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Evaluation of Saffron Ecotypes for Stigma Yield and Yield Components Using Different Maternal Corm Weights

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Abstract
Several saffron ecotypes (Mashhad, Torbat-Jam, Torbat-Haydarieh, Gonabad, Birjand, Ghaen) were evaluated in Urmia for stigma yield and yield components using different maternal corm weights (6, 8, 10, 12 g) in 2013 cropping year. The experiment was arranged as factorial based on randomized complete block design. Analysis of variance showed that there were significant differences among saffron ecotypes and maternal corm weights with respect to all studied agronomical traits. However, there was no interaction between ecotypes and corm weights for the majority of these characters. Torbat-Haydarieh and Mashhad ecotypes, and Gonabad and Ghaen ecotypes had the highest and lowest saffron yield in the Urmia condition, respectively. The yield and yield components of saffron improved when the greater maternal corm weight was used. There were positive relationships between saffron yield and all its components. Based on the stepwise regression analysis, dried stigma weight, stigma length, fresh flower weight, dry leaf weight and leaf length were the main components of saffron yield. We can conclude that maternal corm weight has a very important role in saffron performance. Furthermore, in order to establish a new saffron cultivation, it seems essential to take into account the climate condition of areas from which the corms were selected.

Keywords: Climate condition; Correlation; Ecotype; Maternal corm weight; Regression; Saffron

Introduction

Saffron (*Crocus sativus* L.) is one of the oldest and most expensive crops among aromatic and medicinal plants in the world (Turhan *et al.* 2007). There is increasing interest in saffron because of its specific and multiple properties (Siracusa *et al.* 2010). In recent years, the dried red stigmas of saffron has attracted much attention to natural food colors (Kafi 2006), flavor enhancers and aromas (Anastasaki *et al.* 2010), textile dye, incense, cosmetics and food purposes (Ingram 1969). There has been increased interest in the biological effects and potential medical applications of saffron, particularly those based on their cytotoxic, anticarcinogenic and antitumor properties (Abdullaev 2002; Abdullaev and Espinosa-Aguirre 2004; Fernandez 2004; Magesh *et al.* 2006; Chryssanthi *et al.* 2009; Dalezis *et al.* 2009). The price of saffron depends on its quality, which is closely related to the region of the production (Anastasaki *et al.* 2010; Maggi *et al.* 2011). Saffron is currently cultivated in Iran, Spain, India, Greece, Morocco, China, Italy, Turkey and Azerbaijan. Iran is one of the main producers of saffron in the world. Khorasan province in Iran alone accounts for 92% of area under saffron crop (Jalali-Heravi *et al.* 2010).

There have been some breeding studies in order to develop new varieties in saffron. However, sterility of saffron limits the success through conventional plant breeding so that corm formation of saffron is one of the important characters because corm is the only source for propagation (Turhan *et al.* 2007). Therefore, most studies have focused on increasing yield and quality by different cultivation methods including planting, fertilization, irrigation, growing media, etc. (Behnia *et al.* 1999; Unal and Cavusoglu 2005), especially on corm characteristics (corm quality and quantity). In the saffron cultivation, the quality of corms, such as size and emergence capacity, as well as the number of corms produced are important (Turhan *et al.* 2007). Earlier studies revealed that mature and bigger corms give more flowers and daughter corms (Vurdu *et al.* 2002; Molina *et al.* 2005b; Omidbaigi 2005). Therefore, one of the objectives in the saffron production is to obtain bigger corms (Turhan *et al.* 2007).

The saffron ecotypes of different proveniences have been studied by several researchers such as Molina *et al.* (2004, 2005a), Turhan *et al.* (2007), De Juan *et al.* (2009), Gresta *et al.* (2009), Jalali-Heravi *et al.* (2010), Maggi *et al.* (2011) and Renau-Morata *et al.* (2012). They concluded that there were significant differences among ecotypes, and that climatic conditions affected the quantity and quality of saffron directly or indirectly. Maggi *et al.* (2011) evaluated 28 authentic saffron samples in terms of 16 key quality characters. Results pointed out that there were significant differences among saffron samples and multivariate analysis of the data revealed that 60.7% of saffron samples could be correctly assigned to their respective production countries using the chemical characteristics. Anastasaki, *et al.* (2010) compared 250 saffron ecotypes from Greece (40 samples), Iran (87 samples), Italy (60 samples) and Spain (63 samples) by mid-infrared spectroscopy and observed that there were significant differences among the saffron ecotypes of different countries. Other analytical techniques and characters such as gas chromatography (Kanakis *et al.* 2004), infrared spectroscopy (Zalacain *et al.* 2005; Anastasaki *et al.* 2010), electronic nose (Carmona *et al.* 2006), free amino acids (Del Campo *et al.* 2009) and flavonoids content (Carmona *et al.* 2007) were also used to verify the saffron origin.

