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Correlation between Traits and Path Analysis Coefficient for Grain Yield and Other Quantitative Traits in Bread Wheat under Semi Arid Conditions

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Abstract: Current research was conducted out at the Field Crop Institute-Agricultural Experimental Station of Setif (Algeria) during 2010/11 and 2011/12 crop seasons. The objectives were to determine traits affecting grain yield in 29 bread wheat genotypes and to establish the nature of relation between grain yield and yield components by partitioning the correlation coefficients between grain yield and its components into direct and indirect effects by using simple correlation, stepwise regression and path analysis. The obtained results indicated that grain yield was positively correlated to biological yield, straw yield and number of spike per plant. The results of step by step regression showed that traits including biological yield and harvest index had justified approximately 99. 7% of grain yield variations. In the path coefficient analysis, biological yield and harvest index should be considered as the main yield components because these traits showed a positive direct effects towards increasing grain yield with the values of + 1.051 and + 0.364, respectively. Depending on the findings of this study, biological yield and harvest index may be used an effective selection criterion to improve genetic yield potential of bread wheat genotypes.

Key Words: *Triticum aestivum* L. Correlation, Stepwise regression, Path analysis, Grain yield

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Introduction

Bread wheat (*Triticum aestivum* L.) is one of the most important crops in Algeria and cultivated annually on an area 0.6 million hectares (MADR, 2009). Production is under the influence of year-to-year fluctuation due to low and irregular distribution of rainfall (Baldy, 1974), being 1.1 Mt in 2008/09 (MADR, 2009). Demand of wheat is also increasing with increasing population.The attainment of maximum crop yield under drought condition in such areas is an important objective in most breeding programs and the major emphasis in wheat breeding is on the development of improved varieties. Yield is a complex quantitative trait entailing several contributing factors which are in turn highly susceptible to environment influence. Selection is one of the important tools in crop improvement. It should not only be restricted to grain yield alone but other components related to grain yield must also be considered. Although, the success of selection depends on the choice of selection criteria for improving grain yield (Samonte *et al.*, 1998). Correlation coefficient is an important statistical method which can help wheat breeders in selection for higher yields. Some of the researchers indicated the positive correlation between grain yield and yield components traits in wheat such as spikes numberper plant (Mondal *et al.*, 2001), grains number per spike (Kashif and khaliq, 2004), straw yield (Mohamed, 1999), 1000 kernel weight (Akbar *et al.*, 1995), biological yield (Naderi *et al.*, 2000) and harvest index (Ali and Shakor, 2012). Partitioning the correlation coefficient into direct and indirect effects can be done through path analysis technique (Dewey and Lu, 1959). Path coefficients have been used to develop selection criteria for complex traits in several crop species of economic importance such as rice (Aminpanah and Sharifi, 2011), cotton (Tariq *et al.*, 1992), maize (Ivanovic and Rosic, 1985) and wheat (Larik, 1979; Aydin *et al.*, 2010). Majumder *et al.* (2008) obtained in a path analysis grains per spike followed by 100-grain weight, spikes per plant and harvest index had positive direct effects on grain yield of bread wheat. Stepwise regression analysis was employed to eliminate no effective variables on grain yield in regression model and study only traits affecting significantly yield changes (Mohamed, 1999). Aslani *et al.* (2012) concluded using stepwise regression analysis to wheat genotypes that biological yield and harvest index were two effective traits on yield and choosing based them can useful to improving yield under drought stress. The objective of this study was tofindout the interrelationship of yield and yield contributing characters in bread wheat genotypes and to partition the observed correlations into their direct and indirect effects. The information thusobtained will be used to define the suitable criteria for yield improvement under drought stress conditions.

