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RESEARCH ARTICLE

Combining ability study in sunflower (*Helianthus annuus* L.)

U. K. Singh and Dhiraj Kumar

Department of Plant Breeding and Genetics, Tirhut College of Agriculture, Dholi

Dr. Rajendra Prasad Central Agricultural University, Bihar, Pusa (Samastipur)- 848125, India

Corresponding author's mail ID: uksinghraupusa@gmail.com

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Abstract

The present study of combing ability in sunflower (*Helianthus annuus* L.) was undertaken with the objective of identifying good general combiner for yield and yield component traits. Both General combining ability (gca) and Specific combining ability (sca) variance differ significantly for all the characters. The magnitude of non-additive gene action was higher than the corresponding additive gene action for all the characters in crosses showing suitability of the material for hybrid combinations. In female parents, CMS-SS-502B, CMS-17B came out to be good general combiner for most of the yield contributing traits. CMS-SS-502B was found to be good general combiner for head diameter, 100-seed weight, volume weight, seed yield per plant and seed filling per cent. Likewise CMS-17B was also found to good general combiner for early flowering and maturity, short plant height, 100-seed weight, volume weight and seed filling per cent. Among male parents SS-502-1-1 was good general combiner for biological yield per plant, head diameter, volume weight, seed yield per plant and oil content. Similarly GAUSUF-15 was also good general combiner for early flowering and maturity, short plant height, and 100-seed weight. The crosses showing high desirable sca effect have involved either one or both the parents of high gca effect and in turn had high *per se* performance. The cross DSFH-4 exhibited high sca effect for seed yield and simultaneously high significant sca effect for biological yield, harvest index, plant height and seed filling percentage. Similarly DSFH-30 had high significant sca effects for seed yield, biological yield, head diameter and volume weight. Therefore, DSFH-4 and DSFH-30 were most ideal cross combinations displaying consistent high sca effect with high *per se* performance for seed yield and important characters.

Key words: Combining ability, sunflower, seed yield, gene action, hybrid

Introduction

Sunflower belongs to the genus *Helianthus* of the family *Asteraceae*, tribe *Heliantheae*, sub tribe *Helianthinae*, which includes 20 genera with 400 species. *Helianthus annuus* L. is an important edible oilseed crop. Hybrids are preferred by sunflower growers in many countries in the world due to the high yield performance, uniformity and quality etc. (Kaya *et al*., 2005). With the increase in demand for edible oils, there is a need to develop new sunflower hybrids suited to different agro-climatic zones of India with improved seed yield and oil content. Therefore, it is essential to understand the genetic architecture of sunflower, which provides useful guideline to determine the source population and from which it is possible to derive appropriate genotypes with desired characters. The selection of parents is one of the important aspects in developing a potential hybrid which is practiced after testing of parents for their combining ability effects. It is also useful in understanding the type of gene action controlling various traits to develop suitable breeding strategy.

Materials and Methods

The experimental material consists of four female lines and eight restorers were crossed in Line x Tester model to produce 32 hybrids. The resulting 32 hybrids, 12 parents and two checks were studied in randomized block design with three replications during *rabi/spring* 2014-2015 at oilseeds Research Farm, Dholi. Each plot consisted of three rows of 3.0 meter length with a spacing of 60 cm between rows and 30 cm within row. The recommended dose of fertilizer was applied 60:90:60 kg NPK/ha. The recommended cultural practices including plant protection measures were followed. The morphological observations on 11 quantitative characters *viz*., were recorded by selecting randomly 5 competitive plants in each plot. Random bulk samples of filled seeds were drawn from selected plant produced weighing 15 grams. The percentage was measured using NMR facilities available at DOR, Hyderabad. The analysis was carried out for line × tester mating design with combining ability analysis and the testing of significance of different genotypes was based on the procedure given by Kempthorne (1957).