From an agronomic point of view, saffron is a perennial crop well-adapted to different environmental conditions ranging from dry sub-tropical to continental climates and can be grown on soils varying from sandy to well-drained clay loams (Sampathu *et al.* 1984; Azizbekova and Milyaeva 1999; Mollafilabi 2004; Gresta *et al.* 2008, 2009). However, there is a lack of information on its climatic requirements and agronomic management techniques and their effects on quantity and quality of saffron. In this study, we evaluated several saffron ecotypes in terms of dry stigma yield and its components using different maternal corm weights in order to find the best saffron ecotype and maternal corm weight for establishing a new saffron cultivation in the Urmia condition.

Materials and Methods

The trial was carried out at the experimental field of the University of Urmia, Urmia, Iran. The experiment was laid out in a factorial arrangement based on randomized complete block design with three replications in 2013 cropping year. The following factors were tested: (i) different saffron ecotypes (Mashhad, Torbat-Jam, Torbat-Heydarieh, Gonabad, Ghaen, Birjand) and (ii) different maternal corm weights (6, 8, 10 and 12 grams). The six saffron samples were acquired from different regions of Iran's traditional saffron production areas. Samples 1, 2, 3 and 4 were obtained from Khorasan Razavi province of Iran. Samples 5 and 6 were obtained from the South Khorasan province of Iran. The geographic and climatic characteristics of collection areas are shown in Tables 1 and 2.

Table 1. Geographic characteristics of saffron collection locations under study

Location	Elevation (m)	Longitude (E)	Latitude (N)
Mashhad	999.2	38 59	16 36
Gonabad	1056	58 41	34 21
Torbate Heydarieh	1450.8	13 59	16 35
Torbate Jam	950.4	35 60	15 35
Birjand	1491	59 12	32 52
Ghaen	1432	59 10	33 43
Urmia	1315.9	45 05	37 32

Table 2. Climatic characteristics of saffron collection locations based on annual average

Location	Maximum temperature (C˚)	Minimum temperature (C˚)	Mean daily temperature (C˚)	Relative humidity (%)	Monthly total precipitation (Mm)	Days with minimum temperature equal to or below zero
Mashhad	21.1	7.1	14.1	55	255.2	89.3
Gonabad	23.8	10.7	17.3	37	143.6	49.2
Torbate Heydarieh	21.3	7.3	14.3	46	274.8	95.7
Torbate Jam	22.4	8.8	15.6	45	175.6	73.6
Birjand	24.5	8.4	16.5	36	170.8	76.2
Ghaen	22.3	6.3	14.3	37	175.8	93.8
Urmia	17.6	5.4	11.5	60	341	110.6

After preparing the field in April, 75 kg ha^{-1} nitrogen, 75 kg ha^{-1} phosphorous, 50 kg ha^{-1} potassium were applied to the soil. To prevent *Fusarium* and *Penicillium* infestations, corms were dipped in a prochloraz solution (0.1%) and dried under forced ventilation for 5–7 h to remove the surface water. The cultivation practices were those commonly used for this crop. Each plot consisted of 8 rows with 3-meter length and 25 cm distance between rows (the plot area was 6 m^2). Corm distances on rows were 8 cm and the planting depth was 15 cm (the density was 50 corms m^2). To avoid marginal effects and minimize errors, plots were separated from each other by 50 cm distances. To ensure accuracy, two rows at the beginning and the end of plots as well as 50 cm from both ends of each row were regarded as margins. Rainfed conditions met the water requirements at the start of growth (October to November), but plants were drip-irrigated from December to April.

Data were collected on the following 15 characters in each plot: Dry stigma weight (mg) (DSW), flower number (FN), fresh stigma weight (mg) (FSW), stigma length (cm) (SL), fresh flower weight (mg) (FWF), dry flower weight (mg) (DFW), leaf number (LN), leaf length (cm) (LL), leaf width (mm) (LW), fresh leaf weight (mg) (FLW), dry leaf weight (mg) (DLW), number of daughter corm (NDC), fresh weight of daughter corm (mg) (FWDC), dry weight of daughter corm (mg) (DWDC). Analysis of variance was carried out using the SAS version 9.12 statistical software. Means were compared by the Tukey method at the 1 % probability level.

