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Phenotypic diversity and local dispersion of cornelian cherry accessions in Iran

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Abstract

Cornelian cherry is grown and cultivated in various locales of Iran, mainly grows in Qazvin, East Azerbaijan and Zanjan. By presenting at the mentioned places and conducting field studies, geographical situations and climate conditions of these regions (having cornelian cherry) for each province separately were investigated. The results of the studies showed that cornelian cherry can grows at the heights between 500-300m from sea level, the latitudes 36° 20′ to 39° 20′ and longitudes 46° 29′ to 50° 19′. All the regions of cornelian cherry dispersion are located in mountainous valleys. Also, the characteristics measured among the genotypes showed that fruit length (from 1.48 to 2.40 cm), fruit width rang (from 1.08 to 1.60), fruit length/width ratio rang (from 1.2 to 1.84), fruit fresh weight rang (from 1.57 to 3.52g), fruit dry matter weight rang (from 0.44 to 0.85gr), SSC rang (from 9% to 23/5%), pH (from 2.95 to 3.32), moisture content rang (from 63.19% to 80.30%), fruit flesh weight rang (from 1.26 to 3.01) flesh/stone ratio rang (from 2.89 to 6.87), stone length rang (from 1.08 to 1.62cm), stone width rang (from 0.51 to 0.72cm), stone length/width ratio rang (from 1.2 to 1.84) and stone weight rang (from 0.27 to 0.64) was different.

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Introduction

Cornus (belongs to the family Cornaceae) is a very large genus which comprises forty species of shrubs and trees native to Central and Southern Europe and parts of Western Asia. Cornelian cherry shrubs mostly grow in Germany, Turkey, France, Bulgaria, Slovakia, Ukraine, Australia and Yugoslavia (Klimenko, 2004; Brindza *et al.,* 2009). For example, there are 1.6 million shrubs in Turkey which produce 17000 tons of this fruit (Ercisli, 2004a). There are 3 spices of *cornus* in northern jungle regions of Iran such as Guilan, Arasbaran, specially the jungles on the shores of Khazar sea, Towchal, Gadouk and Bandar Gaz. In Iran, cornelian cherry is cultivated in limited provinces, which are mainly, Qazvin, East Azerbaijan and Zanjan (Table 1). It must be noted that the cultivation level of cornelian cherry in Qazvin on 2008-2009 has increased to 870 hectares and 235 hectares for Azerbaijan (east). Cornelian cheery fruit is used both as food (nutrition) and drug. In these regions, 99% of Cornelian Cherry crop is harvested from open pollinated seedlings of wild genotypes. Because the plants are open pollinated, they vary widely in terms of productivity and fruit characteristics, such as size, shape, color, flavor and nutritional value (Demir and Kalyoncu, 2003; Hassanpour *et al*., 2011). This high genetic diversity from seedings of Cornelian Cherry is essential for selecting most useful genotypes for future breeding programs (Bijelic *et al.,* 2007; Ercisli *et al.,* 2008).

Table 1. Statistics of cultivation level, production and fruit yield of cornelian cherry.

province	Gardens cultivation level (hec)						Production amount (tons)			Yield (kg/hec)	
	Non productive			productive							
	Water farming	Dry farming	sum	Water farming	Dry farming	sum	Water farming	Dry farming	sum	Water farming	Dry farming
Qazvin	85	0	85	765	0	765	9563	0	9563	12500	0
Azerbaijan	15	0	15	208	0	208	402	0	402	1932.7	0
Zanjan	10	0	10	13	0	13	42	0	42	3230.8	0
Guilan	0	1	1	0	4	4	0	5	5	0	1200
Fars	0	0	0	0	3	3	0	0	0	0	0

The fruits are very valuable for fresh consumption and for processing to produce syrups, juices, and jam (Brindza *et al.,* 2007) spirits and other traditional products (Rop *et al.,* 2010). Fruits, leaves, flowers and bark are utilized in traditional and modern medicine to cure many disorders (Ercisli, 2004). Some parts of this plant which are used in nutriothrapy: Fruit, leaves, peel and root of tree which are used as tonic and purifier. This plant has Antocianin in it's peel which it's synthesis has no need to direct sunlight (Turhan *et al.,* 2007; Yilmaz *et al.,* 2009). The shrub's bark has 8.5 percent Tanen, Malat Calcium, Pectic essence and it's flowers have Coercetin. The fruit has the vitamins C, B_1, B_2, E and high amounts of Fe, ca, Folic acid ,Pectins, Organic acids, Tanen and Melatonin. The amount of vitamin C is approximately 2 times of orange which is a great source of vitamin C (Seeram *et al.,* 2002). Also, it's fruit has Glucose, Sacarose, Glyoxalique acid. The immature fruits has high amounts of Tanen and it's Acidity is so high and Isocitric acid is found highly in cornelian cherry. The shrub's boiled bark has therapeutic effects on Malaria disease. (Ercisli, 2004b; Brindza *et al.,* 2007; Rop *et al.,* 2010). Cornelian cherry is applied as hedges and fence between gardens and their surrounding and is interesting because of it's yellow flowers and early flowering time in Green space designs. In Iran, cornelian cherry fruit is used mainly as fresh- eating, dry fruit, tamarind, jam, syrup, fruit- sheets and freezed fruits. Considering the various application of cornelian cherry shrubs in Iran, there have been very limited studies related to selection of cornelian cherry in Iran. Some of the studies on cornelian cherry conducted to determine some morphological and physiological characteristics (Hassanpour *et al.,* 2012). While there have not been enough studies on this fruit, grown naturally in this

