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Regression and path analysis of oil and seed yield in canola cultivars (*Brassica napus* L.)

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Abstract

An experiment was conducted in the layout randomized complete block design with three replications in order to assess the relationship among different agronomic traits with seed and oil yield. Genotypic correlation analysis revealed strong relation of majority of the studied traits with oil and seed yield. Amongst, grain filling rate had highly significant and positive genotypic correlation with oil and seed yield. Step-wise regression of seed and oil yield revealed that 95% of total variation exists in oil yield accounted for by the traits grain filling rate (72%), grain filling duration (20%) and oil percent (3%) while grain filling rate (80%) and grain filling duration (13%) totally 93% for seed yield. Path analysis for seed and oil yield designed high efficiency of the traits grain filling rate and grain filling duration as indirect selection criteria for genetic improvement of oil and seed yield in canola cultivars especially in early generations of breeding programs. In conclusion, significant difference was observed for all the traits especially for oil and seed yield in canola. Also, selection for higher amount of grain filling rate could be promised to choice the best canola genotypes. These genotypes must be mature later than others which bearing higher seed yield resulting oil yield.

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Introduction

Correlation coefficient analyses help researchers to distinguish significant relationship between traits. Step-wise regression can reduce effect of non-important traits in regression model, in this way traits accounted for considerable variations of dependent variable are determined (Agrama, 1996). Path analyses that present by Li (1956) have been extensively used for segregating correlation between yield and its components in field crops. Path analysis is used to determine the amount of direct and indirect effects of the variables on the dependent variable (Li, 1956; Farshadfar *et al*., 1993).

Sheikh *et al*. (1999) reported positive and significant relation among seed yield and the traits 1000-seed weight and no.pod/plant. Ozer *et al*. (1999) emphasized on importance of 1000-seed weight and no.pod/plant as efficient indirect selection criteria for genetic improvement of seed yield in canola cultivars. Algan and Aygun (2001) showed positive and direct effect of the traits no.pod/plant, no.seed/pod, harvest index and seed weight on seed yield in canola genotypes. These traits were determined as indirect selection criteria in canola breeding programs.

Bagheri *et al*. (2008) reported positive and significant relation among oil yield and the traits seed yield, plant height and 1000-seed weight. Fathi *et al*. (2008) emphasized on importance of 1000-seed weight and no.seed/plant as efficient indirect selection criteria for genetic improvement of seed yield in canola cultivars.

Farhudi *et al*. (2008) showed positive and direct effect of the traits no.seed/plant, seed yield, biological yield and 1000-seed weight on oil yield in canola genotypes.

This study was conducted in order to determine the dependence relationship between oil and seed yield of canola cultivars and other traits as well as identify the best selection criteria for genetic improvement of these traits *via* indirect selection.

Materials and methods

Canola cultivars

This experiment was achieved in the layout randomized complete block design with three replications to assess the relationship among different agronomic traits with seed and oil yield.

Twenty canola lines were planted at the beginning of November 2013 at the research field of Isfahan (Khorasgan) branch, Islamic Azad University, Isfahan, Iran. The plots comprising four rows were 4 m long and 0.3 m apart. Distance between plants with in rows was 0.06 m.

Therefore, plant density was 560,000-plant ha^{-1}. In spring 2014, the trial was irrigated every 10 days. Amount of precipitation was 165 mm. Measurement for 13 traits days to shooting, days to full flowering, flowering duration, days to physiological maturity, plant height (cm), no.pod/plant, no. seed/pod, 1000-seed weight (g), seed yield (g), oil percent (%), oil yield (g), grain filling duration and grain filling rate (g/day) were achieved on 20 normal plants randomly selected from two middle rows in each plot.

Statistical analysis

Relationships between traits were investigated using genotypic correlation coefficient analysis. Step-wise regression was achieved to determine the best model, which accounted for variation exist in plant seed and oil yield as dependent variables in separate analysis. Direct and indirect effects of traits entered to regression model were determined by using path coefficient analysis. In this study, path analysis was carried out based on method given by Dewey and Lu (1959). Data analysis was done using $SPSS_{16}$, $Minitab_{15}$ and $Path_2$ soft wares.

Results and discussion

Genotypic correlation coefficient analysis showed positive and significant relationships of oil yield with the traits days to shooting, days to full flowering, days to physiological maturity, no. seed/pod, no. pod/plant, seed yield and grain filling rate (Table 1).

Table 1. Genotypic correlation coefficients for traits studied in canola cultivars.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Days to shooting	1											
(2) Days to full flowering	0.92**	1										
(3) Flowering duration	-0.09	0.52	1									
(4) Days to physiological maturity	0.52*	0.64*	0.35	1								
(5) Plant height	0.62	0.10	-0.96**	-0.14	1							
(6) No. seed/pod	0.48	0.62*	-0.09	0.90**	-0.39	1						
(7) No.pod/plant	0.51*	0.79**	0.79**	0.17	-0.16	0.30	1					
(8) 1000-seed weight	0.44	0.25	-0.16	0.34	0.48	0.38	-0.02	1				
(9) Oil percent	-0.06	0.08	0.26	0.24	-0.01	0.50*	0.01	-0.05	1			
(10) Seed yield	-0.85**	0.87**	0.33	0.52*	0.14	0.82**	0.60*	0.54*	0.31	1		
(11) Oil yield	0.79**	0.84**	0.33	0.53	0.15	0.86**	0.62	0.49	0.52	0.98**	1	
(12) Grain filling rate	-0.55*	-0.60*	-0.27	0.23	-0.16	0.04	-0.82**	0.04	0.19	-0.53*	-0.47	1
(13) Frain filling duration	0.91**	0.97**	0.33	0.42	0.16	0.07	0.76**	0.49	0.43	0.98**	0.95**	-0.63* 1

*, **: Significant at 0.05 and 0.01 probability levels, respectively.

