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Research Article

Assessment of deciduous trees introduction prospect in the taiga zone (Karelia)

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Abstract

The article aimed at assessing introduction prospect for 32 species of the genera *Acer* L., *Betula* L., *Fraxinus* L., *Padus* Mill., *Syringa* L. and *Sorbus* L. at the Botanical Gardens of Petrozavodsk State University (Southern Karelia, central taiga subzone). The degree of introduction prospect was assessed with the use of the integral assessment method by P. I. Lapin and S. V. Sidneva. Such indicators as annual maturing of shoots, regular growth of axial shoots, winter hardiness of plants, habit preservation, shoot-forming capability, generative reproduction capability, capability to reproduce in plantation were taken into account. It was found that *Acer ginnala*, *Acer platanoides*, *Betula platyphylla*, *Betula ulmifolia*, *Fraxinus excelsior*, *Padus virginiana*, *Padus pensylvanica*, *Padus maackii*, *Syringa vulgaris*, *Syringa pubescens*, *Syringa emodi*, *Syringa* × *henryi*, *Syringa josikaea*, *Syringa villosa*, *Syringa vulgaris* var. *Congo*, *Sorbus decora*, *Sorbus virginianis* and *Sorbus americana* have the highest prospect rates (80–100 points), the other studied species – fairly high prospect rates (56–79 points). All the studied introduced species of deciduous trees can be successfully used in Karelia for gardening and landscaping purposes. *Acer platanoides*, *Betula platyphylla*, *Fraxinus excelsior*, *Padus pensylvanica*, *Padus maackii*, *Syringa vulgaris* и *Sorbus decora* show the highest degree of introduction prospect (about100 points).

Keywords

Acer, *Betula*, introduction, *Fraxinus*, *Padus*, *Sorbus*, *Syringa*, woody plants

Introduction

Most indigenous species of woody plants in the taiga zone of Russia are known to be extremely sensitive to progressive environmental pollution. At the same time, many species of deciduous trees from other geographical regions are fairly tolerant to pollution of air with gas and smoke and notable for

their longevity (Plotnikova 1983; Vstovskaya 1983; Lapin 1987; Catalog… 2010; Hatch 2018). Besides, many of these species are characterized by much higher productivity than the local ones and quite often capable of naturalization (Lukin 1977; Kalutsky and Bolotov 1983; Mamaev and Makhiev 1996; Botenkov and Popova 1997). According to many scientists (Bazilevskaya 1964; Bradshaw 1995; Mamaev and Makhiev 1996; Isaev et al. 1997; Budantsev et al. 2004; Houtman 2004.), biological diversity of natural and artificial phytocenoses may be increased only due to woody plants introduction. All this suggests that deciduous woody plants introduction and its prospects assessment are required. The latter can be determined only on the basis of comprehensive study of the test plants adaptation in new conditions (Bazilevskaya 1964; Bulygin and Vekshin 2004; Baryshnikova and Arestova 2008; Loskutov 2008a; Loskutov 2008b; Vstovskaya 2012; Belyuchenko 2014; Alekhin and Shestak 2017).

The studies aimed at assessing introduction prospects for deciduous woody plants. There is no record of any earlier studies of this kind in Karelia.

Materials and methods

The studies were carried out at the Botanical Gardens of Petrozavodsk State University located in the central taiga subzone, in the absence of air pollution (61°47'N, 34°20'E). The subjects of the studies were plants of six species of *Acer* L. (*A. negundo* L., *A. ginnala* Maxim., *A. platanoides* L., *A. pseudoplatanus* L., *A. semenovii* Rgl. et Herd., *Acer tataricum* L.), 6 species and 1 form of genus *Betula* L. [*B. pubescens* Ehrh., *B. pendula* Roth, *B. pendula* Roht. var. carelica (Merckl.) Hamet-Ahti, *B. lutea* Michx., *B. mandshurica* Rgl., *B. platyphylla* Sukacz., *B. ulmifolia* Siebold et Zucc.], 3 species of genus *Fraxinus* L. (*F. excelsior* L., *F. americana* L., *F. pennsylvanica* Marsh.), species of genus *Padus* L. [*P. avium* Mill., *P. maackii* (Rupr.) Kom., *P. virginiana* (L.) Mill., *P. pensylvanica* (L. f.) Sok.], 5 species, 2 hybrids and 1 cultivar of the genus *Siringa* L. [*S. vulgaris* L., *S. pubescens* subsp. *microphylla* (Diels) M.S. Chang & X.L. Chen, *S. emodi* Wall. ex Royle., *S.* × *henryi* Schneid., *S. josikaea* Jacq. ex Rheb. f., *S. villosa* Vahl, *S. vulgaris* var. *Congo* Lemoine], 8 species of genus *Sorbus* L (*S. aucuparia* L., *S. hybrida* L., *S. decora* L., *S. sibirica* Hedl. L., *S. virginiana* Mill., *S. americana* Marsh., *S. amurensis* Koehne., *S. discolor* Maxim.) (Cherepanov 1995). Trees were planted at the age of 6–8 years, 15–30 specimen of each. A description of the study subjects is provided in Table 1.

