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Productivity and tree performance of new plum cultivars from the Czech Republic

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Abstract

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This 12-year study was conducted to evaluate the performance of new plum cultivars from the Czech Republic. A new cultivar, 'Stáňa', was the most productive, followed by 'Kamir' and the standard cultivar 'Stanley'. The new plum cultivar 'Stáňa' also had the highest mean yield per cubic meter of tree canopy. Next in order of production efficiency were 'Stanley', 'Amátka', 'Kamir' and 'Čačanska lepotica'. According to canopy volume, the most vigorous cultivar was 'Kamir' followed by 'Samera' and 'Stáňa'. The least vigorous was 'Dwarf', having a canopy volume distinctly smaller than 'Amátka', which was next in the order. The shape of tree canopies ranged from 'Dwarf', which had the most upright canopy, to 'Simona' with a more distinctly overhanging canopy at the opposite extreme. The highest percentages of fruiting on first and second year wood were observed on trees of 'Simona' and 'Čačanska lepotica'.

Keywords: *Prunus Domestica*; novelties; canopy size; production efficiency; fruiting habit

Evaluation of plums has a long tradition at the Research and Breeding Institute of Pomology in Holovousy. A range of new plum cultivars was evaluated there in a high-density experimental orchard established in the spring of 2004 with a spacing of 5 × 1.5 m. Trees were trained as spindles on 'St. Julien A' rootstock. The highest yields and precocity of fruiting were recorded for the cultivars 'Tophit', 'Jojo', 'Elena' and 'President', whereas the cultivars 'Katinka', 'Jojo', 'Topper' and 'Empress' had the highest yield efficiencies (Blažek, Pištěková 2009).

Development of new plum cultivars with good fruit quality, reduced tree vigour and regular productivity (Rusterholz, Krebs 2001) is still very important for the cultivation of the common plum. At least ten years ago it was observed worldwide that a trend towards high density planting could also be applied in plum groves established for mechanical fruit harvesting in order to ensure earlier returns on investments, economical use of labour and the return of high yields (Peppelman et al. 2007). Plum trees on semi-dwarf rootstock seem to be the most suitable for the new technology of fruit harvesting. Characterised by moderate growth, such trees can be easily kept at the optimum size for the allotted space (Day et al. 2013).

The tree vigour of plum cultivars has usually been evaluated based on their crown volume and trunk circumference (Ivanova et al. 2001). According to the results of a plum rootstock trial from Romania, all cultivars grafted onto 'Saint Julien' rootstock came into bearing in the second year after planting, but their production was lower than trees on 'Myrobalan C5' rootstock from the third year (Butac et al. 2014). In contrast, the 'Saint Julien' rootstock was previously evaluated more positively in Estonia (Jänes et al. 2005). In another study of plum cultivars in Romania, 'Čačanska lepotica' had the

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highest yield per tree, and it was slightly more productive than 'Stanley' (Butac et al. 2012, 2014).

'Stanley' was also observed to be the best variety regarding overall tree productivity based on mean yield per hectare among twelve different plum cultivars evaluated in Bulgaria (Ivanova et al. 2001). Similar results concerning this cultivar have also been reported from Italy (Liverani et al. 2010).

Based on a recent rootstock study from Holovousy, 20-year-old trees of 'Čačanska lepotica' on Pixy rootstock had a trunk cross-sectional area about 21.9% smaller than trees of 'Stanley', but yield efficiency was 18.5% higher (Mészáros et al. 2015). The lower tree vigour of 'Čačanska lepotica' has also been reported from Serbia (Milosevic, Milosevic 2011).

Plum cultivars differ from each other in their fruiting habits. Whereas some exhibit the highest percentage of fruiting on 1-year-old wood, others are bearing predominantly on 2 and 3-year-old wood, while cultivars such as 'Stanley' distribute their bearing on woods of different ages (Bozhkova 2004).

Plum cultivars also differ significantly from each other in their fruiting wood habits. Results from Bulgaria showed that the highest percentage of fruit harvest on 1-year old wood was found in the 'Čačanska lepotica' cultivar, in the case of 'Tuleu timpuriu' bearing was predominantly on 2- and 3-year-old wood, while 'Stanley' distributed its bearing steadily on the skeleton branches (Bozhkova 2004).

Development of a new plum cultivar by classical breeding is a long-term process requiring at least 10 to 12 years (Hartmann 1994; Blažek, Pištěková 2009). Based on the results of a recent paper from the US, however, it appears that this process can be substantially and that the whole process of the development of new plum cultivars can be sped up considerably (Scorza et al. 2013).

MATERIAL AND METHODS

The experimental orchard of plum cultivars budded on 'St. Julien A' rootstock was established at Holovousy in 2004. One-year-old nursery trees obtained after summer budding were planted in a spacing of 5 × 1 m. From each cultivar at least three trees were grown and evaluated. The locality is characterised by an average annual temperature of 8.4°C and by an average rainfall of about 663.5 mm. The climatic conditions at Holovousy are characterised by an average annual temperature of 8.1°C and an average annual rainfall of 650 mm. The soil is medium loam sand with a rather deep cultivated layer on gravelly substrate. The orchard is located at an elevation of 280 m and is situated on a very gentle slope facing the north.