Results and discussion

The combining ability decides the parents for development of hybrids coupled with development of high heterotic hybrids which helps to develop high productive hybrids, thereby increasing the production. In the present investigation efforts were made to have the knowledge of nature of combining ability for yield and other yield attributing characters of newly developed restores and CMS lines of sunflower. The mean sum of square due to treatments was highly significant for all the characters under study indicating the existence of sufficient variability and diversity among the parents (Table1). The analysis of variance for parents and crosses for 11 characters were presented in (Table2). The mean sum of squares for parents and crosses, were found significant for all traits except seed filling per cent. The significance of variance due to parents Vs crosses indicated the presence of heterosis in hybrids for all characters except days to 50% flowering and harvest index. Similar results were also reported by Halaswamy *et al.* (2004) and Ravi-Rana *et al.* (2004) in sunflower.

Mean sum of square due to lines and testers in analysis of variance for combining ability (Table 5) indicated that the variance for combining ability was significant among all traits except 100 seed weight and seed filling per cent in case of lines and except seed yield per plant in case of testers indicating the preponderance of additive gene action in the expression of these traits.

Variances due to lines, testers, lines x tester interaction (Table3) indicated that there was significant variation for combining ability for all the traits among crosses and line x tester effect except oil content suggesting the presence of non- additive gene action in expression of these traits. The gca variance of males was higher than that of females for all characters except 100-

seed weight and seed filling per cent indicating the existence of wide genetic diversity and preponderance of additive variance through males and females for the respective trait. The variance component due to specific combining ability (sca) was greater in magnitude than that of general combining ability (gca) (Table4) for all the characters except oil content indicating the predominance of non-additive type of gene action in expression of these traits which is in agreement with the Dua and Yadava (1983) Kadkol *et al.*(1984) and Ashok *et al.*(2000). Per cent contribution of male lines were highest for traits harvest index (55.92), biological yield (54.45) and head diameter (52.18) while the contribution of interaction was maximum for traits days to 50% flowering (70.32) and days to maturity (69.46).

General and specific combining ability effects helps to pin point the good parent and hybrids, respectively. The perusal of gca effects of 12 parents (4 CMS lines and 8 testers) for 11 traits indicated that the NDCMS-1B was a good general combiner for oil content exhibiting significant gca effects. CMS-339/89/1Bwas good general combiner for biological yield in positive direction and for plant height in negative direction exhibiting significant gca effects. CMS-17B was good combiner for day to 50% flowering and plant height in negative direction and for 100 seed weight, volume weight and seed filling percentage in positive direction exhibiting significant gca effects. CMS-SS-502B was good combiner for head diameter, 100 seed weight, volume weight, seed yield per plant and seed filling percentage exhibiting significant gca effects. Among testers DRSF-108-13 was good combiner for biological yield and head diameter exhibiting significant gca effects. LSF-71-1-9 was good combiner for harvest index, seed yield per plant, and seed filling percentage exhibiting significant gca effects. CSFI-52315 was good combiner for early flowering, early maturity and volume weight exhibiting significant gca effects. CSFI-5313 was good combiner for dwarf plant height, harvest index, 100 seed weight and seed yield per plant exhibiting significant gca effects. GAUSUF-15 was good combiner for early flowering, dwarf plant height, early maturity along with 100 seed weight exhibiting significant gca effects. SS-502-1-1 was good combiner for biological yield, head diameter, volume weight, seed yield per plant and oil content exhibiting significant gca effects. TNUSUF-7B-2-1 was good combiner for head diameter, volume weight and oil content exhibiting significant gca effects. Genepool-2-7-1 was good combiner for biological yield and seed filling percentage exhibiting significant gca effects. All these testers can be exploited for development of better hybrids and also in conventional breeding programme. Our results are in agreement with the previously published reports by Kadkol *et.al.* (1984) and Parmeshwarappa *et al.* (2008).

