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Correlation and Path Analysis in Different Wheat Genotypes for Grain Yield and its Related Traits

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Abstract. Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and is grown all around the world after rice and maize. Wheat plays a vital role in human and animal nutrition because it is a major source of carbohydrates. Wheat is facing different problems like climate change, biotic and abiotic stress. The research was conducted to study heritability and interrelationship among grain yield and its components in different wheat genotypes. The experimental material was composed of 20 genotypes of wheat with three replications. The present study was laid out in the field of the Department of Plant Breeding and Genetics, Ghazi University, Dera Ghazi Khan. At maturity, grain yield and its related traits were observed. Analysis of variance was analyzed using Statistix 8.1 Software. Results for ANOVA showed that all genotypes showed a highly significant effect among all the characters, while phenotypic and genotypic correlations showed that plant height had significant correlations with grain yield and days to maturity had a negatively highly significant effect on grain yield per plant. Path coefficient analysis revealed that the direct effect of flag leaf area, plant height, spike length, spikelets per spike, and grain weight per spike on grain yield was observed as positive. All other traits showed negative direct affect values. The indirect effect of flag leaf area and number of grains per spike was observed as positive for grain yield per plant. Results showed that genotype F_2 had a maximum value for flag leaf area and days to maturity. Genotype AAS 2011 had the highest values for the number of tillers per plant and number of spikelets per plant than other varieties. Genotype A14 had maximum values for yield per plant.

Keywords: wheat, correlation, path analysis, grain yield

Introduction

Wheat is the world's most widely produced food crop. Wheat (*Triticum aestivum* L.) is a key food crop that provides food for the majority of the world's population. Wheat is a staple food for about two billion people or 36% of the world's population (Zaharieva *et al*., 2010). Wheat accounts for around 55% of all carbohydrates consumed globally and 0% of all dietary calories consumed (Breiman and Graur, 1995). Since at least 9000 B.C., it has been grown in the United States. As a result, it is currently said to be spreading around the world. It is also a member of the Graminae or Poaceae family of plants (Yadawad *et al*., 2015). Wheat, which is the majority of people's basic dietary requirement, accounts for over 20% of the world's food and calories in many underdeveloped countries (Yadawad *et al*., 2015).

Wheat is a major staple in Pakistan, with 80% of farmers cultivating it on a total of about 9 million hectares ha/year (about 40% of the country's total farmed land (Zaharieva *et al*., 2010). According to a poll, Pakistan has set a goal of 28.75 million tons of wheat for 2021-2022 but during this year wheat was cultivated on the area of 8.976 million hectare from that area the recorded production was 26.394 million tons (Economic Survey of Pakistan, 2021-2022). Wheat has many household and industrial uses including, baking and bread manufacturing, wheat protein is used to make polymers, resins, adhesives and coatings, among other things. Wheat starch is used in the paper, cosmetics and pharmaceutical sectors, among other things. Wheat has 70% carbohydrates, 2% protein, 1.7% fat, 2.7% minerals and 2% fibre (Zaharieva *et al*., 2010).

The World's leading wheat producers include China, India and Russia. India is the World's second largest wheat producer, after China. Pakistan's production is

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poor in contrast to other countries. When grain yields are low throughout the crop season, a big amount of wheat is needed to meet the demand. The development of wheat genotypes with excellent quality and yield has enhanced grain output in Pakistan. As a result of the struggles of wheat research centers in Pakistan, several genotypes were produced and disseminated from time to time. Wheat varieties with high quality and potential, as well as the extra features required which have been produced in response to changing climatic circumstances in the country (Khan *et al*., 2010).

Genetic diversity is the source of species preservation (Badakhshan *et al*., 2013). More variability in the early breeding makeup increases the chances of developing new crop varieties. Germplasm with a wide genetic diversity is a great approach to boost productivity, adaptability and quality (Gopalakrishnan and Dwivedi, 2008). Wheat has genetic variability due to stress and associated variables, which can be used to find resistance genotypes using an effective screening technique based on morpho-physiological parameters (Jitender *et al*., 2014).

Correlation coefficient analysis is used as a biometrical method to predict the link between various components in genetically diverse plant populations in order to improve crop enhancement (Dhami *et al*., 2018; Kandel *et al*., 2018). Correlation helps the plant breeders to distinguish the yield contributing traits and helps in the development of new varieties having wider adaptability and better performance under changing climate scenario (Bhattarai *et al*., 2022). Genotypic and phenotypic correlations can be used to establish the degree to which different morpho-physiological traits are linked to economic production.

