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Correlation coefficient and path coefficient analysis in some quantitative trait's in bread wheat [*Triticum aestivum* (L.)]

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Abstract
Twenty genotype of wheat were evaluated in Randomized Block Design (RDB) with three replication for yield and its contributing traits during *Rabi* 2016-2017 find out correlation coefficient and path coefficient analysis. Grain yield had a highly positive and significant genotypic correlation with days to 50% flowering, days to maturity, number of effective tillers per plant, spike length, number of seed per spike, biological yield per plant and harvest index, and 1000-grain weight showed positive correlation with grain yield in both (E_1 & E_2) conditions while grain yield had positive and significant correlation with days to 50% flowering, number of effective tillers per plant, biological yield per plant, 1000-grain weight and harvest index in both (E_1 & E_2) conditions. Path coefficient at genotypic recorded that biological yield per plant had highest direct positive effect on grain yield per plant followed by harvest index, days to 50% flowering, number of spikelets per spike, days to maturity and plant height in both (E_1 & E_2) conditions while path coefficient at phenotypic recorded highest direct positive effect on grain yield with biological yield per plant followed by harvest index, number of spikelets per spike, days to 50% flowering and 1000-grain weight in both (E_1 & E_2) conditions.

Keywords: Analysis of variance, correlation coefficient, path analysis and bread wheat

Introduction

Wheat (*Triticum aestivum* L.) is the most important cereal crops belonging to family *Poaceae.* Bread wheat is an allohexaploid (2n=6x=42) and closely related spelt. However, it is cultivated more widely around the world than rice. It is consumed in variety of ways such as bread, chapatti, porridge, flour and suji etc. Therefore, Grafius (1956) [9] and Singh *et al* (1997) emphasized the need to base the selection for yield on principle component which very strong association. The correlation coefficient analysis is useful in the identification of such characters and elimination of those with undesirable correlated changes. The path coefficient analysis is a partial regression technique to partition the correlated response into direct and indirect influence of each character. It is also provides the direction and extent of such influence on yield. The record production in the country during last few years has enabled India to attain the position of being second largest producer of the wheat in the world. During 2018 India area under wheat is 29.90 m ha^{-1} with the production 93.90 million tons and productivity 3140 kg ha^{-1}. Haryana state on the whole has achieved a productivity level of 5.03 tonnes/ha on 2.5 million hectares (Anonymous, 2018) [2].

Method and materials

The experiment was conducted to investigate the correlation coefficient and path coefficient analysis for eleven quantitative traits in bread wheat (*Triticum aestivum* L.) was conducted at Main Experiment Station of Department of Genetics & Plant Breeding, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Faizabad (U.P.) during *rabi*, 2016-17. The experimental material for present investigation comprised of 80 F'$_1$s developed by crossing 20 lines *viz*., DBW-14, HUW-234, K-8962, NW-1014,Raj-4394, Raj-1350, NIAW-1994, MP-3382, HI-1000, GW-455, PHSL-10 HD-2932,DBW-154, PHSL-11, NIAW-2064,PBW-681, HPW-411,VL-977,UP-2864HD-4728 following half R.B.D. A total of 106 treatments (80 F$_1$'s, and 26 parents) were used for the study of thirteen quantitative characters in Wheat. The entries were sown in a single row plot of 3 m length with inter and intra-row spacing of 23 cm and 18 cm, respectively. Recommended agronomic practices were adopted to raise a good crop. The observations recorded on eleven characters *viz*., days to 50 % flowering, days to maturity, plant height (cm), days to maturity, number of effective tillers per plant, spike length, flag leaf area, chlorophyll content, number of seed per spike, 1000-grain weight

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(Test Weight) (g), biological yield (g), harvest index (%) and grain yield per plant (g). The formulae was used for calculating the genotypic and phenotypic coefficient of correlations in both the experiments as suggested by Al-Jibouri et al.(1958) [1] and path coefficient analysis was carried out according to Dewey and Lu (1959) [5].

