Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 5, p. 143-148, 2014
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Heterotic studies in spring wheat across two environments

Manzoor Hussain[1], Ahsan Irshad[1*], Ali Ammar[1], Khalid Mahmood[1], Muhammad Kashif Aziz[1], Muhammad Raheel[1], Chaudhry Ghulam Hussain[1] and Seema Mahmood[2]

[1]*Regional Agriculture Research institute Bahawalpur, Pakistan*

[2]*Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan, Pakistan*

Article published on November 19, 2014

Key words: Triticum aestivum, environment, pavon, heterosis.

Abstract

Eight spring wheat genotypes were crossed in half diallel fashion for heterosis, heterobeltosis and inbreeding depression studies. Six traits including plant height, flag leaf area, number of tillers per plant, number of grains per spike, 1000-grian weight and grain yield per plant were recorded under two different environments (E_1 and E_2). Maximum heterosis and heterobeltosis (39.84%) and (23.29%), were exhibited in the crosses, Pavon / 076397 and 076396 / Aas-11, respectively under E_1. Highly significant heterosis (14.72%) was showed by the cross Pavon / 076396 while the cross Pavon / 076397 gave highly significant grain yield (8.74%) over better parent under E_2. As concerned inbreeding depression, superiority of F_1 over F_2 was observed in most of the crosses in both environments. For yield and some yield related traits, most of combinations exploited the significant inbreeding depression under both environmental conditions. Number of grains per spike was important for heterosis, while better tillering, high 1000 grain weight with less negative growth and dwarfness were important in some of the hybrid combinations.

***Corresponding Author:** Ahsan Irshad ✉ wows_88@yahoo.com

Introduction

Wheat is an important food crop of world, being grown on million hectares in different countries. With respect to green revolution, average yield of wheat was increased. Really it was proper time to have significant increase in production. But due to ever increasing population, there is dire need to increase yield of wheat also to shut the mouths of increasing people. Now it is said that there is need of a new green revolution. Though any possibility in science can not be rejected. F_1 hybrids in some crops are giving significant increase, there is need to search out hybrid vigor in all cereal crops. Similarly in wheat, yield can be increased by introducing hybrids. For hybrid studies, new combinations will have to be generated for increasing hybrid vigor. The term heterosis was proposed by Shull (1952). Singh *et al.* (2004) reported 125% increase in hybrid vigor. Yield of F1 hybrids over mid and BP ranged from 1.73 to 27.12% and 11.88 to 18.21%. The hybrid Koh-i-noor-83 x Mehran-89 displayed maximum heterosis of 27.12 and 18.21% over MP and BP, respectively and heterosis values tended to increase in cross between parents of increasing diversity (Kakar *et al.*, 1999). The heterosis for grain yield ranged from -23.87% to 27.30% in the early sown environment, from -11.60% to 56.71% in the normal sown environment and from -22.50% to 62.16% in the late sown condition. Similarly, heterobeltosis ranged from -26.93% to 13.30% in the early sown condition, from -20.06% to 44.30% in the normal sown condition, and from -26.63% to 36.37% in the late-sown environment (Joshi *et al.*, 2003). Hussain *et al.* reported that 96.4 % of total crosses gave significant positive heterosis and heterobeltosis ranging from 4.44 - 126.64% and 3.87- 114.23%, respectively for grain yield per plant. Inamullah *et al.* (2006) reported maximum positive heterosis for yield per plant over mid parent (56.25%) and maximum positive heterosis over better parent (26.87%).

Present studies were aimed to observe hybrid vigor among the available genetic material. Heterosis and heterobeltosis were estimated under two different environments.

