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Path Coefficient Analysis in Bread Wheat

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Abstract: Phenotypic and genotypic variance, heritability (h^2), genetic advance (GA), correlation coefficients and path coefficient analysis were conducted for yield and yield components in eight genotypes of wheat under rain fed conditions. High heritability estimates coupled with increasingly high genetic advance were observed for plant height, tiller $2m^{-2}$, biological yield, spike length, harvest index and yield kg ha^{-1}.Therefore, these characters were controlled by additive gene action and improvement may be expected by direct selection. High direct effects were contributed by biological yield and spike length with positive association to economic yield. It was observed that high indirect contribution was via biological yield by most of the yield components and hence these two traits (biomass and spike length) should be given emphasis while selecting high yielding wheat genotypes rain fed conditions.

Key words : *Triticum aestivum*, heritability, genetic advance, harvest index, rainfed conditions, biological yield, grain yield, Pakistan

Introduction

Grain yield in wheat (*Triticum aestivum* L.) is the result of a number of complex morphological and physiological processes affecting each other and occurring on different growing stages of vegetation period. Some yield components significantly affect grain yield through effects at different growing stages, from sowing to the harvest. Therefore, one needs to know more about these traits and how they affect grain yield so one can breed new genotypes that have high yields.

Phenotypic and genotypic variance, heritability and genetic advance have been used to assess the magnitude of variance in wheat breeding material (Jhonson *et al*., 1956; Khan, 1990; Zaheer *et al*., 1987). In wheat, breeders try to explain the relations between grain yield and agronomic and morphological traits by using simple correlation coefficient. Although correlation coefficient is very important to determine traits that directly affect grain yield, they are insufficient to determine indirect effects of these traits on grain yield (Bhatt, 1973).

These situations are more common in cereals because of yield traits that occur at a different growing stage and affect each other, especially where early occurring traits influence later traits (Dofing and Knight, 1992). It was pointed out that there was a dynamic balance among yield traits, which prevent improvement of grain yield through selection for just one yield trait (Grafius, 1972).

It has been suggested that yield components have either a direct or an indirect effect on grain yield, or both. Therefore, it was essential to determine the effects of yield components on grain yield. Consequently, path coefficient analysis is the most common statistical method used for this purpose.

Thus, it is possible to calculate both direct and indirect effects of yield components on grain yield through the other components. In other words, path analysis can be used to calculate the quantitative impact on yield of direct or indirect effects caused by one or the other components. Agronomist in wheat (Bhatt, 1973; Fonseca and Patterson, 1968; Weigand *et al*., 1981; Gebeyhou *et al*., 1982a and b; Borojevic and Williams, 1982; Mou, 1990), barley (Pury *et al*., 1982; Kirtok and Colkesen, 1985; Garcia *et al*., 1991), bean (Duarte and Adams, 1972) and cowpea (Altinbas and Sepetoglu, 1993) commonly use path coefficient analysis to explain clearly the relations among yield components.

The aim of this research, carried out with eight common wheat genotypes was to use the path coefficient analysis to determine the direct and indirect effects of plant height, tillers $2m^{-2}$, biological yield, harvest index and spike length on grain yield.

Materials and Methods

The eight bread wheat genotypes viz., Margala-99, Chakwall-97, Kohistan, Suleman-96, MH-97, Rawal-87, Chakwal-86 and Inqlab-91 were planted in randomized complete block design (RCBD) in triplicate fashion during rabi 2000-01 at National Agricultural Research Centre, Islamabad. Six 5 m long rows were planted by keeping 30 cm space between row. Recommended cultural practices such as weeding and hoeing were followed. At maturity, data were recorded for plant height (cm), tillers/2m^2, spikelength (cm), harvest index (%), biological yield (kg ha^{-1}) and grain yield (kg ha^{-1}). The data were recorded on area basis rather than plant, because it is difficult to distinguish individual plants, when planted with wheat drill. The data were subjected to analysis of variance suggested by Steel and Torrie (1960). Heritability estimates in broad sense (h^2_{bs}), genetic advance, genetic correlation and path coefficient analysis were conducted according to the method followed by Singh and Chaudhry (1978). Correlation coefficient were calculated as followed by Al-Jibouri *et al.* (1958).

