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

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
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 acclimatization 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 Miszkiewlo, 2008; Javaid, 2006; Pietkiewicz et al., 2004; Piskier, 2006). Zydluk and Zydluk (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-
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 $\alpha$ 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).
Table 1. The influence of treatments on the percentage of rooted hardwood cuttings and the growth of *Physocarpus opulifolius* ‘Diabolo’ bushes

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

Means followed by the same letters in the columns are not significantly different at α = 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](image-url)
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 Diaz-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.
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


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

Abstrakt
Wstęp. Ze względu na zakaz stosowania syntetycznych auksyn potrzebne są badania dotyczące oceny przydatności innych substancji przy rozmnązaniu 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.


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 stymułował 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, rozmnązanie, sadzonki zdrewniałe, szczepionka mikoryzowa, efektywne mikroorganizmy (EM), Ukorzeniacz AB Aqua

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

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