country, selection studies were initiated for long time ago in other countries such as in Russia (Rudkovsky, 1960), in Yugoslavia (Krgovic, 1987), in Azerbaijan and Ukrainian (Guleryuz, 1996). The genetic pool consists of over a hundred wild and cultivated genotypes from Ukraine, Bulgaria, Slovakia, the United Kingdom, Austria and Georgia. The collection represents a wealth of biological and economic potential (Rop *et al.,* 2010). Generally, the historical areas of cornelian cherry occurrence are important for an adaptation of some genotypes to different local conditions in different regions of several countries (Pirlak, 2003; Yilmaz *et al.,* 2009b; Sandra *et al.,*2010). There are some investigations regarding the physical and chemical properties of cornelian cherry fruits, their antioxidant capacity, Phenol, Ascorbic acid, as well as anthocyanin contents (Guleryuz *et al.,* 1998; Karadeniz, 2002; Klimenko, 2004; Vareed *et al.,* 2006; Tural and Koca, 2008; Rop *et al.,* 2010; Hassanpour *et al.,* 2011). Already, no comprehensive research is done on dispersion places of cornelian cherry. So, in this research, the Phenotypic Diversity and Local Dispersion of Cornelian Cherry Population in various regions of Iran, and suitable geographical and climate conditions for cornelian cherry growth are investigated.

Matherial and method

In this study, three major regions of dispersion In Qazvin, East Azerbaijan and Zanjan Provences were selected and the geographical situations and climate conditions of these regions were investigated separately. Total of 18 cornelian cherry (*Cornus mas* L.) accessions were selected in these regions. These accessions including 5 accessions from Kalibar regions in East Azerbaijan, 10 accessionsfrom Hir regions in Qazvin and 3 accessionsfrom Taroum sofla regions in Qazvin. 3 kg of ripe cornelian cherry fruits per accession were harvested from trees. The fruits were selected according to their uniformity of shape and colour and then transported to the laboratory for further analysis. In totality, 50 fruits in mature status per accession were evaluated for their weight (g), length (mm), width (mm) and other important traits of fruit and seed (Table1). Fruit juice was analyzed to determination of total acidity (TA), total solid content (TSS) and pH using Hassanpour *et al.* (2011) method in which TSS was determined by refrectometry of one drop extracted juice of each fruit at 22°C. TA was determined by diluting each 2 ml aliquot of fruit juice in 20 ml of distilled water and then titrated to pH 8.2 by using 0.1 molar NaOH. The pH value was indicated by pH meter. Data were subjected to analysis of variance and means were separated by Duncan's multiple range test at $p<0.01$ significance level by SAS (Software Version 9.1 SAS). Correlation between the traits was determined using the Pearson correlation coefficient. Relationships among the accessions were investigated by factor analysis. Correlation and factor analysis were performed by SPSS (Software Version 16 SPSS). Scatter plots of the first 2 factors were created with SPSS (Software Version 16 SPSS) as well. Cluster analysis was done to yield a dendrogram depicting the morphological relatedness of the cornelian cherry accessions by SPSS (Software Version 16 SPSS).

Table 1 categorize of fruit characteristics.

Small stones < 0.2 g stones weight *Medium stones = 0.2 to 0.3g stones weight* *Large stones = 0.3 to 0.4g stones weight* *Super large stones > 0.4g stones weight* Stones tip were divided to three forms; rotund, acuminate and acute. Stones forms were categorized in to three shapes as followed: *Spherical shape <1.3 diameter stones to length ratio* *Oval shape = 1.3 to 1.5 diameter stones to length ratio* *Oblong shape > 1.5 diameter stones to length ratio* For the drying samples used 70 ^{0}C in an oven.	Fruit size was categorized as followed: *Small size < 2g weight* *Medium size = 2 to 3g weight* *Large size = 3 to 4g weight* *Super large size > 4g weight* Fruit shape was categorized as followed: *Spherical shape <1.25 length to diameter ratio* *Oval shaped = 1.25 to 1.45 length to diameter ratio between* *Elongated shape >1.45 length to diameter ratio*

Result and discussion

Local dispersion of cornelian cherry accessions in Iran

In this study, the main regions for the growth of cornelian cherry in Qazvin province : Rudbar shahrestan and Taroum sofla, in East Azerbaijan province ; Kalibar, Ahar and Jolfa Towns, In Zanjan province; Abhar Town was determined. Generally, the following interesting results are obtained regarding environmental conditions of cornelian cherry in this study of various Geographical conditions. In East Azerbaijan province, the heights between 500-3620 from sea level (in Ahar andkalibar towns at the heights between 500-1800 meters from sea level, in Jolfa town, Eshtabin village at the heights between 3620 meters from sea level), In Qazvin province, at the heights between 580-1700 meters from sea level), in Zanjan province, Marshon village at the height of 1650 meters from sea level, in East Azerbaijan, between the Latitudes 38° 20' to 39° 20' and longitudes between 46° 29' to 47° 30', in Qazvin province, the latitude 36° 20' to 36° 38' and the longitude 49° 22' to 50° 23', In Zanjan province, Marshon village between the latitudes 36° 20 and longitudes 49° 23', the plant is cultivated. The following cases are noticeable regarding the climate conditions and needed soil for the shrubs (Table 1 and 2; Fig.1).