Results and Discussion

Highly significant difference among genotypes were observed for all the traits studied (Table 1). The variety Margall-99 produced the highest grain yield (916.67 kg ha^{-1}) and was followed Inqlab-91 and Rawal-87 with grain yields of 873.33 and 836.67 kg ha^{-1}, respectively. The variety Margall-99 was the tallest with 93.66 cm plant height and was followed by Rawal-87 (91.39 cm). Chakwal-86 has maximum number of tillers 2m^{-2} (675.67) and spike length but produced less compared to Margall-99 which gave (659) tillers 2m^{-2} with spikelength (9.38) and highest grain yield of (916.67) kg ha^{-1}, thereby suggesting that it had more closer spikelet and more number of grains per spike. It seems that in this variety, which is developed for rainfed area, plant height and biological yield exhibited high effects towards grain yield (Table 1). Variety Chakwal-97 exhibited the highest harvest index (42%). High heritability coupled with high genetic advance were estimates recorded for all traits studied. These characters were controlled by additive gene action and therefore, improvement was expected by direct selection. Khan (1990) reported high heritability along with high genetic advanced for yield and its components, indicating the importance of additive genetic variation. High heritability estimates indicate that large proportion of the total variance was attributable to the genotypic variance and that these characters differ among the population. Wheat breeders considered heritability (h^2) estimates along with the genetic advance values because h^2 alone is not good indicator of the amount of usable genetic variability (Masood *et al*., 1986).

Phenotypic coefficient of variation, in general was higher than the genotypic coefficient of variation for all characters. Tillers/2m^2, biological yield, harvest index and grain yield possessed more than 10% variation both phenotypic and genotypic levels excluding harvest index which was 8.62% at genotypic level. Maximum variation (15.03%) appeared in biological yield followed by grain yield (14.89%) at phenotypic level (Table 1). Ehdaie and Waines (1989) reported high genotypic and phenotypic coefficients of variation for number of spikes/plant, number of grains/spike 100-grain weight, harvest index and grain yield/plant, which partially support present results. The difference between phenotypic and genotypic coefficients of variation was minimum for all the traits. This suggests that they are primarily due to genetic effects. These results are partially in agreement with the findings of Imtiaz uddin and Shamsuddin (1999).

Correlation coefficient analysis: The results on genotypic and phenotypic and environmental correlation coefficient revealed that the genotypic correlation were higher than phenotypic ones for most of the characters, exhibiting high degrees of genetic association among traits under consideration (Table 2). No significant environmental correlation coefficients were found for any character, however its value remained sufficiently high in case of plant height for tiller/2m^2, biological yield and spikelength and grain yield with respect to the other two correlation coefficients (Table 2). The study was conducted under rainfed conditions therefore, these results are also valid for selection under rainfed conditions therefore. Grain yield was positively and significantly correlated with all traits except plant height. Plant height had positive correlation with all traits except harvest index and grain yield where it was negative. These results are partially in concordance with the findings of Ashraf *et al.* (2002). Therefore, short stature genotypes were selected for better harvest index and grain yield. Tillers/2m^2 and biological yield had positive correlation with all. Biological yield and spikelength exhibited positive and significant correlation with harvest index and grain yield, respectively. These findings are partially supported by the work of Ashraf *et al.* (2002). However, harvest index was significantly and positively associated with the grain yield (Table 2). The negative correlation of some important characters viz., plant height vs harvest index (%) and plant height vs grain yield may lead to some undesirable selection based on these characters. The extent of selection depends on whether the negative association is due to linkage or pleiotropic effect. The negative associations of these character pairs were to impose problem in combining important yield components in one genotype. To improve the yield components with negative association with other, suitable recombinations may be obtained through biparental mating, mutation breeding or diallel selective mating by breaking undesirable linkages.

