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GENETIC STUDY FOR IMPROVEMENT OF VARIOUS YIELD ATTRIBUTING TRAITS IN WHEAT

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ABSTRACT

Present study was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, University of Sargodha during the year 2015 -16 to calculate the heritability, heterosis and heterobeltiosis among 40 F_1 hybrids developed from crossing diverse parents. Results showed that Millat-11×UAF1057 had the highest heritability for number of grains spike^{-1} (89.4%) followed by Seher-06 × Galaxy-13 (89.22%) for 1000-kernel weight and grain yield plant^{-1}.The cross CIM-130 (2012-13) × Millat-11 showed the highest heterosis for peduncle length (74.49%). CIM-54 2012-13 × SA42/Shafaq showed high heterosis for number of spikes plant^{-1} (41.05%). The cross Galaxy-13 × Pb-11 showed high heterosis for number of spikelets spike^{-1} (27.88%).The cross (Galaxy-13 × UOS-540) showed high heterosis (55.23%) and heterobeltiosis (54.59%) for 1000-grain weight and 55.41% and 54.84% for number of grains spike^{-1} (27.88%). The cross (Inq-91/Prl/Fsd-08 × Lyp-73) showed high mid parent heterosis for grain yield plant^{-1} (89.27%) and over better parent (45.51%). The cross (Pb-11×CIM E-5 2012-13) showed high heterobeltiosis for number of grains per spike (54.84%) and 1000 grain weight (54.59%). The cross combination AARI-11 × Galaxy-13 showed highest negative heterobeltiosis for days to heading (-3.65). Pb-11 × Galaxy-13 showed highest negative heterobeltiosis for days to maturity (-4.74%). Pb-11×Millat-11 showed high positive value of heterobeltiosis for grain yield plant^{-1} (53.56%). It was concluded that crosses showing high heritability for yield attributing traits should be selected and moved further for varietal developmental procedure. with PGPR.

KEYWORDS: *Triticum aestivum*; Wheat; heritability; heterosis; heterobeltosis; yield traits; Pakistan.

INTRODUCTION

Bread wheat is a well-known crop in the world. Wheat supplies 31% calories, 23% protein and 45 % carbohydrate in daily intake of human consumer (Shewry and Sandra, 2015). Development of high yielding wheat varieties is imperative to feed bulging population. Wheat is the most critical crop of Pakistan occupying significant area under cultivation. Demand of wheat is increasing with expanding population.

Genetic diversity implies biochemical, molecular and phenotypic characteristics in the species (Rauf *et al.*, 2010). Wheat breeders are trying to incorporate wide range of characters that have impact on yield to develop genotypes having genetically divergent origin (Tadesse and Bekele, 2001). Heritability and heterosis provide the knowledge to the plant breeders for selection of desirable genotype in segregating generations. High heritability alongwith high genetic advance helps for suitable selection (Larik *et al.*, 1989). Yagdi and Karan (2000) observed significant heterosis and heterobeltiosis in yield components. Previous scientific reports revealed that if parental combinations are proper than the heterosis will prevail for yield contributing attributes traits (Altinbas and Tosun, 1994; Larik *et al.*, 1995; Yagdi and Karan, 2000).

The handiness of potential segregating germplasm provides greater chances to researchers for making selection of the preferred features. Establishment of such type of material is possible when appropriate parents used in hybridization nick well. So before developing program for hybridization, appropriate selection protocol is essential.

The objective of this research was to investigate the heritability, heterosis and heterobeltiosis effects on different yield contributing traits in wheat.

MATERIALS AND METHODS

This research study was undertaken in the Department of Plant Breeding and Genetics, University of Sargodha during the winter growing season 2015. Seeds of 27 parental genotypes and their 40 F_1 random crosses were sown in triplicated randomized complete block design. Single line of each genotype was planted in each replication. Five random plants from individual row were selected and data were noted at suitable time for grain yield contributing parameters. Number of days to flowering was recorded on 50% spike emergence of all entries of each genotype from each replication. Days to maturity were calculated from planting date to date of physiological maturity. Number of tillers per plant was counted manually from each genotype and each replication. Plant height (cm) was measured excluding awns. For this purpose, mother shoots of each plant were selected from each genotype per replication separately and average plant height was calculated. Peduncle length (cm) of five selected plants was recorded from upper node to the base of spike and average was calculated. Spike length (cm) was measured from base to top portion of spike excluding awns. The same mother shoot was used to measure the numbers of spikelets spike^{-1}. Number of grains from spikes of selected plants was counted manually after harvesting/ threshing. 1000-grain weight and grain yield plant^{-1} were obtained from the harvested seeds of each line with electric balance. Then the average was made for further analysis.

