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Assessment of Relationship between Seed and Oil Yield with Agronomic Traits in Spring Safflower Cultivars under Drought Stress Condition

AHMAD REZA GOLPARVAR
Department of Agronomy and Plant Breeding, Islamic Azad University, Khorasgan Branch, Isfahan, Iran

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*Corresponding author: Email: dragolparvar@gmail.com

ABSTRACT

Identification of the important seed and oil yield components in safflower is very efficient in genetic improvement of these traits via indirect selection. For this reason, ten spring safflower cultivars were sown at drought stress condition in a randomized complete block design with three replications in the Research Field of Islamic Azad University of Khorasgan. Correlation analysis showed positive and significant relation of 1000-seed weight, No. seed/plant and oil yield with seed yield and 1000-seed weight, No. seed/plant, seed yield and seed oil percent with oil yield. Results of correlation, regression and path analysis revealed that 1000-seed weight, No. seed/plant, No. seed/capitulum and biological yield are the best selection criteria for genetic improvement of seed yield and 1000-seed weight and No. seed/plant for oil yield in drought stress condition.

Keywords: Spring safflower, Selection criteria, Genetic Improvement, Correlation Analysis, Step-Wise Regression, Path Analysis

INTRODUCTION

Identification of the traits that affect seed and oil yield in safflower (*Carthamus tinctorius* L.) is very important in genetic improvement of these attributes. Especially, seed yield is a polygenic trait that direct selection isn't effective for this especially in early generations. Therefore, indirect selection via traits having higher heritability and correlated strongly with seed and oil yield has more genetic efficiency than direct selection in genetic improvement of these traits (Falconer, 1998). Correlation coefficient analysis 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 could be determined (Agrama, 1996). Path analyses that presented by Li (1956) have been extensively used in field crops. Path analysis is used to determine the amount of direct and indirect effects of the variables on the dependent variable (Farshadfar, 2000; Li, 1956). Bratulin (1993) reported positive and significant relation between seed yield and capitulum number plant^{-1} and 1000-seed weight in safflower genotypes. Cassato *et al.* observed positive and significant correlation of capitulum number plant^{-1} with seed yield in safflower. Paramaswarapa (1984) identified that capitulum number plant^{-1}

and thin seed pericarp are the best selection criteria for improvement of safflower oil yield. Kumar *et al.* (1982) showed positive and significant relation between plant height, capitulum diameter and seed number capitulum^{-1} with seed and oil yield in safflower. Rao and Ramachandram (1997) found high importance of capitulum number plant^{-1}, capitulum weight and thin seed pericarp in breeding of seed and oil yield in safflower cultivars. Some researches on safflower genotypes revealed negative and significant correlation between oil yield with seed pericarp diameter (Corleto *et al*., 1997; Mozaffari and Asadi, 2006). Zheng *et al.* (1993) and Arslan (2007) emphasized on indirect selection via higher capitulum number plant^{-1} and 1000-seed weight and lower number of branches along with thin seed pericarp for improvement of seed and oil yield in safflower. Ulukan *et al.* (2003) reported positive and significant relationships between biological yield with plant height, pod number plant^{-1} and grain number pod^{-1} in faba bean genotypes. The total coefficient of determination was found as 63.6% in the regression model for biological yield as dependent variable. Direct effects of plant height, pod number plant^{-1} and grain number pod^{-1} upon biological yield were positive. These traits determined as selection criteria for genetic improvement of biological yield. This study was undertaken in order to determine the dependence relationship between seed and oil yield with agronomic traits in spring safflower cultivars under Isfahan province condition and to identify the best indirect selection criteria for genetic improvement of these traits.

