Biological Forum – An International Journal 15(2): 938-943(2023)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Exploitation of Heterosis for Yield and Yield Components in Wheat (*Triticum aestivum* L.)

Shubham Kumawat[1], Aarti Sharma[2], Arvind Kumar[3], Mayur Roshan Sahoo[3], Hemant Kumar Jaiswal[3] and Sunita Choudhary[4]*

[1]Ph.D. Scholar, Genetics and Plant Breeding Department, Govind Ballabh Pant University of Agriculture and Technology, Pant Nagar (Uttarakhand), India.
[2]Genetics and Plant Breeding Department, School of Agriculture, Lovely Professional University (Punjab), India.
[3]Genetics and Plant Breeding Department, Institute of Agricultural Sciences, BHU (Uttar Pradesh), India.
[4]Ph.D. Scholar, Genetics and Plant Breeding Department, College of Agriculture, Ummedganj, AU, Kota (Rajasthan), India.

(Corresponding author: Shubham Kumawat)*

(Received: 09 December 2022; Revised: 13 February 2023; Accepted: 17 February 2023; Published: 22 February 2023)
(Published by Research Trend)

ABSTRACT: The yield of the semi-dwarf wheat varieties hits a plateau which can be due to the restricted exploitation of the gene pool. Heterosis breeding provides ways to overcome yield barriers. Therefore, the present study aimed to investigate heterosis for grain yield and its components in the F_1 generation of wheat using Line × Tester analysis. A total of 79 genotypes, consisting of 22 parents (3 testers + 19 lines) and 57 crosses (F_1s), were grown in a Randomized Block Design with three replications. The percent heterosis over mid-parent and better parent was calculated for yield and yield components. The majority of crosses exhibited significant positive average heterosis and heterobeltiosis for yield and important yield attributing traits, showing the dominant nature of genes with a positive effect. Additionally, several crosses showed promising heterotic behaviour with negative heterosis for maturity-related attributes, indicating the dominance of genes with negative effects for these traits. The hybrids Atilla × HUWL-1723 and HUW-234 × DBW were found to be superior hybrids selected for grain yield since these crosses displayed significant positive heterosis over both the better and mid-parent for grain yield.

Keywords: Wheat, Heterosis, Heterobeltiosis, Line ×Tester, Yield, Dominance.

INTRODUCTION

Wheat (*Triticum aestivum* L. 2n = 42) is an important cereal. It is a member of the grass family Poaceae and has hexaploidy in nature, with three genomes AABBDD (Kumar *et al*., 2021). and the staple diet for more than 2.5 billion people worldwide. It offers 20% of dietary calories and protein globally, significantly contributing to food security (Sharma *et al*., 2022). It is an annual plant which belongs to the genus *Triticum* of the family Poaceae. It is assumed that the yield of the semi-dwarf wheat varieties hits a plateau which can be due to the restricted exploitation of the gene pool and genetic constituent of characters that leads to high yield. According to research studies, the use of heterosis can break the wheat yield plateau. Heterosis is the genetic expression of favorable effects of hybridization to increase or decrease in vigour of hybrids when compared with that of its parents (Joshi and Kumar 2020). Hybrid breeding is well-recognized in many cross-pollinated species but is still under development in wheat (Schwarzwalder *et al*., 2022). The use of heterosis in a self-pollinated crop like wheat is significantly determined by its magnitude and direction. The study on heterosis directly affects the breeding strategy to be used for varietal improvement. Investigation on heterosis also sheds light on the combining ability of the parents and their utilization in breeding programmes (Sharma *et al.,* 1986; Borghi *et al.,* 1988). The present study has been carried out using Line × Tester analysis (19 lines and 3 testers) to estimate the heterosis (%) over mid parent (MP) and better parent (BP) for grain yield and yield attributing characters in common bread wheat.

MATERIALS AND METHODS

The experimental materials for the present investigation comprised of 57 F_1's developed by crossing three testers or Females *viz*., HUW-234, Atilla, HD-3118 with 19 lines or Males *viz*., DBW 88, DBW 173, HD 3171, HI 1612, K 1317, PBW 723, DBW 150, KBRL 82-2, AKAW 4899, HI 1609, DBW129, DBW 187, KRL 386, HUWL-1730, HUWL-1727, HUWL-1726, HUWL-1725, HUWL-1723, HUWL-1731 in Line × Tester design during 2017-18 and evaluation were done at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *rabi* season 2018-19. A total of 79 treatments (genotypes) consisting of 22 parents (three testers + 19 lines) and 57 crosses (F_1s) were grown in a Randomized Block Design with three replications. The row to row distance was maintained at 22.5 cm and plant to plant distance at 10 cm. All the other recommended agronomic practices were followed to raise a healthy crop. Five competitive plant, in each plot of lines, testers and F_1's were randomly selected and observations were recorded for nine characters *viz*., Days to heading, Days to maturity, Plant height (cm), Spike Length (cm), Flag Leaf Length (cm), Number of Tillers per plant, Number of Grains per Spike, Test Weight (g) and Single Plant Yield (g). The data were subjected to statistical analysis for Analysis of Variance as per Panse and Sukhatme (1967). The heterosis (H%) and heterobeltiosis (HB%) were estimated as deviation of F_1 value from the mid-parent and the better-parent values as suggested by Matzinger *et al.* (1962); Fonseca and Patterson (1968), respectively.

RESULTS AND DISCUSSION

The analysis of variance for nine quantitative traits under investigation are presented in Table 1. The analysis of variance showed that the mean sum of squares due to treatments were found to be highly significant for all the nine traits under study. Significant differences among the parents and the crosses were also found for all the nine traits under study. The mean sum of squares due to parents vs crosses were also significant for all the traits except days to maturity, spike length, number of grains per spike and single plant yield. However, the mean sum of squares due to crosses was found to be significant for all the traits which indicates remarkable heterosis for these traits.

