

‘Divna’ – new plum (*Prunus domestica* L.) cultivar developed at Fruit Research Institute, Čačak

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Abstract. The paper presents the results of a two-year (2016–2017) study on major phenological (flowering and ripening time) and pomological (morphometric, chemical and organoleptic) properties and productivity of new plum cultivar ‘Divna’ (‘Stanley’ × ‘Čačanska Rana’), developed at the Fruit Research Institute, Čačak, compared to the characteristics of standard cultivar ‘Stanley’. According to the obtained results, ‘Divna’ is characterized by late flowering and very late ripening time, excellent abundance of flowering and good cropping. Fruits of the cultivar ‘Divna’ are medium-sized, with elliptical shape, violet blue skin colour and heavy bloom. The fruit flesh is yellowish green, firm, aromatic and tasty. Owing to the late ripening time, good productivity and fruit quality, ‘Divna’ is recommended for commercial production, and also has the potential to be used for future plum breeding programmes

Key words: *Prunus domestica* L., flowering and ripening time, morphometric, chemical and organoleptic properties of fruit, cropping

Introduction

Fruit Research Institute, Čačak has a seventy year old tradition in breeding of temperate zone fruit species. The most important results have been achieved in the breeding of European plum (*Prunus domestica* L.). So far, 17 plum cultivars have been named and released at the Institute, i.e. ‘Boranka’, ‘Čačanska Rana’, ‘Valerija’, ‘Čačanska Lepotica’, ‘Timočanka’, ‘Čačanska Najbolja’, ‘Nada’, ‘Zlatka’, ‘Jelica’, ‘Mildora’, ‘Čačanska Rodna’, ‘Krina’, ‘Valjevka’, ‘Čačanski Šećer’, ‘Pozna Plava’, ‘Divna’ and ‘Petra’ (Lukić et al., 2016a). Some of these cultivars are grown not only in Serbia, but also in many other European countries as well (Blažek & Pištekova, 2009; Molnár et al., 2016). What is more, cultivars such as ‘Čačanska Lepotica’, ‘Čačanska Najbolja’ and ‘Čačanska Rodna’ were used as parents in many plum breeding programs in the world (Jacob, 2002; Hartman & Neumüller, 2006).

The main objectives of current plum breeding work at the Fruit Research Institute, Čačak include: large fruit size, high fruit quality, very early to early or very late to late fruit ripening time, regular and high cropping, resistance or tolerance to Sharka virus (*Plum pox virus*) as well as to causal agents of the most important fungal diseases [*Polystigma rubrum* (Pers.) DC, *Puccinia pruni-spinosae* (Pers.: Pers.), *Monilinia laxa* (Aderhold & Ruhland)], reduced vigour, moderately dense and open crown (Lukić et al., 2016b). The newest plum cultivars ‘Divna’ and ‘Petra’ have been recognized in 2018, by Decisions of Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (No. 320-04-00841/2011-11; No. 320-04-00840/2011-11, respectively).

This paper provides a comparative analysis of major phenological (flowering and fruit ripening) and pomological traits (morphometric, chemical and organoleptic properties of fruits), and productivity of the

new cultivar ‘Divna’ (‘Stanley’ × ‘Čačanska Rana’), and the standard cultivar ‘Stanley’.

Materials and Methods

Plant material and experimental design. During a two-year period (2016–2017), a comparative study on major biological and pomological characteristics of new and standard plum cultivars ‘Divna’ and ‘Stanley’ was performed. The experimental plum orchard was established at the Ljubić facility of the Fruit Research Institute, Čačak (43°53’N, 20°20’E, 250 m a.s.l.) in spring 2011, using standard one-year-old nursery trees grafted on Myrobalan (*Prunus cerasifera* Ehrh.) seedlings and planted at the 5 m × 3 m distance (666 trees ha⁻¹), using the randomised block system with five trees in three replications. Experimental trees were trained as a pyramidal crown. Standard cultural practices, except irrigation, were performed in the orchard.

