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RESEARCH PAPER

Combining ability analysis for yield and its components in sunflower (*Helianthus annuus* L.)

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Abstract : Five lines were crossed with 10 testers in L x T mating design to estimate the combining ability for seed yield in sunflower. Non-additive genetic variance played a predominant role in the inheritance of all the characters studied *viz.,* days to 50 per cent flowering, days to maturity, plant height, head diameter, number of seeds per head, 100 seed weight, seed yield per plant, hull content, volume weight and oil content. The lines CMS-148 and CMS-607 and testers SVR-467, SVR-490 and SVR-491 can be considered as superior parents in the present study as they recorded high *per se* performance with positively significant general combining ability effect for seed yield per plant. Good general combiners for seed yield were also the good general combiners for one or more yield contributing traits. Among the 50 hybrids evaluated, crosses *viz.*, CMS-107 x SVR-472, CMS-378 x SVR-444 and CMS-351 x SVR-495 were considered as superior hybrids as they recorded high *per se* performance and significant specific combining ability effect for seed yield per plant.

Key Words : Sunflower, Combining ability, Yield, Additive, Non-additive gene effects

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INTRODUCTION

The choice of parents is an important aspect for the success of crop improvement in any breeding programme. It is necessary to understand the nature of gene action and genetic architecture of the donor parents for the improvement of any plant character through hybridization. Improvement in sunflower emphasizes the urgency of generating heterotic hybrids that is achieved by tapping the excellent combining ability available in the genetically divergent parents. Keeping these objectives in view, the present investigation was undertaken with the specific objectives to choose an appropriate parent for hybridization based on combining ability and to study inter-relationship between GCA and SCA and non-additive gene action for exploitation of hybrid vigour in sunflower.

MATERIAL AND METHODS

The experimental material used in the present study consisted of 15 genotypes including five lines *viz.,* CMS-148, CMS-378, CMS-107, CMS-351 and CMS-607 and 10 testers *viz.,* SVR-467, SVR-490, SVR-491,

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SVR-472, SVR-495, SVR-454, SVR-436, SVR-444, SVR-402 and SVR-496. The five lines and 10 testers were raised in a crossing block at Post Graduate Research Farm, College of Agriculture, Kolhapur during *Rabi*-2012 and crossing was done in a line x tester fashion. A total of 50 hybrids were raised along with 15 parents and two checks Phule Raviraj and KBSH-44 during *Kharif*-2013 for studying the combining ability of hybrids. The experiment was laid out in a Randomized Block Design with three replications. At the time of flowering, five plants were randomly selected and tagged in each of the hybrids and parents in each replication. Observations were recorded on five randomly selected plants from each genotype in each replication at different growth stages of crop for 10 characters *viz.,* days to 50 per cent flowering, days to maturity, plant height, head diameter, number of seeds per head, 100 seed weight, seed yield per plant, hull content, volume weight and oil content. 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).

RESULTS AND DISCUSSION

The analysis of variance indicated that the variance due to lines and testers were highly significant for all the characters except plant height, seed yield per plant and oil content in lines. Line *vs* tester, hybrids and parents *vs* hybrids were also exhibited significant differences for all the characters except plant height and head diameter for line *vs* tester. The presence of variability among the genotypes for the traits of interest is a prerequisite for efficient selection.

Analysis of variance for combining ability (Table 1) revealed that variance due to lines was significant for plant height only. Testers exhibited significant differences for days to maturity, head diameter, 100 seed weight, seed yield per plant, volume weight and oil content. Similar results were also noticed by earlier workers (Pavani *et al*., 2006; Shankar *et al*., 2007; Mohansundaram *et al*., 2010 and Meena *et al*., 2013). The variance due to line x tester interaction was also exhibited significant differences for all the characters studied. It indicated the significance of SCA effects among hybrids. In the present investigation, analysis of gene action expressed the higher proportion of SCA than GCA for all the characters studied (Table 1). It indicated that these characters were predominantly controlled by non-additive genes. The preponderance of non-additive gene action for the characters studied was also supported by earlier reports (Radhika *et al*., 2001; Varaprasad *et al*., 2006 and Mohansundaram *et al*., 2010).

The first important criterion for selection is the *per se* performance of parents. Perusal of the *per se* performance of parents indicated that all the parents used in present investigation varied distinctly in regard to different characters. The female CMS-378 recorded highest seed yield per plant and number of seeds per head, while female CMS-351 showed highest values for plant height, oil content, 100 seed weight and days to 50 per cent flowering. Highest mean values for hull content and head diameter were found in female CMS-407, whereas, females CMS-107 and CMS-607 recorded highest days to maturity and volume weight, respectively. Among the males, SVR-402 ranked first for the traits *viz.,* head diameter, number of seeds per head, seed yield per plant, hull content, volume weight and oil content,

