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Selection of low vigorous sweet and sour cherry rootstocks at the Faculty of Agriculture, Novi Sad

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Abstract. The aim of this study was the selection of potential genotypes as the cherry rootstocks, within the species: *Prunus cerasus* L. (sour cherry), *Prunus fruticosa* Pall. (ground cherry) and *Prunus mahaleb* L. (mahaleb cherry). As a control, the low vigorous rootstock 'Gisela 5' was used. Clonal progeny of the examined germplasm was obtained by the rooting of softwood cuttings under the mist system. A significant variability of the examined germplasm was determined, out of which it was possible to allocate a few very interesting genotypes of 'Oblačinska' sour cherry – ST1 and OV12 NC, and mahaleb cherry – GM1, as a very uniform low vigorous sweet and sour cherry rootstocks. Selections within ground cherry were vigorous, and produced large number of suckers. Proportional growth of rootstock stem, graft point and scion points to good compatibility among all examined interactions of rootstock/scion. The results clearly point to the potential within the examined germplasm of genus *Prunus* sp. as new cherry rootstocks.

Key words: sweet cherry, sour cherry, germplasm, rootstock breeding

Introduction

Cherries represent fruit species with a great potential for the development of fruit growing in the Republic of Serbia, due to high profitability of cultivation and favorable natural conditions for planting intensive orchards (Blagojević & Božić, 2012). For production of cherry nursery trees in our country generative rootstocks are mainly used, predominantly *Prunus avium* L. (wild cherry) and *Prunus mahaleb* L. (mahaleb cherry), while use of vegetative rootstocks is rare. Success in the production of sweet and sour cherries depends to a large extent on the rootstock on which they are grown. The rootstock must have a good compatibility with grafted cultivars, should be well adapted to the soil and climate, and should favorably influence the growth, fertility and fruit quality of the grafted cultivars.

In the last 30–40 years, the cherry rootstock breeding programs have crossed a significant path from the selection of different vigorous wild cherry and mahaleb genotypes, to the developing of inter-species hybrids with significantly reduced vigour and a positive influence on the scion (Milatović et al., 2015). The issue of choosing the right rootstock for commercial sweet cherry plantings in the Republic of Serbia has not been adequately solved. Vigorous generative rootstocks such as wild cherry and mahaleb seedlings are most commonly used (planting density 300–650 *trees /ha*), and to a lesser extent moderately vigorous to vigorous vegetative rootstock 'Colt' (planting density 500–750 *trees/ha*). Among the low vigorous rootstocks, leading rootstock is 'Gisela 5', suitable for dense planting (planting density 1,100–1,700 *trees/ha*) (Radičević et al., 2017). Intensification of sweet cherry growing by introduction of low vigorous rootstocks have not resulted in the long-term trend of increasing yields, because of high productive dwarf rootstocks are not adaptable to arid conditions, poor and light soils. The trees grafted on 'Gisela 5' after the age of seven stagnate in the vegetative growth, differentiate large number of floral buds and often are very precocious, with the consequence of a decline in fruit quality (Koumanov et al., 2018).

The path to the raising of dense plantations must take into account the specificity of each rootstock/scion interaction which implies general combining characteristics of both scion and rootstock, as well as their morphological, anatomical and physiological interaction and adaptability to pedoclimatic conditions (Ljubojević, 2012; Ljubojević et al., 2013).

The aim of this study is the selection of potential genotypes as the cherry rootstocks within the species: *Prunus cerasus* L. (sour cherry), *Prunus fruticosa* Pall. (ground cherry) and *Prunus mahaleb* L. (mahaleb cherry). Cherry rootstock breeding objectives are low to moderately low vigour of grafted cultivars, precocious and high yields, resistance to low winter temperatures, adaptability to different types of soil, resistance to low soil moisture and high temperatures during the summer, as well as the absence of root suckers.

