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Growth and productivity of apricot cultivars in the Belgrade area

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Abstract. Growth and productivity characteristics (shoot length, flower bud density, fruit set, fruit weight, yield per tree, trunk cross-sectional area and yield efficiency) were studied in 15 apricot cultivars in the Belgrade area during the period of two years (2013–2014). The cultivar 'Hungarian Best' was used as a control for comparison. The average length of fruiting shoots ranged from 68.8 to 84.5 cm, and the number of flower buds per 1 cm of shoot length varied from 0.40 to 1.20. Nine cultivars are characterized by higher flower bud density in comparison to the control cultivar. The average fruit set ranged from 2.4 to 36.2%. Compared to control, fruit set was significantly higher in 'Cegledi Arany' and 'Roxana', while it was lower in 'Laycot'. The average fruit weight ranged from 39.3 to 88.9 g. Compared to control, fruit weight was significantly higher in five cultivars: 'Sophia', 'Neptun', 'Roxana', 'Cegledy Arany', and 'Goldrich', and it was lower in two cultivars: 'Ninfa' and 'Tomcot'. The average yield per tree was the lowest in the control cultivar, 'Hungarian Best' (6.6 kg) and the highest in 'Sylred' (29.6 kg). In majority of cultivars (ten) the yield was significantly higher than in the control cultivar. The lowest vigor was recorded in 'Neptun', and the highest in 'Ninfa'. All cultivars had higher cumulative yield efficiency than the control ('Hungarian Best' with 0.13 kg cm^{-2}) and it ranged from 0.18 to 0.49 kg cm^{-2}.

Key words: *Prunus armeniaca*, fruit set, yield, vigor, fruit weight

Introduction

Apricot (*Prunus armeniaca* L.) is an important fruit species in Republic of Serbia. The average production in the period of 2016–2018 was 30,784 t (RZS, 2019). The average yield is low (5.3 t/ha), and there are high oscillations in yield between years. Two basic problems in apricot production are dieback of trees ('apoplexy') and irregular yields due to damage of flowers and fruitlets caused by spring frosts. Besides, the apricot cultivar assortment in Serbia is characterized by small number of cultivars and a short period of maturing. Most apricot fruits are harvested in the season of 'Hungarian Best', which is the most grown cultivar, or at a short time (about ten days) afterwards. The introduction of new foreign cultivars and their study in Serbian environmental conditions allow better choice of cultivars, and may improve the production of apricots. Apricot is an early flowering species. The average time of flowering in the region of Belgrade is the third decade of March (Milatović, 2005a). Adverse weather conditions in spring affect apricot productivity. Spring frosts often damage reproductive organs (flower buds, flowers and fruitlets) and reduce the yield (Bassi et al., 1995; Rodrigo et al., 2006; Milatović et al., 2013a). Besides, low temperatures and wind during the flowering affect bee activity and pollination. However, there are many genotype-dependent factors that influenced fruit set and consequently productivity, such as flower bud density, flower bud drop, ovule develop-

ment stage at anthesis, pollen germination, height difference between the stigma and the anthers, aborted pistils, and the level of autogamy (Ruiz & Egea, 2008).

Apricot cultivars differ in terms of flower bud density, and this indicator has a significant impact on yield (Alburquerque et al., 2006; Thurzó et al., 2006; Ruiz & Egea, 2008; Szabo et al., 2013). In the conditions of continental climate, it is advisable to choose cultivars that have higher flower bud density. This increases the probability of survival of generative organs due to the occurrence of frost and ensure higher yields (Okie & Werner, 1996).

Although apricot cultivars of European ecogeographical group are generally considered self-compatible, the results of the studies done in the last two decades indicate that self-incompatibility is relatively frequent in them (Burgos et al., 1997; Milatović & Nikolić, 2007; Milatović et al., 2013b). When growing self-incompatible apricot cultivars, adequate pollinizer cultivars should be selected.

The fruit set of apricot under open pollination varies from 0 to 80% (Milatović, 2013). Fruit set percentage in apricot can be classified as: low, under 10%, medium, 10–30%, and high, above 30% (Szabó et al., 2003). In the case of abundant flowering, fruit set of 20–30% is necessary to obtain a high yield (Milatović, 2013).