Table 2. Location of many plantations of cornelian cherry in Qazvin province.

Row	Village name	Height from sea level	Geographical location			
			Longitude		latitude	
1	Eslam Abad	1130	49°	29′	36°	24′
2	Akkojan	1550	50°	09′	36°	38′
3	Emamzadeh haroon	813	50°	08′	36°	34′
4	Parchkuh	1700	50°	10′	36°	38′
5	Parrud	1100	50°	9′	33°	36′
6	Talator	1520	50°	10′	36°	37′
7	Darband	1235	50°	15′	36°	35′
8	Dorchal	1020	50°	9′	36°	36′
9	Deh doushab	805	50°	08′	36°	34′
10	Razmian	975	50°	12′	36°	32′
11	Reshkin	1625	50°	11′	36°	38′
12	Ruh Abad	1380	50°	11′	36°	38′
13	Zajkan sofla	1400	49°	25′	36°	20′
14	Zajkan olia	1500	49°	25′	36°	21′
15	Zard Chal	1240	50°	14′	36°	34′
16	Somaq	1510	49°	22′	36°	23′
17	Sogah	1205	50°	14′	36°	34′
18	Shahrestan sofla	875	50°	12′	36°	32′
19	Shahrestan olia	920	50°	12′	36°	32′
20	Sheikhlar	1500	49°	25′	36°	23′
21	Tavinan	1260	49°	34′	36°	29′
22	Ghoncheh khoran	1160	49°	23′	36°	27′
23	feshk	1500	50°	11′	36°	38′

Row	Village name	Height from sea level	Geographical location			
			Longitude		latitude	
24	Ghostin	1620	50°	12′	36°	38′
25	Ghaleh	1140	49°	34′	36°	29′
26	Kiakelaye olia	1130	50°	14′	36°	34′
27	Milak	1530	50°	12′	36°	36′
28	Vargil	1178	50°	12′	36°	35′
29	Viar	1680	50°	16′	36°	37′
30	Hashakelaye	1220	50°	14′	36°	35′
31	Harif	1070	50°	23′	10°	05′
32	Heer	1672	50°	15′	36°	36′
33	uzbashchai	1100	49°	29′	36°	24′

Table 3. Location of many plantations of cornelian cherry in Arasbaran.

Row	Village name	Height from sea level	Geographical location			
			Longitude		latitude	
1	Aquyeh	1610	46°	56′	38°	52′
2	Ayeneloo	1300	46°	47′	38°	54′
3	Ahmad Abad	575	46°	31′	38°	51′
4	Oskaloo	1547	46°	54′	38°	52′
5	Alhard	1060	46°	50′	38°	57′
6	Oula	980	46°	31′	38°	48′
7	Ilankesh	1470	46°	52′	38°	56′
8	Injar	1050	47°	22′	38°	39′
9	Balan	1610	46°	48′	38°	53′
10	Behrooz	1270	46°	48′	38°	52′
11	Baghlar	1100	47°	05′	38°	56′
12	Balasang	1165	46°	58′	38°	56′
13	Pirlar solfa	960	47°	10′	39°	3′
14	Pirlar olia	1140	47°	10′	39°	2
15	Piryusefian sofla	1180	47°	13′	38°	58′
16	Tazekand vinq	1180	46°	53′	38°	59′
17	Jaqtab olia	1660	47°	08′	38°	47′
18	Chai kandi	770	46°	34′	38°	47′
19	Hasan bigloo	1420	46°	41′	38°	50′
20	Khanghah	1200	46°	37′	38°	51′
21	Khaneh khosro	1050	47°	02′	38°	53′
22	Kharil	1750	46°	46′	38°	49′
23	Daranaq	505	46°	36′	38°	54′
24	Dashbashi	1150	46°	53′	39°	00′

Row	Village name	Height from sea level	Geographical location			
			Longitude		latitude	
25	Zavieh	1800	47°	01′	38°	51′
26	Zard vaghan	1700	47°	06′	38°	49′
27	Zirian	1520	47°	02′	38°	50′
28	Siran	1420	47°	05′	38°	58′
29	Shab khaneh	1220	46°	45′	38°	52′
30	Shoja Abad	1710	47°	00′	38°	52′
31	Sadegh bigloo	780	46°	42′	38°	55
32	Some'eh	1320	47°	04′	38°	55′
33	Abbas Abad	1250	46°	29′	38°	55′
34	Ali Abad	1580	46°	56′	38°	51′

Table 4. Continue location of many plantations of cornelian cherry in Arasbaran.

