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Genetic variability, correlation and path coefficient analysis for metric traits in wheat (*Triticum aestivum* L.)

[*] Najibullah Hakimi, G Roopa Lavanya, G Suresh Babu, Ali Ahmad

Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad, Uttar Pradesh, India

Abstract
Wheat genotypes (including one check) were evaluated during *Rabi* 2015-2016 to determine genetic parameters for grain yield and its component characters in order to select the more desirable traits which may contribute for the improvement of yield. The mean sum of squares due to genotypes was significant for all the fifteen characters studied. High magnitude of GCV and PCV were recorded for seed yield per plant, number of grains per spike and biological yield. High heritability (h^2_{bs}) was recorded for all characters under study except. High genetic advance was recorded for plant height, number of grains per spike, peduncle length and test weight. Seed yield exhibited positive significant correlation with biological yield, plant height, test weight, peduncle length, and number of grains per spike at both genotypic as well as phenotypic level. While seed yield exhibited positive significant correlation with harvest index, flag leaf length and number of spikelets per spike at genotypic level. Biological yield and harvest index recorded direct high effect on grain yield per plant both genotypic and phenotypic levels. These traits should be given due emphasis for future bread wheat genetic improvement which may yield high genetic advance under proper selection pressure in a breeding program.

Keywords: bread wheat, genetic variability, correlation coefficient and path analysis

Introduction
Wheat is the most important food crop of India and is a main source of protein and energy. In India, wheat is the second most important food crop after rice both in terms of area and production. It is grown in temperate, irrigated to dry and high-rain-fall areas and in warm, humid to dry, cold environments. Wheat is consumed in a variety of ways such as bread, chapatti, porridge, flour, suji etc. Wheat has relatively high content of niacin and thiamin which are principally concerned in providing the special protein called 'Gluten'. Wheat proteins are of special significance because gluten provides the framework of spongy cellular texture of bread and baked products.

Wheat production estimated in the recent past 2015-2016, is 93.50 million tons from an estimated area 30.23 million hectares with the yield productivity of 3.1 tons per hectare. In Uttar Pradesh, the total area of wheat cultivated was 9.65 million hectares and the total production 26.87 million tons and the yield productivity was 2.8 tons per hectare (All India Coordinated Wheat & Barley Improvement Project, 2016).

However, the demand for wheat is expected to grow and therefore productivity increase is needed. The knowledge about genetic variability, heritability, correlation coefficients and its other parameters help in further improving the grain yield through directed selection of component traits and their interrelationship with yield. The present study was therefore conducted to estimate variability, heritability in wheat for utilization in selection programs aimed at productivity increase of future genotypes (Bhushan *et al*., 2013) [2].

Material and Methods
The experimental material comprised 19 genotypes (including one check) of bread wheat cultivars, grown in a randomized block design (RBD) in three replications during 2015-2016 at the Research Farm, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Allahabad-211007, Uttar Pradesh, India. Recommended package of practices were followed to raise a healthy crop. The observations were recorded on various quantitative characters *viz.*, days to heading, days to flowering, days to maturity, plant height, peduncle length, number of productive tillers per plant, number of spikelets per spike, leaf length, leaf width, no. of grains per spike, test weight (g), biological yield per plant (g), harvest index (%) and grains yield per plant (g). Five plants are randomly selected from each plot and each replication for recording data on all characters under study except days to 50 per cent flowering and days to maturity which was recorded on plot basis.

Results and Discussion
The estimation of genotypic variance (σ^2_g) and phenotypic variance (σ^2_p) were obtained for different characters, a wide range of variance was observed for all the characters. High genotypic variability (v_g) was recorded for plant height (176. 30), while moderate values were observed for number of grains per spike (97.37), whereas peduncle length (36.13), test weight (28.39), biological yield (9.31), days to 50% heading (8.85), leaf length (8.27), days to maturity (7.55), days to 50% flowering (6.87), number of spikelets per spike (2.49), harvest index (2.12), seed yield per plant (1.65), number of spikes per plant (1.27), spike length (1.01) and leaf width (0.01) showed low variance. Phenotypic variance was higher than genotypic variance for all the yield and yield contributing characters,

which indicates the influence of environmental factors on these traits. Similar findings were reported by Khan *et al*. (2015) [3] and Hussain *et al*. (2016). In general for all the traits studied, the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV). The phenotypic coefficient of variation (PCV) ranged from 2.62, (days to plant maturity) to 26.36 (seed yield per plant). The estimate of genotypic coefficient of variation (GCV) ranged from 2.45 (plant maturity) to 22.27 (seed yield per plant).