With respect to days to heading, 15 hybrids showed significant negative mid parent heterosis while seven hybrids displayed significant negative heterobeltiosis. Heterosis in negative direction was desirable because it resulted in early maturity. The cross HD-3118 × HI 1609 (-3.30 %) exhibited the highest significant negative heterosis over mid-parent whereas the cross Atilla × DBW 88 (-1.93 %) showed the highest significant negative heterosis over better parent. Similar findings were also observed previously by Lal *et al.* (2013); Patel *et al.* (2015); El Nahas and Ali. (2021). With regards to days to maturity, 26 hybrids showed significant negative mid parent heterosis and 14 hybrids displayed significant negative heterobeltiosis in desired direction. Cross Atilla × PBW 723 (-3.38 %) exhibited the highest significant negative heterosis over mid-parent while cross Atilla × DBW 88 (-2.39 %) exhibited the highest significant negative heterosis over better parent. Similar findings were also observed previously by Salgotra *et al.* (2002); Patel *et al.* (2015); Raiyani *et al.* (2016); Joshi and Kumar (2020).

The results for plant height demonstrated that 23 crosses exhibited significant negative heterosis over mid parent and nine crosses displayed highly significant negative heterosis over better parent which is desirable in case of plant height. Cross HUW-234 × AKAW 4899 (-7.37%) exhibited the highest significant negative heterosis over mid-parent whereas cross HUW-234 × AKAW 4899 (-6.43 %) exhibited the highest significant negative heterosis over better parent. Salgotra *et al.* (2002); Lal *et al.* (2013); Raj and Kandalkar (2013); Raiyani *et al.* (2016); Kumar *et al.* (2011); El Nahas and Ali (2021) have reported similar results which is in accordance to the present findings. The findings for spike length indicated that eight crosses displayed significant positive mid parent heterosis for this character while five crosses showed significant positive heterobeltiosis in the desired direction. Cross Atilla × HUWL-1723 (-10.38%) exhibited the highest significant positive heterosis over mid-parent whereas cross Atilla × HD 3171 (9.51 %) exhibited highest significant positive heterosis over better parent. Salgotra *et al.* (2002); Raj and Kandalkar (2013); Patel *et al.* (2015); Joshi and Kumar (2020); El Nahas and Ali (2021); Kumar *et al*. (2021); Shah *et al.* (2022) have reported similar results which support the finding of the present study.

In the study of flag leaf length, 36 crosses showed significant positive mid parent heterosis while 19 crosses showed significant positive heterobeltiosis. Cross Atilla × HD 3171 (31.82 %) exhibited the highest significant positive heterosis over mid-parent while cross Atilla × HD 3171 (31.68 %) showed the highest significant positive heterosis over better parent. Longer flag leaf length leads to higher flag leaf area which causes more contribution towards photosynthesis and hence positive heterosis is desirable in this trait. Significant heterosis in positive direction for higher flag leaf area has also been reported by Singh and Singh (2003); Vanpariya *et al.* (2006); Kumar *et al.* (2011); Raiyani *et al.* (2016); Dedaniya *et al.* (2018). For number of tillers per plant, four crosses over mid parent and two crosses over better parent observed to be significantly heterotic in positive direction. Cross HD-3118 × HUWL -1725 (26.39%) exhibited the highest significant positive heterosis over mid-parent which is highly desirable for this trait while the cross HD-3118 ×

HUWL -1723 (20.43 %) exhibited the highest significant positive heterosis over better parent. Vanpariya *et al.* (2006); Raiyani *et al.* (2016); Kumar *et al.* (2011); Kumar *et al*. (2021) reported similar results which support the present findings.

The findings for number of grains per spike indicated that six crosses displayed significant positive mid parent heterosis for this character while four crosses showed significant positive heterobeltiosis in the desired direction. Cross HUW-234 × HI 1609 (13.80 %) exhibited the highest significant positive heterosis over mid-parent while cross HUW-234 × HUWL-1730 (9.33 %) displayed the highest significant positive heterosis over better parent. Higher values of positive heterosis for this trait are favourable as it can lead to more number of grains per spike and thus more grain yield. Baloch *et al.* (2001); Salgotra *et al.* (2002); Dhadhal *et al.* (2008); Kumar *et al*. (2021) reported similar results which support the present findings. For test weight, 42 crosses over mid parent and 29 crosses over better parent were observed to be significantly heterotic in positive direction which is desired for this trait. Cross HUW-234 × DBW-187 (24.57 %) exhibited the highest significant positive heterosis over mid-parent whereas cross HUW-234 × DBW-187 (21.30 %) showed the highest significant positive heterosis over better parent. Salgotra *et al.* (2002); Singh *et al.* (2012); Joshi and Kumar (2020) reported similar results in their studies on wheat.

The results for single plant yield demonstrated that 12 crosses exhibited significant positive heterosis over mid parent and four crosses displayed highly significant positive heterosis over better parent which is desirable in case of single plant yield. Cross Atilla × HUWL-1723 (23.79%) showed the highest significant positive heterosis over mid-parent while cross Atilla × HUWL-1723 (20.49%) exhibited the highest significant positive heterosis over better parent. Similar findings were reported by Singh and Singh (2003); Singh *et al.* (2004); Vanpariya *et al.* (2006); Raj and Kandalkar (2013); Devi *et al.* (2013); Patel *et al.* (2015); El Nahas and Ali (2021); Kumar *et al.* (2021); Shah *et al.* (2022) which support the findings of the present study.

