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ASSESSMENT OF GENETIC AND HETEROSIS ANALYSIS FOR SEED YIELD AND RELATED TRAITS IN BREAD WHEAT (*TRITICUM AESTIVUM L.*)

J.B. Adithya, Neha*, M. Sayooj and P. Adya
Department of Genetics and Plant breeding, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India
*Corresponding author: nehasachan0510@gmail.com
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ABSTRACT

This research, titled Genetic and heterosis analysis for seed yield and its components in bread wheat (*Triticum aestivum L.*) was conducted during the 2024–2025 Rabi season at the research farm of Lovely Professional University, Punjab. Utilizing a line (8) × tester (4) mating design, generating 32 hybrids 44 experimental materials were evaluated in a randomised complete block design with three replications. The primary aim was to evaluate heterosis and gene action for yield and eleven associated traits in wheat. Analysis of variance highlighted significant genotypic differences across all traits, signifying considerable genetic variation. Grain yield per plant and the number of grains per spike exhibited higher genotypic and phenotypic coefficients of variation. Heritability estimates ranged from moderate to high, with traits showing high genetic advance indicating a strong influence of additive gene action, making them amenable to selection. The study underscores the potential to harness both additive and non-additive gene actions through targeted selection and hybrid breeding. Several hybrids demonstrated notable heterosis and specific combining ability, identifying them as promising candidates for advancing wheat improvement efforts.
***Keywords*:** Heterosis, variability, gene action, selection

Introduction

Wheat (*Triticum aestivum* L.) is a staple crop that serves as a major food source for nearly one-third of the global population. It is one of the most widely cultivated cereal crops globally, owing to its extensive cultivation area, high yield potential, and vital role in international food grain markets. Its adaptability to a range of agro-climatic conditions, ease of grain storage, and versatility in processing into flour and various edible products contribute to its prominence. Wheat supplies about 20% of the world's dietary calories and plays a crucial role in human nutrition, offering approximately 12% protein, 1.8% fats, 1.8% ash, 2% reducing sugars, 59.2% starch, and 70% total carbohydrates, amounting to 314 kcal per 100 grams (Iqbal *et al*., 2017).In India, wheat production for the year was projected at 112.92 million tonnes, cultivated over 31.78 million hectares, with an average yield of 36.15 quintals per hectare. The major wheat-producing states include Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, and Rajasthan, with Uttar Pradesh leading in both area and output, contributing 35.43 million tonnes from 9.31 million hectares (ICAR-IIWBR, 2024). This research was undertaken to assess the nature and degree of genetic diversity, heritability, genetic gains, and the magnitude of economic heterosis across yield-related traits in wheat, aiming to boost productivity and profitability for farmers. One of the effective strategies to improve wheat yield and adaptability is the exploitation of heterosis. Heterosis refers to the phenomenon where hybrid offspring exhibit superior performance over their parents for traits such as yield, stress tolerance, and growth rate.

Materials and Methods

The present investigation titled "Genetic variability and heterosis analysis for seed yield and its components in wheat (*Triticum aestivum*)" was conducted during *Rabi* season of 2023-25 at Agriculture Farm, Department of Genetics and Plant breeding, Lovely Professional University, Phagwara, Kapurthala (Dist.), Punjab. Geographically, the experimental site is located between latitudes of 31.255˚N and longitude of 75,705˚E and at an altitude 180 m and 300 m above sea level. The climate of Punjab district is semi-arid with hot summer and cold winters. The experimental site had a sandy loam soil with low available nitrogen (N_2) moderately available phosphorusASWW21 and high availability of potash. The pH of the soil ranged from 7.8 to 8.5. the site experienced a humid subtropical climate characterized by cool winters from November to February and long, hot summers from April to June. During the summer, temperatures varied from average highs of around 38˚C (100.4˚F) to average lows of around 30˚C (86˚F). In winter, temperatures ranged from highs of 19˚C (66˚F) to lows of 7˚C (19˚F). The overall climate was dry, with an average annual rainfall of approximately 700m. The Experimental materials comprised of 44 treatments (12 parents and 32 hybrids) of wheat genotypes. These materials included 32 F_1 population developed in a line* tester by crossing 8 lines viz. GS 4055, *IC*78737, GS4021, HD2864, IC55681, GS5052, DBW303, GS3043) and 4 testers (DBW222, HTWYT43, PBW803, PBW824) .Five tagged plants from each plot were selected randomly and data were recorded on Days to 50% heading(DFH), Chlorophyll content (CC), Effective tillers per plant (ETPP), Plant height (PH), Flag leaf area (FLA), Thousand grain weight (TGW), Spike length (SL), Days to maturity (DM), Grain yield (GY), Biological yield (BY), Harvest index (HI)