Results and Discussion

Analysis of variance

The results showed significant differences among saffron ecotypes for all of studied traits (Tables 3 and 4). This indicates the existence of genetic diversity among the ecotypes under study allowing the selection of proper ecotypes for the climatic conditions of Urmia. On the other hand, saffron plant is a sterile triploid that produces annual replacement corms and is propagated solely from these corms (Botella *et al.* 2002). Thus, the saffron yield may be strongly influenced by the environmental and climatic conditions and it is very important to take into account the environmental condition for establishing a new saffron cultivation in an area. Based on the analysis of variance, there were significant differences among maternal corm weights for all traits studied (Tables 3 and 4). These results confirmed that the maternal corm weight have a significant impact on yield and yield components of saffron. It has been shown that the large corm weight increases the dried stigma yield dramatically in the coming years. Significant maternal corm weight × ecotype interactions were only observed for FLW, DLW and DWDC (Tables 3 and 4). These results suggested that differences among ecotypes remained unchanged at different maternal corm weights for most of the saffron characters under study.

Table 3. Analysis of variance of the effect of ecotype and corm weight on flower traits of saffron

SOV	df	Mean squares						
		DSY [a] (kg/ha)	FN (m^2)	FSW (mg)	DSW (mg)	SL (cm)	FFW (mg)	DFW (mg)
Replication	2	0.02 **	0.34	36.40 **	0.72 **	0.82 **	880.87 **	22.29 **
Ecotype	5	0.36 **	16.59 **	27.42 **	2.30 **	0.91 **	1006.57 **	30.26 **
Corm weight	3	1.14 **	338.60 **	36.98 **	1.29 **	0.57 **	10294.24 **	83.48 **
Ecotype × Corm weight	15	0.00	0.01	0.07	0.04	0.02	0.87	0.07
Error	46	0.00	0.17	2.03	0.09	0.06	30.60	1.67
CV (%)		7.1	3.0	5.2	5.9	6.9	1.63	3.1

*P≤ 0.05 and **P≤ 0.01

[a]Abbreviations are described in the Materials and Methods section.

Table 4. Analysis of variance of the effect of ecotype and corm weight on leaf and daughter corm traits of saffron

SOV	df	Mean squares							
		LN [a]	LL (cm)	LW (mm)	FLW (mg)	DLW (mg)	NDC	FWDC (gr)	DWDC (gr)
Replication	2	0.13	1.85	0.39 **	1457.35 **	73.36 *	0.15	0.61	0.15
Ecotype	5	3.17 **	118.37 **	0.55 **	35415.41 **	3619.82 **	2.77 **	52.63 **	7.03 **
Corm weight	3	31.47 **	127.04 **	0.24 **	5440.41 **	504.62 **	10.36 **	489.81 **	80.19 **
Ecotype × Corm weight	15	0.03	1.03	0.01	128.41 **	42.73 *	0.03	1.75	0.30 *
Error	46	0.16	2.58	0.04	140.53	19.45	0.06	0.96	0.14
CV (%)		8.1	8.1	7.9	4.8	6.1	9.9	7.4	7.22

Mean comparisons

Saffron ecotypes

Torbat-Jam and Mashhad ecotypes had the higher values for saffron yield (0.95 and 0.85 kg ha^{-1}), number of flower (15.36 and 14.97), fresh stigma weight (29.3 and 24.17 mg), dry stigma weight (5.63 and 5.36 mg), stigma length (3.95 and 3.25 cm), fresh flower weight (345.33 and 350.51 mg) and dry flower weight (43.25 and 43.41 mg) as compared to other ecotypes (Table 5). On the contrary, Ghaen and Gonabad ecotypes had the lowest values in this experiment. In general, flowering traits are influenced by the quality of corm and weather conditions (Turhan *et al.* 2007; Siracusa, *et al.* 2010; Renau-Morata *et al.* 2012). Therefore, if the weather conditions and field management are more favorable, subsequently the quality of corm will be better and this will result in higher number of flower buds. Lage and Cantrell (2009) grew saffron in 11 different experimental zones with a disparity of altitudes, soils and climates. Their results showed that environmental conditions highly affected the saffron quality. Siracusa *et al.* (2010) also reported that flower number and stigma yield were significantly affected by the environment and corm provenance.

