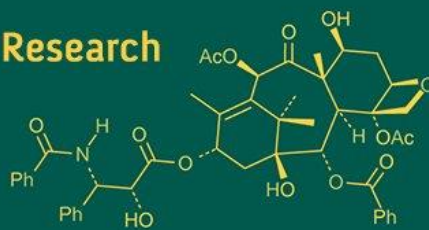


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Genetic variability and correlation studies in bread wheat (*Triticum aestivum* L.) for seed yield attributing traits

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Abstract

The present study evaluated 23 wheat (*Triticum aestivum* L.) genotypes during Rabi 2025-26 in RBD field experimental design with three replications to assess mean performance, genetic variability and trait association, for yield improvement. Analysis of variance revealed highly significant differences among genotypes for all fourteen traits. Moderate variability was observed for number of grains per spike (GCV 12.35%, PCV 14.20), number of spikelets per spike (11.39%, 13.85), and spike weight (11.00%, 14.66), while days to maturity showed the lowest variability (GCV 2.04%, PCV 2.28). High heritability was recorded for days to 50% flowering (91.34%), plant height (90.55%), and test weight (83.97%), with high genetic advance for number of grains per spike (22.10%). Grain yield exhibited strong positive correlations with number of productive tillers per m² ($r_g=0.976$, $r_p=0.866$), spikelets per spike ($r_g=0.960$, $r_p=0.610$), and harvest index ($r_g=0.834$, $r_p=0.743$). These findings suggest that selection based on productive tillers, grains per spike, and test weight can effectively enhance wheat yield.

Keywords: Wheat, GCV, PCV, correlation, diversity, grain yield (g), path coefficient analysis

Introduction

Wheat (*Triticum aestivum* L., $2n=42$) is one of the most important cereal crops of the world and contributes nearly 20% of the total caloric requirement of the global population. It belongs to the family Poaceae and is mainly cultivated as a self-pollinated crop. Among cultivated wheat species, hexaploid wheat occupies more than 90% of the cultivated area and is widely utilized for bread and bakery products due to the presence of gluten proteins (Debasis and Khurana, 2001) [4]. Wheat grains are rich source of carbohydrates, proteins, vitamins and minerals, making it an important component of human nutrition (Shewry, 2007) [14]. India is the second largest producer as well as consumer of wheat after China and contributes more than 12% to the global wheat production. In India, wheat occupies about 33.4 million hectares area and plays a vital role in national food security (Mahajan Sunali, 2025) [7]. Uttar Pradesh is the leading wheat producing state with high productivity under irrigated conditions (Anonymous, 2024-25) [1]. Genetic variability is the basic requirement for any successful crop improvement programme because it provides opportunity for effective selection and development of superior genotypes (Sabharwal and Lodhi, 1995) [13]. Estimates of heritability and genetic advance help breeders in understanding the inheritance pattern and expected genetic gain under selection (Songsri *et al.*, 2008) [15]. Further, correlation and path coefficient analyses are important tools for identifying yield contributing traits and their direct or indirect influence on grain yield. Therefore, the present investigation was conducted during Rabi 2025-26 at Rama University, Kanpur to study genetic variability and character association in wheat genotypes.

Materials and methods

The present investigation was carried out at the research farm of FASAI, Rama University, Kanpur. Twenty-three diverse wheat (*Triticum aestivum* L.) genotypes were collected from GPB department and evaluated in RBD field experimental design with three replications. All recommended agronomic practices have been performed time to time to raise the good crop.

data for 14 important traits viz., Days to 50% Flowering (DFF), Days to Maturity (DTM), Plant Height (PHT), Flag Leaf Length (FLL) cm, Productive Tillers Per sq. Meters (PTPM), Peduncle Length (PL) cm, Spike Length (SL) cm, Spike weight (g) (SW), Spikelet Per Spike (SPS), Grains Per Spike (GPS), Test Weight (g) (TW), Grain yield per plant (g) (GYPP), Biological Yield Per Plant (BYPP) and Harvest Index (HI) % has been recorded from 5 randomly selected competitive plant and their mean value was calculated and subjected to further statistical analysis using Windo-stat 9.0 and OSTAT.

