.72**	34.52**	8.62**	6.51*	93.10**	86.88**	7.95	7.47
9	234A X J/6	11.44**	11.13**	0.89	-0.19	5.40	-1.61	73.93**	45.08**	5.39	4.28
10	62A x EC-623008	-9.84**	-12.95**	19.70**	15.83*	0.69	-2.59	38.82**	18.14**	10.57 *	3.5
11	62A X EC-601957	-12.21**	-15.02**	24.34**	18.96**	2.72	-6.35*	81.92**	53.35**	6.01	2.78
12	62A X EC-601951	0.57	-2.67	5.77	3.92	7.96**	-3.57	27.86**	-0.07	1.16	0.82
13	62A X EC-623026	5.31*	-0.97	25.68**	25.57**	13.72**	8.58**	86.52**	72.07**	5.16	1.81
14	62A X RHA-1-1	0.29	-2.34	21.62**	15.33*	-5.31*	-6.91*	57.91**	49.75**	6.61	1.19
15	62A X RHA-138-2	3.54	-2.48	42.80**	36.86**	14.38**	-0.04	102.18**	89.13**	2.87	1.29
16	62A X R-271-1	-4.19	-8.01**	24.96**	10.19	9.11**	5.50	51.69**	39.91**	2.57	1.56
17	62A X IR-1-1	-15.02**	-19.85**	34.93**	34.24**	6.65*	2.79	91.29**	86.95**	10.33 *	9.14 *
18	62A X J/6	8.13**	5.36*	29.40**	26.17**	10.88**	1.82	86.13**	48.62**	4.28	3.83
19	243A X EC-623008	6.59**	4.93	24.65**	12.82	6.04*	2.63	59.59**	40.66**	12.09 **	10.75 *
20	243A X EC-601957	9.53**	1.00	18.34**	15.27*	13.54**	10.21**	41.88**	23.81**	4.96	2.4
21	243A X EC-601951	5.96*	4.05	14.82*	8.93	9.99**	4.43	27.32**	2.62	3.78	-1.45
22	243A X EC-623026	10.99**	9.68**	5.49	-1.50	3.36	1.38	50.11**	43.97**	4.39	2.01
23	243A X RHA-1-1	7.62**	5.04	7.83	5.99	13.77**	8.38**	22.98**	21.39**	6.56	6.26
24	243A X RHA-138-2	-3.67	-4.65	35.12**	21.20**	22.18**	13.32**	63.11**	58.73**	-1.43	-5.29
25	243A X R-271-1	14.78**	13.64**	15.60**	8.76	0.37	-2.80	51.12**	44.89**	2.7	-1.86
26	243A X IR-1-1	-3.58	-4.42	22.65**	14.98*	5.68	2.67	59.53**	56.66**	9.00 *	4.25
27	243A X J/6	3.99	1.43	11.86*	6.91	14.81**	12.31**	89.08**	55.85**	8.19	2
28	2A X EC-623008	3.15	-0.16	35.21**	27.63**	19.34**	15.42**	69.34**	48.28**	18.17 **	15.42 **
29	2A X EC-601957	-0.19	-3.64	20.07**	17.81*	10.02**	6.87	101.20**	74.45**	12.13 **	5.7
30	2A X EC-601951	-5.11*	-7.93**	9.55	8.65	12.94**	7.31*	14.48**	-8.26	7.97	-0.84
31	2A X EC-623026	-1.44	-7.09**	21.92**	18.91**	14.20**	11.93**	67.80**	59.77**	13.21 **	6.88
32	2A X RHA-1-1	-0.27	-2.64	23.62**	20.19**	4.74	-0.28	123.71**	119.18**	16.09 **	11.76 *
33	2A X RHA-138-2	3.75	-2.05	34.19**	25.48**	23.37**	14.51**	106.75**	99.72**	12.46 **	4.46
34	2A X R-271-1	4.14	0.24	24.30**	12.14*	19.12**	15.27**	45.08**	38.10**	8.75 *	0.49
35	2A X IR-1-1	-9.78**	-14.70**	31.30**	28.61**	16.22**	12.83**	61.92**	60.21**	12.74 **	4.26
36	2A X J/6	-0.06	-2.38	30.41**	30.34**	-1.43	-3.51	74.97**	43.37**	11.40 **	1.6
37	249A X EC-623008	-0.58	-0.82	19.45**	15.74*	10.55**	8.07*	69.74**	58.73**	11.46 *	10.51 *
38	249A XEC-601957	-17.45**	-22.59**	26.44**	20.81**	11.09**	6.76*	53.10**	41.64**	14.29 **	11.13 *
39	249A X EC-601951	3.22	3.21	20.07**	17.82*	11.51**	4.85	34.71**	14.38**	6.1	0.43
40	249A X EC-623026	14.66**	11.29**	29.91**	29.62**	0.45	-0.47	18.51**	15.81**	6.05	3.28
41	249A X RHA-1-1	17.05**	16.31**	39.03**	31.67**	-8.42**	-11.89**	32.83**	26.17**	8.73	8.06
42	249A X RHA-138-2	16.55**	13.32**	42.65**	36.89**	8.65**	-0.17	9.18*	5.15	5.22	0.76
43	249A X R-271-1	2.60	1.76	8.58	-4.37	5.09	2.80	30.49**	27.56**	9.71 *	4.5
44	249A X IR-1-1	13.85**	10.85**	12.11	11.39	3.00	1.08	5.26*	-2.90	15.84 **	10.43 *
45	249A X J/6	-12.91**	-13.51**	40.31**	36.63**	14.90**	11.27**	93.60**	68.43**	13.28 **	6.45
46	17A X EC-623008	9.41**	8.23**	35.55**	21.89**	12.92**	8.98**	137.37**	136.01**	15.67 **	14.03 **
47	17A X EC-601957	6.09**	0.28	2.89	-0.48	10.69**	0.70	110.12**	106.55**	4.36	2.04
48	17A X EC-601951	-0.37	-1.20	17.31**	10.53	8.38**	-3.41	68.58**	51.14**	-0.09	-4.92
49	17A X EC-623026	3.07	-0.77	22.52**	13.63*	9.23**	4.05	108.01**	91.40**	1.36	-0.74
50	17A X RHA-1-1	-8.42**	-8.61**	29.51**	26.41**	6.18*	4.13	129.36**	105.51**	5.57	5.51
51	17A X RHA-138-21	4.26	0.54	39.50**	24.33**	19.97**	4.63	70.76**	55.00**	-2.2	-5.83
52	17A X R-271-1	-1.83	-3.44	25.00**	18.42**	8.13**	4.30	93.15**	77.78**	-2.74	-6.85
53	17A X IR-1-1	6.24**	2.59	38.77**	29.22**	11.46**	7.17*	63.67**	42.71**	3.82	-0.49
54	17A X J/6	6.47**	6.31*	9.18	3.63	11.71**	2.35	155.44**	135.08**	5.40	-0.42
	S.E	0.67	0.77	0.24	0.28	1.01	1.16	0.76	0.88	1.43	1.66
	CD@5%	1.32	1.53	0.48	0.56	1.98	2.89	1.50	1.73	2.83	3.27

