

Full Length Research Paper

Some pomological characteristics of F₁ plum hybrids (*Prunus domestica* L.) developed in Cacak, Serbia

T. Milosevic^{1*} and N. Milosevic²

¹Faculty of Agronomy, Department of Fruit Growing and Viticulture, Cara Dusana 34, 32000 Cacak, Serbia.

²Fruit Research Institute, Department of Fruit Growing Technology, 32000 Cacak, Kralja Petra I/9, Serbia.

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The paper presents results on the development of plum cultivars derived from *Prunus domestica* L. through planned hybridisation in Cacak (Serbia). Cacanska Lepotica, Cacanska Najbolja and Stanley cultivars were used as pollen donors, the Stanley being pollen recipient in all combinations. The study conducted over the 1991-2007 period resulted in the selection of seven highest-quality F₁ hybrids having, according to commonly accepted local and world criteria, positive pomological traits, the ones related to fruit size, mesocarp percentage and soluble solids content being most pronounced with the P₄ (23/III/90) and P₆ (11/IV/90) hybrids.

Key words: Pomological traits, cultivars, hybrids, plum, *Prunus domestica* L.

INTRODUCTION

Breeding programmes focusing on developing new plum cultivars are underway in Serbia. The main breeding objectives include: large fruit size and fruit quality, yield, resistance to diseases, particularly to sharka or Plum pox virus. This complex issue was addressed by an array of different researchers the most eminent of them being: Paunovic et al. (1971, 1975), Paunovic and Ogasanovic (1980), Ogasanovic (1990) and Ogasanovic et al. (2007). The world's highest-ranking plum cultivars derived from *Prunus domestica* L. include Cacanska Rana, Cacanska Lepotica, Cacanska Najbolja, Cacanski Secer, Cacanska Rodna (Paunovic et al., 1971, 1975), and Valjevka, Valeria, Jelica, Boranka, Timocanka, Mildora and Krina (Ogasanovic, 1990; Ogasanovic et al., 2007) developed at the Fruit Research Institute in Cacak, Serbia.

Planned plum hybridisation at the Faculty of Agronomy is being practiced for the essential purpose of developing cultivars the fruit thereof would be suitable for fresh consumption (table fruit) or processing and drying and have maximum tolerance to unfavourable abiotic and biotic factors (Milosevic, 1998, 2000). The main objective of the paper is to study the most essential pomological traits of seven highest-quality F₁ hybrids derived by crossing different commercial cultivars at the Faculty of Agronomy in Cacak (Serbia).

MATERIAL AND METHODS

The hybridisation material involved the cultivar Stanley as the maternal parent and Cacanska Lepotica, Cacanska Najbolja and Stanley cultivars as the paternal parent (inbreeding) in 1991-2007 period. A total of 13 123 flowers were pollinated, that is 3 763 in the Cacanska Lepotica × Stanley combination and 4 039 and 5 321 flowers in the Cacanska Najbolja × Stanley and Stanley × Stanley combinations, respectively. The flowers developed into 3 921 fruits that is "hybrid" seeds. Stratified seeds were sown in the nursery at 80 × 10 cm spacing, yielding 3 013 hybrid seedlings at the end of the growing season. The hybrid seedlings were lifted from nursery beds and planted at a 3 × 0.5 m spacing in the trial field immediately afterwards. Routine care of the hybrid plants was performed accompanied by intensive visual monitoring and recording of all relevant developments. The process also included elimination of all hybrids which exhibited negative traits resulting from their phenotypic properties (excessive thorniness, small leaves, susceptibility to rust, powdery mildew and pathogens of the *Monilinia* spp. family etc.). Particular attention was given devoted to eliminating hybrids with even the slightest rate of plum pox virus infection.

Over the 1997-2000 periods, 1 657 hybrid seedlings were eliminated out of the total of 3013. Seven hybrid seedlings excelling primarily in their organoleptic and morph metric properties (size, shape, colour, bloom or powdery coating, stalk traits etc.) were selected out of the remaining population of 1 356 hybrid seedlings. The hybrid seedlings gave their first yield in 1996. In August 1999, the hybrid seedlings were grafted on Myrobalan (*Prunus cerasifera* Ehrh.) rootstock, and in 2000 the grafted hybrids were planted in the experimental orchard at a 4 × 2 m spacing or 1 250 trees ha⁻¹. The grafted hybrids gave yields in 2003, and fruit, stone and stalk samplings were collected over the 2006-2007 period for examination purposes of this study.