Materials and methods

This experiment was conducted at research area of wheat at Regional Agricultural Research Institute, Bahawalpur. Eight genotypes viz; Seher-06, Fareed-06, Pavon, 076396, Kauz, Aas-11, Seri-82 and 076397 were sown and were crossed in half diallel fashion during 2009-10. 28 F_1 with their parents were sown during 2010-11. Similarly, F_2 was sown during 2011-12. The experiment was sown under two different environments i.e, 15th November and 15th December. Experiment was laid out according to triplicated RCBD was laid out keeping P x P distance as 15 cm with 5 meter single row. Ten guarded plants were selected for data recording. Data on six characters i.e; plant height, flag leaf area, number of tillers per plant, number of grains per spike, 1000-grain weight and grain yield per plant were recorded. Analysis of variance was done according to procedure described by Steel *et al.* (1997). Heterosis, heterobeltosis and inbreeding depression were computed as suggested by Fonsecca and Patterson (1968). Then t test was applied by using SE value on heterosis, heterobeltosis and inbreeding depression for all traits. Similar agronomic practices were applied to all experimental units. Heterosis, heterobeltosis and inbreeding depression was computed according to following formula.

H (%) = F_1- MP/ MP × 100

HB (%) = F_1- BP / BP × 100

Inbreeding depression (ID%) = F_1 - F_2 / F_1 x 100

SE (F_1 - F_2) = (2EMS / r) $^{1/2}$

Results and discussion

Analysis of variance (Table-1) for all traits under both environment i.e, E_1 and E_2, showed that there were significant differences in F_1 and F_2. This indicates that there was diversity in material used for identifying better cross combination for hybrid.

In this study, heterosis (better than mid parent) and heterobeltosis (better than better parent) have been worked out. The range of heterosis and number of crosses showing significant desirable heterosis over mid parent and better parent for all six traits have been presented in Table-3. Grain yield per plant is an important trait which has been selected in this study. Hence positive heterosis is desirable for this trait. Table-3 shows heterosis ranged from -16.55 to 39.84% and -14.55 to 14.72%, respectively under environment-1 and environment-2 ($E_1$and E_2) for grain yield per plant. The results are in agreement with Khan and Sher (1999), Chowdhry *et al.* (2001) and Chowdhry *et al.* (2005). Similarly, heterobeltosis ranged from -29.07% to 23.29% and -16.81 to 8.74% were exhibited under E_1 and E_2, respectively (Table 2).

In this study, results for grain yield per plant showed that out of 28 F_1, significant positive heterosis and heterobeltosis were recorded in 23 and 11 crosses, respectively under E_1 while 12 and 4 crosses exhibited significant positive heterosis and heterobeltosis under E_2, respectively (Table-2). The negative sign is desirable for plant height which showed significant and large scale variation among the genotypes for this particular trait. Eleven out of 28 crosses showed significant positive heterosis and five crosses exhibited significant positive heterobeltosis under E_1 for plant height. While 11 and three crosses depicted significant positive heterosis and heterobeltosis under E_2, respectively.

Table 1. Mean squares for yield and yield components in F_1 and F_2 generations.

S.O.V	Environment	Plant height (cm)		Flag leaf area (cm²)		Tillers per plant		Grains per spike		1000-grain weight (g)		Grain yield per plant (g)	
		F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Replication	E_1	3.89	4.10	1.60	3.30	1.58	6.7	0.23	0.20	8.62	0.12	5.06	3.90
	E_2	12.34	7.80	0.19	4.10	1.82	3.38	4.92	0.13	6.58	0.19	3.59	4.55
Genotype	E_1	30.62**	16.35	20.69**	8.7	2.36*	6.90	28.64**	17.50	11.81**	3.67	10.00**	7.11
	E_2	45.18**	11	17.63**	10.5	4.93**	7.55	16.97**	14	11.01**	3	9.42**	10.16
Error	E_1	3.02	2.15	1.50	3.16	1.11	2.12	3.51	4.07	4.19	1.75	4.22	1.21
	E_2	5.48	3.33	1.23	2.21	0.97	1.95	2.98	2.91	5.10	1.73	4.25	1.17

