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Heterotic Studies for Various Characters in Sunflower (*Helianthus annuus* L.)

Muhammad Sayyar Khan, Muhammad Siraj Swati, Iftikhar Hussain Khalil and [1]Amjad Iqbal
Department of Plant Breeding and Genetics, [1]Department of Agricultural Chemistry,
NWFP Agricultural University, Peshawar, Pakistan

Abstract: An experiment consisting of nine hybrids and their ten parents (inbred lines) was conducted at Agricultural Research Institute, Tarnab, Peshawar, during August 2001, using Randomized complete block design with three replications. Data were recorded on yield and other important characters. Data were analyzed using M-StatC and the means were separated through least significant difference test. Significant genetic differences were observed among inbred lines for number of leaves per plant, plant height, head diameter, number of seeds per head, number of filled and unfilled seeds per head and percent oil content. Genetic differences among the hybrids were significant for all characters. TS-17 x TR-120 showed maximum heterosis for the number of leaves per plant, number of seeds per head and seed yield ha^{-1}. TS-4 x TR-11 showed maximum heterosis for plant height, head diameter and percent oil content. Mean data for percent oil content was higher for TS-17 x TR-120, TS-18 x TR-120 and TS-4 x TR-11 than all other hybrids. Based on the mean performance and heterotic effects for important characters, these three hybrids are suggested for further study and use in the breeding programmes.

Key words: Heterosis, oil content, sunflower

INTRODUCTION

Edible oil is one of the most important food items which is affecting the economy of Pakistan. Pakistan is the third largest importer of edible oil in the world. The domestic oil production does not combat the need of the edible oil in the country. In order to meet the demand of edible oil, a large amount of oil has to be imported each year, which costs a huge amount of foreign exchange. Since the production potential of our traditional oilseed crops such as cotton seed, rape and mustard is limited, efforts are made to supplement the local production through the cultivation of non-traditional oilseed crops such as sunflower, safflower and soybean.

Amongst the non-traditional oilseed crops sunflower can play an important role in narrowing the wide gap between production of edible oils in the country and its import. It can be grown as catch crop in many situations. Being drought resistant it is well suited for rainfed as well as irrigated areas. Moreover, present day sunflower cultivars contain more than 40% oil and 18-20% protein. Sunflower oil is of good quality as it contains high proportion of linoleic acid which is poly unsaturated fatty acid. It is also a good source of calcium, phosphorus and nicotinic acid and vitamin E.

In Pakistan it covered an area of about 113998 ha with a production of 149502 tones in 1999-00 (Agricultural Statistics of Pakistan, 1999-00). Heterosis of these crops has been exploited to increase seed yield only over the past few decades. Utilization of heterosis has allowed sunflower to become the major oilseed in many countries of the globe (Miller, 1998). In spite of having high yield potential, the production of sunflower in Pakistan is very low. One of the reasons for this is the cultivation of exotic hybrids, which are not well adapted to agro-climatic conditions of the country. To make sunflower a successful crop in Pakistan, we need to develop our own hybrids which could mature early, give higher yield and fit easily in our existing cropping pattern. Keeping in view, these facts, this experiment was designed to identify sunflower genotypes which possess desirable combination of genes for higher yield, early maturity and better oil content.

MATERIALS AND METHODS

This research was conducted on silt loam soils with medium organic matter at the Agricultural Research Institute, Tarnab, Peshawar, during August 2001. All the inbred lines and the hybrids were supplied by Pakistan Oilseed Development Board, Tarnab, Pakistan.

The following single cross hybrids and their parents were evaluated in this study.

Single cross hybrids	Parents (restorers)
1. TS-1 x TR-120	1. R-8
2. TS-17 x TR-120	2. TR-11
3. TS-18 x TR-120	3. TR-12
4. TS-1 x TR-12	4. TR-110
5. TS-17 x R-8	5. TR-120
6. TS-4 x TR-6023	6. TR-6023
7. TS-4 x TR-110	Male sterile inbred lines
8. TS-4 x R-8	1. TS-1
9. TS-4 x TR-11	2. TS-4
	3. TS-17
	4. TS-18

The inbred lines and hybrids were evaluated in a Randomized complete block design (RCBD) using three replications. Each row was 5 m long with row to row distance of 0.75 m and plant to plant distance of 0.25 m.

