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RESEARCH ARTICLE

Morphological characteristics of best Cornelian cherry (*Cornus mas* L.) genotypes selected in Serbia

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Abstract On the territory of Serbia, the Cornelian cherry (*Cornus mas* L.) populations grow at different locations and on a variety of geological substrates and they represent a large and important genetic potential for use in breeding programs of this fruit species. Collection and study of Cornelian cherry genotypes, introduction of best selections in commercial production, and preservation of genetic variability are activities that could improve the existing fruit gene pool. In the Vojvodina Province, over 200 Cornelian cherry genotypes have been monitored at all stages of growth and development. Large variability has been observed in all morphological and chemical characteristics under study. This paper deals with 10 Cornelian cherry genotypes, which showed best morphological characteristics in a three-year study (2007–2009), which will be used for the development of standard Cornelian cherry varieties in Serbia.

Keywords *Cornus mas* L. · Germplasm · Genetic resources · Selection · Morphometric characteristics

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Introduction

Preservation of germplasm of the less extensively used fruit species that can be grown in European countries deserves more attention than it has received so far, because the cultivation of these fruits gains increasing importance. Most wild fruits can be consumed fresh or processed. However, although rich in nutrients, these fruit species have been almost completely neglected. Conversely, in some countries, emphasis has been placed on wild fruit species for many years. In recent years, increasing attention has been paid to the study and preservation of plant resources and the selection of genotypes of wild fruit species from natural populations (Padulosi 2000). The Cornelian cherry is one of these less represented but nevertheless interesting fruit species. In the family Cornaceae, the genus *Cornus* includes about 50 species of shrubs and trees, most of which is used for decorative purposes. Only a few species of this genus produce useful fruits. Among these, the most important is the Cornelian cherry (*Cornus mas* L.), which is also suitable for use as a horticultural species on account of a great abundance of flowers and rich foliage, and it produces interesting effects in parks and gardens. The area of distribution of the Cornelian cherry includes central and southeastern Europe and southwestern Asia. The Cornelian cherry is a wild bushy plant or a short tree, 7–8 m in height. In Serbia, it grows mainly as a companion tree in hornbeam and oak forests. It is also found on hills

slopes, in forest clearings and in thickets. Significant populations of this species can be found in the Vojvodina Province, on Fruška Gora, Kopaonik, Stara Planina, Zlatibor and Zlatar mountains. In our country, individual Cornelian cherry tree can be found in gardens and yards, but there are no plantations or cultivated forms, except for the two selections that have been developed at our Department in the course of the 1990s (Korać et al. 1996), but these are still at the stages of large-scale multiplication and introduction.

Cornelian cherry selection has become an important part of breeding programs in various parts of the world. Intensive Cornelian cherry selection from natural populations started back in the 1960s (Rudkovsky 1960, Imamaliev 1977). Until recently, the Cornelian cherry has been considered basically as a wild medicinal and decorative species, but, after the great importance of the Cornelian cherry as healthy food had been recognized in some countries, systematic work was started on the study of natural populations and the establishment of collections. Cornelian cherry breeding programs were started in Ukraine (Klimenko 2004), Slovakia (Brindza 2006), Turkey (Pirlak et al. 2003), Czech Republic, Bulgaria, Poland, Austria and, recently, in Serbia (Ninic-Todorovic et al. 2005, Bijelic et al. 2008a, b). Collection of varieties and selection of prospective Cornelian cherry genotypes represent a notable wealth in terms of biological and economic potentials, as well as a rich source of material for further selection and breeding (Klimenko 2004; Yalcinkaya and Kaska 1992). As the Cornelian cherry is an open-pollinated fruit species (Browicz 1986), which had been multiplied from seed for centuries, there has developed high genetic variability, which in itself is an important resource that could contribute to further improvement of Cornelian cherry varieties (Ercisli et al. 2008). Previous studies have shown the presence of a large phenotypic biodiversity among genotypes in natural populations, while it is known that the basic method of preserving germplasm resources is to maintain genetic diversity (Ercisli 2004a). In the process of fruit production, a standardized varietal production is an important aspect. It is therefore necessary to select genotypes with superior characteristics of the fruit and establish and maintain a standard production of such genotypes.

