THE USEFULNESS OF TWO ROOTSTOCKS FOR SOME PLUM CULTIVARS

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A B S T R A C T

The influence of two rootstocks (*Prunus cerasifera* Ehrh. and *Prunus tomentosa* Thunb.) on growth, yield and fruit quality of five plum cultivars: 'Herman', 'Opal', 'Čačanska Rana', 'Čačanska Lepotica' and 'Dąbrowicka Prune' was estimated. Seven years after planting, the trees of all the considered cultivars grew more vigorously on *P. cerasifera* rootstock than the trees on *P. tomentosa*. The highest yields were harvested from the trees 'Čačanska Lepotica' grafted on *P. cerasifera*. Productivity of all the cultivars of plum trees on *P. tomentosa* rootstock was higher than of these grafted on *P. cerasifera* seedling. The considered rootstocks had no influence on fruit weight of the investigated plum cultivars. 'Čačanska Rana' trees produced the biggest fruit, whereas the smallest were harvested from 'Dąbrowicka Prune' trees.

Key words: plum, rootstocks, cultivars, growth, yield, fruit size

INTRODUCTION

In Poland, plum trees are cultivated mainly on *Prunus cerasifera* seedlings and on Wangenheim Prune rootstocks. Trees on *Prunus cerasifera* rootstock grow strongly and they enter a fructification period relatively late (Rozpara and Grzyb, 1998). What is more, they are characterized by small fertility, especially in the first years after planting (Grzyb et al., 1984; Sitarek et al., 2000). This rootstock is not suitable for strongly growing plum cultivars (Tehrani and Leuty, 1987; Barroso, 1998; Grzyb et al., 1998; Kosina et al., 2000). However, it is still recommended for trees with a medium growth vigour and for those planted

on light soils (Sosna, 2004). Plum trees grafted on Wagenheim Prune rootstock grow weaker than these on *Prunus cerasifera*, they enter a fructification period early and yield abundantly (Grzyb et al., 1998; 2000; Sitarek et al., 2000). Some plum cultivars growing on Wangenheim Prune rootstock, however, tend to bear smaller fruit, especially when planted on light soils (Grzyb et al., 1998).

In intensive orchards, only the rootstocks which significantly reduce the growth vigour of cultivars grafted on them, and at the same time those which guarantee long-lasting liveliness of trees and do not reduce the size of fruit will find their application. For many years studies on rootstocks for plum cultivars have been carried out in Poland (Grzyb et al., 1984; 1998; Rozpara and Grzyb, 1994; Grzyb and Hartmann, 1995; Hartmann and Grzyb, 1997; Grzyb and Sitarek, 1998; Paszko, 1998; Rozpara and Grzyb, 1998; Łysiak, 1999; Sitarek et al., 2001; Sosna, 2002; 2004). At present, vegetatively propagated rootstocks such as 'Pixi', 'GF 655/2' and 'St. Julien A' play a very important role in the intensification of plum orchards. Their suitability for cultivation is evaluated in many countries (Webster and Wertheim, 1993; Ystaas et al., 1994; Boyhan et al., 1998; Embree et al., 1999). Planting plum trees grafted on dwarf or semi-dwarf rootstocks enables an increase in a number of trees in a row and leads to a higher yield per area unit (Botu et al., 1998; Kosina et al., 2000; Sosna, 2002).

The aim of the undertaken studies was the evaluation of the growth and the yield of five plum cultivars growing on the selected *Prunus tomentosa* rootstock compared with a standard *Prunus cerasifera* rootstock.

MATERIAL AND METHODS

The studies were carried out in Experimental Station in Baranowo, Poland, in the years 2002-2008. The experiment was set up in the randomised blocks design in four replications with 5 plum trees planted per a plot (there were 20 trees in each combination). The object of the studies were five cultivars of plum trees: 'Herman', 'Opal', 'Čačanska Rana', 'Čačanska Lepotica' and 'Dąbrowicka Prune', grafted on two rootstocks – *Prunus cerasifera* propagated from seeds and the selected type of *Prunus tomentosa* propagated by soft wood cuttings.

