Study of Correlation and path analysis for yield and yield contributing characters of bread wheat (*Triticum aestivum* L.)

[1]Vijay Kumar*, [2]Amarjeet Kaur, [1]Harish Kumar [1]Jyoti, [1]Ritu Batra [2]Kuldeep Singh and S. K. Singh[3]

[1]School of Agricultural Sciences IIMT University, Meerut U.P.-250001
[2]Dept. of Agriculture Mata Gujri College Fatehgarh Sahib Punjab 140407
[3]Dept. of Genetics and Plant Breeding (Ag. Botany), C.C.R. (PG) College, Muzaffarnagar, U.P.-251001
*Corresponding Author- vijayram9092@gmail.com

Abstract

An investigation was undertaken to study for different characters in 60 genotypes in Wheat (*Triticum aestivum* L.) was carried out at the experimental farm Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib amid *Rabi* season of 2020-21. Perceptions on thirteen vital characteristics *viz.* days to booting, days to heading, days to anthesis, days to maturity, number of productive tillers per plant, plant height (cm), spike length (cm), peduncle length (cm), number of spikelet per spike, number of grains per spike, number of grains per plant, 1000 grain weight (test weight), biological yield per plant (g), grain yield per plant (g) and harvest index (%) These components play an important role in a crop for best selecting of genotypes for making rapid improvement in yield and other desirable characters as well as to select the potential parent for hybridization programme. A study of correlation alone is not enough to provide an exact picture of relative importance of direct and indirect influences of each of the component traits on seed yield.

Keywords: Wheat, Seed yield, Correlation coefficient analysis and Path analysis

Introduction

Wheat (*Triticum aestivum* L.) might be a self-pollinated alters of the portion of Poaceae family and one of the preeminent driving cereals of various nations of the world checking India. Wheat has a place to the tribe Triticeae within the grass family Poaceae (Gramineae). Linnaeus in 1753 to begin with classified wheat. In 1918, (Sakamura *et al*. 1918). It is additionally a great source of minerals and vitamins viz., thiamin (0.30 mg/100g), riboflavin (0.07 mg/100g) and niacin (1.7 mg/100mg) (Kumar *et al*. 2011). Relationship ponders give information of affiliation among

distinctive characters and grains abdicate. The ponder of affiliation among different characteristics is valuable for breeders in selecting genotypes having bunches of wanted characteristics. The relationship coefficients gotten to be inadequately for utilizing surrender components as choice criteria to make strides grain yields. It is sensible to know whether any surrender components includes a coordinate or roundabout impact on grain surrender, so that choice thinks about can be carried out successfully (Kadan *et al*. 2022). In the midst of 2020-2021, word locale underneath wheat 224.49 million hectares and era 772.64 million metric tons (Anonymous, 2021). India is the greatest era nation taking after to china. It has a zone around 31.61 million hectares with an era and proficiency of 109.52 million tons and 3464/kg independently (Secretive, 2021). Uttar Pradesh, Punjab, Madhya Pradesh, Haryana, Rajasthan and Bihar are the major wheat making states in India. Wheat may be a major cereal trim of Punjab. It was created on a locale of 35.20 lakh hectares in the midst of 2019-20 with era of 176.2 lakh tons and ordinary resign of 50.04 quintals per hectare (Secretive, 2021). Way coefficients have been utilized to make assurance criteria for complex characteristics in a couple of alter species of money related noteworthiness such as wheat, rice, maize and cotton (Bloch *et al.* 2014). Way coefficient examination as defined by Wright (1921) is standardized as fragmentary regression coefficient, which makes a contrast in portioning the relationship coefficient into facilitate and circuitous impacts of free variables on the dependant variables the grain yield through coordinated assurance of component characteristics and their interrelationship with abandon.

MATERIALS AND METHOD

The present research work was conducted at Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab amid Rabi season of 2020-21. This place is situated between 30-27’ and 30-46’ latitudes and 76-04’ and 76- 38’E latitudes and a mean height of 247 meters above sea level. The annual precipitation rate is around 710 mm, and soil is sandy loam. The parents were sown in Randomized Block Design (RBD) with three replications. The information were recorded on ten randomly chosen plants e.g. days to booting, days to heading, days to anthesis, days to maturity, number of productive tillers per plant, plant height (cm), spike length (cm), peduncle length (cm), number of spikelet per spike, number of grains per spike, number of grains per plant,1000 grain weight (test weight), biological yield per plant (g), grain yield per plant (g) and harvest index (%) were recorded on five competitive plants randomly

chosen from each plot whereas blooming was recorded on push premise. Investigation of change was calculated utilizing MS Exceed expectations computer program utilizing MSTAT-C computer program. The basic relationship coefficient was gotten by the strategy and way coefficient examination was carried out by Dewey and Lu. Correlation between studied traits was computed using formula suggested by Searle (1961). Direct and indirect effects of yield attributing traits up on grain yield were measured by path analysis as described by Dewey & Lu (1959).

