Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 4, No. 2, p. 111-118, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Correlation, multiple regression and path analysis for some yield-related traits in safflower

Moslem Bahmankar[1*], Daryoosh Ahmadi Nabati[2], Massoud Dehdari[3]

[1]*Department of Agronomy and Plant Breeding, College of Abureyhan, University of Tehran, Tehran, Islamic Republic of Iran*

[2]*Daryoosh Ahmadi Nabati, Department of Agronomy and Plant Breeding, College of Agriculture, University of Shahid Chamran Ahvaz, Ahvaz, Islamic Republic of Iran*

[3]*Massoud Dehdari, Department of Agronomy and Plant Breeding, College of Agriculture, University of Yasuj, Yasuj, Islamic Republic of Iran*

Article published on February 03, 2014

Key words: Path analysis, phenotypic correlation, stepwise multiple regression, safflower.

Abstract

Safflower (*Carthamus tinctorius* L.) is an important oilseed crop which is cultivated predominantly in semiarid and temperate regions of the world. The aim of this study was to use statistical methods of phenotypic correlation, multiple stepwise regressions and path analysis to evaluate the relationship between yield and components yield using 20 different safflower genotypes. Plant characters such as day to initiate flowering, day to 50% flowering, day to maturity, plant height, main head diameter, heads per plants, seeds per head, 1000-seed weight and seed yield per plants were main selected measurements for the data analysis. Phenotypic correlation indicated that seed yield per plants had highly positive correlation with 1000-seed weight (r=0.79**), main head diameter (r=0.77**) and heads per plants (r=0.49*). Stepwise multiple linear regression interpretation also indicated that 90% of variation in seed yield attributed to variation which arose from 1000-seed weight, heads per plants, main head diameter and plant height characters. The results of path analysis strongly suggested that 1000-seed weight; heads per plants and main head diameter contain positive direct effect on seed yield. Therefore, it could be concluded that number of head per plant, 1000-seed weight, main head diameter and plant height are putative morphological markers which can be considered as the desirable tools for screening elite safflower genotype under the field conditions.

***Corresponding Author:** Moslem Bahmankar ✉ bahmankar_64@ut.ac.ir

Introduction

Oilseed crops are the main sources of edible oils with healthy diet and compared to synthetic and animal oils have become more popular with high demand among consumers. Such expectation reinforces plant researchers to concentrate their works toward promoting of oil production in the edible oilseed crops. Beside its oil demand, safflower has been cultivated for many other different reasons in India, the Near East, the Middle East and China. It has been grown primarily to use for its colorful petals as a food coloring, oil extraction and obtaining textile dye in the Far East, Central and North Asia, America, North Africa and Europe for centuries (Ahmadzade *et al.,* 2010, Abd El-Latteif, 2012, Shabana, 2013). A precise agricultural practice in combination with plant breeding would be a great attempt to boost crop production in safflower. A successful breeding program usually depends on the choice of selection indices for improving plant vigor in order to promote seed yield quality (Samonte *et al.,* 1998). It is well documented that yield components can influence directly on the yield, but yield components may simultaneously be affected the yield indirectly, in result of negative or positive influence of certain plant characters (Walton, 1980). The application of some statistical methods indicated that selection of a character can have positive impact on another character and at the same time it may affect negatively on some other or all characters under consideration (Walton, 1980, Prasad *et al.,* 1993). One of these applications appears to be correlation coefficient in which applied to determine the simple linear association between two characters that shows, it does not fit to forecast the success of selection, While, path analysis and regression on standardized variables have defined the relative importance of direct and indirect effects on seed yield (Bhatt, 1973, Toker and Cagirgan, 2004). In past, several workers have been determined the associations between some plants characters in safflower genotypes (Nie *et al.,* 1993, Nie *et al.,* 1987, Pascual and Albuquerque, 1996). They were able to report that number of capitula/plant, number of seeds/capitulum, weight of seed and capitulum diameter were considered to be main yield components (Chaudhary, 1990, Prasad *et al.,* 1993, Omidi, 2000). Chaudhary has reported that three characters; number of seed/capitulum, number of capitula /plant and 1000-seed weight could be primary source of selection indices for producing of high yielding oilseed genotypes in safflower lines (Chaudhary, 1990). Acharya *et al.,* in a study on genotypes of safflower have shown that 1000-weight seed had positively effect on seed yield and also indicated that the direct effect of this character was greater than the other characters in relation to seed yield (Acharya *et al.,* 1994). For promotion of seed yield and oil content in safflower genotype, one has to develop a selection criteria in which are able to bear highly efficient source of genetic variation within selected characters (Golkar *et al.,* 2011). However, for expediting such trend it is required for the plant breeder to deploy a condition for cultivars fitness in the field where is able to select effective traits which have direct influence on yield and oil content (Golkar *et al.,* 2011). Despite the correlation coefficients which express the simple linear association among plant characters, path coefficients can define the relative contribution of various yield related characters which enabling the plant breeders to choose between direct and indirect components during selection process (Bhatt, 1973). The aim of this study was to use the phenotypical correlation, stepwise regression and path analysis to evaluate the relationship among phenological and morphological characters in certain of safflower genotypes in order to elucidate the best selection index for yield improvement in breeding of safflower.

