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Correlation and path coefficient analysis for yield and its components in Dragon's head (*Lallemantia iberica* Fish. et Mey.)

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Abstract

The associations of yield and its components offer important information in breeding plants. A study was conducted at the experimental field of the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran in 2012, on Dragon's head (*Lallemantia iberica* Fish. et Mey.), to determine the association of yield and its components. The association was analyzed by correlation coefficient, and further subjected by path coefficient analysis to estimate direct and indirect effects of each character on seed yield. Plant characters such as biological yield, harvest index, grain per plant, capsule number, number of grain per capsule, lateral stem and 1000 grain weight were main selected measurements for the data analysis. Positive and significant correlation were found between the biological yield and seed yield (0.985^{**}). Stepwise multiple linear regression interpretation also indicated that maximum of variation in seed yield attributed to variation which arose from harvest index and biological yield. The results of path analysis strongly suggested that biological yield and harvest index contain positive direct effect on seed yield. Based on the results of this experiment, the importance of harvest index and biological yield can be seen for selection, in breeding programs, with the goal of improved Dragon's head seed yield under the semiarid conditions.

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Introduction

Dragon's head (*Lallemantia iberica* Fish. et Mey.) is an annual herb belongs to Lamiaceae family and spreads in southwestern Asia and Europe (Ursu and Borcean, 2012). It grows well in arid zones and requires a light well-drained soil (Ion *et al.*, 2011). Dragon's head is a valuable species, *i.e.* all plant parts (leaves or seeds) can be economically used (Hedrick, 1972). However, it is mainly cultivated for its seeds that contain about 30% oil with iodic index between 163 and 203. These seeds are used traditionally as stimulant, diuretic and expectorant as well as food (Naghibi, 1999).

Grain yield is a complex character associated with many interrelated components. Grain yield is the result of a number of complex morphological and physiological processes affecting each other and occurring in different growing stages (Dokuyucu and Akkaya, 1999). Selection for yield, which is polygenic characters, often leads to changes in other characters. Therefore, knowledge of the relationship of grain yield with other characters is desirable in order to adopt the most appropriate selection criteria in breeding. Selection, which is mainly based on phenotypic characters, is the major technique used in a breeding program. Response to selection depends on many factors such as the interrelationship of the characters. Correlation and path coefficient analyses would assist in the choice of characters whose selection would result in the improvement of a complex character such as yield. Correlation estimates the degree of association between the variables. Regression helps to estimate the functional relationship between variables or the relationship between the independent and dependent variables. Path coefficient analysis is a very important statistical tool that can be used to obtain an indication of which variables exert an influence on other variables (Akanda and Mundit, 1996). Each correlation coefficient between a predictor variable and the response variable is partitioned into its component parts: the direct effect or path coefficient (a standardized partial-regression coefficient) for the predictor variable and indirect effects, which involve the product of a correlation coefficient between two predictor variables with the appropriate path coefficient in the path diagram (Dewey and Lu, 1959). Path-coefficient analysis has been useful in determining selection criteria in a number of crops, such as crested wheat grass (Dewey and Lu, 1959), maize (Ivanovic and Rosie, 1985) and rice (Samonte *et al.,* 1998). By determining the inter-relationships among grain yield components, a better understanding of both the direct and indirect effects of the specific components can be attained and applied in Dragon's head improvement programs. Whatever the methods used for improving crops, selection aids are necessary for any effective and efficient breeding program. This technique is useful in determining the direct influence of one variable on another, and also separates the correlation coefficient into its components (Rodriguez *et al.,* 2001). Path analysis is a tool that is available to the breeder for better understanding the causes involved in the associations between traits and to partition the existing correlation into direct and indirect effects, through a main variable (Lorencetti *et al.,* 2006).