Table 1: Analysis of variance for seed yield and its component traits in wheat (*Triticum aestivum* L.)

Sources of Variation	DF	Days to Heading (Days)	Days to Maturity (Days)	Plant Height (cm)	Spike Length (cm)	Flag Leaf Length (cm)	No. of Tillers per plant	No. of Grains per Spike	Test Weight (g)	Single Plant Yield (g)
Replications	2	0.513	0.170	0.089	0.058	0.426	0.220	22.518 *	0.461 **	0.079
Treatments	78	7.204 **	8.002 **	44.010 **	1.701 **	7.871 **	3.185 **	49.570 **	40.752 **	20.532 **
Parents	21	12.539 **	13.232 **	50.080 **	2.195 **	10.473 **	2.589 **	45.453 **	16.685 **	14.178 **
Parents (Testers)	2	18.054 **	9.498 **	67.631 **	1.768 **	6.471 **	4.768 **	104.143 **	25.822 **	8.685 **
Parents (Lines)	18	12.436 **	14.170 **	44.609 **	2.318 **	11.189 **	2.226 **	34.059 **	16.417 **	12.793 **
Parents (L vs T)	1	3.352 **	3.834 **	113.447 **	0.823 *	5.580 **	4.755 *	133.154 **	3.227 **	50.100 **
Parents vs Crosses	1	1.797 **	0.156	75.844 **	0.242	39.301 **	7.308 **	20.462	251.969 **	0.001
Crosses	56	5.300 **	6.181 **	41.166 **	1.541 **	6.334 **	3.335 **	51.634 **	46.006 **	23.282 **
Error	156	0.222	0.266	0.494	0.124	0.199	0.700	6.710	0.089	1.023
Total	**236**	**2.532**	**2.822**	**14.873**	**0.645**	**2.736**	**1.517**	**21.010**	**13.531**	**7.463**

*, ** Significant at 5 per cent and 1 per cent levels, respectively.

Table 2: Estimation of heterosis (%) over mid- parent (MPH) and over better parent (BPH) for Days to Heading, Days to Maturity, Plant Height, Spike Length and Flag Leaf Length in Wheat (*Triticum aestivum* L.)

Sr. No.	Crosses	Days to Heading		Days to Maturity		Plant Height (cm)		Spike length (cm)		Flag leaf length (cm)	
		MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH
1.	HUW-234 × DBW 88	-1.47 **	0.62	-0.83 **	0.32	-2.35 **	5.69 **	-5.86 **	-6.67 **	11.38 **	10.66 **
2.	HUW-234 × DBW 173	-0.48	0.53	-1.30 **	-1.14 **	5.19 **	13.00 **	-6.21 **	-9.33 **	7.38 **	-3.68
3.	HUW-234 × HD 3171	2.77 **	4.07 **	-2.09 **	-1.40 **	-2.25 **	7.54 **	-1.41	-8.95 **	6.85 **	-1.1
4.	HUW-234 × HI 1612	-0.18	0.09	-1.19 **	-1.08 **	-0.72	4.73 **	-3.40 *	-3.67 *	-0.36	-2.13
5.	HUW-234 × K 1317	0.13	0.53	-0.57	-0.33	-2.01 **	1.29	0.95	0.57	7.79 **	6.25 **
6.	HUW-234 × PBW 723	-1.12 *	1.15 *	-3.04 **	-1.02 **	-3.45 **	2.74 **	-0.59	-3.81 *	3.08	-4.78 *
7.	HUW-234 × DBW 150	-1.63 **	1.32 *	-1.79 **	-1.13 **	-4.30 **	0.28	0.19	-0.75	8.45 **	2.57
8.	HUW-234 × KBRL 82-2	1.27 **	1.94 **	-0.79 **	-0.33	2.75 **	11.22 **	-4.09 **	-6.29 **	-3.67 *	-10.17 **
9.	HUW-234 × AKAW 4899	1.93 **	2.47 **	0.3	0.82 *	-7.37 **	-6.43 **	-9.70 **	-11.52 **	0.09	-6.68 **
10.	HUW-234 × HI 1609	0.48	1.15 *	-0.79 **	-0.22	-0.39	0.79	-8.92 **	-11.07 **	-2.37	-6.55 **
11.	HUW-234 × DBW 129	-0.57	0.53	-1.09 **	-0.89 *	6.26 **	11.21 **	1.17	-1.33	-4.70 **	-4.96 *
12.	HUW-234 × DBW-187	-0.48	0.44	-0.38	0.22	-1.03	4.76 **	-2.81	-4.57 **	9.44 **	3.31
13.	HUW-234 × KRL 386	-0.68	-0.09	-0.38	0.16	7.58 **	13.24 **	5.27 **	4.10 *	14.04 **	8.46 **
14.	HUW-234 × HUWL-1730	3.33 **	5.42 **	1.10 **	2.91 **	4.24 **	11.21 **	-6.36 **	-10.29 **	-3.52 *	-4.23 *
15.	HUW-234 × HUWL-1727	2.03 **	3.40 **	-0.27	0.88 *	-6.19 **	-0.75	-0.78	-3.62 *	-4.76 **	-8.10 **
16.	HUW-234 × HUWL-1726	2.80 **	3.44 **	0.19	1.27 **	-6.96 **	-1.48 *	4.06 **	2.48	-3.16	-7.38 **
17.	HUW-234 × HUWL-1725	3.04 **	4.54 **	0	0.77 *	-4.63 **	1.84 *	1.68	-2.29	24.53 **	22.24 **
18.	HUW-234 × HUWL-1723	1.05 *	1.68 **	-0.46	0.05	-0.66	5.68 **	-2.42	-4.00 *	17.05 **	15.44 **
19.	HUW-234 × HUWL-1731	2.23 **	3.53 **	-1.24 **	-0.81 *	-6.34 **	-2.49 **	1.21	0.72	25.11 **	21.14 **
20.	Atilla × DBW 88	-2.53 **	-1.93 **	-2.67 **	-2.39 **	1.03	3.25 **	0	-2.13	-2.5	-9.12 **
21.	Atilla × DBW 173	-1.70 **	-1.25 *	-1.18 **	-0.16	0.46	1.94 **	0.41	0	15.40 **	11.42 **
22.	Atilla × HD 3171	1.17 **	3.98 **	-1.17 **	-1.01 **	2.17 **	6.04 **	15.27 **	9.51 **	31.82 **	31.68 **
23.	Atilla × HI 1612	0.54	1.76 **	-0.64 *	0.32	-2.64 **	-2.38 **	-0.98	-4.17 *	5.64 **	-3.72
24.	Atilla × K1317	-0.67	0.39	0.24	1.36 **	1.04	3.32 **	0.49	-2.84	1.76	-6.96 **
25.	Atilla × PBW 723	-2.02 **	-1.24 *	-3.38 **	-2.23 **	-1.22	-0.66	1.12	0.81	21.95 **	21.55 **
26.	Atilla × DBW 150	-3.15 **	-1.71 **	-1.73 **	-1.54 **	2.80 **	3.73 **	4.76 **	0.75	27.71 **	24.95 **

