

INFLUENCE OF ROOTSTOCKS ON THE PROPERTIES OF FRUITING TWIGS IN PLUM CULTIVARS

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Abstract

The paper presents the results of research on the influence of three clonal rootstocks ('Pixy', 'Fereley' and 'St. Julien A') and one seedling rootstock (Myrobalan as a control) on the properties of fruiting twigs of three table plums cultivars ('Čačanska Rana', 'Čačanska Lepotica' and 'Čačanska Najbolja') for a period of three years (2013-2015). Morphological properties of fruiting twigs (long and short): length, thickness, number of flower buds and vegetative buds were examined. The average length of long fruiting twigs was from 51.4 cm to 73.4 cm. The results of the study showed that clonal rootstocks 'Pixy' had a statistically significant influence on the lowest length and thickness of long fruiting twigs. The medium vigorous clonal rootstock 'Fereley' had a statistically significant influence on the formation of the highest number of the flower buds per twig. Myrobalan seedling rootstock had the highest number of the vegetative buds per twig. Cultivar 'Čačanska Rana' had lower number of the flower buds per twig in relation to 'Čačanska Lepotica' and 'Čačanska Najbolja' cultivars. The average length of short fruiting twigs was from 2.8 cm to 7.1 cm. Number of flower buds per short fruiting twig ranged from 2.3 to 4.8, while the number of vegetative buds ranged from 2.4 to 4.1. Myrobalan seedling rootstock had influence on the formation of lower number of flower buds per short fruiting twigs in relation to clonal rootstocks.

Key words: *Prunus domestica*, rootstock, short fruiting twigs, long fruiting twigs, buds.

Introduction

Plum is the most important fruit species in Serbia. The average production of 466,735 t in the period 2010-2012 ranks Serbia on the 3rd place in the world behind China and Romania (FAO, 2016). Despite of the high production, there are some negative characteristics: big share of old orchards, out-of-date cultivars, and inadequate application of cultural practices.

Intensification of plum production is necessary for the achievement of a high and regular yields and good quality of fruits. It is necessary to plant new orchards with virus-free nursery trees, to introduce new quality cultivars, and to apply regularly cultural practices, with special emphasis on soil management, fertilization, irrigation, pruning and plant protection. The pruning is one of the most complex practices in fruit production. For the proper pruning performance it is necessary to know the basic physiological properties of species and cultivar and the morphology of bearing wood, e.g. properties of fruiting twigs.

Veličković et al. (1997) analyzed the fruiting twigs of plum in function of cultivars and combinations cultivar/rootstock. They found significant differences between plum cultivars in the share of different types of fruiting twigs. Significant differences were found in the flower buds density in different species and cultivars of stone fruits, which are directly related to yield (*Albuquerque et al.*, 2004; *Thurzó et al.*, 2006; *Nenadović-Mratinić et al.*, 2007; *Milatovic et al.*,

2010). Cultivars which are characterized with higher flower bud density are adapted to the conditions of continental climate, considering that this increases the probability of survival of generative organs due to the frost appearance, thereby provides the higher yield (*Okie and Werner, 1996*).

The number of flower buds per fruiting twig is primarily caused by genetic factors and it is correlated with the yield (*Milatović et al., 2010*). The intensity of the flower bud formation on the short fruiting twigs is significantly reduced with increasing of the bearing woodage. The density of flower buds is important for determination of the intensity of pruning, because the cultivars with higher number of flower buds require heavy pruning, while the cultivars with less number of flower buds require light pruning (*Milatović and Đurović, 2010*).

The aim of this study was to examine the influence of rootstocks on the morphological properties of long and short fruiting twigs on table plums cultivars. On the basis of the results obtained, the recommendations will be done for pruning performance, which is the most important cultural practice for yield regulation.

Materials and methods

The study was conducted in the plum orchard at the Experimental Station “Radmilovac” of the Faculty of Agriculture in Belgrade (Serbia). During the three-year period (2013-2015) the influence of a seedling rootstock (Myrobalan as a control) and three clonal rootstocks (‘Pixy’, ‘Fereley’ and ‘St. Julien A’) was studied on the properties of fruiting twigs of three table plum cultivars (‘Čačanska Rana’, ‘Čačanska Lepotica’ and ‘Čačanska Najbolja’).

The orchard was planted in spring of 2010. Planting distance is 4 m between rows, and in the row different distances were applied depending on the rootstock vigor: 2.3 m for Myrobalan seedling, 2.0 m for ‘Fereley’ and ‘St. Julien A’ and 1.7 m for ‘Pixy’. Training system is Spindle. Standard cultural practices were applied, including drip irrigation. Every combination cultivar/rootstock was represented by six trees (two replications with three trees).

