

VIGOUR, YIELD COMPONENTS AND FRUIT WEIGHT OF SOME PLUM (*Prunus domestica* L.) CULTIVARS DURING EARLY YEARS AFTER PLANTING

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Abstract

This study presents three-year results on the effect of pomological practices [shoot bending, pinching off the shoot tip (decapitation), shoot notching, heading back to 3-5 buds at the poorly developed basal leaf zone] undertaken during the growing season in 5 plum cultivars. The research was conducted from planting date until the fifth growing season, involving cvs. Čačanska Rana, Čačanska Lepotica, Čačanska Najbolja, Čačanska Rodna and Stanley, grafted onto Myrobalan seedling rootstock.

The results showed that tree vigour as measured by trunk cross-sectional area was highest in cv. Čačanska Najbolja (55.14 cm²) and lowest in Čačanska Lepotica (27.06 cm²). Čačanska Rodna and Čačanska Najbolja produced their first yields already in the second year after planting. All cultivars obtained their first substantial yields already in the third year after planting (Čačanska Rana 2.48 t ha⁻¹, Stanley 4.17 t ha⁻¹, Čačanska Rodna 7.31 t ha⁻¹, Čačanska Najbolja 7.68 t ha⁻¹, Čačanska Lepotica 8.35 t ha⁻¹). Cumulative yield was highest in Čačanska Rodna (47.18 t ha⁻¹), and lowest in Čačanska Rana (11.09 t ha⁻¹). Yield efficiency showed variations across cultivars and years of the study, whereas the fruit weight values were not significantly different from the literature data reported for the cultivars tested, and ranged from 52.75 g in Čačanska Rana to 24.83 g in Čačanska Rodna.

The use of the above pomological practices during the growing season induced early fruiting, satisfactory to excellent yields in the early years after planting, and reduced tree vigour in the plum cultivars analysed.

Keywords: plum, pomological practices, summer pruning, yield.

Introduction

In terms of the volume of production, plums are the most important fruits in Serbia. In 2010, Serbia ranked second in Europe and third worldwide after China and Romania, with an annual plum production of 426.846 t and an acreage over 130.000 ha of land (FAOSTAT, 2012). The most widely grown cultivars include Čačanska Lepotica, Čačanska Rodna, Stanley, Čačanska Najbolja and Čačanska Rana (Milošević and Milošević, 2011). According to Paunovic et al. (2011), the most dominant and maybe the only rootstock used for plum grafting is Myrobalan seedling (*Prunus cerasifera*, Ehrh.). Primarily due to its vigour, the Myrobalan rootstock causes certain problems in plum cultivation such as late fruit-bearing and high tree vigour (Mika et al., 2001; Milosevic et al., 2008). This fact, along with some other deficiencies of this rootstock, is the reason why some authors do not consider Myrobalan for use in highly intensive plum production (Elfving, 1988; Gaash et al., 1989; Weber et al., 1994). In order to overcome and solve these problems associated with Myrobalan rootstock, adequate pomological practices should be employed to a large extent

during the growing season instead of winter pruning, in the early years after planting (Glišić and Milošević, 2006). Shoot bending, pinching off the shoot tip (decapitation), shoot notching, and summer pruning of shoots can contribute to a reduction in and subsequent control of tree vigour, as well as to early fruiting in plum trees (Mika and Piatkowski, 1989; Dimkova and Vitanova, 2001; Mičić et al., 2005; Gonda, 2006).

The objective of this study was to evaluate the effect of pomological treatments employed during the growing season in the early years after planting on tree vigour and yield components of different plum cultivars grafted onto Myrobalan seedling rootstock.

Material and methods

The research was conducted in a plum orchard at Gornja Gorevnica, 9 km northwest of Čačak (20°57'48" N; 20°19'31" E; 396 m a.s.l). The plum cultivars used in the experiment included Čačanska Rana, Čačanska Lepotica, Čačanska Najbolja, Čačanska Rodna and Stanley. Myrobalan (*Prunus cerasifera* Ehrh.) seedling was used as the rootstock. The orchard was planted at a spacing of 4 m x 2 m (1.250 trees ha⁻¹). Spindle bush training system was used. During the first 4 years (each year), the following pomological treatments were applied during the growing season instead of winter pruning:

1. shoot bending, using toothpicks when shoots reached 30-40 cm in length;
2. pinching off shoot tips (decapitation), applied to 40-50 cm long shoots adequately positioned within the crown. Inadequately positioned or extremely vigorous shoots in the crown were completely pruned off during the growing season;
3. shoot notching, conducted at the stage of bud scale separation (stage 03 of the BBCH scale of vegetative bud development in stone fruit trees (Meier, 2001); with the light green bud sections clearly visible;
4. heading back to 3-5 buds at the poorly developed basal leaf zone, performed 60 days after the end of flowering (mostly the second half of June).