Path coefficient analysis is a dependable statistical technique for assessing the interrelationships of various yield components and identifying whether the influence is directly reflected in the yield or goes through other channels to produce an effect. As a result, this technique enables a thorough examination of the exact components that generate a particular connection, which may then be used to formulate an effective selection strategy. Since Dewey and Lu (1959) utilized path-coefficient analysis on crested wheat grass, it has been widely used to improve selection in a variety of crops. The purpose of this research is to look into the interrelationships between yield components, as well as the type and magnitude of each component's contribution to yield. The knowledge gained thus far could be used to generate new wheat kinds with high yields by incorporating additional breeding tactics and selection procedures. This study was designed with objective to identify genotypes based on yield and its related traits and evaluate the interrelationship among various yield parameters in wheat genotypes studied.

Materials and Methods

The study was carried out in the Department of Plant Breeding and Genetics at Ghazi University in Dera Ghazi Khan. The experimental material was consisted of 20 genotypes of wheat (Table 1). The selected genotypes were sown in the field during the winter season, 2020. Twenty genotypes were grown under randomized complete block design replicated thrice keeping P x P and R x R distance was 15 cm and 30 cm respectively. All agronomic and cultural practices such as weeding, thinning etc. were done timely. Data was noted for different parameters. At maturity, five plants of each genotype were chosen at random from each replication to collect data on the traits *i.e*., flag leaf area, plant height, number of tillers/plant, days to maturity, spike length, number of spikelets/spike, number of grains/spike, grain weight/spike and grain yield/plant.

The collected data were subjected to ANOVA following (Steel *et al*., 1997) to check the variability in breeding

Table 1. List of wheat genotypes under study

Code number	Name of genotypes
V_1	A10
V_2	L4
V_3	Sehar 2006
V_4	Johar 2011
V_5	A9
V_6	C3
V_7	F2
V_8	A12
V_9	AARI 2011
V_{10}	Tob161
V_{11}	AAS 2011
V_{12}	716
V_{13}	Chakwal
V_{14}	Shahid17
V_{15}	Fsd 2008
V_{16}	J4
V_{17}	Inqlab 91
V_{18}	C5
V_{19}	B15
V_{20}	A14

material. Genotypic correlation and phenotypic correlations among various parameters were computed according to (Kown and Torrie, 1964) and Path Analysis by (Dewey and Lu, 1959) was performed to determine the direct and indirect effects of different morphological characters on yield of seeds.

Results and Discussion

Different genotypes included in the study showed highly significantly differences for growth and yield-related traits, *i.e*., flag leaf area, plant height, number of tillers per plant, days to maturity, spike length, number of spikelets/spike, number of grains/spike, grain weight/spike and grain yield/plant (Table 2). These findings are similar as described by (Ullah *et al*., 2021; Bhanu *et al*., 2018) .

Genotypic correlation. The results of genotypic correlation revealed that flag leaf area is significantly correlated with days to maturity and was highly significantly correlated with grains weight/spike. Plant height is significant with grain yield. The number of tillers/plant had a highly significant correlation with number of spikelets/spike. Days to maturity were negatively highly significant with grain yield/plant. Spike length was negatively significantly correlated with grains' weight/spike. The number of spikelets/spike was observed highly significant correlation with the number of grains/spike. All other traits showed a non-significant correlation with each other (Table 3). These results are similar as described by (Bhutto *et al*., 2016; Dutamo *et al*., 2015; Zaharieva *et al*., 2010; Akram *et al*., 2008).

Phenotypic correlation. The current study results of phenotypic correlation showed that flag leaf area was significantly correlated with grains' weight/spike. Plant height was significantly correlated with spike length and grain yield/plant. The number of tillers/plant was highly significantly correlated with number of spikelets/spike. Days to maturity were negatively highly significantly correlated with grain yield/plant. Spike length was negatively significant with several spikelets/spike. Several spikelets/spike were significantly correlated with the number of grains/spike. The number of grains/spike was negatively significantly correlated with grains' weight/spike (Table 3). Research findings were observed similar by the following researchers (Arya *et al*., 2017; Bhutto *et al*., 2016; Dutamo *et al*., 2015; Kaddem *et al*., 2014; Abinasa *et al*., 2011; Kashif *et al*., 2004). Similarly grain yield/plant had positive correlation with spike length, number of grains/spike, plant height, grain weight/spike and harvest index (Patel *et al*., 2020).

