Nauka Przyroda Technologie

2017
Tom 11
Zeszyt 3

ISSN 1897-7820 http://www.npt.up-poznan.net http://dx.doi.org/10.17306/J.NPT.00184
Dział: Ogrodnictwo i Architektura Krajobrazu

SŁAWOMIR ŚWIERCZYŃSKI, ALEKSANDER STACHOWIAK,
MAŁGORZATA GOLCZ-POLASZEWSKA

Department of Dendrology, Pomology and Nursery
Poznań University of Life Sciences

THE INFLUENCE OF TREATMENTS APPLIED TO COMMON NINEBARK (*PHYSOCARPUS OPULIFOLIUS* (L.) MAXIM.) ‘DIABOLO’ CUTTINGS ON THEIR ROOTING AND GROWTH

WPŁYW KILKU SPOSOBÓW TRAKTOWANIA SADZONEK NA UKORZENIANIE I WZROST PĘCHERZNICY KALINOLISTNEJ (*PHYSOCARPUS OPULIFOLIUS* (L.) MAXIM.) ODMIANY ‘DIABOLO’

Abstract

Background. As synthetic auxins are prohibited, it is necessary to conduct research to assess the suitability of other substances used for propagation of ornamental bushes to improve the rooting of cuttings and the growth of plants. The aim of the experiment was to compare the effectiveness of a mycorrhizal inoculum and effective microorganisms in the production of ninebark shrubs.

Material and methods. Between 2010 and 2012 an experiment on *Physocarpus opulifolius* ‘Diabolo’ was conducted to assess how three different treatments applied to cuttings influenced their rooting and growth. Before hardwood cuttings were planted in a field, they had been treated with an endomycorrhizal inoculum, effective microorganisms and Ukorzeniacz AB Aqua. The diameter and length of the shoots were measured. The number of shoots was counted, the percentage of rooted cuttings was calculated and the fresh mass of the root system was weighed.

Results. The mycorrhizal inoculum increased the percentage of rooted cuttings and gave the best results in the diameter and length of lateral shoots as well as the fresh mass of the root system of the bushes. The effective microorganisms (EM) resulted in the highest percentage of rooted cuttings and the largest number of lateral shoots. The EM preparation improved the diameter and fresh mass of the root system. The Ukorzeniacz AB Aqua improved the rooting of the cuttings and increased the diameter and fresh mass of the root system.

Conclusions. The mycorrhizal inoculum improved the rooting of the cuttings and stimulated the growth of the shrubs. The effective microorganisms increased the percentage of rooted cuttings, as the Ukorzeniacz AB Aqua did, and improved the growth of the plants.

Keywords: ninebark, propagation, hardwood cuttings, mycorrhizal inoculum, effective microorganisms (EM), Ukorzeniacz AB Aqua

Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT.00184

Introduction

There is increasing demand for ornamental trees and bushes due to the dynamic development of scenic areas and strong competition among nurseries, which need to deliver the best and largest quantities of bushes in the shortest time possible (Pacholczak et al., 2013). Ninebark (*Physocarpus opulifolius* (L.) Maxim.) is one of the best species of bushes for scenic areas. This plant grows well in different environments and on a wide range of soil types. Moreover, its leaves are resistant to air pollution in cities.

Not all cultivars of ornamental shrubs can be easily propagated by hardwood cuttings in nursery production. The *Physocarpus opulifolius* 'Diabolo' cultivar belongs to a group of bushes that root with more difficulty. Ninebark cultivars differ in the rooting rate of hardwood cuttings (Pacholczak and Szydło, 2008). The effectiveness of rooting of hardwood cuttings depends on numerous factors, including the use of preparations which stimulate rooting (Hartmann et al., 2002). Recently there has been an increasing tendency to use environment-friendly products and to restrict the use of chemical compounds, such as synthetic auxins (Ilczuk et al., 2013; Pacholczak et al., 2010). The elimination of chemical substances is an effective alternative method.

