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Original Research Article

Studies on Correlation and Path Coefficient for Yield and its Component Traits in Bread Wheat (*Triticum aestivum* L. em. Thell)

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A B S T R A C T

The present investigation was carried out at Agriculture Research Farm, B.R.D. Post Graduate College (Campus), Deoria during *rabi* 2017-18 by taking 81 bread wheat genotypes from various eco-geographic regions with three checks in Augmented Block Design. Data on fourteen quantitative traits *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of productive tillers/plant, spike length (cm), number of spikelet/spike, grains/spike, 1000-grain weight (g), grain yield/plant (g), flag leaf area (cm2), peduncle length (cm), grain yield/spike (g), biological yield/plant (g), harvest index (%) were recorded. Analysis of correlation coefficients revealed that generally the amount of genetic correlation coefficients were very close to phenotypic correlation coefficient in most cases, suggesting the existence of inherent associations among the traits studied. Number of tillers per plant, number of spikelets per spike, plant height, biological yield per plant, yield per spike and number of grains per spike had high positive correlation with grain yield per plant. Path analysis showed that number of grains per spike, biological yield per plant, number of spikelets per spike and number of tillers per plant found to have direct and positive effect on grain yield per plant. Number of grains per spike also possessed positive indirect effect on grain yield *via* biological yield per plant, number of spikelets per spike and number of tillers per plant.

Keywords

Bread wheat, Grain yield, Correlation and path coefficient analysis

Introduction

Wheat (*Triticum aestivum* L. em. Thell; 2n=42), a member of Gramineae (Poaceae) family belongs to the genus *Triticum*, is the main cereal crop. It has unique place among the cereals. Bread wheat is an allohexaploid species with 2n=42 chromosome having genome AABBDD (Sleper and Poehlman, 2006). Wheat is the most important food crop of the world. There are seventeen different species of wheat, out of which only three i.e. *Triticum aestivum*, *Triticum durum* and *Triticum dicoccum* are cultivated in the world. *Triticum aestivum* (bread wheat) is occupying more than 90% area followed by *T. durum* (9 to 10%), however, very limited area of wheat is under *T. dicoccum*. The area

under wheat in India is 311.88 lakh ha with a production of 95.91 million tones and productivity of 3075 kg/ha (Annual Report 2017-18, Department of Agriculture & Co-operation Ministry of Agriculture Govt. of India)[1]; whereas the area under wheat in Uttar Pradesh is 9.73 million ha with a production 30.29 million tones and productivity of 3113 kg/ha. (DWR, Annual Report, 2018).

Grain yield is a complex quantitative trait, considerably affected by environment (Khan and Naqvi, 2012). It is important to determine the contribution of the traits which has the greatest influence on grain yield (Desheva, 2016). The most important factor responsible for unfurling such pleasant scenario in wheat production has been the release of dwarf and semi-dwarf, fertilizer responsive, lodging resistant, day length insensitive and widely adopted high yielding varieties of wheat.

The objectives of this study were to estimate the correlations between grain yield and other traits and determine the direct and indirect effects of traits on grain yield in wheat grown under drought stress and non-stress conditions in order to find out suitable traits that could be used for grain yield improvement under both conditions.

Materials and Methods

In the present investigation, experimental material consisted of 81 exotic and indigenous wheat germplasm lines and three check varieties viz., K-65, NW-2036 and PBW-343; collected from genetic stock available in Wheat Section, Department of Genetics and Plant Breeding, ANDUAT Kumarganj, Ayodhya, CSAUAT, Kanpur and B.H.U., Varanasi (U.P.). The experiment was carried out in Augmented Block Design in semi-arid with hot summer and cold winter region of Deoria during Rabi 2017-18. The entire experimental field was divided into 9 plots of equal size. Two rows of each test genotype was present only once in each plot with 3 checks in randomized manner along with the distance of 23 cm between the rows and 5 cm between the plants. Recommended cultural practices were followed to raise good crops. The observation were recorded from five randomly selected plants for 14 quantitative characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of productive tillers/plant, spike length (cm), number of spikelet/spike, grains/spike, 1000-grain weight (g), grain yield/plant (g), flag leaf area (cm2), peduncle length (cm), grain yield/spike (g), biological yield/plant (g), harvest index (%).

