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Combining ability analysis for yield and its contributing characters in Sunflower (*Helianthus annuus* L.)

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Abstract : Thirty hybrids were developed utilizing three CMS lines and ten inbreds and hybrids were evaluated for eight characters in two seasons *viz., rabi/summer* 2005-06 and k*harif2006* in order to understand gene action in sunflower. The combining ability analysis revealed significant differences among the parents for all the characters studied indicating the presence of preponderance of dominance gene action for all the characters. The CMS line 234 A and the testers CSFI 5014 and CSFI 5414 were good general combiner for seed yield, oil content and oil yield. The hybrid CSFH 6009 was a good specific combiners for seed yield, oil yield, hundred seed weight, volume weight, head diameter with earliness to days to fifty per cent flowering. The hybrid CSFH 6008 (234 A x CSFI 5014) showed significant positive *sca* effect for seed yield and oil yield with oil content and exhibited *additive x additive* type of gene action. The hybrids CSFH 6009 (234 A x CSFI 5418), CSFH 6021(851 A x CSFI 5434) and CSFH 6025 (851 A x CSFI 5414) were identified as good specific combiners for most of the yield components and oil content and found to possess *additive x dominance* type of gene action indicated that these could be utilized for exploitation of heterosis in sunflower. The present investigation on inter-relationship of *gca* effects with *sca* effects revealed that predominance of non-additive gene action *viz., additive x dominance* and *dominance x dominance* type gene interactions for most of the hybrid combinations which could be exploited for heterosis in sunflower.

Key words : Sunflower, gene action, additive x dominance.

Introduction

Improvement in sunflower emphasizes the urgency of generating a heterotic hybrid that is achieved by tapping the excellent combining ability and heterotic vigour available in the genetically diverse parental lines. Involvement of genetically divergent parents in hybridization will result in enhanced vigour or heterosis in the resultant hybrid. In any breeding programme, the choice of the parents is an important aspect for the success of the crop improvement. Especially, in heterosis breeding the choice of good combiners plays a vital role. For improvement of any plant character through hybridization, it is necessary to understand the nature of gene action and genetic architecture of the donor parents for that character.

Keeping these points in view, the present investigation was undertaken with the following specific objectives, to choose an appropriate parent for hybridization based on combining ability and to study inter-relationship between *gca* and *sca* of hybrids for understanding nature of additive and non-additive gene action for exploitation of heterosis in sunflower.

Table 1. Analysis of variance for combining ability in pooled over seasons in sunflower

Source	Degrees of freedom	MEAN SQUARE							
		days to fifty per cent flowering (cm)	Plant height (cm)	Head diameter (cm)	Volume weight (g)	Hundred seed weight (g)	Seed yield (g)	Oil content (%)	Oil yield (g)
Seasons	1	0.13	5827.73**	164.01**	7.83**	0.43	292.93**	1.38	35.31**
Lines	2	4.43**	3060.10**	62.26**	143.69**	4.29*	170.59**	94.91**	216.43**
Testers	9	177.62**	1391.27**	15.42**	43.08**	1.46	369.29**	39.63**	51.63**
Line x Tester	18	86.03**	720.93**	8.74**	18.69**	5.51**	348.08**	21.47**	45.62**
Season x Lines	2	0.23	680.93**	11.15**	13.6**	0.14	235.2**	0.51	18.44**
Season x Testers	9	0.17	1091.19**	8.93**	17.28**	0.15	204.41**	0.21	17.42**
Seasons x Lines x Testers	18	0.21	473.50**	4.32**	7.09 **	0.26	87.94**	0.31	8.16**
Error	58	0.25	24.29	1.38	4.22	0.11	57.01	0.11	5.85
Additive variance (F = 0)		0.73	167.95	3.75	10.21	-0.39	60.00	7.04	12.14
Dominance variance (F = 0))		86.05	696.63	7.36	14.47	5.40	291.07	20.37	39.47