Vachün (2002a) studied the yield of 24 apricot cultivars for a period of six years and it was in the range of 3–20 kg per tree. Yield efficiency (yield per unit area of trunk cross-sectional area) is a better indicator of productivity than yield level, and it provides easier comparability of results (Vachun, 2002b). Milatović et al. (2006) studied the yield of 35 apricot cultivars in the period of eight years. On the basis of the average yield per tree, they classified apricot cultivars into four groups cultivars of poor yield (under 10 kg), medium yield (10–20 kg), high yield (20–30 kg) and very high yield (above 30 kg).

The aim of this work was to study the characteristics of growth and productivity in a number of newly introduced apricot cultivars. The results may be useful for the selection of the best cultivars suitable for growing in the Belgrade area.

Material and Methods

Studies were carried out in the apricot collection orchard of the Faculty of Agriculture in Belgrade, at the Experimental Farm 'Radmilovac', in the period 2013–2014. The orchard was planted in 2007, and during the study period the trees were aged 7–8 years. The study included 15 introduced apricot cultivars. The cultivar 'Hungarian Best' was taken as a control for comparison. All cultivars are grafted on seedlings of Myrobalan (*Prunus cerasifera* Ehrh.) and are represented in the collection with five trees. Training system is central leader, and planting distance is 4.5×3 m.

One-year old fruiting shoots were taken for testing in the spring, before flowering. From each cultivar 20 terminally located shoots were taken. Length of shoots was measured by a meter and the number of flower buds was counted. The flower bud density was calculated as the number of flower buds per 1 cm of a shoot length. To determine fruit set under open pollination, three branches of each cultivar at the 'balloon' stage were marked, each containing at least 200 flowers. At the time of flowering, the number of flowers was counted. The number of fruits was counted 2–3 weeks before the harvest and the percentage of fruit set was calculated. The yield was determined by measuring the weight of harvested fruits and is expressed in kg per tree. Trunk cross-sectional area (TCSA) was calculated from the trunk diameter measured at a height of 30 cm above the graft union. Cumulative yield efficiency (CYE) was calculated as a ratio of cumulative yield per tree for two years (2013–2014) and TCSA in the last year of study (2014), and is expressed in kg per cm^2. Fruit weight was determined on a sample of 25 fruits per cultivar.

Data were analyzed statistically by the method of two-factorial analysis of variance. The significance of differences between mean values was determined by Duncan's Multiple Range test for the probability of 0.05.

Results and Discussion

The average length of fruiting shoots ranged from 68.8 cm in the cultivar 'Ninfa' to 84.5 cm in the cultivar 'Leskora' (Tab. 1). The differences in the shoot length between cultivars were statistically significant. The

Tab. 1. Length of fruiting shoots and number of flower buds per 1 cm length of shoots in apricot cultivars (2013–2014)
Tab. 1. Dužina dugih rodnih grančica i broj cvetnih pupoljaka po 1 cm dužine grančice kod sorti kajsije (2013–2014)

	Length of fruiting shoots *Dužina dugih rodnih grančica* (cm)			No. of flower buds per 1 cm of shoot *Broj cvetnih pupoljaka po 1 cm dužine grančice*		
Cultivar/*Sorta*	2013	2014	Mean/*Prosek*	2013	2014	Mean/*Prosek*
'Bella d'Imola'	74.5	78.5	76.5 bc*	0.46	0.76	0.61 cd
'Cegledy Arany'	71.3	73.7	72.5 cd	0.27	0.52	0.40 d
'Goldrich'	92.6	75.5	84.0 a	0.89	1.31	1.10 a
'Harogem'	83.5	85.2	84.3 a	0.61	0.87	0.74 bcd
'Harojoy'	79.9	65.8	72.8 cd	0.82	1.00	0.91 abc
'Laycot'	84.3	82.3	83.3 ab	1.17	0.84	1.01 ab
'Leskora'	92.7	76.4	84.5 a	0.94	0.95	0.95 abc
'Litoral'	64.1	80.2	72.1 cd	0.57	0.79	0.68 bcd
'Neptun'	81.5	61.6	71.5 cd	0.87	1.15	1.01 ab
'Ninfa'	81.3	56.2	68.8 d	0.98	1.42	1.20 a
'Roxana'	72.7	72.3	72.5 cd	0.59	0.81	0.70 bcd
'Sophia' (LE-2926)	72.4	75.4	73.9 cd	0.77	1.51	1.14 a
'Sylred'	68.4	79.5	73.9 cd	1.04	1.01	1.03 ab
'Tomcot'	91.1	64.6	77.9 abc	0.94	1.47	1.21 a
'Hungarian Best' (control)	76.4	79.2	77.8 abc	0.51	0.40	0.46 d
Mean/*Prosek*	79.3	73.4	76.3	0.76	0.99	0.88