The analysis covered fruit weight and stone weight (g), mesocarp percentage (%), soluble solids content (°Brix) and stalk length and stalk thickness (mm). Fruit weight and stone weight were measured

*Corresponding author. E-mail: tomom@tfc.kg.ac.rs.

Table 1. Harvest time and pomological characteristics of fruit and stone of F₁ plum hybrids (mean±SE, CV).

Hybrids	Harvest time*	Fruit shape*	Fruit weight (g)		Stone weight (g)	
			Mean±SE	CV%	Mean±SE	CV%
P ₁	7 Aug	Ovate	48.45±0.982	9.88	1.31±0.052	1.30
P ₂	15 Aug	Ovate	34.93±1.143	9.82	1.48±0.072	1.80
P ₃	20 Aug	Elliptic	47.87±2.051	11.31	1.66±0.089	2.22
P ₄	10 Jul	Rounded	59.21±2.219	12.32	1.70±0.101	2.52
P ₅	5 Aug	Elliptic	26.54±1.342	7.45	1.12±0.051	1.27
P ₆	15 Aug	Rounded	47.94±1.870	12.95	1.47±0.064	1.60
P ₇	25 Aug	Ovate	29.12±0.700	10.19	1.29±0.059	1.47

*IBPGR & UPOV Descriptor list for plum (Zanetto et al., 2002).

Table 2. Skin colour, flesh colour, mesocarp percentage and soluble solids content of F₁ plum hybrids (mean±SE, CV).

Hybrids	Skin colour*	Flesh colour*	Mesocarp percentage (%)		Soluble solids (°Brix)	
			Mean±SE	CV%	Mean±SE	CV%
P ₁	Dark blue	Yellow green	96.59±1.234	24.68	18.80±0.334	14.06
P ₂	Blue	Yellow green	95.76±1.131	22.62	22.50±0.750	6.67
P ₃	Dark blue	Yellow green	96.53±1.221	24.42	20.00±1.000	10.00
P ₄	Dark blue	Yellow green	97.13±1.548	17.20	21.40±0.879	21.97
P ₅	Dark violet	Amber	95.78±1.198	17.11	18.85±0.601	18.21
P ₆	Blue	Yellow green	96.93±1.311	21.85	18.75±0.545	5.81
P ₇	Blue	Amber	95.57±1.321	22.01	18.90±0.520	6.20

*IBPGR & UPOV Descriptor list for plum (Zanetto et al., 2002).

using a Technical ET-1111 technical scale (range of measurement 0.01-120.00 g, precision ± 0.01 g), stalk dimensions (length and thickness - mm) using micrometric screw with a ± 0.01 mm measuring accuracy, and the soluble solids content was estimated using a Zeiss refractometer. IBPGR and UPOV methodology was used to describe the hybrids in pomological terms (Zanetto et al., 2002).

The data were statistically analysed by calculating the average and its absolute and relative variability was defined using the standard error of the arithmetic average (±SE) and coefficient of variation (CV%) of the parameters studied (Hadzivukovic, 1979).

The hybrids have been registered as codes: P₁ (1/I/90), P₂ (2/II/90), P₃ (14/III/90), P₄ (23/III/90), P₅ (7/IV/90), P₆ (11/IV/90) and P₇ (6/V/90).

RESULTS

The results on fruit, stone and stalk traits, mesocarp percentage and soluble solids content of the F₁ plum hybrids derived from *Prunus domestica* L. are presented in Tables 1, 2, 3 and Figures 1-7.

Hybrid P₁: Developed by crossing the cultivars Cacanska Lepotica and Stanley. Average harvest onset between 5

and 9 August, that is 10-15 days earlier than of Stanley. Large fruit, with an average weight of 48.45 g (Table 1 and Figure 1). Ovate shape, distinctly furrow along the fruit, reminiscent of the Stanley. Dark blue skin, thickly covered with bloom. Mesocarp is yellow-green, firm and juicy with a sweet subacid flavour. Average soluble solids content 18.80° Brix. Mesocarp percentage is 96.59% (Table 2). Small stone, with an average weight of 1.31 g, separating from the mesocarp. Stalk medium (11.90 mm), with a diameter of 1.84 mm (Table 3). Long stalk size causing fruit to well adhere to the twig.

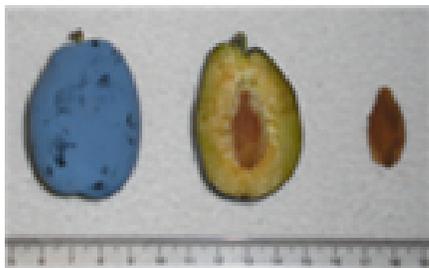
Exhibiting a high degree of absolute (±SE) and relative (CV%) statistical uniformity of the parameters examined.