Three seeds per hill were planted and after germination the seedlings were thinned to one per hill at 3-4 leaf stage. Fertilizer was applied in the form of urea and DAP at the rate of 120 and 60 kg ha^{-1}, respectively. Standard cultural practices were carried out from sowing till harvesting. To study each character three plants were randomly taken from each replication.

The following parameters were studied during this research work.

- Number of leaves per plant were counted after flowers became visible.
- Plant height was measured from the ground level to the attachment point of the head with the stem by means of a meter rod at the time of maturity.
- Head diameter was measured from one edge of the head to the other.
- Number of seeds per head were counted after manually threshing all the seeds. First of all the seeds were threshed and then counted.
- Number of filled seeds per head were obtained by subtracting the number of unfilled seeds from total number of seeds per head.
- Number of unfilled seeds per head were determined by counting their number in total number of seeds per head.
- Seed yield per hectare was determined after threshing the seeds and allowing it to dry up to 9-10% moisture content using the following formula:

$$\text{Seed yield kg ha}^{-1} = \frac{\text{Seed yield (kg) x 10000 m}^2}{\text{Harvested area (m}^2)}$$

- Oil content was determined by taking a representative sample of 1 gram from each replication. Oil was extracted by using petroleum ether (40-60°C) with the help of Soxtech apparatus. The following formula was used to determine oil content (Khalil and Manan, 1990).

$$\%\text{ oil} = \frac{\text{Weight of ether extract x 100}}{\text{Weight of sample}}$$

The data, after compiling, was statistically analyzed. Least significance difference test (LSD) was also applied to test the significance of treatment differences. Heterosis for each character was determined by using the following formula:

$$\%\text{ heterosis} = \frac{F_1 - MP}{MP} \times 100$$

$$MP = \frac{P_1+P_2}{2}$$

RESULTS AND DISCUSSION

Results pertaining to different morphological characters of ten sunflower inbred lines and nine hybrids are presented in tabulated form. Mean squares for each character of inbred lines and their hybrids are presented in Table 1. The means and LSD values for each character of inbred lines, hybrids and mid parent heterotic values are given in Table 2 and 3, respectively.

Number of leaves per plant: Highly significant differences (P<0.01) were observed among the inbred lines and hybrids for the number of leaves per plant (Table 1). Mean data for different inbred lines ranged from 12.8 to 20.8, representing a difference of eight leaves per plant (Table 2). The minimum leaves per plant were observed for TF-18 (12.8) while maximum leaves per plant were observed for TR-11 (20.8). The data for hybrids ranged from 17.9 (TS-18 x TR-120) to 24.2 (TS-17 x TR-120) (Table 3). Mid parent heterosis for the number of leaves per plant ranged from 3.2 to 43.9% (Table 3). Maximum heterosis for the character was exhibited by TS-17 x TR-120 (43.9%) followed by TS-4 x R-8 (38.8%). TS-1 x TR-120 showed minimum heterosis of 3.2%.

These results are in accordance with the findings of Sassikumar and Gopalan (1999) and Yilmaz and Emiroglu (1995), who have reported heterosis of 22.7 and 2 to 14%, respectively for number of leaves per plant.

