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Full Length Research Paper

Determination of the best indirect selection criteria for improvement of seed and oil yield in canola cultivars (*Brassica napus* L.)

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To evaluate the relationship among seed and oil yield as well as determine the best indirect selection criteria for genetic improvement of seed and oil yield in canola a randomized complete block design with three replications was conducted using 17 cultivars. Step-wise regression of seed and oil yield revealed that 98.4 and 98.9% of total variation exists in these traits accounted for by the traits seed yield, oil percent, plant height and days to physiological maturity for oil yield while the traits biological yield, harvest index, days from planting to flowering initiation and no. grain/pod for seed yield . Path analysis for seed and oil yield designed high efficiency of the traits plant height and days to physiological maturity as indirect selection criteria for genetic improvement of oil yield and the traits biological yield and no. grain/pod for seed yield improvement in canola cultivars especially in early generations of breeding programs.

Key words: Canola, correlation analysis, path analysis, indirect selection, selection criteria, genetic improvement.

INTRODUCTION

Determination of the traits affects oil and seed yield is very efficient in breeding of this trait in canola (*Brassica napus* L.). Oil and seed yield are the quantitative trait that direct selection per se is not effective for improvement. Therefore, indirect selection through traits having higher heritability and correlated strongly with oil and seed yield has more genetic efficiency than direct selection in genetic improvement of these traits (Falconer, 1998).

Assessment of relationship using correlation coefficient analysis helps breeders to distinguish significant relation between traits. Step-wise regression can reduce the effect of non-important traits in regression model, in this way traits accounted for considerable variations of dependent variable are determined (Agrama, 1996). Path analysis presented by Li (1956) has been extensively used for segregating correlation between oil yield and its components in oilseed 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 number of 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, and 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 number of 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 of number of seed/plant, seed yield, biological yield and 1000-seed weight on oil yield in canola genotypes. This study was undertaken in order to determine the dependence relationship between seed

Table 1. Pearson's correlation coefficients for the traits studied in canola cultivars.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Days to shooting	1													
(2) Days to flowering initiation	0.043	1												
(3) Days to full flowering	0.860**	-0.038	1											
(4) Days to physiological maturity	0.741**	0.088	0.761**	1										
(5) Flowering duration	0.415*	-0.851**	0.557**	0.327	1									
(6) Plant height	0.741**	0.072	0.537**	0.457**	0.222	1								
(7) No.pod/plant	0.306	0.003	0.214	0.167	0.110	0.055	1							
(8) No. seed/pod	0.799**	-0.008	0.769**	0.631**	0.410*	0.682**	0.324	1						
(9) 1000-seed weight	0.744**	0.113	0.641**	0.499**	0.242	0.797**	0.170	0.739**	1					
(10) Biological yield	0.736**	0.044	0.683**	0.688**	0.322	0.617**	0.189	0.699**	0.664**	1				
(11 Seed yield	0.691**	0.036	0.620**	0.334	0.296	0.803**	0.089	0.674**	0.789**	0.712**	1			
(12) Harvest index	0.080	0.047	0.034	-0.367*	-0.022	0.363*	-0.090	0.102	0.295	-0.243	0.499**	1		
(13) Seed oil percent	0.679**	0.101	0.517**	0.445**	0.188	0.808**	0.178	0.690**	0.857**	0.720**	0.834**	0.290	1	
(14) Plant oil yield	0.712**	0.045	0.628**	0.382*	0.292	0.818**	0.106	0.696**	0.825**	0.746**	0.992**	0.451**	0.892**	1

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

and oil yield of canola cultivars and other traits as well as, identify the best selection criteria for genetic improvement of this traits via indirect selection.

MATERIALS AND METHODS

The 17 canola cultivars namely; Option 500, Hyola 300, Slm 046, Hyola 401, Sargol, Modena, Hysun 110, Swc-Motshot, Echo, Parkland, Landrace, Rinbow, SLM 046, Opera, Zarfam, RGS 003 and Elite were planted at the beginning of November 2009 at the research field of Islamic Azad University in a randomized complete block design.

The plots comprising of four rows were 5 m long and 0.3 m apart. Distance between plants within rows was 0.06 m. Therefore, plant density was 555,000-plant ha^{-1}. In spring 2010 the trial was irrigated every 10 days. Amount of precipitation was 165 mm. Measurement for 14 traits days to shooting, days to flowering initiation, days to full flowering, days to physiological maturity, flowering duration, plant height (cm), number of pod/plant, number of seed/pod, 1000-seed weight (g), biological yield (g), seed yield (g), harvest index (%),oil percent (%) and oil yield (g) were achieved on 10 normal plants randomly selected from two middle rows in each plot.

Relationships between traits were investigated using Pearson's correlation coefficient analysis at both 5 and 1 probability levels. Step-wise regression was achieved for determination of the best model, which accounted for variation existence in plant seed and oil yield as dependent variables in separate analysis. Direct and indirect effects of traits when entered in 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, Minitab and Path2 soft wares.

RESULTS

Pearson's correlation coefficient analysis (Table 1) showed positive and significant relationships of oil yield with the traits days to shooting, days to full flowering, days to physiological maturity, plant height, number of seed/pod, 1000-seed weight, biological yield, seed yield, harvest index and oil percent. Efficacy of these traits are the effective selection criteria to genetic improvement of oil yield in canola cultivars that have been emphasized by Bagheri et al. (2008) and Tang et al. (1997).