Material and Methods

Plant material. The performances of the following genotypes as potential vegetative rootstocks within the species of genus *Prunus* were analyzed, using sweet cherry 'Summit' as a scion cultivar: Mahaleb (*Prunus mahaleb* L.): MM1 (genotype originated from village Udovice, Grocka), GM1 (genotype collected in the village Udovice, Grocka);

– Ground cherry (*Prunus fruticosa* Pall.): SV7 (selection from natural population at Fruška Gora Mountain, locality Venac), SV6 FG2 (selection from natural population at Fruška Gora Mountain, locality Stražilovo);

– Sour cherry (*Prunus cerasus* L.): OV12 NC (selection from the plantation of 'Oblačinska' sour cherry, village Nova Crvenka), OV2 IR (selection from the plantation of 'Oblačinska' sour cherry, Irig), D3 (selection from the plantation of 'Oblačinska' sour cherry, village Dešilovo, Prokuplje), ST1 (selection from the plantation of 'Oblačinska' sour cherry, Prokuplje), SEV1 (genotype collected in Prokuplje, local name 'Severna Višnja'), genotype 'Cigančica' (Danubian bush cherry);

– 'Gisela 5 '(selected by inter-species hybridization between *P. cerasus* and *P. canescens*; Walter & Franken-Bembenek, 1998) was used as a control.

Sweet cherry cultivar 'Summit' was grafted on all potential rootstock genotypes. This cultivar was selected in Summerland, British Columbia, Canada by K.O. Lapins in 1957, from the progeny of the crossbreeding 'Van' × 'Sam' (Miljković, 2011).

Eksperimental design. The research was carried out in an experimental sweet cherry plantation at Rimski Šančevi, facility of Faculty of Agriculture in Novi Sad (altitude 80 *m*). Plantation was established in the autumn 2015, in the conditions without irrigation, with planting distance 4 × 2 *m*, and Spindle training system. Field trial is located in the moderate-continental climate zone of the Pannonian type, with extremely warm summers and cold winters.

Rootstock/scion performance investigation. Softwood cuttings rooting of the examined genotypes were obtained under the conditions of mist system with the computer controlled fogging. For foliar nutrition and chemical protection, the sprinkler system was used, and rooting percentage was measured. Characterization of the rootstock/scion interaction was done by measuring rootstock diameter, depth and root branching, the rootstock stem, grafting point and scion diameter, determination of suckers occurrence and the calculation of the crown volume as the vigour indicator of the 'Summit' cultivar on different rootstocks. The crown volume of two-year-old fruit trees was calculated according to the following equation: CD2 × CH × crown shape index = tree crown volume (CD – crown diameter, CH – crown height) (Lim, 2007). All measurements were performed in October, after the vegetative growth ended. The measurements were taken in *mm* and *cm*, whereby crown volume was expressed in dm^3.

Statistical analysis. Statistical data processing was done in program Statistica 13. The significant differences between mean values was determined using the Duncan's Multiple Range Test (P < 0.05).

Results and Discussion

For the breeding purposes and the adequate cheery rootstock candidate's selections, important step was to analyze the behaviour of sour cherry (*P. cerasus* L.), ground cherry (*P. fruticosa* Pall.) and mahaleb (*P. mahaleb* L.) as rootstocks in plantation conditions. Rootstock uniformity was achieved by vegetative softwood cuttings multiplication. Important characteristic for every future rootstock is its ability to propagate easily and rapidly. Results regarding the rooting effectiveness of examined *Prunus* germplasm in the mist system conditions are presented in the Table 1. Rooting percentage was very variable in sour cherry, ranging from 37.3% in genotype ST1 to 88.9% in 'Cigančica'. In ground cherry, highest rooting percentage was determined in genotype SV7 (53.3%). Regarding mahaleb genotypes, the best results were achieved in GM1 (55.2%). The highest rooting percentage in relation to above investigated *Prunus* germplasm was determined in the control rootstock 'Gisela 5', with the value of 60.3%, and in the already mentioned 'Cigančica'.