Result and Discussion

Analysis of Variance

The analysis of variance revealed highly significant differences among the wheat genotypes for all the studied characters, indicating presence of substantial genetic variability in the experimental material (Table 1). The genotype mean square values were considerably higher than the corresponding error variances for most traits, suggesting that variability was mainly genetic in nature and effective selection can be practiced. For flowering and maturity traits, genotype mean squares of 62.15 for days to 50% flowering and 15.99 for days to maturity were highly significant over their respective error values (1.906 and 1.248). Plant height also showed high variability with genotype mean square of 207.40 against error variance of 6.984. Among yield

contributing traits, productive tillers per m² (2283.84), grains per spike (62.27) and test weight (59.57) exhibited highly significant variation among genotypes. Similarly, spike related traits such as spike length (3.28), spikelets per spike (10.38) and spike weight (0.30) also showed significant differences, indicating good scope for selection. The most important trait, grain yield per plot, recorded highly significant genotype mean square value of 39690.24 compared to error variance of 6094.148, suggesting wide genetic diversity for yield potential. Biological yield per plot (75188.81) and harvest index (39.46) also exhibited significant variability among the genotypes. Overall, the ANOVA results confirmed the presence of adequate genetic variation for further wheat improvement programme.

Overall, the ANOVA results clearly demonstrated that sufficient amount of genetic variability was present among the evaluated genotypes for all the studied characters. The low magnitude of error variance for most traits further indicated reliability and precision of experimental data. Since genotype mean squares were highly significant for all characters, it may be concluded that the breeding material possesses wide genetic diversity and selection based on these traits would be effective in future crop improvement programme. Such findings are commonly reported in cereal breeding experiments where significant variability forms basis for further studies like heritability, genetic advance, correlation and path coefficient analysis.

Table 1: Analysis of variance for 14 different traits of wheat genotypes (*Triticum aestivum* L.)

S. No.	Source of variance	Replication	Genotype	Error
	Degree of freedom	2	22	44
1	Days to 50% flowering	1.06	62.15**	1.906
2	Days to maturity	0.54	15.99**	1.248
3	Plant height (cm)	8.54	207.40**	6.984
4	Flag leaf length (cm)	3.49	13.25**	1.553
5	No. of productive tillers/m ²	840.11	2283.84**	282.147
6	Peduncle length (cm)	4.62	13.28**	1.763
7	Spike length	0.75	3.28**	0.291
8	Spike weight (g)	0.03	0.30**	0.06
9	No. of spikelets per spike	2.32	10.38**	1.431
10	No. of grains per spike	4.41	62.27**	6.063
11	Test Weight (g)	2.77	59.57**	3.566
12	Biological Yield per Plot (g)	68569.57	75188.81**	21522.6
13	Harvest Index (%)	9.22	39.46**	6.103
14	Grain Yield per plot (g)	13609.76	39690.24**	6094.148

Mean performance of 23 diverse wheat genotypes

The mean performance of 23 wheat genotypes revealed considerable variability for all the studied traits, indicating presence of good genetic diversity among the breeding material (Table 2). The mean value for days to 50% flowering was 68.51 days, where HD3249 (61 days) was earliest and Akbar (76.67 days) was latest flowering genotype. For days to maturity, the overall mean was 109.06 days, with minimum maturity in DDW-187 (104.67 days) and maximum in HD-3086 (113.67 days). Plant height ranged from 69.6 cm (HD3249) to 100.2 cm (DDW-187) with general mean of 86.77 cm. Flag leaf length varied between 15.47 cm (PBW-752) and 23.2 cm (Nawab), while the average value was 18.14 cm. Productive tillers per square meter ranged from 278.67 (HD3291) to 390 (Nawab) with population mean of 324.88 tillers/m². The number of

spikelets per spike varied from 11.27 (HD3298) to 18.4 (Nawab), whereas grains per spike ranged between 25.93 (HD3291) and 42.27 (Nawab). Test weight showed considerable variation with highest value in PBW-752 (51.67 g) followed by WH1402 (50.17 g) and lowest in HD3298 (36.67 g). The mean test weight was 42.56 g.

