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

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Abstract

The show consider was conducted including 60 genotypes in Wheat (*Triticum aestivum* L.) was carried out at the Investigate Cultivate, Division of Agriculture, Mata Gujri College, Fatehgarh Sahib amid Rabi season of 2020-21. Experimental developed in Randomized Piece Plan with three replications with the targets to gauge the relationship coefficient and way investigation, hereditary inconstancy, heritability, hereditary progress. Perceptions on thirteen vital characteristics viz. days to booting, days to heading, days to anthesis, days to development, number of beneficial tillers per plant, plant stature (cm), spike length (cm), peduncle length (cm), number of spikelet per plant, number of grains per spike, number of grains per plant, 1000 grain weight, organic surrender per plant (g), grain surrender per plant (g), and gather record (%) of 60 genotypes of wheat, displayed in Table.

Keywords: Wheat, genetic variability, correlation, path coefficient and heritability

Introduction

Wheat (*Triticum aestivum* L.) might be a self-pollinated alter of the portion of Poaceae family and one of the preminent 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) [18]. 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) [11]. 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) [12]. In the midst of 2020-2021, word locale underneath wheat 224.49 million hectares and era 772.64 million metric tons (Anonymous, 2021) [1]. 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) [7]. 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 information around innate changeability, GCV, PCV, heritability, relationship coefficients and its other parameters offer help in energize making strides the grain yield through coordinated assurance of component characteristics and their interrelationship with abandon.

Materials and Method

The show inquire about was carried out at the exploratory cultivate Investigate Cultivate, Division of Horticulture, Mata Gujri College, Fatehgarh Sahib amid Rabi season of 2020-21.

Test developed in Randomized Square Plan 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 development, number of profitable tillers per plant, plant stature (cm), spike length (cm), peduncle length (cm), number of spikelet per plant, number of grains per spike, number of grains per plant, 1000 grain weight, natural surrender per plant (g), grain abdicate per plant (g), and gather file (%) 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 genotypic (GCV) and phenotypic (PCV) coefficient of variety was computed by Burton. Heritability and hereditary development were decided as portrayed by numerous researchers. 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) [20]. Direct and indirect effects of yield attributing traits up on grain yield were measured by path analysis as described by Dewey & Lu (1959) [10].

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. It was moreover reflected by the wide ranges for each characteristic as displayed in (Table- 2). The hereditary differences among genotypes will be accommodating in determination strategies of encourage bread wheat breeding program. Comparable comes about were detailed by Awale *et al.* (2013) [2]; Kumar *et al.* 2014 [14]; Zeeshan *et al.* (2014) [27]; Adhiena *et al.* (2016) [5] and Ayer *et al.* (2017) [3] 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. The 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 an 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 assention with the finding of prior specialists *viz.* Kalimullah *et al.* 2012 [13]; Laei *et al.* 2012 [17]; Zafarnaderi *et al.* 2013 [25].

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) [22] 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) [9], too detailed positive and coordinate impact of collect list (0.2436) and organic abdicate (0.03386) 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.

Genetic variability and heritability

It was found that GCV was found higher for the number of grains per spike (11584.9) ,test weight (10.31) and Grain weight per spike (6.82) plant stature (22.16), days to anthesis (11.43), gather file (31.61) days to development (9.80). whereas it was lower for the character viz., number of beneficial tillers (4.87), peduncle length (4.62), number of spikelet per spike (3.10), and spike length (0.43).The most noteworthy genotypic change watched by number of grain per plant (10858.2), grain surrender per plant (32.93), gather record (27.47), organic abdicate per plant (27.19), plant tallness (8.91), days to anthesis (7.14), days to development (6.72) and test weight (5.50). Direct genotypic fluctuation watched number of beneficial tillers (4.59), days to booting (3.86), days to heading (3.48) and number grain per spike (2.85). Most reduced esteem for genotypic fluctuation appeared by peduncle length (2.52), number of spikelet per spike (2.44) and spike length (0.25). Among the surrender qualities greatest PCV and GCV was delineated by grain yield per plant (17.17 and 16.69), number of grain per plant (16.38 and 15.86), number of profitable tillers (15.89 and 15.43), gather list (11.11 and 10.36), number of spikelet per spike (8.78 and 7.78), organic surrender per plant (8.70 and 7.71), test weight (6.14 and 4.48), spike length (6.02 and 4.61), peduncle length (5.87 and 4.33), number of grain per spike (5.51 and 3.56), plant stature (4.47 and 2.83) and days to anthesis (3.33 and 2.63). The least esteem for PCV and GCV was appeared by days to booting (2.88 and 2.31) taken after by days of development (2.44 and 2.02) and days to heading

(2.78 and 1.94). A scrutiny of Table- 2 demonstrated that PCV was higher than particular GCV for all the characteristics indicating environmental variables affecting their expression to a few degree or other. The comparative discoveries were detailed by Dhakar *et al.* (2012) [9], Tambe *et al.* (2013) [21], Wolde *et al.* (2016) [23] and Malbhage *et al.* (2020) [16].