27.	Atilla × KBRL 82-2	-1.14 **	-0.35	-0.35	0.98 **	-1.99 **	0.17	2.91	2.2	8.51 **	-5.72 **
28.	Atilla × AKAW 4899	-0.58	0.35	-1.16 **	0.22	-2.13 **	4.63 **	-1.63	-6.40 **	7.23 **	-6.84 **
29.	Atilla × HI 1609	-0.37	0.44	-1.26 **	0.16	-3.51 **	0.82	-4.50 **	-9.44 **	3.49	-7.90 **
30.	Atilla × DBW 129	-1.36 **	-0.99 *	-0.39	0.68	4.67 **	5.74 **	9.16 **	8.62 **	9.25 **	1.48
31.	Atilla × DBW 187	-1.23 **	-0.69	-0.38	1.09 **	-2.85 **	-2.79 **	3.80 *	2.57	12.57 **	10.35 **
32.	Atilla × KRL 386	-0.3	0.57	-0.11	1.31 **	-3.77 **	-3.32 **	-1.84	-5.77 **	9.09 **	-3.48
33.	Atilla × HUWL-1730	1.80 **	5.42 **	0.44	3.13 **	0.73	1.55 *	-2.56	-3.85 *	-11.40 **	-17.35 **
34.	Atilla × HUWL-1727	-0.26	2.58 **	0.22	2.26 **	-2.81 **	-2.79 **	4.35 **	4.24 *	3.52	-7.20 **
35.	Atilla × HUWL-1726	0.63	2.77 **	0.05	2.01 **	-2.07 **	-1.97 **	8.08 **	6.48 **	5.85 **	-5.87 **
36.	Atilla × HUWL-1725	1.43 **	4.45 **	-2.05 **	-0.44	-2.17 **	-1.29	0.61	-0.4	9.72 **	3.44
37.	Atilla × HUWL-1723	-1.23 **	-0.39	0.24	1.63 **	-0.99	-0.46	-10.38 **	-11.61 **	0.3	-5.86 **
38.	Atilla × HUWL-1731	0.81	3.62 **	-1.38 **	-0.96 **	-0.28	1.27	2.52	-0.98	17.10 **	11.87 **
39.	HD-3118 × DBW 88	0.57	4.62 **	-1.50 **	0.22	2.23 **	6.81 **	-4.83 **	-6.86 **	2.89	2.79
40.	HD-3118 × DBW 173	1.47 **	4.39 **	1.20 **	1.61 **	7.90 **	11.90 **	-3.40 *	-7.79 **	11.98 **	1.12
41.	HD-3118 × HD 3171	3.82 **	4.39 **	0.19	1.47 **	0.21	6.35 **	-0.58	-9.28 **	2.7	-4.29 *
42.	HD-3118 × HI 1612	-3.14 **	-1.10 *	-1.14 **	-0.68	3.34 **	5.30 **	-4.97 **	-5.94 **	6.73 **	4.08 *
43.	HD-3118 × K 1317	1.83 **	4.12 **	1.17 **	1.50 **	5.06 **	5.15 **	-5.06 **	-5.94 **	3.28	1.07
44.	HD-3118 × PBW 723	-0.09	4.12 **	-1.22 **	1.42 **	2.64 **	5.47 **	-1.36	-5.75 **	10.73 **	2.99
45.	HD-3118 × DBW 150	-0.35	4.57 **	0.16	1.42 **	4.85 **	6.16 **	-4.47 **	-4.82 **	13.81 **	8.40 **
46.	HD-3118 × KBRL 82-2	-2.90 **	-0.46	-1.47 **	-1.36 **	1.74 **	6.29 **	0.96	-2.6	-1.12	-8.43 **
47.	HD-3118 × AKAW 4899	4.92 **	7.41 **	3.05 **	3.11 **	3.66 **	8.37 **	-0.55	-1.28	6.78 **	-1.11
48.	HD-3118 × HI 1609	-3.30 **	-0.87	-0.98 **	-0.98 **	-1.29 *	0.9	-3.85 **	-4.90 **	5.92 **	0.67
49.	HD-3118 × DBW 129	0.93 *	3.93 **	1.40 **	1.77 **	-0.52	0.6	-2.12	-5.75 **	4.74 **	4.25 *
50.	HD-3118 × DBW 187	1.38 **	4.21 **	1.45 **	1.47 **	2.71 **	5.01 **	-5.84 **	-8.72 **	21.30 **	15.30 **
51.	HD-3118 × KRL 386	5.16 **	7.73 **	4.80 **	4.83 **	2.58 **	4.31 **	-2.97 *	-3.15	10.27 **	4.15 *
52.	HD-3118 × HUWL -1730	-1.56 **	-1.38 *	-1.10 **	0.08	-3.38 **	-0.46	-7.65 **	-12.62 **	-8.58 **	-8.58 **
53.	HD-3118 × HUWL -1727	4.94 **	5.44 **	2.22 **	2.81 **	-4.23 **	-2.13 **	-5.03 **	-8.91 **	-5.27 **	-9.25 **
54.	HD-3118 × HUWL -1726	3.03 **	4.25 **	2.11 **	2.62 **	0.38	2.67 **	-1.15	-3.90 *	4.59 **	-0.67
55.	HD-3118 × HUWL -1725	8.39 **	8.78 **	3.91 **	4.11 **	2.33 **	5.51 **	2.44	-2.78	5.66 **	4.48 *
56.	HD-3118 × HUWL -1723	0.18	2.65 **	1.85 **	1.91 **	-2.58 **	0.08	-3.34 *	-6.12 **	7.42 **	6.72 **
57.	HD-3118 × HUWL-1731	4.64 **	5.22 **	1.35 **	2.37 **	0.95	1.56 *	0.82	0	16.12 **	13.25 **
S.Em±		**0.3645**	**0.4209**	**0.3645**	**0.4209**	**0.4972**	**0.5741**	**0.2493**	**0.2878**	**0.3152**	**0.364**
RANGE		**-3.30 to 8.39**	**-1.93 to 8.78**	**-3.38 to 4.80**	**-2.39 to 4.83**	**-7.37 to 7.90**	**-6.43 to 13.00**	**-10.38 to 15.27**	**-12.62 to 9.51**	**-11.40 to 31.82**	**-17.35 to 31.68**
N		**38**	**41**	**38**	**41**	**42**	**43**	**28**	**37**	**43**	**41**
N +ve		**23**	**34**	**12**	**27**	**19**	**34**	**8**	**5**	**36**	**19**
N -ve		**15**	**7**	**26**	**14**	**23**	**9**	**20**	**32**	**7**	**22**