From the second to the fifth growing season, measurements included trunk diameter at 10 cm above the graft union, yield per tree, yield per unit area, and fruit weight, whereas trunk cross-sectional area and yield efficiency were calculated. The experiment was conducted in 3 replications, each with 10 plum cultivars i.e. 20 fruits.

The data were subjected to analysis of variance, and differences between arithmetic means were assessed by the LSD test at $P < 0.05$ and $P < 0.01$ using the statistical software SPSS 5.0 (SPSS Inc., Chicago, IL, USA).

Results and discussion

The results on the effect of pomological practices used during the growing season on the trunk cross-sectional area (TCSA) of plum cultivars are presented in Graph 1.

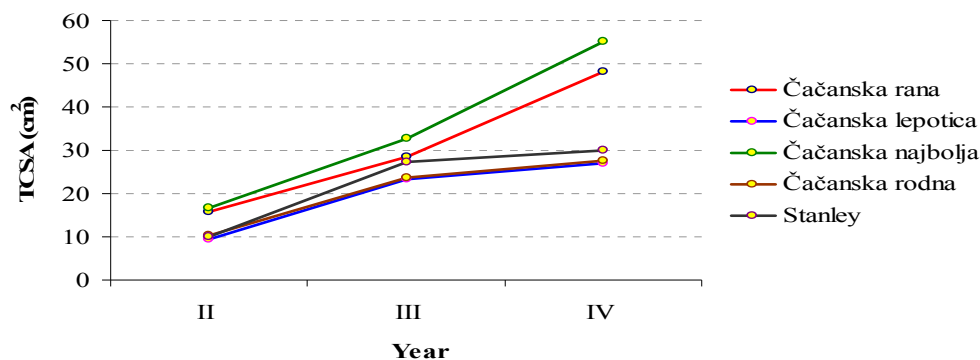


Fig. 1. Trunk-cross sectional area (TCSA) of plum cultivars

The results show that, during all years, TCSA was lowest in cv. Čačanska Lepotica, followed by cvs. Čačanska Rodna and Stanley, and highest in Čačanska Rana and Čačanska Najbolja. At the end of the fourth growing season, TCSA was $27.06 \pm 1.12 \text{ cm}^2$ in Čačanska Lepotica, $27.43 \pm 1.02 \text{ cm}^2$ in Čačanska Rodna and $29.99 \pm 2.05 \text{ cm}^2$ in Stanley, whereas the highest values were found in Čačanska Rana - $48.32 \pm 3.90 \text{ cm}^2$ and Čačanska Najbolja - $55.14 \pm 4.10 \text{ cm}^2$. The difference between Čačanska Najbolja and Čačanska Rana was statistically significant, whereas the vigour of both cultivars highly significantly differed from that of Stanley, Čačanska Rodna and Čačanska Lepotica, which showed no significant differences at the end of the fourth growing season.

TCSA values were almost identical to those obtained by Dinkova et al. (2007) who produced plum cultivars on Myrobalan seedling, but with no substantial use of pomological practices during the growing season. This suggests that it is difficult to affect TCSA values by pomological treatments during the first and second years after planting. However, in the third and fourth growing seasons, in the present study, tree vigour was lower than that of the same cultivars grown at a higher spacing with the use of winter pruning only (Milošević et al., 2001; Vitanova et al., 2007).

The results on the effect of pomological treatments applied during the growing season on yield components in plum cultivars are given in Tab. 1.

