Ornamental Horticulture
ISSN 2447-536X | HTTPS://ORNAMENTALHORTICULTURE.EMNUVENS.COM.BR/RBHO
SBFPO Sociedade Brasileira de Floricultura e Plantas Ornamentais

Scientific Article

Exploration and morphologic variation of *Iris* wild species with ornamental potential

Elham Asgari[1], Mina Taghizadeh[1*], Ahmadreza Abbasifar[1]

[1] Arak University, Faculty of Agriculture and Environmental Science, Department of Horticultural Engineering, Arak, Iran

Abstract

Nowadays, the flower industry is growing so fast that its development requires introducing new varieties to the flower market. Iran is the habitat of numerous species of wild plants that are among the valuable genetics in the breeding process. The identification of native *Iris* species, investigation of morphological diversity, and distribution method have a significant effect on the introduction of this flower as new and superior cultivars cut flower and bedding plant. The documentation of the most important habitats of *Iris* in Arak province, identification of morphological characteristics and correlation determination of morphological traits are the most important aims of this research. The results showed that there is a correlation between some of the traits. The highest positive correlation was related to the height of flower and length of the leaf, length of the flowering stem and the length of the leaf and the height of the flower and the length of the flowering stem. The ecotypes of *Iris* sp. were divided into six groups. Based on the results of the cluster diagram, the bulbous species were separated from rhizome species. Generally, due to the color diversity of *Iris* sp. and unique beauty of the flowers and the resistance of the native species, they can be used as native foundations. Due to the prominent traits such as high durability of *Iris meda*, odor of *I. hymernospatha* Subsp. leptoneura and color diversity of *I. persica*, *I. songarica* and height of *I. spuria*, they can be used to introduce new ornamental species. *Iris spuria* is the most suitable genotype because of the high height, large flower, high durability, and beautiful flower.

Keywords: endemic plants, flowers, germplasm, Iran, variation.

Resumo

Exploração e variação morfológica de espécies selvagens de *Iris* com potencial ornamental

A indústria de flores está crescendo tão rápido que seu desenvolvimento exige a introdução de novas variedades no mercado de flores. O Irã é o habitat de numerosas espécies de plantas selvagens que estão entre as valorizadas geneticamente no processo de melhoramento. A identificação de espécies nativas de *Iris*, pesquisas de diversidade morfológica e o método de distribuição têm efeito significativo na introdução de cultivares superiores como flor de corte e forração. A documentação dos habitats mais importantes de *Iris* na província de Arak, identificação de características morfológicas e determinação de correlação de características morfológicas são os objetivos mais importantes desta pesquisa. Os resultados mostraram que existe a correlação entre algumas das características. A correlação mais positiva foi relacionada ao tamanho da flor e comprimento da folha, comprimento da haste floral e comprimento da folha, e tamanho da flor e comprimento da haste floral. Os ecótipos de *Iris* sp. foram divididos em seis grupos. Com base nos resultados do diagrama de agrupamento (*cluster)*, as espécies bulbosas foram separadas das espécies com rizoma. Geralmente, por causa da diversidade de cores de *Iris* sp. e a beleza única das flores e a resistência das espécies nativas, estas podem ser usadas como base nativa. Devido a características proeminentes, como alta durabilidade de *Iris meda*, aroma de *I. hymernospatha* Subsp. *leptoneura* e diversidade de cores de *I. persica*, *I. songarica* e altura de *I. spuria*, podem ser usados para introduzir novas espécies ornamentais. *Iris spuria* é o genótipo mais adequado devido à maior altura, tamanho da flor, elevada durabilidade e beleza da flor.

Palavras-chave: plantas endêmicas, flores, germoplasma, Irã, variação.

Introduction

Iran is the habitat of numerous species of wild plants that are among the valuable genetics in the breeding process and supports a great share of exotic and/or endemic plant genera and species (Kiani et al., 2017; Parvin and Alizadeh, 2017). Generally, in addition to being as infrastructure for agricultural development, the genetic plant resources are a source of genetic compatibility and also a defense against challenging environmental issues (Parvin and Alizadeh, 2017). Furthermore, for the production of plants with enhanced quality, the presence of species with attractive

*Corresponding author: m-taghizadeh@araku.ac.ir

https://doi.org/10.1590/2447-536X.v28i1.2409
Received: June 17, 2021 | Accepted: Sept 13, 2021 | Available online: Oct 19, 2021

