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A Study on Correlation and Path Coefficient Analysis for Yield and Associated Traits in Bread Wheat (*Triticum aestivum* L.)

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Abstract

Wheat (*Triticum aestivum* L.) is the world's most important cereal grain which contains carbohydrate, protein, fat, minerals and significant amounts of vitamins. A study was conducted in Augmented Block Design with 105 genotypes of bread wheat with four checks (HD-2967, DBW-222, DBW-107, and HD-2733) for estimation of means, range, correlations and path-coefficient. A wide range of variations were observed for different characters under study. The genotype RAJ-4549 (16.35), UP-3056 (15.78), DBW-344 (15.78), produced highest grain yield plant^{-1} followed by NW-8076 (15.36) and NW-8019 (15.14). In case of correlation study, grain yield plant^{-1} had a highly significant and positive correlation with tillers plant^{-1}, biological yield plant^{-1}, peduncle length, and spike length; whereas a non-significant negative correlation was found with days to 50% flowering, plant height and days to maturity. In path coefficient analysis, major positive direct effect on grain yield plant^{-1} was exerted by biological yield plant^{-1}, followed by harvest-index, number of grain spike^{-1}, peduncle length, number of tillers plant^{-1}, test weight, days to 50% flowering and spike length. Tillers plant^{-1} and peduncle length exhibited high order positive indirect effects on grain yield plant^{-1} *via* biological yield (0.87) and (0.69) respectively. The characters showing highly significant positive correlation among yield and its components can be further validated and if consistent performance is found in future study; emphasis should be given to those characters while developing high yielding varieties.

Keywords: Correlation, Grain yield, High yielding varieties, Path coefficient, Wheat

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal grain in world, belonging to the family Graminae (Poaceae) and genus Triticum. Wheat production in 2020-21 reached 109.52 million tonnes, with an average national productivity of 3464 kg acre^{-1}. Wheat being the second most important crop in India, supplies 55% nutrient of country's population and categorized according to species, growth patterns and commercial forms (Malik and Dwivedi, 2021). Wheat accounts for approximately 36% of India's total food grain production, according to the fourth advance estimates released by the Directorates of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare, India (Bathla and Hussain, 2022). In the evolution of civilization, Bread wheat always plays an important part of agriculture (Balfourier *et al.*, 2019). Identification of genotypes based on quantitative characteristics is critical for wheat development. Various statistical metrics like correlation and path analysis plays a beneficial role in selecting optimal genotypes in any

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environmental condition. Correlation analysis is useful to estimate the relationship between different traits in order to improve crop improvement processes (Dhami *et al*., 2018). Correlation studies, by using simple correlation coefficients aid in finding key features that explain the relations among grain yield and different yield contributing morphological traits.

Selection based only on grain yield performance, a polygenically regulated complex feature, is frequently inefficient (Arega, 2016). As a result, selection based on yield components was proposed to be more successful than selection based only on yield. Identifying and controlling characteristics that contribute to grain yield is so significant since it improves breeding efficiency. Correlations are particularly essential in plant breeding because they represent the degree of dependence between two or more variables. The strength of dependency (correlation) between investigated qualities is shown *via* correlation analysis. The goal of this study was to determine the interrelationships and direct and indirect impacts of various yield components on grain yield in wheat genotypes (Khan *et al*., 2013). For starting a breeding programme based on these yield components needs understanding of the link between yield and its component traits. In this regard, determining the correlation coefficient among the traits is critical in selecting breeding materials (Afroz *et al*., 2004). Path analysis on the other hand estimates the changes in the dependent variable due to changes in the independent variable. A path coefficient which is a regression coefficient (partial) helps in dividing the correlation coefficient into direct and indirect effects (Phougat *et al.,* 2017). With the help of path coefficient analysis, plant breeders identify traits that are used as selection criteria for improvement of any crops (Bhujel *et al.*, 2018). Path coefficient analysis has been shown to provide more particular information on the direct and indirect effect of each component feature on grain yield. The current study was conducted with an aim to determine the link between yield and its component features, and the causes of such relationships were further investigated.