Row	Village name	Height from sea level	Geographical location			
			Longitude		latitude	
35	Ali bolaqi	1246	46°	41′	38°	51′
36	Qhare tikanloo	600	46°	47′	38°	59′
37	Qeshlagh	1650	47°	11′	38°	45′
38	Qaliansaz	1000	47°	12′	39°	2′
39	Kafshan ivi	1100	47°	03′	38°	52′
40	Kalalaq	1280	47°	03′	38°	49′
41	Kalaleh eslami	505	46°	36′	38°	53′
42	Kalaleh sofla	1040	46°	45′	38°	57′
43	Kalaleh olia	1090	46°	45′	38°	57′
44	Kovanaq	500	46°	33′	38°	51′
45	Kojan	1080	47°	24′	38°	49′
46	Kiaraq	940	47°	01′	38°	55′
47	Garmnab	1200	46°	48′	38°	56′
48	Galoosang	1160	47°	00′	38°	53′
49	Gandom nan	1180	46°	52′	39°	00′
50	Goozlan	1240	47°	15′	38°	56′
51	Lame aramaneh	980	46°	42′	38°	55′
52	Lame eslami	820	46°	41′	38°	55′
53	Mardanqom	580	46°	33′	38°	50′
54	Masjed loo	555	46°	46′	38°	59′
55	Meqias jadid	1250	47°	05′	38°	52′
56	Meqias qadim	1280	47°	04′	38°	51′
57	Makdi	1630	46°	54′	38°	51′
58	Molook	1450	47°	08′	38°	55′

Row	Village name	Height from sea level	Geographical location			
			Longitude		latitude	
59	Miandarq	1400	47°	12′	38°	56′
60	Naqdi	830	47°	25′	38°	52′
61	Noje deh shojaian	1250	46°	59′	38°	56′
62	Niq	1400	47°	19′	38°	49′
63	Hejran dost	1610	46°	57′	38°	53′
64	Horand	1090	47°	22′	38°	54′
65	Hoosh	1260	46°	39′	38°	50′
66	yusefloo	1140	46°	51′	38°	57′

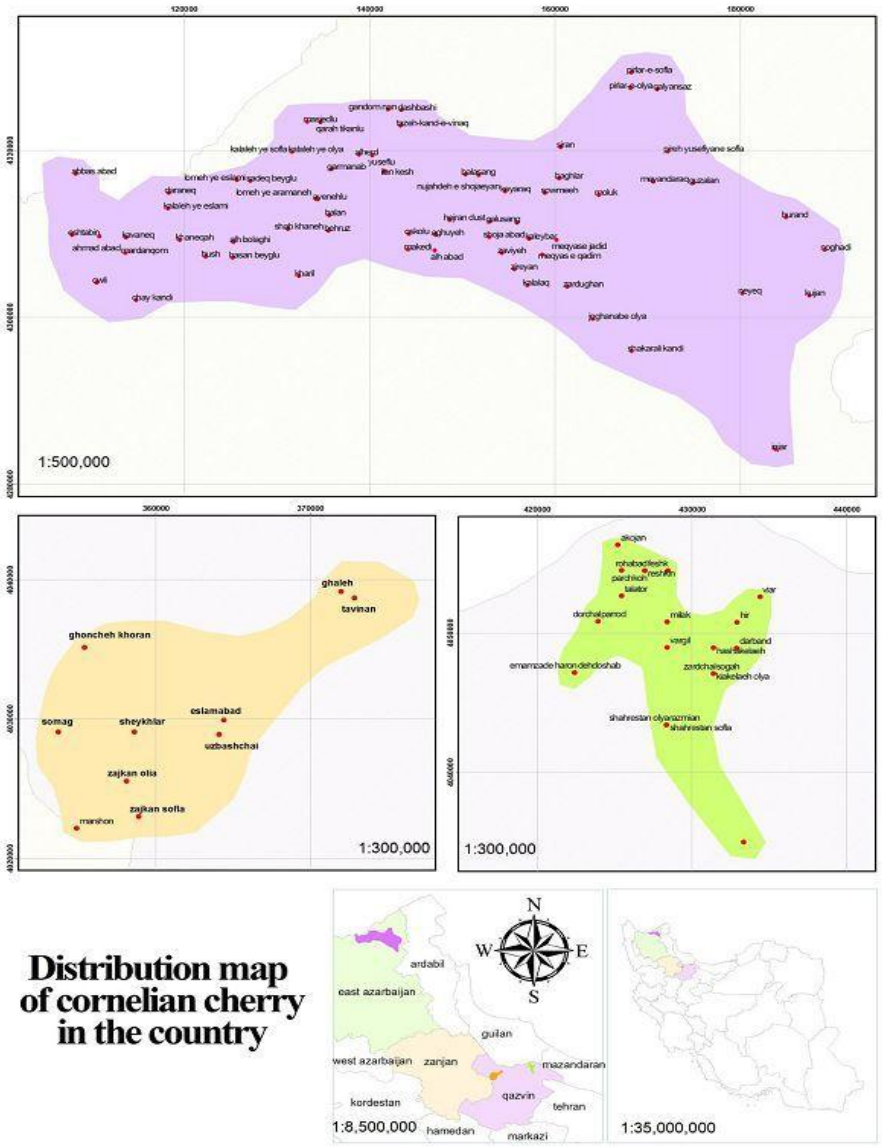

Fig. 1. The dispersion and distribution map of cornelian cherry shrub in Iran.

According to the above map, it can be said that the dispersion level of the shrubs is very high in north, north western and north eastern and very low (rare) in south eastern. By comparing the growth regions of cornelian cherry in Iran, it shows that this shrub grows well in regions with moderate and mountainous climate with mild winters and cool summers.