Efficacy of these traits as the effective selection criteria in order to genetic improvement of oil yield in canola cultivars have been emphasized by Tang *et al.* (1997), Bagheri *et al.* (2008) and Golparvar and Karimi (2012).

Step-wise regression analysis for oil yield as dependent variable (Table 2) revealed that traits grain filling rate, grain filling duration and oil percent accounted for 95% of variation exist in oil yield. Therefore, these traits were determined as the main oil yield components. Amongst, trait grain filling rate accounted for 72% of total variation of oil yield lonely, that designated importance of this trait to explain variation of oil yield. Traits grain filling duration and oil percent accounted for 20 and 3% of variation of oil yield, respectively (Table 2).

Table 2. Step-wise regression for oil yield (dependent variable) in canola cultivars.

Variable	$b_{(1)}$	Partial R^2	Model R^2	t
Grain filling rate	0.92	0.72	0.72	**
Grain filling duration	0.41	0.20	0.92	**
Oil percent	0.30	0.03	0.95	**
Intercept	1.12			

Path analysis for oil yield (Table 3) based on traits entered to regression model indicated that trait grain filling rate has the high and positive direct effect on oil yield. On the other hand, this traits correlated positively and significantly with oil yield. Therefore, positive indirect effect of this trait on oil yield *via* the traits grain filling duration and oil percent must be considered, simultaneously (Farshadfar *et al*, 1993; Chaudhary *et al*., 1999).

Traits grain filling duration and oil percent showed the positive and medium direct effects on oil yield. Also, indirect effects of these traits *via* grain filling rate on oil yield are positive (Table 3).

Table 3. Path analysis for oil yield in canola cultivars.

Variable		(1)	(2)	(3)	Sum of effects
(1)	Grain filling rate	1.13	-0.131	0.047	0.95
(2)	Grain filling duration	-0.66	0.190	0.026	-0.47
(3)	Oil percent	0.246	0.025	0.214	0.45
Residual effects		0.098			

Thus, indirect selection for oil yield improvement through these traits and consider their direct and indirect effects on oil yield can be efficient in canola breeding programs. Therefore, these traits are introduced as the effective traits for indirect selection of genotypes having higher oil yield specifically in early generations. These results are inconsistent with reported by Abolhasani and Saeidi (2006) and Arslan (2007) in safflower and Bagheri *et al.* (2008), Farhudi *et al.* (2008) and Golparvar and Karimi (2012) in canola.

Genotypic correlation coefficient analysis showed positive and highly significant relationships of the traits days to shooting, days to full flowering, days to physiological maturity, no. seed/pod, no.pod/plant, 1000-seed weight, oil yield and grain filling rate with seed yield (Table 1).

Step-wise regression analysis for seed yield as dependent variable (Table 4) revealed that traits grain filling rate and grain filling duration accounted for 93% of variation exist in seed yield.

Amongst, trait grain filling rate accounted for 80% of total variation designated importance of this trait to explain variation of seed yield. Trait grain filling duration accounted for 13% of variation of seed yield (Table 4).

Table 4. Step-wise regression for plant seed yield (dependent variable) in canola cultivars.

Variable	$b_{(1)}$	Partial R^2	Model R^2	t
Grain filling rate	2.21	0.80	0.80	**
Grain filling duration	1.13	0.13	0.93	**
Intercept	3.25			

Path analysis for seed yield (Table 5) based on traits entered to regression model indicated that trait grain filling rate had the highest and positive effects on seed yield. Therefore, this trait is introduced as the effective trait for indirect selection of canola genotypes having higher seed yield specifically in early generations.

Grain filling duration has positive but low direct effect on seed yield. Indirect effects of this trait on seed yield also was negative and high. Overall, this trait is improper for using in selection superior canola genotypes (Table 5).

Table 5. Path analysis for plant seed yield in canola cultivars.

Variable		(1)	(2)	Sum of effects
(1)	Grain filling rate	1.125	-0.130	0.992
(2)	Grain filling duration	-0.744	0.203	-0.492
Residual effects		0.189		

Sheikh *et al* (1999) reported no. grain/pod as the best indirect selection criteria for genetic improvement of seed yield in canola genotypes. Rai *et al.* (1993), Ozer *et al* (1999) and Golparvar and karimi (2012) determined the traits no. grain/pod, no. pod/plant and biological yield as the most efficient criteria for selection superior canola and linseed genotypes especially in early breeding generations. These results are inconsistent with finding given by my research. However, the similar results reported by Bagheri *et al* (2008).

Conclusion

In conclusion, we can suggest indirect selection in early generations *via* traits that have the highest direct effect on dependent variables. These traits usually determine by means of statistical procedure like correlation, regression and path analysis. In present study, revealed that traits grain filling rate is the best indirect selection criterion for genetic

improvement of oil and seed yield in canola cultivars improvement specifically in early generations. On the other hand, traits grain filling duration and oil percent with low direct effect have lower importance as selection criteria.

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