Table 2 presents morphometric vegetative characteristics measured at two years old sweet cherry trees of 'Summit', grafted on selected *Prunus* genotypes. Rootstock diameter, measured 5 *cm* bellow the grafting point achieved maximal value in genotype MM1 (50 *mm*). Minimal values were measured in genotypes OV12 NC and ST1 (28 *mm*). Regarding the grafting point, the greatest diameter was recorded for genotypes SV7 and MM1 (51 *mm*), while the lowest (32 *mm*) was determined for genotype ST1. In control rootstock 'Gisela 5', grafting point diameter was 53 *mm*.

Maximal average scion diameter, measured 5 *cm* above the grafting point, was achieved in genotypes SV7 and SV6FG2 selected from the ground cherry germplasm, with average value of 41 *mm*, while the minimal was in GM1 (26 *mm*).

Crown volume ranged from very vigorous, compared to trees on standard rootstock 'Gisela 5', down to 30% lesser than on the same standard rootstock. In 'Oblačinska', the greatest crown volume value were determined in genotypes D3 (955 dm^3) and OV2 IR (437 dm^3). The lowest value for this characteristic was achieved in genotype GM1, with only 84 dm^3. Regarding ground cherry, the maximal value was achieved in genotype SV7 with 894 dm^3. Especially valuable genotype GM1, which belongs to *P. mahaleb*, is cha-

Tab. 1. Softwood cuttings' rooting effectiveness of investigated *Prunus* germplasm
Tab. 1. Efikasnost ožiljavanje zelenih reznica ispitivane Prunus germplazme

Rootstock *Podloga*	Rooting percentage/*Procenat ožiljavanja* (%)	
	Genotype *Genotip*	Rooting medium *Medijum za ožiljavanje* Steckmedium
Sour cherry/*Obična višnja*	OV12 NC	45.0 b[1]
Prunus cerasus L.	OV2 IR	52.9 b
	ST1	37.3 b
	SEV1	65.3 b
	D3	39.4 b
	'Cigančica'	88.9 c
Ground cherry/*Stepska višnja*	SV7	53.3 b
Prunus fruticosa Pall.	SV6 FG2	41.7 b
Mahaleb/*Mahaleb*	MM1	18.3 a
Prunus mahaleb L.	GM1	55.2 b
Control/*Kontrola*	'Gisela 5'	60.3 b

[1]Mean values followed by different letters within a column represent significant differences at P < 0.05 according to Duncan's Multiple Range Test/*Srednje vrednosti u kolonama praćene različitim malim slovima su statistički značajno različite prema Dankanovom testu višestrukih intervala za P < 0,05*

Tab. 2. Morphometrical vegetative characteristics of two years old sweet cherry 'Summit' trees, grafted on selected *Prunus* rootstock genotypes
Tab. 2. Morfometrijske vegetativne karakteristike dvogodišnjih sadnica trešnje sorte Summit, kalemljene na izdvojene genotipove roda Prunus

