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Morphological and morphometric characteristics of Cornelian Cherry (*Cornus mas* L.) in natural conditions of the Crimean Peninsula

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Abstract. Cornelian cherry **(***Cornus mas* L.) is a valuable fruit and ornamental plant in the Cornaceae family. This is a promising frost- and drought-resistant crop, undemanding to growing conditions. Fruits and leaves of plants are rich with biologically active substances which allows them to be used in pharmaceutical, food, liquor, and other industries. In the natural non-cultivated communities on the Crimean Peninsula the species is represented by a wide variety of forms that are promising for study from the point of view of botanical and breeding research. There is practically no information in the scientific literature about the characteristics of cornelian cherry for the most common places of its growth on the Crimean Peninsula, regarding the morpho-biological features and patterns of development of cornelian cherry plants, which determines the relevance of research. The purpose of this work was to study the intraspecific variability of cornelian cherry plants within natural coenopopulations under varying ecological conditions in the foothill, mountain, and South Coast of the Crimea in order to identify the most promising forms for further breeding research. The results of a three-year study (2017 to 2019) revealed differences in the life form of plants, in the timing of fruit maturation, in the shape and color of the leaf and fruit, and in their metric parameters. Promising forms of plants with the largest fruits (an average weight from 1.65 g to 1.81 g) and a low percentage of endocarp - from 10% to15% (Form 1 - CP I, CP II, CP V, Form 2 a - CP IV) can be recommended for further breeding research.

Key words: *Cornus mas* L., coenopopulation, leaf, fruit, metric parameters.

INTRODUCTION

The gene pool of economically valuable plants of scientific and practical interest is enriched by selecting the best forms from natural coenopopulations for use in breeding and applications (Mratinić et al., 2015). Flora of Crimea, according to many authors, numbers from 2,532 to 2,775 species of higher plants growing across the ecological

zones of the Crimean Peninsula. Many of them have economic and cultural significance, providing people with food, medicines, fuel, clothing, building materials, and raw materials for production (Yena, 2012; Czerwińska & Melzig, 2018). The study of wild plants is a promising direction for understanding the characteristics of the species and the laws of evolution, and is also the basis for conducting selection research (Tarko et al., 2014; Jaćimović & Božović, 2017; Salejda et al., 2018; Khoury et al., 2019).

In recent years, the problem of extinction of certain species of plants has exacerbated owing to shrinking of their native habitat areas, in connection with changes in the environment due to several factors: deforestation, mowing of herbaceous cover, uncontrolled cattle grazing, invasion by alien species, destruction of ecosystems, climate change, depletion of soil, etc. Therefore, it is important to study wild plants in order to preserve the extant intraspecific diversity and the species as a whole and further to study the most promising forms for the selection purposes (Klimenko, 2007; Koblyakov, 2008; Bijelić, 2015; Szot et al., 2020).

Among the multitude of wild fruit plants, cornelian cherry is very popular and perspective crop - a culture that is little studied across the Crimean Peninsula. It is undemanding to growing conditions, tolerant to low negative temperatures (low as -35 °C) and drought, because it is able to regulate transpiration by folding leaves into a tube, and is very rarely damaged by pests and pathogens (Cornescu & Cosmulescu, 2017; De Biaggi et al., 2018; Kazimierski et al., 2019). The fruits and leaves of cornelian cherry contain physiologically active substances: organic acids, glucose, fructose, vitamins C, B3, and P, flavonoids, micro-and macronutrients, essential oils, phytoncides, which allows them to be used in pharmaceutical, food, liquor, and other industries (Tarko et al., 2014; Kucharska et al., 2015; Dinda et al., 2016; Hosseinpour-Jaghdani et al., 2017; Adamenko et al., 2018; Salejda et al., 2018; Dumitrașcu et al., 2019). Due to its decorative properties (resistant to pruning, winter-hardy, resistance to industrial pollution, early-flowering), cornel can be used in landscaping and in home gardens alike, in soil-protecting plantings, as well as a medium-forming phytoncide plant (De Biaggi et al., 2018; Dumitrașcu et al., 2019; Yarılgaç et al., 2019).

Cornelian cherry trees are native in Southern Europe and South west Asia, being spread in many countries such as Turkey, Bulgaria, Romania, Italy as wild fruit trees and are crop due to its resistance in harsh environmental conditions (Klimenko, 2007; Dumitrașcu et al., 2019; Ochmian et al., 2019). It cultivated mainly in Central and Southern Europe, in Asia Minor, and in the Caucasus (Cetkovská et al., 2015). In the Ukraine, Bulgaria, Slovakia, Austria, France, Germany, Poland and Turkey a systematic collecting, selecting and breeding program has started in the last years (Klimenko, 2004, 2007). Large plantings are found in Moldova, Rostov, Krasnodar, Stavropol, the Crimea, and the Caucasus (Klimenko et al., 2003; Klimenko, 2007). The Caucasus is one of the world's richest hotbeds of various forms of this plant (Ujukhu, 2006; Tigieva, 2007). In the native of the Crimea cornelian cherry is part of the forest undergrowth, rising to a nelevation of up to 1,200 m above sea level. On the southern macroslope of the Main ridge, it is present in oak and oak-hornbeam forests and forms a belt of juniper-oak forests with separate bushes. A wide variety was observed on the territory of the villages of Sokolinoe, Golubinka, Schastlivoye, Shelkovichnoye, Maloe Sadovoe (Bakhchisarai district), Perevalnoye, Petrovka, Novo-Pavlovka (the Simferopol district), Kizilovka, Sinekamenka (the Belogork district) (Klimenko et al., 2003; Klimenko, 2007).

Cornelian cherry is 2–8 m high shrub and tree with a spherical, pyramidal, oval, umbrella-shaped, or spreading crown (Klimenko, 2007; Cetkovská et al., 2015; Czerwińska & Melzig, 2018; Szczepaniak et al., 2019). The plants develop yellow flowers, small, actinomorphic, that are collected in paniculiform, umbel-shaped, or head-shaped inflorescences. The species is also grown as an ornamental plants for its late winter yellow flowers. The fruit is a lower syncarpous drupe with a juicy and fleshy exocarp and a hard endocarp. The color of the fruit varies from bright red to dark red, almost black, oval shaped, 10–30 mm long drupes with a weight of 2–5 g. As a result of selection, varieties with yellow and pink fruits were released (Klimenko, 2007; Cetkovská et al., 2015; Jaćimović et al., 2015; Cornescu & Cosmulescu, 2017; Popović et al., 2017; Adamenko et al., 2018).