Mycorrhizal inoculation increases the survival and growth rates of horticultural plants cultivated in greenhouses and under natural conditions (Crews et al., 1978; Lovato et al., 1995). It improves the acclimatisation of *in vitro* micropropagated plants (Vestberg et al., 2002) and promotes earlier flowering and fruiting (Lovato et al., 1995; Świerczyński, 2008). Many authors (Chong et al., 1992; Douds et al., 1995; Hartmann et al., 2002; Raju and Prasad, 2010) proved the positive effect of exogenous products on the rooting of cuttings of trees and bushes. The combination of mycorrhizal inoculum and exogenous auxin intensified the rooting of *Sciadopitys verticillata* cuttings (Douds et al., 1995), Hick's yew (Scagel et al., 2003) and miniature rose cuttings (Scagel, 2004).

So far effective microorganisms (EM), including bacteria and fungi (Higa and Parr, 1994), have chiefly been tested on field plants (Chaudhry et al., 2005; Faltyn and Miszkieło, 2008; Javaid, 2006; Pietkiewicz et al., 2004; Piskier, 2006). Zydlik and Zydlik (2008) reported that the EM preparation intensified the growth of M.9 rootstock. Recent studies proved that some bacterial genera induced root formation in stem cuttings (Bassil et al., 1991; Ercisli et al., 2004; Erturk et al., 2010; Hatta et al., 1996; Jacob et al., 1991; Rinallo et al., 1999).

The aim of this study was to assess how three different treatments applied to *Physocarpus opulifolius* 'Diabolo' cuttings influenced the rooting and growth of these bushes.

Material and methods

The study was conducted in three replicates in Mr Muszyński's private nursery located in the village of Koszary near Konin, Poland. The experiment was set up in a random sub-block design, in four replications with 50 hardwood cuttings planted in one plot. The cuttings were prepared in December, stored and planted into the ground in mid-April. They were 15 cm long and 6 mm thick. Before planting in the field the cuttings were treated with an endo-mycorrhizal inoculum (Biopon, Poland), effective mi-

Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT.00184

croorganisms (EM-Farming, Poland) and Ukorzeniacz AB Aqua. The endomycorrhizal inoculum and Ukorzeniacz AB Aqua (0.2% NAA, 0.1% IBA, 0.1% 1-naphthylacetic acid amide) were used as powder; the effective microorganisms (photosynthetic bacteria, actinomyces, lactic acid bacteria, fermentation fungi) was used as an aqueous suspension. The remaining cuttings were the control sample. The place of the base cut on the cuttings was submerged in the suspension or powder for a few seconds. The cuttings were rooted in the ground, where grain had been cultivated. In autumn green manure (*Sinapsis alba* L.) was applied. The bushes were cultivated on podsolic soil of the fourth valuation class, with 1.2% humus content and pH 6.2. A special 4-metre-wide protective zone was established to separate the treated and untreated plants.

Weeds in the nursery were controlled mechanically, without fungicides. The plots with the bushes were watered. After the growth period, at the end of November, all the bushes were measured. The diameter (mm) and length (cm) of the shoots were measured slightly above the ground. The number of shoots was counted and the percentage of rooted cuttings was calculated. When the shrubs were removed from the ground, the fresh mass (g) of the root system of all the plants was weighed. Samples of the roots were collected to confirm the presence of mycorrhizal fungi. They were stained with 0.05% trypan blue in lactic acid. Later they were discoloured and the presence of mycorrhizal structures was evaluated under a microscope. The photographs can be found at the end of this paper.

The data were statistically analysed with the STAT program, with univariate analysis of variance, using Duncan's test, where the probability level α was 0.05. The rooting percentage of the cuttings was converted according to the method developed by Bliss. The results shown in the table are mean values in three consecutive years of the research.

Results and discussion

The percentage of rooted *Physocarpus opulifolius* 'Diabolo' cuttings depended on their treatment before planting. The EM preparation and Ukorzeniacz AB Aqua resulted in the largest number of rooted cuttings. The number of rooted cuttings after treatment with Ukorzeniacz AB Aqua was similar to the number of rooted cuttings after treatment with the mycorrhizal inoculum. Fewer cuttings were rooted in the control variant (Table 1).