In the spring of 2002, one-year maiden plum trees, equalized in respect of the measured growth features, were planted into the orchard at 4 x 2.5 m spacing (1000 trees ha^{-1}). The yield of the trees was evaluated within five succeeding years starting from the third year after planting. The ripe fruit were collected several times. The yield from each tree was weighed, and the mass of randomly chosen fruit was checked. The circumference of the trunk of each tree was measured at the height of 30 cm above the level of the ground. The height of the trees and the width of their crowns were measured with a pole in two directions (east-west

and north-south). The vigour of growth was estimated on the basis of trunk cross-sectional area (cm^{-2}) calculated from the measurement of the tree trunk circumference. All the measurements of the tree growth vigour were conducted in the autumn of 2008. The productivity of the individual trees was calculated on the basis of the yield of fruit per 1 cm^{-2} of the trunk cross-sectional area. During the period of the experiment no visual symptom of incompatibility between the rootstocks and the cultivars was observed, and neither were suckers.

All the trees in the experiment were trained as a spindle and pruned after fruiting. The trees were not irrigated except for the year 2003 and 2008 when the orchard was irrigated twice because of a drought. Agrotechnical practices followed the guidelines for commercial orchards. Chemical pest and disease control was carried out in accordance with the current recommendations of the Orchard Protection Programme. During the first two years after planting no herbicides were used, whereas in the next years they were applied. The plum trees growing on *Prunus tomentosa* were supported with wooden poles till the moment they entered the fructification period.

The statistical analysis of the obtained data was carried out by two-factorial analysis of variance (the rootstocks and the cultivars) using Duncan's test for means separation at probability level $p = 0.05$.

RESULTS AND DISCUSSION

Till the 7th year after planting the studied rootstocks and cultivars significantly influenced the vegetative growth of the trees expressed by the height of these trees. The trees of 'Čačanska Rana' growing on *Prunus cerasifera* rootstock were the highest. With the exception of 'Čačanska Rana', the trees grafted on *Prunus tomentosa* were the lowest (Tab. 1).

The mean height of the plum trees on *Prunus tomentosa* was significantly smaller compared with the height of the trees growing on *Prunus cerasifera.* Also Siegler (1997) obtained much lower plum trees on *Prunus tomentosa* – 3.5 m compared with trees growing on rootstocks: 'St. Julien A' – 4.3 m, 'GF 655/2' – 4.1 m and 'Pixi' – 3.9 m. The height of eight-year-old plum trees on *Prunus tomentosa* rootstock obtained by Karyczew and Jankowa (1999) was within the range 2.4-3.5 m, depending on the grafted plum cultivar, and it was similar to that obtained in the experiment presented. Among the studied plum cultivars only the trees of 'Čačanska Rana' were significantly higher than the rest.

The volume of the crowns was differentiated by the applied rootstock and the cultivar. The biggest volume of the crown was observed for 'Čačanska Rana' grafted on *Prunus cerasifera* rootstock and the smallest were found for 'Herman', 'Opal' and 'Dąbrowicka Prune' trees which grew on *Prunus tomentosa* rootstock (Tab. 1).

The volume of the crowns on *Prunus tomentosa* rootstock was significantly smaller than on *Prunus cerasifera* rootstock, independently from the cultivar. A smaller size of the crown on *Prunus tomentosa* rootstock was also obtained by Siegler (1997) – 223 cm compared with the rootstocks such as GF 655/2 – 279cm, St. Julien – 271 cm and Pixy – 248 cm. For plum trees growing on *Prunus tomentosa* rootstock, Karyczew and Jankowa (1999) noted the size of the crown circumference from 1.9 m to 3.5 m, which is similar to the results obtained in the present experiment.