Correlation coefficients generally show the degree of relationships among characters. It is not sufficient to describe this relationship when the causal relationship of the characters among them is unknown. Path analysis is used when we want to know causal effects. In other words, path analysis is used when we want to determine the amount of direct and indirect effects of the causal components on the effect components. For this reason, Serivichayaswadi *et al.* (1997), Koauychai *et al.* (2001), Arshad *et al.* (2004) and Musaana and Nahdy (1998), had determined the direct and indirect effects of various plant characters on yield using path analysis in sugarcane, baby corn, chickpea and pigeon pea, respectively. As in previous studies, plant breeders could find certain characters which have importance direct and indirect effects on plant yield from path analysis, and used this information as selection criteria in breeding. Path coefficient analysis has also been used in determining the relationships among yield and its components in Turkish tobacco (Kara and Esendal, 1996), rice (Surek and Beser, 2003), and soybean (Faisal *et al.*, 2007). However, to date this has not been done in Dragon's head.

Therefore, this paper attempted (1) to evaluate the importance of different yield components in Dragon's head, (2) to determine the direct and indirect effects of these components on yield, and (3) to develop selection criteria for higher grain yield.

Materials and methods

Site description and experimental design

The field experiment was conducted in 2012 at the Research Farm of the University of Tabriz, Iran (latitude 38°05_N, longitude 46°17_E, altitude 1360 m above sea level). The climate of research area is characterized by mean annual precipitation of 285 mm, mean annual temperature of 10°C, mean annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C. The experiment was arranged as split plot design with four replications. Irrigation treatments (I_1, I_2, I_3, I_4 and I_5: irrigation after 70, 100, 130, 160 and 190 mm evaporation from class A pan, respectively) were assigned to main plots and four plant density levels (D_1, D_2, D_3 and D_4: 200, 300, 400, 500 plant/ m^2) were allocated to the sub plots. All plots were irrigated immediately after sowing. Irrigation treatments were applied after seedling establishment. Hand weeding of the experimental area was performed as required.

Measurement of traits

To specify capsule number per plant ten plants were selected from the middle of the plots and then, they were measured. Also to determine of grain yield and biological yield an area equal to 1 m^2 was harvested from middle part of each plot considering marginal effect. Harvested plants were dried in 25°C and under shadow and air flow then grains were separated from their remains by threshing.

Statistical analysis

Simple correlation coefficients calculated among all possible combinations of traits related to seed yield. Correlation coefficients among all pairs of variables, standardized regression coefficients and multi regression using Stepwise method calculated by SPSS 16.0 statistical software. The path coefficient analysis was conducted according to Lee (1977).

Results and discussion

Correlation coefficients analysis

The analysis of correlation coefficient has revealed information in which the scale of seed yield production is related to biological yield, grain per plant and capsule number with high and positively manner at the ($p<0.01$) (Table1). This information indicated that the selection for these three characters can be effective tool for the yield improvement. The capsule number per plant was correlated significantly with grain per plant at the positive range. The finding in the present study was similar to those reports by Tuncturk and Ciftci (2004) who demonstrated that number of capsule and grain per plant possessed highly positive correlation with seed yield. Correlation analysis among grain yield and other traits showed that the biological yield had the highest significant positive correlation with grain yield, which confirmed with similar result finding by De-Bruin and Pedersen (2009) who demonstrated that there is positive correlation between biological yield and grain yield. In this investigation the correlation between seed yield and other characters was not significantly differenced (Table 1), while the capsule number was significantly correlated with lateral stem. When compared the yield components with seed yield, harvest index, number of grain per capsule, lateral stem and 1000 grain weight did not significantly correlate with seed yield (Table 1). A negative association was detected between harvest index and lateral stem. This report was also observed in a study by Golkar *et al.* (2011) and Aytac and Esendal (1996). The above arguments confirmed that when selecting criteria initiated indirectly to screen the individual with more biological yield, grain per plant and capsule number per plant can be a noble approach to upgrade seed yield in Dragon's head.

Table 1. The simple correlation coefficients among evaluated traits.

	Grain yield	Biological yield	Harvest index	Grain per plant	Number of grain per capsule	Capsule number	Lateral stem	1000 grain weight
Grain yield	1							
Biological yield	0.985**	1						
Harvest index	0.16	0.005	1					
Grain per plant	0.74**	0.803**	-.305	1				
Number of grain per capsule	-0.389	-0.39	-0.024	-0.212	1			
Capsule number	0.865**	0.898**	-0.174	0.941**	-0.385	1		
Lateral stem	0.122	0.189	-0.489*	0.66**	0.032	0.447*	1	
1000 grain weight	0.002	-0.016	0.059	0.019	0.331	-0.06	0.098	1

*and ** significant at $P<0.05$ and $P<0.01$ respectively.

