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Association Analysis of Grain Yield and its Components in Spring Wheat (*Triticum aestivum* L.)

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Abstract: The experiment was designed to investigate the association of some agronomic traits (plant height, number of tillers per plant, flag leaf area, spike length, number of spikelets per spike, number of grains per spike and 1000-grain weight) on grain yield using fifteen wheat genotypes. The obtained results revealed that flag leaf area, spikelets per spike, grains per spike and 1000-grain weight had positive and significant correlation with grain yield at both genotypic and phenotypic levels whereas, spike length was correlated positively and significantly with grain yield at genotypic level but non-significantly at phenotypic level while, tillers per plant showed negative and significant association with grain yield at both levels. Furthermore, path-coefficient analysis revealed that plant height, spike length, grains per spike and 1000-grain weight had positive direct effect on grain yield, whereas, tillers per plant, flag leaf area and spikelets per spike showed negative direct effects on same trait. These results indicated that spike length, grains per spike and 1000-grain weight may be used as direct selection criteria to isolate superior genotypes/lines from genetically mixed populations to develop higher yielding varieties due to positive association and direct effects of these traits on grain yield.

Key words: Correlation · Genotypic · Phenotypic · Path analysis · Grain yield

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important grain and a staple food for more than one third of the world population. The demand of wheat is increasing day by day due to increasing population. Grain yield is a complex trait that is influenced by many traits both in positive and negative direction. Plant height was observed to cause reduction in grain yield due its negative correlation with grain yield [1, 2]. It was found that tillers per plant and spike length were correlated positively with grain yield and contributed to grain yield due to direct positive effects on grain yield [3, 4]. So, tillers per plant and spike length may be used as effective selection criteria. Khan *et al*. [5] reported that tillers per plant had the highest positive direct effect on grain yield followed by spikelets per spike and 1000-grain weight, whereas plant height and spike length had negative direct effect on grain yield. Haq *et al*. [6] observed that spike length, spikelets per spike, grains per spike, tillers per m^2, 1000-grain weight had positive correlation with grain yield. But, selection based merely on phenotype without taking into consideration the direct and indirect effects via other correlated characters, may not prove fruitful. Therefore, path coefficient analysis is considered helpful for plant breeders as it partitions the genotypic correlation coefficient into direct and indirect components. The present study was conducted to estimate the association of different morphological traits with grain yield along with the type and extent of their contribution to yield. The obtained information may play pivotal role in developing breeding strategies to evolve genotypes with higher grain yield production under irrigated conditions.

MATERIALS AND METHODS

The experiment was conducted consecutively two years 2009-10 in the experimental area of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad Pakistan. The experimental material was comprised of fourteen inbred lines viz. V-05082, HB-10, DN-62, V-15, PR-102, ZAS-70, V-05, V-70309, QS-111, AVP-4008, V-10, SD-4085, V-9476 and CT-4192 and one standard variety Sehar-2006. The seeds of these genotypes were planted through dibbler, with inter-plant and inter-row distances 15 and 30 cm, respectively, in randomized complete block design with three repeats under normal irrigated conditions. Single row of 5m length

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served as an experimental unit. Non-experimental plants were also raised at the borders to eliminate competition among marginal plants. At maturity, ten guarded plants from each row was randomly selected and data were recorded for plant height (cm), number of tillers per plant, flag leaf area (cm^2), spike length (cm), number of spikelets per spike, number of grains per spike, 1000 grain weight (g) and grain yield per plant.

The obtained data were used to determine the genotypic and phenotypic correlation coefficients between all possible pairs of the characters from the genotype means through the method given by Kwon and Torrie [7] and the path coefficient analysis as described by Dewey and Lu [8].

RESULTS AND DISCUSSION

Correlation: Genotypic and phenotypic correlations for all possible combinations for traits under study are presented in the Table 1. In general, the genotypic correlation coefficients were larger in values as compare to their corresponding phenotypic correlation coefficients. This indicates greater contribution of genetic factors in development of associations among traits. The observations regarding the association of various traits are explained separately as under.

Plant height was observed to be associated positively but non-significantly with tillers per plant, flag leaf area, spike length and spikelets per spike at genotypic and phenotypic levels. Whereas, negative and significant correlation of plant height with grains per spike was found at both levels indicating longer the genotype lesser may be grain number per spike. While negative and non-significant association of plant height with 1000-grain weight and grain yield was observed at both levels. Mondal *et al.* [1] also reported negative and non-significant association of plant height with grain yield.