Area Editor: Elisabeth Regina Tempel Stumpf

appearance and desired features has been emphasized in the improvement of ornamental plants. Nowadays, the flower industry is growing so fast that its development requires introducing new varieties to the flower market. One of the important purposes of this industry is to improve the product features such as high flower production ability, flowering uniformity, resistance to diseases and pests as well as flower vase life (Noman et al., 2017). To Know different behavior of plants in the growth period and flowering phenology, not only helps carefully plan for the fertilization and harvesting, but also saves expenses and energy consumption in the flowering period (Van Der Ploeg and Heuvelink, 2006). *Iris* species have large colorful flowers and are distributed in the Northern Hemisphere from Europe to the Middle East (Yang et al., 2017). *Iris* sp. grow near springs, rivulets, uncultivable deserts and calcareous soils and some of the species are specific to the cliff and rock regions (Kandemir et al., 2019). Different species of *Iris* are used not only as ornamental flowers, but also as one of the resources that produce perfumes in the cosmetics and beauty industry (Demir and Çelikel, 2018). There is a very wide diversity of *Iris* sp. and new cultivars can be obtained by hybridization techniques. *Iris* sp. is an ornamental plant used in landscape and cut flowers. Producing new cultivars of *Iris* is the main purpose in the programs of cultivation and production of ornamental plants (Demir and Çelikel, 2018). In addition to the ornamental aspect, *Iris* sp. has other features. The researchers showed that some of the *Iris* species have the capability of the uptake of heavy metals which can be used in the phytoremediation and remediation of heavy metals (Singaba et al., 2016). During the last three decades, the classical methods have been increasingly performed for evaluating the genetic diversity with molecular methods, such as anatomy, morphology and physiology (Mosa et al., 2019). There are different methods for investigating the diversity among plant species, and one of the low-cost and widely-used methods is to investigate the physiological or morphological variations. Although morphology is more affected by environmental conditions than molecular diversity, it is used in different plants (Hosseini et al., 2017). The morphological features can show the diversity among the population. Wendelbo and Mathew (1975) introduced 45 species of *Iris* where the 24 species and subspecies are naturally distributed in Iran and 10 species are endemic in Iran. In this colorful flora, Ghahraman introduced 21 native species of *Iris* sp. (Azimi et al., 2019). In another research, Azimi et al. (2011) evaluated the existing genetic diversity in 18 species of *Iris* sp. collected from different provinces of Iran by 10 random primers of RAPD in the polymerase chain reaction. According to RAPD data, cluster analysis divided different 18 species into 6 groups. The results of study on the morphological characteristics of 12 populations from three *Iris* species with Iranian and German origin showed that the studied populations of *Iris* were different considering most of the qualitative and quantitative morphological traits. These superior populations were introduced to improve existing hybrid and species of Iris. To identify the *Iris* species of Hamedan province, a study was conducted by Khakizadeh and Ghanavati (2010). The collected samples consisted of 9 species: *I. reticulata* M.B.*, I. songarica* Schrenk*, I. spuria* L., *I. humenospatha subsp. Leptoneura* Mathew & Wendelbo*, I. barnumae* Baker & Foster*, I. meda* Stupe*, I. pseudocaucasica* Grossh*, I. germanica* L., *I. acutiloba* C.A. Mey. In another study, the genotype of wild *Iris* species including *I. fosteriana*, *I. songarica* and *I. kopetdaghensis* were collected from different areas of Khorasan province to investigate the genetic diversity of some *Iris* sp. using the ISSR marker and 16 primers. The investigation of 6 ISSR molecular markers among 126 reproduced bands showed 119 polymorphism bands (94/4%). The results of this research showed that this marker can distinguish the species and genotypes of the population in this species (Attari et al., 2016). The researchers studied the morphological traits of Oncusyclus subspecies *Iris* to determine the classification relations and morphology. The vegetative and reproductive characteristics related to 42 populations (9 species) were measured and it was concluded that the natural selection (including weather conditions and geographical separation) caused the differentiation among the population. They divided the mentioned groups into two main groups by cluster analysis where the first group includes the populations with dark color and the second group includes the population with bright color (Yuval et al., 2002). Rahimi et al. (2011) studied the Iran's endemic *Iris*. The morphological characteristics of 24 accessions belonging to 5 species were analyzed in the flowering season. The researchers divided the studied *Iris* into three main groups. In another research, the anatomic features of the leaves of eight species of *Iris* were compared and their relationships were determined. The species *I. pamphylica, I. histrioides, I. celikii, I. danfordiae, I. histrio* ssp*., I. pamphylica, I. histrioides, I. celikii, histrio* ssp*., I. aintabensis, I. bakeriana, I. aintabensis* and *I. histrio* are exclusive native to Turkey (Kandemir, 2019).

Markazi province is the suitable place for conducting this research because of having a mountain environment and a suitable climate for *Iris* species. Hence, the documentation of the most important habitats of *Iris* in this province, identification of morphological characteristics., and correlation determination of morphological traits are the most important aims of this research.

Materials and Methods

Study Area

This study was conducted in Markazi province in western Iran (Figure 1). To investigate the morphology of wild genotypes according to the geographical distribution, different regions including the mountains of different areas were studied. The areas were located at 33-37° North latitude and 40-50° East longitude and 1700-2500 m height above sea level. The average annual air temperature over 40 years

in Arak is 13.8 °C, and the average annual rainfall in the same period is 341.7 mm. The average annual air humidity is 58.46%, which indicates the dry air. The Arak region has cold and humid winters and hot and dry summers, and the winters usually last for a long period of 4 to 6 months. Spring and autumn are short seasons. Arak has a semi-arid climate according to the De Martone method, and it is in the dry climate of the Embereger climate zone (MPMO).

Figure 1. Location of study areas in Arak, Markazi province, Iran

Sampling method

The data were collected from the end of March 2017 to the end of June 2018. The main purpose was to identify and evaluate the qualitative and phonological characteristics of germplasm collection in this species. For this purpose, the sites located in the rangelands, meadows, open plains, foothills, heights and rivers were carefully visited. The sampling was started from the areas that had early spring and had species with early flowering. Due to the lack of accurate maps from the vegetation site, collecting the paths was started with the exploration from the climbers and native people. To avoid possible vegetative similarities, the samples were randomly chosen and marked at intervals of 5-20 m apart (Hosseini et al., 2018; Schai-Braun et al., 2020). GPS device was used to record the exact location of sampling (Table 1).

Table 1. Flowering period, propagation and geographical location of the species identified with ornamental potential in Markazi province, Iran.

Species	Family	Period of flowering	propagation	Habitat	Geographic coordinates
Tulipa biflora	Liliaceae	March- April	Seed and Bulb	Sorkheh, Shahbaz mountain, Nazm Abad	Latitude:34° 22′-34° 34′ Longitude:40° 40′-49° 44′ Altitude:2696
T. armena	Liliaceae	April	Seed and Bulb	Aseman valley	Latitude:37° 86′ Longitude:35° 48′ Altitude:2135
T. orphanidea	Liliaceae	April	Seed and Bulb	Aseman valley	Latitude:37° 86′ Longitude:35° 48′ Altitude:2135
T. montana	Liliaceae	April- May	Seed and Bulb	Aseman valley	Latitude:37° 86′ Longitude:35° 48 Altitude:2141
T. sylvestris	Liliaceae	April	Seed and Bulb	Sorkheh mountain	Latitude:34° 34′ Longitude:40° 40′ Altitude:1879
T. violacea	Liliaceae	April	Seed and Bulb	Nazm Abad	Latitude:34° 2′ Longitude:49° 44′ Altitude:2696
Fritillaria imperialis	Liliaceae	April	Seed and Bulb	Aseman valley	Latitude:37° 86′ Longitude:35° 48 Altitude:2140- 2203

Table 1. cont.

