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Estimates of Heterosis and Heterobeltiosis for Morphological Traits in Wheat (*Triticum aestivum* L.)

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Abstract: An 8x8 full diallel set of bread wheat (*Triticum aestivum* L.) was studied for heterosis and heterobeltiosis. The magnitudes of heterosis (mid-parent) and heterobeltiosis (better-parent) from F_1 were calculated for days to heading, flag leaf area, plant height, spike length, days to maturity and harvest index. All the 56 F_1 hybrids and their parents were planted in a randomized complete block design in three replicates. Out of the 56 F_1 hybrids, 18 and 16 hybrids for days to heading; 11 and 2 for flag leaf area; 24 and 15 for spike length; 8 and 3 for days to maturity and in 3 and 1 for harvest index expressed significant heterosis and heterobeltiosis, respectively. Maximum limits of heterobeltiosis for flag leaf area, spike length, harvest index, plant height, days to heading and days to maturity were 22.3, 13.03, 11.23, 3.27, 2.60 and 1.82%, respectively. Among parent cultivars, Takbeer, Inqilab-91, Tatara and Idaho-458 proved to be superior combiners. Populations of Tatara x Khattakwal, Takbeer x Inqilab-91, Idaho-458 x Fakhre Sarhad, Fakhre Sarhad x Takbeer and Ghaznav-98 x Takbeer were the best for most of the traits and their use in breeding programmes is suggested.

Key words: Wheat, heterosis, heterobeltiosis, physiological traits

INTRODUCTION

Hybrid wheat technology can play an effective role in enhancing grain production. Although, the presence of heterosis in wheat was earlier reported in 1919 by Freeman yet its large-scale exploitation had not been realized to recent past. Due to the self-pollinating nature of the wheat, an appropriate mechanism for hybrid seed production has not been developed. Studies on heterosis would help for generating breeding strategies of hybrid wheat production. Obtaining genetic information from diallel cross progenies is a common practice of plant breeders working with autogamous crops. Insight information about the desirable parental combination is a prerequisite in any plant breeding programme, focusing on a high degree of heterotic response. Pal and Sikka[1] reported that Heterosis is a quicker, cheaper and an easier method of increasing crop production. With sufficient level of heterosis, commercial production of hybrid varieties would be justified and heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in breeding programmes.

Significant heterosis over superior parents for plant height existed[2,3]. Petrovic and Cermin[4] estimated heterotic effect of wheat for plant height in a 4x4 complete diallel cross during two seasons. Sadeque *et al.*[5] in an 8 wheat lines full diallel recorded significant negative heterosis in 9 crosses for days to heading and negative heterobeltiosis in most of the crosses for days to heading and plant height. Khan and Bajwa[6] reported positive and significant heterosis for plant height in seven crosses of wheat. Panialvi *et al.*[7] found heterosis and heterobeltiosis of various magnitudes for flag leaf area and plant height in spring wheat. Palve *et al.*[8] reported heterosis over the mid-parental value and over the better parent for days to 50% heading. Patwary *et al.*[9] reported significant negative heterosis (desired) for days to flowering (from -12.48 to -35.86%) in 32 out of 42 F_1 wheat hybrids. Khan *et al.*[10] recorded 7.3% heterobeltiosis for plant height in a 5-parent diallel of spring wheat.

The present study was conducted firstly to estimate heterosis and heterobeltiosis for some morphological traits in an 8 x 8 diallel set of bread wheat and secondly to identify potential parental lines for hybrid combinations.

MATERIALS AND METHODS

The experiment was conducted at the experimental farm, Department of Plant Breeding and Genetics, NWFP Agricultural University, Peshawar. Eight wheat

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genotypes viz., Khattakwal (KW), Fakhre Sarhad (FS), Ghaznavi-98 (GZ), Inqilab-91 (Inq), Takbeer (Tkb), Tatara (Tat), Pirsabak-85 (PS) and Idaho-458 (ID), were crossed in all possible combinations (excluding self crossed) in a 8 x 8 diallel fashion during 2001-2002. During the next crop season, 2002-2003, the parent varieties and their 56 F_1 hybrids were grown in a randomized complete block design with three replications. All the F_1 hybrids and their parent varieties were randomly assigned to experimental plots. Each plot comprised two rows of 3 m with space of 30 cm between rows. Seed was planted 15 cm apart.