There were differences in the number of lateral 'Diabolo' bush shoots. The treatment with the EM preparation and with the mycorrhizal inoculum resulted in the largest number of shoots. The Ukorzeniacz AB Aqua did not have significant effect on the number of lateral shoots, as compared with the control variant (Table 1).

The mycorrhization of the cuttings increased the lengths of the shoots more than the other treatments, but these values did not differ significantly (Table 1).

The diameter of the aerial part of the bush depended on the treatment applied. The biggest diameter was measured after treatment with the mycorrhizal inoculums, followed by the EM preparation and Ukorzeniacz AB Aqua. The smallest diameter of the bush was noted in the control combinations (Table 1).

Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT.00184

Table 1. The influence of treatments on the percentage of rooted hardwood cuttings and the growth of *Physocarpus opulifolius* 'Diabolo' bushes

Treatment	Percentage of rooted cuttings	Number of lateral shoots	Total length of lateral shoots (cm)	Diameter of main shoot (mm)	Fresh mass of root system (g)
Mycorrhizal inoculum	57.0 b	2.3 b	74.4 b	11.8 c	110.1 c
Ukorzeniacz AB Aqua	60.5 bc	2.0 a	38.2 a	9.2 b	72.8 b
Effective microorganisms	65.5 c	2.5 b	43.1 a	9.8 b	65.3 b
Control	48.5 a	1.9 a	41.7 a	8.0 a	46.8 a

Means followed by the same letters in the columns are not significantly different at $\alpha = 0.05$.

The combinations differed in the fresh mass of the root system. The mycorrhiza resulted in the best fresh mass. The Ukorzeniacz AB and EM preparation gave better values than the control variant (Table 1).

Pictures taken under a microscope confirmed the presence of mycorrhizal structures in the rooting system of bushes after treatment with the mycorrhizal inoculum (Fig. 1).

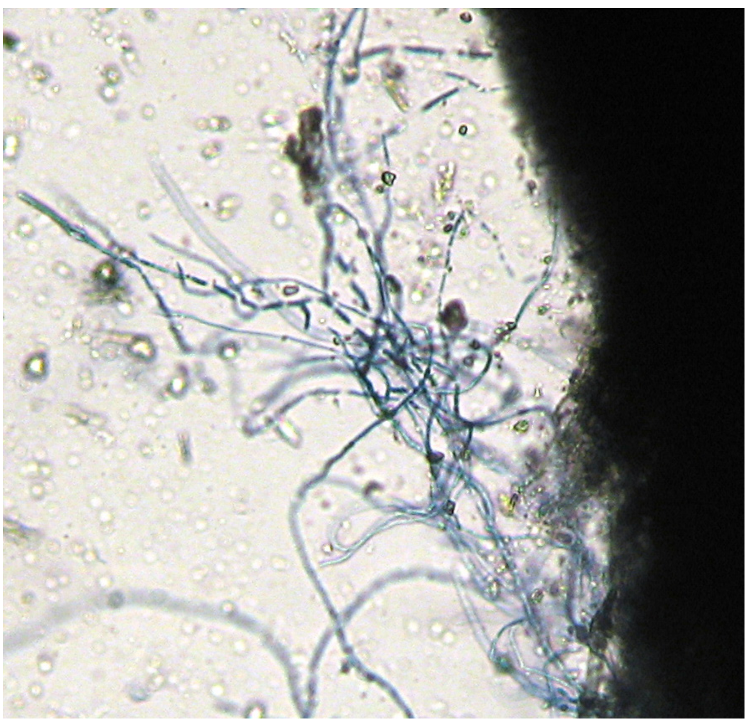

Fig. 1. A fragment of the *Physocarpus opulifolius* 'Diabolo' root with mycorrhizal fungal hyphae

Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT.00184

The mycorrhizal inoculum had very positive influence on the rooting of the cuttings and the growth of 'Diabolo' bushes. This observation is not fully consistent with the results of the experiment conducted by Trepanier and Rioux (1997), where the presence of a mycorrhizal inoculum in the rooting system of *Juniperus sabina* 'Blue Danube' did not have significant effect during the rooting stage. However, when rooted cuttings were potted, after one season the mycorrhizal plants grew 50% larger. Also, during the propagation of *Taxus* ×*media* 'Hicksii' the number of roots per cutting and the total root dry weight were significantly greater in the presence of mycorrhizal fungi than in the control variant. Both growth parameters were similar or better after mycorrhizal inoculation than after treatment with the rooting hormone only (Scagel et al., 2003). Mycorrhizal inoculation of roses increased the percentage of rooted plants, the number and weight of the roots more than treatment with the rooting hormone (Scagel, 2001). In the experiment conducted on Colombian blueberries by Díaz-Granados et al. (2009) the presence of mycorrhizal fungi in the substrate increased the viability of cuttings up to 95%, but reduced the rooting percentage, the number of roots, and the root length on stem cuttings. On the other hand, Matysiak and Falkowski (2010) did not observe any significant effects of mycorrhizal inoculation on the growth of *Physocarpus opulifolius* 'Diabolo' shrubs during the first and second year of their growth. However, in their experiment fungi developed under much more difficult conditions, as they grew in containers filled with peat and compost. Linderman and Davis (2004) reported that peat inhibited the growth of mycorrhizal fungi and colonisation of the root system of the host plant. In our experiment the soil conditions favoured the growth of the plants.

The percentage of rooted cuttings and the growth of 'Diabolo' bushes after treatment with the EM preparation were significantly better than in the control variant. Many researchers reported better yield of plants cultivated in the ground after treatment with effective microorganisms (Daly and Stewart, 1999; Javaid, 2006; Khaliq et al., 2006; Yan and Xu, 2002). However, other researches indicated that the effect of EM on the growth of plants usually was not evident or it was even negative (Bajwa et al., 1995; Daiss et al., 2008; Javaid et al., 2008). In the experiment conducted by Zydlik and Zydlik (2008) the EM-A preparation mixed with EM-5 increased the volume of the root system of the M.9 rootstock. Also, McAfee et al. (1993) observed a higher percentage of rooted pine and larch cuttings after treatment with *Agrobacterium rhizogenes*. Similarly, Ercisli et al. (2004) observed better root formation on hardwood stem cuttings of two roses after treatment with exogenous IBA and *Agrobacterium rubi*. Caesar and Burr (1987) reported that specific strains of bacteria resulted in better root formation in apple seedlings and rootstocks. Eşitken et al. (2003) tested how plant growth promoting rhizobacteria (PGPR) affected the rooting of sour cherry cuttings and found that they resulted in high rooting percentage.

Many authors (Douds et al., 1995; Hartmann et al., 2002; Howard, 1986; Loach, 1988; Raju and Prasad, 2010) demonstrated that the use of exogenous auxin improved the rooting of different species of ornamental trees and shrubs. In our experiment the Ukorzeniacz AB Aqua increased the percentage of rooted cuttings and intensified the development of the root system of 'Diabolo' shrubs. Also, Pacholczak et al. (2013) observed an increase in the percentage of rooted cuttings (10%) of two ninebark cultivars when commercial rooting powder Rhizopoon AA was used. Chong and Hamersma (1995) reported that it was possible to obtain almost 100% of rooted hardwood cuttings

Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT.00184

of *Physocarpus opulifolius*. However, these authors rooted the primary species rather than the *Physocarpus opulifolius* 'Diabolo' cultivar. Similarly, in an earlier experiment Pacholczak and Szydło (2008) observed different percentage of rooted cuttings of two ninebark cultivars (50–85%).