The study of the natural gene pool and selection of the most promising forms of cornelian cherry in Russia is carried out in the South of the country, in the Caucasus - in the Republics of North Ossetia-Alania and Adygea, in the Krasnodar Krai (Ujukhu, 2006; Tigieva, 2007; Koblyakov et al., 2008). In the scientific literature there is practically no information about the characteristics of the places of growth and morpho-biological features of the development of cornelian cherry plants on the Crimean Peninsula. Rational use of the species is difficult without knowledge of the features of intraspecific variability or the biology of development and fruiting of plants. Therefore, the study of the degree and nature of the form variability of cornelian cherry in natural conditions of growth on the Crimean Peninsula is an urgent and promising direction.

The **purpose of the research** is the study of intraspecific variability of cornelian cherry plants within the coenopopulations of the species in different ecological condition of the Crimea and identification of promising forms for selection research.

MATERIALS AND METHODS

Studies on the diversity of cornelian cherry plants in native on the territory of the Crimea in various ecological conditions were conducted in 2017 to 2019: in the Western and Eastern parts of the mountainous and foothill zones on the Northern macroslope of the Main ridge of the Crimean Mountains and on the Southern coast.

The study of coenopopulations was carried out according to standard methods of geobotanical research. The type of forest vegetation was determined according to the typological classification of Crimean forests developed by Posokhov (1971) and supplemented by Plugatar`, 2015. The species of plants was determined according to the Keys to Higher Plants of Crimea (Rubtzov, 1972), the names of taxa are given according to the database ‘The Plant List’ (2013), and ‘International Plant Names Index’ (2020). Analyzing intraspecific variability, we paid attention to the life form of plants, the variety of fruits and leaves forms. Morphological analysis of fruits and their classification were carried out according to Klimenko (2007).

The sample size depended on the number of plants in the coenopopulation and ranged from 15 to 26 individuals. For morphological analysis, 35 leaves and fruits per tree were selected from the lower, middle, and upper parts of the plant crown in each coenopopulation to remove metric parameters. The biometric data of eight quantitative traits (leaf length, leaf width, fruit weight, fruit length, fruit diameter, endocarp weight, endocarp length, endocarp diameter) were subjected to statistical analyses using the

Microsoft Office Excel 2010 and Statistica 10 software package using standard indicators (arithmetic mean value, standard deviation (SD) and coefficient of variation (Cv). To assess the influence of the interaction of factors, a two-way analysis of variance (ANOVA) was used (Lakin, 1990; Lotova, 2001; Dospekhov, 2012).

The first studied coenopopulation of cornelian cherry (CP 1) is located on the Southern Coast of the Crimea in the Ulu-Uzen river valley (near Generalskoe village, near Alushta), on a slope with a gentle slope of 25 to 30° of the Southern right-bank exposure, at an altitude of 250 to 300 m above sea level. The coenopopulation inhabits an area of 0.10 ha, represented by 18 specimens of woody life forms. According to the typological classification of Crimean forests (Posokhov, 1971; Plugatar`, 2015) this coenopopulation is a part of the dry oriental hornbeam sudubrava (C1-ohOd), where the type-forming rock is *Quercus pubescens* Willd. IV growth class, with a tall of no more than 10 m. The community forest stand is composed (0.65). The composition of the shrub layer, in addition to *Cornus mas*, contains *Carpinus orientalis* Mill., *Paliurus spina-christi* Mill., *Juniperus excelsa* M. Bieb., and *Cotinus coqqyqria* Scop. occurs occasionally. The grass cover is dominated by steppe perennial grasses with a projective cover of no more than 25%.

The second coenopopulation of cornelian cherry (CP 2), is located in the western part of Mountainous Crimea, on the northern macroslope eat an altitude of 600 to 650 above sea level in the vicinity of the Nauchny village (Bakhchisaray district). This coenopopulation is represented by 26 plants, with a total area inhabited of 0.25 ha, and is a part of dry hornbeam oakery with *Quercus pubescens* (D_1- ohOd), along the South-Eastern slope of one of the unnamed spurs of Sel-Bukhra mountain, gently descends into a deep gill. The community forest stand is composed (0.7). Both shrubs and tree life forms of *Cornus mas* are found here. The dominant role belongs to *Quercus pubescens* IV–III growth class. The plants does not exceed 12 m. tall of In the first tier, *Fraxinus excelsior subsp. coriariifolia* (Scheele) A.E. Murrey is separately found. In the undergrowth, *Cornus mas*, *Carpinus orientalis*, and *Euonymus europaeus* L. create a weakly expressed shrub layer. The herbaceous cover is sparse, poor in floristic terms, with a projective cover of no more than 20% and is represented by xerophilous grasses and dicotyledonous species.

The third coenopopulation of cornelian cherry (CP 3) is located in the eastern part of Mountainous Crimea, on the northern macroslope of the Main ridge, grows in the area of the Sheitan-Kapu gorge of the Tanasu river valley (the vicinity of Krasnoselovka village (Belogorsky district) at an altitude of 570 m above sea level. The gorge is formed by four tower-like rocks located in pairs on each side of the river up to 50 m high. This coenopopulation, inhabiting an area of about 0.30 ha, is represented by shrub life forms in the number of 22 plants, and is part of fresh hornbeam oakery with *Quercus petraea* (Matt.) Liebl. (D2-hOf), where it forms a section of oak-cornel forest, with a slope of 10 with *Quercus petraea*. The forest stand is closed (0.75 to 0.85). The trees does not exceed 20 m tall. In the community, *Fagus sylvatica* L. is found separately. The second tier contains *Cornus mas* (dominate), *Carpinus betulus* L., *Acer campestre* L. The herbaceous layer is strongly sparse, with a projective cover of no more than 8%, formed by mesoxerophytic dicotyledonous plants.

The fourth coenopopulation of cornelian cherry (CP 4) is located in the eastern part of the foothill zone on the northern macroslope, in the vicinity of the village of Topolevka (Belogorsky district), at an altitude of 480 m above sea level. To the South is

Tau-Bashi mountain (772 m), to the North - Kulyaba mountain (521 m), to the West - Kubalach mountain area (768 m). The coenopopulation inhabiting an area of about 0.30 ha, is represented by shrub and tree life forms in the number of 23 plants of cornel, and is part of dry oakery (D1-Od-Of). The forest stand is closed (0.8), clearly defined, formed by two types of oak *Quercus pubescens* and *Quercus petraea* up to 18 m tall. *Cornus mas* along with *Euonymus europaeus, Ligustrum vulgare* L. and few single plants of *Carpinus betulus* form a dense shrubby undergrowth. The herbaceous layer changes its projection coverage from 90% in spring (April) to 15% in summer (July) and is represented by xeromesophytic grasses.