Hybrid P₂: Developed by crossing the cultivars Cacanska Najbolja and Stanley. Average harvest onset around 15 August or 5 days before Stanley harvest.

Medium large to large fruit, with an average weight of 34.93 g (Table 1 and Figure 2). Ovate shape, markedly convex sides. Blue skin covered with moderate bloom. Mesocarp is yellow-green, juicy, sweet and pleasantly flavoured. Soluble solids content 22.50° Brix, the highest

Table 3. Stalk length and thickness in F₁ plum hybrids (mean±SE, CV).

Hybrids	Stalk length (mm)		Stalk thickness (mm)	
	Mean±SE	CV%	Mean±SE	CV%
P ₁	11.90±0.250	8.12	1.84±0.101	10.15
P ₂	19.17±1.012	12.94	1.28±0.080	15.23
P ₃	18.86±0.471	6.60	1.51±0.098	17.10
P ₄	10.32±0.221	4.42	2.37±0.113	22.60
P ₅	14.91±0.382	7.64	1.89±0.105	21.00
P ₆	14.64±0.361	6.51	1.33±0.080	15.94
P ₇	17.22±0.513	12.62	0.84±0.031	15.48

**Figure 1.** Cacanska lepotica x Stanley (P₁).**Figure 2.** Cacanska Najbolja x Stanley (P₂).**Figure 3.** Stanley x Stanley (P₃).

in all seven hybrids. Flesh percentage 95.76% (Table 2).

Relatively small stone, with an average weight of 1.48 g (Table 1), partly separating from the flesh. Stalk long

(19.17 mm), 1.28 mm thick, therefore strongly adhering to the twig (Table 3). Exhibiting a high degree of absolute (±SE) and relative (CV%) statistical uniformity of the parameters examined.

Hybrid P₃: Developed by crossing cv. Stanley with Stanley. Fruit harvest around 20 August, as that of the parental couple.

Average fruit weight 47.87 g (Table 1 and Figure 3). Elliptic and asymmetrical shape, markedly convex at the stalk base. Dark blue skin, covered with heavy bloom. Yellow-green, firm, juicy mesocarp, with a sweet subacid flavour, 20.00° Brix soluble solids and 96.53% percentage (Table 2). Larger stone than that of former two hybrids, its weight being 1.66 g (Table 1). Stone is partly separating from the flesh. Stalk 18.86 mm in length, 1.51 mm in thickness, strongly attaching the fruit to the twig and easily separating from the twig at harvest (Table 3).

Exhibiting a high degree of absolute (±SE) and relative (CV%) statistical uniformity of the parameters examined.

Hybrid P₄: Developed by crossing Cacanska Lepotica and Stanley. Exhibited the highest-quality traits – appearance, large fruit size, yield, etc. - of all the hybrids examined. Harvest onset around 10 July or 40 days before that of Stanley.

Very large fruit, with an average weight of 59.21 g (Table 1 and Figure 4). Rounded, distinctly but not too markedly furrow, reminiscent of the Cacanska Lepotica fruit. Dark blue skin, covered with intense bloom improving its attractiveness. Yellow-green mesocarp, with a sweet subacid pleasant flavour. Mesocarp percentage the highest of all the hybrids (97.13%). Given the early ripening season, the soluble solids content is high, being 21.40° Brix (Table 2). Proportionately small stone, with an average weight of 1.70 g, fully separating from the mesocarp (Table 1). Short and stout stalk, with an average weight of 10.32 mm, and an average thickness of 2.37 mm (Table 3). But, fruit strongly adhering to the twig, harvest being easily done without any visible damage to the bloom.

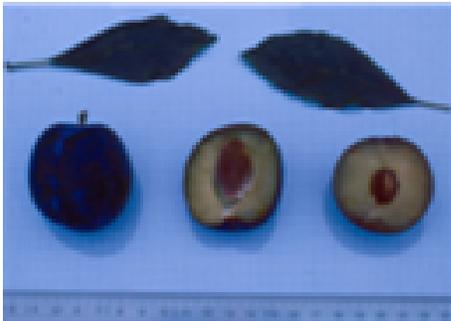


Figure 4. *Cacanska Lepotica* × *Stanley* (P₄).



Figure 5. *Cacanska Lepotica* × *Stanley* (P₅).



