

## EVALUATION OF EARLY PLUM CULTIVARS IN THE REGION OF BELGRADE (SERBIA)

Dragan MILATOVIĆ<sup>1\*</sup>, Dejan ĐUROVIĆ<sup>1</sup>, Gordana ZEC<sup>1</sup>, Đorđe BOŠKOV<sup>1</sup>, Mirjana RADOVIĆ<sup>2</sup>

<sup>1</sup>Faculty of Agriculture, University of Belgrade, Serbia

<sup>2</sup>Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina

\*Corresponding author: mdragan@agrif.bg.ac.rs

### Abstract

Phenological traits, yield, and fruit characteristics of nine plum cultivars of early maturation time were studied in the region of Belgrade (Serbia) in the five-year period (2013-2017). The control cultivar for comparison was 'Čačanska Rana'. The average time of flowering of tested cultivars was in the first half of April, and the average duration of flowering varied from 7.4 to 10.4 days. The average time of maturation ranged from June, 22 ('Boranka') to July, 14 ('Minerva'). The average yield per tree was lowest in the control cultivar, 'Čačanska Rana' (8.4 kg) and highest in the cultivar 'Dalikatnaya' (25.5 kg). Compared to control, significantly higher yield was achieved in four cultivars: 'Dalikatnaya', 'Opal', 'Minerva', and 'Katinka'. The lowest vigor was recorded in the cultivar 'Katinka', and the highest in the cultivar 'Opal'. The average fruit weight ranged from 22.9 g in the cultivar 'Katinka' to 55.9 g in the cultivar 'Čačanska Rana'. Compared to control, fruit weight was significantly lower in all cultivars except 'California Blue'. Soluble solids content was lowest in the cultivar 'Boranka' and highest in cultivars 'Opal', 'Herman' and 'Minerva'. The best rated cultivars for fruit appearance were 'Čačanska Rana' and 'California Blue', while cultivars 'Opal' and 'Katinka' had the best scores for taste.

**Key words:** *Prunus domestica*, flowering, maturation, yield, fruit characteristics

### Introduction

Plum (*Prunus domestica* L.) is the most important fruit species in Serbia. The average annual production of 403.060 t in the period of 2014-2016 ranks Serbia on the third place in the world, after China and Romania (FAOSTAT, 2018). The assortment of plum cultivars is dominated by those intended for processing. The most of produced plum fruits is processed into brandy (more than 70%), while much smaller amounts are dried, frozen, and processed into other products. Fresh consumption of plums is quite small. The highest profit in plum production is gained by growing table cultivars, especially that of early maturing time. The most important cultivars for fresh consumption are 'Čačanska Lepotica' and 'Čačanska Rana'. In recent years, there is a tendency to increase export of fresh fruits, mostly to Russia (Milatović, 2013). A lot of work has been done in the world on creation of new European plum cultivars with improved characteristics, such as better adaptation to different environmental conditions, increased disease resistance, self-fertility, higher yield and better fruit quality. In the last 20 years more than 170 new plum cultivars were released in Europe (Butac et al., 2013). The introduction of new foreign cultivars and their study in Serbian climatic and soil conditions allow better choice of cultivars, and may improve the production of plums. The aim of this study was to evaluate phenological traits, yield and fruit characteristics of European plum cultivars of early maturation time. The best performing cultivars will be recommended for growing in the region of Belgrade, as well as in other regions with similar environmental conditions.

### Material and Methods

The study was conducted in the plum collection orchard at the Experimental Station "Radmilovac" of the Faculty of Agriculture in Belgrade during the period of five years (2013–2017). The orchard was planted in 2009. The rootstock is Myrobalan (*Prunus cerasifera* Ehrh.) seedling, training system is central leader, and planting distance is 4.5 m × 3 m. The study included eight plum cultivars: 'Boranka' (from Serbia), 'Dalikatnaya' (Belarus), 'Herman' (Sweden), 'California Blue' (USA), 'Katinka' (Germany), 'Minerva' (Romania), 'Opal' (Sweden) and 'Ruth Gerstetter' (Germany). Control cultivar for comparison was 'Čačanska Rana'. All cultivars are represented by five trees.