Statistical analysis

Estimation of heterosis and heterobeltiosis: The percentage decrease/increase of F_1 progeny over the mid and better parents was computed to estimate likely heterotic effects for parameters under study by employing the equation of Fonseca and Patterson (1968).

$$\text{Heterosis} = \frac{F_1 - MP}{MP} \times 100$$

$$\text{Heterobeltiosis} = \frac{F_1 - BP}{BP} \times 100$$

Estimation of heritability: Broadsense heritability was estimated after derivation of the variance components (Singh and Chaudhary, 1985).

$$H^2 = \frac{V_g}{V_p} = \frac{V_g}{V_p + V_e}$$

H^2: Broad sense heritability.
V_g: Genetic variance
V_P and V_e: Phenotypic variance and Error variance.

RESULTS AND DISCUSSION

Analysis of variance for various yield attributing traits showed highly significant differences amongst wheat genotypes and its crosses (Table 1). Plant height is the most important attribute in crop plants. In wheat due to lodging problem optimum plant height (65 to 83 cm) is preferred. The estimates of heritability, heterosis and heterobeltiosis are presented in table 2, 3 and 4. The heritability estimates for plant height (PH) ranged from 28.94% (AARI-11×Galaxy-13) to 82.47% (UOS-950×Pb-11). The high heritability shows the extent of transfer of traits to the next generation. Noorka *et al.* (2013) noted high estimation of heritability for Plant height. Heterosis for Plant height ranged from -32.64 (Millat-11 × UAF1057) to 22.29 (AARI-11×Galaxy-13) (Table 3). So it was concluded that the cross AARI-11×Galaxy-13 was best in case of plant height as it better performed than mid parent value. Increase in size of upper node contributes to the heterosis in plant height (Zhang *et al.*, 2007). The cross combinations Kalyansona × K-8962 followed by crosses K-8962 × HUW-234, Sonalika × K-8962, HUW-510 × HUW-234 and Kalyansona × HUW234 showed more mid parent heterosis and proved best hybrids. The positive value for heterobeltiosis ranged from 2.89 (Seher-06×82003) to 10.95 (UOS-540×UOS-520) (Table 4).

The heritability estimates for number of grains spike^{-1} (NG/S) ranged from 23.56% (Pb-11xLyp-73) to 89.4% (Millat-11×UAF1057) (Table 2). The heterosis for this trait ranged from -23.43 % (Pb-11x Inq-91/Prl/Fsd-08) to 55.41 % (Galaxy -13xUOS-540) (Table 3). The positive value for heterobeltiosis ranged from 0.62 % (Inq-91×Galaxy-13) to 54.84 % (Pb-11×CIM E-5 2012-13) (Table 4). The heritability estimates for days to heading ranged from 23.56% (Millat-11×Galaxy-13) to 89.43% (AARI-11×Galaxy-13) (Table 2). The heterosis for this trait ranged from -2.61% (AARI-11×Galaxy-13) to 4.39% (Millat-11×Galaxy-13) (Table 3). In case of heterosis over better parent, 26 crosses proved best and showed negative value for hetrobeltiosis than the better parent and remaining showed positive value of hetrobeltiosis for days to heading. Akinci *et al.,* (2009) noted better parent and mid parent heterosis was -2.16% and -0.74% for days to heading.

The heritability estimates for days to maturity ranged from 28.74 % (Pb-11×Millat-11) to 88.43 % (Seher-06×82003) (Table 2). The heterosis for this trait ranged from -4.10 % (Pb-11×Galaxy-13) to -0.05 % (CIM-130 (2012-13)×Inq-91/Prl/Fsd-08) (Table 3). In hetrobeltiosis for days to maturity 43 crosses proved best and showed negative value for hetrobeltiosis than the better parent and remaining showed positive value of hetrobeltiosis. Kaled *et al.*, (2013) observed maximum heterosis value from cross (P_3 × P_4) for days to maturity.

The heritability estimates for peduncle length ranged from 33.67 % (Pb-11xLyp-73) to 87.45 % (Inq-91/Prl/Fsd-08×Pb-11) (Table 2). Noorka *et al.*, (2013) found high estimation of heritability for different characteristics like plant height, peduncle length and spike length which caused transfer of these traits to next generation. Heterosis for peduncle length ranged from -44.15 (Inq-91/Prl/Fsd-08×Pb-11) to 74.49 (CIM-130 (2012-13)×Millat-11) (Table 3). So it was concluded that cross CIM-130 (2012-13)×Millat-11 was best in case of peduncle length as it better performed than mid parent value. The positive value for heterobeltiosis ranged from 0.52 (Seher-06×82003) to 55.46 (CIM-130 (2012-13)×Millat-11) (Table 4). Noorka *et al.* (2013) recorded that cross Pasban-90 × Seher-06 was best cross and showed high value of heterobeltiosis for peduncle length.

