

Assessment of Trait Interrelationships and Yield Determinants in Wheat (*Triticum aestivum* L.)

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ABSTRACT

The present investigation was conducted to study correlation and path coefficient analysis for yield contributing traits in 90 genotypes of wheat along with four checks. The field trials were conducted at Main Experimental Station and Student Instructional Farm (SIF) of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya during Rabi 2023-24 and 2024-25 resp. in Augmented Design. All the recommended packages of practices were followed to raise a good crop. Phenotypic correlation analysis in wheat revealed several significant associations among 12 traits. Days to 50% flowering was positively correlated with days to maturity and plant height. Plant height was positively linked with test weight and biological yield, but negatively with harvest index. Effective tillers per plant showed strong positive correlation with grains per spike. Test weight had a very strong positive correlation with biological yield but a negative one with harvest index. Grain yield per plant correlated highly with both test weight and biological yield. Path coefficient analysis identified biological yield per plant as having the strongest direct positive effect on grain yield, followed by harvest index. Grains per spike, maturity, flowering days, and plant height also had minor positive effects. Negative direct effects came from test weight, spike length, peduncle length, and tiller number. Significant indirect effects included positive contributions from plant height via biological yield and negative effects from harvest index via biological yield. Hence, these traits can be considered as important attributes for suitable selection criteria for both direct and indirect selection.

Keywords: Augmented design, Correlation analysis, Grain yield, Path analysis, Wheat

Introduction

Wheat (*Triticum aestivum* L.) is an autogamous annual monocot that belongs to tribe triticeae under the grass family poaceae. It is extensively grown as staple food crop globally and it is one of the most important crops among the prime cereals at the global level (Jaiswal *et al.*, 2021). Wheat is a hexaploid (allohexaploid) species ($2n = 6x = 42$) having AABBDD with A, B and D genome. The species of wheat may be divided into diploid, tetraploid and hexaploid species with chromosome numbers varying as $2n=2x=14$ (AA and/or BB), $2n=4x=28$ (AABB)

and $2n=6x=42$ (AABBDD) respectively with basic chromosome numbers $x = 7$ (Pal *et al.*, 2023). The global wheat production for the 2023-24 period was around 785 million tonnes. India secures the third position with an estimated production of 110.5 million tonnes (USDA report, 2023) from an area of about 31.9 million hectares in the 2023-24 period (All India Wheat Survey Report 2023-2024). U.P. records for the highest share of production among states with estimated value of 32.1 million tonnes, (DES, MoA & FW, India 2022-23). Wheat has played a crucial role in human diets since ancient times. Its protein content is approximately 12.1%, along with

1.8% lipids, 1.8% ash, 2.0% reducing sugars, 6.7% pentosans, 59.2% starch, 70% total carbohydrates, and 314 kilocalories per 100 grams, making it a significant source of energy (Lavkush *et al.*, 2022). Yield being a complex trait is governed by a large number of genes and it depends on plant genotype and its interaction with environment (Khatab *et al.*, 2016). The influence of each trait on yield could be known through correlation studies with a view to determine the extent and nature of relationships prevailing among yield and yield attributing traits. Successful selection of high yielding genotypes depends on information available for genetic variability and the association of morpho-agronomic traits with grain yield. The degree of association between two or more variables is estimated by the correlation coefficient (r). Correlation and path coefficient analysis when combined provide a clear picture of the inter-relationship and relative contribution of independent characters to the dependent variable allowing a plant breeder to apply appropriate selection procedure for crop improvement. Correlation coefficients are commonly used in breeding studies to determine the relationship between grain yield and yield components, which aids in selection to improve yield and its contributing characters at the same time. It is necessary to consider the implications of the inter-relationships of multiple characteristics, as well as path coefficients in order to utilize the best combination of yield contributing characters in a single genotype (Chaudhary *et al.*, 2024). Path analysis is a multivariate analysis, which deals with a closed system of variables, which are linearly related. Dewey and Lu (1959) firstly employed this method to disentangle the direct and indirect influences of components of seed yield. Path coefficient analysis separates the direct effects from the indirect effects through other related characters by partitioning the correlation coefficient. The information obtained by path coefficient analysis helps in indirect selection for genetic improvement of traits that have low heritability as direct selection is not effective for such traits. In this manuscript, trait interrelationships and yield determinants of yield components in wheat is comprehensively presented to identify traits that are significantly affecting the grain yield and nutrient contents.

