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MORPHOLOGICAL CHARACTERISTICS FOR FRUITS OF *ARONIA MITSCHURINII* A.K. SKVORTSOV & MAITUL.

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ABSTRACT

The aim of this study was to determine morphometric characteristics of fruits within some phenotypes of *Aronia mitschurinii* A.K. Skvortsov & Maitul. Their morphometric parameters were following: weight from 0.75 g (AM-03) to 1.52 g (AM-04), length from 9.46 mm (AM-03) to 12.73 mm (AM-04), diameter from 10.49 mm (AM-03) to 13.73 mm (AM-04), fruits number in the corymb from 11.33 (AM-07) to 20.13 (AM-03), cumulative weight of fruits in the corymb from 10.42 g (AM-07) to 21.73 g (AM-04), volume of fruits from 0.55 (AM-03) to 1.26 (AM-04) cm^3. The shape index of the fruits was found in the range of 0.87 (AR-01, AR-05, AR-07) to 0.93 (AM-02). The analysis of coefficient of variation showed the difference of variability in morphological characteristics between *Aronia mitschurinii* samples. Data showed that the most variability of important selection characteristics are the average cumulative mass of fruits in a corymb – from 12.34 (AM-03) to 38.61 (AM-02) % and fruit number of fruits in the corymb – from 14.56 (AM-03) to 36.88 (AM-02) %. The other characteristics are more or less stable. The introduction population of the *Aronia mitschurinii*, was created in the M.M. Gryshko National Botanical Garden in Kyiv, has a sufficient potential for successful selection work.

Keywords: *Aronia mitschurinii*; fruits; morphometric characteristics

INTRODUCTION

Nowadays, the conversance is given more and more to underutilized and unusual fruits plants as *Cornus mas* L. **(Brindza et al., 2007)**, *Sorbus domestica* L. **(Žiarovská and Poláčeková, 2012)**, *Cydonia oblonga* Mill., *Pseudocydonia sinensis* Schneid. **(Monka et al., 2014; Bystrická et al., 2017)**, *Ziziphus jujuba* Mill., *Castanea sativa* Mill. **(Grygorieva et al., 2014; 2017)**, *Morus nigra* L. **(Kucelova et al., 2016)**.

Aronia mitschurinii A. K.Skvortsov & Maitul. also has a great resource potential. This species is still sometimes not considered self consistent taxon, but is included in the *Aronia melanocarpa* (Michx.) Elliott, which was the wild ancestor of this species **(Skvortsov and Maitulina, 1982; Skvortsov et al., 2005; Vinogradova and Kuklina, 2014)**.

Meanwhile, North American *Aronia melanocarpa* is considered a low-quality ornamental shrub and thus is seldom cultivated, sometimes even exterminated as a weed by chemical applications. At the same time, the black-fruited aronia cultivated in Europe and considered to be *Aronia melanocarpa*, is well distinguished from its wild ancestors. It characterized by extremely low variability because of apomixes. In addition, mass of fruits from cultivated plants is 2 – 3 times as large as that of fruits originating from North American plants. In the North American wild plants, fruits are oval or slightly pyriform (pear-shaped), shiny, less juicy. In the cultivated aronia, they are globular, mostly somewhat depressed (at least at the apex), and always opaque, juicier than those wild-collected. There are differences in size and quantity of flowers: North American plants have fewer and smaller flowers than specimens of cultivated aronia. Reliable differences in the shape and size of leaf blades were also revealed. While North American aronia is only moderately hardy (Zone 4), aronia cultivated in the Europe is extremely hardy, so that it is possible to assign it to Zone 2 **(Skvortsov and Maitulina, 1982)**. Cultivated black-fruited aronia is capable of autonomous, spontaneous apomixes and is a tetraploid race 2n = 68 **(Skvortsov et al., 1983)**. On the contrary, in *Aronia melanocarpa* within its natural range (North Carolina), similar experiments (isolation, castration, and artificial pollination) did not yield any evidence of apomixis **(Hardin, 1973; Hall et al., 1978)**.

Since the cultivated aronia exhibits distinct differences from its wild ancestors, remains constant in its characteristics, and has acquired a very wide range across Northern Eurasia, it appears to be described as a new species *Aronia mitschurinii* **(Skvortsov and Maitulina, 1982)**.