Result and Discussion
Analysis of variance for the design of experiments has been present in Table 1 for all the eleven characters. The square due to treatment were highly significant for all the eleven characters in both (E_1 & E_2) conditions except for number of spikelets per spike and number of grains per spike in E_1 condition. Correlation coefficients in E_1: The estimates of the correlation coefficients between thirteen characters are presented in E_1 and E_2condition is presented in Table 1 and Table 1 Grain yield per plant exhibited highly positive correlation with biological yield per plant (0.425) and harvest index (0.262).number of seed per spike significant, (0.179), 1000-grain weight (0.162). These finding was in agreement with result of Bergale et al. (2002), Lad et al. (2003), Payal et al. (2007), Yausaf et al. (2008), Nagireddy and Jyothula (2009), Dharmendra and Singh (2010), Tripathi et al. (2011) and E1- Mohsen et al. (2012) [4, 10, 12, 11, 17, 16, 6, 7]. number of effective tillers per plant (0.048) and harvest index (0.262) while plant height (-0.015) showed negative correlation. Similar finding were reported by Sherif et al. (2005) [13] and Tripathi et al. (2011) [16]. Days to maturity showed significant positive correlation with days to 50 per cent flowering (0.370).1000-seed weight showed significant negative association plant height (-0.287) and non-significant positive by correlated with spike length (0.067).Biological yield per plant significant positive correlation with plant height (0.251) and non-significant negative by correlated biological yield per plant (-0.092).Harvest index significant positive correlation with biological yield per plant (0.318), plant height (0.217) and non-significant negative by correlated 1000-seed weight (-0.166). Correlation coefficients in E_2: The estimates of the correlation coefficients between thirteen characters are presented in E_1 condition is presented in Table 1.Grain yield per plant exhibited highly positive correlation with spike length (0.58), biological yield per plant (0.040) number of seed per spike (0.036) and showed negative correlation days to maturity (-0.12) and peduncle length (-0.022) and positive correlation with tiller per plant (0.003).Days to maturity showed significant positive correlation with days to 50 per cent flowering (0.978).Tiller per plant showed significant negative association plant height (-0.205) and non significant positive by correlated with days to 50 per cent flowering (0.016).Flag leaf area showed significant negative association plant height (-0.193) and non significant positive by correlated with tiller per plant (0.025). Chlorophyll content significant positive correlation with flag leaf area (0.199) and non significant positive by correlated plant height (0.100). Similar results in Wheat have been also reported by Lad et al. (2003), Payal et al. (2007), Yousaf et al. (2008) and El-Mohsen et al. (2012) [10, 12, 17, 7]. However, number of spikelets per spike and number of grains per spike showed positive correlation with grain yiled per plant. Similar finding were