Table 1. Characteristics of objects

Species and form	Place of origin of seedlings, city	Age, years old
Acer negundo	St. Petersburg	51
A. ginnala	St. Petersburg	46
A. platanoides	St. Petersburg	61
A. pseudoplatanus	St. Petersburg	51
A. semenovii	St. Petersburg	46
A. tataricum	St. Petersburg	61
Betula pubescens	Petrozavodsk (indigenous species)	45
B. pendula	Petrozavodsk (indigenous species)	42
B. pendula var. *carelica*	Petrozavodsk (indigenous species)	18
B. lutea	Arkhangelsk	18
B. mandshurica	St. Petersburg	44
B. platyphylla	St. Petersburg	44
B. ulmifolia	St. Petersburg	44
Fraxinus excelsior	St. Petersburg	54
F. americana	St. Petersburg	40
F. pennsylvanica	St. Petersburg	40
Padus maackii	St. Petersburg	48
P. virginiana	St. Petersburg	61
P. pensylvanica	St. Petersburg	51
P. avium	Petrozavodsk (indigenous species)	50
Syringa vulgaris	Kiev	51
S. vulgaris var. *Congo*	Moscow	53
S. pubescens	Moscow	53
S. emodi	Moscow	53
S. × *henryi*	Moscow	51
S. josikaea	Moscow	63
S. villosa	Moscow	51
Sorbus aucuparia	Petrozavodsk (indigenous species)	50
S. hybrida	St. Petersburg	37
S. decora	Minsk	21
S. sibirica	St. Petersburg	41
S. virginiana	St. Petersburg	42
S. americana	St. Petersburg	45
S. amurensis	St. Petersburg	43
S. discolor	Arkhangelsk	41

Prospects of the plants introduction were assessed in points with the use of the methods by P. I. Lapin and S.V. Sidneva (Lapin and Sidneva 1973). We took into account indicators such aslignification shoots, winter hardiness, preservation habitus, conducive ability, increase in height, the ability to generative development, opportunity breeding in culture breeding in culture.

Results

Annual maturing of shoots is one of the most important indicators of successful introduction characterizing successful wintering. It is mainly determined by shoot stiffening degree, development of plug, waxy bloom, fuzz and shoot protection degree. Maximum grade is 20 points (Table 2).

The studies demonstrated that the majority of the studied species have maximum annual maturing of shoots or close to it, only *Padus virginiana*, *Sorbus hybrida*, *Syringa vulgaris var. Congo*, *Sorbus sibirica* and *Sorbus discolor* have lower results of 12–15 points.

Winter hardiness of plants is the main indicator of successful woody plants introduction in the temperate zone where winter weather conditions often have a negative impact on the introduced plants. Maximum winter hardiness grade is 25 points. The lowest grade of 5–10 points was recorded for *Fraxinus americana*, *Fraxinus pennsylvanica*, *Syringa vulgaris var. Congo*, the middle one of 13–18 points – for *Sorbus hybrida*, *Sorbus sibirica*, *Sorbus amurensis* and *Sorbus discolor*, all the other studied species were found to have the highest grade or close to it. Similar conclusion regarding *Sorbus sibirica* was previously drawn by O.V. Vvedenskaya (Vvedenskaya 2011).

Habit preservation characterizes plants capability to maintain to one degree or another the biologically inherent form of growth which is, on the whole, determined by their winter hardiness. The highest grade for habit preservation is 10 points. All species with the exception of *Sorbus hybrida* and *Sorbus sibirica* (7 points) preserve completely their habit. Similar conclusions regarding the introduced species *Acer* in the Bashkir Cis-Ural region were previously drawn by N. A. Ryazanova and V.P. Putenikhin (Ryazanova and Putenikhin 2010), in Siberia – I. A. Alekhin and K. V. Shestak (Alekhin and Shestak 2017), regarding *Syringa* – N. V. Polyakova (Polyakova 2016).

Shoot-forming capability of plants enables them to maintain the form of growth by ensuring its regeneration even after severe crown freezing. Maximum shoot-forming capability grade is 5 points. Lower shoot-forming capability grade (2–3 points) was documented for *Acer pseudoplatanus*, *Acer semenovii*, *Betula lutea*, *Fraxinus americana*, *Fraxinus pennsylvanica*, *Syringa emodi*, *Syringa* × *henryi*, *Syringa josikaea*, *Syringa villosa* and *Syringa vulgaris* var. Congo. All the other studied species were found to have the highest grade or close to it. In the Orenburg Cis-Ural region the high shoot-forming capability for the same species *Syringa* as in this study has been previously documented by N. M. Nazarova (Nazarova 2013).

Maximum grade of regular growth of axial shoots (5 points) was documented for all species with the exception of *Padus avium*, *Padus virginiana* and *Padus maackii* (3–4 points). E. A. Arestova (Arestova 2011) previously determined that the species *Sorbus* having the same names as those in the study had normal development cycle during the vegetation period in the city of Saratov.