Phenological properties. The flowering phenophase was investigated by monitoring and recording dates of flowering onset (10% open flowers); full flowering (80 open flowers) and end of flowering (fallen over 90% petals) (Wertheim, 1996). Furthermore, the abundance of flowering was examined and expressed on a scale 0–5: excellent (5), very good (4), good (3), poor (2), very poor (1) and no flowers (0). Ripening time was determined as a date when the fruits were sufficiently coloured and soft to be eaten (Funt, 1998).

Morphometric properties of fruits. Twenty-five fruits in three replications were randomly selected and used for determination of fruit and stone weight (g) and fruit dimensions (mm). Fruit and stone weight were taken using technical scale Adventurer Pro AV812M (Ohaus Corporation, Switzerland). Digital calliper (0–150 mm, Kronen GmbH, Kehl am Rhein, Federal Republic of Germany) for determination dimensions of fruit (height, width and thickness) was used. Flesh percentage (%) was calculated as the ratio of the weight of the edible part of the fruit to the total fruit mass.

Chemical properties of fruits. Six chemical properties of fruit (soluble solids, total sugar, invert sugar, sucrose, total acids, and fruit pH) were evaluated in the stage of commercial maturity. Soluble solids content (%) was determined by a binocular refractometer (Carl Zeiss, Germany) and fruit pH by a CyberScan 510 pH-meter (Nijkerk, Netherlands). For determination of the content of total sugar (%), invert sugar (%) and sucro-

se (%) Luff-Schoorl method (Egan et al., 1981) was used. Total acids (%) were expressed as malic acids and determined by titration with 0.1 N NaOH up to pH 8.1, using phenolphthalein as an indicator.

Organoleptic properties of fruits. Organoleptic properties of fruits of the studied cultivars were evaluated in accordance with the guidelines for testing the values for cultivation and use of a plum variety specified by the Regulations of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia. Attractiveness of fruits (0–6), as well as taste (0–8), aroma (0–4) and consistency (0–2) were assessed by positive scoring by five panellists. The overall organoleptic score (0–20) is the total of all individual points.

Productivity. To test productivity, yield per tree and unit area were determined. Yield per tree (kg) was measured by ACS System Electronic Scale (Zhejiang, China), while yield per unit area (t ha⁻¹) was calculated and represents multiplication of the yield per tree and the number of trees per hectare.

Description of the cultivar. ‘Divna’ was described on the base of obtained results and using the UPOV guidelines for the conduct of tests for distinctness, uniformity and stability of European plum (2002), as well as, the methodology recommended by IBPGR (1984) for evaluation the degree of field resistance to causal agents of the economically most important viral and fungal diseases.

Data analysis. The obtained results related to morphometric properties of fruits and productivity were statistically analysed by the Fisher model analysis of variance (ANOVA) using the software package Microsoft Office Excel 2003. The means were separated by LSD test at $p \leq 0.05$.

Results and Discussion

Phenological properties. In both plum cultivars, flowering onset was at the end of March and duration of flowering was ten days (Tab. 1). Considering that ‘Stanley’ was classified as a cultivar of late flowering time (Neümüller, 2010), ‘Divna’ had a late flowering time compared to ‘Stanley’ in the examined period. Also, ‘Divna’ was characterised by excellent abundance of flowering and in this respect it was in the line with ‘Stanley’, referred to as a cultivar of high yielding potential (Mišić, 2002).

Tab. 1. Characteristics of flowering and ripening phenophases of 'Divna' and 'Stanley' cultivars (2016–2017, average)
Karakteristike fenofaza cvjetanja sorti Divna i Stanley (2016–2017. godina, prosek)

Cultivar <i>Sorta</i>	Flowering phenophase/ <i>Fenofaza cvjetanja</i>			Abundance <i>Obilnost</i>	Ripening time <i>Vreme sazrevanja</i>
	Flowering onset <i>Početak cvjetanja</i>	Full flowering <i>Puno cvjetanje</i>	End of flowering <i>Kraj cvjetanja</i>		
'Divna'	31 March	03 April	10 April	5	11 September
'Stanley'	30 March	02 April	09 April	5	30 August