Flowering was recorded according to recommendations of the International Working Group for pollination: start of flowering – 10% open flowers, full bloom – 80% open flowers, end of flowering – 90% of the petal fall (Wertheim, 1996). Trunk cross-sectional area (TCSA) was calculated on the basis of trunk circumference measured at the height of 30 cm above the ground level. Cumulative yield efficiency was calculated by dividing the cumulative yield over five years by TCSA in the last year (2017). Fruit characteristics were measured on a sample of 25 fruits per cultivar. Fruit shape index was calculated using the formula: length × length / width × thickness. Soluble solids were determined by refractometer and total acids (expressed as malic acid) by titration with 0.1 N NaOH. Sensory characteristics of the fruit (appearance and taste) were evaluated by a five-member jury, scoring the cultivars using the scale from 1 to 5 points.

The obtained data were statistically analyzed using analysis of variance. The significance of differences between mean values was determined using Duncan's multiple range test at 0.05 level of probability.

### Results and Discussion

Average time of flowering of tested cultivars was in the first half of April (Table 1). The earliest start of flowering was recorded in the cultivar 'Dalikatnaya' (March, 30), and the latest in cultivars 'Herman' and 'California Blue' (April, 4). The average difference between cultivars with earliest and latest flowering was six days.

Table 1. Phenological characteristics of plum cultivars (average, 2013–2017).

Cultivar	Flowering dates			Duration of flowering (days)	Abundance of flowering (0-5 scale)	Harvest date
	Start	Full	End			
Čačanska Rana (control)	1 April	4 April	11 April	9.8	3.9	3 July
Boranka	2 April	5 April	11 April	8.8	4.2	22 June
Dalikatnaya	30 March	2 April	9 April	10.4	4.2	13 July
Herman	4 April	6 April	11 April	7.4	4.0	30 June
California Blue	4 April	6 April	11 April	7.6	3.9	5 July
Katinka	2 April	5 April	10 April	8.0	3.7	5 July
Minerva	2 April	5 April	11 April	8.2	3.6	14 July
Opal	2 April	5 April	11 April	9.0	2.7	10 July
Ruth Gerstetter	2 April	5 April	11 April	8.4	4.5	25 June

Among years, the earliest flowering was in 2014, when the average date of the flowering onset for all cultivars was March, 24. The latest flowering was in 2013 when the average date of the flowering onset was April, 17. The difference between years with earliest and latest flowering was 24 days and it was much bigger than the difference between cultivars.

The average duration of flowering ranged from 7.4 days ('Herman') to 10.4 days ('Dalikatnaya'). Among years, the average duration of flowering for all cultivars ranged from

6.8 days in 2015 to 10.6 days in 2016. The most abundant flowering was recorded in cultivar 'Ruth Gerstetter' (score 4.5 on the 0-5 scale). The lowest flowering intensity (score 2.7) was recorded in the cultivar 'Opal'.

The range of fruit maturity was from June 22 ('Boranka') to July 14 ('Minerva'). For most cultivars the earliest fruit maturation was in 2016, and the latest in 2013 or 2014. Difference between years with earliest and latest fruit maturation varied from 4 to 8 days.

Both flowering and fruit maturation of plum cultivars in the region of Belgrade were earlier comparing to Czech Republic (Blažek et al., 2004), Central Bulgaria (Dragoyski et al., 2010), Northern Montenegro (Božović and Jaćimović, 2012) and Poland (Markuszewski and Kopytowski, 2013). These differences can be explained by different environmental conditions between the study regions.

