Biological Forum – An International Journal 16(7): 240-245(2024)

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

Exploitation of Heterosis for Grain Yield and Yield Component Traits in Bread Wheat (*Triticum aestivum* L.) over Environments

Sunita Choudhary[1]*, N.R. Koli[2], S.C. Sharma[2], D.S. Meena[3], K.M. Sharma[3], C.B. Meena[4] and Narendra Padra[1]

[1]Ph.D. Scholar, Department of Genetics and Plant Breeding, College of Agriculture, Ummedganj, Agriculture University, Kota (Rajasthan), India.
[2]Associate Professor, Department of Genetics and Plant Breeding, Agriculture Research Station, Ummedganj, Agriculture University, Kota (Rajasthan), India.
[3]Associate Professor, Department of Agronomy, Agriculture Research Station, Ummedganj, Agriculture University, Kota (Rajasthan), India.
[4]Associate Professor, Department of Plant Pathology, Agriculture Research Station, Ummedganj, Agriculture University, Kota (Rajasthan), India.

(Corresponding author: Sunita Choudhary)*
(Received: 01 May 2024; Revised: 19 May 2024; Accepted: 03 June 2024; Published: 15 July 2024)
(Published by Research Trend)

ABSTRACT: The yield of the semi-dwarf wheat varieties hits a plateau which can be due to the limited 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 under three different environmental conditions *viz.,* Early sowing (30/10/2022) (E_1), Normal sowing (17/11/2022) (E_2) and Late sowing (05/12/2022) (E_3) during *Rabi*, 2022-23. A total of 36 genotypes, consisting of one check, 11 parents (3 testers + 8 lines) and 24 crosses (F_1s), were grown in a Randomized Block Design with three replications. The percent heterosis over mid-parent, better parent and standard check was calculated for yield and yield contributing components. The majority of crosses exhibited significant positive average heterosis, heterobeltiosis and standard heterosis for grain 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 flowering and maturity-related attributes, indicating the dominance of genes with negative effects for these traits. The F_1s, Raj 4037 × Raj 4238, Raj 3077 × DBW 110, Raj 3765 × Raj 4079 and GW 322 × Raj 4079 were considered as the best heterotic hybrids for grain yield so these hybrids may be utilized to obtain desirable genotypes in wheat. For protein content and zinc content Raj 4037 × DBW 110 and Sonalika × Raj 4238 considered as better hybrids respectively.

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

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops, providing food for more than one-third of the world's population which belongs to genus *Triticum* and family Poaceae. It is a staple food source for a large population of the world and also provides a range of diversified baked food products. It offers 20% of dietary calories and protein globally, significantly contributing to food security (Sharma *et al*., 2022). 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). 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.

MATERIALS AND METHODS

Experimental material was developed through 24 crosses between 3 testers *viz*., Raj 4079, Raj 4238 and DBW 110 and 8 lines *viz*., Raj 3077, Raj 3765, Raj 3777, Raj 4037, Raj 4120, Sonalika, Kalyan Sona and GW 322 in Line × Tester design during *Rabi*, 2021-22. Subsequently, the resulting 24 F_1s crosses along with parents (lines and testers) and standard check (HI 1544) were evaluated at ARS, Ummedganj, Kota, Rajasthan under three different environmental conditions *viz.,* Early sowing (30/10/2022) (E_1), Normal sowing (17/11/2022) (E_2) and Late sowing (05/12/2022) (E_3) during *Rabi*, 2022-23. Recommended cultural practices were adopted in order to raise a healthy crop. The observations were recorded for 12 characters *viz.,* days to 50% flowering, days to 75% maturity, plant height (cm), number of effective tillers per plant, number of grains per head, test weight (g), biological yield per plant (g), grain yield per plant (g), harvest index (%), protein content (%), zinc content (ppm) and iron content (ppm) in grains (The iron and zinc estimation were done by using Atomic Absorption Spectrophotometer by following the method proposed by Jackson (1973). Heterosis was estimated for 24 hybrids for 12 characters using the formulae given by Fonseca and Patterson (1968) and Standard heterosis according to Meredith and Bridge (1972).