Materials and methods

Twenty genotypes of the safflower including; 6 Iranian genotypes and 14 exotic genotypes provided from Institute of Plant Genetics and Crop Plant Research (IPK) in Gatersleben of the Germany) were sown in spring 2011 at Research Farm of the Researches Center for Agriculture and Natural Resources located in Yasuj (51° 31´ E and 30° 41´ N, 1734 m asl), Iran. Yasuj located in cold climates and possess cold to moderate cold weather. The soil of research field had a loamy texture. Genotypes were set to grow in a trail study of randomized completed blocks design with three replications. Each plot had four rows with 3m length and with spacing of 50cm; seeds were sown by hand with 5cm distance in rows. Recommended crop management practices were implemented to raise the crops to desirable growth stages. Plots were kept weed, pest and disease free till harvesting time. Plant characters measurements were including: Days to initiated flowering (DIF), Days to 50% flowering (DF 50%), Days to maturity (DM) on basis field observations, while plant height (PH), number of head per plant (HP), number of seed per head (SH), 1000- seed weight (SW) (g), main head diameter (MHD) (mm) and seed yield per plant (SYP) (g) were recorded using seven randomly selected plants from each plot. Phenotypic correlation and multiple stepwise regressions were estimated using SAS program and Path coefficients analysis were carried out by SPSS Ver.16 using seed yield as dependent variable and the remaining characters as independent variables.

Table 1. List of names and origin of safflower genotypes.

Genotype	Origin	Genotype	Origin
Khatam Yazd	Iran	C130	Morocco
Goldasht	Iran	C132	Germany
Sina411	Iran	C161	Soviet Union
Local Isfahan	Iran	C24	Morocco
Isfahan 14	Iran	C151	Pakistan
IL111	Iran	C83	Tajikistan
C19	Polish	C9	Republic of Czech
C160	Soviet Union	C56	USA
C173	Indian	C55	Polish
C124	Pakistan	C159	Germany