Materials and Methods

The current study used one hundred and five (105) advance germplasm lines and four controls (HD-2967, DBW-222, DBW-107, and HD-2733) following augmented block design at the ANDUA&T Main Experiment Station in Kumarganj, Ayodhya. The experimental field was split into seven blocks, with each block containing 19 plots (15 genotypes plus four checks). Each plot has two rows of 2.5 m spacing with a 5 cm plant-to-plant spacing inside the row and 20 cm spacing between the rows. Observations were recorded on five (5) randomly selected plants for most of the characters, leaving border plants in each replication except days to 50% flowering and days to maturity were data recorded on plot basis. Observations *viz*., traits such as days to 50% flowering (DTF), days to maturity (DTM), plant height (PH), number of productive tillers plant^{-1} (TPP), spike length (SL), peduncle length (PL), number of grains spike^{-1} (GPS), 1000-seed weight in gram (TW), biological yield plant^{-1} (BYPP), harvest index (HI), grain yield plant^{-1} (GYPP) were taken into consideration in the present study. Recorded mean values of genotypes in each replication were used for estimation of analysis of variance by Federer (Scott and Milliken, 1993), estimation of correlation coefficients (Searle, 1961), path coefficient analysis (Dewey and Lu, 1959) and genotypic and phenotypic correlation coefficients (Johnson *et al.*, 1955).

Results and Discussion

Analysis of Variance

Analysis of variance for augmented design (Table 1) was carried out for eleven characters to test the significance of differences among various treatments, checks and due to blocks. The variation due to treatments, checks and blocks were significant for all the traits (except number of grains spike^{-1} which is non-significant) under study although level of significance varied from one character to another.

Estimation of Correlation Coefficient

The estimates of phenotypic correlation coefficient computed between eleven characters of wheat under study are presented in table 2. The grain yield plant^{-1} exhibited highly significant and positive correlation with tillers plant^{-1} (0.765), biological yield plant^{-1} (0.675), peduncle length (0.582) and spike length (0.426) and non-significant negative

Table 1: Analysis of variance (ANOVA) of augmented design for eleven (11) characters of wheat genotypes

SV	DF	DTF	DTM	PH	TPP	SL	PL	GPS	BYPP	TW	HI	GYPP
Blocks	6	7.02**	2.95**	7.39**	0.22**	5.73**	5.95**	3.67	9.14**	11.03**	20.22**	1.27**
Treat	108	5.17**	5.06**	9.34**	1.01**	3.53**	8.05**	50.56**	56.89**	10.00**	26.34**	3.86**
Checks	3	16.89**	16.24**	7.54**	6.44**	3.92**	20.25**	490.96**	81.71**	20.16**	111.10**	18.66**
T. Entry	104	5.11**	4.94**	9.01**	0.82**	3.84**	8.03**	37.10**	56.54**	9.84**	24.76**	3.53**
cHKvTest	1	-24.59**	-15.24**	48.28**	4.84**	-30.12**	-27.14**	129.78**	18.45**	-3.12	-62.80**	-6.67**
Error	18	0.48	0.68	0.76	0.09	0.14	0.63	2.90	3.45	2.17	5.13	0.36
Total	132	4.61	4.37	8.08	0.85	3.17	6.94	41.93	47.43	8.98	23.17	3.26

SV: Source of variation; DTF: DTF (Days to 50% flowering); DTM: DTM (Days to maturity); PH: Plant height (cm); TPP: TPP (Tillers plant^{-1}); SL: SL (Spike length) (cm); PL: PL (Peduncle length) (cm); GPS: GPS (No. of grains spike^{-1}); BYPP: BYPP (Biological yield plant^{-1}) (g); TW: TW (Test weight) (g); HI: HI (Harvest index) (%); GYPP: GYPP (Grain yield plant^{-1}) (g); * Significant at 5% probability level; ** Significant at 1% probability level.

Table 2: Estimates of simple correlation coefficients between eleven (11) characters in wheat

Characters	DTF	DTM	PH	TPP	SL	PL	GPS	BYPP	TW	HI	GYPP
Days to 50% flowering	**1.000**	0.254**	0.207*	-0.044	0.201*	0.100	-0.234*	-0.007	0.320**	-0.208*	-0.178
Days to maturity		**1.000**	0.165	0.127	0.276**	0.205*	-0.389**	0.081	0.328**	-0.231*	-0.114
Plant height (cm)			**1.000**	0.065	0.105	0.029	-0.189*	-0.062	0.255**	-0.048	-0.118
Tillers plant^{-1}				**1.000**	0.552**	0.689**	-0.323**	0.808**	0.285**	-0.262**	0.765**
Spike length (cm)					**1.000**	0.737**	-0.368**	0.493**	0.445**	-0.234*	0.426**
Peduncle length (cm)						**1.000**	-0.384**	0.643**	0.443**	-0.276**	0.582**
No of grain spike^{-1}							**1.000**	-0.272**	-0.475**	0.589**	0.218*
Biological yield plant^{-1} (g)								**1.000**	0.284**	-0.619**	0.675**
Test weight (g)									**1.000**	-0.366**	0.049
Harvest index (%)										**1.000**	0.147

