ACTA Acta Sci. Pol., Hortorum Cultus 11(2) 2012, 149-159

USEFULNESS OF FOUR ROOTSTOCKS AND MYCORHIZATION TREATMENT IN PRODUCTION OF SWEET CHERRY MAIDEN TREES IN A NURSERY

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Abstract. In nursery production there are very few verified rootstocks for production of sweet cherry maiden trees. They do not always guarantee good growth results as well. GiSelA 5 and PHL-A seem to be very interesting ones, however, so far not well examined in a nursery. For a better adaptation of plants and improvement of condition for their growth, mycorrhizal fungus are used more and more often. In the experiment carried out in years 2007–2010 usefulness of four rootstocks and also of mycorrhization treatment for nursery production of maiden trees of two cultivars of sweet cherry trees was checked. The studies covered the following rootstocks: *Prunus avium*, Colt, GiSelA 5, PHL-A, and sweet cherry trees cultivars: 'Sumit' and 'Vanda', as well as mycorrhizal inoculum produced by companies: 'Mycoflor'(inoculum 1) and 'Suplo' (inoculum 2). *Prunus avium* rootstock grew the strongest in the nursery, the weakest one was PHL-A. Mycorrhization process, together with the application of inoculum 1 significantly influenced on the growth of rootstocks, but application of inoculum 2 did not significantly change results of growth compared to control group without mycorrhization. The most intensive growth of sweet cherry maiden trees was obtained on 'Colt' rootstock and the least on PHL-A. The best productivity of maiden trees was obtained on 'Colt' and PHL-A rootstocks and the worst on *Prunus avium*. Application of mycorrhization process positively influenced the diameter of maiden trees and their fresh mass.

Key words: rootstocks, mycorrhizal inoculums, growth of maiden sweet cherry trees

INTRODUCTION

In recent years production of sweet cherry trees has been very popular with many people. However, still one can notice shortage of good rootstocks for sweet cherry trees,

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previously verified in a nursery. Most often maiden sweet cherry trees are produced on *Prunus avium* seedlings. However, maiden trees growing on this rootstock do not ramify well, and in an orchard trees grow too strong. PHL-A and GiSelA 5 are interesting for sweet cherry trees production. However, there are very few results of experiments carried out in a nursery with these rootstocks [Baryła and Kapłan 2005, Chełpiński 2007, Sitarek and Grzyb 2007]. So far application of mycorhization process has been very successful in the production of rootstocks [Granger et al. 1983, Branzanti et al. 1992, Fortuna et al. 1992, Calvet et al. 1995, Rapparini et al. 1994, Cordier et al. 1996, Rapparini et al. 1996, Granger et al. 1997, Lopez et al. 1997, Monticelli et al. 2000, Schubert and Lubranco 2000, Rutto and Mizutani 2006, Borkowska et al. 2008, Aka-Kacar et al. 2010]. Not always, however, did the inoculation process give a positive result [Dosskey et al. 1990, Colpaert et al. 1992, 1996, Conjeaud et al. 1996, Eltrop and Marschner 1996, Correa et al. 2008, Stachowiak and Świerczyński 2009]. Mycorrhizal inoculums, so far, have been used in an apple trees nursery [Raj and Sharma 2009]. Inoculation of plants affected the increase in length of lateral shoots and roots of maiden apple trees. Also Druzic-Orlic et al. [2008] used different mycorrhizal inoculums while planting the rootstocks into the nursery ground (GiSelA 5 and GF 655/2) obtaining a better growth of plants in comparison with rootstocks not treated with the mycorrhizal inoculum.

MATERIAL AND METHODS

The experiment was carried out on the grounds of Experimental Station in Baranowo belonging to University of Life Sciences in Poznań. In the experiment the following rootstocks were compared: GiSelA 5, PHL-A, Colt (*Prunus avium* L. × *Prunus pseudocerasus* L.) and Mazzard (*Prunus avium* L.). Rootstocks PHL-A and GiSelA 5 were obtained by propagation on *in vitro* cultures, Colt in mother field by use stooling propagation method. *Prunus avium* was produced in the process of generative propagation. The experiment was set up three times in random blocks design, in four replications with 40 rootstocks in 90 × 30 cm spacing planted on one field. On one part of the experiment rootstocks after mycorrhization treatment were planted, on the second, separated one, the control group of rootstocks was planted. These two parts were separated with a special 5.4 m wide zone. While planting the rootstocks into the nursery grounds two mycorrhizal inoculums, one of 'Mycoflor' company (inoculum 1) and second of 'Suplo' company (inoculum 2) were applied separately. Before using a inoculum containing live mycelium (500 ml inoculum, dry weight 36.3 g) it was 15 seconds mixed with 500 ml of distilled water and added a special gel. For one rootstock were used approximately 20 ml of suspension.

