Научная статья

Original article

UDC 635.925 + 635.037

DOI 10.55186/25876740_2022_6_5_8

ROOTING OF CUTTINGS OF JUNIPERUS SABINA AND THUJA OCCIDENTALIS DEPENDING ON THE ACIDITY OF PEAT

УКОРЕНЕНИЕ ЧЕРЕНКОВ МОЖЖЕВЕЛЬНИКА КАЗАЦКОГО И ТУИ ЗАПАДНОЙ В ЗАВИСИМОСТИ ОТ КИСЛОТНОСТИ ТОРФА

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Abstract. Substrate acidity is important for reproduction of Juniperus sabina L. and Thuja occidentalis L. by cuttings. However, the effect of changes in this indicator within a single-component substrate (peat) on the rooting of these crops has been studied slightly. In the nursery "Tsvetnik Urala" (Republic of Bashkortostan, Russia) in the conditions of a spring greenhouse with artificial fog, the influence of top peat acidity on the rooting of semi-woody cuttings of Juniperus sabina L. and Thuja occidentalis L. 'Danica' was studied. In options with peat pH of 4.0, 4.5, 5.0, 6.0, and 6.5, cuttings of Juniperus sabina L. better rooted at pH = 5.0–6.0 (77.0–75.7 %), while the control option with pH = 6.5 showed only 65.7% rooting. The use of peat with pH = 5.0 allowed to increase profitability level by 34%. Cuttings of Thuja occidentalis L. ‘Danica’ rooted better in the option with peat pH = 5.5 (67.4%), which increased profitability level by 59% compared with the control variant with pH = 6.5, in which only 43.2% of cuttings rooted. Juniperus sabina L. and Thuja occidentalis L. ‘Danica’ proved to be amphitolerant plant forms with a wide range of tolerance to pH of organic substrate (peat) from 4.0 to 6.5. Alkalinization of peat to pH = 7.0 led to a sharp decrease in the rooting of cuttings of Thuja occidentalis L. ‘Danica’ (up to 24.1%). The growth of cuttings during rooting was not statistically significantly affected by the change in peat acidity.

Аннотация. Для размножения можжевельника казацкого (Juniperus sabina L.) и туи западной (Thuja occidentalis L.) черенкованием имеет значение кислотность субстрата. Однако влияние изменения этого показателя в пределах однокомпонентного субстрата (торфа) на укоренение данных культур практически не изучено. В питомнике «Цветник Урала» (Республика Башкортостан, Россия) в условиях весенней теплицы с искусственным туманом проведено изучение влияния кислотности верхового торфа на укоренение в нем полуодревесневших черенков можжевельника казацкого и туи западной ‘Danica’. В вариантах с pH торфа 4,0, 4,5, 5,0, 6,0 и 6,5 черенки можжевельника казацкого лучше укоренились при pH = 5,0-6,0 (77,0-75,7 %), в то время как контрольный вариант с pH = 6,5 показал укоренение только 65,7 %. Использование торфа с pH = 5,0 позволило повысить уровень рентабельности на 34 %. Черенки туи западной ‘Danica’ лучше укоренились в варианте с pH торфа = 5,5 (67,4 %), что повысило уровень рентабельности на 59 % с сравнении с контрольном вариантом с pH = 6,5, в котором укоренилось только 43,2 % черенков. Можжевельник казацкий и туя западная ‘Danica’ показали себя амфитолерантными формами растений с широким диапазоном толерантности к pH органического субстрата (торфа) от 4,0 до 6,5. Подщелачивание торфа до pH = 7,0 привело к резкому снижению укоренения черенков туи западной ‘Danica’ (до 24,1 %). На прирост черенков за время укоренения изменение кислотности торфа статистически достоверно не повлияло.

