

Combining Ability Studies in Multi Branched Restorer Lines of Sunflower (*Helianthus annuus* L.)

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Abstract

A diallel set of 30 F_1 's (including reciprocals) involving six restorer parents were studied to estimate the combining ability. The parents R-8297 and RHA-274 were the best general combiners with high gca effects for most of the characters studied. The direct cross combinations R-393 \times R-5 and R-127 \times R-5 were found to be promising for yield and its attributing characters like head diameters, plant yield and seed yield. While the reciprocal crosses RHA-275 \times R-393 and RHA-275 \times R-127 exhibited significant specific combining abilities for most of the characters studied.

Key words : Combining ability, Multi branched restorer line sunflower.

Sunflower is one of the most important oilseed crops of India. It is also a crop in which heterosis is exploited for better seed and oil yield. The value of hybrids and the importance of heterosis breeding was recognised very early in sunflower. The discovery of cytoplasmic male sterility (1) in France and fertility restoration (2) in USA has provided the required break through for heterosis breeding in sunflower. As a result, plant breeders have extensively used and exploited heterosis to improve seed and oil yield in sunflower. In a systematic breeding program it is essential to identify superior parents for hybridization and crosses to expand the variability reservoir for selection of superior genotypes. Combining ability analysis helps the breeder in selecting desirable parents and provides information on the relative importance of GCA and SCA for interpreting the genetic basis of important traits. In the present study an attempt was

made to assess the combining ability for different traits in multi branched restorer lines of sunflower by employing diallel analysis.

Methods

The material comprised of six restorer lines viz., RHA-274, R-393, R-127, RHA-275, R-8297 and R-5. These parents were crossed in diallel fashion (including reciprocals) to generate 30 hybrids. These crosses along with parents were grown in Randomized Block Design with two replications. The experiment was conducted at regional agricultural research station, Raichur campus located in north eastern dry zone of Karnataka. The crossing and evaluation was done during 2006-2007. Each entry was sown in two rows of 3m length each with a spacing 60 cm between rows and 30 cm between plants. All the recommended pack-

Table 1. ANOVA for ten different characters in 6 \times 6 diallel crosses in sunflower restorer lines. *, ** Significant at 5 and 1% probability respectively.

Source	df	Mean sums of squares									
		Days to 50% flowering	Head diameter (cm)	Plant height (cm)	Leaf size (dm ²)	Days to maturity	Volume weight (g/100 ml)	100 seed weight (g)	Plant yield (g)	Oil content (%)	Seed yield (kg/ha)
1. Replication	1	0.125	0.244	0.061	0.292	0.888	1.547	0.016	0.036	0.0849	51863.31
2. Treatment	35	10.496**	5.542**	768.836**	0.606**	8.841**	26.759**	0.991**	91.598**	7.079**	277013.82**
3. Error	35	0.964	0.061	23.770	0.033	0.517	1.390	0.125	1.990	0.195	15620.87

Table 2. Estimates of general combining ability effects in 6 × 6 diallel for various characters in sunflower restorer lines. *, ** Significant at 5% and 1% probability respectively.

Parents	Days to 50% flowering	Head diameter (cm)	Plant height (cm)	Leaf size (dm ²)	Days to maturity	Volume weight (g/ 100 ml)	100 seed weight (g)	Plant yield (g)	Oil content (%)	Seed yield (kg/ha)
1. RHA-274	-0.58**	-0.13**	-4.37**	0.08**	-0.68**	-1.42**	-0.13*	1.63**	-0.70**	-46.26
2. R-393	0.83**	-0.33**	-11.52**	0.11**	0.15	-0.90**	0.38**	-0.57*	0.09	-1.63
3. R-127	0.92**	-0.10*	13.15**	0.03	0.82**	0.98**	0.01	-1.17**	0.52**	68.53**
4. RHA-275	-0.46**	0.41**	-5.88**	-0.18**	-0.43**	-0.39	0.03	0.14	-0.53**	22.63
5. R-8297	-0.75**	0.73**	11.54**	0.12**	-0.56**	-1.85**	-0.03	2.94**	0.01	20.11
6. R-5	0.04	-0.58**	-2.93**	-0.16**	0.69**	3.57**	-0.27**	-2.97**	0.62**	-63.69**
SE (g _i)	0.054	0.044	0.964	0.031	0.134	0.219	0.063	0.262	0.083	23.289
CD (g _i) at 5% level	0.111	0.090	1.957	0.064	0.272	0.444	0.128	0.533	0.169	47.281
CD (g _i) at 1% level	0.149	0.121	2.626	0.086	0.365	0.596	0.172	0.715	0.227	63.436