Plant height: The ANOVA regarding plant height showed highly significant genetic differences (P<0.01) among inbred lines and their hybrids (Table 1). The mean values for inbred lines ranged from 61.4 in TR-18 to 108.6 cm in

Table 1: Mean squares and coefficient of variation (CV) for number of leaves per plant (NL), plant height (PH), head diameter (HD), number of seeds per head (NS), number of filled seeds per head (NFS), number unfilled seeds per head (NUFS), seed yield ha^{-1} (SY) and oil content (OC) of ten sunflower inbred lines and nine sunflower hybrids evaluated at agricultural research institute, Tarnab, Peshawar, during August, 2001

Source of variation	Df	NL	PH	HD	NS	NFS	NUFS	SY	OC
Inbred lines									
Replications	2.0	0.55	11.22	1.19	280.83	291.90	162.23	11923.66	9.94
Inbred lines	9.0	22.33**	817.88**	6.47**	182999.17**	136844.03**	6390.67**	454417.58**	165.84**
Error	18.0	1.63	6.33	1.54	6829.10	7134.56	558.27	33680.82	25.71
C.V(%)		7.7	2.94	9.88	15.11	17.32	39.89	19.87	13.00
Hybrids									
Replications	2.0	0.52	34.44	0.22	21928.04	5404.78	3513.44	11063.70	59.52
Hybrids	8.0	17.52**	673.88**	11.00**	104003.51**	56707.58*	15986.33**	1620303.99**	143.03**
Error	16.0	1.03	36.78	0.56	15698.45	17547.90	666.32	96505.97	15.00
C.V(%)		13.78	5.73	4.03	11.74	13.78	23.59	12.06	9.80

** = Significant at 1% probability level   * = Significant at 5% probability level   NS = Non significant

Table 2: Means for the number of leaves per plant (NL), plant height (PH), head diameter (HD), number of seeds per head (NS), number filled seeds per head (NFS), number unfilled seeds per head (NUFS), seed yield ha^{-1} (SY) and per cent oil content (OC) of ten sunflower inbred lines evaluated at agricultural research institute, Tarnab, Peshawar during August, 2001

Inbred lines	NL	PH (cm)	HD (cm)	NS	NFS	NUFS	SY (kg ha^{-1})	OC (%)
TR-11	20.8a	108.6a	14.4a	1139.0a	977.3a	161.3a	1369a	32.8d
TR-110	17.9bc	78.4e	12.3abc	349.3de	296.3de	53.0de	517d	35.3bcd
R-8	16.1cd	95.2c	11.9bcd	579.0bc	560.7bc	18.3de	1492a	48.0a
TR-120	14.8def	68.3f	13.1ab	308.3de	293.3de	15.0e	542cd	46.1a
TR-6023	13.4ef	88.6d	10.8cd	275f	230.7e	44.3de	330d	34.3cd
TR-12	15.7d	102.3b	10.0d	446.7cd	420.7cd	26.0de	845bc	31.5d
TF-17	18.9ab	90.7d	13.1ab	622.7b	528.0bc	94.7bc	1337a	48.6a
TF-18	12.8f	61.4g	11.9bcd	575.3bc	548.7bc	26.7de	941b	41.9abc
TF-4	15.4de	64.2fg	13.8ab	650.7b	594.7b	56.0cd	944b	43.5ab
TF-1	20.1a	97.0c	14.3a	523.7bc	426.7cd	97.0b	919b	28.3d
LSD (5%)	2.1	4.3	2.1	142.0	144.9	40.5	315.0	8.7

Table 3: Means and mid parent hetrosis for number of leaves per plant (NL), plant height (PH), head diameter (HD), number seeds per head (NS), number of filled seeds per head (NFS), number of unfilled seeds per head (NUFS), seed yield ha^{-1} (SY) and oil content (OC) of nine sunflower hybrids evaluated at agricultural research institute, Tarnab, Peshawar during August, 2001