Keywords: Juniperus sabina L., Thuja occidentalis L., acidity, peat, cutting, rooting

Ключевые слова: можжевельник казацкий, туя западная, кислотность, торф, черенкование, укоренение

INTRODUCTION

When cutting, so many factors influence the rooting of tree crops that this reproduction technology is still perceived by some researchers not only as a science but also as an art [Whitcomb C.E., 1998; Ciubotaru A., Roshca I., 2011]. In our opinion, this is reminiscent of the situation with vegetable growing at the beginning of the XX century in Russia, when people said about a successful vegetable grower that he "has good tomatoes." And only the experiments of Edelshtein at Russian State Agrarian University — Moscow Timiryazev Agricultural Academy made it possible to clearly show that all processes of growing vegetables are quite amenable to scientific justification. This should also happen with cutting: as all factors are studied, their role and quantitative influence on rooting will be clarified, which will allow us to get away from "success instability" stated by some authors [Dirr M., Heuser C.J., 1987] with this reproduction method.

Acidity of substrates used for cutting coniferous crops is considered one of the little-studied factors. When studying reproduction technology of coniferous by cutting, many researchers give great importance to substrate composition, the ratio of its parts: peat, sand, vermiculite, perlite, etc. [Ciubotaru A., Roshca I., 2011; Szasz-Len A.M. et al., 2015; Sampayo-Maldonado et al., 2016; Tokman V.S., 2015; Mamedov F.M., 1966; Velegurov A.S., Baraishchuk G.V., 2017]. In this case, actual acidity of the obtained substrate can be given when mixing various components, but we have practically no studies on the effect of acidity on the rooting of cuttings within a single-component substrate. In other words, acidity factor is was not studied separately from other factors, it is believed that it is secondary since it is set by the percentage of components in the substrate.

Meanwhile, in the practice of cuttings in nurseries, the use of a single–component substrate, peat, is widespread. Its acidity can vary in a wide range (pH from 3.5 to 7.5 and above). It is regulated by peat producers on an individual order of nurseries, by adding dolomite powder to acidic top peat. However, not all nurseries in Russia use the opportunity to change peat acidity individually, by preferring to root conifers in "standardly deoxidized" peat with pH of about 6.5.

In the process of discussing plant reproduction technologies at the IX Conference of the Russian Nursery Stock Association (Moscow, 2016), it turned out that nurseries had quite a different percentage of rooting junipers with seemingly similar technology. A more detailed analysis of the technology showed that one of the different factors is the acidity of used peat. Considering the relevance of this topic to optimize the technology of reproduction of ornamental varieties of coniferous crops, we are in the nursery "Tsvetnik Urala" (Ufa, Republic of Bashkortostan, Russia) conducted experiments to identify the optimal peat acidity for rooting thuja and juniper.

The work objective was to identify the quantitative effect of changes in top peat acidity on the rooting of Juniperus sabina L. (local Ural form) and Thuja occidentalis L. ‘Danica'.

LITERATURE REVIEW ON SUBSTRATE ACIDITY FOR CUTTINGS OF JUNIPER AND THUJA

It is believed that for cultivation of most coniferous crops, soil should be more acidic than for deciduous, with a pH value of about 5.5 [Cregg V., 2005; South D.B., 2017]. This has certain grounds, especially for junipers (Juniperus). Thus, juniper species related to Juniperus sabina L. prefer a low pH of substrate or soil. For microclonal reproduction of J. excelsa, J. chinensis, and J. oxycedrus, it is recommended to use substrates with pH = 5.6–5.8 [Hazubska-Przybyl, 2019].

J. communis naturally grows on soils with pH of 4.1 to 5.7 [Forbes, Proctor 1986], J. virginiana — from 4.7 to 7.8 [Lawson, E.R., 1990].

J. scopulorum Blue Arrow showed the best growth when grown in a substrate with pH = 4.5 [Korszun, Bykowski, 2003]. At the same time, optimal pH value was not established since conducted experiments had no option with pH value less than 4.5, the other options were only higher: pH = 5.0; 5.5; 6.0; 6.5, and 7.2. However, it was shown that with an increase in pH, the growth of juniper worsened, and pH (H_2O) = 7.2 had a strong negative effect on the growth and color of young plants.