The Cornelian cherry fruits have a balanced chemical composition, primarily due to a favorable ratio between the dry matter content and total acids, which determines the fruit taste. Our previous studies on Cornelian cherry populations in Serbia (Bijelic et al. 2008a) indicate that this ratio was considerably higher than the values reported by other authors (Pirlak et al. 2003). Also, it has been noted that the domestic genotypes have a higher sugar content in the fruit (from 11% to 41%) (Bijelić et al. 2010), than the results provided by Brindza (2006) and Demir (2002). This characteristic contributes to a higher quality of fruits and it provides a definite taste, which are significant factors, both from the point of fresh consumption and processing. For these reasons, the Cornelian cherry meets high standards for use for medical purposes, the fruits have a unique taste and useful dietary properties, the species is winterhardy and tolerant to dry conditions, resistant to diseases and pests, and suitable for organic production (Bijelić 2008). Furthermore, the Cornelian cherry is a plant species with traditional significance (Pieroni 2008), because its cherries are not only an edible fruit but are also used, fresh or processed, to mark important dates in the family, attributing to the fruits a large sociological and cultural importance among common people.

When a decision was brought to intensify the Cornelian cherry breeding program at the Department of Pomology, Viticulture, Horticulture and Landscape Architecture (Bijelić et al. 2008a, Bijelić et al. 2009), the first step was to identify most promising genotypes from natural populations, non-commercial orchards, yards and home gardens. The identification was based on morphometric characteristics of the fruit, yield, time of blooming and ripening, chemical properties of the fruit and a number of other characteristics. This paper describes 10 best Cornelian cherry genotypes selected on the territory of the Vojvodina Province on the basis of morphometric characteristics of the fruit assessed in the period 2007–2009. The next step in the breeding program is the establishment of a Cornelian cherry collection, which will be the first facility of that kind in our region, as well as a rich source of valuable material for further selection. The final step will be the selection and introduction of standard varieties of Cornelian cherry into full-scale commercial production.

Materials and methods

To determine the economic importance of the Cornelian cherry populations which are widely distributed across the Vojvodina Province and in the region of Mačva, in natural populations, non-commercial orchards and home gardens, over 200 genotypes had been selected and included into an evaluation program. The objective of the program was to identify best genotypes in the experimental set. Based on the age of trees, yield, flowering and ripening times, duration of individual phenophases of growth and development, and morphometric characteristics of the fruit, we selected 66 genotypes in the second year of study. In the third year, based on the above parameters, we selected 10 best genotypes, whose morphological characteristics of the fruit are presented in this paper (Fig. 1). All genotypes, except for the selection Bačka, were selected from the natural population or secondary populations from Serbia. Presently they are cultivated in a recently established *ex situ* collection in our nursery in Novi Sad. New genotypes, considered prospective for further breeding work, will be added to the collection each year.

This paper reviews morphometric characteristics (fruit length, fruit width, fruit weight, stone weight, mesocarp weight, fruit shape index and flesh to stone ratio) of the ten genotypes that were found to be superior in comparison with the other tested genotypes. The genotypes have not been described in accordance with any standard list of descriptors, such as UPOV and IPGRI descriptors which are used for most fruit types, because the Cornelian cherry as a species does not fit any of the existing descriptor lists. The available literature indicates that such descriptors are being prepared with maximum haste (Brindza et al. 2005), and their introduction will be of great importance for the determination and description of the existing and future Cornelian cherry cultivars.

Fruits of the selected genotypes were picked at the stage of full maturity, in the course of 3 years (2007–2009). Samples that contained 50 fruits per genotype, in three replications, were then subjected to morphometric measurements of the above fruit characteristics. Measurements were done by means of precision analytical scales and digital micrometer calipers. Fruit shape index was calculated as a ratio of squared fruit length to width. Flesh to stone ratio was interpreted as a share of the mesocarp compared with fruit weight, expressed in percentage.