Grain yield per plant, which is the most important economic trait, ranged from 992 g (HD3291) to 1530 g (Nawab), followed by Akbar (1483 g) and BIO-2003 (1478 g). The overall mean grain yield was 1311 g.

The CV values were generally low for most traits, indicating reliability and precision of the experiment. Overall, genotypes like Nawab, Akbar, BIO-2003 and DDW-187 performed better for several yield contributing traits and may be useful in future wheat improvement programme. Our findings are in

Table 2: Mean performance of 23 diverse wheat genotypes of wheat genotypes for 14 characters studied during rabi 2025-26

Treatment	DFF	DTM	PHT (cm)	FLL (cm)	PTPM	PL (cm)	SL (cm)	SW (g)	SPS	GPS	TW	BYPP(g)	HI (%)	GYPP(g)
DDW-55	68.33	106	83.53	16.57	301.67	31	7.73	2.5	15.1	33.47	41.5	2717	46.73	1266
DDW-187	63.67	104.67	100.2	17.5	345.67	37.33	10.93	2.91	15.87	39.87	42.33	2767	50.52	1396
DBW-332	68.67	109.33	89.93	16.53	320.67	31.87	9.2	2.62	15.07	37.47	41.5	2800	46.44	1296
Nawab	76.33	110.33	88.73	23.2	390	30.67	9.53	3.04	18.4	42.27	43.83	2933	52.36	1530
Akbar	76.67	111.67	89.8	21.67	371.33	34.73	8.73	3.04	16.33	39.33	43.02	3167	46.87	1483
BHU-31	74	110.67	89.2	21.53	336.33	32.27	9.47	2.53	15.4	34.33	42.17	3300	41.9	1383
HBW-338	69	107.33	93.2	17.8	334	34	10	2.46	16.6	36.07	43	2867	45.94	1316
DBW327	66.33	105	94.07	16	353.33	36.2	9.4	2.56	16.07	38.2	45.33	3033	46.04	1396
WH1402	71.33	109.67	98.47	20.6	327.67	36.93	10.13	2.47	16.93	36.4	50.17	2883	46.2	1333
CRD GEHU-1	66	106	94.13	16.5	322.33	35.13	9.67	2.18	16.47	39.87	48	2833	46.59	1316
CRD GEHU-2	62	107	96	15.6	326	37.4	10.93	2.19	16.6	40.8	39.83	2817	47.19	1330
BIO-2003	70.67	109.33	90.2	18.27	369.33	36.8	9.8	2.86	17.27	41.07	45.83	2783	53.21	1478
HD-3086	73	113.67	88.8	18.93	318.33	34.47	10.33	2.8	15.93	34.2	47.17	2900	46.94	1358
HI-1633	72	109.67	91.13	18.53	294	33.93	9	2.52	12.6	32.67	49	2927	42.14	1233
PBW-752	69	109.33	86.07	15.47	312.67	37.67	8.87	2.83	14.93	32.6	51.67	2883	45.07	1300
HD-3298	73	113	90.4	16.87	315.67	37	9.27	2.34	11.27	37.47	36.67	2900	42.47	1233
HD3406	64.33	109.33	78.47	18.67	303.67	33.47	8.33	2.33	14.67	29.53	39.67	2633	46.68	1229
HD3291	62	108.33	79.6	16.27	278.67	34.27	7.93	1.84	11.53	25.93	36.83	2647	37.47	992
HD3249	61	108	69.6	17.6	288.33	33	7.35	2.19	13.3	28.8	38.5	2850	42.61	1215
Black Wheat	70.33	109.67	75.07	17.07	306.33	35.6	7.63	2.43	15.8	31.07	37	2883	42.45	1221
K-1317	62.67	110	77.6	16.67	331.33	32.87	8.4	2.58	15.53	35.2	39	2933	45.75	1342
K-1006	67.33	111	76.13	19.13	296.67	33	8.6	2.08	12.07	32.47	37.17	2683	43.64	1170
MP-1323	68	109.33	75.27	20.2	328.33	35.63	7.47	2.75	15.07	27.6	39.67	2650	50.95	1349
Mean	68.51	109.06	86.77	18.14	324.88	34.58	9.07	2.52	15.17	35.07	42.56	2860	45.92	1311
CV %	2.02	1.02	3.05	6.87	5.17	3.84	5.94	9.67	7.89	7.02	4.44	5.13	5.38	5.95
SEm±	0.8	0.65	1.53	0.72	9.7	0.77	0.31	0.14	0.69	1.42	1.09	84.7	1.43	45.07
CD at 5%	2.27	1.84	4.35	2.05	27.64	2.18	0.89	0.4	1.97	4.05	3.11	241.41	4.07	128.46