Juniperus sabina L. studied by us has a very large distribution area: central and southern Europe, Russia, North Africa, China [Adams R.P. et al., 2007]. This causes its wide tolerance to soil conditions, including pH level. Thus, the Ural forms of Juniperus sabina L. used in our study grow naturally in the soil pH range from 5.0 to 7.0. At the same time, pH value even within the slope of one mountain inhabited by a population of juniper may vary from 5.9 to 6.8 [Mavletova-Chistyakova M.V. et al., 2017].

Thuja occidentalis L. grows in natural habitats in the USA on soils with a pH range from 5.5 to 7.2 [Curtis J. D., 1946; Petraborg W.H., 1969] and even on more acidic soils with pH from 4.1 to 5.7 [Bentley P.A., Smith E.C. 1960]. Natural communities of Thuja occidentalis L. were found on soils with pH from 6.69 to 7.37 [Slaughter B.S., Skean J.D.Jr. 2003]. In general, Thuja occidentalis L. is a species that is rather undemanding to soils, growing in a variety of habitats, including mixed forests, limestone cliffs, sand dunes, and coastal ecosystems

[Anwar G. et al., 2020]. In the studies of Nelson T.C. (1951), soil pH did not affect the germination of Thuja occidentalis L. seeds in the range from 4.0 to 8.0, however, pH below 4.0 inhibited germination, soil pH below 6.0 negatively affected the number of seedlings per unit area.

As with juniper, scientists have quite little data on the study of the effect of acidity factor on rooting of Thuja occidentalis L. cuttings within a single substrate. The experiment of Bruckel D.W. and Johnson E.P. (1969), in which cuttings of Thuja occidentalis L. were rooted in perlite at pH 5.1, 6.0, 7.1, 8.0, and 9.3, can be considered classic. The best results of rooting and root growth were obtained at pH = 7.1.

More often we found studies on the effect of various substrates with different pH values. For example, in Tokman V.S. (2015), in a mixture of substrates (sand, peat, perlite) with pH = 3.5-4.0, cuttings of Thuja occidentalis L. did not take root at all, in a substrate with pH = 6.0 (peat + sand) they took root by 16%. Certainly, rooting by 16% raises doubts about the effectiveness of the used technology, but in relative terms, the result can be considered indicative. But in addition to different levels of acidity, different substrates have different other indicators, including agrophysical (moisture capacity, porosity, etc.), which are very important for rooting. Therefore, it is not possible to focus on such studies in terms of optimal pH level.

RESEARCH METHODOLOGY AND CUTTING TECHNOLOGY

Objects of research: semi-woody cuttings of Juniperus sabina L. and Thuja occidentalis L., top peat with varying degrees of acidity.

The study used plants of Juniperus sabina L., one of the local Ural forms collected by the author on the slopes of the mountains of the Southern Urals. Our earlier investigations on the study of winter hardiness of Juniperus sabina L. varieties of European origin revealed their insufficient winter hardiness in the conditions of Blagoveshchensk district of the Republic of Bashkortostan (southern

Urals of Russia). Therefore, in 2012-2016, the author undertook expeditions to the South Ural mountains to search for local winter-hardy forms of junipers. As a result, a collection of ornamental forms of Juniperus sabina L. with winter hardiness at the level of USDA zone 2 (up to -45 °C) was collected.

Thuja occidentalis L. is quite winter-hardy in the conditions of the Republic of Bashkortostan. Damage to thuja in winter is associated with the "burning out" of needles: "double" light (direct from the sun and reflected from snow) in March and early April causes heating and awakening of the physiological processes of needles. If, after planting, thuja plants could not take root deep enough into the soil before winter, then their root system is located in the top freezing layer and cannot supply the awakened needles with moisture, which leads to the drying of needles. However, it is true only for the vertical forms of Thuja occidentalis L. Low spherical varieties, such as ‘Danica’ variety used in our studies, do not have such a problem. ‘Danica’ variety is one of the most common spherical dwarf varieties of Thuja occidentalis L., used in landscaping both Ufa and other cities and regions of Russia.