*Significant at 0.05, **significant at 0.01

Heterosis ranged from -13.42 to 6.71% and -13.94 to 12.27% under E_1 and E_2, respectively for plant height. While range of heterobeltosis for plant height was varied from -9.42 to 7.43% and -12.68 to 4.00% under E_1 and E_2, respectively (Table-3). For flag leaf area significant heterosis was observed by ten crosses and significant heterobeltosis displayed by five crosses under E_1. Similarly, under E_2, out of 28, seven and nine crosses explained significant heterosis and heterobeltosis for flag leaf area. As for as range is concerned, heterosis over mid parent ranged between -26.98 to 31.13% and -17.74 to 38.11% while heterosis for better parent ranged from -30.82 to 9.10 and -29.06 to 33.32% under E_1 and E_2, respectively as shown in table-3. Nine crosses showed significant positive heterosis and five crosses showed significant positive heterobeltosis under E_1 conditions while eight and seven crosses exhibited significant positive heterosis and heterobeltosis, respectively under E_2 for number of tillers per plant. Range for heterosis showed from -20.79 to 34.75% and -36.25 to 68.91% and heterobeltosis range varied from -19.01 to 19.30and -37.25 to 34.47% under E_1 and E_2 conditions, respectively (Table-3). For number of grains per spike, significant positive heterosis over mid and better parent was showed in nine and seven crosses, respectively under E_1 conditions. 12 crosses depicted significant positive heterosis and five crosses showed significant positive heterobeltosis under E_2. Table-3 showed range of heterosis over mid parent from -16.80 to 12.23% and -17.47 to 10.26% and over better parent from -17.93 to 15.00% and -20.39 to 8.66%, respectively under E_1 and E_2 conditions. The significant positive heterosis for 1000-grain weight was exhibited in 11crosses whereas, significant positive heterobeltosis showed by six crosses under E_1 conditions. Out of 28, ten and seven crosses displayed significant positive heterosis over mid and better parent under E_2 conditions shown in table-2. Range includes both minimum and maximum value of heterosis over mid parent and better parent. For 1000-grain weight, heterosis ranged from -15.42 to 13.00% and -16.74 to 18.72% under E_1 conditions whereas, range for heterobeltosis was from -13.71 to 7.27% and -19.47 to 6.60% under E_2 conditions (Table-3).

As concerned inbreeding depression, superiority of F_1 over F_2 was observed in most of the crosses in both environments. Only Maximum favorable plants observed in second filial generation of four crosses in E_1 and seven crosses in E_2. This shows that there was accumulation of favorable gene in F_2 under both conditions was important. Similarly, Singh *et al.,* (2004) reported superiority of F_2 over F_1 for grain yield under different environments. It is right heterosis is not simple but it is due to different traits independently associated with many traits it may be combination of different genes as reported by Mackay (1976). According to results, table-5 shows that number of grains per spike was vital in most of the combinations. While 1000-grain weight was important in timely planting. Dwarfness and low vegetation were also supporting the heterosis. Tillering and 1000-grain weight was important in E_1 conditions only. Singh *et al.*, (2004) also reported that number of grains per spike was supporting the heterosis. The results also indicates heterosis may be due to first two conditions as reported by Mackey (1976) and Singh *et al.*, (2004).

Table 2. Estimation of heterosis (H), heterobeltosis (HB) and inbreeding depression (ID) for grain yield per plant.