Result and discussion

Analysis of variance

Results of analysis of variance, maximum, minimum and means of the traits measurement and value of their coefficient variation (CV) are showed in Table 2. There was a highly significant difference among genotypes in regard of the growth characters, and showed that these differences can be due to the genetic variation within the genotypes. In this investigation CV ranged from 1.3 for 1000-seed weight to 22.2 for the seed yield per plant. The genotype C173 with 77 and genotype Sina411 with 54.7 ranked the highest and lowest in character of day to initiation flowering respectively. Present genotypes indicated differences in their day to maturity as well. Days to maturity were significantly differed among genotypes which showed that two genotypes of Isfahan14 and C151 had the highest (134.7 DM) and lowest (105 DM) days to maturity, plant height that attributed to genotype of C130 and Isfahan14 with the lowest and highest plant height, head per plant was shared with genotypes of C160 and C173 with the highest and lowest number of head per plant and the minimum and maximum numbers of seed per head were belonged to C173 and C83, respectively, (Table 2). Main head diameter was ranged from 297mm to 174mm for genotypes of Goldasht and C173 which counted for the highest and lowest main head diameter, respectively. At harvesting time, genotypes of C160 and C55 with 21.9 g and 6.9 g seeds had showed the highest and the lowest yield per plant, respectively (Table 2).

Table 2. Analysis of variance of nine plant characters in twenty safflower genotypes.

		Mean of Square								
Source	df	DIF	50%DIF	DM	PH	HP	SH	SW	MHD	SYP
Replication	2	11.3	4.7	24.4**	0.78	0.74	6.85	0.44	40.8*	5.87
Genotype	19	93.5**	103.1**	113.1**	262.1**	8.1**	79.9**	1118.3**	5650**	47.5**
Error	38	4.7	1.8	2.6	1.4	1.1	2.2	0.2	10.7	0.2
CV (%)		3.5	1.9	1.4	1.7	9.4	4.3	1.3	1.4	22.2
Max		77	87	134.7	96.4	14.2	44.5	46.5	297	21.9
		C_{173}	C_{19}	$Isfahan_{14}$	$Isfahan_{14}$	C_{160}	C_{83}	C_{160}	Goldasht	C_{160}
Min		54.7	67	105	61.3	9	25.4	26.3	174	6.9
		$Sina_{411}$	C_{173}	C_{151}	C_{130}	C_{173}	C_{173}	C_{124}	C_{173}	C_{55}
Mean		63.3	73.7	116.7	72.1	11.3	34.7	35.1	233.7	12.6

*and**significant at the 0.05 and 0.01 level respectively

DIF: Days to initiate flowering; 50%DF: days to 50% flowering; DM: Days to maturity; PH: plant height; MHD: Main head diameter; HP: heads per plant; SH: seeds per head; SW: 1000-seed weight; SY: seed yield per plant.

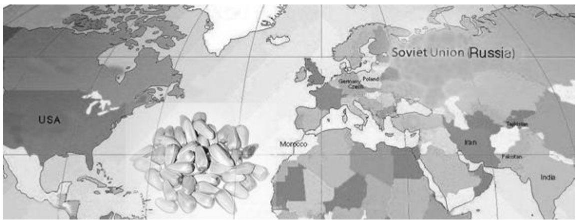

Fig. 1. geographical distribution of safflower genotypes.

