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Studies on correlation and path coefficients analysis in bread wheat (*Triticum aestivum* L.)

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Abstract
The present investigation entitled “Study of correlation and path coefficient analysis in bread wheat (*Triticum aestivum* L.)” was carried out during rabi 2016-2017 at Crop Research Farm, Nawabganj of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.). A collection of fifty wheat genotypes from different eco-geographic origins were evaluated for nine quantitative characters. Data were recorded and analyzed on the bases of following 11 characters viz, days to flowering, days to maturity, plant height, number of productive tillers per plant, length of spike, number of grains/spike, grain weight/spike, 1000-grain weight, and grain yield per plant. Generally, the estimates of genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients for all the character combinations. Grain yield per plant shows positive and significant associationship with days to flowering, days to maturity, spike length and number of productive tiller per plant. Path coefficient analysis indicated that the highest positive direct effect on seed yield per plant was exerted by spike length, days to maturity, number of productiver tillers per plant, 1000-grain weight, grain weight per spike.

Keywords: Correlation coefficient, path coefficient analysis

Introduction
Wheat (*Triticum aestivum* L.) is the most important cereal crop for the majority of world’s populations. It is the most important staple food of about two billion people (36% of the world population). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally. Wheat is cultivated over a wide range of climatic conditions and therefore understanding of genetics is of great value for plant breeding purposes. Wheat belongs to family *Poaceae* (Gramineae) which includes major crop plants such as wheat (*Triticum* spp.), barley (*Hordeum vulgare*), oat (*Avena sativa*), rye (*Secale cereale*), maize (*Zea mays*) and rice (*Oryza sativa*). The native home of wheat is in Asia Minor. Some 8000 years ago the resident of Asia Minor found a new way of living in course of civilization through the cultivation of general *Triticum* and *Hordeum*. The excavation of Mohan –jo –Daro and our scriptures like” Atharva-Veda” indicate that wheat cultivation begins in India some times more than 5000 years ago. Wheat is world’s most widely cultivated food crop. In India it is the second important staple food crop after rice and it is used in several forms to make flour for leavened, flat and steamed breads, biscuits, cookies, cakes, breakfast cereal, pasta, noodles, couscous and for fermentation to make beer other alcoholic beverages, and biofuel. Wheat provides 20% dietary calories of the world. Wheat is the most important source of carbohydrate in majority of countries. Wheat contains minerals, vitamins and fats and with a small amount of nutrition’s. It contains 70% carbohydrates, 22% crude fibers, 12% protein, 12% water 2% fat, and 1.8% minerals. A predominately wheat-based diet is higher in fiber than a meat-based diet.

The United States Department of Agriculture (USDA) estimates that the World Wheat Production in 2017-2018 will be 739.53 million metric tons. Wheat Production last year was 754.1 million tons. This year's 739.53 estimated million tons could represent a decrease of 14.57 million tons or a -1.93% in wheat production around the globe. India is the largest wheat producing country in the world after China and account for more than13.06 percent of the world’s wheat production. During the crop year 2014-15, India harvested 95.85 million tones of wheat in an area of 31 million hectares with productivity of 2800 kg/ha.) As per Second Advance Estimates for 2015-16, total production of wheat estimated at 96.76 million tons with coverage area of 259.37 lakh hectare is a new record. U.P is the leading state in wheat production. The major wheat producing states are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh., Rajasthan, Bihar, Maharashtra, Gujarat, Karnataka, West Bengal, Uttaranchal, Himachal Pradesh and Jammu Kashmir. These states contribute about 99.5 per cent of total wheat production in the country. Remaining states namely Jharkhand, Assam, Chhattisgarh, Delhi and other North East states contributes only about 0.5 per cent of the total wheat production in the country.

Materials and Methods

The present investigation entitled, "Study of genetic divergence, correlation, and path coefficient analysis in bread wheat (*Triticum aestivum* L.)" was carried out during *rabi* 2016 –17 at crop research farm Nawabganj crop research farm of Chandra Shekhar Azad University of Agriculture And Technology Kanpur is situated between 26.4607^o N latitude, 80.3334^o E longitude and at an altitude of 126 m above the mean sea level in about 3 km, away from CSA Uni. of Agri. and Tech. Kanpur. The climate of district Kanpur is humid subtropical and It has one of the lowest temperatures in northern plains during the winter season and is one of the warmest during the summer season. Nearly 80% of total rainfall is received during the monsoon (up to September) with a few showers in the winter. The experimental materials of the study comprised of 50 germ plasm/varieties from Indian origin. These varieties/lines were procured from germplasm lines available in wheat Section, Department of Genetics and Plant Breeding, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. A field experiment was conducted during *Rabi* season 2016-17 at Nawabganj Crop Research Farm, CSAUAT, Kanpur. All the strains were sown in Randomized Complete Block Design with three replications and recording of observations on Days to flowering, Days to maturity, Plant height (cm), Spike length (cm), Number of productive tillers per plant, Number of grains per spike, Grain weight per spike, 1000-grain weight (g) and Grain yield/plant (g).