Results of Phenotypic diversity of cornelian cherry accessions from Qazvin (3 accessions from Taroum Sofla and10 accessions from Rodbar) and East Azerbaijan (5 accessions from Kalibar) provinces are presented in Table 1 to 3 and fig.2. Means of fruit length were different in the accessions, which were from 1.48 to 2.40cm. Lowest fruit length was belonging to the Hir4 from Rodbar and highest fruits length was belonging to the Hir1 in Rodbar, Qazvin Province. Means of fruit diameter ranges were measured from 1.08 to 1.60 cm. This was lowest in Hir4 in Rodbar, Qazvin Province and the highest fruit diameter was measured in Taroum2 in Taroum Sofla, Qazvin Province. Most of the fruit diameter was observed in abdominal parts of the fruits and lowest was observed in the apical end of the fruits. The highest fruit diameter was calculated in Taroum1 in Taroum Sofla, and Hir1, Hir6, Hir7, Hir8 and Hir10 in Rodbar, Qazvin Province and Kalibar4 from East germplasm were spherical and the rest were elongated and oval shape (Table 1). Fruit size was from small till large in different population cultivars (Table 1). Most of the cultivars were in medium size from 2 to 3g. Fruit of Hir4 and Kalibar5 were small and Hir2, Taroum2, and Kalibar2 were large in size and the rest were observed medium in size (Table 1). Fruit Stone to pulp ratio range were from 2.89 to 6.87. Which was low in accession of Kalibar4 and it was high in Hir3 from Rodbar, Qazvin. The colour of the flesh and pill was much closed to red colour (Table 2). The mean of fruit stone length range were obtained from1.08 to 1.59cm. The lowest fruit stone length was observed in Kalibar5 and the highest was identified in Hir2. Fruit stones diameter ranges were measured from 0.51 to 0.72 cm, this was low in Kalibar5 and it was high in Kalibar3 and Kalibar4 from Kalibar, East Azerbaijan Province. The lowest fruit diameter was measured in Kalibar3 from the East Azerbaijan Province. Fruit length to fruit diameter ratio range was measured from 1.2 to 1.84cm, this was lowest in Kalibar4 in East Azerbaijan Province and the highest was measured in Hir1 accession in Rodbar, Qazvin Province (Table 1). The mean of soluble solid content (SSC) range was measured from 9.00 to 23.50 %. The lowest SSC was measured in the Hir3 accession in Rodbar area from Qazvin Province and the highest SSC was indicated in Ka5 in East Azerbaijan Province . Mean of pH ranges were calculated from 2.95 to 3.32, which were low in the accession of Hir7and Hir8 respectively in Rodbar, Qazvin. This was high in T.S3, from Taroum, Qazvin. The mean of fruit fresh weight rang was calculated from 1.57 to 3.52g and mean of dry fruit weight rang was achieved from 0.44 to 0.94g. Those were low in the germplasm of Rodbar, which were high in accession of Hir2, in Rodbar, Qazvin Province. Fruit shapes were from spherical to elongated forms but the majority was oval to elongate shape such as the Kalibar3, Kalibar4 and Ka5 Azerbaijan, Iran (Table 2). Fruit stone lengths to fruit stone diameter ratio range were measured from 1.2 to 1.84 cm. This was low in Kalibar4 and the highest was observed in Hir1. Fruit stone weight range was from 0.27 to 1.43g. The lowest fruit stone weight was measured in Kalibar5 and it was highset in Kalibar2 in Kalibar, East Azerbaijan Province of Iran. Fruit stone shape was identified long in all of the cultivars. The fruit stone tip form was rotund, acuminate and acute, but most of the fruit stone tips were rotund. There were some of the accession with acute stone tip such as Kalibar1, Kalibar2, and Hir1and Hir2. Fruit stone sizes were identified large in all of the accession except Ka5 (Table 2). Our findings supported by a previous research, which was conducted by Svitlana (2004). He reported that the fruits of the cornelian cherry could be dark red, cherry red, pink or yellow. Formwise, they can be oval, pear shaped or bottle shaped. An average fruit weight ranges was from 5.0 to 8.0g. The stone makes up 7.5 to 11.0% of the total fruit weight. Total sugar content ranges were from 8.0 to

11.0%. Organic acids content ranges were from 1.3 to 1.9%. Vitamin C content ranges were from 101 to 193 mg %. Anthocyanin content ranges were 670 to 850 mg% in the skin, and it was from 36 to 121 mg% in pulp. Cornelian cherry genotypes from different provinces of Turkey were studied. Fruit weight ranged were from 1.0 to 6.5 grams, fruit length were from 1.3 to 2.8 cm, fruit width were from 0.9 to 2.3 cm, flesh to stone ratio were from 2.0 to 9.4, soluble solids content were from 8.0 to 22.5%, and Vitamin C content was from 36 to 122 mg/100g. The trees were found growing anywhere from 300 to 1200 meters above sea level (Ercisli, 2004a). A study was conducted regarding cornelian cherry in Turkey by Guleryuz *et al.* (1996). They mentioned that the characteristics of the fruit ranged from 2.907 to 3.906 for fruit weights, 5.950 to 10.707 for flesh/seed ratio, 11.5% to 16.8% for TSS, 43.78 to 76.75 mg Vitamin C per 100 g, 2.215% to 4.690% for total acidity (as Malic acid), 3.0242 to 7.168 TSS/acid ratio, 4.220 to 9.960 for sugar and 2.024% to 5.664% for reducing sugar, respectively.

