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Research Article

Inbred line development through B × B crosses for combining ability and gene action in sunflower (*Helianthus annuus* L.)

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Abstract
To estimate general combining ability and specific combing ability effects for various characters eight inbred lines were crossed in 8×8 full diallel fashion. The 56 F_1 crosses along with parents and checks were planted in simple lattice design with two replication at Main Agricultural Research Station, Raichur during *rabi* 2015-16. The results exhibited that SCA variances were higher than GCA variances for all traits studied which indicated the presence of non-additive gene action. Three inbreds 39 B, 852 B and 400 B were found to be the best general combiners for majority of the traits. Three crosses 104 B×39 B, 400 B×234 B and 17 B×400 B were found to be the best specific combiners for majority of the characters studied *viz.*, days to 50 % flowering, days to maturity, head diameter, stem girth, volume weight, oil content and seed yield per plant. These specific crosses could be further utilized for deriving desirable inbreds from advanced generations.

Key words
Combining ability, *gca*, *sca*, gene action

Introduction

Sunflower (*Helianthus annuus* L.) is an important oilseed crop of India. Heterosis breeding requires identification of good inbred lines. High self fertility, better seed set, uniform maturity, high yield potential and stability are the most important parameters of any sunflower hybrid (Seetharam *et al.,* 1980). It is clear that use of good general combining B lines (maintainer lines) for back cross transferring of CMS traits will improve the performance of resulting hybrids. Combining ability analysis provides information on nature and magnitude of gene effects on yield and yield attributing characters (Sprague and Tatum, 1942). Choosing desirable lines for breeding as a parental component of a hybrid variety is of great importance.

Materials and methods

The parent materials for the present study consisted of eight diverse maintainer lines *viz.,* 103 B, 104 B, 39 B, 17 B, 852 B, 400 B, 207 B, 234 B and two check hybrids RSFH -130 and RSFH 1887. The seed materials were obtained from the Professor and Head AICRP on Sunflower, Main Agricultural Research Station, Raichur. The eight parents were crossed during the summer 2014-15 in full diallel manner (Griffings, 1956) obtained 56 crosses (both direct and reciprocal crosses) and these 56 F_1 crosses were evaluated along with their parents and checks during *rabi* 2015-16 using simple lattice design with two replications at Main Agricultural Research Station, Raichur. The data were collected on yield and yield attributing characters *viz.,* for days to 50 per cent flowering, days to maturity, plant height, number of leaves per plant, head diameter, stem girth, test weight, volume weight, seed yield per plant and oil content and data were analyzed by using Griffings (1956) method-I of model-II statistical method.

Results and discussion

The results of analysis of variance for combining ability for ten different characters in a full diallel design (Table 1) indicated that variance due to parents was highly significant for all the characters except head diameter, days to maturity, number of leaves, volume weight, and test weight thus justifying the selection of parents for combining ability analysis. The crosses also showed highly significant variability for all the characters except head diameter and number of leaves.

The comparative estimates of variance due to general combining ability (GCA) and specific combining ability (SCA) revealed the predominance of SCA variance compared to GCA variance for all the traits which indicated that all the characters were predominantly under the control of non-additive gene action (Table 1) these results were observed in the results corroborating with the findings of Patil *et al.* (2012) and Suresh (2014).

It was quite evident that, none of the parent's recorded significant *gca* effect for all the characters studied (Table 2). Among the parents, 207 B was found to possess genes for earliness as evident from its significant negative *gca* effects (-3.90) in desirable direction for days to 50 per cent flowering and for days to maturity (-0.36). The highest significant negative *gca* effect was noticed in 400 B (-19.30) which indicated desirable line for dwarf plant stature. The parent 39 B recorded the significant positive *gca* effects (4.20) for oil content and seed yield per plant and

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also showed positive *gca* effects for test weight (0.45), volume weight (1.37) and head diameter (1.00).The significant positive *gca* effects were observed in 852 B for stem girth (0.15), oil content (0.95) and volume weight (1.60). Many workers *viz*., Manivannan *et al*. (2004), Tavade *et al*. (2009), Patil *et al*. (2012) and Suresh (2014) reported good general combiners for most of the traits studied.