age of practices were followed and observations were recorded on days to 50% flowering, head diameter, plant height, leaf size, days to maturity, volume weight, , 100 seed weight, plant yield, oil content and seed yield. The combining ability analysis was carried out following the model proposed by Griffings in 1956.

Results and Discussion

The analysis of variance for restorers showed

significant differences for all the characters (Table 1). Further crosses were also found to differ significantly from each other for all the characters studied revealing the existence of genetic diversity in parental material and justifying their selection for combining ability analysis.

A perusal of gca effects of six parents for 10 characters indicated that no single restorer was a good general combiner for all the characters studied, however R-8297 and RHA-274 were the best general com-

Table 3. Estimates of specific combining ability effects in 6 × 6 diallel (direct crosses) for various characters in sunflower restorer lines. *, ** Significant at 5% and 1% probability respectively.

Crosses	Days to 50% flowering	Head diameter (cm)	Plant height (cm)	Leaf size (dm ²)	Days to maturity
1. RHA-274 × R-393	0.79**	0.89**	-5.40*	0.23**	-1.31**
2. RHA-274 × R-127	0.96**	0.52**	17.30**	0.37**	1.14**
3. RHA-274 × RHA-275	-1.42**	-0.12	-14.15**	-0.32**	-1.61**
4. RHA-274 × R-8297	0.13	-0.02	2.74	-0.48**	-0.74*
5. RHA-274 × R-5	0.58**	-0.16	0.26	0.11	-0.74*
6. R-393 × R-127	-0.96**	-0.64**	-7.50**	0.26**	-1.19**
7. R-393 × RHA-275	-0.83**	-0.30**	22.35**	-0.07	-0.69*
8. R-393 × R-8297	-0.79**	-0.62**	5.09*	0.44**	-1.57**
9. R-393 × R-5	0.42**	0.99**	3.21	-0.46**	0.68*
10. R-127 × RHA-275	-2.42**	1.88**	3.76	0.14	-1.86**
11. R-127 × R-8297	1.88**	-0.77**	8.62**	-0.29**	1.51**
12. R-127 × R-5	-0.67**	0.42**	-0.11	0.10	-0.24
13. RHA-275 × R-8297	-0.75**	1.05**	6.30**	0.55**	-1.24**
14. RHA-275 × R-5	0.46**	-0.42**	-2.23	-0.11	0.26
15. R-8297 × R-5	-0.75**	0.58**	0.40	0.35**	-0.86**
SE (s _{ij})	0.130	0.104	2.198	0.077	0.304
CD (s _{ij}) @ 5% level	0.264	0.212	4.463	0.157	0.619
CD (s _{ij}) @ 1% level	0.354	0.285	5.988	0.210	0.830

Table 3. Continued.

