Assessment of Yield Criteria in Bread Wheat through Correlation and Path Analysis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Path coefficient analysis was used by plant breeders to help identify traits that could be useful as a selection criterion for improving crop yield. The path coefficient divides correlation coefficients into direct and indirect effects within the correlation system of traits. When there is a genetic correlation between two traits, the selection for one of them will produce a change in the other trait. In other words, the response of the correlation to the act of selection will take place. The present investigation was conducted during *rabi* season of 2022-23 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University, Solan, Himachal Pradesh. The experiment consisted of 75 genotypes of wheat with three check varieties viz., RAJ 3765, PBW 343 and HP 1633. The experimental field was divided into three blocks of equal size. Twenty-four entries including checks were accommodated in each block. Results indicated that grain yield per plant(g) have a positive and highly significant correlation with biological yield per plant (g), number of productive tillers per plant, harvest index (%), number of grains per spike. Path analysis identified biological yield per plant and number of productive tillers per plant as important direct components

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for grain yield per plant (g). As per the analysis of variance, variations due to blocks and checks were found to be significant for all the traits. Ten clusters were formed according to Non-hierarchical Euclidean cluster analysis and the maximum inter cluster was recorded between cluster 6 and 8 (86.478), followed by cluster 4 and 8 (83.180). Early maturing genotypes were contained in cluster 1 whereas cluster 4 contained the genotypes which gave the maximus grain yield per plant. High yielding genotypes identified were: DBW- 187, DBW-303, DBW-222, HD-3226 and HS-240. The identified superior can be further utilized in wheat improvement breeding programs.

1. INTRODUCTION

"The wheat crop (*Triticum aestivum* L.) is unique among all cereal crops in terms of importance and is considered one of the most important strategic grain crops in reducing the food gap, which has become the problem of the world as it supplies the world's population with more than 20% of Energy". [1]. "The improvement of cereal crops depends on the continuous processing of new genetic materials that carry different genes, granting many of the desired agricultural characteristics. To meet the growing demand for wheat, it is necessary to work to increase the yield using new genetic resources in the genetic improvement programs for wheat on the one hand and to improve the yield components of the wheat on the other hand, and since the yield is the result of interaction with a large number of its components" [1]. "To determine the best genotypes with desirable traits and use those later in breeding programs and to choose an appropriate selection index that can help in the success breeding programs. Here it is necessary to conduct studies to analyze the variance, find the relationships between the different characteristics, by analysis correlation coefficient and path analysis between yield and its components. Wheat is one of the most important cereal crop grown in different environments due to its versatile nature over the world. At global level, it was cultivated over 221.18 million ha and production of 774.74 million tones with an average productivity of 35 quintals per hectare. In India, it is grown in area of 31.36 million hectares with a production of 107.86 million tones and productivity of 34.4 quintals per hectare" [2]. In Himachal Pradesh, it is grown in area of 3.30 hectares with a production of 6.17 metric tons and productivity of 1869.70 kg per hectare. Wheat holds a prominent position as the primary *rabi* crop in Himachal Pradesh, particularly in Kangra district, where it is cultivated on a large scale.

Correlation coefficients provide insights into the associations between different yield components.

Conducting correlation studies allows us to gauge the strength of these associations between any two traits. Thus, understanding character associations is vital for the concurrent improvement of both yield and its components. Path coefficient analysis was used by plant breeders to help identify traits that could be useful as a selection criterion for improving crop yield. The path coefficient divides correlation coefficients into direct and indirect effects within the correlation system of traits.

2. MATERIALS AND METHODS

The present investigation was conducted during *rabi* season of 2022-23 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University, Solan, Himachal Pradesh. The experimental research farm is located at Chamelti. Geographically, this place is situated at a latitude of 30^0 85"67.30"N and 77^0 13"20.38"E longitude with altitude of 1284 m above sea level. The soil texture is characterized as sandy loam. The weather conditions of *rabi*, 2022-23 (November to April) during the evaluation period were almost normal. The experiment consisted of 75 genotypes of wheat with three check varieties viz., RAJ 3765, PBW 343 and HP 1633. The experimental field was divided into three blocks of equal size. Twenty-four entries including checks were accommodated in each block. Path analysis identified biological yield per plant and number of productive tillers per plant as important direct components for grain yield per plant (g). Analysis of variance for design of experiment was carried out according to Panse and Sukhatme [3]. An estimate of experimental error variance, which was used to compute standard error and least significant difference, was obtained using following format for analysis of variance of the checks yield. The correlation coefficients were worked out using the following formula given by Pearson [4]. Path coefficient analysis was calculated according to the given formula by Dewey and Lu [5].

3. RESULTS AND DISCUSSION

3.1 Correlation Coefficient

The estimate of simple correlation coefficient among 11 characters under study is presented in Table 1.

Biological yield per plant had highest significant positive correlation with grain yield per plant followed by number of productive tillers per plant, harvest index, number of grains per spike, number of spikelets per spike, plant height and test weight. Plant height, days of 75% flowering and spike length had significant negative correlation with grain yield per plant.

