Research Journal of Biological Sciences 3 (2): 181-185, 2008
ISSN: 1815-8846

Grain Yield and Morphological Characters of Spring Safflower Genotypes: Evaluation Relationship Using Correlation and Path Analysis

[1]Ali Reza Ahmadzadeh, [2]Eslam Majedi, [3]Behroz Darbani,
[4]Ahmad Rzban Hagegat and [1]Mohamad Reza Dadashe
[1]Islamic Azad University, Faculty of Agriculture, Shabestar Branch,
Shabestar City, East Azarbaigan Province, Iran
[2]Institute of Seed and Plant Improvement, KARAJ, Iran
[3]Faculty of Agriculture, Tabriz University, Iran
[4]Institute of Seed and Plant Improvement, Tabrez, Iran

Abstract: Correlation among yield components and their direct and indirect influence on grain yield of safflower were investigated. In this survey, 30 spring safflower genotypes were tested via the randomized complete block experiment design for two years of 2005 and 2006. The phenotypic correlations among the traits and their path coefficient were estimated in both years. Grain yield was significantly correlated with some characters, like the plant height ($r = 0.563^{**}$ and $r = 0.536^{**}$), hectoliter weight ($r = 0.574^{**}$ and $r = 0.577^{**}$) and biological yield ($r = 0.980^{**}$ and $r = 0.977^{**}$) in 2005 and 2006, respectively. Path coefficient analysis revealed that plant height, hectoliter weight and 100-seed weight had the highest positive direct effects on grain yield in 2005 and 2006, respectively. Therefore, improvement of the grain yield will immensely be efficient via plant height, hectoliter weight and 100-seed weight based selection.

Key words: *Carthamus tinctorius*, grain yield, path analysis, phenotypic correlation, yield components

INTRODUCTION

Safflower (*Carthamus tinctorius* L.), a member of the family of *Asteraceae*, is a multipurpose crop for oil, medicinal and industrial uses (Khan *et al*., 2003). Traditionally, it was first grown for the pigment of flowers in order to coloring foods and dyeing cloths. Safflower seed is the harvestable part, either for feeding poultry or to extract its oil content (Pahlavani, 2005). Development of oil seeds cultivation has an important role to provide the requisite edible oils for human beings (Pasban, 2004).

Path analysis has been used by plant breeders to assist for identifying useful selectable traits (Dewey and Lu, 1959; Milligan *et al*., 1990). Partitioning of the correlation coefficient into its components, one component being the path coefficient that measures the direct effect of a predictor variable upon its response variable; the second component being the indirect effect(s) of a predictor variable on the response variable through another predictor variable is the advantage of path analysis (Dewey and Lu, 1959). Number of head per plant and number of seed per head were reported by Abel and Driscol (1976) as important traits to produce high yield safflower lines. Corleto and Ventricelli (1997) reported the number of heads per plant as the most efficient character for yield improvement of safflower. Evaluation of relationships among traits in safflower during two year (2001 and 2002) indicted positive and significant relationships among grain yield with plant height, number of head per plant, percent of oil and oil yield at the first experimental year but with the primary branches, number of head per plant, number seed per head and 100-seed weight were positive and significant at the second year (Tuncturk and Ciftici, 2004. Plant height, branch height, number of branches per plant, number of heads per plant, number seeds per head, head diameter, stem diameter, 1000- seed weight and oil content are the most useful characters in safflower improvement for increasing seed yield (Mahasi *et al*., 2006). Some of these characters are more affected from one environment than another one based on environmental and genotypical differences (Arsalan, 2007).

In this study, an attempt was made to study the direct and indirect influences of some important yield components on grain yield of safflower by correlation and path coefficient analysis. The results might be capable as

Corresponding Author: Ali Reza Ahmadzadeh, Islamic Azad University, Shabestar Branch Agriculture Faculty, Shabestar City, East Azarbaigan Province, Iran

the selection criteria in further studies in order to increase the selection efficiency.