Correlation coefficients analysis

The analysis of correlation coefficient has revealed information in which the scale of seed yield production is related to SW and MHD with high and positively manner at the (α<0.01) probability, whereas has associated with heads per plant in medium range with positively manner at the (α<0.05) probability (Table3). This information indicated that the choice of indirect selection for these three characters can be effective tool for the yield improvement. The 1000-seed weight was correlated significantly with seed yield per plant at the positive range. The finding in the present study was similar to those reports by Acharya et al. and Nie *et al.,* who demonstrated that 1000-seed weight possessed highly positive correlation with seed yield in safflower (Acharya *et al.,* 1994, Nie *et al.,* 1987). While, Chaudhary showed that there is a highly positive correlation between head diameter and seed yield per plant in safflower and Golkar *et al.*, reported that number of head per plant possessed the highest positive correlation with seed yield per plant in safflower (Chaudhary, 1990, Golkar *et al.,* 2011). In this investigation the correlation between seed yield and other phenological and morphological characters was not significantly differenced (Table 3), while the main diameter head was significantly correlated with SH and SW. Golkar *et al.,* showed that there was a significant correlation between seed weight and head diameter in safflower (Golkar *et al.,* 2011). In the present study, the result also indicated that there is a highly positive association between two characters of PH and number of head per plants but, Mokhtassi *et al.,* was reported that association between plant height and number of head per plant was not significant (Mokhtassi *et al.,* 2006). When compared the yield components with seed yield, only number of seed per head did not significantly correlate with seed yield (Table 3). A negative association was detected between plant heights with 1000-seed weight. This report was also observed in a study by Golkar *et al.,* (Golkar *et al.,* 2011). The lack of significant correlation between plant height and seed yield in the present study was similar to those findings by Mozzafari and Asadi (Mozzafari and Asadi, 2006). Plant height positively and significantly associated with days to initiate flowering and is in agreement with the report of Dwivedi *et al.,* (Dwivedi *et al.,* 2005). So, there was a positive correlation between the main head diameter and days to maturity which confirmed with similar result finding by Mozzafari and Asadi who demonstrated that there is positive correlation between head diameter and days to maturity in safflower (Mozzafari and Asadi, 2006). Correlation between 50%DF and DM was a positive and significant (Table 3). Days to initiate flowering with heads per plant and seed yield per plant had a positive association (Table3). The results of this investigation was supported by Rafeaie *et al.,* who demonstrated that there is significant and positive association between days to initiate flowering with HP and seed yield per plant (Rafeaie *et al.,* 2006). The result also showed a negative correlation between DIF and seeds per head. This finding was contrary to those findings by Golkar *et al.,* who reported that number of seeds per head possessed highly positive association with days to flowering (Golkar *et al.,* 2011). The above arguments confirmed that when selecting criteria initiated indirectly to screen the individual with more 1000-seed weight, thick main head diameter and large number of head per plant can be a noble approach to upgrade seed yield in safflower crop.

Table 3. Study of correlation coefficient among nine characters of twenty safflower genotypes.

Characters	DIF	50%DF	DM	HP	PH	MHD	SH	SW	SYP
DIF	1								
50%DF	0.91**	1							
DM	0.41	0.56**	1						
HP	0.18	0.02	0.13	1					
PH	0.45*	0.38	0.30	0.46*	1				
MHD	-0.27	-0.16	0.36	0.14	-0.01	1			
SH	-0.45*	-0.48*	0.11	0.03	-0.05	0.65**	1		
SW	-0.17	0.02	0.20	0.08	-0.15	0.72**	0.06	1	
SYP	0.02	0.12	0.35	0.49*	0.26	0.77**	0.26	0.79**	1

*and ** significant at P<0.05 and P<0.01 respectively.

DIF: Days to initiate flowering; 50%DF: days to 50% flowering; DM: Days to maturity; PH: plant height; MHD: Main head diameter; HP: heads per plant; SH: seeds per head; SW: 1000-seed weight; SYP: seed yield per plant.

Multiple stepwise regression analysis

In this research seed yield per plant considered as dependent variable and all other remaining characters were as independent variable for multiple stepwise regressions. The equations for analysis of the regression elucidated that 82% of total variation for the seed yield could be explained by two characters; 1000-seed weight (64%) and heads per plant (18%). When characters such as main head diameter and plant height were added to the regression model, the output could just explain only 8% of total variation of seed yield (Table 4). On the other hand when four other characters were added to the model, it has been observed that the remaining of 10% of variation was not being able to explain. This shows that this amount of variation may disseminate within other components. Positive regression coefficients of these variables indicated that a logical and reasonable index selection for these, one has to considering their narrow-sense heritability and correlation coefficient in order to improve seed yield in safflower (Golkar *et al.,* 2011).

Table 4. Equations of stepwise multiple regression of seed yield and nine phenological and morphological in safflower genotypes.