*, ** Significant at 5% and 1%, respectively, MPH= mid parent heterosis, BPH=Better parent heterosis

N, N +ve and N -ve: total, positive and negative significant heterotic crosses respectively.

Table 3: Estimation of heterosis (%) over mid- parent (MPH) and over better parent (BPH) for No. of Tillers per plant, No. of Grains per Spike, Test weight and Single Plant Yield in Wheat (*Triticum aestivum* L.)

Sr. No.	Crosses	No. of tillers per plant		No. of grains per spike		Test weight (gm)		Single plant yield (gm)	
		MPH	BPH	MPH	BPH	MPH	BPH	MPH	BPH
1.	HUW-234 × DBW 88	-26.97 **	-36.81 **	11.67 **	6.06	2.82 **	0.02	-15.30 **	-17.88 **
2.	HUW-234 × DBW 173	-16.13 **	-24.64 **	8.30 *	7.09	5.01 **	4.69 **	0.82	-6.56
3.	HUW-234 × HD 3171	-18.98 **	-26.38 **	2.23	-2.66	14.70 **	10.44 **	-6.2	-6.44
4.	HUW-234 × HI 1612	-11.82 *	-20.00 **	3.24	-1.53	4.90 **	2.31 **	3.67	3.53
5.	HUW-234 × K 1317	-25.55 **	-29.28 **	-7.09	-7.79	11.74 **	9.94 **	-20.50 **	-21.49 **
6.	HUW-234 × PBW 723	-11.79	-25.22 **	-3.52	-3.72	18.89 **	17.18 **	18.50 **	4.82
7.	HUW-234 × DBW 150	-7.12	-13.04 *	11.77 **	11.27 *	17.91 **	13.70 **	14.43 **	9.55 *
8.	HUW-234 × KBRL 82-2	-10.6	-20.58 **	-6.28	-12.20 **	18.30 **	15.57 **	9.07 *	3.62
9.	HUW-234 × AKAW 4899	-21.73 **	-26.38 **	-18.16 **	-20.33 **	-12.56 **	-18.01 **	-36.44 **	-41.75 **
10.	HUW-234 × HI 1609	-8.35	-18.84 **	13.80 **	9.05 *	11.25 **	9.32 **	17.96 **	6.51
11.	HUW-234 × DBW 129	-11.33	-21.74 **	-5.99	-9.16 *	22.08 **	20.91 **	14.38 **	7.84
12.	HUW-234 × DBW-187	-10.78	-22.03 **	4.76	2.91	24.57 **	21.30 **	23.12 **	14.53 **
13.	HUW-234 × KRL 386	-18.11 **	-19.42 **	6.3	3.65	5.83 **	3.54 **	-1.22	-1.42
14.	HUW-234 × HUWL-1730	-5.6	-19.42 **	12.13 **	9.33 *	1.64 **	0.37	14.84 **	1.71
15.	HUW-234 × HUWL-1727	-22.46 **	-30.43 **	-6.58	-10.35 *	13.23 **	13.02 **	-3.82	-6.86
16.	HUW-234 × HUWL-1726	-16.48 **	-22.90 **	10.98 **	8.91 *	20.56 **	12.78 **	15.76 **	1.69
17.	HUW-234 × HUWL-1725	-22.54 **	-25.80 **	-1.3	-1.75	15.46 **	15.36 **	-5.9	-6.65
18.	HUW-234 × HUWL-1723	-15.55 **	-25.22 **	-17.30 **	-19.07 **	18.26 **	18.04 **	6.54	1
19.	HUW-234 × HUWL-1731	-9.55	-21.74 **	8.82 *	3.3	11.43 **	5.63 **	14.22 **	-6.14
20.	Atilla × DBW 88	9.77	4.29	-10.37 **	-11.62 **	-9.17 **	-14.82 **	-23.94 **	-28.17 **
21.	Atilla × DBW 173	11.71	10.71	-0.38	-5.13	-9.58 **	-13.18 **	2.52	-2.51
22.	Atilla × HD 3171	-0.71	-1.06	-6.42	-7.49	-0.67	-0.69	-16.75 **	-19.18 **
23.	Atilla × HI 1612	-3.03	-3.2	-9.65 **	-10.51 *	-1.55 **	-7.43 **	-18.21 **	-20.50 **
24.	Atilla × K1317	3.98	-1.13	-1.21	-5.58	0.05	-5.13 **	5.58	4.04
25.	Atilla × PBW 723	3.85	-3.57	-3.95	-7.73	-6.06 **	-10.78 **	-8.64	-17.21 **
26.	Atilla × DBW 150	-8.43	-11.63	-5.71	-8.83 *	-2.97 **	-3.10 **	-19.51 **	-20.87 **
27.	Atilla × KBRL 82-2	-4.38	-6.43	-6.78	-9.38 *	14.61 **	12.94 **	12.57 **	9.81 *
28.	Atilla × AKAW 4899	-8.22	-11.84	-17.50 **	-18.44 **	11.91 **	8.84 **	-5.69	-11.35 *
29.	Atilla × HI 1609	0	-2.5	-15.04 **	-21.49 **	-0.24	-5.52 **	-6.32	-13.29 **
30.	Atilla × DBW 129	9.56	6.43	4.69	4.29	-2.70 **	-7.16 **	0.02	-3.2
31.	Atilla × DBW 187	15.99 *	11.43	-4.54	-6.49	-1.93 **	-3.04 **	-0.08	-4.63
32.	Atilla × KRL 386	-17.92 **	-24.55 **	-2.35	-8.25 *	-3.92 **	-9.39 **	-26.27 **	-28.09 **
33.	Atilla × HUWL-1730	6.49	-0.36	0.48	-5.58	-8.24 **	-12.69 **	-2.69	-11.71 *

