

SELECTION OF SOME AUTOCHTHONOUS PLUM CULTIVARS SEEDLING ROOTSTOCKS IN THE REGION OF NORTH MONTENEGRO

Gordana Šebek^{1*}

¹Biotechnical Faculty, University of Montenegro, Mihaila Lalića 1,
81000 Podgorica, Montenegro

*e-mail: sebek@t-com.me

Abstract

Plum is the major fruit species in the area of North Montenegro. Over a long period of growing in this region, autochthonous cultivars adapted, and have been achieving satisfactory results, despite poor growing conditions. A study conducted over a period of tree years in North Montenegro region included in situ identification of autochthonous plum cultivars. Observation and recording of their phenological and pomological traits were performed using IBPGR and UPOV methodologies.

Eighteen cultivars derived from *Prunus domestica* L. and two cultivars derived from *P. insititia* L. were identified. Flowering started between 26th March and 12th April and fruit ripening between 13th July (Petrovača) and 18th September (Trnovača). Fruit weight ranged from 6.65 ± 0.235 to 53.88 ± 0.654 g and stone weight from 0.16 ± 0.003 . The cultivars were classified as being extremely small in terms of fruit size, except for cultivars Crvena durgulja (small fruit size). Rounded fruit shape and light green ground color were dominant. Skin color ranged from amber to black. Yellow green was a dominant flesh color and medium flesh firmness predominated. The fruits of the above cultivars could be processed, particularly into plum brandy, or they could be used fresh or dried.

The selected plum cultivars can be used both in breeding programs and as rootstocks. The study was made to assess the performance of autochthonous plum cultivars seedlings as rootstocks. Selection process consisted of tree stages: a) initial selection from the population and pomological characterization, b) evaluation of seedling rootstocks, and c) evaluation of scions. The considerable genetic diversity was detected between seedling progenies of different autochthonous plum cultivars especially concerning rootstock vigor, branching and uniformity. Autochthonous plum cultivars rootstocks have significantly influenced tree size of Čačanska rodna plum, respectively, including plant height and stem diameter.

Key words: Fruit, genetic bases, germplasm, *Prunus domestica* L., *Prunus insititia* L.

1. Introduction

Požegača and number of cultivars used for brandy production predominate in the assortment. The Montenegro plum production is characterized by extensive growing technology, low unstable yields, low-quality fruit, PPV-induced problems and a multitude of cultivars. The cultivars include Požegača (35%), foreign standard and introduction newly bred cultivars (15%) and autochthonous (local, primitive) cultivars (50%), and their fruit is typically used for brandy production. Autochthonous plum cultivars are a limiting factor in improving plum production in Montenegro. Nevertheless, they are used as an outstanding source of germplasm and as a genetic basis underlying breeding activities, principally the development of new cultivars, clonal selection (Ogasanovic *et al.* [14], Djuric *et al.* [3] and Milosevic [11]), the development of new plum, apricot and peach rootstocks (Paunovic [15] and Djuric *et al.* [3]), resistance to economically important diseases (Paunovic and Paunovic [17] and Rodrigues *et al.* [19]) or intensive cultivation (Mratinic [13]). Similar investigations focusing on identical or similar objectives were also conducted in the other countries of the former Yugoslavia - Serbia (Milosevic [12]), Bosnia and Herzegovina (Jarebica and Muratović [7] and Buljko [1]), Croatia (Jelacic *et al.* [8]) and Slovenia (Usenik *et al.* [23]). In situ investigations of cultivars derived from *Prunus domestica* L. and *P. insititia* L. in Serbia were conducted by a number of researchers (Paunovic *et al.* [15], Paunovic, [16], Paunovic and Paunovic [17] and Petrovic *et al.*, [18]) who defined important biological, pomological and technological traits of both fruit and tree. They reported that the selected cultivars could be used as breeding programs and as rootstocks, as well as in further disease-related systematic studies under

field and laboratory conditions. The main objective of this study was to determine *in situ* basic biological and pomological traits of some autochthonous plum cultivars derived from *P. domestica* L. and *P. insititia* L. in the area of North Montenegro that could be used as a genetic basis and source of germplasm for future breeding studies.