RESULT AND DISCUSSION

Analysis of variance cruel squares of characters beneath consider from ANOVA for the tried materials were displayed in Tables - 1. The result displayed within the table -1 uncovered that there were exceedingly noteworthy contrasts ($P< 0.05$ and $P< 0.01$) among the genotypes for all the examined agro-morphological characteristics, demonstrating the presence of adequate hereditary changeability among bread wheat genotypes will be accommodating in determination strategies of encourage bread wheat breeding program. Comparable comes about were detailed by Awale *et al.* (2013); Kumar *et al.* 2014); Zeeshan *et al.* (2014); Adhiena *et al.*(2016) and Ayer *et al.* (2017) in their past considers on bread wheat. Phenotypic relationship coefficient days to booting showed up basically positive relationship with days to anthesis (0.325), test weight (0.249) and days of development (0.183) while adversely correlated with number of useful tillers (0.078), number of grain per spike (-0.060) and peduncle length (-0.012).Days to heading showed up negative relationship with days of anthesis (-0.246) and number of spikelet per spike (-0.174).

Correlation between yield and yield attributing traits

Basic relationship coefficients were assessed for all the characters considered with grain abdicate per plant and displayed in table-.3 The grain abdicate per plant shown exceedingly noteworthy and positive relationship with organic abdicate per plant (0.726), gather record (%) (0.773), plant height (0.239) The noteworthy relationship recommends that these characteristics may be utilized as backhanded choice characteristics for grain surrender, i.e., increment of these characteristics would increment grain abdicate per plant. They consider of relationship among abdicate and surrender contributing characteristics too recommends that plant tallness, number of beneficial tillers per plant, 1000 grain weight, collect list and natural surrender were the foremost imperative characters which had profoundly positive relationship with grain abdicate per plant.

In this manner, these characters might be utilized in assist breeding program for improvement of tall yielding wheat bread.

Correlation between yield and yield attributing traits

Days to heading had exceedingly critical positive relationship with days to development; gather record (%) and natural abdicate per plant at phenotypic level. This suggested that expanding days to heading would increment days to development, collect list (%) and natural abdicate per plant.

Days to development positive critical correlated with natural abdicate per plant, collect list (%) and tillers per plant which demonstrates that increment within the crevice between heading date and development date leads to extend in organic abdicate per plant, tillers per plant, and collect record. Mohammad *et al.* (2005) [15] moreover detailed that days to development had noteworthy positive genotypic relationship with grain-filling period, plant stature, number of spikelets spike−1, and thousand seed weight. Plant tallness displayed positive noteworthy affiliation with organic abdicate per plant, spike length, thousand seed weight, natural surrender and gather file which infers that increment in plant stature leads to extend in spike length, thousand seed weight, natural surrender and collect record.

Number of profitable tillers per plant shown positive and critical relationship with the spike length, Natural yield per plant, 1000- grain weight and gather file recommending that increment in tiller number includes the esteem of those characteristics. It was moreover demonstrated that number of tillers per plant may be a compelling characteristic to choose higher yielding genotypes. Positive and noteworthy relationship between spike length, thousand seed weight and collect file was too watched.

The interrelation between abdicate contributing characters shows that thousand seed weight was emphatically correlated with gather record, Natural surrender per plant and hail leaf region which demonstrated tall parcel of photosynthesis was due to extend thousand seed weight. This result is in assertion with the finding of prior specialist's *viz*. Kalimullah *et al.* 2012; Laei *et al.* 2012; Zafarnaderi *et al.*2013.