Wheat spike length is the most important attribute as more spike length leads to more number of spikelets spike^{-1} which results in improved grain yield. The heritability estimates for this trait ranged from 33.87 % (Galaxy-13×CIM-1 2012-13) to 87.52% (Galaxy-13×Uqab2000/Inq-91) (Table 2). Similar results were found by Hussain *et al.* (2013). The heterosis for spike length ranged from -13.52% (Seher-06x82003) to 35.21% (Fsd-08xMillat-11) (Table 3). The positive value for heterobeltiosis ranged from 0.71% (SA-42/PrlxMillat-11) to 32.55% (Millat-11×Inq-91/Prl/Fsd-08) (Table 4). Maximum range of hetrobeltiosis for spike length, plant height, days to heading, days to maturity were observed at 13.03%, 3.27%, 2.60% and 1.82%, respectively (Jan *et al.*, 2005).

The heritability calculated for number of spikes plant^{-1} ranged from 23.67% (Pb-11xMillat-11 and UOS-540×UOS-520) to 87.62% (Inq-91/Prl/Fsd-08×Galaxy-13) (Table 2). The high heritability shows the extent of transfer of traits to the next generation. High estimation of heritability was found for characteristics i.e. number of tillers, peduncle length, spike length and 1000-grain weight (Khan *et al.*, 2011). The heterosis for this trait ranged from -28.99 % (UOS-540xUOS-520 and Inq-91/Prl/Fsd-08×Pb-11) to 41.05% (CIM-54 2012-13×SA42/Shafaq) (Table 3). So it was concluded that cross CIM-54 2012-13×SA42/Shafaq was best in case NS/P as it better perfumed than mid parent value. The positive value for heterobeltiosis ranged from 0.62 % (Millat-11×Pb-11 and Galaxy-13×Uqab2000/Inq-91) to 39.58% (CIM-54 2012-13×SA 42/Shafaq) (Table 4). Akbar *et al.* (2007) recorded high heterosis and hetrobeltiosis from cross V-00055 × V-00125 for NS/P, 1000-G. Wt., biomass plant^{-1} and grain yield.

The heritability noticed for number of spikelets spike^{-1} (NS/S) ranged from 23.29 % (Pb-11xMillat-11) to 88.43 % (Inq-91/Prl/Fsd-08×Galaxy-13) (Table 2). Li *et al.* (2003) (Table 2) stated that traits like spike length, plant tallness, grains spike^{-1}, spikelets spike^{-1}, and 1000-grain weight showed high observation of broad sense heritability. The heterosis for this trait ranged from -19.34 % (Galaxy-13xFsd-08) to 27.88 % (Galaxy-13×Pb-11) (Table 3). Kumar *et al.* (2011) found highest magnitude of heterosis (21.74%) for spikelets spike over best parent. The positive value for heterobeltiosis ranged from 0.91% (Inq-91/Prl/Fsd-08×Lyp-73) to 25.41% (Galaxy-13×Pb-11) (Table 4).

For 1000-grain weight, heritability ranged from 22.88 % (Galaxy-13×Uqab2000/Inq-91) to 89.22 % (Seher-06×Galaxy-13) (Table 2). Kaled (2013) reported highly broad sense heritability associated with moderate value of narrow sense heritability for number of grains spike spike^{-1}, 1000-grain weight and grain yield plant^{-1}. The heterosis for 1000-grain weight ranged from -23.56 % (Pb-11× Inq-91/Prl/Fsd-08) to 55.23 % (Galaxy -13×UOS-540) (Table 3). The positive value for heterobeltiosis ranged from 0.10 % (Seher-06×82003) to 54.59 % (Galaxy -13×UOS-540) (Table 4). Salman *et al.* (2015) found high heterosis and hetrobeltiosis in cross Pari-73 × Hashim-08 for 1000-grain weight (29 and 22%), grain spike^{-1} (19 and 11%) and spike length (33 and 22%). Akinci *et al.* (2009) noted hetrobeltiosis (1.64%) and heterosis (3.78%) for 1000-grain weight.