The average yield per tree was lowest in the control cultivar 'Čačanska Rana' (8.4 kg) and highest in the cultivar 'Dalikatnaya' (25.5 kg) (Table 2). Compared to control, significantly higher yield was achieved in four cultivars: 'Dalikatnaya', 'Opal', 'Minerva', and 'Katinka'.

Table 2. Yield, trunk cross-sectional area (TCSA), and cumulative yield efficiency (CYE) of plum cultivars.

Cultivar	Yield (kg per tree)						TCSA (cm <sup>2</sup> )	CYE (kg/cm <sup>2</sup> )
	2013	2014	2015	2016	2017	Average		
Čačanska Rana (control)	2.8	12.1	9.8	7.4	9.9	8.4 d	156.5 ab	0.27
Boranka	3.9	7.7	11.9	4.4	19.6	9.5 cd	137.1 bc	0.35
Dalikatnaya	8.7	51.4	14.4	47.4	5.6	25.5 a	163.9 ab	0.78
Herman	4.8	21.3	21.9	11.2	1.6	12.2 bcd	121.1 bc	0.50
California Blue	5.3	14.7	19.3	13.2	21.7	14.8 bcd	119.6 bc	0.62
Katinka	5.9	34.7	4.5	28.1	7.3	16.1 bc	101.5 c	0.79
Minerva	9.7	31.3	9.0	29.8	5.4	17.0 b	131.7 bc	0.65
Opal	8.9	45.5	7.5	26.9	6.2	19.0 ab	186.5 a	0.51
Ruth Gerstetter	2.7	17.2	15.1	3.5	5.3	8.8 d	166.6 ab	0.26

Mean values followed by the same letter within a column do not differ significantly according to Duncan's multiple range test at  $P \leq 0.05$ .

Among studied cultivars, the lowest vigor was found in the cultivar 'Katinka', and the highest in the cultivar 'Opal'. Our results of low vigor and high yield of cultivar 'Katinka' confirm previous findings of Blažek and Pišteková (2009).

Cumulative yield efficiency ranged from 0.26 to 0.79 kg/cm<sup>2</sup>. Cultivars 'Katinka' and 'Dalikatnaya' stands out for high cumulative yield efficiency. On the other side, cultivars 'Ruth Gerstetter', 'Čačanska Rana' and 'Boranka' are characterized by low yield efficiency.

Fruit weight ranged from 22.9 g in the cultivar 'Katinka' to 55.9 g in the cultivar 'Čačanska Rana' (Table 3). Compared to control, fruit weight was significantly lower in all cultivars except 'California Blue'.

Stone weight ranged from 1.12 g ('Herman') to 2.80 g ('Čačanska Rana'), and its share in the fruit weight ranged from 3.0% ('California Blue') to 5.2% ('Katinka'). Significant differences were found between cultivars for fruit dimensions. Fruit length was highest in the control cultivar ('Čačanska Rana'), whereas width and thickness were highest in the cultivar 'California Blue'. Based on the fruit dimensions the shape index was calculated, whose values ranged from 1.03 in 'California Blue' (round shape) to 1.83 in 'Čačanska Rana' (elliptic shape). Stalk length was shortest in 'Herman' (0.8 cm), and longest in the control cultivar, 'Čačanska Rana' (2.1 cm).

Results of fruit characteristics are in accordance with the previous findings for some cultivars (Hodun et al., 1998; Blažek et al., 2004; Ogašanović et al., 2007; Milatović et al., 2011; Milošević and Milošević, 2011; Glišić et al., 2015).

Table 3. Fruit characteristics of plum cultivars (average, 2013–2017).

