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Correlation and Path Analysis of Traits Affecting Grain Yield of Canola (*Brassica napus* L.) Varieties

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ABSTRACT

In order to determine the most important traits affecting grain yield in Canola and identify the quantity of direct and indirect effects on grain yield, an experiment was conducted with ten Canola varieties in a Randomized Complete Block Design (RCBD) with three replications. The evaluation of correlation coefficients illustrated that the total dry matter, harvest index, 1000- grain weight, the number of grains per pod, number of pods per plant, plant height; days to maturity and flowering period trait have a positive significant correlation with grain yield. Stepwise regression and path analysis indicated that, the number of pods per plant had the highest direct effect on grain yield. In addition, total dry matter, 1000- grain weight, and flowering and maturity period also had a high direct effect on grain yield. Thus, direct selection for these traits is suggested.
KEY WORDS: Canola, Yield, Correlation, Path analysis.

INTRODUCTION

Grain yield is considered to be a complicated trait, which can be affected by many factors, and usually as a result of insufficient yield heritability factor, direct -selection yield. is not much effective for it; as a result, for yield breeding we would better use indirect selection [7]. Knowing about grain yield issue and its components plays an important role for being successful in evaluative programs. Success in breeding and having fruitful varieties of agricultural products with a higher quality depends on knowledge about genetic grain yield controlling and its relation with grain yield components, also to phenologic traits and forage quality [12].

Canola grain yield is dependent to on the capacity of variety yielding, climate conditions, the type of soil and agronomic management. Also genetic and agronomic factors determine growth of the plant and grain yield [15].

Some statistical methods, such as correlation analysis, indicate partial role of each component of yield in the amount of yield; also, they provide necessary information for choosing indirect traits in superior genotypes to have yield breeding [7].

Correlation between traits for evaluation and planning on breeding programs is useful. In other words, when an evaluation is conducted on a trait, knowing its effects on the other traits is totally important. Also by knowing if correlation exists between important traits, interpretation on previous results would become easier and the basis for effective future plans would be provided. Also correlation between important and non-important traits provides plant breeding experts with a significant assistance in indirect selection of important traits, through non-important traits which their measurement is easier [17].

One of the most important objectives of Canola plant breeding is to increase yield in a region. By having an increase in yield, we mean to increase physiological efficiency of the plant and to improve yield in a region. This is because many other objectives indirectly affect yield increase. Yield is the resultant of all parts of the plant, and it is considered as the final target of many characteristics. We can use correlation or regression method to measure the relationship between two traits or two variables [8].

Correlation coefficient, which is used as a standard of measuring linear relationship between two variables, only has one mathematical interpretation, and does not refer to cause and effect relationships [1].

Path coefficient analysis is used as a means, to evaluate the importance of effective traits on yield. This method illustrates the relations between traits, and their direct or indirect effects on yield [25].

The aim of path coefficient analysis is to be able to present an appropriate interpretation of correlation between variables, by creating cause and effect models [21].

In this method, Correlation coefficient which exists between two traits is divided in to components which measure direct and indirect effects. Making use of this method requires the knowledge about cause and effect relations which exist between traits, and assuredly must determine the direction of causes according to previous information and experimental evidences [10].

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In fact, path coefficient analysis depicts a more complete image of a simple correlation, and correlation coefficient between two variables, divides cause and effect into direct and indirect effects. Several studies have been conducted to determine the correlation between different traits and to divide them by path coefficient analysis method in Canola [14, 17 and 21].

According to the results of path coefficient analysis in Canola plant, it was illustrated that the duration of growth had the most direct and negative effects on oil grain percentage and the number of pod per plant had the most positive and direct effect on grain yield [15].

Some researchers introduced traits of the number of fertile stems, and grains per pod, as an index for selecting yield of rice varieties although in path coefficient analysis method, direct effect of 100- grain weight on yield was relatively high [2].

Path coefficient analysis in Bean varieties indicated that, the number of grains per pod, and the number of pods per plant are the most important components of grain yield for evaluation of superior varieties [20].

Also in promising lines of barley, biological yield and length of spicula have the maximum direct and negative effect on grain yield [3].

By having Canola varieties evaluated, observed that grain yield has the most correlation with 1000- grain weight, biological yield, harvest index and oil yield. Accumulation of dry matter in plant causes better assimilate transfer, therefore the plant makes the best use of assimilate for grain filling [19].

A researcher reported that there is a positive and significant correlation between Plant height traits, grains per pod and 1000- grain weight with grain yield [22].