The obtained data were processed by a factorial analysis of variance (ANOVA) using the statistical program STATISTICA 9.1 (StatSoft Inc 2010). Significance of mean differences among the characteristics was tested by Duncan's multiple range test for the significance level of 0.01%. Results are presented in

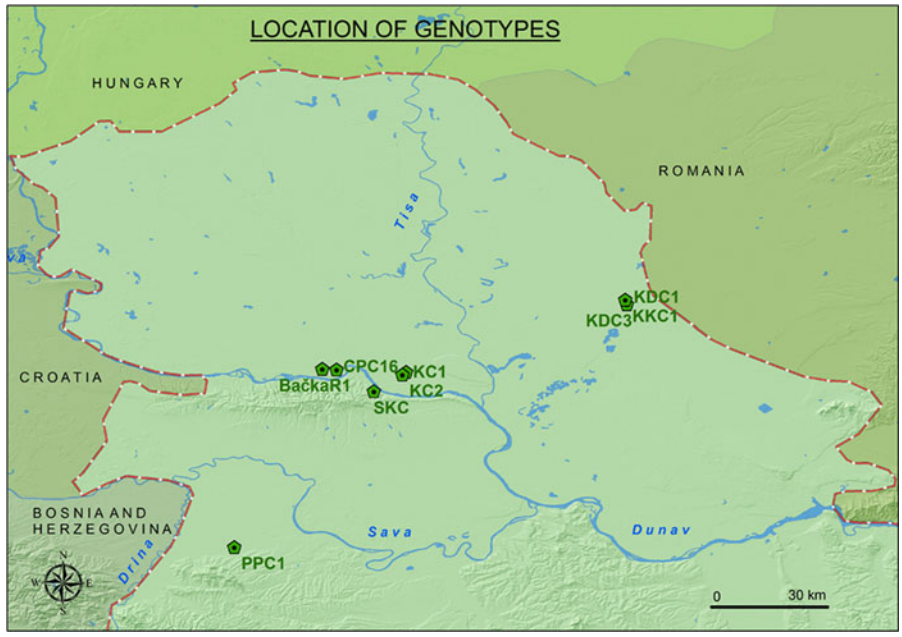

Fig. 1 Location of the genotypes

tables providing average value for each of the characteristics examined during the three-year test period. To determine the variability of the characteristics, coefficient of variation (CV) was calculated for each of them, as the most reliable indicator of relative dispersion of data.

Table 1 Average values of fruit characteristics of Cornelian cherry genotypes selected in Serbia in the period 2007–2009

Genotype	Fruit length (mm)	Fruit width (mm)	Index	Fruit weight (g)	Stone weight (g)	Flesh/stone ratio (%)
CPC16	18.88 H	17.38 B	1.18 H	3.91 CD	0.54 F	86.22 C
KC1	21.74 E	16.43 C	1.75 F	3.84 D	0.61 D	84.05 F
KC2	21.59 EF	16.01 D	1.84 E	3.69 E	0.55 F	84.92 E
SKC	23.66 C	15.48 E	2.35 A	3.98 CD	0.82 A	79.32 H
Bačka	22.22 D	16.51 C	1.82 EF	4.09 C	0.72 C	82.36 G
R1	25.07 B	16.76 C	2.25 B	4.51 B	0.55 F	87.73 B
PPC1	27.89 A	19.02 A	2.17 C	6.64 A	0.76 B	88.55 A
KDC1	20.20 G	15.27 E	1.76 EF	4.02 CD	0.58 E	85.62 D
KDC3	18.79 H	15.22 E	1.53 G	3.42 G	0.47 G	86.18 C
KKC1	21.19 FG	15.18 E	1.95 D	3.57 F	0.49 G	86.12 C

Values in the same column with different letters are significantly different at $P < 0.01$

Fig. 2 Variability of the fruit in the Cornelian cherry genotypes examined in Serbia in the period 2007–2009

Results and discussions

The main objectives in the first phase of the breeding program were to improve yield and fruit characteristics such as size, shape, color, taste. All of the examined morphometric characteristics of the fruit (Table 1) showed that significant differences existed in these parameters among the genotypes (Fig. 2).