In sunflower negative sca effects are considered to be desirable for days to 50% flowering, plant height and days to maturity. Among 32 crosses, seven hybrids for days to 50% flowering, six hybrids for plant height and nine hybrids for days to maturity exhibited highly significant sca effects in desirable direction (Table4). Similarly positive and significant sca effects were observed in eight hybrids for seed yield per plant, eleven hybrids for biological yields, six hybrids for head diameter, six hybrids for harvest index, three hybrids for 100 seed weight, eleven hybrids for volume weight, nine hybrids for seed filling percentage and one hybrid for oil content.

The hybrid DSFH-23 was having significant gca effect in desirable direction for maximum number of traits i.e. early maturity, biological yield, volume weight, seed filling percentage and oil content. The hybrid DSFH-4 was having significant gca effect for seed yield per plant, biological yield, harvest index, and seed filling percentage while hybrid DSFH-29 was having significant gca effect for seed yield per plant, biological yield, head diameter and volume weight. The hybrid DSFH-30 was also having significant gca effect for seed yield per plant, biological yield, head diameter and volume weight. For all the traits under study the crosses with significant sca effects in the desirable direction involved parents with high x high or high x low or low x low gca effects indicating high performance of these crosses due to additive, dominance and epispastic gene interaction. The ideal crosses combination to be exploited is one whose high magnitude of sca is present in addition to gca in both or at least in one of the parents. Therefore, the hybrid DSFH-30, DSFH-4 and DSFH-6 can be exploited for seed yield per plant through heterosis breeding. These findings are in agreement to those of Dua and Yadva (1983) and Parmeshwarappa *et al.* (2008). The crosses showing high desirable sca effect have involved either one or both the parents of high gca effect and in turn had high per se performance. The sca effect of DSFH-2 (-6.49) for early maturity, DSFH-22 (-52.60) for dwarf plant height, DSFH-4 (15.32) and (15.63) for seed yield per plant and seed filling percentage and DSFH-25 (2.48) for 100-seed weight were significantly higher than checks, which indicated good specific combination. The cross DSFH-4 exhibited high sca effect for seed yield and simultaneously high significant sca effect for biological yield, harvest index, plant height and seed filling percentage. Similarly DSFH-6 for seed yield, biological yield and head diameter. DSFH-10 for seed yield, days to maturity and biological yield. DSFH-18 for seed yield, volume weight, and seed filling percentage. DSFH-29 for seed yield, volume weight, biological yield and head diameter. Therefore, DSFH-4 and DSFH-30 were most ideal cross combinations with high sca effect with high *per se* performance for seed yield and other important yield contributing characters.

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Table 1. Analysis of variance for eleven characters

Sl. No.	Character	Source of variation		
		Replication (df=2)	**Treatment (df=45)**	**Error (df=90)**
1	Days to 50% flowering	4.87	1351.72**	223.13
2	Plant height(cm)	542.61	110585.12**	9495.97
3	Days to maturity	0.69	3035.27**	292.64
4	Biological yield/ plant (g.)	89.23	157223.08**	5667.61
5	Head diameter(cm)	14.88	2963.58**	249.36
6	Harvest index(%)	140.64	18601.20**	2287.10
7	100 seed weight(g)	0.58	171.77**	17.67
8	Volume weight (g.)	6.31	29082.85**	415.72
9	Seed yield per plant (g.)	7.5	8032.47**	1351.84
10	Seed filling percent(%)	15.95	67167.11**	1569.12
11	Oil content (%)	1.86	1036.34**	249.89

