Biological Forum – An International Journal **14(3): 267-273(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Line × Tester Study in Bread Wheat (*Triticum aestivum* L.) for the Estimation of Correlation and Path coefficients for Important Morphological and Biochemical Traits

Anand Kumar[1], Shabir H. Wani[2*], Lokendra Singh[1], and Som Veer Singh[3], Zahoor A. Dar[4], J.A. Lone[2], Abid H. Lone[2], M.S. Dar[2], Saba Mir[2], Shakir Ayoub[5] and Audil Gull[5]

[1]Department of Genetics and Plant Breeding,
Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh), India.
[2]Mountain Research Centre for Field Crops,
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Khudwani, Anantnag (J&K), India.
[3]Section of Rabi Cereal,
Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh), India.
[4]Dryland Agricultural Research Station, Rangreth,
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (J&K), India.
[5]Division of GPB, FoA,
Wadura- Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (J&K) India.

(Corresponding author: Shabir H. Wani)*
(Received 15 May 2022, Accepted 02 July, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: In this paper, the present investigation aims to evaluate the correlation and path coefficients analysis under normal conditions through line × tester analysis. 15 diverse genotypes including 10 lines, 5 testers and their 50 F_1s hybrids were evaluated for 13 morphological and 2 biochemical traits. The two different locations were taken characters studied. The correlation coefficient of grain yield per plant showed high degree of positive significant association with days to flowering, days to maturity, number of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index, seed hardness and protein content at phenotypic level and days to flowering, days to maturity, number of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index, seed hardness and protein content at genotypic level. The path coefficients analysis of such characters plant height, number of productive tillers per plant, number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index, seed hardness, protein content, exerted positive direct effect on seed yield per plant at both genotypic and phenotypic level while days to maturity, spike length, test weight/1000 grain weight, phenol color reaction exerted negative direct effect on seed yield per plant at both phenotypic level and genotypic level. Among Parents+F_1+F_2 grain yield per plant showed desirable and positive significant association with days to flowering, days to maturity, number of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index, seed hardness and protein content at both phenotypic and genotypic level. Hence, it is clear from study that numbers of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, biological yield per plant are important traits for grain yield improvement.

Keywords: Bread wheat, correlation coefficients, direct and indirect effect.

INTRODUCTION

Ever since human civilization took place, the bread wheat is an important cereal crop and a staple food cultivated globally to fulfil the requirement of human beings (FAOSTAT, 2015; Istipliler *et al*., 2015). Wheat consists of about 55% carbohydrates, 10-18 % of protein and 19% of calories which is required for humans and it is also used as a straw for feeding to animals (Shewry and Hey 2015). It is assumed that population will be 10 billion by 2050, so feed to this explosive population, the wheat yield has to be doubled by 2050, that's why, the extensive research is required to enhance the grain yield of wheat, the improvement of wheat yield may increase by applying agronomic

practices, and breeding programme (Mohammadi *et al*., 2021). The complex trait like grain yield is governed by minor genes and is the product of several contributing traits directly or indirectly. There are several morphological and biochemical traits are associated with economic productivity which is depending on genotypic and phenotypic correlation (Al-Ashkar *et al*., 2021). Knowledge about nature and magnitude of genetic association of components of economic importance can help to improve the efficiency of selection by making possible use of suitable combination of characters (Paux *et al*., 2022). It is considered that yield and their components are determined at different stage of the plant. These different characters are affected by various environmental factors. The correlation pattern of yield and yield components are necessary when compensation between yield components lead variation (Fernandes *et al*., 2021). The importance of genotypic and environmental interaction and their contribution to genetic slippage in the selection of complex characters improved the yield. The knowledge about correlation of yield and yield contribution traits reveals the indication in that selection pressure could be most profitable to be exercised in order to obtain plants having high yield ability (Poudel *et al*., 2021).