Days to 75% flowering had high significant positive correlation with days to maturity and it had non-significant correlation with the number of productive tillers per plant, spike length, number of spikelets per spike, number of grains per spike, biological yield per plant, test weight, harvest index, grain yield per plant and plant height. Plant height had highly significant positive correlation with spike length, biological yield per plant and grain yield per plant and it had non-significant correlation with days to maturity, number of productive tillers per plant, number of spikelets per spike, number of grains per spike, biological yield per plant, test weight and harvest index. Days to maturity had significant negative correlation with number of spikelets per spike, number of grains per spike, number of productive tillers per plant, spike length, biological yield per plant, test weight, harvest index and grain yield per plant. Number of productive tillers per plant had significant positive correlation with number of spikelets per spike, number of grains per spike, biological yield per plant, harvest index and grain yield per plant. It had non- significant correlation with spike length and test weight. Spike length had non-significant correlation with number of spikelets per spike, number of grains per spike, biological yield per plant, test weight, harvest index and grain yield per plant. Number of spikelets per spike had significant positive correlation with number of grains per spike, biological yield per plant, harvest index and grain yield per plant and it had non-significant correlation with test weight. Number of grains per spike had significant positive correlation with biological yield per plant, harvest index, grain yield per plant and it had non-significant correlation with test weight. Biological yield per plant had significant positive correlation with harvest index, grain yield per plant and it had

non-significant correlation with test weight. Test weight had significant positive correlation with grain yield per plant. It had non-significant correlation with harvest index.

"The grain yield in almost all 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 cent 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 component" [6]. In the present investigation, simple correlation coefficients were computed among 11 characters given in Table 2.

In previous studies the grain yield per plant showed positive and highly significant correlation with biological yield per plant, number of productive tiller per plant, harvest index, number of spikelets per spike, number of grains per spike, plant height and test weight except days to maturity, days to 75% flowering, spike length negative correlation with grain yield. The strong positive association of grain yield with one or more of the above traits has also been observed by previous worker [7-9].

The strong positive association of grain yield with above mentioned components, which were also highly correlated with each other, indicated highly favourable situation for obtaining high response through selection. Thus, selection practiced for improving these traits individually or simultaneously is likely to bring improvement in other due to correlated response.

"The above discussion revealed that all the highly significant estimates of correlation coefficient observed among the important yield components. Thus, selection practiced for improving these traits individually or simultaneously is likely to bring improvement in

Table 1. Estimates of simple correlation coefficients between eleven characters in wheat genotypes

Character	Days to 75% Flowering	Plant height (cm)	Days to maturity	Number of productive tillers/plant	Spike length(cm)	Number of spikelets/ spike	Number of grains/ spike	Biological yield /plant(gm)	Test weight (gm)	Harvest index (%)	Grain yield / plant (gm)
Days to 75% Flowering	1.000	0.010	0.271*	-0.056	-0.026	-0.086	-0.082	-0.010	-0.079	-0.124	-0.024
Plant height(cm)		1.000	-0.199	0.131	0.352*	0.056	0.067	0.225*	0.025	0.142	0.223*
Days to maturity			1.000	-0.190	-0.199	-0.261*	-0.250*	-0.044	0.010	-0.134	-0.063
Number of productivee tillers/ plant				1.000	-0.002	0.825*	0.819*	0.898*	0.158	0.764*	0.902*
Spike length(cm)					1.000	0.083	0.067	-0.040	0.047	0.027	-0.029
Number of spikelets /spike						1.000	0.986*	0.769*	0.165	0.736*	0.784*
Number of grains/spike							1.000	0.774*	0.145	0.736*	0.788*
Biological yield /plant(gm)								1.000	0.174	0.792*	0.995*
Test weight(gm)									1.000	-0.012	0.149*
Harvest index(%)										1.000	0.843*
Grain yield /plant(gm)											1.000

others due to correlated response. This suggests that selection would be quite efficient in improving yield and these three yield components in wheat, especially in context of the germplasm collections evaluated. Positive association was reported between plant height with spike length, number of productive tillers per plant and grain yield per plant, number of spikelets per spike and number of grain per spike and between number of grains per spike and grain yieldper plant" [7-11].

3.2 Path Coefficient Analysis

Estimates of direct and indirect effects of different traits on seed yield per plant in path coefficient analysis using simple correlations are given in Table 2.

According to Table 2, revealed that the highest positive direct effects on grain yield per plant were exerted by biological yield per plant (0.8767) followed by harvest index (0.1471). However, other characters contributing significant positive direct effect on seed yield were number of spikelets per spike (0.0138), number of productive tillers per plant (0.0029), plant height (0.0038) and days to 75% flowering (0.0042). The non- significant direct effects on seed yield per plant were exerted by test weight (-0.0020), number of grain per spike (-0.0157), spike length (-0.0001) and days to maturity (-0.0048). Low direct effect recorded for the characters indicating that direct contribution of these characters was too low to be considered for any consequences.

