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Studies on Heterosis for Yield and Yield Components in Wheat

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Abstract: In 6x6 diallel cross, heterosis was studied in 15 F_1. The variances due to heterosis were significant for all the characters. Overall heterosis partitioned into components and showed that average, variety and specific heterosis were significant for plant height, harvest index, days to 90% maturity and grain yield per plant. Spikes per plant estimated significant variety and specific heterosis and 100-grain weight estimated significant average and variety heterosis. Spike length and grains per spike showed only significant specific heterosis. Mid parent heterosis for grain yield per plant was observed maximum (110.34%) in the cross $P_3 \times P_6$.

Key words: Wheat, heterosis, diallel, Bangladesh

Introduction

Wheat an important cereal crop in the world. Produced extensively in the temperate zones, has now become the staple food crop in Bangladesh. Its total area and production is increasing day by day. The climatic and soil condition of Bangladesh is suitable for wheat cultivation. The yield potentiality of the varieties cultivated in Bangladesh is much less than cultivars of the developed countries (Kadir ***et al.***, 1997). Heterosis is a genetic expression of the beneficial effects of hybridization. In practice, high degree of heterosis over parent is more desirable. Many workers have reported, heterosis for yield and yield components in wheat (Atale and Vitkare, 1990; Krishna and Ahmad, 1992; Islam and Srivastava, 2001). In the present study, the extents of heterosis in spring wheat for yield components in 6 X 6 diallel set have been reported.

Materials and Methods

This research work was carried out at the Field Laboratory of the Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh in two consecutive Rabi seasons of 2000-2001 and 2001-2002. The study included six genotypes of spring wheat used as parents and their fifteen F_1's obtained from a diallel cross without reciprocals. In Table 1 name and origin of parental genotypes are given.

The parental materials were sown in crossing block during November 2000. Plants at flowering stage just before anthesis stage were selected and crossed in diallel fashion excluding reciprocals.

Table 1: List of genotypes and their origin

Sr. No.	Genotype	Origin
P_1.	Ananda	Bangladesh
P_2.	Rawal	Pakistan
P_3.	Moyoor	CIMMYT
P_4.	BAW-935	Bangladesh
P_5.	Chyria	Mexico
P_6.	Kheri	Bangladesh

On November 18, 2001, the six parents and their 15 F_1 hybrids were sown in a randomized block design with three replications. Each genotype was grown in a single row plot of 1m long in each replication. The spacing was 25 cm between rows and 5 cm between plants of the same row.

Ten plants were randomly selected from each entry on days to flowering, days to 90% maturity, spikes per plant, plant height, spikes per plant, plant height, spike length, grains per spike, 100-grain weight, harvest index and grain yield per plant. Heterosis was calculated by Gardner and Eberhart's (1966) methods.

Results and Discussion

Heterosis for grain yield and its contributing characters

The variances due to heterosis were significant for all the characters studied (Table 2). This suggested the presence of non-additive gene action for all the characters. Contribution of additive gene action was assessed by estimating variance due to varieties (the variances within parents). Variances due to varieties were significant for all the characters that indicated the presence of additive gene action.

The estimates of variance due to average heterosis (parents vs. crosses) indicated the direction of dominance for the characters (Table 2). All the characters except spikes per plant, spike length and grains per spike showed significant average heterosis indicated the unidirectional dominance for these characters. The non-significant variance due to average heterosis for spikes per plant, spike length and grains per spike indicated unpredictable direction of dominance.

Variety heterosis was estimated to judge overall contribution of a variety to its array heterosis. The variances due to variety heterosis were significant for spikes per plant, plant height, 100-grain weight, harvest index, days to 90% maturity and grain yield per plant. The results indicated the differences among the parental arrays for the heterosis of these characters. Grains per spike and spike length showed no difference among the parental arrays for heterosis.

Importance of total heterosis of the crosses was assessed by the variance due to specific heterosis. The variances due to specific heterosis were significant for all the characters except 100-grain weight. The present results explained that heterosis of a cross was usually contributed by average, variety and specific heterosis. Similar types of results also reported by others Sharma and Ahmad (1978), Sharma ***et al.*** (1984) and Rahman (2000).