The experiment was located on loam soil belonging to third valuation class. The rootstocks and maiden trees were not irrigated. Fertilization and plants protection were according to the up-to-date recommendations for the nurseries of stone fruit trees. During the research no herbicides were use and the nursery was mechanically and – if needed – manually weeded. The rootstocks were budded with two cultivars of sweet cherry: 'Sumit' and 'Vanda' in the first decade of August using 'chip budding' method.

In the first year of growth the measurements of rootstocks in the nursery were conducted in two terms: before budding and after the finish of the process of their growth. The measurements covered: height of rootstocks (cm), their diameter measured just above the ground (mm).

In the second stage of the experiment only mycorrhizal inoculum of 'Mycoflor' company was considered as it had given better results of rootstocks' growth in the first year of the nursery. In the second year the measurements were taken after vegetation period of the maiden trees. The following parameters were measured: height of maiden trees (cm), diameter – measured 20 cm above the budding place (mm), length of lateral shoots (cm) and their number. Also fresh mass (g) of maiden trees was checked and the number of obtained maiden trees in comparison to budded rootstocks was calculated (%). Fifteen of maiden trees from each field, chosen randomly that were growing in turn in one row were taken for measurements.

Statistical analysis of the obtained data was carried out with the STAT program. Two-factor variance analysis of results connected with rootstocks' growth (rootstock and mycorrhizal inoculum), as well as three-factor one connected with the growth of maiden sweet cherry trees (rootstock, cultivar, mycorrhizal inoculum) were carried out using Duncan's test, with probability level $\alpha = 0.05$.

RESULTS AND DISCUSSION

Statistical analysis of the results of rootstocks' growth before budding and after the period of growth showed significant differences. Each of the studied rootstocks had a different height. The highest one was *Prunus avium*, and the lowest PHL-A (tab. 1). Baryła and Kapłan [2005] in their studies obtained a smaller height of *Prunus avium* (118.8 cm) and bigger of Colt (111.4 cm) and PHL-A (90.2 cm). Medium height before budding and after the process of growth differed depending on the influence of mycorrhizal inoculums. Rootstocks treated with mycorrhizal inoculum 1 were the highest and the lowest ones were those coming from control combination (tab. 1, 2).

On the basis of the measurements of rootstocks' diameters in the two studied terms, differences among examined objects were found. The biggest diameter was reached by Colt, a little bit smaller one was noticed for *Prunus avium* and GiSelA 5 and the thinnest one was PHL-A. Other results of rootstocks' diameters were obtained by Baryła and Kapłan [2005]. They observed a smaller diameter of Colt (16.6 mm) and *Prunus avium* (13.5 mm) and bigger of PHL-A (14.1 mm) than the discussed ones. A weaker growth of PHL-A in the discussed experiment might have resulted from not too concise soil, on which this rootstock grows worse. The diameters of rootstocks differed as well looking at the applied mycorrhizal inoculum. Application of mycorrhizal inoculum 1 resulted in obtaining much bigger diameter of rootstocks. Mycorrhizal inoculum 2 did not significantly increase this parameter compared with the control (tab. 1, 2).

