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Character association and path coefficient analysis in wheat (*Triticum aestivum* L. em. Thell)

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Abstract
A field experiment was carried out with 109 diverse indigenous genotypes of bread wheat along with four checks in Augmented Block Design for study of character association and path coefficient, divided in to 7 blocks of equal size. Each block had 15 plots of test entries along with 4 checks (*viz.* LOK-1, HD-2009, WH-147 and DBW-17). The trial was conducted at Main Experimental Station Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during *Rabi* 2015-16. The observations were recorded on eleven quantitative characters *viz.,* days to 50% flowering, days to maturity, plant height (cm), tillers per plant, spike length (cm), flag leaf area (cm), peduncle length (cm), 1000 grain weight (g), biological yield per plant (g), harvest index (%) and grain yield per plant (g). Results revealed that the experimental field was divided in 7 blocks. Each have had 15 plots of the entries with 4 checks.

Keywords: Wheat (*Triticum aestivum*), path coefficient

Introduction

Wheat, (*Triticum aestivum* L. *em.* Thell) is the world's largest cereal crop which belongs to Gramineae family of the genus *Triticum*. It has been described as the 'King of cereals' because of the acreage it occupies, high productivity and the prominent position in the international food grain trade. Wheat is consumed in a variety of ways such as bread chapatti, porridge, flour, suji etc.

India stands second rank in production and consumption next to china in the world. India's share in world wheat production is about 14.13% of world's wheat production, is the only crop where production increase more than fifteen fold during last sixty three years (6.5 million tonnes in 1950 to 95.51 million tonnes in 2016-17 (Anonymous, 2016-17) [1].

The world acreage under wheat crop during 2012-13 was 221.47 million ha with production of 654 million tonnes with an average yield of 31.50 q/ha. (Anonymous; 2014). In India, the total area for wheat crop during 2015-16 was 30.23 million hectares with the production of 93.50 million tonnes and average productivity was 30.93 q/ha. (Anonyms 2016) [1].

During the year 2015-16 in Uttar Pradesh, the total wheat production was 26.87 million tonnes and average productivity was 27.86 q/ha. Uttar Pradesh ranked first with an area of 9.65 mha with the production of 26.87 million tonnes with average productivity of 27.86 q/ha. The productivity of wheat in other state is comparatively lower than that of Punjab and Haryana.

Wheat may be compared well with other cereals in nutritive value. It has good nutrition profile with 12.6 percent protein, 1.7 percent reducing sugars, 66.8 percent starch, 68.5 percent total carbohydrates and provides 314K cal/100g of food. It is also a good source of minerals and vitamins *viz*., thiamin (0.30 mg/100g), riboflavin (0.07 mg/100g) and niacin (1.7 mg/100mg) (Kumar *et al*., 2011).

For maintaining the sustainability and self-sufficiency, the country need to target of 100 million tonnes by year 2030. Overall, there was 1.546% decrease in production while area sown to wheat increased by only 1.37% relative to previous crop season. In Haryana, there was increase in production by 5.2% with marginal increase in area *i.e*. 0.9%. However, Punjab recorded 3.0% increase in production with little decrease in area *i.e*. 0.7%. Although, the increase in production would be largely attributed to extend cool winter and cool weather and relatively high amount of rains during the crop season.

Yield being a complex character is a function of several component characters and their interaction with environment. Probing of structure of yield involves assessment of mutual relationship among various characters contributing to the yield. In this regard, genotypic and phenotypic correlation reveals the degree of association between different characters and thus aid in selection to improve the yield and yield attributing characters simultaneously. Further, path coefficient analysis helps in partitioning of correlation coefficients into direct and indirect effects in the assessment of relative contribution of each component character to the yield.

In the present study, 104 geographically diverse indigenous genotypes were used for the study of character association of path coefficient analysis in wheat.

Material and Methods

A field experiment was carried out during *Rabi* 2015-16 at Main Experimental Station Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). The experiment was conducted to evaluate the 109 wheat germplasm lines along with 4 checks (namely LOK-1, HD-2009, WH-147 and DBW-17) in Augmented Block Design. These genotypes exhibited wide spectrum of variation for various agronomical and morphological characters. The experimental field was divided into 7 blocks and 19 plots in each block (15 test genotypes along with 4 checks). Each plot was consisted two rows of 2.5 m length with spacing of 5 cm within the rows and 25 cm between the rows.

