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Heritability, Correlation and Path Coefficient Analysis for Some Metric Traits in Wheat

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ABSTRACT

Heritability, inter-relationship and path coefficient studies were performed in a 5 × 5 diallel cross of wheat. Moderate to very high broad sense heritability was estimated for all the morphological characters except fertile tillers per plant. Plant height exhibited highest heritability value of 92.08% while fertile tillers per plant showed minimum value of 40.71%. Genotypically plant height, spike length, spikelets per spike, grains per spike and 1000-grain weight were positively and significantly correlated with grain yield while highly significantly associated phenotypically. Flag leaf area was positively but non-significantly associated with grain yield; whereas, fertile tillers per plant was negatively and non-significantly correlated with grain yield. Plant height, flag leaf area, spike length and grains per spike had positive direct effects on grain yield. While fertile tillers per plant, spikelets per spike and 1000-grain weight exhibited negative direct effects on grain yield. The traits having positive direct effects on grain yield are considered to be suitable selection criteria for evolving high yielding genotypes

Key Words: Heritability; Correlation; Path analysis; Morphological traits; Grain yield

INTRODUCTION

Grain production is a complex phenomenon, entailing several contributing factors. These factors influence grain production both directly and indirectly and the breeder is naturally interested in investigating the extent and type of association of such traits. Towards a clear understanding of the type of plant traits, correlation and path coefficient analysis are logical steps. Phenotypic and genotypic correlations within varieties are of value to indicate the degree to which various characters are associated with economic productivity. Path coefficient analysis is a reliable statistical technique which provides means not to quantify the interrelationships of different yield components but also indicates whether the influence is directly reflected in the yield or takes some other path way for ultimate effects. Studies like heritability estimates could also be helpful to know the performance of parents in hybrids.

Akbar *et al.* (1995) studied genetic variability and inter-relationships between agronomic traits in 24 bread wheat genotypes and indicated that all the traits except plant height were positively associated with grain yield. Correlation of number of spikes and number of grains per spike with grain yield were significant. However, both these components were negatively interrelated. Path coefficient analysis revealed higher direct effect of number of grains per spike, followed by number of spikes and 1000-grain weight on grain yield. Uddin *et al.* (1997) observed the highest coefficient of variation for grains per spike followed by 1000-grain weight and grain yield per plant. Grain yield per plant was positively and significantly correlated with spikelets per spike and 1000-grain weight; whereas, in path coefficient analysis high direct effect was observed for spikelets per spike and tillers per plant. High broadsense heritability was exhibited by 1000-grain weight, moderate for grains per spike and low for rest of the characters. Subhani and Chowdhry (2000) observed highly significant differences among the genotypes and found that grain yield was positively and significantly correlated with flag leaf area, tillers per plant, spike length, grains per spike and 1000-grain weight. Path coefficient analysis showed that tillers per plant and spikelets per spike had positive direct effects on grain yield under irrigated conditions. Jedynski (2001) explained the correlation and path coefficient for grain yield and its components in wheat. He also reported heritability estimates which were very high for plant height, high for 1000-grain weight, intermediate for number of grains per spike and very low for grain yield per plant.

MATERIALS AND METHODS

The research work was carried out in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad (Pakistan) during the rabi crop season 2002-03. The experimental material consisted of five local varieties of bread wheat viz., Inqalab 91, Uqab 2000, Punjab 96, MH. 97 and Fsd. 85 and their 20 F_1 hybrids were sown in the field in a triplicated randomized complete block design. The seeds were dibbled in rows keeping within and between row distances at 15 and 30 cm, respectively. Single row of 5 m length served as an experimental unit. Three seeds per hill were sown to ensure the crop stand, which were thinned to single seedling per site after germination. Non-experimental plants were also raised at the borders to eliminate competition among marginal plants. At maturity 10 guarded plants from each row were randomly selected and data were recorded for plant height (cm), flag leaf area (cm^2), number of fertile tillers per plant, spike length (cm), number of spikelets per spike, number of grains per spike, 1000-grain weight (g) and grain yield per plant (g).

Analysis of variance was done using the method of Steel and Torrie (1984). Heritability in broad sense was estimated from the result of variance analysis according to the formula used by Burton and DeVane (1953). Genotypic and phenotypic correlations were worked out according to the method given by Kwon and Torrie (1964). The direct and indirect effects of each trait were assessed by path analysis using the method of Dewey and Lu (1959).