The fruits of 'Divna' ripened at the beginning of second decade of September, on average twelve days after 'Stanley' (Tab. 1). Considering ripening time and recommended methodology by UPOV (2002), 'Divna' can be characterized as a very late cultivar, while 'Stanley' as a late ripening-time cultivar. Very late ripening time is very important property of 'Divna', because better price of fruits are usually released at the end of harvesting season (Neümuller, 2010). Also, 'Divna' can be used as a basis in further plum breeding programmes, because the extension of ripening time is known to be one of the most important plum breeding objectives (Ognjanov *et al.*, 2007).

Morphometric properties of fruits. 'Divna' had lower average values for fruit weight (25.52 g), fruit height

and width (45.53 mm and 32.73 mm, respectively) and stone weight (1.06 g) than 'Stanley' (27.87 g, 47.89 mm, 36.32 mm and 1.79 g, respectively), but difference between cultivars was not significant in the case of fruit weight. On the other hand, 'Divna' had higher average values for fruit thickness and flesh percentage (31.29 mm and 95.83%, respectively) than standard (30.97 mm and 93.53%, respectively). The differences showed statistical significance only in the case of flesh percentage. Moreover, the analysis of variance of the fruit morphometric traits showed a statistically significant effect of year on fruit height and fruit thickness and significant effect of interaction between cultivar and year on all of studied parameters (Tab. 2).

Tab. 2. Morphometric properties of fruits of 'Divna' and 'Stanley' cultivars (2016–2017)
Morfometrijske osobine ploda sorti Divna i Stanley (2016–2017. godina)

Cultivar/Year <i>Sorta/Godina</i>	Fruit weight <i>Masa ploda</i> (g)	Fruit height <i>Dužina ploda</i> (mm)	Fruit width <i>Širina ploda</i> (mm)	Fruit thickness <i>Debljina ploda</i> (mm)	Stone weight <i>Masa koštice</i> (g)	Flesh percentage <i>Randman ploda</i> (%)
Cultivar (A)/Sorta (A)						
'Divna'	25.52 ± 0.63	45.53 ± 0.22 b	32.73 ± 0.34 b	31.29 ± 0.15	1.06 ± 0.02 b	95.83 ± 0.07 a
'Stanley'	27.87 ± 1.01	47.89 ± 0.35 a	36.32 ± 1.07 a	30.97 ± 0.44	1.79 ± 0.02 a	93.53 ± 0.21 b
Year (B)/Godina (B)						
2016	26.72 ± 1.42	46.08 ± 0.46 b	35.34 ± 1.51	30.48 ± 0.22 b	1.41 ± 0.18	94.78 ± 0.49
2017	26.67 ± 0.39	47.35 ± 0.59 a	33.71 ± 0.16	31.78 ± 0.08 a	1.44 ± 0.15	94.59 ± 0.58
Cultivar × Year (A×B)/Sorta × Godina (A×B)						
'Divna' 2016	24.35 ± 0.37 c	45.04 ± 0.01 d	31.97 ± 0.03 c	30.96 ± 0.03 b	1.02 ± 0.02 b	95.81 ± 0.12a
'Divna' 2017	26.68 ± 0.69 b	46.02 ± 0.10 c	33.48 ± 0.11 b	31.62 ± 0.04 a	1.10 ± 0.01 b	95.87 ± 0.10a
'Stanley' 2016	29.99 ± 0.66 a	47.11 ± 0.01 b	38.71 ± 0.02 a	29.99 ± 0.07 c	1.80 ± 0.03 a	93.75 ± 0.38b
'Stanley' 2017	26.65 ± 0.54 b	48.68 ± 0.07 a	33.93 ± 0.06 b	31.95 ± 0.04 a	1.78 ± 0.02 a	93.31 ± 0.14b
ANOVA						
A	NS	*	*	NS	*	*
B	NS	*	NS	*	NS	NS
A×B	*	*	*	*	*	*