Step-wise regression analysis for oil yield as dependent variable (Table 2) revealed that traits seed yield, oil percent, plant height and days to physiological maturity accounted for 98.4% of variation existence in oil yield. Therefore, these traits were determined as the main oil yield components. Amongst, trait seed yield accounted for 86.1% of total variation of oil yield only, that designated the significance of this trait in explaining variation of oil yield. Traits oil percent, plant height and days to physiological maturity accounted for 3.1, 6.6 and 2.6% of variation of oil yield, respectively (Table 2).

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

Variable	$b_{(1)}$	S.E	R^2	t	Prob
Seed yield	0.44	0.01	0.861	58.42	0.000
Oil percent	23.76	1.64	0.892	14.51	0.000
Plant height	-1.26	0.49	0.958	-2.60	0.014
Days to physiological maturity	0.71	0.23	0.984	3.09	0.004
Intercept	-1074.79	57.19		-18.80	0.000

(1): b values have been tested relative to zero.

Table 3. Path analysis for oil yield in canola cultivars (underlined data show the direct effects of the traits on oil yield).

Variable	(1)	(2)	(3)	(4)	Sum of effects
(1) Seed yield	-2.64	-0.48	1.89	2.22	0.99
(2) Oil percent	-0.88	-1.42	1.05	2.15	0.89
(3) Plant height	-2.12	-0.63	2.36	1.21	0.82
(4) Days to physiological maturity	-2.20	-1.15	1.08	2.66	0.38
Residual effects	1.39				

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

Variable	$b_{(1)}$	S.E	R^2	t	Prob
Biological yield	0.240	0.010	0.644	30.500	0.000
Harvest index	102.950	3.070	0.720	33.580	0.000
Days to flowering initiation	-1.270	0.620	0.952	-2.050	0.0490
No. seed/pod	-40860	3.040	0.988	1.600	0.021
Intercept	-2185.990	140.720		-15.530	0.000

(1): b values have been tested relative to zero.

Path analysis for oil yield (Table 3) based on the traits entered to regression model indicated that traits seed yield and oil percent has high and negative direct effects on oil yield. On the other hand, these traits correlated positively and significantly with oil yield. Therefore, positive indirect effects of these traits on oil yield via the traits plant height and days to physiological maturity must be considered, simultaneously (Farshadfar, 2008; Chaudhaty et al., 1999).

Pearson's correlation coefficient analysis (Table 1) also showed positive and highly significant relationships of all the traits studied except traits as regard days to flowering initiation, days to physiological maturity, flowering duration, number of pod/plant and harvest index with seed yield.

Step-wise regression analysis for seed yield as dependent variable (Table 4) revealed that traits biological yield, harvest index, days to flowering initiation and no. seed/pod accounted for 98.8% of variation exist in seed yield. Amongst, traits biological yield and harvest index accounted for 72% of total variation designated importance of these traits to explain variation of seed yield. Traits days to flowering initiation and number of seed/pod accounted for 23.2 and 3.2% of variations of seed yield, respectively (Table 4).

Path analysis for seed yield (Table 5) based on the traits entered to regression model indicated that traits biological yield and no. grain/pod have the highest and positive effects on seed yield. Therefore, these traits are introduced as the effective traits for indirect selection of genotypes having higher seed yield specifically in early generations.

DISCUSSION

Traits plant height and days to physiological maturity has positive and high direct effects on oil yield. Also, indirect effects of plant height via days to physiological maturity and days to physiological maturity via plant height on oil yield are positive (Table 3). Thus, indirect selection for oil yield improvement through these traits are considered as direct and indirect effects on oil yield and can be efficient in canola breeding programs. Therefore, these traits are

Table 5. Path analysis for seed yield in canola cultivars (underlined data show the direct effects of the traits on seed yield).

Variable	(1)	(2)	(3)	(4)	Sum of effects
Biological yield	1.250	-0.298	0.001	-0.243	0.712
Harvest index	0.873	-0.426	0.003	0.046	0.499
Days to flowering initiation	0.055	-0.044	0.032	-0.008	0.035
No. seed/pod	-0.304	-0.020	-0.001	0.998	0.674
Residual effects	-0.352				

introduced as the effective traits for indirect selection of genotypes having higher oil yield specifically in early generations. These results are inconsistent with that as reported by Bagheri *e*t al. (2008) and Farhudi et al. (2008) in canola, Abolhasani and Saeidi (2006) and Arslan (2007) in safflower.

Harvest index has negative direct effect on seed yield, while its correlation with seed yield is positive. On the other hand, direct effect of harvest index on seed yield is positive and considerable. Therefore, indirect effect of this trait on seed yield via biological yield must be considered in selection program. Days to flowering initiation has positive but low direct effect on seed yield. Indirect effects of this trait also are low. Overall, this trait is improper for using in selection superior canola genotypes. Bagheri *et al.* (2008) reported no. grain/pod as the best indirect selection criteria for genetic improvement of seed yield in canola genotypes. Fathi et al. (2003), Tang et al. (1997) and Rai et al. (1993) determined the traits number of grain/pod, number of 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 consistent with finding given by my research. Also, the similar results reported by Farhudi et al. (2008) in canola, Abolhasani and Saeidi (2006) and Golparvar et al. (2009) in safflower. In conclusion, we can suggest indirect selection in early generations via traits that have the highest direct effect on dependent variables. These traits are usually determined by means of statistical procedure like correlation, regression and path analysis. This research revealed that traits like plant height and days to physiological maturity are the best indirect selection criteria for genetic improvement of oil yield in canola cultivars. On the other hand, traits biological yield and number of grain/pod are the best indirect selection criteria for seed yield improvement specifically in early generations.

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