The fifth coenopopulation of cornelian cherry (CP 5) is located in the eastern part of the foothill zone on the northern macroslope of the Crimean Mountains in the vicinity of the city of Stary Krym (Kirovskyi district) at an altitude of 350 to 400 m above sea level. On a total area of 0.20 ha, it is represented by 15 plants of shrub life forms, grows on the edge of an oak-cornel forest, is a part of dry cornel oakery with *Quercus pubescens* (D1-COd). The dominant tree species is *Quercus pubescens*, up to 12 m tall. The forest stand is closed (0.6). The undergrowth is formed by *Cornus mas* (projective cover up to 60%), *Corulus avellana* (L.) H. Karst., *Cornus sanguinea* L., *Ligustrum vulgare*, *Carpinus orientalis*, sporadically - *Rosa canina* L. and *Acer campestre*. The herbaceous layer is represented by xeromesophytic grasses with a projective cover of up to 40%.

RESULTS AND DISCUSSION

Weather conditions in the natural zones of the Crimean Peninsula are quite contrasting, due to the influence of the Black and Azov seas and the presence of mountains. The presence of seas softens the climate during the cold season and provides coolness during the warm period; mountains serve as a barrier that holds back cold air flows (Bagrova et al., 2001). Weather conditions in the locations of coenopopulations (foothill and mountain zones, Southern Coast) were different and unstable during the growing seasons of 2017 through 2019 (Table 1). These weather conditions were obtained from weather stations located near the study areas: Belogorsk, Vladislavovka, Pochtovoye, and Generalskoe (https://rp5.ru).

The Southern Coast of Crimea (Generalskoe village, CP 1) is characterized by a Mediterranean climate. The duration of the frost-free period is 220 to 240 days, and the summer period is 120 to 140 days (Bagrova et al., 2001). The average annual temperature is 14.2 °C. Winter is quite warm and humid, the average temperature of the coldest month (January) - +4.4 °C, and the warmest (August) - 27.7 °C (Table 1). The maximum summer temperature for the three years of the study was 37.5 °C (https://rp5.ru). The temperature regime in 2017 was within the limits of the average long-term indicators, only in February, March, and June there was an excess of the norm by 2; 3.6, and 2.2 °C, respectively. In 2018, the indicators exceeded the long-term average during the entire vegetation period of plants by 2.4 to 5.4 °C. In 2019, an excess of average annual indicators was noted in all months of the growing season. The maximum excess was recorded in March (+2.4 °C to normal), June (+5.6 °C to normal), August (+3.7 °C to normal).

Precipitation in 2017 was below the long-term average, with the exception of a slight excess in May and August. Conditions in 2018 were characterized by very low

amount of precipitation during the active fruit formation phase (June to August). The average annual precipitation varied from 280 to 400 mm (Table 1).

Table 1. Average amount of precipitation and air temperature during the active vegetation period Cornelian cherry, 2017 through 2019

Coeno-population (CP)	Years	Months								
		January	February	March	April	May	June	July	August	September
amount of precipitation, mm										
CP 1	2017	49.0	10.0	17.0	23.0	48.0	19.0	37.0	52.0	9.0
	2018	61.0	73.0	35.0	5.0	40.0	8.0	17.0	1.0	45.0
	2019	81.0	45.0	9.0	49.0	9.0	7.0	15.0	12.0	15.0
	Normal*	63.2	49.4	44.0	39.0	46.0	55.0	45.0	45.0	40.0
CP 2	2017	15.0	43.0	24.0	15.0	41.0	28.0	18.0	44.0	0.7
	2018	19.0	45.0	19.0	12.0	24.0	19.0	119.0	2.0	71.0
	2019	40.0	30.0	15.0	34.0	28.0	100.0	58.0	22.0	21.0
	Normal	49.1	36.5	36.0	33.0	37.0	51.0	44.0	39.0	39.0
CP 3	2017	46.0	37.0	27.0	73.0	72.0	57.0	55.0	19.0	1.0
	2018	24.0	19.0	18.0	4.0	34.0	23.0	80.0	3.0	43.0
	2019	20.0	18.0	8.0	18.0	20.0	66.0	61.0	11.0	24.0
	Normal	46.6	37.6	42.0	39.0	47.0	69.0	53.0	48.0	37.0
CP 4	2017	47.0	29.0	34.0	10.0	49.0	54.0	44.0	32.0	4.0
	2018	43.0	24.0	31.0	7.0	40.0	25.0	52.0	12.0	43.0
	2019	49.0	28.0	10.0	35.0	48.0	77.0	40.0	22.0	31.0
	Normal	41.5	33.1	42.0	39.0	47.0	69.0	53.0	48.0	37.0
CP 5	2017	35.0	23.0	29.0	25.0	17.0	44.0	34.0	29.0	16.0
	2018	30.0	19.0	25.0	0.3	12.0	20.0	46.0	1.0	45.0
	2019	81.0	29.0	13.0	16.0	44.0	27.0	44.0	15.0	6.0
	Normal	51.0	42.0	39.0	38.0	43.0	48.0	41.0	47.0	40.0
average monthly temperature, °C										
CP 1	2017	3.6	4.5	8.9	9.7	15.7	21.5	24.8	17.7	22.9
	2018	4.6	5.4	7.4	14.5	16.6	23.4	25.3	27.7	21.9
	2019	4.9	4.9	7.7	11.3	17.1	25.9	24.0	26.0	21.2
	Normal	2.1	2.5	5.3	10.9	16.2	20.3	22.9	22.3	18.0
CP 2	2017	1.4	2.5	5.5	12.1	13.8	19.7	22.4	24.7	20.7
	2018	2.1	3.7	6.8	13.1	17.8	21.6	22.6	23.4	18.7
	2019	2.5	3.1	5.8	9.2	16.5	23.0	21.2	22.9	17.4
	Normal	0.7	1.5	4.1	10.4	15.4	19.3	21.8	21.2	16.9
CP 3	2017	-1.7	1.2	7.9	9.4	15.2	20.1	22.9	24.1	16.8
	2018	0.8	1.7	5.5	13.8	18.0	21.3	23.1	23.6	17.9
	2019	2.3	1.8	5.4	9.5	17.3	22.6	21.8	22.3	17.7
	Normal	-0.8	-0.5	3.2	10.0	14.9	18.5	22.3	20.2	15.2
CP 4	2017	0.8	2.7	5.6	10.8	13.0	19.4	21.5	23.8	21.0
	2018	1.0	3.1	6.1	12.7	17.7	21.1	23.1	22.7	18.6
	2019	1.5	1.8	5.8	8.7	16.5	22.5	21.4	22.2	17.0
	Normal	-0.8	-0.5	3.2	10.0	14.9	18.5	22.3	20.2	15.2
CP 5	2017	1.0	1.6	6.3	14.1	14.1	20.9	23.3	26.1	22.1
	2018	1.3	2.1	5.7	12.5	18.0	22.7	25.4	25.2	19.6
	2019	4.3	4.2	6.4	9.4	16.5	24.3	22.8	23.6	18.9
	Normal	-0.5	-0.3	2.6	9.0	14.6	18.9	21.7	21.3	16.6

Note: * average annual indicator over 20 years (Bagrova et al., 2001).