The heritability ranged from 23.47% (Galaxy-13×CIM-130 (2012-13) to 89.22% (Seher-06×Galaxy-13) for grain yield plant^{-1} (Table 2). Firouzian (2003) noted broad sense heritability ranged for 1000-grain weight (45.4-74.5%), spike density (58-87%), plant tallness,(46.1 to 85%) grain yield plant^{-1} (75.1 to 93.5%) and spikelets spike^{-1} 85.6 to 56%).Akinci *et al.* (2009) observed better parent and mid parent heterosis i.e. 2.24 and 5.24 % for grain yield plant^{-1}. Akbar *et al.* (2007) found high heterosis and hetrobeltiosis from cross V-00055 × V-00125 for spike plant^{-1}, 1000-grain weight, biomass plant^{-1} and grain yield plant^{-1}.The heterosis for grain yield plant^{-1} ranged from -99.02% (Pb-11xCIM-126 (2012-13) to 89.27% (Inq-91/Prl/Fsd-08×Lyp-73) (Table 3). So it was concluded that the cross Inq-91/Prl/Fsd-08×Lyp-73 best yielded than mid parent as it showed maximum positive value for grain yield plant^{-1}. In case of hetrobeltiosis, four crosses showed positive value of hetrobeltiosis while remaining showed negative value of hetrobeltiosis. Pb-11×Millat-11 was best than better parent as it showed maximum value of 53.56% for grain yield plant^{-1}. Fellahi *et al.* (2013) noted that hybrids A-899 × Wifak, A-1135 ×Wifak and A-899 × Rmada showed better heterotic effects for grain yield than their parents. Noorka *et al*. (2013) observed that Pasban-90 × Seher-06 proved to be the superior cross with maximum value of hetrobeltiosis for grain yield plant^{-1}.

Table1. Analysis of variance for various yield attributing traits of wheat genotypes and it crosses

S.O.V	DF	Mean square									
		Plant height	Number of grains spike^{-1}	Days to heading	Days to maturity	Peduncle length	Spike length	Number of spikes plant^{-1}	Number of spikelets spike^{-1}	1000-grain weight	Grain yield plant^{-1}
Replications	2	1.78	2.04	13.75	14.42	0.65	0.13	5.78	0.42	0.53	4.92
Genotypes	66	97.71**	66.17**	69.41**	17.26**	9.14**	2.27**	28.72**	2.24**	41.90**	166.87**
Error	132	0.36	1.68	0.05	0.26	2.03	0.11	6.72	0.34	1.14	108

** Highly significant

Table 2. Wheat crosses broad sense heritability for various yield attributing traits