Heritability and hereditary progress

All the characteristics but number of gather list were found to be exceedingly heritable on the premise of wide sense heritability gauges Table 2. The most elevated esteem of heritability watched by grain yield per plant (94.43%) taken after by number of productive tillers (94.32%), number of grain per plant (93.73%).Direct heritability was watched for biological yield (78.70%) taken after by number of spikelet per spike (78.63%), days of maturity (68.53%), days to booting (64.36%), days to anthesis (62.45) decently affected by environmental offices than genotypic contrasts. The most reduced heritability was watched by days to heading (48.56%) taken after by number of grain per spike (41.78%) and plant stature (40.22%).Direct hereditary development as a cruel of rate was watched spike length (9.34), test weight (8.64), peduncle length (8.44), number of grain per spike (6.08) and days to anthesis (5.48). The least esteem watched by days to booting (4.89) taken after by plant tallness (4.75), days of development (4.42) and days to heading (3.56). Gauges of tall heritability coupled with the tall hereditary pick up for the characteristics like sedimentation esteem (ml), days to 50% heading, number of grains per spike and 1000-grain weight demonstrated that all these characters are directed by additive quality activity and the coordinate choice be expected to appear change in such characteristics. The comes about were comparable to those detailed by Tsegaye *et al.* (2012) [22], Wolde *et al.* (2016) [23], Adhikari *et al.* (2018) [4] Zemade *et al.* (2019) [26] and Alemu *et al.* (2020) [6].

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

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 2: Estimation of different genetic parameters of variation for 15 traits among the parents in bread wheat (*Triticum aestivum* L.)

Genotypes	Mean	Min	Max	var (g)	var (p)	Heritability (%)	GA	GA% mean	GA 1%	GA mean 1%	GCV (%)	PCV (%)	ECV (%)	% cont
Days to booting	85.12	80.83	90.60	3.86	6.00	64.36	3.25	3.82	4.16	4.89	2.31	2.88	1.72	8.68
Days to heading	96.30	90.37	102.63	3.48	7.17	48.56	2.68	2.78	3.43	3.56	1.94	2.78	1.99	9.57
Days to anthesis	101.67	95.00	107.20	7.14	11.43	62.45	4.35	4.28	5.57	5.48	2.63	3.33	2.04	9.00
Days of maturity	128.25	116.83	132.23	6.72	9.80	68.53	4.42	3.45	5.66	4.42	2.02	2.44	1.37	9.18
No. of productive tillers	13.88	9.57	18.23	4.59	4.87	94.32	4.29	30.88	5.49	39.57	15.43	15.89	3.79	5.69
Plant height (cm)	105.31	97.37	114.80	8.91	22.16	40.22	3.90	3.70	5.00	4.75	2.83	4.47	3.46	8.43
Peduncle length (cm)	36.63	30.67	39.62	2.52	4.62	54.46	2.41	6.59	3.09	8.44	4.33	5.87	3.96	9.23
Spike length (cm)	10.90	9.83	12.60	0.25	0.43	58.76	0.79	7.28	1.02	9.34	4.61	6.02	3.86	8.51
No. of spikelet/ spike	20.06	14.70	23.93	2.44	3.10	78.63	2.85	14.21	3.65	18.22	7.78	8.78	4.06	5.55

No. of grain/ spike	47.39	41.27	51.50	2.85	6.82	41.78	2.25	4.74	2.88	6.08	3.56	5.51	4.20	5.88
No. of grain per plant	656.95	453.25	939.90	10858.2	11584.9	93.73	207.82	31.63	266.33	40.54	15.86	16.38	4.10	3.97
Test weight	52.33	45.55	57.70	5.50	10.31	53.36	3.53	6.74	4.52	8.64	4.48	6.14	4.19	6.38
Biological yield/plant(g)	67.59	55.79	79.99	27.19	34.55	78.70	9.53	14.10	12.21	18.07	7.71	8.70	4.01	4.41
Harvest index	50.61	36.13	65.77	27.47	31.61	86.90	10.06	19.89	12.90	25.49	10.36	11.11	4.02	3.91
Grain yield/plant	34.39	22.07	52.61	32.93	34.87	94.43	11.49	33.40	14.72	42.81	16.69	17.17	4.05	1.63

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

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