Orchard management is based on using mown grass kept in driveways and herbicide strips (1.5 m) based upon application of contact herbicides along the rows of trees. Trees were trained as spindles using wooden stakes as supports at the beginning to help in the process of tree canopy training in the first years. No irrigation was applied in the orchard. Spraying treatments against pests and diseases were conducted according to the recommendations for commercial orchards.

The trees started their fruiting stage in 2005, i.e., in the second year after planting. Since that time onwards up to 2016, annually weights of fruits harvested from each tree were gathered and canopy sizes were measured. In the last three years (2014–2016), fruiting patterns according to the age of fruiting wood were estimated as percentages. In the last year (2016), the trunk cross-sectional area of each tree was measured and tree growth habit was characterised according to a 1–9 rating scale (1 – most upright; 9 – most overhanging).

Values of production efficiency were calculated for the years 2007–2016, but with the exclusion of the year 2011, when almost total damage of flowers by late spring frost took place.

Data were statistically evaluated using analysis of variance (ANOVA) procedures.

RESULTS

Yields and productivity

The overall survey of quantities of fruits (kg per tree) harvested during the whole period of this study from 2005 to 2016 according to cultivars is provided in Table 1. The year 2011 represented an exception within the whole period of this evaluation as, owing to the extreme damage of flowers by late spring frost, there was no harvest in the cultivars at all or only negligible one. The most productive cultivar was 'Stáňa', which produced in total 150.5 kg of fruits per tree for the whole period of the study. It was followed by 'Kamir' with a total harvest of 135.7 kg and the standard cultivar 'Stan-

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Table 1. Fruit harvest per tree in kg from 2005 to 2016

Cultivar	The mean weight of fruit harvest per tree												
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Amátka	2.3	8.0	11.2	13.3	12.8	13.9	0	13.0	8.3	4.6	13.6	5.6	106.5
Dwarf	0.4	2.1	1.0	2.4	2.9	4.5	0.1	0.6	2.0	0.7	4.9	5.3	27.0
Čačanska lepotica	0.8	3.2	10.8	7.4	11.7	8.5	0	11.9	14.5	10.8	17.8	11.8	109.2
Kamir	1.7	6.3	10.7	14.8	16.4	17.6	1.3	5.5	19.6	2.2	24.0	15.7	135.7
Samera	0	2.5	8.9	8.0	14.6	12.2	0	19.3	12.8	7.1	20.6	8.5	114.5
Simona	0	3.2	9.4	1.8	7.8	6.6	0	5.8	4.3	9.6	5.3	15.4	69.4
Stanley	0.7	3.9	7.5	12.4	13.5	14.5	0.5	19.5	13.9	11.6	21.3	7.0	126.2
Stáňa	2.0	8.7	11.2	9.6	16.7	12.0	2.0	23.6	10.8	20.0	26.6	7.2	150.5
LSD (P = 0.05)	0.25	0.77	1.14	1.80	2.21	2.15	0.27	3.34	1.97	2.08	2.93	1.52	14.7

ley', which produced 126.2 kg and 'Samera' with 114.5 kg. The lowest total harvest per tree of only 27 kg was observed in 'Dwarf'. In increasing order, it was preceded by 'Simona' (68.4 kg), 'Amátka' (106.5 kg) and the second standard 'Čačanska lepotica' (109.2 kg). The absolute highest yields per tree were recorded in 2015 when 'Stáňa' produced 26.6 kg, 'Kamir' 24.0 kg and 'Stanley' 21.3 kg.

The evaluated cultivars differed significantly also in the onset of fruiting. The most precocious cultivars in terms of fruiting were 'Amátka' and 'Stáňa', whereas 'Samera' and 'Simona' reached this stage one year later.

Tree vigour

Tree vigour was evaluated based on trunk cross-sectional area and canopy volume measured at the end of the growing season in 2016 (Table 2). The most vigorous according to the trunk cross-sectional area was 'Stáňa' (59.6 cm^2). In decreasing order, it was followed by 'Kamir' (59.6 cm^2), 'Stanley' (59.6 cm^2) and 'Simona' (59.6 cm^2). The least vigorous according to the trunk cross-sectional area was 'Dwarf' (14.5 cm^2). In increasing order, it was preceded by 'Amátka' (44.5 cm^2), 'Simona' (47.2 cm^2) and 'Čačanska lepotica' (49.6 cm^2).

On the basis of canopy volume, the most vigorous was 'Kamir' (2.61 m^3). In decreasing order, it was followed by 'Samera' (2.56 m^3), 'Stáňa' (2.41 m^3) and 'Stanley' (2.32 m^3). The least vigorous, also according to the canopy volume, was 'Dwarf' (0.89 m^3). In increasing order, it was preceded by 'Amátka' (1.85 m^3), 'Simona' (1.93 m^3) and 'Čačanska lepotica' (2.22 m^3).