The simple Correlation coefficients (r) between different characters were estimated according to Searle, (1961)[3] and Path coefficient analysis was carried out according to Dewey and Lu (1959). Grain yield was assumed to be dependent variable (effect) which is influenced by all other characters, the independent variables (causes), directly as well as indirectly through other. All these calculations were done by using Windostat Version 9.3 from indostat services, Hyderabad Licensed to Central Sericultural Germplasm Research Centre Hosur.

Results and Discussions

Correlation coefficients

Relationship among yield and its attributing traits were studied through analysis of Correlation among them. Genotypic and Phenotypic correlation coefficients among the fourteen traits of 81 wheat genotypes presented in Table 1 and 2 respectively. Correlation analysis revealed that genotypic correlation coefficient in most cases were very close to their phenotypic correlation coefficients indicating the associations were largely due to genetic region (Bhattacharaya

et al., 2007). The phenotypic correlation coefficient in some cases was higher than their genotypic correlation coefficient, which indicates the supressing effect of the environment that can alter the expression of traits at the phenotypic level. At both genotypic and phenotypic level significant positive correlation were observed for grain yield per plant with number of tillers per plant, number of spikelets per spike, plant height, biological yield per plant, Yield per sipke, number of grains per spike and harvest index. These observations are in agreement with the earlier reports of Lad *et al.*, (2003); Dogan, (2009); Esmail, (2001); Singh and Singh (2010); Bergale *et al*., (2002); Bergale *et al*., (2001) and Subhani, (2000) respectively. Significant positive correlation at genotypic and phenotypic level observed for number of tillers per plant with Yield per spike, number of grains per spike and biological yield per plant. Similar results were also reported by Subhani, (2000).

Number of spikelets per spike possesses significant and positive correlation with length of spike, plant height, biological yield per plant, Yield per spike and number of grains per spike at genotypic as well as phenotypic level. Earlier supported by Kumar *et al.*, (2018)[16].

A significant and positive correlations were recorded for length of spike with plant height, Yield per spike and number of grains per spike at genotypic and phenotypic level. Earlier Kumar *et al*., (2018) and Sharma *et al*., (2018) have recorded the similar pattern of positive correlation. Peduncle length showed significant positive correlation with plant height. Earlier supported by Sharma *et al.*, (2018)[17]. Significant positive correlations were also observed for plant height with biological yield per plant, Yield per spike and number of grains per spike. Similar pattern of results have also been recorded by Kumar *et al*., (2018) and Zare *et al.*, (2017). Biological yield per plant was highly correlated with Yield per spike and number of grains per spike at both genotypic and phenotypic level. A significant and positive correlation coefficient was also seen for yield with number of grains per spike; and number of grains per spike with harvest index (Table 1 and 2). Such type of results has been estimated by Bergale *et al*., (2002) and Zare *et al*., (2017).

The negative associations were also recorded for days to 50% flowering with peduncle length, days to maturity with number of grains per spike and biological yield per plant with harvest index. The characters exhibiting strong positive association with grain yield indicate that selection based on morphological traits could definitely lead to improvement in grain yield.

The overall results revealed that most of these traits were positively correlated with yield per spike and number of grains per spike. Hence these traits can be focussed for improvement in breeding programmes.

Path coefficients

Coefficient of correlation measures the degree and association between two characters. However, this may not give true picture under complex situation. Under such conditions, path coefficient analysis provides a means of measuring the direct as well as indirect effect via other variables on the end product by partitioning correlation coefficients. The direct and indirect effects on grain yield were estimated for all characters under study, which provided a better index for selection rather than correlation coefficient. Earlier reported by Kumar *et al.*, (2018).

Table.1 Estimates of Genotypical correlation coefficients computed between 14 characters of indigenous and exotic lines of wheat