Conclusions

1. All the three treatments increased the percentage of rooted cuttings, especially the effective microorganisms (EM) and Ukorzeniacz AB Aqua.
2. The mycorrhizal inoculum stimulated the growth of *Physocarpus opulifolius* 'Diabolo' bushes most.
3. Apart from the mycorrhizal inoculum, the other treatments did not cause differences in the length of lateral shoots. The Ukorzeniacz AB Aqua did not affect their number, either. However, they had significantly positive influence on the diameter and fresh mass of the root system of the bush.

References

Ávila Díaz-Granados, R. A., Orozco Silva, O. J., Moreno, G. L., Magnitskiy, S., Rodríguez, A. (2009). Influence of mycorrhizal fungi on the rooting of stem and stolon cuttings of the Colombian blueberry (*Vaccinium meridionale* Swartz). Int. J. Fruit Sci., 9, 4, 372–384. http://dx.doi.org/10.1080/15538360903378575
Bajwa, R., Javaid, A., Tasneem, Z. (1995). Response of indigenous soil microflora to EM inoculation in Pakistan. Biota, 1, 73–79.
Bassil, N. V., Proebsting, W. M., Moore, L. W., Lightfoot, D. A. (1991). Propagation of hazelnut stem cuttings using *Agrobacterium rhizogenes*. HortScience, 26, 8, 1058–1060.
Caesar, A. J., Burr, T. J. (1987). Growth promotion of apple seedlings and rootstocks by specific strains of bacteria. Phytopathology, 77, 11, 1583–1588.
Chaudhry, A. N., Latif, M. I., Jilani, G., Khan, A. A., Iqbal, T. (2005). Comparison of chemical fertilizer with organic manures by using effective microorganisms under maize cropping in rainfed areas. Int. J. Biol. Biotechnol., 2, 4, 1001–1006.
Chong, C., Allen, O. B., Barnes, H. W. (1992). Comparative rooting of stem cuttings of selected woody landscape shrub and tree taxa to varying concentrations of IBA in talc, ethanol and glycol carriers. J. Environ. Hortic., 10, 4, 245–250.
Chong, C., Hamersma, B. (1995). Automobile radiator antifreeze and windshield washer fluid as IBA carriers for rooting woody cuttings. HortScience, 30, 2, 363–365.
Crews, C. E., Johnson, C. R., Joiner, J. N. (1978). Benefits of mycorrhizae on growth and development of three woody ornamentals. HortScience, 13, 4, 429–430.
Daiss, N., Lobo, M. G., Socorro, A. R., Brückner, U., Heller, J., Gonzalez, M. (2008). The effect of three organic pre-harvest treatments on Swiss chard (*Beta vulgaris* L. var. *cycla* L.) quality. Eur. Food Res. Technol., 226, 3, 345–353. http://dx.doi.org/10.1007/s00217-006-0543-2
Daly, M. J., Stewart, D. P. C. (1999). Influence of "effective microorganisms" (EM) on vegetable production and carbon mineralization – a preliminary investigation. J. Sustain. Agric., 14, 2–3, 15–25. http://dx.doi.org/10.1300/J064v14n02_04

Douds, Jr., D. D., Bécard, G., Pfeffer, P. E., Doner, L. W., Dymant, T. J., Kayser, W. M. (1995). Effect of vesicular–arbuscular mycorrhizal fungi on rooting of *Sciadopitys verticillata* Sieb. & Zucc. cuttings. HortScience, 30, 1, 133–134.

Ercisli, S., Esitken, A., Sahin, F. (2004). Exogenous IBA and inoculation with *Agrobacterium rubi* stimulate adventitious root formation on hardwood stem cuttings of two rose genotypes. HortScience, 39, 3, 533–534.

Erturk, Y., Ercisli, S., Haznedar, A., Cakmakci, R. (2010). Effects of plant growth promoting rhizobacteria (PGPR) on rooting and root growth of kiwifruit (*Actinidia deliciosa*) stem cuttings. Biol. Res., 43, 1, 91–98. http://dx.doi.org/10.4067/S0716-97602010000100011

Eşitken, A., Ercişli, S., Şevik, İ., Şahin, F. (2003). Effect of indole-3-butyric acid and different strains of *Agrobacterium rubi* on adventive root formation from softwood and semi-hardwood wild sour cherry cuttings. Turk. J. Agric. For., 27, 1, 37–42.