Regression equations	Coefficient of partial determination	Cumulative coefficient determination
*SYP= -5.19+ 0.51SW	0.64	0.64
SYP= -15.8+ 1.03SW+ 0.49HP	0.18	0.82
SYP= -0.16.85+ 0.33SW+ 0.96HP+ 0.03MHD	0.05	0.87
SYP= -21.63+ 0.37SW+ 0.72HP+ 0.03MHD+ 0.09PH	0.03	0.90

*SYP= seed yield per plant, SW= 1000 seed weight, HP = Heads per plant and, MHD=Main head diameter, PH=plant height

Path analysis

Results of multiple stepwise regression was revealed information in which four characters; 1000-seed weight, heads per plant, main head diameter and plant height were performed the key characters for estimation of variation in dependent variables. Therefore, the correlation coefficients between these characters and seed yield per plant can be broken to direct and indirect effects, in which helps to gain more and accurate aware of the relationships between characters that could have maximum impact on seed yield per plant using path analysis. Evaluation of path analysis demonstrated that direct effect of 1000-seed weight on seed yield exhibited a highly positive trend (Table 5). The direct effects of main head diameter, number of head per plant and plant height on the seed yield per plant as dependent character were also positive. The former three direct effects had less impact on seed yield per plant than direct effect of the SW. Due to positive direct effect of the character of 1000-seed weight on seed yield and as well as its positive indirect effects through characters such as MHD and HP, genetic correlation between SW and seed yield was highly positive (Table 5). The result showed that an individual plant with a high 1000-seed weight can be considered as a desirable plant character to improve seed yield production in safflower. The similar result was also recommended in a study by Acharya et al. and Nie *et al.,* (Acharya *et al.,* 1994, Nie *et al.,* 1993). It has been observed that when the characters influence the yield component increased, can effect directly on the efficient index which result in beneficial trend to promote the yield production in safflower. It has been observed that the next to 1000-seed weight, main head diameter had a positive direct effect on SYP, but showed that it has a negative indirect effect on PH which caused to minimize seed yield.

A noticeable approach in here indicated that indirect effect of MHD via 1000-seed weight has more influenced on seed yield than their direct effect. So, this process may a cause for leading to high genetic correlation between MHD and seed yield (Table 5). In perspective of path analysis, the results indicated that the negative indirect effects of PH through SW and main head diameter cause to lead decrease the correlation between seed yield and plant height. Although the results of this investigation showed that the relationships of some yield components such as height plant on seed yield were not significantly due to correlation of coefficient, but their direct effects on seed yield were significant according to path coefficient, therefore they can be classified as characters with high correlation coefficient.

Table 5. Direct and indirect effects of remained characters in the regression model on seed yield per plant in safflower genotypes using path coefficients analysis.

Characters	Genotypic Correlation	Direct effects	Indirect effects via SW	MHD	HP	PH
SW	0.80	0.58**	----	0.220	0.020	-0.030
MHD	0.78	0.31*	0.422	----	0.051	-0.002
HP	0.51	0.30**	0.055	0.049	----	0.106
PH	0.27	0.22*	-0.087	-0.003	0.144	----

1000-seed weight (SW), main head diameter (MHD), Number of head per plant (HP), plant height (PH)
*and ** significant at P<0.05 and P<0.01 respectively.

Acknowledgement

The authors would like to thank of the staff of Province Agriculture Organization for providing facilities in the field trials. We also like to thank A. Izadi Darbandi, A.Arminyan, for their help and assistance in carrying out works in the research field and invaluable guidance during this research project.

References

Acharya S, Dhaduk LK, Maliwal GL. 1994. Path analysis in safflower (Carthamus tinctorius L) under conserved moisture conditions. University Research Journal **20,**154- 157.

Ahmadzade AR, Majidie E, Alizade B, Omidi AH. 2010. Study the Yield, Yield Components and Morphological Traits in the Spring Safflower (Carthamus tinctorius L.) Using Journal of new Agriculture Science. Journal of new Agriculture Science **6,** 1-8.

