INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2002/04–2–214–216
http://www.ijab.org

Estimation of Heterosis for Yield and some Yield Components in Bread Wheat

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ABSTRACT

Heterosis was estimated over mid and better parents for yield and some important yield related traits in 10 crosses of bread wheat. Grain yield per plant revealed maximum heterosis over the mid parent (31.65%) followed by number of grains per spike (15.56%), spike length (7.42%), number of spikelets per spike (7.29%), 1000 grain weight (5.79%) and number of tillers per plant (-2.14%). The maximum heterobeltiosis was recorded for grain yield per plant (27.11%) and number of spikelets per spike (6.59%).

Key Words: Bread wheat; Heterosis; Grain yield; Yield components

INTRODUCTION

Wheat is a staple food of the people of Pakistan and is grown on an area of about 8.4 million hectares annually. The attainment of maximum crop yield is an important objective in most breeding programmes and the major emphasis in wheat breeding is on the development of improved varieties. Significant efforts have been made to find the economically feasible systems for the production of F_1 hybrids. The possible heterosis exploitation in wheat crop continues to be a critical question. The choice of parental material used in the hybridization scheme does contribute significantly for the development of a suitable genotype. The parents which are genetically superior and diverse in the traits of interest are utilized for varietal development programme.

Briggle (1963) and Sajnani (1968) did suggest the possibility of heterotic effects in wheat as well. Krishna and Ahmed (1992) reported that maximum mean heterosis was obtained for 1000-grain weight (14.60%) and grain yield (12.52%). Yagdi and Karan (2000) observed significant heterosis and heterobeltiosis in spike length, number of spikelets per spike, number of grains per spike, 1000 gain weight and grain yield per plant.

The present studies were under taken to estimate the level of heterosis and heterobeltiosis among F_1 hybrids of five wheat varieties/lines. These informations would be useful to investigate the performance and relationship of F_1 hybrids and parents and to select suitable parents and population for designing an effective wheat breeding programme.

MATERIALS AND METHODS

The studies were conducted during 1999-2001 in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. The genotypes Punjab-96, Kohistan-97, MH-97, 4943A and 5039 were used to attempt F_1 crosses. The list of crosses is given below.

1. Punjab-96 x Kohistan-97	6. Kohistan-97 x 5039
2. Punjab-96 x MH-97	7. MH-97 x 4943A
3. Punjab-96 x 4943A	8. MH-97 x 5039
4. Punjab-96 x 5039	9. 4943A x Kohistan-97
5. Kohistan-97 x MH-97	10. 5039 x 4943A

In November 2000, these crosses were planted in field using randomized complete block design to evaluate their performance as compared to their parents. The seeds of five parents and above mentioned 10 crosses were sown by using dibbling method. The methodology used was to maintain two seeds per hole keeping plant to plant distance of 15 cm and row to row distance of 30 cm in three replications. Thinning and other agronomic practices were done timely to achieve good crop stand. At maturity 10 guarded plants were selected at random and data were recorded for spike length, number of tillers per plant, number of spikelets/spike, number of grains per spike, 1000-grain weight and grain yield per plant.

To estimate significant differences among parents and F_1 hybrids, the data were subjected to statistical analysis by using the analysis of variance technique (Steel & Torrie, 1980). Significant differences were further subjected to Duncan's New Multiple Range Test (DMR).

The percent increase or decrease of F_1 hybrids over mid parent as well as better parent was calculated to estimate possible heterotic effects for above mentioned parameters (Fonseca & Patterson, 1968).

$$Ht(\%) = \frac{F_1 - MP}{MP} \times 100$$

$$Hbt(\%) = \frac{F_1 - BP}{BP} \times 100$$

Where

Ht = Heterosis

Hbt = Heterobeltiosis

MP = Mid Parent Value
BP = Better Parent Value

The 't' test was manifested to determine whether F_1 hybrid means were statistically different from mid parent and better parent means as follows (Wynne *et al*., 1970).

$$tij = \frac{F_1 ij - MP}{\sqrt{3/8\,EMS}}$$

The 't' value for heterobeltiosis was calculated following the formula.

$$tij = \frac{F_1 ij - BP}{\sqrt{1/2\,EMS}}$$

Where
F_1 ij = The Mean of the ij^{th} F_1 cross
M.P ij = The mid parent for the ij^{th} cross
B.P ij = The better parent values for ij^{th} cross
EMS = Error mean square

RESULTS AND DISCUSSION

The analysis of variance for spike length, number of grains per spike, 1000-grain weight and grain yield per plant manifested highly significant differences between parents and F_1 crosses except for number of tillers/plant which is significant (Table I). The mean performance of parents and F_1 crosses regarding above mentioned traits is presented in Table II. The estimates of heterosis of F_1's over mid and better parent(s) for all five traits are presented in Table III.

