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Correlation and Path Analysis in Candidate Bread Wheat (*Triticum aestivum*) Lines Evaluated in Micro-Plot Test Trial

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Abstract. Correlation and path analysis among yield and yield-associated traits of eight candidate bread wheat lines, including two check varieties, were studied during 2001-02. All the characters studied differed significantly from each other, except biological yield and harvest index. Positive genotypic and phenotypic correlation was estimated between plant height and biological yield. Plant height was negatively correlated with harvest index and grain yield, both at the genotypic and phenotypic levels. It was, however, non-significant at both levels. Significant and positive genotypic correlations were observed between biological yield with harvest index and grain yield. Path analysis showed that days to heading, days to maturity, and plant height had negative direct effect on grain yield, whereas biological yield and harvest index had a high and positive direct effect on grain yield. It may be concluded from the present studies that biological yield and harvest index may be considered as the best selection criteria in the selection of high yielding genotypes, at least from the standpoint of the evaluated set of genotypes.

Keywords: genotypic correlation , phenotypic correlation, bread wheat, path analysis, micro-plot trial, *Triticum aestivum*

Introduction

The yielding ability of a genotype is the result of the relationship among the yield contributing components (Gupta *et al.,* 1999). These yield components are interdependent in expression. Correlation analysis indicates the degree of association between traits. It cannot, however, provide the reasons of association. Therefore, simple correlation coefficients are not always effective in determining the real relationship among traits. Even though correlation analysis can quantify the degree of association between two characters, a significant correlation merely indicates the degree of association between the two characters. The method of path coefficient analysis provides effective means of determining the direct and indirect causes of association. A path coefficient is a standardized partial regression coefficient. As such, it measures the direct influence of one trait upon another and permits the separation of correlation coefficient into components of direct and indirect effects (Dewey and Lu, 1959).

The 1000-grain weight, in modern high grain number cultivars, has reduced slightly (Waddington *et al.,* 1986). The major factor of low yield of varieties, in the era before the green-revolution, was their tallness that is negatively correlated with yield (Hatam and Akbar, 1995). It was earlier found that correlations of days to heading with harvest index, 1000-grain weight with harvest index, and yield with harvest index were positive and significant (Ihsanullah and Mohammed, 2001). Thus, the lines with medium height and higher harvest index would have potential for higher grain yield. Plant height showed a strong negative genotypic correlation with grain yield (Shahid *et al.,* 2002). Path analysis identified that 1000-grain weight and days to maturity had the positive direct effect on grain yield, whereas days to heading and plant height had negative direct influence on the grain yield (Pawar *et el.,* 1990).

In the common wheat, long vegetative period partly contributed to higher grain yield (Bingham, 1969). Positive correlation was observed between length of grain filling period and grain yield in the spring wheat (Spiertz *et al.,* 1971). Donald and Hamblin (1976) reported that the harvest index could be considered as a breeding criteria in cereals. To improve grain yield, selection in the F_2 population should be for plants having high harvest index and high biological yield (Chowdhry *et al.,* 2000; Hakam *et al.,* 1997), since all these characters are correlated with grain yield. Correlation studies between seed yield and nine components in the durum wheat genotypes were carried out (Belay *et al.,* 1993), and it was found that seed yield exhibited a strong positive association with all the characters studied, except days to heading and harvest index. Besides the seed yield itself, plant height and 1000-grain weight may be considered good indirect selection criteria. Duration of vegetative period has a positive influence on grain yield and negative influence on grain filling period (Razzaq *et al.,* 1986). Cultivars with the

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highest harvest index were found superior and efficient in apportioning their dry matter into grain yield and vegetative part in proper proportions.

The aim of the present study was to determine the interrelationship and association of yield, some yield contributing components, and to measure the direct and indirect influence of these component characters on yield.

Materials and Methods

The experimental material was comprised of eight candidate wheat lines, along with two standard varieties as check. These were planted in micro-plot test trials in a randomized complete block design, with three replications at the experimental farms of Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Pakistan, during 2001-02. The genotypes studied were: CT-97150, CT-99245, IDA-97026, CT-99187, CT-99197, ID-A97044, CT-99059, and IDA-97107, along with two check varieties, namely, Bakhtawar-92 and Fakhre-Sarhad. The genotypes were selected from the International Wheat Screening Nursery (IBWSN) raised at NIFA. These genotypes originated from the International Maize and Wheat Improvement Centre, Mexico for testing and evaluation at NIFA. The genotype numbers of the lires were the code numbers assigned to the selected genotype lines at NIFA. The plot size harvested was 5 m x 1.2 m (4 rows, 5 m long) with row-to-row spacing of 30 cm. The data were recorded on days to heading, days to maturity, plant height (cm), biological yield (kg/plot), grain yield (kg/plot), and harvest index (%). The harvest index was computed from the formula: economic yield/total biological yield x 100 (Singa, 1977). Economic yield was the grain yield obtained by harvesting and threshing the two central rows of each experimental plot, while total yield was the weight of the above ground biomass (grain plus straw) of the same central two rows. A plant was assumed to be physiologically mature when 75 percent of the glumes of the primary spike had turned yellow. The 1000-grain weight was computed by counting the grains with a grain counter and then weighed on electronic balance.

