BEHAVIOR OF SOME CULTIVARS OF APRICOT (*PRUNUS ARMENIACA* L.) ON DIFFERENT ROOTSTOCKS

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The trial was conducted in Prislonica village near Čačak (western Serbia) from 2011 to 2017 in order to determine the impact of Myrobalan (vigorous), St. Julien A (semi-vigorous) and Pumiselect (dwarfing) rootstocks on tree growth, productivity and main fruit physico-chemical traits of three newly-bred Serbian apricot genotypes grown under dry, sandy-loam and acidic soil conditions. Tree survival was registered from 2011 to 2018. The orchard was established in autumn 2011 at a 5.5 m × 3 m planting distance. Apricots on Myrobalan had strong growth, lower yield and poorest fruit quality traits in most cases in comparison to St. Julien A and Pumiselect. Pumiselect showed a good capacity to reduce tree growth, increased yield, fruit weight, flesh rate, soluble solids content and ripening index. St. Julien A exhibited similar influences as Pumiselect. In the case of genotypes, 'Novosadska Rodna' had higher vigour, lower yield, better physical, but poorest chemical properties of fruit in comparison to 'NS 4' and 'NS 6' genotypes. The best yield traits were determined with 'NS 4', whereas the best fruit chemical properties were found in 'NS 6'. Tree mortality depended on rootstock, but also on genotype. By 2018, 56 %, 18 % and 40 % of the trees on Pumiselect, St. Julien A and Myrobalan, respectively, had died. In the case of genotypes, until 2018 'Novosadska Rodna' showed 64 % , 'NS 4' 79 % and 'NS 6' only 43 % survival on all rootstocks on average.
Keywords: apricot, fruit size, genotype, rootstock, vegetative growth, yield

Verhalten einiger Marillensorten (*Prunus armeniaca* L.) auf verschiedenen Unterlagen. Die Untersuchung wurde von 2011 bis 2017 im Dorf Prislonica in der Nähe von Čačak (Westserbien) durchgeführt, um den Einfluss der Unterlagssorten Myrobalane (starkwüchsig), St. Julien A (mittelwüchsig) und Pumiselect (schwachwüchsig) auf Baumwachstum, Produktivität und wichtige physikalisch-chemische Merkmale dreier neu gezüchteter serbischer Marille-Genotypen unter trockenen, sandig-lehmigen und sauren Bodenbedingungen zu bestimmen. Das Überleben der Bäume wurde von 2011 bis 2018 registriert. Der Obstgarten wurde im Herbst 2011 mit einer Pflanzweite von 5,5 m × 3 m angelegt. Marillen auf Myrobalane hatten im Vergleich zu denen auf St. Julien A und Pumiselect in den meisten Fällen ein starkes Wachstum, geringere Erträge und die schlechtesten Fruchtqualitätsmerkmale. Pumiselect zeigte sich gut geeignet dafür, das Baumwachstum zu reduzieren bzw. den Ertrag, das Fruchtgewicht, den Fruchtfleischanteil, den Gehalt an löslichen Feststoffen und den Reife-Index zu erhöhen. St. Julien A zeigte ähnliche Einflüsse wie Pumiselect. Bei den Genotypen hatte 'Novosadska Rodna' eine höhere Wüchsigkeit, einen geringeren Ertrag, bessere physikalische, aber die schlechtesten chemischen Fruchteigenschaften im Vergleich zu den 'NS 4'- und 'NS 6'-Genotypen. Die besten Ertragsmerkmale wurden bei 'NS 4' bestimmt, während die besten chemikalischen Eigenschaften bei 'NS 6' gefunden wurden. Die Baumsterblichkeit hing von der Unterlage ab, aber auch vom Genotyp. Bis 2018 waren 56 %, 18 % und 40 % der Bäume auf Pumiselect bzw. St. Julien A und Myrobalane abgestorben. Bei den Genotypen zeigte im gleichen Zeitraum 'Novosadska Rodna' im Durchschnitt bei allen Unterlagen eine Überlebensrate von 64 %, 'NS 4' 79 % und 'NS 6' nur 43 %.
Schlagwörter: Marille, Fruchtgröße, Genotyp, Unterlage, vegetatives Wachstum, Ertrag

Apricot (*Prunus armeniaca* L.) is a very popular fruit species worldwide, including Serbia. The fruit are suitable for fresh consumption, industrial processing, drying and deep freezing. For these reasons, apricot is important for human nutrition. It has been known that successful production is achieved in areas without explicit so-called transient seasons (without spring and autumn) such as parts of Central Asia, followed by warm Mediterranean areas and individual micro-areas that have moderate and/or continental climate regimes.