In the experiment much better results of rootstocks' growth were obtained in both terms of measurements after applying one of the mycorrhizal inoculum. It is confirmed by Druzic-Orlic et al. [2008], who also noticed more intensive growth of GiSelA 5 and GF 655/2 rootstocks in their nursery after inoculation. A mycorrhizal inoculum was also

Table 1. The height (cm) and diameter (mm) of rootstock before budding in the years 2007–2009
Tabela 1. Wysokość (cm) i średnica (mm) podkładek przed okulizacją w latach 2007–2009

Rootstock Podkładka	Mycorrhiza 1 – Mikoryza 1		Mycorrhiza 2 – Mikoryza 2		Control – Kontrola		Mean for rootstock and height Średnia dla podkładki i wysokości	Mean for rootstock and diameter Średnia dla podkładki i średnicy
	height wysokość cm	diameter średnica mm	height wysokość cm	diameter średnica mm	height wysokość cm	diameter średnica mm		
Prunus avium	156.1 e *	17.9 cd	154.6 e	17.3 cd	150.8 de	16.8 c	153.8 d	17.3 c
Colt	96.3 b	19.1 d	93.8 b	18.8 d	89.3 b	18.8 d	93.1 b	18.9 d
PHL – A	79.9 a	13.1 ab	76.8 a	12.6 ab	76.6 a	11.6 a	77.7 a	12.4 a
GiSelA 5	144.2 cd	14.2 b	142.7 cd	13.7 b	137.6 c	13.1 ab	141.5 c	13.7 b
Mean for mycorrhiza Średnia dla mikoryzy	119.1 b	16.0 b	117.0 ab	15.6 ab	113.6 a	15.1 a		

*Mean followed by the same letters within the columns are not significantly different at the level of $\alpha = 0.05$
* Średnie oznaczone tymi samymi literami w obrębie kolumn nie różnią się między sobą istotnie przy poziomie $\alpha = 0,05$

Table 2. The height (cm) and diameter (mm) of rootstock after the end of growth in the years 2007–2009
Tabela 2. Wysokość (cm) i średnica (mm) podkładek po zakończeniu wzrostu w latach 2007–2009

Rootstock Podkładka	Mycorrhiza 1 – Mikoryza 1		Mycorrhiza 2 – Mikoryza 2		Control – Kontrola		Mean for rootstock and height Średnia dla podkładki i wysokości	Mean for rootstock and diameter Średnia dla podkładki i średnicy
	height wysokość cm	diameter średnica mm	height wysokość cm	diameter średnica mm	height wysokość cm	diameter średnica (mm)		
Prunus avium	159.9 d *	18.5 d-f	157.7 d	17.9 c-e	151.7 cd	17.8 c-e	156.4 d	18.1 c
Colt	106.8 b	19.8 f	99.9 b	19.3 ef	99.0 b	19.4 ef	101.9 b	19.5 d
PHL – A	81.1 a	14.0 a	78.4 a	13.0 a	79.2 a	12.4 a	79.5 a	13.1 a
GiSelA 5	152.3 cd	17.4 b-d	150.9 cd	16.4 bc	144.6 c	15.9 b	149.2 c	16.6 b
Mean for mycorrhiza Średnia dla mikoryzy	125.0 b	17.4 b	121.7 ab	16.7 ab	118.6 a	16.4 a		

*For explanation, see table 1 – Wyjaśnienie, patrz tabela 1

Table 3. The height (cm) and diameter (mm) of maiden sweet cherry trees in the years 2008–2010
Tabela 3. Wysokość (cm) i średnica (mm) okulantów czereśni w latach 2008–2010

Rootstock Podkładka	Cultivar Odmiana	Mycorrhiza – Mikoryza		Control – Kontrola		Mean for rootstock and height Średnia dla podkładki i wysokości	Mean for rootstock and diameter Średnia dla podkładki i średnicy	Mean for cultivar and height Średnia dla odmiany i wysokości	Mean for cultivar and diameter Średnia dla odmiany i średnicy
		height wysokość cm	diameter średnica mm	height wysokość cm	diameter średnica mm				
Prunus avium	Sumit	144.7 a-c *	15.7 bc	142.0 ab	14.7 a-c	153.1 b	15.3 b	154.1 a	16.6 a
	Vanda	163,0 b-d	15.0 a-c	162.7 b-d	15.6 a-c				
Colt	Sumit	176.0 de	22.2 d	177.3 de	21.3 d	184.4 c	21.7 c		
	Vanda	189.7 de	23.0 d	194.7 e	20.2 d				
PHL – A	Sumit	136.7 ab	13.5 ab	139.0 ab	12.5 a	135.4 a	13.5 a	164.4 b	16.6 a
	Vanda	144.0 a-c	14.8 a-c	122.0 a	13.5 ab				
GiSelA 5	Sumit	170.0 c-e	17.2 c	147.3 a-c	15.5 a-c	164.1 b	15.9 b		
	Vanda	175.8 de	16.2 bc	164.0 b-d	14.6 a-c				
Mean for mycorrhiza Średnia dla mikoryzy		162.4 a	17.2 b	17.2 b	16.0 a				