Path analysis. The path coefficient analysis sets up a procedure that aids to evaluate the direct and indirect effects of different characters on the subsequent feature by dividing the genotypic correlation coefficients. Therefore, the evidence delivered by analysis is very useful in estimating the connected reactions of various characters for guiding selections. Grain yield/plant is moveable, the results obtained via this analysis studied the performance of plant traits these traits include flag leaf area, plant height, number of tillers/plant, days to maturity, spike length, number of spikelets/spike, number of grains per spike and grains weight/spike. Path analysis was run by Dewey and Lu (1959). Therefore in Table 2, twenty one revealed the direct and indirect effect of different traits on grain yield/plant. Results of path analysis showed (Table 4) that flag leaf area, plant height, spike length, number of spikelets/spike and grains weight/spike had a positive direct effect on grain yield, while numbers of tillers/plant, days to maturity and number of grains/spike were showed a negative direct effect on grain yield. The indirect effect of flag leaf area on the number of spikelets/spike, number of grains/spike and grains weight/spike were observed

Table 2. Mean sum of square for flag leaf area, plant height, number of tillers/plant, days to maturity, spike length, number of spikelets/spike, number of grains/spike, grain weight/spike and grain yield/plant

		Mean sum of squares								
Source	DF	FLA	PH	NTPP	DM	SL	NSLP	NGPS	GWPS	GYPP
Replication	2	0.76	31.77	0.64	1.22	0.10	2.61	1.08	0.04	0.04
Genotype	19	4.79**	55.65**	0.91**	19.51**	1.58**	5.01**	8.42**	0.17**	1.02**
Error	38	1.37	23.23	0.22	3.84	0.43	1.59	2.64	0.04	0.26

Where DF is degrees of freedom, ** = highly significant at 0.01 probability level; * = significant at 0.05 probability level; NS= non-significant.

Table 3. Genotypic correlation (upper diagonal) and phenotypic correlation (below diagonal) among wheat genotypes

Traits	FLA	PH	NTPP	DM	SL	NSLPS	NGPS	GWPS	GYPP
FLA	1	-0.026	0.222	0.480*	-0.306	0.051	-0.102	0.580**	-0.210
PH	-0.117	1	0.165	-0.236	0.063	0.353	0.217	-0.009	0.507*
NTPP	0.007	0.024	1	0.012	-0.254	0.679**	-0.057	0.042	0.147
DM	0.240	-0.107	0.033	1	0.116	-0.092	-0.019	0.038	-0.765**
SL	0.042	0.235*	-0.068	0.136	1	-0.268	-0.242	-0.560*	-0.013
NSLPS	0.008	-0.001	0.366**	-0.077	-0.260*	1	0.792**	-0.153	0.094
NGPS	-0.186	0.139	-0.041	0.090	-0.153	0.272*	1	-0.195	-0.056
GWPS	0.240 *	-0.032	-0.065	0.046	-0.130	-0.175	-0.133*	1	0.082
GYPP	-0.240	0.324*	0.073	-0.493**	-0.022	0.087	0.043	0.143	1

**= higuly significant at 0.01 probablity level; *= significant at 0.05 probablity level; NS=non significant

Table 4. Path coefficient analysis, direct and indirect effect of different traits on grain yield/plant

Traits	FLA	PH	NTPP	DM	SL	NSLPS	NGPS	GWPS
FLA	**0.098**	-0.008	-0.031	-0.350	-0.032	0.017	0.036	0.059
PH	-0.002	**0.315**	-0.023	0.171	0.006	0.118	-0.077	-0.093
NTPP	0.021	0.052	**-0.143**	-0.008	-0.026	0.227	0.020	0.004
DM	0.047	-0.074	-0.001	**-0.728**	0.012	-0.030	0.006	0.003
SL	-0.030	0.020	0.036	-0.084	**0.105**	-0.089	0.086	-0.057
NSLPS	0.0051	0.111	-0.097	0.067	-0.028	**0.334**	-0.283	-0.015
NGPS	-0.010	0.068	0.008	0.014	-0.025	0.265	**-0.357**	-0.019
GWPS	0.057	-0.002	-0.006	-0.027	-0.058	-0.051	0.069	**0.101**