F. persica	Liliaceae	April	Seed and Bulb	Aseman valley	Latitude:37° 86′ Longitude:35° 48′ Altitude: 2140- 2203
F. zagrica	Liliaceae	March- April	Seed and Bulb	Nazm Abad	Latitude:34° 2′ Longitude:49° 44′ Altitude:2696
Iris songarica	Iridaceae	April- May	Seed and Rhizome	Amr abad, Amir kabir Township, Aman abad	Latitude:34° 14′- 34° 86′ Longitude:50° 70′-50° 73′ Altitude:1771- 1730
I. meda	Iridaceae	April- May	Seed and Rhizome	Tafresh	Latitude:34° 38′ Longitude:50° 49′ Altitude:1909
I. hymenospatha	Iridaceae	March	Seed and Bulb	Sorkheh, Shahbaz mountain, Daen, Tafresh Aseman valley	Latitude:33° 25′-34° 38′ Longitude:40° 40′- 50° 49′ Altitude:2507- 1896
I. persica	Iridaceae	March	Seed and Bulb	Sorkheh, Shahbaz mountain, Daen, Tafresh, Hazaveh, Haftad gholeh, Daen, Tafresh, Hazaveh, Ghayenaroogh, Cheshmeh sarab,Aseman valley	Latitude:33° 25′- 34° 78′ Longitude:40° 40′- 50° 49′ Altitude:2487- 1788
I. spuria	Iridaceae	May- June	Seed and Rhizome	Far village	Latitude:34° 38′ Longitude:50° 48′ Altitude:2492
Gladiolus atroviolaceus	Iridaceae	April- May	Seed and Bulb	Aghil abad, Enaj	Latitude:33° 59′-34° 12′ Longitude:49° 21′- 49° 38′ Altitude:1878-1967
Colchicum autumnal	Colchicaceae	October	Seed and Corm	Aseman valley, Nazm abad, Sorkheh, Shahbaz mountain, Ghayenaroogh	Latitude:33° 25′- 37° 86′ Longitude:40° 40′- 49° 44′ Altitude:2400
Crocus cartwrightianus	Iridaceae	March	Seed and Bulb	Sorkheh, Shahbaz mountain	Latitude:33° 25′- 34° 34′ Longitude: 40° 40′-49° 25′ Altitude:2035
Anemone biflora	Ranunculaceae	March-April	Seed and Rhizome	Sorkheh, Shahbaz mountain Aseman valley	Latitude: 33° 25′-37° 86′ Longitude: 35° 48′-49° 25′ Altitude: 1861-2135
Corydalis verticillaris	Papaveraceae	March-April	Seed and Tuber	Sorkheh, Shahbaz mountain	Latitude: 33° 25′-34° 34′ Longitude: 40° 40′-49 25′ Altitude:1861-2145

The traits of length and width of calyx, length of petals, height of inflorescence, and length and width of flower were measured by Mm ruler, and the caliper was used to measure the bulb and rhizome, diameter of pedicel and diameter of stem. In this research, the characteristics of flower such as the number of flowers, length of petals, length of flowering stem, odor, length of flower, diameter of pedicel, length of calyx, width of calyx, height of inflorescence, and color of flower were recorded in the habitats. The traits such as the length of leaf, number of leaves and width of leaf were measured and the bulbs were removed from the soil and their lengths and widths were measured. The diameter and length of rhizome were measured for the rhizome species. The length of leaves was measured with Mm ruler and the diameter of bulbs and rhizomes were measured with a caliper. The code number was used for the odor, so that code number 1 belongs to flowers with odor and code number 0 belongs to flowers without odor. The colors were classified by code for the intensity of color where code number 1 belonged to the palest (white) and code number 6 belonged to the most chromatic (purple) flowers based on the color classification of Iris by Crişan et al. (2018).

The seed production was calculated based on the number of seed capsules per inflorescence. All collected samples were identified according to the keys found in the plant flora (Wendelbo, 1977; Ghahraman, 1998; Al Maarri et al., 2017; Kandemir, 2019; Azimi at al., 2019, Azimi, 2021).

Statistical analysis

Statistical design used in this experiment was completely random with uneven duplicates. To analyze the variance of morphological features in the *Iris* ecotypes, the SAS software (version 9.1) was used. The Duncan Multiple Range Test (DMRT) was conducted to determine the significance of statistical difference between the average treatments. The descriptive statistics and simple correlation among features were done by SPSS software (version 16). The Pearson coefficient was used to calculate the correlation between the features. To obtain the genetic intervals and expected dendrogram, the PAST drawing software was used. The analysis of factors was done by SPSS software (version 16) and varimax technique. The coefficients above 1 were significant in each main and independent factor.

Results

In this research, the areas between the longitudes of 25º49' and 73º50' and latitudes of 52º33' and 86º34' were investigated. The five species of *Iris* including *I. presica* and *I. hymernospatha* Sub Spleptoneura from bulb species and *I. mada*, *I. songarica*, and *I. spuria* from rhizome species were identified. The *I. persica* includes 4 ecotypes, *I. meda* includes two ecotypes, and *I. songarica* includes seven ecotypes. *Iris songarica* Schrenk var. albitodo Ghahreman was identified for the first time in Markazi province, and so far, there have been no reports of such species in this area. The best time for collecting *Iris* sp. was the first week of April to early May for *I. persica* and *I. hymernospatha*. It was early May to early June for *I. meda* and *I. songarica* and early June to early July for *I. spuria*. A variety of *I. songarica* Schrenk var. albitodo Ghahreman was identified. Different colors were identified in *I. songarica* and *I. persica* (Figure 2 and Table 2).