Table 1: Means, phenotypic and genotypic coefficients of variation, heritability($_{bs}$) and genetic advance for yield and yield contributing characters in bread wheat

Genotypes	X1	X2	X3	X4	X5	X6
Margala-99	93.66	659	2673.33	9038	0.41	916.67
Chakwal-97	85.17	605.33	2760	9027	0.42	750
Kohistan	80.67	556.67	2133.33	8.50	0.38	826.67
Suleman-96	91.30	552.67	1850	7.55	0.30	566.67
MH-97	80.28	506	1883.33	8.93	0.38	726.67
Rawal-87	91.39	517.33	2166.67	9.83	0.38	836.67
Chakwal-86	84.3	675.67	2150	9.93	0.37	806.67
Inqlab-91	81.74	610.33	2400.33	8.60	0.36	873.33
Means	86.06	585.37	2252.12	8.99	0.37	787.91
F ratio(V)	142.62**	115.16**	97.67**	9.63**	6.80**	11.56**
F ratio(R)	2.94ns	2.13ns	6.14ns	0.98ns	0.27ns	1.74ns
St.error	0.45	5.83	33.92	0.25	1.34	31.86
Heritability(bs)	0.97	0.97	0.96	0.74	0.65	0.77
GA	9.13	107.47	570.62	0.94	1.43	158.63
GA%	10.60	18.35	25.33	10.69	38.54	20.13
PCV	6.23	10.80	15.03	9.57	10.61	14.89
GCV	6.16	10.64	14.81	8.24	8.62	13.14

GA=genetic advance % at 10% selection differential, *,** significancy levels at 5% and 1%, respectively, PCV= phenotypic and GCV= genotypic coefficient of variability, X1= plant height (cm), X2= tillers/2m^2, X3= biological yield (kg ha^{-1}), X4= spike length (cm), X5= harvest index, X5= grain yield (kg ha^{-1})

Table 2: Genotypic (rg), phenotypic (rp) and environmental (re) correlations between grain yield and its different yield contributing characters in bread wheat

X1	X2	X3	X4	X5	X6
rg	0.151	0.205	0.10	-.089	.033
rp	0.153	0.189	0.072	-.069	-0.04
re	0.205	0.438	-0.178	.030	-0.170
X2					
rg		0.596	0.375	0.298	0.458
rp		0.590	0.299	0.181	0.371
re		0.368	-0.246	-0.612	0.73
X3					
rg			0.430	0.806*	0.613*
rp			0.354	0.592	0.534
re			-0.120	-0.516	0.011
X4					
rg				0.740*	0.674*
rp				0.596	0.532
Re				0.264	.079
X5					
rg					0.665*
rp					0.639
re					0.592

* significancy level at 5%, X1= plant height (cm), X2= tillers/2m^2, X3= biological yield (kg ha^{-1}), X4= spike length (cm), X5= harvest index, X5= grain yield (kg ha^{-1})

Table 3: Direct (parentheses) and indirect effects of five yield components in wheat

	X1	X2	X3	X4	X5	rg
X1	(-8.14)	-1.7139	5.4089	1.6972	2.7152	-0.0326
X2	-1.2355	(-11.29)	15.696	6.3769	-9.0877	0.4581
X3	-1.6728	-6.7339	(26.31)	7.3028	-24.602	0.6636
X4	-0.8138	-4.2413	11.3213	(16.98)	-22.5689	0.6748
X5	0.7248	-3.3651	21.2324	12.5653	(-30.50)	0.6157

X1= plant height (cm), X2= tillers 2m^{-2}, X3= biological yield (Kg ha^{-1}), X4= spike length (cm), X5= harvest index, X5= grain yield (Kg ha^{-1})

Path coefficient analysis: The genotypic correlation coefficients were partitioned in to direct and indirect effects by various yield contributing characters (Table 3). The path coefficient analysis was carried out to find factors involved in determining yield. The direct effects for biological yield and spikelength were positive and the rest were negative. The highest direct effect of (-30.4936) was exhibited by harvest index followed by biological yield with the value of (26.3195) where both had positive association with the grain yield. Plant height had negative direct effect coupled with negative correlation with the grain yield. Ashraf *et al.* (2002) reported positive direct effect for plant height on yield with positive correlation coefficient. Tillers 2m^{-2} and harvest index showed negative direct effect but positively correlated with the grain yield (Table 3). The direct effect of biological yield was higher than spikelength on yield. The present study conducted under rainfed conditions indicated that biological yield and spikelength had the maximum contribution in determining grain yield in wheat and further it was observed that high indirect contribution was also exhibited via biological yield, yield components and hence these two traits were given emphasis while selecting high yielding wheat cultivars for rainfed conditions.

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