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Heterosis for Yield Components in Sunflower (*Helianthus annuus* L.)

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Abstract: To study the effects of heterosis on important agronomic and yield contributing traits, this experiment was conducted at Agricultural Research Institute, Tarnab, Peshawar during August 2001, using Randomized complete block design with three replications. The planted material consisted of ten sunflower inbred lines (Parents) and their nine crosses. Highly significant genetic differences were observed among the inbred liens for head weight per plant, seed weight per head, 1000-seed weight and harvest index, however, the differences among the inbred lines for the weight of filled seeds per head were statistically non significant. Genetic differences among the hybrids were significant for all characters except for head weight per plant. High levels of heterosis were observed for the hybrids TS-17xTR-120 and TS-18xTR-120 for important agronomic characters such as head weight per plant (184 and 183%, respectively), seed weight per head (322.3 and 292.7%, respectively) and weight of filled seeds per head (302.7 and 295.5%, respectively). TS-4xTR-11 showed maximum heterosis for 1000-seed weight (104.6%) and harvest index (128.6%). Mean data for 1000-seed weight, weight of filled seeds per head and seed weight per head were higher for TS-17xTR-120, TS-18xTR-120 and TS-4xTR-11 than all other hybrids. Based on the mean performance and high heterotic effects for important characters, these hybrids and their parents are suggested for further study and use in sunflower breeding programs.

Key words: Heterosis, yield components, sunflower

INTRODUCTION

Three crop species, soybean, rapeseed and sunflower, account for approximately 78% of the world vegetable oil production. Heterosis of these crops has been exploited to increase seed yield only over the past few decades. Utilization of heterosis has allowed sunflower (*Helianthus annuus* L.) *to* become one of the major oilseed in many countries of the Eastern and Western Europe, Russia and South America and is an important crop in the USA, Australia, South Africa, China, India and Turkey. Of the approximately 16.5 million ha of sunflower grown in the major producing countries, 11.5 million ha are planted to hybrids. Hybrid vigor has been the main driving force for acceptance of this oilseed crop[1].Virtually 100% of the oilseed sunflower production is with hybrid cultivation in the United States, Western Europe, Argentina and Australia. Advantages of hybrids over open pollinated cultivars are higher yields, greater uniformity, increased self fertility and resistance to three major diseases including rust, downy mildew and verticillium wilt.

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 the agro-climatic conditions of the country[2]. To make sunflower a successful crop in Pakistan, we need to develop our own hybrids which are well adapted to our agro-climatic conditions. Keeping in view, the importance of hybrids, this experiment was designed to find out the best combination of sunflower inbred lines for important agronomic and yield contributing traits.

MATERIALS AND METHODS

This research was conducted at Agricultural Research Institute, Tarnab, Peshawar, Pakistan 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)
TS-IxTR-120	R-8
TS-17xTR-120	TR-11
TS-18xTR-120	TR-12

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Ts-IxTR-12	TR-110
TS-17xR-8	TR-120
TS-4xTR-6023	TR-6023
TS-4xTR-110	Male sterile inbred lines
TS-4xR-8	TS-1
TS-4xTR-II	TS-4
	TS-17
	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. 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. The following parameters were studied during this research work.

- Head weight per plant was recorded after drying it in the sunlight when the crop reached full maturity.
- Seed weight per head was determined by weighing total number of seeds per head.
- Weight of filled seeds per head was obtained by weighing the total number of filled seeds.
- Thousand seed weight was determined after threshing by weighing a representative sample of 1000-seed from each replication.
- Harvest index was calculated by using the following formula:

$$HI = \frac{\text{Seed yield (kg)}}{\text{Head weight (kg)}} \times 100$$

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:

$$\text{Mid parent heterosis (\%)} = \frac{F_1\text{-MP}}{MP} \times 100$$

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

RESULTS AND DISCUSSION

Results pertaining to different morphological characters of ten sunflower inbred lines and their nine hybrids are discussed in the following paragraphs.