In Serbia, apricot cultivation is endangered by a large number of individual and connected factors which are identical to those in temperate and continental parts of Europe. The most important are the dying off of flower buds prior to bloom during winter, blossoms killed by spring frosts, sudden (premature) wilting – apoplexy –, *Plum Pox Virus* infection and absence of modern growing technologies (Milošević et al., 2010 and 2019). Choosing the right rootstocks for apricot is one of the most important factors, apart from choosing good cultivar, training and/or pruning system. Right rootstocks not only influence graft-quality, but also the long-term efficiency of the orchard. Hence, the choice of an appropriate rootstock for different cultivars and different pedoclimatic conditions is a major problem for apricot growers worldwide. It has been long known that there is no universal rootstock for this fruit species such as, for example, M9 for apple and/or quince clones for pear. Apricot seedling rootstocks are widely used worldwide (Crossa-Raynaud and Audergon, 1987), they, however, do not tolerate heavy soils or water logging (Hernández et al., 2010). Therefore plum rootstocks such as, for example, Marianna 2624 and/or Myrobalan 29 C are preferred for apricots in heavy and water-logged soils in California (Okie, 1983) or in Turkey (Son and Küden, 2003). It appears that every country in which apricot is grown, has one main and few alternative rootstocks, that are suitable for specific ecological conditions. For example, in some areas of Spain, the predominant rootstocks are apricot seedlings ('Real Fino' and 'Canino' cultivars), plum known as 'Pollizos de Murcia' (*P. insititia*) and other plum rootstocks (Hernández et al., 2010). Similarly, in Czech Republic, apricot seedlings are the most popular rootstocks for apricot (Vachůn, 2001), whereas in Poland, the main rootstock is seedlings of Myrobalan (*Prunus divaricata* Ledeb.) (Sosna and Licznar-Małańczuk, 2012; Licznar-Małańczuk and Sosna, 2013). The seedlings of apricots and/or Myrobalan are still used in more areas, but the tendency is towards their substitution by clonal rootstocks due to lack of tree uniformity and other desirable traits (Hernández et al., 2010; Milošević et al., 2015).

In Serbia, apricot trees are grown mainly on seedlings of Myrobalan (*P. cerasifera*). This rootstock has some negative points – insufficient compatibility with some cultivars, too vigorous growth, only average winter-hardiness (Milošević et al., 2015). Apricot trees on Myrobalan seedlings also grow very strong, which complicates picking, pruning and chemical plant protection (Sosna and Licznar-Małańczuk, 2012), the physiological incompatibility is evident and the mortality of trees is high (Milošević et al., 2015). The second important rootstock for apricot under Serbian conditions is suckers of local (autochthonous) plum called 'Belošljiva'. Its compatibility with apricots, especially with 'Hungarian Best' (major cultivar in Serbia) is better compared to Myrobalan, precocity is good, vigour is a little lower, susceptibility to *Plum Pox Virus* and tendency towards suckering is very high (Milošević et al., 2019). Both of them are unsuitable for semi- and/or high-density orchards due to their very high vigour (Milošević et al., 2015). Experiences with other rootstocks in Serbia, especially clonal rootstocks, are very poor. The controversies regarding rootstocks for apricot underline the very complex nature of this problem and the need to study it with a view to identify the most suitable rootstocks for each apricot cultivar (Milošević et al., 2011).

For these reasons, the main goal of this study is to determine the influence of three rootstocks – one generative (Myrobalan) and two clonal (St. Julien A and Pumiselect) – on tree growth, precocity, productivity and main fruit physical and chemical properties of three newly-bred Serbian apricot cultivars grown on sandy-loam and acidic soil in semi-high density planting system.

MATERIAL AND METHODS

PLANT MATERIAL, FIELD TRIAL AND EXPERIMENTAL PROCEDURE

Three newly-bred apricot cultivars selected at the Faculty of Agriculture in Novi Sad (Serbia) were used (Đurić et al., 2005). Cultivars were grafted on Myrobalan seedlings, St. Julien A (*Prunus insititia* (L.) Juss.) and Pumiselect (*P. pumila* L.) at 60 cm above ground level. St. Julien A is a traditional semi-vigorous rootstock (like MM106 or Colt) for plum and apricot selected at the English Research Center East Malling, Kent. Pumiselect is a selection of *P. pumila* that has shown superior qualities in German trials for many years. The selection was made by Helmut Jacob at the Research Station in Geisenheim, Germany, in 1973. The first trials were carried out from 1986 to 1995. Apricots: dwarfed (~50 %) compared to seedling apricot rootstock (Licznar-Małańczuk and Sosna, 2009). Pumiselect is also cold, drought and root knot nematode tolerant. In USA this rootstock is tested in many experiments as 'Rhenus 2' (Danilovich and Shane, 2004).

Research was conducted from 2011 to 2017 at a private orchard located in Prislonica village (43°53'N latitude, 20°21'E longitude, 340 m a.s.l.) near Čačak, western Serbia. In autumn of 2011, one-year-old nursery apricot trees were planted at spacing of 5.5 m x 3 m (607 trees/ha). The experiment was established in a randomized block design with six trees for each cultivar-rootstock combination in four replicates (n = 24). The trees were trained as open-vase canopy. This training system controlled tree vigour by pruning in the summer. Standard cultural practices were used, except irrigation.

TREE GROWTH, TREE MORTALITY, YIELD AND FRUIT PHYSICO-CHEMICAL ATTRIBUTES

Growth of the trees was evaluated each year in November at the end of the vegetative cycle by calculating the cross-section area of the trunk (TCSA, cm^2) 40 cm above the ground level. The number of died trees was recorded every year for all cultivar-rootstock combinations from 2011 to 2018.