*For explanation, see table 1
* Wyjaśnienie, patrz tabela 1

Table 4. The number and the sum of lateral shoots length (cm) of maiden sweet cherry trees in the years 2008–2010
Tabela 4. Liczba pędów i suma długości pędów bocznych (cm) okulantów czereśni w latach 2008–2010

Rootstock Podkładka	Cultivar Odmiana	Mycorrhiza – Mikoryza		Control – Kontrola		Mean for rootstock and number of lateral shoots Średnia dla podkładki i liczby pędów bocznych	Mean for rootstock and sum of lateral shoots length Średnia dla podkładki i sumy długości pędów bocznych	Mean for cultivar and number of lateral shoots Średnia dla odmiany i liczby pędów bocznych	Mean for cultivar and sum of lateral shoots length Średnia dla odmiany i sumy długości pędów bocznych
		number of lateral shoots liczba pędów bocznych	sum of lateral shoots length suma długości pędów bocznych cm	number of lateral shoots liczba pędów bocznych	sum of lateral shoots length suma długości pędów bocznych cm				
Prunus avium	Sumit	0.8 a *	38.0 a	0.6 a	39.7 a	1.0 a	61.2 a	1.7 a	92.4 a
	Vanda	1.2 a	82.7 a	1.3 a	84.3 a				
Colt	Sumit	4.8 b	262.7 b	3.8 b	269.7 b	4.9 b	338.5 b		
	Vanda	6.7 c	539.7 c	4.3 b	282.0 b				
PHL – A	Sumit	0.5 a	18.1 a	0.4 a	21.6 a	0.8 a	30.6 a	2.2 a	141.3 b
	Vanda	1.5 a	52.4 a	1.0 a	30.5 a				
GiSelA 5	Sumit	0.9 a	34.3 a	0.9 a	55.3 a	0.8 a	37.2 a		
	Vanda	0.7 a	26.7 a	0.7 a	32.3 a				
Mean for mycorrhiza Średnia dla mikoryzy		2.1 a	131.8 a	1.6 a	101.9 a				

*For explanation, see table 1
* Wyjaśnienie, patrz tabela 1

Table 5. The fresh mass (g) and number of obtained maiden sweet cherry trees in the years 2008–2010
Tabela 5. Świeża masa (g) i liczba otrzymanych okulantów czereśni w latach 2008–2010

Rootstock Podkładka	Cultivar Odmiana	Mycorrhiza – Mikoryza		Control – Kontrola		Mean for rootstock and fresh mass Średnia dla podkładki i świeżej masy	Mean for rootstock and number of obtained maidens Średnia dla podkładki i liczby otrzymanych okulantów	Mean for cultivar and fresh mass Średnia dla odmiany i świeżej masy	Mean for cultivar and number of obtained maidens Średnia dla odmiany i liczby otrzymanych okulantów
		fresh mass świeża masa g	number of obtained maidens liczba otrzymanych okulantów	fresh mass świeża masa g	number of obtained maidens liczba otrzymanych okulantów				
Prunus avium	Sumit	44.5 a-c *	625.0 bc	550.0 a-c	37.8 ab	39.1 a	573.8 b	51.8 a	609.4 a
	Vanda	38.3 ab	560.0 a-c	560.0 a-c	35.8 a				
Colt	Sumit	60.7 d-g	996.7 d	720,0 c	62.2 e-g	62.8 c	1049.2 c		
	Vanda	63.3 e-g	1263.3 e	1216.7 d	65.1 fg				
PHL – A	Sumit	60.0 c-g	530.0 a-c	373.3 a	48.0 a-e	57.8 c	479.2 a	52.7 a	725.4 b
	Vanda	66.6 g	540.0 a-c	473.3 ab	56.6 c-g				
GiSelA 5	Sumit	48.3 a-e	570.0 bc	510.0 ab	52.7 b-g	49.2 b	567.5 b		
	Vanda	45.5 a-d	613.3 bc	576.7 bc	50.2 a-f				
Mean for mycorrhiza Średnia dla mikoryzy		53.8 a	712.3 b	51.0 a	622.5 a	51.0 a			