Experiments with Juniperus sabina L. have been started in 2017, with Thuja occidentalis L. — in 2018. Cutting of juniper and thuja was carried out by us in mid-May. Some nurseries in Russia use winter cuttings, by rooting cuttings in heated greenhouses to optimize the turnover of nursery areas [Rey A., 2019; Demchenko G.A., Moiseenko V.I., 2019]. However, in this matter we adhere to a more classical scheme, by rooting conifers in spring greenhouses: the growing season in the Republic of Bashkortostan is quite enough for rooting Juniperus sabina L. and Thuja occidentalis L. without additional heating costs.

Cuttings were cut in a semi-woody state, about 15 cm long in juniper and 8 cm in thuja. At the same time , the cuttings had a woody part about 4 cm long. Since it was planned to account for the increase, the size of the cuttings was relatively aligned, with a deviation of 2.0 cm in juniper and 1.5 cm in thuja. After cutting, the cuttings were soaked for 30 minutes in a solution of Fundazol (benomyl, 500 g/kg) for disinfection. Before planting in peat, the cuttings were dipped with the lower ends into the powder preparation Kornevin (indole butiric acid, 5 g/kg).

The planting of cuttings was carried out in top peat fractions of 0-20 mm with different acidity. Different peat acidity was determined by mixing acidic peat (pH = 4.0) and peat deoxidized with dolomite powder (pH = 6.5 in 2017 and pH = 7.0 in 2018) in certain proportions. The main difficulty here was to select the mixing ratio to obtain the actual substrate acidity with accurate pH values for each option. The acidity was determined using a portable pH meter calibrated at two pH points (4.01 and 6.86).

The options of the experiment with Juniperus sabina L. in 2017 were as follows: peat pH 4.0, 4.5, 5.0, 6.0, and 6.5.

The options of the experiment with Thuja occidentalis L. in 2018 were as follows: peat pH 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, and 7.0.

Cuttings were planted in plastic cell packs (54 cells per cell pack). Each cell pack was a working plot of one of the options, respectively, the experiments can be considered micro-plots. The number of repetitions (cell packs) in each option was 10, which was much higher than 3-5 repetitions accepted in crop production [Dospekhov B.A., 1979] and to some extent compensated for the small size of the working plot. The arrangement of cell packs in the experiment was randomized.

Cell packs were installed on racks with drainage. The greenhouse was covered with a white nonwoven fabric with a density of 40 g/m^2. To maintain high humidity, the greenhouse is equipped with a "low pressure" fog system. Water for fog is supplied at a pressure of 7 atm., automatically using timers. Depending on weather conditions, fog supply mode was as follows: switching on for 5-15 seconds every 15-40 minutes, turned off at night. In early September, the interval between fog supply was increased to 1.5-2 hours to adapt the rooted cuttings to drier air before being removed from the greenhouse to a shaded area.

The calculation of rooted cuttings was carried out in mid-September. All cuttings that formed roots more than 1 cm long were counted. To account for the increase, the height of aboveground part of the cuttings was measured using a measuring ruler; the measurement was carried out for all rooted cuttings.

The evaluation of experiment results was carried out using variance analysis [Rushninskii L.Z., 1971] using the program STATISTICA 5.0 for Windows. Economic efficiency assessment was carried out according to actual costs.

RESULTS AND DISCUSSION

The conducted experiment has shown that "standardly deoxidized" peat with pH = 6.5 is not optimal for either Juniperus sabina L. or Thuja occidentalis L. With a decrease in this indicator to pH = 5.0–6.0, rooting ability of juniper cuttings increased statistically significantly by 10–11% (Table 1). In Thuja occidentalis L., a decrease in pH from 6.5 to 5.5 showed an even greater increase in rooting — by 24% (Table 2). It is interesting that peat alkalinization to pH = 7.0 led to an almost twofold decrease in rooting ability of Thuja occidentalis L., even in comparison with the control option. At the same time, the change in peat acidity did not affect the growth of cuttings significantly.