Material and Methods

Field experiments

This study was carried in two consecutive growing years (2010/11 and 2011/12) out at the Field Crop Institute-Agricultural Experimental Station of Setif (ITGC-AES) which is located at longitude 05°24'E and latitude 36°12'N with an average altitude of 1.081m above sea level in the northeast of Algeria. Experimental material for the present study consisted of five lines (female parents) *viz.*, $Acsad_{901}$, $Acsad_{899}$, $Acsad_{1135}$, $Acsad_{1069}$ and Ain Abid were crossed with four testers (male parents) *viz.*, Mahon-Demias, Rmada, HD_{1220} and Wifak in Line x Tester mating design according to Kempthorne (1957) to produce 20 hybrids during 2011 season. Parents and their resulting 20 F_1's were sown in a randomized complete block design with three replications during the 2nd week of December, 2011 for evaluation. Each replication had one row of 2.5 m length for each treatment while plant-to-plant and row to row distance was 15 and 30 cm, respectively. Other recommended cultural practices for wheat production were applied during the growing season to raise a good crop. Observations and measurements were recorded on five guarded plants (excluding border plants) chosen at random from each plot for the following characters: number of spike per plant, grain number per spike, thousand kernel weight (g), grain yield per plant, biological yield (g), straw yield (g) and harvest index.

Data analysis

The estimates of correlation coefficient among various characters were worked out by using the formulae suggested by Kwon and Torrie (1964). To test the significance of correlation coefficient, the calculated t-value can be compared with tabulated t-value at (n-2) degree of freedom (Snedecor and Cochran, 1981). Stepwise regression analysis was employed to determine the best combination of variables that determinate grain yield in bread wheat genotypes (Draper and Smith, 1981). Path coefficient analysis was performed to assess direct and indirect effect of the measured traits on grain yield according to the technique outlined by Dewey and Lu (1959). For this purpose, free software LazStats was used.

Results and Discussion

Correlation among characters

The correlation coefficients among the various characters are presented in Table 1. Positive and significant relationships existed between grain yield and biological yield, straw yield and number of spike per plant (r = 0.916***, r = 0.670***, r = 0.855***, respectively). Some authors also reported positive and significant correlations between yield and seed number (Mondal *et al.*, 2001; Siahbidi *et al.*, 2012), above ground biomass (Gupta *et al.*, 2001) and straw weight (Khan *et al.*, 1999). Also, the biological yield correlated positively and significantly with straw yield (r = 0.894***), number of spike (r = 0.942***) and thousand kernel weight (r = 0.456*), but negatively with grain number per spike (r = - 0.486**). While our findings are in compliance with those of Leilah and Al-Khateeb (2005), they are contrary to the results suggested by Mohammad *et al.* (2005). Straw yield had positive and significant correlation with number of spikes per plant (r = 0.860***) and thousand-kernel weight (r = 0.601***); while negative correlation coefficients were found for grain number per spike (r = - 0.697***). Ahmadizadeh *et al.* (2011) studied the relationship between the quantitative traits and grain yield in 25 durum wheat genotypes in drought stress conditions and they reported that the length of peduncle, the number of grains in spike, the weight of 1000 grains weight, biological yield and harvest index justified the most yield variations. Number of spikes per plant correlated negatively with total number of grains per spike (r = - 0.632***). Siahbidi *et al.* (2012) studying correlation between traits in durum wheat genotypes showed positive association between number of spikes and grain number per spike. There was negative and significant relationship between spike fertility and thousand kernel weight (r = - 0.785***). Some researchers reported a positive association between total number of grain per spike and thousand-kernel weight (Moghaddam *et al.,* 2011; Karimizadeh *et al.,* 2012); however, a study in the literature reported a negative correlation between them (Okuhama *et al.*, 2004). Under the present growing conditions, the results suggested that is, somewhat, difficult to achieve simultaneously high grain number per plant with high thousand kernel weight in a single genotype, due to compensating effects (Bensemane *et al.,* 2011).

Stepwise multiple regression

Stepwise multiple regression analysis is a multiple statistical method that can screen or select the most important variables through a dependent variable such as the grain yield. Based on this method, biological yield was the most important character and had the strongest variation in grain yield per plant. This model could justify significantly more than 83 percent changes in performance (R^2=83.9%) according to the equation:

$$GY = + 0.405 + 0.374 \ BY$$

Where, GY and BY are the grain yield per plant and biological yield, respectively.