Moreover, the path coefficients analysis is a method of calculation direct and indirect effects of traits on grain yield, and provides a way for examining specific forces responsible to produce a given correlation. The method of path analysis depends on the combination of knowledge of degree of correlation among the variables in a system and helps us to know the casual and effect relations, through partitioning of total correlation into direct and indirect effects to get actual information on the contribution of different components traits towards grain yield. In cases where the casual relations are uncertain, the method can be used to find out the logical consequences of any particular hypothesis in regard to them (Zhang *et al*., 2021). In the present study, the design line × tester is used to obtain the knowledge of the genotype, genetic mechanism that control the yield and yield contributing characters that have become of importance for the breeders.

MATERIAL METHODS

A. Parental genotype and crossing

The basic material was 15 diverse wheat genotypes based on origin diversity that divided into two groups *viz*: 10 females (lines) and 5 males (testers). Ten females and five males were sown during rabi 2018-2019 for crossing purpose in L × T fashion at Section of Rabi cereals Nawabganj farm. All the females were crossed with each of five males to produce a sufficient amount of F_1 seed of 50 crosses. The 50 F_1 progenies were selfed to produce F_2 seeds. The testers are selected based on wider adaptability, poor yielder, lower performance and broad genetic base. The details of genotypes are as follows (Table 1).

Table 1: Source and details of important characters of wheat (*Triticum aestivum* L.) genotypes/varieties.

Sr. No.	Genotypes/Varieties	Source of origin
	Lines	
1.	HD-2733	IARI, New Delhi
2.	K-1317	CSAUA&T, Kanpur
3.	DBW-88	IIWBR, Karnal (Haryana)
4.	K-402	CSAUA&T, Kanpur
5.	HD-3086	IARI, New Delhi
6.	WR-544	IARI, New Delhi
7.	HD-2967	IARI, New Delhi
8.	KRL-210	CSSRI, Karnal (Haryana)
9.	PBW-343	PAU, Ludhiana
10.	DBW-39	IIWBR, Karnal (Haryana)
	Testers	
11.	K-8962	CSAUA&T, Kanpur
12.	K-9107	CSAUA&T, Kanpur
13.	K-68	CSAUA&T, Kanpur
14.	K-0307	CSAUA&T, Kanpur
15.	HD-3171	IARI, New Delhi

Development of F_1 seed: All fifteen genotypes, 10 lines (female) and 5 testers (males) were grown during Rabi season 2018-19 for making crosses in line × tester fashion and resultant seeds of 50 hybrids (F_1) were harvested.

Development of F_2 seed: The half seed of each hybrid was sent for advancement at IIWBR-Regional Station, India in an off-season nursery to obtain seed for raising F_2 generation. Rest half seed of each cross was procured to rase F_1 generation in the final trial.

B. Experimental sites and agronomic practices

The parents and their crosses were evaluated under two different locations during the 2018-2019 and 2019-2020

growing seasons. The investigating material consisting of 115 genotypes (15 parents, 50 F_1s and 50 F_2) was sown on 27 November 2019. The whole experiment is conducted in a randomized completely block design (RCBD) with three replication at crop research farm Nawabganj of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Each parent and F_1 were planted in a single row while each F_2 were planted in two rows of 3-meter-long plot and 22.5 cm apart, 10 cm Plant to plant distance was maintained.

C. Morphological and biochemical characterization

The biochemical and morphological characterizations were examined as Days to flowering (75%), Plant height (cm), Days to maturity, Number of productive tillers/plants, Flag leaf area $(cm)^2$, Spike length (cm), Number of spikelets/spike, Number of grains/spike, biological yield/plant (gm), Grain yield /plant (gm), Test weight/1000 grain weight (gm), Harvest index (%), Seed hardness, Phenol color reaction and protein content (%). The following observation was recorded and summarized as given below.

D. Data analysis

The correlation and path coefficients among Parent + F_1 + F_2 had analyzed using the R statistical software package. The experiment results were analyzed to study parameters among treatments, and the significance association was calculated using least significant differences (LSD) $P < 0.05$. Statistical significance was marked at $P<0.05$ unless stated otherwise. Other factors such as temperature, climatic condition, topography, and soil characteristics affected the experiment.

