Journal of Cereal Research
Volume 16 (3): 325-330
Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR
Short Communication

Correlation and path coefficient analysis among yield and yield attributing traits of wheat (*Triticum aestivum* L.) genotypes

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Article history: Received: 28 Sep., 2024 Revised: 04 Dec., 2024 Accepted: 19 Dec., 2024

Citation: Tiwari S and B Singh. 2024. Correlation and path coefficient analysis among yield and yield attributing traits of wheat (*Triticum aestivum* L.) genotypes. *Journal of Cereal Research* ***16 (3):*** *325-330.* http://doi.org/10.25174/2582-2675/2024/157232

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Due to the prominent position in global food grain trade, the acreage occupies by it and its high productivity, it has been called as the 'King of cereals'. Wheat is a major staple food crop of the world after rice. According to Thomas et al. (2017), wheat (*Tritium aestivum* L.) is the 2nd most significant crop that has an important effect on global food security. "Wheat is classified into three types based on ploidy levels: diploid (2n = 14, n = 7), allotetraploid (2n = 28, n = 14), and allohexaploid (2n = 42, n = 21). The genome of hexaploid wheat (*Triticum aestivum L.*, 2n = 42, AABBDD) is around 1.7 × 10^{10} base pairs, making it about 100 times larger than the Arabidopsis genome, 40 times larger than that of rice, and nearly six times larger than the maize genome (Bennett and Smith, 1976; Amuruganathan and Earle, 1991). Commonly referred to as bread wheat, *Triticum aestivum L.* is a self-pollinating, hexaploid member of the Poaceae family and accounts for 90–95% of global wheat production.

Wheat is the world's most important food crop, with a planted area of 221.18 million hectares, production of 774.74 million metric tonnes, and productivity of 35 quintals per hectare (USDA, 2021). The 2023–24 wheat crop season marked a historic milestone in over 60 years of coordinated wheat research, achieving a record-breaking production of 110.55 million tones across 31.40 million hectares, with an average productivity of 35 quintals per hectare in the nation (ICAR-IIWBR Annual Report, 2023). In comparison, the 2022–23 seasons recorded a planted area of 30.45Mha, producing 104.00 MMT of wheat with a productivity rate of 34 quintals per hectare (ICAR-IIWBR Annual Report, 2022).

Consequently, attempts were undertaken to examine the degree of variability, heritability, and the potential genetic gain anticipated from selection for yield enhancement. Likewise, an effort was made to use correlation and path coefficient analysis to examine wheat yield and the characteristics that contribute to it.

In kharif 2023-2024, 25 wheat inbred strains were grown in a RBD manner with 3 replications at the research farm of Department of Genetics and Plant Breeding, Faculty of Agriculture Science and Technology, AKS University, Satna, M.P. The spacing was 20 × 10 cm. The crop was raised using cultural approaches that were consistent with normal recommendations.

In order to record observations on fourteen characters– namely, the NTP(Number of effective tillers), PH(Plant Height), DFF(Days to 50% Flowering), FLL(Flag Leaf Length), FLW(Flag Leaf Width), DM(Days to maturity), NSP(Number of Spikelet's/Panicles), KL(Kernel Length), KW (Kernel Width), PL(Panicle Length), TW(Test Weight), BYP (Biological Yield/Plant),HI(Harvest Index), and EY(Economic Yield) five randomly chosen plants were used. After compiling the experimental data by calculating the mean value of randomly chosen plants from each

replication, Panse and Sukhatme (1978) conducted the statistical analysis. Burton (1952), Johanson *et al.* (1955) proposed a formula for estimating the G.C.V, P.C.V, Heritability (h^2) (Broad Sense), and genetic advancement as a percentage of mean.

Genotypic correlation coefficients were calculated following the method outlined by Al-Jibouri *et al.* (1958). Path analysis, based on these genotypic correlations, was utilized to assess the direct and indirect influences of various components on yield, as described by Wright (1921) and further demonstrated by Dewey and Lu (1957).