Cultivar	Fruit weight (g)	Stone weight (g)	Stone share (%)	Fruit dimensions (cm)			Shape index	Stalk length (cm)
				Length	Width	Thickness		
Čačanska Rana (control)	55.9 a	2.80 a	5.0	5.2 a	4.2 a	3.6 bc	1.83	2.1 a
Boranka	34.8 c	1.38 cd	4.0	3.9 cd	3.7 bc	3.7 bc	1.08	0.9 fg
Dalikatnaya	45.3 b	2.28 b	5.0	4.2 bc	4.0 ab	4.0 ab	1.07	1.8 b
Herman	30.0 cd	1.12 d	3.7	3.6 d	3.3 de	3.3 cd	1.15	0.8 g
California Blue	52.4 ab	1.60 c	3.0	4.3 b	4.3 a	4.3 a	1.03	1.5 ed
Katinka	22.9 d	1.18 d	5.2	3.8 cd	3.1 e	3.1 d	1.53	1.3 de
Minerva	33.9 c	1.29 cd	3.8	4.2 bc	3.5 cde	3.6 bc	1.42	1.1 ef
Opal	31.7 c	1.33 cd	4.2	3.8 cd	3.6 cd	3.5 cd	1.15	1.6 bc
Ruth Gerstetter	29.1 cd	1.14 d	3.9	3.7 d	3.5 cde	3.4 cd	1.15	1.0 efg

Mean values followed by the same letter within a column do not differ significantly according to Duncan's multiple range test at  $P \leq 0.05$ .

Cultivars 'Opal', 'Herman' and 'Minerva' are characterized by high soluble solids content (15.6-16.0%). On the other hand, lowest soluble solids content (12.8%), significantly lower than in previous cultivars, was found in the earliest maturing cultivar - 'Boranka' (Table 4). Cultivar 'Dalikatnaya' is characterized by high total acids content (1.94%), that was significantly higher than in all other cultivars.

Table 4. Indicators of fruit quality of plum cultivars (average, 2013–2017).

Cultivar	Soluble solids (%)	Total acids (%)	Soluble solids /Total acids	Sensory evaluation (1-5 scale)	
				Appearance	Taste
Čačanska Rana (control)	13.8 ab	1.13 b	12.2	4.6 a	3.7 ab
Boranka	12.8 b	1.06 bc	12.1	3.2 c	3.1 b
Dalikatnaya	15.2 ab	1.94 a	7.8	3.7 bc	3.6 ab
Herman	15.8 a	0.88 bc	17.9	3.7 bc	3.6 ab
California Blue	14.7 ab	1.14 b	12.9	4.2 ab	3.4 b
Katinka	14.8 ab	0.84 c	17.6	3.6 c	4.1 a
Minerva	15.6 a	0.95 bc	16.4	3.5 c	3.3 b
Opal	16.0 a	1.09 bc	14.7	3.3 c	4.2 a
Ruth Gerstetter	14.6 ab	1.02 bc	14.3	3.8 bc	3.6 b

Mean values followed by the same letter within a column do not differ significantly according to Duncan's multiple range test at  $P \leq 0.05$ .

The ratio between contents of soluble solids and total acids (SSC/TA), rather than the very content of soluble solids, represents a reliable indicator of a cultivar's suitability for acceptance by consumers (Crisosto et al., 2004). Cultivars 'Herman' and 'Katinka' are characterized by high SSC/TA ratio (17.6-17.9).

The data on the chemical composition of fruits are in good agreement with most of the previous findings (Bohačenko et al., 2010; Milatović et al., 2011; Glišić et al., 2015).

The best rated cultivars for fruit appearance were 'Čačanska Rana' and 'California Blue', while cultivars 'Opal' and 'Katinka' were best scored for taste. Our results of good taste for cultivar 'Katinka' are in accordance with those of Hartmann (1998) and for cultivar 'Opal' with those of Kemp and Wustenberghs (1998).

### **Conclusion**

Control cultivar, 'Čačanska Rana' is characterized by the best fruit appearance, especially by large fruit size. All other cultivars had significantly smaller fruit size, except 'California Blue'. However, productivity of 'Čačanska Rana' cultivar is low. Significantly higher yield was found in four cultivars: 'Dalikatnaya', 'Opal', 'Minerva', and 'Katinka'. Besides, cultivars 'Opal' and 'Katinka' had the best scores for taste.

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