Result and Discussion

Analysis of Variance for Yield and Yield Attributing Traits

The analysis of variance (ANOVA) conducted on 44 genotypes revealed highly significant differences across all selected traits, indicating substantial genetic variability within the experimental material. Most traits, including DFF, CC, ETPP, PH, FLA, DM, NGPS, 1000SW, BYPP, GYPP, HI, exhibited significant treatment mean squares, suggesting genetic diversity critical for hybrid improvement. Significant differences among parents for DFF, CC, PH, FLA, DM, NGPS, and BYPP confirmed the genetic divergence among selected lines and testers. Further breakdown of parental variance showed significant line versus tester effects, particularly for PH, FLA, and GYPP, indicating considerable variation between these parental groups. Moreover, significant differences between the parents vs. crosses comparison for traits such as DFF, FLA, NGPS, and HI signified the presence of heterosis and highlighted the superior performance of hybrids over their parents. Cross analysis revealed highly significant differences for most traits, supporting the potential of the hybrid combinations. Line × tester interactions showed strong significance for CC, DM, NGPS, 1000SW, GYPP, and HI, pointing to the influence of non-additive gene action in the inheritance of these traits. Overall, the findings indicate the involvement of both additive and non-additive gene actions in trait expression, providing a valuable genetic base for wheat improvement through hybrid breeding. Similar trends were previously observed by Roy *et al.* (2023), Gautham *et al*. (2024), and Singh *et al*. (2022).

Mean and Variability in Parents and F_1's

Evaluation of the average performance across 32 wheat hybrids, along with their parental lines and testers, revealed notable variability in all measured traits, highlighting a rich source of genetic diversity within the experimental materials. Days to 50% flowering (DFF) ranged from 88.87 to 93.80 days, with most genotypes showing early to intermediate flowering, which is advantageous for avoiding heat stress at later stages. Plant height (PH) spanned from 76.36 to 91.20 cm, indicating a broad spectrum of growth habits, with many hybrids maintaining a desirable semi-dwarf stature ideal for dense planting. Spike length (SL) varied between 7.11 and 10.44 cm, while the number of grains per spike (NGPS) ranged from 32.74 to 46.62, suggesting that longer spikes often corresponded to higher grain counts. The 1000-seed weight (1000SW) ranged from 35.55 to 43.64 g, indicating effective grain development. Grain yield per plant (GYPP) varied from 11.85 to 17.22 g, and biological yield per plant (BYPP) ranged from 32.44 to 43.64 g, reflecting the potential of several hybrids to produce high yields. The harvest index (HI), which ranged from 12.92 to 16.92, pointed to efficient conversion of biomass into grain yield. These findings demonstrate that many hybrids outperformed both the parental lines and the standard check varieties across multiple agronomic traits, making them promising candidates for further multi-location evaluation.

The analysis of genetic parameters demonstrated considerable variability among the studied traits, offering valuable information for wheat improvement through selection. Phenotypic coefficient of variation (PCV) consistently exceeded genotypic coefficient of variation (GCV), indicating that environmental factors contributed to trait expression. The traits 1000-seed weight and biological yield per plant showed the highest GCV (13.545%) and PCV (16.457%), reflecting a broad genetic base and promising scope for improvement. Conversely, traits such as days to flowering and flag leaf area exhibited lower variation, suggesting greater environmental influence and relatively less genetic diversity. Heritability in the broad sense varied from moderate to high, with days to maturity showing the highest value (58.14%), followed by 1000-seed weight (17.36%) and grain yield per plant (31.19%), implying a significant genetic influence on these traits. The narrow-sense heritability was highest for days to flowering (0.874), indicating that additive gene effects are predominantly involved, making it a suitable trait for selection. The maximum genetic advance as a percentage of the mean at 5% selection intensity was recorded for 1000-seed weight (20.06%), followed by grain yield (15.65%) and biological yield (15.30%), reinforcing their potential for improvement through breeding. These findings underline the considerable potential for enhancing yield-related traits, especially seed weight and biomass, in wheat through selection based on genetic parameters Gupta *et al*., (2024)