References

1. Alone RK, Patil RD, Mate SN, Manjare MR. Combining ability in sunflower. Indian. J Agric. Res. 2003;30(4):215-220.
2. Amenla I. Evaluation of new inbred lines of *per se* performance and combining ability in sunflower (*Helianthus annuus* L). M.Sc. (Agri). Thesis, Univ. Agri. Sci., Bangalore; c1996.
3. Chidambaram S, Sudarshan N. Correlation between yield and yield components in sunflower. Madras Agric. J. 1990;77:406-407.
4. Deengra SK, Kumar N, Kumar V, Dhaka RPS. Combining ability studies in sunflower (*Helianthus annuus* L.). Society for Recent Development in

Agriculture Prog. Agric. 2012;12(1):154 -157.
5. Dudhe MY, Moon MK, Lande SS. Evaluation of restorer lines for heterosis studies on sunflower, (*Helianthus annuus* L.). J Oilseeds Res. 2009;26:140-141.
6. Dudhe MY, Moon MK, Lande SS. Study of gene action for restorer lines in sunflower. Helia. 2011;34(54):159-164.
7. Karasu A, Mehmet O, Sincik M, Abdurrahim TZM. Combining ability and heterosis for yield and yield components in sunflower. Not. Bot. Hort. Agrobot. Cluj. 2010;38(3):259-264.
8. Kempthorne O. An Introduction to genetical statistics. Jhon Wiley and Sons. INC New York; c1957. p. 217-568.
9. Kinman ML. New development in the USDA and state experiment station, sunflower breeding programme. Proc. Fourth Intl. Sunflower Conf. Memphis Tennessa; c1970. p. 181-183.
10. Leclercq P. One sterilite male cytoplasmique, chezle tounerol. Annls. Amel. P. 1969;12:99-106.
11. Machikowa T, Saetang C, Funpeng K. General and Specific Combining ability for quantitative characters in sunflower. Journal of Agricultural Science. 2011;3(1):203-207.
12. Masood J, Farhatullah, Hassan G. Heterosis estimates for yield and yield components in sunflower (*Helianthus annuus* L.). Pakistan J Biol. Sci. 2009;8(4):553-557.
13. Mohan Kumar S. Development of hybrids using new cytoplasmicmale sterile and fertility restorer lines for higher seed and oil yield character in sunflower (*Helianthus annuus* L.). M.Sc. (Agri). Thesis, Univ. Agri. Sci., Bangalore; c2002.
14. Sawant PH, Manjare MR, Kankal VY. Heterosis for seed yield and its components in sunflower (*Helianthus annuus* L.). J Oilseeds Res. 2007;24(2):313-314.
15. Sujatha M, Reddy VA. Heterosis and combining ability for seed yield and other yield contributing characters in sunflower (*Helianthus annuus* L.). J Oilseeds Res. 2009;26(1):21-31.
16. Usatov AV. The relationship between heterosis and genetic distances based on SSR markers in *Helianthus annuus*. American J Agril. Biol. Sci. 2014;10(3):270-276.