* - Significance of P at 5 % level ** - Significance of P at 1 % level

Materials and Methods

The experimental materials used in the present study consisted of 13 genotypes included three CMS lines *viz.*, 17A, 234A and 851A and ten testers *viz.*, CSFI 5014, CSFI 5118, CSFI 5169, CSFI 5274, CSFI 5325, CSFI 5414, CSFI 5418, CSFI 5434, CSFI 5435 and CSFI 5436 in sunflower *(Helianthus annuus* L.). All the three CMS lines and 10 testers were raised in a crossing block at Department of Oilseeds, Tamil Nadu Agricultural University, Coimbatore during *kharif* 2005 and the second crossing block during *rabi / summer* 2005 - 2006. Crossing was done in a line x tester fashion. A total of 30 hybrids were raised along with their 13 parents and check hybrids KBSH 44, TCSH 1 and Sunbred 275 during *rabi / summer* '2005 - 2006 and *kharif,* 2006 for studying the combining ability of hybrids. The experiment was laid out in a randomized block design with two replications. At the time of flowering, five plants in each of the hybrids and parents were selected at random and tagged. Observations were recorded on five randomly selected plants from each hybrid combination per replication for eight traits *viz.*, days to fifty per cent flowering, plant height, head diameter, volume weight, hundred seed weight, seed yield, oil content and oil yield. Oil content for the seeds of selected plants was determined with the help of Oxford 4000 Nuclear Magnetic Resonance (NMR) Spectrometer available at Department of Oilseeds,

Table 2. General combining ability effects of parents for different characters in sunflower

S.No.	Parents	Days to fifty percent flowering	Plant height (cm)	Head diameter (g)	Vol. weight (g)	Hundred seed weight (g)	Seed yield (g)	Oil content (%)	Oil yield (g)
Lines									
1	17A	-0.37**	-3.39*	-1.21**	-0.61*	-0.21*	0.80	-1.45**	-0.94
2	234A	0.08	9.93**	1.28**	2.13*	-0.16*	6.21*	1.62*	2.65*
3	851 A	0.28	-6.54**	-0.07	-1.51*	0.38**	-5.41**	-0.16	-1.71**
SE (lines)		0.05	0.53	0.13	0.22	0.04	0.81	0.11	0.26
Testers									
1	CSF15014	-3.1**	-7.95**	-0.27	-1.65	0.70**	5.46**	1.40**	2.57**
2	CSFI5118	-2.52**	6.51*	-0.47*	1.05*	-0.48**	-1.00	-2.63	-1.38
3	CSFI5169	-1.68**	-9.57**	-2.17**	0.04	-0.13	-4.03*	-0.42	-1.31
4	CSFI5274	2.57**	-18.42**	0.73*	-0.12	-0.08	-4.45	1.89*	-0.8
5	CSFI5325	5.15**	7.17**	-0.19	0.80	-0.03	-3.69	-0.47	-1.30
6	CSFI5414	-4.68**	14.45**	1.58*	-1.93*	0.02	10.49*	2.24*	4.24*
7	CSFI5418	0.82**	-4.67**	-0.10	-3.50**	-0.06	-1.17	2.34*	0.57
8	CSFI5434	6.07**	3.24*	-0.39*	0.65	0.44*	6.41*	-1.72	0.91
9	CSFI5435	1.73**	13.89*	1.76*	2.91**	0.02	-1.59	-1.36	-1.07
10	CSFI5436	-4.35**	-4.65*	-0.49	1.73*	-0.40*	-6.45*	-1.26**	-2.43**
SE(Testers)		0.11	1.13	0.27	0.47	0.08	1.73	0.24	0.55

* - Significance of P at 5 % level ** - Significance of P at 1% level

TNAU and expressed in percentage. Oil yield per plant was calculated as per cent ratio of seed yield per plant (g) multiplied with oil content (%) gave yield per plant. The gene action for yield and yield components besides general and specific combining ability effects of the parents, were assessed by line x tester analysis (Kempthorne, 1957). To understand the real picture of genetic architecture of the hybrids and their parents, the data of both seasons were subjected to pooled analysis (Panse and Sukhatme, 1961).

Results and Discussion

Analysis of variance for combining ability was pooled over seasons in sunflower (Table 1). The interaction of line x seasons and tester x seasons, line x testers x seasons were significant for all the traits except days to fifty percent flowering, plant height and oil content suggesting that lines and testers interacted in different ways across the environments. The relative estimate of variances due to additive and dominance components revealed the preponderance of dominant component for all the characters studied for pooled over seasons (Marinkovic *et al.,* 2000; Skoric *et al.,* 2000). The *gca* is generally attributed to the additive effects of genes and is fixable (Sprague and Tatum, 1942). Hence selection of parents based on *gca* effects is of great importance in breeding programme.