Results indicated that none of the cross was good specific combiner for all studied traits table 3. In present study results revealed that crosses 104 B × 39 B, 400 B × 234 B and 17 B × 400 B were the best specific combiner for majority of the characters studied *viz.*, days to 50 per cent flowering, days to maturity, head diameter, stem girth, volume weight, oil content and seed yield per plant. While the cross 103 B × 234 B showed good *sca* effects for test weight and the cross 104 B × 234 B showed high *sca* effects for days to maturity and plant height. Among the reciprocal crosses, 234 B × 400 B and 17 B × 39 B were the best specific combiners for most of the traits *viz.*, days to 50 per cent flowering, days to maturity, plant height, stem girth, oil content and seed yield per plant. The crosses 234 B × 400 B, 852 B × 17 B and 207 B × 17 B recorded as good specific combiners for head diameter, test weight and volume weight respectively. Manivannan *et al*. (2004), Tavade *et al*. (2009) and Patil *et al*. (2012) reported the significant sca effects in desirable direction for most of the characters studied.

In the present investigation, it was observed that all the characters studied were governed by non-additive gene action. The best parents for specific combing ability for seed yield and oil content were 234 B and 852 B. These inbred B lines could be used for developing CMS lines through backcross breeding. The best crosses for seed yield, oil content were 234 B × 400 B and 400 B × 234 B. These could be further selfed to produce good inbred lines from advanced generations.

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Table 1. Analysis of variance for 10 different characters in 8 x 8 diallel crosses in sunflower

Source	D.f	Mean sum of squares									
		Days to 50 % flowering	Days to maturity	Number of leaves	Plant height (cm)	Head diameter (cm)	Stem girth (cm)	Volume weight (g/100ml)	Test weight (g)	Oil content (%)	Seed Yield per plant(g)
Replication	1	2.82	5.28	22.95	617.60	32.96	0.03	17.91	0.028	0.03	21.80
Treatments	63	38.06**	19.46**	21.52	2021.20**	10.26	0.20**	37.24**	2.05*	5.93**	66.36**
Parents	7	20.34**	16.06	35.33	2470.70**	10.82	0.16*	36.11	1.24	7.48**	111.70**
Crosses	55	41.00**	19.89**	20.14	2000.56**	9.97	0.20**	36.57**	2.16*	5.60**	61.71**
Parent Vs. Crosses	1	0.50	20.04	0.86	9.89	22.06	0.33*	82.04*	1.42	13.92**	4.51
F_1's	27	42.92**	19.08**	20.91	1751.46**	11.38	0.18**	37.58*	2.60**	5.98**	68.04**
Reciprocals	27	39.90**	20.71**	16.96	2298.72**	7.63	0.22**	32.55*	1.60	5.22**	57.32**
F_1 Vs Reciprocals	1	18.90*	21.43	85.05*	675.86**	35.15*	0.00007	117.73*	5.18*	5.01**	9.34
Error	63	1.64	8.58	20.84	168.69	8.46	0.06	18.55	1.23	0.005	15.32
GCA variance		2.8658	0.0257	0.5033	108.5977	0.1866	0.0112	1.2740	0.0470	0.3290	4.1478
SCA variance		15.6340	2.0940	0.9556	549.1037	1.2271	0.0249	5.8713	0.5416	2.6530	14.1341
GCA/SCA Ratio		0.1833	0.0123	0.5267	0.1978	0.1520	0.4490	0.2170	0.0868	0.1240	0.2934

*, ** Significant at 5 and 1 per cent levels, respectively

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Table 2. Estimates of general combining ability effects of parents for 10 different characters in sunflower

Sl. No.	Parents	Days to 50 % flowering	Days to maturity	Number of leaves	Plant height (cm)	Head diameter (cm)	Stem girth (cm)	Volume weight (g/100ml)	Test weight (g)	Oil content (%)	Seed Yield per plant(g)
1	103 B	0.10	-0.047	0.19	-2.20	0.03	0.04	-0.26	0.24	0.26**	0.22
2	104 B	1.66**	-0.10	1.61	8.70**	0.33	0.08	-0.008	0.04	-0.32**	-0.30
3	39 B	1.23**	0.73	-0.37	10.62**	1.00	0.09	1.37	0.45	0.52**	4.20**
4	17 B	0.92	0.07	0.99	-3.14	0.07	-0.09	-0.63	-0.25	-0.05**	-2.90**
5	852 B	-0.02	-0.40	-0.47	12.61**	-0.41	0.15**	1.60	0.10	0.95**	1.63
6	400 B	-0.21	-0.67	-2.02**	-19.30**	0.44	0.10	-0.74	-0.03	-0.58**	-1.50
7	207 B	-3.90**	-0.36	0.11	-7.85**	-0.12	-0.17**	-2.48**	-0.50**	-0.78**	-1.07
8	234 B	0.23	0.76	-0.04	0.54	-1.27	0.01	1.15	-0.06	-0.72**	-0.28
C.D @ 5%		0.50	1.14	1.80	5.07	1.13	0.09	1.70	0.44	0.03	1.53
C.D @ 1%		0.73	0.73	2.64	7.15	1.68	0.14	2.50	0.64	0.04	2.26