Figure 6. *Stanley* × *Stanley* (P₆).

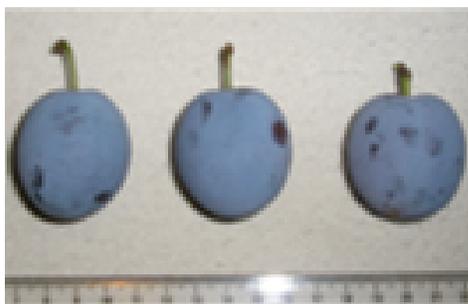


Figure 7. *Cacanska Lepotica* × *Stanley* (P₇).

Exhibiting a high degree of absolute (\pm SE) and relative (CV%) statistical uniformity of the parameters examined.

Hybrid P₅: Derived from the same line of hybrid seedlings as the P₄ hybrid was. Harvest onset around 5 August or two weeks before that of *Stanley*.

Fruit is elliptic, and small to medium large with an average weight of 26.54 g (Table 1 and Figure 5). Dark violet skin. Mesocarp is amber-yellow, firm, juicy, with a pleasant sweet subacid flavour. Flesh percentage 95.78%, and soluble solids content 18.85° Brix (Table 2). Very small stone, with an average weight of 1.12 g, completely separating from the mesocarp (Table 1). Stalk 14.91 mm long, its diameter being 1.89 mm (Table 3).

Exhibiting a high degree of absolute and relative statistical uniformity of the parameters examined.

Hybrid P₆: Developed by crossing cv. *Stanley* with *Stanley*. Harvest in mid-August.

Large to very large fruit, with an average weight of 47.94 g (Table 1 and Figure 6). Elongated rounded shape, blue skin, covered with highly intense bloom. Excellent appearance. Mesocarp is yellow-green, juicy, sweet-subacid, with a very pleasant and characteristic flavour. Flesh percentage 96.93%, the soluble solids content 18.75° Brix (Table 2). Relatively small stone, with an average weight of 1.47 g, completely separating from the flesh (Table 1). Stalk 14.64 mm long, 1.33 mm in diameter (Table 3).

Exhibiting a high degree of absolute (\pm SE) and relative (CV%) statistical uniformity of the parameters examined.

Hybrid P₇. - Developed by crossing cv. *Cacanska Leptotica* and *Stanley*. Harvest onset about 25 August. The fruits harvested at physiological maturity can be stored about 10 days at room temperature.

Small to medium large fruit with an average weight of 29.12 g (Table 1 and Figure 7). Ovate shape, blue skin, covered with intense bloom. Amber, markedly juicy and sweet mesocarp with a pleasant pronounced flavour. Mesocarp percentage 95.57%, soluble solids content 18.90° Brix (Table 2). Small stone with an average weight of 1.29 g (Table 1) and completely separating from the mesocarp. Stalk very long (17.22 mm) and thin, only 0.84 mm in diameter (Table 3).

Exhibiting a high degree of absolute (SE) and relative (CV) statistical uniformity of the parameters examined.

DISCUSSION

Although small, the Republic of Serbia is one of the World's highest producers of plums derived from *P. domestica* L. (Milosevic et al., 2008). The varietal structure is composed of the so-called brandy (autochthonous) cultivars (50%), *Pozegaca* (30%) and traditional world and newly-developed local cultivars (20%). Plum production is burdened with numerous problems, the most

important thereof being: excessive percentage of cultivars with poor productive traits, low and fluctuating yields, low fruit quality and high percentage of sharka-infested trees, which is a separate problem. The disease is particularly dangerous to the Pozegaca, the most commonly grown cultivar in Serbia, exhibiting extreme susceptibility to the presence of this virus (Millosevic, 1997). Since the 1950s, the American plum cultivar Stanley has widely spread substituting Pozegaca in plum plantings. There exist opposing approaches in Serbian professional and scientific circles on the Stanley cultivar cultivation, but it is being welcomed to plum plantings in Serbia due to its high yield, large blue fruit and PPV tolerance (Millosevic, 2002; Ogasanovic et al., 2007). It is only in the last 10-15 years that high-scale cultivation of Cacanska Lepotica, Cacanska Najbolja and Cacanska Rodna has started, the Cacanska Rodna being, however, extremely susceptible to the PPV (sharka). The stated cultivars have been given high importance by Decroocq et al. (2004) from a genetic point of view, and the Cacanska Najbolja cultivar has been used as a parent in a new plum cultivar breeding programme in Geisenheim (Jacob, 2004).