The purpose of this research is to identify the correlation between some agronomic traits, and to recognize traits with maximum direct and indirect effects on grain yield by making use of path coefficient analysis, so that by using important traits which are related to yield, we can achieve improvement on these breeding goals.

MATERIAL AND METHODS

This research was conducted in the agronomic year of 2007-2008, in Randomized Complete Block Design (CRBD) with three replications, in the experimental field of Science and Research Branch, Islamic Azad University, south west of Iran (32°20' N, 40°20' E and altitude 22.5m) with moderate winters and hot summers. The texture of the soil was Siltclay, electricity conductivity of condensed saturation was 3.5 $ds.m^{-1}$ and acidity of the soil was 7.3. The average annual precipitation was 248 mm, (30-year) daily temperature was 24.45 degrees centigrade, the average precipitation of agronomic year was 136.88 mm and the average temperature of agronomic year was 20 degrees centigrade in this region. Each plot consisted of 8 rows with 30 cm distance from each other and each plot was 6 meters long. The average distance between the plants was considered to be 3 to 4 cm. The amount of fertilizer used in the field was according to soil experiments before planting, hence, 50 Kg N ha^{-1}, 100 Kg P_2O_5 ha^{-1}, 100 Kg K_2O ha^{-1} and 100 Kg N ha^{-1} during stem elongation period was utilized.

In order to determine grain yield components, at the physiological maturity stage, 10 plants were taken from each plot randomly. Then traits of pod per plant, grains per pod and 1000- grain weight were evaluated. In the final harvest, from one square meter of each plot, grain yield and biological yield were estimated, and harvest index was calculated; by means of grain yield proportion to biological yield. For studying the type of relations between the independent variables (agronomic traits and yield components), and the dependent variable (grain plant yield), grain yield path coefficient analysis was performed in order to achieve the direct and indirect effects. For doing statistical calculations, identifying correlation coefficients and regression analysis, Minitab 13 was utilized, and for coefficient analysis, Path74 software was used.

RESULTS AND DISCUSSION

Simple correlation coefficients between traits

These coefficients were estimated according to Pearson coefficient (Table 1). The most positive and significant correlation was observed in dry matter trait ($r=0.932^{**}$), harvest index ($r=0.810^{**}$), pod per plant ($r=0.955^{**}$), 1000- grain weight ($r= 0.909^{**}$), flowering duration ($r= 0.824^{**}$), plant height ($r= 0.715^{**}$) and maturity time trait ($r= 0.67^{**}$). The traits of grains per pod ($r=0.575^{*}$) and days to emergence ($r=0.656^{*}$) had correlation with the grain yield at 5 percent probability level.

Some researchers reported that traits of -days to flowering -and -days to maturity- have a significant and positive correlation with grain yield of Canola varieties [21], therefore varieties with longer flowering duration would have a better chance for fertilization of flowers and turning them to pods. In serotinal varieties or delayed-growing plants the decrease of length in growing period, poor environmental conditions (temperature and humidity) during the flowering period and fertilization and pod formation, decreases in the number of pods per plant, the number and weight of the grain finally lead to the decrease of Canola yield [18].

Earning maximum correlation coefficient in grain yield by number of pods per plant ($r= 0.955^{**}$), is because it is assimilate supplier for the grains, therefore, we can consider the positive and significant correlation of grains per pod, with grain yield, a natural thing. As a result, the more this trait is observed, the bigger sink plant would have for metabolic materials. These results had conformity with other researchers ([13, 16].

The increase of total dry matter and its direct relation with grain yield show the relations between photosynthesis efficiency of plant and grain yield, therefore varieties which have gained more profit of production factor according to growth conditions and they keep more photosynthesis materials in their sinks, have more efficiency. This status was in conformity with the results of some other researchers [14, 17]. The significant and positive correlation between harvest index and grain yield ($r=0.810^{**}$) indicate efficiency and kind of photosynthesis materials distribution in different parts of plant, especially in grain. Results of some other researchers verify the mentioned issues [19, 24].

Stepwise regression analysis

In Stepwise regression analysis, grain yield was considered as a dependent variable, while other traits were considered as independent variables. All the traits were put into regression model and finally five traits of pod per plant, total dry matter, flowering duration, 1000- grain weight and maturity time remained in the regression model. This model generally justified 92.5 percent of changes, related to the grain yield trait (Table 3).