MATERIALS AND METHODS

The present investigation for correlation and path analysis studies of morphological traits of spring safflower (*Carthamus tinctorius* L.) was conducted in the research station of Faculty of Agriculture, Islamic Azad University- Shabestar branch in 2005 and 2006. The experimental material consists of thirty genotypes of spring safflower. These genotypes were planted in the field based on the randomized complete block design with three replications in each of the years. The genotypes included 4 lines in each replication. Seeds were sown row to row distance of 40 cm and plant to plant distance of 15 cm. All other agronomic practices were kept uniform. Characters were evaluated on ten randomly selected plants in the mid-rows of plots. Grain yield (kg ha^{-1}), plant height (cm), number of heads per plant, number of seeds per head, 100 seed weight (g), effective head weight (g), plant weight (g), hectoliter weight (g), biological yield (kg h^{-1}), harvest index, days to 50% flowering and days to maturity were recorded in order to the path and correlation analyses following the methods of Dewey and Lu (1959) and Snedecor and Cochran (1989), respectively. The data in 2005 and 2006 were analyses separately. The averages of replications were used for the analysis.

RESULTS AND DISCUSSION

Correlation: The correlation among the all pairs of variables in 2005 and 2006 are shown in Table 1. Grain yield was significantly correlated with plant height ($r = 0.563^{**}$ and $r = 0.536^{**}$), hectoliter weight ($r = 0.574^{**}$ and $r = 0.577^{**}$) and biological yield ($r = 0.980^{**}$ and $r = 0.977^{**}$) in 2 consequence years, respectively. The other characters expressed a non-significant correlation, except for number seeds per head; it had a positive and significant correlation with grain yield only in 2005 ($r = 0.413^{**}$).

Therefore, the function of the each of traits is assessed in its performance on grain yield. Positive and significant of correlation between grain yield and the plant height could be resulted via genotypes ability in competition of light absorption in order to promote the photosynthesis process.

Arslan (2007) reported positive and significant relationships between grain yield and traits of plant height, number heads per plant, branch height, stem diameter, head diameter, number seeds per head. It is quotable, the reported results by Dingming *et al.* (1993), Zheng (1993), Patil (1998) and Omidi (2001) have supported the present results. These results showed that any positive increase in such characters will suffice the boost in grain yield.

The highest positive correlations were obtained between biological yield with some characters include; plant height ($r = 0.61^{**}$ and $r = 0.60^{**}$), day to 50% flowering ($r = 0.35$ and $r = 0.37^{*}$) and day to maturity ($r = 0.38^{*}$ and $r = 0.42^{*}$).

In this term, it is notable the long time maturation of high length plants possibly leads to increase the biological yield performance.

Authenticity of the highly significant positive correlation between biological yield and number of head per plant with seed yield were approved by Mozaffar and Asadi (2006) and Omidi (2005).

The highest positive correlation were determined between plant height with number of seed per plant ($r = 0.46^{**}$ and $r = 0.46^{**}$), hectoliter weight ($r = 0.45^{**}$ and $r = 0.51^{**}$), biological yield ($r = 0.61^{**}$ and $r = 0.60^{**}$), days to 50% flowering ($r = 0.53^{**}$ and $r = 0.64^{**}$), days to maturity ($r = 0.64^{**}$ and $r = 0.54^{**}$) and grain yield ($r = 0.56^{**}$ and $r = 0.54^{**}$) in the both consequence years, respectively but it had negative and significant correlation with harvest index in 2006 and negative non significant in 2005. Since the plant height is increased due to the increasing of days to maturation, confirmedly, Arsalan (2007), Tuncturk and Ciftici (2004); Mozaffari and Asadi (2006) determined these positive and significant relationships between above mentioned components. Among these correlated traits with plant height, the highest correlation was observed for grain yield (Table 1). According to the results, plant height could efficiently be responsible for high grain yield in safflower.

There were positive and significant correlations between days to 50% flowering with plant height with days to maturity with hectoliter weight in both years and with biological yield only in 2006. Prolongation of the growth phase to 50% flowering results most vigor for interning the production phase. This condition could be effective to increase the hectoliter weight, plant height and biological yield.