DTF: DTF (Days to 50% flowering); DTM: DTM (Days to maturity); PH: Plant height (cm); TPP: TPP (Tillers plant^{-1}); SL: SL (Spike length) (cm); PL: PL (Peduncle length) (cm); GPS: GPS (No. of grains spike^{-1}); BYPP: BYPP (Biological yield plant^{-1}) (g); TW: TW (Test weight) (g); HI: HI (Harvest index) (%); GYPP: GYPP (Grain yield plant^{-1}) (g); * & ** significant at 5% and 1% level, respectively

correlation with days to 50% flowering (-0.178), plant height (-0.118) and days to maturity (-0.114). Similar positive association was also observed between grain yield and one or more of the above mentioned traits by previous workers (Ayer *et al.*, 2017; Ojha *et al.*, 2018; Baranwal *et al.*, 2012; Zare *et al.*, 2017; Karimizadeh *et al.*, 2012; Fellahi *et al.*, 2013; Singh *et al.*, 2015). The grain yield plant^{-1} exhibited non-significant and positive correlation with harvest index (0.147) followed by test weight (0.049). Harvest-index showed highly significant and positive correlation with no. of grain spikes^{-1} (0.589) and it had highly significant and negative correlation with biological yield plant^{-1} (-0.619), followed by test weight (-0.366), peduncle length (-0.276) and tiller plant^{-1} (-0.262) and significant and negative character shown by spike length (-0.234) followed by days to maturity (-0.231), days to 50% flowering (-0.208) and negative and non-significant character shown by plant height (-0.048). Majumder *et al.* (2008) found positive correlation between harvest index and different yield related traits in previous study. The 1000-grain weight (test weight) contributed highly significant and positive correlation with spike length (0.445) followed by peduncle length (0.043), days to maturity (0.328), days to 50% flowering (0.320), tillers plant^{-1} (0.285), biological yield plant^{-1} (0.284), and plant height (0.255), it had negative and highly significant correlation with number of grain spike^{-1} (-0.475). Biological yield plant^{-1} showed highly significant and positive correlation coefficient with tillers plant^{-1} (0.808) followed by peduncle length (0.643) and spike length (0.493), it had negative and highly significant character for number of grain spike^{-1} (-0.272) and negative and non-significant correlation with plant height (-0.062) followed by days to 50% flowering (-0.007) and positive and non-significant correlation are days to maturity (0.08). Number of grain spike^{-1} showed highly significant and negative correlation with days to maturity (-0.389) followed by peduncle length (-0.384), spike length (-0.368) and tillers plant^{-1} (-0.323) and it had negative and significant correlation with days to 50% flowering (-0.234) followed by plant height (-0.189). Peduncle length expressed positive and highly significant correlation coefficient with spike length (0.737) followed by number of tillers plant^{-1} (0.689), it had positive and significant correlation coefficient with days to maturity (0.205) and positive and non-significant correlation coefficient with days to 50% flowering (0.100) followed by plant height (0.029). Spike length showed the highly significant and positive correlation with tillers plant^{-1} (0.552) followed by days to maturity (0.276), it had positive and significant correlation with days to 50% flowering (0.20) and showed positive and non-significant with plant height (0.105). In previous study also, spike length showed positive correlation with grain yield (Ayer *et al.*, 2017). Tillers plant^{-1} showed positive and non-significant correlation coefficient with days to maturity (0.127) followed by plant height (0.065). It shows negative and non-significant correlation with days to 50% flowering (-0.044). Plant height exerted significant and positive correlation with days to 50% flowering (0.207) and positive and non-significant correlation coefficient with days to maturity (0.105). Days to maturity exhibited highly significant and positive correlation with days to 50% flowering (0.254). Days to anthesis showed positive correlation with 1000-kernel weight in different study on wheat (Ojha *et al.*, 2018). Interaction between several traits or components manifests the degree of expression of grain yield. Therefore, for developing an efficient breeding strategy, it is essential to find out the major contributors of grain yield and also their association. The correlation coefficient estimates the degree of linear association between traits and provide an about the nature and magnitude of association among yield and its components. In the current investigation, grain yield plant^{-1} exhibited highly significant and positive correlation with tillers plant^{-1}, biological yield plant^{-1}, peduncle length, spike length and non-significant negative correlation with days to 50% flowering, plant height and days to maturity. Therefore emphasize should be given to those above characters while improving varieties in wheat crop.