RESULTS AND DISCUSSION

Heritability. Analysis of variance for yield and its components of 25 genotypes of wheat for eight quantitative characters measured (Table I), revealed that the differences among genotypes were highly significant ($P \leq 0.01$) for all the characters.

The genotypic coefficient of variability ranged from 4.07 to 10.72% and phenotypic coefficient of variability from 4.36 to 16.79% suggesting that environment had no influence on the characters under study.

Highest heritability of 92.08% was exhibited by plant height. The present results are in accordance with those previously reported by Jedynski (2001) in wheat for this character. Heritability of 86.27 and 85.80% was observed for spike length and grain yield per plant, respectively. These results contradicted with findings of Nabi *et al.* (1998) and Jedynski (2001) who reported very low heritability estimates for spike length and grain yield per plant. High heritability estimates depict that plant height, spike length and grain yield per plant have high transmitting ability to next generation.

The other traits like grains per spike, 1000-grain weight, spikelets per spike and flag leaf area displayed moderately high heritability values of 78.41, 71.53, 70.61 and 61.20%, respectively. Pawar *et al.* (1988) and Mandal *et al.* (1991) reported similar results for spikelets per spike and 1000-grain weight; whereas, Chowdhry and Salahuddin (1990) and Alam *et al.* (1996) illustrated similar findings for number of grains per spike. Lowest heritability was observed for fertile tillers per plant with value of 40.71%. While in contrast, Pal and Garg (1992) and Mahmood and Shahid (1993) reported high heritability value for fertile tillers per plant. The difference in findings may be due to various reasons including the genetic material used and environmental conditions.

The results presented in Table I indicate that highest value of genetic advance 12.036 was displayed by the trait grains per spike, followed by plant height and flag leaf area with values of 7.487 and 6.068, respectively.

Correlation. Genotypic and phenotypic correlations for all possible combinations for traits under study are presented in Table II. In almost all the cases genotypic correlations were higher as compared to phenotypic ones. The observations regarding the association of various traits are explained as under.

Table I. Estimates of mean squares, means, genotypic and phenotypic coefficients of variability, heritability and genetic gain

Character	Mean squares (Genotypes)	Mean	Coefficient of variability		Heritability (%)	Genetic advance
			Genotypic (%)	Phenotypic (%)		
Plant height	60.987**	106.308	4.18	4.36	92.08	7.487
Flag leaf area	70.977**	53.613	8.24	10.54	61.20	6.068
Fertile tillers per plant	8.285**	12.724	10.72	16.79	40.71	1.527
Spike length	3.775**	14.400	7.59	8.17	86.27	1.782
Spikelets per spike	2.731**	21.993	4.07	4.84	70.61	1.319
Grains per spike	196.137**	73.365	10.55	11.91	78.41	12.026
1000-grain weight	25.157**	37.964	7.17	8.47	71.53	4.039
Grain yield per plant	21.670**	25.204	10.38	11.21	85.80	4.253

Table II. Genotypic (G) and phenotypic (P) correlation coefficients of various metric traits in wheat

Character		Flag leaf area	Fertile tillers per plant	Spike length	Spikelets per spike	Grains per spike	1000-grain weight	Grain yield per plant
Plant height	r_g	0.409*	-0.240	0.254	0.548*	0.602*	0.510*	0.681*
	r_p	0.346*	-0.109	0.219	0.445**	0.523**	0.416**	0.610**
Flag leaf area	r_g		-0.778	0.151	0.631*	0.217	0.489*	0.298
	r_p		-0.262	0.182	0.519**	0.249	0.306*	0.293
Fertile tillers per plant	r_g			-0.784	-0.831	-0.525	-0.657	-0.161
	r_p			-0.310*	-0.290*	-0.121	-0.452**	0.023
Spike length	r_g				0.823*	0.793*	0.199	0.467*
	r_p				0.792**	0.755**	0.130	0.446**
Spikelets per spike	r_g					0.866*	0.297	0.618*
	r_p					0.822**	0.232	0.548**
Grains per spike	r_g						0.109	0.640*
	r_p						0.034	0.598**
1000-grain weight	r_g							0.506*
	r_p							0.419**

* = Significant ($P \leq 0.05$); ** = Highly significant ($P \leq 0.01$)

The correlation between plant height and flag leaf area was positive and significant ($P \leq 0.05$) at both genotypic and phenotypic levels. Whereas, negative and non-significant association with fertile tillers per plant was observed at genotypic and phenotypic levels, hence lesser the plant height more will be number of tillers per plant. Positive and non-significant correlation with spike length at genotypic and phenotypic level was observed. While positive correlation of plant height, significant at genotypic level and highly significant ($P \leq 0.01$) at phenotypic level with characters like spikelets per spike, grains per spike, 1000-grain weight and grain yield per plant was observed. Akhtar *et al.* (1992) also reported similar findings.