Residual Effect = 0.265931.

positive for grain yield/plant, while indirect negative path coefficient values were observed in plant height, number of tillers/plant, days to maturity and spike length. These findings were similar to (Ullah *et al*., 2021; Akram *et al*., 2009; Kashif *et al*., 2004). The indirect effect of plant height on number of days to maturity, spike length, and number of spikelets/spike were observed positive for grain yield/plant, while indirect negative path coefficient values were observed in flag leaf area, number of tillers/plant, number of grains/spike and grain weight/spike. Research findings were observed similar by the following researchers (Bhutto *et al*., 2016; Dutamo *et al*., 2015; Kaddem *et al*., 2014; Abinasa *et al*., 2011; Kashif *et al*., 2004). The indirect effect of tillers/plant on flag leaf area, plant height, number of spikelets/spike, number of grains/spike and grain weight/spike were observed positive for grain yield/plant, while indirect negative path coefficient values were observed in days to maturity and spike length. These results are similar to Zaharieva *et al*. (2010) who reported that number of tillers/plant, number of spikelets/spike and grain weight showed indirect positive effect for grain yield/plant. The indirect effect of days to maturity on flag leaf area, spike length, number of grains/spike and grain weight/spike was observed positive for grain yield/plant, while indirect negative path coefficient values were observed in plant height, number of tillers/plant and number of spikelets/spike. These results are similar as described by Akram *et al*. (2008). The indirect effect of spike length on plant height, number of tillers/plant and number of grains/spike were observed positive for grain yield/plant, while indirect negative path coefficient values were observed in flag leaf area, days to maturity, number of spikelets/spike and grain weight/spike. These findings were similar to (Ullah *et al*., 2021; Kashif *et al*., 2004). The indirect effect of spikelets/spike on flag leaf area, plant height and days to maturity were observed as positive for grain yield/plant, while indirect negative path coefficient values were observed in the number of tillers/plant, spike length, number of grain/spike and grain weight/spike. These findings were similar to those published by Abinasa *et al*. (2011) and Munjal *et al*. (2016). The indirect effect of grains/spike on plant height, number of tillers/plant, days to maturity and number of spikelets/spike were observed positive for grain yield/plant, while indirect negative path coefficient values were observed in flag leaf area, spike length and grain weight/spike. Results are similar as described by (Bhutto *et al*., 2016; Dutamo *et al*., 2015). The indirect effect of grain weight/spike on flag leaf area and number of grains/spike were observed positive for grain yield/plant, while indirect negative path coefficient values were observed in plant height, number of tillers/plant, days to maturity, spike length and number of spikelets/spike. Research findings were observed to be similar by the following researchers (Arya *et al*., 2017; Kashif *et al*., 2004). The residual effect was found to be moderate which indicated that there might be some more of its components that were contributing towards grain yield.

Conclusion

In the present experiment, all genotypes showed a highly significant effect among all the characters. Both phenotypic and genotypic correlation showed that plant height had a significant correlation with grain yield and days to maturity had a negatively highly significant effect on grain yield/plant. Path coefficient analysis revealed that the direct effect of flag leaf area, plant height, spike length, spikelets/spike and grain weight/spike on grain yield was observed as positive. On the basis of results, it is concluded that genotype “F2” had a maximum value for flag leaf area and days to maturity and Genotype “AAS 2011” had highest values for the number of tillers/plant and number of spikelets/plant than other varieties. Genotype “A14” had maximum values for yield/plant and these genotypes found best having desirable traits which help to increase yield directly and indirectly and the relationship among plant traits studied is found to be important for improving yield so these traits can be used directly for contributing high yield and selection of genotypes having these traits is vital to increase per acre yield at local farming community. So, it is recommended that the breeders need focus more on yield components for better yield and these genotypes can be used in wheat improvement varietal trials for breeding as high yield varieties and these genotypes can be used in hybrid breeding program in future.

Abbreviations: FLA=Flag leaf area; PH=Plant height; NTPP=Number of tillers/plant; DM=Days to maturity; SL=Spike length; NSLPS=Number of spikelets/spike; NGPS=Number of grains/spike; GWPS=grains weight/spike.

Conflict of Interest. The authors declare that they have no conflict of interest.

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