The fruiting twigs were taken in the spring, before flowering. From each combination cultivar/rootstock were taken 20 long fruiting twigs (shoots) and five two-year old twigs, where all short fruiting twigs (spurs) were analyzed. Length of twigs was measured with a meter, and thickness with a caliper. Number of flower and vegetative buds was registered on every node. The density of flower buds was calculated as the number of flower buds per 1 m length of fruiting twig (*Lombard et al., 1988*).

The results were processed statistically using the analysis of variance. The significance of differences between mean values was evaluated using Duncan's multiple range test for significance level of 0.05. Data analysis was performed using the statistical software package IBM SPSS Statistics 20 (SPSS Inc., Chicago, IL, USA).

Results and discussion

The properties of long fruiting twigs of table plums cultivars are show in table 1.

The largest values of length of long fruiting twigs were found in combination ‘Čačanska Lepotica’/Myrobalan (73.4 cm), while the lowest values were found in combination ‘Čačanska Lepotica’/‘Pixy’ (51.4 cm). Among rootstocks, a dwarf rootstock ‘Pixy’ had a statistically significant lower value of the length of long fruiting twigs then other rootstocks. Between other three rootstocks there were no statistically significant differences.

Among cultivars the average length of long fruiting twigs, varied from 66.1 cm (‘Čačanska Rana’) to 69.4 cm (‘Čačanska Lepotica’). Differences in the length of long fruiting twigs between cultivars were not statistically significant.

Table 1. The properties of long fruiting twigs in plum cultivars on different rootstocks (average, 2013-2015).

Combination Cultivar/rootstock	Length (cm)	Thickness (mm)	No. of FBs per twig	No. of VBs per twig	Ratio FB/VB	No. of FBs per 1 m	
Čačanska Rana/Pixy	56.2 e	7.1 de	9.0 ef	18.2 f	0.5	16.0	
Čačanska Lepotica/Pixy	51.4 bcde	6.9 de	15.7 bc	22.4 de	0.7	30.5	
Čačanska Najbolja/Pixy	60.7 de	6.8 e	17.7 bc	22.5 de	0.8	29.2	
Čačanska Rana/Myrobalan	72.8 a	7.5 bcd	7.3 f	26.1 abc	0.3	10.0	
Čačanska Lepotica/Myrobalan	73.1 a	7.8 bc	15.4 bcd	27.6 ab	0.6	21.1	
Čačanska Najbolja/Myrobalan	70.8 a	7.6 bcd	16.3 bc	28.3 a	0.6	23.0	
Čačanska Rana/Fereley	67.6 abcd	7.3 cde	14.6 cd	22.8 de	0.6	21.6	
Čačanska Lepotica/Fereley	69.8 abc	7.9 bc	23.3 a	25.0 bcd	0.9	33.4	
Čačanska Najbolja/Fereley	67.2 abcd	8.0 ab	19.1 b	24.3 cde	0.6	22.5	
Čačanska Rana/St. Julien A	68.0 abcd	7.4 bcde	11.6 de	21.8 e	0.5	17.1	
Čačanska Lepotica/St. Julien A	73.4 a	8.5 a	15.0 bcd	26.7 abc	0.6	20.4	
Čačanska Najbolja/St. Julien A	70.3 ab	7.8 bc	18.0 bc	26.1 abc	0.7	25.6	
Rootstock	Pixy	59.4 b	6.9 b	14.1 b	21.0 c	0.7	23.7
	Myrobalan	72.2 a	7.6 a	12.9 b	27.4 a	0.5	17.9
	Fereley	68.2 a	7.8 a	19.0 a	24.0 b	0.8	27.9
	St. Julien A	70.6 a	7.9 a	14.9 b	24.9 b	0.6	21.1
Cultivar	Čačanska Rana	66.1 a	7.3 b	10.6 b	22.2 b	0.5	16.0
	Čačanska Lepotica	69.4 a	7.8 a	17.4 a	25.4 a	0.7	25.1
	Čačanska Najbolja	67.3 a	7.6 ab	17.8 a	25.3 a	0.7	26.5

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

Differences in the length of long fruiting twigs were statistically significant between years. In the second year of the study (2014), the length of long fruiting twigs was the largest (80.8 cm), while it was the lowest (48.1 cm) in the third year of study (2015).