Head weight per plant: Analysis of variance revealed highly significant genetic differences ($P<0.01$) among inbred lines, however, the differences among hybrids were non significant ($P>0.05$) for this character (Table 1). Head weight per plant for the inbred lines ranged from 56.7 to 280 g (Table 2). Minimum value was recorded for TR-6023, whereas the maximum value for this character was recorded for TR-11. Mean data among the nine hybrids ranged from 220 to 465 g (Table 3), but these differences were statistically non significant. Per cent heterosis over the mid parent value ranged from 11.9 to 184%. Maximum positive heterosis of 184 and 183% was recorded for TS-17xTR-120 and TS-18xTR-120, respectively.

The hybrids showing maximum value for head weight per plant, also generally possess higher values for thousand seed weight and weight of filled seeds per head, which shows the importance of this character for the selection of superior hybrids.

Seed weight per head: Inbred lines and hybrids showed highly significant genetic differences ($P<0.01$) for this character (Table 1). Mean data for this character among inbred lines varied from 6.2 to 28 g (Table 2). Mean data for the hybrids ranged from 29.4 to 74.4 g (Table 3). TS-17xTR-120 had significantly higher seed weight per head (74.4 g) than all hybrids. Maximum heterosis of 322.3% was observed for TS-17xTR-120 followed by TS-18xTR-120 (292.7%). The least positive heterosis of 10.7% was recorded for TS-17xR-8.

These findings are supported by the work of Goksoy *et al.*[3], Rather and Sandha[4] and Gill *et al.*[5] who have reported high positive heterotic effect for this character. Limbore *et al.*[6] have reported heterosis as low as -53% and as high as 146.4% for this character.

Weight of filled seeds per head: Non-significant differences were observed among inbred lines, whereas highly significant differences ($P<0.01$) were observed among hybrids for this character (Table 1). Mean data for this character ranged from 9.1 to 27.9 g for different inbred lines (Table 2). For hybrids mean data varied from 27.3 to 69 g (Table 3). Minimum weight was recorded for TS-17xR-8 (29.9 g), whereas maximum weight was recorded for TS-17xTR-120 (69 g).

Heterosis relative to midparental value ranged from 4.3 (TS-17xTR-120) to 302.7% (TS-17xR-8). In general the hybrids showing high values for the weight of filled seeds per head possess heavy seeds and it has been reported by Hussain *et al.*[7] that oil content increases significantly in hybrids possessing heavy seeds. This shows the importance of this character for selection.

Table 1: Mean squares and Coefficient of Variation (Cv) for Head Weight per plant (Hw), Seed Weight per head (Sw), Weight of Filled Seeds per head (Wfs), Thousand Seed Weight (1000-sw) and Harvest Index (Hi) of ten sunflower inbred lines and nine sunflower hybrids evaluated at Agricultural Research Institute, Tarnab, Peshawar, during August, 2001

S.V.	Df	HW	SW	WFS	1000-SW	HI
Inbred lines						
Replications	2	131.53	4.19	79.08	1.52	1.16
Inbred lines	9	13023.48**	159.76**	107.82^{NS}	84.88**	38.43**
Error	18	251.74	11.84	89.79	23.57	8.42
C.V(%)		10.72	19.87	52.10	15.00	23.69
Hybrids						
Replications	2	22245.37	3.89	2.21	76.65	74.07
Hybrids	8	16705.09^{NS}	569.64**	514.72**	327.76**	51.20*
Error	16	7853.70	33.93	34.99	12.41	18.24
C.V(%)		26.98	12.09	12.74	7.80	26.93

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

Table 2: Means for Head Weight per plant (HW), Seed Weight per head (SW), Weight of Filled Seeds per head (WFS), Thousand Seed Weight (1000-SW) and Harvest Index (HI) of ten sunflower inbred lines evaluated at Agricultural Research Institute, Tarnab, Peshawar during August, 2001