*Mean values followed by the same letter within a column do not differ significantly according to Duncan's Multiple Range test at $P \leq 0.05$
**Prosečne vrednosti praćene istim slovom unutar kolone ne razlikuju se značajno prema Dankanovom testu višestrukih intervala ($P \leq 0,05$)*

shoots shorter than those in the control were found in the cultivar 'Ninfa'.

The number of flower buds per 1 cm of shoot length is an important parameter, which indicates the flower density, and thus the potential productivity. The average number of flower buds per 1 cm of shoot length varied from 0.40 to 1.20. Nine cultivars are characterized by higher flower bud density in comparison to the control cultivar.

Large number of flower buds per 1 cm (more than 1.00) was found in cultivars: 'Ninfa', 'Tomcot', 'Sophia', 'Goldrich', 'Sylred', 'Laycot' and 'Neptun'. With the exception of the cultivar 'Sophia', all other cultivars bloom early or medium-early. This is in line with the results of Alburquerque et al. (2004) who stated that early flowering cultivars have a higher density of flower buds in comparison to late flowering cultivars. Our results of flower bud density are consistent with previous findings (Milatović, 2005b; Thurzó et al., 2006).

The average fruit set varied from 2.4% in 'Laycot' to 36.2% in 'Cegledi Arany' (Tab. 2). Compared to control, fruit set was significantly higher in 'Cegledi Arany' and 'Roxana', while it was lower in 'Laycot'. In most cultivars (except 'Bella d'Imola' and 'Ninfa') percentages of fruit set were lower in 2013 compared to 2014. The reason for this are lower temperatures during flowering of apricot in this year.

According to the classification for apricot given by Szabó et al. (2003), most of studied cultivars (nine, including the control) had a medium fruit set (10–30%), five cultivars had a low fruit set (<10%), while only 'Cegledi Arany' had a high fruit set. In previous studies, it was found that the fruit set depends of both genotype and year. Different authors determined a large variation in the percentage of fruit set under open pollination: 4.5–31.3% (Balta et al., 2007); 14.6–38.6% (Muradoglu et al., 2007); 5.3–78.2% (Ruiz & Egea, 2008); 2.3–14.0% (Polat & Çaliskan, 2014). Apricots have lower fruit set than European plums (Szabo, 2003; Glišić et al., 2012), and higher than Japanese plums (Szabó & Nyéki, 2002; Guerra & Rodrigo, 2015).

The average fruit weight ranged from 39.3 g in 'Tomcot' to 88.9 g in 'Sophia'. Compared to control, fruit weight was significantly higher in five cultivars: 'Sophia', 'Neptun', 'Roxana', 'Cegledy Arany', and 'Goldrich', and it was lower in two cultivars: 'Ninfa' and 'Tomcot'. Our results of fruit size are consistent with previous findings for some cultivars (Lo Bianco et al., 2010; Krška et al., 2013; Szalay et al., 2013).

Tab. 2. Fruit set and fruit weight of apricot cultivars (2013–2014)
Tab. 2. Zametanje plodova i masa ploda sorti kajsije (2013–2014)