Path analysis

The result of way coefficient investigation of the show think about was displayed in Tables 6. Greatest positive coordinate impact on grain abdicate per hectare was applied by organic surrender per plant taken after collect list (0.2436), days to heading (0.0188), plant tallness (0.0301), number of grain per spike (0.1036).The tall greatness coordinate impacts of these

characters on grain surrender may be considered as causes of such tall relationship. This implies that a slight increment in one of these characteristics may specifically contribute to grain abdicate. Sabit *et al.* (2017) have been detailed that plant stature, days to anthesis, organic surrender, and gather file had positive coordinate impact on grain surrender per plant at genotypic level in bread wheat which is comparable with the display consider. Chowdhry *et al.* (1991), too detailed positive and coordinate impact of collect list (0.2436) and organic abdicate (0.0.3386) on grain surrender per plant. (0.3296) Negative coordinate impact was displayed by remaining abdicate ascribing characteristics *viz*. Peduncle length (-0.0605).Since the coordinate impact was negative, so the coordinate choice for these characteristics to move forward surrender will be undesirable.

The most noteworthy positive circuitous impact on grain abdicate was displayed by natural abdicate per plant (0.2554) by means of test weight, collect list (0.0744) by means of days to anthesis, plant tallness (0.0220) by means of days to development. Remaining examined surrender ascribing characteristics applied negative backhanded impact on grain abdicates per plant. The comes about were comparable to those detailed by Tsegaye *et al*. (2012), Wolde *et al*. (2016), Adhikari *et al*. (2018) Zemade *et al*. (2019) and Alemu *et al*.(2020).

REFFERENCES

AdhienaMesele, Wassu Mohammed, TadesseDessalegn. Estimation of Heritability and Genetic Advance of Yield and Yield Related Traits in Bread Wheat (*Triticum aestivum* L.) Genotypes at Ofla District, Northern Ethiopia. International Journal of Plant Breeding and Genetics, 2016; 10: 31-37.

Adhikari S, Rana N, Ojha BR, Khare R, Chauhan S, Thapa D. Study of variability and association of yield attributing traits in durum wheat genotypes. International Journal of Agriculture and Ecology research, 2018; 14: 1-2.

Alemu YA, Anley AM, Abebe TD. Genetic variability and association of traits in Ethiopian durum wheat (Triticum turgidium L. var. durum) landraces at Dabat Research Station, North Gondar. Cogent Food & Agriculture, 2020; 6:1778604

Anonymous. 2021. Wheat – statistics & facts. https:// www. Statista .com/ topics /1668 /wheat/.

Awale D, Takele D, Sharif M. Genetic variability and traits association in bread whea (*Triticum aestivum* L.) genotypes. Int. J Agric. Res 2013; 1:19-29.

Ayer Dipendra, Sharma Anupama, Ojha Br, Paudel A, Dhakal Krishna. Correlation and path coefficient analysis in advanced wheat genotypes. SAARC Journal of Agriculture 2017;15:1. 10.3329/sja.v15i1.33155.

Baloch A W. Baloch M, Baloch I A, Mari S N, Mandan D K and Abro S A. Association and Path Analysis in Advance Pakistani Bread Wheat Genotypes. Pure and Applied biology, 2014;(3): 15-120

Chowdhry MA, Tariq G, Cheema NM. Correlation analysis and path coefficient for grain yield and yield components in bread wheat (*Triticum aestivum* L.). J Agric. Res 1991, 151-157.

Dewey D R and Lu K H. A correlation and path coefficient analysis of components of crested wheat grass and seed production. Agronomy Journal.1959;**51**: 515-518.

Dhakar MR, Jat BL, Bairwa LN, Gupta JK. Genetic variability in wheat (Triticum species). Environment and Ecology 2012; 30:1474-1480.

Kadan D J, Karwar S H and Jadhav P S. Correlation analysis for different characteristics in wheat. The Pharma Innovation Journal. 2022; 11 (1):98-100.

Kalimullah Khan SJ, Irfaq M, Rahman HU. Genetic variability, correlation and diversity studies in bread wheat (*Triticum aestivum L.*) The Journal of Animal & Plant Sciences 2012;22(2):330-333.

Kumar Y, Lamba RAS, Balbir Singh, Vinod Kumar. Genetic variability, correlation and Path analysis in wheat varieties under late sown condition. Annals of Agri Bio Research 2014; 19 (4):724-727.

Kumar Y, Lamba RAS, Singh B, Kumar V. Genetic variability, correlation and path analysis in wheat varieties under late sown condition. Annuals of Agric. Bio. Res 2011; 19 (4):724-727.