RESULTS AND DISCUSSION

Pooled analysis of variance (Table 1) for testers were highly significant for all the traits except number of effective tillers per plant, number of grains per head, biological yield per plant, grain yield per plant and harvest index. Pooled analysis of mean squares due to lines vs. testers showed significant variation for most of the characters except biological yield per plant and protein content. The pooled analysis of variance due to parents vs. hybrids indicated significant response for all characters except days to 50% flowering and days to 75% maturity over environments. Highly significant variance observed due to hybrids in the pooled analysis for all the component traits indicating presence of considerable amount of variability among parents.

Mean squares due to genotype × environment revealed influence of environmental variation for all the traits under study except days to 50% flowering, days to 75% maturity, plant height, protein content, zinc content and iron content in grains. Variance due to different environmental conditions exhibited differential response rate for all the component traits.

With respect to Days to 50 % flowering, 13, 15 and 7 hybrids showed significant negative mid parent heterosis, better parent heterosis and standard heterosis, respectively over pooled basis (Table 2). The cross GW 322 × Raj 4238 exhibited the highest significant negative heterosis over mid-parent (-5.15%) and heterobeltiosis (-8.84%). Whereas the crosses GW 322 × Raj 4079 (-4.15%) and Raj 3765 × Raj 4079 (-4.15%) showed the highest significant negative standard heterosis. For Days to 75 % maturity, 11, 16 and 6 hybrids showed significant negative mid parent heterosis, better parent heterosis and standard heterosis, respectively over pooled basis. Heterosis in negative direction was desirable because it resulted in early maturity (Table 2). Similar findings were reported by Desale and Mehta (2013); Dhoot *et al*. (2020); Malav *et al.* (2020) in wheat.

Table 1: Pooled Analysis of variance (M.S.S.) for different characters in bread wheat (*Triticum aestivum* L.).

Source of variation	DF	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	No. of effective Tillers per Plant	No. of grains per head	Test Weight (g)	Grain Yield per Plant (g)	Biological Yield per Plant (g)	Harvest Index (%)	Protein Content (%)	Zinc Content (ppm)	Iron Content (ppm)
Replications	2	0.06	0.20	2.96	0.25	0.29	0.34	0.37	0.10	1.02	0.01	0.14	0.05
Environments	2	926.23**	2709.61**	2073.72**	338.93**	721.71**	650.25**	1041.84**	2084.57**	1833.78**	7.00**	53.58**	51.29**
Rep. vs Env.	4	0.06	0.12	0.54	0.07	0.21	0.08	0.19	0.39	0.93	0.01	0.05	0.11
Genotypes	34	68.82**	64.04**	218.62**	14.24**	49.09**	18.78**	35.78**	17.62**	132.21**	4.39**	336.35**	207.64**
Parents	10	87.45**	68.72**	376.18**	10.13**	33.70**	14.79**	30.21**	6.54	140.70**	1.65**	472.13**	332.52**
Lines	7	68.01**	61.05**	484.17**	10.29**	39.68**	17.17**	30.99**	6.87	135.00**	1.27**	515.21**	434.50**
Testers	2	81.15**	37.44**	152.53**	0.88	4.23	7.01*	4.17	5.86	38.44	3.78**	509.15**	103.05**
Lines vs Testers	1	236.11**	185.00**	67.51*	27.49**	50.81**	13.70**	76.81**	5.55	385.13**	0.06	96.50**	77.67**
Parents vs Crosses	1	1.29	6.18	230.88**	172.59**	311.31**	125.60**	247.56**	152.95**	708.80**	70.86**	178.47**	60.07**
Crosses	23	63.66**	64.52**	149.59**	9.15**	44.37**	15.86**	29.00**	16.56**	103.45**	2.70**	284.18**	159.76**
Genotype × Env.	68	0.39	0.21	0.86	3.02**	7.14**	2.94*	7.06**	11.46**	26.62**	0.18	1.58	3.13
Parents × Env.	20	0.65	0.17	1.17	1.35	5.65	2.36	3.83**	14.73**	14.79	0.08	1.22	4.74**
Female × Env.	14	0.18	0.16	1.40	1.15	5.36	2.98	3.27*	16.78**	7.97	0.08	0.69	5.83**
Males × Env.	4	1.37	0.22	0.09	2.19	6.01	1.20	6.89**	3.21	40.91*	0.07	1.26	0.87
Female vs Male × Env.	2	2.53	0.13	1.72	1.08	6.94	0.39	1.64	23.43**	10.23	0.09	4.89*	4.84
Parents vs Crosses × Env	2	1.33	0.01	0.37	1.72	0.33	1.25	3.86	9.30	29.49	1.10**	7.43**	6.58
Crosses × Env.	46	0.23	0.23	0.74	3.80**	8.08**	3.27**	8.61**	10.14**	31.64**	0.19	1.49	2.28
Pooled error	204	2.11	2.25	11.55	1.07	4.50	1.96	1.70	4.04	14.48	0.17	1.55	2.34