RESULTS AND DISCUSSION

Phenotypic and genotypic correlation coefficients were estimated for fifteen characters in all possible pairs based on pooled calculation presented in Table 2. In this study, the pooled material parents+F_1+F_2 were studied. Days to flowering, days to maturity, number of productive tillers per plants, spike length, number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index, seed hardness, seed hardness, and protein content showed high degree of positive correlation with grain yield per plant at phenotypic level, however, days to flowering, days to maturity, number of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index, seed hardness, and protein content showed positive significant association with seed per plant at genotypic level (Table 2).

Similar findings were reported for most of the characters by Aycicek and Yildirim (2006); Joshi *et al.* (2008); Anwar *et al.* (2009); Khan and Dar (2010); Mohsen *et al.* (2011); Khan *et al.* (2012); Kyosev and Desheva (2015). In general, the genotypic correlations were higher in magnitude than phenotypic correlation coefficients indicating strong positive inherent relationship between the characters (Table 2).

The path coefficients analysis carried out at genotypic as well as phenotypic correlation coefficients, estimate based on pooled data were used to assess direct and indirect effects of various characters on the expression of grain yield per plant (Table 3 and 4 respectively). The path coefficients analysis of Days to flowering (0.0032), plant height (0.0073), number of productive tillers per plant (0.537), number of spikelets per spike (0.433), number of grains per spike (0.0073), biological yield per plant (0.8838), harvest index (0.3526) and seed hardness (0.0043) and protein content (0.0045) exerted positive direct effect on seed yield per plant, whereas days to maturity (-0.0113), flag leaf area (-0.0085), spike length (-0.0139), test weight/1000 grain weight (-0.0112), phenol color reaction (-0.0079) exerted negative direct effect on seed yield per plant at phenotypic level (Table-3).Plant height (0.0106), number of productive tillers per plant (0.0080), flag leaf area (0.0015), number of spikelets per spike (0.0220), number of grains per spike (0.0009), biological yield per plant (0.9261), harvest index (0.3625), seed hardness (0.0168), protein content (0.0022) exerted positive direct effect on grain yield per plant, whereas days to flowering (-0.0003), days to maturity (-0.0569), spike length (-0.0289), test weight/1000 grain weight (-0.0008), phenol color reaction (-0.0067) exerted negative direct effect on seed yield per plant at genotypic level (Table 4). These results are in agreement with the findings of Aycicek and Yildirim, (2006); Munir *et al*. (2007); Joshi *et al.* (2008); Anwar *et al.* (2009); Khan and Dar (2010); Mohsen *et al.* (2011); Khan *et al.* (2012); Kyosev and Desheva (2015). The residual effect determines how best the causal factors account for the variability of the dependent variable *i.e.* seed yield per plant. The low estimate of residual effect suggested that most of the important traits contributing to yield have been included in the study.

Table 2: Estimate of genotypic (rg) upper diagonal and phenotypic (rp) lower diagonal correlation coefficients among 15 characters in Parents+F_1s+F_2s in wheat (*Triticum aestivum* L.).

