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Heterosis and Heterobeltiosis Studies for Flowering Traits, Plant Height and Seed Yield in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

Eighty four, sunflower hybrids were developed by crossing 14 cytoplasmic male sterile male lines and 6 testers in a line x tester fashion during Spring 2000. The hybrids and parents were evaluated during Spring 2001. Highly significant differences existed among genotypes, parents and parents vs crosses indicating the presence of heterosis for recorded traits. The highest heterosis and heterobeltiosis for days to flower initiation was showed by crosses ORI-6 x RL-69 and ORI-6 x RL-77, respectively in the required direction. The cross combination ORI-20 x RL-77 exhibited maximum increase over mid and better parent for flowering period. The maximum decrease over mid and better parent for days to maturity was showed by the crosses ORI-20 x RL-27 and ORI-6 x RL-46, respectively. The hybrid ORI-20 x RL-77 showed highest positive heterosis and heterobeltiosis values for plant height. The highest positive heterosis over mid and better parent for seed yield was showed by the cross ORI-3 x RL-77.

Key Words: Sunflower; Heterosis; Heterobeltiosis; Flowering traits; Plant height and Seed yield

INTRODUCTION

Sunflower is a rich source of good quality edible oil. It can be successfully grown in different parts of Pakistan due to its wide adaptability, photo-insensitive and thermo-insensitie nature. In sunflower, being the cross-pollinated crop, heterosis can be exploited for better seed yield and other desired traits. The discovery of cytoplasmic male sterility (Lecklereq, 1966) in France and fertility restoration (Kinman, 1970) in America has provided the desired means for the development of hybrids through heterosis breeding. Gill *et al*. (1998) reported that high heterosis can be utilized for earliness, seed yield and head diameter in sunflower.

Pakistan needs hybrids with early maturity and maximum seed yield to make them west fit in the existing cropping pattern of different ecological regions. Sunflower hybrids exhibit varied magnitude and direction of heterosis for different characteristics (Gangappa *et al*., 1997). Standard heterosis for plant height, heterobeltiosis for days to 50% flowering, days to maturity and seed yield can be exploited effectively (Kandhola *et al*., 1995). The main objective of this study was to observe the standard heterosis and heterosis over better parent in the sunflower hybrids developed form diverse nature of lines and testers. Heterosis is significant for seed yield and is one of driving forces behind the hybrid seed industry in cultivated sunflower *Helianthus annuus* L. (Cheres *et al*., 2000).

MATERIALS AND METHODS

The present research study was carried out at Oilseeds Research Institute, Faislabad, Pakistan. Fourteen cytoplasmic male sterile lines namely ORI-1, ORI-3, ORI-4, ORI-6, ORI-10, ORI-20, ORI-22, ORI-27, ORI-29, ORI-37, ORI-41, ORI-47, ORI-48 and ORI-49 and 6 testers namely RL-27, RL-46, RL-55, RL-69, RL-77 and RL-84 were crossed in a line x tester fashion to obtain 84 cross combinations in Spring 2000. The seed was harvested separately from each cross at maturity. F_0 seed of 84 crosses alongwith their 20 parents were planted in a randomized complete block design in Spring 2001. 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 a single row plot of 4.6 m length with plant to plant and row to row distances of 23 and 60 cm, respectively.

All other standard practices were applied to the crop to both replications of the experiment. The data were recorded on ten randomly selected plants of each entry of each replication for days to flower initiation (DFI), days to flower completion (DFC), flowering period (FD), days to maturity (DM), plant height (PH) and seed yield (SY). The data thus recorded were analyzed according to the analysis of variance technique as outlined by Steel and Torrie (1980) for the plant traits in order to determine significance differences among the sunflower genotypes, parents, parents vs crosses, crosses, lines, testers and line x tester interaction.

The increase (+) or decrease (-) of F_1 cross over mid parent as well as better parent was calculated to observe the heterotic effects for all the parameters. The estimated of heterosis over mid parent and better parent (heterobeltiosis) was calculated using the procedure of Matzingar *et al*. (1962). The difference of F_1 mean form the respective mid parent and better parent value was evaluated by using t-test according to Wynne *et al*. (1970).