The analysis of variance showed notable variations among all 14 quantitative traits assessed, as outlined in Table 1. High GCV and PCV were observed for traits such as FLW(flag leaf width) (57.617–60.302), NTP(Number of Tillers/plant) (18.689–23.063), and TW (Test Weight) (18.659–18.687), while other traits exhibited moderate to low GCV and PCV values. It is important to note that the PCV values were consistently greater than the GCV values, suggesting a significant environmental impact on the traits. These findings are consistent with those observed in earlier studies by Ahmad and Gupta (2023) and Tiwari *et al.* (2017).

Table 1: Variance analysis for several quantitative and physiological characteristics in 25 wheat genotypes

Traits	MSS(Mean sum of squares)		
	Replica.tion d.f. =02	Treatments d.f. =24	Error. d.f. =48
Days To 50 % Flowering	3.453	30.752	8.977**
Days To Maturity	2.773	46.861	13.043**
Plant Height	0.782	402.301	343.967**
No. Of Tillers Per	10.253	6.563	2.912**
Flag Leaf Length	0.601	56.052	61.464**
Flag Leaf Width	0.092	0.529	11.484**
No.Of Spikelet's Per Ear	0.013	36.774	28.482**
Panicle Length (Cm	0.578	66.586	258.073**
Test Weight Seed	1.011	110.234	333.505**
Biological Yield	21.175	464.414	171.716**
Harvest Index	10.190	81.812	12.693**
Kernel Length	0.000	0.000	2.244**
Kernel Width	0.000	0.000	0.545**
Economic Yield	8.793	79.005	30.047**

** Significant at 5% level

Test weight exhibited the highest heritability (99.7), followed closely by PH (Plant height) (99.7) and BY (Biological Yield) (99.4). The largest genetic advance as a percentage of the mean was observed for FLL (flag leaf length) (39.120), TW (test weight) (38.380), and the NSPE (number of spikelet's per ear) (35.171), while KW (kernel width) (16.518) and HI (harvest index) (22.109) showed moderate values. These results, detailed in Table 2. This suggests that traits with high heritability are less affected by environmental factors. Comparable findings were reported in the studies by Ahmad and Gupta (2023) and Tiwari *et al.* (2017).

Table 3 shows the genotypic simple correlation among all of the characters, as well as the estimates of extremely positive significant. correlation with yield for five characters. SYP (Seed yield/plant) had a positive and significant. genotypic correlation with TW(Test Weight) (0.8465**), BYP(Biological Yield/Plant) (0.6903**),NTP (Number of Tillers/ Plant) (0.3396**), and HI(Harvest Index%) (0.2504**). The correlation coefficient (-0.2393)

Table 2: Assessing variance components and genetic parameter values for 14 quantitative traits in wheat genotypes

Traits	h^2%	GCV	PCV	GA	GA as % means
Days To 50 % Flowering	88.9	4.034	4.280	5.861	7.834
Days To Maturity	92.3	3.399	3.537	7.517	6.728
Plant Height	99.7	15.450	15.473	23.786	31.781
No. Of Tillers Per	65.7	18.689	23.063	2.001	31.199
Flag Leaf Length S	98.4	19.147	19.304	8.760	39.120
Flag Leaf Width Sc	91.3	57.617	60.302	0.790	113.406
No.Of Spikelet's	96.5	17.381	17.695	6.959	35.171
Panicle Length (Cm)	99.6	16.098	16.130	9.668	33.099
Test Weight Seed	99.7	18.659	18.687	12.450	38.380
Biological Yield	99.4	15.699	15.744	25.481	32.245
Harvest Index	92.1	11.182	11.650	9.910	22.109
Kernel Length	55.4	6.097	8.188	0.007	9.352
Kernel Width	83.5	8.778	9.609	0.004	16.518
Economic Yield	96.7	14.435	14.682	10.220	29.237

indicated a negative significant relationship with days to 50% flowering. These characters were indicating their genuine relationship to yield. Similar findings were replicated in studies by Pankaj Singh Rajput and Bineeta Singh (2023), Devi et al. (2013), Ahmad and Gupta (2023), and Tiwari *et al.* (2017).

