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Original Research Article

Character Association and Path Coefficient Studies in Bread Wheat (*Triticum aestivum* L. em. Thell)

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A B S T R A C T

The field experiment under present investigation was conducted at Agriculture Research Farm of B.R.D. Post Graduate College (Campus), Deoria (U.P.) during *rabi* 2014-15 in normal soil, timely sown and irrigated conditions. Total 81 genotypes excluding 3 checks were evaluated for 14 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) and harvest index (%)] under Augmented Block Design. 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. Plant height, productive tillers per plant, biological yield per plant, number of grains per spike and harvest index had significant positive correlation with grain yield per plant. The traits ear length, yield per spike and peduncle length also possessed significant positive correlation with number of grains per spike, 1000 grains weight and number of grains per spike respectively. Path analysis revealed that productive tillers per plant, biological yield per plant, number of grains per spike and 1000 grains weight found to have direct and positive effect on grain yield per plant. The characters plant height *via* days to 50% flowering, productive tillers per plant *via* spikelets per spike, spikelets per spike *via* productive tillers per plant, yield per spike *via* days to 50% flowering and number of grains per spike *via* spikelets per spike also possessed positive indirect effect on grain yield.

Keywords

Bread wheat, Grain yield, Correlation coefficient and Path coefficient

Introduction

Wheat (*Triticum aestivum* L. em. Thell, 2n=42); a self-pollinating annual plant in the true grass family *Gramineae* (Poaceae) and genus *Triticum*, is the world's most famous energy rich cereal crop. It has been described as the "*King of the cereals*" because of the acreage it occupies, high productivity and the prominent position it holds in the international food grain trade. It is a C_3 plant grown from temperate , irrigated to dry, high rain fall areas and from warm, humid to dry, cold environments. Undoubtedly, this wide adaptation has been possible due to the complex nature of the plants genome which provides great plasticity to the crop. Wheat is the most important staple food crop in the

world. It is currently grown on approximately 225 mha Area globally, with an average productivity of 3 t/ha. It exhibits considerable variation between different agro-ecological zones (Singh *et al.*, 2008). India is set to harvest a record wheat production of 106.21 MT in the 2019-20 crop year on the back of food grains, according to latest government of India. Wheat production is rising year-on-year and the previous record of 103.60 MT was achieved during the 2018-19 crop year (Source: m.economicstimes.com, April, 2020).

Materials and Methods

The field experiment under present investigation was conducted during *rabi* 2014-15 at Agriculture Research form of B.R.D.P.G College (Campus), Deoria UP). Geographically, Baba Raghav Das Post Graduate College, Deoria is located in the east part of up India. The site of experiment is located at 26.5°N latitude, 83.79°E longitude and 68 meter (223feet) above the sea level. The climate of district Deoria is semi-arid with hot summer and cold winter nearly 80% of total rain fall is received during the monsoon (only up to September) with a few show in the winter. The experimental materials of studies comprised of 81 wheat genotypes form exotic and indigenous with 3 check varieties. These genotypes were procured from Genetic stock available in wheat section, Department of Genetics and Plant Breeding, I.A.Sc., B.H.U., Varanasi (UP) India. The experiment was conducted to evaluate 81 wheat germplasm lines in normal soil under timely soon and irrigated conditions following augmented block design the entire experiment field was divided in 9 blocks of equal size and each the 3 checks, namely, PUSHA-2733, PBW-154 and PBW-502 were randomly allocated each block. The remaining a plots of a block were used for accommodating the test genotypes which were not replicated. A test genotype was present only one block while the three checks were replicated in all the 9 blocks. Each plot consisted of two rows 2.5 meters length with spacing of five cm in the row and 23 cm between the rows. Recommended cultural practices were followed to raise good crops. The data on days to 50% flowering, days to maturity, number of effective tillers per plant, flag leaf area, plant height, spike length, number of spikelets per spike, peduncle length, biological yield per plant, grain yield per spike, number of grains per spike, grain yield per plant, 1000 grains weight and harvest index were recorded to estimate genetic variability parameters.

The simple correlation coefficients (r) between different characters and path coefficient analysis were estimated according to 1 and 2 respectively. 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.

Results and Discussions

Correlation coefficient

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 was 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.