The difference among the ecotypes under study can be attributed to the effects of genotype and collection site (Khorasan Razavi Province: Mashhad, Torbat-Jam, Torbat-Heydarieh and Gonabad; South Khorasan Province: Birjand and Ghaen). Therefore, these differences could be related partly to different climates of the collection sites. Meteorological data indicated that Mashhad and Torbat-Heydarieh had the highest and Gonabad and Ghaen had the lowest similarity to the Urmia climate (Table 2). Thus, the corms from Torbat-Heydarieh and Mashhad ecotypes performed better because they were gathered from the locations that were more similar in weather conditions to Urmia. Increasing relative humidity and decreasing temperature in the fall season had positive effect on the flower number per square meter and dried stigma yield per acre. Benschop (1993) and Molina *et al.* (2005b) noted that temperature is the most important environmental factor controlling growth and flowering of crocus species by affecting enzyme activity in the plant metabolism. The study by Gresta *et al.* (2009) also showed that colder environments enhance flower number of the saffron plant.

Table 5. Mean comparison of ecotypes and corm weights for flower traits in saffron

	DSY [a] (kg/ha)	FN (m^2)	FSW (mg)	DSW (mg)	SL (cm)	FFW (mg)	DFW (mg)
Ecotype							
Birjand	0.62 d*	13.94 b	26.45 b-c	4.64 d	3.39 b-c	335.14 c	41.61 b
Torbat-Jam	0.76 c	14.09 b	28.54 a	5.12 b-c	3.49 b	342.58 b	43.21 a
Gayen	0.52 e	12.52 c	25.44 c	4.49 d	3.17 c	331.52 c-d	39.38 c
Mashhad	0.85 b	14.97 a	24.71 a-b	5.36 a-b	3.25 b-c	350.51 a	43.41 a
Torbat-Heidarieh	0.95 a	15.36 a	29.3 a	5.63 a	3.95 a	345.33 a-b	43.25 a
Gonabad	0.54 e	12.60 c	26.06 b-c	4.52 c-d	3.4 b-c	326.18 d	39.38 b
Corm Weight (gr)							
6	0.39 d	8.09 d	25.48 c	4.67 c	3.24 c	307.02 c	39.31 c
8	0.66 c	13.58 c	26.86 b	4.94 b	3.36 b-c	332.97 b	41.30 b
10	0.79 b	15.65 b	27.81 a-b	5.14 a-b	3.52 a-b	355.99 a	43.41 a
12	0.99 a	18.32 a	28.85 a	5.29 a	3.65 a	358.19 a	44.05 a

*For each factor and column, means with common letters are not significantly different based on the Tukey's method at 1% probability level.

[a]Abbreviations are described in the Materials and Methods section.

There were significant differences among saffron ecotypes with respect to the leaf traits including LN, LL, LW, FLW and DLW (Table 6). Overall, it was found that Torbat-Heydarieh and Mashhad ecotypes had better vegetative growth, especially in terms of LL and DLW, as compared with other ecotypes. Corms from Ghaen and Gonabad ecotypes had good quality, but due to large differences of Urmia with Ghaen and Gonabad in terms of rainfall and relative humidity (Table 2), ecotypes from these cities didn't show good performance for leaf characters.

Similar to leaf characteristics, large and significant differences among saffron ecotypes were also observed for daughter corm traits such as number of daughter corm, fresh daughter corm weight and dried daughter corm weight (Table 6). These results were expected because saffron corms absorb their nutrients from either roots or leaves. Therefore, the ecotypes that had higher leaf number and leaf area (leaf length and width) had more daughter corms with higher fresh and dry weight. Therefore, Torbat-Heydarieh and Mashhad ecotypes that had higher number of leaves, leaf area and fresh and dried leaf weight, performed better also in terms of daughter corm characteristics. On the other hand, Ghaen and Gonabad ecotypes with the lowest number of daughter corms as well as the lowest fresh and dry weight of daughter corms, performed weakly in the Urmia weather condition. Botella *et al.* (2002), Kafi (2006) and Kumar *et al.* (2009) reported that replacement corms develop at the base of the shoots, and the photosynthetic activity of the leaves during the winter and early spring months contributes to the formation of these corms. These works introduced leaf traits as the most important growth traits in the saffron plant. Lundmark *et al.* (2009) reported that the mother corm in crocus genus could supply up to 20% of the biomass, indicating a larger contribution of source leaves to the daughter corm production in saffron. It has also been shown that the size of the mother corm has a significant effect on the vegetative development and the production of daughter corms (De Mastro and Ruta, 1993; Negbi *et al.* 1999; De Juan *et al.* 2003).