*, ** Significant at 5% and 1%, respectively

With regards to plant height, 6, 17 and 18 hybrids showed significant negative mid parent heterosis, better parent heterosis and standard heterosis in desired direction, respectively over pooled basis. Cross Raj 4120 × Raj 4238 exhibited the highest significant negative heterosis over mid parent (-7.83%), over better parent (-15.20%) and over standard check (-15.06) (Table 2). Similar findings were also reported by Desale and Mehta (2013); Raj and Kandalkar (2013); Baloch *et al.* (2016); Thomas *et al.* (2017); Saren *et al.* (2018); Kumar *et al.* (2020); Malav *et al.* (2020) in wheat.

The results for no. of effective tillers per plant demonstrated that 17, 8 and 2 crosses exhibited significant negative average heterosis, heterobeltiosis and heterosis over check, respectively (Table 3). The cross GW 322 × DBW 110 displayed highest significant positive heterosis over mid parent (23.88%), over better parent (23.66%) and heterobeltiosis (16.30%) which is desirable in case of no. of effective tillers per plant. The findings for no. of grains per head and test weight indicated that 2 and 9 crosses displayed significant positive standard heterosis while 8 and 5 crosses showed significant positive heterobeltiosis in the desired direction. Cross Raj 4037 × Raj 4079 exhibited the highest significant positive heterosis over mid parent (11.50%), heterobeltiosis (10.43%) and standard heterosis (8.98%) for test weight (Table 3). These findings are in confirmation with Raj and Kandalkar (2013); Ismail and Samier (2015); Singh *et al.* (2016); Baloch *et al.* (2016); Rajput and Kandalkar (2018).

In the study of grain yield per plant, 13, 10 and 5 crosses showed significant positive average heterosis, over better parent and over standard check, respectively. The cross GW 322 × DBW 110 displayed significant highest positive standard heterosis (11.71%) (Table 4). With respect to biological yield per plant, 12 and 8 hybrids showed significant positive mid parent heterosis and better parent heterosis, respectively over pooled basis. The cross Raj 3765 × Raj 4079 exhibited the highest significant positive heterosis over mid parent (9.34%) and heterobeltiosis (9.18%) (Table 4). With regards to harvest index, 12 and 2 crosses showed significant positive average heterosis and over better parent, respectively. The cross Raj 3077 × Raj 4079 displayed the highest significant positive heterosis over mid parent (18.45%) and heterobeltiosis (14.16%). Rahul (2017); Rajput and Kandalkar (2018); Kumar *et al.* (2020) also reported similar results in bread wheat.

For protein content, 21, 18 and 5 crosses reported significant positive average heterosis, over better parent and over standard check, respectively (Table 5). The cross Raj 4037 × DBW 110 showed highest significant positive heterosis over mid parent (25.83%), heterobeltiosis (22.67%) and standard heterosis (8.60%). With regards to zinc and iron content, 10 and 14 crosses reported significant positive standard heterosis, respectively. The cross Sonalika × Raj 4238 showed highest significant positive heterosis over mid parent (29.76%) and heterobeltiosis (14.44%), while the cross Sonalika × DBW 110 displayed highest significant positive amount of standard heterosis (34.08%) (Table 5). Rahul (2017); Rajput and Kandalkar (2018); Kumar *et al.* (2020); Reddy *et al.* (2023) also reported similar results in bread wheat.

Table 2: Extent of Average heterosis, heterobeltiosis and economic heterosis for days to 50% flowering, Days to 75 % Maturity and Plant height (cm) in bread wheat (*Triticum aestivum* L.) on pooled basis.