Selection of chokeberry is conducted in Russia, Belarus, Finland, Poland, Sweden and the USA, sometimes with the involvement of other species (*Sorbus, Aronia, Crataegus*). In the USA, while the selection of fruit cultivars, the forms *Aronia mitschurinii*, obtained from Eastern Europe, are more often used **(Strik and Wrolstad, 2003)**. In the literature, there are data on several varieties of *Aronia mitschurinii*, but these cultivars are difficult to distinguish one from another according to morphological characteristics **(Leonard, 2011)**. Moreover, all these cultivars have a similar genotype **(Persson-Hovmalm et al., 2004)**. So we are talking about the only selective form, cultivated in different countries under different names. Artificial pollination of experimental plants does not lead to the production of hybrids and has no significance since the fruits develop by apomixes and are, as it were, clones of the mother plant. The following cultivars used for fruit production have been obtained from *Aronia mitschurinii*: Nero (Czech Republic), Ahonnen, De Belder, Hakkija, Rubina, Viking (Finland), Hugin (Sweden), Aron (Denmark), Chernookaja, Chernoplodnaja, Chernavka, Altaiskaja krupnoplodnaja (Russia), Venisa, Nadzeja (Belarus), Albigowa, Darbrowice, Egerta, Kutno, Nowa Wies, Galicjanka (Poland), Zerina (Germany), Fertődi (Hungary), Moskva (Norway) **(Vinogradova and Kuklina, 2014)**.

Nutritional supplements, syrup, juice, jellies, and tea were made from the fruits. The Aronia is also used for liqueur and spirit production and wines **(Ara, 2002)**.

The juice from fruits of Aronia has an antimutagenic activity **(Gasiorowski et al., 1997)**, gastroprotective effect **(Matsumoto et al., 2004)**, hepatoprotective activity **(Valcheva-Kuzmanova S.V., Belcheva, 2006)**, anticancer activity **(Sharif et al., 2012)**, cardioprotective and antidiabetes effect **(Kulling and Rawel, 2008; Denev et al., 2012)**, anti-inflammatory effect **(Martin et al., 2014)**, antiatherogenic activity **(Daskalova et al., 2015)**.

Aronia mitschurinii have a very high content of polyphenols **(Mayer-Miebach et al., 2012; Bräunlich, 2013; Taheri, 2013)**, namely cyanidin anthocyanins, proanthocyanins, flavonols, chlorogenic acid and neochlorogenic acid **(Oszmiański and Wojdylo, 2005; Slimestad et al., 2005; Koponen et al., 2007)**.

Scientific hypothesis

The aim of this study was to distinguish the best phenotypes from our collections of Aronia mitschurinii, which could be successfully grown on plantations. The high variability of the artificial introduction population will contribute to successful results of directed selection work with this fruit plant in the future.

MATERIAL AND METHODOLOGY

Locating trees and data collection

The objects of the research were 10-year-old plants of *Aronia mitschurinii*, which are growing in the Forest-Steppe of Ukraine in M.M. Gryshko National Botanical Garden of NAS of Ukraine (NBG). They are well adapted to the climatic and soil conditions. Observations on the collection's forms of *Aronia mitschurinii* in the period 2015-2016 were performed during mass fruiting. We have described 7 phenotypes of *Aronia mitschurinii*.

Morphometric characteristics

Pomological characteristics were conducted with four replications on a total 30 fruits and 30 corymb per phenotypes. In the study only one plant (tree) used for per phenotype.

The following measurements were taken: fruit weight, in g, fruit length, in mm, fruit width, in mm, fruit volume, in cm^3 (calculated according formula of ellipsoid 4\3 πabc where a, b, c are semiaxises of fruits), number of fruits in the corymb, corymb weight, in g. Data, we are working with, were tested for normal distribution.

Statistical analyses

Basic statistical analyses were performed using PAST 2.17; hierarchical cluster analyses of similarity between phenotypes were computed on the basis of the Bray-Curtis similarity index; multi-dimensional scaling (MDS) analyses were performed in PRIMER **(Clarke and Gorley, 2006)**. Variability of all these parameters was evaluated using descriptive statistics. Level of variability determined by **Stehlíková (1998)**.