The fruit yield (kg/tree) was calculated taking into account the total fruit collected from each tree of each cultivar-rootstock combination. The cumulative production (kg/tree) was obtained by adding the yields obtained in previous years. Yield efficiency was estimated as cumulative yield/final TCSA ratio and expressed as kg/cm.

Samples of 25 fruit per cultivar-rootstock combination in four replicates (n = 100) were hand-harvested randomly for experimentation at the commercial maturity stage, on the basis of their skin ground colour, i. e. fully coloured. Fruit and stone weight (g) were measured with a digital balance MAULsteel 5000 G (Jakob Maul GmbH, Bad König, Germany). The flesh rate (%) was calculated by subtracting the stone weight from the whole apricot fruit weight. Sphericity or fruit shape index was calculated by using the equations proposed by Mohsenin (1980), after measurements of three fruit linear dimensions (length, width, thickness).

After measuring of physical parameters, the same fruit were used for chemical evaluation. After sample preparation, soluble solids content (SSC, °Brix) was assessed with a hand refractometer Milwaukee MR 200 (ATC, Rocky Mount, USA) at 20 °C. For titratable acidity (TA, % of malic acid), prepared juice was titrated with 0.1 mol/l NaOH, up to pH 8.1 using a titrimeter Metrohm 719 Titrino (Metrohm, Herisau, Switzerland). Once the SSC and TA contents were assessed, the ripening index (SSC/TA ratio) was calculated.

Both physical and chemical analyses of fruit were carried out in 2016 and 2017. Results were presented as means ± standard error for these two years.

SOIL AND WEATHER CONDITIONS

Soil physical-chemical analysis was performed prior to trial establishment. Results showed that the trial was conducted on soil with 1.62 % organic matter, 0.16 % N_{TOT}, 17.8 mg P_2O_5 in 100 g of dry soil, 22.0 mg K_2O/100 g, 0.39 % CaO and 0.62 mg MgO/100 g. Available micronutrients amounts ranged from very high for Fe (78 µg/g), high for Cu (1.6 µg/g) and B (2.3 µg/g), low for Mn (7.8 µg/g) to very low for Zn (0.52 µg/g). Soil texture is sandy-loam with low pH, ranging from 4.86 in the first (0 to 30 cm) to 4.33 in the second soil depth (31 to 60 cm). In general, soil conditions were unfavorable for optimal growth and development of apricot trees.

The climate is maritime temperate, with moderate to strong winters and hot and semi-dry to dry summers, characterized by the average annual temperature of 11.3 °C and total annual rainfall of 690.2 mm (long-term average). The average air temperature during the vegetative cycle was 17.0 °C.

DATA ANALYSIS

The obtained results were evaluated statistically using one-way analysis of variance (ANOVA) with help of Microsoft Excel software (Microsoft Corporation, Roselle, USA). The significance of differences between means was evaluated according to LSD test at P ≤ 0.05.

RESULTS AND DISCUSSION

VEGETATIVE GROWTH, PRODUCTIVITY AND TREE SURVIVAL

Results in Figure 1 revealed that tree growth increased from 2011 to 2017 in all tested trees. The obtained results correspond with our earlier opinion on apricot (Milošević et al., 2015 and 2019). In the first three years after planting, differences between rootstocks were not significant; later, i. e. from 2014 to 2017, differences became evident. From this year (2014) on, we found significant differences in the increasing rates of TCSA of all rootstocks evaluated. As expected, the most intensive tree growth was found with Myrobalan, whereas the growth on St. Julian A and Pumiselect was weaker. Similar results were obtained by a number of researchers for strong growth intensity of apricots on the vigorous Myrobalan rootstock (Son and Küden, 2003; Sosna and Licznar-Małańczuk, 2012; Milošević et al., 2015). On the other hand, apricot trees planted in high density grow weaker than with wider spacing (Milošević et al., 2011). In 2017, rootstock effects on tree vigour significantly differed in the final TCSA values (Table 1). The highest value was exhibited by Myrobalan, a moderate one by St. Julien A and the lowest by Pumiselect. This order has been expected and described in earlier studies on apricot (Wurm, 2007; Milošević et al., 2011 and 2015). The semi-vigorous influence of St. Julien A as a rootstock was described earlier (Kosina, 2004).