Sr. No.	Genotypes	E₁			E₂		
		H	HB	ID	H	HB	ID
1.	$P_1 \times P_2$	-0.68	-9.88*	3.20*	3.60*	1.32	4.10*
2.	$P_1 \times P_3$	7.25*	-8.64*	4.50*	-1.20	-5.74*	5.00*
3.	$P_1 \times P_4$	-2.99*	-25.29**	-2.80*	-1.44	-9.65*	3.21*
4.	$P_1 \times P_5$	-13.48*	-29.07**	-1.90*	-14.55**	-16.81**	1.90*
5.	$P_1 \times P_6$	-8.11*	-16.05*	2.35*	-5.41*	-9.09*	-3.12*
6.	$P_1 \times P_7$	2.74*	-8.54*	4.85*	4.50*	3.57*	4.00*
7.	$P_1 \times P_8$	11.45*	-9.88*	5.10*	2.83*	-1.80	2.25*
8.	$P_2 \times P_3$	-16.55*	-28.40**	3.22*	-9.77*	-13.39**	3.30*
9.	$P_2 \times P_4$	20.00*	-6.90*	2.75*	6.80*	-3.51*	4.80*
10.	$P_2 \times P_5$	14.08*	-5.81*	4.87*	2.30*	-1.77*	5.90*
11.	$P_2 \times P_6$	8.11*	7.38*	3.20*	-6.25*	-7.89*	6.00*
12.	$P_2 \times P_7$	10.20*	-1.22	1.28	-1.36	-2.68*	-3.10*
13.	$P_2 \times P_8$	31.82**	17.57*	0.95	9.09*	1.79*	0.28
14.	$P_3 \times P_4$	36.51**	-1.15	-4.46*	14.72**	-0.88	1.12
15.	$P_3 \times P_5$	9.77*	-15.12*	3.00*	-1.92*	-9.73*	3.25*
16.	$P_3 \times P_6$	17.14*	12.33*	6.50*	5.83*	-0.46	0.69
17.	$P_3 \times P_7$	7.25*	-9.76*	5.10*	-3.77*	-6.42*	2.64*
18.	$P_3 \times P_8$	39.84**	16.22*	1.20	12.00**	8.74*	-2.11*
19.	$P_4 \times P_5$	37.98**	3.49*	1.29	10.55*	-2.65*	-4.16*
20.	$P_4 \times P_6$	32.35**	23.29**	4.65*	6.86*	3.81*	0.32
21.	$P_4 \times P_7$	14.93*	-6.10*	-3.25*	1.48	-5.50*	3.66*
22.	$P_4 \times P_8$	36.13**	9.46*	4.00*	7.85*	0.98	2.65*
23.	$P_5 \times P_6$	3.50*	1.37	0.7	0.95	-4.07*	5.00*
24.	$P_5 \times P_7$	12.06*	-3.66*	1.01	-1.87*	-3.67*	4.20*
25.	$P5 \times P_8$	28.57**	9.46*	4.09*	1.98*	-1.90*	-3.72*
26.	$P_6 \times P_7$	2.70*	-7.32*	-1.11	-11.11**	-13.79**	-5.12*
27.	$P_6 \times P_8$	18.80*	5.33*	3.14*	-7.98*	-15.52**	-1.21
28.	$P_7 \times P_8$	32.82**	6.10*	2.22*	-1.94*	-7.34*	4.05*

*Significant at p - 0.05 and **significant at p - 0.01; P_1 – Seher 06, P_2 – Fareed 06, P_3 - Pavon, P_4 - 076396, P_5 – Kauz, P_6 – Aas 11, P_7 – Seri 82 and P_8 - 076397

Table 3. Range of heterosis and heterobeltosis for six traits in two different environments in bread wheat.

Characters	Range of heterosis (%) H E_1	H E_2	HB E_1	HB E_2	No. of crosses showing heterosis H E_1	H E_2	HB E_1	HB E_2
Plant height	-13.42-6.71	-13.94-12.27	-9.42-7.43	-12.68-4.00	7	8	6	1
Flag leaf area	-26.98-31.13	-17.74-38.11	-30.82-9.10	-29.06-33.32	6	6	1	5
Tillers per plant	-20.79-34.75	-36.25-68.91	-19.01-19.30	-37.25-34.47	3	5	2	4
Grains per spike	-16.80-12.23	-17.47-10.26	-17.93-15.00	-20.39-8.66	7	4	2	1
1000-grain weight	-15.42-13.00	-16.74-18.72	-13.71-7.27	-19.47-6.60	6	5	2	3
Grain yield per plant	-16.55-39.84	-14.55-14.72	-29.07-23.29	-16.81-8.74	20	5	7	1

Table 4. Better performing crosses for grain yield.

S.No	Crosses	H		HB	
		E_1	E_2	E_1	E_2
1	Pavon x 076397	39.84**	12.00**	16.22ns	8.74ns
2	076396 x Kauz	37.98**	10.55*	3.49ns	-2.65ns
3	Pavon x 076396	36.51**	14.72**	-1.15ns	-0.88ns

Table 5. Relation of significant desirable heterosis (BP) for grain yield with heterosis (BP) in other traits under two different environments in Bread wheat.