Table 1: Analysis of variance for combining ability

Source of variation	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	No. of seeds/head	100 seed weight (g)	Seed yield/ plant (g)	Hull content (%)	Volume weight (g/100ml)	Oil content
Lines	4	7.63	31.21	1109.17*	3.26	24837.92	2.68	51.22	377.22	64.37	34.72
Testers	9	7.93	76.35*	127.79	30.21**	112396.3	24.30**	417.63**	363.31	101.32*	66.83*
Line x tester	36	5.97**	26.08**	314.30**	7.91**	63644.66**	6.05**	94.87**	233.07**	39.54**	25.88**
Error	98	1.08	2.33	62.93	0.97	1204.52	0.04	7.77	5.16	1.17	0.64
Variance components											
σ^2 GCA		0.21*	2.22**	24.22**	0.70**	2995.53*	0.59**	10.10**	16.20*	3.43**	2.22**
σ^2 SCA		1.04**	7.48**	80.26**	2.34**	20809.04**	2.00*	29.26**	75.82**	11.30**	8.39**
GCA/SCA		0.20	0.29	0.30	0.29	0.14	0.29	0.34	0.21	0.30	0.26

* and ** indicate significance of values at P=0.05 and 0.01, respectively

whereas, SVR-496 for days to 50 per cent flowering, days to maturity and plant height. While the male SVR-436 ranked first for 100 seed weight.

The general combining ability (GCA) effects (Table 2) of parents is the second criterion of selection as the parents with high mean values may not necessarily transmit their superior performance to their progenies. The results of GCA analysis indicated that the tester SVR-402 had higher or average mean values and significant GCA effects for nine characters *viz.,* days to 50 per cent flowering, days to maturity, head diameter, number of seeds per head, 100 seed weight, seed yield per plant, hull content, volume weight and oil content. Such trend of relations between GCA and *per se* performance was also observed in most of the testers. Thus, close relation between GCA and *per se* performance could also be used as a criterion to select the parents to involve them in breeding programme. Among the parents, lines CMS-148 and CMS-607 and testers SVR-467, SVR-491 and SVR-490 were the best general combiners for seed yield per plant. Similarly for days to 50 per cent flowering, line CMS-148 and testers SVR-454 and SVR-444, for days to maturity line CMS-148 and testers SVR-467 and SVR-490, for plant height lines, CMS-107 and CMS-351 and tester SVR-490, for head diameter testers SVR-467, SVR-490, SVR-444 and SVR-496, for number of seeds per head lines, CMS-378 and CMS-407 and testers SVR-467, SVR-472, SVR-444 and SVR-496, for 100 seed weight, lines CMS-107, CMS-351 and CMS-607 and testers SVR-467, SVR-490, SVR-454 and SVR-496, for hull content lines CMS-148 and CMS-107 and testers SVR-491, SVR-495 and SVR-444, for volume weight line, CMS-607 and testers SVR-467 and SVR-490 and for oil content, lines CMS-148 and CMS-607 and testers SVR-467, SVR-490 and SVR-491 were found to be the best general combiners. Thus, it would be worthwhile to use parents with high GCA in breeding programme to exploit additive gene effects. Similar results were reported by Kumar *et al*. (1998) and Mohansundaram *et al*. (2010).

Among the 50 hybrids evaluated the best three crosses *viz.*, CMS-107 x SVR-472, CMS-378 x SVR-

Table 2: Estimates of GCA effects for different characters in sunflower

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	No. of seeds/head	100 seed weight (g)	Seed yield/ plant (g)	Hull content (%)	Volume weight (g/100ml)	Oil content (%)
Lines										
CMS-148	0.61*	1.63**	-7.90**	0.02	-17.22**	-0.05	1.36**	4.76**	-1.33**	1.14**
CMS-378	0.41	-0.57	-3.47*	-0.56**	41.51**	-0.48**	0.20	-3.33**	-1.24**	-0.09
CMS-107	-0.10	-0.26	6.61**	0.27	-25.50**	0.17**	-1.66**	2.47**	0.54	-1.40**
CMS-351	-0.31	0.21	5.40**	0.18	-17.28**	0.08*	-0.99*	-0.78	-0.17	-0.61**
CMS-607	-0.59	-1.02**	-0.63	0.07	18.49**	0.28**	1.08*	-3.11**	2.21**	0.97**
S.E.±	0.30	0.34	1.56	0.17	6.37	0.03	0.48	0.43	0.43	0.15
Testers										
SVR-467	-0.36	2.77**	-0.58	2.64**	169.19**	1.51**	11.91**	-3.63**	4.58**	3.75**
SVR-490	0.01	4.03**	5.38*	1.08**	-9.10	2.39**	2.06**	-3.81**	3.58**	2.12**
SVR-491	-0.07	-0.89	-3.98	0.29	-2.44	-0.11*	5.15**	7.61**	0.64	1.75**
SVR-472	0.51	0.58	0.33	-1.45**	35.20**	-0.78**	-0.46	-1.25*	-1.50*	-0.04
SVR-495	0.18	-0.24	-2.27	-0.84**	-109.25**	-0.67**	-5.03**	7.51**	-0.56	-0.87**
SVR-454	1.02*	-1.20*	0.83	0.13	-56.26**	0.49**	-5.30**	-3.52**	-1.03	-0.54*
SVR-436	-0.83	-3.12**	-3.30	-0.91**	-33.66**	-0.86**	-2.97**	-2.28**	-0.45	-3.55**
SVR-444	1.11*	0.33	3.65	0.48*	66.06**	-0.76**	-0.64	5.88**	-4.38**	0.12
SVR-402	-0.98*	-2.96**	0.76	-2.28**	-116.76**	-1.86**	-3.73**	-3.82**	-1.66**	-2.05**
SVR-496	-0.60	0.70	-0.81	0.86**	57.00**	0.66**	-0.98	-2.69**	0.79	-0.69**
S.E.±	0.435	0.49	2.21	0.24	9.00	0.05	0.68	0.61	0.61	0.21

