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IMPACT OF PLANTING DENSITY ON THE INCIDENCE RATE OF FRUITING BRANCHES OF LATE-RIPENING PLUM CULTIVARS INTENDED FOR PROCESSING*

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SUMMARY: The paper examines the incidence rate of fruiting branches of plum (mixed-type, long and short fruiting branches, thorn shoots and May blossoms), depending on the planting density in the newer plum cultivars, Krina and Mildora. A simultaneous study was conducted comparing the said cultivars intended for processing, with the standard cultivars of the same purpose, Čačanska rodna and Stanley. The study established that the differences in the quantitative share of the corresponding types of fruiting branches occur as a result of the conditions and systems of cultivation, as well as the cultivar traits and the development phase. May flowers are the most frequent type of fruiting branches in all of the examined cultivars, with a higher percentage share in the dense planting treatments; at the same time, the other types of fruiting branches recorded a higher incidence in the classical cultivation treatments, compared to the dense planting treatments.

Key words: *plum, planting density, fruiting branches.*

INTRODUCTION

Planting density, in combination with adequate cultivation forms and application of specific pomo-technical measures, has a direct impact on the fruit set, amount of yield and quality of plum fruits. In dense-planting conditions, balance between the vegetative and generative potential is reached fairly quickly, thus enhancing an earlier fruit set and

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high yields (Miletić et al., 2011a; 2011b; Čmelik et al., 2006; Glišić et al., 2011). In dense formations, tree crowns are characterised by a specific structure of a fruit-bearing tree, dominated by short less vigorous fruiting branches and May blossoms (Mićić et al., 2006). Types of fruiting branches in plum have been described in detail by Mišić (1996) in the classical planting systems at standard distances 5.5-7.0 x 4.0-6.0 m, where the trees were grafted on the cherry plum (*Prunus cerasifera* Ehrh) seedling.

The share of the fruiting twigs of plum in the conditions of dense-cultivation formations was studied by Glišič and Milošević (2005). According to these authors, plum cultivars grafted on the cherry plum stem, planted in the second year of growth using the 4 x 2 m distance pattern, showed presence of different types of fruiting twigs. Veličković et al. (1997) and Mratinić et al. (2007a) report that the established differences in the quantity share of major types of fruiting twigs in the examined plum cultivars were primarily caused by the cultivar traits and the development phase of the plants.

The impact of the density of planting on the share of fruiting twigs was examined in with an aim to develop the growing technologies for new plum cultivars intended for processing, primarily drying (Mildora and Krina), as compared to the standard cultivars (Čačanska rodna and Stanley) of the same designation.

MATERIAL AND METHODS

The research was conducted during 2012 and 2013 at the Zdravljak facility of the Fruit Research Institute in Čačak. The plantation was set up in 2006, at an altitude of 550 m above the sea level, on a lot with a south-east exposition. The soil is of the brown-reddish albic luvisol type on limestone. The trial included the following cultivars: Čačanska rodna, Stanley, Mildora and Krina. The cultivars were grafted on the cherry plum seedlings (*Prunus cerasifera* Ehrh), with well-developed premature twigs. The selected cultivars were cultivated in five treatments:

a) I treatment – 4.0 x 1.0 m (2500trees/ha),
b) II treatment – 4.0 x 1,5 m (1666.6 trees/ha),
c) III treatment – 4.0 x 2.0 m (1250 trees/ha),
d) IV treatment – 5.0 x 3.0 m (666.6 trees/ha),
e) V treatment – 5.0 x 4.0 m (500 trees/ha).

In treatments I, II and III, by using corresponding pomo-technical measures, trees were given the shape of the modified planning form – the spindle bush, with changes in the layout, position and number of skeletal branches from the base, to the top of the crown. In this manner, it was possible to regulate the development of the vegetative mass in the higher sections of the crown, by developing shorter fruiting twigs and thorn shoots. In treatments IV and V, the adopted shape was the classical improved pyramid crown. In addition to the specific pomo-technical measures used in forming the cultivation form, measures of winter and summer pruning were also implemented, together with the cultivation of soil, fertilizing and protection against diseases and pests.

Determination of the share of fruiting twigs was performed in the flowering phase, when these are most easily spotted and recognised. The crowns of all the cultivars per planting

treatment (five trees) showed presence of mixed-type fruiting twigs, long fruiting twigs, short fruiting twigs, thorn shoots and May blossoms, as described by Mišić (1996).

