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Research Article

ASSESSMENT OF SOME QUANTITATIVE TRAITS AS INDIRECT SELECTION CRITERIA FOR IMPROVEMENT OF SEED YIELD IN RAPESEED (*BRASSICA NAPUS* L.)

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ABSTRACT
To evaluate the correlation of seed yield per plant with some quantitative traits as well as determine the best indirect selection criteria for genetic improvement of seed yield in canola a randomized complete block design with four replications was achieved using 29 cultivars during 2012-2013 farming season. Correlation analysis showed that no. seed/pod had the highest significant and positive relationship with seed yield and accounted for the highest variations of seed yield. The largest direct and positive effect on seed yield also belonged to this trait. Furthermore, grain filling rate showed positive and significant correlation as well as high and positive direct effect on seed yield. Therefore no. seed/pod and grain filling rate are the best indirect selection criteria for genetic improvement of seed yield in canola cultivars. Concerning harvest index and flowering duration, indirect effects of these traits through no. seed/pod and grain filling rate have higher efficiency than their direct effects on seed yield.

Keywords: *Canola, Simple Correlation, Path Analysis, Indirect Selection, Breeding Strategy*

INTRODUCTION
The field area cultivated by rapeseed (*Brassica napus* L.) has been almost doubled in the World over the last fifteen years and nowadays it is grown on approximately 27 million hectares. In Europe, it is grown on 3.5 million hectares with increasing tendency. The largest field areas cultivated by rapeseed in Europe belong to Germany, France and Poland. It is primarily grown because of both, high quality oil, which meets criteria of the most demanding nutritionists, and proteins that are used as a feed pellets for the majority categories of livestock species (Marjanović - Jeromela *et al.,* 2007; Pospišil *et al.,* 1997). Rapeseed has also been used for biodiesel production since recently.
Rapeseed breeding strategies are mostly dealing with developing varieties characterized by high and stable seed and oil yield, as well as by low content of glucosinolates and erucic acids. Seed yield is a quantitative trait, which expression is the result of genotype, environmental effect and genotype-environment interaction (Huhn and Leon, 1985; Engqvist and Becker, 1993; Gunasekera *et al.,* 2006). Complexity of this trait is a result of diverse processes that occur during plant development (Ali *et al.,* 2003). Knowing the relationship among these processes and investigating other quantitative traits make breeding programs and their success more optimistic and secure (Mijić *et al.,* 2006).
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. Hashemi and Golparvar (2010) reported the high efficiency of biological yield and no. grain/pod as indirect selection criteria for genetic improvement of seed yield in canola cultivars.

The goal of this research was the assessment of simple correlation between some quantitative traits and seed yield per plant. Path analyses was also performed in order to determine yield related traits that could serve as indirect selection criteria in rapeseed breeding programs.

MATERIALS AND METHODS

The 29 canola cultivars namely; SLM 046, SW Falstaff, Talaye, Tassilo, Triangle, WRH 262, Modena, NK Aviator, NK Karibik, NK Octans, Okapi, Opera, RNX 3621, RPC 2033, Savanna, Olivia, GKH 0724, GKH 1605, GKH 2005, GKH 305, GKH 3705, GKH 5060, Karun, Licord, Adriana, Champlain, Cooper, ES Betty and GK Helena were planted at the beginning of November 2009 at the research field of Islamic Azad University, Khorasgan branch in a randomized complete block design with four replications.

The plots comprising four rows were 6 m long and 0.3 m apart. Distance between plants with in rows was 0.06 m. Therefore; the plant density was 555,000-plant ha^{-1}. In spring 2013 the trial was irrigated every 7 days. Amount of precipitation was 178 mm.

Measurement for ten traits days to flowering initiation, days to flowering termination, flowering duration, days to maturity, plant height (cm), no.pod/plant, no. seed/pod, seed weight (g), harvest index (%), grain filling duration, grain filling rate and seed yield (g) were achieved on ten normal plants randomly selected from two middle rows in each plot.

The relationship between investigated traits was examined by simple correlation coefficients. Direct and indirect effects of all above-mentioned investigated traits on seed yield per plant were estimated according to Dewey and Lu (1959). Data analysis was done using $SPSS_{16}$ and $Path_2$ softwares.