Crosses	Days to 50 % flowering (pooled)			Days to 75 % Maturity (pooled)			Plant height (cm) (pooled)		
	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis
Raj 3077 × Raj 4079	-0.14	-0.85	0.43	-0.09	-0.77	0.52	-1.14	-7.90 **	-0.94
Raj 3077 × Raj 4238	-0.62	-4.62 **	3.58 **	0.26	-1.84 **	2.35 **	-7.19 **	-10.38 **	-3.60 *
Raj 3077 × DBW 110	-2.97 **	-4.32 **	-1.72 *	-1.60 **	-2.48 **	-0.78	-2.95 *	-9.95 **	-3.15 *
Raj 3765 × Raj 4079	-2.55 **	-5.37 **	-4.15 **	-1.88 **	-3.52 **	-2.26 **	0.26	-4.73 **	-1.78
Raj 3765 × Raj 4238	-0.42	-6.46 **	1.58 *	-0.22	-3.26 **	0.87	0.92	-0.51	2.56
Raj 3765 × DBW 110	-1.52 *	-5.02 **	-2.44 **	-1.05 *	-2.91 **	-1.22 *	0.21	-5.16 **	-2.23
Raj 3777 × Raj 4079	4.44 **	1.41	2.72 **	2.85 **	0.86	2.18 **	-0.9	-6.49 **	-2.13
Raj 3777 × Raj 4238	0.28	-5.80 **	2.29 **	0.91 *	-2.42 **	1.74 **	-0.03	-2.17	2.38
Raj 3777 × DBW 110	-2.39 **	-5.86 **	-3.30 **	-1.22 **	-3.34 **	-1.65 **	-2.14	-8.04 **	-3.76 *
Raj 4037 × Raj 4079	2.79 **	1.23	5.73 **	1.88 **	1.19 *	3.92 **	-0.15	-1.33	-8.38 **
Raj 4037 × Raj 4238	-4.77 **	-6.60 **	1.43	-2.44 **	-3.17 **	0.96	0.05	-4.70 **	-4.55 **
Raj 4037 × DBW 110	3.60 **	2.74 **	7.31 **	2.26 **	1.78 **	4.53 **	-1.51	-2.25	-10.04 **
Raj 4120 × Raj 4079	0.9	-0.82	4.01 **	0.89 *	0	3.13 **	0.12	-4.58 **	-11.41 **
Raj 4120 × Raj 4238	-4.16 **	-5.80 **	2.29 **	-2.06 **	-2.59 **	1.57 **	-7.83 **	-15.20 **	-15.06 **
Raj 4120 × DBW 110	1.86 **	0.82	5.73 **	1.10 **	0.42	3.57 **	-0.8	-5.06 **	-12.62 **
Sonalika × Raj 4079	6.46 **	4.95 **	6.30 **	3.56 **	2.49 **	3.83 **	-0.82	-3.42 *	-5.37 **
Sonalika × Raj 4238	-3.67 **	-8.18 **	-0.29	-1.28 **	-3.67 **	0.44	-3.02 *	-4.08 **	-3.92 *
Sonalika × DBW 110	-1.57 *	-3.63 **	-1	-0.91 *	-2.14 **	-0.44	0.46	-2.59	-4.56 **
Kalyan Sona × Raj 4079	4.57 **	3.54 **	4.87 **	2.73 **	1.89 **	3.22 **	-5.90 **	-7.81 **	-10.77 **
Kalyan Sona × Raj 4238	-2.69 **	-6.86	1.15	-0.81	-3.01 **	1.13 *	-5.27 **	-6.87 **	-6.71 **
Kalyan Sona × DBW 110	-3.12 **	-4.74 **	-2.15 **	-1.90 **	-2.91 **	-1.22 *	-2.25	-4.65 **	-7.72 **
GW 322 × Raj 4079	-4.84 **	-5.37 **	-4.15 **	-3.15 **	-3.61 **	-2.35 **	-1.05	-1.83	-8.85 **
GW 322 × Raj 4238	-5.15 **	-8.84 **	-1	-2.76 **	-4.59 **	-0.52	-0.77	-5.12 **	-4.96 **
GW 322 × DBW 110	-3.53 **	-4.74 **	-2.15 **	-2.33 **	-2.99 **	-1.31 *	3.56 *	3.2	-5.02 **
Desirable crosses	13	15	7	11	16	6	6	17	18

*, ** Significant at 5% and 1%, respectively

Table 3: Extent of Average heterosis, heterobeltiosis and economic heterosis for No. of effective tillers per plant, No. of grains per head and Test weight in bread wheat (*Triticum aestivum* L.) on pooled basis.