2. Materials and Methods

Investigations were conducted continuously in years 2007, 2008 and 2009. They involved *in situ* identification, marking and careful observation of autochthonous plum cultivars (accessions) in the area of North Montenegro. Eighteen genotypes or cultivars, derived from *P. domestica* L., except for cultivars Trnovača and Turgulja originating from *P. insititia* L., were selected in Western Serbia [15]. The sampled trees were aged 35 (Plavski Piskavac) to 55 years (Turgulja). The trees of all the cultivars grew on their own roots.

The study focused on few segments. Very first one included recording of the phenological traits - first flowering, full flowering, end of flowering and harvest date. Phenological characteristics were determined as below: the beginning of flowering was recorded when at least 5% of the flowers bloomed; full flowering was accepted when at least 80% of the flowers bloomed, the end of flowering was determined when 90% of the flowers bloomed and corollas began to fall off, and harvest date was established when the fruits were sufficiently colored and soft to be eaten [5]. The other segment comprised pomological, i.e. physical [fruit weight (g), stone weight (g) and fruit size (on a scale of 1-9)] and sensorial traits of the fruit [fruit shape (1-6), ground color (1-5), skin color (0-9), flesh color (1-9), flesh firmness (1-9) and fruit usage (1-4)]. IBPGR and UPOV methodologies were used to describe the cultivars in phenological, pomological and sensorial terms (Zanetto *et al.* [21]). Measurements included the weight of 25 fruits and as much stones per cultivar. Fruit and stone weights were determined using a Metler 1200 technical scale (range of measurement 0.01-120.00 g, precision ± 0.01 g). Data were averaged over the tree growing seasons and then subjected to statistical analysis performed using the SAS (SAS Institute [22]). Seeds from 20 autochthonous plum cultivars (accessions) were planted in the nursery and raised seedlings were evaluated for nursery characteristics: germination, seedling vigor, uniformity and branching. Raised seedlings were used as rootstocks for scion cultivar Čačanka rodna plum. Uniformity was low (grade 1) when coefficient of variation was less than 15%, medium (grade 2) when it was from 15 to 25% and height (grade 3) when exceeding 25%.

3. Results and Discussion

The phenological characteristics of autochthonous (local, primitive) plum cultivars are given in Table 1. The data showed that the onset of flowering was recorded in the last five days of March and in the first twelve days of April. The earliest onset of flowering was observed in cultivar Trnovača (26.03) derived from *P. insititia* L., and the latest in cultivar Dupljanka (12.04) originating from *P. domestica* L. Among the 20 cultivars examined, 8 (40 %) started to flower at the end of March, and 12 (60 %) during the middle of the first twelve-day period of April. The full flowering stage lasted from 30th March (Trnovača) to 18th April (Dupljanka), and the end of flowering from 7th April (Trnovača) to 24th April (Dupljanka). Flowering lasted 9 (Turgulja, Plavski Piskavac, Grkaja, Kapavac and Komperuša) to 14 days (Crvena durgulja, Mednica, Petrovača, Belošljiva and Šara).