Our results of length of long fruiting twigs were slightly lower than in the report of *Milatović et al.* (2015), who studied 11 European plum cultivars grafted on the seedling rootstock Myrobalan in conditions of Belgrade. However, in our study the length of long fruiting twigs of cultivars 'Čačanska Najbolja' and 'Čačanska Rana' was larger, while in cultivar 'Čačanska Lepotica' was lower than in results of *Nenadović-Mratinić et al.* (2007). The differences can be explained by the influence of different factors such as environmental conditions, rootstocks, age of trees, yield, and cultural practices.

Among rootstocks, the average thickness of the long fruiting twigs varied from 6.9 mm ('Pixy') to 7.9 ('St. Julien A'). Among cultivars, these values were from 7.3 mm ('Čačanska Rana') to 7.8 mm ('Čačanska Lepotica'). Significant differences in thickness of the long fruiting twigs were also found between years. The largest value of thickness of the long fruiting twigs was in 2015 (8.9 mm), while the lowest value was in 2014 (6.5 mm). Results of thickness of the long fruiting twigs in our research were in accordance with the previous findings (*Nenadović-Mratinić et al.*, 2007; *Milatović et al.*, 2015).

The medium vigorous clonal rootstock 'Fereley' had a statistically significant influence on the formation of higher number of the flower buds per twig (19.0 on average) than other rootstocks. Among cultivars, 'Čačanska Rana' had a significantly lower number of the flower buds per twig in relation to 'Čačanska Lepotica' and 'Čačanska Najbolja' cultivars. Significant differences in

number of the flower buds per twig were also found between years. The highest number of the flower buds per twig was in the first year of study (2013), compared to two other years.

Myrobalan seedling rootstock had the highest number of vegetative buds per twig (27.4 on average) compared to three other rootstocks. Among cultivars, 'Čačanska Rana' had lower number of the vegetative buds per twig in relation to 'Čačanska Lepotica' and 'Čačanska Najbolja' cultivars. Significant differences were also found between years. The highest number of the flower buds per twig was in the second year of study (2014).

According to many authors (Nenadović-Mratinić *et al.*, 2007; Thurzó *et al.*, 2008; Milatović *et al.*, 2014), the density of flower buds is an important parameter which indicates the potential yield of cultivars. The highest density of flower buds on one-year old twigs (27.9 per 1 m) was on the medium vigorous clonal rootstock 'Fereley', while this value was lowest in the control rootstock - Myrobalan (17.9 per 1 m). Results of density of flower buds in our research were lower than in the study of Milatović *et al.* (2015), and higher than in the study of Nenadović-Mratinić *et al.* (2007).

Very important parameter for the yield and quality of fruit is a balanced relationship between flower buds and vegetative buds. Specifically, a certain number of leaves per fruit was necessary to achieve optimal quality of fruit. The lowest ratio of flower to vegetative buds per long fruiting twig was in the combination 'Čačanska Rana'/Myrobalan (0.3) while the highest ratio was in the combination 'Čačanska Najbolja'/'Fereley' (0.9). The lower value of the ratio of flower to vegetative buds points to lower yield, while the higher ratio indicates a potentially higher yield, but can have negative characteristics in terms of lower fruit quality because in that case a smaller number of leaves per fruit could be expected.

The short fruiting twigs were analyzed on the two-year old twigs and their characteristics are shown in table 2.

Table 2. The properties of short fruiting twigs in plum cultivars on different rootstock (2013-2015).

Combination Cultivar/rootstock	Length (cm)	No. of FBs per twig	No. of VBs per twig	Ratio FB/VB	No. of FB per 1 m of 2-year old twig	
Čačanska Rana/Pixy	7.1 a	3.7 bcd	4.1 a	0.9	58.4	
Čačanska Lepotica/Pixy	3.8 cde	3.4 cd	2.8 bcd	1.2	59.9	
Čačanska Najbolja/Pixy	3.4 de	4.4 ab	2.4 d	1.8	85.6	
Čačanska Rana/Džanarika	4.6 bcd	2.3 e	2.9 bcd	0.8	37.8	
Čačanska Rana/Myrobalan	3.1 e	2.8 de	3.1 bc	0.9	51.7	
Čačanska Lepotica/Myrobalan	3.6 de	3.8 bc	2.7 bcd	1.4	70.8	
Čačanska Najbolja/Myrobalan	5.7 b	3.6 bcd	3.0 bcd	1.2	68.1	
Čačanska Rana/Fereley	3.9 cde	3.3 cd	3.2 b	1.0	63.1	
Čačanska Lepotica/Fereley	4.0 cde	4.7 a	2.5 cd	1.9	99.0	
Čačanska Najbolja/Fereley	4.9 bc	3.1 cde	2.9 bcd	1.1	71.6	
Čačanska Rana/St. Julien A	2.8 e	3.1 cde	2.5 cd	1.2	64.6	
Čačanska Lepotica/St. Julien A	3.7 cde	4.8 a	2.8 bcd	1.7	102.0	
Rootstock	Pixy	4.8 a	3.8 a	3.1 a	1.7	66.5
	Myrobalan	3.7 c	2.9 b	2.9 a	1.2	51.6
	Fereley	4.6 ab	3.9 a	2.9 a	1.0	76.6
	St. Julien A	3.8 bc	3.6 a	2.7 a	1.3	78.1
Cultivar	Čačanska Rana	5.6 a	3.2 b	3.2 a	1.3	58.1
	Čačanska Lepotica	3.4 b	3.1 b	2.9 b	1.0	58.7
	Čačanska Najbolja	3.7 b	4.4 a	2.6 b	1.1	88.2