also reported by Bergale et al. (2002), Nagireddy and Jyothula (2009) and Tripathi et al. (2011) [4, 11, 16]. The result of correlation coefficient implied that positive correlation were recorded for harvest index with plant height and number of spikelets per spike; biological yield with days to 50% flowering, days to maturity, number of effective tillers per plant and 1000-grain weight; 1000-grain weight with days to 50% flowering and number of effective tillers per plant; number of grain per spike with days to 50% flowering and number of spikelets per spike; number of spikelets per spike with days to 50% flowering and number of effective tiller per plant with days to 50% flowering. Negative correlation was recorded for grain filling period with grain yield, harvest index, biological yield per plant, and number of grains per spike. Number of spikelets per spike and number of grains per spike, number of spikelets per spike and number of effective tillers per plant, while plant height with number of effective tiller per plant and days to 50% was flowering negatively associated with grain filling period. These finding are in agreement with result of Sherif et al. (2005) and Tripathi et al. (2011) [13, 16]. When two characters show negative phenotypic and genotypic correlation it would be difficult to exercise simultaneous selection for these characters in development of a variety. Path correlation analysis: The path correlation analysis using correlation coefficient estimated carried out to asses direct and indirect effects of thirteen characters on the expression of grain yield per plant in E_1 and E_2condition is presented in Table 2 and Table 3 The result of path analysis using correlation coefficient computed in E_1 condition generations are presented in Table 4 The highest positive direct effect on seed yield per plant was exerted by harvest index (0.194) followed by biological yield per plant (0.126). The very low value of direct effect recorded in case of remaining ten characters indicated that their direct contribution to seed yield per plant was too low be considered of any consequence. Biological yield per plant (0.062), number of seed per spike (0.011), 1000-seed weight (-0.037) tiller per plant (-0.022) exerted substantial positive indirect effect on seed yield via harvest index. The result of path analysis using correlation coefficient computed in E_2 condition generations are presented in Table 5, the similar finding were reported by Esmail (2001) [8], Asif et al.(2004) [3], Tripathi et al. (2011) [16], EI- Mohsen et al. (2012) [7] and Singh et al. (2012) [14]. The highest negative direct effect on seed yield per plant was exerted by harvest index (-0.101) followed by biological yield per plant (0.002). The very low value of direct effect recorded in case of remaining ten characters indicated that their direct contribution to seed yield per plant was too low be considered of any consequence. Biological yield per plant (0.062) These findings are in agreement with results of Esmail (2001) [8], Asif et al. (2004) [3], Gupta et al. (2007), Tripathi et al. (2011) [16], El-Mohsen et al. (2012) [7] and Singh et al. (2012) [14]. number of seed per spike (-0.001), 1000-seed weight (-0.001) tiller per plant (0.00) exerted substantial negative indirect effect on seed yield via harvest index, Similar finding were reported by Esmail (2001) [8], Asif et al. (2004) [3], Tripathi et al. (2011) [16], El-Mohsen et al. (2012) [7] and Singh et al. (2012) [14].

Table 1: Estimates of Phenotypic correlation coefficients between 13 characters in bread wheat (*Triticum aestivum* L. em. Thell.) in E$_2$

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Tiller per plant	Flag leaf (cm)	Chlorophyll content (mg/100g)	Spike length (cm)	Peduncle length (cm)	Numbers of Seed per spike	1000-seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seeds yield per plant (g)
Days to 50% flowering	1.000	0.978**	-0.074	0.016	-0.015	-0.018	0.011	-0.021	-0.008	-0.021	-0.018	-0.011	-0.030
Days to maturity		1.000	-0.058	0.009	-0.032	-0.015	-0.003	-0.017	-0.011	-0.034	0.007	-0.031	-0.012
Plant height (cm)			1.000	-0.205*	-0.193*	0.100	-0.042	0.015	0.062	-0.123	-0.059	0.008	0.029
Tiller per plant				1.000	0.025	-0.056	0.012	-0.011	-0.089	0.062	0.003	0.068	0.003
Flag leaf (cm)					1.000	0.199**	0.061	-0.013	-0.035	0.027	0.094	0.067	0.012
Chlorophyll content (mg/100g)						1.000	0.025	0.071	-0.015	-0.055	0.048	-0.003	-0.015
Spike length (cm)							1.000	0.002	-0.088	0.077	0.043	-0.019	0.058
Peduncle length (cm								1.000	-0.069	0.006	0.022	0.061	-0.022
Numbers of Seed per spike									1.000	-0.072	-0.033	0.068	0.036
1000-seed weight (g)										1.000	0.030	-0.007	-0.039
Biological yield per plant (g)											1.000	0.060	0.040
Harvest index (%)												1.000	-0.100

* &** Signficant at 5% & 1% respectively

Table 2: Estimation of direct and indirect effects of 13 characters on grain yield per plant at phenotypic level in bread wheat (*Triticum aestivum* L. em. Thell.) in E$_2$