S.No.	Name of crosses	Plant height (cm)	Number of grains spike^{-1}	Days to heading	Days to maturity	Peduncle length (cm)	Spike length (cm)	Number of spikes plant^{-1}	Number of spike lets spike^{-1}	1000-grain weight (g)	Grain yield plant^{-1} (g)
1	Inq-91/Prl/Fsd-08×Pb-11	66.66	83.66	55.69	62.48	87.45	76.83	52.65	52.65	88.34	66.66
2	Millat-11×1057UAF	75.75	89.43	32.45	76.53	82.86	79.32	37.29	61.69	45.68	75.75
3	Millat-11×SA-42/Shafaq	82.35	50.23	54.78	72.89	78.93	72.45	74.39	34.39	76.52	82.35
4	Pb-11×CIM E-5 2012-13	40.38	34.67	31.45	50.34	65.47	45.89	45.32	45.68	78.32	40.38
5	Pb-11×Seher-06/Pavon	66.67	78.32	53.89	82.54	64.78	34.58	53.45	32.44	47.58	66.67
6	King bird×Frontana/Galaxy-13	37.56	56.02	49.53	50.43	45.67	39.63	37.98	37.98	52.08	85.36
7	CIM-54 2012-13X SA42/Shafaq	74.37	50.43	57.83	50.89	54.38	53.89	53.45	53.45	83.66	49.06
8	Millat-11×Inq-91/Prl/Fsd-08	48.97	78.32	83.66	86.23	76.53	67.44	67.83	67.83	89.43	58.44
9	AARI-11×Galaxy-13	28.94	49.06	89.43	53.78	67.84	53.68	57.34	57.34	50.23	37.65
10	Inq-91/Prl/Fsd-08×Inq-91/Millat-11	38.73	58.44	50.23	48.32	56.42	57.34	84.67	84.67	34.67	78.43
11	Galaxy-13×CIM-130 (2012-13)	41.56	37.65	34.67	49.67	45.33	45.68	50.43	50.43	78.32	23.47
12	SA-42/PRL×Fsd-08	75.47	78.43	78.32	57.17	48.67	37.83	37.86	37.86	56.02	50.43
13	Pb-11×Lyp-73	68.32	23.56	56.02	78.39	33.67	65.78	49.53	49.53	78.34	37.86
14	Inq-91/Prl/Fsd-08×UAF1057	67.72	50.43	78.34	85.23	63.74	73.45	51.46	51.46	85.36	85.36
15	Seher-06×Galaxy-13	73.86	37.86	85.36	73.24	72.35	50.32	37.22	37.22	89.22	89.22
16	Galaxy-13×CIM-1 (2012-13)	71.45	49.53	88.53	78.45	71.45	33.87	76.45	76.45	32.56	32.56
17	Millat-11×Pb-11	67.77	51.46	32.56	65.89	78.34	85.43	83.26	83.26	50.43	50.43
18	Galaxy-13×Millat-11	81.23	37.22	50.43	62.85	45.98	52.66	57.83	57.83	78.32	81.23
19	Millat-11×Galaxy-13	62.36	76.45	23.56	84.56	67.88	67.45	53.89	34.78	49.06	62.36
20	Fsd-08×Millat-11	45.67	83.26	50.43	50.32	33.67	56.23	32.45	74.39	58.44	45.67
21	SA-42/Prl×Millat	65.73	57.83	37.86	77.06	55.43	34.76	54.78	32.76	37.65	65.73
22	Pb-11×Galaxy-13	52.37	53.89	85.36	85.97	45.87	45.16	31.45	48.23	78.43	52.37
23	Fsd-08×Pb-11	42.36	32.45	89.22	48.63	51.63	47.83	53.89	47.67	23.56	37.65
24	Seher-06×82003	34.57	54.78	49.06	88.43	57.88	85.22	49.53	49.88	32.67	78.43
25	SA-42/Prl×Galaxy-13	47.93	31.45	58.44	62.78	53.24	67.04	51.46	28.65	48.82	23.56
26	Galaxy-13×Pb-11	76.45	53.89	37.65	57.84	78.89	78.33	83.45	83.45	75.23	32.67
27	Inq-91/Prl/Fsd-08×Galaxy-13	67.32	49.53	78.43	78.44	67.45	73.56	87.62	88.43	45.32	48.82
28	Pb-11× Inq-91/Prl/Fsd-08	63.33	51.46	24.32	50.49	62.34	85.23	56.34	56.34	58.93	75.23
29	Pb-11×CIM-126 (2012-13)	31.79	83.45	32.67	76.34	65.77	48.67	53.89	53.89	76.22	45.32
30	CIM-130 (2012-13) × Inq-91/Prl/Fsd-08	57.36	87.62	48.82	34.67	56.78	67.43	32.45	32.45	83.67	58.93
31	Inq-91×Galaxy-13	55.80	56.34	31.45	39.23	45.64	34.89	54.78	54.78	27.54	76.22
32	Galaxy-13xUqab2000/Inq-91	64.39	57.83	53.89	42.08	55.37	87.52	31.45	31.45	22.88	48.23
33	CIM-130 (2012-13)×Millat-11	32.56	34.78	49.53	55.32	73.24	37.12	50.43	50.43	53.84	47.67
34	Pb-11×Millat-11	73.48	74.39	51.46	28.74	65.72	35.66	23.67	23.29	45.21	49.88
35	Inq-91/Prl/Fsd-08×Lyp-73	75.62	32.76	83.45	47.89	83.67	50.34	28.45	28.45	39.05	28.65
36	Galaxy-13×Fsd-08	64.78	48.23	34.39	34.56	54.37	39.67	50.43	67.32	43.78	83.45
37	UOS-127×UOS-520	55.89	47.67	45.68	56.23	76.58	76.28	23.67	36.09	78.45	87.62
38	UOS-950×Pb-11	82.47	49.88	32.44	59.87	78.32	87.45	28.45	45.83	35.21	56.34
39	UOS-950×UOS-135	71.83	28.65	37.98	50.34	35.77	82.34	67.32	50.42	79.45	53.89
40	Galaxy -13×UOS-540	54.97	83.45	56.73	55.87	87.28	56.43	82.09	38.05	88.67	32.45