The climate of eastern part the Crimean foothill zone (Topolevka village, CP 2, Staryi Krym, CP 5) is moderately continental. The average annual temperature is 12.5 °C. The temperature of the coldest month (January) - +0.8 °C, and the warmest (August) -25.4 °C (Table 1). The maximum temperature in summer during the three years of the study is 34.4 °C (https://rp5.ru). The temperature regime in 2017 was characterized by increased indicators in winter and spring (1.2 to 2.1 °C above normal). In the summer, the indicators were at the level of the long-time average. In 2018, there was an excess of the average values from May to August by 1.5 to 2.6 °C. The warm period lasted, on average, 290 days, and the cold period lasted up to three months. The duration of the frost-free period, on average, was 190 to 200 days (https://rp5.ru). In 2019, in all months of research, an excess of the average long-term of the temperature regime by 0.7 to 5.4 °C was noted. The maximum excess was recorded in March (+3.8 °C to normal), June (+5.4 °C to the long-term average). In 2017, the average amount of precipitation in the summer period was slightly lower than the average annual values, creating good conditions for plant moisture supply (Table 1). The maximum amount of precipitation fell in June (54 mm with a norm of 68 mm). In 2018, there was an increased amount of precipitation in winter compared to the norm. However, in the phase of active fruit formation (March to August), this indicator was lower than the long-term average. The average annual precipitation was 360 to 440 mm. In 2019, the amount of precipitation was lower than the average long-term data, with the exception of January (81 mm at a rate of 51 mm in the Staryi Crimea) and June (77 mm at a rate of 69 mm in Topolevka). The climate of the Mountainous Crimea (Nauchny village, CP 3, Krasnoselovka, CP 4) is moderately continental. The amount of precipitation falling here increases, and temperatures decrease with increasing altitude of the area above sea level. The average annual air temperature is +11.7 °C. The temperature of the coldest month (January) is -1.7 °C, and the warmest (July) is 23.1 °C (Table 1). The maximum air temperature in the summer period 2017 to 2019, (July to August) - 37 to 40 °C. There was an excess of the norm during the entire growing season of plants by 1.3 to 5 °C (April, August). The warm period lasted 260 to 280 days, and the cold period lasted up to three months. The average duration of the frost-free period is 170 days.

In 2017, over the entire period of the study, precipitation was at the level or slightly lower than the long-time average annual (Table 1). In 2018, extremely dry conditions were noted, with the exception of July (80 mm with a norm of 53 mm in the village of Krasnoselovka and 119 mm with a norm of 44 mm in Nauchny village). In some months, the amount of precipitation was 1.5 to 3 times below normal. In 2019, the amount of precipitation fell significantly from the average long-term data. In June, the largest amount of precipitation fell - 100 mm at a rate of 51 mm in Nauchny village; in July in Krasnoselovka village by 8 mm, and in Nauchny village by 14 mm above the norm). The average annual precipitation was 360 to 520 mm.

The highest values for the weather indicators of the analyzed characteristics were noted in 2017. This is associated with the optimal temperature regime and sufficient precipitation during the flowering period, formation, and development of leaves and fruits. On the contrary, 2018 was characterized by arid conditions and high temperatures, which led to accelerated fruit maturation and shedding before the due date. In general, the analysis of data from two years of research showed minor differences in the main morphometric parameters, which is obviously due to the high adaptive properties of the

species. In 2019, the temperature and water regime were intermediate compared to the two previous years.

The vegetation period of the plants of the studied cornelian cherry coenopopulations began from the second decade of February, which was facilitated by the accumulation of average temperatures in the range of 5 to 12 °C for 5 to 7 days. Flowering lasted about 20 to 25 days, after which the formation of fruits began. Growth and development of plants, fruiting, and quality of fruits are influenced by the growing conditions, including the exposure of the slope, the terrain. It was noted that the Southern, South-Western and South-Eastern slopes are more favorable for the growth and development of plants and the early onset of all phenological phases of development and the intensity of fruiting.

Analysis of plants in the studied coenopopulations revealed differences in the metric and morphological characteristics of leaf and fruits.

The leaf is a soft organ that plays an important role in the study of morphometric indicators of plant variability. Providing many functions of the plant organism, it is exposed to external factors and adapts to them through long-term selection. Often within the same species there are leaf of the same shape, but significantly different in size, and vice versa - leaves of different shapes, but similar in size parameters. Such differences may be related to the peculiarities of plant ontogenesis (Klimenko, 2007). Analysis of the morphological characteristic of the cornelian cherry leaf in various coenopopulations revealed the following shape: oval, ovoid, and lanceolate with a wedge-shaped base and a pointed tip (Fig. 1).

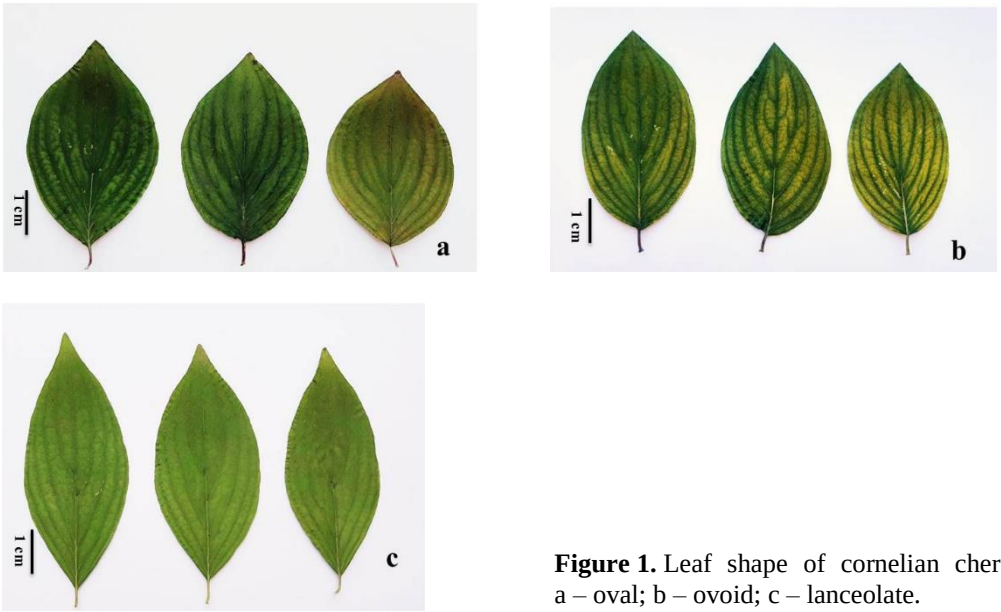

Figure 1. Leaf shape of cornelian cherry: a – oval; b – ovoid; c – lanceolate.