*, ** Significant at 5 and 1 per cent levels, respectively

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Table 3. Estimates of specific combining ability effects of crosses for 10 different characters in sunflower

Crosses	Days to 50% flowering	Days to maturity	Number of leaves	Plant height (cm)	Head diameter (cm)	Stem girth (cm)	Volume weight(g)	Test weight(g)	Oil content (%)	Seed yield per plant(g)
Direct crosses										
103 B × 104 B	-4.54**	-1.23	0.27	2.14	1.55	-0.15	0.27	-1.26*	0.10**	-0.75
103 B × 39 B	1.40*	-1.58	1.16	21.97**	0.74	0.32**	-1.86	1.27*	-1.18**	2.30
103 B × 17 B	3.71**	0.83	-1.70	3.30	0.83	0.05	-1.74	-0.07	1.00**	1.17
103 B × 852 B	-0.10	0.04	-1.44	19.48**	-1.22	0.06	-1.54	-0.65	0.99**	4.87**
103 B × 400 B	-2.16**	-0.67	-0.19	-26.18**	-0.30	-0.09	5.20*	-0.56	-0.36**	-4.47*
103 B × 207 B	-2.98**	-1.98	-1.33	-26.19**	-0.50	-0.09	-1.09	0.004	-0.55**	0.88
103 B × 234 B	6.14**	1.39	1.77	24.55**	0.91	0.15	0.07	1.91**	-0.84**	-0.72
104 B × 39 B	-3.16**	-0.01	-0.55	-13.96*	-0.02	-0.09	4.30*	0.17	1.31**	-1.24
104 B × 17 B	-1.35*	-2.10	-1.67	-3.88	-0.73	0.06	2.45	-0.01	-0.23**	1.77
104 B × 852 B	6.08**	2.36	-2.60	2.16	-1.65	-0.03	4.47*	0.35	0.17**	-2.54
104 B × 400 B	2.27**	1.40	2.59	27.19**	1.36	0.32**	-0.33	0.63	-0.90**	3.53
104 B × 207 B	-0.54	-1.17	1.00	2.30	-0.50	0.04	-2.62	-0.09	0.04	-1.06
104 B × 234 B	-1.16*	-2.54	-0.74	-29.95**	1.03	-0.24*	-5.26*	-0.55	-1.81**	-3.61*
39 B × 17 B	0.08	-3.95**	-3.83	-35.20**	-0.05	-0.25*	-3.18	-1.06*	-1.48**	-7.25**
39 B × 852 B	3.77**	1.01	3.08	0.09	0.06	0.004	-2.11	0.01	-0.25**	0.78
39 B × 400 B	1.21*	1.30	-2.32	5.20	-0.61	0.01	0.40	0.37	1.25**	-2.52
39 B × 207 B	-0.60	2.73*	-0.61	-0.12	1.56	-0.02	1.49	-0.53	-0.76**	-0.52
39 B × 234 B	-2.98**	1.36	-2.55	-0.64	-1.27	0.009	1.45	-0.17	0.09*	1.03
17 B × 852 B	-0.66	-0.32	1.96	-8.38	1.05	0.03	1.95	1.60**	-0.55**	2.71
17 B × 400 B	-1.78**	2.45	2.30	27.72**	0.60	0.03	2.14	0.57	2.11**	1.70
17 B × 207 B	-0.29	0.64	0.52	-2.16	-0.86	0.03	-0.05	0.60	-0.42**	3.12
17 B × 234 B	2.33**	0.01	3.52	-0.31	-1.00	-0.02	2.81	-0.91	1.46**	-4.50*
852 B × 400 B	-1.79**	-1.57	2.57	6.53	-1.31	-0.03	1.09	-0.10	-1.23**	0.72
852 B × 207 B	-2.85**	-1.14	0.94	6.64	0.70	0.06	1.24	-0.23	-1.34**	0.45
852 B × 234 B	-3.72**	-1.26	-1.15	3.80	0.50	0.30**	-0.28	0.10	-0.17**	-0.46
400 B × 207 B	1.33*	1.89	-2.21	-5.40	0.53	0.13	-0.26	0.10	-0.70**	-0.13
400 B × 234 B	-1.28*	-2.73*	0. 14	-3.08	2.00	-0.01	-0.80	-0.06	-0.15**	5.47**
207 B × 234 B	2.90**	0.70	0.25	5.33	0.99	-0.02	0.24	-0.30	0.94**	1.26