Tab. 1. Yield components of plum cultivars

Cultivar	Yield per tree (kg)			Yield per ha (t)			Cumulative yield (t ha ⁻¹)
	2 nd year	3 rd year	4 th year	2 nd year	3 rd year	4 th year	
Čačanska Rana	/	1.99±0.09d	6.88±0.05d	/	2.48±0.12d	8.61±0.08d	11.09±0.09d
Čačanska Lepotica	/	6.68±0.07a	11.45±0.09c	/	8.35±0.09a	14.31±1.30c	22.66±2.08c
Čačanska Najbolja	1.47±0.10a	6.14±0.07ab	4.10±0.05d	1.85±1.40a	7.68±0.08ab	5.12±0.07d	14.65±1.12d
Čačanska Rodna	1.08±0.08b	5.85±0.04b	30.82±2.88a	1.35±0.10b	7.31±0.07b	38.52±3.50a	47.18±3.90a
Stanley	/	3.34±0.03c	22.70±1.85b	/	4.17±0.04c	28.38±2.15b	32.55±3.00b

Čačanska Rodna and Čačanska Najbolja produced their first yields already in the second year after planting ($1.35 \pm 0.10 \text{ t ha}^{-1}$ and $1.85 \pm 1.40 \text{ t ha}^{-1}$, respectively). The first substantial yield in all cultivars was obtained in the third year after planting, ranging from $2.48 \pm 0.12 \text{ t ha}^{-1}$ in Čačanska Rana to $8.35 \pm 0.09 \text{ t ha}^{-1}$ in Čačanska Lepotica. In the fourth year after planting, cvs. Čačanska Rodna and Stanley attained almost maximum yield potential – $38.52 \pm 3.50 \text{ t ha}^{-1}$ and $28.38 \pm 2.15 \text{ t ha}^{-1}$, respectively. Čačanska Lepotica gave a moderate yield – $14.31 \pm 1.30 \text{ t ha}^{-1}$. Likewise, the yield of fresh market cultivars Čačanska Rana and Čačanska Najbolja in the fourth year after planting was not negligible – $8.61 \pm 0.08 \text{ t ha}^{-1}$ and $5.12 \pm 0.07 \text{ t ha}^{-1}$, respectively. The cumulative yield obtained in the first four years after planting was lowest in Čačanska Rana ($11.09 \pm 0.09 \text{ t ha}^{-1}$) and somewhat higher in Čačanska Najbolja ($14.65 \pm 1.12 \text{ t ha}^{-1}$), but the difference between the two cultivars was not significant. Cumulative yield was $22.66 \pm 2.08 \text{ t ha}^{-1}$ in Čačanska Lepotica, $32.55 \pm 3.00 \text{ t ha}^{-1}$ in Stanley, and $47.18 \pm 3.90 \text{ t ha}^{-1}$ in Čačanska Rodna. The differences among the cultivars were highly significant, as well as those compared to Čačanska Rana and Čačanska Najbolja.

The results on yield typically provide the best indication and estimate of the care and management practices and cultivation systems used. In this study, the first yield was attained as early as in the second year, which is highly important in terms of the return on investment, but also due to the fact that vigour is best controlled by yield (Mika, 1992; Blažek et al.,

2004). Mičić et al. (2005) evaluated plum cultivars trained to slender spindle and grown on Myrobalan rootstock, and reported an initial yield of 48-112 fruits per tree or 1.2-2.8 kg per tree in Čačanska Rodna in the second year. Similar results were obtained in the present study. The yield produced in the third and fourth years after planting was almost double the yield reported by Mitrović et al. (2005) in a cultivation system without the use of shoot bending and other pomological treatments during the growing season. For the sake of illustration, the yield produced in the third year in the present study was similar to that obtained by Janković et al. (1997) from the fifth to the eighth year at a spacing of 6 m x 4 m, with winter pruning applied. The use of pomological treatments during the growing season instead of winter pruning significantly contributed to early cropping and early production of substantial yields. The vegetative development during the initial years after planting was characterised by an intense growth of shoots, due to the use of Myrobalan seedling as a rootstock. Shoot bending during the growing season and other practices reduce the mobility of nitrogen and cause carbohydrate accumulation in the shoots by the end of the growing season (Gaudillère et al., 1992; Moing et al., 1993). This resulted in a high degree of flower bud differentiation in all cultivars and fruit-bearing in some cultivars in the second year, and led to significant yields of all cultivars already in the third year.

The results on the effect of pomological practices used during the growing season on yield efficiency and fruit weight in plum cultivars are presented in Tab. 2.