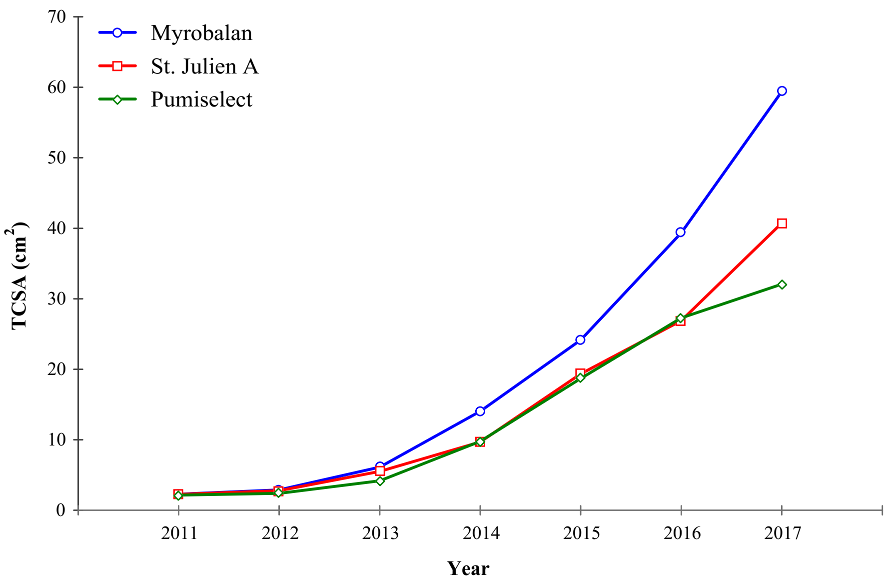

Fig. 1: Effect of rootstock on trunk cross-sectional area (TCSA) of apricots from the first (2011) to the sixth (2017) year after planting

In relation to Myrobalan, Pumiselect reduced vegetative growth in the examined apricots by 46.7 %, 34.2 % and 65 %, respectively, i. e. about 48.3 % in average. Growth reduction of apricot trees on Pumiselect rootstock was also observed earlier by Wurm (2007) and Sosna and Licznar-Małańczuk (2013).

According to our results, it can be said that both St. Julien A and Pumiselect rootstocks can be classified as size-controlling rootstocks (Southwick and Weis, 1998), i. e. St. Julien A as semi-dwarfing (Kosina, 2004) and Pumiselect as a dwarfing rootstock for apricot (Wurm, 2007). Hence, Pumiselect showed high suitability for apricot trees planted at high density because it significantly reduces growth vigour (Sosna and Licznar-Małańczuk, 2013).

Regarding cultivars, tree growth increased from 2011 to 2017 with no significant differences in increasing rates in the first four years after planting (Fig. 2). Later, i. e. from 2015 to 2017, differences in growth intensity were significant, especially in the latest year (2017) (Table 1). In this year, the highest TCSA was found with 'Novosadska Rodna', an intermediate one in 'NS 4', and the lowest in 'NS 6', which is in agreement with data presented by Đurić et al. (2005) with small discrepancies. Namely, in a study of the same authors, 'NS 6' classified as a semi-vigorous to vigorous genotype whereas 'Novosadska Rodna' classified as semi-vigorous. Probably, genetic background of the rootstock influences the scion, but the response of a scion grafted onto different rootstocks may be very different and vice versa. In addition, the apricot cultivars used in our study as well as the limiting soil conditions could have accounted for further differences in vigour as previously reported (Hernández et al., 2010). However, in grafted trees, the control of tree size is mainly due to rootstock, although the mechanism by which rootstock regulates scion-vigour is still unclear (Basile et al., 2003).

Table 1: Vegetative growth and productivity traits of three apricot cultivars grafted on different rootstocks

Cultivar	Rootstock	TCSA (cm^2) Year - 2017	Yield (kg/tree) Year - 2017	Cumulative yield (kg/tree) (2014-2017)	Yield efficiency (kg/cm)
Novosadska Rodna	Myrobalan	74.5 ± 5.9 a	4.6 ± 0.1 a	8.4 ± 0.4 a	0.122 ± 0.02 b
	St. Julien A	55.5 ± 5.4 b	5.4 ± 0.3 a	8.3 ± 0.2 a	0.127 ± 0.00 b
	Pumiselect	39.7 ± 2.0 c	4.0 ± 0.3 a	8.5 ± 0.3 a	0.218 ± 0.01 a
	Average	56.6 ± 4.4 A	4.7 ± 0.3 B	8.4 ± 0.3 B	0.155 ± 0.01 C
NS 4	Myrobalan	48.5 ± 6.7 a	6.4 ± 0.4 b	9.8 ± 0.5 c	0.199 ± 0.04 c
	St. Julien A	39.0 ± 1.6 b	15.8 ± 1.1 ab	18.3 ± 2.4 b	0.488 ± 0.02 b
	Pumiselect	31.9 ± 1.7 c	21.2 ± 0.6 a	25.7 ± 0.8 a	0.816 ± 0.02 a
	Average	39.8 ± 3.4 B	14.5 ± 0.7 A	17.9 ± 1.3 A	0.501 ± 0.05 A
NS 6	Myrobalan	60.3 ± 1.4 a	4.0 ± 0.2 b	5.5 ± 0.2 b	0.091 ± 0.00 c
	St. Julien A	25.7 ± 1.6 b	5.5 ± 0.4 a	7.7 ± 0.8 b	0.378 ± 0.03 b
	Pumiselect	21.1 ± 1.8 c	6.0 ± 0.5 a	12.5 ± 1.0 a	0.482 ± 0.03 a
Average		35.7 ± 1.6 C	5.2 ± 0.4 B	8.6 ± 0.7 B	0.317 ± 0.02 B

Different small and capital letter(s) in same column indicate significantly different values within each rootstock and within each cultivar, respectively at $P \leq 0.05$ by LSD test.

