RESEARCH PAPER

Performance of branching and non-branching restorer lines in producing heterotic hybrids of sunflower (*Helianthus annuus* L.)

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To know the performance of branching and non branching restorer lines of sunflower in producing high yielding and high oil content hybrids, a study was undertaken at University of Agricultural Sciences,Dharwad to assess the magnitude of heterosis involving seventeen inbred lines of sunflower. The inbred comprised of five new male sterile lines and twelve diverse restorer lines (six branching and six non-branching) which were crossed in all possible combinations during *Kharif*-2005. The resulting 60 F_1 hybrids along with their parents were studied for the extent of Heterosis during Summer 2006 for nine characters by adopting line x tester analysis, considerable average heterosis was observed for all characters studied. Highest magnitude of average heterosis was observed for seed yield per plot (150.34) followed by seed yield per plant (118.86), head diameter (26.79), plant height (15.32), thousand seed weight (7.49) and oil content (2.13) for the characters days to 50 per cent flowering, the hybrids recorded negative average heterosis. Percentage contribution of component characters, *viz*., thousand seed weight, plant height and head diameter towards expression of heterotic effect for seed yield was to the extent of 15.06, 30.82 and 53.86 per cent, respectively

Key words **:** Heterosis, Sunflower, Branching, Non branching, Line x tester analysis

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INTRODUCTION

Sunflower is mainly grown for its oil and ranks third among oil seed crops in the world. The introduction of this crop to India in 1969 has helped a great deal in increasing oil seed production and the area under cultivation is increasing due to its day neutrality, wide adaptability, short duration, high yielding potential, remunerative market price and good quality oil.

Commercial cultivation of sunflower started in mid-seventies with open pollinated varieties like EC-68414, Sunrise, EC-68415 and Morden. However, favourable characters of the hybrids like production stability, suitability to high input agriculture, high self-fertility, uniform growth and maturity shifted the focus towards heterosis breeding leading to the release of the first ever sunflower hybrid in India, BSH-1 by Seetharam (1981). Since then, many hybrids have been released for cultivation by utilizing cytoplasmic genetic male sterility systems. The crop is gaining rapid popularity in India, but the productivity levels of sunflower still continue to be low against the world productivity. Sunflower, being a highly cross-pollinated crop is ideally suited for exploitation of heterosis. The discovery of cytoplasmic male sterility by Leclercq (1969) and fertility restoration by Kinman (1970) provided the required breakthrough in the development of hybrids.

Branching type of restorer lines are characterized by small multi-heads and low test weight. However, in general these lines have high per se oil content and ensure pollen supply for longer duration in hybrid seed production plots. In contrast, the non-branching restorer lines with mono-head have comparatively large head size and high test weight. But in hybrid seed production pollen supply is restricted for shorter period. The utility of non-branching types in heterosis breeding programme should concentrate on nicking of parental lines in hybrid seed production plots.

Comprehensive studies involving non-branching restorer lines are limited in heterosis breeding programmes in sunflower. Hence, an attempt in the present study has been made to assess and compare the relative performance of branching and non-branching restorer lines and their hybrids for heterosis.

RESEARCH METHODOLOGY

Present experimental material consisted of five cytoplasmic male sterile lines, DSF-15A,VRFXNDOL-2, 4546AXNDOL-2, 4546AXNDOL-3, 234AXNDOL-2 and restorer lines V-20 (Br), RHA-857 (Br), R-8297 (Br), VI-46 (Br), VI-66 (Br), 6D-1 (Br), RHA-265 (NB), RHA-298 (NB), IV-57 (NB), IX-79 (NB), R-274 (NB) and IV-41 (NB), for crossing at the time of flowering all heads in lines and testers covered with cloth bags to prevent open pollination. Pollens from 12 restorers collected in Petriplates with the help of camel hair brunch, during morning hours and pollinated to each of the male sterile lines separately.

All the resultant 60 hybrids with 12 restorer 5 maintainer and 2 cheeks were planted in randomized complete block design with three replication at G-Block, MARS, University of Agricultural Sciences, Dharwad during Summer 2006. Each entry was sown in three rows of 3m length per replication with spacing of 60x30 cm. observations were recorded on five randomly chosen plants per replication. Data were recorded on days to fifty per cent flowering, days to 100 per cent flowering, days to maturity seed yield per plant (g), seed yield per plot (g), seed yield per plot per meter row thousand seed weight (g), head diameter (cm), plant height (cm), oil content (%).