Mollasadeghi and Shahryari (2011), Zarei *et al.* (2011) and Aslani *et al.* (2012) in their researches indicated that through biological yield, we could have some yield changes. After biological yield three variables, including harvest index, thousand kernel weight and straw yieldwere entered to regression model; at last these variables with biological yield had justified 99.7% of grain yield alteration (Table 2). The other variables were not included in the analysis due to their low relative contributions. Regression coefficients for the accepted variables are shown in Table 2. Therefore, based on the final step of stepwise regression analysis, the equation for prediction of grain yield was computed as follows:

$$GY = - 15.22 + 1.048BY + 0.352HI - 0.043TKW - 0.115 \ SY$$

Where, GY is the grain yield per plant; BY, HI, TKWand SY are biomass, Harvest index, thousand kernel weight and straw yield, respectively. Existence of positive and significant R square (regression coefficient) of biological yield and harvest index in a successful regression equation indicates the effectiveness of these traits to increase grain yield. Furthermore, regarding the negative and significant regression coefficient of thousand kernel weight and straw yield, it could be said that increasing the amount of this trait would decrease grain yield under semi-arid conditions. Naderi *et al.* (2000) and Mollasadeghi *et al.* (2011) showed that the most important components for grain yield based on this method are biological yield and harvest index. Leilah and Al-Khateeb (2005) also, demonstrated that five traits of grain weight per spike, harvest index, biological yield, number of spike per square meter and spike length were introduced into stepwise regression model accounting for 98.1% of grain yield variations of wheat.

Path coefficient analysis

Path coefficients were computed to estimate the contribution of individual characters to grain yield. Path coefficient analysis using grain yield as dependent variable and biological yield, harvest index, thousand-kernel weight and straw yield as independent variables is presented in Table 3 and the diagrammatic presentation of the effects of variables on yield is given in Figure 1. The highest positive direct effect on grain yield per plant were exhibited by biological yield (+1.051**) and harvest index (+0.364**). In most of the previous studies, biological yield and harvest index had positive direct effect on the grain yield (Singh and Diwivedi, 2002; Leilah and Al-Khateeb, 2005; Ali and Shakor, 2012). While, straw yield, number of spikes per plant, number of grain per spike and thousand kernel weights had negative but non-significant direct effects on grain yield per plant with a value of -0.109, -0.013, -0.0261 and -0,062, respectively. These results are consistent with the findings of Ali and Shakor (2012). Highest positive indirect effects on yield were observed for straw yield (0.939), number of spikes per plant (+0.990) and thousand kernel weight (+0.479) via biological yield. Theses traits caused increasing of grain yield indirectly. These findings are partially in concordance with the results of Abinasa *et al.* (2011). Similarly, number of grain per spike expressed positive and significant indirect effect on yield per plant (+0.160) through harvest index. On the other hand, negative value for number of grain per spike was obtained from indirect effects through biological yield (-0.510).Similarly, characters like straw yield (-0.130) and thousand kernel weight (-0.131) had negative indirect effects via harvest index. High values of indirect effects via biological yield and harvest index suggested that indirect selection for straw yield, spike number per plant and thousand kernel weights through these characters may also increase the grain yield. The residual effect is low (+ 0.055) indicating appropriateness of characters chosen. Totally, it can be declared that, under rainfed conditions; the highest direct and indirect effects were relevant to traits of biological yield and straw yield, respectively.

Our results obtained from 29 bread wheat genotypes proved that biological yield and harvest index appeared to be the most important sources affecting grain yield variation in semi arid regions and consequently may be considered as effective criteria for selecting towards grain yield improvement in bread wheat.

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Table 1. Simple correlation coefficients between grain yield and other related traits in bread wheat genotypes.