Crosses	No. of effective tillers per plant (pooled)			No. of grains per head			Test weight (g)		
	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis
Raj 3077 × Raj 4079	20.45 **	15.46 **	6.48	7.43 **	5.71 **	1.06	7.13 **	5.15 **	7.75 **
Raj 3077 × Raj 4238	1.74	-0.36	-12.10 *	-3.1	-5.14 *	-8.38 **	4.56 **	4.04 *	6.62 **
Raj 3077 × DBW 110	14.77 **	9.18	2.32	7.77 **	4.59 *	2.84	-2.97	-5.94	-0.23
Raj 3765 × Raj 4079	19.23 **	14.38 **	5.47	8.64 **	8.26 **	3.5	5.40 **	4.04 *	2.68
Raj 3765 × Raj 4238	-6.49	-8.34	-19.15 **	-1.67	-2.51	-5.83 **	1.72	-2.86	0.5
Raj 3765 × DBW 110	8.19	3	-3.48	5.93 **	4.11	2.36	7.78 **	4.10 *	7.42 **
Raj 3777 × Raj 4079	10.75 *	-1.65	-9.3	3.16	1.51	-2.95	-0.54	-4.77	-1.17
Raj 3777 × Raj 4238	1.51	-8.07	-18.90 **	0.68	-1.43	-4.79 *	1.54	0.84	2.31
Raj 3777 × DBW 110	14.38 **	0.87	-5.47	3.51	0.47	-1.21	1.46	-0.08	3.1
Raj 4037 × Raj 4079	17.89 **	15.48 **	6.49	4.58 *	3.62	0.91	11.50 **	10.43 **	8.98 **
Raj 4037 × Raj 4238	19.77 **	19.61 **	5.79	4.60 *	4.18 *	1.45	4.03 *	1.64	3.12
Raj 4037 × DBW 110	11.12 *	7.99	1.21	5.60 **	5.09 *	3.33	3.15	-0.05	3.14
Raj 4120 × Raj 4079	7.33	2.75	-5.25	6.69 **	6.22 **	2.45	1.56	-0.06	1.88
Raj 4120 × Raj 4238	19.92 **	17.29 **	3.47	3.35	3.28	-0.25	0.27	0.04	1.98
Raj 4120 × DBW 110	22.87 **	16.72 **	9.39	7.13 **	6.12 **	4.34 *	2.26	1.64	4.88 **
Sonalika × Raj 4079	13.51 **	-0.38	-8.14	-0.71	-3.24	-7.49 **	-1.3	-2.24	-3.52
Sonalika × Raj 4238	21.75 **	8.94	-3.9	-4.13 *	-7.04 **	-10.21 **	-2.94	-5.16 **	-3.77 *
Sonalika × DBW 110	5.49	-8.06	-13.84 **	5.39 **	1.32	-0.38	4.84 **	1.6	4.84 **
Kalyan Sona × Raj 4079	23.51 **	6.87	-1.45	4.69 *	-0.8	-5.17 *	6.30 **	3.68	2.32
Kalyan Sona × Raj 4238	16.50 **	2.73	-9.38	0.19	-5.52 *	-8.75 **	2.1	-1.74	-0.31
Kalyan Sona × DBW 110	19.81 **	2.96	-3.51	6.87 **	-0.06	-1.74	4.24 *	-0.49	2.68
GW 322 × Raj 4079	7.58	6.53	0.19	3.33	1.73	0.37	5.51 **	2.97	6.76 **
GW 322 × Raj 4238	21.39 **	17.62 **	10.62 *	3.22	2.14	0.77	1.27	0.18	3.87 *
GW 322 × DBW 110	23.88 **	23.66 **	16.30 **	6.38 **	6.20 **	4.77 *	3.77 *	3.53	7.34 **
Desirable crosses	17	8	2	13	8	2	11	5	9

*, ** Significant at 5% and 1%, respectively

Table 4: Extent of Average heterosis, heterobeltiosis and economic heterosis for Grain yield per plant, Biological yield per plant and harvest index in bread wheat (*Triticum aestivum* L.) on pooled basis.