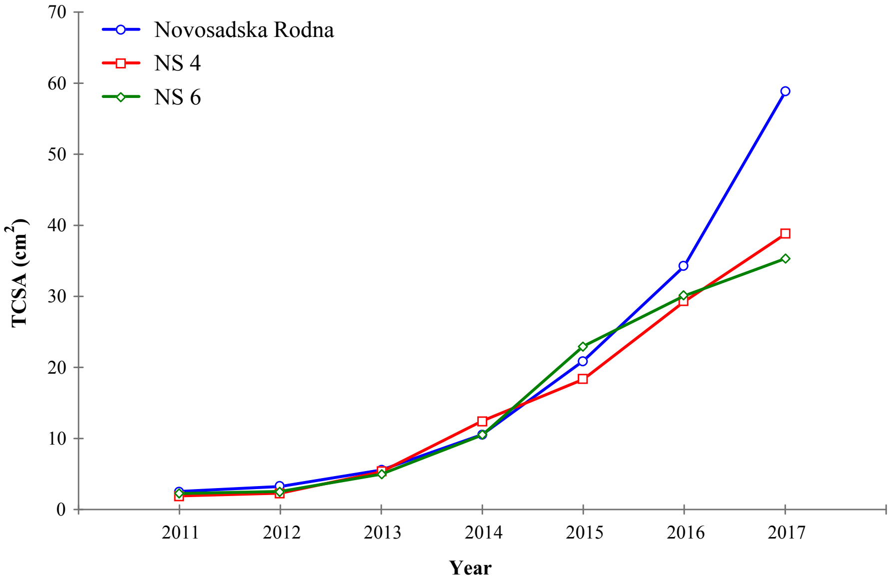

Fig. 2: Effect of cultivar on trunk cross-sectional area (TCSA) of apricots from the first (2011) to the sixth (2017) year after planting

Productivity, as assessed by yield per tree, was significantly affected by rootstock starting from the third year after planting (Fig. 3). The increasing rate of yield per tree was highly affected by the rootstocks (Table 1), being similar and higher for Pumiselect and St. Julien A, and statistically lower for Myrobalan in case of 'NS 4' and 'NS 6', whereas for 'Novosadska Rodna' yield per tree rates were not affected by rootstocks. SON and KÜDEN (2003) also reported that apricots grafted on Myrobalan GF-31 gave low yield.

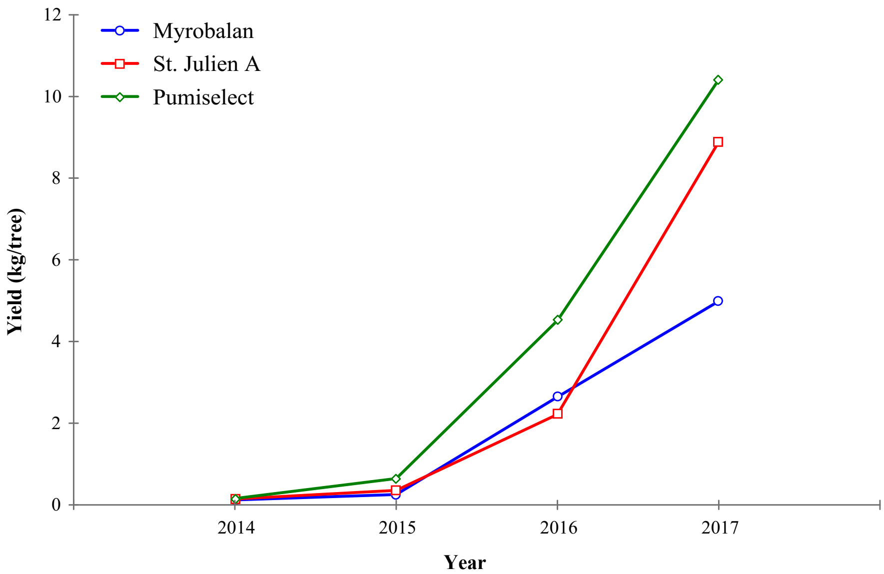

Fig. 3: Effect of rootstocks on precocity and yield of apricots from the third (2014) to the sixth (2017) year after planting

Fruit yield was also influenced by cultivar (Fig. 4), being higher in 'NS 4' than in both 'Novosadska Rodna' and 'NS 6' with no significant differences between them (Table 1). In general, the apricot trees start to produce in the third or fourth year after planting, which was the case in our trial. Several authors also reported similar data (Milošević et al., 2011; Sosna and Licznar-Małańczuk, 2012). In general, yields in the final year (2017) were moderate. In a study of Milatović et al. (2017), the same apricots on Myrobalan had higher yield per tree rates than those obtained in our trial. These opposing responses in tree yield may be due to a better or worse adaptation of newly-bred Serbian apricots and/or rootstocks to a typical sandy-loam and acidic soil which is different to the fertile soil from where these genotypes were obtained in Vojvodina (north part of Serbia) and/or Belgrade region. Generally, apricot on Myrobalan gives a low yield (Crossa-Raynaud and Audergon, 1987). In addition, Egea et al. (1991) reported that 'Bulida' apricot on Pollizo (St. Julien) rootstock gave the highest yield which is case in our trial.