	Rootstock – Genotype/*Podloga – Genotip*										
	Sour cherry/*Obična višnja* *Prunus cerasus* L.					Ground cherry *Stepska višnja* *Prunus fruticosa* Pall.			Mahaleb/*Mahaleb* *Prunus mahaleb* L.		Control *Kontrola*
Cultivar/*Sorta* *'Summit'*	OV12 NC	OV2 IR	D3	ST1	SEV1	Cigančica	SV7	SV6 FG2	GM1	MM1	'Gisela 5'
Rootstock diameter 5 *cm* below grafting point *Prečnik podloge na 5 cm ispod spojnog mesta (mm)*	28 a	36 b	43 c	28 a	34 b	39 b	43 c	49 d	36 b	50 d	38 b
Grafting point diameter *Dijametar spojnog mesta (mm)*	36 a	46 b	49 b	32 a	38 a	41 a	51 b	49 b	36 a	51 b	53 b
Scion diameter 5 *cm* above grafting point *Dijametar plemke na 5 cm iznad spojnog mesta (mm)*	28 a	35 ab	40 b	27 a	28 a	39 b	41 b	41 b	26 a	40 b	35 ab
Trunk height *Visina debla (cm)*	57 a	70 b	77 b	70 b	72 b	72 b	79 b	79 b	64 a	72 b	78 b
Tree height *Visina sadnice (cm)*	165 a	220 c	250 d	160 a	200 b	230 c	250 d	244 cd	137 a	203 b	213 b
Crown diameter *Prečnik krune (cm)*	90 b	90 b	132 c	80 b	80 b	122 c	120 c	106 bc	61 a	132 c	78 b
Crown height *Visina krune (cm)*	85 a	110 a	142 b	81 a	62 a	126 b	148 b	140 b	60 a	130 b	76 a
Anchorage* *Ukorenjavanje*	4	4	4	4	5	5	4	4	5	5	4
Sucker occurrence** *Pojava izdanaka*	0	0	3	1	1	1	3	3	0	0	0
Crown shape index *Indeks oblika krune*	S8	S7	S7	S7	S8	S8	S7	S8	S7	S7	S8
Crown volume *Zapremina krune (dm^3)*	216 b	437 c	955 d	172 b	166 b	636 c	894 d	641 c	84 a	662 c	210 b

*Anchorage: (1) very weak, (2) weak, (3) medium, (4) strong, (5) very strong/*Ukorenjavanje: (1) veoma slabo, (2) slabo, (3) srednje, (4) jako, (5) veoma jako*

** Root sucker ocurance: (1) absent, (3) medium intensity, (5) high intensity/*Pojava izdanaka: (1) odsutna, (3) srednjeg intenziteta, (5) visokog intenziteta*

[1]Mean values followed by different letters within a column represent significant differences at P < 0.05 according to Duncan's Multiple Range Test/*Srednje vrednosti u kolonama praćene različitim malim slovima su statistički značajno različite prema Dankanovom testu višestrukih intervala za P < 0,05*

racterized by good anchorage and absence of sucker formation, and does not require a support during the first two years in the orchard.

Vegetative characteristics similar to the control rootstock 'Gisela 5', were determined in SEV1 and ST1, which belong to *P. cerasus*. All three rootstocks are suitable for establishment of intensive cherry orchards. Compared to 'Gisela 5', these two genotypes were better adapted to drought stress and extreme insolation during the summer of 2017. The best anchorage ability, marked with highest mark – extremely good anchorage (5), was recorded for mahaleb genotypes (GM 1 and MM1), followed by sour cherries 'Cigančica' and SEV1. Other genotypes were uniform and marked with high value - good anchorage (4).

Gruppe (1985) suggested that cherry rootstock breeding should have sequential approach: (1) first cycle of hybridisation of cherry species, (2) raising test trees of sweet cherry cultivars grafted onto rootstocks of pre-selected seedling-progenies and clones, (3) evaluation of the orchard behaviour of these rootstocks in preliminary trials, (4) preliminary trials with clones of promising crosses not previously tested, (5) research into other attributes of hybrid rootstocks and scion-rootstock combinations, (6) rootstock-cultivar trials with promising candidate clones under different environmental and pomological conditions, and (7) initiation of a second breeding cycle utilizing the results from orchards trials and special studies. In our research, germplasm was introduced into breeding process as vegetatively uniform rootstocks by rooting soft wood cuttings. It had enabled the establishment of field trials in third year after gemplasm preservation work, which made breeding work very efficient. Field trial revealed different rootstocks effects on the sweet cherry cultivar 'Summit', that have been identified already in the second year. Many of *Prunus* species were tested as potential dwarfing and productive rootstocks all over the world, including numerous interspecific hybrid seedlings. Consequently, several series of dwarfing rootstocks have been bred by research institutes and universities in the 1960s and 1970s (Bujdoso & Hrotko, 2005). However, incompatibility became one of the major problems to solve during the selection work (Callesen, 1998). Proportional growth of rootstock stem, graft point and scion, points to the good compatibility between our advanced rootstock selections, and 'Summit' sweet cherry cultivar.