Crosses	Grain yield per plant (pooled)			Biological yield per plant (pooled)			Harvest index (%) (pooled)		
	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis
Raj 3077 × Raj 4079	23.97 **	19.65 **	6.24	4.63 *	4.03	-0.13	18.45 **	14.16 **	5.89
Raj 3077 × Raj 4238	2.9	-2.28	-10.24 *	2.23	1.09	-0.74	0.11	-4.11	-9.88 *
Raj 3077 × DBW 110	21.38 **	12.23 **	9.15 *	5.85 **	5.10 *	0.9	14.19 **	5.01	7.67
Raj 3765 × Raj 4079	21.22 **	20.84 **	7.98 *	9.34 **	9.18 **	3.91	11.28 **	11.19 *	3.3
Raj 3765 × Raj 4238	3.18	1.78	-6.52	0.83	-0.72	-2.52	9.32 *	8.7	2.16
Raj 3765 × DBW 110	15.56 **	10.86 **	7.83 *	6.38 **	6.09 *	0.97	1.94	-2.85	-0.38
Raj 3777 × Raj 4079	6.35	-4.25	-14.98 **	3.69	2.22	-3	2.58	-5.92	-12.74 **
Raj 3777 × Raj 4238	-2.96	-13.92 **	-20.94 **	0.51	-2.55	-4.31	-4	-12.48 *	-17.74 **
Raj 3777 × DBW 110	3.02	-10.84 **	-13.28 **	2.25	0.93	-4.47	0.93	-11.45 *	-9.20 *
Raj 4037 × Raj 4079	17.45 **	15.78 **	2.81	5.78 **	5.52 *	0.63	8.91 *	8.85	1.07
Raj 4037 × Raj 4238	20.07 **	16.43 **	6.94	6.71 **	5.18 *	3.27	9.79 *	9.12	2.56
Raj 4037 × DBW 110	14.48 **	8.02 *	5.06	3.86	3.47	-1.33	8.11 *	3	5.61
Raj 4120 × Raj 4079	3.02	-1.29	-12.35 **	-5.19 *	-5.22 *	-10.00 **	10.09 *	4.49	-3.08
Raj 4120 × Raj 4238	6.25	0.18	-7.99 *	-1.04	-2.67	-4.43	15.46 **	8.9	2.35
Raj 4120 × DBW 110	20.97 **	11.09 **	8.04 *	5.53 **	5.36 *	0.05	11.02 **	0.61	3.16
Sonalika × Raj 4079	2.46	-7.96	-18.27 **	-1.14	-1.34	-6.01 **	3.75	-6.87	-13.62 **
Sonalika × Raj 4238	-3.85	-14.91 **	-21.85 **	0.29	-1.2	-2.99	-2.28	-12.79 **	-18.03 **
Sonalika × DBW 110	5.89	-8.55 *	-11.06 **	1.49	1.16	-3.63	4.37	-10.28 *	-8
Kalyan Sona × Raj 4079	10.69 *	-6.05	-16.57 **	4.84 *	2.49	-2.75	4.05	-6.93	-13.68 **
Kalyan Sona × Raj 4238	7.01	-10.41 *	-17.71 **	3.44	-0.54	-2.34	-1.64	-12.53 **	-17.79 **
Kalyan Sona × DBW 110	13.53 **	-7.08	-9.63 *	6.63 **	4.36	-1.22	4.11	-10.79 *	-8.53
GW 322 × Raj 4079	11.39 **	6.1	4.1	5.40 **	4.11	1.28	8.52 *	4.26	4.95
GW 322 × Raj 4238	11.50 **	7.94 *	5.91	5.51 **	5.02 *	3.12	4.89	1.41	2.09
GW 322 × DBW 110	14.36 **	13.86 **	11.71 **	7.54 **	6.09 *	3.2	5.07	4.11	6.75
Desirable crosses	13	10	5	12	8	0	12	2	0

*, ** Significant at 5% and 1%, respectively

Table 5: Extent of Average heterosis, heterobeltiosis and economic heterosis for protein content, zinc content and iron content in bread wheat (*Triticum aestivum* L.) on pooled basis.