RESULTS AND DISCUSSION

The images of Aronia mitschurinii fruits of various phenotypes are shown in Figure 1, 2.

Morphometric characteristics

The average weight of *Aronia mitschurinii* fruits of present study was in the range from 0.48 to 1.92 g (Table 1). The coefficient of variation was 26.50%, which shows a high degree of variability of fruit weight. According to **Khromov (2016)**, the fruit weight of cultivars such as Chernookaja, Venisa, Nadzeja was determined as 0.91 – 1.03 g and choice genotypes 1.13 – 1.24 g.

The average length of fruit in our analyses was determined in the range from 8.14 to 14.40 mm. The value of the coefficient of variation was 10.30%, which shows a medium level of variability of fruit length.

In our experiments, the average diameter of fruit was determined in the range from 8.67 to 15.44 mm. The variation coefficient (9.84%) confirmed the medium level of variability for this characteristic within the collection.

Figure 1 Variability in the shape of *Aronia mitschurinii* A.K. Skvortsov & Maitul. fruits.

Figure 2 Variability in the shape and number of fruits in the corymb of *Aronia mitschurinii* A.K. Skvortsov & Maitul.

Ochmian et al. (2012) have established a range of fruit's weight of cultivar Galicjanka from 12.9 to 16.4 mm, Hugin from 6.1 to 7.2 mm, Nero from 12.1 to 15.8 mm and Viking from 12.8 to 16.2.

The size of fruit will be better illustrated by using such characteristic as a volume of fruit. The average volume of *Aronia mitschurinii* fruits in the present study was in the range from 0.32 to 1.61 cm^3. The coefficient of variation was 28.70%, which shows a very high level of fruit's volume variability.

An average number of fruits in the corymb was identified in range from 6 to 36. Coefficient of variation was 32.16%, which shows a very high degree of variability.

The average number of fruits in the corymb was determined in a range of cultivar 13 – 14 and choice genotype from 12 – 20 by **Khromov (2016)**.

The average cumulative mass of fruits in a corymb was determined in the range from 6.10 to 47.12 g. The coefficient of variation was 36.42%, which shows a very high degree of variability of corymb weight. According to **Khromov (2016)**, the same characteristic of corymb for cultivars was determined as 11.83 – 13.72 g and for choice genotypes – 13.80 – 24.80 g.

The shape of each object can be characterized by the shape index, i.e. the length to width ratio. Figure 3 represents the shape indexes of fruits. The shape index of the fruits was found in the range from 0.87 (AM-01, AM-05, AM-07) to 0.93 (AM-02). These parameters can be used for the identification of different phenotypes and genotypes (at a later stage).

The analysis of coefficient of variation showed the difference of variability of morphological signs between *Aronia mitschurinii* samples. Data showed that the most variability of important selection characteristics are the average cumulative mass of fruits in a corymb – from 12.34 (AM-03) to 38.61 (AM-02) % and fruit number of fruits in the corymb – from 14.56 (AM-03) to 36.88 (AM-02) %. The other characteristics are more or less stable (Figure 3).

Table 1 The variability of some morphometric parameters of fruits for the whole collection of *Aronia mitschurinii* A.K. Skvortsov & Maitul. genotypes from Kyiv.

Characteristics	Unit	n	min	max	mean	CV%
Fruit weight	**g**	210	0.48	1.92	1.07	26.50
Fruit length	**mm**	210	8.14	14.4	10.94	10.30
Fruit diameter	**mm**	210	8.67	15.44	12.09	9.84
Fruit volume	**cm^3**	210	0.32	1.61	0.86	28.70
Number of fruits in the corymb		3370	6.0	36.0	16.04	32.16
Corymb weight	**g**	210	6.10	47.12	15.78	36.42

Note: n – number of measurements; min, max – minimal and maximal measured values; mean – arithmetic mean; CV – coefficient of variation (%).