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

No	Character	Days to 50% flowering	Plant Height (cm)	Peduncle Length (cm)	Flag Leaf Area (cm²)	Ear Length (cm)	Productive Tillers/ Plant	Spikelets/ Spike	Day to Maturity	Biological Yield/ Plant (g)	Yield/ Spike (g)	Grains/ Spike	1000 Grains Weight (g)	harvest Index %
	Days to 50% flowering	**1.0000**	0.2034	-0.5885	-0.0465	-0.2592	-0.6281	-1.8932	1.0049	0.0565	0.5659	1.3372	-0.1918	-0.0880
	Plant Height (cm)		**1.0000**	0.0702	-0.1816	0.4940	-1.3254	2.4432	0.0675	0.2695	0.4871	-0.9616	0.5949	0.0379
	Peduncle Length (cm)			**1.0000**	0.9899	-1.5450	1.4668	-4.0539	-0.0525	0.5524	2.1017	7.7635	-1.4266	-1.0183
	Flag Leaf Area (cm²)				**1.0000**	0.7803	-1.3800	3.2259	-0.2035	-0.0147	-0.6361	-3.4914	0.8399	0.1056
	Ear Length (cm)					**1.0000**	2.4624	-3.7090	-0.0094	0.1193	0.2508	4.6373	-1.1484	-0.4862
	Productive Tillers/ Plant						**1.0000**	6.3760	-0.3815	0.4331	-0.6850	-7.2574	1.5868	1.6673
	Spikelets/ Spike							**1.0000**	-0.0731	-0.1052	-0.0718	17.0606	-3.3286	-0.9516
	Day to Maturity								**1.0000**	0.0474	0.1791	-0.5889	0.0694	-0.3047
	Biological Yield/ Plant (g)									**1.0000**	0.2413	0.7135	0.3445	-0.2882
	Yield/ Spike (g)										**1.0000**	-0.1341	0.7764	-0.0736
	Grains/ Spike											**1.0000**	4.9824	3.3413
	1000 Grains Weight (g)												**1.0000**	-0.3700
	harvest Index %													**1.0000**
	Grain Yield/ Plant (g)	**-0.1278**	**0.3346**	**0.0138**	**0.0151**	**-0.0194**	**0.7938**	**-1.1968**	**-0.0521**	**0.8741**	**0.3344**	**2.6564**	**0.1971**	**0.2708**

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	Plant Height (cm)	Peduncle Length (cm)	Flag Leaf Area (cm²)	Ear Length (cm)	Productive Tillers/ Plant	Spikelets/ Spike	Day to Maturity	Biological Yield/ Plant (g)	Yield/ Spike (g)	Grains/ Spike	1000 Grains Weight (g)	harvest Index %
	Days to 50% flowering	**1.0000**	0.0707	0.1356	-0.0767	0.1422	-0.0646	-0.0081	0.8456	0.0857	0.1406	-0.0655	0.0130	-0.2132
	Plant Height (cm)		**1.0000**	0.2647	0.2432	0.5117	0.1084	0.2744	0.1033	0.3414	0.2605	0.4291	0.2285	-0.2737
	Peduncle Length (cm)			**1.0000**	0.1630	0.2569	0.1569	0.1056	0.1347	0.1139	0.2534	0.1936	0.3702	-0.0994
	Flag Leaf Area (cm²)				**1.0000**	0.3000	0.0969	-0.0106	-0.0873	0.2260	0.0342	0.1423	0.2325	-0.1687
	Ear Length (cm)					**1.0000**	0.1203	0.4309	0.1535	0.3912	0.4071	0.5133	0.5474	-0.3817
	Productive Tillers/ Plant						**1.0000**	-0.0385	-0.0880	0.4746	-0.0133	0.0722	0.2593	-0.0965
	Spikelets/ Spike							**1.0000**	0.0980	0.1728	0.2331	0.3937	0.3082	-0.1346
	Day to Maturity								**1.0000**	0.0784	0.1631	0.0073	0.0739	-0.2257
	Biological Yield/ Plant (g)									**1.0000**	0.3501	0.3844	0.1107	-0.3963
	Yield/ Spike (g)										**1.0000**	0.4978	0.2014	-0.2362
	Grains/ Spike											**1.0000**	0.3448	-0.0044
	1000 Grains Weight (g)												**1.0000**	-0.0842
	harvest Index %													**1.0000**
	Grain Yield/ Plant (g)	**-0.0182**	**0.2265**	**0.0757**	**0.1478**	**0.1677**	**0.4672**	**0.0872**	**-0.0420**	**0.8004**	**0.2019**	**0.3868**	**0.0726**	**0.1852**