rg / rp	Days to flowering (75%)	Plant height (cm)	Days to maturity	Number of productive tillers/ plant	Flag leaf area $(cm)^2$	Spike length (cm)	Number of spikelets/ spike	Number of grains/ Spike	Biological yield/plant (gm)	Test weight/ 1000 grain weight (gm)	Harvest index (%)	Seed hardness	Protein content (%)	Phenol color reaction	Grain yield/ plant (gm)
Days to flowering (75%)	**1.000**	-0.146**	0.204**	0.045	0.142**	0.152**	-0.011	0.019	0.203**	0.002	0.004	0.390**	0.154**	-0.169**	0.180**
Plant height (cm)	-0.087	**1.000**	-0.009	-0.101	-0.049	0.104	-0.114*	-0.113*	-0.138*	0.197**	-0.005	-0.008	-0.168**	-0.036	-0.126*
Days to maturity	0.079	-0.008	**1.000**	-0.045	0.202**	0.004	-0.124*	-0.212**	0.442**	0.041	0.330**	0.406**	-0.038	0.080	0.475**
Number of productive tillers/plant	0.031	-0.093	-0.010	**1.000**	0.181**	0.456**	0.386**	0.251**	0.642**	-0.061	-0.149**	-0.073	0.232**	0.105	0.545**
Flag leaf area $(cm)^2$	0.083	-0.049	0.066	0.174**	**1.000**	-0.058	-0.098	-0.099	0.153**	-0.116*	-0.181**	0.035	0.103	-0.183**	0.068
Spike length (cm)	0.102	0.090	-0.012	0.425**	-0.055	**1.000**	0.443**	0.281**	0.475**	0.128*	-0.040	0.117*	0.035	-0.316**	0.415**
Number of spikelets/spike	0.038	-0.104	-0.023	0.345**	-0.098	0.388**	**1.000**	0.554**	0.503**	0.128*	-0.048	-0.071	0.226**	-0.129*	0.467**
Number of grains/spike	0.007	-0.102	-0.059	0.218**	-0.086	0.240**	0.481**	**1.000**	0.245**	-0.004	-0.010	-0.030	0.258**	-0.020	0.241**
Biological yield/plant (gm)	0.133*	-0.134*	0.138*	0.633**	0.151**	0.451**	0.465**	0.218**	**1.000**	-0.146**	0.056	0.173**	0.204**	-0.164**	0.927**
Test weight/ 1000 grain weight (gm)	0.004	0.192**	0.010	-0.061	-0.113*	0.122*	0.116*	-0.002	-0.144**	**1.000**	0.055	-0.077	-0.019	0.066	-0.120*
Harvest index (%)	-0.009	-0.006	0.096	-0.141**	-0.173**	-0.045	-0.034	-0.007	0.047	0.051	**1.000**	0.153**	-0.164**	-0.168**	0.397**
Seed hardness	0.239**	-0.007	0.112*	-0.066	0.031	0.109*	-0.066	-0.012	0.169**	-0.076	0.145**	**1.000**	0.071	-0.222**	0.205**
Protein content (%)	0.073	-0.164**	-0.002	0.221**	0.103	0.040	0.196**	0.209**	0.196**	-0.020	-0.150**	0.058	**1.000**	-0.068	0.140**
Phenol color reaction	-0.032	-0.014	0.033	0.056	-0.101	-0.186**	-0.076	-0.033	-0.094	0.041	-0.106*	-0.129*	-0.031	**1.000**	-0.222**
Grain yield/ plant (gm)	0.117*	-0.122*	0.143**	0.537**	0.067	0.394**	0.433**	0.215**	0.924**	-0.119*	0.391**	0.201**	0.135*	-0.128*	**1.000**

*, ** significant at 5 and 1 percent level, respectively

Table 3: Estimate of direct and indirect effect of 15 different characters on seed yield / plant at phenotypic level in Parents+F_1+F_2 in wheat (*Triticum aestivum* L.).