Number seed per plant had significant positive correlation with plant weight and effective head weight in both years. These results are partially in concordance with the findings of Tuncturk (2004). Therefore, positive effect of seed number per head on grain yield could be exploited via plant weight and effective head weight.

Path analysis: In order to determine the traits with biggest effect on the grain yield, all of the traits (except biologic yield and harvest index: these traits are completely

Table 1: Correlation coefficients between characters measured in the years 2005 (above diagonal) and 2006 (below diagonal)

Characters	PH	DF	DM	PW	NH	EHW	NS	HW	SW	GY	BY	HI
PH	-	0.53**	0.64**	0.26	0.01	0.25	0.46**	0.45**	-0.27	0.56**	0.61**	-0.33
DF	0.53**	-	0.40**	-0.16	-0.11	-0.17	0.21	0.54**	-0.34	0.27	0.35	-0.48**
DM	0.54**	0.46**	-	.06	0.01	-0.04	0.37*	0.33	-0.11	0.32	0.38*	-0.38*
PW	0.14	-0.22	0.03	-	0.62**	0.53**	0.49**	-0.09	-0.07	0.35	0.31	0.21
NH	-0.06	-0.33	-.018	0.73**	-	0.08	0.18	-0.13	-0.17	0.18	0.10	0.45*
EHW	0.14	-0.13	-0.11	0.52**	0.16	-	0.54**	0.08	0.31	0.29	0.19	0.39*
NS	0.46*	0.11	0.34	0.39*	0.14	0.49**	-	0.29	-0.25	0.42*	0.39*	0.04
HW	0.51**	0.66**	0.39*	-0.13	-0.36	0.06	0.18	-	-0.1	0.57**	0.57**	-0.03
SW	-0.34	-0.28	-.06	-0.03	-0.13	0.42*	-0.18	-0.10	-	0.22	0.15	0.31
GY	0.54**	0.27	0.34	0.25	-0.08	0.36	0.33	0.58**	0.17	-	0.98**	0.08
BY	0.60**	0.37*	0.42*	0.19	-0.16	0.27	0.31	0.60**	0.10	0.97**	-	-0.11
HI	-0.48**	-0.57**	-0.45*	0.24	0.43*	0.30	-0.05	-0.22	0.31	-0.07	-0.28	-

*p< 0.05, ** p<0.01, Plant Height = PH, Days to 50% Flowering = DF, Days to Maturity = DM, Plant Weight = PW, Number of heads per plant = NH, Effective Head Weight = EHW, Number of seeds per head = NS, Hectoliter Weight = HW, 100 seed weight = SW, Grain yield = GY, Biological Yield = BY and Harvest Index = HI

Table 2: The direct (diagonal and bolded) and indirect effects of seven traits on grain yield in 2005 and 2006

Characters	Year	PH	DM	PW	EHW	NS	HW	SW	Correlationwith grain yield
PH	2005	0.599	-0.2045	0.0979	-0.134	0.1872	0.1971	-0.1801	0.56**
	2006	0.423	-0.0492	0.0400	-0.0167	0.0461	0.240	-0.1476	0.54**
DM	2005	0.3828	-0.320	0.0208	0.0193	0.1522	0.1428	-0.0765	0.32ns
	2006	0.2263	-0.092	0.0088	0.0134	0.0339	0.1802	-0.0260	0.34ns
PW	2005	0.1551	-0.0176	0.378	-0.2830	0.2007	-0.0403	-0.0440	0.35ns
	2006	0.0579	-0.0028	0.292	-0.0629	0.0389	-0.0627	-0.0139	0.25ns
EHW	2005	0.1498	0.0115	0.1996	-0.536	0.2214	0.0337	0.2099	0.29ns
	2006	0.0588	0.0103	0.1530	-0.120	0.0499	0.0267	0.1818	0.36ns
NS	2005	0.2755	-0.1197	0.1864	-0.2916	0.407	0.1257	-0.1706	0.41**
	2006	0.1929	-0.0309	0.1127	-0.0594	0.101	0.0847	-0.076	0.33ns
HW	2005	0.2696	-0.1043	-0.0348	-0.0413	0.1168	0.438	-0.0697	0.57**
	2006	0.2170	-0.0354	-0.0391	-.0068	0.0183	0.468	-0.0447	0.58**
SW	2005	-0.1593	0.0361	-0.2046	-0.1662	-0.1026	-0.0451	0.677	0.22ns
	2006	-0.1438	0.0055	-0.0093	-0.0503	-0.0177	-0.0482	0.434	0.17ns