Spike length. Maximum spike length was observed from Punjab-96 (15.50 cm) among parents and from Punjab-96 x 5039 (14.70 cm) among crosses. Positive heterosis over mid parent was observed from 6 crosses and positive heterosis over better parent was observed from 3 or 4 crosses out of 10 crosses. Kohistan 97 x 5039 showed highest value for heterosis i.e. 7.42% as well as for heterobeltiosis (6.24%). Similar results were reported by Iqbal *et al.* (1990), Wang *et al*. (1997) and Subhani *et al*. (2000).

Number of tillers per plant. Kohistan 97 gave maximum number of tillers per plant (17.20) among parents and from crosses, Kohistan 97 x 5039 showed maximum mean value (15.07) for this trait. All the crosses exhibited negative estimates for heterotic effects. While at the top was Kohistan 97 x 5039 (-2.14%) in case of mid parent heterosis and with regard to better parent heterosis, 5039 x 4943A was at maximum level (-9.34%). Chakraborty and Tewari (1995) and Knobel *et al*. (1997) also reported negative heterosis for this trait.

Number of spikelets per spike. Among parents, Punjab 96 contributed maximum mean value (23.30) for number of spikelets per spike. While among crosses Punjab 96 x 5039 showed maximum mean value (24.27) for this trait. In case of heterotic effects, Punjab 96 x 5039 contributed highest value for mid-parent heterosis (7.29%) as well as for better parent heterosis (6.59%). These results are in agreement with Iqbal *et al*. (1990) and Mujahid *et al*. (2000).

Number of grains per spike. Among parents MH-97 exhibited highest mean value (66.0) while among crosses, Punjab 96 x Kohistan 97 exhibited maximum mean value (67.33) for number of grains per spike.

Table I. Analysis of variance (mean square values) for different traits in wheat

S.O.V	df	Spike length	Tillers/ plant	Spikelets/ spike	Number of grains / spike	1000-grian weight	Grain yield/ plant
Replications	2	$0.0009^{N.S}$	$4.491^{N.S}$	$0.009^{N.S}$	$7.969^{N.S}$	$0.648^{N.S}$	$0.824^{N.S}$
Genotype	14	1.706**	7.907*	1.429**	53.862**	6.039**	21.420**
Error	28	0.272	3.467	0.095	5.296	0.778	2.567

* = Significant, **= Highly significant, N.S. = Non-significant

Table II. Mean performance and statistical significance for different traits in wheat

Genotypes	Spike length (cm)	Tillers per plant	Spikelets per spike	Grains per spike	1000-grain weight (g)	Grain yield per plant (g)
Punjab 96	15.50 a	14.20 ab	23.30 b	65.53 abc	38.69 b	19.70 cd
Kohistan 97	13.62 cde	17.20 a	21.43 f	51.00 g	35.95 de	21.17 bcd
MH 97	12.52 f	17.07 a	21.60 f	66.00 ab	35.47 e	22.75 bc
4943A	14.23 bcde	13.33 b	22.77 bcd	61.33 cdef	35.55 e	21.81 bcd
5039	13.31 ef	13.60 b	22.47 cd	61.67 bcdef	40.73 a	18.88 de
Punjab-96 x Kohistan-97	14.46 bcd	13.53 b	22.57 cd	67.33 a	35.59 e	26.91 a
Punjab-96 x MH-97	13.56 de	13.33 b	22.43 d	64.93 abcd	38.13 bc	20.11 bcd
Punjab-96 x 4943A	14.57 abc	12.87 b	22.43 d	63.40 abcde	37.77 bc	21.82 bcd
Punjab-96 x 5039	14.70 ab	12.13 b	24.27 a	65.67 abc	38.40 bc	16.27 e
Kohistan-97 x MH-97	13.38 ef	12.93 b	22.23 de	57.42 f	37.50 bcd	19.16 d
Kohistan-97 x 5039	14.47 bcd	15.07 ab	22.43 d	60.13 ef	37.40 bcd	21.73 bcd
MH-97 x 4943A	13.41 ef	12.80 b	23.03 bc	63.93 abcde	36.80 cde	21.32 bcd
MH-97 x 5039	13.66 cde	12.13 b	22.80 bcd	60.73 def	38.07 bc	16.19 e
4943A x Kohistan-97	14.65 ab	12.27 b	22.47 cd	62.53 bcde	37.82 bc	23.13 b
5039 x 4943A	13.61 cde	12.33 b	21.83 ef	57.67 f	37.69 bc	20.28 bcd