The average leaf length (L_{cp}) varied from 58.6 mm to 81.8 mm, and the width (B_{cp}) - from 23.4 mm to 47.4 mm (Table 2). The longest leaf is noted in CP 4 with an ovoid shape, and the smallest in CP 1, CP 3, and CP 5 with an oval shape. Lanceolate leaves in CP 2 and CP 4 had intermediate values for this parameter.

In terms of the leaf width, the smallest values are noted in CP 2 and CP 4 with a lanceolate shape, and the largest - in CP 4 with an ovoid shape. CP 1, CP 3, and CP 5 with an oval shape had intermediate values for this indicator. Analyzing the data obtained for 2017 to 2019, it should be noted that the maximum values of the length and width of the cornelian cherry leaf for all coenopopulations were in 2017, with the exception of CP 4, and the lowest values were in 2018. In CP 4 with a lanceolate leaf shape, the maximum values were recorded in 2019. The values of the coefficient of variation (Cv - from 3.5% to 19.7%) made it possible to conclude that the indices of the parameters of the cornelian cherry leaf over the entire period of the study are insignificant (Table 2). Although in literature there is little information about the shape diversity and metric parameters of cornelian cherry leaves, our data confirm the information previously provided by other authors (Ujukhu, 2006; Klimenko, 2007; Tigieva, 2007).

Table 2. Morphological and metric characteristics of cornelian cherry leaf in various coenopopulation

Coeno populations (Factor B)	Leaf shape	Year (Factor A)	Metric parameters of the leaf			
			length (L_{cp}), mm	Cv, %	width (B_{cp}), mm	Cv, %
CP 1	Oval	2017	67.5 ± 0.09	8.2	40.3 ± 0.12	17.1
		2018	60.2 ± 0.09	9.5	34.4 ± 0.06	10.8
		2019	64.8 ± 0.11	8.9	36.2 ± 0.07	11.3
		Average	63.9 ± 0.10	8.9	37.7 ± 0.08	13.1
CP 2	Lanceolate	2017	79.8 ± 0.16	12.1	29.6 ± 0.05	10.8
		2018	72.6 ± 0.08	6.3	23.4 ± 0.02	4.7
		2019	76.8 ± 0.08	5.9	26.2 ± 0.02	4.2
		Average	76.2 ± 0.11	8.1	26.5 ± 0.03	19.7
CP 3	Oval	2017	64.6 ± 0.06	5.8	36.2 ± 0.04	6.7
		2018	58.6 ± 0.07	7.7	29.4 ± 0.03	5.1
		2019	60.3 ± 0.07	7.3	36.2 ± 0.05	8.1
		Average	61.6 ± 0.07	6.9	32.8 ± 0.04	6.6
CP 4	Ovoid	2017	81.8 ± 0.08	5.6	47.4 ± 0.02	3.0
		2018	76.3 ± 0.08	5.7	39.8 ± 0.10	13.5
		2019	75.4 ± 0.08	6.0	43.3 ± 0.06	8.1
		Average	79.1 ± 0.08	5.8	43.6 ± 0.06	8.2
	Lanceolate	2017	75.4 ± 0.12	8.9	28.9 ± 0.12	15.4
		2018	70.5 ± 0.05	3.5	24.6 ± 0.05	7.2
		2019	79.3 ± 0.06	4.5	35.1 ± 0.04	5.3
		Average	73.0 ± 0.08	5.6	29.5 ± 0.07	9.3
CP 5	Oval	2017	74.4 ± 0.06	4.6	38.7 ± 0.04	6.2
		2018	66.7 ± 0.06	5.5	31.8 ± 0.03	5.4
		2019	71.1 ± 0.06	4.5	44.0 ± 0.06	7.5
		Average	70.6 ± 0.06	4.9	35.2 ± 0.04	6.4
LSD_{05} (Factor A)			0.09		0.07	
LSD_{05} (Factor B)			0.14		0.10	

Cv – the coefficient of variation.

The data of two-way analysis of variance (ANOVA) showed that the greatest influence on the biometric parameters of leaf is exerted by genetic characteristics of

studied plants (factor A). The share of influence in terms of leaf length was 82.9%, and in width - 77.3%. The share of influence of factor B was insignificant and amounted to 10.20% in terms of leaf length and 12.30% in terms of leaf width (Table 3).

Table 3. Data of two-way analysis of variance of cornelian cherry leaf in various coenopopulations

Factor	SS	dF	MS	F	*p*-value	Shape of influence, %
Leaf length						
A	38.41	2	19.21	74.1	0.000000	10.2
B	313.27	5	62.65	241.7	0.000000	82.9
AB	10.04	10	1.00	3.9	0.000041	2.7
Error	15.86	612	0.26			4.2
Leaf width						
A	38.97	2	19.485	161.11	0.00	12.3
B	246.61	5	49.323	407.81	0.00	77.3
AB	21.31	10	2.132	17.63	0.00	6.7
Error	12.01	612	0.121			3.7

Fruits are an important generative structure in the plant body, so the study of their diversity by morphological and anatomical features gives an idea of the degree of intraspecific polymorphism in coenopopulations. Such research is also very relevant in connection with the search for desirable natural forms of cornelian cherry in order to create varieties with a high content of mesocarp (pulp) and a low percentage of endocarp.

The conducted research allowed to identify the diversity in shape, color, ripening period, and metric parameters of fruits in studied coenopopulation (Table 4).

Table 4. Morphological characteristics of cornelian cherry fruit in various coenopopulations

Coenopopulation	Form	Fruit color	Fruit shape	Ripening period
CP 1	1*	Bright-red – dark-red	Oval	Average
CP 2	1*	Bright-red – dark-red	Oval	Late
CP 3	3	Dark-red, almost black	Barrel-shaped	Early
CP 4	4 a	Red	Oval-cylindrical	Average
	4 b	Dark-red	Broad-pear	Late
CP 5	1*	Bright-red – dark-red	Oval	Average

Note: * plant shapes are distinguished by the morphological structure of fruits.