*p< 0.05, ** p<0.01, Plant Height = PH, Days to Maturity = DM, Plant Weight = PW, Effective Head Weight = EHW, Number of seeds per head = NS, Hectoliter Weight = HW, 100 seed weight = SW. (2005 Adjusted $R^2 = 0.797$), (2006 $R^2 = 0.601$)

dependent on grain yield), were considered as an independent and grain yield as a dependent variables in both studies. In the first experiment (2005) stepwise and forward regression for grain yield indicated four entered traits of plant height, 100 seed weight, plant weight and hectoliter weight at the model while by using backward regression seven traits of plant height, 100 seed weight, plant weight, hectoliter weight, number of seeds per head, effective head weight and days to maturity partook in the model.

In contrast to the first experiment, at the second study (2006) stepwise and forward regression for grain yield indicated the traits of effective head weight and hectoliter weight have hand in the model while four traits of plant height, 100 seed weight, plant weight and hectoliter weight entered to the model by using backward regression.

Consequently, the direct and indirect effects of seven examined traits on the grain yield were estimated by path coefficient in both years (Table 2). Path coefficient analysis revealed the plant height, 100 seed weight and hectoliter weight characters as the traits with highest positive direct effects on grain yield in both years. Also, plant weight and number of seeds per head traits had positive direct effects on grain yield in both years. The plant height, 100 seed weight, hectoliter weight and number of seeds per head seem to be important under this survey. This outputs suggest the increasing of these characters as the immensely efficient criteria to improve yield of safflower. Similar result were reported by Ashri *et al.* (1975), Guo yahai *et al.* (1993) and Abel and Driscol (1976). Tuncturk *et al.* (2004) found positive direct effect of the traits of plant height, 1000-seed weight and number of seeds per heads on grain yield. But Pahlavani (2005) reported that improvement of grain yield in safflower could be decline through oil content and 1000-seed weight due to negative association between these traits with grain yeild. In this term, Mozaffari and Asadi (2006) reported that under irrigated condition the number of seed per head, 100 seeds weight and stem diameter had the greatest positive direct effects consequently.

The indirect effects of the plant height via hectoliter weight and plant weight were positive on grain yield in both years. Number of seeds per head had positive indirect effects through the plant weight and hectoliter weight and negative indirect effects through effective

head weight and 100 seed weight on grain yield in both years. Nevertheless, the 100 seed weight had positive direct effect on grain yield, it had also negative indirect effects through plant weight, effective head weight, number seeds per head and hectoliter weight on grain yield in 2005 and 2006. Mahasi *et al*. (2006) measured a high positive direct effect of 100 seeds weight and a indirect negative effect through number of seed per head, effective head weight and number head per plant on grain yield. However, the days to maturity and the effective head weight showed negative direct effects while these characters had positive indirect effect (via other characters except 100 seeds weight) on grain yield in both years, which correspond to the results of Mozaffari and Asadi (2006).

CONCLUSION

This survey revealed the plant height, number of seeds per head and hectoliter weight were significantly correlated with the grain yield as well as a positive direct effects on the grain yield. Some of the traits such as plant weight and 100 seed weight had positive but non-significant correlation with grain yield, but their direct effect on the grain yield was higher and positive. Therefore, grain yield improvement could be achieved by using traits of plant height, hectoliter weight and 100 seeds weight as the efficient selectable phenotypic markers.

ACKNOWLEDGEMENT

This research was supported by the Islamic Azad University Shabestar branch. The authors thank Karaj-Lran seed and plant improvement institute for providing safflower germplasm.