No	Character	Days to 50% Flowering	Flag Leaf Area(cm²)	Days to Maturity	Tillering	No.of Spikelets	Length of Spike (cm)	Peduncle Length (cm)	Plant Height (cm)	Biological Yield/ Plant (gm)	Yield/ Spike (gm)	Grains/ Spike	Weight 0f1000 Grains(gm)	Harvest Index
	Days to 50% Flowering	1.0000	**0.0290**	0.1228	0.1741	0.0583	0.0728	-0.2808**	-0.0568	0.0485	0.0525	-0.1018	-0.0218	-0.0446
	Flag Leaf Area(cm²)		1.0000	0.0599	**0.0934**	-0.1151	-0.0007	0.0780	-0.0570	0.1026	0.0797	0.0601	0.1842	0.0016
	Days to Maturity			1.0000	-0.0848	-0.2089	**-0.0103**	0.0404	-0.1361	-0.0739	-0.2104	-0.2491*	-0.1500	0.0297
	Tillering				1.0000	0.1432	-0.0155	-0.1644	**0.1689**	0.3227**	0.2533*	0.2799**	-0.0533	0.1096
	No.of Spikelets					1.0000	0.5781***	-0.0101	0.4065***	0.2322*	**0.6896*****	0.6900***	0.0271	0.1953
	Length of Spike (cm)						1.0000	-0.0340	0.3314**	0.1979	0.3277**	0.3592***	**0.1713**	0.0447
	Peduncle Length (cm)							1.0000	0.4805***	-0.0560	0.0029	0.0665	0.0187	0.0738
	Plant Height (cm)								1.0000	0.2457*	0.2425*	0.3561***	0.0088	-0.0676
	Biological Yield/ Plant (gm)									1.0000	0.2238*	0.2280*	0.1179	-0.4921***
	Yield/ Spike (gm)										1.0000	0.8277***	-0.0178	0.2025
	Grains/ Spike											1.0000	0.1738	0.2702*
	Weight 0f1000 Grains(gm)												1.0000	0.0072
	Harvest Index													1.0000
	Grain Yield/ Plant(gm)	**-0.0484**	**0.1051**	**-0.1343**	**0.5261**	**0.4435**	**0.1444**	**0.0739**	**0.2232**	**0.5432**	**0.4568**	**0.5785**	**0.1676**	**0.3993**

Table.2 Estimates of Phenotypical correlation coefficients computed between 14 characters of indigenous and exotic lines of **wheat (var P = var G + E)**

No	Character	Days to 50% Flowering	Flag Leaf Area(cm²)	Days to Maturity	Tillering	No.of Spikelets	Length of Spike (cm)	Peduncle Length (cm)	Plant Height (cm)	Biological Yield/ Plant (gm)	Yield/ Spike (gm)	Grains/ Spike	Weight 0f1000 Grains(gm)
	Days to 50% Flowering	1.0000	**0.0312**	0.1296	0.1786	0.0608	0.0778	-0.2867**	-0.0505	0.0509	0.0578	-0.1050	-0.0201
	Flag Leaf Area(cm²)		1.0000	0.0668	**0.0984**	-0.1189	-0.0043	0.0799	-0.0591	0.1054	0.0876	0.0699	0.1851
	Days to Maturity			1.0000	-0.0807	-0.3063	**-0.056**	0.0357	-0.1374	-0.0697	-0.2001	-0.2501*	-0.1509
	Tillering				1.0000	0.1499	-0.034	-0.1540	**0.1697**	0.3272**	0.2433*	0.2810**	-0.0501
	No.of Spikelets					1.0000	0.5802***	-0.0112	0.4009***	0.2377*	**0.6981*****	0.6590***	0.0279
	Length of Spike (cm)						1.0000	-0.0383	0.3342**	0.2019	0.3299**	0.3601***	**0.1732**
	Peduncle Length (cm)							1.0000	0.4883***	-0.0503	0.0112	0.0699	0.0191
	Plant Height (cm)								1.0000	0.2499*	0.2501*	0.3593***	0.0101
	Biological Yield/ Plant (gm)									1.0000	0.2234*	0.2187*	0.1197
	Yield/ Spike (gm)										1.0000	0.8302***	-0.0112
	Grains/ Spike											1.0000	0.1921
	Weight 0f1000 Grains(gm)												1.0000
	Harvest Index												
	Grain Yield/ Plant(gm)	**-0.0484**	**0.1053**	**-0.1236**	**0.5376**	**0.4598**	**0.1511**	**0.0787**	**0.2201**	**0.5336**	**0.4875**	**0.5800**	**0.1432**

Table.3 Genotypic direct and indirect effects of various 14 traits on grain yield / Plant in wheat germplasm