Crosses	Volume weight (g/100 ml)	100 seed weight (g)	Plant yield (g)	Oil content (%)	Seed yield (kg/ha)
1. RHA-274 × R-393	-1.25*	-0.49**	-0.65	-1.29**	-196.59**
2. RHA-274 × R-127	0.39	0.43**	3.81**	-2.19**	38.55
3. RHA-274 × RHA-275	1.17*	-0.46**	1.81**	-1.42**	279.15**
4. RHA-274 × R-8297	0.63	-0.25	0.40	1.19**	162.33**
5. RHA-274 × R-5	2.38**	0.36*	-5.47**	0.92**	-203.56**
6. R-393 × R-127	0.15	-0.23	2.55**	0.31	162.78**
7. R-393 × RHA-275	0.72	0.98**	-2.27**	-1.76**	117.75*
8. R-393 × R-8297	0.06	0.06	0.32	0.85**	37.04
9. R-393 × R-5	-0.47	0.70**	3.75**	-0.92**	125.79*
10. R-127 × RHA-275	-0.28	0.42**	-5.66**	1.94**	-463.45**
11. R-127 × R-8297	2.05**	-0.34*	-3.58**	-0.73**	44.66
12. R-127 × R-5	-0.20	-0.15	6.08**	-0.24	540.66**
13. RHA-275 × R-8297	0.98	-0.64**	12.73**	-0.83**	462.79**
14. RHA-275 × R-5	0.43	-0.32*	-0.14	-0.49*	49.06
15. R-8297 × R-5	-2.09**	0.83**	-3.56**	-1.46**	-222.03**
SE (s_{ij})	0.500	0.151	0.599	0.187	53.107
CD (s_{ij}) @ 5% level	1.016	0.307	1.216	0.379	107.819
CD (s_{ij}) @ 1% level	1.364	0.412	1.631	0.509	144.665

biners with high gca effects for most of the characters studied viz., days to 50% flowering, head diameter, plant height, leaf size, days to maturity and plant yield, while the line RHA-275 was the second best general combiner for four characters viz., days to 50% flowering, head diameter, plant height and days to maturity (Table 2). The line R-127 was a good general combiner for yield and yield attributing characters like volume weight, oil content and seed yield. While the line R-393 was the best general combiner for plant height, leaf size and 100 seed weight. For leaf size, volume weight and oil content the line R-5 exhibited significant general combining ability effects.

The sca effects showed that none of the crosses were good specific combiners for all the characters studied. In the present study the results (Table 3) revealed that the direct crosses RHA-274 × RHA-275, R-393 × R-127 and RHA-275 × R-8297 were best specific combiners for majority of the characters studied viz., days to 50% flowering, head diameter, leaf size, days to maturity, volume weight, plant yield and seed yield. The crosses R-127 × RHA-275 and R-8297 × R-5 were the second best specific combiners for days to 50% flowering, head diameter, leaf size, days to maturity and 100 seed weight. The cross R-393 × R-5 and R-127 × R-5 exhibited good specific combining abili-

ties for yield and its attributing characters like head diameter, plant yield and seed yield. Since none of the parental lines were good combiners for all the traits and also none of the crosses exhibited high sca effects for all the traits, improvement in individual components and certain associated traits may be considered as a desirable approach. The ideal cross combinations to be exploited is one where high magnitude of sca is present in addition to high gca in both or at least one of the parents. Identification of heterotic crosses involving high × low gca cross combinations as revealed in the present study were earlier reported by Kadkol et al. (3). In addition crosses with high sca effects involving parents with high × high gca effects were also reported by Rudra Naik et al. (4) and Sugoor et al. (5), low × low by Kadkol et al. (3) and Sugoor et al. (5), low × high by Sheriff et al. (6) and Limbore et al. (7).

The present study revealed that none of the reciprocal crosses exhibited significant specific combining effects for all the characters studied (Table 4). However, the reciprocal crosses RHA-275 × R-393 and RHA-275 × R-127 exhibited significant reciprocal effects for most of the characters studied viz., days to 50% flowering, head diameter, leaf size, days to maturity, volume weight, 100 seed weight, oil content and

Table 4. Estimates of specific combining ability effects for ten characters in 6 × 6 diallel (reciprocal crosses) in sunflower restorer lines. *, ** Significant at 5% and 1% probability respectively.