REFERENCES

Abel, G.H and M.F. Driscol, 1976. Sequential traits development and breeding for high yield. Crop. Sci., 16: 213-216.

Arsalan, B., 2007. The path analysis of yield and its components in safflower (*Carthamus tinctorius* L.). Asian J. Biol. Sci., 7: 668-672.

Ashri, A., D.E. Zimmer, A.L. Urie, A. Cahaner and P.F. Knowles, 1975. Evaluation of the germplasm collection of safflower Carthamus tinctorius L.VI. Length of planting to flowering period and plant height in Israel. Utah and Washington. Theor. Applied. Genet, 46: 356-364.

Corleto, A. and E. Ventricelli, 1997. Performance of Hybrid and Open-pollinated Safflower in Two Different Mediterranean Environments. In: 4th Int. Safflower Conference, Bari Italy. (Corleto, A. and H.-H Mundel Senior .Eds., pp: 276-278.

Dawey, D.R. and K.H. Lu, 1959. A correlation and path co-efficient analysis of components of crested wheat grass and seed production. Agron. J., 51: 515-518.

Dingming, K., J. Yuguang, J. Yunfeng and Z. Jizheng, 1993. Principal component analysis and cluster analysis of agricultural properties 30 safflower cultivars in Xingjian In: Proceedings of the 3rd Int. Safflower Conference, Beijing, China.

Guo Yahai, X. and L. Lianlu, 1993. The relations between yield formation and development of flowering parts as well as growth of branches and leaves. Proceedings: Third Int. Safflower Conference, Beijing, China, pp: 465-477.

Khan, M.A., S. Witzke-Ebrecht, B.L. Maass and H.C. Becker, 2003. Evaluation of a worldwide collection of safflower for morphological diversity and fatty acid composition. Technological and Institutional Innovations for Sustainable Rural Development. Deutscher Tropentag, Göttingen.

Mahasi, M.J., R.S. Pathak, F.N. Wachira, T.C. Riungu. M.G. Kinyua and J.W. Kamundia, 2006. Correlation and path coefficient analysis in exotic safflower *(Carthamus tinctorius* L.) genotypes tested in the arid and semi arid lands (Asals) of Kenya. Asian J. Plant Sci., 5:1035-1038.

Milligan, S. B., H. A. Gravois, H. P. Bischoff and F. A. Martin. 1990. Crop Sci. 30: 924-931.

Mozaffari, K. and A.K. Asadi, 2006. Relationships among traits using Correlation, principal components and path analysis in safflower mutants sown in irrigated and drought stress conditioa. Asian J. Plant Sci., 5: 977-983.

Omidi Tabrizi, A.H., 2001. Correlation between traits and path analysis for grain and oil yield in spring safflower. 5th Int. Safflower Conference, Williston, N.D., USA.

Omidi Tabrizi, A.H., 2005. Study of some important agronomic traits in spring safflower genotypes using principal component analysis. In: Proceeding of the 6th Int. Safflower Conference, Istanbul. Turkey.

Pahlavani, M.H., 2005. Some technological and morphological characters of safflower (*Carthamus tinctorus* L.) from Iran. Asian J. Plant Sci., 4: 234-237.

Pasban Eslam, B., 2004. Evaluation of yield and yield components in new spring genotypes of safflower (*Carthamus tictorius* L.). The Joint Agriculture and Natural Resources Symposium, Tabrez-Ganja.

Patil, H.S., 1998. Genetic variability, association and path analysis in safflower. Indian J. Agric. Res., 23: 46-50.

Snedecor, W. and W.G. Cochran, 1989. Statistical methods. Oxford and IBM Calcutta, pp: 593.

Tuncturk, M. and V. Ciftici, 2004. Relationship among traits using correlation and path coefficient analysis in safflower. Asian J. Plant Sci., 3: 683-686.

Zheng. N., C. Futang, S. Xinchun and W. Yancai, 1993. Path analysis of correlation characters on flower yield of safflower individuals. 3rd International Safflower Conference. China. pp: 583-588.