Table 6. Mean comparison of ecotypes and corm weights for leaf and daughter corm traits in saffron

	LN [a]	LL (cm)	LW (mm)	FLW (mg)	DLW (mg)	NDC	FWDC (gr)	DWDC (gr)
Ecotype								
Birjand	5.02 b-c*	19.67 b	2.4 b-c	269.38 c	77.79 c	2.26 c	12.35 c	4.83 c
Torbat-Jam	5.14 a-b	20.44 b	2.51 a-b	253.13 d	68.76 d	2.62 b	13.58 b	5.53 b
Gayen	4.02 d	15.72 c	2.24 c-d	192.35 e	58.23 e	1.94 d	10.94 d	4.39 c
Mashhad	4.94 b-c	18.74 b	2.69 a	308.65 a	96.13 a	2.93 a	14.09 b	5.56 b
Torbat-Heidarieh	5.52 a	25.27 a	2.52 a-b	285.43 b	85.19 b	3.22 a	16.88 a	6.53 a
Gonabad	4.59 c	18.71 b	2.09 d	169.83 f	49.19 f	2.25 c	11.92 c-d	4.8 c
Corm Weight (gr)								
6	3.02 d	16.28 c	2.26 b	231.24 c	66.47 b	1.57 c	6.87 d	2.68 d
8	4.94 c	19.39 b	2.40 a-b	233.04 c	69.86 b	2.31 b	11.39 c	4.49 c
10	5.44 b	20.81 b	2.46 a	254.27 b	77.81 a	3.04 a	16.44 b	6.53 b
12	6.09 a	22.56 a	2.53 a	267.29 a	76.06 a	3.23 a	18.47 a	7.38 a

*For each factor and column, means with common letters are not significantly different based on the Tukey's method at 1% probability level.

[a]Abbreviations are described in the Materials and Methods section.

Weight of maternal corm

Maternal corm weight had significant effect on flowering characteristics and saffron yield (Table 3). Increasing the maternal corm weight from 6 to 12 g improved the dried saffron yield and flowering traits in the first year dramatically (Table 5). For the maternal corm weights of 6 and 12 g, the saffron yields were 0.39 and 0.99 kg/ha and the number of flowers in square meter were 8.09 and 18.32, respectively. These results showed that with increasing maternal corm weight, not only saffron yield and flower number increased by 2.5 and 2.3 times, respectively, but also saffron field had a good economic performance in the subsequent year. The effect of the corm size on saffron yield has been studied by several researchers. Salinger (1991), Rees (1992), Benschop (1993), Le Nard and De Hertogh (1993), Sadeghi (1993), Mashayekhi and Latifi (1997) and Mollafilabi (2004) concluded that the number of flowers depends on the size of the corm and if the corm does not reach a certain size (at least 1 cm in diameter), it only produces leaves. Furthermore, Gómez *et al.* (1987), De Mastro and Ruta (1993) and Negbi *et al.* (1999) reported the increase in the number of flowers per corm when larger corms (above 8 g) were used at planting.

Our results showed that maternal corm weight affected the saffron leaf characteristics, especially leaf number and leaf length. As shown in Table 6, leaf number for the corm weight of 12 g (6.09) was approximately increased by two folds as compared with the corm weight of 6 g (3.02). Also, leaf length was increased from 16.28 to 22.56 cm, when the corm weight increased from 6 g to 12 g. However, other traits such as leaf width and fresh and dry leaf weight were only increased slightly as the maternal corm weight increased. In addition, bigger corms had more dry material as well as more leaves and flowering buds as compared with the smaller corms. These corms were superior in the quality and vigor, so their growth rate was high, producing higher leaf number in the shorter time. According to Renau-Morata *et al.* (2012), the major constraint limiting saffron cultivation is the difficulty of obtaining high quality corms for propagation.

The maternal corm weights of 12 g and 10 g were significantly different from the corm weights of 8 and 6 g in terms of daughter corm production, but they were not significantly different from each other (Table 6). The fresh and dry weight of daughter corms decreased significantly as the corms decreased from 12 to 6 grams. One of the important findings of this study was that the bigger maternal corms produced the daughter corms with higher number and weight. This result was expected because the maternal corms with higher weight had better quality and more vigor as well as higher growth rate, so these corms could develop the green surface faster and benefit better from the environmental factors such as light, nutrient, water, etc. In general, it can be concluded that with increasing maternal corm weight, not only dried saffron yield increases directly in the first year but also with increasing the daughter corm number, dried saffron yield will increase indirectly and exponentially in coming years.