Faltyn, U., Miszkieło, T. (2008). Wpływ efektywnych mikroorganizmów (EM®) na zdolność kiełkowania ziarna pszenicy jarej. Zesz. Nauk. UP Wroc., 568, Roln., 92, 31–35.

Hartmann, H. T., Kester, D. E., Davies, Jr., F. T., Geneve, R. L. (2002). Hartmann & Kester's plant propagation: principles and practices. Englewood Cliffs, NJ: Prentice Hall.

Hatta, M., Beyl, C. A., Garton, S., Diner, A. M. (1996). Induction of roots on jujube softwood cuttings using *Agrobacterium rhizogenes*. J. Hortic. Sci., 71, 6, 881–886. http://dx.doi.org/10.1080/14620316.1996.11515470

Higa, T., Parr, J. F. (1994). Beneficial and effective microorganisms for a sustainable agriculture and environment. Vol. 1. Atami, Japan: International Nature Farming Research Center.

Howard, B. H. (1986). Factors affecting the rooting response of fruit tree cuttings to IBA treatments. Acta Hortic. (ISHS), 179, 829–840. https://dx.doi.org/10/17660/ActaHortic.1986.179.144

Ilczuk, A., Jagiełło-Kubiec, K., Jacygrad, E. (2013). The effect of carbon source in culture medium on micropropagation of common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diable D'or'. Acta Sci. Pol. Hort. Cult., 12, 3, 23–33.

Jacob, M., Plietzsch, A., Schulze, K. (1991). Results of model trials on the rooting of ornamental trees and shrubs. Gartenbau, 38, 3, 44–46.

Javaid, A. (2006). Foliar application of effective microorganisms on pea as an alternative fertilizer. Agron. Sustain. Dev., 26, 4, 257–262. https://dx.doi.org/10.1051/agro:2006024

Javaid, A., Bajwa, R., Anjum, T. (2008). Effect of heat-sterilization and EM (effective microorganisms) application on wheat (*Triticum aestivum* L.) grown in organic-amended sandy loam soil. Cereal Res. Commun., 36, 3, 489–499. https://dx.doi.org/10.1556/CRC.36.2008.3.13

Khaliq, A., Abbasi, M. K., Hussain, T. (2006). Effects of integrated use of organic and inorganic nutrient sources with effective microorganisms (EM) on seed cotton yield in Pakistan. Bioresour. Technol., 97, 8, 967–972. https://dx.doi.org/10.1016/j.biortech.2005.05.002

Linderman, R. G., Davis, E. A. (2004). Varied response of marigold (*Tagetes* spp.) genotypes to inoculation with different arbuscular mycorrhizal fungi. Sci. Hortic., 99, 1, 67–78. https://dx.doi.org/10.1016/S0304-4238(03)00081-5

Loach, K. (1988). Hormone applications and adventitious root formation in cuttings – a critical review. Acta Hortic. (ISHS), 227, 126–133. https://dx.doi.org/10.17660/ActaHortic.1988.227.19

Lovato, P. E., Schüepp, H., Trouvelot, A., Gianinazzi, S. (1995). Application of arbuscular mycorrhizal fungi (AMF) in orchard and ornamental plants. In: A. Varma, B. Hock (eds.), Mycorrhiza. Structure, function, molecular biology and biotechnology (pp. 443–467). Berlin: Springer. https://dx.doi.org/10.1007/978-3-662-08897-5

Matysiak, B., Falkowski, G. (2010). Response of three ornamental plant species to inoculation with arbuscular mycorrhizal fungi depending on compost addition to peat substrate and the rate of controlled release fertilizer. J. Fruit Ornam. Plant Res., 18, 2, 321–333.

Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT.00184

McAfee, B. J., White, E. E., Pelcher, L. E., Lapp, M. S. (1993). Root induction in pine (*Pinus*) and larch (*Larix*) spp. using *Agrobacterium rhizogenes*. Plant Cell Tissue Org. Cult., 34, 1, 53–62. https://dx.doi.org/10.1007/BF00048463

Pacholczak, A., Szydło, W. (2008). Effect of ammonium zinc acetate on rooting of stem cutting in *Physocarpus opulifolius*. Ann. Warsaw Univ. Life Sci. SGGW Hortic. Landsc. Archit., 29, 59–64.

Pacholczak, A., Szydło, W., Petelewicz, P., Szulczyk, K. (2013). The effect of AlgaminoPlant on rhizogenesis in stem cuttings of *Physocarpus opulifolius* 'Dart's Gold' and 'Red Baron'. Acta Sci. Pol. Hort. Cult., 12, 3, 105–116.

Pacholczak, A., Szydło, W., Pijus, J. (2010). Effect of Asahi SL preparation on rhizogenesis in stem cuttings of *Physocarpus opulifolius* 'Dart's Gold' and 'Diabolo'. Ann. Warsaw Univ. Life Sci. SGGW Hortic. Landsc. Archit., 31, 11–17.

Pietkiewicz, S., Kołpak, R., Wiertrzyńska, A., Łoboda, T., Ostrowska, D. (2004). Wpływ efektywnych mikroorganizmów na wzrost i plonowanie ziemniaków rozmnażanych z minibulw. Rocz. Glebozn., 55, 1, 285–290.

Piskier, T. (2006). Reakcja pszenicy jarej na stosowanie biostymulatorów i absorbentów glebowych. J. Res. Appl. Agric. Eng., 51, 2, 136–138.

Raju, N. L., Prasad, M. N. V. (2010). Influence of growth hormones on adventitious root formation in semi-hardwood cuttings of *Celastrus paniculatus* Willd.: a contribution for rapid multiplication and conservation management. Agrofor. Syst., 79, 2, 249–252. https://dx.doi.org/10.1007/s10457-009-9251-9

Rinallo, C., Mittempergher, L., Frugis, G., Mariotti, D. (1999). Clonal propagation in the genus Ulmus: improvement of rooting ability by *Agrobacterium rhizogenes* T-DNA genes. J. Hortic. Sci. Biotechnol., 74, 4, 502–506. http://dx.doi.org/10.1080/14620316.1999.11511143

Scagel, C. F. (2001). Cultivar specific effects of mycorrhizal fungi on the miniature rose cutting. J. Environ. Hortic., 19, 1, 15–20.

Scagel, C. F. (2004). Changes in cutting composition during early stages of adventitious root rooting of miniature rose altered by inoculation with arbuscular mycorrhizal fungi. J. Am. Soc. Hortic. Sci., 129, 624–634.

Scagel, C. F., Reddy, K., Armstrong, J. M. (2003). Mycorrhizal fungi in rooting substrate influences the quantity and quality of roots on stem cutting of Hick's yew. HortTechnology, 13, 1, 62–66.

Świerczyński, S. (2008). Influence of rootstocks and applying mycorrhizal vaccine on the growth of maiden trees and trees three years after planting of 'Woodii' cultivar. Acta Sci. Pol. Hort. Cult., 7, 4, 3–11.

Trepanier, M., Rioux, J.-A. (1997). Effects of vesicular-arbuscular mycorrhizal fungi on rooting and growth of two woody ornamentals. HortScience, 32, 3, 447.

Vestberg, M., Cassells, A. C., Schubert, A., Cordier, C., Gianinazzi, S. (2002). Arbuscular mycorrhizal fungi and micropropagation of high value crops. In: S. Gianinazzi, H. Schüepp, J. M. Barea, K. Haselwandter (eds.), Mycorrhizal technology in agriculture: from genes to bioproducts (pp. 223–233). Basel: Birkhäuser.