**** indicate significance at 1%**

Table 2. Analysis of variance for parents and crosses of eleven characters

Character	Source of variation								
	Repliction (df=2)	**Treatmnt** (df=43)	**Parent** (df=11)	**Line** (df=3)	**Tester** (df=7)	**Line v/s Tester** (df=1)	**Parent v/s Cross** (df=1)	**Cross** (df=31)	**Error** (df=86)
Days to 50% flowering	4.36	30.3**	17.5**	14.7**	20.5**	4.5	9.2	35.5**	2.36
Plant height(cm)	85.52	130.3**	129.2**	166.7**	197.4**	39.0	630.4**	114.5**	77.87
Days to maturity	0.29	69.16**	12.1**	12.7*	13.6**	0.1	44.3**	90.1**	3.2
Biologicalyield/plant	69.82	334.8**	901.1**	167.4**	639.4**	378.1*	1349.7**	494.5**	58.25
Head diameter(cm)	9.51*	66.30**	68.4**	26.8**	65.6**	212.9**	376.6**	55.5**	2.57
Harvest index (%)	62.85	432.1**	132.1**	271.2**	78.6**	88.7	11.8	552.1**	26.31
100 seed weight(g.)	0.37	3.9**	1.5**	0.2	1.9**	1.8**	56.7**	3.1**	0.20
Volume weight (g.)	2.49	650.6**	26.8**	46.2**	15.5**	47.5**	16133.5**	372.5**	4.77
Seed yield / plant (g)	2.94	183.3**	54.8**	128.3**	30.9	2.2	1578.2**	183.9**	15.22
Seed filling percent	7.87	167.6**	34.1	21.7	39.3*	35.0	44249.5**	596.1**	18.00
Oil content (%)	1.35	23.9**	27.9**	15.9**	33.6**	15.9*	409.0**	10.4**	2.78

**** and * indicates significant at 1% and 5% respectively**

Table 3. Analysis of variance for combining ability of eleven characters

Character	**Replication** (df=2)	**Cross** (df=31)	**Line effect** (df=3)	**Tester effect** (df=7)	**Line x Tester Effect** (df=21)	**Error** (df=62)
Days to 50% flowering	2.34	35.56**	24.12	36.41	36.92**	2.67
Plant height(cm)	225.93	1214.6**	1732.21	1465.53	1057.**	80
Days to maturity	0.50	90.17**	7.09	118.90	92.47**	4.06
Biological yield per plant(g.)	173.24	4194.58**	543.65	10114.3**	2742.88**	56.81
Head diameter(cm)	5.67	55.51**	18.24	128.30*	36.58**	3.01
Harvest index(%)	42.51	552.12**	51.92	1367.20**	351.88**	28.91
100 seed weight(g.)	0.01	3.16**	8.21	1.56	2.97**	0.19
Volume weight(g./l)	1.08	372.59**	759.14	535.76	262.98**	5.71
Seed yield per plant(g.)	4.50	183.92**	96.79*	263.52	169.83**	18.71
Seed filling percent(%)	17.30	596.17**	2111.71**	379.64	451.84**	23.15
Oil content (%)	1.19	10.40**	25.91**	20.82**	4.71	3.30

**** and * indicates significant at 1% and 5% respectively**

Table 4. General and specific combining ability effects

Character	δ^2gca(f)	δ^2gca(m)	δ^2gca(ave.)	δ^2 sca	δ^2gca/sca
Days to 50% flowering	0.91	2.84	1.55	11.52**	0.13
Plant height(cm)	68.93	115.63	84.50*	326.37**	0.26
Days to maturity	0.16	9.63	3.32	29.73**	0.11
Biological yield/plant(g.)	20.23	838.00**	292.82**	894.87**	0.33
Head diameter (cm)	0.65	10.48*	3.93**	11.33**	0.35
Harvest index(%)	1.07	111.74**	37.96**	108.52**	0.35
100 seed weight (g.)	0.33	0.11	0.26*	0.93**	0.28
Volume weight (g./l)	31.43	44.25	35.70**	86.07**	0.41
Seed yield per plant (g.)	3.39	20.69	9.16	51.54**	0.18
Seed filling percent (%)	87.24*	30.14	68.20**	144.61**	0.47
Oil content (%)	0.96**	1.50**	1.14**	0.64	1.77

**** and * indicates significant at 1% and 5% respectively**