34.	Atilla × HUWL-1727	-6.14	-7.14	-18.83 **	-19.10 **	1.36 *	-2.56 **	-20.72 **	-21.13 **
35.	Atilla × HUWL-1726	-5.94	-7.88	-7.01	-12.08 **	-3.00 **	-5.89 **	-23.89 **	-31.51 **
36.	Atilla × HUWL-1725	-18.79 **	-23.42 **	-28.59 **	-31.56 **	-15.04 **	-18.25 **	-48.89 **	-50.64 **
37.	Atilla × HUWL-1723	4.03	1.43	8.42 *	6.62	11.63 **	7.31 **	23.79 **	20.49 **
38.	Atilla × HUWL-1731	-4.51	-9.29	-10.79 **	-18.31 **	4.34 **	2.64 **	-8.09	-22.80 **
39.	HD-3118 × DBW 88	-0.56	-5.38	-9.48 **	-14.28 **	-1.42 **	-2.38 **	-9.65 **	-11.93 **
40.	HD-3118 × DBW 173	-11.91	-12.54	2.12	-8.80 *	11.22 **	7.49 **	7.64 *	-5.22
41.	HD-3118 × HD 3171	-18.72 **	-19.15 **	-6.45	-11.63 **	7.13 **	-0.47	-15.26 **	-19.66 **
42.	HD-3118 × HI 1612	-27.86 **	-28.11 **	-17.24 **	-21.95 **	-8.42 **	-9.55 **	-45.05 **	-47.96 **
43.	HD-3118 × K 1317	1.1	-4.03	-11.20 **	-20.43 **	9.82 **	7.50 **	-7.77 *	-13.80 **
44.	HD-3118 × PBW 723	-0.58	-7.53	-3.35	-12.98 **	7.45 **	5.01 **	-16.14 **	-29.32 **
45.	HD-3118 × DBW 150	11.72	7.64	-7.41 *	-16.14 **	10.25 **	2.58 **	2.94	-6.55
46.	HD-3118 × KBRL 82-2	10.42	8.24	-7.02 *	-10.72 **	3.72 **	-2.27 **	-1.41	-11.15 **
47.	HD-3118 × AKAW 4899	-11.15	-14.80 *	-11.93 **	-18.57 **	10.58 **	0.16	-7.43	-19.35 **
48.	HD-3118 × HI 1609	-8.99	-11.11	-3.83	-16.48 **	6.66 **	4.55 **	2.65	-11.81 **
49.	HD-3118 × DBW 129	-27.81 **	-29.75 **	-4.85	-11.40 **	3.21 **	0.38	-28.05 **	-35.62 **
50.	HD-3118 X DBW 187	3.54	-0.36	-13.70 **	-20.88 **	8.55 **	1.94 **	-4.28	-15.43 **
51.	HD-3118 × KRL 386	-27.57 **	-33.53 **	-0.32	-12.08 **	6.93 **	5.26 **	-9.28 *	-14.36 **
52.	HD-3118 × HUWL -1730	-2.87	-8.96	-4.67	-15.91 **	2.44 **	-0.08	-1.48	-16.87 **
53.	HD-3118 × HUWL -1727	-8.86	-9.68	-11.80 **	-17.33 **	1.42 **	-2.11 **	-15.51 **	-22.47 **
54.	HD-3118 × HUWL -1726	14.89 *	12.33	-0.25	-11.51 **	13.53 **	2.60 **	4.44	-12.54 **
55.	HD-3118 × HUWL -1725	26.39 **	18.99 **	0.5	-9.71 **	-0.99	-4.52 **	5.86	0.88
56.	HD-3118 × HUWL -1723	23.30 **	20.43 **	-3.83	-11.51 **	8.62 **	4.85 **	4.02	-6.44
57.	HD-3118 × HUWL-1731	-13.37 *	-17.56 *	-9.45 **	-22.01 **	1.58 **	-7.03 **	-17.21 **	-34.85 **
S.Em±		**0.5914**	**0.6829**	**1.8316**	**2.115**	**0.2105**	**0.2431**	**0.7151**	**0.8258**
Range		**-27.86 to 26.39**	**-36.81 to 20.43**	**-28.59 to 13.80**	**-31.56 to 9.33**	**-15.04 to 24.57**	**-18.01 to 21.30**	**-48.89 to 23.79**	**-47.96 to 14.53**
N		**22**	**29**	**26**	**39**	**54**	**50**	32	35
N +ve		**4**	**2**	**6**	**4**	**42**	**29**	12	4
N -ve		**18**	**27**	**20**	**35**	**12**	**21**	20	31