In the assessed morphological characteristics, the highest coefficient of variation was related to the diameter of leafless stem (94.87) and the lowest coefficient of variation was related to seeding (0) (Table 2).

Figure 2. Species of *Iris* in Arak region A) *I. songarica* B) *I. meda* C) *I. persica* D) *I. hymenospatha* E) *I. spuria*

Table 2. Descriptive statistics for morphological characters in the studied accessions of *Iris*.

No.	Character	Abbreviation	Unit	min	max	Mean	sd	CV(%)
1	Number of flowers	nflo	number	1	4	1.69	0.82	39.55
2	Petal length	pele	cm	3	7.2	2.85	0.86	62.88
3	Calyx length	cale	cm	0.07	5.5	1.4	0.97	50.47
4	Calyx width	cawi	cm	0.1	2	0.31	0.31	66.42
5	Scent	Sce	code	0	1	0.48	0.5	59.95
6	Flower height	inle	cm	6.5	124	24.69	30.51	26.01
7	Diameter of peduncle	stdi	cm	0.1	1.2	0.2	0.16	76.65
8	Flowering stem length	shle	cm	1.3	38	9.62	7.97	63.03
9	Diameter of leafless stem	stle	cm	0.168	3.82	0.78	0.32	94.78
10	Leaf lenght	lele	cm	6	100	24.23	20.31	21.77
11	Leaf width	lewi	cm	0.2	3.3	0.78	0.77	37.44
12	Number of leaf	nle	number	2	17	4.89	2.45	37.45
13	bulb/rhizome length	blue	cm	1	11.5	6.17	2.61	27.1
14	bulb/rhizome diameter	budi	cm	0.6	2.7	1.34	0.53	18.91
15	Seed	see	%	8.8	95	55.37	32.37	0

The results of correlation of traits showed that the highest positive correlation was between the height of the flower and the length of the leaf (0.94), the length of the flowering stem and the length of the leaf (0.86) and the height of the flower and the length of the flowering stem (0.83), and in contrast, the highest negative correlation was obtained for the number of leaves and the diameter of bulb/rhizome (-0.42), the length of bulb/rhizome and the length of calyx (-0.37) and the width of bulb/rhizome and seeding (-0.36). This means that the higher the flower height, the larger the diameter of the leafless stem and the higher the number of leaves, the lower the bulb/rhizome diameter (Table 3). The traits having a high coefficient of variation have a wider range of quantitative traits and are considered as the wider selection of the characteristics. The important traits such as the length of calyx, diameter of pedicel, length of flowering stem, length of petal, diameter of leafless stem, length of leaf, width of leaf, and odor have the highest diversity.

Table 3. Bivariate correlations among the measured variables in the studied accessions of native *Iris* ecotype. Number of flowers (nflo), Petal length (pele), Calyx length (cale), Calyx width (cawi), Scent (Sce), Flower height (inle), Diameter of peduncle (stdi), Flowering stem length (shle), Diameter of leafless stem (stle), Leaf length (lele), Leaf width (lewi), Number of leaf (nle), bulb/rhizome length (blue), bulb/rhizome diameter (budi), Seed (see)

	nflo	Pele	Cale	cawi	sce	inle	stdi	shle	Stle	lele	lewi	nle	blue	budi	see
Nflo	*1.00*														
Pele	*0.21***	*1.00*													
Cale	*0.3***	*0.56***	*1.00*												
cawi	*0.18**	*0.48***	*0.38***	*1.00*											
Sce	*0.23***	*0.41***	*0.24***	*0.51***	*1.00*										
Inle	*0.19**	*0.54***	*0.32***	*0.7***	*0.45***	*1.00*									
Stdi	*0.35***	*0.3***	*0.44***	*0.47***	*0.29***	*0.37***	*1.00*								
Shle	*0.25***	*0.64***	*0.55***	*0.62***	*0.34***	*0.83***	*0.38***	*1.00*							
Stle	*-0.007*	*0.16*	*0.03*	*0.21***	*0.18**	*0.18**	*0.12*	*0.12*	*1.00*						
Lele	*0.2**	*0.52***	*0.34***	*0.64***	*0.35***	*0.94***	*0.29***	*0.86***	*0.11*	*1.00*					
Lewi	*0.03*	*0.2*	*0.14*	*0.37***	*0.21**	*0.71***	*0.09*	*0.45***	*0.24***	*0.63***	*1.00*				
Nle	*0.14*	*0.02*	*0.21***	*0.09*	*0.31***	*0.07*	*0.15*	*0.02*	*0.05*	*0.09*	*0.16*	*1.00*			
Bule	*0.07***	*0.16*	*0.13*	*0.04*	*0.27***	*0.14*	*0.01*	*0.25***	*0.01*	*0.23***	*0.21***	*-0.18**	*1.00*		
Budi	*-0.37*	*-0.04*	*-0.37***	*-0.05*	*-0.17**	*0.24***	*-0.24***	*0.06*	*0.04*	*0.24***	*0.66***	*-0.42***	*0.42***	*1.00*	
See	*0.42***	*0.63***	*0.68***	*0.72***	*0.63***	*0.6***	*0.6***	*0.7***	*0.2**	*0.55***	*0.12*	*0.25***	*-0.01*	*-0.36***	*1.00*

