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Magnitude of Heterosis for Achene Yield and Oil Content in Sunflower (*Helianthus annuus* L.)

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Abstract: The objective of this study was to determine magnitude of heterosis for yield and oil content in sunflower. For this purpose, a study was conducted during 2003-2004 at NWFP Agricultural University, Peshawar on a diallel cross of sunflower to find out the extent of heterosis for achene yield (kg ha^{-1}) and oil content (g kg^{-1}). Heterosis was observed for these both parameters. The magnitude of heterosis of F_1 over mid-parent was 1.29 in direct crosses while 3.73% in reciprocal crosses for achene yield ha^{-1}. Similarly the magnitude of heterosis for oil content was 31.19 in direct crosses while this magnitude was 5.71% in reciprocal crosses for oil content in sunflower. The study showed that the direct and reciprocal crosses showed totally different magnitude of heterosis for both traits studied. In cross combinations heterosis for both traits was more in those crosses where parents were phenotypically at distance.

Key words: Sunflower, heterosis, achene yield, oil

INTRODUCTION

Pakistan is facing tremendous shortage of edible oils. The domestic edible oil production does not meet the need of the country and a huge amount of foreign exchange is spent on its import. This huge drain on our hard-earned foreign exchange resources is a great challenge for our planners, agricultural scientists and extension workers. Any attempt to help in amelioration of this worsening situation is the need of the day. In order to save the foreign exchange, the government has encouraged the cultivation of edible oilseed crops in the country. Domestic edible oil production from all sources has grown at the rate of 2.56% annually over the last 24 years, whereas consumption has been increasing at an annual rate of 7.7%. The total import of edible oils during 1999-2000 was 1.051 million tons costing 21401 million rupees (Agricultural Statistics of Pakistan, 1999-2000). The demand of oilseed the need of the hour is to increase the local oilseed production. The heterosis shows a vertical increase of oilseed production per unit area.

Heterosis (hybrid vigour) plays a major role in improving crop productivity and quality in order to feed the ever-increasing human population, particularly in developing countries. Heterosis is significant for seed yield and is one of the driving forces behind the hybrid seed industry in cultivated sunflower (*Helianthus annuus* L.). There are reports that cross 336A x MRHA2 exhibited highest heterosis and hetero-beltiosis for seed yield and oil content[1] Similarly Limbore *et al.*[2] found that two hybrids viz., 2A x IB-222 (166.45%) and 2A x IBC-132/1 (161.32%) showed a high degree of heterosis for number of seeds per head followed by 2A x 132/1 (146.40%) and 2A x IB60 (114.79%) for seed yield per plant, respectively. On the other hand, the highest negative and significant heterotic values were noted in crosses 2A x BLC-183 (-72.50%) followed by 21A x IB-174/2-2 (-57.15%) and BLC-183 (-53.03%) for number of seeds per head and grain yield per plant, respectively. The primary objective of this study was to estimate the magnitude of the heterosis for achene yield and oil content in sunflower (*Helianthus annuus* L.).

MATERIALS AND METHODS

The present research was carried out at Malakandher farm NWFP Agricultural University Peshawar for four years i.e., 2003-2004. Five different sunflower selections from Tarnab Fertile (TF) Lines viz., TF-1, TF-4, TF-7, TF-11 and TF-335 along with three hybrid cultivars viz., Gulshan-98, Aritar-93 and Peshawar-93 were taken. Inbred lines were developed from all the genetic material (TF-lines and hybrid cvs.). For this purpose the material was selfed for four generations and selections were made in each generation for these parameters. The main purpose of the inbred line development was to bring homozygosity in these lines and cvs. for traits under study. These inbred lines were re-named as TF-1, TF-4, TF-7, TF-11, TF-335, GUL, ARI and PESH for easily recognition.

All inbred lines were planted in rows of 4 m length with a row to row and plant to plant distance of 60 and 25 cm, respectively. The NPK was applied at the rate of 74, 74, 0 kg ha^{-1}, respectively. All the related tillage practices, fertilizer application and irrigations were made

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Table 1: Heterosis (%) of 28 direct and reciprocal crosses for achene's yield (kg ha^{-1}) in sunflower