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Tiller per plant	Flag leaf (cm)	Chlorophyll content (mg/100g)	Spike length (cm)	Peduncle length (cm)	Numbers of Seed per spike	1000-seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seeds yield per plant (g)
Days to 50% flowering	-0.374	0.345	-0.003	0.000	0.000	0.001	0.001	0.000	0.000	0.001	-0.001	0.001	-0.030
Days to maturity	-0.366	0.353	-0.002	0.000	-0.001	0.000	0.000	0.000	-0.001	0.001	0.000	0.003	-0.012
Plant height (cm)	0.028	-0.020	0.034	-0.005	-0.006	-0.003	-0.003	0.000	0.003	0.005	-0.002	-0.001	0.029
Tiller per plant	-0.006	0.003	-0.007	0.023	0.001	0.002	0.001	0.000	-0.004	-0.002	0.000	-0.007	0.003
Flag leaf (cm)	0.005	-0.011	-0.007	0.001	0.032	-0.006	0.004	0.000	-0.002	-0.001	0.004	-0.007	0.012
Chlorophyll content (mg/100g)	0.007	-0.005	0.003	-0.001	0.006	-0.028	0.002	-0.001	-0.001	0.002	0.002	0.000	-0.015
Spike length (cm)	-0.004	-0.001	-0.001	0.000	0.002	-0.001	0.066	0.000	-0.004	-0.003	0.002	0.002	0.058
Peduncle length (cm)	0.008	-0.006	0.001	0.000	0.000	-0.002	0.000	-0.013	-0.003	0.000	0.001	-0.006	-0.022
Numbers of Seed per spike	0.003	-0.004	0.002	-0.002	-0.001	0.000	-0.006	0.001	0.048	0.003	-0.001	-0.007	0.036
1000-seed weight (g)	0.008	-0.012	-0.004	0.001	0.001	0.002	0.005	0.000	-0.003	-0.037	0.001	0.001	-0.039
Biological yield per plant (g)	0.007	0.002	-0.002	0.000	0.003	-0.001	0.003	0.000	-0.002	-0.001	0.038	-0.006	0.040
Harvest index (%)	0.004	-0.011	0.000	0.002	0.002	0.000	-0.001	-0.001	0.003	0.000	0.002	-0.101	-0.100

Residual Effect = 0.986064

Table 3: Estimates of Phenotypic correlation coefficients between 13 characters in bread wheat (*Triticum aestivum* L. em. Thell.) in E$_1$

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Tiller per plant	Flag leaf (cm)	Chlorophyll content (mg/100g)	Spike length (cm)	Peduncle length (cm	Numbers of Seed per spike	1000-seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seeds yield per plant (g)
Days to 50% flowering	1.000	0.370**	0.033	0.013	0.017	0.053	0.035	-0.050	-0.024	-0.022	-0.033	-0.016	-0.144
Days to maturity		1.000	-0.025	-0.007	0.043	0.084	0.045	-0.107	0.031	-0.013	0.037	0.038	-0.023
Plant height (cm)			1.000	-0.022	0.036	-0.009	-0.079	-0.045	-0.033	-0.287**	0.251**	0.217**	-0.015
Tiller per plant				1.000	-0.011	-0.011	-0.057	0.018	-0.023	0.046	-0.056	-0.089	0.048
Flag leaf (cm)					1.000	-0.005	0.035	-0.022	-0.016	-0.067	0.020	0.085	0.019
Chlorophyll content (mg/100g)						1.000	0.023	0.125	-0.036	0.000	-0.012	0.046	-0.044
Spike length (cm)							1.000	0.042	-0.002	0.067	-0.047	-0.028	-0.086
Peduncle length (cm								1.000	0.029	0.018	0.026	-0.038	0.073
Numbers of Seed per spike									1.000	0.042	0.027	0.000	0.179*
1000-seed weight (g)										1.000	-0.092	-0.166*	0.162
Biological yield per plant (g)											1.000	0.318**	0.425**
Harvest index (%)												1.000	0.262**

*, ** Signficant at 5% and 1% respectively

Table 4: Estimation of direct and indirect effects of 13 characters on grain yield per plant at phenotypic level in bread wheat (*Triticum aestivum* L. em. Thell.) E_1