The trees of 'Herman' and 'Opal' growing on the two studied rootstocks had the smallest volume of the crown, and of 'Čačanska Rana', the biggest. Examining the growth of trees of different plum cultivars on *Prunus cerasifera* rootstock, Sosna (2004) have found that the volume of the crowns of 'Herman', 'Čačanska Rana' and 'Čačanska Lepotica' did not differ significantly. In the present experiment, the volume of the crown of 'Čačanska Rana' cultivar was much bigger than the rest.

An applied rootstock and cultivar differentiated the most important growth parameter of the trees – the trunk cross-sectional area (TCSA). Taking into consideration this parameter, the trees of 'Čačanska Rana' cultivar on *Prunus cerasifera* seedling grew the strongest whereas the weakest growth was observed for all the analysed cultivars except for 'Čačanska Rana', on *Prunus tomentosa* rootstock (Tab. 1).

Prunus tomentosa is commonly regarded as a dwarf rootstock (Bernhard and Mesnier, 1975; Tretjak, 1975; Helton, 1976; Van Oosten, 1979; Webster, 1980; Tu CueiQin et al., 1996; Karyczew and Jankowa, 1999; Świerczyński, 2001). Also in the discussed experiment the plum trees of all cultivars growing on *Prunus tomentosa* had a weaker growth than on *Prunus cerasifera*. Weakening in the plum trees' growth on *Prunus tomentosa* is consistent with the results obtained by Brenhard and Mesnier (1974) who noted the value of TCSA of eight-year-old plum trees growing on *Prunus tomentosa* rootstock – 38 cm^2 compared with *Prunus cerasifera* – 211 cm^2. In the experiment presented such a big difference was not observed. Siegler (1997) noted 36% decrease in TCSA of trees grown on *Prunus tomentosa* rootstock as compared with 655/2 rootstock and 15% decrease compared with Pixy. Also Ogašanović and Papić (1997) obtained TCSA smaller by 25% to 70%, for trees growing on *Prunus tomentosa* rootstock, depending on a cultivar.

Among the cultivars studied, three – 'Herman', 'Opal' and 'Dąbrowicka Prune' – had the lowest values of TCSA, whereas the cultivars of 'Čačanska Rana' and 'Cacanska Lepotica', the biggest ones. Also Sosna (2004) in his studies observed a high value of TCSA for 'Čačanska Rana' cultivar – 144.9 cm^2. He did not confirm it, however, for 'Čačanska Lepotica' cultivar – 85.6 cm^2. Łysiak (1999) noticed much stronger

Table 1. Tree size, cumulative yield, yield efficiency and mean fruit weight of five plum cultivars grafted on two different rootstocks (trees were planted in the spring 2002)

Cultivar	Rootstock	Height of trees [cm]	Volume of crown, in autumn 2008 [m^3]	TCSA** in autumn 2008 [cm^2]	Cumulative yield 2004-2008 [kg $tree^{-1}$]	Productivity index [kg cm^{-2}]	Mean fruit weight [g]
Herman	*Prunus cerasifera*	385.0 c*	9.7 d	78.5 c	91.5 cd	1.17 b	34.5 de
	Prunus *tomentosa*	300.0 a	4.5 a	32.2 ab	78.1 abc	2.43 e	33.7 de
Opal	*Prunus cerasifera*	393.0 c	9.3 d	84.9 c	108.0 e	1.27 c	25.7 c
	Prunus tomentosa	318.0 a	4.4 a	30.2 a	88.6 bcd	2.93 g	24.7 bc
Čačanska Rana	*Prunus cerasifera*	468.0 d	17.0 f	124.6 e	73.8 ab	0.59 a	40.0 e
	Prunus tomentosa	350.0 b	8.2 c	47.8 b	64.4 a	1.35 cd	38.1 e
Čačanska Lepotica	*Prunus cerasifera*	410.0 c	11.9 e	102.0 d	145.6 f	1.42 d	31.3 cd
	Prunus tomentosa	310.0 a	5.4 b	38.5 ab	111.4 e	2.90 g	29.4 cd
Dąbrowicka Prune	*Prunus cerasifera*	400.0 c	12.2 e	75.9 c	96.4 de	1.28 c	18.8 ab
	Prunus tomentosa	305.0 a	5.1 ab	26.4 a	72.6 ab	2.75 f	17.2 a

*Mean values followed by the same letter are not significant different at p = 0.05 according to Duncan's multiple range test. Comparison of averages is possible only for columns
**Trunk cross-sectional area

growth of plum trees of 'Dąbrowicka Prune' cultivar – 126.1 cm^2 on *Prunus cerasifera* than these reported in the presented paper.