Heritability and genetic advance

The estimates of heritability ranged to from 39.05% (harvest index) to 89.86% (number of grains per spike), 89.86 days to initial flowering and days to maturity (87,33%) recorded high heritability among all the characters and high heritability (>75 percent) as observed for traits like (89.86%) number of grains per spike, plant height (89.49), peduncle length (88.78), days to maturity (87.33), test weight (81.42), number of spikes per plant (76.97), days to 50% heading (75.08), seed yield per plant (71.21), leaf width (68.96), biological yield (68.47), leaf length (67.75) and number of spikelets per spike (65.18). Knowledge of heritability of a character is important as it indicate the possibility and extend to which improvement is possible through selection. It is a measure of relationship between parent and progeny and has been widely used to assess the degree to which a character may be transmitted from parent to progeny. These results are in accordance with the findings of Bhushan *et al*. (2013) [2].

Table 1: Estimation of components of variance and genetic parameters for 15 quantitative characters in wheat.

Characters	V_g	V_p	GCV	PCV	h^2	GA	GA (as %) of mean
Days to 50% heading	8.85	11.79	3.89	4.49	75.08	5.31	6.95
Days to 50% flowering	6.87	12.48	3.27	4.41	55.01	4	5
Days to Maturity	7.55	8.64	2.45	2.62	87.33	5.29	4.72
Plant height	176.3	196.99	13.46	14.23	89.49	25.88	26.23
Peduncle length	36.13	40.7	16.89	17.93	88.78	11.67	32.79
No of Spikes per plant	1.27	1.65	17.36	19.78	76.97	2.04	31.37
No of Spikelets per spick	2.49	3.81	9.1	11.27	65.18	2.62	15.14
Leaf length	8.27	12.21	12.79	15.54	67.75	4.88	21.69
Leaf width	0.01	0.02	7.07	8.51	68.96	0.21	12.09
Spike length	1.01	1.91	9.26	12.75	52.83	1.51	13.87
No of grain per spike	97.37	108.36	21.66	22.85	89.86	19.27	42.3
Test Weight	28.39	34.87	14.8	16.4	81.42	9.9	27.51
Biological yield	9.31	13.59	21.38	25.83	68.47	5.2	36.44
Harvest index	2.12	5.44	3.61	5.77	39.05	1.88	4.64
Seed yield per plant	1.65	2.32	22.27	26.39	71.21	2.23	38.71

Where- V_g = Genotypic variance, V_p = Phenotypic variance GCV = Genotypic coefficient of variance PCV = Phenotypic coefficient of variance $h^2_{(bs)}$ = Heritability (broad sense) GA = Genetic advance

Correlation coefficient

Correlation coefficient is a statistical measure which is used to find out the degree (strength) and direction of relationship between two or more variables. A significant positive value of correlation shows that the changes of two variables are in the same direction. In the present investigation correlation coefficient analysis measure the mutual relationship between various plant character and to determine the component characters on which selection can be used for genetic improvement in yield while selecting the suitable plant type, correlation studies would provide reliable information in nature extent and the direction of the selection especially when the breeder needs to combine high yield potential with desirable traits and seed quality characters. The results showed that, in general, the genotypic correlation coefficients (r_g) were higher than the phenotypic correlation coefficients (r_p) which indicated that association among these characters was under genetic control, indicating the preponderance of genetic variance in expression of characters. It might be due to depressing effect of environment on character association as reported earlier for wheat crop (Ahmad *et al.*, 1978, Paroda and Joshi, 1970).

Seed yield per plle ant showed the positive significant genotypic association with biological yield (0.980**), plant height (0.806**), test weight (0.595**), peduncle length (0.570**), flag leaf width (0.525**), number of grains per spike (0.418**), harvest index (0.368**), flag leaf length (0.355**) and number of spikelets per spike (0.297*) (Table 2). These results were in agreement with those of Munir *et al*. (2007) [4].

Table 2: Genotypic and phenotypic correlation confection of different yield component with grain yield.

