

PHENOLOGICAL TRAITS, YIELD AND FRUIT QUALITY OF PLUM CULTIVARS BRED AT THE FRUIT RESEARCH INSTITUTE IN ČAČAK, SERBIA

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Abstract

Phenological traits, yield and fruit characteristics of ten plum cultivars bred at the Fruit Research Institute in Čačak were studied in the region of Belgrade in the period of four years (2012-2015). Average time of flowering of tested cultivars was in the first half of April. The earliest flowering was recorded in 'Čačanska Rana' and 'Valerija', at the latest in 'Zlatka'. The range of fruit maturity was about 2.5 months, from June 24 ('Boranka') to September 6 ('Pozna Plava'). The average yield per tree was the lowest in 'Boranka' (7.8 kg) and the highest in 'Čačanska Najbolja' (23.6 kg). The cultivars 'Čačanska Rodna', 'Nada' and 'Valerija' stand out for high cumulative yield efficiency (0.34 to 0.36 kg/cm²). Fruit weight was the lowest in the cultivar 'Mildora' (23.9 g), and the highest in the cultivar 'Čačanska Rana' (51.3 g). The cultivar 'Zlatka' is distinguished by a small stone (weight of 0.83 g and the share in a fruit weight of 3.1%). The cultivars 'Mildora', 'Pozna Plava' and 'Čačanska Rodna' are characterized by high soluble solids content (19.8-21.0%), while the cultivars 'Mildora' and 'Nada' are characterized by low acid content (0.47-0.48%) and a very sweet taste. The highest scores for fruit appearance obtained the cultivars 'Čačanska Najbolja', 'Čačanska Rana' and 'Nada', and for taste the cultivars 'Nada', 'Mildora' and 'Čačanska Rodna'.

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

Introduction

Plum is the most important fruit species in Serbia. The average production of 466.735 t in the period of 2010-2012 ranks Serbia on the third place in the world, behind China and Romania (FAO, 2016). However, plum production in Serbia has some negative characteristics. The average yield is very low, only 3 t/ha. This is because the production is mainly extensive and cultural practices are often at a low level. The use of fruits is very unfavorable. The largest amount of produced fruits is processed into brandy (more than 60%). Much smaller amounts of plums are dried, frozen, and processed into other products, while fresh consumption is quite small. In recent years, there is a tendency to increase export of fresh fruits, mostly in Russia (Milatović, 2013).

Plum breeding has been developed in continuity at the Fruit Research Institute in Čačak since its establishment in 1946. The result of this programme are 15 released cultivars (Glišić et al., 2015). The main breeding objectives are high fruit quality, self-fertility, regular and high yield and resistance or tolerance to Sharka (Plum Pox Virus).

New plum cultivars bred at the Fruit Research Institute in Čačak were studied by many researchers in Serbia (Ogašanović et al., 2005; Mitrović et al., 2006; Glišić et al., 2011; Milatović et al., 2011; Milošević and Milošević, 2011) and abroad (Hodun et al., 1998; Blažek et al., 2004; Dragoyski et al., 2005; Dinkova et al., 2007).

The aim of this study was to evaluate phenological traits, yield and fruit characteristics of ten plum cultivars bred at the Fruit Research Institute in Čačak. 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 four years (2012–2015). 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 x 3 m. All cultivars are represented by five trees.

The study included ten plum cultivars bred at the Fruit Research Institute in Čačak: ‘Boranka’, ‘Čačanska Lepotica’, ‘Čačanska Najbolja’, ‘Čačanska Rana’, ‘Čačanska Rodna’, ‘Mildora’, ‘Nada’, ‘Pozna Plava’, ‘Valerija’ and ‘Zlatka’.

Flowering was recorded by 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 three years by TCSA in the last year (2015). 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 flowering was recorded in ‘Čačanska Rana’ and ‘Valerija’, at the latest in ‘Zlatka’. The average difference between cultivars with earliest and latest flowering was 4 days, and by years it varied from 2 to 8 days.

Table 1. Phenological characteristics of plum cultivars (average, 2012–2015).

Cultivar	Flowering dates			Duration of flowering (days)	Harvest date	No. of days from full flowering to harvest
	Start	Full	End			
Boranka	7 April	8 April	14 April	7.8	24 June	77
Čačanska Lepotica	6 April	8 April	15 April	9.0	22 July	107
Čačanska Najbolja	6 April	8 April	14 April	8.5	9 August	125
Čačanska Rana	5 April	7 April	14 April	8.5	4 July	90
Čačanska Rodna	6 April	8 April	14 April	7.8	13 August	129
Mildora	7 April	9 April	14 April	7.5	15 August	130
Nada	7 April	9 April	16 April	8.8	16 August	131
Pozna Plava	8 April	10 April	15 April	7.8	6 September	151
Valerija	5 April	7 April	15 April	9.5	18 July	104
Zlatka	9 April	10 April	16 April	7.0	12 August	125

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 difference between cultivars with earliest and latest flowering.