*, ** Significant at 5% and 1%, respectively, MPH= mid parent heterosis, BPH=Better parent heterosis
N, N +ve and N -ve : total, positive and negative significant heterotic crosses respectively.

Table 4: Top three best heterotic crosses for various characters.

Characters	**Best three heterotic crosses over**	
	Mid parent	**Better parent**
Days to Heading	HD-3118 × HI 1609	Atilla × DBW 88
	Atilla × DBW 150	Atilla × DBW 150
	HD-3118 × DBW 129	HD-3118 × DBW 187
Days to maturity	Atilla × PBW 723	Atilla × DBW 88
	HUW-234 × PBW 723	Atilla × PBW 723
	Atilla × DBW 88	Atilla × DBW 150
Plant Height (cm)	HUW-234 × AKAW 4899	HUW-234 × AKAW 4899
	HUW-234 × HUWL-1726	Atilla × KRL 386
	HUW-234 × HUWL-1731	Atilla × DBW 187
Spike length (cm)	Atilla × HD 3171	Atilla × HD 3171
	Atilla × DBW 129	Atilla × DBW 129
	Atilla × HUWL-1726	Atilla × HUWL-1726
Flag leaf length (cm)	Atilla × HD 3171	Atilla × HD 3171
	Atilla × DBW 150	Atilla × DBW 150
	HUW-234 × HUWL-1731	HUW-234 × HUWL-1725
No. of tillers per plant	HD-3118 × HUWL -1725	HD-3118 × HUWL -1723
	HD-3118 × HUWL -1723	HD-3118 × HUWL -1725
	Atilla × DBW 187	HUW-234 × DBW 150
No. of grains per spike	HUW-234 × HI 1609	HUW-234 × DBW 150
	HUW-234 × HUWL-1730	HUW-234 × HUWL-1730
	HUW-234 × DBW 150	HUW-234 × HI 1609
Test weight (gm)	HUW-234 × DBW-187	HUW-234 × DBW-187
	HUW-234 × DBW 129	HUW-234 × DBW 129
	HUW-234 × HUWL-1726	HUW-234 × HUWL-1723
Single plant yield (gm)	Atilla × HUWL-1723	Atilla × HUWL-1723
	HUW-234 × DBW-187	HUW-234 × DBW-187
	HUW-234 × PBW 723	Atilla × KBRL 82-2

CONCLUSIONS

The current study found that the majority of crosses had positive significant average heterosis and heterobeltiosis for yield and key yield attributing traits, implying the dominance nature of genes with a positive effect. Furthermore, a number of crosses displayed favourable heterotic behaviour with negative heterosis for maturity-related attributes, indicating that the genes with negative effects were dominant for these characters. Thus, it can be concluded that the hybrids namely Atilla × HUWL-1723 and HUW-234 × DBW- were found to be superior hybrids selected for grain yield since these crosses exhibited significant positive heterosis over both the better and mid parent for grain yield.

FUTURE SCOPE

The present findings based on heterotic performance of cross combinations could be used in future breeding programmes to create a good heterotic gene pool of wheat for boosting grain yield and other contributing attributes.

Acknowledgement. The authors are extremely acknowledged to the Department of Genetics & Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.) for providing the research material, necessary facilities and field assistance for conducting the experiment.

Conflict of Interest. None.

REFERENCES

Baloch, M. Z., Ansari, B. A., Memon, N., Kumbhar, M. B. and Soomro, A. (2001). Combining ability and heterotic performance of some agronomic traits in bread wheat (*Triticum aestivum* L.). *Pakistan Journal of Biological Sciences*, *4*(2), 138-140.

Borghi, B., Perenzin, M. and Nash, R. J. (1988). Agronomic and qualitative characteristics of ten bread wheat hybrids produced a chemical hybridizing agent. *Euphytica*, *39,* 185-194.

Dedaniya, A. P., Pansuriya, A. G., Vekaria, D. M., Memon, J. T. and Vekariya, T. A. (2018). Estimation of heterosis in different crosses of bread wheat (*Triticum aestivum* L.). *International Journal of Chemical Studies*, *6*(3), 3622-3628.