Correlation and regression

The correlation coefficients between different saffron traits are shown in Table 7. Dry saffron yield had significant positive relationships with all of other traits. Therefore, any increase in the yield components such as leaf number, leaf length and leaf width will improve the number and weight of daughter corm, and subsequently, will increase the number of flowers, stigma weight as well as dried saffron yield per acre. Gresta *et al.* (2009) also reported similar findings. However, the linear correlation coefficient between two traits could be misleading if other traits vary in the population. In this condition, it is better to carry out multiple regression analysis instead to determine the most influential traits on dry saffron yield (as the dependent variable). The results of stepwise multiple regression analysis indicated that dry stigma weight, stigma length, fresh flower weight, dry leaf weight and leaf length with entering into the regression model could explain 99% of the variation of dry saffron yield (Table 8). Therefore, these traits can be regarded as the most influential traits on the saffron yield and obviously any improvement in these traits will subsequently increase the dry saffron yield.

Table 7. Correlation coefficients among agronomical traits of saffron ecotypes

Trait	DSY [a]													
FN	0.92 **	FN												
FSW	0.95 **	0.81 **	FSW											
DSW	0.87 **	0.67 **	0.91 **	DSW										
SL	0.72 **	0.61 **	0.81 **	0.72 **	SL									
FFW	0.91 **	0.96 **	0.82 **	0.70 **	0.54 **	FFW								
DFW	0.93 **	0.89 **	0.92 **	0.84 **	0.68 **	0.91 **	DFW							
LN	0.92 **	0.97 **	0.85 **	0.71 **	0.69 **	0.92 **	0.91 **	LN						
LL	0.86 **	0.76 **	0.90 **	0.82 **	0.92 **	0.70 **	0.81 **	0.84 **	LL					
LW	0.79 **	0.64 **	0.77 **	0.74 **	0.38	0.72 **	0.76 **	0.61 **	0.55 **	LW				
FLW	0.67 **	0.49 *	0.67 **	0.68 **	0.41 *	0.56 **	0.67 **	0.49 *	0.55 **	0.90 **	FLW			
DLW	0.64 **	0.47 *	0.60 **	0.66 **	0.34	0.57 **	0.62 **	0.45 *	0.48 *	0.89 **	0.96 **	DLW		
NDC	0.96 **	0.92 **	0.92 **	0.87 **	0.72 **	0.94 **	0.96 **	0.92 **	0.86 **	0.72 **	0.62 **	0.61 **	NDC	
FWDC	0.94 **	0.96 **	0.87 **	0.76 **	0.72 **	0.95 **	0.91 **	0.94 **	0.84 **	0.62 **	0.50 *	0.48 *	0.97 **	FWDC
DWDC	0.93 **	0.96 **	0.86 **	0.74 **	0.71 **	0.95 **	0.91 **	0.94 **	0.82 **	0.61 **	0.48 *	0.45 *	0.96 **	0.98 **

*P≤ 0.05 and **P≤ 0.01

[a]Abbreviations are described in the Materials and Methods section.

Table 8. Regression coefficients of different agronomic characters with dry saffron yield using stepwise regression method

Model	Standardized coefficients	t	Sig.	Collinearity statistics		R Square
				Tolerance	VIF	
Constant	---	-4.79	0.00	---	---	0.99
DSW [a]	0.30	3.29	0.00	0.08	11.96	
SL	0.59	9.61	0.00	0.19	5.40	
FFW	0.28	4.02	0.00	0.15	6.71	
DLW	0.14	3.25	0.00	0.39	2.60	
LL	-0.21	-2.29	0.04	0.09	11.71	

[a]Abbreviations are described in the Materials and Methods section.

Conclusion

The results of this study showed significant differences among saffron ecotypes for all of the studied traits. The results also indicated that increasing maternal corm weight (from 6 to 12 grams) not only increased saffron yield in the first year, but also improved the yield components (especially leaf and daughter corm traits) and consequently, increased the dried saffron yield in the coming years dramatically. It may be concluded that climate conditions are extremely important for establishing a new saffron cultivation. Therefore, Torbat-Heydarieh and Mashhad ecotypes were recommended in this area because they are most compatible to Urmia climate conditions.

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