Analyses of variance were computed for all the traits, and genotypic and phenotypic correlations coefficients between all the possible pairs of all characters as described by Steel and Torrie (1960). Path coefficient analysis was carried out according to the methodology adopted by Dewey and Lu (1959) at genotypic level by the solutions of simultaneous equations. Grain yield was kept as the resultant variable, with other characters as causal factors.

Results and Discussion

The data revealed that the genotypes differed significantly from each other for all the characters studied, except biological yield and harvest index (Table 1). Although the values for biological yield and harvest index of the wheat genotypes did not differ significantly, it had a positive correlation with other characters, specially the grain yield. It was reported by Hakam *et al.* (1997) that the selection for plants with high biological yield, and high harvest index leads to high yielding lines in wheat. Genotypic and phenotypic correlations coefficients are presented in Table 2, and direct and indirect effect of each trait contributing towards grain yield is given in Table 3. Apparently, the variations for the four characters, namely, days to heading, days to maturity, plant height, and grain yield, were not great, though significant differences among varieties were observed. Similar results were reported earlier by Gupta *et al.* (1999) and Singh *et al.* (1982).

Days to heading. Genotypic and phenotypic correlations of days to heading with days to maturity, plant height, biological yield, and grain yield were positive, while these were negative with harvest index and were non-significant in all cases. Path analysis showed that days to heading had negative direct effect on grain yield (- 0.0248) and positive indirect effect through biological yield (0.2323), while negative indirect effect through days to maturity (- 0.0002), plant height (- 0.0064) and harvest index (- 0.8910). Similar results have been reported by Gupta *et al.* (1999).

Table 1. Mean squares for analysis of variance of different characters in micro-plot trial for correlation and path analysis in candidate bread wheat lines

Source of variation	d.f.	Days to heading	Days to maturity	Plant height (cm)	Biological yield (kg/plot)	Harvest index (%)	Grain yield (kg/ha)
Varieties	9	7.392^{**}	1.667^{**}	78.955^{**}	$0.173^{n.s.}$	$20.030^{n.s.}$	442325.4^{**}
Replications	2	$0.234^{n.s.}$	$1.063^{n.s.}$	$3.781^{n.s.}$	$1.895^{n.s.}$	$4.627^{n.s.}$	$74016.0^{n.s.}$
Error	18	0.382	0.326	6.210	7.493	12.710	55957.3
Total	29						

* = significant; ** = highly significant; n. s. = non-significant

Table 2. Genotypic and phenotypic correlation coefficients matrix of micro-plot trial for correlation and path analysis in candidate bread wheat lines

Variables	Correlation (vg; vp)	Days to heading	Days to maturity	Plant height (cm)	Biological yield (kg/plot)	Harvest index (%)	Grain yield (kg/ha)
Days to heading	vg	1					
	vp	1					
Days to maturity	vg	0.2968	1				
	vp	0.2379	1				
Plant height (cm)	vg	0.1900	- 0.1426	1			
	vp	0.2058	- 0.0599	1			
Biological yield (kg/plot)	vg	0.3967	0.3459	0.4535	1		
	vp	0.2675	- 0.0751	0.4216	1		
Harvest index (%)	vg	- 0.1744	- 0.7403*	- 0.4947	0.6781*	1	
	vp	- 0.1316	- 0.1145	- 0.4255	- 0.4719	1	
Grain yield (kg/ha)	vg	0.1118	- 0.1790	- 0.0253	0.9066**	0.9293**	1
	vp	0.0745	- 0.1897	- 0.1034	0.3503	0.6571*	1

* = significant; ** = highly significant; vg = genotypic correlation; vp = phenotypic correlation

Table 3. Direct (in parenthesis) and indirect matrix effect of different traits in micro-plot trial for correlation and path analysis in candidate bread wheat lines