	Direct crosses		Reciprocal crosses	
Genotypes	Yield (kg ha^{-1})	Heterosis (%)	Yield (kg ha^{-1})	Heterosis (%)
TF-1	2117.62		2117.62	
TF-4	2201.83		2201.83	
TF-7	2114.67		2114.67	
TF-11	2152.00		2152.00	
TF-335	2103.33		2103.33	
GUL	2216.33		2216.33	
ARI	2312.00		2312.00	
PESH	2293.67		2293.67	
TF-1xTF-4	2208.49 m	2.26**	2281.03 j	5.62**
TF-1xF-7	2225.39 l	5.16**	2254.00 n	6.51**
TF-1xTF-11	2101.40 u	-1.57**	2168.00 q	1.55**
TF-1xTF-335	2198.22 n	4.16**	2295.33 I	8.76**
TF-1XGUL	2122.30 s	-2.06**	2245.33 o	3.62**
TF-1XARI	2454.33 a	10.81**	2325.00 c	4.98**
TF-1xPESH	2157.00 q	-2.21**	2301.67 h	4.35**
TF-4xTF-7	2114.73 t	-2.02**	2168.00 q	0.45**
TF-4xTF-11	2265.70 h	4.08**	2252.00 n	3.45**
TF-4xTF-335	2137.03 r	-0.72**	2096.00 t	-2.63**
TF-4xGUL	2351.37 d	6.44**	2303.00 h	4.25**
TF-4xARI	2434.33 b	7.86**	2317.89 e	2.70**
TF-4xPESH	2247.11 ij	-0.03NS	2317.22 e	3.09**
TF-7xTF-11	2265.70 h	6.20**	2140.33 s	0.33**
TF-7xTF-335	2192.00 o	3.94**	2294.00 I	8.77**
TF-7xGUL	2389.00 c	10.32**	2271.67 l	4.90**
TF-7xARI	2165.33 p	-2.17**	2312.00 f	4.46**
TF-7xPESH	2243.00 j	1.76**	2258.78 m	2.48**
TF-11xTF-335	2251.67 I	5.83**	2164.00 r	1.71**
TF-11xGUL	2232.00 k	2.19**	2275.00 k	4.16**
TF-11xARI	2286.33 g	2.43**	2308.78 g	3.44**
TF-11xPESH	1219.00 v	-45.16**	2325.67 c	4.63**
TF-335xGUL	2303.33 f	6.64**	2316.00 e	7.23**
TF-335xARI	2303.33 f	4.33**	2328.00 b	5.45**
TF-335xPESH	2307.00 f	4.94**	2346.00 a	6.71**
GULxARI	2318.00 e	2.38**	2281.33 j	0.76**
GULxPESH	2305.67 f	2.25**	2308.56 g	2.38**
ARIxPESH	2284.67 g	-0.79**	2320.67 d	0.77**
G/Means	2217.27		2270.55	Paschal value 5% 1.07
C/Variation	1.3%		0.13	Paschal value 1% 1.04
LSD	4.68		4.68	
Increase of F_1 over mid-parent 1.29			% Increase of F_1 over mid-parent 3.73	

* : Significant at 5% levels
** : Significant at 1% levels
NS : Non-significant
The combinations in the Achene yield column followed by similar alphabet are not significantly different.

as usual and equally to all the treatments. These eight inbred lines were crossed in diallel fashion, i.e., direct as well as reciprocal. To produce good enough F_0 seeds, the crossings were made for three consective years and F_0 seed was harvested separately from each cross at maturity.

Hybrid seeds (F_1) of 56 crosses along with their eight parents were tested in an experiment in a Randomized Complete Block Design with three replications. In the experiment sowing was done by dibbling 3 seeds per hill that was thinned to one plant per hill. Each row was 4 m long. Plant to plant and row-to-row distance was kept at 25 and 60 cm, respectively. Normal cultural practices and plant protection measures were adopted during the crop season. The data on achene yield (kg ha^{-1}) and oil content (g kg^{-1}) were recorded for each treatment on a plot size of 18 m^2 (4.5x4 m^2).

The heterosis for individual crosses was calculated using following formula by Sugoor [3]

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

Where, MP is the Mid-parent achieved as:

$$MP = \frac{P1 + P2}{2}$$

Tests of significances were performed on the differences between F_1 value and mid-parent. Differences among means were computed by Paschal and Wilcox [4] formula:

Mid-parent: $SD = t \propto (3MS\varepsilon/2r)^{1/2}$

Table 2: Heterosis (%) of 28 direct and reciprocal crosses for oil content (g kg^{-1}) in sunflower