Characters	Days to 50% flowering	Days of plant Maturity		Plant height (Cm)	Peduncle length (Cm)	No of Spikes per plant	No of Spikelets per spike	Leaf length (Cm)	Leaf width (Cm)	Spike length (Cm)	No. of grains per spike	Test Weight	Biological yield (Gr)	Harvest index	Seed yield per plant
Days to 50% heading	G	0.998**	0.508**	-0.230	-0.041	-0.568**	0.238	0.323*	0.168	0.143	0.340**	-0.035	-0.218	-0.604**	-0.321*
	P	0.936**	0.414**	-0.081	-0.084	-0.393**	0.209	0.265*	0.216	0.113	0.350**	-0.108	-0.177	-0.360**	-0.262*
Days to 50% flowering	G	1.00	0.482**	-0.229	0.050	-0.637**	0.194	0.420**	0.189	0.245	0.319*	-0.120	-0.293*	-0.643**	-0.401**
	P	1.00	0.338*	-0.004	-0.048	-0.322*	0.167	0.293*	0.279*	0.160	0.344**	-0.162	-0.199	-0.353**	-0.283*
Days of plant maturity	G		1.00	0.020	-0.051	0.120	-0.048	0.123	0.329*	-0.354**	-0.002	0.182	0.161	-0.262*	0.110
	P		1.00	0.025	-0.036	0.089	-0.046	0.070	0.243	-0.192	0.008	0.137	0.190	-0.163	0.148
Plant height	G			1.00	0.860**	-0.186	0.329*	0.502**	0.553**	0.690**	0.492**	0.761**	0.743**	0.540**	0.806**
	P			1.00	0.777**	-0.100	0.313*	0.397**	0.478**	0.458**	0.447**	0.637**	0.568**	0.350**	0.635**
Peduncle length	G				1.00	-0.494**	0.317*	0.604**	0.730**	0.792**	0.632**	0.642**	0.532**	0.342**	0.570**
	P				1.00	-0.443**	0.242	0.452**	0.510**	0.492**	0.486**	0.585**	0.383**	0.281*	0.442**
Spikes per plant	G					1.00	-0.392**	-0.502**	-0.225	-0.730**	-0.589**	-0.191	0.205	0.060	0.199
	P					1.00	-0.177	-0.423**	-0.078	-0.451**	-0.383**	-0.194	0.206	0.026	0.198
Spikelets per spike	G						1.00	0.351**	0.093	0.597**	0.849**	0.182	0.307*	-0.042	0.297*
	P						1.00	0.221	0.104	0.322*	0.644**	0.067	0.194	-0.119	0.164
Leaf length	G							1.00	0.602**	0.737**	0.537**	0.154	0.389**	-0.087	0.355**
	P							1.00	0.406**	0.474**	0.362**	0.150	0.163	-0.062	0.148
Leaf width	G								1.00	0.254	0.549**	0.444**	0.587**	-0.194	0.525**
	P								1.00	0.195	0.434**	0.289*	0.355**	-0.193	0.301*
Spike length	G									1.00	0.608**	0.516**	0.152	0.466**	0.233
	P									1.00	0.347**	0.310*	0.082	0.249	0.143
Grains per spike	G										1.00	0.317*	0.473**	-0.201	0.418**
	P										1.00	0.180	0.333*	-0.273*	0.272*
Test weight	G											1.00	0.479**	0.759**	0.595**
	P											1.00	0.286*	0.553**	0.414**
Biological yield	G												1.00	0.178	0.980**
	P												1.00	0.012	0.970**
Harvest index	G													1.00	0.368**
	P													1.00	0.247

*: Significant at 5% level of significance, **: Significant at 1% level of significance

Table 3: Direct (diagonal) and indirect effects of component traits attributing to grain yield per plant in wheat at phenotypic level.