Crosses	Env.	Grain yield	Plant height	Flag leaf area	Tillers per plant	Grains per spike	1000-grain weight
$P_1 \times P_2$	E_1	3.43**	-5.02	-19.01*	2.50	1.61	-9.88
	E_2	2.84*	-13.99	-15.36	-0.83	1.89	3.60
$P_1 \times P_8$	E_1	6.94**	9.10**	-1.38	15.00**	2.42	-8.54
	E_2	1.79ns	-----	-----	-----	-----	------
$P_2 \times P_3$	E_1	3.13*	-2.10	-18.11	-1.27	-9.68*	-28.40**
	E_2	0.73	-----	------	------	------	------
$P_2 \times P_6$	E_1	-----	-----	------	-----	-----	-----
	E_2	2.55*	-4.75	-17.82*	-5.88	5.00	-6.25
$P_3 \times P_4$	E_1	2.01*	-13.21**	-1.66	5.84	4.03	-1.15
	E_2	2.18*	-23.00	-23.6**	-9.02**	-3.77	-0.88
$P_5 \times P_8$	E_1	4.24**	-1.08	-12.66	4.70	6.78	-3.66
	E_2	4.00**	7.77	14.56	-13.39	4.72	-3.67

References

Abdullah GM, Khan AS, Ali Z. 2002. Heterosis Study of Certain Important Traits in Wheat. International Journal of Agriculture and Biology, **4(3),** 326-328.

Chowdhry MA, Iqbal M, Subhani GM, Khaliq I. 2001. Heterosis, inbreeding depression and line performance in crosses of *Triticum aestivum*. Pakistan Journal of Biological Sciences. **4(1),** 56-58.

Chowdhry MA, Parveen N, Khaliq I, Kashif M. 2005. Estimation of heterosis for yield and yield components in bread wheat. Journal of Agriculture Social Sciences. **1(4),** 304-308.

Fonsecca SF, Patterson L. 1968. Hybrid vigour in seven-parent diallel cross in common wheat. Crop Sciences. **2,** 85-88.

Hussain F, Ashraf M, Mehdi SS, Ahmad MT. 2004. Estimation of heterosis for grain yield and its related traits in wheat (*Triticum aestivum*. L.) under leaf rust conditions. Journal of Biological Sciences. **4(5),** 637-644.

Inamullah Ahmad H, Mohammad F, Din SU, Hassan G, Gul R. 2006. Evaluation of heterotic and heterobeltiotic potential of wheat genotypes for improved yield. Pakistan Journal of Botany. **38(4),** 1159-1167.

Joshi SK, Sharma SN, Singhania DL, Sain RS. 2003. Hybrid vigor over environments in a ten-parent diallel cross in common wheat. SABRAO Journal of Breeding and Genetics. **35(2),** 81-91.

Kakar AA, Larik AS, Kumbhar MB, Anwar M, Naz MA. 1999. Estimation of heterosis, potence ratio and combining ability in bread wheat (*Triticumaestivum* L.). Pakistan Journal of Agricultural Sciences. **36(3-4),** 169-174.

Khan AS , Sher A. 1999. Estimation of heterotic effects for yield and its components in bread wheat (*Triticumaestivum* L.). Pakistan Journal of Biological Sciences. **2(3),** 928-930.

Mackey I. 1976. Genetics and evolutionary principles of heterosis. In: Janossy, A and Lupton, F. G. H. (eds), Heterosis of plant breeding. Proceeding 8th Congress Eucarpia Elsevier: 17-33.

Shull GH. 1952. Beginnings of the heterosis concept. In: Heterosis J. W. Gowen (Ed.). Lowa State College Press, Amsterdam. 14-48.

Singh H, Sharma SN, Sain RS. 2004. Heterosis studies for yield and its components in bread wheat over environments. Hereditas, **141**, 106-114.

Steel RGD, Torri JH, Dickey DA. 1997. Principles and procedures of statistics; A biometrical approach. 3rd Ed., McGraw Hill Book Cooperation. New York.