Estimates of genetic parameters of 23 wheat genotypes for 14 characters under study

The estimates of genetic parameters revealed considerable amount of variability among the wheat genotypes for all the studied traits (Table 3). In general, the Phenotypic Coefficient of Variation (PCV) was slightly higher than Genotypic Coefficient of Variation (GCV) for all characters, indicating some influence of environment on trait expression. However, the narrow difference between PCV and GCV for most traits suggested that environmental influence was comparatively low and variability was mainly genetic in nature. Moderate to high PCV and GCV values were observed for traits like spike weight (PCV = 14.66%, GCV = 11.00%), number of grains per spike (PCV = 14.20%, GCV = 12.35%) and flag leaf length (PCV = 12.88%, GCV = 10.89%), indicating presence of sufficient variability for effective selection. On the other hand, lower estimates of PCV and GCV were recorded for days to maturity (2.28% and 2.04%), suggesting comparatively less variability for this trait.

High heritability coupled with high genetic advance as percent of mean generally indicates additive gene action and effectiveness of direct selection. In the present study, high heritability was observed for days to 50% flowering (91.33%), plant height (90.54%) and test weight (83.97%). Among these traits, plant height also exhibited relatively high genetic advance as percent of mean (18.47%), suggesting good scope for improvement through selection. The trait number of grains per spike showed high heritability (75.56%) along with high GA percent mean (22.10%), indicating predominance of additive gene effects and effectiveness of phenotypic selection. Similarly, spike length recorded heritability of 77.38% with GA percent mean of 19.92%, while spikelets per spike showed 67.56% heritability and 19.28% GA over mean. These traits may therefore serve as important selection criteria for yield improvement. Similar findings has also been reported by Bhardwaj (2018)^[2], Rathwa *et al.* (2018)^[12], Thapa *et al.* (2018)^[16], and Poudel *et al.* (2021)^[11]

Table 3: Genetic variability estimates for grain yield and its component traits in wheat during rabi 2025-26