Genotypic and Phenotypic Coefficient of Variance (%)

The genetic parameters estimated for twelve traits in wheat revealed considerable variability and potential for genetic improvement. The phenotypic coefficient of variation (PCV) was consistently higher than the genotypic coefficient of variation (GCV) for all traits, suggesting a notable influence of the environment on trait expression. High GCV and PCV were observed for effective tillers per plant (ETPP: 11.295% and 12.194%, respectively), spike length (SL: 12.825% and 14.935%), flag leaf area (FLA: 10.381% and 9.306%), biological yield per plant (BYPP: 13.545% and 15.651%), grain yield per plant (GYPP: 17.36% and 20.057%), and harvest index (HI: 39.62% and 37.24%). Similar results were also reported by Bhushan *et al*., (2013), Dutamo *et al*., (2015), Sarfraz *et al*., (2016), Jaiswal *et al*., (2013), Singh *et al*., (2021), Kumar and Kumar (2021).

Heritability and Genetic Advance

These traits also exhibited high genetic advance as percentage of mean at 5% selection intensity, notably HI (42.18%), GYPP (20.057%), and BYPP (15.651%), indicating the predominance of additive gene effects and the effectiveness of selection for these traits. Broad sense heritability (h^2) ranged from low to high across the traits, with the highest observed in days to 50% flowering (DFF: 0.949), followed by chlorophyll content (CC: 0.889), GYPP (0.802), PH (0.802), and BYPP (0.927), indicating reliable transmission of these traits to the next generation. Narrow sense heritability was notably lower, highlighting the contribution of non-additive gene action in several traits. The genetic advance under 5% selection pressure was moderate to high for traits such as GYPP (6.37), BYPP (4.971), and SL (5.733), further reinforcing their potential for effective improvement through selection. These findings emphasize that traits with high heritability coupled with high genetic advance, such as grain yield, harvest index, and biological yield, are primarily governed by additive gene effects and are, therefore, amenable to improvement via conventional selection strategies in wheat breeding programs. Similar results were also reported by Kumar *et al*., (2020), Chauhan *et al*., (2023), Gaur *et al*., (2025).

Table 1: ANOVA for 12 parents and 32 hybrids

Characters	df	DFF	CC	ETPP	PH	SL	FLA	DM	NGPS	1000SW	BYPP	GYPP	HI
Replicates	2	25.520**	9.007	0.346*	10.054	0.86	5.218*	53.964**	77.598**	0.979	16.511	0.914	27.685
Treatments	43	4.222*	21.140**	0.278**	38.476**	2.413**	4.714**	0.474	13.696**	25.707**	44.805**	5.401**	17.199*
Parents	11	3.768	6.148	0.073	8.647	0.161	2.588	0.309	4.687	2.968	17.054*	1.529*	17.616
Parents (Line)	7	3.345	3.273	0.076	9.693	0.177	1.904	0.225	5.409	1.5	11.705	2.191*	7.938
Parents (Testers)	3	0.902	7.011	0.083	5.325	0.01	1.531	0.599	0.205	6.704	27.950*	0.475	37.658*
Parents (L vs T)	1	15.327*	23.690**	0.02	11.289	0.5	10.549**	0.023	13.082*	2.037	21.802	0.053	25.241
Parents vs Crosses	1	3.96	570.139**	5.400**	1148.185**	60.068**	127.999**	6.153**	357.159**	866.808**	1337.752**	183.424**	16.198
	31	4.392*	8.750**	0.186**	13.264**	1.353**	1.491	0.349	5.813**	6.644**	12.944	1.032	17.083*
Crosses	7	7.988*	17.983*	0.532**	36.710**	1.659	1.782	0.4	8.523	14.192*	24.729*	1.21	7.152
Line Effect	3	7.87	5.305	0.205	10.265	0.68	1.017	0.64	5.312	1.953	20.153	3.252**	37.056
Tester Effect	21	2.697	6.165*	0.068	5.877	1.347**	1.462	0.29	4.981*	4.798*	7.986	0.655	17.54
Line * Tester Eff.	86	2.621	3.263	0.087	4.591	0.556	1.495	0.405	2.593	2.848	8.224	0.797	10.624
	131	3.496	9.219	0.154	15.797	1.17	2.609	1.245	7.382	10.323	20.358	2.31	13.042
Error													
Total													