Hybrids	NL	% hetrosis	PH (cm)	% hetrosis	HD (cm)	% hetrosis	NS	% hetrosis
TS-1xTR-120	18.0D	3.2	103.3bc	25.0	19.6bc	46.7	1159.0bc	178.6
TS-17xTR-120	24.2a	43.9	105.4bc	32.6	20.0b	57.2	1384.0a	197.3
TS-18xTR-120	17.9d	29.8	83.5d	28.7	16.1f	32.8	878.7de	98.9
TS-1xTR-12	23.7a	32.4	131.3a	31.8	16.8ef	37.9	780.0e	60.8
TS-17xR-8	19.9c	13.7	98.0c	5.4	18.4cd	47.5	1111.0bc	84.9
TS-4xTR-6023	17.9d	23.9	95.2c	24.7	18.0de	46.7	952.3cde	127.9
TS-4xTR-110	20.8bc	24.6	97.9c	37.2	18.6cd	42.2	1252.0ab	175.2
TS-4xR-8	21.9b	38.8	112.9b	41.6	17.4de	35.9	1037.0bcd	82.0
TS-4xTR-11	20.9bc	15.33	124.7a	44.3	22.5a	59.5	1048.0bcd	23.3
LSD (5%)	1.8	-	10.4	-	1.3	-	217.0	-

Table 3: Continue

Hybrids	NFS	% hetrosis	NUFS	% hetrosis	SY (kg ha^{-1})	% heterosis	OC (%)	% hetrosis
TS-1xTR-120	1021abc	183.6	137.3b	145.2	2839 b	288.6	35.4c	-4.9
TS-17xTR-120	1117ab	172.0	267.3a	387.5	3967a	322.3	50.4a	6.5
TS-18xTR-120	846cd	100.9	32.0d	53.6	2911b	292.6	45.2ab	2.7
TS-1xTR-12	709d	67.4	70.7cd	14.9	1708d	93.6	39.8bc	3.7
TS-17xR-8	937abcd	72.2	174.0b	208.0	1566d	10.7	38.7bc	-19.9
TS-4xTR-6023	900 bcd	118.0	52.7cd	5.0	2460bc	286.1	34.2c	-12.0
TS-4xTR-110	1166a	161.7	86.0c	57.8	2771b	279.4	39.7bc	0.7
TS-4xR-8	984abc	70.3	86.3c	132.3	2057cd	66.4	27.1d	-40.7
TS-4xTR-11	969abc	23.3	78.7c	-27.6	2906b	151.3	45.1ab	18.3
LSD (5%)	229.0	-	447.0	-	538.0	-	6.7	-

Means sharing the same letter(s) in a column are not significantly different at 5% probability level

TR-11 (Table 2). Mean data for different hybrids was found high as compared to the inbred lines. TS-18 x TR-120 showed minimum plant height of 83.5 cm where as TS-1 x TR-12 showed maximum plant height of 131.3 cm (Table 3). The heterotic values for plant height were ranging from 5.4 (TS-17 x R-8) to 44.3% (TS-4 x TR-11).

These results confirm the findings of many researchers. Sassikumar and Gopalan (1999) and Yilmaz and Emiroglu (1995) have reported heterosis of 22.5, 3.5 to 43.1 and 10 to 22%, respectively.

Head diameter: Inbred lines and hybrids showed highly significant genetic differences (P<0.01) for head diameter (Table 1). Mean data recorded for inbred lines varied from 10.0 to 14.4 cm (Table 2). TR-12 had the minimum value (10.0 cm) and was found to be significantly different from all the inbred lines except R-8 (11.9 cm), TR-6023 (10.8 cm) and TF-18 (11.9 cm). Mean data for hybrids was ranging from 16.1 to 22.5 cm (Table 3). TS-4 x TR-11 had the maximum head diameter while minimum head diameter was observed for TS-18 x TR-120. Heterotic effects for head diameter were positive for all hybrids. TS-4 x TR-11 (59.5%) and TS-17 x TR-120 (57.2%) showed the maximum positive heterosis over the mid parent value for head diameter. The lowest heterotic effect of 32.8% was recorded for TS-18 x TR-120.

The results are in line with those of Sassikumar and Gopalan (1999), who have reported 25.2% heterosis and Goksoy (1999) who has reported 10 to 64.5% heterosis for this character. Gill *et al.* (1998) and Gangappa *et al.* (1997) have also reported high heterotic effects for this character.