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

Among rootstocks, the average length of short fruiting twigs varied from 3.7 cm (Myrobalan) to 4.8 cm ('Pixy'). Cultivar 'Čačanska Rana' had statistically significant higher length of short fruiting twigs compared to cultivars 'Čačanska Lepotica' and 'Čačanska Najbolja'. Among years, the differences in the length of short fruiting twigs were statistically significant. In the third year of the study (2015), the length of short fruiting twigs was the largest compared to other two years. Compared to results of *Milatovic et al.* (2015) in our study the lower length of short fruiting twigs was found.

Number of flower buds per short fruiting twig ranged from 2.3 to 4.8. Myrobalan seedling rootstock had influence on the formation a less number of flower buds per short fruiting twig compared to clonal rootstocks. Cultivar 'Čačanska Najbolja' had a statistically significant influence on the formation of higher number of the flower buds per twig then other cultivars.

The number of vegetative buds ranged from 2.4 to 4.1, and there were no statistically significant differences between the rootstocks. Among cultivars, 'Čačanska Rana' had the higher number of the vegetative buds per twig then cultivars 'Čačanska Lepotica' and 'Čačanska Najbolja'.

The average ratio of flower to vegetative buds was from 0.8 ('Čačanska Rana' /Myrobalan) to 1.9 ('Čačanska Najbolja'/'Fereley'). Too high ratio can indicate lower fruit quality and also greater tendency to bare wood formation.

The number of flower buds per 1 m of 2-year old twig was lowest in the combination 'Čačanska Rana'/Myrobalan (37.8), while the highest value was in cultivar 'Čačanska Najbolja' grafted on 'St. Julien A' (102.2). Among rootstocks, the lowest value was on the control - Myrobalan (51.6), and the highest was on the clonal rootstock 'St. Julien A' (78.2). Among cultivars, the lowest value was on cultivar 'Čačanska Rana' (58.1), and the highest in cultivar 'Čačanska Najbolja' (88.2). This parameter indicates the potential yield of the cultivar, as the low density of flower buds points to a lower yield potential. Results of flower bud density on 2-years old twig in our research were lower in cultivars 'Čačanska Najbolja' and 'Čačanska Lepotica' and higher in cultivar 'Čačanska Rana' compared with the previous findings (*Milatović et al.*, 2015; *Nenadović-Mratinić et al.*, 2007).

Conclusions

Based on the three-year trial in the region of Belgrade, it can be concluded that the rootstocks had significant influence on the properties of long and short fruiting twigs on table plums cultivars. The clonal rootstocks 'Pixy' had a statistically significant influence on the lowest length and thickness of long fruiting twigs. The medium vigorous clonal rootstock 'Fereley' had a statistically significant influence on the formation of the highest number of the flower buds per twig. Myrobalan seedling rootstock induced the highest number of the vegetative buds per twig. Myrobalan seedling rootstock had influence on the formation a less number of flower buds per short fruiting twigs in relation to clonal rootstocks.

Based on the number of flower buds per 1 m, it can be concluded that in studied table plums cultivars flower bud density was higher on short fruiting twigs than on long fruiting twigs. Therefore, the short fruiting twigs are the main holders of the yield.

Based on these results, we can make recommendations for pruning performance. Cultivars and rootstocks, which are characterized with higher density of flowers buds on short and long fruiting twigs, require more severe pruning for the better quality of fruit and preventing the bare wood formation. The cultivar/rootstock combinations that have lower density of flower buds require pruning of lower intensity. Among cultivars, 'Čačanska Lepotica' and 'Čačanska Najbolja' had

higher flower bud density than 'Čačanska Rana'. Also, flower bud density was higher on clonal rootstocks compared to Myrobalan seedling rootstock.

Acknowledgements

This work was realized as a part of the project No. 19/6-020/961-91/14 financed by the Ministry of Science and Technology of the Republic of Srpska.

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