According to the cluster diagram, the ecotypes are divided into 6 groups in the interval of 15 Euclid where the both ecotypes of *I. meda* are in the same group. The genotype of white and blue-white *I. songarica* collected from Amirkabir Shahrak area, purple-white collected from Amrabad and white-purple collected from Amirkabir Shahrak all had the traits in common. The most common characteristics were the flower number, length of petal, width of calyx, odor, length of flowering stem, length of leaf, width of leaf, number of leaves and amount of seeding. The purple-white, pink and pink-white *I. songarica* all collected from Amirkabir Shahrak were in the same group and had common features that make them close to each other. The purple-white color of *I. songarica*, *I. songarica* 2, and *I. songaric*a 3 were categorized into two separate groups considering having the same color. *I. persica* from Shahbaz area, *I. persica* from Tafresh, *I. persica* from Aseman valley, *I. persica* from Gerdoo mountain, *I. hymernospat* from Aseman valley and *I. persica* from Haftad Ghole all had common traits, especially the length of stem and width of leaf. *Iris persica* 2 from Cheshmeh Sarab, *I. persica* from Daen, *Iris persica* from Ghaynarogh, *Iris persica* from Hezaveh, *Iris persica* from Gerdo mountain and *Iris hymernospata* from Daen had more common features and closer relationship (Figure 3).

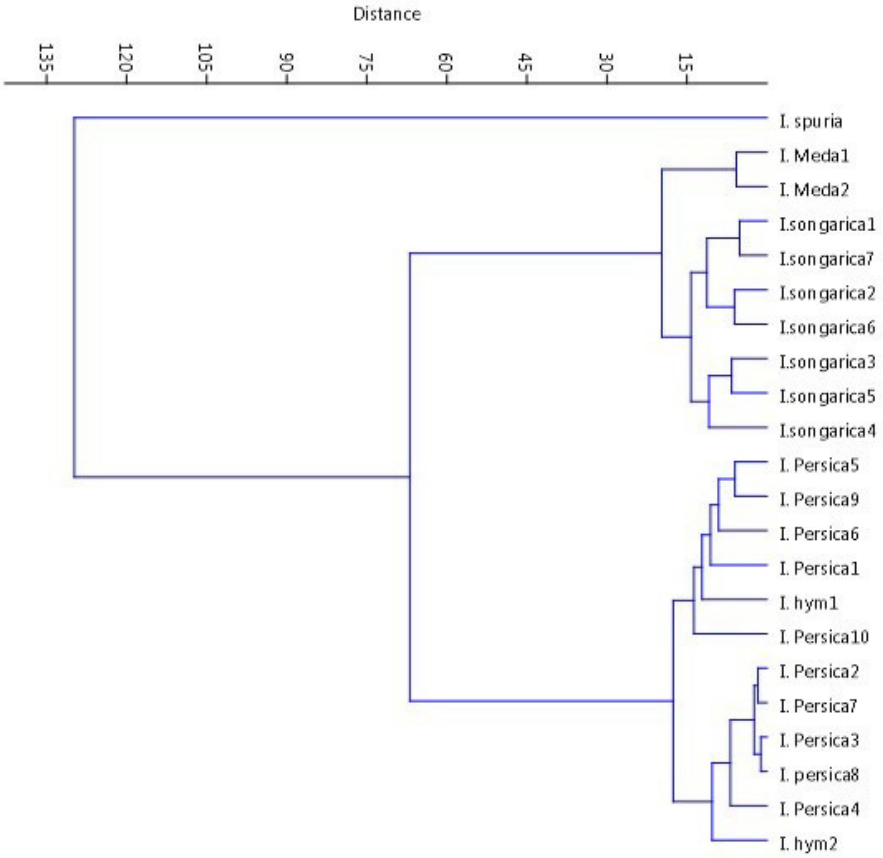

Figure 3. Dendrogram of cluster analysis for the studied accessions of *Iris* sp. Based on morphological traits.

The results of the analysis divided the morphological data into 4 factors (Tables 4 and 5). These four factors could justify 84.79% of total variance. In the first factor, the traits of petal length, height of flower, seeding, number of flowers, length and width of calyx had a higher coefficient and justified 45% of the total variance. In the second factor, the features of odor, length of bulb and number of leaves justified 19% of the total variance. In the third factor, the features of bulb diameter, width of leaf and diameter of leafless stem justified 11% of the total variance. In the fourth factor, the feature of pedicel justified 7% of the total variance.

Table 4. Principle component analysis (PCA) for morphological traits in *Iris* sp.

Factors	Cumulative percentage of variance	Eigenvalues in percent	Variance of eigenvalues
1	6.97	46.52	46.52
2	2.89	19.26	65.78
3	1.68	11.25	77.03
4	1.16	7.75	84.79
5	0.78	5.21	90
6	0.46	3.1	93.11
7	0.34	2.3	95.41
8	0.26	1.79	97.21
9	0.14	0.96	98.7
10	0.1	0.7	98.87
11	0.07	0.49	99.37
12	0.05	0.38	99.75
13	0.02	0.18	99.94
14	0.007	0.04	99.98
15	0.002	0.01	100

Table 5. Factor coefficient after rotation of Verimax for 4 main factors. Number of flowers (nflo), Petal length (pele), Calyx length (cale), Calyx width (cawi), Scent (Sce), Flower height (inle), Diameter of peduncle (stdi), Flowering stem length (shle), Diameter of leafless stem (stle), Leaf length (lele), Leaf width (lewi), Number of leaf (nle), bulb/rhizome length (blue), bulb/rhizome diameter (budi), Seed

Traits	1	2	3	4
Pele	0.82	0.34	-0.12	0.12
Lele	0.82	0.03	0.42	-0.05
Inle	0.75	0.06	0.55	0.12
Sce	0.56	0.71	0.21	0.03
Blue	0.22	-0.85	0.07	0.06
Budi	-0.38	-0.54	0.59	-0.23
Nle	0.21	0.83	-0.12	0.06
Lewi	0.05	-0.16	0.95	0.1
See	0.92	0.25	-0.15	0.15
Nflo	0.53	0.44	-0.13	0.44
Cale	0.85	0.01	-0.4	0.16
Cawi	0.91	0.19	0.12	0.11
Stdi	0.04	-0.05	0.05	0.91
Shle	0.9	-0.16	0.16	0.05
Stle	0.24	0.2	0.54	0.54

According to the plot diagram (Figure 4), the ecotypes of the found *Iris* sp. were divided into four groups according to the justifying traits. The first group included *Iris persic*a collected from Shahbaz mountain area, *Iris persica* collected from Gerdo Mountain, and *Iris hymernospatha* collected from Aseman valley.

