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BIODIVERSITY OF WILD FRUIT SPECIES OF SERBIA

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Several field collecting trips in the 2009-2011 period confirmed that forest fruit species are an inexhaustible genofond of extremely important varieties that yield fruit of excellent quality and high nutritive value, with wide range of applications, including nutritional, medicinal and food production. The aim of this work was to develop long term interactive and integrated strategy for selection of wild fruit species through different breeding methods, as well as popularization of selected products and their integration into intensive fruit growing. The most important morphological, ecological, and biological characteristics were studied and presented for

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Cornus mas, *Sambucus nigra*, *Morus sp.* and *Rosa sp.* For each studied fruit species, advanced selections for cultivar release has been reported.

Key words: breeding , *Cornus mas*, *Morus sp.*, *Rosa sp.*, *Sambucus nigra*.

INTRODUCTION

Owing to the unique diversity, the Balkan Peninsula could be considered a secondary center of genetic diversity for several species, such as *Malus × domestica*, *Malus sylvestris*, *Pyrus communis*, *Prunus cerasifera*, *Prunus persica*, *Prunus mahaleb*, *Prunus armeniaca*, *Prunus fruticosa*, *Prunus amygdalus*, *Prunus nana*, *Morus sp.*, *Juglans regia*, *Corylus colurna*, *Corylus avellana*, *Castanea sativa*, *Fragaria vesca*, *Olea europaea*, *Cornus mas*, *Sambucus nigra*, *Sorbus sp.*, *Rosa sp.* (MRATINIĆ and KOJIĆ, 1998; OGNJANOV *et al.*, 2009). Of particular interest are wild fruit species, due to their excellent quality and high nutritive value fruit, used in the human diet, medicine and in industrial processing.

Cornelian cherry (*Cornus mas L.*) is a naturally grown fruit species in woody regions of Serbia (OGNJANOV and CEROVIĆ, 2003; BIJEIĆ *et al.*, 2008). It is a cross-pollinated species characterized by wide genetic diversity (NINIĆ-TODOROVIĆ *et al.*, 2005; BIJEIĆ *et al.*, 2011). Fruits are mainly dark red, cherry red or occasionally yellow (BIJEIĆ *et al.*, 2008). Cornelian cherry is easy to grow and tolerant of most soils, sites and diseases. Owing to its nutritional, medicinal and industrial applications, cornelian cherry is a good source of dye, oil, tannin and wood, cornelian cherry is a plant for a healthier future world (GOLOŠIN *et al.*, 2009a, 2009b).

Black elderberry (*Sambucus nigra L.*) is a high quality fruit crop grown on a small scale in USA and several European countries (CHRISTENSEN *et al.*, 2008). Historically, its processed fruit or flower had wide range of applications, both as medicine and food. However, it was also popular in crafts and ornamental gardening. MRATINIĆ and FOTIRIĆ (2007) recommended 5 selections from natural population of Serbia for growing in organic-based production.

In 18th century, in Serbia, mulberry trees were grown for their leaves as food for silkworms; however, presently, it is predominantly grown for its fruit. Three mulberry species, namely black (*Morus nigra*), red (*Morus rubra*) and white (*Morus alba*), are grown for fruit production (SHARMA *et al.*, 2000). Recently, wild edible plants have received much attention as sources of biologically active substances including antioxidants, antimutagens and anticarcinogens (ATMAKURI *et al.*, 2009).

The genus *Rosa* contains over 100 species that are widely distributed in Europe, Asia, the Middle East and North America. These deciduous shrubs are widely grown in gardens for their flowers and fruits. The native rose species are an extremely rich source of nutrients, in particular, phenolics, carbohydrates, ascorbic acid and some minerals (ERCISLI, 2007). However, the significant variation in their content and composition, could be useful for selection of relevant species or genotypes in future plant-breeding studies (DAVIS, 1997). In general, rose hips are

used in the food industry to obtain different products, such as tea, jam, jelly and marmalade.

The objective of the work presented here was to collect, evaluate, conserve and promote wild fruit germplasm of Serbia as a fruit plant for the future and make it available to breeding programs, fresh consumption and food industry.

MATERIALS AND METHODS

During the systematic exploration trips conducted over the three-year period, accessions were collected over wide areas of Serbia (Fig.1), whereby local collaborators pointed out valuable wild fruit species germplasm available under both natural and managed habitats. Some of these areas have extreme climatic conditions and are effectively isolated.