RESULTS AND DISCUSSION

Mean sum of squares from analysis of variance of 6 sunflower traits are presented in Table I. It is evident for the table that highly significant differences among sunflower genotypes, parents, parents vs crosses, crosses, lines and testers exist for days to flower initiation, days to flower completion, flowering period, days to maturity, plant height and seed yield.

Highly significant differences among parent vs crosses indicate the presence of considerable heterosis for all the studied traits. The significant differences could be attributed to genetically diverse nature of female and male parents. The estimates of heterosis and heterobeltiosis for indicated sunflower traits are presented in Table II.

Days taken to initiate the flowering are of significance in the sense that if flowering starts earlier, sufficient time will be available for grain formation process. Thus early flowering is desirable in sunflower and negative heterosis for days to flower initiation is useful. Sixty two of 84 crosses showed negative heterosis for this trait only but 40 crosses have significant values. Maximum decrease over mid parent (-5.88%) was recoded in hybrid ORI-6 x RL-69. Significant negative heterobeltiosis was observed in 59 crosses, where maximum negative value (-7.79%) was displayed by the cross ORI-6 and RL-77. These results are in close conformity with the finding of Petrov (1992) and Kandhola *et al*. (1995), who also reported negative heterosis for days to flower initiation. However, Gangappa *et al*. (1997) found none of the hybrids with significant heterosis in a desirable direction for days to flower initiation in his respective study.

Regarding days to flower completion, 53 out of 84, crosses exhibited negative heterosis but only 29 had significant values. The maximum negative heterosis (-6.79%) was displayed by the cross ORI-1 x RL-46 for days to flower completion. The negative and significant heterobeltiosis was manifested by 63 cross combinations for days to flower completion. The hybrid viz. ORI-6 x RL-77 and ORI-1 x RL-46 showed the highest negative heterobeltiosis with the value of -10.77 and –10.12%, respectively for days to flower completion.

Longer the flowering period, more will be the seed settings. So longer flowering period is a desirable plant trait for a hybrid seed development programme. Heterosis studies for flowering period (Table II) revealed that 54 cross combination manifested positive increase over the mid parent value. However, significant positive heterosis was indicated in 25 of the crosses. The considerable combinations in this respect included ORI-20 x RL-77, ORI-47 x RL-77, ORI-29 x RL-77, ORI-10 x RL-77, ORI-41 x RL-77 and ORI-49 x RL-77 in the descending order. Heterobeltiosis was positive and significant in only 9 crosses for flowering period. The maximum positive and significant heterobeltiosis value (35.71%) was observed in the cross ORI-20 x RL-77.

Days taken to maturity is an effective trait for earliness and thus negative heterosis for this trait is desirable. Out of 84 crosses 17 showed negative heterosis for days to maturity, while significantly negative heterosis was recorded in 9 cross combinations. Maximum decrease over mid parent was recorded in cross ORI-20 x RL-27 for days to maturity. Negative heterobeltiosis for days to maturity was recorded in 44 cross combinations, while 25 crosses showed negative and significant heterobeltiosis for this trait. The maximum decrease over better parent was observed in ORI-6 x RL-46. Negative heterosis for days to maturity has also been reported by Petrov (1992) Kandhola *et al*. (1995) and Gill *et al*. (1998).

Plant height has a high positive genetic association with seed yield and it also had a positive direct effect for seed yield (La *et al*., 1997). Thus more plant height is a useful trait in sunflower and thus positive heterosis is important. Heterotic studies for plant height revealed that all the 84 crosses expressed positive increase over mid and better parent (Table II). All the 84 cross combinations indicated significant heterosis and heterobeltiosis for plant height except heterobeltiosis in ORI-37 x RL-69. High heterosis was indicated in ORI-20 x RL-77, ORI-3 x RL-77, ORI-48 x RL-77, ORI-3 x RL-84, ORI-27 x RL-77 and ORI-29 x RL-77 hybrids with a value of 77.9, 72.8, 70.7, 70.4, 70.0, 64.4%, respectively. However, lowest heterosis (11.2%) was recorded in the cross ORI-1 x RL-46, for plant height. Prominent heterobeltiosis was observed in ORI-20 x RL-77, ORI-20 x RL-84, ORI-48 x RL-77, ORI-3 x RL-77,

Table I. Mean squares from analysis of variance of indicated plant traits of 104 sunflower genotypes