The numerical values have been recalculated and shown as percentage values for each cultivar per cultivation treatment. The obtained two-yearly results have been statistically processed using the Fisher model of variance analysis, the ANOVA. The degree of significance of the differences between the presence of the same type of fruiting twigs per treatment was tested using the Duncan test for significance level of $p \leq 0.05$.

RESULTS AND DISCUSSION

In the past, during 19th and 20th centuries, Serbia was a leader in the field and enjoyed a worldwide reputation as a producer of prunes. However, more recently, Serbia's output and sales of prunes have been at a modest level (Mitrović, 2012). In order to increase the production and raise competitiveness in the global market, in addition to developing new technologies of cultivation and drying, Serbia will need to introduce in the production new cultivars with high quality features, which will also require a completely new approach to this issue. Modern plum-drying technologies require high quality fruits, with uniform size and mass (Mitrović et al., 2000). A high proportion of high quality fruits for drying are secured by using appropriate cultivation techniques, specific pruning and other pomo-technological measures (Mratinić et al., 2007 b; Miletić et al., 2011b; Čmelik et al., 2006).

According to Mišić (1996), the plum has various types of fruiting branches. The mixed-type fruiting branches (usually 50 cm or longer) feature between two and four flower and vegetative buds at each node. The long fruiting branches (app. 40 cm long) and short fruiting branches (10 to 20 cm long) are studded on all sides with flower buds, with a vegetative bud at the top. The thorny, spear-shaped twigs represent short vegetative branches (between 0.5 and 10 cm long), most typically developed in domestic plum cultivars. These thorny Twigs bear good quality fruits. The May flowers (fruit blossoms) are short fruiting branches (2 to 4 cm long) with a large number of buds; while the middle section is occupied by vegetative buds, the remaining ones are flower buds. Similar descriptions and classifications of the fruit bearing branches in plum have been used by Tošić (1983), Bulatović and Mratinić (1996) and Milošević (2002). The results of the percentage share of the fruiting twigs in the examined cultivars are shown in Table 1.

Based on the above description, the percentage share of the mixed-type and long fruiting twigs in this trial was at a minimum value in the dense planting treatments, but it was radically increased in treatments IV and V. This tendency was marked in all of the tested cultivars, albeit in different ratios. In the Čačanska rodna cultivar, the percentage share of the mixed-type fruiting twigs in the dense planting formations was between 1.5 and 2.2%, as opposed to the 3.7 to 4.7% in the control group, while the share of other types of fruiting twigs ranged from 4.6 to 7.7%, i.e. from 9.1 to 10.9%.

In the Stanley cultivar, the mixed-type fruiting twigs were present in the dense planting treatments in the range from 4.1% to 7.7%, as opposed to the 9.1 to 10.4% in the control group, while the share of the long fruiting twigs ranged from 4.0 to 6.5%, i.e. 10.0 to 11.0%. Similar ratios were recorded in the new Krina cultivar in dense planting treatments, where the share

of the mixed fruiting branches ranged between 1.5 and 3.5%, as opposed to the 3.8 to 4.1% in the control group, whereas the share of the long fruiting branches ranged between 1.8% and 3.8%, i.e. between 5.5% and 5.9%. Compared to the Krina cultivar, the more vigorous Mildora cultivar grown in the dense planting treatments recorded a share of the mixed-type fruiting twigs in the range from 1.3 to 2.8 %, as opposed to the share ranging from 5.0 to 5.6% in the control group, while the share of the long fruiting twigs was in the range between 2.0 and 4.0%, i.e. 7.3 to 8.5%.

The obtained results indicate that all of the examined cultivars in the treatments of dense planting (I, II and III) recorded a high percentage share of short fruiting twigs and May blossoms. However, their share begins to decline with the increase of the planting distance (treatments IV and V). In the example of the non-vigorous Čačanska rodna cultivar, the share of the short fruiting twigs in the dense planting treatments ranged from 45.2 (treatment III) to 47.8% (treatment I), i.e. from 42.4 to 42.7%, whereas the share of the May blossoms was in the range from 44.7 (treatment III) to 45.9% (treatment I), i.e. from 41.6 to 44.6% in the control group. In contrast to this, the more vigorous Stanley cultivar recorded the percentage share of short fruiting twigs in the range between 31.6 (treatment III) and 36.9% (treatment I), as opposed to the control group, where this share ranged from 30.4 (treatment IV) to 31.6% (treatment V), whereas the share of May blossoms fell in the range from 46.4 (treatment II) to 48.8% (treatment I), i.e. from 40.1 (treatment V) to 48.8% (treatment I) in the control group.