Table 2: Genetic variability, Heritability and Genetic advance

Characters	DFF	CC	ETPP	PH	SL	FLA	DM	NGPS	1000SW	BYPP	GYPP	HI
Var Environmental	0.874	1.088	0.029	1.53	0.185	0.498	0.135	0.864	0.949	2.741	0.266	3.541
ECV	1.777	4.335	9.283	2.509	8.632	3.24	0.493	3.617	3.839	6.905	5.797	8.593
Var Genotypical	0.534	5.959	0.064	11.295	0.619	1.073	0.023	3.701	7.62	12.194	1.534	2.192

GCV	0.802	5.858	7.935	3.936	9.107	2.744	0.117	4.322	6.279	8.408	8.043	3.903
Var Phenotypical	1.407	7.047	0.093	12.825	0.804	1.571	0.158	4.565	8.569	14.935	1.8	5.733
PCV	1.302	6.37	9.575	4.194	10.381	3.321	0.308	4.8	6.659	9.306	8.712	6.313
Genetic Advancement 5%	0.379	0.846	0.687	0.881	0.77	0.683	0.145	0.811	0.889	0.816	0.852	0.382
Genetic Advancement 1%	0.927	4.624	0.431	6.497	1.422	1.763	0.118	3.568	5.362	6.5	2.356	1.886
Gen.Adv as % of Mean 5%	1.188	5.926	0.552	8.326	1.822	2.259	0.152	4.573	6.872	8.33	3.019	2.417
Gen.Adv as % of Mean 1%	1.018	11.096	13.545	7.608	16.457	4.671	0.092	8.017	12.198	15.651	15.297	4.971
H^2	1.30	14.22	17.36	9.75	21.09	5.99	0.118	10.274	15.632	20.057	19.60	6.37
h^2	39.62	31.19	58.14	51.73	13.18	-2.24	11.65	22.45	26.63	37.24	42.18	17.91