Cumulative yield was also affected by rootstock with exception of 'Novosadska Rodna' (Table 1). In this cultivar, similarly to yield per tree rate, values were not influenced by rootstock. In other two apricots, Pumiselect induced the highest cumulative yield, whereas Myrobalan induced the lowest. St. Julien A along with Myrobalan induced the lowest and similar cumulative yield in 'NS 6'. Regarding cultivars, 'NS 4' promoted better cumulative yield in comparison with two other apricots. These data are not in agreement with results of Milatović et al. (2017) who reported that 'Novosadska Rodna' had better cumulative yield than both 'NS 4' and 'NS 6' at the same age. Licznar-Małańczuk and Sosna (2013) noted that total yield of the cultivar 'Harcot' on Pumiselect exceeded 40 kg per tree during four years. In addition, Sosna and Licznar-Małańczuk (2012) found that cumulative yield of apricots was higher on seedlings of Myrobalan in comparison with 'Wangenheim Prune' seedlings. Probably, cultural practice and pedoclimatic conditions, along with cultivar and rootstock, play an important role in yield formation of apricots.

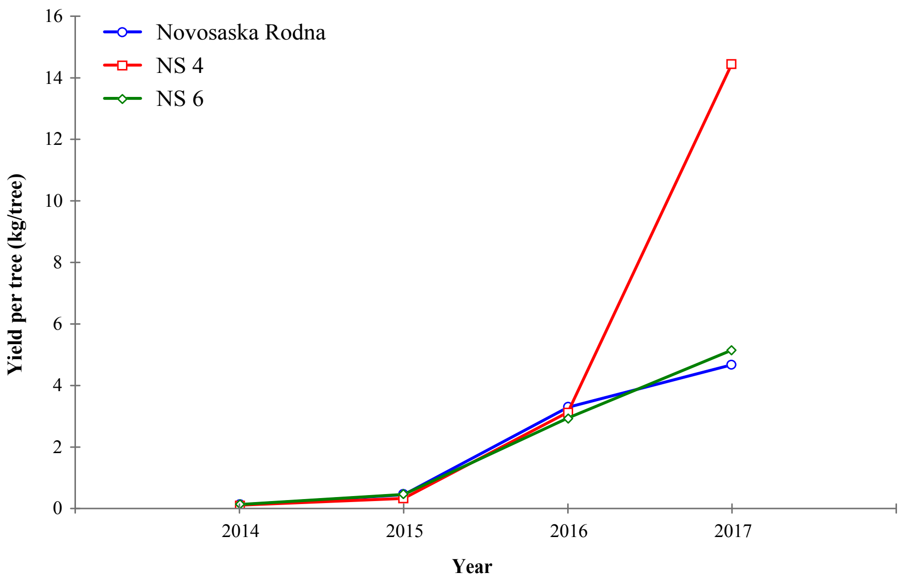

Fig. 4: Effect of cultivar on precocity and yield of apricots from the third (2014) to the sixth (2017) year after planting

In our trial, rootstocks significantly influenced yield efficiency. The highest values were promoted by Pumiselect, intermediate ones by St. Julien A, and the poorest by Myrobalan. The highest yield efficiency recorded on Pumiselect for all three cultivars could be associated with its lower vigour as previously reported (Licznar-Małańczuk and Sosna, 2013). The low yield efficiency shown by Myrobalan has already been reported by other authors (Son and Küden, 2003; Milosević et al., 2011). In addition, Egea et al. (1991) reported that 'Bulida' apricot on Pollizo (St. Julien) rootstock gave the highest yield which was confirmed by our results. Other authors also reported similar ranges of this coefficient for the same (Milatović et al., 2017) and other apricot genotypes (Vachůn, 2001; Milošević et al., 2013a, b). The first individual tree mortality appeared in 2016, a more intensive one in 2017 and especially in 2018. Tree mortality depends on the rootstock but also on the genotype (data not shown). By 2018, 56 %, 18 % and 40 % of the trees on Pumiselect, St. Julien A and Myrobalan in the trial had died, respectively. The percentage of dead apricot trees on Pumiselect is very close to the results of other researchers. For example, Wurm (2007) does not recommend this rootstock because 60 % of the trees died through the eight years after planting. In a study of Licznar-Małańczuk and Sosna (2013), percentage of died-off apricot trees on Pumiselect varied from 25 to 50 % up to the end of the sixth year after planting. High mortality (about 50 %) was found also in peach on this rootstock (Hudina et al., 2006). Excellent apricot tree survival on St. Julien (100 %) was previously described by Knowles et al. (1994). Tree mortality on Myrobalan due to its incompatibility with apricots has been long known and varies from case to case in extremely wide ranges (Milošević et al., 2015).