Table 4 displays the direct and indirect impacts of different traits on SYP(Seed Yield/ Plant).. BYP (Biological yield/ Plant) (1.2903), HI (Harvest Index) (0.9583), DM(Days to Maturity) (0.1157), DFF(Days to 50% flowering) (0.0626),FLW (Flag Leaf Width) (0.0123), and KL (Kernel Length) (0.0941) showed direct positive effects on SYP (Seed Yield/Plant). In contrast, traits such as PH(Plant height) (-0.0943), NTP(Number of Tillers/ plant) (-0.0229), FLL (flag leaf length) (-0.0389), NSE (Number of Spikelets/ear) (-0.0391), TW (Test weight) (-0.0995), and kernel length (-0.1776) exhibited a direct negative influence. Studies by Ali et al. (2012), Baranwal *et al.* (2012), Kumar *et al.* (2014, 2019), and Liu *et al.* (2018) similarly highlighted the importance of these traits in grain production. Positive direct effects of these traits emphasize their significance in improving seed yield, making them crucial targets for selection. The indirect effects of these traits were less pronounced, indicating their direct contribution to grain yield.

The genotypes AD2967 (42.23), Gwala (42.08), HI 8381 (41.22), and HI8498 (40.36) were identified as the most promising, exhibiting high seed yield per plant. Traits such as flag leaf width, flag leaf length, and test weight showed high estimates of PCV and GCV, with phenotypic coefficients of variation exceeding genotypic coefficients, indicating environmental influences. Test weight demonstrated high heritability (99.7%) and genetic progress (38.38), highlighting its importance in future breeding programs.

Seed yield per plant showed a positive and significant genotypic correlation with test weight (0.8465**), biological yield per plant (0.6903**), number of tillers per plant (0.3396**), and harvest index (0.2504**), while a significant negative correlation (-0.2393) was observed with days to 50% flowering. Positive direct genotypic effects on seed yield per plant were noted for biological yield per plant (1.2903), harvest index (0.9583), days to maturity (0.1157), days to 50% flowering (0.0626), flag leaf width (0.0123), and kernel length (0.0941). These traits should be prioritized in future selection strategies for enhancing wheat genotype yields.

Table 3: Genotypic correlation of different yield component with grain yield per plant in wheat

Traits	DFF	DM	PH	NTP	FLL	FLW	NS	PL	TW	BY	HI	KL	KW	"r"
DFF	**1.0000**	-0.3458**	0.0413	-0.2279	0.1036	0.2299	0.1048	0.0363	-0.0565	-0.1650	-0.0822	-0.2283	-0.1502	-0.2393*
DM		**1.0000**	0.1091	-0.0322	0.0830	-0.2266	0.3244**	0.1219	-0.2062	0.1748	-0.3453**	0.6352**	-0.0611	-0.1319
PH			1.0000	0.2424*	-0.2345	0.0900	0.2253	0.0680	-0.1666	0.1941	-0.2589*	-0.1999	-0.3383**	-0.0573
NTP				1.0000	-0.4863**	-0.2755*	0.1627	-0.2715	0.2310	0.1503	0.2271	0.0966	0.3794**	0.3396**
FLL					1.0000	0.0518	0.0214	0.3145**	0.3299**	0.2968*	-0.1376	0.3844**	0.1690	0.1910
FLW						1.0000	-0.0923	-0.0345	0.1238	-0.0838	0.1021	-0.0255	-0.3109**	-0.0490
NS							1.0000	0.4111**	0.0159	0.1156	-0.0210	0.3181**	-0.2055	0.0492
PL								1.0000	-0.0846	-0.0116	-0.1978	0.2256	0.0147	-0.1997
TW									1.0000	0.5315**	0.2919*	-0.0128	0.1192	0.8465**
BY										1.0000	-0.5124**	-0.0042	-0.2910	0.6903**
HI											1.0000	0.1708	0.4303**	0.2504*
KL												1.0000	0.1185	0.0520
KW													1.0000	0.1032