	Days to 50% heading	Days to 50% flowering	Days of plant Maturity	Plant height	Peduncle length	No of Spikes per plant	No of Spikelets per spike	Leaf length	Leaf width	Spike length	No of grains per spike	Test Weight	Biological yield	Harvest index
Days to 50% heading	-0.017	-0.0174	0.008	-0.0005	0.0019	0.0039	-0.0027	0.0011	0.0003	0.0006	0.0152	0.0002	-0.1688	-0.0868
Days to 50% flowering	-0.0159	-0.0186	0.0065	0.000	0.0011	0.0032	-0.0022	0.0012	0.0004	0.0008	0.0149	0.0003	-0.1896	-0.0853
Days of plant Maturity	-0.007	-0.0063	0.0194	0.0001	0.0008	-0.000	0.0006	0.0003	0.0004	-0.001	0.0003	-0.0002	0.1809	-0.0394
Plant height	0.0014	0.0001	0.0005	0.0058	-0.0173	0.001	-0.0041	0.0016	0.0007	0.0024	0.0193	-0.001	0.5407	0.0844
Peduncle length	0.0014	0.0009	-0.0007	0.0045	-0.0223	0.0044	-0.0032	0.0018	0.0007	0.0026	0.0211	-0.0009	0.3643	0.0678
No of Spikes per plant	0.0067	0.006	0.0017	-0.0006	0.0099	-0.009	0.0023	-0.0017	-0.0001	-0.0024	-0.0166	0.0003	0.196	0.0064
No of Spikelets / spike	-0.0035	-0.0031	-0.0009	0.0018	-0.0054	0.0017	-0.013	0.0009	0.0002	0.0017	0.0279	-0.0001	0.1843	-0.0288
Leaf length	-0.0045	-0.0054	0.0014	0.0023	-0.0101	0.0042	-0.0029	0.004	0.0006	0.0025	0.0157	-0.0002	0.1552	-0.0149
Leaf width	-0.0037	-0.0052	0.0047	0.0028	-0.0114	0.0008	-0.0014	0.0016	0.0014	0.001	0.0188	-0.0005	0.338	-0.0465
Spike length	-0.0019	-0.003	-0.0037	0.0027	-0.011	0.0044	-0.0042	0.0019	0.0003	0.0053	0.015	-0.0005	0.0778	0.0602
No of grains per spike	-0.0059	-0.0064	0.0002	0.0026	-0.0108	0.0038	-0.0084	0.0015	0.0006	0.0018	0.0433	-0.0003	0.3166	-0.066
test weight	0.0018	0.003	0.0027	0.0037	-0.013	0.0019	-0.0009	0.0006	0.0004	0.0016	0.0078	-0.0016	0.272	0.1335
Biological yield	0.003	0.0037	0.0037	0.0033	-0.0085	-0.002	-0.0025	0.0007	0.0005	0.0004	0.0144	-0.0005	0.9514	0.0028
Harvest index	0.0061	0.0066	-0.0032	0.002	-0.0063	-0.000	0.0016	-0.0003	-0.0003	0.0013	-0.0118	-0.0009	0.0111	0.2413

Residual are 0.00199

Correlation between grain yield and other characters

Days to 50% heading recorded positive significant genotypic association with days to 50% flowering (0.998**), days to maturity (0.508**), number of grains per spike (0.340*) and leaf length (0.323*). The correlation coefficient showed negative significant association with number of spikes per plant (-0.568**) and harvest index (-0.604**). Number of grains per spike showed positive significant genotypic association with biological yield (0.473**) and test weight (0.317*), while the correlation showed negative non significant association with harvest index (-0.201). Test Weight showed positive significant genotypic association with harvest index (0.759**) and biological yield (0.479**). Biological yield showed positive significant genotypic association with test weight (0.759**). This was supported by the study of Tsegaye *et al*. (2012) [6] and Munir *et al*. (2007) [4].

Correlation at Phenotypic level (r_p)

Total yield per plant (g) showed the positive significant phenotypic association with biological yield (0.970**), plant height (0.635**), peduncle length (0.442**), test weight (0.414**) and leaf width (0.301*) (Table 2). Similar results of significant and positive association of grain yield per plant with spike length and productive tillers per plant were observed by Deshpande (1992) and Dawari and Lutra (1991). The correlation showed positive non significant association with flag leaf width harvest index (0.247), number of spikes per plant (0.198), number of spikelets per spike (0.164), days of plant maturity (0.148), leaf length (0.148) and spike length (0.143). Days to 50% heading showed positive significant phenotypic association with days to 50% flowering (0.936**), days of plant maturity (0.414**), number of grains per spike (0.350**), and leaf length (0.265*). The correlation showed negative significant association with number of spikes per plant (-0.393**), harvest index (-0.360**). Singh *et al.* (2011). Number of grains per spike showed positive significant phenotypic association with only biological yield (0.333*), while negative significant association with harvest index (-0.273*). The positive non- significant association with test weight (0.18). Test Weight showed positive significant phenotypic association with biological yield (0.553**), harvest index (0.286*).this was supported by the study of Singh *et al*. (2011). Biological yield showed positive non significant phenotypic association with harvest index (0.012). This was supported by the study of Singh *et al*. (2011).

Path Analysis

In Path coefficient analysis revealed that some traits exhibited highest positive direct effect on grain yield and each must be given preference in selection along with optimum harvest index, biological yield, no. of grain per plant, flag leaf length, No. of spikelets per plant, days of maturity and days to 50% flowering grains yield with spike length plant height and days to maturity direct effect on seed yield these characters can be used as selection indies. It is detailed in table 3.

phenotypic Path coefficient analysis revealed that same traits exhibited highest positive direct effect on grains yield and each must be given preference in selection along with optimum harvest index (0.2413), biological yield (0.9514), no. of grains per spike (0.0053), leaf length (0.004), days of maturity (0.0194) and plant height (0.0058) direct effect on seed yield these characters can be used as selection indies. Its details are given in table 3.

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