Characters	Days to flowering (75%)	Plant height (cm)	Days to maturity	Number of productive tillers/plant	Flag leaf area $(cm)^2$	Spike length (cm)	Number of spikelets/ spike	Number of grains/ spike	Biological yield/ plant (gm)	Test weight/ 1000 grain weight (gm)	Harvest index (%)	Seed hardness	Protein content (%)	Phenol color reaction	Grain yield/ plant (gm)
Days to flowering (75%)	**0.0032**	-0.0006	-0.0009	0.0007	-0.0007	-0.0014	0.0010	0.0000	0.1171	0.0000	-0.0030	0.0010	0.0003	0.0003	0.117*
Plant height (cm)	-0.0003	**0.0073**	0.0001	-0.0022	0.0004	-0.0013	-0.0029	-0.0007	-0.1180	-0.0021	-0.0020	0.0000	-0.0007	0.0001	-0.122*
Days to maturity	0.0003	-0.0001	**-0.0113**	-0.0002	-0.0006	0.0002	-0.0006	-0.0004	0.1223	-0.0001	0.0337	0.0005	0.0000	-0.0003	0.143**
Number of productive tillers/plant	0.0001	-0.0007	0.0001	**0.0238**	-0.0015	-0.0059	0.0095	0.0016	0.5590	0.0007	-0.0497	-0.0003	0.0010	-0.0004	0.537**
Flag leaf area $(cm)^2$	0.0003	-0.0004	-0.0007	0.0041	**-0.0085**	0.0008	-0.0027	-0.0006	0.1336	0.0013	-0.0610	0.0001	0.0005	0.0008	0.067
Spike length (cm)	0.0003	0.0007	0.0001	0.0101	0.0005	**-0.0139**	0.0107	0.0018	0.3987	-0.0014	-0.0157	0.0005	0.0002	0.0015	0.394**
Number of spikelets/ spike	0.0001	-0.0008	0.0003	0.0082	0.0008	-0.0054	**0.0277**	0.0035	0.4111	-0.0013	-0.0122	-0.0003	0.0009	0.0006	0.433**
Number of grains/spike	0.0000	-0.0007	0.0007	0.0052	0.0007	-0.0033	0.0133	**0.0073**	0.1930	0.0000	-0.0023	-0.0001	0.0009	0.0003	0.215**
Biological yield/plant (gm)	0.0004	-0.0010	-0.0016	0.0150	-0.0013	-0.0063	0.0129	0.0016	**0.8838**	0.0016	0.0165	0.0007	0.0009	0.0007	0.924**
Test weight/ 1000 grain weight (gm)	0.0000	0.0014	-0.0001	-0.0015	0.0010	-0.0017	0.0032	0.0000	-0.1272	**-0.0112**	0.0181	-0.0003	-0.0001	-0.0003	-0.119*
Harvest index (%)	0.0000	0.0000	-0.0011	-0.0034	0.0015	0.0006	-0.0010	0.0000	0.0415	-0.0006	**0.3526**	0.0006	-0.0007	0.0008	0.391**
Seed hardness	0.0008	-0.0001	-0.0013	-0.0016	-0.0003	-0.0015	-0.0018	-0.0001	0.1489	0.0009	0.0512	**0.0043**	0.0003	0.0010	0.201**
Protein content (%)	0.0002	-0.0012	0.0000	0.0053	-0.0009	-0.0006	0.0054	0.0015	0.1729	0.0002	-0.0530	0.0003	**0.0045**	0.0002	0.135*
Phenol color reaction	-0.0001	-0.0001	-0.0004	0.0013	0.0009	0.0026	-0.0021	-0.0002	-0.0831	-0.0005	-0.0374	-0.0006	-0.0001	**-0.0079**	-0.128*

R SQUARE = 0.9766, RESIDUAL EFFECT = 0.0234

Table 4: Estimate of direct and indirect effect of 15 different characters on seed yield / plant at genotypic level in Parents+F_1+F_2 in wheat (*Triticum aestivum* L.).