However, there were no significant differences between the cornelian cherry genotypes from Turkey and Iran except fruit weight and flesh/ fruit stone ratio. In the current study, major population of cornelian cherry from Iran has been studied. There were no studied more about and should consider on fruit quality and quantity of cornelian cherry. Based on the results from the current study, can conclude that the accession of Hir4 showed lowest dry weight, fresh weight and flesh weight but the highest fruit weight, flesh/ fruit stone ratio were performed in Taroum2, Kalibar2 and Hir2 accession. Kalibar5 was sweetest accession among the collected cultivars. High pH was measured in Hir7 and Hir8 accessions of Rodbar, Qazvin Province. However, more research on this topic needs to identify the best accession of cornelian cherry in Iran.

Table 1. Fruit characteristics of local accessions .

Areas	**Code Name**	**flesh/seed ratio**	**Flesh (g)**	**Length/ diameter ratio**	**Fruit diameter (cm)**	**Fruit length (cm)**
Youzbash Chaie, Taroum-Sofla	*Taroum*1	4.06±0.10	2.10±0.04	1.40±0.05	1.46±0.04	2.04±0.06
	*Taroum*2	5.67±0.32	3.00±0.12	1.40±0.03	1.60±0.03	2.28±0.01
	*Taroum*3	3.70± 0.17	1.70±0.08	1.37±0.01	1.35±0.01	1.86±0.01
Hir, Rodbar, Qazvin	Hir1	5.30± 0.40	2.30±0.14	1.84±0.09	1.31±0.05	2.40±0.03
	Hir2	5.10± 0.30	2.95±0.03	1.49±0.01	1.57±0.01	2.33±0.01
	Hir3	6.87±0 .84	2.55±0.12	1.48±0.01	1.49±0.01	2.20±0.01
	Hir4	3.94±0.75	1.26±0.1	1.37±0.01	1.08±0.03	1.48±0.03
	Hir5	5.16±0.44	2.08±0.18	1.38±0.01	1.46±0.01	2.01±0.04
	Hir6	4.96±0.59	2.20±0.15	1.49±0.02	1.44±0.04	2.15±0.03
	Hir7	4.10± 0.39	1.65±0.13	1.57±0.01	1.25±0.01	1.96±0.01
	Hir8	4.49± 0.70	2.10±0.25	1.46±0.03	1.45±0.03	2.12±0.01
	Hir9	5.34 ± 0.30	2.40±0.04	1.52±0.01	1.42±0.01	2.16±0.01
	Hir10	4.60 ± 0.36	1.99±0.08	1.45±0.04	1.40±0.03	2.03±0.03
Kalaibar, Villages, Eastern Azarbaijan	Kalibar1	3.77±0.46	1.82±0.1	1.37±0.01	1.38±0.03	1.89±0.06
	Kalibar2	3.96±0.47	2.54±0.17	1.30±0.01	1.56±0.03	2.05±0.03
	Kalibar3	3.72 ± 0.30	2.17±0.05	1.22±0.02	1.50±0.01	1.83±0.03
	Kalibar4	2.80± 0.15	1.60±0.07	1.20±0.01	1.38±0.03	1.67±0.04
	Kalibar5	5.80± 0.21	1.36±0.07	1.23±0.03	1.25±0.03	1.54±0.05

*Taroum : Taroum-Sofla*Hir*: Rodbar, QazvinKa:Kalaibar, Eastern Azarbaijan*

Table 2. Continued. Fruit characteristics of local accessions.

areas	Code Name	Fruit size	shape	Flesh Colour Grade	Peel Colour Grade
Youzbash Chaie,	*Taroum*1	M	O	2	3
Taroum-Sofla	*Taroum*2	L	O	2	2
	*Taroum*3	M	O	1	1
H.ir, Rodbar, Qazvin	Hir1	M	E	5	5
	Hir2	L	E	3	3
	Hir3	M	E	3	3
	Hir4	S	O	4	4
	Hir5	M	O	6	6
	Hir6	M	E	1	1
	Hir7	M	E	2	2
	Hir8	M	E	3	3
	Hir9	M	E	3	3
	Hir10	M	O	3	3
Kolaibar, Villages,	Kalibar1	M	O	2	2
Eastern Azarbaijan	Kalibar2	L	O	4	3
	Kalibar3	M	Sph	1	1
	Kalibar4	M	Sph	5	5
	Kalibar5	S	Sph	3	4

*Taroum : Taroum-Sofla*Hir*: Rodbar, Qazvin*Ka:*Kalaibar, Eastern Azarbaijan,*
L=LargeM= Medium S=SmallE=Elongated O=OvalSph= Spherical

Table 3. Fruit stone characteristics of local accessions.