Material and Method

In the present study the experimental material is

comprised of 90 genotypes of wheat along with with four checks namely KRL 1-3, KRL 1-4, KRL 3-4 and NW 1014 which were used to assess correlation and path coefficient analysis for yield contributing traits. at Main Experimental Station and Student Instructional Farm (SIF) of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya during *Rabi* 2023-24 and 2024-25 resp. in Augmented Design. Observations were recorded on five randomly selected plants from each plot for 12 quantitative characters which are days to 50% flowering, days to maturity, plant height (cm), spike length (cm), spikelet per spike, peduncle length (cm), tillers per plant, grains per spike, test weight (g), grain yield per plant (g), biological yield per plant (g) and harvest index (%). The data collected throughout the investigation have been subjected to statistical analysis.

Biometrical Analysis

Correlation coefficient is used to discover the strength of the inter-relationship between two variables. The genotypic and phenotypic correlation coefficients between two characters say X and Y under study was calculated using the variance and covariance component as suggested by Pearson (1932). The significance of correlation coefficient was tested by comparing the observed value of correlation coefficient with the table value at 5 per cent and 1 per cent probability level with (n-2) degree of freedom for its significance. Path coefficient analysis was carried out using phenotypic correlation values of morphological traits on yield as suggested by Dewey and Lu (1959).

Results

Correlation coefficient analysis

Phenotypic correlation among the twelve quantitative traits of studied wheat genotypes was computed and presented in Table 1. Days to 50% flowering showed positive and highly significant association with days to maturity (0.3102) while positive and significant association with plant height (0.2438). Days to maturity showed positive and highly significant association with days to 50% flowering (0.3102). Plant height showed positive and highly significant association with test weight (0.3096) and biological yield per plant (0.2892) and negative and highly significant association with har-

vest index (-0.4662) and positive significant with days to 50% flowering (0.2438). Effective tillers per plant showed positive and highly significant association with grains per spike (0.8061) and positive and significance association with spike length (0.2614). Spike length showed positive and significant association with effective tillers per plant (0.2614) and positive significant with grains per spike (0.2184). Grains per spike showed positive highly significant association with effective tillers per plant (0.8061) and positive significant association with spike length (0.2184). Test weight showed positive and very highly significant association with

biological yield per plant (0.9511) and plant height (0.3096) while negative and highly significant association with harvest index (0.5280). Biological yield per plant showed high negative significant association with harvest index (-0.4810) while positive and very highly significant association with test weight (.9511) and plant height (0.2892). Harvest index showed negative and highly significant association with test weight -0.5280 and biological yield per plant (-0.4810). Grain yield per plant showed positive and highly significant association with test weight (0.667) and biological yield per plant (0.7657).

Table 1. Phenotypic Correlation coefficients among the traits under study

	FLW	DTM	PH	PL	ETP	SL	SPS	GPS	TW	BYPP	HI	GYPP
FLW	1.0000	0.3102**	0.2438*	0.1594	0.1979	-0.0006	-0.0829	0.1089	0.1261	0.0909	-0.0742	0.0275
DTM		1.0000	-0.0084	0.1458	0.0419	0.0533	-0.1567	0.0480	-0.1540	-0.1120	0.1200	-0.0269
PH			1.0000	0.0882	0.0016	-0.0568	0.0726	-0.0016	0.3096**	0.2892**	-0.4662**	-0.0005
PL				1.0000	0.0017	-0.0042	-0.0204	-0.0419	-0.1100	-0.0389	0.0341	-0.0372
ETP					1.0000	0.2614*	0.0502	0.8061**	0.0695	0.1449	-0.0538	0.1206
SL						1.0000	0.0658	0.2184*	-0.1084	-0.1039	0.0599	-0.1018
SPS							1.0000	-0.0242	-0.0833	-0.0670	0.0427	-0.0263
GPS								1.0000	-0.1054	-0.0051	0.1149	0.0923
TW									1.0000	0.9511**	-0.5280**	0.6672**
BYPP										1.0000	-0.4810**	0.7657**
HI											1.0000	0.1852
GYPP												1.0000

FLW: Days to 50 % flowering; DTM: Days to maturity; PH: Plant height; PL: Peduncle length; ETP: Effective tillers per plant; SL: Spike length; SPS: Spikelet per spike; GPS: Grains per spike; TW: Test weight; BYPP: Biological yield per plant; HI: Harvest index; GYPP: Grain yield per plant.