The mean of each replication for the nine characters recorded for the hybrids and parents were subjected to statistical analysis and variance due to different sources was worked out as mentioned by Panse and Sukhatme (1967).

Estimation of average heterosis:

The average heterosis (H) was calculated for each character by diciding the differences between the mean of all the hybrids and the mean of all parents, by the mean of all parent and expressed as percentage.

$$H = \frac{\overline{F_1} - \overline{Parents}}{\overline{Parents}} \times 100$$

RESEARCH FINDINGS AND ANALYSIS

The variance due to treatments was highly significant for all the characters expect for head diameter (Table 1). Female parents showed highly significant variation for all the characters except days to 50 per cent flowering and days to 100 per cent flowering. Male parents showed highly significant variation for all the characters expect days to 50 per cent flowering. For the hybrids/crosses, there was a highly significant variation for all the characters.

Average heterosis involving six branching restorers:

Highest average heterosis to the extent of 84.90 per cent was recorded for the character seed yield per plot followed by seed yield per plant (77.47%), thousand seed weight (39.62%) and head diameter (33.88%). The least average heterosis was recorded for the character plant height (11.25%). The means for all these characters was high in hybrids compared to their parental means. Negative average heterosis was recorded for the character days to 50 per cent flowering (-9.34%), days to 100 per cent flowering (-5.13%), days to maturity (-4.49%) and oil content (-0.72%) indicating that the hybrids flowered and matured earlier compared to the parents (Table 2).

Average heterosis involving six non-branching restorers:

Highest average heterosis was recorded for the character seed yield per plot (59.68%) followed by seed yield per plant (58.78%), head diameter (9.61%), 1000 seed weight (7.29%), plant height (6.57%) and oil content (1.24%). Negative heterosis was recorded for the characters days to 50 per cent flowering (-7.86%), days to maturity (-4.77%) and days to 100 per cent flowering (-3.17%) as indicated in Table 3.

Average heterosis:

The actual means of the parents and their hybrids for each character under the study revealed a general tendency that the hybrids showed relatively high heterosis per cent whose parents are comparatively low performing for the trait under consideration (Table 4).

Table 1 : Analysis of variance of nine quantitative traits recorded in parents and hybrids

Source	Degree of freedom (df)	DFF	DHF	DM	SYP	SYPT	TSW	HD	PH	OC
Replications	2	0.32	0.24	1.21	8.16	22222.13*	1.89	0.96	101.12**	139.32**
Treatments	76	15.03**	17.47**	10.15**	1424.45**	800917.49**	528.59**	18.47**	673.82**	71.41**
Parents	16	0.97**	2.23**	8.87**	620.12**	183880.90**	545.55**	15.54	894.92**	97.55**
Crosses	59	3.02**	14.18**	4.02**	1176.01**	620676.60**	415.67**	12.22**	495.64**	65.17**
Lines	4	1.01*	0.81	9.96**	367.07**	183123.90**	194.43**	2.90**	349.26**	24.10**
Testers	11	0.82*	1.99**	2.49**	415.23**	128040.20**	614.89**	16.63**	1087.94**	132.62**
Lines x testers	1	2.42*	10.64**	114.13**	3886.10**	801156.00**	1187.20**	54.13**	954.40**	5.51*
Error	152	0.37	0.48	0.67	8.77	5360.97	2.12	0.40	4.51	0.88

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

Table 2 : Range and mean performance of parents and their F_1 and average heterosis for 30 crosses involving branching restores

Characters	Female parents			Male parents			Parent mean	Hybrids			Average heterosis (%)
	Range		Mean	Range		Mean		Range		Mean	
DFF	57.50	58.83	58.16	56.67	58.67	57.67	57.91	51.17	53.83	52.50	-9.34
DHF	68.50	69.83	69.16	68.50	70.83	70.16	69.66	62.67	69.50	66.08	-5.13
DM	85.00	85.33	85.16	80.00	83.33	81.66	83.41	77.00	82.33	79.66	-4.49
SYP	30.33	59.57	44.95	11.00	49.00	30.00	37.47	32.67	100.33	66.50	77.47
SYPT	531.33	1184.17	857.75	228.00	942.67	585.33	721.54	585.33	2083.00	1334.16	84.90
TSW	40.33	60.00	50.16	24.00	49.00	36.50	43.33	42.33	78.67	60.50	39.62
HD	10.00	12.67	11.33	6.00	12.67	9.33	10.33	10.67	17.00	13.83	33.88
PH	104.27	130.27	117.27	96.67	155.73	126.20	121.73	107.07	173.73	140.40	11.25
OC	27.80	35.07	31.43	19.83	39.07	26.45	30.44	19.37	41.07	30.22	-0.72