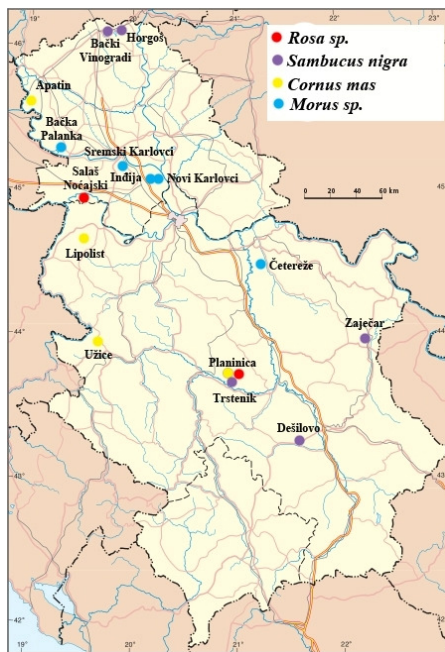


Figure 1. Exploration trip locations included in the selection of wild fruit species

All the accessions were evaluated and conserved *in situ*, *ex situ* and *in vitro*. The passport data were permanently determined with GPS method. Our germplasm collecting missions may be broadly categorized into species-specific or trait-specific, rather than broad-based or non-specific that relies on random sampling in order to collect maximum diversity of the species and relatives in a single trip. The evaluation and characterization of individual accessions was conducted based on following features: yield, fruit size, flesh/stone ratio, skin color, flesh color, dry

matter, taste and aroma. Special attention was paid to the disease resistance of selected accessions making them suitable for organic or integrated fruit production. Statistical analysis included Duncan multiple range tests. Results were processed using STATISTICA 10 software (StatSoft, Inc., Tulsa, OK, USA).

RESULTS AND DISCUSSION

An extensive field and laboratory characterization of the germplasm materials was undertaken on all important agro-morphological parameters.

Cornelian cherry (*Cornus mas L.*)

Average population fruit weight based on 8 selections, was 4.34 g, ranging from 1.52 to 14.55 g, of which, on average stone weighed 0.51 g. Fruit was of oblong shape, red to dark red in color, with total soluble solids up to 23.74%. All selections were late maturing with ripening season from August 17th to September 20th (Tab.1). Selected material represents a wealth of biological and economic potential, as well as a rich source of material for further breeding.

Table 1. Pomological characteristic of *Cornus mas* selections

Genotype	Ripening time	Weight (g)	Skin color	Flesh color	Dry matter (%)	Stone weight (g)
Loboderac	25. Aug	3.51 ^{b*}	Dark red	Red	17.52 ^b	0.58 ^a
VR 10	25. Aug	14.55 ^a	Red	Red	12.90 ^c	0.60 ^a
Srem	29. Aug	3.55 ^b	Red	Red	18.94 ^b	0.52 ^{ab}
D1	29. Aug	3.96 ^b	Red	Yellow	18.86 ^b	0.60 ^a
D2	26. Aug	4.10 ^b	Red	Yellow	17.34 ^b	0.54 ^{ab}
TS 5	20. Sep	1.52 ^c	Red	Red	19.26 ^b	0.45 ^{bc}
TS 3	30. Aug	1.56 ^c	Light red	Red	20.16 ^b	0.41 ^c
TS 1	17. Aug	1.94 ^c	Dark red	Pink	23.74 ^a	0.37 ^c

*Significance of differences was tested by Duncan multiple range test ($p < 0.01$).

Elderberry (*Sambucus nigra*)

The largest inflorescences were found in genotype ZLJ with maximum weight exceeding 350 g. Ripening period ranged from August 15th to 25th. Average inflorescence and 10 berries weighed 64.95 - 241.52 g and 1.11 - 7.72 g, respectively. Best fruit quality was observed in ZLJ due to highest content of colored matter, dark red colored juice, and 15.14% of dry matter (Tab.2). However, genotypes Z23 and Z24, selected from Horgoš, had better set of morphological traits compared to standard variety "Haschberg".