Devi, E., Goel, P., Singh, M. and Jaiswal, J., (2013). Heterosis studies for yield and yield contributing traits in bread wheat (*Triticum aestivum* L.). *The Bioscan*, *8*(3), 905-909.

Dhadhal, B. A., Dobariya, K. L., Ponkia, H. P. and Jivani, L. L. (2008). Gene action and combining ability over environments for grain yield and its attributes in bread wheat (*Triticum aestivum* L.). *International Journal of Agricultural Science and Research*, *4*(1), 66-72.

El Nahas, M. M. and Ali, O. A. (2021). Estimation of combining ability and heterosis for wheat yield and its components under water stress conditions. *Egyptian Journal of Agronomy*, *43*(2), 277-293.

Fonseca, S. and Patterson, F. L. (1968). Hybrid vigour in seven parent diallel cross in common wheat (*Triticum aestivum* L.). *Crop Sci., 8*, 85–88.

Joshi, A. and Kumar, A. (2020). Heterosis for yield and its contributing traits in wheat. *Journal of Crop and Weed*, *16*(3), 09-22.

Kumar, A., Swati, S. A., Joshi, A., Kumar, L., Bharati, A., Prasad, B. and Kumar, A. (2021). Heterotic performance of Morpho-Physiological Traits for Heat Tolerance in Bread Wheat (*Triticum aestivum* L.). *Biological Forum–An International Journal*, *13*(3b), 16-24.

Kumar, A., Mishra, V. K., Vyas, R. P. and Singh, V. (2011). Heterosis and combining ability analysis in bread wheat (*Triticum aestivum L.). Journal of Plant Breeding and Crop Science, 3*(10), 209-217.

Lal, C., Kumar, V. and Maloo, S. R. (2013). Heterosis and inbreeding depression for some quantitative and heat tolerance characters in bread wheat (*Triticum aestivum* L.). *Journal of Wheat Research*, *5*(2), 52-55.

Matzinger, D. F., Mannand, T. J. and Cockerham, C. C. (1962). Diallel cross in Nicotiana tabacum. *Crop Sci*., *2*, 238-286.

Panse, V. G. and Sukhatme, P. V. (1967). Statistical methods of agricultural workers. ICAR publication, New Delhi.

Patel, D., Moitra, P. K., Shukla, R. S. and Singh, S. K. (2015). Heterosis and combining ability estimates in partial diallel crosses of bread wheat (*Triticum aestivum* L.). *Trends in biochemical sciences*, *8*(19), 5321-5329.

Raiyani, A. M., Kapadia, V. N., Boghara, M. C., Bhalala, K. C. and Patel, D. A. (2016). Estimation of heterosis in different crosses of bread wheat (*Triticum aestivum* L.). *The Bioscan*, *11*(2) 1117-1121.

Raj, P. and Kandalkar, V. S. (2013). Combining ability and heterosis analysis for grain yield and its components in wheat, *Journal of Wheat Research*, *5*(1), 45-49.

Salgotra, R. K., Thakur, K. S., Sethi, G. S. and Sharma, J. K. (2002). Heterosis in winter × spring wheat crosses. *The Indian Journal of Genetics* and *Plant Breeding*, *62*(2), 104-106.

Schwarzwalder, L., Thorwarth, P., Zhao, Y., Reif, J. C. and Longin, C. F. H. (2022). Hybrid wheat: quantitative genetic parameters and heterosis for quality and rheological traits as well as baking volume. *Theoretical and Applied Genetics*, *135*(4), 1131-1141.

Shah, A. H., Rattar, T. M., Zhang, D., Tian, L., Solangi, Z. A., Rattar, Q. A., Rattar, M. J., Memon, S. A., Ali, B., Memon, S., Nizamani, S., Ali, S., Abro, A. A. and Anwar, M. (2022). Heterosis and correlation studies in F_1 hybrids of hexaploid wheat (*Triticum aestivum* L.) cultivars. *World Journal of Biology Pharmacy and Health Sciences, 11*(03), 119-131.

Sharma, R., Rana, V., Verma, S., Gupta, C., Priyanka, R. A. and Aparajita, D. (2022). Genetic Variability Studies in Bread Wheat (*Triticum aestivum* L.) under Multi-Environment Trials in Northern Hills Zone. *Biological Forum–An International Journal*, *14*(2), 307-313.

Sharma, S. K., Singh, I. and Singh, K. P. (1986). Heterosis and combining ability in wheat. *Crop improvement, 13*, 101-/103.

Singh, H., Sharma, S. N. and Sain, R. S. (2004). Heterosis studies for yield and its components in bread wheat over environments. *Hereditas*, *141*(2), 106-114.

Singh, K. H. and Singh, T. B. (2003). Combining ability and heterosis in wheat. *Indian Journal of Agricultural Research*, *37*(4), 274-278.

Singh, V., Krishna, R., Singh, S. and Vikram, P. (2012). Combining ability and heterosis analysis for yield traits in bread wheat (*Triticum aestivum* L.). *Indian Journal of Agricultural Sciences*, *82*(11), 916.

Vanpariya, L. G., Chovatia, V. P. and Mehta, D. R. (2006). Heterosis for grain yield and its attributes in bread wheat (*Triticum aestivum* L.). *National Journal of Plant Improvement*, *8*(2), 100-102.

How to cite this article: Shubham Kumawat, Aarti Sharma, Arvind Kumar, Mayur Roshan Sahoo, Hemant Kumar Jaiswal and Sunita Choudhary (2023). Exploitation of Heterosis for Yield and Yield Components in Wheat (*Triticum aestivum* L.). *Biological Forum – An International Journal*, *15*(2): 938-943.