*For explanation, see table 1
* Wyjaśnienie, patrz tabela 1

used in acclimatization of *Prunus avium* [Cordier et al. 1996] propagated in vitro. Its application increased growth and diminished the number of not taken rootstocks after planted in nursery. Also Rapparini et al. [1996] noticed more intensive growth of shoots and roots in the first and second year of cultivation in case of mycorrhization of OH × F 51 rootstock. A positive influence of mycorrhizal inoculum on growth of OH × F 333 rootstock was confirmed by Lopez et al. [1997]. In another experiment [Monticelli et al. 2000] inoculation increased a diameter of roots and their mass in case of Citation and GF 677 rootstocks propagated in vitro. In the experiment carried out by Schubert and Lubranco [2000] mycorrhization of MM 106 improved its growth and intake of nutritive substances. Inoculation of peach trees seedlings intensified their growth also on re-planted soil [Rutto and Mizutani 2006]. A positive effect of mycorhization on survival rate and growth of rootstocks propagated in vitro was also observed by [Granger and others 1983, Branzanti and others 1992, Fortuna and others 1992, Rapparini and others 1994, Grange and others 1997, Borkowska and others 2008, Aka-Kacar and others 2010]. Both results obtained in the experiment presented in this paper and of other authors confirm usefulness of mycorrhization of rootstocks before planting them into a nursery.

Rootstocks and cultivars used in a nursery influence the height of sweet cherry maiden trees. The highest ones were obtained on Colt. Next, as far as their height was concerned, were maiden trees obtained on GiSelA 5 and *Prunus avium*. The lowest ones grew on PHL-A. Much lower sweet cherry maiden trees on PHL-A (101.1 cm) and *Prunus avium* (111.7 cm) were obtained by Chełpiński [2007]. Also Sitarek and Grzyb [2007] noticed different heights of sweet cherry maiden trees in a nursery depending on the rootstock. Higher maiden trees grew on F 12/1, and lower on PHL-A, PHL-B and GiSelA 5. Trees of 'Vanda' cultivar, independently from rootstocks, were higher than those of 'Sumit'. Mycorrhization of rootstocks carried out in the nursery did not have influence on important differentiation of height results of sweet cherry maiden trees (tab. 3).

The rootstocks considered in the experiment significantly affected results of diameters of maiden trees. Trees with the biggest diameter grew on Colt. Significantly smaller diameter had maiden trees growing on GiSelA and *Prunus avium*. The smallest diameter was obtained for trees on PHL-A. Also Sitarek and Grzyb [2007] observed a smaller diameter of maiden sweet cherry trees on PHL-A and GiSelA 5 than on F 12/1 rootstock. The diameters of maiden sweet cherry trees obtained by Chełpiński [2007] on PHL-A – 10.7 mm i *Prunus avium* – 11.8 mm were smaller than the discussed ones. The budded cultivar of sweet cherry did not affect the diameter of maiden trees. Mycorrhization of rootstocks significantly increased the diameter of maiden trees (tab. 3).

Results of number of lateral shoots of sweet cherry maiden trees did not differ significantly as far as the considered rootstocks, cultivars and mycorrhizal inoculum are concerned. The only exception was their bigger number on Colt (tab. 4).

Maiden trees produced on 'Colt' had significantly bigger sum of lengths of lateral shoots than those obtained on the remaining rootstocks. 'Vanda' cultivar was characterized by genetic conditions to create a bigger number of lateral shoots than 'Sumit' cultivar. Application of mycorrhizal inoculum did not influence the process of ramification of maiden sweet cherry trees (tab. 4).

Rootstocks, cultivars and mycorrhizal inoculum that were used in the experiment had a very important impact on fresh mass of sweet cherry trees. The heaviest trees were obtained on Colt, significantly lighter ones on *Prunus avium* and GiSelA 5, and the lightest on PHL-A. A bigger fresh mass had maiden trees of 'Vanda' cultivar. Inoculation of rootstocks resulted in obtaining trees with a bigger mass (tab. 5).