The data was recorded on 5 randomly selected plants from each plot for eleven characters *viz.* days to 50% flowering, days to maturity, plant height (cm), tillers per plant, spike length (cm), flag leaf area (cm^2), peduncle length (cm), 1000-grain weight (g), biological yield per plant (g), grain yield per plant (g) and harvest index (%). Data recorded on the above characters were subjected to estimation of correlation coefficient and path coefficient according to Searle (1961) [26] and Dewey and Lu (1959) [5] respectively.

Result and Discussion

The grain yield or economic yield, in most of the crops, is a complex character, which manifests from multiplicative interaction of several other characters that are 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 responsible for conditioning it. Thus, identification of important component characters and information about their association with yield and also with each other are very useful for developing efficient breeding strategy for evolving high yielding varieties. The correlation coefficient is the measure of degree of linear association between two variables or characters and helps us in understanding the nature and magnitude of association among yield and yield components. In the present investigation, simple correlation coefficients were computed among 11 quantitative characters and given in Table-1. The grain yield per plant exhibited highly significant and positive correlation with biological yield per plant (0.79), harvest index (0.62), test weight (0.28) and plant height (0.27). The grain yield per plant showed highly significant and negatively correlation with Days to 50% flowering (-0.32). Grain yield per plant showed significant and positively correlation with Flag leaf area and Tillers per plant. Day to maturity, Spike length and Peduncle length showed non-significant and negative correlation with grain yield. Thus, harvest index, biological yield per plant, peduncle length, days to maturity, tillers per plant, plant height, spike length and days to 50% flowering emerged as closely correlated yield attributes. The strong positive association of grain yield with one or more of the above traits has also been observed by previous workers (Rizwana Maqbool, 2010; Singh *et al.;* 2010; Deepti Bist 2009; Khan *et al.*; 2002; Sharma and Singh; 2009; Khokhar *et al.;* 2010 [12]; Anwar *et al.*; 2009; Vivek Sharma, 2006; Singh *et al.*, 2010; Singh *et al.*, 2012; Potdukhe *et al.*, 2013; Kumar *et al*., 2014; Dargicho Dutamo *et al.*, 2015; Ompal Singh *et al*., 2017) [2, 6, 20, 21, 27, 30, 31].

Harvest index had the strong positive and highly significant correlation with days to 50% flowering and days to maturity. The 1000-grain weight contributed non-significant and positive correlation with days to 50% flowering. Highly significant and positive correlation coefficient of biological yield per plant was recorded with plant height (0.32). Peduncle length expressed positive and highly significant correlation coefficient with Spike length (0.55). Tillers per plant recorded the positive and non-significant correlation coefficient with days to 50% flowering (0.17), flag leaf area (0.13), days to maturity (0.12) and plant height (0.05).

Days to maturity exhibited highly significant and positive correlation with days to 50% flowering (0.74) and flag leaf area (-0.23) shows negative & significant correlation. Plant height exerted the non-significant and positive correlation with days to 50% flowering (0.12) and flag leaf area (0.06).

The above discussion revealed that all the highly significant estimates of correlation coefficient observed among the important yield components such as biological yield per plant, harvest index, tillers per plant, peduncle length and plant height were highly significant and positively associated with grain yield per plant. Thus, selection practiced for improving these traits individually or simultaneously is likely to bring improvement in others due to correlated response. This suggests that selection would be quite efficient in improving yield and these five yield components in wheat, especially in context of the varieties/lines collections evaluated.

Out of 55 estimates of correlation coefficients, only 19 correlations were significant while 36 character pairs were non-significant nature either in positive or negative direction the existence of non-significant correlations between most of the characters may be attributed presence of high diversity in germplasm collection. Certain traits were found to be inter correlated with each other both either in positive or in negative direction.

Path-coefficient analysis

Sewall Wright (1921) developed the concept of path-coefficient analysis as a tool to partition the observed correlation coefficients in to direct and indirect effects of independent variables on the dependent variable. Path 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. Path analysis has emerged as a powerful and widely used technique for understanding the direct and indirect contributions of different characters to economic yield in crop plants so that the relative importance of various yield contributing characters can be assessed.