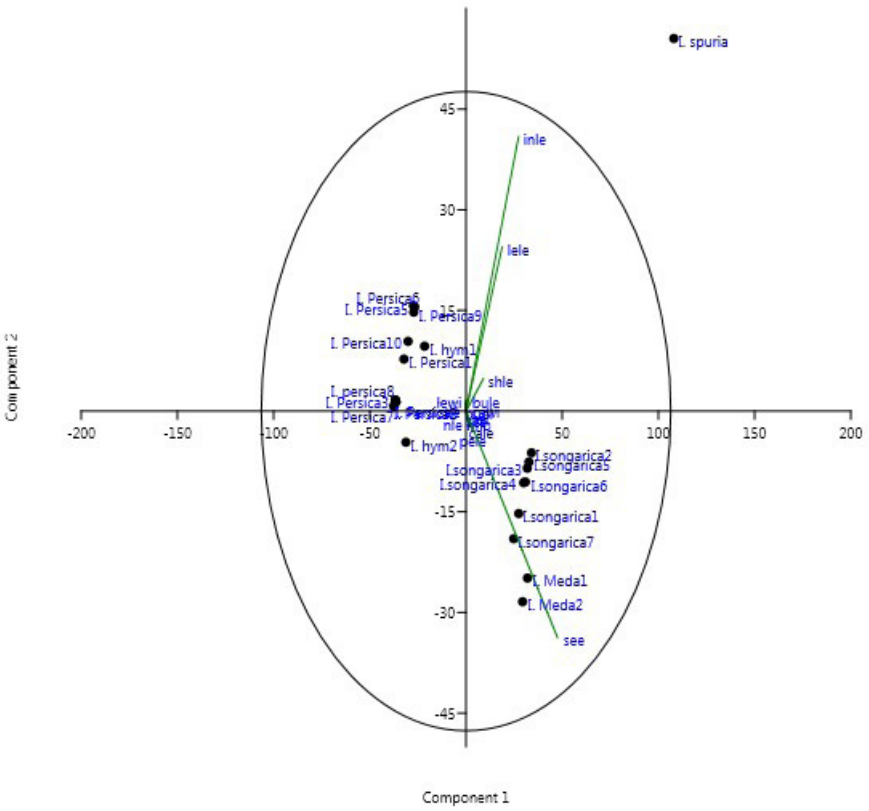

Figure 4. Two-dimensional scatter plot for the first two principal components (PC1/PC2, 24.41% of the total variability) for the studied accessions of I. sp.

The second group included *Iris persica* collected from Cheshmeh Sarab, *Iris persic*a collected from Daen, *Iris persica* collected from Ghanarough, *Iris persica* collected from Hezaveh, *Iris persica* collected from Gerdo mountain, and *Iris hymernospatha* collected from Daen. The third group included white *Iris songarica*, purple-white *Iris songaric*a of Amrabad area, Purple-white *Iris songarica* of Amirkabir town, pink *Iris songarica*, pink-white *Iris songarica*, white-purple *Iris songarica*, white-blue *Iris songarica*, creamy and a little purple *Iris meda*, and yellow-purple *Iris meda*. The fourth group including *Iris spuria* independently formed a group.

Discussion

According to the observations during this research, the rhizome species were found in different areas from high mountains to vast sandy plains or different swamps and ponds, but the bulb species were only found in the mountain areas. Based on observational findings, different insects lived around the rhizome species, especially the ants had nests where *Iris songarica* grew. Considering the found colorful diversity of this species and the existence of many insects, it can be stated that this species had many other ways of pollination and included different varieties that have not yet been identified. Five species were identified in Arak and surroundings where *Iris persica* species includes four ecotypes, *Iris meda* includes two ecotypes, and *Iris songarica* includes seven ecotypes consisting of six colors. For the first time, *Iris songarica* Schrenk var. albitodo was identified in Arak and it was already identified by Ghahraman in Shiraz in 1998 and found in Amirkabir area in our research. Similarly, Beiramizadeh (2009) identified 9 species, but the species were not mentioned. Also, Rahimi et al. (2011) mentioned one species for Markazi province in 2011 and Azimi et al. 2019 mentioned one species for Markazi province, and we also identified these species.

The diversity in different characteristics shows the enriched germplasm of this bulbous plant for the breeding of the desired traits to develop, increase in the efficiency, and commercial exploitation. The results showed that there is a correlation between some of the traits. The highest positive correlation was related to the height of flower and length of leaf, length of leaf and length of petal, number of leaf and length of leaf, length of flowering leaf and length of leaf, and flower height and length of flowering stem, which was consistent with the results of Azimi et al. (2016) and Roueen et al. (2015). The coefficient of correlation between the length of stem and the size showed that there is a direct relationship between the length of stem and the leaf size, so that the genotypes with higher height produced larger leaves (Roueen et al., 2015; Azimi and Banijamali, 2019).