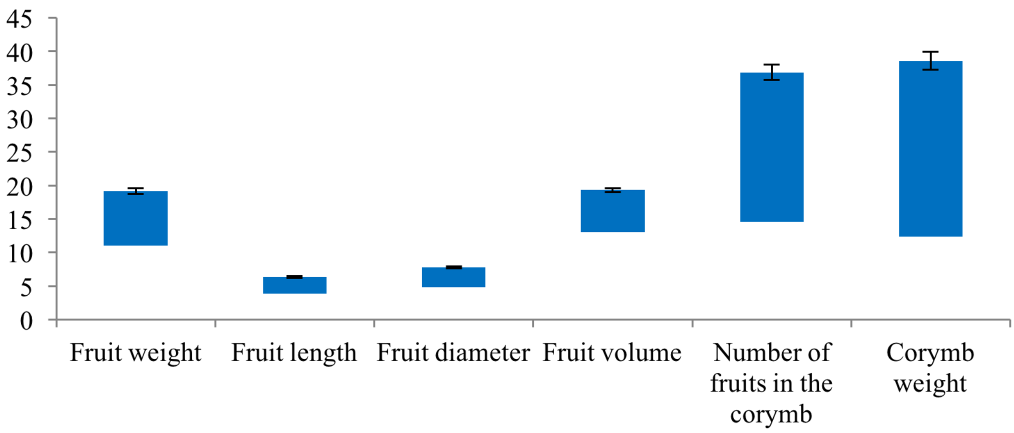

Figure 3 Variability level according to the minimum and maximum means of a coefficient of variation (CV) of every morphological character of fruit *Aronia mitschurinii* A. K. Skvortsov & Maitul. (%).

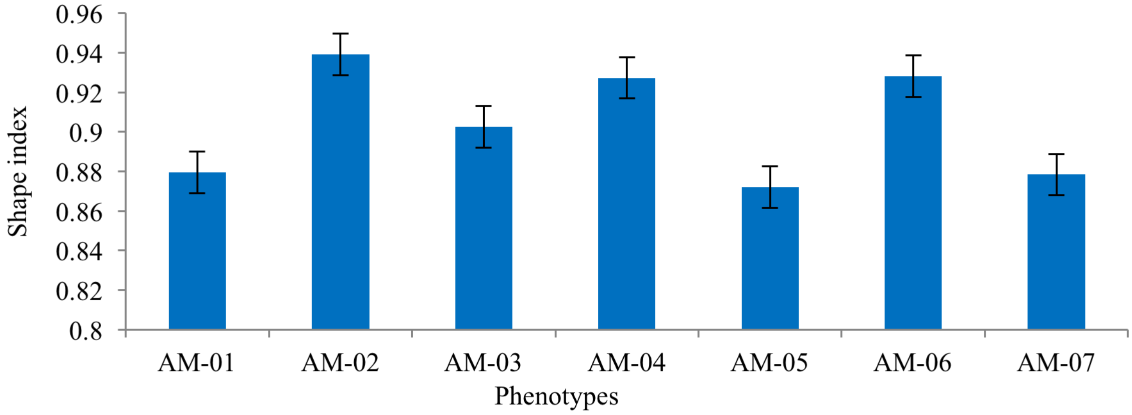

Figure 4 Comparison of the tested *Aronia mitschurinii* A. K. Skvortsov & Maitul phenotypes in the shape index of fruit.

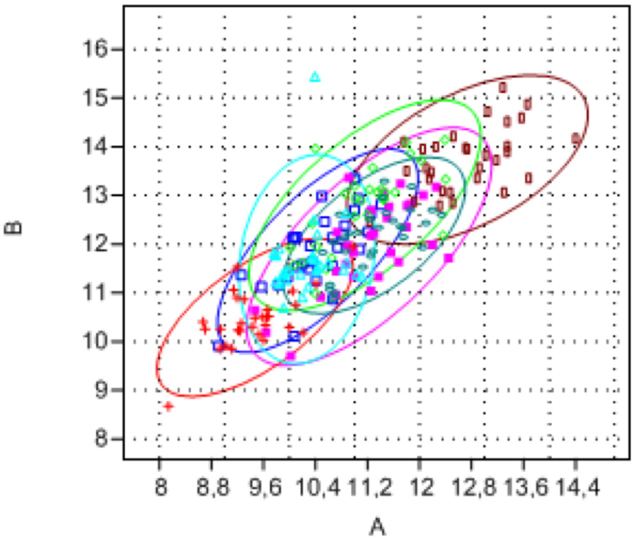

Figure 5 MDS plot of the similarity illustrating the length (A) and diameter (B) of fruits for studying samples of *Aronia mitschurinii* A. K. Skvortsov & Maitul.