Abd El-Latteif EA .2012. Evaluation of 25 safflower genotypes for seed and oil yields under Arid Environment in Upper Egypt. Asian Journal of Crop Science 1-8.

Bhatt GM. 1973. Significance of path coefficient analysis in determining the nature of character association. Euphytica **22**, 338–343.

Chaudhary SK. 1990. Path analysis for seed yield in safflower (Carthamus tinctorius L.) in acid soil under mid altitude conditions. International Journal Tropical Agricultural **8,** 129–132.

Dwivedi SL, Upadhyaya HD, Hegde DM. 2005. Development of core collection using geographic information and morphological descriptors in safflower (Carthamus tinctorius L.) germplasm. Directorate of Oilseed Research, Rajandra Nagar, Heyderabad 500 030, India. Genetic Resources and Crop Evolution **52,** 821-830.

Golkar P, Arzani A, Rezaei AM. 2011. Determining relationships among seed yield, yield components and Morpho-phenological traits using multivariate analyses in safflower (Carthamus tinctorious L.). Annals of Biological Research **2,** 162-169.

Knowles PF. 1969. Centers of plant diversity and conservation of crop germplasm Safflower. Economic Botany **23,** 324-329.

Mokhtassi A, Akbar GA, Mirhadi MJ, Zand E, Soufizade S. 2006. Relationships among characters using correlation, principal components and path analysis in safflower (Carthamus tinctorious L.) Euphytica **148**, 261-268.

Mozzafari K, Asadi AA. 2006. Relationships among characters using correlation, principal components and path analysis in safflower mutants sown in irrigated and drought stress condition. Asian Journal of Plant Sciences **5,** 977-983.

Nie Z, Chen FT, Shi XC. 1993. Path analysis of character related to seed yield in safflower. Oil Crop of China **3,** 26-29.

Nie Z, Shi XC, Chen FT, Chang C. 1987. A study on the heritability, genetic advance and genetic correlations of the main agronomic characters in safflower Oil Crops of China **2,** 18–22.

Omidi Tabrizi AH. 2000. Correlation between characters and path analysis for grain and oil yield in spring safflower. Sesame and Safflower Newsletter **15,** 78–83.

Pascual-Villalobos MJ, Albuquerque N. 1996. Genetic variation of a safflower germplasm collection grown as a winter crop in southern Spain. Euphytica **92,** 327–332.

Prasad S, Agrawal RK. 1994. Correlation and path coefficients studies in safflower hybrids. Sesame and Safflower Newsletter **9,** 69–75.

Prasad S, Chaudhary BR, Agrawal RK. 1993. Correlation and path analysis of yield and its components in safflower hybrids (Carthamus tinctorius L.). Sesame and Safflower Newsletter **8,** 74–78.

Rafeaie F, Saeidi G. 2006. Genotypic and phenotypic relationships among agronomic characters and yield components in safflower (Carthamus tinctorious L.). Agriculture scientific journal **28,**137-149.

Samonte SO, Wilson LT, McClung AM. 1998. Path analyses of yield and yield-related characters of fifteen diverse rice genotypes. Crop Science **38,** 1130–1136.

Shabana R, Abd El Mohsen AA, Gouda HAH, Hafez HS. 2013. Impact of temperature fluctuation on yield and quality traits of different safflower genotypes. Scientific Research and Review Journal **1,** 74-87.

Toker C, Cagirgan MI. 2004. The use of phenotypic correlations and factor analysis in determining characters for grain yield selection in chickpea (Cicer arietinum L.). Hereditas **140,** 226-228.

Tuncturk M, Ciftici V. 2004. Relationships among traits using correlation and path coefficient analysis in safflower (Carthamus tinctorious L.) sowed different fertilization levels and row spacing. Asian Journal Plant Science **3,** 683-686.

Walton PD. 1980. The production characteristics of Bromus inermis Leyss. And their inheritance. Advances in Agronomy **32,** 341–369.