Also, our results were consistent with other bulbous species such as shallots. According to the results of Hosseini et al. (2017) on the shallots, the correlation between the height of stem and the length and width of leaf was positive and significant, that is, with increasing the leaf length and width, the stem height can be increased. The highest negative correlation was related to the length of leaf and the length of bulb/rhizome with the length of calyx and diameter of bulb/rhizome and seeding. Most

likely, the diameter and length of bulb/rhizome affect the morphology of aerial organs. They have been rarely mentioned so far and the results were inconsistent with the results of Kapczynska (2014) who stated that the average produced leaves in the 5.1-6 cm bulbs were similar to larger bulbs, but the number of produced leaves in the bulbs less than 5 cm were significantly less than other bulbs. There were not many differences between the species in the traits related to leaf.

There were not many differences between the species in the traits related to leaf. The obtained results in the morphological diversity of native *Iris* sp. of Iran showed that there were significant differences between all the studied qualitative traits where the highest phonotype diversity was observed for the feature of leaf width (Rahimi et al., 2011). The studied species of *Iris* had significant differences in the most characteristics that were consistent with the findings of Azimi et al. (2018), Azimi (2021), Rahimi et al. (2011) and Abroshan et al. (2017).

According to the cluster diagram, the ecotypes were divided into six groups in the interval of 15 Euclid where the both colors of *Iris meda* species are in the same group. The white and blue-white *Iris singarica* collected from Amirkabir, purple-white collected from Amrabad and white-purple collected from Amirkabir all had traits in common and the most common features were the number of flowers, length of petal, width of calyx, odor, length of flowering stem, length of leaf, width of leaf, number of leaves, and amount of seeding.

The purple-white, pink and pink-white *Iris songarica* collected from Amirkabir were grouped and have common characteristics that make them close to each other. The purple-white colors of *Iris songaric*, *Iris songarica* 2, and *Iris songarica* 3 were divided into two separate groups which can be due to the environment effects, geographical area and climate of the habitat of two different areas. Kandemir (2019) found that the natural selection (including weather conditions and geographical separation) caused the differentiation among the populations.

Based on the results of the cluster diagram, the bulbous species were separated from rhizome species. As was found from the Azimi et al. (2019) results, the cluster analysis based on the quantitative traits can separate the rhizome *Iris* sp. from bulbous *Iris* sp. as qualitative traits. *Iris spuria* was not mentioned in the Ghahraman colorful flora in Arak, but the identification of this species in Poldoab was mentioned in a research in 2016, and we identified this species around the village of Far.

Conclusions

Generally, because of color diversity of *Iris* sp. and unique beauty of the flowers and the resistance of the native species, they can be used as native foundations. Due to the prominent traits such as high durability of *Iris meda*, odor of *I. hymernospatha* Subsp. leptoneura and color diversity of *I. persica*, *I. songarica* and height of *I. spuria*, they can be used to introduce new ornamental species. Also, considering the beauty of *Iris persica*, *Iris meda*, *Iris songarica*, and *Iris spuria* flowers, they can be introduced as ornamental flowers among which *Iris spuria* is the most suitable genotype because of the high height, large flower, high durability, and beautiful flower.

Acknowledgments

The authors are grateful to Arak University for supporting this work under research.

Author Contribution

MT: participated in all of experiments, coordinated the data-analysis and contributed to the writing of the manuscript. **EA**: Coordinated the farm work and writing of the manuscript. **ARA**: Coordinated the farm work and reviewing of the manuscript.

References

ABROSHAN, M.; ZAHEDI, B.; SIAH MANSOUR, R. Morphological variation of *Fritillaria imperialis* L in five regions of Lorestan Province. **Iranian Journal of Horticultural Science,** v.48, n.1, p.9-1, 2017.

AL MAARRI, K.H.; ABOU ZEDAN, T.H.; AL BATAL, N. Wild golden Iris (*Iris aurantica*) in Syria. **Current Trends in Biomedical Engineering & Biosciences**, v.1, n.5, p.555573, 2017.

ATTARI, Z.; SHOOR, M.; GHORBANZADEH NIQAB, M.; TEHRANI FAR, A.; MALEKZADEH SHAFAROODI, S. Evaluation of genetic diversity of Iris genotypes (*Iris* spp) using ISSR. **Journal of Horticultural Sciences (Food Science)**, v.30, p.382-376, 2016. https://doi.org/10.22067/JHORTS4.V30I3.28044

AZIMI, M.; SADEGHIAN MOTAHAR, Y.; BIRAMIZADEH, A.; SADEGHI, L. Investigation of genetic diversity of some Iranian iris species using RAPD markers. **Iranian Journal of Horticultural Science and Technology,** v.12, n.1, p.95-85, 2011.

AZIMI, M.; TEHRANZADEH, Z.; ZAMANI, M. Genetic variation within Iranian Iris species using morphological traits. **International Journal of Horticultural Science and Technology,** v.3, n.1, p.89-98, 2016.

AZIMI, M.H. Evaluation of heterosis and important traits in new hybrids of *Iris germanica* in F1. **Journal of Horticulture and Postharvest Research,** v.4, n.2, p.231-242, 2021.

AZIMI, M.H.; BANIJAMALI, S.M. Introducing superior cultivars of *Gladiolus* by important quality and quantity indexes. **Journal of Ornamental Plants**, v.9, n.1, p. 33-40, 2019.

AZIMI, M.H.; JOZGHASEMI, S.; HASANZADEH DAVARANI, F.; ALIABADI, H.M. A review of Iranian Iris germplasm. **International Symposium on Wild Flowers and Native Ornamental Plants**, v.1, n.20, p.51-56, 2019. https://doi.org/10.17660/ActaHortic.2019.1240.8

BEIRAMIZADEH, A. **Final report of the project for collecting, identifying and evaluating the inherited reserves of *Iris* and *Gladiolus* in Iran for use and protection**. National Research Station for Flowers and Ornamental Plants (Mahalat), 2009. p.100.

CRIŞAN, I.; VIDICAN, R.; MOREA, A.; SIMEA, Ş. Dyeing potential of linen fabric with *Iris* flower extracts. **ProEnvironment,** v.11, n.36, p. 223-227, 2018.