The harvest period was longer than the flowering period [6], as it lasted from 13th July (Petrovača) to 18th September (Trnovača). Local plum cultivars began to flower at the end of March or at the beginning of April under the environmental conditions of Serbia (Paunovic [15], Paunovic and Paunovic [17], Mratinic [13] and Milosevic [11]). Similar data on the period and duration of flowering of autochthonous plum cultivars were reported by Jarebica and Muratovic [7] and confirmed by the results of this study. Somewhat later flowering under Slovenian conditions was reported by Usenik *et al.* [23] and early flowering in the Tokat province (Turkey) by Gunes [6], the reason being environmental, particularly climate effects by Buljko [1]. In terms of fruit ripening, the results of this study were similar to the ones obtained by Paunovic *et al.* [15], Paunovic [16] and Mratinic [13]. Measurable pomological characteristics of fruit and stone are given in Table 2. Fruit weight ranged from $6.65 \text{ g} \pm 0.235 \text{ g}$ (Plavski piskavac) to $53.88 \pm 0.654 \text{ g}$ (Crvena durgulja). Jarebica and Muratovic [7] determined that the plum fruit weight ranged from 14.17 to 41.70 g. Jovancevic [9], reported minimum and maximum values of fruit weights of some local plum cultivars, being 5.03 and 23.86 g, respectively. In the study conducted by Petrovic *et al.* [18], fruit weight of eight local plum cultivars in Eastern Serbia and in the region of Čacak (Western Serbia) ranged from 15.20 - 26.40 g and from 6.68 - 36.50 g, respectively (Paunovic *et al.* [15]). According to Mratinic [13], fruit weight of autochthonous plum cultivars in a broader region of south-western Serbia and Šumadija fell within a range of 6.20 - 28.00 g with 50% of the cultivars having the fruit weight of 15.00 g.

Similar data for autochthonous plum cultivars were reported by researchers from other countries. In Turkey, for example, Gunes [6] reported the fruit weight of local plum cultivars in the Tokat province to range from 5.23 - 25.18 g and from 8.30 - 29.50 g in the Van province. The results obtained in this study confirmed

those provided by the above authors in terms of the high degree of genotypic variability in fruit weight of autochthonous (local) plum cultivars. The cultivars selected in this study were classified as being extremely small in terms of fruit size, whereas the fruits of cultivar Crvena durgulja were the only ones classified as being small ([15], [13] and [21]). Crvena durgulja-fruits are elongated 49 mm long, 44,10 mm wide, 46,8 mm thick and weight 60.65 g on average [2].

Table 1. Phenological characteristics of autochthonous plum cultivars in the region of North Montenegro

Cultivar (Local name)	Location			Flowering				Harvest date
	longitude	latitude	altitude (m)	onset	full	end	duration	
Crvena durgulja	19° 48' E	42° 57' N	870	30.03	03.04	13.04	14	15.08
Crvena ranka	19° 43' E	42° 59' N	601	29.03	03.04	11.04	13	05.08
Crnošljiva	19° 20' E	42° 38' N	978	31.03	04.04	13.04	13	08.08
Dupljanka	19° 59' E	43° 02' N	1180	12.04	18.04	24.04	12	11.09
Dronga	19° 55' E	42° 33' N	940	09.04	15.04	21.04	12	09.09
Turgulja	19° 56' E	42° 37' N	910	04.04	08.04	13.04	9	23.08
Trnovača	19° 20' E	42° 38' N	979	26.03	30.03	07.04	12	18.09
Mednica	19° 59' E	42° 70' N	670	30.03	03.03	13.04	14	25.07
Plavski piskavac	19° 55' E	42° 33' N	940	07.04	11.04	16.04	9	21.08
Petrovača	19° 41' E	41° 01' N	879	27.03	31.03	10.04	14	13.07
Obični Piskavac	18° 49' E	42° 26' N	858	07.04	10.04	17.04	10	23.08
Grkaja	19° 59' E	42° 70' N	670	01.04	04.04	10.04	9	02.08
Belošljiva	19° 52' E	43° 03' N	850	30.03	03.04	13.04	14	07.08
Šara	19° 57' E	42° 40' N	900	28.03	01.04	11.04	14	12.08
Kapavac	19° 29' E	42° 50' N	974	03.04	06.04	12.04	9	29.07
Komperuša	19° 49' E	42° 43' N	850	09.04	13.04	18.04	9	24.08
Mudovalj	19° 55' E	42° 33' N	940	09.04	15.04	21.04	12	02.09
Mudara	19° 43' E	42° 59' N	601	01.04	06.04	13.04	12	06.08
Metlaš	19° 29' E	42° 51' N	984	01.04	06.04	12.04	11	13.08
Jesenka	19° 55' E	42° 33' N	940	10.04	16.04	22.04	12	11.09