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

No	Character	Days to 50% flowering	Plant Height (cm)	Peduncle Length (cm)	Flag Leaf Area (cm²)	Ear Length (cm)	Productive Tillers/ Plant	Spikelets/ Spike	Day to Maturity	Biological Yield/ Plant (g)	Yield/ Spike (g)	Grains/ Spike	1000 Grains Weight (g)	harvest Index %
	Days to 50% flowering	**1.1860**	0.2413	-0.6980	-0.0551	-0.3074	-0.7450	-2.2454	1.1918	0.0670	0.6712	1.5859	-0.2274	-0.1044
	Plant Height (cm)	-0.0534	**-0.2625**	-0.0184	0.0477	-0.1297	0.3479	-0.6414	-0.0177	-0.0707	-0.1279	0.2524	-0.1562	-0.0100
	Peduncle Length (cm)	0.1073	-0.0128	**-0.1823**	-0.1805	0.2816	-0.2674	0.7390	0.0096	-0.1007	-0.3831	-1.4153	0.2601	0.1856
	Flag Leaf Area (cm²)	0.0013	0.0049	-0.0269	**-0.0272**	-0.0212	0.0375	-0.0877	0.0055	0.0004	0.0173	0.0949	-0.0228	-0.0029
	Ear Length (cm)	-0.0003	0.0007	-0.0021	0.0011	**0.0013**	0.0033	-0.0050	0.0000	0.0002	0.0003	0.0062	-0.0015	-0.0007
	Productive Tillers/ Plant	-0.0840	-0.1772	0.1961	-0.1845	0.3293	**0.1337**	0.8526	-0.0510	0.0579	-0.0916	-0.9705	0.2122	0.2230
	Spikelets/ Spike	-0.2002	0.2583	-0.4287	0.3411	-0.3922	0.6742	**0.1057**	-0.0077	-0.0111	-0.0076	1.8040	-0.3520	-0.1006
	Day to Maturity	-1.2881	-0.0865	0.0673	0.2609	0.0121	0.4890	0.0938	**-1.2819**	-0.0608	-0.2296	0.7549	-0.0890	0.3906
	Biological Yield/ Plant (g)	0.0513	0.2446	0.5015	-0.0133	0.1083	0.3932	-0.0955	0.0430	**0.9078**	0.2191	0.6478	0.3128	-0.2616
	Yield/ Spike (g)	0.1425	0.1226	0.5291	-0.1601	0.0631	-0.1724	-0.0181	0.0451	0.0607	**0.2517**	-0.0337	0.1955	-0.0185
	Grains/ Spike	0.0088	-0.0064	0.0513	-0.0231	0.0307	-0.0480	0.1128	-0.0039	0.0047	-0.0009	**0.0066**	0.0329	0.0221
	1000 Grains Weight (g)	-0.0030	0.0092	-0.0221	0.0130	-0.0178	0.0246	-0.0516	0.0011	0.0053	0.0120	0.0773	**0.0155**	-0.0057
	harvest Index %	0.0041	-0.0017	0.0470	-0.0049	0.0224	-0.0769	0.0439	0.0141	0.0133	0.0034	-0.1541	0.0171	**-0.0461**
	Grain Yield/ Plant (g)	**-0.1278**	**0.3346**	**0.0138**	**0.0151**	**-0.0194**	**0.7938**	**-1.1968**	**-0.0521**	**0.8741**	**0.3344**	**2.6564**	**0.1971**	**0.2708**
	Partial R²	-0.1516	-0.0878	-0.0025	-0.0004	0.0000	0.1062	-0.1265	0.0668	0.7936	0.0842	0.0176	0.0031	-0.0125