Table 2. Pomological characteristic of *Sambucus nigra* selections

Genotype	Ripening time	Inflorescence weight (g)	10 berry weight (g)	Juice color	10 seeds weight(g)	Dry matter (%)
Haschberg	25. Aug	121.32 ^{bc*}	1.77 ^{bc}	Dark red	0.12 ^a	12.84 ^c
ZBV	25. Aug	64.95 ^d	1.11 ^{cd}	Red	0.06 ^b	17.00 ^a
ZB	15. Aug	127.03 ^{bc}	1.72 ^{bc}	Dark pink	0.12 ^a	15.07 ^b
Z23	25. Aug	169.50 ^b	1.37 ^{cd}	Dark pink	0.07 ^b	14.85 ^b
Z24	25. Aug	134.95 ^{bc}	1.90 ^b	Dark pink	0.02 ^c	13.64 ^{bc}
ZP1	19. Aug	99.95 ^{cd}	1.21 ^d	Dark pink	0.06 ^b	14.87 ^{bc}
ZLJ	19. Aug	241.52 ^a	7.72 ^a	Dark red	0.09 ^{ab}	15.14 ^{bc}
ZB2	19. Aug	129.90 ^{bc}	1.19 ^d	Light red	0.05 ^{bc}	12.34 ^c
ZB3	19. Aug	75.56 ^{cd}	1.80 ^b	Dark red	0.09 ^{ab}	12.52 ^c

*Significance of differences was tested by Duncan multiple range test (p<0.01).

Mulberry (*Morus alba*)

Edible mulberry germplasm accessions from diverse regions of Serbia were identified and classified in three species *M. alba*, *M. nigra* and *M. rubra*, of which the majority belong to *M. alba*. More than 300 promising mulberry accessions were visited and preliminary tree and fruit characteristics were investigated, whereby considerable variation was observed for most of the traits. Fruit weight ranged from 1.40 g to 5.87 g with an average of 3.61 g, with smaller mean values associated with *M. rubra*, compared to those of *M. alba*. Soluble solids ranged from 11.72% to 24.56% with an average of 16.06%. Wide genetic variations were observed amongst

mulberry accessions, with fruit ranging from cream to dark color. *M. rubra* accession ripened at the same time as *M. alba*, with its ripening season extended by a month after the latest *M. alba* matured (Tab.3).

Table 3. Pomological characteristic of *Rosa sp.* selections

Genotype	Ripening time	Fruit shape	Weight (g)	Seed number	Seed weight (g)	Randman (%)
<i>R. canina</i> Inermis	10. Sep	Very elongate	2.48 ^{a*}	28 ^c	0.76 ^{abc}	69.35 ^a
<i>R. dumetorum</i> Laxa	15. Sep	Elongate	2.39 ^a	30 ^c	0.76 ^{abc}	68.20 ^a
<i>R. canina</i> Polmeriana	1. Oct	Cordate	2.62 ^a	40 ^a	0.98 ^a	62.60 ^a
ŠTS1	1. Sep	Elongate	2.12 ^{ab}	38 ^{ab}	0.82 ^{abc}	61.32 ^a
ŠD1	1. Sep	Elongate	1.72 ^b	31 ^{bc}	0.55 ^c	68.02 ^a
Š1 TS	1. Sep	Elongate	2.40 ^a	30 ^c	0.70 ^{bc}	70.83 ^a

*Significance of differences was tested by Duncan multiple range test (p<0.01).

Rosa sp.

The rose shrubs were examined with regard to the following fruit and plant properties: growth habit and branching, thorn-free branches, as well as hip size, color and shape. The pioneer rose hip orchard in Salaš Nočajski for commercial production was established in response to the initiative to develop intensive outdoor financially viable crop. *Rosa* “Laxa” and *Rosa* “Polmeriana” seedlings were selected as plant material due to very low thornless genotypes of the latter, vigorous enough for sufficient renewal of fruiting branches. It has sufficient commercial values to justify its release to growers as high quality rose hip cultivar (Tab. 4).

Public awareness of the importance of fruit genetic resources and wild fruit species through media, academic articles, numerous lectures for growers and general public was the key to mobilizing country-wide community support, whereby extensive network was developed. The expected benefits and outcomes were fulfilled: continuing scientific synergy and rapid dissemination of the pertinent information through collaboration of many extension specialists, graduate students, crop consultants and, most importantly, local growers met through crop, area/region and season specific collecting trips.