Results and Discussion

The economic product *i.e. g*rain yield in wheat, is the complex characters which manifest from multiplicative interactions of several other characters that is termed as yield components. The genetic architecture of grain yield in wheat as well as other crops is based on the balance or overall net effect produced by various yield components directly or indirectly by interacting with one another. Therefore, selection for yield per se alone would not matter much as such unless accompanied by the selection for various component characters. Thus, identification of important components and information about their association with yield and with each other are very yielding varieties. The correlation coefficient is the measure of degree of symmetrical association between two variables or characters which helps us in understanding the nature and magnitude of association among yield and yield components and provides opportunity for indirect selection. The improvement normally depends upon the efficiency and accuracy of selection which is only possible when the selection is made not only on the basis of single characters but several other contributing characters are taken in consideration. It is therefore, necessary to study the nature and magnitude of association of particular traits with the other traits. Study of correlation provides us information about relationship of traits which are not easily observable or have low heritability and provide us idea about the suitability of various characters for indirect selection, because selection for one or more than one traits resulted in formulation of correlation response for several other traits (Searle 1965). For obtaining the real relationship of the characters, the estimation of genotypic correlation is essential. All possible genotypic and phenotypic correlations were worked out for nine characters under study. Correlation of characters among themselves indicate that strong positive correlation was observed between days to flowering showed highly significant and positive association with days to maturity, 1000- grain weight, grains per spike, number of productive tillers per plant and grains weight per spike at phenotypic and genotypic level. Similar observations were also reported by Wahid Abdul and Karim Shahla (2014). Grain yield per plant was positively correlated with days to flowering, days to maturity, spike length and number of reproductive tillers per plant both at genotypic and phenotypic level. Subhani (2000) noted positive and significant correlation between grain yield per plant and flag leaf area, specific flag leaf weight, tillers per plant, panicle length, spike length, grains per spike, 1000-grain weight, grain weight of mother shoot, biomass per plant and harvest-index. Observations revealed that the genotypic correlation of grain yield per plant were higher with almost all the characters than phenotypic correlations, but in the same direction in the present research. High magnitude of genetic association may be due to pleiotropic rather than linkage. Grain yield per plant shows highly positive correlations with days to flowering, days to maturity, spike length and number of productive tillers per plant. Positive correlation indicates that when one character increases other character increases automatically. Grain yield per plant shows negative non significant correlation with plant height, grains per spike, grains weight per spike and 1000-grain weight. Negative Correlation indicates increase in one character brings about a decrease on the other character and vice versa. Esmail (2001) observed that grain yield per plant was positively correlated with number of spikes per plant, plant height and days to heading but negatively correlated with grain weight per spike in the parents, F_1 and F_2 generations at the phenotypic and genotypic levels. Number of spikes per plant, followed by grain weight per spike had the highest contribution to grain yield either through its direct effect and/or its indirect effects via other traits. Thus observations revealed that the genotypic correlations of grain yield were higher with almost all the characters than phenotypic correlations. By improving the characters which are directly and positively associated with grain yield will ultimately improve yield and also by elimination the negative correlated characters with grain yield.

Path coefficient analysis is a tool of partitioning the observed correlation coefficient into direct and indirect effects of yield components on grain yield. Path analysis provides clear picture of character associations for formulating efficient selection strategy. Path coefficient analysis differs from simple correlation in that it points out the causes and their relative importance whereas, the later measures simply the mutual association ignoring the causation. The concept of path coefficient was developed by Sewal wright (1921) and technique was first used for plant selection by Dewey and Lu (1959) [6]. Path analysis has emerged as a powerful and widely used technique for understanding the direct and indirect contribution of different characters to economic yield in crop plants so that the relative importance of various yield contributing characters can be assessed. Correlation provides relationship between two characters but in path analysis direct and indirect of independent trait on dependent trait will be known. Path coefficient analysis was done to determine direct and indirect influence of days to flowering, days to maturity, plant height, spike length, number of productive tillers per plant, number of grain per spike, grain weight per spike and test weight on grain yield per plant. Estimates of path coefficient have been furnished in table 8. All the characters viz. days to flowering, days to maturity, spike length and number of productive tillers per plant was positive correlation with grain yield. Subhani (2000) noted positive and significant correlation between grain yield per plant and flag leaf area, specific flag leaf weight, tillers per plant, panicle length, spike length, grains per spike, 1000-grain weight, grain weight of mother shoot, biomass per plant and harvest-index. A large number of characters contributed to total grain yield per plant via several agronomic and yield related traits. So improving these characters will finally improve grain yield. Residual effects of study were high (0.7393). It indicates that many traits which were contributing to the yield were not included in the study.