	Fruit set/*Zametanje plodova* (%)			Fruit weight/*Masa ploda* (g)		
Cultivar/*Sorta*	2013	2014	Mean/*Prosek*	2013	2014	Mean/*Prosek*
'Bella d'Imola'	29.0	11.8	20.4 bc*	62.9	66.5	64.7 de
'Cegledy Arany'	32.3	40.1	36.2 a	79.6	72.5	76.0 bcd
'Goldrich'	3.1	5.9	4.5 ef	89.0	58.1	73.5 cd
'Harogem'	12.8	13.4	13.1 cde	49.6	66.7	58.2 efg
'Harojoy'	7.4	9.8	8.6 def	63.0	41.3	52.1 fg
'Laycot'	2.4	2.5	2.4 f	76.2	58.5	67.4 de
'Leskora'	5.2	11.1	8.1 def	54.0	48.4	51.2 fg
'Litoral'	10.5	23.5	17.0 bcd	67.1	71.3	69.2 de
'Neptun'	5.9	16.7	11.3 def	101.6	71.9	86.8 ab
'Ninfa'	22.6	6.1	14.3 cd	36.3	57.7	47.0 gh
'Roxana'	2.3	46.5	24.4 b	79.8	86.1	82.9 abc
'Sophia' (LE-2926)	4.4	13.1	8.8 def	78.9	98.8	88.9 a
'Sylred'	6.8	12.3	9.5 def	83.3	55.4	69.4 de
'Tomcot'	10.4	12.6	11.5 cde	43.0	35.7	39.3 h
'Hungarian Best' (control)	4.3	21.4	12.8 cde	65.1	55.8	60.4 ef
Mean/*Prosek*	10.6	16.5	13.5	68.6	63.0	65.8

*Mean values followed by the same letter within a column do not differ significantly according to Duncan's Multiple Range test at $P \leq 0.05$
**Prosečne vrednosti praćene istim slovom unutar kolone ne razlikuju se značajno prema Dankanovom testu višestrukih intervala ($P \leq 0,05$)*

Tab. 3. Yield per tree, trunk cross-sectional area (TCSA) and cumulative yield efficiency (CYA) in apricot cultivars
Tab. 3. Prinos po stablu, površina poprečnog preseka debla (PPPD) i kumulativni koeficijent rodnosti (KKR) sorti kajsije

	Yield (*kg* per tree)/*Prinos (kg po stablu)*				
Cultivar *Sorta*	2013	2014	Mean/*Prosek*	TCSA/*PPPD* (cm^2)	CYE/*KKR* (kg/cm^2)
'Bella d'Imola'	18.4	14.8	16.6 bcd*	112.7 bcd	0.29
'Cegledy Arany'	14.9	27.6	21.3 b	110.2 bcd	0.39
'Goldrich'	4.8	18.9	11.8 de	129.3 abc	0.18
'Harogem'	11.9	16.0	14.0 bcde	105.3 cd	0.27
'Harojoy'	9.6	22.7	16.2 bcd	98.2 cd	0.33
'Laycot'	2.0	20.8	11.4 de	99.6 cd	0.23
'Leskora'	5.1	30.9	18.0 bcd	143.8 ab	0.25
'Litoral'	7.1	32.1	19.6 bc	94.8 cd	0.41
'Neptun'	8.4	32.7	20.6 b	84.6 d	0.49
'Ninfa'	20.7	15.3	18.0 bcd	149.3 a	0.24
'Roxana'	1.3	36.3	18.8 bcd	85.8 d	0.44
'Sophia' (LE-2926)	5.2	19.8	12.5 cde	96.8 cd	0.26
'Sylred'	24.1	35.1	29.6 a	140.4 ab	0.42
'Tomcot'	21.9	18.4	20.1 b	116.5 abcd	0.35
'Hungarian Best' (control)	3.0	10.3	6.6 e	101.5 cd	0.13
Mean/*Prosek*	10.6	23.4	17.0	111.3	0.31

*Mean values followed by the same letter within a column do not differ significantly according to Duncan's Multiple Range test at $P \leq 0.05$
**Prosečne vrednosti praćene istim slovom unutar kolone ne razlikuju se značajno prema Dankanovom testu višestrukih intervala ($P \leq 0,05$)*

The average yield per tree was the lowest in the control cultivar, 'Hungarian Best' (6.6 kg) and the highest in 'Sylred' (29.6 kg) (Tab. 3). In majority of cultivars (ten) the yield was significantly higher than in the control cultivar. Yield was generally lower in 2013 than in 2014. The reason of the low yield in 2013 was cold weather during the flowering, which resulted in low fruit set (Zec et al., 2013). During the study period, strong winter frosts or spring frosts that could damage apricot reproductive organs were not recorded. Results for yield of some cultivars are consistent with previous findings (Vachun, 2002a; Milatović et al., 2006; Fajt et al., 2013).