Other traits which were studied did not have a significant influence on this model, therefore different varieties according to grain yield, are because of differences in the mentioned traits above. In a research project in stepwise regression analysis of traits of pod per plant verified 64% of coefficient, the number of grains per pod 67%, 1000- grain weight 72%, oil percentage78% and the number of nodes in stem verified 80% coefficient of changes in regression model, which were related to Canola varieties comparison [5].

In regression model conducted by some researchers, in order to determine effective traits on bean yield, traits of 100 grain weight, total number of pods and the number of grains per pod were entered into the model [20].

The results of stepwise regression analysis on bean varieties indicated that, 5 traits of pod weight, the number of grains in plant, the total number of pods, biological yield and harvest index justified 97% of the changes in grain yield, yet" pod weight" devoted 95% of changes to itself [4].

PATH ANALYSIS

In order to have a better conception and interpretation of the results achieved by correlation and stepwise regression analysis, path analysis for the variables was conducted which were entered into the final regression model. The highest direct effect was that of Pods per plant trait (Table 4). All indirect effects in this analysis were trivial or negative. Pod per plant trait had the highest positive- direct effect on grain yield, also it had positive indirect effects on total dry matter (0.138), 1000- grain weight (0.027), and maturity duration (0.04). negative- indirect effects were through flowering duration. Due to the fact that, negative- indirect effects were little, they had no profound impact to positive-indirect effects. There was a significant correlation between pod per plant and grain yield, which was in conformity with the results of some other researchers [5, 11].

It seems the sink which is made by the higher number of grains per pod, is for having more yield. Changes in the number of pods potentially increase yield because the source has photosynthesis and increases sink capacity.

On the other hand, characteristics which occur first can have direct effects on production and have indirect effect on yield through other traits which appear on the other processes of growth [23].

In path analysis, after pod per plant trait, total dry matter with direct effect (0.657), play an important role. It seems with an increase in biological yield (because of having source productions), preparation of grains for receiving total dry matter, through traits of the number of pods per plant (0.17), 1000- grain weight (0.097) and maturity duration (0.045), had positive-indirect effects on grain yield, yet it's indirect effects were (- 0.037).

By using path analysis on agronomic traits of pea, realized that, the maximum direct effect on grain yield was related to the following issues; harvest index trait (95.6), total dry matter (48.3) and number of pods per plant (9.34). Flowering duration trait, by having positive-direct effect on grain yield (0.570), also by having positive-indirect effects of number of pods per plant (0.11), total dry matter (0.046), 1000 grain weight (0.051) and maturity duration (0.047). caused positive correlation with grain yield [9]. These outcomes have conformity with the results that some other researchers [21]. 1000 grain weight had a little positive-direct effect on grain yield (0.112), yet positive-indirect effects of this trait with traits of the number of pods per plant (0.646), total dry matter (0.151) and maturity duration (0.036) devoted a large amount of correlation with grain yield. Therefore negative-indirect effect of flowering duration (-0.036) had no effect at all. Therefore weight of the grains decreased [2]. 1000 grain weight should be considered for breeding or increasing yield. Due to the fact that yield components are produced in order, and lack of one component can be compensated by another component, this trait increases to compensate deficiencies of first components of plant yield. In such situations, the increase is considered as an important index for a variety, some researchers have come to this conclusion in their studies too [6, 17 and 21]. The last trait which was gained by stepwise regression analysis among 12 traits was the length of maturity duration. The same as 1000 grain weight trait, positive-indirect effects of this trait with traits of Pod per plant (0.476), total dry matter (0.124) and 1000 grain weight (0.064), confirmed a large amount of correlation in maturity duration with grain yield. This was because direct effect of that to grain yield was only (0.064).

Conclusion

According to the results of this research, traits of pods per plant, total dry matter and flowering duration, had the most positive-direct effects on Canola grain yield. Therefore better genotype evaluation according to grain yield can be made by direct selection of these traits. Some researchers also reported similar results about this research [5, 20 and 26].