Table 1. Rooting and height of Juniperus sabina cuttings depending on the acidity of the peat substrate (Blagoveshchensky district of the Republic of Bashkortostan, Nursery "Tsvetnik Urala", 2017)

Peat acidity, pH	Rooting, %	Aboveground height, cm
4.0	61.6	19.4
4.5	67.6	19.8
5.0	77.0	20.5
6.0	75.5	19.0
6.5 (control)	65.7	19.8

LSD_{05}	3.1	1.9

Table 2. Rooting and height of Thuja occidentalis 'Danica' cuttings depending on the acidity of the peat substrate (Blagoveshchensky district of the Republic of Bashkortostan, Nursery "Tsvetnik Urala", 2018)

Peat acidity, pH	Rooting, %	Aboveground height, cm
4.0	45.1	10.2
4.5	56.8	10.6
5.0	62.3	11.0
5.5	67.4	10.3
6.0	45.7	9.9
6.5 (control)	43.2	10.5
7.0	24.1	9.5
LSD_{05}	4.8	1.7

A similar increase in rooting of cuttings with a decrease in substrate pH has been noted for holly [Maynard V.K., 2000] and apple trees [Harbage J.F et al., 1998]. This may be due to the fact that auxin penetrates into the cell, including by passive diffusion. If the extracellular pH is lower than in the cytoplasm, passive auxin diffusion into the cell provides greater absorption of this substance that promotes root development [Rubery P.H., Sheldrake A.R., 1974].

According to the results of our research, Juniperus sabina L. and Thuja occidentalis L. have shown themselves to be amphitolerant plant forms with a fairly wide optimum from slightly acidic to slightly alkaline peat pH values and with a tolerance range from 4.0 to 6.5. An important fact should be noted here: pH value = 6.5 of peat organic substrate in terms of availability of nutrients to plants (phosphorus, manganese, magnesium, boron, copper and zinc) approximately corresponds to pH = 8.0 of mineral soil, i.e. it is "alkaline" in relation to peat [Kuhns L.J., 1987]. Perhaps this also explains the better rooting of juniper and thuja cuttings in options with a lower peat pH. This can also explain the difference with the results of the experiments of Bruckel D.W. and Johnson E.P. (1969), where the best rooting of thuja was at pH = 7.1 in perlite, which is not an organic substrate.

In nature, amphitolerance helps plants to survive in conditions of high competition in phytocenoses. If plants do not withstand competition within their physiological optimum, then they are pushed back to places with less intensity of competition. Then they fully use the boundaries of their tolerance to soil pH, by ccupying niches that are little used by other plants [Larekh V., 1978]. Probably, this explains the widespread distribution of Juniperus sabina L. and Thuja occidentalis L. both on acidic and alkaline soils.

For reproduction technology of Juniperus sabina L., in this regard, its tolerance to the substrate acidity during cutting is important. It allows nurseries to use "standardly deoxidized" peat with pH = 6.5 relatively successfully. However, when adjusting peat substrate acidity to not quite "standard" pH levels = 5.0–6.0, rooting of cuttings may increase by an additional 10%. According to the calculations of economic efficiency of cultivation carried out on the basis of actual costs in the nursery "Tsvetnik Urala" (Ufa, Republic of Bashkortostan, Russia), this allowed to increase profitability level by 34%.

For Thuja occidentalis L. 'Danica', tolerance to substrate acidity during cutting is less important. The use of peat substrate with pH = 5.5 significantly (by an additional 24%) increased rooting ability of its cuttings compared to pH = 6.5, which made it possible to increase the profitability of its cutting in the nursery "Tsvetnik Urala" by 59%.

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Для цитирования: Костылев Д.А. ROOTING OF CUTTINGS OF JUNIPERUS SABINA AND THUJA OCCIDENTALIS DEPENDING ON THE ACIDITY OF PEAT //International agricultural journal. 2022. № 5, 122-136.