The average yield for all cultivars was 12.6 t ha^{-1}, and it ranged from 4.9 to 21.9 t ha^{-1}. In years with optimal weather conditions, a yield of 40–50 t ha^{-1} can be achieved in some cultivars (Milatović et al., 2006). However, the long-term average yield of apricot is much lower due to the occurrence of spring frosts and dieback ('apoplexy') of trees (Vachun, 2001).

The lowest vigor, expressed through the trunk cross-sectional area (TCSA), was determined in the cultivar 'Neptun' (84.6 cm^2). The highest vigor was determined in 'Ninfa', 'Leskora' and 'Sylred' (TCSA of 149.3, 143.8 and 140.4 cm^2, respectively). These three cultivars had significantly higher TCSA compared to the control cultivar.

Yield efficiency (YE) is an important indicator of productivity of apricot cultivars, that combines yield and vigor. All cultivars had higher cumulative yield efficiency than the control cultivar ('Hungarian Best' with 0.13 kg cm^{-2}) and it ranged from 0.18 to 0.49 kg cm^{-2}. The rank of cultivars according to yield (in kg per tree) and YE is not identical. On the basis of YE, low vigorous cultivars such as 'Neptun' and 'Roxana' are much better ranked than on the basis of yield. The opposite case is with vigorous cultivars, such as 'Ninfa' and 'Leskora'. Our results for YE of apricot are in accordance with previous findings (Milatović et al., 2006; Tabakov & Yordanov, 2012; Licznar-Malanczuk & Sosna, 2013; Milošević et al., 2013).

Conclusion

Tested apricot cultivars showed higher flower bud density compared to control cultivar. Most cultivars had medium fruit set (10–30%) and large fruits (above 60 g). A high yield (over 20 kg per tree) was found in 'Sylred', 'Cegledy Arany', 'Neptun' and 'Tomcot', and a high yield efficiency (over 0.40 kg cm^{-2}) in 'Neptun', 'Roxana', 'Sylred' and 'Litoral'. Based on these results, in terms of productivity and fruit size, 'Sylred', 'Cegledy Arany', 'Neptun' and 'Roxana' are distinguished as promising cultivars for growing in the Belgrade region. However, for more reliable conclusions a long-term study is necessary.

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RAST I RODNOST SORTI KAJSIJE NA PODRUČJU BEOGRADA

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Rezime

Karakteristike rasta i rodnosti (dužina dugih rodnih grančica, gustina cvetnih pupoljaka, zametanje plodova, prinos po stablu, površina poprečnog preseka debla i koeficijent rodnosti) su proučavane kod 15 sorti kajsije na području Beograda u periodu od dve godine (2013–2014). Kao standard sorta za poređenje uzeta je Mađarska najbolja. Prosečna dužina dugih rodnih grančica varirala je od 68,8 do 84,5 cm, a broj cvetnih pupoljaka po 1 cm dužine grančice varirao je od 0,40 do 1,20. Devet sorti je imalo veću gustinu cvetnih pupoljaka u poređenju sa standard sortom. Prosečno zametanje plodova iznosilo je od 2,4 do 36,2%. U poređenju sa standard sortom, zametanje plodova je bilo statistički značajno veće kod sorti Cegledy Arany i Roxana, dok je bilo manje kod sorte Lejkot. Prosečna masa ploda bila je u rasponu od 39,3 do 88,9 g. U poređenju sa standard sortom, masa ploda je bila statistički značajno veća kod pet sorti: Sophia, Neptun, Roxana, Cegledy Arany i Goldrich, a manja kod dve sorte: Ninfa i Tomcot. Prosečan prinos po stablu je bio najniži kod standard sorte, Mađarske najbolje (6,6 kg), a najviši kod sorte Sylred (29,6 kg). Kod većine ispitivanih sorti (10) prinos je bio značajno viši u odnosu na kontrolu. Najmanja bujnost ustanovljena je kod sorte Neptun, a najveća kod sorte Ninfa. Sve ispitivane sorte su imale veći kumulativni koeficijent rodnosti u odnosu na kontrolu (Mađarska najbolja sa 0,13 kg cm^{-2}) i on je varirao od 0,18 do 0,49 kg cm^{-2}.

Ključne reči: *Prunus armeniaca*, zametanje plodova, prinos, bujnost, masa ploda