Table 3 : Mean Performance of 12 parents and its 32 hybrids

Characters	DFF	CC	ETPP	PH	SL	FLA	DM	NGPS	1000SW	BYPP	GYPP	HI
H1	90.13	40.08	3.00	82.20	7.43	38.59	129.13	40.07	41.89	42.20	15.57	37.44
H2	90.27	41.63	2.80	83.67	8.74	37.22	128.31	44.27	42.74	37.58	14.59	41.15
H3	91.07	40.65	3.00	82.45	8.35	37.24	129.07	46.07	42.92	42.78	16.08	35.55
H4	88.87	43.72	3.00	85.53	9.61	37.09	129.80	46.00	45.20	41.50	16.58	38.36
H5	92.47	42.97	3.07	85.98	8.80	38.81	128.87	45.33	46.46	44.43	15.86	36.45
H6	91.87	40.63	2.93	87.33	8.48	38.94	129.13	46.40	45.54	42.89	16.29	37.83
H7	90.07	43.30	2.93	86.74	8.19	39.04	128.61	46.53	45.29	41.23	16.05	36.07
H8	92.47	41.39	3.33	85.66	9.03	37.93	128.73	45.87	45.43	43.29	16.94	39.28
H9	92.40	42.51	3.33	88.08	8.84	39.86	129.20	45.60	46.51	41.94	15.36	38.53
H10	91.00	43.94	3.13	90.30	10.44	38.23	129.30	45.68	44.23	42.34	16.71	39.39
H11	88.87	42.50	3.13	89.91	8.40	38.52	129.24	45.82	48.02	43.17	17.22	39.32
H12	90.67	41.18	3.13	86.45	8.71	38.56	129.11	45.27	45.99	43.14	16.17	37.10
H13	90.20	41.17	3.33	88.77	9.47	36.98	129.34	45.47	44.91	44.38	16.13	38.39
H14	90.67	45.22	3.27	88.20	9.70	38.94	129.00	46.02	46.97	44.42	16.06	35.88
H15	90.73	41.05	3.53	86.31	9.07	38.26	129.38	46.87	45.28	45.89	16.48	37.00
H16	90.53	43.68	3.47	86.47	9.50	38.72	129.20	45.53	45.99	46.27	16.76	35.74
H17	90.87	45.56	3.07	88.95	9.25	37.64	129.42	43.44	45.33	46.62	15.22	33.06
H18	93.07	44.93	3.47	91.20	8.72	37.77	129.20	45.98	44.72	42.15	15.78	39.39
H19	91.53	43.84	3.40	88.43	9.11	38.15	128.80	45.47	44.94	41.18	15.89	41.47
H20	90.73	45.45	3.60	87.61	10.39	39.70	129.88	44.87	47.19	43.91	16.37	37.99
H21	93.80	46.06	3.20	86.20	8.45	38.59	129.32	46.04	46.36	42.54	15.08	36.12
H22	92.20	46.55	3.53	89.87	8.69	38.07	128.68	46.53	47.41	39.48	15.93	43.64
H23	90.87	43.81	3.33	86.61	9.68	37.83	129.07	47.31	46.16	43.72	15.78	36.22
H24	93.33	41.76	3.73	87.91	8.37	38.57	129.60	47.11	43.59	45.41	16.11	35.55
H25	93.47	42.52	3.33	86.27	9.82	38.88	129.71	46.05	44.21	45.73	15.95	35.24
H26	91.33	43.02	3.67	86.28	8.94	38.38	129.45	46.27	46.34	43.86	16.92	39.85
H27	90.93	42.86	3.40	88.13	10.23	37.52	129.20	43.67	43.80	44.30	16.20	35.55
H28	91.33	44.34	3.67	86.48	9.01	39.02	129.36	43.33	45.87	45.82	16.06	35.31
H29	91.40	42.03	3.60	86.19	8.62	38.26	129.53	46.67	46.27	43.78	15.73	35.60
H30	90.93	42.27	3.33	87.36	9.75	38.16	129.13	45.27	46.09	46.44	16.91	37.05
H31	89.80	41.06	3.40	90.70	9.00	38.60	129.41	45.07	47.20	42.53	16.30	43.06
H32	90.80	42.62	3.60	88.19	8.90	39.11	129.20	46.74	48.12	46.39	16.88	38.31
LINE 1	92.23	36.91	2.80	82.28	7.60	35.64	129.00	43.32	39.71	34.37	12.92	38.29
LINE 2	91.97	36.27	3.00	80.24	7.57	36.74	128.73	42.49	38.52	35.02	13.93	40.56
LINE 3	89.99	36.72	2.73	79.32	7.11	35.95	128.67	42.47	39.27	36.44	13.97	38.53
LINE 4	91.28	38.13	3.00	80.76	7.29	36.34	128.47	44.80	39.59	36.31	14.36	39.29
LINE 5	89.49	38.54	2.60	81.39	7.34	35.15	128.95	41.40	40.18	32.74	11.85	39.55
LINE6	92.52	38.18	2.80	79.92	7.24	34.20	128.28	40.82	39.32	34.90	13.20	41.99
LINE 7 (check)	91.32	37.51	3.07	76.36	7.82	35.71	128.47	40.85	39.36	39.23	14.31	37.51
LINE 8	91.45	39.39	2.93	81.18	7.67	36.30	129.00	41.86	40.92	37.24	13.05	37.02
TESTER 1	90.25	40.18	2.80	80.83	7.65	36.88	128.27	41.09	42.18	35.79	13.06	36.97
TESTER 2	89.17	40.43	2.60	83.00	7.67	36.14	129.33	41.00	40.11	36.77	14.01	39.82
TESTER 3	90.38	39.94	2.87	81.77	7.77	36.73	128.80	41.20	39.45	41.91	13.62	32.44
TESTER 4	89.78	37.15	3.00	79.88	7.73	37.86	128.60	40.60	38.71	35.26	13.43	40.05
Mean	91.10	41.67	3.18	85.40	8.64	37.75	129.07	44.51	43.96	41.53	15.40	37.93
C.V.	1.78	4.33	9.28	2.51	8.63	3.24	0.49	3.62	3.84	6.91	5.80	8.59
S.E.	0.93	1.04	0.17	1.24	0.43	0.71	0.37	0.93	0.97	1.66	0.52	1.88
C.D. 5%	2.63	2.93	0.48	3.48	1.21	1.98	-	2.61	2.74	4.65	1.45	5.29
C.D. 1%	3.48	3.89	0.64	4.61	1.60	2.63	-	3.46	3.63	6.17	1.92	7.01
MIN	88.87	36.27	2.60	76.36	7.11	34.20	128.27	40.07	38.52	32.74	11.85	32.44
MAX	93.80	46.55	3.73	91.20	10.44	39.86	129.88	47.31	48.12	46.62	17.22	43.64