Table 2: Analysis of variance for heterosis for grain yield and its contributing characters in spring wheat

Sources of variation	D.F.	Spikes per plant (no.)	Plant height (cm)	Spike length (cm)	Grains per spike (no.)	100-grain weight (g)	Harvest index (%)	Days to 90% maturity	Grain yield per plant (g)
SS (entry)	20	1.251**	102.8165**	1.0585**	36.623**	0.5497**	17.622**	5.8412**	1.2067**
SS (variety)	5	1.0196**	149.7058**	1.6662**	38.247*	1.2229**	14.9255**	15.2302**	0.9657**
Overall heterosis	15	0.9626**	24.2904**	0.8154**	27.1952	0.1015**	19.1081**	5.9409**	1.5161**
Average heterosis	1	0.027	3.639**	0.064	16.344	0.462**	43.9085**	9.5027**	2.97**
Variety heterosis	5	0.6802*	11.8204**	0.5343	7.7887	0.1502**	16.462*	11.895**	1.4149**
Specific heterosis	9	1.2234**	33.5127**	1.055**	39.182*	0.0344	17.8225**	2.2373**	1.5645**
Error	40	0.261	0.239	0.246	14.923	0.034	5.89	0.749	0.3099

Table 3: Estimates of variety (hj) heterosis for grain yield and its contributing characters in spring wheat

Parents	Spikes per plant (no.)	Plant height (cm)	100-grain weight (g)	Harvest index (%)	Days to 90% maturity	Grain yield per plant (g)
P_1	0.218	0.9845*	0.267	-20.071**	-18.223**	-4.031**
P_2	-1.868**	-1.123*	-0.964**	-5.646*	3.11**	-2.544**
P_3	3.688**	-1.452**	-0.994**	9.939**	3.778**	2.871**
P_4	1.293*	-13.972**	1.257**	8.456**	11.778**	3.609**
P_5	-1.777**	7.775**	-0.38*	6.639**	1.112*	0.883
P_6	-1.434**	4.947**	0.866**	0.73	-1.555**	-0.788
S.E.	0.3297	0.3155	0.119	1.5665	0.3121	0.3593

Table 4: Estimates of heterosis in F_1 hybrids over mid parent for grain yield and its contributing characters in spring wheat

Crosses	Spikes per plant (no.)	Plant height (cm)	Spike length (cm)	Grains per spike (no.)	100-grain weight (g)	Harvest index (%)	Days to 90% maturity	Grain yield per plant (g)
$P_1 \times P_2$	-12.106	-1.767	-9.240	14.873	-1.657	4.917	-5.594**	-33.665*
$P_1 \times P_3$	-1.705	-0.699	13.235	-21.729	5.1	-7.808	-5.722**	-27.442*
$P_1 \times P_4$	49.249*	6.234	6.873	-22.396	24.548**	-30.62	-0.688	58.337*
$P_1 \times P_5$	4.471	0.863	12.202	25.783	4.134	20.167	-4.371**	27.308*
$P_1 \times P_6$	-16.111	9.544*	5.179	-13.316	22.109*	-3.135	-4.594**	-10.900
$P_2 \times P_3$	-0.299	1.282	-8.649	8.596	-7.678	30.394	1.839	15.558
$P_2 \times P_4$	8.852	1.955	2.040	3.631	10.494	5.835	1.714	59.69*
$P_2 \times P_5$	-11.444	5.754	9.722	-7.511	11.376*	5.423	-0.142	5.754
$P_2 \times P_6$	-15.786	1.619	-1.106	9.241	1.426	13.461	-1.263	9.921
$P_3 \times P_4$	19.946	-0.715	-20.008**	14.172	3.306	89.441**	2.425*	80.434*
$P_3 \times P_5$	12.023	0.292	-10.559	2.917	2.088	19.374	-0.283	82.054*
$P_3 \times P_6$	57.705**	7.311	7.571	29.76	15.605*	30.408	-1.12	110.339**
$P_4 \times P_5$	-7.043	2.071	-0.967	71.739**	4.576	53.063**	0.143	75.519*
$P_4 \times P_6$	-21.202	-14.048**	-23.958**	10.610	30.026**	28.702	0.141	27.121
$P_5 \times P_6$	-26.937	9.840*	3.912	3.596	5.588	17.015	-0.561	-6.937

*,** indicate significant at 5% and 1% level of probability, respectively

Variety heterosis of the parents

The parents P_3 and P_4 had significant variety heterosis for spikes per plant. Significant positive variety heterosis for plant height was obtained in the varieties P_1, P_5 and P_6. The parents P_4 and P_6 expressed significant variety heterosis for 100-grain weight. P_3, P_4, P_5 showed significant positive variety heterosis for harvest index (Table 3). Significant negative heterosis for days to 90% maturity was exhibited by the varieties P_1 and P_6. Out of six parents, P_3 and P_4 showed significant positive heterosis for grain yield per plant. These two parents also had significant heterosis for some yield contributing characters such as spikes per plant, harvest index and 100-grain weight. These results are agreement with Shamsuddin (1990) and Sharma ***et al.*** (1984).