Flowering of plum cultivars in the region of Belgrade was earlier comparing to Central Bulgaria (Dragoyski et al., 2010), Western Serbia (Glišić et al., 2011) and Northern Montenegro (Božović and Jaćimović, 2012). Differences in flowering time can be explained by differences in environmental conditions between the study regions.

The average duration of flowering ranged from 7.0 days (‘Zlatka’) to 9.5 days (‘Valerija’). Among years, the average duration of flowering for all cultivars ranged from 7.4 days in 2015 to 9.6 days in 2014.

The range of fruit maturity was about 2.5 months, from June 24 (‘Boranka’) to September 6 (‘Pozna Plava’). Similarly, the number of of days from full flowering to harvest ranged from 77 to 151. For most cultivars the earliest fruit maturation was in 2014, and the latest in 2012. Difference between years with earliest and latest fruit maturation varied from 2 to 15 days. Similar to flowering time, harvest dates in conditions of Belgrade were earlier than in Czeck Republik (Blažek et al., 2004), Central Bulgaria (Dragoyski et al., 2010), Western Serbia (Glišić et al., 2011) and Northern Montenegro (Božović and Jaćimović, 2012).

The average yield per tree was the lowest in ‘Boranka’ (7.8 kg) and the highest in ‘Čačanska Najbolja’ (23.6 kg)(Table 2). Although in some previous studies cultivar ‘Čačanska Najbolja’ showed medium productivity (Blagojević et al., 2006; Milatović et al., 2011) in this study it was the most productive cultivar. High yield in this cultivar was also reported by Faber et al. (2002) in Poland and Blažek et al. (2004) in Czeck Republik. Since ‘Čačanska Najbolja’ is self-incompatible cultivar (Nikolić and Milatović, 2010), its cropping highly depends on pollen transfer from polliniser cultivars and on weather conditions during flowering. High yield of this cultivar can be explained by favourable weather conditions during the period of study.

Table 2. Yield, trunk cross-sectional area, and yield efficiency of plum cultivars.

Cultivar	Yield (kg per tree)				Trunk cross-sectional area (cm ²)	Cumul. yield efficiency (kg/cm ²)
	2013	2014	2015	Average		
Boranka	3.9	7.7	11.9	7.8 d	72.6 ab	0.11 d
Čačanska Lepotica	10.3	36.7	7.5	18.2 ab	63.9 abc	0.28 b
Čačanska Najbolja	14.9	23.5	32.3	23.6 a	85.7 a	0.28 b
Čačanska Rana	2.8	12.1	9.8	8.2 d	71.7 ab	0.11 d
Čačanska Rodna	8.5	15.6	21.6	15.2 bc	42.5 c	0.36 a
Mildora	12.3	23.5	5.3	13.7 bc	83.6 a	0.16 cd
Nada	5.9	26.5	23.4	18.6 ab	53.1 bc	0.35 a
Pozna Plava	3.1	15.8	11.4	10.1 cd	56.8 bc	0.18 c
Valerija	13.3	29.4	12.1	18.3 ab	53.8 bc	0.34 a
Zlatka	2.7	10.4	11.2	8.1 d	51.8 bc	0.16 cd

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 vigour was found in 'Čačanska Rodna', and the highest in 'Čačanska Najbolja'. Cumulative yield efficiency ranged from 0.11 to 0.36 kg/cm². The cultivars 'Čačanska Rodna', 'Nada' and 'Valerija' stand out for high cumulative yield efficiency. The results for yield efficiency correspond well to results obtained by other authors (Blažek et al. 2004; Dinkova et al., 2007; Milošević and Milošević, 2011).

Fruit weight ranged from 23.9 g in the cultivar 'Mildora' to 51.3 g in the cultivar 'Čačanska Rana' (Table 3). Most of the studied cultivars are characterized by large fruit (more than 30 g). Exceptions are only cultivars: 'Mildora', 'Čačanska Rodna', 'Zlatka' and 'Pozna Plava' that had medium large fruit.

The cultivar 'Zlatka' is distinguished by a small stone (weight of 0.83 g and the share in a fruit weight of 3.1%). On the other hand, 'Čačanska Rana' had the largest stone (2.67 g).

Table 3. Fruit characteristics of plum cultivars (average, 2012–2015).