Areas	Code Name	Diameter (cm)	Length (cm)	Length/diameter ratio	Tip stone form	Size	Weight (g)
Youzbash	*Taroum*1	0.68±0.03	1.36±0.01	1.40±0.05	R	L	0.53±0.01
Chaie, Taroum-	*Taroum*2	0.69±0.01	1.41±0.01	1.40±0.03	R	L	0.53±0.02
Sofla	*Taroum*3	0.63±0.01	1.30±0.04	0.37±0.004	Ac	L	0.45±0.014
	Hir1	0.56±0.01	1.59±0.01	1.84±0.09	A	L	0.43±0.01
Hir, Rodbar,	Hir2	0.62±0.01	1.62±0.05	1.49±0.01	A	L	0.58±0.03
Qazvin	Hir3	0.61±0.01	1.49±0.01	1.48±0.01	Ac	L	0.41±0.12
	Hir4	0.53±0.03	1.20±0.03	1.37±0.01	R	L	0.32±0.03
	Hir5	0.62±0.01	1.36±0.01	1.38±0.01	R	L	0.45±0.02
	Hir6	056±0.01	1.45±0.03	1.49±0.02	R	L	0.45±0.02
	Hir7	059±0.01	1.45±0.03	1.57±0.01	R	L	0.40±0.03
	Hir8	0.57±0.01	1.46±0.01	1.46±0.03	R	L	0.47±0.02
	Hir9	0.57±0.01	1.42±0.01	1.52±0.01	R	L	0.45±0.02
	Hir10	0.61±0.01	1.32±0.03	1.45±0.04	R	L	0.43±0.02
Kolaibar,	Kalibar1	0.69±0.01	1.24±0.01	1.37±0.01	A	L	0.48±0.03
Villages,	Kalibar2	0.71±0.01	1.42±0.01	1.32±0.01	A	L	0.64±0.04
Eastern	Kalibar3	0.72±0.01	1.29±0.02	1.22±0.02	Ac	L	0.59±0.04
Azarbaijan	Kalibar4	0.72±0.01	1.24±0.01	1.20±0.01	Ac	L	0.57±0.01
	Kalibar5	0.51±0.01	1.08±0.01	1.23±0.03	Ac	S	0.27±0.01

E=Elongated L=LargeS=Small R= Rotund Ac= Acuminate A= Acute, T.S: *Taroum-Sofla* R.Q: *Rodbar, Qazvin* Ka:*Kalaibar, Eastern Azarbaijan*

Fig. 1. Phenotype of main accessions fruit of cornelian cherry in Iran.

Table 3. Correlation coefficients among physical properties in cornelian cherry genotypes.

	Flesh (g)	Fruit Dry Matter (g)	Length (cm)	pH	TSS (%)	Stone Diameter (cm)	Stone Length (cm)	Stone Weight (g)
Flesh(g)	1							
Fruit Dry Matter(g)	0.14ns	1						
Length (cm)	0.14ns	0.40*	1					
pH	0.12ns	0.27ns	0.47*	1				
TSS (%)	-0.25ns	-0.09ns	-0.64*	-0.16ns	1			
StoneDiameter(cm)	0.18ns	0.24ns	0.13ns	-0.37ns	-0.19ns	1		
StoneLength(cm)	0.55*	-.18ns	-0.17ns	-0.33ns	-0.08ns	-0.05ns	1	
StoneWeight(g)	0.08ns	0.23ns	0.12ns	-0.38ns	-0.35ns	0.141ns	0.48*	1

*, **: Correlation coefficient is significant at $p<0.05$ and $p<0.01$ respectively. ns: Non- significant.

The data were compared and analyzed by multivariate techniques [correlation matrix calculation and principal component analysis (PCA)]. The highest positive correlation was found between TSS and fruit Length (r > 0.64) (Table 3). Using PCA, different genotypes of cornelian cherry can be grouped in clusters based on similarity in their chemical composition (Table 3, Fig. 1 and Fig. 1).

Correlation coefficient for different physicochimical parameters showed that significant correlations existed among most of the traits (Tab. 3). There were significant positive correlations between some of physicochimical traits ($p<0.01$), whereas a significant negative correlation existed between some of other ($p<0.01$). It was observed that there was no apparent correlation between some of other physicochimical parameters. Therefore, it is possible, some of physicochimical parameters for use in breeding programs of this fruit species (Bijelić *et al.,* 2011). The first sixth Principle component explained by Factor analysis in Table 4. Among the studied variables tested, the pH, fruit diameter and fruit length, were highly correlated with factor 1. The highly correlated variables with factor 2 were flesh/stone ratio, TSS (%) and fruit dry matter. The highest correlation with factor 3 was calculated from stone diameter and stone diameter. The highest correlation with factor 4, 5 and 6 was calculated from stone diameter, TSS and flesh/stone ratio respectively. The PC analysis of Yilmaz *et al.* (2009) study in Turkey indicated that the first three PC explained 61% of the total variation. Our results in comparison with other results conducted on cornelian cherries (Yilmaz *et al.,* 2009; Bijelić *et al.,* 2011; Hassanpour *et al.,* 2011).

Table 4. Eigen values and cumulative variance for 5 factors resulted from factor analysis.