Generative reproduction capability of plants is a highly important indicator for introduction assessment, since the selection of the most adapted species grown from the seeds of the local generation ensures successful plant acclimatization. Maximum grade of this capability is 25 points. The lowest generative reproduction capability (5–10 points) is typical of *Acer ginnala*, *Acer negundo*, *Acer pseudoplatanus*, *Acer semenovii*, *Acer tataricum*, *Sorbus hybrida* и *Sorbus discolor*, middle one (15–18 points) – for *Betula lutea*, *Betula mandshurica*, *Syringa vulgaris var. Congo*, *Sorbus sibirica* and *Sorbus americana*, the highest one (20–25 points) – for the other species. In the Krasnoyarsk Region T.A. Karaseva (Karaseva 2004) also found generative reproduction capability for the introduced species *Acer* to be low.

Capability to reproduce in plantation by seeds show a high degree of plants adaptation to natural conditions of a new region and therefore practical relevance. Capability to reproduce in plantation has a maximum grade of 10 points. *Acer negundo*, *Acer pseudoplatanus*,

Table 2. Evaluation of the prospects for the introduction of deciduous trees, scores

Species	Lignification shoots	Winter hardiness	Preservation habitus	Conduciveability	Increase in height	The ability to generative development	Opportunity breeding in culture breeding in culture	Overall Perspective Assessment
Acer ginnala	20	23	10	5	5	10	10	83
A. negundo	16	21	10	3	5	5	5	65
A. platanoides	20	25	10	5	5	20	10	95
A. pseudoplatanus	17	22	10	3	5	5	5	67
A. semenovii	16	21	10	3	5	5	5	65
A. tataricum	20	23	10	4	5	10	5	77
Betula lutea	20	22	10	3	5	15	3	73
B. mandshurica	20	20	10	4	5	15	5	79
B. platyphylla	20	22	10	5	5	20	10	92
B. ulmifolia	20	25	10	5	5	20	10	90
Fraxinus excelsior	20	25	10	5	5	25	10	100
F. americana	20	5	10	3	5	25	10	78
F. pennsylvanica	20	5	10	3	5	25	10	78
Padus avium	18	25	10	5	4	25	10	97
P. virginiana	15	20	7	4	3	25	10	84
P. pensylvanica	19	25	10	5	5	25	10	99
P. maackii	17	25	10	5	4	25	10	96
Syringa vulgaris	20	25	10	5	5	25	10	100
S. pubescens	20	20	10	4	5	20	10	89
S. emodi	20	20	10	3	5	20	10	88
S. × *henryi*	20	20	10	3	5	20	10	88
S. josikaea	20	20	10	3	5	20	10	88
S. villosa	20	20	10	3	5	20	10	88
S. vulgaris var. *congo*	15	10	10	2	5	15	10	67
Sorbus hybrida	15	17	10	5	8	8	3	66
S. decora	20	22	10	5	10	20	5	92
S. sibirica	15	18	10	5	7	15	4	74
S. virginianis	18	20	10	5	8	20	5	86
S. americana	20	20	10	5	8	18	4	85
S. amurensis	13	14	10	5	6	10	4	62
S. discolor	12	13	10	5	6	8	4	58

Acer semenovii, *Acer tataricum*, *Betula lutea*, *Betula mandshurica*, *Sorbus hybrida*, *Sorbus decora*, *Sorbus sibirica*, *Sorbus virginianis*, *Sorbus americana*, *Sorbus amurensis* and *Sorbus discolor*were found to reproduce poorly in plantation (3–5 points), the other studied species have high grades.

Discussion

The above data was used for a summary assessment of the introduction prospects with the maximum of 100 points. *Acer ginnala*, *Acer platanoides*, *Betula platyphylla*, *Betula ulmifolia*, *Fraxinus excelsior*, *Padus virginiana*, *Padus pensylvanica*, *Padus maackii*, *Syringa vulgaris*, *Syringa pubescens*, *Syringa emodi*, *Syringa* × *henryi*, *Syringa josikaea*, *Syringa villosa*, *Sorbus decora*, *Sorbus virginianis* and *Sorbus americana*were found to have the highest prospect rates (80–100 points), whereas the other species have fairly high prospect rates (56–79 points). Similar data for the taiga zone was previously recorded by other researchers (Vstovskaya 1983; Plotnikova 1983; Botenkov and Bradshaw 1995; Popova 1997; Houtman 2004; Karaseva 2004; Baryshnikova and Arestova 2008; Polyakova 2016; Alekhin and Shestak 2017; Hatch 2018; http://www.jfschmidt.com/pdfs/JFS_New_2009.pdf).

Conclusion

All 32 studied species of deciduous woody plants introduced at the Botanical Gardens of Petroza-

vodsk State University show a high degree of introduction prospect and can be successfully used in settlements of the taiga zone for gardening and landscaping purposes. *Acer platanoides*, *Betula platyphylla*, *Fraxinus excelsior*, *Padus pensylvanica*, *Padus maackii*, *Syringa vulgaris* and *Sorbus decora* were found to have the highest degree of adaptation (about 100 points).

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