The results of the sum of fruit yields during five fructification years depended both on the rootstock and the cultivar. The yield of fruit from 'Čačanska Lepotica' cultivar growing on both rootstocks was significantly higher. The fructification of 'Čačanska Rana' cultivar on both rootstocks and the cultivars 'Herman' and 'Dąbrowicka Prune' on *Prunus tomentosa* rootstock was the weakest (Tab. 1).

The sum of fruit yield from plum trees growing on *Prunus cerasifera* rootstock was much bigger than from those on *Prunus tomentosa* rootstock. Also Hartmann (1984) observed worse fructification of plum trees on *Prunus tomentosa* rootstock from trees growing on *Prunus cerasifera* (on average 8 and 27.5 kg $tree^{-1}$ yearly, respectively). Similarly, Ogasanović and Papić (1997) obtained the yield of fruit not bigger

than 10 kg tree^{-1} from trees growing on *Prunus tomentosa* rootstock. The sum of yields during five years of fructification from plum trees growing on *Prunus tomentosa* obtained by Siegler (1997) was 42.2 kg tree^{-1}. In the discussed experiment, this sum for five years of fructification was from 64.4 kg tree^{-1} to 111.4 kg tree^{-1}, depending on the cultivar. All these authors, however, studied fructification of different plum cultivars. Fructification of 'Čačanska Rana' and 'Čačanska Lepotica' cultivars on *Prunus cerasifera* rootstock during 7 years observed by Sosna (2004) was similar to these obtained in the present experiment within 5 years of fructification (73.2 and 138.5 kg tree^{-1}, respectively). Łysiak (1999), however, observed much better yield of 'Dąbrowicka Prune' cultivar – 288.6 kg tree^{-1} within 7 years of fructification than in the discussed experiment. Many factors determine fructification, apart from the cultivar and rootstock, also climate and soil conditions.

The best yield of fruit was harvested from the trees of 'Čačanska Lepotica' cultivar, while the worst, from 'Čačanska Rana'. Also Sosna (2004) in his experiment observed the weakest fructification of 'Čačanska Rana' trees. The low yielding of 'Čačanska Rana' was previously mentioned by other authors (Lipecki et al., 1994; Sosna, 2002). Completely different results were obtained by Łysiak (1999) who noted high fructification of 'Čačanska Rana' and 'Herman' cultivars, which was not confirmed in the present experiment. In Sosna's experiment (2004), the trees of 'Čačanska Lepotica' cultivar yielded much better than 'Čačanska Rana' and 'Herman', which was confirmed by the results of the present experiment. This cultivar should be regarded as the one useful for commercial cultivation.

Crop efficiency coefficient (CEC) of plum trees depended on the rootstock and the cultivar. The best CEC was obtained for the trees of 'Opal' and 'Čačanska Lepotica' cultivars growing on *Prunus tomentosa* rootstock, whereas the worst, for 'Čačanska Rana' cultivar on *Prunus cerasifera* rootstock (Tab. 1).

On average, the CEC obtained on *Prunus tomentosa* rootstock was almost twice as large as on *Prunus cerasifera.* In earlier studies Hartmann (1984) obtained the value of CEC more than twice higher on *Prunus tomentosa* compared with *Prunus cerasifera.* Also Siegler (1997) noticed the highest CEC on *Prunus tomentosa* (1.23) rootstock in comparison with other rootstocks. CEC obtained by this author is lower than the one obtained in our experiment which ranged from 1.35 to 2.93, depending on the cultivar. CEC obtained by Sosna (2004) for 'Čačanska Rana' and 'Čačanska Lepotica' trees on *Prunus cerasifera* rootstock (0.51 and 1.6, respectively) was higher than in our experiment but for 'Herman' cultivar much lower (0.66).