Significantly more maiden trees were obtained on Colt and PHL-A and less on *Prunus avium* and GiSelA 5 rootstock. Similar number of obtained maiden sweet cherry trees on PHL-A (54.2%) and on *Prunus avium* rootstock (43.0%) were obtained by Chełpiński [2007]. Budded cultivar of sweet cherry, as well as the process of mycorrhization of rootstocks did not differentiate the number of obtained maiden trees (tab. 5).

In case of growth parameters of sweet cherry maiden trees mycorrhizal inoculum positively influenced a diameter of a trunk and fresh mass of maiden sweet cherry trees. Mycorrhizal inoculums used by Raj and Sharma [2009] in a nursery also increased the length of maiden apple trees' roots. The authors also obtained longer lateral shoots of maiden apple trees after inoculation of rootstocks, which was not found in the discussed experiment. Also in a previous experiments [Stachowiak and Świerczyński 2009] the applied mycorrhizal inoculum did not intensify the growth of maiden sweet cherry trees and ornamental maiden tress of 'Woodii' cultivar [Świerczyński 2008].

Previous results and the results considered in his paper do not fully confirm a positive effect of mycorrhization of rootstocks on growth of sweet cherry maiden trees growing on these rootstocks in a nursery.

CONCLUSIONS

1. Rootstocks differed with their vigour of growth in the first year of nursery. PHL-A. rootstock grew significantly weaker than others.

2. After the application of mycorrhizal inoculum 1 rootstocks grew better than control.

3. The strongest growth of sweet cherry maiden trees was observed on Colt and the weakest on PHL-A rootstock.

4. Application of mycorrhizal inoculum significantly increased the diameter and fresh mass of sweet cherry maiden trees and it did not influence their ramification and number of obtained maiden sweet cherry trees.

5. The largest number of maiden sweet cherry trees was obtained on Colt and PHL-A, and the smallest on *Prunus avium* rootstock.

6. The obtained results are not fully confirmed the advisability of application of the treatment of mycorrhization.

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PRZYDATNOŚĆ CZTERECH PODKŁADEK I ZABIEGU MIKORYZACJI W PRODUKCJI OKULANTÓW CZEREŚNI W SZKÓŁCE

Streszczenie. W szkółkarstwie mało jest sprawdzonych podkładek do produkcji okulantów czereśni oraz nie zawsze uzyskuje się przy ich zastosowaniu pożądane wyniki wzrostu drzewek. Ciekawymi podkładkami, ale mało jeszcze poznanymi w szkółce są GiSelA 5 i PHL-A. Do łatwiejszej adaptacji roślin i polepszenia warunków ich wzrostu stosuje się coraz częściej szczepionki mikoryzowe. W doświadczeniu przeprowadzonym w latach 2007–2010 sprawdzono przydatność czterech podkładek oraz zabiegu mikoryzacji do produkcji okulantów dwóch odmian czereśni w szkółce. Badaniami objęto następujące podkładki: *Prunus avium*, Colt, GiSelA 5, PHL-A i odmiany czereśni: 'Sumit' i 'Vanda' oraz szczepionkę mikoryzową firmy 'Mycoflor' (szczepionka 1) i 'Suplo' (szczepionka 2). W szkółce najsilniej rosła podkładka *Prunus avium*, a najsłabiej PHL-A. Zabieg mikoryzacji przy zastosowaniu szczepionki 1 wpłynął istotnie na wzrost podkładek, a szczepionki 2 nie zmienił istotnie wyników wzrostu w stosunku do kontroli bez mikoryzacji. Najintensywniejszy wzrost okulantów czereśni uzyskano na podkładce Colt, a najsłabszy na podkładce PHL-A. Najlepszą wydajność okulantów otrzymano na podkładkach Colt i PHL-A, a najgorszą na *Prunus avium*. Zastosowanie zabiegu mikoryzacji podkładek wpłynęło pozytywnie na średnicę okulantów i ich świeżą masę.

Słowa kluczowe: podkładki, szczepionki mikoryzowe, wzrost okulantów czereśni

Accepted for print – Zaakceptowano do druku: 15.12.2011