Number of seeds per head: Number of seeds per head revealed highly significant differences (P<0.01) among inbred lines and their hybrids (Table 1). Among the inbred lines, TR-6023 showed minimum number of seeds per head (275) whereas maximum value was recorded for TR-11 (1139) (Table 2). Mean data for hybrids ranged from 780 in TS-1 x TR-12 to 1384 in TS-17 x TR-120 (Table 3). Data pertaining to number of seeds per head revealed that mid parent heterosis was found maximum in TS-17 x TR-120 (197.3) while it was minimum in TS-4 x TR-11 (23.3).

The present work is in accordance with the work of Yilmaz and Emiroglu (1995), who have reported 20 to 77% heterosis for number of seeds per head. In contrast to this work, Limbore *et al.* (1999) have reported heterosis as low as -72.50% and as high as 166.45% for this character.

Number of filled seeds per head: Highly significant genetic differences (P<0.01) were observed among inbred lines, whereas the differences among hybrids were significant (P<0.05) for this character (Table 1). The number of filled seeds per head for different inbred lines ranged from 230.7 to 977.3 (Table 2). The lowest value was observed for TR-6023, whereas maximum value was observed for TR-11. Mean data for different hybrids ranged from 709.3 to 1166 (Table 3). The hybrid TS-1 x TR-12 had the lowest number of filled seeds per head, whereas TS-4 x TR-110 had the highest number of filled seeds per head. Mid parent heterosis for number of filled seeds per head ranged from 23.3 (TS-4 x TR-11) to 183.6% (TS-1 x TR-120).

The results are in line with the findings of Burli and Jadhav (2001), Lande *et al.* (1998) and Gangappa *et al.* (1997).

Number of unfilled seeds per head: The ANOVA revealed highly significant differences (P<0.01) among inbred lines and their hybrids for the number of unfilled seeds per head (Table 1). Among the inbred lines, TR-120 had the minimum number of unfilled seeds per head (15), while TR-11 had the maximum number of unfilled seeds per head (161.3) (Table 2). Among the hybrids, the maximum number of unfilled seeds per head were observed in TS-17 x TR-120 (267.3), while the minimum number of unfilled seeds per head were observed for TS-18 x TR-120 (32) (Table 3). Most of the heterotic effects for the number of unfilled seeds per head were positive except for TS-4 x TR-11 which showed negative heterosis of –27.6%. Maximum positive heterosis of 387.5% was observed for TS-17x TR-120, followed by TS-17 x R-8 with 208.0% heterosis.

Seed yield ha^{-1}: Highly significant differences (P<0.01) were observed among the inbred lines and their hybrids for this character (Table 1). Seed yield ha^{-1} was minimum in TR-6023 (330 kg ha^{-1}) whereas the maximum value was recorded for R-8 (1492 kg ha^{-1}). The seed yield for the hybrids ranged from 1566 kg ha^{-1} in TS-17 x R-8 to 3967 kg ha^{-1} in TS-17 x TR-120 (Table 3). Data pertaining to seed yield ha^{-1} revealed that heterosis relative to mid parental value ranged from 10.7 to 322.3%. Among the hybrids, maximum heterosis of 322.3 and 292.6% was found for TS-17 x TR-120 and TS-18 x TR-120, respectively. The lowest positive heterotic effect was observed for TS-17 x R-8 (10.7%).

This study is supported by the work of Singh *et al.* (2002) and Goksoy (1999), who have reported 278.0 and 15.9 to 178.1% heterosis for this character, respectively.

Oil content (%): Analysis of variance revealed highly significant differences (p<0.01) among inbred lines and their hybrids for oil content (Table 1). Mean oil content ranged from 28.3 to 48.6% among the inbred lines (Table 2). The lowest oil content was observed in TF-1 (28.3%) where as highest oil content was observed in TF-17 (48.6%). Mean oil content for the hybrids ranged from 27.1% in TS-4 x R-8 to 50.4% in TS-17 x TR-120 (Table 3). Data regarding oil content revealed that heterosis relative to mid-parental value ranged from -40.7 to 18.3%. The lowest negative heterotic effect was observed in TS-4 x

R-8 (-40.7%). Maximum positive heterosis of 18.3 and 6.5% was observed for TS-4 x TR-11 and TS-17 x TR-120, respectively.