Data were collected on numbers of days to 50% heading (DSH), Flag Leaf Area (FLA), Plant Height (PH), Spike Length (SL), Days to Maturity (DM) and Harvest Index (HI). Data were analyzed according to Steel and Torrie [11]. The percent increase (+) or decrease (-) of F_1 hybrids over mid-parent as well as better parent was calculated to estimate heterotic effects for all the parameters. The estimate of heterosis over mid and better parents was calculated using the procedure of Matzingar *et al.*[12]. The difference of F_1 hybrids mean from the respective mid parent and better parent value was compared using a t-test according to Wyne *et al.*[13].

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences among the genotypes (including 8 parents and their 56 F_1 hybrids) for all the characters (Table 1). All the 56 hybrids were compared with mid and better parents for the estimation of heterosis and heterobeltiosis, respectively.

Table 1: Mean squares for days to heading (DSH), flag leaf area (FLA), plant height (PLH), spike length (SPL), days to maturity (DSM) and Harvest index (HI) in Wheat

		Mean squares					
SOV	DF	DSH	FLA	PLH	SPL	DSM	HI
Replications	2	15.90	2.33	4.40	156.83	18.48	54.56
Genotypes	63	6.40**	50.55**	297.00**	2.31**	9.63**	49.63**
Error	126	1.43	7.54	13.10	0.48	1.92	12.44

** = Significant at 1% probability level

Number of days to 50% heading: Early heading provides sufficient time for grain formation process and if heading is late, the duration of grain filling is squeezed resulting modest grain weight. Therefore, early heading is desirable in wheat and negative heterosis for days to heading is useful. Out of 56 F_1 hybrids, 48 showed negative heterosis for days to heading in the range of -0.12 to -3.35 while only 18 hybrids expressed significantly negative heterosis. The crosses with the most negative heterosis were Tat x KW, followed by Tat xTkb and GZ x KW (Table 2). Significantly negative heterobeltiosis was recorded for 16 hybrids and the values ranged between -0.25 and -2.60. The crosses with the most negative heterobeltiosis were Tat x KW, followed by TatxTkb and GZ x KW (Table 2). These results are in accordance with the findings of Sadeque *et al.*[5] and Patwary *et al.*[9] who reported negative heterosis for days to heading. However, Palve *et al.*[8] has reported positive heterosis over mid-parent value in the crosses for this trait. The difference may be assigned to difference in materials or other environmental factors.

Flag Leaf Area (FLA): Positive heterosis for Flag Leaf Area (FLA) is important because it is an effective

Table 2: Heterotic effects for number of fertile tillers/plant, grain yield/plant, grains/spike, grain weight/spike and 1000-grain weight in wheat

	0. crosses with heterosis over		0. of crosses with significant heterosis over		Crosses with the highest heterosis in rank order over	
Traits	MP*(% Range)	BP*(% Range)	MP	BP	MP	BP
Days to 50% heading	48 (-0.12 to -3.35)	28 (-0.25 to -2.60)	18	16	Tat x KW Tat x Tkb GZ x KW	Tat x KW Tat x Tkb GZ x KW
Flag leaf area	29 (0.32 to 22.56)	11 (1.40 to 22.32)	11	2	Tkb x Inq Inq x Tkb Inq x Tat	Tkb x Inq Inq x Tkb
Plant height	1 (-3.67)	1 (-3.27)	0	0	ID x FS	ID x FS
Spike length	42 (0.44 to 15.61)	36 (0.56 to 13.03)	24	15	Inq x PS PS x ID Tat x ID	FS x Tkb Inq x PS PS x Tat
Days to maturity	24 (-0.10 to -2.41)	12 (-0.20 to -1.82)	8	3	Tkb x ID PS x FS PS x Inq	Tkb x ID PS x FS Tat x Tkb
Harvest index (%)	35 (0.20 to 22.85%)	10 (0.60 to 11.23%)	3	1	PS x FS FS x ID Inq x ID	GZ x Tkb