The genotype PPC1 had significantly longest (27.89 mm) and widest fruits (2.19 mm). Lowest values were recorded in the genotypes CPC16 and KC2 (18.88 and 16.01 mm, respectively). At the same time, the genotype CPC16 had the most round fruit, or the lowest shape index value for all 3 years (1.18). Fruit shape, on average for the study period, was given as fruit shape index. The highest fruit shape index, i.e., the longest fruit, was found in the genotype SKC (2.35). There was no significant difference in the index value between the genotypes with round fruits (Bačka, KDC1 and KC1). An important objective in Cornelian cherry breeding is bigger and more attractive fruit. The average fruit weight of the tested Cornelian cherry genotypes ranged from 3.42 g (KDC3)–6.64 g (PPC1), although significantly higher maximum and lower minimum values of fruit weight were recorded during the measurements. The Cornelian cherry genotypes selected in Turkey had larger or smaller values of fruit length and width compared with our results, the actual values depending on the experiment region (Ercisli 2004b). The stone weight, on average, ranged in an interval from 0.47 g (KDC3)–0.82 g (SKC). Cornelian cherry selection should be primarily focused on fruit weight increase, as a characteristic that has the highest direct correlation with mesocarp weight (Bijelić et al. 2007). The ratio ranged in an interval from 79.32 (SKC)–88.55% (PPC1), although, during measurements, individual fruits were found to have higher or lower values. Generally, all Cornelian cherry genotypes from the Vojvodina Province, except for SKC, had very high flesh to stone ratio, which is a major indicator of economic value of the genotype and a main objective in Cornelian cherry selection. These results are consistent with data of other authors, both for selected genotypes and recognized varieties of the Cornelian cherry (Ercisli 2004a, Yalcinkaya et al. 1999, Klimenko 2004, Yilmaz et al. 2009). On average for all three test years, the genotype PPC1 (Fig. 3) stands out

Fig. 3 Biggest fruits recorded in genotype PPC1

regarding the tested characteristics. It had the greatest fruit length (27.89 mm), fruit width (19.02 mm), fruit weight (6.64 g) and flesh to stone ratio (88.55%). This, however, does not diminish the importance of the other tested genotypes as important selection potential in further testing and multiplication and introduction in production, both in intensive commercial plantations and home gardens.

The average variability of the fruit characteristics measured in the period 2007–2009 is given in Table 2, being expressed through the coefficient of variation as a best indicator of the relative data dispersion. The highest variability was found for fruit weight (CV = 19.12%) and stone weight (CV = 17.43%) in KC1, and then for fruit weight (CV = 17.27%) and shape index (CV = 15.80%) in KC2. The other genotypes did not show high variability of the measured characteristics over the three test years. Therefore, these characteristics are considered to be stable, which means that they are suitable for further selection.

Considering all tested genotypes, highest variability values were registered for fruit and stone weights,

Table 2 Average values of variation coefficient (%) for fruit morphometric characteristics of Cornelian cherry genotypes selected in Serbia in the period 2007–2009

Genotype	Fruit length	Fruit width	Index	Fruit weight	Stone weight	Flesh/stone ratio
CPC16	5.45	4.76	8.80	12.18	11.66	1.54
KC1	7.75	6.46	9.07	19.12	17.43	1.19
KC2	7.37	7.78	15.80	17.27	13.04	1.87
SKC	4.79	4.86	11.53	9.97	10.61	2.13
Bačka	4.18	4.49	8.71	10.84	11.69	1.71
R1	4.69	4.29	10.88	11.16	10.05	1.23
PPC1	6.78	5.66	14.21	13.51	12.33	1.37
KDC1	4.42	4.66	11.28	10.05	10.70	1.07
KDC3	5.13	6.06	8.95	13.39	13.10	1.57
KKC1	5.44	4.36	9.35	11.51	11.34	1.19

while the flesh to stone ratio was the most stable characteristic. Depending on region of growing, other authors too reported a high variability in morphometric characteristics of the Cornelian cherry genotypes they tested (Ercisli 2004b; Brindza 2006).

Conclusion

On the territory of Serbia, high variability has been observed in the morphometric characteristics of the fruit of different Cornelian cherry genotypes. The best among them, the genotypes presented in this paper, will be multiplied and planted in fruit collections for subsequent breeding work. The first Cornelian cherry collection in Serbia is currently in the process of being established in the nursery of the Faculty of Agriculture in Novi Sad. The nursery is located in the immediate vicinity of the city, at Rimski Šančevi. Presently, the collection includes 33 genotypes and several selections that are in the experimental stage. To successfully continue the Cornelian cherry breeding program it is necessary to preserve the available genetic material, which will play a crucial role in the development of productive varieties, fully adapted to the needs of commercial growers and amateur gardeners.

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