Pre-exploration review focused on gathering prior knowledge of the topography, eco-habitats and species occurring as semi-cultivated, semi-wild or wild, as well as associated species in the area and specific diversity to look for. In addition, the terrain accessibility, information on previous surveys and collecting trips made in the area and their results, as well as established local contacts/networks, was also sought. The nature of species diversity and its spatial occurrence was mapped, followed by the implementation of method of individual selection from local natural populations. Applied selection strategy resulted in tremendous progress in genetic gain and diversity, such as VR10 and Loboderac in cornelian cherry, ZLJ, Z23 and Z24 in elderberry and MR1 and ŽP2 in mulberry. All collected accessions were regenerated and inventoried in order to be entered into the referent collection for future distinctiveness, uniformity and stability (DUS) tests. The collected fruits were dried or frozen and subsequently processed in traditional ways for further biochemical analysis of their nutritional and medicinal values. That part of research was enabled by the frequent interactions and discussions with the local villagers, who shared their knowledge on traditional uses of wild edible fruits.

Table 4. Pomological characteristic of *Morus sp.* selections

Genotype	Ripening time	Fruit color	Weight (g)	Dry matter (%)
PB1	15. June	Dark purple	5.00 ^{ab*}	14.48 ^{cde}
DT1	10. June	Black	1.40 ^d	19.08 ^b
MG 1	12. June	Pink-purple	3.73 ^{bc}	16.66 ^{bc}
ŽD 1	10. June	Multicolor	2.90 ^c	24.56 ^a
JP 2	10. June	Black	1.87 ^d	16.08 ^{bc}
MR 1	15. June	Pink-purple	5.05 ^{ab}	19.68 ^b
DJ 1	12. June	White	5.85 ^a	15.12 ^{cd}
ŽP 1	12. June	White	5.87 ^a	13.40 ^{de}
ŽP 2	12. June	Multicolor	4.82 ^{ab}	13.10 ^{de}
ŽP 3	12. June	Black	1.87 ^d	13.20 ^{de}
BP 1/4	10. June	Black	3.87 ^{bc}	13.98 ^{cde}
BP 3/9	12. June	White	3.67 ^{bc}	16.92 ^{bc}
ŽP 1/5	12. June	White	3.08 ^{bcd}	19.64 ^b
PK	10. June	Black	2.62 ^{bc}	15.54 ^{cd}
MN 1	10. June	Black	2.95 ^{bc}	11.72 ^e
FR	10. June	Black	3.18 ^{bcd}	13.84 ^{cde}

*Significance of differences was tested by Duncan multiple range test ($p < 0.01$).

CONCLUSION

Forest ecosystems cover a vast territory in Serbia. Among the several hundred forest species, fruit species, of which there are over 100, attract special attention. The information generated from this study is another proof that The Balkan Peninsula is one of the world's richest and inexhaustible secondary centers of wild fruit species diversity. Our extensive work in identifying the areas most abundant in wild fruit species included subjecting several selections—VR10 and Loboderac in cornelian cherry; ZLJ, Z23 and Z24 in black elderberry; MR1 and ŽP2 in mulberry—to immediate in-depth research. The aim of this effort was to achieve advanced selection for cultivar release, based on specific pomological, agronomical, and biochemical traits, of particular interest in finding new sources for natural antioxidants, traditional utilization and processing as functional food that provides health and medical benefits.

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BIODIVERZITET SAMONIKLIH VOĆNIH VRSTA SRBIJE

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I z v o d

Oplemenjivački rad na očuvanju genetičkih resursa u periodu 2009-2011. potvrdio je da su šumske voćne vrste neiscrpan genofond koje daju plodove izuzetnog kvaliteta i visoke nutritivne vrednosti sa važnom ulogom u ljudskoj ishrani, i velikim mogućnostima prerade i primene u medicini. Cilj istraživanja je bio razvijanje dugoročnog multidisciplinarnog pristupa selekciji samoniklih voćnih vrsta kroz razne metode oplemenjivanja, kao i popularizacija izabranih selekcija i njihovo uvođenje u intenzivne zasade. Izučavane su najvažnije morfološke, ekološke i biološke karakteristike vrsta *Cornus mas*, *Sambucus nigra*, *Morus sp.* i *Rosa sp.* Kod svake izučavane voćne vrste izdvojena je jedna ili više perspektivnih selekcija kao potencijalno novih sorti samoniklih voćnih vrsta u Srbiji.

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