The obtained values of the studied morphometric parameters of the fruits of examined plum cultivars in this research are slightly lower than the results reported by Milošević *et al.* (2016), which could be the consequence of different meteorological conditions and yield. Fruits of 'Divna' can be classified as medium-sized (Mišić, 1996). In addition, the new cultivar is characterized by a lower fruit size compared to both parent cultivars ('Stanley' and 'Čačanska Rana'). This can be explained by quantitative inheritance of fruit weight (Crisosto *et al.*, 2004), which is in accordance with the results of Paunović *et al.* (1968) who reported that the parent with large fruit size have descendants that are mostly characterized by smaller fruits. Also, in the present study, smaller fruit weight of 'Divna' compared to 'Stanley' could be related with higher yield of new cultivar (Tab. 5).

Chemical properties of fruits. The chemical composition of the fruits varies by cultivar and year of study (Tab. 3) (Usenik *et al.*, 2014). Compared to the standard, the fruits of 'Divna' characterized by the higher values of soluble solids, total sugar, sucrose and total acids (19.70%, 12.45%, 5.08% and 0.91%, respectively) and lower values of invert sugar and pH of fruit juice (7.10%, 3.69) in the first year of study. In contrast, in the second year higher values of all the studied parameters, except total acids, were determined in fruits of 'Stanley'.

The previous results (Milošević *et al.*, 2016) point to a somewhat higher value of the parameters of the chemical composition of fruits of 'Divna', which may be due to the different time of harvesting (Casquero & Guerra, 2009), applied agrotechnical measures (Day *et al.*, 1992) and climatic conditions (Mitrović *et al.*, 2006). The content of soluble solids play important rule in consumer acceptance of some plum cultivar (Crisosto *et al.*, 2004). Neimüller (2010) stated that late ripening cultivars should have more than 17% of soluble solids and therefore could be concluded that 'Divna' meets the criteria in this regard.

Organoleptic properties of fruits. Fruit quality is a combination of physical and chemical properties (Kramer & Twigg, 1966) evaluated by consumers based on observation of the attractiveness, taste, aroma and consistency (Abbott, 1999). In the final assessment of the acceptance of a cultivar, besides its quality, the subjective perception of the consumers is of great importance (Crisosto *et al.*, 2007).

The plum cultivars tested in our research showed the same results regarding the fruit attractiveness, which was expected because of similarity in terms of fruit weight and fruit dimensions (Tab. 4). The fruits of analysed cultivars did not differ in terms of aroma though differences in terms of taste and consistency were found. Flesh of 'Stanley' fruits had better taste in the second year of study, while the flesh of 'Divna' fruits had better consistency during both years.

Tab. 3. Chemical properties of fruits of 'Divna' and 'Stanley' cultivars (2016–2017)
Hemijske osobine ploda sorti Divna i Stanley (2016–2017. godine)

Cultivar <i>Sorta</i>	Year <i>Godina</i>	Soluble solids	Sugar content/ <i>Sadržaj šećera (%)</i>			Total acids	pH
		<i>RSM (%)</i>	Total <i>Ukupni</i>	Inverted <i>Invertni</i>	Sucrose <i>Saharoza</i>	<i>Ukupne kiseline (%)</i>	
'Divna'	2016	19.70	12.45	7.10	5.08	0.91	3.69
	2017	17.70	12.25	8.23	3.77	1.01	3.63
'Stanley'	2016	18.80	12.70	7.35	5.08	0.83	3.89
	2017	22.50	15.45	8.85	6.27	0.70	4.17

Tab 4. Organoleptic properties of fruits of 'Divna' and 'Stanley' cultivars (2016–2017)
Organoleptičke osobine ploda sorti Divna i Stanley (2016–2017. godine)