Table 3. Wheat crosses heterosis percentage for various yield attributing traits

Sr.No.	Name of crosses	Plant height (cm)	Number of grains spike^{-1}	Days to heading	Days to maturity	Peduncle length (cm)	Spike length (cm)	Number of spikes plant^{-1}	Number of spikelets spike^{-1}	1000-grain weight (g)	Grain yield plant^{-1} (g)
1	Inq-91/Prl/Fsd-08×Pb-11	15.75	-11.11	1.53	-1.45	-44.15	-11.16	-28.99	-9.27	-8.32	-24.25
2	Millat-11×1057UAF	-32.64	17.79	-0.25	-1.64	-38.59	-9.95	-6.38	3.38	16.78	-0.39
3	Millat-11×SA-42/Shafaq	-28.26	43.63	-1.50	-1.08	-37.93	3.63	-10.89	3.79	43.06	-32.29
4	Pb-11×CIM E-5 2012-13	5.41	55.41	0.76	-0.49	-30.31	-2.95	23.40	-6.09	55.23	-33.05
5	Pb-11×Seher-06/Pavon	-24.17	28.31	2.86	-0.86	-15.38	-1.73	17.89	-0.53	27.55	-48.45
6	King bird×Frontana/Galaxy-13	8.34	45.63	-0.52	-1.60	16.99	12.87	15.21	-2.16	45.53	-12.17
7	CIM-54 2012-13×SA42/Shafaq	-15.80	35.08	0.31	-1.49	-16.51	10.28	41.05	16.13	34.90	-27.45
8	Millat-11×Inq-91/Prl/Fsd-08	3.05	13.93	-2.09	-2.07	24.80	27.37	14.89	22.03	14.02	-28.62
9	AARI-11×Galaxy-13	22.29	1.37	-2.61	-0.49	22.09	-5.31	18.45	9.92	1.39	-34.82
10	Inq-91/Prl/Fsd-08×Inq-91/ Millat-11	-3.25	21.67	0.51	-0.23	-6.71	-6.72	-4.38	16.99	21.85	-28.75
11	Galaxy-13×CIM-130 (2012-13)	-1.01	33.92	1.47	-1.12	2.42	-6.18	34.69	24.89	32.52	-46.18
12	SA-42/PRL×Fsd-08	-23.14	10.75	3.34	-1.94	9.52	5.06	10.02	2.78	8.03	-49.64
13	Pb-11×Lyp-73	-17.61	40.31	-0.76	-2.17	0.08	-6.36	5.54	-7.47	41.05	-40.49
14	Inq-91/Prl/Fsd-08×UAF1057	-16.95	16.83	1.78	-3.00	-12.34	-6.92	31.72	-5.20	16.82	-40.47
15	Seher-06×Galaxy-13	-26.28	-10.25	2.79	-3.00	-24.08	-1.69	14.16	-1.47	-10.16	-56.8
16	Galaxy-13×CIM-1 (2012-13)	-6.12	-4.61	2.02	-2.62	-10.88	19.61	11.96	4.07	-3.96	-51.96
17	Millat-11×Pb-11	-7.73	25.97	0.00	-2.82	-22.05	5.16	5.38	2.46	25.67	-49.17
18	Galaxy-13×Millat-11	13.01	38.48	2.77	-3.80	5.63	-5.04	6.76	-5.17	33.63	-42.81
19	Millat-11×Galaxy-13	5.63	24.06	4.39	-2.47	-17.71	10.77	-1.61	-5.93	24.30	-44.78
20	Fsd-08×Millat-11	-4.47	-15.40	1.33	-0.91	7.03	35.21	2.46	13.29	-14.22	-46.69
21	SA-42/Prl×Millat	-25.76	21.48	-0.66	-3.55	-25.92	10.03	10.94	-1.43	21.39	-47.60
22	Pb-11×Galaxy-13	9.86	41.60	3.47	-4.10	-14.96	-8.34	-3.71	3.45	40.17	-44.63
23	Fsd-08×Pb-11	-11.59	0.93	1.92	-1.88	-14.53	-3.38	0.59	13.98	1.26	-39.09
24	Seher-06×82003	7.34	1.80	2.04	-2.72	0.65	-13.52	10.45	2.76	0.72	-43.08
25	SA-42/Prl×Galaxy-13	-11.45	-9.31	3.11	-2.64	1.11	-12.06	-5.98	-0.52	-8.98	-48.15
26	Galaxy-13×Pb-11	7.96	-1.66	0.59	1.14	2.06	2.47	0.00	27.88	-1.44	-54.83
27	Inq-91/Prl/Fsd-08×Galaxy-13	-8.91	-6.20	-1.54	-1.12	-9.75	-3.26	0.02	-9.01	-6.39	-64.02
28	Pb-11× Inq-91/Prl/Fsd-08	-15.96	-23.43	-1.11	0.37	-27.04	2.08	-13.0	-1.14	-23.56	-77.47
29	Pb-11×CIM-126 (2012-13)	-6.73	-22.04	-1.79	-0.45	-27.89	26.05	-4.70	19.82	-21.65	-99.02
30	CIM-130 (2012-13) × Inq-91/Prl/Fsd-08	3.63	-10.62	-0.43	-0.05	-20.05	-8.76	3.18	8.21	-10.41	-39.16
31	Inq-91×Galaxy-13	-17.95	1.68	0.52	-0.11	8.47	-5.08	4.53	-7.12	2.21	-40.16
32	Galaxy-13xUqab2000/Inq-91	-8.85	11.85	-0.96	-0.37	-14.14	5.61	0.48	-0.99	11.71	-74.58
33	CIM-130 (2012-13)×Millat-11	1.44	-7.59	-0.59	0.53	74.49	11.86	-9.04	2.39	-8.03	47.61
34	Pb-11×Millat-11	-17.49	-7.36	1.46	-0.18	2.14	0.31	9.68	10.85	-6.69	77.81
35	Inq-91/Prl/Fsd-08×Lyp-73	-17.88	-5.32	1.54	-0.72	11.92	9.83	3.19	6.31	-5.73	89.27
36	Galaxy-13×Fsd-08	-23.30	-3.73	-0.10	-1.00	-12.19	-3.06	-7.02	-19.34	-2.83	77.97
37	UOS-127×UOS-520	15.75	-11.11	1.53	-1.46	-44.15	-11.16	-28.99	-9.27	-8.32	-24.25
38	UOS-950×Pb-11	-32.65	17.79	-0.25	-1.64	-38.59	-9.95	-6.38	3.38	16.78	-0.39
39	UOS-950×UOS-135	-28.26	43.63	-1.50	-1.08	-37.93	3.63	-10.89	3.79	43.06	-32.29
40	Galaxy -13×UOS-540	5.43	55.41	0.76	-0.49	-30.31	-2.95	23.40	-6.09	55.23	-33.05