*MP = Mid-Parent, BP = Better-Parent

yield related parameter. Bigger FLA helps to synthesize photosynthates in greater quantities that are translocated to grains increasing their weight. For flag leaf area 29 hybrids manifested positive heterosis that ranged between 0.32 and 22.56%, however, significantly positive heterosis was indicated in 11 of the hybrids (Table 2). The crosses with the highest heterosis were Tkb x Inq, Inq x Tkb and Inq x Tat. Heterobeltiosis was recorded for 11 cross combinations that ranged from 1.40 to 22.32%, whereas, only two crosses Tkb x Inq and Inq x Tkb exhibited significant values. Mahmood and Chowdhry[14] and Panialvi *et al.*[7] for flag leaf area have also reported positive heterosis. While, Khan *et al.*[3] have reported significant heterosis and heterobeltiosis for flag leaf area.

Plant Height (PH): Short-stature wheat plants are preferred because plants with greater height are likely to lodge quite often. Therefore, negative heterosis is desirable when breeding for lodging resistance. Only one hybrid (ID x FS) showed significant negative heterosis (-3.67) and heterobeltiosis (-3.27) for plant height (Table 2). Sadeque *et al.*[5] have reported negative heterosis for plant height while Patil *et al.*[2] recorded significant heterosis over superior parents for plant height. However, Khan and Bajwa[6], Panialvi *et al.*[7] Khan *et al.*[10] have reported positive heterosis for plant height. Two groups (Taller and Semi dwarf) when hybridized yielded taller plants in first filial generation indicating tallness being controlled by dominant genes.

Spike Length (SL): Forty two hybrids exhibited positive heterosis for spike length (Table 2) ranging from 0.44 to 15.61%. However, significantly positive heterosis was observed in 24 cross combinations. The crosses with the highest heterosis were Inq x PS followed by PS x ID and Tat x ID. Heterobeltiosis was observed in 36 hybrids that ranged between 0.56 and 13.03%. Fifteen of the crosses showed significant positive heterobeltiosis. The cross with the highest heterobeltiosis was FS x Tkb followed by Inq x PS and PS x Tat. Sadeque *et al.*[5], Khaliq *et al.*[15] and Moiscu[16] have also reported positive heterosis for spike length.

Days to Maturity (DM): Genotypes with early maturing habit are desirable, therefore, negative heterosis for days to maturity is considered useful. Heterotic studies for days to maturity (Table 2) revealed that 24 crosses displayed negative heterosis in the range of -0.10 to -2.41% but 8 had significantly negative values. The crosses with the highest heterosis were Tkb x ID, PS x FS and PS x Inq. Heterobeltiosis was positive in 12 crosses that ranged between -0.20 and -1.82%. Overall heterobeltiosis was negative and significant in 3 crosses viz., Tkb x ID, PS x FS and Tat x Tkb. Therefore, these populations can yield lines with early maturity.

Harvest Index % (HI): Out of 56 hybrids, 35 showed positive heterosis for harvest index that ranged from 0.20 to 22.85% (Table 2). Heterosis was significant in 3 crosses. The crosses with the highest heterosis were PS x FS, FS x ID and Inqx ID. Ten hybrids showed heterobeltiosis ranging between 0.60 and 11.23%. A single cross GZ x Tkt showed significantly positive heterobeltiosis for the trait.

Three crosses with the highest heterosis for each trait are shown in Table 2. Parents Takbeer, Inqilab-91, Tatara and Idaho-458 proved to be superior when used as parents in most of the hybrid combinations. Maximum heterobeltiosis for days to 50% heading was indicated by hybrid Tat x KW, for flag leaf area by Tkb x Inq, for plant height by ID x FS, for spike length by FS x Tkb, for days to maturity by Tkb x ID and for harvest index by GZ x Tkb. These crosses, thus, can be yield potential lines. The high heterosis and heterobeltiosis of these crosses suggest them to be sources of transgressive segregants.

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