	BY	SY	SN	GN	GY	TKW	HI
BY	1						
SY	0,894***	1					
SN	0,942***	0,860***	1				
GN	-0,486**	-0,697***	-0,632***	1			
GY	0,916***	0,670***	0,855***	-0,243^{ns}	1		
TKW	0,456*	0,601***	0,478**	-0,785***	0,354^{ns}	1	
HI	-0,027^{ns}	-0,359^{ns}	-0,043^{ns}	0,442*	0,366^{ns}	-0,036^{ns}	1

BY: Biological yield, SY: Straw yield, SN: Number of spike per plant, GN: Number of grain per spike, TKW: Thousand kernel weight. ns, *, ** and *** : correlation coefficient non significant, significant at 5%, 1% and 0.1% level according to the t-test, respectively.

Table 2. Regression coefficient, standard error, t-value and probability of the accepted variables by the stepwise procedure to predict grain yield.

Variable	B	SE	t	Sig.
BY	1.048	0.018	23.809	0.000***
HI	0.352	0.026	16.597	0.000***
TKW	-0.043	0.020	-2.366	0.026*
SY	-0.115	0.045	-2.130	0.044*

B: Regression coefficient, SE: Standard error, t: Student *t*-value and Sig: Probability, BY: Biological yield, HI: Harvest index, TKW: Thousand kernel weight, SY: Straw yield. R^2 = 0.997, Adj R^2 = 0.996. * and ***: correlation coefficient significant at 5% and 0.1% level according to the t-test, respectively.

Table 3: Direct (diagonal) and indirect effects of different characters on grain yield of bread wheat genotypes.

	Effects via						Total effects
	BY	SY	SN	GN	TKW	HI	
BY	**1.051****	-0.097	-0.012	0.012	0.028	-0.010	**0.972**
SY	0.939	**-0.109^{ns}**	-0.011	0.018	-0.037	-0.130	**0.670**
SN	0.990	-0.093	**-0.013^{ns}**	0.016	0.029	-0.010	**0.919**
GN	-0.510	0.073	0.008	**-0.026^{ns}**	0.048	0.160	**-0.247**
TKW	0.479	-0.065	-0.006	0.020	**-0.062^{ns}**	-0.131	**0.235**
HI	-0.028	0.039	0.000	0.011	0.022	**0.364****	**0.408**

BY: Biological yield, SY: Straw yield, SN: Spike number per plant, GN: Grain number per spike, TKW: Thousand kernel weight, HI: Harvest index. ns and ** = correlation coefficient non significant and significant at 1% level according to the t-test, respectively.

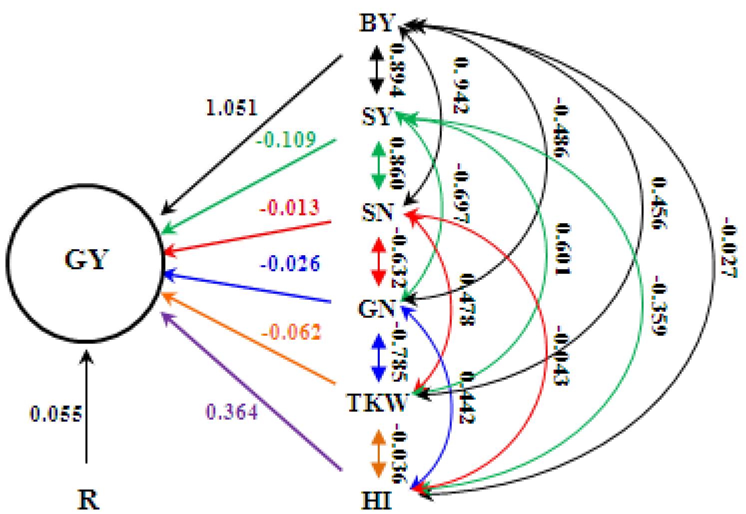

Figure 1. Diagrammatic representation of direct and indirect influence of variables on grain yield. Single arrow lines indicate path coefficients and double arrow lines indicate correlation coefficient. GY: Grain yield, BY: Biological yield, SY: Straw yield, SN: Spike number per plant, GN: Grain number per spike, TKW: Thousand kernel weight, HI: Harvest index. R: Residual effect.