RESULTS AND DISCUSSION

Seed yield showed significant correlation only with no. seed/pod, harvest index and grain filling rate (table 1). This result emphasized on possibility of seed yield increasing along with improvement of these traits. Also, these traits have efficacy as indirect selection criteria to improve seed yield in canola cultivars specifically from early breeding generations (Algan and Aygun, 2001; Haghighorbani and Golparvar, 2010).

No. pod/plant showed non-significant relationship with seed yield, however this trait was entered to the regression model and verified 10% of seed yield variations. On the other hand, no. pod/plant have only significant correlation with no. seed/pod (table 1). Thus, selection for seed yield improvement should be done via no. seed/pod.

No. seed/pod is the first variable that have been entered to the regression model and verified 60% of seed yield variations. Grain filling rate along with flowering duration accounted for 20% of seed yield variation.

No. seed/pod had significant correlation with harvest index and grain filling rate designated high efficiency of these traits for indirect selection programs for seed yield improvement of canola cultivars.

Path analysis revealed the highest and positive direct effect of no. seed/pod and grain filling rate on seed yield (table 2). Therefore, these traits are suggested as the best indirect selection criteria to improve seed yield of canola cultivars especially in early breeding generations (Hashemi and Golparvar, 2010).

Indirect effects of these traits through each other on seed yield are positive and considerable, so emphasize on high efficacy of selection via these. Mean while, genotypes having no. seed/pod higher than the others also show the higher grain filling rate. Although, the genotypes should be considered that are specific to non-drought stress condition to maintain these traits at maximum amount. Under drought stress condition the different reaction might be detected from these genotypes. These results are in agreement with the findings of Pospišil *et al.,* (1997), Gunasekera *et al.,* (2006) and Marjanović - Jeromela *et al.,* (2007).

Direct effects of harvest index and flowering duration on seed yield were negative. However, indirect effects of these traits via no. seed/pod and grain filling rate were positive and considerable. Thus, indirect effects of these traits through no. seed/pod and grain filling rate have higher efficiency than its direct effects.

Table 1: Simple correlation coefficients for traits studied in canola cultivars

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Days to flowering initiation	1										
(2) Days to flowering termination	0.560**	1									
(3) Flowering duration	-0.085	0.778**	1								
(4) Days to maturity	0.185	0.105	-0.014	1							
(5) Plant height	0.677**	0.491**	0.077	0.184	1						
(6) No.pod/plant	0.144	0.158	0.080	-0.042	0.154	1					
(7) No. seed/pod	-0.281	0.080	0.310	0.058	-0.105	-0.640**	1				
(8) Seed weight	-0.141	0.050	0.167	0.170	-0.007	0.052	0.184	1			
(9) Harvest index	-0.065	-0.019	0.026	-0.220	0.025	-0.273	0.428*	0.277	1		
(10) Grain filling duration	-0.398*	-0.835**	-0.702**	0.459*	-0.337	-0.164	-0.040	0.049	-0.104	1	
(11) Grain filling rate	0.292	0.594**	0.493**	-0.224	0.400*	0.030	0.510**	0.101	0.391*	-0.655**	1
(12) Seed yield	-0.218	0.115	0.304	0.180	0.044	-0.154	0.795**	0.174	0.381*	-0.003	0.644**

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

Table 2: Path analysis for plant seed yield in canola cultivars

Variable	Flowering duration	No. seed/pod	Harvest index	Grain filling rate	Sum of effects
Flowering duration	-0.077	0.200	-0.001	0.180	0.303
No. seed/pod	-0.024	0.648	-0.017	0.186	0.795
Harvest index	-0.002	0.277	-0.038	0.142	0.381
Grain filling rate	-0.038	0.330	-0.015	0.365	0.643
Residual effects	0.535				

In conclusion, canola seed yield improvement, as one of the most important oil crops is the main breeding goal. In this study no. seed/pod showed the highest significant and positive correlation with seed yield and verified the maximum variations exist in seed yield. The highest direct and positive effect on seed yield also belonged to this trait. On the other hand, grain filling rate also showed positive and significant correlation as well as high and positive direct effect on seed yield. Therefore no. seed/pod and grain filling rate are the best indirect selection criteria for genetic improvement of seed yield in canola cultivars. Direct selection for seed yield improvement is better that delayed until advanced generations and increase of its heritability.

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