*: significant p=0.05, á=5%; **: highly significant p=0.01, á=1%

Table 2. Estimates of direct and indirect effects of independent traits on grain yield

	FLW	DTM	PH	PL	ETP	SL	SPS	GPS	TW	BYPP	HI
FLW	0.0205	-0.0064	-0.0050	-0.0033	-0.0041	0.0000	0.0017	-0.0022	-0.0026	-0.0019	0.0015
DTM	0.0066	0.0213	-0.0002	0.0031	0.0009	0.0011	-0.0033	0.0010	-0.0033	-0.0024	0.0026
PH	0.0046	-0.0002	0.0190	0.0017	0.0000	-0.0011	0.0014	0.0000	0.0059	0.0055	-0.0088
PL	-0.0041	-0.0037	-0.00023	-0.0256	0.0000	0.0001	0.0005	0.0011	0.0028	0.0010	-0.0009
ETP	-0.0050	-0.0011	0.0000	0.0000	-0.0253	-0.0066	-0.0013	-0.0204	-0.0018	-0.0037	0.0014
SL	0.0000	-0.0017	0.0019	0.0001	-0.0085	-0.0327	-0.0021	-0.0071	0.0035	0.0034	-0.0020
SPS	-0.0016	-0.0031	0.0014	-0.0004	0.0010	0.0013	0.0196	-0.0005	-0.0016	-0.0013	0.0008
GPS	0.0037	0.0016	-0.0001	-0.00014	0.0275	0.0074	-0.0008	0.0341	-0.0036	-0.0002	0.0039
TW	-0.0128	0.0157	-0.0315	0.0112	-0.0071	0.0110	0.0085	0.0107	-0.1019	-0.0969	0.0538
BYPP	0.1095	-0.1349	0.3484	-0.0468	0.1746	-0.1252	-0.0808	-0.0061	1.1459	1.2048	-0.5796
HI	-0.0529	0.0855	-0.3322	0.0243	-0.0383	0.0427	0.0304	0.0818	-0.3762	-0.3427	0.7125
GYPP(r)	0.0275	-0.0269	-0.0005	-0.0372	0.1206	-0.1018	-0.0263	0.0923	0.6672	0.7657	0.1852

R SQUARE = 0.9927 RESIDUAL EFFECT = 0.0856

FLW: Days to 50 % flowering; DTM: Days to maturity; PH: Plant height; PL: Peduncle length; ETP: Effective tillers per plant; SL: Spike length; SPS: Spikelet per spike; GPS: Grains per spike; TW: Test weight; BYPP: Biological yield per plant; HI: Harvest index; GYPP: Grain yield per plant.

Path Coefficient Analysis

Path-coefficient analysis was studied at phenotypic level considering grain yield as dependent character and it attributes as independent character. The independent characters were days to 50% flowering, days to maturity, plant height (cm), spike length (cm) , spikelet per spike, peduncle length (cm), tillers per plant, grains per spike, test weight (g), grain yield per plant (g), biological yield per plant (g) and harvest index (%). The estimates of phenotypic path coefficient for the different traits on the grain yield per plant are presented in Table 1 and Fig. 1. The highest direct positive effect on grain yield was shown by biological yield per plant (1.2048) followed by harvest index (0.7125). This is followed by grains per spike (0.0341), days to maturity (0.0213), days to 50% flowering (0.0205) and plant height (0.0109). The negative direct effect on grain yield was shown by test weight (-0.1019) followed by spike length (-0.0327), peduncle length (-0.0256) and effective tillers per plant (-0.0253). Plant height showed a high positive indirect effect on grain yield via biological yield per plant (0.3484) while high negative indirect effect on grain yield via harvest index (-0.3322). Test weight showed a high negative indirect effect on grain yield via harvest index (-0.3762) while harvest index showed high negative indirect effect on grain yield via biological yield per plant (-0.5796). The other traits under

study have either positive or negative low indirect effect on grain yield.