*and ** indicate significance of values at P=0.05 and 0.01, respectively

444 and CMS-351 x SVR-495 exhibited highly significant SCA effects for seed yield per plant and most of its component traits (Table 3). The parents involved in these cross combinations were with poor GCA effects, eventhough the hybrids had highly significant SCA effects. These could be because of cancellation of undesirable effects. In such combinations, to obtain better segregants, selection may be postponed to later generation to develop high yielding inbreds. While the crosses CMS-607 x SVR-454 and CMS-351 x SVR-467 also had significant SCA effects but they involved one good general combiner and other poor general combiner for seed yield. Such occurrence of good hybrids by the combination of one good combiner may be due to accumulation of favourable genes and partly due to dominance interaction. Similar findings were reported by Mohansundaram *et al*. (2010); Ahmad *et al*. (2011); Chandra *et al*. (2011); Ghaffari *et al*. (2011); Andarkhor *et al*. (2012) and Meena *et al*. (2013).

Thus, on the basis of GCA effects, the parents CMS-148, CMS-607, SVR-467, SVR-491 and SVR-490 could be better choices for improvement of yield and its component traits through hybridization. The crosses CMS-107 x SVR-472, CMS-378 x SVR-444 and CMS-351 x SVR-495 had highly significant SCA effects for seed yield per plant and most of its component traits along with high *per se* performance, hence, may be exploited for the development of hybrids.

Lines, testers and their interaction revealed different contribution in expression of the studied traits (Table 4). The per cent contribution of lines to hybrids is lower than the testers for all traits. The contribution due to line x tester is higher than the contribution of lines and testers in the expression of all traits. Contribution of lines in the expression of plant height was greatest. Testers contributed maximum in the expression of seed yield per plant followed by 100 seed weight and head diameter. The line x tester interaction expressed high contributions in almost all the traits, being the highest in days to 50 per cent flowering and number of seeds per head. Higher contribution of line x tester interaction in the expression of various traits was also reported by Marinkovic *et al*. (1993).

Table 3 : Estimates of sca effects of best three crosses based on *per se* performance

Characters	CMS-107 x SVR-472		CMS-378 x SVR-444		CMS-351 x SVR-495		SE	C.D. (P=0.05)
	Per se	SCA	*Per se*	SCA	*Per se*	SCA	*Per se*	*Per se*
Days to 50% flowering	64.84	3.72**	65.27	3.03**	59.57	-1.00	1.02	2.85
Days to maturity	100.47	4.10**	99.93	4.12**	92.32	-3.70**	1.12	3.14
Plant height (cm)	157.64	5.59	148.11	2.93	143.59	-4.54	5.11	14.31
Head diameter (cm)	15.88	1.90**	14.47	-0.60	15.22	0.73	0.53	1.49
No. of seeds/head	818.84	236.49**	1023.21	342.97**	530.24	84.13**	20.23	56.59
100 seed weight (g)	3.58	-1.35**	3.64	-0.63**	4.63	-0.31**	0.11	0.31
Seed yield/plant (g)	40.62	12.17**	40.78	10.65**	33.41	8.88**	1.52	4.27
Hull content (%)	38.57	1.48	31.61	-6.81**	31.63	-10.96**	1.34	3.77
Volume weight (g/100ml)	27.60	-3.30*	20.08	-6.15**	34.23	3.11*	1.36	3.81
Oil content (%)	38.92	6.41**	39.20	5.20**	35.46	2.99**	0.48	1.35

*and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 4: Average contribution (%) of lines, testers and their interaction in expression of individual traits

Contribution of	Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	No. of seeds/head	100 seed weight (g)	Seed yield/ plant (g)	Hull content (%)	Volume weight (g/100ml)	Oil content (%)
Lines	9.62	7.13	26.24	2.28	2.92	2.40	2.77	11.45	9.93	8.30
Testers	22.53	39.24	6.80	47.72	29.73	48.89	50.93	24.82	35.16	35.97
Line x Testers	67.83	53.62	66.94	49.98	67.34	48.70	46.28	63.71	54.90	55.71

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