	Direct crosses		Reciprocal crosses	
Genotypes	Oil content (g kg^{-1})	Heterosis (%)	Oil (g kg^{-1})	Heterosis (%)
TF-1	32.20		32.20	
TF-4	31.83		31.82	
TF-7	32.58		32.58	
TF-11	35.51		35.51	
TF-335	34.56		35.28	
GUL	27.25		27.25	
ARI	37.93		37.93	
PESH	38.29		38.29	
TF-1xTF-4	43.87 a	37.03**	33.79 efghi	5.55**
TF-1xTF-7	30.69 lmn	-5.25**	34.84 cdefghi	7.55**
TF-1xTF-11	33.33 ghijklm	-1.57NS	39.53 ab	16.74**
TF-1xTF-335	35.28 efghijk	5.68**	36.01 bcdefgh	6.72**
TF-1xGUL	26.83 n	-9.73**	40.62 a	36.66**
TF-1xARI	30.99 klmn	-11.62**	32.68 fghijk	-6.82**
TF-1xPESH	31.23 klm	-11.40**	39.11 abc	10.96**
TF-4xTF-7	31.16 klm	-3.23NS	39.53 ab	22.73**
TF-4xTF-11	39.61 abcd	17.64**	36.76 abcdef	9.18**
TF-4xTF-335	37.21 bcdefgh	12.09**	31.41 ijk	-6.38**
TF-4xGUL	37.83 bcdef	28.07**	38.53 abcd	30.45**
TF-4xARI	32.00 jklm	-8.27**	33.55 efghij	-3.81*
TF-4xPESH	40.12 abc	14.44**	39.19 abc	11.79**
TF-7xTF-11	39.61 abcd	16.33**	33.41 efghij	-1.88NS
TF-7xTF-335	36.77 cdefghij	9.52**	31.61 hijk	-6.84**
TF-7xGUL	35.80 defghij	19.67**	33.70 efghij	12.64**
TF-7xARI	37.60 bcdefg	6.64**	36.74 abcdef	4.19**
TF-7xPESH	39.34 bcde	11.01**	34.34 defghi	-3.11*
TF-11xTF-335	33.35 ghijklm	-4.82**	34.41 defghi	-2.78NS
TF-11xGUL	41.18 ab	31.24**	38.51 abcd	22.71**
TF-11xARI	31.64 jklm	-13.84**	29.27 jk	-20.30**
TF-11xPESH	32.22 jklm	-12.69**	32.22 ghijk	-12.68**
TF-335xGUL	34.60 fghijkl	11.95**	37.38 abcde	19.57**
TF-335xARI	32.56 ijklm	-10.16**	36.92abcdef	0.86NS
TF-335xPESH	37.63 bcdefg	3.29*	32.74fghijk	-10.99**
GULxARI	33.13 hijklm	1.65NS	39.55ab	21.36**
GULxPESH	29.50 mn	-9.99**	39.35ab	20.07**
ARIxPESH	30.62 lmn	-19.66**	36.50abcdefgh	-4.22**
G/Means	34.85		35.79	Paschal value 5% 1.07
C/Variation	7.56		7.56	Paschal value 1% 1.40
LSD	4.31		4.31	
% Increase of F_1 over mid-parent 31.19			% Increase of F_1 over mid-parent 5.71	

* : Significant at 5% pb. levels
** : Significant at 1% pb. levels
NS : Non-significant
The combinations in the Oil content column followed by similar alphabets are not significantly different

Where, SD = difference between F_1 and mid-parent, required for significance at a stated probability level and given degree of freedom, r = No. of replications and $t\propto$ = tabulated value at 5 and 1% probability levels.

RESULTS AND DISCUSSION

Achene yield (kg ha^{-1}): In direct crosses (Table 1), maximum heterosis (10.81 and 10.32 %,) was shown by cross combination TF-1xARI and TF-7xGUL, respectively. In reciprocal crosses, maximum heterosis (8.77%) was recorded by cross combination TF-335xTF-7, followed by TF-335xTF-1 with 8.76 % heterosis for the trait. These results showed that maximum heterosis was shown by crosses involving at least one parent with high potential for the trait. Chaudry and Anand[5] reported 70% heterosis for the trait, while Reddy *et al.*[6] and Deokar and Patil[7] reported more than 100% heterosis for seed yield. The value of overall average percentage increase of F_1 hybrids over mid-parent was 1.29 in the direct crosses while this percentage increase of F_1 hybrid over mid-parent was 3.73 in the reciprocal crosses.

Oil content: In direct crosses of F_1 generation (Table 2), cross combination TF-1xTF-4 gave the highest heterosis (37.03 %) followed by TF-11xGUL with heterotic value of 31.24 %. In reciprocal crosses, combination GULxTF-1 gave the highest heterosis (36.66%) followed by GULxTF-4 with heterotic value of 30.45%. Ali *et al.*[8] reported 13.48% while Chaudry and Anand[5] reported 23%

heterosis for oil content in their experiments. In reciprocal crosses, cross combination (GULxTF-4) with the 2nd highest heterosis for the character involved parents with the least amount of oil content, which showed complementary nature of recessive genes for the character in F_1 generation. The value of overall average percentage increase of F_1 hybrids over mid-parent was 31.19 in the direct crosses while this percentage increase of F_1 hybrid over mid-parent was 5.71 in the reciprocal crosses.

All cross combinations in F_1 generation exhibited heterosis or hybrid vigour for the characters studied, though no cross combination was consistent for having maximum heterosis in both achene yield and oil content.

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