Cultivar	Fruit weight (g)	Stone weight (g)	Stone share (%)	Fruit dimensions (mm)			Shape index	Stalk length (mm)
				Length	Width	Thickness		
Boranka	32.0 c	1.31 de	4.1	38.0 c	36.2 abc	36.6 bc	1.09	10.2 d
Čačanska Lepotica	39.1 b	1.56 cd	4.0	43.9 b	38.3 ab	37.6 b	1.34	13.9 cd
Čačanska Najbolja	40.8 b	2.01 b	4.9	47.0 ab	37.6 ab	37.8 b	1.55	18.1 bc
Čačanska Rana	51.3 a	2.67 a	5.2	50.5 a	39.5 a	34.3 bc	1.89	22.7 ab
Čačanska Rodna	25.7 cd	1.23 e	4.8	42.7 bc	31.9 c	33.9 bc	1.69	24.6 a
Mildora	23.9 d	1.11 ef	4.6	38.0 c	31.6 c	31.9 c	1.43	11.2 d
Nada	40.2 b	1.71 bc	4.4	47.5 ab	37.6 ab	37.5 b	1.61	18.4 bc
Pozna Plava	28.5 b	1.56 cd	5.5	42.7 bc	33.9 bc	32.6 bc	1.65	23.1 ab
Valerija	46.0 ab	1.98 b	4.3	42.5 bc	41.1 a	43.2 a	1.02	16.9 c
Zlatka	26.6 cd	0.83 f	3.1	44.4 b	31.0 c	33.2 bc	1.92	17.5 c

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

Significant differences were found between cultivars for fruit dimensions. Based on the fruit dimensions the shape index was calculated, whose values ranged from 1.02 in ‘Valerija’ (round shape) to 1.92 in ‘Zlatka’ (elliptic shape). Stalk length was the shortest in ‘Boranka’ (10.2 mm), and the longest in ‘Čačanska Rodna’ (24.6 mm).

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., 2005; Dragoyski et al., 2010; Glišić et al., 2011; Milatović et al., 2011).

The cultivars ‘Mildora’, ‘Pozna Plava’ and ‘Čačanska Rodna’ are characterized by high soluble solids content (19.8-21.0%), while the cultivars ‘Mildora’ and ‘Nada’ are characterized by low acid content (0.47 to 0.48%) and a very sweet taste (Table 4).

Table 4. Indices of fruit quality of plum cultivars (average, 2012–2015).

Cultivar	Soluble solids (%)	Total acids (%)	Soluble solids /Total acids	Sensory evaluation (1-5)	
				Appearance	Taste
Boranka	12.3 e	1.13 ab	11.0	3.1 d	3.1 c
Čačanska Lepotica	15.5 cd	1.30 a	13.1	4.3 abc	4.1 a
Čačanska Najbolja	17.4 bc	0.95 bc	19.1	4.8 a	4.0 ab
Čačanska Rana	13.6 de	1.19 ab	11.5	4.7 ab	3.8 ab
Čačanska Rodna	19.8 ab	0.64 de	33.8	3.3 d	4.3 a
Mildora	21.0 a	0.48 e	46.9	2.3 e	4.3 a
Nada	18.5 ab	0.47 e	42.0	4.5 ab	4.4 a
Pozna Plava	20.0 ab	0.78 cd	27.5	3.9 c	4.0 ab
Valerija	14.2 de	0.98 bc	14.7	4.2 bc	3.4 bc
Zlatka	18.0 bc	0.78 cd	23.8	3.3 d	4.0 ab

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 results of the soluble solids content in the fruits of the cultivars examined in this study confirm the existence of a positive correlation between the soluble solids content and the ripening time of the fruit (Neumüller, 2010). Late ripening cultivars had soluble solids content over 17% which is in accordance to high quality requirements (Neumüller, 2010). Very high soluble solids content and low acid content of cultivar ‘Mildora’ confirms its suitability for drying (Ogašanović et al., 2005).

It is a well-known that the ratio between the soluble solids content 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). Early ripening cultivars had lower values of SSC/TA ratio (11,1-19,1) while late ripening cultivars had much higher values (24.8-46,9).

The data on the chemical composition of fruits are in good agreement with most of the previous findings (Mitrović et al., 2006; Dragoyski et al., 2010; Glišić et al., 2011; Milatović et al., 2011). Significantly higher soluble solids content for some cultivars was obtained in this study comparing with the results of Fajt and Usenik (2010) in Slovenia.

The highest scores for fruit appearance obtained the cultivars ‘Čačanska Rana’ and ‘Nada’, and for taste the cultivars ‘Nada’, ‘Mildora’ and ‘Čačanska Rodna’.

Conclusion

Based on the four-year evaluation of ten plum cultivars bred at the Fruit Research Institute in Čačak, for growing in Belgrade area can be recommended the cultivars 'Čačanska Lepotica' and 'Čačanska Najbolja' for fresh fruit consumption and 'Čačanska Rodna' and 'Mildora' for fruit processing. Besides them, the cultivar 'Nada' seems to be very promising as a cultivar of combine traits, suitable both for fresh consumption and processing.

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