Sources of variation	d.f	Days to flower initiation	Days to flower completion	Mean squares Flowering period	Days to maturity	Plant height	Seed yield
Replication	1	3.77*	7.31*	0.58	7.31*	3228.8**	3331229**
Genotypes	103	4.42**	12.81**	3.57**	4.88**	646.9**	1635728**
Parents (P)	19	8.72**	20.17**	4.07**	11.45**	265.7**	889111**
P vs Crosses	1	39.94**	32.08**	0.87**	55.50**	47411.6**	96070474**
Crosses	83	3.01**	10.89**	217.96**	2.76**	170.7**	668872**
Lines (L)	13	10.42**	46.96**	3.78**	6.12**	545.4**	1116769**
Testers (T)	5	6.62**	19.06**	1.14**	12.17**	522.2**	3876113**
L T	65	1.25**	3.04**	0.27**	1.37ns	68.7ns	332582ns
Error	103	0.68	1.27	0.56	1.44	67.6	300607

*, ** significant at 5% and 1% probability levels, respectively; ns = non-significant.

Table II. Estimates of heterosis and heterobeltiosis for indicated plant traits of sunflower hybrids

S. No.	Crosses	Days to flower initiation		Days to flower completion		Flowering period (days)		Days to maturity		Plant height (cm)		Seed yield (kg/ha)	
		Ht	Hbt	Ht	Hbt	Ht	Hbt	Ht	Hbt	Ht	Hbt	Ht	Hbt
1	ORI-1 RL-27	-1.39	-2.07 **	-3.18 **	-3.80 **	-23.08 **	-23.08 **	-2.68 **	-1.48 *	31.6 **	21.6 **	152.4 **	83.6 **
2	ORI-1 RL-46	-2.39 **	-4.67 **	-6.79 **	-10.12 **	-48.39 **	-55.56 **	2.77 **	-1.92 **	12.0 *	11.2 *	57.8 **	26.3 *
3	ORI-1 RL-55	-3.09 **	-4.73 **	-4.70 **	-6.75 **	-21.43 **	-26.67 **	-0.74	-0.99	34.7 **	22.4 **	233.1 **	123.5 **
4	ORI-1 RL-69	-3.05 **	-5.92 **	-4.62 **	-8.28 **	-20.00 **	-29.41 **	2.28 **	-0.49	38.6 **	26.0 **	258.1 **	144.1 **
5	ORI-1 RL-77	0.35	0.00	0.33	-1.28	0.00	-15.38 *	0.25	-0.99	48.1 **	28.1 **	214.0 **	118.1 **
6	ORI-1 RL-84	-2.07 **	-3.40 **	-3.77 **	-5.56 **	-21.43 **	-26.67 **	2.54 **	-0.49	40.5 **	29.3 **	318.7 **	176.8 **
7	ORI-3 RL-27	0.00	0.00	0.32	0.00	4.00	0.00	0.00	3.06 **	61.3 **	37.7 **	236.8 **	196.4 **
8	ORI-3 RL-46	0.34	-1.33	1.54	-1.79 *	13.33 *	-5.56	4.10 **	-2.40 **	42.0 **	12.9 **	120.8 **	50.0 **
9	ORI-3 RL-55	1.02	0.00	1.88 *	0.00	11.11	0.00	2.01 **	3.57 **	56.5 **	35.6 **	338.4 **	244.7 **
10	ORI-3 RL-69	-1.68 *	-3.95 **	-1.23	-4.73 **	3.45	-11.76 *	5.15 **	0.99	51.7 **	31.5 **	338.0 **	252.2 **
11	ORI-3 RL-77	1.74 *	0.69	3.25 **	1.27	23.81 **	8.33	3.55 **	4.08 **	72.8 **	57.4 **	437.2 **	343.3 **