In the case of genotypes, 'Novosadska Rodna' showed 64 % survival until 2018 on all rootstocks in average, 'NS 4' 79 % and 'NS 6' only 43 %. Interestingly, by 2018, 100 % of the trees of 'NS 6' on Pumiselect had died, whereas 'NS 4' on the same rootstock showed 100 % survival at the same time. Vachůn (2002) and Licznar-Małańczuk and Sosna (2013) noted that precocious apricot tree decline was importantly caused by cultivars. Hence, proper choice of harmonious cultivar-rootstock combination in apricot can prevent precocious tree decline (Vachůn, 2002; Gonçalves et al., 2006).

FRUIT PHYSICO-CHEMICAL ATTRIBUTES

Data presented in Table 2 showed that main fruit physical properties were significantly affected by rootstocks with exception of stone weight and fruit shape (sphericity) in some cases. Pumiselect increased fruit weight in 'NS 4' and 'NS 6', whereas St. Julien A induced better fruit weight in 'Novosadska Rodna'. All cultivars on Myrobalan gave the smallest fruit as previously reported (Crossa-Raynaud and Audergon, 1987; Son and Küden, 2003; Egea et al., 2004). Several authors stated that rootstocks may influence fruit weight and fruit size (Knowles et al., 1994; Hernández et al., 2010). On this line, Wurm (2007) reported that Pumiselect decreased mean fruit weight with the cultivar 'Bergeron' which was not the case in our trial. In contrast, Sosna and Licznar-Małańczuk (2012) noted that rootstock had no influence on mean apricot weight. However, the key factors that determine fruit weight are the genetic base of genotype and crop load. So, at lower crop load, larger fruit are obtained and vice versa (Egea et al., 2004). In addition, harmonious relationship between cultivar and rootstock also plays an important role in terms of fruit size and other quality attributes (Gonçalves et al., 2006). This can explain the contrary results of the effect of Pumiselect on fruit weight.

Regarding cultivars, 'Novosadska Rodna' had the significantly largest fruit, intermediate ones were found with 'NS 4' and the smallest with 'NS 6'. In a study of Milatović et al. (2017), 'Novosadska Rodna' also had the largest fruit, whereas 'NS 4' and 'NS 6' had similar and the lowest fruit weight.

Stone weight was not affected significantly by rootstock (Milošević et al., 2015), but cultivar variation is evident. 'Novosadska Rodna' and 'NS 4' had similar and higher stone weight than 'NS 6'. Otherwise, apricot stones are more stable traits and used in genotype identifi-

Table 2: Fruit physical properties of three apricot cultivars on different rootstocks

Cultivar	Rootstock	Fruit weight (g)	Stone weight (g)	Flesh rate (%)	Sphericity
Novosadska Rodna	Myrobalan	68.8 ± 1.0 c	3.1 ± 0.2 a	95.5 ± 0.3 b	0.95 ± 0.0 a
	St. Julien A	100.3 ± 5.5 a	3.1 ± 0.3 a	96.7 ± 0.3 a	0.95 ± 0.0 a
	Pumiselect	88.8 ± 3.3 b	3.0 ± 0.2 a	96.5 ± 0.2 a	0.94 ± 0.0 a
	Average	86.0 ± 3.3 A	3.1 ± 0.2 A	96.2 ± 0.3 A	0.94 ± 0.0 A
NS 4	Myrobalan	70.4 ± 0.8 c	3.1 ± 0.2 a	95.5 ± 0.3 a	0.95 ± 0.0 a
	St. Julien A	79.9 ± 1.8 b	3.0 ± 0.1 a	96.2 ± 0.2 a	0.93 ± 0.0 b
	Pumiselect	90.0 ± 3.4 a	3.2 ± 0.3 a	96.3 ± 0.4 a	0.92 ± 0.0 c
	Average	80.1 ± 2.0 B	3.1 ± 0.2 A	96.0 ± 0.3 A	0.94 ± 0.0 A
NS 6	Myrobalan	67.2 ± 1.0 c	2.4 ± 0.1 a	96.4 ± 0.2 b	0.95 ± 0.0 a
	St. Julien A	78.7 ± 1.9 b	2.8 ± 0.2 a	96.4 ± 0.2 b	0.94 ± 0.0 a
	Pumiselect	84.4 ± 2.5 a	2.4 ± 0.2 a	97.2 ± 0.2 a	0.95 ± 0.0 a
Average		76.8 ± 1.8 C	2.5 ± 0.1 B	96.7 ± 0.2 A	0.95 ± 0.0 A

Different small and capital letter(s) in same column indicate significantly different values within each rootstock and within each cultivar, respectively at P ≤ 0.05 by LSD test.

cation (Vachůn, 2003).

Flesh rate was significantly affected by rootstock in 'Novosadska Rodna' and 'NS 6', whereas no influence on this trait in 'NS 4' occured. Similar values for flesh rate for same genotypes were observed by Rahović et al. (2013). Otherwise, the higher flesh rate is a desired fruit trait in apricot for both fresh consumption and processing (Gezer et al., 2003).

In the case of sphericity (fruit shape), rootstock induced small but significant changes only in 'NS 4'. Namely, Pumiselect elongated fruit, whereas the other two rootstocks induced more spherical fruit shape in this genotype. Differences between cultivars were not significant probably due to their similar origin (Đurić et al., 2005).