Tab. 2. Yield efficiency and fruit weight of plum cultivars

Cultivar	Yield efficiency (kg cm ⁻²)				Fruit weight (g)			
	2 nd year	3 rd year	4 th year	Average	2 nd year	3 rd year	4 th year	Average
Čačanska Rana	/	0.07±0.01c	0.14±0.01 d	0.10±0.01 c	/	52.75±4.11 a	50.26±4.02 a	51.50±4.06 a
Čačanska Lepotica	/	0.29±0.02a	0.42±0.03 c	0.36±0.03 b	/	36.69±1.15 b	32.65±1.02 b	34.67±1.08 b
Čačanska Najbolja	0.09±0.01	0.28±0.01a	0.07±0.01 d	0.14±0.01 c	51.27±4.88 a	48.80±3.20 a	51.74±4.00 a	50.60±4.01 a
Čačanska Rodna	0.10±0.01	0.25±0.01a	1.12±0.09 a	0.49±0.04 a	25.26±1.12 b	28.75±2.00 c	20.48±0.16 c	24.83±1.09 c
Stanley	/	0.12±0.01b	0.75±0.03 b	0.43±0.02 ab	/	36.61±2.03 b	33.49±3.05 b	35.05±2.54 b

The average yield efficiency was lowest in Čačanska Rana (0.10±0.01 kg cm⁻²), and somewhat higher in Čačanska Najbolja (0.14±0.01 kg cm⁻²). However, the difference between the two cultivars was not statistically significant. Significantly higher yield efficiency values were obtained in Čačanska Lepotica (0.36±0.03 kg cm⁻²), Stanley (0.43±0.02 kg cm⁻²) and Čačanska Rodna (0.49±0.04 kg cm⁻²). Although Čačanska Rodna and Stanley gave the highest values for yield efficiency, they exhibited very large variations across years, whereas Čačanska Lepotica had stable yield efficiency throughout the study. These results completely comply with those of Nenadović-Mratinić et al. (2007), who reported highly stable yields of Čačanska Lepotica during a three-year study, as compared to Čačanska Rodna and Stanley. In general, the average values of yield efficiency are satisfactory and in agreement with the results obtained by other authors in highly intensive plum orchards (Blažek et al., 2004; Meland, 2005). The average values obtained for fruit weight were consistent with cultivar-specific traits. The average fruit weight was lowest in Čačanska Rodna (24.83±1.09 g), significantly higher in Čačanska Lepotica (34.67±1.08 g) and Stanley (35.05±2.54 g), and highest in Čačanska Najbolja and Čačanska Rana (50.60±4.01 g and 51.50±4.06 g, respectively). Fruit weight showed differences across years, and was found to correlate inversely with yield. Sosna (2010) reported an average fruit weight of Čačanska Lepotica of 31-32 g, but a total annual yield of over 32 t ha⁻¹. The average values of fruit weight in the present study are mostly in agreement with the findings obtained under different cultivation

systems by many authors (Mitrović et al., 2005; Magyar and Hrotkó, 2006; Vitanova et al., 2007; Sosna 2010). The pomological practices used during the growing season did not significantly contribute to obtaining a stable increase in fruit weight in plum cultivars during the initial cropping years.

Conclusion

The pomological practices used during the growing season in plum cultivars in the early years after planting induced a reduction in tree vigour as measured by trunk cross-sectional area (TCSA). Reduced vigour was highest in Čačanska Lepotica, Čačanska Rodna and Stanley, and somewhat lower in Čačanska Rana and Čačanska Najbolja.

Čačanska Rodna and Čačanska Najbolja produced their first yields already in the second year after planting. All cultivars obtained their first substantial yields already in the third year after planting. Cumulative yield by the end of the fourth year was highest in Čačanska Rodna, followed by Stanley and Čačanska Lepotica. Likewise, the yield of fresh market cultivars Čačanska Rana and Čačanska Najbolja was not negligible.

Yield efficiency was highest in Čačanska Rodna and Stanley, and most stable throughout the years in Čačanska Lepotica.

The results on fruit weight were in agreement with cultivar-specific traits, with Čačanska Rana and Čačanska Rodna obtaining the highest and lowest values, respectively.

In the early years after plum planting, the pomological treatments used during the growing season induced reduced tree vigour, early fruiting, and satisfactory to very high yields in the third and fourth growing seasons, but did not lead to increased fruit weight in the plum cultivars analysed.

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