Heterosis of the crosses

Heterosis over mid parent for grain yield and its contributing characters in spring wheat are given in Table 4. The specific heterosis of the crosses were not estimated because they are the same as SCA effects estimated in method IV and model 1 of Griffing (1956a) where the parents and reciprocal crosses were excluded. Seven crosses viz. $P_1\times P_4$, $P_1\times P_5$, $P_2\times P_4$, $P_3\times P_4$, $P_3\times P_5$, $P_3\times P_6$ and $P_4\times P_5$ showed positive and significant heterosis for grain yield per plant. Heterosis for different yield contributing characters was significant in the crosses, $P_1\times P_4$ and $P_3\times P_6$ that showed significant positive heterosis for spikes per plant, 100-grain weight and grain yield per plant.

The cross $P_4\times P_5$ showed significant heterosis for grains per spike and harvest index. The cross $P_1\times P_6$ was significant for plant height, 100-grain weight and days to maturity but was non-significant for grain yield per plant. Two crosses, $P_2\times P_4$ and $P_3\times P_5$ showed significant heterosis for yield per plant but no significant heterosis were obtained for yield contributing characters. The ranges of heterosis for the characters were -26.937 to 57.705% for spikes per plant, -14.048 to 9.84% for plant height, -23.958 to 13.235% for spike length, -22.396 to 71.739% for grains per spike, -7.678 to 30.026% for 100-grain weight, -30.62 to 89.441% for harvest index, -5.722 to 2.425% for days to 90% maturity and -33.665 to 110.339% for grain yield per plant.

Khan and Khan (1996) studied heterosis in bread wheat over mid parent and observed up to 31.91% heterosis for spikes per plant, 5.23% heterosis for plant height and -11.8 to 10.0% heterosis for days to maturity. Deshpande and Nayeem (1999) reported negative heterosis for plant height. Prasad ***et al.*** (1998) studied heterosis over better parent and reported -25.1 to 16.9% heterosis for spike length, -33.0 to 26.7% heterosis for grains per spike and -16.4 to 10.7% heterosis for harvest index. Positive and significant heterosis for 100-grain weight was observed by Khan ***et al.*** (1995).

The cross $P_3\times P_6$ showed 110.34% mid parent heterosis for grain yield. This was much higher than the heterosis for other yield contributing characters. Shamsuddin ***et al.*** (1991) studied heterosis in spring wheat and observed positive heterosis up to 151.31% for grain yield. Prasad ***et al.*** (1998) observed maximum heterosis for grain yield. Singh and Kandola (1969) and Singh (1978) estimated higher heterosis for grain yield than any other characters studied. Boyce (1948) explained heterosis of grain yield in wheat was the product of the heterosis of its component characters. So higher estimate of heterosis for grain yield than other characters was expected.

The positive and significant heterotic crosses for grain yield had significant and positive heterosis for some yield contributing characters. Among them positive and significant heterosis for spikes per plant, grains per spike, 100-grain weight and harvest index were frequently associated with the significant heterosis for grain yield. Shamsuddin ***et al.*** (1991) reported positive relation between heterosis for grain yield and heterosis for some yield components. Prasad ***et al.*** (1998) reported that heterosis for grains per spike and 100-grain weight was independently associated with heterosis for grain yield per plant.

Study on combining ability and heterosis showed that the crosses $P_1 \times P_4$, $P_2 \times P_4$, $P_3 \times P_5$ and $P_3 \times P_6$ expressed both significant SCA effects and heterosis for grain yield and yield contributing characters such as spikes per plant and 100-grain weight. Therefore, it was suggested that development of hybrid variety programme if feasible would be worthwhile in the crosses.

Heterosis for yield and yield contributing characters

Analysis of variance due to heterosis was significant for all the characters, which indicated the presence of non-additive gene action for these characters. Average heterosis was significant for all the characters except spikes per plant, spike length and grains per spike. All the characters except spike length and grains per spike showed significant variation due to variety heterosis. Significant variation for specific heterosis was observed for all characters except 100-grain weight.

Estimates of variety heterosis showed that the parents P_3 and P_4 had significant and positive variety heterosis for grain yield per plant and some yield contributing characters such as, spikes per plant, harvest index and 100-grain weight. These genotypes could be used as parents for breeding hybrid variety in spring wheat.

The crosses $P_1 \times P_4$, $P_1 \times P_5$, $P_2 \times P_4$, $P_3 \times P_4$, $P_3 \times P_5$, $P_3 \times P_6$ and $P_4 \times P_5$ showed positive and significant mid parent heterosis for grain yield per plant. Heterosis for grain yield was more than 27% in these crosses with maximum 110.34% in $P_3 \times P_6$. These crosses had significant and positive heterosis for some yield contributing characters among which spikes per plant, grains per spike, 100-grain weight, harvest index and days to 90% maturity were more frequent. Analysis of combining ability and heterosis showed that the crosses $P_1 \times P_4$, $P_2 \times P_4$, $P_3 \times P_5$ and $P_3 \times P_6$ expressed both significant heterosis. Therefore, in these crosses hybrid variety development programme was suggested.

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