MATERIALS AND METHODS

Ten spring safflower cultivars namely; Isfahan landrace, Kuseh landrace, Arak-2811, Nebraska-10, U.S.10, S149, C111, S3110, A.C.sterling and Gila were planted at the beginning of March 2007 at the Research Field of Islamic Azad University in a randomized complete block design with three replications. The plots comprising four rows were 2 m long and 0.5 m apart. Distance between plants within rows was 5 cm. Therefore, plant density was 400,000 plants ha^{-1}. In spring 2007 the trial was irrigated based on 150 mm evaporation from pan class A. Total amount of precipitation in agronomic season was 152 mm. Measurement for 14 traits days to 50% flowering, days to physiological maturity, grain filling duration, grain filling rate (g day^{-1}), plant height (cm), capitulum number plant^{-1}, seed number capitulum^{-1}, 1000-seed weight (g), seed number plant^{-1}, biological yield (g), harvest index (%), seed yield/plant (g), seed oil percent (%) and oil yield/plant (g) were done on 10 normal plants were randomly selected from the two middle rows of each plot. Grain filling duration was considered as days from flowering until physiological maturity and grain filling rate was calculated as the ratio of seed yield to grain filling duration. Harvest index was computed as the ratio of seed yield to biological yield. Seed oil percent was measured by NMR instrument in research laboratory of Karaj Jihad Agriculture Institute. Relationships between traits were investigated using simple correlation coefficient analysis. Step-wise regression was performed for determination of the best models, which accounted for most of the variation existed in plant seed and oil yield as dependent variables in separate analysis. Direct and indirect effects of traits entered to regression model were determined 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.

Table 1. Simple correlation coefficients for traits studied in safflower cultivars

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) 1000-seed weight (g)	1													
(2) Capitulum number plant^{-1}	0.17	1												
(3) Seed number capitulum^{-1}	-0.22	-0.76**	1											
(4) Seed number plant^{-1}	-0.17	0.06	-0.03	1										
(5) Seed yield/plant (g)	0.65**	-0.03	0.16	0.39*	1									
(6) Seed oil percent (%)	-0.20	-0.06	-0.16	0.04	-0.32	1								
(7) Oil yield/plant (g)	0.44*	-0.07	0.02	0.37*	0.65**	0.51**	1							
(8) Biological yield (g)	0.19	0.83**	-0.53**	0.06	0.17	-0.22	-0.01	1						
(9) Plant height (cm)	0.10	0.44*	-0.57**	0.32	0.20	-0.10	0.11	0.49**	1					
(10) Harvest index (%)	0.04	-0.80**	0.83	0.02	0.29	-0.12	0.16	-0.79**	-0.54**	1				
(11) Days to 50% flowering	0.12	0.01	0.04	-0.26	-0.13	-0.07	-0.18	-0.24	-0.23	0.18	1			
(12) Days to physiological maturity	-0.09	0.02	-0.05	-0.12	-0.30	0.03	-0.23	-0.19	-0.14	0.04	0.75**	1		
(13) Grain filling duration	-0.30	0.01	-0.13	0.20	-0.24	0.15	-0.08	0.06	0.13	-0.20	-0.36	0.35	1	
(14) Grain filling rate (g day^{-1})	0.41	0.04	0.20	0.10	0.62	-0.34	0.26	0.14	-0.07	0.23	0.12	-0.44	-0.79**	1

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

Table 2. Step-wise regression for seed yield/plant (dependent variable) in safflower cultivars

Variable	$b_{(1)}$	S.E	t	R^2
1000-seed weight (g)	0.186	0.019	9.789**	0.428
Seed number plant^{-1}	0.124	0.018	6.889**	0.690
Seed number capitulum^{-1}	0.301	0.057	5.281**	0.812
Biological yield (g)	0.020	0.008	2.500*	0.853
Intercept	-6.188	1.287	-4.808**	

(1): b values have been tested relative to zero.
*, **: Significant at 0.05 and 0.01 probability levels, respectively.