S. No.	Character	Mean	Range		Coefficient of Variations		h ² (bs) %	GA	GA % Mean
			Max	Min	PCV (%)	GCV (%)			
1	Days to 50% flo.	68.51	77	61	6.85	6.55	91.33	8.83	12.88
2	Days to maturity	109.06	113.67	104.67	2.28	2.04	79.74	4.08	3.74
3	Plant height (cm)	86.77	100.2	69.6	9.91	9.43	90.54	16.03	18.47
4	Flag leaf length (cm)	18.14	23.2	15.47	12.88	10.89	71.51	3.44	18.96
5	No. of productive tillers/Sqm	324.89	390	278.67	9.49	7.96	70.29	44.61	13.74
6	Peduncle length (cm)	34.58	37.67	30.67	6.85	5.67	68.53	3.35	9.67
7	Spike length	9.08	10.94	7.35	12.5	10.99	77.38	1.81	19.92
8	Spike weight (g)	2.53	3	1.84	14.66	11	56.42	0.44	17.03
9	No. of spikelets per spike	15.17	18.4	11.27	13.85	11.39	67.56	2.93	19.28
10	No. of grains per spike	35.08	42.27	25.94	14.2	12.35	75.56	7.76	22.1
11	Test Weight	42.56	51.67	36.67	11.08	10.16	83.97	8.16	19.17
12	Biological Yield per Plot (g)	2860.44	3300	2633.34	6.95	4.68	45.4	185.63	6.49
13	Harvest Index (%)	45.93	53.22	37.48	9.04	7.27	64.56	5.52	12.02
14	Grain Yield per plot (g)	1311.89	1530	991.67	10.03	8.07	64.76	175.43	13.38

Correlation estimates of 14 characters for grain yield and its attributing traits in wheat genotypes during rabi 2025-26

A. Genotypic correlation estimates

The correlation analysis revealed significant association among different yield and yield contributing traits in wheat under study. Grain Yield Per Plot (GYPP) exhibited strong and positive correlation with important traits such as number of productive tillers per square meter (0.976), number of spikelets per spike (0.960), harvest index (0.834), number of grains per spike (0.827) and spike weight (0.808), indicating that these traits contributed substantially towards yield improvement (Table 4). Grain yield also showed significant positive association with flag leaf length (0.551), days to 50% flowering (0.549), spike length (0.533), test weight (0.492) and biological yield per plot (0.487), suggesting that simultaneous improvement of these characters may enhance wheat productivity. Among inter-character relationships, plant height had strong positive correlation with spike length (0.940), grains per spike (0.801) and test weight (0.610), while productive tillers/m² showed highly significant association with spike weight (0.892), spikelets per spike (0.859) and grains per spike (0.846). Harvest index also exhibited strong positive relationship with spike weight (0.825) and spikelets per spike (0.874). Some negative correlations were observed, particularly days to maturity with plant height (-0.247) and spikelets per spike (-0.259), though their effect on grain yield was comparatively low. Overall, the study indicated that productive tillers/m², spikelets per spike, grains per spike, spike weight and harvest index were the major yield determining traits and therefore should be given due emphasis during selection in wheat breeding programme.

B. Phenotypic correlation estimates

The correlation analysis revealed significant association among grain yield and its contributing traits in wheat (Table

5). Grain yield per plot showed strong positive correlation with number of productive tillers per square meter (0.866), followed by harvest index (0.743), number of grains per spike (0.623), spike weight (0.617) and number of spikelets per spike (0.610), indicating that these traits are major contributors towards yield improvement. Grain yield also exhibited positive association with plant height (0.452), days to 50% flowering (0.424), spike length (0.398), flag leaf length (0.390), test weight (0.346) and biological yield per plot (0.513), suggesting that simultaneous improvement in these characters may enhance productivity. Among inter-character relationships, plant height showed strong positive correlation with spike length (0.792) and grains per spike (0.691), while productive tillers/m² had significant positive association with harvest index (0.645), grains per spike (0.658) and spikelets per spike (0.622). Spike length also exhibited positive correlation with grains per spike (0.632) and test weight (0.370). Some negative associations were observed, particularly days to maturity with plant height (-0.222) and harvest index (-0.127). Overall, the study indicated that productive tillers, grains per spike, spike weight and harvest index were the most important traits influencing grain yield in wheat.