Laei GH, Afshar H, Jalal Kamali MR, Hassanzadeh AH. Study yield and yield components comparison correlation some physiological characteristics, 20 genotypes of bread wheat. Annals. Biol. Res 2012;3(9):4343-4351.

Malbhage AB, Talpada MM, Shekhawat VS, Mehta DR. Genetic variability, heritability and genetic advance in durum wheat (Triticum durum L.). Journal ofPharmacognosy and Phytochemistry. 2020; 9:3233-3236.

Mohammad T, Haider S, Amin M, Khan MI, Zamir R. Path coefficient and correlation studies of yield and yield associated traits in candidate bread wheat (*Triticum aestivum* L.) lines. Suranaree Journal of Science and Technology 2005; 13(2):175-180.

Sabit Z, Yadav B, Rai PK. Genetic variability, correlation and path analysis for yield and its components in f5 generation of bread wheat (*Triticum aestivum* L.). Journal of Pharmacognosy and Phytochemistry 2017; 6(4):680:687.

Sakamura T Kurze. Mitteilunguber die Chromosomenzahlen und die Verwandt-schaftsverhaltnisse der Triticum-Arten. Bot Mag (Tokyo). 1918; 32:150-153.

Searle SR. Phenotypic, genotypic and environmental correlations. Biometrics 1961; 17(3):474-480.

Tambe A, Mehta DR, Chovatia VP, Bhatiya VJ. Genetic variability, character association and path coefficient analysis in durum wheat (Triticum durum Desf.). Electronic Journal of Plant Breeding, 2013; 4:1303-1308.

Tsegaye D, Dessalegn T, Dessalegn Y, Share G. Genetic variability, correlation and path analysis in durum wheat germplasm (Triticum durum Desf). Agricultural Research and Reviews 2012; 1:107-112.

Wolde T, Eticha F, Alamerew S, Assefa E, Dutamo D. Genetic variability, heritability and genetic advance for yield and yield related traits in Durum wheat (Triticum durum L.) accessions. Sky Journal of Agricultural Research 2016; 5:042-047.

Wright S. 1921. Correlation and causation. Journal of Agriculture Research**20**: 557-558.

Zafarnaderi N, Aharizad S, Mohammadi SA. Relationship between grain yield and related agronomic traits in bread wheat recombinant inbred lines under water deficit condition. Ann Biol Res 2013; 4(4):7–11.

Zeeshan M, Arshad W, Khan MI, Ali S, Tariq M. Character association and casual effects of polygenic traits in spring wheat (*Triticum aestivum* L.) genotypes. International Journal of Agriculture, Forestry and Fisheries, 2014; 2(1):16-21.

Zemede A, Mekbib F, Assefa K, Bishaw Z. Variability in Ethiopian durum wheat under rainfed environment subjected to drought at anthesis. Ethiopian Journal of Agricultural Sciences 2019; 29:17-29.

Table 1. Analysis of variances (ANOVA)

Source of variation	DF	Days to booting	Days to heading	Days to anthesis	Days of maturity	No. of productive tillers	Plant height (cm)	Peduncle length (cm)	Spike length (cm)
Replication	2	1.45	2.80	7.85	1.63	0.28	20.12	1.44	0.05
Treatment	59	13.73**	14.13**	25.70**	23.23**	14.05**	39.98**	9.66**	0.94**
Error	118	2.14	3.69	4.29	3.08	0.28	13.24	2.10	0.18

Conti..

Source of variation	DF	No. of spikelet / spike	No. of grain/ spike	No. of grain per plant	Test weight	Biological yield/plant(g)	Harvest index	Grain yield/plant
Replication	2	0.11	4.70	568.91	12.38	25.03	16.58	5.23
Treatment	59	7.97**	12.52**	33301.49**	21.31**	88.94**	86.54**	100.72**
Error	118	0.66	3.97	726.72	4.81	7.36	4.14	1.94

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

Table 3. Phenotypic correlations analysis showing effect of 15 characters on grain yield bread wheat (*Triticum aestivum* L.)