Among the cultivars tested the best CEC was obtained for 'Čačanska Lepotica' and 'Opal', while the worst, for 'Čačanska Rana'. Also

Sosna (2004) obtained three times higher value of CEC for 'Čačanska Lepotica' compared with 'Čačanska Rana'. In his experiment, however, the index for 'Herman' cultivar was on a similar level as for 'Čačanska Rana', which was not confirmed in our experiment.

Mean fruit weight depended only on the cultivar, and the applied rootstock did not influence fruit size. Independently from the rootstock used, the fruit of 'Čačanska Rana' and 'Herman' had the biggest mass whereas 'Dąbrowicka Prune', the lowest (Tab. 1). The mass of the fruit of 'Herman' cultivar growing on *P. cerasifera* was bigger than the one observed by Grzyb et al. (2000) – 29.8 g, but smaller than the one obtained by Sitarek et al. (2000) – 40.5 g. Similar mass of 'Herman' fruit (31.8 g) was obtained by Sosna (2004). The mass of 'Čačanska Rana' fruit observed by Sitarek et al. (2000) – 59.5 g -, and Sosna (2004) – 54.8 g – was higher than in the experiment presented. In both above mentioned experiments, however, the trees were irrigated, which was not done in the discussed experiment, except for the periods of drought. The rootstocks used did not influence the size of fruit of the studied plum cultivars. Similarly, Grzyb et al. (2000) did not notice any effect of the rootstock on the size of fruit.

CONCLUSIONS

1. All the plum cultivars grafted on *P. cerasifera* grew more vigorously and had higher cumulative yields than those grafted on *P. tomentosa.*
2. Cumulative yield efficiencies of all the cultivars growing on *P. tomentosa* were significantly higher than for those on *P. cerasifera*.
3. Among all the plum cultivars studied, trees of 'Čačanska Rana' grew the most vigorously and had the lowest cumulative yield.
4. Cumulative yield efficiencies recorded for the trees of 'Cacanska Lepotica' were higher than for the rest cultivars, independently from rootstocks.
5. The trees of 'Čačanska Rana' produced the biggest fruit, whereas the smallest were produced by 'Dąbrowicka Prune'. The rootstock had no influence on the size of fruit.

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PRZYDATNOŚĆ DWÓCH PODKŁADEK DLA KILKU ODMIAN ŚLIWY

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S T R E S Z C Z E N I E

Oceniano wpływ dwóch podkładek (*Prunus cerasifera* Ehrh. and *Prunus tomentosa* Thunb.) na wzrost, plonowanie i jakość owoców pięciu odmian śliwy: 'Herman', 'Opal', 'Čačanska Rana', 'Čačanska Lepotica' i 'Węgierka Dąbrowicka'. Drzewa wszystkich rozpatrywanych odmian śliwy na podkładce *P. cerasifera* rosły silniej po siedmiu latach po posadzeniu niż na podkładce *P. tomentosa.* Najwyższe plony zebrano z drzew odmiany 'Čačanska Lepotica' zaszczepionej na podkładce *P. cerasifera.* Produktywność drzew wszystkich odmian śliwy na podkładce *P. tomentosa* była wyższa niż na siewce *P. cerasifera*. Rozpatrywane podkładki nie miały wpływu na masę owocu badanych odmian śliwy. Drzewa śliwy 'Čačanska Rana' produkowały największe owoce, podczas gdy najmniejsze zebrano z drzew odmiany 'Węgierka Dąbrowicka'.

Słowa kluczowe: śliwa, podkładki, odmiany, wzrost, plon, wielkość owoców