Table 1. Share of different types of fruiting branches per cultivation treatment (%)

Cultivar	Treat-ment	Mixed-type fruiting twigs	Long ruiting twigs	Short fruiting twigs	Thorn shoots	May blossoms
Čačanska Rodna	I	1.5 d	4.6 e	47.9 a	0.1 b	45.9 a
	II	1.9 c	6.3 d	46.1 ab	0.1 b	45.6 a
	III	2.2 c	7.7 c	45.2 b	0.2 a	44.7 a
	IV	3.7 b	9.1 b	42.4 c	0.2 a	44.6 a
	V	4.7 a	10.9 a	42.7 c	0.1 b	41.6 b
Year (2012–2013)		*	*	*	*	*
Stanley	I	4.1 e	4.0 c	36.9 a	6.2 a	48.8 a
	II	6.3 d	5.5 b	35.1 a	6.7 a	46.4 ab
	III	7.7 c	6.5 b	31.6 b	6.9 a	47.3 a
	IV	9.1 b	10.0 a	30.4 b	6.3 a	44.2 b
	V	10.4 a	11.0 a	31.6 b	6.9 a	40.1 c
Year (2012–2013)		*	*	*	ns	*
Krina	I	1.5 a	1.8 d	42.8 a	1.1 b	52.8a
	II	3.0 a	3.1 c	40.9 ab	2.2 a	50.8b
	III	3.5 ab	3.8 b	40.8 ab	2.0 a	50.1b
	IV	3.8 b	5.5 a	40.4 b	2.0 a	48.3c
	V	4.1 c	5.9 a	39.8 b	1.9 a	48.3c
Year (2012–2013)		*	*	*	*	*

Mildora	I	1.3 d	2.0 e	43.1 a	0.6 d	53.0 ab
	II	1.5 d	3.1 d	41.6 a	0.9 cd	52.9 ab
	III	2.8 c	4.0 c	38.2 b	1.2 bc	53.8 a
	IV	5.0 b	7.3 b	34.5 c	1.4 ab	51.8 ab
	V	5.6 a	8.5 a	34.4 c	1.6 a	49.9 b
Year (2012–2013)		*	*	*	*	*

*Values within each column followed by the same small letter are not significantly different at the $p \leq 0.05$ by Duncan's test;
ns – non significant.

The Krina and Mildora cultivars belong to the category of vigorous cultivars. It is worth observing that when cultivated in the dense planting formations, Krina demonstrated a proportion of short fruiting branches (40.8 - 42.8%) similar to that recorded in the control treatments (39.8 - 40.4%), with the share of the May blossoms in the range between 50.1 and 52.8%, compared to 48.3% in the control group in both treatments. The Mildora cultivar recorded the share of the short fruiting branches in the range from 38.2 to 43.1%, compared to the share of 34.4 to 34.5% in the control group, whereas the May flowers reached the range from 52.9 to 53.8%, i.e. from 49.9 to 51.8% in the control group.

Milenković et al. (2006) state that the Krina and Mildora cultivars primarily bear fruits on the May blossoms and one-year fruiting branches, which corresponds to our results. Similar conclusions have been made about the Čačanska rodna and Stanley cultivars (Mišić, 1996).

Thorny shoots are a characteristic of the domestic plum cultivars (Mišić, 1996). Their presence in the crown, however, shows a declining tendency as the tree becomes older. Among the examined cultivars in the seventh, i.e. eighth year after planting, this trait was the least expressed in the Čačanska rodna cultivar where it ranged between 0.1% and 0.2%, while it was the strongest in the Stanley cultivar, ranging from 6.2 to 6.9%. As for the Krina and Mildora cultivars, the proportion of the thorny shoots fell in the range between 1.1 to 2.2% and 0.6 and 1.6%, respectively.

In general, the May blossoms are the most frequent type of fruiting twigs in all of the examined cultivars, with a higher percentage share recorded in the dense planting treatments (treatments I, II and III), and conversely – a lower share tendency recorded in the treatments implying larger planting distances (treatments IV and V).