No	Character	Days to 50% Flowering	Flag Leaf Area(cm²)	Days to Maturity	Tillering	No.of Spikelets	Length of Spike (cm)	Peduncle Length (cm)	Plant Height (cm)	Biological Yield/ Plant (gm)	Yield/ Spike (gm)	Grains/ Spike	Weight 0f1000 Grains(gm)	Harvest Index
	Days to 50% Flowering	**-0.0242**	-0.0007	-0.0030	-0.0042	-0.0014	-0.0018	0.0068	0.0014	-0.0012	-0.0013	0.0025	0.0005	0.0011
	Flag Leaf Area(cm²)	-0.0001	**-0.0045**	-0.0003	-0.0004	0.0005	0.0000	-0.0004	0.0003	-0.0005	-0.0004	-0.0003	-0.0008	0.0000
	Days to Maturity	-0.0040	-0.0020	**-0.0329**	0.0028	0.0069	0.0003	-0.0013	0.0045	0.0024	0.0069	0.0082	0.0049	-0.0010
	Tillering	0.0269	0.0144	-0.0131	**0.1543**	0.0221	-0.0024	-0.0254	0.0261	0.0498	0.0391	0.0432	-0.0082	0.0169
	No.of Spikelets	0.0071	-0.0139	-0.0253	0.0173	**0.1210**	0.0699	-0.0012	0.0492	0.0281	0.0834	0.0835	0.0033	0.0236
	Length of Spike (cm)	-0.0103	0.0001	0.0015	0.0022	-0.0822	**-0.1421**	0.0048	-0.0471	-0.0281	-0.0466	-0.0510	-0.0243	-0.0064
	Peduncle Length (cm)	-0.0279	0.0077	0.0040	-0.0163	-0.0010	-0.0034	**0.0993**	0.0477	-0.0056	0.0003	0.0066	0.0019	0.0073
	Plant Height (cm)	0.0035	0.0035	0.0084	-0.0105	-0.0252	-0.0205	-0.0297	**-0.0619**	-0.0152	-0.0150	-0.0220	-0.0005	0.0042
	Biological Yield/ Plant (gm)	0.0414	0.0876	-0.0631	0.2753	0.1981	0.1689	-0.0478	0.2096	**0.8533**	0.1910	0.1945	0.1006	-0.4199
	Yield/ Spike (gm)	-0.0061	-0.0093	0.0244	-0.0294	-0.0800	-0.0380	-0.0003	-0.0281	-0.0260	**-0.1160**	-0.0960	0.0021	-0.0235
	Grains/ Spike	-0.0204	0.0120	-0.0499	0.0561	0.1383	0.0720	0.0133	0.0714	0.0457	0.1659	**0.2005**	0.0349	0.0542
	Weight 0f1000 Grains(gm)	-0.0011	0.0089	-0.0072	-0.0026	0.0013	0.0083	0.0009	0.0004	0.0057	-0.0009	0.0084	**0.0482**	0.0003
	Harvest Index	-0.0331	0.0012	0.0221	0.0814	0.1450	0.0332	0.0548	-0.0502	-0.3653	0.1503	0.2006	0.0054	**0.7424**
	Grain Yield/ Plant(gm)	**-0.0484**	**0.1051**	**-0.1343**	**0.5261**	**0.4435**	**0.1444**	**0.0739**	**0.2232**	**0.5432**	**0.4568**	**0.5785**	**0.1676**	**0.3993**
	Partial R²	0.0012	-0.0005	0.0044	0.0812	0.0536	-0.0205	0.0073	-0.0138	0.4635	-0.0530	0.1160	0.0081	0.2965

R SQUARE = 0.9440 RESIDUAL EFFECT = 0.2367

Table.4 Phenotypic direct and indirect effects of various 14 traits on grain yield / Plant in wheat germplasm