Crosses	Protein content (pooled)			Zinc content (pooled)			Iron content (cm) (pooled)		
	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis	Average heterosis	Better parent heterosis	Standard heterosis
Raj 3077 × Raj 4079	6.12 **	5.07 **	-3.72 *	10.14 **	9.08 **	1.17	12.54 **	8.73 **	23.27 **
Raj 3077 × Raj 4238	15.69 **	13.37 **	8.22 **	7.21 **	3.99 *	-5.41 **	8.95 **	-1.09	12.13 **
Raj 3077 × DBW 110	9.06 **	4.57 *	-4.18 *	15.39 **	-2.83 *	29.17 **	1.35	0.51	13.95 **
Raj 3765 × Raj 4079	15.07 **	12.06 **	0.66	2.95 *	-7.15 **	7.15 **	3.17	-4.49 *	18.56 **
Raj 3765 × Raj 4238	14.28 **	8.09 **	3.19	2.03	-11.19 **	2.49	11.07 **	-3.1	20.29 **
Raj 3765 × DBW 110	11.17 **	10.50 **	-5.94 **	-3.13 *	-9.51 **	20.28 **	3.03	-2.22	21.39 **
Raj 3777 × Raj 4079	-0.12	-1.9	-8.62 **	-6.10 **	-8.92 **	-10.13 **	3.03	1.35	10.73 **
Raj 3777 × Raj 4238	1.74	0.51	-4.05 *	3.32 *	-3.58 *	-4.87 **	0.55	-7.18 **	1.42
Raj 3777 × DBW 110	2.66	-2.33	-9.02 **	-0.58	-13.39 **	15.13 **	-2.59	-3.57	7.52 **
Raj 4037 × Raj 4079	7.81 **	7.03 **	-3.86 *	12.78 **	-5.35 **	29.39 **	3.09 *	-10.09 **	27.69 **
Raj 4037 × Raj 4238	11.83 **	7.78 **	2.88	9.49 **	-11.01 **	21.64 **	9.34 **	-9.74 **	28.19 **
Raj 4037 × DBW 110	25.83 **	22.67 **	8.60 **	-4.91 **	-6.22 **	28.20 **	3.93 **	-7.24 **	31.74 **
Raj 4120 × Raj 4079	8.02 **	5.19 **	-0.28	-0.4	-6.69 **	-13.45 **	2.23	-2.31	3.25
Raj 4120 × Raj 4238	8.71 **	8.33 **	3.41 *	14.30 **	11.32 **	-4.83 **	-0.14	-2.13	-5.74 **
Raj 4120 × DBW 110	16.69 **	10.10 **	4.37 *	-8.62 **	-26.46 **	-2.24	-9.01 **	-15.21 **	-5.46 *
Sonalika × Raj 4079	16.34 **	15.52 **	3.77 *	8.50 **	-0.79	11.03 **	2.93	1.51	10.34 **
Sonalika × Raj 4238	4.55 **	0.78	-3.80 *	29.76 **	14.44 **	28.08 **	9.87 **	1.67	10.52 **
Sonalika × DBW 110	13.80 **	10.92 **	-1.76	9.52 **	0.87	34.08 **	9.90 **	8.52 **	21.00 **
Kalyan Sona × Raj 4079	4.45 **	2.78	-4.63 **	9.74 **	3.65	-3.87 *	-0.44	-0.91	4.73 *
Kalyan Sona × Raj 4238	9.21 **	7.69 **	2.8	10.19 **	8.23 **	-7.47 **	7.23 **	0.97	5.72 **
Kalyan Sona × DBW 110	12.24 **	6.98 **	-0.73	-5.82 **	-23.70 **	1.42	-7.65 **	-10.46 **	-0.17
GW 322 × Raj 4079	5.59 **	4.38 *	-6.24 **	-5.08 *	-25.71 **	-31.10 **	0.41	-15.07 **	-10.24 **
GW 322 × Raj 4238	7.55 **	3.21	-1.47	8.42 **	-12.55 **	-25.24 **	8.41 **	-2.94	-10.25 **
GW 322 × DBW 110	15.44 **	13.02 **	-0.8	-24.99 **	-47.70 **	-30.48 **	10.30 **	-8.69 **	1.8
Desirable crosses	21	18	5	14	5	10	11	2	14

CONCLUSIONS

The current study found that the majority of crosses had positive significant average heterosis, heterobeltiosis and standard heterosis for grain 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 Raj 4037 × Raj 4238, Raj 3077 × DBW 110 and GW 322 × Raj 4079 were considered as the best heterotic hybrids for grain yield and attributing traits so these hybrids may be utilized to obtain desirable genotype.