Table 3. Specific combining ability effects of hybrids for different characters in sunflower

S.No.	Hybrids	Days to fifty percent flowering	Plant height (cm)	Head diameter (g)	Vol. weight (g)	Hundred seed weight (g)	Seed yield (g)	Oil content (%)	Oil yield (g)
1	CSFH6018	-0.55	7.22*	0.64	-0.31	-0.90*	2.45	1.34	1.03
2	CSFH 6017	0.87*	-31.36**	-0.22	-0.56	-0.32	-1.92	-1.27	-0.84
3	CSFH 6020	8.03**	5.24*	1.88*	-0.19	1.19**	-3.51	-2.78**	-1.83
4	CSFH6014	-3.22**	-0.14	0.60*	1.07	1.15**	5.13	2.31**	2.73**
5	CSFH 6012	-4.30**	8.86*	-0.20	1.60*	-0.15	3.28	-0.48	0.88
6	CSFH6015	1.28**	5.55*	-1.50*	1.28	0.46*	-0.85	-1.64	-1.21
7	CSFH 6019	6.03**	3.62*	-0.36	-0.95	-0.46*	-11.19**	1.95*	-2.97**
8	CSFH6011	-6.47**	5.53*	0.48*	-1.97	-1.09**	6.58*	-1.53*	1.15
9	CSFH 6013	-3.38**	2.31	-1.45*	1.19	1.08**	-1.97	-1.20	-0.83
10	CSFH6016	1.70**	-6.83*	0.13	-1.15	-0.97**	2.01	3.30**	1.88*
11	CSFH 6008	1.75**	1.52	1.59*	0.83	0.18*	8.34*	2.25**	3.87**
12	CSFH 6007	0.42	3.84	-1.61*	-0.57	0.23	-2.75	1.63*	-0.41
13	CSFH6010	-2.42**	1.47	-0.56	-1.10	-0.71**	5.38	1.35	2.08
14	CSFH 6004	-1.92**	-16.53**	-1.19*	0.31	-1.07**	-1.40	-3.18**	-1.71
15	CSFH 6002	1.75**	-1.87	-0.09	1.88	-0.49*	7.01*	0.10	2.04
16	CSFH 6005	1.58**	-6.23*	0.49	-2.41*	-1.81**	-10.99*	-1.26*	-4.07**
17	CSFH 6009	-4.92**	1.32	2.14*	2.96*	1.79**	15.94**	-27.00	5.27**
18	CSFH6001	5.08**	-1.72	0.11	-1.58	1.51**	-15.54**	1.20	-4.09**
19	CSFH 6003	-2.58**	1.51	-0.16	-2.43*	-0.69*	-3.76	-0.47	-1.52
20	CSFH 6006	1.25**	16.67**	-0.71	2.11	1.06**	-2.23	-1.37	-1.46
21	CSFH 6028	-1.20**	-8.75**	-2.23**	-0.53	0.71*	-10.79**	-3.59**	-4.90**
22	CSFH 6027	-1.28**	27.52**	1.84*	1.12*	0.09	4.67	-0.36	1.25
23	CSFH 6030	-5.62**	-6.71**	-1.31*	1.29	-0.48*	-1.87	1.43	-0.24
24	CSFH 6024	5.13**	16.67**	0.59	-1.38	-0.09	-3.73	0.87	-1.02
25	CSFH 6022	2.55**	-6.99*	0.29	-3.48	0.64	-10.29**	0.38	-2.92**
26	CSFH 6025	-2.87**	0.68	0.01	1.13	1.35**	11.84**	2.90**	5.28**
27	CSFH 6029	-1.12**	-4.95*	-1.78*	-2.00	-1.33**	-4.75	-1.69	-2.30
28	CSFH6021	1.38**	-3.81*	-0.59	3.56**	-0.43*	8.96*	0.33	2.94*
29	CSFH 6023	5.97**	-3.81	1.61*	1.24	-0.39	5.74	1.66	2.34
30	CSFH 6026	-2.95**	-9.85*	0.59	-0.95	-0.09	0.22	-1.94*	-0.43
	SE	0.16	1.59	0.38	0.66	0.11	2.44	0.34	0.78