Characters	Days to flowering (75%)	Plant height (cm)	Days to maturity	Number of productive tillers/plant	Flag leaf area $(cm)^2$	Spike length (cm)	Number of spikelets/spike	Number of grains/spike	Biological yield/plant (gm)	Test weight/1000 grain weight (gm)	Harvest index (%)	Seed hardness	Protein content (%)	Phenol color reaction	Grain yield/ plant (gm)
Days to flowering (75%)	**-0.0003**	-0.0015	-0.0116	0.0004	0.0002	-0.0044	-0.0002	0.0000	0.1882	0.0000	0.0016	0.0065	0.0003	0.0011	0.180**
Plant height (cm)	0.0000	**0.0106**	0.0005	-0.0008	-0.0001	-0.0030	-0.0025	-0.0001	-0.1281	-0.0002	-0.0019	-0.0001	-0.0004	0.0002	-0.126*
Days to maturity	-0.0001	-0.0001	**-0.0569**	-0.0004	0.0003	-0.0001	-0.0027	-0.0002	0.4094	0.0000	0.1197	0.0068	-0.0001	-0.0005	0.475**
Number of productive tillers/plant	0.0000	-0.0011	0.0025	**0.0080**	0.0003	-0.0132	0.0085	0.0002	0.5948	0.0000	-0.0542	-0.0012	0.0005	-0.0007	0.545**
Flag leaf area $(cm)^2$	0.0000	-0.0005	-0.0115	0.0014	**0.0015**	0.0017	-0.0022	-0.0001	0.1417	0.0001	-0.0657	0.0006	0.0002	0.0012	0.068
Spike length (cm)	0.0000	0.0011	-0.0002	0.0036	-0.0001	**-0.0289**	0.0097	0.0002	0.4403	-0.0001	-0.0146	0.0020	0.0001	0.0021	0.415**
Number of spikelet's/ spike	0.0000	-0.0012	0.0070	0.0031	-0.0001	-0.0128	**0.0220**	0.0005	0.4655	-0.0001	-0.0174	-0.0012	0.0005	0.0009	0.467**
Number of grains/spike	0.0000	-0.0012	0.0120	0.0020	-0.0001	-0.0081	0.0122	**0.0009**	0.2265	0.0000	-0.0035	-0.0005	0.0006	0.0001	0.241**
Biological yield/plant (gm)	-0.0001	-0.0015	-0.0251	0.0051	0.0002	-0.0138	0.0110	0.0002	**0.9261**	0.0001	0.0201	0.0029	0.0005	0.0011	0.927**
Test weight /1000 grain weight (gm)	0.0000	0.0021	-0.0023	-0.0005	-0.0002	-0.0037	0.0028	0.0000	-0.1352	**-0.0008**	0.0201	-0.0013	0.0000	-0.0004	-0.120*
Harvest index (%)	0.0000	-0.0001	-0.0188	-0.0012	-0.0003	0.0012	-0.0011	0.0000	0.0514	0.0000	**0.3625**	0.0026	-0.0004	0.0011	0.397**
Seed hardness	-0.0001	-0.0001	-0.0231	-0.0006	0.0001	-0.0034	-0.0016	0.0000	0.1600	0.0001	0.0555	**0.0168**	0.0002	0.0015	0.205**
Protein content (%)	0.0000	-0.0018	0.0022	0.0018	0.0002	-0.0010	0.0050	0.0002	0.1885	0.0000	-0.0593	0.0012	**0.0022**	0.0005	0.140**
Phenol color reaction	0.0001	-0.0004	-0.0046	0.0008	-0.0003	0.0091	-0.0028	0.0000	-0.1521	-0.0001	-0.0609	-0.0037	-0.0002	**-0.0067**	-0.222**

R SQUARE = 0.9822, RESIDUAL EFFECT = 0.017

CONCLUSION

The results obtained from 15 diverse genotypes and their combination exhibited that the association of days to flowering, days to maturity, number of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, biological yield per plants, harvest index, seed hardness, and protein content are significant and positive on seed yield per plant. Moreover, plant height, number of productive tillers per plants, number of spikelets per spike, biological yield per plant, harvest index, seed hardness and protein content at path coefficient level showed positive effect on seed yield per plant at both phenotypic and genotypic level. However, negative direct effect on seed per plants was of days to maturity, spike length, test weight/1000 grain weight, phenol color reaction at both genotypic and phenotypic level and it is considered that these traits can increase the yield of bread wheat. It is proved by study that these characters and their combination may improve the yield further.

Acknowledgments. The authors are thankful to the anonymous reviewers for their careful read.
Conflict of interest. None.

REFERENCES

Al-Ashkar, I., Ibrahim, A., Ghazy, A., Attia, K., Al-Ghamdi, A.A. and Al-Dosary, M. A. (2021). Assessing the correlations and selection criteria between different traits in wheat salt-tolerant genotypes. *Saudi Journal of Biological Sciences*, *28*(9): 5414-5427.

Anwar, J., Ali, M.A., Hussain, M., Sabir, W., Khan, M. A., Zulkiffal, M. and Abdullah, M. (2009). Assessment of yield criteria in bread wheat through correlation and path analysis. *Journal of Animal and Plant Sciences*, *19*(4): 185-188.