Table 1: Upper Diagonal (genotypic) lower diagonal (phenotypic) shows correlation coefficient among nine characters in wheat:

Character	Days to flowering	Days to maturity	Plant height (cm)	Spike length (cm)	Number of productive tillers/plant	Grain per spike	Grain weight per spike	1000- grain weight	Yield per plant
Days to flowering	1.0000	0.7209	-0.0049	0.0818	0.4954	0.0226	0.0738	0.0156	0.6253
Days to maturity	0.6491**	1.0000	0.1642	0.2167	0.5296	0.0174	0.1733	0.1820	0.4946
Plant height (cm)	-0.0059	0.1611	1.0000	0.2897	0.0187	0.0960	0.1289	0.1936	-0.0320
Spike length (cm)	0.0867	0.2049**	*0.2736***	1.0000	0.0381	0.0044	-0.1062	-0.0428	0.1683
Number of productive tillers/plant	0.4705**	0.5098**	0.0172	0.0443	1.0000	0.1882	0.1765	0.0871	0.5780
Grain per spike	0.0255	0.0123	0.0917	0.0075	0.1751**	1.0000	0.0664	-0.3734	-0.1127
Grain weight per spike	0.0838	0.1588**	0.1203	-0.0747	0.1494	0.0663	1.0000	0.7939	-0.1630
1000-grain weight	0.0158	0.1810**	0.1789**	-0.0371	0.0914	-0.3535**	0.6718**	1.0000	-0.0722
Yield per plant	0.5652**	0.4188**	-0.0373	0.1598	0.4883**	-0.0724	-0.1249	-0.0509	1.0000

* Significant at 5% levels **Significant at 1% level

Table 2: Phenotype path matrix of Grain Yield/ Plant (gm)

Character	Days to flowering	Days to maturity	Plant height (cm)	Spike length (cm)	Number of productive tillers/ plant	Grains/ spike	Grain weight/ spike	1000-Grain weight
Days to flowering	0.4543	0.3153	-0.0027	0.0394	0.2137	0.0116	0.0381	0.0072
Days to maturity	-0.0454	-0.0654	-0.0105	-0.0134	-0.0333	-0.0008	-0.0104	-0.0118
Plant height (cm)	0.0002	-0.0048	0.0299	-0082	-0005	-0.0027	-0.0036	-0.0053
Spike length (cm)	0.0098	0.0232	0.0309	0.1131	0.0050	0.0008	-0.0084	-0.0042
Number of productive tillers/ plant	0.1659	0.1797	0.0061	0.0156	0.3526	0.0617	0.0527	0.0322
Grains/ spike	-0.0031	-0.0015	-0.0112	-0.0009	-0.0213	-0.1217	-0.0081	0.0430
Grain weight/ spike	-0.0168	-0.0318	-0.0241	0.0150	-0.0299	-0.0133	-0.2003	-0.1346
1000 Grain weight	0.0004	0.0041	0.0041	-0.0008	0.0021	-0.0080	0.0150	0.0227
Yield/plant	0.5652	0.4188	-0.0373	0.1598	0.4883	-0724	-0.1249	-0.0509
Partial R^2	0.2567	-0.0274	0.0011	0.0181	0.1722	0.0088	0.0250	-0.0012

Table 8: Genotype path matrix of Yield/ Plant

Character	Days to flowering	Days to maturity	Plant height (cm)	Spike length (cm)	Number of productive tillers/ plant	Grains/ spike	Grain weight/ spike	1000 -Grain weight
Days to flowering	0.4563	0.3290	-0.0022	0.0373	0.2261	0.0103	0.0337	0.0071
Days to maturity	-0.0374	-0.0518	-0.0085	-0.0112	-0.0275	-0.0009	-0.0090	-0.0094
Plant height	0.0001	-0.0039	-0.0240	-0.0070	-0.0004	-0.0023	-0.0023	-0.0046
Spike length (cm)	0.0084	0.0221	0.296	0.1021	0.0039	0.0004	-0.0108	-0.0044
Number of productive tillers/ plant	0.2237.	0.2392	0.0084	0.0172	0.4516	0.0850	0.0797	0.0393
Grains/ spike	-0.0032	-0.0025	-0.0137	-0.0006	-0.0269	-0.1428	-0.0095	0.0533
Grain weight/ spike	-0.0244	-0.0572	-0.0426	0.0351	-0.0583	-0.0219	-0.3302	-0.2621
1000- Grain weight	0.0017	0.0198	0.0210	-0.0046	0.0095	-0.0405	0.0862	0.1086
Yield/plant	0.6253	0.4946	-0.0320	0.1683	0.5780	-0.1127	-0.1630	-0.0722
Partial R^2	0.2853	-0.0256	0.0008	0.0172	0.2610	0.0161	0.0538	-0.0078

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