Means having the same letters do not differ significantly at 0.05 level of probability by Duncan's new multiple range test

Table III. Estimation of percent heterosis (Ht%) and heterobeltiosis (Hbt%) for different parameters

Crosses	Spike length		Tillers per plant		Spikelets per spike		Grains per spike		1000-grian weight		Grain yield per plant	
	Ht%	Hbt%	Ht%	Hbt%	Ht%	Hbt%	Ht%	Hbt%	Ht%	Hbt%	Ht%	Hbt%
Punjab-96xKohistan-97	-0.69 N.S	-6.71**	-13.82*	-21.33**	2.13*	-0.88 N.S	15.56**	2.75 N.S	-4.64**	-8.01**	31.65**	27.11**
Punjab-96xMH-97	-3.21 N.S	-12.52**	-14.76*	-21.91**	-2.65*	-3.73**	-1.27 N.S	-1.62 N.S	2.83*	-1.45 N.S	-5.27 N.S	-11.60*
Punjab-96x4943A	-2.02 N.S	-6.00**	-6.53 N.S	-9.36 N.S	1.08 N.S	-1.49 N.S	-0.05 N.S	-3.25 N.S	1.75 N.S	-2.38 N.S	5.13 N.S	0.05 N.S
Punjab-96x5039	2.01 N.S	-5.16*	-12.80 N.S	-9.57 N.S	7.29**	6.59**	3.25 N.S	0.21 N.S	-3.14*	-5.57**	-15.52**	-17.41**
Kohistan-97xMH-97	2.37 N.S	-1.76 N.S	-24.54**	-24.83**	-0.63 N.S	-4.59**	-1.85 N.S	-13.00 N.S	5.01**	4.31**	-12.75**	-15.78**
Kohistan-97x5039	7.42**	6.24*	-2.14 N.S	-12.38 N.S	2.19*	-0.18 N.S	6.74**	-2.50 N.S	-2.45*	-8.18**	8.49*	2.65 N.S
MH-97x4943A	0.22 N.S	-5.76*	-15.79*	-25.01**	2.58*	-1.16 N.S	0.42 N.S	-3.14 N.S	3.63*	3.52*	-4.31 N.S	-6.32 N.S
MH-97x5039	5.76*	2.63 N.S	-20.90**	-28.94**	-0.39 N.S	-2.15 N.S	-4.86*	-7.98**	-0.08 N.S	-6.53**	-22.22**	-28.84**
4943AxKohistan-97	5.17*	2.95 N.S	-19.62**	-28.66**	4.41**	4.03**	11.33**	1.96 N.S	5.79**	5.20**	7.63 N.S	6.05 N.S
5039x4943A	-1.16 N.S	-4.36 N.S	-8.46 N.S	-9.34 N.S	-0.95 N.S	-2.85*	-6.23**	-6.49**	-1.18 N.S	-7.46**	-0.34 N.S	-7.02 N.S

* = Significant, ** = Highly significant, N.S. = Non-significant

The estimates of heterotic effects showed that among crosses. The cross Punjab 96 x Kohistan 97 had maximum value (15.56%) for mid-parent heterosis as well for better parent heterosis (2.75%). Similar findings were reported by Chakraborty and Tewari (1995) and Wang *et al*. (1997).

1000-grain weight. The parent 5039 showed maximum 1000-grain weight (40.73 g) while among hybrids, Punjab 96 x 5039 revealed maximum mean value (38.46 g). Regarding heterotic estimates, 4943A x Kohistan 97 contributed maximum better parent heterosis i.e. 5.79% as well as maximum better parent heterosis i.e. 5.20%. The results are in agreement with the findings of Khaliq *et al*. (1985), Iqbal *et al*. (1990), and Khan and Khan (1996).