Characters	Days to booting	Days to heading	Days to anthesis	Days of maturity	No. of productive tillers	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	No. of spikelet/ spike	No. of grain/ spike	No. of grain per plant	Test weight	Biological yield/ plant (g)	Harvest index	Grain yield/ plant
Days to booting	1.000	0.059	0.325**	0.183*	-0.078	0.100	-0.012	0.032	0.015	0.006	-0.060	0.221**	0.026	0.011	0.031
Days to heading		1.000	-0.246**	0.071	-0.020	-0.134	0.009	-0.040	-0.174*	0.035	-0.024	-0.027	-0.075	0.058	-0.018
Days to anthesis			1.000	0.090	0.040	0.103	0.076	0.017	0.112	-0.003	0.044	0.122	0.000	0.100	0.089
Days of maturity				1.000	-0.053	-0.198**	0.197**	-0.108	0.187*	-0.050	-0.079	0.242**	0.017	-0.011	-0.019
No. of productive tillers					1.000	0.063	0.012	-0.057	-0.036	0.015	0.904**	0.080	0.726**	0.773**	0.871**
Plant height (cm)						1.000	-0.155*	-0.017	0.016	0.015	0.239**	-0.185*	0.142	0.074	0.173*
Peduncle length (cm)							1.000	-0.062	0.174*	-0.097	-0.042	0.188*	-0.084	0.067	-0.075
Spike length (cm)								1.000	0.216**	0.123	-0.054	-0.043	0.072	-0.049	0.022
No. of spikelet/ spike									1.000	-0.138	0.002	0.134	0.007	0.096	0.028
No. of grain/ spike										1.000	0.097	0.090	-0.061	0.232**	0.192**
No. of grain per plant											1.000	-0.035	0.775**	0.802**	0.918**
Test weight												1.000	0.090	0.305**	0.218**
Biological yield/plant(g)													1.000	0.482**	0.818**
Harvest index														1.000	0.832**
Grain yield/plant															1.000

Table 4. Genotypic correlations analysis showing effect of 15 characters on grain yield bread wheat (*Triticum aestivum* L.)

Characters	Days to booting	Days to heading	Days to anthesis	Days of maturity	No. of productive tillers	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	No. of spikelet/ spike	No. of grain/ spike	No. of grain per plant	Test weight	Biological yield/ plant(g)	Harvest index	Grain yield/ plant
Days to booting	1.000	0.006	0.403**	0.234**	-0.073	0.073	0.023	-0.009	0.025	-0.029	-0.087	0.403**	0.018	0.020	0.033
Days to heading		1.000	-0.435*	0.025	-0.023	-0.223**	-0.020	-0.101	-0.316**	0.023	-0.007	-0.089	-0.128	0.062	-0.017
Days to anthesis			1.000	0.064	0.055	0.154*	0.154*	0.009	0.161*	0.005	0.066	0.155*	0.023	0.147*	0.101
Days of maturity				1.000	-0.070	-0.355**	0.297**	-0.178*	0.250**	-0.083	-0.089	0.336**	0.030	-0.028	-0.004
No. of productive tillers					1.000	0.197**	-0.006	-0.049	0.008	-0.160*	0.984**	-0.016	0.913**	0.827**	0.927**
Plant height (cm)						1.000	-0.083	-0.074	0.156*	0.591**	0.212**	-0.123	-0.071	0.355**	0.171*
Peduncle length (cm)							1.000	0.180*	0.229**	0.003	0.008	-0.194*	0.028	-0.071	0.020
Spike length (cm)								1.000	0.470**	0.035	-0.010	0.099	-0.093	0.005	-0.050
No. of spikelet/ spike									1.000	0.032	-0.021	0.329**	0.032	0.047	0.058
No. of grain/ spike										1.000	0.308**	-0.054	0.101	0.358**	0.228**
No. of grain per plant											1.000	0.073	0.863**	0.926**	0.970**
Test weight												1.000	0.446**	0.302**	0.407**
Biological yield/plant(g)													1.000	0.710**	0.903**
Harvest index														1.000	0.976**
Grain yield/plant															1.000

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

Table 5. Environmental correlations analysis showing effect of 15 characters on grain yield bread wheat (*Triticum aestivum* L.)