Yan, P.-Sh., Xu, H.-L. (2002). Influence of EM bokashi on nodulation, physiological characters and yield of peanut in nature farming fields. J. Sustain. Agric., 19, 4, 105–112. http://dx.doi.org/10.1300/J064v19n04_10

Zydlik, P., Zydlik, Z. (2008). Impact of biological effective microorganisms (EM) preparations on some pysico-chemical properties of soil and the vegetative growth of apple-tree rootstocks. Nauka Przyr. Technol., 2, 1, #4.

Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius* (L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT.00184

WPŁYW KILKU SPOSOBÓW TRAKTOWANIA SADZONEK NA UKORZENIANIE I WZROST PĘCHERZNICY KALINOLISTNEJ (*PHYSOCARPUS OPULIFOLIUS* (L.) MAXIM.) ODMIANY 'DIABOLO'

Abstrakt

Wstęp. Ze względu na zakaz stosowania syntetycznych auksyn potrzebne są badania dotyczące oceny przydatności innych substancji przy rozmnażaniu krzewów ozdobnych w celu poprawy ukorzenienia sadzonek i wzrostu roślin. Celem eksperymentu było porównanie skuteczności stosowania szczepionki mikoryzowej i efektywnych mikroorganizmów w produkcji krzewów pęcherznicy kalinolistnej.

Materiał i metody. W eksperymencie wykonanym w latach 2010–2012 oceniono wpływ trzech różnych traktowań sadzonek na ukorzenienie i wzrost krzewów *Physocarpus opulifolius* 'Diabolo'. Przed sadzeniem zdrewniałych sadzonek w pole zastosowano szczepionkę endomikoryzową, efektywne mikroorganizmy i Ukorzeniacz AB Aqua. Zmierzono średnice i długości pędów, policzono liczbę pędów na roślinie i procent ukorzenionych sadzonek oraz zważono świeżą masę systemu korzeniowego.

Wyniki. Zastosowanie szczepionki mikoryzowej zwiększyło procent ukorzenionych sadzonek oraz dawało najlepsze wyniki długości pędów bocznych, średnicy i świeżej masy systemu korzeniowego krzewu. Po użyciu efektywnych mikroorganizmów (EM) uzyskano największy procent ukorzenionych sadzonek oraz liczbę pędów bocznych. Preparat EM zwiększył średnicę i świeżą masę systemu korzeniowego krzewu. Ukorzeniacz AB Aqua stymulował lepsze ukorzenianie się sadzonek oraz wpłynął pozytywnie na średnicę i świeżą masę systemu korzeniowego roślin.

Wnioski. Stwierdzono, że szczepionka mikoryzowa poprawiła ukorzenienie sadzonek, a zwłaszcza stymulowała wzrost krzewów. Również efektywne mikroorganizmy zwiększyły odsetek ukorzenionych sadzonek, podobnie jak Ukorzeniacz AB Aqua, oraz polepszyły wzrost krzewów w porównaniu z kombinacją kontrolną.

Słowa kluczowe: pęcherznica kalinolistna, rozmnażanie, sadzonki zdrewniałe, szczepionka mikoryzowa, efektywne mikroorganizmy (EM), Ukorzeniacz AB Aqua

Corresponding address – Adres do korespondencji:
Sławomir Świerczyński, Katedra Dendrologii, Sadownictwa i Szkółkarstwa, Uniwersytet Przyrodniczy w Poznaniu, ul. Dąbrowskiego 159, 60-594 Poznań, Poland, e-mail: slawomir.swierczynski @up.poznan.pl

Accepted for publication – Zaakceptowano do opublikowania:
11.09.2017

For citation – Do cytowania:
*Świerczyński, S., Stachowiak, A., Golcz-Polaszewska, M. (2017). The influence of treatments applied to common ninebark (*Physocarpus opulifolius *(L.) Maxim.) 'Diabolo' cuttings on their rooting and growth. Nauka Przyr. Technol., 11, 3, 315–323. http://dx.doi.org/10.17306/J.NPT. 00184*