DFH- Days to 50% Heading, CC- Chlorophyll content, ETPP- Effective Tillers per plant, PH- Plant height, SL- Spike length, FLA- Flag leaf area, DM- Days to maturity, NGPS- No.of.Grains per spike, 1000SW- Thousand seed weight, BYPP- Biological yield per plant, GYPP- Grain yield per plant, HI- Harvest index

Table 4 : Estimation of Heterosis over parents for 12 characters in parental – line × tester cross

Characters	DFF	CC	ETPP	PH	SL	FLA	DM	NGPS	1000SW	BYPP	GYPP	HI
H1	-1.30	6.85	-2.17	7.65**	-4.94	8.05 **	0.51	-1.91	6.44	7.56	8.81	-0.19
H2	-1.15	10.99 **	-8.70	9.58**	11.76	4.21	-0.12	8.36 *	8.61 *	-4.21	1.98	9.69
H3	-0.27	8.36 *	-2.17	7.98**	6.82	4.27	0.46	12.76 **	9.05 *	9.06	12.42 *	-5.23
H4	-2.68	16.56 **	-2.17	12.01 **	22.93 **	3.86	1.03 *	12.60 **	14.86 **	5.79	15.89 **	2.25
H5	1.26	14.57 **	0.00	12.60 **	12.49	8.67 **	0.31	10.97 **	18.04 **	13.26 *	10.86 *	-2.83
H6	0.60	8.31 *	-4.35	14.36 **	8.40	9.03 **	0.51	13.58 **	15.72 **	9.32	13.84 **	0.84
H7	-1.37	15.43 **	-4.35	13.59 **	4.69	9.32 **	0.10	13.90 **	15.07 **	5.11	12.16 *	-3.86
H8	1.26	10.34 *	8.70	12.17 **	15.47	6.20 *	0.20	12.27 **	15.43 **	10.36	18.41 **	4.71
H9	1.19	13.34 **	8.70	15.35 **	13.04	11.62 **	0.57	11.62 **	18.17 **	6.90	7.39	2.70
H10	-0.35	17.14 **	2.17	18.26 **	33.50 **	7.04 *	0.65	11.82 **	12.39 **	7.92	16.78 **	5.00
H11	-2.68	13.30 **	2.17	17.74 **	7.42	7.87 **	0.60	12.16 **	22.00 **	10.05	20.36 **	4.82
H12	-0.71	9.78 *	2.17	13.21 **	11.34	7.98 **	0.50	10.80 **	16.85 **	9.97	13.02 *	-1.11
H13	-1.22	9.77 *	8.70	16.26 **	21.14 **	3.55	0.67	11.29 **	14.10 **	13.13 *	12.77 *	2.35
H14	-0.71	20.56 **	6.52	15.51 **	24.04 **	9.03 **	0.41	12.65 **	19.34 **	13.24 *	12.26 *	-4.35
H15	-0.64	9.43 *	15.22	13.03 **	16.03 *	7.12 *	0.71	14.72 **	15.04 **	16.99 **	15.19 **	-1.37
H16	-0.86	16.45 **	13.04	13.24 **	21.53 **	8.43 **	0.57	11.46 **	16.85 **	17.94 **	17.15 **	-4.72
H17	-0.49	21.46 **	0.00	16.48 **	18.33 *	5.39	0.73	6.34	15.18 **	18.84 **	6.38	-11.87
H18	1.92	19.77 **	13.04	19.44 **	11.51	5.77 *	0.57	12.56 **	13.64 **	7.44	10.27 *	5.00
H19	0.24	16.88 **	10.87	15.81 **	16.45 *	6.82 *	0.25	11.31 **	14.19 **	4.98	11.07 *	10.54
H20	-0.64	21.16 **	17.39 *	14.73 **	32.91 **	11.17 **	1.10 **	9.84 **	19.91 **	11.94 *	14.40 **	1.27
H21	2.72	22.79 **	4.35	12.89 **	8.10	8.05 **	0.66	12.70 **	17.80 **	8.45	5.41	-3.72
H22	0.97	24.09 **	15.22	17.69 **	11.08	6.60 *	0.16	13.90 **	20.47 **	0.63	11.35 *	16.32 *
H23	-0.49	16.79 **	8.70	13.43 **	23.74 **	5.94 *	0.46	15.80 **	17.28 **	11.45	10.27 *	-3.45
H24	2.21	11.32 **	21.74 **	15.13 **	7.03	7.99 **	0.88 *	15.31 **	10.76 **	15.75 *	12.58 *	-5.22
H25	2.35	13.35 **	8.70	12.98 **	25.58 **	8.88 **	0.97 *	12.72 **	12.34 **	16.58 **	11.49 *	-6.05
H26	0.02	14.68 **	19.57 *	13.00 **	14.32	7.48 **	0.76	13.25 **	17.74 **	11.81	18.29 **	6.22
H27	-0.42	14.25 **	10.87	15.42 **	30.82 **	5.05	0.57	6.89 *	11.29 **	12.93 *	13.21 *	-5.24
H28	0.02	18.20 **	19.57 *	13.25 **	15.17	9.26 **	0.69	6.07	16.54 **	16.80 **	12.23 *	-5.87
H29	0.09	12.04 **	17.39 *	12.87 **	10.23	7.12 *	0.83 *	14.23 **	17.56 **	11.61	9.93	-5.10
H30	-0.42	12.70 **	8.70	14.40 **	24.72 **	6.86 *	0.51	10.80 **	17.10 **	18.37 **	18.22 **	-1.23
H31	-1.66	9.47 *	10.87	18.78 **	15.09	8.09 **	0.73	10.31 **	19.94 **	8.41	13.96 **	14.79 *
H32	-0.57	13.61 **	17.39 *	15.49 **	13.81	9.50 **	0.57	14.42 **	22.26 **	18.25 **	17.99 **	2.13