Aycicek, M. and Yildirim, T. (2006). Path coefficient analysis of yield and yield components in bread wheat (*Triticum aestivum* L.) genotypes. *Pakistan Journal of Botany*, *38*(2): 417.

FAOSTAt, F. (2015). Agriculture Organization of the United Nations FAO statistical database Available from: http://faostat. fao. org. *Accessed June*, *30*.

Fernandes, R.C., Busanello, C., Viana, V.E., Venske, E., de Oliveira, V. F., Lopes, J. L., da Maia, L. C., Costa de Oliveira, A. and Pegoraro, C. (2021). Genetic variability and heritability of agronomic traits in a wheat collection used in southern Brazil. *Journal of Crop Science and Biotechnology*, 1-12.

Istipliler, D., Ilker, E., Tonk, F. A., Gizem, C. I. V. I. and Tosun, M. (2015). Line × tester analysis and estimating combining abilities for yield and some yield components in bread wheat. *Turkish Journal of Field Crops*, *20*(1): 72-77.

Joshi, B. K., Mudwari, A. and Thapa, D. B. (2008). Correlation and path coefficients among quantitative traits in wheat (*Triticum aestivum* L.). *Nepal Journal of Science and Technology*, *9*: 1-5.

Khan, M. H. and Dar, A. N. (2010). Correlation and path coefficient analysis of some quantitative traits in wheat. *African Crop Science Journal*, *18*(1).

Khan, N. and Naqvi, F. N. (2012). Correlation and path coefficient analysis in wheat genotypes under irrigated and non-irrigated conditions. *Asian Journal of Agricultural Sciences*, *4*(5), pp.346-351.

Kumar, V. and Maloo, S. R. (2011). Heterosis and combining ability studies for yield components and grain protein content inbread wheat (*Triticum aestivum* L.) *Indian J Genet Plant Breed., 71*: 363-366.

Kyosev, B. and Desheva, G. (2015). Study on variability, heritability, genetic advance and associations among characters in emmer wheat genotypes (*Triticum dicoccon* Schrank). *Journal of BioScience& Biotechnology*.

Mohammadi, M., Mirlohi, A., Majidi, M. M. and Soleimani Kartalaei, E. (2021). Emmer wheat as a source for trait improvement in durum wheat: a study of general and specific combining ability. *Euphytica*, *217*(4): 1-20.

Munir, M., Chowdhry, M. A. and Malik, T. A. (2007). Correlation studies among yield and its components in bread wheat under drought conditions. *International Journal of Agriculture and Biology (Pakistan)*.

Paux, E., Lafarge, S., Balfourier, F., Derory, J., Charmet, G., Alaux, M., Perchet, G., Bondoux, M., Baret, F., Barillot, R. and Ravel, C. (2022). Breeding for Economically and Environmentally Sustainable Wheat Varieties: An Integrated Approach from Genomics to Selection. *Biology*, *11*(1), p.149,

Poudel, M.R., Poudel, P.B., Puri, R.R. and Paudel, H.K., (2021). Variability, Correlation and Path Coefficient Analysis for Agro-morphological Traits in Wheat Genotypes (*Triticum aestivum* L.) under Normal and Heat Stress Conditions. *International Journal of Applied Sciences and Biotechnology*, *9*(1): 65-74.

Shewry, P. R. and Hey, S. J. (2015). The contribution of wheat to human diet and health. *Food and energy security*, *4*(3): 178-202.

Zhang, C., Zheng, B. and He, Y. (2021). Improving Grain Yield via Promotion of Kernel Weight in High Yielding Winter Wheat Genotypes. *Biology*, *11*(1): 42.

How to cite this article: Anand Kumar, Shabir H. Wani, Lokendra Singh, and Som Veer Singh, Zahoor A. Dar, J.A. Lone, Abid H. Lone, M.S. Dar, Saba Mir, Shakir Ayoub and Audil Gull (2022). Line × Tester Study in Bread Wheat (*Triticum aestivum* L.) for the Estimation of Correlation and Path coefficients for Important Morphological and Biochemical Traits. *Biological Forum – An International Journal*, *14*(3): 267-273.