Fruits, in CP 1, 2, 5 are of oval shape with color from bright-red to dark-red, medium (August 20 - through September 10) and late ripening (September 10 through 25), are combined into a single Form 1 due to similar morphological and morphometric characteristics. In CP 3, growing in the area of the Sheitan-Kapu gorge, the plants had small fruits of a dark-red, almost black color, ripening early (August 5 through 20), barrel-shaped, separated into a distinct Form 3. In CP4 two distinct fruit shape forms were identified: Form 4a - with a oval-cylindrical shape, bright-red color, average ripening time (August 20 - through September 10) and Form 4b - with an broad-pear shape, dark-red color, late maturity (September 10 through 25) (Fig. 2). In CP 2, individuals with shrub and tree life forms were found, but the relationship between the shape of the fruit and their life form was not established.

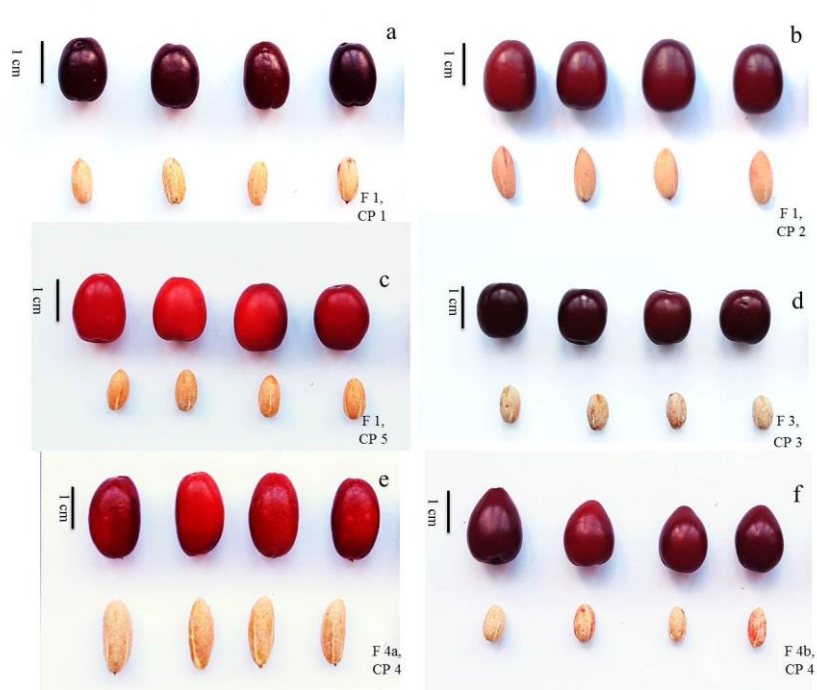

Figure 2. Fruit shape of cornelian cherry plants: a, b, c – oval (CP 1, CP 2, CP 5); d – barrel-shaped (CP 3); e – oval-cylindrical (CP 4); f – broad-pear (CP 4).

The shape and color variety of cornelian cherry fruits in native is noted by other authors. The color of the fruit varies from bright red to dark red, almost black, Most often, fruits are oval, spherical, barrel-shaped, cylindrical shape, less common are pear-shaped fruits. Fruit ripening was noted in July - September (Demir & Kalyoncu, 2003; Ujukhu, 2006; Klimenko, 2004, 2007; Tigieva, 2007; Prokaj et al., 2009; Mratinić et al., 2015; Dinda et al., 2016; Cornescu & Cosmulescu, 2017). As a result of selection, varieties with yellow and pink fruits were released (Klimenko, 2004, 2007; Cetkovská et al., 2015; Jaćimović et al., 2015; Cornescu & Cosmulescu, 2017; Popović et al., 2017; Adamenko et al., 2018).

As a result of studying the morphometric characteristics, it was found that fruits in various coenopopulations differed in length - from 12.1 mm to 17.2 mm, in diameter - from 8.0 mm to 12.8 mm, and in weight - from 0.56 g to 1.77 g. The greatest length and diameter were found in plants with oval-cylindrical fruits in CP 2 (Lcp = 17.2 mm, Bp = 12.8 mm), and the smallest - in plants with barrel-shaped fruits in CP 3 (Lcp = 12.1 mm, Bp = 8.0 mm).Fruits with the greatest weight are noted in CP 5, and with the smallest - in CP 3. The maximum values of the fruit diameter are noted in CP 4, the minimum - in CP 3. Endocarp length varied from 6.7 mm to 13.5 mm, diameter - from 3.1 mm to 5.1 mm, and weight - from 0.148 g to 0.267 g. The longest endocarp was noted in CP 5, and the shortest - in CP 3. High endocarp weigth was noted in CP 5, low - in CP 3. The share of endocarp to pulp varied from 10.75 to 26.28%. The maximal values for this indicator were in CP 3, the minimal - in CP 2 (Table 5).

Table 5. Morphometric characteristics of cornelian cherry fruit in various coenopopulations