Character	PC1	PC2	PC3	PC4	PC5	PC6
Flesh/Stone Ratio	-0.131	-0.497**	-0.133	-0.361	0.165	-0.617
Flesh(g)	-0.272	-0.337	0.070	0.208	0.023	0.186
Humidity%	0.336	-0.008	-0.103	-0.189	-0.006	0.120
Fruit Dry Matter	0.223	-0.439	0.046	0.206	0.291	-0.072
Fruit Fresh Weight	0.211	-0.297	0.208	0.448	-0.380	-0.337
Length/ Diameter Ratio	0.284	0.041	0.270	0.187	-0.497	-0.041
Fruit Diameter	0.350	-0.077	-0.066	-0.123	0.058	0.031
Fruit Length (cm)	0.348	-0.107	-0.040	-0.043	-0.033	0.039
pH	0.353	0.033	-0.090	-0.096	0.076	-0.018
TSS(%)	0.067	0.463	0.065	0.483	0.511**	-0.437
StoneDiameter(cm)	0.011	-0.245	-0.632**	0.485	0.090	0.309
StoneLength(cm)	-0.340	-0.082	0.140	0.099	-0.057	0.133
StoneLength/Diameter ratio	-0.345	-0.054	0.143	0.090	-0.124	-0.112
StoneWeight(g)	0.119	-0.231	0.625**	-0.008	0.446	0.361
Eigenvalue	7.744	2.134	1.416	1.003	0.699	0.397
% of variance	0.553	0.152	0.101	0.072	0.050	0.028
Cumulative variance %	0.553	0.706	0.807	0.878	0.928	0.957

** Significant factor loading (values above 0.50).

Grouping of cornelian cherry accessions based on these 6 factors was performed and accessions were divided into three sub-clusters (Fig. 1).

The distribution of accessions on the factor 1 and factor 2 plots is showed in Fig. 2. Starting from the negative to the positive values of factor 1, the accessions indicated a general increase in the fruit flash weight, length and width, and a decrease in seed weight. Starting from the negativetowards the positive values of factor 2, the accessions were characterized by a large seed. The factor analysis provided a simplified classification of the cornelian cherry accessions for collection and for breeding. The scatter plot (Fig. 2) also shows geometrical distances among the accessions in the plot that reflect a similarity among them in terms of variables measured. Three groups of related accessions were separated. Group A includes those accessions with a low negative value of factor 1 and intermediate of

factor 2 (6, 10, 14, 15, 16 and 17). Group B consists of seven accessions that corresponded with a high negative factor 2 and a low positive factor 1 value (2, 3, 5, 9 and 12). Four accessions that have an intermediate positive factor 1 and 2 value are in the third, C group, of related accessions (1 and 7). For further collection it is sufficient to take just one accession from each of these groups. Based on the position, a small genetic distance is observed between 4, 11, 13 and 18 accessions. In this study, the data were compared and analyzed by multivariate techniques such as correlation matrix and principal component analysis.

The results demonstrated that phenotypic diversity profiles are valuable tools with great potential the genetic diversity of Iranian cornelian cherry accessions. In addition, complete comprehension of the genetic diversity within cultivars would contribute to a more efficient use of germplasm in plant breeding programs. As a tool for germplasm biodiversity description, we have used principal component analysis to study correlations among variables and establish relationship among accessions. This method is commonly applied for characterization of bio-diversity of genetic resources in such studies (Guleryuz *et al.,* 1996; Pirlak *et al.,* 2003; Yilmaz *et al.,* 2009).

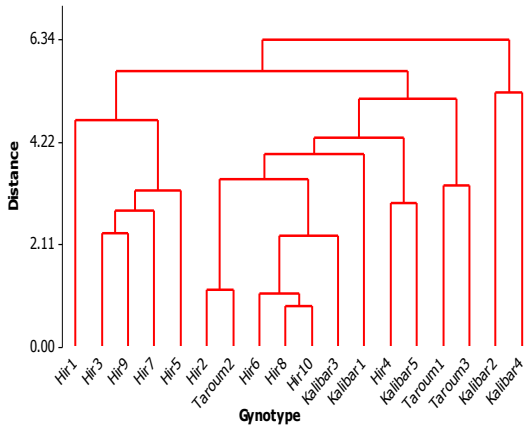

Fig. 1. Dendrogram of grouping 18 cornelian cherry accessions based on 5 main factors and Ward's method.

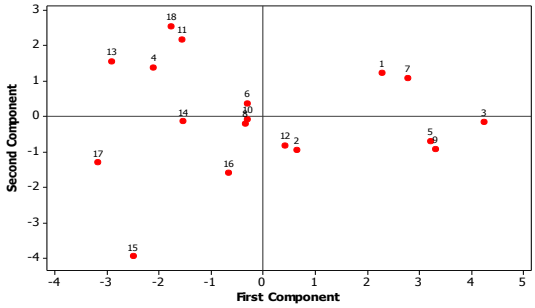

Fig. 2. Factor analysis plot of the first two factors depicting relationship among cornelian cherry (*cornus mas*) accessions established in Iran.
1= Hir1; 2= Hir2;3= Hir3;4= Hir4; 5= Hir5; 6= Hir6; 7= Hir7; 8= Hir8; 9= Hir9; 10= Hir10; 11= Taroum1; 12= Taroum2; 13= Taroum3; 14= Kalibar1;15= Kalibar2; 16= Kalibar3; 17= Kalibar4; 18= Kalibar5

Conclusions

This research obviously points to that phenotypic diversity and Local dispersion of promising cornelian cherry accessions in Iran. High variability in the natural population of the cornelian cherry in the region of Iran is an important genetic potential for use in breeding programs. Therefore, collection and study of cornelian cherry genotypes, introduction of best selections in commercial production can be helpful.

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