No	Character	Days to 50% Flowering	Flag Leaf Area(cm²)	Days to Maturity	Tillering	No.of Spikelets	Length of Spike (cm)	Peduncle Length (cm)	Plant Height (cm)	Biological Yield/ Plant (gm)	Yield/ Spike (gm)	Grains/ Spike	Weight 0f1000 Grains(gm)	Harvest Index
	Days to 50% Flowering	**-0.0212**	-0.0033	-0.0039	-0.0089	-0.0019	-0.0028	0.0075	0.0027	-0.0019	-0.0019	0.0026	0.0027	0.0032
	Flag Leaf Area(cm²)	-0.0021	**-0.0087**	-0.0021	-0.0032	0.0012	0.0009	-0.0023	0.0014	-0.0016	-0.0008	-0.0005	-0.0018	0.0034
	Days to Maturity	-0.0056	-0.0002	**-0.0318**	0.0056	0.0089	0.0008	-0.0002	0.0051	0.0034	0.0073	0.0084	0.0054	-0.0021
	Tillering	0.0285	0.0122	-0.0121	**0.1546**	0.0201	-0.0011	-0.0243	0.0234	0.0467	0.0398	0.0433	-0.0039	0.0172
	No.of Spikelets	0.0088	-0.0167	-0.0278	0.0178	**0.1244**	0.0703	-0.0024	0.0522	0.0289	0.0837	0.0832	0.0066	0.0236
	Length of Spike (cm)	-0.0099	0.0012	0.0066	0.0042	-0.0844	**-0.1433**	0.0056	-0.0489	-0.0288	-0.0466	-0.0511	-0.0265	-0.0073
	Peduncle Length (cm)	-0.0301	0.0079	0.0099	-0.0102	-0.0034	-0.0039	**0.0999**	0.0493	-0.0067	0.0003	0.0061	0.0030	0.0079
	Plant Height (cm)	0.0089	0.0036	0.0045	-0.0145	-0.0278	-0.0223	-0.0304	**-0.0628**	-0.0163	-0.0150	-0.0222	-0.0015	0.0054
	Biological Yield/ Plant (gm)	0.0478	0.0888	-0.0672	0.2778	0.1992	0.1678	-0.0492	0.2311	**0.8544**	0.1915	0.1943	0.1060	-0.4178
	Yield/ Spike (gm)	-0.0003	-0.0112	0.0289	-0.0304	-0.0768	-0.0356	-0.0012	-0.0289	-0.0268	**-0.1164**	-0.0964	0.0028	-0.0221
	Grains/ Spike	-0.0233	0.0129	-0.0434	0.0588	0.1401	0.0729	0.0155	0.0723	0.0478	0.1666	**0.2005**	0.0355	0.0522
	Weight 0f1000 Grains(gm)	-0.0043	0.0102	-0.0113	-0.0064	0.0026	0.0093	0.0023	0.0013	0.0062	-0.0002	0.0086	**0.0490**	0.0023
	Harvest Index	-0.0376	0.0033	0.0243	0.0778	0.1459	0.0367	0.0565	-0.0543	-0.3673	0.1513	0.2007	0.0064	**0.7428**
	Grain Yield/ Plant(gm)	**-0.0484**	**0.1053**	**-0.1236**	**0.5376**	**0.4598**	**0.1511**	**0.0787**	**0.2201**	**0.5336**	**0.4875**	**0.5800**	**0.1432**	**0.3405**
	Partial R²	0.0055	-0.0023	0.0211	0.0824	0.0573	-0.0222	0.0082	-0.0147	0.4641	-0.0522	0.1169	0.0087	0.2944

SQUARE = 0.9613 RESIDUAL EFFECT = 0.2391

The results show that number of grains per spike (0.2005) has direct and positive effect on grain yield per plant (0.5785). These results are in agreement with earlier reports of Lad *et al*., (2003) and Sharma *et al*., (2018), and it also possesses positive and indirect effect on grain yield per plant *via* biological yield per plant (0.1945), number of spikelets per spike (0.0835) and number of tillers per plant (0.0432) supported by Soni *et al*., (2011); Dogan, (2009) and Gaur *et al.*, (2015).

Above mentioned characters (*viz.*, biological yield per plant, number of tillers per plant and number of spikelets per spike) found to have positive direct effect 0.8533, 0.1543 and 0.1210 on grain yield per plant respectively (Table 3 and 4).

Present study illustrates, characters *viz.*, biological yield per plant, number of tillers per plant and number of spikelets per spike possesses positive correlation with grain yield. Also these characters have reported positive and direct effect on grain yield and also found to have positive indirect effect on grain yield through each other. Therefore the four traits mentioned can be capitalized further for improvement in breeding programmes in wheat.

The residual effect determines how best the causal factors account for the variability of the resultant factor, the yield per plant. In the present study the residual effect was 0.2367 and 0.2391 at genotypic and phenotypic level, respectively (Table 4). Residual effect (0.2367) indicated that the characters which were selected in this study contributed about 77% to the yield. The reason seems to be very low and non-significant correlation of some traits with yield. Besides, some other factors like sampling error, personal error and geographical position which have not been considered here need to be included in this analysis to account fully for the variation in yield. Sharma *et al.*, (2018) has also recorded similar results.

Conclusion of the study is as folliws:

In a nutshell, the studied genotypes of bread wheat have the potential for incorporating certain important and valuable traits. Estimation of correlation analysis and path coefficient analysis revealed that the grain yield per plant, biological yield per plant, number of tillers per plant and number of spikelets per spike were the most reliable traits for yield improvement in bread wheat. So the utmost importance should be given to these characters during the selection for yield improvement in bread wheat.

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