Table 4. Wheat crosses heterobeltiosis percentage for various yield attributing traits.

S.No	Name of crosses	Plant height (cm)	Number of grains spike^{-1}	Days to heading	Days to maturity	Peduncle length (cm)	Spike length (cm)	Number of spikes plant^{-1}	Number of spike lets spike^{-1}	1000-grain weight (g)	Grain yield plant^{-1} (g)
1.	Inq-91/Prl/Fsd-08×Pb-11	10.94	-11.71	3.11	-0.97	-44.30	-13.08	-33.82	-16.97	-8.88	-39.03
2.	Millat-11×1057UAF	-33.69	6.48	-0.99	-1.79	-46.82	-11.11	-8.33	2.81	5.61	-0.77
3.	Millat-11×SA-42/Shafaq	-34.27	42.40	-2.48	-1.19	-42.92	-2.56	-15.09	1.14	41.66	-48.81
4.	Pb-11×CIM E-5 2012-13	-2.42	54.84	-1.00	-0.97	-32.44	-11.53	23.40	-15.14	54.59	-49.69
5.	Pb-11×Seher-06/Pavon	-36.66	15.00	2.59	-0.97	-21.25	-13.08	16.66	-15.13	14.39	-65.28
6.	King bird×Frontana/Galaxy-13	3.36	32.24	-1.54	-2.22	2.50	1.78	12.76	-8.58	32.12	-21.74
7.	CIM-54 2012-13×SA42/Shafaq	-18.90	33.91	-2.00	-2.22	-25.90	5.36	39.58	9.09	33.79	-43.10
8.	Millat-11×Inq-91/Prl/Fsd-08	2.94	13.58	-3.13	-2.65	23.15	32.55	14.89	21.34	13.53	-44.50
9.	AARI-11×Galaxy-13	5.6	-6.17	-3.65	-0.98	18.44	-10.76	8.92	-5.96	-6.15	-51.69
10.	Inq-91/Prl/Fsd-08×Inq-91/Millat-11	-16.98	9.49	-1.51	-1.49	-17.09	-10.48	-11.76	16.02	9.69	-44.68
11.	Galaxy-13×CIM-130 (2012-13)	-9.68	33.08	0.00	-2.22	-13.41	-18.75	29.41	14.64	31.54	-63.19
12.	SA-42/PRL×Fsd-08	-24.97	9.47	3.02	-2.96	-4.32	0	5.36	-8.58	5.44	-66.36
13.	Pb-11×Lyp-73	-25.52	40.15	-2.97	-2.25	-2.93	-10.76	6.25	-16.05	40.95	-57.66
14.	Inq-91/Prl/Fsd-08×UAF1057	-22.23	16.21	-0.99	-3.48	-15.23	-8.54	25.00	-10.10	16.42	-57.62
15.	Seher-06×Galaxy-13	-30.97	-10.72	0.00	-3.48	-26.59	-3.41	8.33	-6.56	-10.47	-72.46
16.	Galaxy-13×CIM-1 (2012-13)	-7.002	-13.99	0.00	-2.76	-14.14	3.65	6.91	3.46	-13.41	-68.36
17.	Millat-11×Pb-11	-9.55	13.97	-0.99	-3.47	-25.85	-5.69	0.62	2.49	13.66	-65.94
18.	Galaxy-13×Millat-11	-16.77	36.00	2.24	-4.44	-0.91	-11.53	6.91	-9.50	36.04	-59.97
19.	Millat-11×Galaxy-13	-3.66	12.00	4.12	-2.76	-18.28	-7.69	-1.46	-14.53	12.21	-61.86
20.	Fsd-08×Millat-11	-6.45	-21.37	0.00	-1.28	-23.16	20.00	-0.73	11.76	-20.33	-63.71
21.	SA-42/Prl×Millat	-31.19	10.61	-2.52	-3.72	-31.81	0.71	11.11	-6.94	10.20	-64.51
22.	Pb-11×Galaxy-13	-19.07	41.00	2.93	-4.74	-20.22	-14.61	-3.56	-1.27	42.71	-61.73
23.	Fsd-08×Pb-11	-27.29	-0.12	1.92	-3.48	-19.77	-8.06	-6.25	9.09	0.00	-56.23
24.	Seher-06×82003	2.89	1.11	3.63	-2.47	0.52	-15.38	2.94	-5.96	0.10	-60.24
25.	SA-42/Prl×Galaxy-13	-22.99	-16.28	2.21	-3.00	-5.58	-18.46	-9.96	-4.02	-15.90	-65.02
26.	Galaxy-13×Pb-11	-8.79	-1.85	-1.67	0.23	-3.88	3.38	-5.55	25.41	-1.52	-70.84
27.	Inq-91/Prl/Fsd-08×Galaxy-13	-11.23	-13.79	-3.52	-1.78	-12.27	-3.74	-4.21	-9.98	-13.62	-78.08
28.	Pb-11× Inq-91/Prl/Fsd-08	-19.87	-28.12	-2.05	-0.74	-33.86	-1.78	-15.85	-4.42	-28.27	-87.32
29.	Pb-11×CIM-126 (2012-13)	-1.98	-25.92	-1.64	-0.49	-29.26	12.99	-11.93	13.17	-24.82	-99.51
30.	CIM-130 (2012-13)×Inq-91/Prl/ Fsd-08	-6.33	-10.74	-2.64	-0.20	-27.72	-13.07	-1.46	-2.19	-10.53	-59.36
31.	Inq-91×Galaxy-13	-32.52	0.62	0.52	-1.73	1.82	-0.17	-2.57	-11.11	0.94	-67.16
32.	Galaxy-13xUqab2000/Inq-91	-15.39	1.36	-1.72	-0.74	-20.00	-6.42	0.62	-5.55	1.11	-73.26
33.	CIM-130 (2012-13)×Millat-11	-5.37	-13.01	-1.03	-0.74	55.46	0	-13.51	-1.14	-13.26	26.18
34.	Pb-11×Millat-11	-23.84	-12.79	0.03	-0.74	-6.11	-13.84	8.60	-0.36	-13.47	53.56
35.	Inq-91/Prl/Fsd-08×Lyp-73	-18.61	-12.79	-0.30	-0.94	13.83	4.85	2.00	0.91	-13.36	45.51
36.	Galaxy-13×Fsd-08	-27.20	-5.99	-0.83	-1.73	-22.72	-12.50	-11.81	-21.04	-5.25	32.42
37.	UOS-127×UOS-520	10.95	-11.71	3.11	-0.97	-44.30	-13.07	-33.82	-16.97	-8.88	-39.03
38.	UOS-950×Pb-11	-33.69	6.48	-0.99	-1.79	-46.83	-11.11	-8.33	2.81	5.61	-0.77
39.	UOS-950×UOS-135	-34.27	42.40	-2.48	-1.19	-42.92	-2.56	-15.09	1.14	41.66	-48.81
40.	Galaxy -13×UOS-540	-2.44	54.84	-1.00	-0.97	-32.44	-11.54	23.40	-15.11	54.59	-49.69