The most dominant fruit shape was rounded - in twelve cultivars, followed by ovate - in four cultivars, elliptical - in three cultivars and oblong - in one cultivar (Grkaja). Ground color in most of the cultivars was light green (10) and light yellow (6), being yellow in cultivar Trnovača, cultivar Dupljanka and cultivar Grkaja. Skin color ranged from white yellow (1) and red (1) and violet (1) and blue (1) and dark blue (1), and to dark violet (2), black (2), mahagoni (4) to red violet (7 cultivars). Flesh color was yellow green in most cultivars (12) and light yellow only in cultivar Plavski Piskavac and amber only in cultivar Dupljanka. As for flesh firmness, it was medium in 15 cultivars, firm in tree and soft in two cultivars. The fruits of all the cultivars could be used for different types of processing, particularly for plum brandy production (Joshi and Sandhu [10]). Crvena Ranka can

be used fresh (Mratinic [13]). Crvena ranka - fruits can be consumed immediately. Fruits are also used to produce an alcoholic drink that is called "Raki" in Albanian [2].

Similar data for Serbian autochthonous plum cultivars in terms of pomological, physical and sensorial characteristics were reported by Paunovic *et al.* [15], Paunovic [16], Petrovic *et al.* [18] and Milošević and Milošević [12], and data on local cultivars grown in the former Yugoslavia were given by Jovancevic [9], Jarebica and Muratovic [7], Usenik *et al.* [23], Jelacic *et al.* [8]. Stone weight ranged from 0.16 ± 0.003 g (Trnovača) to 2.20 ± 0.711 g (Crvena durgulja), which was in similar with the results obtained by Paunovic *et al.* [15], Paunovic [16], Paunovic and Paunovic [17], Mratinic [13] and Milošević and Milošević [12]. Those obtained values, particularly those for fruit weight and fruit size, were lower than the ones reported for standard commercial cultivars, both foreign and domestic ones. The fact that substantial climate- and soil-dependent variations could occur in the above traits should be taken into account. Importantly, some cultivars are found to be promising in terms of fruit traits. Almost all the fruits can be processed, particularly into plum brandy, or used fresh (Crvena Ranka). More importantly, the autochthonous (primitive, local) cultivars or accessions observed in this study can be used as an outstanding genetic basis and source of germplasm in plum breeding aimed at developing new cultivars and rootstocks [3 and 4].

The results of this research show that the seed germination, plant height, stem diameter, branching and uniformity of rootstocks are genetic characteristics of autochthonous plum cultivars, from which rapid growth and uniformity of scions depend (Table 3). The highest germination ability was 90% (sort Mednica) and the lowest 25% (sort Trnovača). The plant height of researched rootstocks of autochthonous cultivars of plum was from 54.2cm (sort Plavski piskavac), to 132.7cm (sort Crvena durgulja). The stem diameter of researched rootstocks of autochthonous cultivars of plum was from 6mm (sort Plavski piskavac), to 12mm (sort Crvena durgulja). The most significant nursery characteristics which must be estimated in selection of plum rootstocks are ability to propagate, growth-rate, uniformity and compatibility (Vachun [20]). In most of genotypes plant height and stem diameter at the height of 10 cm above the ground were sufficient for successful grafting in August (Table 3). The bud take of researched rootstocks of autochthonous cultivars of plum was from 45 % (Trnovača) to 100% (Crvena durgulja). From the aspect of production of generative rootstocks, the most interesting autochthonous plum cultivars are Mednica and Mudara.