The differences among different inbred lines and their hybrids were highly significant for this character supported by the work of Hussain *et al.* (2000). Heterosis relative to mid-parental value ranged from –40.9 to 18.3%. This is supported by the work of a wide range of researchers around the world i.e Singh *et al.* (2002), Kumar *et al.* (1999), Yenice and Arslan (1997) and Cheres *et al.* (2000).

REFERENCES

Agricultural Statistics of Pakistan (ASP), 1999-2000. Economic Wing. Ministry of Food. Agric. and Livestock's. Govt. Pakistan, Islamabad, Pakistan.

Burli, A. and M.G. Jadhav, 2001. Heterosis and nature of gene effects for oil content and seed filling in sunflower. J. Maharashtra Agri. Univ., 26: 326-327.

Cheres, M.T, J.F. Miller, J.M. Crane and S.J. Knapp, 2000. Genetic distance as a predictor of heterosis and hybrid performance within and between heterotic groups in sunflower. Theoretical and Applied Genetics, 100: 889-894.

Gangappa, E., K.M. Channakrishnaiah, S. Ramesh and M.S. Harini, 1997. Exploitation of heterosis in sunflower (*Helianthus annuus* L.). Crop Research Hisar, 13: 339-348.

Gill, H.S., S.R. Khurana, T.P. Yadava and R.K. Sheoran, 1998. Expression of heterosis for different characters in sunflower over environments. Haryana Agri. Univ. J. Res., 28: 95-100.

Goksoy, A.T., A. Turkec and Z.M. Turan, 1999. A study on the analysis of heterotic effects for certain agronomical characters in cross populations of sunflower (*Helianthus annuus* L.). Turkish J. Agri. and Fore., 23: 247-255.

Hussain, T., H.S. Pooni and B.M.H. Philimon, 2000. The nature of seed oil content variation in a large set of sunflower test crosses. J. Genetics and Breeding, 54: 207-211.

Khalil, I.A. and F. Manan, 1990. Chemistry one. Bio-analytical chemistry, 2: 39.

Kumar, A.A., M. Ganesh, S.S. Kumar and A.V.V. Reddy, 1999. Heterosis in sunflower (*Helianthus annuus* L.). Annals Agri. Res., 20: 478-480.

Lande, S.S., M.N. Narkhede, D.G. Weginwar, M.C. Patel and S.R. Golhar, 1998. Heterotic studies in sunflower (*Helianthus annuus* L.). Annals Pl. Physio., 12: 15-18.

Limbore, A.R., D.G. Weginwar, S.S. Lande, B.D. Gite, G. Manjusha and M. Ghodke, 1999. Heterosis in sunflower (*Helianthus annuus* L.). Annals Pl. Physio., 13: 11-15.

Miller, J.F., 1998. Oilseeds and heterosis. Tektran. United States Department of Agriculture. Agriculture Research Service.

Sassikumar, D. and A. Gopalan, 1999. Heterosis for seed yield and its components in sunflower (*Helianthus annus*. L.). Madras Agri. J., 86: 565-567.

Singh, D.P, S. Singh and R.K. Raheja, 2002. Heterosis for fatty acid composition over environments in sunflower (*Helianthus annuus* L.). J. Res., 39: 1-5.

Yenice, N. and O. Arslan, 1997. Heterosis reported for a synthetic variety obtained from selfed sunflower (*Helianthus annuus* L.) lines. Turkish J. Agri. and Fore., 21: 307-309.

Yilmaz, H.A. and S.H. Emiroglu, 1995. Broomrape resistance, yield, yield components and some chemical characteristics in breeding hybrid sunflower (*Helianthus annuus* L.). Turkish J. Agri. and Fore., 19: 397-406.