Variables	Days to heading	Days to maturity	Plant height (cm)	Biological yield (kg/plot)	Harvest index (%)	Grain yield (kg/ha)
Days to heading	**(- 0.0248)**	- 0.0002	- 0.0064	0.2323	- 0.8910**	0.1118
Days to maturity	- 0.0074	**(- 0.0007)**	0.0048	0.2025	- 0.3782	- 0.1790
Plant height (cm)	- 0.0047	0.0001	**(- 0.0335)**	0.2655	- 0.2527	- 0.0253
Biological yield (kg/plot)	- 0.0098	- 0.0002	- 0.0152	**(0.5855)**	0.3464	0.9066**
Harvest index (%)	0.0043	0.0005	0.0166	0.3970	**(0.5108)**	0.9293**

* = significant; ** = highly significant

Days to maturity. Days to maturity were negatively correlated with plant height, harvest index and grain yield, both at the genotypic and phenotypic levels, while these were positively correlated with biological yield at the genotypic level (0.3459) and negatively correlated at the phenotypic level (- 0.0751). Negative genotypic correlation of days to maturity was significant only with harvest index (- 0.7403). Similar results were reported earlier by Singh *et al.* (1982). Days to maturity showed low, but negative direct effect on grain yield (- 0.0007). Its indirect effect was negative through days to heading (- 0.0074) and harvest index (- 0.3782) and was positive through plant height (0.0048) and biological yield (0.2025).

Plant height. Positive genotypic and phenotypic correlations were observed between plant height and biological yield. Plant height was negatively correlated with harvest index and grain yield, both at the genotypic and phenotypic levels, but it was non-significant at both the levels. Similar results were observed by Ahmad *et al.* (1980). Plant height directly affected the grain yield in a negative direction (- 0.0335) as was earlier reported by Nabi *et al.* (1998) and Chowdhry *et al.* (1986). The possible explanation is that an adequate amount of dry matter is partitioned towards the height of the plant in taller plants, affecting the grain yield adversely. Positive indirect effect of plant height was through days to maturity (0.0001) and biological yield (0.2655), which was counter-balanced by negative indirect effect through days to heading (- 0.0047) and harvest index (- 0.2527).

Biological yield. Significant and positive genotypic correlations were observed between biological yield with harvest index (0.6781) and grain yield (0.9006). At the phenotypic level, negative correlation was observed between biological yield and harvest index (- 0.4719), and positive but non-significant correlation was observed between biological yield and grain yield (0.3503). Biological yield had the highest and positive direct effect on grain yield (0.5855). Singh and Singh (2001) and Chowdhry *et al.* (2000) also reported highly significant and positive genotypic correlation between grain yield and biological yield. It had negative indirect effect through days to heading (- 0.0098), days to maturity (- 0.0002) and plant height (- 0.0152), while positive indirect effect through harvest index (0.3464).

Harvest index. Harvest index was positively correlated with grain yield at the genotypic (0.9293) and phenotypic (0.6571) levels. It was highly significant ($p < 0.01$) at the genotypic level and significant ($p < 0.05$) at the phenotypic level. The direct effect of harvest index on grain yield was high and positive (0.5108). Indirect positive effects were found through days to heading (0.0043), days to maturity (0.0005), plant height (0.0166) and biological yield (0.3970). These results are in agreement with those reported by Singh and Singh (2001) and Shoran *et al.* (2000).

Grain yield. Highly significant and positive genotypic correlations were observed between grain yield and biological yield (0.9066) and harvest index (0.9293). At the phenotypic level, the association between grain yield and harvest index (0.6571) was positive and significant, while it was positive but non-significant with biological yield (0.3503). Grain yield had negative and non-significant genotypic and phenotypic correlation with days to maturity and plant height. Earlier, Ashraf *et al*. (2002) revealed that grain yield was positively correlated with plant height. They also observed that in grain yield, high direct effects were contributed by biomass and harvest index, although the latter had negative association with grain yield. They further observed that high indirect contribution was via the biomass by most of the yield components and hence the two traits (biomass and harvest index) should be given emphasis while selecting high yielding wheat cultivars.

Days to heading had positive, but non-significant, genotypic and phenotypic correlations with grain yield. Biological yield (0.5855) and harvest index (0.5108) had the highest and positive direct effect on grain yield, while days to heading (- 0.0248), days to maturity (- 0.0007) and plant height (- 0.0335) had negative direct effects on grain yield.

Present studies have revealed that the higher biological yield and higher harvest index may be considered as the best selection criteria in the selection of high yielding genotypes. Previously, Razzaq *et al.* (1986), and Donald and Hamblin (1976) also reported biological yield and harvest index as importent selection criteria in wheat.

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