Plant height showed positive correlation with grain per plant via high indirect effects of biological yield per plant followed by harvest index. Number of productive tillers per plant showed positive correlation with grain per plant via high indirect effects of biological yield per plant followed by harvest index. Number of spikelets per spike showed positive correlation with grain per plant via high indirect effects of biological yield per plant followed by harvest index. Number of grains per spike showed positive correlation with grain per plant via high indirect effects of biological yield per plant followed by harvest index. Biological yield per plant showed positive correlation with grain per plant via high indirect effects of harvest index.

Test weight showed positive correlation with grain per plant via high indirect effects of biological yield per plant. Harvest index showed positive correlation with grain per plant via high indirect effects of biological yield per plant.

The correlation coefficient is divided into direct and indirect effects using the common partial regression technique known as the path coefficient (Falconer and Mackay, 1996). Although Wright first developed the idea in 1921, Dewey and Lu applied it for the first time in plant selection in 1959. It has become a potent and popular tool for determining the relative weights of several yield-determining characteristics [12,13]. Since grain yield is a complicated quantitative property, several traits must be taken into account to improve it. Path coefficient analysis is a key tool for creating effective selection strategies because correlation studies alone does not provide a comprehensive picture of the relationship between features.

"Studies have shown a positive direct effect on grain yield for traits like plant height, flag leaf area, days to flowering, 50% heading, days to maturity, peduncle length, spike length, spike per meter, number of spikelets per spike, grain-filling periods, grain weight per spike, biological yield and harvest index, indicating the relationship between these traits as good contributors to grain yield [14,15]. Grain yield was directly impacted most favorably by harvest index, then biomass yield" [14]. The yield of bread wheat may be improved through selection based on these qualities.

In previous studies, days to maturity and 1000 seed weight directly affected grain output in a negative way [15]. These results were in contrast to those of Mecha et al. [16] and Khan et al. [1], who found a direct relationship between days to maturity and 100- seed weight and grain yield that was positive.

This suggests that the environment may have an impact on how yield-related features affect grain yield [15]. Similar studies reported indirect effects of days to maturity via plant height, number of spikes via number of seed/spike [14] in contrast, reported a direct favorable influence of days to maturity. Similar results were obtained in previous studies [17-19,14].

Table 2. Direct and indirect effects of ten characters on grain yield per plant in wheat germplasm

Characters	Days to75% Flowering	Plant height (cm)	Days to maturity	Number of productive tillers/ plant	Spike length (cm)	Number of spiikelets/ spike	Numberof grains/ spike	Biological yield/Plant (gm)	Test weight (gm)	Harvest index (%)	Grain yield/plant (gm)
Days to 75% flowering	**0.0042**	0.0001	-0.0013	-0.0002	0.0001	-0.0012	0.0013	-0.0088	0.0002	-0.0182	-0.024
Plant height(cm)	0.0001	**0.0038**	0.0010	0.0004	0.0001	0.0008	-0.0010	0.1973	0.0001	0.0209	0.223*
Days to maturity	0.0011	-0.0008	**-0.0048**	-0.0005	0.0001	-0.0036	0.0039	-0.0386	0.0001	-0.0197	-0.063
Number of productive tillers/plant	-0.0002	0.0005	0.0009	**0.0029**	0.0001	0.0114	-0.0128	0.7873	-0.0003	0.1124	0.902*
Spike length(cm)	-0.0001	0.0013	0.0010	0.0001	**-0.0001**	0.0011	-0.0010	-0.0351	-0.0001	0.0040	-0.029
Number ofspikelets/ spike	-0.0004	0.0002	0.0013	0.0024	0.0001	**0.0138**	-0.0154	0.6742	-0.0003	0.1083	0.784*
Number of grains/spike	-0.0003	0.0003	0.0012	0.0023	0.0001	0.0136	**-0.0157**	0.6786	-0.0003	0.1083	0.788*
Biological yield/plant(gm)	0.0001	0.0009	0.0002	0.0026	0.0001	0.0106	-0.0121	**0.8767**	-0.0003	0.1165	0.995*
Test weight(gm)	-0.0003	0.0001	0.0001	0.0005	0.0001	0.0023	-0.0023	0.1525	**-0.0020**	-0.0018	0.149*
Harvest index (%)	-0.0005	0.0005	0.0006	0.0022	0.0001	0.0102	-0.0115	0.6943	0.0001	**0.1471**	0.843*

Direct effects on main diagonal (bold figures)

4. CONCLUSION

Grain yield per plant have a positive and highly significant correlation with biological yield per plant, number of productive tillers per plant, harvest index, number of grains per spike, number of spikelets per spike, plant height and test weight. It showed non- significant correlation with days to 75% flowering, spike length and days to maturity. Path analysis identified biological yield per plant and number of productive tillers per plant, number of grains per spike, number of spikelets per spike, plant height and test weight as important direct components for grain yield per plant. The aforementioned traits were recognized as significant direct and indirect components that should be taken into account when formulating an efficient selection strategy for pea in order to create high yielding varieties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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