*, ** Significant at 5 and 1 per cent levels, respectively

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Table 3. Contd.,

Crosses	Days to 50% flowering	Days to maturity	Number of leaves	Plant height (cm)	Head diameter (cm)	Stem girth (cm)	Volume weight(g)	Test weight(g)	Oil content (%)	Seed yield per plant(g)
Reciprocal crosses										
104 B × 103 B	1.00	1.50	-0.15	1.25	0.99	0.19	4.52*	-0.17	2.15**	1.78
39 B × 103 B	-0.50	-0.50	2.30	-4.50	-0.50	0.005	-0.61	-0.58	0.04	-1.28
39 B × 104 B	-2.50**	1.00	3.10	-9.30	-1.73	0.18	1.25	-0.17	-0.38**	-0.37
17 B × 103 B	1.50*	-2.25	-0.10	-38.45**	2.60	-0.07	-3.40	-0.72	-1.50**	5.42**
17 B × 104 B	-1.00	-5.25**	-2.75	-29.07**	-2.44	-0.40**	-4.90*	-1.43**	-2.22**	-9.92**
17 B × 39 B	-5.00**	-2.75*	-0.50	-38.87**	-0.53	-0.30**	-5.75**	-0.05	-1.20**	-3.30
852 B × 103 B	0.25	1.00	-0.25	4.50	-1.00	-0.12	-1.75	-0.17	-0.58**	-1.50
852 B × 104 B	1.50*	3.25*	2.35	12.08*	-1.34	0.04	1.00	-0.75	1.70**	1.60
852 B × 39 B	-2.25**	1.75	-0.05	9.77	-1.90	0.10	3.25	-0.12	1.36**	3.06
852 B × 17 B	-1.50*	0.25	-1.80	-1.81	-0.72	0.19	-30	0.95	0.60**	3.45
400 B × 103 B	-0.50	4.50**	2.00	11.08	2.50	0.26*	2.47	-0.80	-0.24**	-3.12
400 B × 104 B	-1.00	2.00	2.80	5.94	0.15	-0.05	-1.75	-0.25	-0.90**	3.00
400 B × 39 B	5.00**	-1.75	1.20	49.87**	0.72	0.23*	3.17	-0.15	1.30**	-1.05
400 B × 17 B	2.75**	3.25*	2.30	-2.37	0.31	0.06	2.46	0.20	-0.83**	0.70
400 B × 852 B	-1.75**	2.25	2.80	10.56	-0.90	0.13	4.52*	-0.17	-1.22**	1.02
207 B × 103 B	-1.00	3.00*	0.60	26.84**	-0.28	0.02	3.85	0.05	1.25**	5.77**
207 B × 104 B	6.00**	-2.25	-0.25	20.25**	-0.28	0.17	0.68	0.85	0.66**	1.31
207 B × 39 B	-2.00**	-1.00	-3.75	-29.75**	1.45	-0.50**	-1.98	-0.83	1.60**	-8.48**
207 B × 17 B	-2.00**	-2.25	0.15	-17.56**	-2.33	-0.40**	5.38**	-0.75	0.44**	-4.56*
207 B × 852 B	-1.00	1.50	2.20	-13.00*	-2.21	-0.28*	0.75	-1.03*	-0.05	-3.17
207 B × 400 B	0.50*	3.25*	-0.80	-22.96**	-2.21	-0.20	0.630	-0.13	0.26**	-3.94*
234 B × 103 B	-0.25	3.00*	1.65	1.50	0.38	0.10	-1.70	0.65	0.90**	3.93*
234 B × 104 B	3.50**	4.50**	4.75*	50.26**	0.46	0.40**	4.48*	0.33	0.87**	4.64*
234 B × 39 B	-0.75	-2.75*	2.75	-10.12	-1.22	-0.23*	1.13	0.83	0.70**	-5.12**
234 B × 17 B	3.25**	-2.25	2.60	10.06	-3.06*	-0.007	4.72*	-0.53	1.96**	-0.05
234 B × 852 B	2.25**	-2.00	3.75	-7.05	-0.007	-0.28*	2.54	-1.20*	0.94**	2.97
234 B × 400 B	0.50	2.75*	3.70	54.25**	-5.55**	0.44**	4.25*	0.20	0.08*	7.70**
234 B × 207 B	7.00**	-0.50	1.35	29.87**	1.97	0.30**	-1.60	-0.25	-1.70**	2.30
CD @ 5%	1.15	2.65	4.14	11.77	2.63	0.21	3.90	1.00	0.07	3.54
CD @ 1%	1.55	3.58	5.60	15.90	3.56	0.29	5.27	1.35	0.09	4.79

*, ** Significant at 5 and 1 per cent levels, respectively