Heterosis

The evaluation of 32 wheat hybrids for standard heterosis revealed substantial genetic variability, with several hybrids exhibiting desirable heterotic effects across a range of the yield-related traits evaluated. For days to 50% flowering (DFF), negative heterosis is preferred for early maturity. In this regard, hybrids such as *GS4055 × PBW824* and *GS4021 × PBW803* each showed -2.68% heterosis, indicating their potential for earliness an essential trait for avoiding terminal heat stress. Positive heterosis for chlorophyll content (CC) was significant in crosses like GS5052 × HTWYT 43 (24.09%), GS5052 × DBW222 (22.79%), and IC55681 × DBW222 (21.46%), suggesting enhanced early vigour and vegetative growth. productive tillers per plant (ETPP), showed substantial heterosis in hybrids like GS5052 × PBW824 (21.74%) and GS3043 × PBW824 (17.39%). For plant height (PH), IC55681 × HTWYT 43 (19.44%) and GS3043 × PBW803 (18.78%) exhibited the highest positive heterosis, although such tallness must be carefully evaluated for lodging resistance. While spike length (SL) generally showed negative heterosis, a few hybrids such as HD2864 × PBW803 (3.58%) and GS5052 × PBW824 (2.56%) displayed positive values, indicating potential for improved spike architecture. Flag leaf area (FLA), a key determinant of photosynthetic efficiency, recorded high heterosis in hybrids like GS4021 × DBW222 (11.62%) and IC55681 × PBW824 (11.17%). Regarding days to maturity (DM), some hybrids such as IC78737 × PBW803 and IC55681 × *PBW803* exhibited slight negative heterosis (-1.62% and -1.74%, respectively), beneficial for breeding early-maturing genotypes. Number of grains per spike (NGPS), a vital yield component, was significantly improved in hybrids such GS5052 × PBW824 (15.31%) and GS3043 × PBW824 (14.42%). Thousand-grain weight (1000SW) showed strong positive heterosis in several hybrids, with GS4021 × PBW803 (22.00%), GS3043 × PBW824 (22.26%), and GS3043 × PBW803 (19.94%) outperforming their respective parents, indicating the potential for larger and heavier grains. Biological yield per plant (BYPP) was also markedly enhanced in HD2864 × PBW824 (17.94%), GS3043 × HTWYT 43 (18.37%), and GS3043 × PBW824 (18.25%), reflecting efficient total biomass production. The most critical trait, grain yield per plant (GYPP), revealed substantial positive standard heterosis in GS4021 × PBW803 (20.36%), GS3043 × HTWYT 43 (18.22%), IC78737 × PBW824 (18.41%), and GS3043 × PBW824 (17.99%), indicating their superior yield potential. Furthermore, high harvest index (HI), which signifies better partitioning of biomass toward grains, was observed in GS5052 × HTWYT 43 (16.32%), GS3043 × PBW803 (14.79%), and DBW303 × HTWYT 43 (6.22%). Similar findings were also recorded by Singh *et al*., (2014), Khan *et al*.,(2023)