Multiple stepwise regression analysis

In this research seed yield considered as dependent variable and all other remaining characters were as independent variable for multiple stepwise regressions. The equations for analysis of the regression elucidated that highest of the total variation for the seed yield could be explained by two characters; biological yield and harvest index. When other characters such as grain per plant, capsule number and 1000 grain weight were added to the regression model, the output could just explain the lowest of total variation of seed yield (Table 2). On the other hand when other characters were added to the model, it has been observed that the remaining of variation was not being able to explain. This shows that this amount of variation may disseminate within other components. Positive regression coefficients of these variables indicated that a logical and reasonable index selection for these, one has to considering their narrow-sense heritability and correlation coefficient in order to improve seed yield (Burhan, 2007).

Table 2. Equations of stepwise multiple regression of seed yield and yield components in Dragon's head.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
α	-118.688	9.833	-	-12.71	.000
Biological yield	0.308	0.004	0.986	73.003	.000
Harvest index	3.844	0.314	0.165	12.252	.000
R^2=0.997					

Path analysis

Results of multiple stepwise regressions were revealed information in which two characters; biological yield and harvest index were performed the key characters for estimation of variation in dependent variables. Therefore, the correlation coefficients between these characters and seed yield can be broken to direct and indirect effects, in which helps to gain more and accurate aware of the relationships between characters that could have maximum impact on seed yield using path analysis. Evaluation of path analysis demonstrated that direct effect of biological yield on seed yield exhibited a highly positive trend (Table 3). The direct effect of harvest index on the seed yield per plant as dependent character was also positive. Due to positive direct effect of the character of biological yield on seed yield and as well as its positive indirect effects through characters, total correlation between grain yield and biological yield was highly positive (Table 3). The result showed that an individual plant with a high biological yield can be considered as a desirable plant character to improve seed yield production in Dragon's head. The similar result was also recommended in a study by Acharya *et al.* (1994) and Nie *et al.,* (1993). It has been observed that when the characters influence the yield component increased, can effect directly on the efficient index which result in beneficial trend to promote the yield production. It has been observed that biological yield had a positive direct effect on grain yield and also showed that it has a positive indirect effect on harvest index which caused to maximize seed yield. Indirect effect of biological yield via harvest index has less influenced on seed yield than their direct effect. So, this process may a cause for leading to high genetic correlation between harvest index and seed yield (Table 3).

Mokhtassi *et al.* (2006) reported that seed yield was significantly correlated with total biomass which variation in this trait could explain 94% of the total variations in seed yield according to stepwise multiple regression analysis and were most important selection criteria for seed yield in safflower. Omidi (2000) revealed that biomass affected seed yield and to be linear relationship between oil yield and seed yield in spring safflower.

In perspective of path analysis, the results indicated that the positive indirect effects of biological yield through harvest index cause to lead increase the correlation between seed yield and harvest index. Although the results of this investigation showed that the relationships of some yield components such as harvest index on seed yield were not significantly due to correlation of coefficient, but their direct effects on seed yield were significant according to path coefficient, therefore they can be classified as characters with high correlation coefficient.

In conclusion, correlation coefficient analysis measures the magnitude of relationship between various plant characters and determines the component character on which selection can be based for improvement in Dragon's head seed yield. However, path coefficient analysis helps to determine the direct effect of traits and their indirect effects on yield. Biological yield and harvest index had major contributions on grain yield and hence selection for these traits can possibly lead to improvement in seed yield of Dragon's head. Therefore, biological yield and harvest index could have priorities in breeding programs for the conditions of Iran.

Table 3. Direct and indirect effects of remained characters in the regression model on seed yield in Dragon's head using path coefficients analysis.

Traits	Direct effect	Indirect effect		Total correlation
		Biological yield	Harvest index	
Biological yield	0.986	-	0.008	0.947**
Harvest index	0.165	0.04	-	0.913**

*and ** significant at P<0.05 and P<0.01 respectively.

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