The results of path-coefficient analysis done using simple correlation coefficients among 11 quantitative characters are given in Table. The highest positive direct effect on grain yield per plant was exerted by biological yield per plant (0.7836) followed by harvest-index (0.5998) whereas test weight (0.1541), flag leaf area (0.0072), tillers per plant (0.0065) and days to maturity (0.0048) showed positive direct effect. Thus, biological yield per plant followed by harvest index emerged as most important direct contributors towards grain yield per plant. Vivek Sharma, 2006; Singh *et al.*, 2008 [31, 32]; Singh and Sharma, 2007, Khan *et al;* 2008 [17], Anwar, *et al.*, 2009 [2], Kumar *et al.*, 2014; Dargicho Dutamo *et al.*, 2015 [6] and Ompal Singh *et al.*, 2017 [21] have also identified biological yield per plant as a character making substantial direct positive contribution towards manifestation of grain yield in wheat.

Flag leaf area, days to maturity, plant height, and tillers per plant, spike- length and 1000 grain weight showed considerable negative direct effects on grain yield per plant. The direct effects of remaining characters were found to be too low to be considered of any consequence. The indirect effects of harvest index, peduncle length, tiller per plant, flag leaf area and plant height were high order positive on grain yield per plant via biological yield per plant. Thus, above mentioned characters emerged as most important indirect yield contributing characters because they showed substantial positive indirect effects towards grain yield per plant via biological yield per plant, which also made high direct contribution to grain yield.

The remaining estimates of indirect effects in this analysis were very low indicating their negligible indirect contribution towards grain yield per plant. The existence of negative as well as positive direct and indirect effects by same character on grain yield per plant via one or other characters simultaneously presents a complex situation where a compromise is needed to attain proper balance of different yield components in determining an ideotype for high grain yield in wheat.

In contrary to most of the previous reports in wheat, comparatively smaller proportion of direct and indirect effects of different characters attained high order values in the present study. Majority of the estimates of direct and indirect effects were too low to be considered of any consequence. This may be attributed to presence of very high genetic variability and diversity in the fairly large number of indigenous varieties/lines. The existence of different character combinations in diverse varieties/lines might have led to different types of character associations in different lines. Thus, presence of several contrasting types of character associations and inter-relationships might have resulted into cancellation of contrasting associations by each other ultimately leading to lowering of the net impact or effect.

In the present study, path analysis identified biological yield per plant and harvest index as important direct yield contributing characters. Harvest index, peduncle length, tillers per plant and plant height emerged as most important indirect yield components. These findings are similar to those of the references Anwar *et al.*; 2009 [2]; Vivek Sharma, 2006; Singh *et al.*, 2010 [21, 27, 30, 31]; Singh *et al.*, 2012 [21, 27, 30, 31]; Potdukhe *et al.*, 2013 [20]; Kumar *et al.*, 2014; Dargicho Dutamo *et al.*, 2015 [6]; Ompal Singh *et al.*, 2017 [21] as most important indirect yield components. The characters mentioned above, had merit due to consideration at the time of devising selection strategy aimed at developing high yielding varieties in wheat. The estimate of residual effect was very low (0.0866) which reflects that majority of the characters responsible for the yield enhancement have been considered in this study.

Table 1: Estimates of simple correlation coefficients between 11 characters in wheat

S. No.	Character	Days to 50% flowering	Flag leaf area (cm^2)	Plant height (cm)	Days to maturity	Tillers per plant	Spike length (cm)	Peduncle length (cm)	Biological yield per plant (g)	Test weight (g)	Harvest index (%)	Grain yield per plant (g)
1	Days to 50% Flowering	1.0000	-0.1740	0.1223	0.7487**	-0.1749	0.0760	0.0443	-0.1745	-0.2474**	-0.2860**	-0.3277**
2	Flag Leaf Area (cm^2)		1.0000	0.0694	-0.2377*	0.1381	0.1052	-0.0639	0.1601	0.1215	0.1151	0.2004*
3	Plant Height (cm)			1.0000	0.0203	0.0552	-0.1306	0.1138	0.3240**	-0.0131	0.0486	0.2760**
4	Days to Maturity				1.0000	-0.1264	0.1720	0.1144	-0.0284	-0.0989	-0.2596**	-0.2012
5	Tillers per Plant					1.0000	-0.0671	-0.1193	-0.1974*	0.1410	0.0662	0.1967*
6	Spike Length (cm)						1.0000	0.5584**	0.1082	0.1109	-0.2267*	-0.0587
7	Peduncle Length (cm^2)							1.0000	-0.0142	0.0421	-0.2353*	-0.1568
8	Biological Yield per Plant (g)								1.0000	0.1969*	0.0344	0.7934**
9	Test Weight (g)									1.0000	0.2252*	0.2896**
10	Harvest Index (%)										1.0000	0.6289**
11	Grain Yield per Plant (g)											1.0000

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