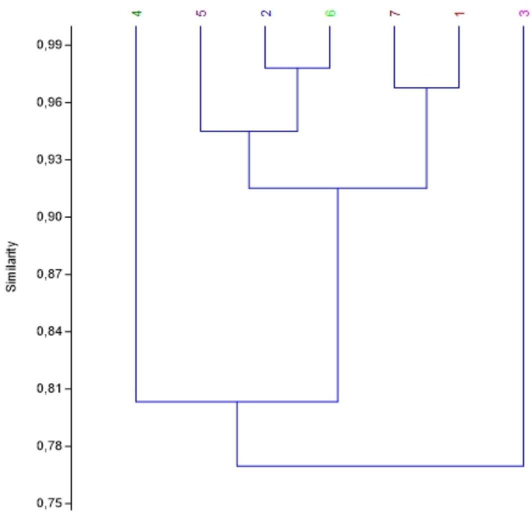

Figure 6 Cluster dendrogram of studying phenotypes of *Aronia mitschurinii* A.K. Skvortsov & Maitul.

Results of multi-dimensional scaling are shown in Figures 4. In Figure, it is possible to see the visual distribution the size of the fruits of the studied phenotypes. The sample AM-03 (red ellipse) with the smallest fruit size and the sample AM-04 (brown ellipse) with the largest fruit size differ each another with the probability of 95% (the ellipses in the figure do not overlap). Differences in fruit size for other samples are not reliable.

Based on the cluster analysis of all 6 studied fruit's characteristics, a dendrogram for the phenotypes of Aronia was made (Figure 5). On the dendrogram (Figure 6), you can see that the sample AM-03 is really separated from the other samples. It is distinguished not only by the smallest fruits but also by reddish branches of the corymb.

This sample is probably a unique genotype and can be used in the future for the selection of decorative forms of Aronia. A sample AM-04 with the largest fruits is separated almost immediately, too. This sample also represents perhaps a particular genotype (this hypothesis will be tested later by molecular genetic methods). Samples 1 – 2 and 5 – 7 do not differ significantly from each other and, apparently, represent an integrated cluster.

This is a very high indicator for this species, given into consideration its apomixis and the presence of only one genotype on the cultural plantations of Europe and America **(Persson-Hovmalm et al., 2004)**. According to **Skvortsov et al. (2008)**, for successful selection work, it is necessary at the first stage to create a wide variable introduction population that is resistant to the environmental and climatic conditions of the region. At the second stage, it is necessary to get rid of extremely undesirable phenotypes (for example, individuals with very small or bitter fruits). And only in the third stage, after free or controlled pollination in the introduction population, new sortotypes can be selected. The multiplication of new sortotypes and the creation of cultivars is the final stage of selection. The cultivars were created by this method are not as "beautiful" as those obtained with traditional artificial pollination, but can bear fruit every year and are resistant to unfavorable conditions.

CONCLUSION

The results of the experiment, which presented in this work, are consistent with the results reported earlier. Selection potential of chokeberry in the M.M. Gryshko National Botanical Garden is quite high, and our data demonstrate the presence at least 2 or 3 genotypes of Aronia mitschurinii in the collection. Their morphometric parameters were following: the weight from 0.75 to 1.52 g, the length from 9.46 to 12.73 mm, the diameter from 10.49 to 13.73 mm, the fruits number in the corymb from 11.33 to 20.13, the cumulative weight of fruits in the corymb from 10.42 to 21.73 g, the volume of fruits from 0.55 to 1.26 cm^3. The shape index of the fruits was found in the range of 0.87 to 0.93. The most variability of important selection characteristics are the average cumulative mass of fruits in a corymb – from 12.34 to 38.61% and fruit number of fruits in the corymb – from 14.56 to 36.88%.

The introduction population of the Aronia mitschurinii, was created in the Botanical Garden, has a sufficient potential for successful selection work.

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