Estimation of Path Coefficient Analysis

Simple correlation estimates simply the mutual association whereas path coefficient analysis points out the causes and their relative importance. Path analysis is used as a popular technique to understand the direct and indirect contribution of traits towards the expression of grain yield so that relative importance of different yield contributing characters can be estimated. In the present study, the cause and effects of relationship between yield and its contributing traits were explained in table 3. The highest positive direct effect on grain yield plant^{-1} was exhibited by biological yield plant^{-1} (1.083), followed by harvest-index (0.809), number of grain spike^{-1} (0.1023), peduncle length (0.0864) number of tillers plant^{-1} (0.0647), test weight (0.021), days to 50% flowering (0.0102) and spike length (0.0091). The characters contributed negative direct effect on days to maturity (-0.0155) followed by plant height (0.0077). Earlier study also revealed that plant height had negative direct effect on grain yield (Aycicek and Yildirim, 2006). Tillers plant^{-1} and peduncle length exhibited high order positive indirect effects on grain yield plant^{-1} *via* biological yield (0.87) and (0.69) respectively. Biological yield plant^{-1} (-0.500) and test

Table 3: Direct and indirect effects of eleven (11) characters on grain yield plant^{-1} in wheat

Characters	DTF	DTM	PH	TPP	SL	PL	GPS	BYPP	TW	HI	GYPP
Days to 50% flowering	0.0102	-0.0040	-0.0016	-0.0028	0.0018	0.0086	-0.0240	-0.0074	0.0093	-0.1683	-0.178
Days to maturity	0.0026	-0.0155	-0.0013	0.0082	0.0025	0.0177	-0.0398	0.0883	0.0095	-0.1867	-0.114
Plant height (cm)	0.0021	-0.0026	-0.0077	0.0042	0.0010	0.0025	-0.0194	-0.0671	0.0074	-0.0390	-0.118
Tillers plant^{-1}	-0.0005	-0.0020	-0.0005	0.0647	0.0050	0.0596	-0.0331	0.8752	0.0083	-0.2117	0.765**
Spike length (cm)	0.0021	-0.0043	-0.0008	0.0357	0.0091	0.0636	-0.0377	0.5346	0.0130	-0.1893	0.426**
Peduncle length (cm)	0.0010	-0.0032	-0.0002	0.0446	0.0067	0.0864	-0.0392	0.6968	0.0129	-0.2237	0.582**
No of grains spike^{-1}	-0.0024	0.0060	0.0015	-0.0209	-0.0034	-0.0331	0.1023	-0.2948	-0.0138	0.4767	0.218*
Biological yield plant^{-1} (g)	-0.0001	-0.0013	0.0005	0.0522	0.0045	0.0556	-0.0278	1.0834	0.0083	-0.5005	0.675**
Test weight (g)	0.0033	-0.0051	-0.0020	0.0184	0.0041	0.0383	-0.0486	0.3078	0.0291	-0.2965	0.049
Harvest index (%)	-0.0021	0.0036	0.0004	-0.0169	-0.0021	-0.0239	0.0603	-0.6702	-0.0107	0.8091	0.147

DTF: DTF (Days to 50% flowering); DTM: DTM (Days to maturity); PH: Plant height (cm); TPP: TPP (Tillers plant^{-1}); SL: SL (Spike length) (cm); PL: PL (Peduncle length) (cm); GPS: GPS (No. of grains spike^{-1}); BYPP: BYPP (Biological yield plant^{-1}) (g); TW: TW (Test weight) (g); HI: HI (Harvest index) (%); GYPP: GYPP (Grain yield plant^{-1}) (g); Residual effect = 0.010 Bold figures indicate the direct effect; * & ** significant at 5% and 1% level, respectively weight (-0.296) showed considerable negative indirect effect on grain yield plant^{-1} *via* harvest index. Although in many previous studies, biological yield plant^{-1} was identified as an important direct contributor towards expression of grain yield (Arya *et al.,* 2017; Sharma *et al.*, 2018; Bhushan *et al.*, 2013; Dutamo *et al.*, 2015; Kumar *et al*., 2014). For remaining characters, direct and indirect effects was estimated to be very low as their contribution to grain yield was very low to be considered for any consequences. The value of residual effect was 0.10 which indicates, characters studied was contributed 90% of the yield. Therefore, further research should be done with more traits to estimate other characters which contribute remaining percentage of the yield.

Conclusion

The correlation and path coefficient analysis of the present study revealed that grain yield plant^{-1} had a highly significant and positive correlation with tillers plant^{-1}, biological yield plant^{-1}, peduncle length, and spike length, but a non-significant negative correlation with days to 50% flowering, plant height, and days to maturity. The features that showed a highly significant positive association between yield and its components recommended that these traits should be prioritized during selection in order to generate high yielding varieties. The path analysis identified the major positive direct effect on grain yield plant^{-1} was exerted by biological yield plant^{-1}, followed by harvest-index, number of grain spike^{-1}, peduncle length number of tillers plant^{-1}, test weight, days to 50% flowering and spike length and thus selection in plant breeding programme based on these characters will be more effective.

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