Cultivar <i>Sorta</i>	Year <i>Godina</i>	Attractiveness	Flavour	Aroma	Consistency	Total
		<i>Atraktivnost (0–6)</i>	<i>Ukus (0–8)</i>	<i>Aroma (0–4)</i>	<i>Konzistencija (0–2)</i>	<i>Ukupno (0–20)</i>
'Divna'	2016	5.00	6.00	1.00	4.00	16.00
	2017	5.00	6.00	1.00	4.00	16.00
'Stanley'	2016	5.00	6.00	1.00	3.00	15.00
	2017	5.00	7.00	1.00	3.00	16.00

Tab. 5. Yield of of 'Divna' and 'Stanley' cultivars (2016–2017)
Prinos sorti Divna i Stanley (2016–2017. godina)

Cultivar/Year <i>Sorta/Godina</i>		Yield per tree <i>Prinos po stablu</i> (kg)	Yield per unit area <i>Prinos po jedinici površine</i> (t ha ⁻¹)
<i>Cultivar (A)/Sorta (A)</i>			
'Divna'		17.95 ± 1.37 a	11.95 ± 0.92 a
'Stanley'		16.62 ± 0.91 b	11.06 ± 0.61 b
<i>Year (B)/Godina (B)</i>			
	2016	14.82 ± 0.14 b	9.87 ± 0.96 b
	2017	19.75 ± 0.66 a	13.15 ± 0.44 a
<i>Cultivar × Year (A×B)/Sorta × Godina (A×B)</i>			
'Divna'	2016	14.90 ± 0.21 c	9.92 ± 0.14 c
	2017	21.00 ± 0.15 a	13.98 ± 0.10 a
'Stanley'	2016	14.73 ± 0.23 c	9.81 ± 0.16 c
	2017	18.51 ± 0.76 b	12.33 ± 0.51 b
ANOVA			
A		*	*
B		*	*
A×B		*	*

Productivity. Yield per tree and per unit area significantly differed between experimental cultivars, as well as between experimental years (Tab. 4). On average, 'Divna' had higher yield per tree (17.95 kg) and per unit area (11.95 t ha⁻¹) compared to the 'Stanley' (16.62 kg and 11.06 t ha⁻¹, respectively), which was referred as a good donor for high yield (Mišić, 2002; Neümüller, 2010). Also, ANOVA showed significant impact of cultivar and year interaction on investigated parameters of productivity.

Description of the cultivar. 'Divna' ('Stanley' × 'Čačanska Rana') is a vigorous cultivar with dense crown. Flowering time is late, similar with 'Stanley'. It starts bearing early, in the second or third year after planting. It is a regular and heavy bearer. In the field conditions it shows tolerance to Sharka virus (*Plum pox virus*), as well as to causal agents of economically most important fungal diseases [*Polystigma rubrum* (Pers.) DC, *Puccinia pruni-spinosae* (Pers.: Pers.), *Monilinia laxa* (Aderhold & Ruhland)]. The ripening season is very late, at the beginning of second decade of September. The fruit is medium-sized, of elliptical shape, violet blue skin colour and heavy bloom. The flesh is yellowish green, firm, aromatic and tasty. The fruits are suitable for fresh consumption and various types of processing.

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Conclusion

The results of the two-year comparative study of the most significant phenological, morphometric, chemical and organoleptic properties, and productivity of the newly released plum cultivar 'Divna', and standard cultivar 'Stanley' indicate that 'Divna' deserves to be included in the existing plum assortment in the Republic of Serbia. Due to the many positive biological and production characteristics, especially late ripening time and productivity, this cultivar is an important source of genetic variability for future plum breeding programmes.

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DIVNA – NOVA SORTA ŠLJIVE (*PRUNUS DOMESTICA* L.) STVORENA U INSTITUTU ZA VOĆARSTVO, ČAČAK**Ivana Glišić, Nebojša Milošević, Žaklina Karaklajić-Stajić, Milena Đorđević, Milan Lukić**

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Rezime

U radu su prikazani rezultati dvogodišnjih (2016–2017. godine) uporednih proučavanja najznačajnijih fenoloških (fenofaza cvetanja i sazrevanja) i pomoloških (morfometrijske, hemijske i organoleptičke) osobina i rodnosti nove sorte šljive Divna i standard sorte Stanley. Divna je stvorena u Institutu za voćarstvo, Čačak iz ukrštanja Stanley × Čačanska rana. Oplemenivači su dr Dobrivoje Ogašanović, dr Darko Jevremović i dr Ivana Glišić.