Most of the germplasm resources has never been subjected to proper germplasm conservation research work. Many local types of genetic value have already

disappeared or will be lost in the next few years without any possibility of recovery. Fortunately genetic resources in sparsely populated and less developed areas of Serbia and Montenegro have been less eroded. The main objective of this work was selection of new rootstocks with better bio-agronomic characteristics such as uniformity of growth, high productivity, reduction of vigour and adaptation to the pedoclimatic environment. However, since the results obtained in this study are only preliminary, reliable estimation will be possible only through a multi-disciplinary approach to examining selected cultivars grown in a collection orchard as well as through further findings to be attained under field and laboratory conditions over the next five to ten years.

Table 2. Pomological and sensorial characteristics of autochthonous plum cultivars in the Region of North Montenegro

Cultivar	Fruit			Ground	Skin		Flesh		Use	Stone
(Local name)	weight (g)	size ¹	shape ²	colour ³	colour ⁴	colour ⁵	firmness ⁶	****	weight (g)	
Crvena durgulja	53.88±0.654	3	3	3	3	5	5	2	2.20±0.711	
Crvena ranka	19.30±0.041	1	4	3	3	3	5	1.2	0.66±0.004	
Crnošljiva	12.77±0.221	1	3	2	7	3	7	2	0.50±0.009	
Dupljanka	22.66±0.22	1	4	4	3	6	5	2	1.88±0.440	
Dronga	20.15±0.233	1	2	2	5	3	5	2	0.99±0.15	
Turgulja	20.91±0.221	1	2	2	9	3	5	2	1.59±0.013	
Trnovača	7.23±0.015	1	2	1	7	2	7	2	0.16±0.003	
Mednica	16.09±0.223	1	4	2	3	5	3	2	1.43±0.075	
Plavski piskavac	6.65±0.235	1	2	4	7	4	5	2	0.52±0.015	
Petrovača	13.11±0.078	1	2	2	5	3	5	2	1.19±0.032	
Obični Piskavac	13.62±0.042		2	2	6	3	5	2	0.74±0.004	
Grkaja	14.78±0.778	1	6	4	2	2	5		0.90±0.075	
Belošljiva	13.90±0.300	1	2	3	0	3	3	2	0.99±0.025	
Šara	19.02±0.057	1	2	2	4	3	5	2	0.82±0.019	
Kapavac	11.88±0.084	1	3	2	8	3	5	2	0.53±0.007	
Komperuša	16.88±0.106	1	2	2	7	3	5	2	1.19±0.033	
Mudovalj	18.55±0.125	1	2	3	3	2	5	2	1.19±0.086	
Mudara	35.60±0.299	2	2	3	3	2	5	2	1.87±0.035	
Metlaš	18.33±0.071	1	2	3	3	3	7	2	0.70±0.009	
Jesenka	23.81±0.251	1	2	2	9	3	5	2	1.81±0.023	

IBPGR and UPOV Descriptor List for Plum:

¹**Fruit size:** 1=extremely small, 2=very small; 3=small, 4=small/medium, 5=medium, 6=medium/large, 7=large, 8=very large, 9=extremely large.

²**Fruit shape:** 2 = rounded, 3 = elliptical, 4 = ovate, 6 = oblong.

³**Ground color:** 1=green, 2=light green, 3=light yellow, 4=yellow, 5=deep yellow.

⁴**Skin color:** 0=white yellow, 1=pink, 2=red, 3=red violet, 4=violet, 5=dark violet, 6=blue, 7=mahogany, 8=dark blue, 9=black.

⁵**Flesh color:** 1=green, 2=light green, 3=yellow-green, 4=light yellow, 5=yellow, 6=amber, 7=light orange, 8=orange, 9=red.

⁶**Flesh firmness:** 3 = soft, 5 = medium, 7 = firm.

⁷**Use:** 1 = fresh, 2 = processing, 4 = other (drying).