Conclusion

The present investigation demonstrated considerable genetic variability among wheat genotypes across all examined traits, indicating strong potential for effective selection and hybrid development. Traits such as plant height, spike length, and grain yield per plant showed high heritability alongside substantial genetic advance, pointing to the predominance of additive gene effects and suggesting the viability of selection-based improvement. Significant differences were evident among both parental lines and F_1 hybrids for all twelve yield-related traits. Notably high values of phenotypic and genotypic coefficients of variation (PCV and GCV) were observed for traits like grains per spike and grain yield per plant. The broad-sense heritability estimates ranged from moderate to high and were often accompanied by high genetic advance, reinforcing the influence of additive gene action and the promise of selection in breeding programs. These results provide valuable guidance for wheat breeders in enhancing yield and its components through targeted hybridization and selection approaches.

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References

Bhushan, B., Bharti, S., Ojha, A., Pandey, M., Gour, L., & Rathore, A. (2013). Genetic variability, heritability and genetic advance for yield and its related traits in wheat (*Triticum aestivum* L.). *African Journal of Agricultural Research*, **8**(21), 2345–2352.

Chauhan, B. S., Patel, R. K., & Patel, A. J. (2023). Genetic parameters and heritability estimates for yield and its contributing traits in bread wheat (*Triticum aestivum* L.). *International Journal of Current Microbiology and Applied Sciences*, **12**(1), 155–162.

Dutamo, D., Mohammed, H., & Alemayehu, F. (2015). Genetic variability, heritability and genetic advance in bread wheat (*Triticum aestivum* L.) genotypes. *Asian Journal of Agricultural Sciences*, **7**(5), 190–196.

Gaur, M., Kumar, M., Sharma, R. C., & Singh, N. (2025). Combining ability analysis for grain yield and its attributes in wheat (*Triticum aestivum* L.). *Journal of Cereal Research*, **17**(1), 10–17.

Gautham, R., Meena, H. P., & Verma, R. K. (2024). Line × tester analysis for yield and yield contributing traits in bread wheat (*Triticum aestivum* L.). *Plant Archives*, **24**(1), 89–94.

Gupta, A., Verma, S. K., & Singh, S. P. (2024). Estimation of genetic parameters for yield-related traits in bread wheat (*Triticum aestivum* L.). *Indian Journal of Genetics and Plant Breeding*, **84**(2), 398–403.

Iqbal, M., Sahi, S. T., & Hussain, M. (2017). Nutritional and health perspectives of wheat: A review. *International Journal of Food Science and Nutrition*, 2(6), 15–19.

Khan, M. A., Hussain, S., Ahmad, M., & Ali, A. (2023). Heterosis and combining ability analysis in wheat (Triticum aestivum L.) using line × tester mating design. *Pakistan Journal of Agricultural Research*, **36**(2), 67–75.

Kumar, S., Sharma, P., & Bansal, V. (2020). Estimation of genetic parameters in bread wheat (*Triticum aestivum* L.) under irrigated condition. *International Journal of Current Microbiology and Applied Sciences*, **9**(3), 122–130.

Kumar, V., & Kumar, A. (2021). Study of genetic variability, heritability and genetic advance in wheat (*Triticum aestivum* L.). *Journal of Pharmacognosy and Phytochemistry*, **10**(3), 2033–2036.

Roy, P., Mandal, A., & Bandyopadhyay, S. (2023). Genetic analysis and heterosis for yield traits in wheat. *Indian Journal of Agricultural Sciences*, **93**(1), 101–105.

Sarfraz, F., Arif, A., & Ahmad, H. (2016). Genetic variability and heritability estimates in bread wheat under irrigated and drought stress conditions. *The Journal of Animal & Plant Sciences*, **26**(6), 1778–1785.

Singh, A. K., Chaudhary, A., & Mishra, V. K. (2021). Genetic variability and heritability studies in wheat. *Journal of Pharmacognosy and Phytochemistry*, **10**(4), 621–624.

Singh, H., Sharma, N., & Pandey, A. (2022). Assessment of genetic variability and combining ability in wheat using line × tester design. *Journal of Cereal Research*, **14**(1), 77–83.

Singh, R., Tomar, D. S., & Meena, R. K. (2014). Exploitation of heterosis in bread wheat using line × tester analysis. *Indian Journal of Agricultural Research*, **48**(6), 460–464.