Characters	Days to booting	Days to heading	Days to anthesis	Days of maturity	No. of productive tillers	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	No. of spikelet/ spike	No. of grain/ spike	No. of grain per plant	Test weight	Biological yield/ plant (g)	Harvest index	Grain yield/ plant
Days to booting	1.000	0.129	0.191*	0.082	-0.147*	0.135	-0.063	0.099	-0.009	0.045	0.047	-0.037	0.048	-0.016	0.034
Days to heading		1.000	-0.016	0.140	-0.024	-0.063	0.040	0.029	0.065	0.046	-0.106	0.036	0.012	0.068	-0.036
Days to anthesis			1.000	0.141	-0.019	0.054	-0.034	0.028	-0.005	-0.011	-0.046	0.079	-0.057	-0.038	0.076
Days of maturity				1.000	0.021	-0.026	0.041	0.015	0.012	-0.013	-0.052	0.101	-0.019	0.053	-0.119
No. of productive tillers					1.000	-0.315**	0.101	-0.138	-0.391**	0.633**	-0.357**	0.563**	-0.549**	0.276**	-0.072
Plant height (cm)						1.000	-0.223**	0.039	-0.201**	-0.385**	0.559**	-0.243**	0.510**	-0.486**	0.371**
Peduncle length (cm)							1.000	-0.378**	0.079	-0.192**	-0.282**	0.635**	-0.327**	0.472**	-0.560**
Spike length (cm)								1.000	-0.349**	0.217**	-0.286**	-0.223**	0.456**	-0.228**	0.395**
No. of spikelet/ spike									1.000	-0.443**	0.176*	-0.251**	-0.083	0.339**	-0.195**
No. of grain/ spike										1.000	-0.499**	0.222**	-0.338**	0.060	0.273**
No. of grain per plant											1.000	-0.505**	0.291**	-0.371**	0.096
Test weight												1.000	-0.631**	0.403**	-0.439**
Biological yield/plant(g)													1.000	-0.629**	0.365**
Harvest index														1.000	-0.605**
Grain yield/plant															1.000

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

Table 6. Path coefficient analysis showing direct and indirect effect of 15 characters on grain yield at phenotypic level in bread wheat (*Triticum aestivum* L.)

Characters	Days to booting	Days to heading	Days to anthesis	Days of maturity	No. of productive tillers	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	No. of spikelet/ spike	No. of grain/ spike	No. of grain per plant	Test weight	Biological yield/ plant(g)	Harvest index	R with grain yield/ plant
Days to booting	**0.0059**	0.0011	0.0109	0.0001	-0.0100	0.0030	0.0007	0.0007	0.0002	0.0006	-0.0198	0.0258	0.0087	0.0028	0.031
Days to heading	0.0004	**0.0188**	-0.0082	0.0000	-0.0025	-0.0040	-0.0006	-0.0009	-0.0017	0.0036	-0.0078	-0.0032	-0.0255	0.0142	-0.018
Days to anthesis	0.0019	-0.0046	**0.0334**	0.0000	0.0051	0.0031	-0.0046	0.0004	0.0011	-0.0003	0.0144	0.0143	0.0000	0.0244	0.089
Days of maturity	0.0011	0.0013	0.0030	**0.0004**	-0.0068	-0.0060	-0.0119	-0.0024	0.0018	-0.0052	-0.0259	0.0283	0.0058	-0.0026	-0.019
No. of productive tillers	-0.0005	-0.0004	0.0013	0.0000	**0.1280**	0.0019	-0.0008	-0.0013	-0.0004	0.0015	0.2979	0.0094	0.2458	0.1883	0.871**
Plant height (cm)	0.0006	-0.0025	0.0034	-0.0001	0.0081	**0.0301**	0.0094	-0.0004	0.0002	0.0016	0.0787	-0.0217	0.0480	0.0179	0.173*
Peduncle length (cm)	-0.0001	0.0002	0.0025	0.0001	0.0016	-0.0047	**-0.0605**	-0.0014	0.0017	-0.0101	-0.0139	0.0220	-0.0284	0.0163	-0.075
Spike length (cm)	0.0002	-0.0008	0.0006	-0.0001	-0.0073	-0.0005	0.0038	**0.0220**	0.0021	0.0128	-0.0177	-0.0050	0.0244	-0.0120	0.022
No. of spikelet/ spike	0.0001	-0.0033	0.0037	0.0001	-0.0046	0.0005	-0.0106	0.0047	**0.0097**	-0.0143	0.0008	0.0157	0.0024	0.0233	0.028
No. of grain/ spike	0.0000	0.0007	-0.0001	0.0000	0.0019	0.0005	0.0059	0.0027	-0.0013	**0.1036**	0.0320	0.0106	-0.0207	0.0566	0.192**
No. of grain per plant	-0.0004	-0.0004	0.0015	0.0000	0.1157	0.0072	0.0026	-0.0012	0.0000	0.0101	**0.3296**	-0.0041	0.2624	0.1954	0.918**
Test weight	0.0013	-0.0005	0.0041	0.0001	0.0103	-0.0056	-0.0114	-0.0009	0.0013	0.0094	-0.0115	**0.1169**	0.0304	0.0744	0.218**
Biological yield/plant(g)	0.0002	-0.0014	0.0000	0.0000	0.0929	0.0043	0.0051	0.0016	0.0001	-0.0063	0.2554	0.0105	**0.3386**	0.1174	0.818**
Harvest index	0.0001	0.0011	0.0034	0.0000	0.0989	0.0022	-0.0040	-0.0011	0.0009	0.0241	0.2643	0.0357	0.1632	**0.2436**	0.832**