12	ORI-3 RL-84	4.11 **	3.40 **	5.96 **	4.32 **	25.93 **	13.33 *	7.49 **	5.05 **	70.4 **	45.9 **	389.2 **	276.5 **
13	ORI-4 RL-27	-1.39	-2.07 **	-1.60	-2.53 **	-4.00	-7.69	-1.73 *	1.02	23.9 **	13.9 **	76.3 **	12.4
14	ORI-4 RL-46	2.39 **	0.00	0.93	-2.98 **	-13.33 *	-27.78 **	4.35 **	-1.92 **	29.3 **	29.0 **	33.8 *	33.3 *
15	ORI-4 RL-55	-1.72 *	-3.38 **	-1.89 *	-4.29 **	-3.70	-13.33 *	-2.26 **	-1.02	24.3 **	12.5 *	62.1 **	-2.2
16	ORI-4 RL-69	0.34	-2.63 **	0.62	-3.55 **	3.45	-11.76 *	3.86 **	0.00	32.7 **	20.1 **	129.6 **	40.1 **
17	ORI-4 RL-77	1.05	0.70	2.61 **	1.29	23.81 **	8.33	1.27	1.52 *	46.4 **	26.1 **	137.0 **	46.4 **
18	ORI-4 RL-84	2.07 **	0.68	2.84 **	0.62	11.11	0.00	4.12 **	2.02 **	45.8 **	33.6 **	119.0 **	30.9 *
19	ORI-6 RL-27	-1.67 *	-4.55 **	-2.42 **	-6.40 **	-9.68	-22.22 **	-2.44 **	-0.99	48.3 **	47.0 **	202.9 **	143.6 **
20	ORI-6 RL-46	-2.63 **	-3.90 **	-4.12 **	-5.23 **	-16.67 **	-16.67 **	1.01	-3.85 **	36.6 **	26.2 **	86.6 **	35.2 **
21	ORI-6 RL-55	-4.64 **	-6.49 **	-5.67 **	-8.14 **	-15.15 **	-22.22 **	-1.98 **	-1.98 **	43.8 **	40.2 **	226.6 **	138.0 **
22	ORI-6 RL-69	-5.88 **	-6.49 **	-7.33 **	-8.14 **	-20.00 **	-22.22 **	2.03 **	-0.50	43.7 **	40.0 **	277.0 **	180.2 **
23	ORI-6 RL-77	-4.05 **	-7.79 **	-4.64 **	-10.47 **	-11.11	-33.33 **	-0.50	-1.49 *	44.3 **	33.2 **	293.9 **	199.4 **
24	ORI-6 RL-84	-2.99 **	-5.19 **	-4.79 **	-7.56 **	-21.21 **	-27.78 **	1.27	-1.49 *	45.8 **	44.1 **	313.5 **	195.9 **
25	ORI-10 RL-27	-1.04	-1.38	-2.22 *	-2.53 **	-15.38 *	-15.38 *	0.50	4.12 **	42.7 **	40.5 **	170.8 **	114.5 **
26	ORI-10 RL-46	-1.36	-3.33 **	-2.77 **	-5.95 **	-16.13 **	-27.78 **	5.15 **	-1.92 **	22.2 **	13.8 **	52.7 **	12.1
27	ORI-10 RL-55	-2.74 **	-4.05 **	-4.38 **	-6.13 **	-21.43 **	-26.67 **	0.00	2.06 **	46.0 **	41.3 **	234.3 **	140.6 **
28	ORI-10 RL-69	-3.38 **	-5.92 **	-3.07 **	-6.51 **	0.00	-11.76 *	4.66 **	0.00	44.8 **	40.0 **	208.3 **	126.2 **
29	ORI-10xRL-77	-0.70	-1.39	1.95 *	0.00	36.36 **	15.38 *	1.02	2.06 **	51.4 **	38.9 **	187.1 **	115.3 **
30	ORI-10xRL-84	-0.34	-1.36	-1.57	-3.09 **	-14.29 *	-20.00 **	3.90 **	1.01	49.0 **	46.1 **	237.5 **	138.7 **
31	ORI-20 RL-27	0.00	-0.68	0.31	-0.62	3.70	0.00	-3.65 **	-2.46 **	53.0 **	51.0 **	156.6 **	84.4 **