Table 1 - Summary results of analysis variance of traits

S.O.V	df	Days to Emergence	Percent of Emergence	initiation of flowering	End of flowering	Flowering duration	Days to ripening	Plant heights	Pod per plant	Grain Per Pod	1000 grain weight	Total dry matter	Harvest index	Grain yield
Replication	2	0.1	0.9	0.6	1.5	4.1	4.2	695.2	235.9	2.8	0.16	227.02	71.12	36548.1
Planting date	3	68.4**	50.8*	29.7*	45.9*	122.9**	2440.1**	13702.5**	3596.4**	82.0**	1.75**	174453**	86.95**	377812.7**
Error	9	1.6	6.5	3.2	1.4	5.6	18.0	65.3	28.5	0.7	0.03	33.43	0.0108	89643.1
Genotype	9	51.9**	26.7*	41.6*	39.3*	35.7**	20.5**	2379.6**	1517.2**	105.9**	1.16**	91498**	30.16**	237854.3**
Planting date × Genotype	27	1.8*	18.9*	1.5*	3.8*	3.8*	4.3*	374.7*	105.3*	5.9**	0.07*	6533.2**	11.47**	331796.9**
Error	72	0.7	3.2	1.2	2.6	1.8	1.6	180.8	47.1	1.7	0.03	26.1	0.0503	20513.8
CV (%)	-	9.3	5.5	6.1	8.2	6.9	1.0	9.1	8.8	7.8	6.8	3.65	4.08	7.0

ns, * and **: No significant and Significant at 5 and 1% Level of Probability, Respectively

Table 2 - Correlation coefficients of agronomic traits of canola Genotypes

Traits	Day to emergence	Percent of emergence	initiation of flowering	End of flowering	Flowering duration	Days to ripening	Plant heights (Cm)	Pod Per plant	Grain per pod	1000 grain weight (g)	Harvest index (%)	Total dry matter (gm^{-2})
Percent of emergence	-0.686**											
Initiation of flowering	-0.197 ^{ns}	-0.88 ^{ns}										
End of flowering	-0.336 ^{ns}	-0.184 ^{ns}	0.962**									
Flowering duration	-0.861**	0.513*	0.81 ^{ns}	0.523*								
Days to ripening	-0.544*	0.130 ^{ns}	0.697**	0.755**	0.753**							
Plant heights (Cm)	-0.690**	0.400 ^{ns}	0.572*	0.682**	0.823**	0.849**						
Pod per plant	-0.723**	00.321 ^{ns}	0.400 ^{ns}	0.41 ^{ns}	0.855**	0.764**	0.822**					
Grain per pod	-0.316 ^{ns}	0.206 ^{ns}	0.87 ^{ns}	0.75 ^{ns}	0.637**	0.65 ^{ns}	0.526*	0.620*				
1000 grain weight (g)	-0.655**	0.195 ^{ns}	0.25 ^{ns}	0.66 ^{ns}	0.831**	0.581*	0.683**	0.863**	0.652**			
Harvest index (%)	-0.617*	00.157 ^{ns}	0.431 ^{ns}	0.45 ^{ns}	0.786**	0.653**	0.689**	0.907**	0.568*	0.886**		
Total dry matter (gm^{-2})	-0.720**	0.294 ^{ns}	0.414 ^{ns}	0.485*	0.888**	0.729**	0.819**	0.943**	0.602*	0.886**	0.929**	
Grain yield (Kg.ha^{-1})	-0.656**	0.202 ^{ns}	0.407 ^{ns}	0.430 ^{ns}	0.824**	0.670**	0.715**	0.955**	0.575*	0.909**	0.810**	0.932**

ns, * and **: No significant and Significant at 5 and 1% Level of Probability, Respectively

Table 3 - The stepwise regression for yield and other traits as the dependent variable as independent variables

Variable added to model	The stepwise regression				
	1	2	3	4	5
Constant	-1503	-1878	-1764	-1723	-1843
Pod per plant	198	154	153.7	146.1	145.7
Total dry matter		1.04	1.13	0.97	0.76
Flowering duration			-2.1	-2.3	-4.2
1000 grain weight				110	143
Days to ripening					3.2
Coefficient R2 (%)	45	63	72	85.6	92.5

Table 4 - Path analysis of yield traits between remaining in the stepwise regression model

		Indirect effect					
Character	**Direct effect**	**Pod Per plant**	**Total dry matter**	**1000 grain weight**	**Flowering duration**	**Days to ripening**	**Total effect**
Pod per plant	**0.784**	**----**	**0.138**	**0.027**	**-0.034**	**0.04**	**0.955**
Total dry matter	**0.657**	**0.17**	**----**	**0.097**	**-0.037**	**0.045**	**0.932**
1000 grain weight	**0.112**	**0.646**	**0.151**	**----**	**-0.036**	**0.036**	**0.909**
Flowering duration	**0.570**	**0.11**	**0.046**	**0.051**	**----**	**0.047**	**0.824**
Days to ripening	**0.062**	**0.476**	**0.124**	**0.064**	**-0.058**	**----**	**0.670**

Error= 0.54 (Residual effect)

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