Grain yield per plant. Among parents MN-97 gave maximum grain yield per plant (22.75 g) while among crosses, it was maximum for Punjab 96 x Kohistan 97 (26.91 g). The estimates of heterotic effects revealed that maximum mid-parent and better parent heterosis was contributed by the cross Punjab 96 x Kohistan 97, 31.65% and 27.11%, respectively. Hybrid vigour expressed for this character had also been reported earlier by Khaliq *et al*. (1985), Iqbal *et al*. (1990), Krishna and Ahmad (1992), Ansari *et al*. (1998), Munir *et al*. (1999), Subhani *et al*. (2000), and Yagdi and Karan (2000).

CONCLUSIONS

It is concluded from present studies that cross Punjab 96 x Kohistan 97 could be further evaluated for selecting high yielding wheat genotypes due to its highest heterotic value for important yield related traits. i.e. number of grains per spike and grain yield per plant.

REFERENCES

Ansari, B.A., K.A. Ansari, A.M. Khushk, A.J. Malik and A.S. Larik, 1998. Evaluation of bread wheat hybrids for useful agronomic characters. *Pakistan J. Agri. Engg. Vet. Sci.*, 14: 23–5.

Briggle, L.W., 1963. Heterosis in wheat, a review. *Crop Sci.*, 3: 407–12.

Chakraborty, S.K. and V. Tewari, 1995. Heterosis in Bread Wheat. *J. Res. Bisra Agri. Univ.*, 7: 109–11.

Fonseca, S. and F.L. Patterson, 1968. Hybrid vigour in seven parental diallel cross in common wheat (*Triticum aestivum* L.). *Crop Sci.*, 8: 85–8.

Iqbal, M., K. Alam and M.A. Chowdhry, 1990. Exploitation of heterosis and heterobeltiosis for yield and its components in some intraspecific crosses of wheat. *Pakistan J. Agric. Sci*., 27: 73–9.

Khaliq, A., M.A. Chowdhry, G. Nabi and A.H. Shah, 1985. Study of heterosis in various intra–specific crosses of wheat. *J. Agric. Res.*, 23: 5–9.

Khan, M.A. and A.S. Khan, 1996. Heterosis studies for yield and yield components in some crosses of bread wheat. *Pakistan J. Agri. Sci.*, 33: 66–8.

Knobel, H.A., M.T. Labuschagne and C.S. Deventer, 1997. The expression of heterosis in the F_1 generation of a diallel cross of diverse hard red winter wheat genotypes. *Cereal Res. Communications*, 25: 911–5.

Krishna, R. and Z. Ahmad, 1992. Heterosis for yield components and development traits in spring wheat. *Genetika*, 24: 127–32.

Mujahid, M.Y., N.S. Kisana, Z. Ahmad, I. Ahmad, S.Z. Mustafa and A. Majid, 2000. Estimation and utilization of heterosis and heterobeltiosis in some bread wheat crosses derived from diverse germplasm. *Pakistan J. Biol. Sci.*, 3: 1148–51.

Munir, I., M.S. Swati, F. Muhammad, R. Ahmad and R.M. Imtiaz, 1999. Heterosis in different crosses of wheat. *Sarhad J. Agric.*, 15: 299–303.

Sajnani, D.N., 1968. Studies of hybrid vigour and combining ability in wheat diallel crosses. *Diss. Abst.*, 28: 4641B.

Steel, R.G.D. and J.H. Torrie, 1980. *Principles and Procedures of Statistics*, 2nd Ed., McGraw Hill Book Co., New York, USA.

Subhani, G.M., M.A. Chowdhry and S.M.M. Gillani, 2000. Manifestation of heterosis in bread wheat under irrigated and drought conditions. *Pakistan J. Biol. Sci.*, 3: 971–4.

Wang, Y., L. Shuren., Z. Yuijie and D. Yanling, 1997. Studies on testing and utilization of herterosis in spring wheat hybrids. *Acta Agri. Boreali-Sinica.*, 12: 17–21.

Wynne, J.C., D.A. Emery and P.H. Rice, 1970. Combining ability estimation in *Arachis hypogaea* L. 11. Field Performance of F_1 hybrids. *Crop. Sci.*, 10: 713–5.

Yagdi, K. and S. Karan, 2000. Hybrid vigour in common wheat. *Turkish. J. Agric. Forestry*, 24: 231–6.

(Received 13 February 2002; Accepted 20 March 2002)