No consistent differences were found between rootstocks for SSC, TA and SSC/TA ratio along the study for any of the cultivars (Table 3) as it has been previously mentioned by other authors (Hernández et al., 2010). With exception of 'NS 4', rootstocks significantly affect SSC in the other two apricots. The highest values were found with Pumiselect, intermediate ones with Myrobalan and the lowest with St. Julien A. 'NS 6' is the genotype with the highest SSC, whereas 'Novosadska Rodna' and 'NS 4' had similar and lower SSC. Titratable acidity and SSC/TA ratio were not significantly affected by the rootstocks in fruit of 'Novosadska Rodna' and 'NS 4', but in contrast, only in fruit of 'NS 6' these values varied between rootstocks. In this case, TA was higher in 'NS 6' on Myrobalan, and similar and lower on the other two rootstocks. Quite contrary, SSC/TA ratio was higher in the same cultivar on Pumiselect, and similar and lower on the more vigorous St. Julien A and Myrobalan. It seems that cultivar had a stronger effect on these properties than rootstocks as previously reported (Daza et al., 2008). Namely, the highest TA was found in 'NS 4' and similar and lower ones in 'NS 6' and 'Novosadska Rodna'. The situation is completely reversed in the case of ratio between SSC and TA. Similar tendencies of behavior of apricot cultivars on different rootstocks were observed by Hernández et al. (2010). In general, our values for SSC and TA are similar to results of Milatović et al. (2017) and Rahović et al. (2017) for the same apricots.

It has been long known that SSC is a very important quality attribute, influencing notably the fruit taste. Some authors reported that apricot genotypes which have a SSC >12 °Brix were characterized by an excellent sensory quality (Egea et al., 1991). In the present study, fruit of all cultivar-rootstock combinations had higher SSC than 12 °Brix. Therefore, the SSC/TA ratio or ripening index is commonly used as a quality index for different fruit species, such as peach, nectarine, plum and sweet cherry, and higher ratios are usually preferred (Crisosto et al., 2002). According to the same authors, this ratio has been reported to have a closer relationship with fruit eating quality than TA or SSC. In addition, in the case of cultivars with TA >0.90 % and SS <12.0 °Brix, consumer acceptance was influenced by the interaction between TA and SSC rather than SSC alone. Based on this result, it can be said that the apricots investigated, regardless of the rootstocks and inadequate soil conditions, have a good and harmonious taste.

CONCLUSION

The eight year results of this work showed that under sandy-loam and acidic soil growing conditions apricots grafted on Pumiselect and St. Julen A show lower tree growth, higher yield, yield efficiency and respectable fruit quality. Myrobalan showed a tendency to induce a higher vigour in comparison to the other rootstocks, which seems to reduce their yield efficiency and decrease yield and fruit quality. Results also showed the suitability of Pumiselect as a dwarfing clonal rootstock only for 'NS 4' and St. Julien A as a semi-dwarfing clonal rootstock only for the 'Novosadska Rodna', further intensive investigation should be undertaken to estimate influence of these both rootstocks, including Myrobalan, on evaluated properties of other apricots and elimination of their precocious decline. Only by long-term testing of above rootstocks on specific soils with desired cultivars best choices can be made.

Table 3: Soluble solids content, titratable acidity and ripening index of three apricot cultivars on different rootstocks

Cultivar	Rootstock	Soluble solids content (°Brix)	Titratable acidity (g)	Ripening index
Novosadska Rodna	Myrobalan	14.3 ± 0.1 b	1.1 ± 0.0 a	13.3 ± 0.3 a
	St. Julien A	12.9 ± 0.3 c	1.0 ± 0.0 a	12.6 ± 0.4 a
	Pumiselect	15.5 ± 0.4 a	1.1 ± 0.0 a	14.1 ± 0.6 a
	Average	14.2 ± 0.3 B	1.1 ± 0.0 B	13.3 ± 0.4 A
NS 4	Myrobalan	14.2 ± 0.1 a	1.4 ± 0.0 a	10.1 ± 0.2 a
	St. Julien A	14.6 ± 0.4 a	1.3 ± 0.0 a	11.7 ± 0.6 a
	Pumiselect	14.4 ± 0.2 a	1.3 ± 0.0 a	11.7 ± 0.4 a
	Average	14.4 ± 0.3 B	1.3 ± 0.0 A	11.2 ± 0.4 B
NS 6	Myrobalan	15.5 ± 0.2 b	1.2 ± 0.0 a	12.7 ± 0.3 b
	St. Julien A	13.1 ± 0.2 c	1.1 ± 0.0 b	12.6 ± 0.5 b
	Pumiselect	16.3 ± 0.8 a	1.1 ± 0.0 b	14.5 ± 0.8 a
Average		15.0 ± 0.4 A	1.1 ± 0.0 B	13.3 ± 0.5 A

Different small and capital letter(s) in same column indicate significantly different values within each rootstock and within each cultivar, respectively at P ≤ 0.05 by LSD test.

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