Canopy shape

The classification of the canopy shapes of the assessed cultivars according to their sectional outline is provided in Table 2. The most upright was the canopy of 'Dwarf'. The canopy of 'Stanley' was

Table 2. Mean tree parameters of cultivars at the end of the growing season in 2016

Cultivar	Trunk cross section area (cm^2)			Canopy volume (m^3)			Canopy shape
	mean	min.	max.	mean	min.	max.	
Amátka	44.5	28.5	52.3	1.85	1.23	2.47	6
Dwarf	14.5	12.7	16.9	0.89	0.69	1.14	3
Čačanska lepotica	49.6	32.4	61.7	2.22	1.71	2.61	5
Kamir	56.2	40.6	62.7	2.61	2.18	2.98	5
Samera	53.7	38.9	61.7	2.56	1.83	3.01	6
Simona	47.2	34.2	53.3	1.93	1.67	2.30	7
Stanley	54.1	45.0	60.7	2.32	2.07	2.52	4
Stáňa	59.6	41.8	64.1	2.41	2.10	3.25	5
LSD (P = 0.05)	4.57			0.24			

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Table 3. Cultivar productivity expressed as canopy volume in cubic meters (kg/m^3)

Cultivar	Mean	Max
Amátka	7.31	12.04
Dwarf	4.04	7.14
Čačanska lepotica	6.55	8.79
Kamir	6.83	10.11
Samera	6.22	10.06
Simona	4.53	7.94
Stanley	7.55	11.20
Stáňa	8.10	13.07

only slightly upright. The intermediate globular form (grade 5) was observed in three cultivars – 'Čačanska lepotica', 'Kamir' and 'Stáňa'. A slightly overhanging canopy was observed in 'Amátka' and 'Samera'. A more distinctly overhanging canopy (grade 7) was found in 'Simona'.

Production efficiency

The cultivar 'Stáňa' was distinguished by the highest mean yield per cubic meter of tree canopy at the level of 8.1 kg (Table 3). In decreasing order, it was followed by 'Stanley' (7.6 kg), 'Amátka' (7.3 kg), 'Kamir' (6.8 kg), 'Čačanska lepotica' (6.5 kg) and 'Samera' (6.2 kg). Overall, the smallest yield per cubic meter of tree canopy was found in 'Dwarf' (4 kg), followed by 'Simona' (4.5 kg).

The cultivar 'Stáňa' also had the maximum yield per cubic meter of tree canopy, equal to 13.1 kg. It was followed in this characteristic by 'Amátka' (12 kg), 'Stanley' (11.2 kg) 'Kamir' and 'Simona' (both with 11.1 kg).

Fruiting pattern according to the age of fruiting wood

The proportioning of fruiting according to the age of fruiting wood in the evaluated cultivars is given in Table 4. 'Simona' was distinguished by the highest percentage of fruiting on first and second year wood (53%), followed by 'Čačanska lepotica' (42.1%). The opposite pattern of fruiting was observed in 'Samera', with a significant share of fruiting on older fruiting wood. A similar pattern of fruiting was also observed in 'Stanley' and 'Kamir'.

DISCUSSION

General levels of productivity concerning the standard cultivar yields recorded in this study are similar to values reported from similar dense plantings (Blažek, Kneifl 2005).

Our results regarding the productivity of the standard cultivar 'Stanley' are fully in agreement with findings from abroad (Ivanova et al. 2001; Liverani et al. 2010). In contrast, our results concerning the productivity of the second standard cultivar 'Čačanska lepotica' are different from a study in Romania (Butac et al. 2012, 2014). The relatively lower yields in our study might be explained by the somewhat colder climatic conditions in the Czech Republic in comparison to Romania.

Our finding concerning the older age of fruiting wood in the case of the standard cultivar 'Stanley' essentially confirms previous findings from Serbia (Bozhkova 2014).

The most productive cultivar in the early years of the evaluation was 'Kamir', but later on its productivity was slightly reduced by its stronger tree

Table 4. The proportioning (%) of fruit according to the age of the fruiting wood

Cultivar	The age of fruiting wood				
	1st year	2nd year	3rd year	4th year	5th year and older
Amátka	4.5	28.6	41.8	15.9	9.3
Dwarf	2.6	39.7	29.8	17.7	10.1
Čačanska lepotica	17.5	24.6	29.8	19.9	8.3
Kamir	2.1	33.5	36.1	15.8	12.5
Samera	0	30.4	36.5	17.6	15.4
Simona	16.5	36.5	31.9	8.5	6.6
Stanley	2.8	28.7	36.9	19.4	12.1
Stáňa	22.9	37.6	20.5	11.2	7.9

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vigour. The cultivar 'Simona' had a moderately smaller yield than 'Kamir', but its yield efficiency was the highest due to its smaller canopy size (Blažek, Šecová 2013).

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