** Significant at 5% level

Table 4: Direct and indirect effects of component traits attributing to grain yield per plant in wheat at genotypic level

Traits	DFF	DM	PH	NTP	FLL	FLW	NS	PL	TW	BY	HI	KL	KW	"r"
DFF	**0.0626**	-0.0217	0.0026	-0.0143	0.0065	0.0144	0.0066	0.0023	-0.0035	-0.0103	-0.0051	-0.0143	-0.0094	-0.2393
DM	-0.0400	0.1157	0.0126	-0.0037	0.0096	-0.0262	0.0375	0.0141	-0.0239	0.0202	-0.0399	0.0735	-0.0071	-0.1319
PH	-0.0039	-0.0103	-0.0943	-0.0229	0.0221	-0.0085	-0.0212	-0.0064	0.0157	-0.0183	0.0244	0.0188	0.0319	-0.0573
NTP	0.0052	0.0007	-0.0055	**-0.0229**	0.0111	0.0063	-0.0037	0.0062	-0.0053	-0.0034	-0.0052	-0.0022	-0.0087	0.3396
FLL	-0.0040	-0.0032	0.0091	0.0189	-0.0389	-0.0020	-0.0008	-0.0122	-0.0128	-0.0115	0.0054	-0.0150	-0.0066	0.1910
FLW	0.0028	-0.0028	0.0011	-0.0034	0.0006	0.0123	-0.0011	-0.0004	0.0015	-0.0010	0.0013	-0.0003	-0.0038	-0.0490
NS	-0.0041	-0.0127	-0.0088	-0.0064	-0.0008	0.0036	-0.0391	-0.0161	-0.0006	-0.0045	0.0008	-0.0124	0.0080	0.0492
PL	0.0017	0.0058	0.0032	-0.0130	0.0150	-0.0016	0.0196	0.0477	-0.0040	-0.0006	-0.0094	0.0108	0.0007	-0.1997
TW	0.0056	0.0205	0.0166	-0.0230	-0.0328	-0.0123	-0.0016	0.0084	-0.0995	-0.0529	-0.0291	0.0013	-0.0119	0.8465
BY	-0.2129	0.2255	0.2505	0.1939	0.3829	-0.1081	0.1491	-0.0150	0.6858	1.2903	-0.6611	-0.0054	-0.3754	0.6903
HI	-0.0788	-0.3309	-0.2481	0.2177	-0.1319	0.0979	-0.0201	-0.1895	0.2797	-0.4910	0.9583	0.1637	0.4124	0.2504
KL	0.0406	-0.1128	0.0355	-0.0172	-0.0683	0.0045	-0.0565	-0.0401	0.0023	0.0007	-0.0303	-0.1776	-0.0210	0.0520
KW	-0.0141	-0.0057	-0.0318	0.0357	0.0159	-0.0293	-0.0193	0.0014	0.0112	-0.0274	0.0405	0.0111	0.0941	0.1032

R SQUARE = 0.9948 RESIDUAL EFFECT = 0.0724

Acknowledgement

The author extends heartfelt gratitude to the Hon'ble Pro-Chancellor, Hon'ble Vice-Chancellor, and the Directorate of Research, AKS University, Satna (M.P.), for their invaluable support and for providing the essential facilities required to carry out this experiment.

Author contributions

The final version of the text was prepared with equal contributions from all writers.

Conflict of Interest Authors

The authors confirm that there are no conflicts of interest related to this manuscript.

Ethical Approval

The article doesn't contain any study involving ethical approval.

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