Table 3. Path analysis for seed yield/plant in safflower cultivars

Variable	(1)	(2)	(3)	(4)	Sum of effects
(1) 1000-seed weight (g)	0.806	-0.091	-0.107	0.045	0.653
(2) Seed number plant^{-1}	-0.138	0.531	-0.105	0.013	0.391
(3) Seed number capitulum^{-1}	-0.180	-0.017	0.479	-0.125	0.158
(4) Biological yield (g)	0.153	0.029	-0.252	0.237	0.168
Residual effects	0.385				

Table 4. Step-wise regression for oil yield/plant (dependent variable) in safflower cultivars

Variable	$b_{(1)}$	S.E	t	R^2
1000-seed weight (g)	0.023	0.007	3.286**	0.544
Seed number plant^{-1}	0.021	0.007	3.000**	0.752
Intercept	-0.353	0.433	-0.815	

(1): b values have been tested relative to zero.
**: Significant at 0.01 probability level.

Table 5. Path analysis for oil yield/plant in safflower cultivars

Variable	(1)	(2)	Sum of effects
(1) 1000-seed weight (g)	0.517	-0.080	0.437
(2) Seed number plant^{-1}	-0.089	0.462	0.374
Residual effects	0.774		

RESULTS AND DISCUSSION

Correlation analysis showed the significant and positive relationship exist between seed yield/plant and traits 1000-seed weight, seed number plant^{-1} and oil yield/plant (Table 1). On the other hand, oil yield/plant correlated positively and significantly with 1000-seed weight, seed number plant^{-1}, seed yield/plant and seed oil percent.

Harvest index showed negative and significant relation with capitulum number plant^{-1}, biological yield and plant height.

Therefore, decrease in these traits can improve harvest index in spring safflower cultivars under drought stress condition. Grain filling rate had significant correlation with any of the traits.

Omidi-Tabrizi (2002), Johnson *et al.* (1997) and Corletto *et al.* (1997) also reported similar findings in their studies on spring safflower cultivars.

Step-wise regression analysis for seed yield/plant as dependent variable and the other traits as independent revealed that 1000-seed weight, seed number plant^{-1}, seed number capitulum^{-1} and biological yield are the most important seed yield/plant components (Table 2). These traits accounted for 85% of total variation exist in seed yield/plant.

Path analysis was achieved using these traits. Results given from path analysis showed direct and positive effects of these traits on seed yield/plant (Table 3). Therefore, indirect selection via these traits for genetic improvement of seed yield/plant has high genetic efficiency. Indirect effects of biological yield from path of 1000-seed weight on seed yield/plant also must be considered.

Arslan (2007) and Mozaffari and Asadi (2006) also emphasized on 1000-seed weight, seed number plant^{-1} and seed number capitulum^{-1} as the best selection criteria for improvement of seed yield/plant in safflower genotypes. These reports are similar to results of this research.

Step-wise regression for oil yield/plant as dependent variable and the other traits as independent assigned that 1000-seed weight and seed number plant^{-1} have positive and significant regression coefficient and accounted for 75% of total variation exist in oil yield/plant (Table 4).

Path analysis based on traits entered to regression model showed that these traits have direct and positive effects on oil yield/plant. Therefore, 1000-seed weight and seed number plant^{-1} were introduced as the best indirect selection criteria for genetic improvement of oil yield/plant in spring safflower cultivars under drought stress condition (Table 5).

Omidi-Tabrizi (2002) studied spring safflower cultivars under drought stress and determined biological yield, capitulum number plant^{-1}, number of branches and seed number capitulum^{-1} as the most important components of oil yield/plant. Arslan (2007), Parasad and Agrawal (1993), Paliwal and Solanki (1984) and Mozaffari and Asadi (2006) also reported similar results.

CONCLUSION

We can suggest that indirect selection 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. Our results, revealed that traits 1000-seed weight, seed number plant^{-1}, seed number capitulum^{-1} and biological yield for seed yield/plant, and 1000-seed weight and seed number plant^{-1} for oil yield/plant are the best indirect selection criteria in safflower cultivars under this study.

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