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, college of agriculture, Ummedganj, Kota for providing the research material, necessary facilities and field assistance for conducting the experiment.
Conflict of Interest. None.

REFERENCES

Baloch, M., Baloch, A. W., Siyal, N. A., Baloch, S. N., Soomro, A. A., Baloch, S. K. and Gandahi, N. (2016). Heterosis analysis in F_1 hybrids of bread wheat. *Sindh University Research Journal (Science Series)*, *48*(2), 261-264.

Desale, C. S. and Mehta, D. R. (2013). Heterosis and combining ability for grain yield and quality traits in bread wheat (*Triticum aestivum* L.). *Electronic Journal of Plant Breeding*, *4*(3), 1205-1213.

Dhoot, M., Sharma, H., Dubey, R. B., Badya, V. K. and Dhoot, R. (2020). Combining ability analysis for yield and its associated characters in late sown condition in bread wheat [*Triticum aestivum* (L.) em. Thell]. *Journal of Pharmacognosy and Phytochemistry*, *9*(2), 283-286.

Fonseca, S. and Patterson, F. L. (1968). Hybrid vigour in seven parent diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Science, 8*(1), 85-88.

Ismail, K. and Samier, A. (2015). Heterosis and combining ability analysis for yield and its components in bread wheat (*Triticum aestivum* L.). *International Journal of Current Microbiology and Applied Sciences, 4*(8), 1-9.

Jackson, M. L. (1973). Soil and plant analysis. Prentice Hall of India Private Ltd, New Delhi.

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, D., Panwar, I. S., Singh, V., Choudhary, R. R. and Samita (2020). Heterosis studies using Diallel analysis in bread wheat (*Triticum aestivum* L.). *International Journal of Chemical Studies*, *8*(4), 2353-2357.

Malav, A. K., Vyas, M., Choudhary, J., Meghawal, D. R. and Bangarwa, S. K. (2020). Assessment the heterosis and combining ability for grain yield components and heat tolerance traits in bread wheat. *International Journal of Current Microbiology and Applied Sciences, Special issue* (11), 1372-1397.

Meredith, W. R. and Bridge, R. R. (1972). Heterosis and gene action in cotton (*Gossypium hirsutum). Crop Science, 12*(3), 304-310.

Rahul, S. R. (2017). Combining ability and heterosis for morpho-physiological characters on bread wheat (*Triticum aestivum* L.). *Agricultural Research and Technology Open Access Journal*, *13*(1), 03-10.

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.

Reddy, B. R. K., Kumar, B., Kumar, R. and Thota, H. (2023).

Analysis of Heterotic Potential for Yield and Its Contributing Traits in Wheat (*Triticum aestivum* L.). *International Journal of Environment and Climate Change, 13*(9), 388-400.

Rajput, R. S. and Kandalkar, V. S. (2018). Combining ability and heterosis for grain yield and its attributing traits in bread wheat (*Triticum aestivum* L.). *Journal of Pharmacognosy and Phytochemistry*, *7*(2), 113-119.

Saren, D., Mandal, A. B. and Soren, C. (2018). Heterosis studies in bread wheat (*Triticum aestivum* L.). *IOSR Journal of Agriculture and Veterinary Science*, *11*(9), 80-84.

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.

Singh, S., Kumar, A. and Singh, M. K. (2016). Hybrid performance and heterosis for yield and yield contributing traits in bread wheat (*Triticum aestivum* L.). *International Journal of Current Research*, *8*(6), 33177-33181.

Thomas, N., Marker, S., Lal, G. M. and Dayal, A. (2017). Study of heterosis for grain yield and its components in wheat (*Triticum aestivum* L.) over normal and heat stress condition. *Journal of Pharmacognosy and Phytochemistry*, *6*(4), 824- 830.

How to cite this article: Sunita Choudhary, N.R. Koli, S.C. Sharma, D.S. Meena, K.M. Sharma, C.B. Meena and Narendra Padra (2024). Exploitation of Heterosis for Grain Yield and Yield Component Traits in Bread Wheat (*Triticum aestivum* L.) over Environments. *Biological Forum – An International Journal, 16*(7): 240-245.