One of the most important problems urge to be solved is the insufficient drought adaptability of low vigorous cherry rootstocks selected in the climate conditions of Western Europe. Those wide spread rootstocks derived and selected in Atlantic climate condition which is characterized by moderately warm summers and balanced precipitation distribution throughout the entire vegetation. During our trial work we had to take into consideration that dwarfing rootstocks should suit the Serbian climate. Preselection model must include root system, rootstock stem and stem morphological parameters, but also the preparation of cross-sectional samples for the anatomicall analysis and calculation of theoretical hydraulic conductance through the roots, rootstock stem and the scion (Ljubojević et al., 2013). No bare branches were observed in the canopy of 'Summit' cultivar grafted on selections suggested as promising, which had as result an adequate number of leaves to ensure a good fruit size.

In this research, different genotypes of *P. cerasus*, *P. fruticosa* and *P. mahaleb* have been introduced into cherry rootstock breeding. It was inspired by the positive effects of 'Oblačinska' sour cherry as a rootstock on scion precocity, fruit size, and cropping efficiency in traditional orchards in Prokuplje region, combined with reductions in tree size, and adaptation to environmental conditions (Ognjanov et al., 2012).

Conclusions

A broad diversity within *Prunus* germplasm, that could serve as a source of low-vigorous cherry genotypes suitable as a rootstocks was collected. The vegetative progeny can be obtained by softwood cuttings, which results in a uniform clonal progeny as the most important precondition to avoid variability caused by the genetic diversity within the genotypes. Rooting effectiveness ranged from 18.3 to 88.9% in all investigated genotypes. Two sour cherry (*P. cerasus*) genotypes – ST1 and OV12 NC, as well as one mahaleb (*P. mahaleb*) genotype – GM1, were selected as uniform, low vigorous cherry rootstocks. The proportionality of the rootstock stem, graft point and the scion thickening were better in all investigated combinations than in control, which indicates the good scion/rootstock compatibility. Anchorage in all selections suggested as promising was good, which provides orchard establishment without support.

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SELEKCIJA SLABOBUJNIH PODLOGA ZA TREŠNJU I VIŠNJU NA POLJOPRIVREDNOM FAKULTETU U NOVOM SADU

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Rezime

Cilj ovoga rada je bio selekcija potencijalnih genotipova kao podloga za trešnju i višnju u okviru vrsta *Prunus cerasus* L. (obična višnja), *Prunus fruticosa* Pall. (stepska višnja), *Prunus mahaleb* L. (magriva). Kao kontrola korišćena je slabobujna podloga Gisela 5. Rezultati jasno ukazuju na potencijal u okviru izučavane germplazme vrsta roda *Prunus* kao novih podloga za trešnju i višnju. Klonsko potomstvo ispitivane germplazme dobijeno je ožiljavanjem zelenih reznica u uslovima „mist" sistema. Utvrđena je značajna genotipska varijabilnost ispitivanog selekcionog materijala odakle je bilo moguće izdvojiti nekoliko veoma interesantnih selekcija Oblačinske višnje – ST1 i OV12 NC, i magrive – GM1, kao slabobujnih, vrlo uniformnih podloga za trešnju i višnju. Potpuno suprotni rezultati dobijeni su selekcijom unutar stepske višnje jer su stabla trešnje kalemljena na njenim selekcijama bila bujna i verovatno, s obzirom na njeno prirodno stanište koje pripada klimi sa toplim letima, hladnim zimama i vrlo maloj količini padavina tokom leta, vrlo otporna na abiotički stres izazvan sušom. Srazmernost debljanja korenovog vrata, spojnog mesta i plemke ukazuje na dobru kompatibilnost kod svih izučavanih interakcija podloga/plemka.

Ključne reči: trešnja, višnja, germplazma, oplemenjivanje podloga