DFF :Days to 50% flowering, DHF: Days to 100% flowering, DM: Days to maturity, SYP: Seed yield per plant (g), SYPT:Seed yield per plot (g), TSW:Thousand seed weight (g) , HD:Head diameter (cm),PH: Plant hight (cm), OC:Oil Content (%)

Table 3 : Range and mean performance of parents and their F_1 and average heterosis for 30 crosses involving non-branching restores

Characters	Female parents			Male parents			Parent mean	Hybrids			Average heterosis (%)
	Range		Mean	Range		Mean		Range		Mean	
DFF	57.50	58.83	58.16	58.17	58.50	58.33	58.24	51.50	55.83	53.66	-7.86
DHF	68.50	69.83	69.16	69.17	70.67	69.92	69.54	63.17	71.50	67.33	-3.17
DM	85.00	85.33	85.16	82.00	82.67	82.33	83.83	78.00	81.67	79.83	-4.77
SYP	30.33	59.57	44.95	18.00	40.33	29.16	37.05	31.00	86.67	58.83	58.78
SYPT	531.33	1184.17	857.75	328.33	764.67	546.50	702.12	359.67	1882.67	1121.17	59.68
TSW	40.33	60.00	50.16	24.33	71.67	48.00	49.08	21.00	84.33	52.66	7.29
HD	10.00	12.67	11.06	7.33	11.33	9.33	10.19	6.67	15.67	11.17	9.61
PH	104.27	130.27	117.27	122.60	171.93	147.26	132.26	117.93	164.00	140.96	6.57
OC	27.80	35.07	31.43	26.30	40.77	33.53	32.48	22.10	43.67	32.88	1.24

DFF :Days to 50% flowering,DHF: Days to 100% flowering, DM: Days to maturity,SYP: Seed yield per plant (g), SYPT:Seed yield per plot (g), TSW:Thousand seed weight (g) , HD:Head diameter (cm),PH: Plant hight (cm), OC:Oil Content (%)

Table 4 : Average performance of parents, F_1 and average heterosis for seed yield and other characters

Characters	Parents involving twelve restorers			Parents involving branching restores			Parents involving non-branching restores		
	Parental mean	Means of hybrids	Average heterosis (%)	Parental mean	Means of hybrids	Average heterosis (%)	Parental mean	Means of hybrids	Average heterosis (%)
Days to 50% flowering	58.00	53.50	-7.61	58.00	53.00	-9.30	58.00	53.50	-7.86
Days to 100% flowering	69.50	67.50	-3.58	69.66	66.00	-5.13	69.50	67.00	-3.17
Days to maturity	83.00	79.00	-2.45	83.00	79.50	-4.49	83.00	79.50	-4.77
Seed yield per plant (g)	37.47	65.66	118.86	37.47	66.5	77.47	37.05	58.83	58.78
Seed yield per plot (g)	721.54	1465.33	150.34	721.54	1334.16	84.90	702.12	1121.17	59.68
Thousand seed weight (g)	48.99	52.66	7.49	43.33	60.5	39.62	49.08	52.66	7.29
Head diameter (cm)	10.33	11.83	26.79	10.33	13.83	33.88	10.19	11.17	9.61
Plant height (cm)	121.73	140.38	15.32	121.73	140.40	11.25	132.26	140.96	6.57
Oil content (%)	30.86	31.53	2.13	30.44	30.22	-0.72	32.48	32.88	1.24

Miller and Lee (1964) in their study on cotton showed that heterosis was associated with the differences in the base performance of the parental varieties per se rather than with the differences in the amount of heterosis expressed by different crosses. Average heterosis, therefore, was computed to assess the relative magnitude of heterosis for seed yield and component characters.

The mean performance of the parents and hybrids for plant height indicated that there was not much difference among the branching or non-branching restorers but the average heterosis recorded for this character was higher in hybrids involving branching restorers (11.25%). Generally branching group of restorers flowered earlier compared to non-branching restorers. The average heterosis recorded for days to 50 per cent flowering was -9.34 per cent in crosses involving branching restorers and -7.86 per cent in crosses involving non-branching restorers. The average heterosis recorded for days to 100 per cent flowering was -5.13 per cent involving branching restorers and -3.17 per cent involving non-branching restorers. Whereas, there was no difference for days to maturity in the two group of restorers.The average heterosis recorded for this character was -4.49 per cent (in hybrids involving branching restorers), -4.77 per cent (in hybrids involving non-branching restorers).