Coeno populations (CP) (Factor B)	Form (F)	Year (Factor A)	Metric parameters ($X_{cp} \pm m_{cp}$)						Share of endocarp, %
			Fruit			Endocarp			
			Length (L_{cp}), mm	Diameter (D_{cp}), mm	Weight (m_{cp}), g	Length (L_{cp}), mm	Diameter (D_{cp}), mm	Weight (m_{cp}) , g	
CP 1	F 1	2017	16.2 ± 0.02	12.1 ± 0.01	1.74 ± 0.01	11.7 ± 0.02	5.0 ± 00.1	0.210 ± 0.003	12.07 ± 0.02
		2018	15.5 ± 0.02	11.2 ± 0.01	1.65 ± 0.02	10.1 ± 0.02	4.3 ± 0.01	0.197 ± 0.002	11.94 ± 0.02
		2019	16.0 ± 0.01	11.8 ± 0.01	1.70 ± 0.01	11.3 ± 0.01	4.6 ± 0.01	0.202 ± 0.002	11.88 ± 0.02
		Average	15.9 ± 0.02	11.7 ± 0.01	1.70 ± 0.01	11.03 ± 0.02	4.6 ± 0.01	0.203 ± 0.002	11.96 ± 0.02
CP 2	F 1	2017	17.7 ± 0.02	13.1 ± 0.01	1.67 ± 0.04	13.0 ± 0.03	4.0 ± 0.01	0.171 ± 0.004	10.24 ± 0.04
		2018	16.8 ± 0.01	12.5 ± 0.01	1.54 ± 0.03	12.2 ± 0.01	3.2 ± 0.01	0.178 ± 0.003	11.56 ± 0.03
		2019	17.0 ± 0.01	12.8 ± 0.01	1.71 ± 0.01	12.7 ± 0.01	3.5 ± 0.01	0.179 ± 0.003	10.46 ± 0.02
		Average	17.2 ± 0.01	12.8 ± 0.01	1.64 ± 0.03	12.6 ± 0.023	3.6 ± 0.01	0.159 ± 0.004	10.75 ± 0.02
CP 3	F 3	2017	12.5 ± 0.01	8.5 ± 0.01	0.60 ± 0.02	8.1 ± 0.01	4.9 ± 0.01	0.154 ± 0.003	25.67 ± 0.02
		2018	11.6 ± 0.02	7.9 ± 0.02	0.53 ± 0.02	7.7 ± 0.01	4.2 ± 0.01	0.148 ± 0.004	27.92 ± 0.02
		2019	12.2 ± 0.01	7.6 ± 0.01	0.57 ± 0.01	6.7 ± 0.02	4.1 ± 0.01	0.144 ± 0.002	25.26 ± 0.01
		Average	12.1 ± 0.01	8.0 ± 0.01	0.56 ± 0.01	7.5 ± 0.01	4.4 ± 0.01	0.148 ± 0.003	26.28 ± 0.02
CP 4	F 4a	2017	16.6 ± 0.01	11.1 ± 0.01	1.12 ± 0.02	13.2 ± 0.01	3.9 ± 0.01	0.213 ± 0.006	19.01 ± 0.01
		2018	15.6 ± 0.01	10.3 ± 0.01	1.03 ± 0.03	12.6 ± 0.02	3.1 ± 0.01	0.198 ± 0.002	19.22 ± 0.02
		2019	15.9 ± 0.01	10.9 ± 0.02	1.09 ± 0.01	12.9 ± 0.01	3.4 ± 0.01	0.191 ± 0.003	17.52 ± 0.01
		Average	16.0 ± 0.01	10.8 ± 0.01	1.08 ± 0.01	12.9 ± 0.01	3.5 ± 0.01	0.207 ± 0.005	18.58 ± 0.01
	F 4b	2017	15.9 ± 0.02	8.9 ± 0.02	0.79 ± 0.01	13.1 ± 0.02	3.8 ± 0.01	0.179 ± 0.004	22.65 ± 0.01
		2018	15.0 ± 0.02	7.9 ± 0.02	0.70 ± 0.01	12.5 ± 0.02	3.2 ± 0.01	0.171 ± 0.005	24.44 ± 0.01
		2019	15.4 ± 0.01	8.5 ± 0.01	0.76 ± 0.01	12.9 ± 0.01	3.7 ± 0.01	0.174 ± 0.002	22.89 ± 0.01
		Average	15.4 ± 0.02	8.4 ± 0.02	0.70 ± 0.02	12.8 ± 0.01	3.6 ± 0.01	0.175 ± 0.004	23.33 ± 0.01
CP 5	F 1	2017	16.9 ± 0.01	12.4 ± 0.01	1.81 ± 0.03	13.5 ± 0.02	5.1 ± 0.01	0.271 ± 0.003	14.97 ± 0.02
		2018	15.5 ± 0.01	11.6 ± 0.01	1.73 ± 0.03	12.6 ± 0.01	4.4 ± 0.01	0.260 ± 0.005	15.03 ± 0.02
		2019	16.2 ± 0.01	12.2 ± 0.01	1.77 ± 0.01	13.2 ± 0.01	5.0 ± 0.01	0.269 ± 0.003	15.19 ± 0.01
		Average	16.2 ± 0.3	12.1 ± 0.01	1.77 ± 0.02	13.1 ± 0.01	4.8 ± 0.01	0.267 ± 0.004	15.00 ± 0.02
LSD$_{05}$ (Factor A)			$F_f < F_{tabl}$	0.02	0.013	$Ff < F_{tabl}$	$Ff < F_{tabl}$	0.004	$Ff < F_{tabl}$
LSD$_{05}$ (Factor B)			$Ff < F_{tabl}$	0.02	0.023	$Ff < F_{tabl}$	$Ff < F_{tabl}$	0.005	$Ff < F_{tabl}$

Our data confirm the information previously provided by other authors about the phenotypic diversity of cornelian cherry fruit. Evaluation of cornelian cherry fruit, even in a small area studied coenopopulation of the Crimean Peninsula, revealed phenotypic diversity among accessions for all the characters studied. Similar level of variability and similar intervals of variation for fruit were found with different cornelian cherry growth in natural population in Serbia (Mratinić et al., 2015), Adydea (Ujukhu, 2006), Slovakia (Brindza et al., 2009), Romania (Cornescu & Cosmulescu, 2017), Hungary (Prokaj et al., 2009), Turkey (Demir & Kalyoncu, 2003; Ercisli et al., 2006), Iran (Hassanpour et al., 2012) (Table 6). According to the data of references, the majority cornel populations in other region have a fruit weight from 1.2 to 3.3 g, fruit length - from 15.0 to 22.0 mm, fruit diameter - from 9/0 to 15.0 mm. The lowest parameters of fruit weghts were found in natural population in Serbia, Adygea and Crimean Peninsula.

Table 6. Average metric parameters of cornelian cherry fruit in various region

Metric parameters	Region							
	Crimean Peninsula	Serbia	Adygea	Slovakia	Hungary	Romania	Turkey	Iran
Average fruit length (Lcp), mm	11.6–17.7	14.9–18.6	13.5–21.0	12.0–19.5	15.4–20.0	12.0–21.0	16.0–20.8	15.2–22.3
Average fruit diameter (Dcp), mm	7.6–13.1	10.7–12.8	8.0–15.0	7.4–15.2	10.4–14.7	9.0–12.0	10.9–16.4	10.3–16.3
Shape index, (Lcp/Dcp)	1.33–1.89	1.40–1.48	1.40–1.69	1.28–1.62	1.36–1.48	1.05–1.55	–	1.19–1.51
Average fruit weight, g	0.53–1.81	1.25–1.91	1.40–1.70	0.50–3.40	1.20–2.85	1.33–2.31	1.49–4.12	1.49–3.29
Average endocarp (stone) lengths (Lcp), mm	6.7–13.5	12.0–13.4	9.0–16.0	9.5–15.9	–	–	–	11.6–14.2
Average endocarp diameter (Dcp), mm	3.1–5.1	5.5–6.1	4.0–7.0	4.5–8.9	–	–	–	6.1–7.5
Average endocarp weight, g	0.144–0.271	–	0.155–0.210	–	0.270–0.410	0.340–0.590	–	0.249–0.425
Endocarp ratio, %	10.5–27.9	–	7.0–18.0	–	–	20.7–27.9	–	10.5–21.8
Mesocarp ratio, %	72.1–89.5	–	82.0–93.0	–	72.9–86.7	72.1–79.3	–	78.2–89.5

The analysis of the data obtained showed that the maximum values of the biometric parameters of the fruits were noted in 2017, the minimum - in 2018, and the 2019 values were intermediate. At the same time, low values of the coefficient of variation (Cv < 10%) were set for most parameters. Only for the endocarp diameter in almost all coenopopulations in all years of studied, the average values of the variation of the trait were established (Cv up to 17.3%) (Table 7).