A non-significant and negative correlation was observed between flag leaf area and tillers per plant. Flag leaf area was positively and non-significantly associated with spike length, grains per spike and grain yield per plant at both genotypic and phenotypic levels. Subhani and Chowdhry (2000) also reported positive and non-significant association of flag leaf area and grain yield per plant. The trait 1000-grian weight was significantly and positively correlated with flag leaf area at both levels. Highly significant and positive correlation at phenotypic level but only significant at genotypic level was observed between spikelets per spike and flag leaf area.

Fertile tillers per plant displayed negative and non-significant relationship at genotypic level with spike length, spikelets per spike, grains per spike, 1000-grian weight and grain yield per plant, suggesting that increase in tiller number reduces the grain number, grain size and ultimately low grain yield per plant. While negative and significant correlation for spike length, spikelets per spike and negative and highly significant correlation with 1000-grian weight was observed with tillers per plant at phenotypic level.

There was a positive and significant correlation between spike length and spikelets per spike, grains per spike and grain yield per plant at genotypic level. Whereas spike length was positively and highly significantly associated with spikelets per spike, grains per spike and grain yield per plant at phenotypic level. Correlation between spike length and 1000-grain weight was positive and non-significant at both genotypic and phenotypic levels. The value of genotypic correlation was found to be greater than phenotypic correlation so, it indicates a relationship between 1000-grain weight and spike length and this association merits attention in the improvement process. These results were in agreement with those of Chowdhry *et al.* (1991) and Nabi *et al.* (1998). Thus, increase in spike length is directly associated with increase in spikelets per spike, grain number per spike, grain weight and ultimately the grain yield per plant.

A review of Table II reveals that genotypic correlation coefficient between spikelets per spike and grains per spike, grain yield per plant was positive and significant while phenotypic correlation coefficients were positive and highly significant (Uddin *et al,.* 1997; Nabi *et al.,* 1998). The pattern of association suggests that selection for more number of spikelets per spike may result in an increased number of grains per spike and ultimately greater yield per plant. Whereas, correlation between spikelets per spike and 1000-grain weight was positive but non-significant at genotypic as well as phenotypic level.

Association of grains per spike and grain yield per plant was positive and significant at genotypic level and highly significant at phenotypic level. Nabi *et al.* (1998) also reported similar results. While positive and non-significant correlation was observed between grains per spike and 1000-grain weight. Positive and significant relationship was recorded at genotypic level and highly significant at phenotypic level between 1000-grain weight and grain yield per plant, indicating that increase in 1000-grain weight would increase grain yield per plant. Similar results have also been reported by Mikheev (1992) and Narwal *et al.* (1999).

Path coefficient. Path coefficient analysis provides an effective way of finding out direct and indirect sources of correlations, using genotypic correlations of different plant attributes. Grain yield per plant was selected as resultant variable and plant height, flag leaf area, fertile tillers per plant, spike length, spikelets per spike, grains per spike and 1000-grain weight as casual variables. The results of path analysis are illustrated in Table III.

The direct effect of plant height on grain yield per plant was positive showing a computed path coefficient value of 7.599. The indirect effects via flag leaf area (4.167), fertile tillers per plant (2.383), spike length (2.399) and grains per spike (5.893) were positive. The indirect negative effects were contributed through spikelets per spike and 1000-grain weight with values of -17.524 and -4.236, respectively. However, the deleterious negative indirect effects were neutralized by its positive indirect effects. Positive direct effect of plant height suggests that direct

Table III. Direct (diagonal) and indirect effects of various metric traits on grain yield in wheat

Character	Plant height	Flag leaf area	Fertile tillers per plant	Spike length	Spikelets per spike	Grains per spike	1000-grain weight	Correlation coefficient (r)
Plant height	7.599	4.167	2.383	2.399	-17.524	5.893	-4.236	0.681
Flag leaf area	3.109	10.188	7.728	1.421	-20.211	2.122	-4.059	0.298
Fertile tillers per plant	-1.822	-7.922	-9.938	-7.393	26.593	-5.138	5.459	-0.161
Spike length	1.932	1.535	7.786	9.437	-26.336	7.763	-1.650	0.467
Spikelets per spike	4.160	6.433	8.256	7.764	-32.009	8.482	-2.468	0.618
Grains per spike	4.571	2.207	5.213	7.479	-27.720	9.795	-0.905	0.640
1000-grain weight	3.874	4.977	6.529	1.874	-9.505	1.067	-8.310	0.506

selection for this trait for high grain yield would be effective. The results were in agreement with the findings of Akhtar *et al.* (1992).