There were much differences recorded in the mean performance of parents and hybrids for head diameter and the average heterosis recorded for this character was 33.88 per cent (in hybrids involving branching) and 9.61 per cent (in hybrids involving non-branching restorers), respectively, which indicated that there was differential contribution of both branching and non-branching restorers for this character.

Oil content also differed much as indicated by more differences recorded in the mean performance of parents and hybrids and average heterosis recorded for this character was -0.72 per cent (in hybrids involving branching restorers) and 1.24 per cent (in hybrids involving non-branching restorers), respectively. It indicated that non-branching restorers contributed higher for this character compared to branching restorers.

For thousand seed-weight, the average heterosis was higher for branching restorers (39.62%) compared to non-branching restorers (7.29%). The higher heterotic value for this character indicated that there is higher contribution of branching restorers for the increased test weight recorded. In contrast, Dedio (1980) reported significantly lower heterosis for test weight in branching than in non-branching lines.

Substantial heterotic effect was evident for seed yield per plant as the hybrids recorded average heterosis 118.86 per cent. However, heterosis for seed yield per plant was 77.47 per cent in hybrids involving six branching restorers and 58.78 per cent in hybrids involving six non-branching restorers. The higher heterotic value may be attributed to the parental diversity for this character. In general, the contribution of branching restorers was higher for this character. Though per se yield level of branching restorers was low but it has higher contribution for increased heterosis in hybrids.

The non-branching restorer lines were higher in achene oil content and recorded an average heterosis of 1.24 per cent compared to -0.74 per cent heterotic effect involving branching restorers (Table 3). This may be mainly due to the smaller achene size accompanied with smaller heads in hybrids developed by branching restorers. In general, the contribution of non-branching restorers was higher for this character.

For seed yield per plant, the average heterosis was of 118.86 per cent and it was 77.47 per cent in hybrids involving six branching restorers and 58.78 per cent in hybrids involving six non-branching restorers. In general, the contribution of branching restorers was higher for this character. Branching restorers contributed for larger head diameter and high seed weight as compared to non-branching restorers. So, increased yield of hybrids was mainly contributed by the branching restorers.

Also, substantial heterotic effect was evident for seed yield per plot as the hybrids averaged 150.34 per cent and it was 84.90 per cent in hybrids involving branching restorers and 59.68 per cent in hybrids involving non-branching restorers. The higher heterotic value may be attributed to the parental diversity for this character. In general, the contribution of branching restorers was higher for this character.

Graficus (1959) was of the opinion that the heterotic in yield is an artefact, as it can be accounted by the yield components in the hybrid. Based on this observation, many workers made attempts to relate the heterotic effect of seed yield to the heterosis observed in yield components.

Cruz (1986), Giriraj *et al.* (1987b), Ahire *et al.* (1994) and Kandhola *et al.* (1995) reported that the main component characters for seed yield are plant height, head diameter and 1000-seed weight which are highly correlated with yield. The present study also indicated that the heterosis for seed yield per plant was mainly due to high heterotic effect expressed in plant height (15.32%), head diameter (26.79%) and thousand seed weight (7.49%).

Taking expression of heterosis for seed yield as 100 per cent the contribution of each component character was assessed. This was revealed that the three characters *viz.*, 1000 seed weight, plant height and head diameter contributed to the extent of 15.06, 30.82 and 53.86 per cent, respectively.

The higher contribution exhibited by these characters may be ascribed to increased seed size, capitulum diameter, and seed weight and plant height in hybrids. In similar studies, conducted by Giriraj *et al.* (1986), number of filled seeds, leaf area per plant, head diameter and seed weight contributed to the extent of 47.7, 20.7, 15.2 and 9.7 per cent, respectively. Hence, it may be said that head diameter, plant height and seed weight are important yield components and weightage be given to their yield components in heterosis breeding programmes.

From the results of the present study and from the earlier studies in sunflower, it may be inferred that the increased heterosis in hybrids depends on magnitude of heterosis effect in component characters, particularly, plant height, head diameter and thousand seed weight and it is always the positive complementation of various interrelated characters that lead to higher yield.

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