32	ORI-20 RL-28	-1.01	-2.00 **	-1.52	-3.57 **	-6.25	-16.67 **	1.76 *	-2.88 **	48.2 **	37.6 **	37.8 *	11.9
33	ORI-20 RL-29	-1.02	-1.35	-0.62	-1.23	3.45	0.00	-1.23	-1.48 *	53.4 **	48.9 **	148.4 **	65.1 **
34	ORI-20 RL-69	-2.34 **	-3.95 **	0.00	-2.37 **	22.58 **	11.76 *	1.27	-1.48 *	57.1 **	52.4 **	153.9 **	71.4 **
35	ORI-20 RL-77	1.04	-0.68	5.77 **	2.48 **	65.22 **	35.71 **	-0.25	-1.48 *	77.9 **	63.6 **	301.4 **	175.8 **
36	ORI-20 RL-84	-1.36	-1.36	0.31	0.00	17.24 **	13.33 *	2.03 **	-0.99	60.7 **	58.1 **	229.3 **	115.7 **
37	ORI-22 RL-27	-2.07 **	-2.07 **	-2.21 *	-2.52 **	-3.70	-7.14	-0.99	2.04 **	44.8 **	36.6 **	186.7 **	94.8 **
38	ORI-22 RL-46	-1.02	-2.67 **	-0.92	-3.57 **	0.00	-11.11 *	3.59 **	-2.88 **	36.6 **	32.6 **	52.9 **	34.6 **
39	ORI-22 RL-55	-1.02	-2.03 **	-1.86 *	-3.07 **	-10.34	-13.33 *	0.00	1.53 *	38.8 **	28.8 **	121.6 **	40.8 *
40	ORI-22 RL-69	-3.70 **	-5.92 **	-3.05 **	-5.92 **	3.23	-5.88	3.09 **	-0.99	30.2 **	20.7 **	107.9 **	33.8
41	ORI-22 RL-77	-0.35	-1.38	0.65	-1.89 *	13.04	-7.14	1.52 *	2.04 **	54.3 **	36.0 **	158.2 **	68.8 **
42	ORI-22 RL-84	-2.74 **	-3.40 **	-2.80 **	-3.70 **	-3.45	-6.67	2.84 **	0.51	50.5 **	41.4 **	188.3 **	80.9 **
43	ORI-27 RL-27	-0.68	-2.01 **	-1.54	-4.19 **	-9.68	-22.22 **	-2.96 **	-0.51	30.4 **	25.9 **	119.7 **	59.2 **
44	ORI-27 RL-46	-2.34 **	-2.67 **	-5.07 **	-5.36 **	-27.78 **	-27.78 **	2.04 **	-3.85 **	33.1 **	26.1 **	35.4 *	8.9
45	ORI-27 RL-55	-1.68 *	-2.01 **	-3.03 **	-4.19 **	-15.15 **	-22.22 **	0.50	1.52 *	52.0 **	44.4 **	204.0 **	103.4 **
46	ORI-27 RL-69	-1.66 *	-2.63 **	-1.19	-1.78 *	2.86	0.00	3.59 **	0.00	53.4 **	45.7 **	199.2 **	103.3 **
47	ORI-27 RL-77	0.34	-2.01 **	0.00	-4.79 **	-3.70	-27.78 **	1.52 *	1.52 *	70.0 **	53.2 **	251.0 **	142.9 **
48	ORI-27 RL-84	0.00	-0.67	2.74 **	1.20	27.27 **	16.67 **	5.40 **	3.54 **	56.3 **	50.4 **	256.8 **	135.2 **
49	ORI-29 RL-27	-2.01 **	-4.58 **	-0.61	-4.12 **	13.33 *	0.00	-0.74	2.56 **	45.4 **	36.2 **	186.9 **	116.9 **
50	ORI-29 RL-46	-2.31 **	-3.27 **	-1.78 *	-2.35 **	2.86	0.00	4.88 **	-1.92 **	46.3 **	43.0 **	104.2 **	56.6 **
51	ORI-29 RL-55	-3.65 **	-5.23 **	-3.30 **	-5.29 **	0.00	-5.88	0.76	2.56 **	60.5 **	47.9 **	185.5 **	97.8 **
52	ORI-29 RL-69	-1.64 *	-1.96 **	0.29	0.00	17.65 **	17.65 **	5.43 **	0.99	58.8 **	46.3 **	233.7 **	135.3 **