Similarly, Chitrakha *et al.* (2018) [3], Pooja *et al.* (2018) [10], Kumar *et al.* (2018) [6], and Meles *et al.* (2017) [9] reported significant positive correlations of grain yield per plot with number of productive tillers per plot, plant height, and biological yield per plot. Mondal *et al.* (1994), Mecha *et al.* (2017) [8], and Dogan (2009) [5] also reported significant positive correlations of grain yield per plot with number of productive tillers per plot, plant height, and biological yield per plot. Overall, the correlation analysis indicated that productive tillers per square meter, harvest index, grains per spike, spike weight and spikelets per spike were the most important traits influencing grain yield. Therefore, emphasis on these traits during selection may be effective for developing high yielding wheat genotypes.

Table 4: Genotypic correlation coefficient estimates for grain yield and its component traits in wheat genotypes studied in 2025-26

	DF	DM	PH	FLL	NPTPS	PL	SL	SW	NSPS	NGPS	TW	BYPP	HI	GYPP
DF	1.000													
DM	0.626**	1.000												
PH	0.292*	-0.247*	1.000											
FLL	0.703**	0.507**	0.022	1.000										
NPTPS	0.531**	-0.018	0.532**	0.536**	1.000									
PL	-0.123	-0.131	0.422**	-0.378**	0.089	1.000								
SL	0.178	-0.118	0.940**	0.027	0.517**	0.423**	1.000							
SW	0.688**	0.223	0.352**	0.559**	0.892**	0.004	0.280*	1.000						
NSPS	0.284*	-0.259*	0.493**	0.362**	0.859**	0.039	0.534**	0.705**	1.000					
NGPS	0.355**	-0.15	0.801**	0.145	0.846**	0.221	0.826**	0.528**	0.687**	1.000				
TW	0.367**	-0.086	0.610**	0.119	0.324**	0.290*	0.509**	0.538**	0.460**	0.360**	1.000			
BYPP	0.657**	0.294*	0.352**	0.401**	0.478**	-0.043	0.311**	0.524**	0.346**	0.440**	0.326**	1.000		
HI	0.21	-0.172	0.332**	0.374**	0.798**	0.103	0.403**	0.825**	0.874**	0.654**	0.352**	-0.074	1.000	
GYPP	0.549**	0.015	0.493**	0.551**	0.976**	0.072	0.533**	0.808**	0.960**	0.827**	0.492**	0.487**	0.834**	1.000

Table 5: Genotypic correlation coefficient estimates for grain yield and its component traits in wheat genotypes studied in 2025-26

	DF	DM	PH	FLL	NPTPS	PL	SL	SW	NSPS	NGPS	TW	BYPP	HI	GYPP
DF	1.000													
DM	0.555**	1.000												
PH	0.280*	-0.222	1.000											
FLL	0.594**	0.410**	0.012	1.000										
NPTPS	0.413**	0.041	0.419**	0.423**	1.000									
PL	-0.125	-0.129	0.349**	-0.284*	0.064	1.000								
SL	0.143	-0.075	0.792**	0.056	0.399**	0.343**	1.000							
SW	0.440**	0.11	0.255*	0.300*	0.571**	0.108	0.231	1.000						
NSPS	0.215	-0.17	0.349**	0.213	0.622**	0.07	0.354**	0.462**	1.000					
NGPS	0.294*	-0.089	0.691**	0.077	0.658**	0.112	0.632**	0.373**	0.527**	1.000				
TW	0.337**	-0.061	0.523**	0.088	0.223	0.211	0.370**	0.328**	0.424**	0.321**	1.000			
BYPP	0.440**	0.216	0.293*	0.321**	0.434**	-0.069	0.154	0.214	0.209	0.305*	0.233	1.000		
HI	0.146	-0.127	0.280*	0.2	0.645**	0.107	0.328**	0.542**	0.531**	0.461**	0.21	-0.19	1.000	
GYPP	0.424**	0.033	0.452**	0.390**	0.866**	0.051	0.398**	0.617**	0.610**	0.623**	0.346**	0.513**	0.743**	1.000

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