* - Significance of P at 5 % level ** - Significance of P at 1% level

Character wise estimation of *gca* effects of lines and testers are presented in table 2. The CMS line 234A was found to be a good general combiner for seed yield, oil content, oil yield, head diameter and volume weight, while 851A had high *gca* effect for head diameter and plant height in desirable direction. The testers, CSFI 5014 and CSFI 5414 were good general combiners for seed yield, oil yield, oil content along with earliness to days to fifty per cent flowering. Similar result for oil content was reported (Javed and Aslam, 1995). Among the parents, 234A, CSFI 5434, CSFI 5414 and CSFI 5014 recorded significant positive *gca* effects for seed yield. Significant *gca* effect for seed yield and yield components as observed in the present study was recorded in sunflower by Rao and Singh (1977).

Specific combining ability of 30 hybrid combinations were studied (Table 3). Significant *sca* effects for seed yield were recorded in hybrids CSFH 6009 (234 A x CSFI 5418), CSFH 6025 (851 A x CSFI 5414), CSFH 6021 (851 A x CSFI 5434), CSFH 6008 (234 A x CSFI 5014), CSFH 6021 (851A x CSFI 5434), CSFH 6002 (234 A x CSFI 5325) and CSFH 6011 (17 A x CSFI 5434).The results are in accordance with Halaswamy *et al.* (2004). Positive and significant *sca* effects for seed yield, oil content, oil yield, hundred seed weight and head diameter were observed in hybrid CSFH 6008 (234 A x CSFI 5014). Similarly the hybrid CSFH 6021 (851A x CSFI 5434) recorded positive significant *sca* effect for seed yield, oil yield and volume weight with plant height in desirable direction. Hence the hybrids CSFH 6009 (234A x CSFI 5418), CSFH 6008 (234 A x CSFI 5014) and CSFH 6021 (851 A x CSFI 5434) will be useful for enhanced seed yield. In the present study there was a positive relationship between *sca* effects for seed yield with other component characters in most of the cross combinations. Such relationship was also reported by Sivaram (1981).

Significant positive *gca* effect in any one of the parents and negative or non significant effect on the other parents leading to significant *sca* effect in hybrids could be observed for seed yield in hybrid CSFH 6021(851 A x CSFI 5434) and hybrid CSFH 6011(17 A x CSFI 5434). Seed yield, oil content, oil yield, volume weight and head diameter in CSFH 6009 (234 A x CSFI 5418); seed yield in CSFH 6002 (234 A x CSFI 5325) to quote few instances. This indicates the presence of *additive x dominance* type of gene action.

Instances where the *gca* effects of both the parents were positive but the *sca* effect of the resultant hybrid was negative was observed for seed yield and plant height in hybrid CSFH 6005 (234 A x CSFI 5414). Few instances were found in which both the parents had significant negative *gca* effect, while the hybrid had significant positive *sca* effect as could be seen for days to flowering in hybrids CSFH 6017(17 A x CSFI 5118). This may be due to the presence of *dominance x dominance* type of gene action.

The crosses were derived from parents having high *gca* resulted in high *sca* effects for hundred seed weight in hybrid CSFH 6028 (851A x CSFI 5014); CSFH 6008 (234A x CSFI 5014) for oil yield suggesting the presence of *additive x additive* type of gene action. This indicated that selection could be effective in F_2 generation and utilized in transgressive breeding.

The present investigation on inter-relationship of *gca* with *sca* revealed that predominance of non-additive gene action *viz., additive x dominance* and *dominance x dominance* type

gene interaction for most of the hybrid combinations which could be exploited for heterosis breeding programme in sunflower. The parental lines 234 A and the testers CSFI 5014 and CSFI 5414 could be used as potential donors for improving seed and oil yield along with oil content. The hybrids *viz.*, CSFH 6009 (234 A x CSFI 5418), CSFH 6021 (851 A x CSFI 5434) and CSFH 6025 (851 A x CSFI 5414) were found to possess *additive x dominance* type of gene action with desirable *sca* effects for yield and yield contributing traits. These hybrids may be specifically suitable for exploiting heterosis for increased seed yield, oil content and oil yield in sunflower.

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