The P₁, P₂, P₃, P₄, P₅, P₆ and P₇ hybrids as offspring's of Cacanska Lepotica, Cacanska Najbolja and Stanley crossings, developed and examined over the 2006-2007 period exhibited good pomological traits, both as seedlings and grafted seedlings in the experimental planting employing highly intensive growing technology. Specifically, some of their traits, that is harvest time, fruit shape, large fruit size, small stone weight and fruit colour surpass those of their parents, Cacanska Lepotica, Cacanska Najbolja, Stanley and P₄ hybrid, in particular (Tables 1 and 3). According to Paunovic et al. (1971, 1975) and Millosevic (2000, 2002), average fruit weights of the Cacanska Lepotica, Cacanska Najbolja and Stanley cultivars in modern Serbian plantings are 38-40, 45 and 38 g, respectively. The P₁, P₃, P₄ and P₆ hybrids were reported to have higher fruit weight as compared to that of their parents, lower one being recorded only with the P₅ and P₇ hybrids. According to Millosevic (2000, 2002), an average soluble solids content of fruit ranges between 9.0-12.0° Brix in the Cacanska Lepotica, Cacanska Najbolja and Stanley cultivars, being much higher in the hybrids examined, that is from 18.75-22.50° Brix (Table 2).

Conclusion

The results obtained and analysed and the research data presented in this study suggest that this is a new genetic material which exhibited positive biological and economic traits over the 1991-2007 period. The largest fruits were recorded with the P₄, P₆ and P₃ hybrids and the smallest stone with the P₅ and P₇ hybrids. The highest flesh percentage was registered with the P₄ and P₆ hybrids and the highest soluble solids content of fruit with the P₂ and

P₄. The P₂ hybrid gave the longest stalk and that of the P₄ was the shortest and thickest.

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REFERENCES

- Decroocq V, Hagen SL, Favé GM, Eyquard PJ, Pierronnet A (2004). Microsatellite markers in the hexaploid *Prunus domestica* species and parentage lineage of three European plum cultivars using nuclear and chloroplast simple-sequence repeats. *Mol. Breed.* 13: 135-142.
- Hadzivukovic S (1979). *Statistika. Izdavacka radna organizacija Rad, Beograd* pp: 1-245.
- Jacob BH (2004). Experiences with new Mirabelle breeding program from Geisenheim Belamura and Miragrande as fruit for fresh market and for distillation. In: 8th Int. Symp. on Plum and Prune, Book of Abstracts, Lofthus, Norway p. 68
- Millosevic T (1997). Special Topics in Fruit Growing. Fac. of Agron. and Community for Fruits and Vegetables, Cacak-Belgrade, (in Serbian). pp. 99-134
- Millosevic T (1998). Pomological characteristics of the plum hybrids seedlings. In: XXV Int. Hort. Congress (ISHS), Book of Abstracts, Brussels, Benelux p. 462
- Millosevic T (2002). *Sljiva - tehnologija gajenja. Agronomski fakultet, Cacak* pp. 67-69.
- Millosevic T, Zornic B, Glisic I (2008). A comparison of low-density and high-density plum plantings for differences in establishment and management costs, and in returns over the first three growing seasons. *J. Hort. Sci. Biotech.* 83: 539-542.
- Millosevic T. (2000). Osobine novih hibrida sljive. In: Naucni simpozijum sa medjunarodnim ucescem Dani sljive, Zbornik radova, Kostunici, Srbija pp. 163-170.
- Ogasanovic D (1990). Valjevka - nova sorta sljive za susenje. *Jug. vocarstvo* 14: 13-16.
- Ogasanovic D, Plazinic R, Rankovic M, Stamenkovic S, Milinkovic V (2007). Pomological characteristics of new plum cultivars developed in Cacak. *Acta Hort.* 734: 183-186.
- Paunovic S, Gavrilovic M, Mistic P (1971). Biolosko-pomoloske osobine najboljih hibrida i klonova sljive. *Jug. vocarstvo* 18: 357-364.
- Paunovic S, Ogasanovic D (1980). Biolosko-privredne osobine perspektivnih hibrida sljive. *Jug. Vocarstvo*, 14: 71-77.
- Paunovic SA, Gavrilovic M, Mistic PD (1975). The breeding and introduction of new plum selections. *Acta Hort.* 48: 91-110.
- Zanetto A, Maggoni L, Tobutt KR, Dosba F (2002). *Prunus* genetic resources in Europe: Achievement and perspectives of a networking activity. *Genet. Res. Crop Ev.* 49: 331-337.