A negative and non-significant correlation of tillers per plant with flag leaf area and spikelets per spike was observed at both levels whereas, correlation between tillers per plant and grains per spike was significantly negative at phenotypic level but non-significantly at genotypic level. But, tillers per plant was found to be associated positively but non-significantly with 1000-grain weight. A significant negative correlation between tillers per plant and grain yield was recorded at genotypic and phenotypic levels indicating selection based on tillers per plant may lead to reduction in yield that contradicted the findings of Khan *et al.* [5].

There was observed positive and non-significant correlation of flag leaf area with spike length and spikelets per spike at both levels, while, negative and non-significant correlation with grains per spike and 1000-grain weight was found. A positive and significant association of flag leaf area with grain yield indicated the importance of flag leaf area in evolving superior genotypes. These results were in agreement with those of Ali *et al.* [9].

A review of table 1 reveals that spike length had positive and highly significant correlation with spiklelets per spike at genotypic as well as phenotypic level. The relationship between spike length and grains per spike was positive and significant at genotypic and phenotypic levels while, non-significant positive correlation between spike length and 1000-grain weight was observed. Spike length was found correlated positively and significantly with grain yield at genotypic level [10]. These results showed that genotypes with longer spike length may produce more yields as compared to those with shorter spike length.

Table 1: Genotypic and phenotypic correlation coefficients among yield and its components in wheat.

Characters	Tillers/ plant	Flag leaf area	Spike length	Spikelets/spike	Grains/ spike	1000-grain weight	Grain yield
Plant r_g	0.0795	0.2090	0.2877	0.1434	-0.5399*	-0.3312	-0.107
Height r_p	0.12340	0.1933	0.1877	0.1227	-0.4699*	-0.2614	0.0888
Tillers/ r_g		-0.4303	0.1995	-0.2959	-0.0064	0.089	-0.3679*
Plant r_p		-0.3467	0.1954	-0.1898	-0.0071*	0.0619	- 0.2887*
Flag leaf r_g			0.1192	0.0534	-0.1391	-0.0424	0.2432*
Area r_p			0.0697	0.052	-0.1356	-0.0317	0.2395*
Spike r_g				0.7265**	0.1490*	0.1436	0.4469*
Length r_p				0.5692**	0.0954*	0.0815	0.3235
Spikelets r_g					0.0991**	-0.0943**	0.5592*
Per spike r_p					0.0887**	-0.0945**	0.5183*
Grains/ r_g						0.2356*	0.2460*
Spike r_p						0.2285*	0.2437*
1000- r_g							0.4679*
Grain r_p							0.4607*
Weight							

* = Significant at 5% level

** = Highly Significant at 1% level

Table 2: Direct and Indirect effects of various traits on grain yield in wheat.

Characters	Plant height	Tiller/ plant	Flag leaf area	Spike length	Spikeletper spike	Grain/ spike	1000-grain wt
Plant height	0.1927	-0.0497	-0.0083	0.3062	-0.0266	-0.8030	-0.2786
Tillers/ plant	0.0153	-0.6248	0.0172	0.2123	0.0548	0.0001	-0.3679
Flag leaf area	0.0403	0.2689	-0.0399	0.1269	-0.0099	-0.207	-0.0357
Spike length	0.0554	-0.1247	-0.0048	1.064	-0.1346	0.022	0.4469
Spikelets per spike	0.0276	0.1849	-0.0021	0.7732	-0.1853	0.0147	0.5592
Grains per spike	-0.104	-0.0004	0.0055	0.1586	-0.0184	0.1487	0.1982
1000-grain weight	-0.0638	-0.0556	0.0017	0.1528	0.0175	0.035	0.8411

Highly significant and positive association between spikelets per spike and grains per spike at genotypic and phenotypic levels was recorded indicating that genotypes having more spikelets per spike would produce more grains per spike and hence grain yield [6]. Highly significant negative correlation between spikelets per spike and 1000-grain weight was observed whereas, positive and significant correlation between spikelets per spike and grain yield at both levels was found suggesting that spikelets per spike should be considered important selection criteria in evolving higher yielding genotypes [10].

There was found positive and significant correlation between number of grains per spike and 1000-grain weight at both genotypic and phenotypic levels that contradicted the work of Ali *et al*. [9]. Grains per spike was associated positively and significantly with grain yield at both genotypic and phenotypic levels that lead to infer grains per spike an important selection criteria for enhancing grain yield. Positive and significant correlation was recorded between 1000-grain weight and grain yield at both genotypic and phenotypic levels that contradicted the findings of Khan *et al.* [11] who reported significant negative correlation between 1000-grain weight and grain yield. The results of this study indicated that genotypes with higher 1000-grain weight would produce more grain yield under irrigated conditions as earlier proposed by Mondal *et al*. [1].