Inbred lines	HW (g)	SW (g)	WFS (g)	1000-SW (g)	HI (%)
TR-11	280.0a	25.7a	23.5	22.6d	9.1d
TR-110	130.0e	9.7d	9.1	27.9cd	7.5d
R-8	183.3bc	28.0a	27.9	48.2a	15.4abc
TR-120	96.7f	10.2cd	10.0	32.7bc	10.8cd
TR-6023	56.7g	6.2d	21.7	22.7d	11.2cd
TR-12	100.0f	15.9bc	15.5	35.4bc	16.3ab
TF-17	173.3cd	25.1a	23.4	40.7ab	14.4abc
TF-18	100.0f	17.6b	17.4	31.9c	18.0a
TF-4	210.0b	17.7b	17.0	28.3cd	8.4d
TF-1	150.0de	17.2b	16.4	33.2bc	11.4bcd
LSD (5%)	27.2	5.9	NS	8.4	5.0

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

Table 3: Means and mid parent hetrosis for Head Weight per plant (HW), Seed Weight per head (SW), Weight of Filled Seeds per head (WFS), Thousand Seed Weight (1000-SW) and Harvest Index (HI) of nine sunflower hybrids evaluated at Agricultural Research Institute, Tarnab, Peshawar during August, 2001

Hybrids	HW (g)	Heterosis (%)	SW (g)	Heterosis (%)	WFS (g)	Heterosis (%)	1000-SW (g)	Heterosis (%)	HI (%)	Heterosis (%)
TS-1xTR-120	298.3	141.9	53.2b	288.8	51.5b	289.4	46.0cd	39.6	19.2ab	73.1
TS-17xTR-120	383.3	184.0	74.4a	322.3	69.0a	302.7	54.0b	47.1	20.0a	58.2
TS-18xTR-120	278.3	183.0	54.6b	292.7	54.2b	295.5	62.5a	93.8	20.7a	44.1
TS-1xTR-12	306.7	145.3	32.0d	93.7	29.9de	87.8	41.2de	20.1	10.9c	-21.3
TS-17xR-8	326.7	83.2	29.4d	10.7	27.3e	4.3	26.5f	-40.3	9.8c	-34.2
TS-4xTR-6023	280.0	110.0	46.1bc	286.1	45.1bc	31.4	46.4cd	81.8	16.6abc	68.8
TS-4xTR-110	398.3	134.3	52.0b	279.3	50.4b	286.4	40.6de	44.7	14.9abc	88.1
TS-4xR-8	220.0	11.9	38.6cd	68.9	37.7cd	67.8	37.3e	-2.4	18.7ab	57.3
TS-4xTR-11	465.0	89.9	54.5b	151.3	52.9b	160.8	52.1bc	104.6	12.1bc	128.6
LSD (5%)	NS	-	10.1	-	16.3	-	6.1	-	7.4	-

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

Thousand seed weight: The analysis of variance for thousand seed weight revealed highly significant differences among the inbred lines and their hybrids (Table 1). Mean data for different inbred lines ranged from 22.6 to 48.2 g (Table 2). Among hybrids, mean data for this character varied from 26.5 to 62.5 g (Table 3). Most of the heterotic effects for this character were positive except for TS-17xR-8 and TS-4xR-8, which showed negative heterosis of -40.3 and -2.4%. Maximum heterosis regarding mid parental value was recorded for TS-4xTR-11 (104.6%) and TS-18xTR-120 (93.8%).

This study is in accordance with the findings of Goksoy *et al.*[3], Radhika *et al.*[8], Gill and Punia[9] and Zinovatanya *et al.*[10] who have reported positive heterotic effect for this character. Similarly Sassikumar and Gopalan[11] have reported heterosis of 14.52% for 100-seed weight.

Harvest index: The ANOVA regarding harvest index revealed highly significant differences ($P<0.01$) among inbred lines and significant differences ($P<0.05$) among hybrids (Table 1). Mean data for this character ranged from 7.5 to 18% among inbred lines (Table 2). The minimum harvest index was recorded for TR-110, whereas the maximum harvest index was noted for TF-18. Among hybrids, harvest index ranged from 9.8 to 20.7% (Table 3). Mid parent heterosis for this character ranged from -43.2 to 128.6%. This study is supported by the work of

Madrap and Makne[12], who have reported high levels of heterosis for this character.

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