DEMIR, S.; CELIKEL, F.G. A study on plant height control of *Iris* Flowers. **Agrofor**, v.3, n.3, p.131-141, 2018.

GHAHRAMAN, A. **Iran Color Flora**. Iran: Institute for Research and Rangeland 18, 1998. p.1055-1200.

HOSSEINI, A.M.; TEHRANI FAR, A.; SAMIEI, L.; SHOR, M.; MEMARIANI, F. Collection and evaluation of morphological diversity of some species of allium (L. *Allium*) native to Khorasan. **Journal of Horticultural Science,** v.30, n.4, p.701-713, 2017.

HOSSEINI, A.S.; AKRAMIAN, M.; KHADIVI, A.; SALEHI-ARJMAND, H. Phenotypic and chemical variation of black mulberry (*Morus nigra*) genotypes**. Industrial Crops and Products**, v.117, p.260-271, 2018. https://doi.org/10.1016/j.indcrop.2018.03.007

KANDEMIR, N. Comparative morphological and anatomical studies on *Iris peshmeniana* Güner & T. Hall. and *Iris aucheri* (Baker) Sealy (Iridaceae). **Trakya University Journal of Natural Sciences**, v.20, n.2, p.105-113, 2019.

KANDEMIR, N.; KHAN, G.; CELIK, A. Comparative morphological and anatomical and ecological studies on two varieties of *Iris unguicularis* subsp. carica (*Iridaceae*) in Turkey. **Planta Daninha,** v.37, p.1-12, 2019.

KAPCZYNSKA, A. Effect of bulb size on growth, flowering and bulb formation in lachenalia cultivars. **Horticultural Science**, v.41, n.2, p.89–94, 2014. https://doi.org/10.17221/183/2013-HORTSCI

KHAKIZADEH, G.H.; GHANAVATI, F. Biodiversity of *Iris* species in Hamadan Province. Urmia: National Conference on Biodiversity and its Impact on Agriculture and Environment, 2010.

KIANI, M.; MOHAMMADI, S.H.; BABAEI, A.R.; SEFIDKON, F.; NAGHAVI, M.R.; RANJBAR, M.; RAZAVI, A.; SAEIDI, K.A.; JAFARI, H.; ASGARI, D.; POTTER, D. Iran supports a great share of biodiversity and floristic endemism for *Fritillaria* spp. (*Liliaceae*): A review. **Plant Diversity**, v.39, p.245-262, 2017.

MOSA, K.A.; GAIROLA, S.; JAMDADE, R.; EL-KEBLAWY, A.; AL SHAER, K.I.; AL HARTHI, E.K.; SHABANA, H.A.; MAHMOUD, T. The promise of molecular and genomic techniques for biodiversity research and DNA barcoding of the Arabian Peninsula Flora. **Fronteirs in Plant Science**, v.9, p.1929, 2019. https://doi.org/10.3389/fpls.2018.01929

NOMAN, A.; AQEEL, M.; DENG, J.; KHALID, N.; SANAULLAH, T.; SHUILIN, H. Biotechnological advancements for improving floral attributes in ornamental plants. **Frontiers in Plant Science**, v.8, p.530, 2017. https://doi.org/10.3389/fpls.2017.00530

PARVIN, M.R.; ALIZADEH, F. **Sustainable development of essential plant genetic resources at the same time in the development and support of biotechnology and conservation of biodiversity**. Gorgan: National cooperation of human rights with regard to environmental challenges in the northern regions of the country, 2017.

RAHIMI, V.; SADAT-HOSSEINI, GROUH; SOLYMANI, M.; BAHERMAND, A.; MEFTAHIZADE, N. Assessment of cytological and morphological variation among Iranian native *Iris* species. **African Journal of Biotechnology**, v.10, n.44, p.8805-8815, 2011.

ROUEEN, Z.; HASSANPOUR, A.S.L.M.; SABURI, A.S. Investigation of morphological traits, genetic evaluation and grouping of chrysanthemum genotypes. **Journal of Production and Processing of Crop and Horticultural Products**, v.16, p.359-345, 2015.

SCHAI-BRAUN, S.C.; LAPIN, K.; BERNHARDT, K.J.; ALVES, P.C.; HACKLÄNDER, K. Effect of landscape type, elevation, vegetation period, and taxonomic plant identification level on diet preferences of Alpine mountain hares (*Lepus timidus varronis*). **European Journal of Wildlife Research,** v.66, p.57, 2020.

SINGABA, A.N.B.; AYOUB, I.M.; EL-SHAZLYA, M.; KORINEK, M.; TUNG-YING, W.; YUAN-BIN, CH.; FANG-RONG, CH.; YANG-CHANG, W. Shedding the light on Iridaceae: Ethnobotany, phytochemistry and biological activity**. Industrial Crops and Products**, v.92, p.308-335, 2016.

VAN DER PLOEG, A.; HEUVELINK, E. The influence of temperature on growth and development of chrysanthemum cultivars: A review. **The Journal of Horticultural Science and Biotechnology**, v.81, p.174-182, 2006.

WENDELBO, P. Tulips and irises of Iran and neighboring species**. Botanical Garden, Iran,** p.81-68, 1977.

WENDELBO, P.; MATHEW, B. **Iridaceae, Flora of Iranian Highlands**. Graz: Akademische Druck-u Verlaganstalt, 1975.

YANG, Z.; TONGFEI, M.; XIAOYING, B.; JIAJUN, L. Investigation and evaluation of wild Iris resources in Liaoning Province, China**. Genetic Resource Crop,** v.64, p.967-978, 2017.

YUVAL, S.; AVI, S.; ORI, F.; PETER, C. Morphological variation of the *Oncocyclus Iirises* (*Iris*:*Iridaceae*) in the southern Levant**. Botanical Journal of the Linnean Society**, v.139, p.369-382, 2002.