Path Coefficient: Path coefficient analysis helps to estimate the influence of each variable upon the resultant variable directly as well as indirectly by partitioning the genetic correlation coefficients. Grain yield per plant was selected as resultant variable and plant height, tillers per plant, flag leaf area, spike length, spikelets per spike, number of grains per spike and 1000-grain weight as causal variables. The results of path analysis are illustrated in Table 2.

The direct effect of plant height on grain yield was positive (0.1927). The indirect effects of plant height via tillers per plant, flag leaf area, spikelets per spike, grains per spike and 1000-grain weight were negative with values of -0.0497, -0.0083, -0.0266, -0.0342 and -0.2786, respectively. The indirect positive contributor to grain yield was spike length with value of 0.3062. These results revealed that plant height had positive indirect effects on grain yield mainly through spike length. Therefore, plant height and spike length may be considered simultaneously in any breeding programme designed to improve grain yield while negative indirect effects can be reduced by using careful breeding strategies. These results contradicted with the findings of Mahmood [12].

It is evident from Table 2 that direct effect of tillers per plant on grain yield was negative (-0.6248). In contrast, Narwal *et al*. [3], reported high positive direct effect of tillers per plant on grain yield. The indirect effects via plant height, flag leaf area, spike length, spikelets per spike and grains per spike were recorded positive with values of 0.0153, 0.0172, 0.2123, 0.0548 and 0.0001, respectively whereas, indirect effect via 1000-grain weight was negative (-0.3679). Positive indirect effects of tillers per plant via plant height, flag leaf area, spike length, spikelets per spike and grains per spike suggested that indirect selection for tillers per plant may increase grain yield in the long run.

Flag leaf area showed negative direct effect on grain yield with value of -0.0399 that contradicted with the finding of Bhutta *et al.* [13] who reported positive direct effect of flag leaf area on grain yield. Indirect effects via plant height (0.0403), tillers per plants (0.2269) and spike length (0.1269) were recorded positive whereas, indirect negative contributors were spikelets per spike (-.0099), grains per spike (-0.0207) and 1000-grain weight (-0.0357).

The direct effect of spike length on grain yield was recorded to be positive with a value of 1.0642. The indirect positive effects of spike length via plant height (0.0554), grains per spike (0.0222) and 1000-grain weight (0.1208) on grain yield were observed whereas, negative indirect effects via tillers per plant (-0.1247), flag leaf area (-0.0048) and spikelets per spike (-0.1346) were observed. The results revealed that spike length may be used as direct selection criteria in any breeding programme designed to increase grain yield. These findings were in accordance with those of Narwal *et al*. [3] and Mohsin *et al.* [4].

Path coefficient results in table 2 showed that direct effect of spikelets per spike on grain yield was negative (-.1853) whereas, Uddin *et al*. [14] reported positive direct effect of spikelets per spike on grain yield. The indirect effects via plant height, tillers per plant, spike length and grains per spike were found positive with the values of 0.0276, 0.1849, 0.7732 and 0.0147 respectively. While, indirect effects of spikelets pwer spike via flag leaf area and 1000-garain weight were negative having path coefficient values of -0.0021 and -0.0793, respectively. The results thus revealed that selection based on traits like plant height, tillers per plant, spike length and grains per spike may be practiced for the evolving high yielding genotypes.

A review of Table 2 showed that the direct effect of grains per spike on grain yield was positive with value of 0.1487 hence selection for yield improvement can be done on the basis of grains per spike. Indirect effects via plant height, tillers per plant and spikelets per spike were negative with path coefficient values of -0.104, -0.0004 and -0.0184, respectively. However, positive indirect effects were recorded via flag leaf area (0.0055), spike length (0.1586) and 1000-grain weight (0.1982). These results were in agreement with those of Narwal *et al.* [3]. The direct effect of 1000-grain weight on grain yield was positive with value of 0.8411, suggesting its importance in breeding programme for developing wheat genotypes with higher grain yield. The indirect effects of 1000-grain weight via plant height and tillers per plant were recorded negative with the values of -0.0638 and -0.0556, respectively. Indirect positive effects via flag leaf area (0.0017) spike length (0.1528), spikelets per spike (0.0175) and grains per spike (0.035) were recorded.

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