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Tiller per plant	Flag leaf (cm)	Chlorophyll content (mg/100g)	Spike length (cm)	Peduncle length (cm	Numbers of Seed per spike	1000-seed weight (g)	Biological yield per plant (g)	Harvest index (%)	Seeds yield per plant (g)
Days to 50% flowering	-0.112	0.002	-0.003	0.001	0.000	-0.002	-0.003	-0.003	-0.004	-0.004	-0.013	-0.003	-0.144
Days to maturity	-0.041	0.005	0.002	0.000	0.001	-0.004	-0.003	-0.006	0.005	-0.003	0.014	0.007	-0.023
Plant height (cm)	-0.004	0.000	-0.093	-0.002	0.001	0.000	0.006	-0.003	-0.005	-0.057	0.099	0.042	-0.015
Tiller per plant	-0.001	0.000	0.002	0.075	0.000	0.000	0.004	0.001	-0.004	0.009	-0.022	-0.017	0.048
Flag leaf (cm)	-0.002	0.000	-0.003	-0.001	0.020	0.000	-0.003	-0.001	-0.002	-0.013	0.008	0.017	0.019
Chlorophyll content (mg/100g)	-0.006	0.000	0.001	-0.001	0.000	-0.043	-0.002	0.008	-0.005	0.000	-0.005	0.009	-0.044
Spike length (cm)	-0.004	0.000	0.007	-0.004	0.001	-0.001	-0.077	0.003	0.000	0.013	-0.019	-0.005	-0.086
Peduncle length (cm	0.006	-0.001	0.004	0.001	0.000	-0.005	-0.003	0.060	0.004	0.004	0.010	-0.007	0.073
Numbers of Seed per spike	0.003	0.000	0.003	-0.002	0.000	0.002	0.000	0.002	0.153	0.008	0.011	0.000	0.179*
1000-seed weight (g)	0.002	0.000	0.027	0.003	-0.001	0.000	-0.005	0.001	0.006	0.197	-0.037	-0.032	0.162
Biological yield per plant (g)	0.004	0.000	-0.023	-0.004	0.000	0.000	0.004	0.002	0.004	-0.018	0.395	0.062	0.425**
Harvest index (%)	0.002	0.000	-0.020	-0.007	0.002	-0.002	0.002	-0.002	0.000	-0.033	0.126	0.194	0.262**

Residual effect = 0.8292

Table 5: Analysis of variance for 13 characters in bread wheat under E_1 and E_2 conditions involving parents and F_1s

Characters	Source of variation					
	Replication		Treatments		Error	
	2		105		210	
df	E_1	E_2	E_1	E_2	E_1	E_2
Days to 50% flowering	8.51**	0.54	2.23**	6.40**	1.26**	2.39
Days to maturity	83.43**	1.34	55.94**	12.87**	51.09	4.49
Plant height (cm)	0.24	47.34**	94.11**	46.55**	0.36	5.89
Tillers per plant	37.76**	1.67**	1.15	0.49**	1.12	0.14
Flag leaf area (cm^2)	0.37	10.93**	1.08**	1.32**	0.63	0.36
Chlorophyll content (mg/100g)	141.99**	23.14**	5.48	14.00**	4.54	4.61
Spike length (cm)	5.38**	3.57**	0.19*	0.37**	0.13	0.31
Peduncle length (cm)	7.09**	6.93**	0.93*	1.43**	0.67	0.87**
Number Seeds per spike	16.89**	8.13**	0.49	0.83	1.12	1.46
1000-grain weight (g)	55.34**	56.56**	3.92**	2.67**	1.34**	0.68
Seed yield per plant (g)	14.71**	2.63	3.98**	0.37	1.45**	0.94
Biological yield per plant (g)	534.64**	3.50	36.80**	1.00	16.09**	1.40
Harvest index (%)	134.91**	49303.11	14.57**	49694.76	5.53**	49793.59

*, ** significant at 5% & 1% probability levels, respectively

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