The percentage share of the fruiting twigs is a specific trait of each cultivar. A higher incidence of short fruiting twigs and May blossoms occurs as a result of the applied pruning principles (winter and, especial, summer pruning) and bending of twigs. The formation of fruiting branches is also determined by the time of onset and increase in the yield. Yield has a direct impact on the vegetative growth of the crown, thus determining the percentage share of the fruiting branches.

The agro-ecological conditions and the implementation of care and pomological-technical measures have a direct impact on the form of the morphological traits of the crown, which a specific trait of each individual cultivar. These conclusions are in accordance with the findings made by Veličković et al. (1997) and Mratinić et al. (2007a), who pointed out that the structure of the fruiting twigs depends on the cultivar and the development phase of the fruit. Hrotko (2004) states that in intensive plum plantations in Hungary containing 1400 – 2500 trees per hectare, implementation of suitable pomological-technical measures enables formation of a significant number of fruit-bearing trees in the very early years after planting, both on the bearing branches and on the central leader. Glišić and Milošević (2005) established that in the Čačanska rodna, Čačanska rana,

Čačanska lepotica and Stanley grafted on the cherry plum stock, planted at the 4 x 2 m distance, differences appeared in the presence of fruiting twigs in the second year after planting.

In the Čačanska rodna and Stanley cultivar, the dominant share was taken by the mixed-type fruiting twigs. While Čačanska rana recorded an even albeit very low proportion of all types of fruiting branches, in the Čačanska lepotica cultivar the dominant form were the short fruiting twigs (thorny shoots and blossom fruiting branches)

According to the authors, the highest number of the fruiting twigs per tree was recorded in the Čačanska lepotica cultivar, followed by the Čačanska rodna cultivar, while the smallest number of fruiting twigs was recorded in the Čačanska rana cultivar. This tendency was partly reflected in our trial as well, taking into account the age of the fruits, i.e. the time of the analysis of the fruiting twigs share.

The features of the fruiting twigs and their position in the crown have an impact on the size, mass and quality of the fruits (Mišić, 1996). The principles of standardisation and the increasingly demanding global and domestic markets insist on implementation of the comprehensive agro-technical and pomo-technical measures in order to secure high quality fruits. A high share of the fruits satisfying the quality requirements in the crown of each fruit tree also makes a positive impact on the higher economy of the fruit production and better financial indicators.

CONCLUSIONS

Based on the study of the impact made by the density of planting on the proportion of the various types of fruiting twigs (mixed-type, long and short fruiting twigs, thorny shoots and May blossoms) in the plum cultivars suitable for drying (Čačanska rodna, Stanley, Krina and Mildora), it is possible to make the following conclusion:

The differences in the quantitative share of the different types of the fruiting branches in the examined plum cultivars occurred primarily as a consequence of the prevailing conditions and the cultivation system applied, as well as the cultivar traits and the development phase.

The May blossoms are the most frequent type of the fruiting branches in all the examined cultivars. While their percentage share tended to be higher in the dense planting treatments, it also showed a declining tendency in the treatments utilising larger planting distances.

Other types of fruiting twigs recorded a higher percentage share in the classical cultivation treatments, when compared to the dense planting treatments.

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ZASTUPLJENOST RODNIH GRANČICA POZNIH SORTI ŠLJIVA NAMENJENIH PRERADI U ZAVISNOSTI OD GUSTINE SADNJE

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Izvod

U cilju razvoja tehnologije gajenja novijih sorti šljiva pogodnih za sušenje (Krina i Mildora u komparaciji sa standardnim sortama (Čačanska rodna i Stanley) iste namene, ispitvana je i zastupljenost rodnih grančica (mešovite, duge i kratke rodne grančice, trnasti izraštaji i majski buketići) u zavisnosti od gustine sadnje. Razlike u kvantitativnoj zastupljenosti tipova rodnih grančica u ispitivanih sorti šljive je pre svega posledica uslova i sistema gajenja, sortnih karakteristika i stadijnog razvitka. Majski buketići su najzastupljeniji tip rodnih grančica kod svih ispitivanih sorti, pri čemu je procentualna zastupljenost veća u teretmanima guste sadnje, sa tendencijom smanjenja u tretmanima sa većim rastojanjima sadnje. Ostali tipovi rodnih grančica su procentualno više zastupljeni u tretmanima klasičnog uzgoja u odnosu na tretmane guste sadnje.

Ključne reči: šljiva, gustina sadnje, sorte za sušenje, rodne grančice.

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