CONCLUSION

It is concluded that exploitation of heritability, heterosis and heterobeltiosis for grains spike^{-1}, 1000-grain weight and grain yield plant^{-1} greatly contribute towards wheat yield maximization. It revealed that most crosses demonstrated remarkable heterosis over mid and better parents with different morphological traits. Millat-11×UAF1057 showed highest heretability for number of grains spikte^{-1} whereas Seher-06 × Galaxy-13 for 1000 grain weight. As far as heterosis and heterobeltiosis are concerned cross Galaxy-13 × UOS-540 showed best response towards number of grains spike^{-1} and 1000-grains weight. While Pb-11×Millat-11 responded positively towards heterobeltiosis for grain yield plant^{-1}. These crosses may be considered in breeding program for development of high yielding wheat varieties.

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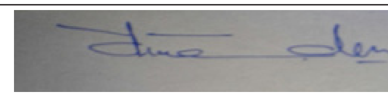
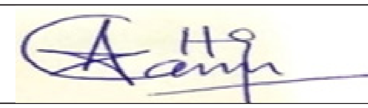
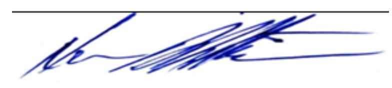
2.	Kashif Javed	Conducted the research and analysed data	
3.	Ikram ul Haq	Supervisor	
4.	Naeem Akhtar	Co-supervisor	
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