The data of two-way analysis of variance showed that the greatest influence on the biometric parameters of fruits is exerted by the diversity form and genetic characteristics of studied plants (fruit length - 72.2%, fruit diameter - 81.8%, fruit weight - 96.4%, endocarp length - 80.2%, endocarp diameter - 70.1%, endocarp weight - 79.4%, $p < 0.00001$). The share of the influence of weather conditions of the year (factor A) was insignificant and amounted from 0.6% to 9.8% (Table 8).

Table 7. Coefficients of variation of morphometric parameters of cornelian cherry fruit in various coenopopulation

Coeno population (CP)	Form (F)	Year	Coefficient of variation (Cv), %					
			Fruit			Endocarp		
			Length (Lcp)	Diameter (Dcp)	Weight	Length (Lcp)	Diameter (Dcp)	Weight
CP 1	F 1	2017	7.4	5.8	4.6	9.5	16.0	5.0
		2018	7.8	8.0	7.3	7.9	10.0	5.3
		2019	4.4	6.8	2.9	6.3	10.9	4.9
		Average	6.5	6.7	4.9	7.9	12.3	5.1
CP 2	F 1	2017	5.1	6.2	3.0	11.5	14.7	5.9
		2018	12.5	5.6	10.4	5.7	15.6	6.7
		2019	4.8	3.1	4.7	5.5	14.8	5.9
		Average	7.5	5.0	6.0	7.6	15.0	6.2
CP 3	F 3	2017	7.2	5.9	15.2	8.8	14.6	6.7
		2018	10.3	11.4	10.4	7.9	17.1	7.1
		2019	4.9	6.6	7.0	13.4	12.2	7.6
		Average	7.5	7.8	10.8	10.0	14.6	7.1
CP 4	F 4a	2017	3.1	6.3	12.0	5.3	17.3	14.3
		2018	4.5	7.6	4.7	8.1	14.2	5.1
		2019	4.4	8.3	8.6	5.8	14.3	9.1
		Average	4.0	7.4	8.4	6.4	15.3	9.5
	F 4b	2017	5.7	11.1	6.3	8.1	13.2	13.4
		2018	7.1	13.8	5.4	8.1	15.2	5.9
		2019	4.5	5.9	7.8	8.5	10.8	5.8
		Average	5.8	10.3	6.5	8.2	13.1	8.4
CP 5	F 1	2017	4.7	6.5	3.7	8.1	14.0	5.9
		2018	3.6	5.9	3.5	4.6	11.3	11.6
		2019	4.9	7.7	3.2	3.1	8.9	7.8
		Average	4.4	6.7	3.5	5.3	11.4	8.4

Table 8. Data of two-way analysis of variance of cornelian cherry fruit in various coenopopulations

Factor	SS	dF	MS	F	*p*-value	Shape of influence, %
Fruit length						
A	0.86	2	0.434	52.5	0.000000	2.9
B	22.84	5	3.139	379.5	0.000000	79.2
AB	0.09	10	0.009	1.1	0.347701	0.3
Error	5.06	612	0.008			17.6
Fruit diameter						
A	0.56	2	0.2839	44.4	0.000000	2.2
B	20.34	5	4.0698	636.0	0.000000	81.8
AB	0.12	10	0.0124	1.9	0.037854	0.4
Error	3.91	612	0.0064			13.5
Fruit weight						
A	0.76	2	0.3822	55.3	0.000000	0.6
B	142.92	5	28.5843	4133.4	0.000000	96.4
AB	0.23	10	0.0237	3.4	0.000223	0.2
Error	4.23	612	0.0069			2.8

Table 8 (continued)

Endocarp length						
A	0.69	2	0.3460	42.0	0.000000	2.2
B	25.03	5	5.0074	608.3	0.000000	80.2
AB	0.48	10	0.0488	5.9	0.000000	1.6
Error	5.03	612	0.0082			16.0
Endocarp diameter						
A	0.44	2	0.2218	61.69	0.000000	9.8
B	1.80	5	0.3605	100.28	0.000000	70.1
AB	0.08	10	0.0084	2.34	0.010389	1.8
Error	2.20	612	0.0036			18.3
Endocarp weight						
A	0.007	2	000380	11.38	0.000014	6.5
B	0.852	5	017048	510.09	0.000000	79.4
AB	0.009	10	000091	2.72	0.002788	0.8
Error	0.204	612	000033			13.3

Plants with a largest fruits (an average weight from 1.65 g to 1.81 g) and a low endocarp ratio - from 10% to15% (Form 1 - CP I, CP 2, CP 5, Form 4a - CP 4) are interest for breeding research, since there is continued search for new forms with a high of contents mesocarp.

CONCLUSIONS

Studies conducted have shown that cornelian cherry on the territory of the Crimean Peninsula has a wide range of variability in a number of morphological features, which indicates a high form diversity of the species within its natural habitat. The greatest variety of cornelian cherry fruits was noted in the foothill zone and mountain zones, and our data confirm the information previously provided by other authors (Klimenko et al., 2003; Klimenko, 2004 and 2007) about the significant intraspecific diversity of cornel forms on the Crimean Peninsula.

The results of the test of differences in means using ANOVA tests indicates that the cornelian cherry plants differ significantly with respect to most metric characteristics in various coenopopulations. Analysis showed that the hydrothermal indicators of the year practically did not affect on the metric parameters of cornelian cherry plants. The genetic characteristics of plants within coenopopulations significantly influenced the studied biometric parameter.

The results have shown that there was a high diversity in cornelian cherry populations within different ecological areas of the Crimean Peninsula. For most of the studied morphometric parameters of leaves and fruits in 2017 to 2019, a low value of the coefficient of variation was revealed, which made it possible to conclude that these characteristics are not very variable. Differences were exhibited in terms of fruit size and shape. The results obtained can be useful for botanical research as additional information about this species, as well as in selection research when searching for natural forms of desirable characteristics for creating cultural varieties of cornelian cherry. The plants with largest fruits and the lowest proportion of endocarp in the total mass of the fruit can be recommended for further breeding research.

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