Table 3. Seed germination and morphological characteristics of autochthonous plum cultivars candidate generative rootstocks and scion growth of young Čačanska rodna plum trees

Cultivar (local name)	Seed germination (%)	Plant height (cm)	Stem diameter (mm)	Branching	Uniformity	Bud take (%)	Grow of scions (cm)	Uniformity of scions
Crvena durgulja	53	132.7	12.0	1	1	100	205	1
Crvena ranka	46	111	9.8	2	1	85	195	2
Crnošljiva	65	110.5	9.2	4	1	77	193.5	1
Dupljanka	65	126.5	11.0	2	1	86	198.2	1
Dronga	58	119.8	10	2	2	88	195.5	2
Turgulja	62	92.2	8.0	3	1	77	155.6	1
Trnovača	25	58.2	6.5	3	1	45	132.2	1
Mednica	90	115.2	10.2	2	2	92	198	2
Plavski piskavac	35	54.2	6	3	1	45	130.8	1
Petrovača	30	87	7.8	1	2	55	150.4	2
Obični Piskavac	65	114.2	9.5	2	1	85	197.2	1
Grkaja	72	112.5	9.5	2	1	88	188.4	1
Belošljiva	68	109	8.0	2	1	70	197.5	1
Šara	40	122.4	10.5	1	1	75	146.5	2
Kapavac	58	74	7.2	4	1	68	195.4	1
Komperuša	58	120.3	10.8	2	1	88	180	1
Mudovalj	66	109.4	9.1	2	2	75	200	2
Mudara	80	129.5	11.4	1	2	95	155	2
Metlaš	31	88	7.8	3	1	65	154	1
Jesenka	72	102.7	8.8	2	1	73	173.5	1

4. Conclusions

- The data showed that the onset of flowering was recorded in the last five days of March and in the first twelve days of April. The earliest onset of flowering was observed in cultivar Trnovača (26.03) derived from *P. insititia* L., and the latest in cultivar Dupljanka (12.04) originating from *P. domestica* L. Among the twenty cultivars examined, eight (40 %) started to flower at the end of March, and twelve (60 %) during the middle of the first twelve-day period of April. The full flowering stage lasted from 30 March (Trnovača) to 18th April (Dupljanka), and the end of flowering from 7th April (Trnovača) to 24th April (Dupljanka). Flowering lasted 9 (Turgulja, Plavski piskavac, Grkaja, Kapavac and Komperuša) to 14 days (Crvena durgulja, Mednica, Petrovača, Belošljiva and Šara).
- The harvest period was longer than the flowering period, as it lasted from 13th July (Petrovača) to 18th September (Trnovača).
- Fruit weight ranged from 6.65 ± 0.235 g (Plavski piskavac) to 53.88 ± 0.654 g (Crvena durgulja).
- The most dominant fruit shape was rounded - in

twelve cultivars, followed by ovate - in four cultivars, elliptical - in 3 cultivars and oblong - in one cultivar (Grkaja).

- Ground color in most of the cultivars was light green (10) and light yellow (6), being yellow in cultivars Trnovača, Dupljanka and Grkaja.
- Skin color ranged from white yellow (1), red (1), violet (1), blue (1), dark blue (1) to dark violet (2), black (2), mahogany (4) to red violet (7 cultivars).
- Flesh color was yellow green in most cultivars (12) and light yellow only in cultivar Plavski Piskavac and amber only in cultivar Dupljanka.
- As for flesh firmness, it was medium in 15 cultivars, firm in tree and soft in two cultivars.
- Stone weight ranged from 0.16 ± 0.003 g (Trnovača) to 2.20 ± 0.711 g (Crvena durgulja).
- All the fruits could be processed, and cultivar Crvena Ranka could be used fresh.
- The autochthonous (local) plum cultivars or accessions observed in this study could serve as an outstanding genetic basis and a source of germplasm for plum breeding aimed at developing new cultivars and rootstocks.
- The results of this research show that the seed germination, plant height, stem diameter, branching and uniformity of rootstocks are genetic characteristics of autochthonous plum cultivars, from which rapid growth and uniformity of scions depend.
- In most of genotypes plant height and stem diameter at the height of 10 cm above the ground were sufficient for successful grafting in August. From the aspect of production of generative rootstocks, the most interesting autochthonous plum cultivars are Mednica and Mudara.

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