53	ORI-29 RL-77	1.69 *	-1.96 **	5.30 **	-0.59	46.15 **	11.76 *	2.80 **	3.59 **	64.4 **	44.0 **	232.4 **	139.1 **
54	ORI-29 RL-84	-2.00 **	-3.92 **	-1.20	-3.53 **	6.25	0.00	3.63 **	1.01	53.7 **	43.5 **	310.7 **	179.9 **
55	ORI-37 RL-27	-1.35	-3.31 **	-1.83 *	-5.29 **	-6.25	-21.05 **	-2.96 **	-0.51	23.3 **	11.9 *	98.0 **	42.4 *
56	ORI-37 RL-46	-1.66 *	-1.99 **	-1.18	-1.76 *	2.70	0.00	4.59 **	-1.44 *	30.1 **	28.6 **	25.5	1.9
57	ORI-37 RL-55	-1.67 *	-2.65 **	-1.50	-3.53 **	0.00	-10.53 *	0.50	1.52 *	27.5 **	13.9 **	77.1 *	17.7
58	ORI-37 RL-69	-3.63 **	-3.95 **	-4.42 **	-4.71 **	-11.11 *	-15.79 **	3.08 **	-0.50	22.0 **	9.0	198.3 **	101.4 **
59	ORI-37 RL-77	1.02	-1.99 **	2.80 **	-2.94 **	21.43 **	-10.53 *	2.02 **	2.02 **	55.6 **	32.4 **	247.7 **	139.0 **
60	ORI-37 RL-84	-1.34	-2.65 **	0.00	-2.35 **	11.76 *	0.00	3.86 **	2.02 **	39.1 **	25.8 **	205.6 **	100.3 **
61	ORI-41 RL-27	0.00	-1.99 **	0.61	-2.94 **	6.25	-10.53 *	-2.42 **	-1.94 **	28.7 **	17.1 **	58.5 **	3.1
62	ORI-41 RL-46	0.33	0.00	-0.59	-1.18	-8.11	-10.53 *	1.50 *	-2.40 **	32.8 **	31.5 **	20.8	15.2
63	ORI-41 RL-55	-1.00	-1.99 **	0.30	-1.76 *	11.76 *	0.00	0.49	-0.49 **	37.2 **	22.9 **	29.5	-20.6
64	ORI-41 RL-69	-0.99	-1.32	0.29	0.00	11.11 *	5.26	1.51 *	-1.94 **	44.7 **	29.5 **	92.8 **	19.6
65	ORI-41 RL-77	0.34	-2.65 **	3.43 **	-2.35 **	35.71 **	0.00	0.99	-0.97	59.3 **	35.8 **	147.5 **	55.7 **
66	ORI-41 RL-84	0.00	-1.32	0.60	-1.76 *	5.88	-5.26	2.77 **	-0.97	44.5 **	31.0 **	146.6 **	49.6 **
67	ORI-47 RL-27	-2.97 **	-6.96 **	-0.30	-4.09 **	30.77 **	30.77 **	-3.38	-2.91 **	34.4 **	25.3 **	64.2 *	11.1
68	ORI-47 RL-46	-1.95 **	-4.43 **	-0.29	-1.17	16.13 **	0.00	3.00 **	-0.96	24.8 **	22.7 **	2.8	-8.9
69	ORI-47 RL-55	-3.92 **	-6.96 **	-2.40 **	-4.68 **	14.29 *	6.67	-1.47	-2.43 **	43.5 **	31.7 **	101.3 **	27.4
70	ORI-47 RL-69	-4.52 **	-6.33 **	-2.94 **	-3.51 **	13.33 *	0.00	3.02 **	-0.49	35.0 **	23.8 **	176.9 **	77.6 **
71	ORI-47 RL-77	-2.00 **	-6.96 **	1.86 *	-4.09 **	54.55 **	30.77 **	1.49 *	-0.49	53.5 **	33.9 **	141.5 **	57.2 **
72	ORI-47 RL-84	-4.26 **	-7.59 **	-3.30 **	-5.85 **	7.14	0.00	3.78 **	0.00	43.8 **	33.6 **	178.5 **	74.1 **
73	ORI-48 RL-27	-3.07 **	-4.05 **	-2.18 *	-3.68 **	7.14	0.00	-2.45	-0.50	39.0 **	38.8 **	107.6 **	39.9 *