Residual effect = 0.04728

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

Table 7. Path coefficient analysis showing direct and indirect effect of 15 characters on grain yield at genotypic level in bread wheat (*Triticum aestivum* L.)

Characters	Days to booting	Days to heading	Days to anthesis	Days of maturity	No. of productive tillers	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	No. of spikelet/ spike	No. of grain/ spike	No. of grain per plant	Test weight	Biological yield/ plant(g)	Harvest index	R with grain yield/ plant
Days to booting	**0.1142**	-0.0009	-0.0655	-0.0475	0.0119	-0.0160	0.0038	0.0019	0.0029	0.0026	-0.0138	0.0174	0.0026	0.0195	0.033
Days to heading	0.0007	**-0.1513**	0.0706	-0.0050	0.0037	0.0490	-0.0033	0.0200	-0.0366	-0.0020	-0.0011	-0.0038	-0.0192	0.0614	-0.017
Days to anthesis	0.0460	0.0658	**-0.1625**	-0.0130	-0.0090	-0.0338	0.0252	-0.0019	0.0187	-0.0004	0.0106	0.0067	0.0034	0.1453	0.101
Days of maturity	0.0267	-0.0037	-0.0104	**-0.2032**	0.0113	0.0779	0.0484	0.0351	0.0290	0.0074	-0.0142	0.0145	0.0045	-0.0274	-0.004
No. of productive tillers	-0.0084	0.0035	-0.0090	0.0141	**-0.1628**	-0.0432	-0.0009	0.0096	0.0010	0.0143	0.1570	-0.0007	0.1369	0.8156	0.927**
Plant height (cm)	0.0084	0.0338	-0.0250	0.0721	-0.0320	**-0.2196**	-0.0135	0.0147	0.0181	-0.0529	0.0339	-0.0053	-0.0107	0.3495	0.171*
Peduncle length (cm)	0.0027	0.0030	-0.0251	-0.0603	0.0009	0.0182	**0.1630**	-0.0356	0.0265	-0.0003	0.0012	-0.0084	0.0042	-0.0697	0.020
Spike length (cm)	-0.0011	0.0153	-0.0015	0.0361	0.0079	0.0163	0.0294	**-0.1978**	0.0545	-0.0031	-0.0017	0.0043	-0.0139	0.0052	-0.050
No. of spikelet/ spike	0.0029	0.0478	-0.0262	-0.0508	-0.0014	-0.0342	0.0373	-0.0929	**0.1160**	-0.0029	-0.0033	0.0142	0.0047	0.0464	0.058
No. of grain/ spike	-0.0033	-0.0034	-0.0007	0.0169	0.0260	-0.1298	0.0005	-0.0069	0.0037	**-0.0894**	0.0491	-0.0024	0.0151	0.3525	0.228**
No. of grain per plant	-0.0099	0.0010	-0.0108	0.0180	-0.1602	-0.0466	0.0013	0.0021	-0.0024	-0.0275	**0.1596**	0.0031	0.1295	0.9128	0.970**
Test weight	0.0461	0.0134	-0.0251	-0.0683	0.0026	0.0270	-0.0316	-0.0195	0.0382	0.0049	0.0116	**0.0431**	0.0668	0.2978	0.407**
Biological yield/plant(g)	0.0020	0.0194	-0.0037	-0.0061	-0.1485	0.0156	0.0045	0.0184	0.0037	-0.0090	0.1378	0.0192	**0.1500**	0.6999	0.903**
Harvest index	0.0023	-0.0094	-0.0240	0.0056	-0.1347	-0.0779	-0.0115	-0.0011	0.0055	-0.0320	0.1478	0.0130	0.1065	**0.9857**	0.976**

Residual effect = 0.0715

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