Discussion

Correlation coefficient analysis is a widely used measure of the direction and degree of relationships between various traits. Schober *et al.*, (2018). Pearson correlation is a measure of a linear association between two normally distributed random variables. Correlation study between different characters may help the plant breeder to know how the improvement of one character will bring simultaneous changes in other characters Sabit *et al.* (2017). Dwivedi and Singh (2025) confirmed that days to 50% flowering positively correlates with plant height and test weight, while negatively associating with days to maturity and biological yield. Additionally, Kumari *et al.* (2020) highlighted the importance of biological yield and harvest index in improving grain yield, emphasizing the need to focus on traits like test weight and days to 50% flowering for effective breeding programs. Borkhatariya *et al.* (2025) found that traits such as biological yield, effective tillers per plant, and harvest index had high correlations with grain yield. Similarly, Singh *et al.* (2019) also highlighted that grain yield was positively correlated with biological yield, harvest index, plant height, and days to maturity, suggesting these traits should be prioritized in selection strategies.

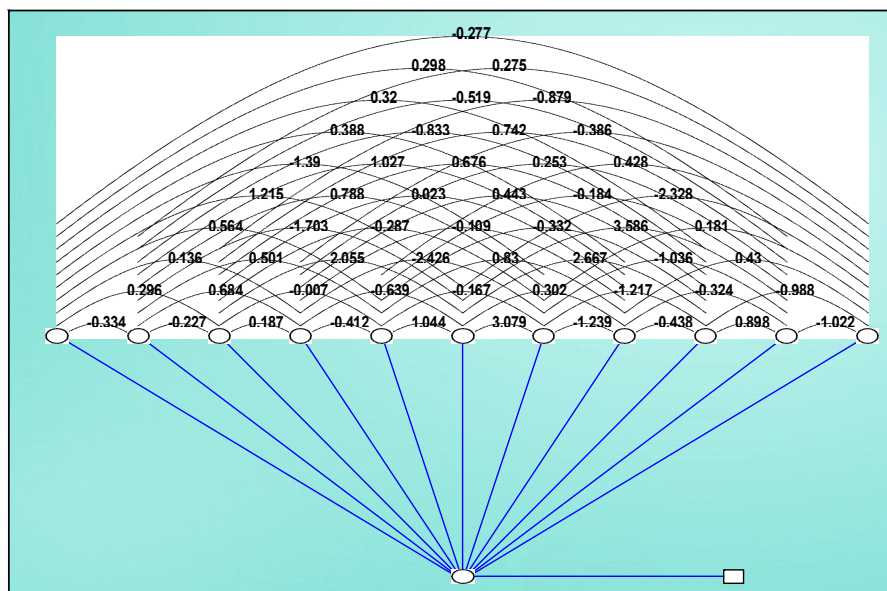


Fig. 1. Phenotypic path diagram showing direct and indirect effect of traits under study on grain yield

Path coefficient is a standard partial regression analysis that partitions the correlation coefficient into direct and indirect effects (Falconer and Mackay, 1996). It has emerged as powerful and widely used measure to understand the relative importance of different parameters as selection criteria for yield Maurya *et al.* (2020) Upadhyay *et al.* (2020). Grain yield is a complex quantitative trait hence multiple traits are needed to be considered for its improvement. Since correlation study alone does not depict the clear picture of the relationship among traits and path coefficient analysis serves as an important tool for formulating efficient selection strategy Rachana *et al.* (2021). Similar result was reported by (Verma *et al.*, 2019). For days to 50% flowering, plant height consistently showed negative direct effects on yield (Khan *et al.*, 2010; Iftikhar *et al.*, 2012; Verma *et al.*, 2019). Spike length and peduncle length demonstrated mixed results (Iftikhar *et al.*, 2012) and others showing negative effects (Khan *et al.*, 2010; Verma *et al.*, 2019). Test weight (1000-grain weight) exhibited positive direct effects in most studies (Iftikhar *et al.*, 2012; Verma *et al.*, 2019).

Conflict of Interest- None

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