Crosses	Days to 50% flowering	Head diameter (cm)	Plant height (cm)	Leaf size (dm ²)	Days to maturity
1. R-393 × RHA-274	0.00	-1.90**	-18.30**	-0.57**	-0.50
2. R-127 × RHA-274	0.25	1.75**	-1.38	0.14	0.00
3. RHA-275 × RHA-274	0.50**	1.93**	-3.60	0.21*	-0.50
4. R-8297 × RHA-274	-2.50**	-0.05	-22.20**	-0.45**	-2.25**
5. R-5 × RHA-274	-2.00**	-0.20	2.75	-0.11	-1.50**
6. R-127 × R-393	0.25	-1.60**	7.18**	-0.56**	-0.50
7. RHA-275 × R-393	-1.00**	0.65**	-3.25	0.01	-1.25**
8. R-8297 × R-393	-1.25**	1.45**	-7.90**	-1.00**	-1.25**
9. R-5 × R-393	3.75**	-0.25	-18.45**	-0.62**	2.75**
10. RHA-275 × R-127	-3.00**	2.55**	3.82	0.56**	-2.25**
11. R-8297 × R-127	1.00**	0.38**	5.40*	0.04	0.00
12. R-5 × R-127	-1.25**	-0.30**	-15.60**	0.14	0.00
13. R-8297 × RHA-275	-2.00**	-1.75**	1.25	-0.17	-1.00**
14. R-5 × RHA-275	1.00**	-1.28**	7.75**	-0.17	0.75*
15. R-5 × R-8297	0.50**	0.90**	4.00	0.23*	0.50
SE (r_{ij})	0.154	0.122	2.587	0.089	0.359
CD (r_{ij}) @ 5% level	0.314	0.248	5.252	0.181	0.729
CD (r_{ij}) @ 1% level	0.421	0.333	7.046	0.243	0.978

Table 4. Continued.

Crosses	Volume weight (g/100 ml)	100 seed weight (g)	Plant yield (g)	Oil content (%)	Seed yield (kg ha ⁻¹)
1. R-393 × RHA-274	-1.67**	0.68*	-8.75**	-0.25	-416.67**
2. R-127 × RHA-274	-1.30*	0.13	5.25**	0.62**	297.47**
3. RHA-275 × RHA-274	-3.75**	0.05	0.07	0.50*	-155.56*
4. R-8297 × RHA-274	-4.40**	0.20	-4.60**	-0.45*	-91.67
5. R-5 × RHA-274	3.83**	0.08	-5.52**	1.60**	-470.16**
6. R-127 × R-393	1.88**	-0.32	3.90**	-0.27	-92.49
7. RHA-275 × R-393	1.83**	0.00	0.65	0.55*	189.06**
8. R-8297 × R-393	-0.65	-1.03**	2.17**	-1.80**	-11.11
9. R-5 × R-393	-0.35	-0.02	-2.25**	0.10	-221.92**
10. RHA-275 × R-127	-0.70	0.92**	1.15	-1.13**	138.86*
11. R-8297 × R-127	2.22**	0.60**	-2.78**	1.85**	-50.00
12. R-5 × R-127	-0.30	-0.30	-1.97**	-1.00**	-168.06*
13. R-8297 × RHA-275	-0.87	0.32	-3.85**	-0.40	-5.56
14. R-5 × RHA-275	3.50**	-0.00	-3.02**	1.15**	-163.89*
15. R-5 × R-8297	1.08	-0.30	-8.30**	1.27**	-551.39**
SE (r_{ij})	0.589	0.176	0.705	0.221	62.491
CD (r_{ij}) @ 5% level	1.197	0.357	1.432	0.449	126.870
CD (r_{ij}) @ 1% level	1.606	0.479	1.922	0.602	170.227

seed yield. The reciprocal cross R-8297 × R-393 was the second best cross which exhibited significant specific combining effects for five characters viz., days to 50% flowering, head diameter, plant height, days to maturity and plant yield. The reciprocal

crosses R-127 × RHA-274 and R-8297 × R-127 exhibited significant reciprocal effects for yield attributing characters like head diameter, volume weight, 100 seed weight, plant yield, oil content and seed yield. The significant reciprocal differences might be due to cy-

toplasmic inheritance.

In conclusion the parents R-8297 and RHA-274 were the best general combiners with high gca effects for most of the characters studied while the direct crosses RHA-274 × RHA-275, R-393 × R-127 and RHA-275 × R-8297 were best specific combiners for majority of the characters studied and the reciprocal crosses RHA-275 × R-393 and RHA-275 × R-127 exhibited significant specific combining effects for most of the characters studied.

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