Tok i trajanje cvetanja ispitani su putem beleženja datuma početka (otvoreno 10% cvetova), punog (otvoreno 80% cvetova) i kraja (otpalo preko 90% kruničnih listića) cvetanja. Obilnost cvetanja je izražena ocenama: odličan – 5, vrlo dobar – 4, dobar – 3, slab – 2, rđav – 1 i nije bilo cvetova – 0. Vreme sazrevanja je obeleženo datumom kada su plodovi bili adekvatno obojeni i postigli najbolji kvalitet za potrošnju. Primenom standardnih morfometrijskih metoda na uzorku od 25 plodova u tri ponavljanja određene su masa ploda i koštice i dužina, širina i debljina ploda. Prinos po stablu je izmeren uz pomoć elektronske vage ACS System Electronic Scale (Zhejiang, China). Randman ploda i prinos po jedinici površine su dobijeni računskim putem. Ispitivanje hemijskih osobina obuhvatilo je: sadržaj rastvorljivih suvih materija – RSM (binokularnim refraktometrom Carl Zeiss, Nemačka), sadržaj ukupnih i invertnih šećera i saharoze (volumetrijski po Luff-Schoorl-u), sadržaj ukupnih kiselina izražen u jabučnoj kiselini (titracijom sa 0,1 N NaOH uz prisustvo fenolftaleina kao indikatora do pH 8,1), pH vrednost soka ploda (pehametar CyberScan 510, Singapur). Organoleptička ocena ploda je određena metodom pozitivnog poentiranja izgleda (0–6), ukusa (0–8), arome (0–2) i konzistencije ploda (0–4).

Dobijeni podaci vezani za morfometrijske osobine ploda i prinos su statistički obrađeni primenom Fišerovog modela analize varijanse (ANOVA) i LSD testom za prag značajnosti od $P < 0,05$. Na bazi dobijenih rezultata i međunarodnih deskriptora za šljivu dat je opis sorte.

Sorta Divna se odlikuje bujnim stablom i gustom krunom. Cveti kasno, istovremeno sa sortom Stanley. U periodu ispitivanja odlikovala se značajno višim prinosom po stablu i jedinici površine (17,95 kg i 11,95 t ha⁻¹) u odnosu na standard sortu Stanley (16,62 kg i 11,06 t ha⁻¹). Vreme sazrevanja nove sorte je veoma pozno, na početku druge dekade septembra, u proseku 12 dana posle standard sorte. Plodovi sorte Divna su srednje krupnoće (prosečno 25,52 g), eliptičnog oblika (dužina – 45,53 mm; širina – 32,73 mm; debljina 31,29 mm), ljubičasto-plave boje pokožice sa obilnim pepeljkom. Prema rezultatima dobijenim u ovim proučavanjima masa i debljina ploda nove sorte su u nivou standard sorte Stanley, dok su dužina i širina ploda, kao i masa koštice značajno manje, a randman ploda značajno veći. Mezokarp ploda sorte Divna je žuto-zelene boje, čvrst, ukusan i aromatičan. U zavisnosti od godine sadrži 17,70–19,70% RSM; 12,25–12,45% ukupnih šećera; 7,10–8,23% invertnih šećera; 3,77–5,08% saharoze i 0,91–1,01% ukupnih kiselina. Plodovi su pogodni za upotrebu u svežem stanju, kao i za različite vidove prerade. U prirodnim uslovima zaražavanja ne ispoljava simptome karakteristične za ekonomski najznačajnije gljivične bolesti šljive. Tolerantna je na virus šarke šljive.

Ključne reči: *Prunus domestica* L., fenofaza cvetanja i sazrevanja, morfometrijske, hemijske i organoleptičke osobine ploda, rodnost