R SQUARE = 0.6899 RESIDUAL EFFECT = 0.5568

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

No	Character	Days to 50% flowering	Plant Height (cm)	Peduncle Length (cm)	Flag Leaf Area (cm²)	Ear Length (cm)	Productive Tillers/ Plant	Spikelets/ Spike	Day to Maturity	Biological Yield/ Plant (g)	Yield/ Spike (g)	Grains/ Spike	1000 Grains Weight (g)	harvest Index %
	Days to 50% flowering	**0.0433**	0.0031	0.0059	-0.0033	0.0062	-0.0028	-0.0004	0.0366	0.0037	0.0061	-0.0028	0.0006	-0.0092
	Plant Height (cm)	0.0041	**0.0580**	0.0154	0.0141	0.0297	0.0063	0.0159	0.0060	0.0198	0.0151	0.0249	0.0133	-0.0159
	Peduncle Length (cm)	0.0005	0.0010	**0.0037**	0.0006	0.0009	0.0006	0.0004	0.0005	0.0004	0.0009	0.0007	0.0014	-0.0004
	Flag Leaf Area (cm²)	-0.0010	0.0033	0.0022	**0.0134**	0.0040	0.0013	-0.0001	-0.0012	0.0030	0.0005	0.0019	0.0031	-0.0023
	Ear Length (cm)	-0.0061	-0.0221	-0.0111	-0.0130	**-0.0432**	-0.0052	-0.0186	-0.0066	-0.0169	-0.0176	-0.0222	-0.0236	0.0165
	Productive Tillers/ Plant	-0.0025	0.0042	0.0060	0.0037	0.0046	**0.0385**	-0.0015	-0.0034	0.0183	-0.0005	0.0028	0.0100	-0.0037
	Spikelets/ Spike	0.0000	-0.0003	-0.0001	0.0000	-0.0005	0.0000	**-0.0013**	-0.0001	-0.0002	-0.0003	-0.0005	-0.0004	0.0002
	Day to Maturity	-0.0145	-0.0018	-0.0023	0.0015	-0.0026	0.0015	-0.0017	**-0.0171**	-0.0013	-0.0028	-0.0001	-0.0013	0.0039
	Biological Yield/ Plant (g)	0.0870	0.3463	0.1155	0.2293	0.3968	0.4815	0.1753	0.0796	**1.0144**	0.3552	0.3899	0.1123	-0.4020
	Yield/ Spike (g)	-0.0022	-0.0041	-0.0040	-0.0005	-0.0064	0.0002	-0.0037	-0.0026	-0.0055	**-0.0158**	-0.0078	-0.0032	0.0037
	Grains/ Spike	0.0001	-0.0005	-0.0002	-0.0002	-0.0006	-0.0001	-0.0004	0.0000	-0.0004	-0.0005	**-0.0011**	-0.0004	0.0000
	1000 Grains Weight (g)	0.0001	0.0025	0.0041	0.0026	0.0060	0.0029	0.0034	0.0008	0.0012	0.0022	0.0038	**0.0110**	-0.0009
	harvest Index %	-0.1269	-0.1630	-0.0592	-0.1004	-0.2273	-0.0574	-0.0801	-0.1344	-0.2360	-0.1406	-0.0026	-0.0501	**0.5953**
	Grain Yield/ Plant (g)	**-0.0182**	**0.2265**	**0.0757**	**0.1478**	**0.1677**	**0.4672**	**0.0872**	**-0.0420**	**0.8004**	**0.2019**	**0.3868**	**0.0726**	**0.1852**
	Partial R²	-0.0008	0.0131	0.0003	0.0020	-0.0072	0.0180	-0.0001	0.0007	0.8119	-0.0032	-0.0004	0.0008	0.1102

R SQUARE = 0.9453 RESIDUAL EFFECT = 0.2339

At genotypic level days to 50% flowering exhibited significant positive correlation with number of grains per spike (1.3372) followed by days to maturity (1.0049), yield per spike (0.5659) and plant height (0.2034). Plant height showed highest significant positive correlation with spikelets per spike (2.4432) followed by 1000 grains weight (0.5949), ear length (0.4940), yield per spike (0.4871) and grain yield per plant (0.3346). Peduncle length was positively correlated with number of grains per spike (7.7635), yield per spike (2.1017), productive tillers per plant (1.4688), flag leaf area (0.9899) and biological yield per plant (0.5524). Flag leaf area showed significant positive correlation with spikelets per spike (3.2259), 1000 grains weight (0.8399) and ear length (0.7803).

The character ear length was correlated with number of grains per spike (4.6373) and productive tillers per plant (2.4624). Productive tillers per plant exhibited significant positive correlation with spikelets per spike (6.3760) followed by 1000 grains weight (1.5868), harvest index percent (1.6673) and grain yield per plant (0.7938). The traits spikelets per spike with number of grains per spike (17.0606) and days to maturity with yield per spike (0.1791) also possessed positive correlation. Biological yield per plant showed significant positive correlation with grain yield per plant (0.8741), 1000 grains weight (0.3445) and yield per spike (0.7135). Yield per spike exhibited positive correlation with 1000 grains weight (0.7764) and grain yield per plant (0.3344); number of grains per spike with 1000 grains weight (4.9824), harvest index (3.3413) and grain yield per plant (2.6564); harvest index with grain yield per plant (0.2708) also possessed significant positive correlation. 1000 grains weight had no positive correlation with any of the traits (Table 1).

The estimates of genotypic correlation coefficient between different characters showed close parallelism in direction with their corresponding phenotypic correlation coefficients (Table 2). The genotype correlations were higher in magnitude then corresponding correlations at phenotypic level.

Path coefficient

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.

At genotypic level, productive tillers per plant (0.1337), biological yield per plant (0.9078), number of grains per spike (0.0066) and 1000 grain weight (0.0155) exerted positive direct effect on grain yield. Plant height exerted indirect positive effect on grain yield *via* days to 50% flowering (0.2413). Productive tillers per plant *via* spikelets per spike (0.6742) and days to maturity (0.4890); spikelets per spike *via* productive tillers per plant (0.8526) and peduncle length (0.7390); yield per spike *via* days to 50% flowering (0.6712) and number of grains per spike *via* days to 50% flowering (1.5859) and spikelets per spike (1.8040) also exerted indirect positive effects on grain yield (Table 3). However, the direct and indirect effects of rest of the characters were too low to be considered of any consequence. The estimates of genotypic path coefficient between different characters showed close parallelism in direction with their corresponding phenotypic path coefficients (Table 4). Keeping these results in mind a breeder can focused more on these traits in his breeding program.

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