Table II. Continued

74	ORI-48	RL-46	-1.34		-2.00	**	-2.11	*	-3.57	**	-9.09		-16.67		4.06	**	-1.44	*	26.8	**	16.4	**	-2.5		-13.0	
75	ORI-48	RL-55	-2.70	**	-2.70	**	-1.84	*	-1.84	*	6.67		6.67		0.00		0.50		36.2	**	33.7	**	78.2	**	12.4	
76	ORI-48	RL-69	-1.33		-2.63	**	-1.20		-2.96	**	0.00		-5.88		3.06	**	0.00		43.4	**	40.7	**	112.1	**	35.6	*
77	ORI-48	RL-77	0.69		-1.35		3.18	**	-0.61		33.33	**	6.67		3.02	**	2.50	**	70.7	**	58.6	**	204.2	**	97.3	**
78	ORI-48	RL-84	-0.34		-0.68		0.92		0.61		13.33	*	13.33	*	2.81	**	0.50		50.3	**	49.6	**	213.4	**	95.4	**
79	ORI-49	RL-27	-1.36		-2.68	**	-0.61		-3.57	**	6.25		-10.53		-1.96		0.00		30.8	**	25.5	**	224.9	**	129.2	**
80	ORI-49	RL-46	-3.01	**	-3.33	**	-2.38	**	-2.38	**	2.70		0.00		3.55	**	-1.92	**	19.4	**	14.0	**	93.1	**	60.8	**
81	ORI-49	RL-55	-1.68	*	-2.01	**	-1.51		-2.98	**	0.00		-10.53		0.50		1.00		38.7	**	30.8	**	167.6	**	75.2	**
82	ORI-49	RL-69	-1.66	*	-2.63	**	-1.48		-1.78	*	0.00		-5.26		4.08	**	0.99		46.5	**	38.1	**	288.3	**	158.0	**
83	ORI-49	RL-77	1.72	*	-0.67		4.70	**	-0.60		35.71	**	0.00		1.51	*	1.00		62.4	**	45.4	**	237.9	**	128.3	**
84	ORI-49	RL-84	-0.68		-1.34		-0.61		-2.38	**	0.00		-10.53		1.51	*	1.00		47.8	**	41.2	**	256.7	**	130.3	**

ORI-27 x RL-77 and ORI-20 x RL-69 for plant height in descending order. The results get support from the earlier findings of Sugoor *et al*. (1996), Gangappa *et al*. (1997) Sessiikumar and Gopalan (1999) and Jayalakshmi *et al*. (2000) how also reported positive mid parent heterosis for plant height in sunflower.

Heterotic studies for seed yield revealed positive heterosis in all 84 crosses. Seventy nine hybrids showed significant heterosis for seed yield. Maximum heterosis was recorded in ORI-3 x RL-77, ORI-3 x RL-84, ORI-3 x RL-55, ORI-3 x RL-69, ORI-1 x RL-84, ORI-6 x RL-84, ORI-29 x RL-84 and ORI-20 x RL-77 with a value of 437.2, 389.2, 338.4, 338.0, 318.7, 315.5, 310.7 and 310.4%, respectively for seed yield per hectare.

Positive heterobeltiosis for seed yield was recorded in 81 crosses. Positive and significant increase over better parent was observed in 68 hybrids for sunflower seed yield. Maximum heterobeltiosis for this trait was recorded in ORI-3 x RL-77, followed by ORI-3 x RL-84, ORI-3 x RL-69, ORI-3 x RL-55 and ORI-6 x RL-77 with the value of 343.3, 276.5, 252.2, 244.7 and 199.4%, respectively. Positive mid parent heterosis has also been reported by Sugoor *et al*. (1994), Gamgappa *et al*. (1997), Yenice and Arslan (1997), Limbore *et al*. (1998), Gill *et al*. (1998), Kumar *et al*. (1999), Goksoy *et al*. (2000) and Cheres *et al*. (2000) in sunflower. Similarly, positive heterosis over the best parent has also been reported by Kandola *et al*. (1995), Rather and Sandha (1999) and Nehru *et al*. (2000) for seed yield in sunflower (*Helianthus annuus* L.).

It is, therefore, concluded that five hybrids viz., ORI-3 x RL-77, ORI-3 x RL-84, ORI-3 x RL-69, ORI-3 x RL-55 and ORI-6 x RL-77 can be exploited for hybrid seed development on commercial basis.

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