The perusal of Table III indicated that flag leaf area had positive direct effect on grain yield per plant (10.188), as also reported by Alam *et al.* (1993). While similar positive values were obtained from the indirect effects via plant height (3.109), fertile tillers per plant (7.728), spike length (1.421), and grains per spike (2.122); whereas, spikelets per spike and 1000-grain weight had negative indirect effects on grain yield per plant with path coefficient values of -20.211 and -4.059. Highly positive direct effects suggest that flag leaf area is an important component of grain yield, hence merits special attention in the selection strategies.

Fertile tillers per plant had negative direct effect on grain yield per plant with a value of -9.938. Similarly, negative values were obtained from indirect effects via plant height (-1.822), flag leaf area (-7.922), spike length (-7.393) and grains per spike (-5.138), only two traits indicated positive indirect effects via spikelets per spike (26.593) and 1000-grain weight (5.459). The present studies contradicted with the findings of Ahmad *et al.* (1994) who reported highly positive direct association between fertile tillers per plant and grain yield. The difference may be due to different environmental conditions and breeding material used. In this case, the direct selection for number of tillers per plant will decrease the yield, however, indirect selection through spikelets per spike and 1000-grain weight may be beneficial.

The path coefficient analysis indicated that spike length had a positive direct effect on grain yield per plant with computed value of 9.437 (Akhtar *et al.,* 1992). While similar positive indirect effects of plant height, flag leaf area, fertile tillers per plant and grains per spike were observed with calculated coefficient values of 1.932, 1.535, 7.786 and 7.763, respectively. However, characters like spikelets per spike (-26.336) and 1000-grain weight (-1.650) had negative indirect effects. These results suggest that grain yield can be enhanced through selection for spike length, plant height, flag leaf area, fertile tillers per plant and grains per spike but in this process care must be exercised to minimize the negative effect likely to be produced through spikelets per spike and 1000-grain weight.

The direct effect of spikelets per spike on grain yield was recorded to be negative and highest with a value of -32.009. The indirect effects via plant height (4.160), flag leaf area (6.433), fertile tillers per plant (8.256), spike length (7.764) and grains per spike (8.482) were positive. The trait 1000-grain weight was the only indirect negative contributor with value of -2.468. These results clearly indicated that although direct effect of spikelets per spike was negative but it exerted positive effects through other traits like plant height, flag leaf area, fertile tillers per plant, spike length and grains per spike to finally increase yield.

The results presented in Table III indicated that grains per spike had positive direct effect on grain yield (9.795). The indirect effects via plant height, flag leaf area, fertile tillers per plant and spike length were positive with path coefficient values of 4.571, 2.207, 5.213 and 7.479, respectively. While indirect effects via spikelets per spike (-27.720) and 1000-grain weight (-0.905) were negative. Positive direct effect of grains per spike suggests that direct selection for this trait for high grain yield would be effective. These results are in agreement with those of Akbar *et al.* (1995). High values of indirect effects via. spike length, fertile tillers per plant and plant height suggested that indirect selection for grains per spike through these characters may also increase the grain yield.

It is obvious from Table III that 1000-grain weight showed negative direct effects on grain yield by displaying a value of -8.310. In contrast, Akbar *et al.* (1995) reported high positive direct effect of 1000-grain weight on grain yield per plant. Whereas 1000-grain weight had positive indirect effects through plant height, flag leaf area, fertile tillers per plant, spike length and grains per spike with the magnitudes of 3.874, 4.977, 6.529, 1.874 and 1.067, respectively. While negative effects on grain yield were exerted through spikelets per spike with a value of -9.505. However, the deleterious negative effects directly and indirectly were neutralized by its positive indirect effects. So, selection can be made for 1000-grain weight indirectly through plant height, flag leaf area, fertile tillers per plant, spike length and grains per spike.

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