FORESTRY IDEAS, 2023, vol. 29, No 1 (65): 74–83.

Assessment of introduction success of *Viburnum* L. taxa under Right-Bank Forest-Steppe of Ukraine

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Received: 29 October 2022 / Accepted: 29 March 2023 / Available online: 07 April 2023

Abstract

On the territory of Ukraine, 24 species and 11 cultivars of the genus *Viburnum* were introduced at different times. We discovered 11 species and 5 cultivars in the Right-Bank Forest-Steppe of Ukraine. Therefore, it is important to assess the success of the introduction of *Viburnum* taxa in new growing conditions and it was analysed. The studied taxa belong to the groups that are quite promising and promising for introduction into culture. Plants of other groups were not detected. The studied species were well acclimatised in local conditions (acclimatisation number is from 83 to 95). The highest values were for *V. prunifolium* L. and *V. sargentii* Koehne. The degree of acclimatisation of all research objects was defined as good. The introduction capacity of the future viburnum introduction area for the Right-Bank Forest-Steppe of Ukraine is 0.85. The species were successfully acclimatised in the conditions of the Right-Bank Forest-Steppe of Ukraine; their seasonal rhythm of development corresponds to the climatic conditions of this region. The assortment of 22 species and 7 cultivars are proposed for further introduction work and the prospects for use in the region.

Key words: acclimatisation, introductory capacity, promising, viability.

Introduction

According to literature data, to the genus *Viburnum* L. belong up to 250 species (Egolf 1962, Hillebrand and Fairbrothers 1969). Two native species grow in Ukraine: *Viburnum opulus* L. and *Viburnum lantana* L. In total, 24 species and 11 cultivars from different geographical origins were introduced to the territory of Ukraine over the years (Kokhno and Kurdyuk 1994), which is only a tenth of the world's volume of the genus and represents almost all areas of natural habitats, except for Central and South America. According to the introduction test in the conditions of the Forest-Steppe of Ukraine (Kokhno and Kurdyuk 1994) 16 species and 5 cultivars of *Viburnum* successfully passed. We found there 11 species and 5 cultivars (Demchenko 2000, 2016). Analysis of the conditions of the Forest-Steppe of Ukraine and the experience of introduction of *Viburnum* species indicated that

this region is prospective for their cultivation. Special attention should be paid to cultivars and species of *Viburnum* such as *V. carlesii* Hemsl. ex Forb. & Hemsl. 'Aurora', *V. carlesii* 'Charis', *V. carlesii* 'Compactum', *V. carlesii* 'Diana', *V. rhytidophyllum* Hemsl. ex Forb. & Hemsl. 'Roseum', *V. opulus* L. 'Tatteri', *V. macrocephalum* Fortune 'Keteleerii' and so on (Egolf 1975, 1979, 1981a, b; Uleyskaya 1993).

The study of species in the conditions of introduction in different regions was devoted to the works of many researches (Petrova 1961; Rubtsov et al. 1974; Solodukhin 1985; Kokhno et al. 1986, 2005; Luchnyk 1988; Mamushkina 1988; Trofimenko et al. 2009; Chen et al. 2012; Acharya and Mukherjee 2014).

Research of species of genus *Viburnum* was carried out in many countries. In particular, useful properties and use of species in culture were considered in the works of Karatoprak and İlgün 2022, and Gopal et al. 2023. A work (Gonçalves Silva et al. 2009) was devoted to the study of species of genus *Viburnum* on the island of Madeira. The phylogenetic connections of species of genus *Viburnum* in Korea were highlighted in the work of Choi and Oh (2019).

It is impossible to speak about the prospects of using a particular introducer in crop without estimating the success of its introduction. Therefore, it is important to assess the success of the introduction of *Viburnum* taxa in new growing conditions.

According to the introduction area zoning of the territory of Ukraine (Kokhno and Kurdyuk 1994), Right-Bank Forest-Steppe belongs to the North-Eastern introduction area, the Right-Bank introduction sub-area, where the introduction and wide crop of all species of woody plants from the extreme northern regions of the Mediterranean, Caucasus, Northern regions – Eastern China, Korea, and Primorsky Krai, the northern part of Japan is possible; the northern and central parts of the Atlantic and Pacific regions of North America, that is, exactly those territories where the largest number of species of *Viburnum* naturally grows.

The success of plant introduction depends on the viability of plants in the new habitat, which is demonstrated by the peculiarities of plants passing through the cycles of seasonal development and ontogenesis.

The purpose of the study is a comparative analysis of introduction success and the viability and prospects of further introduction into the culture of species of the genus *Viburnum* in connection with the formation of their taxonomic composition in collections and rational use in landscaping and decorative horticulture in the Forest-Steppe of Ukraine.

Materials and Methods

The studies were carried out with the following taxa of the genus *Viburnum*: *V. opulus*, *V. opulus* 'Roseum', *V. opulus* 'Nanum', *V. lantana*, *V. lantana* 'Aureum', *V. lantana* 'Variegatum', *V. carlesii* Hemsl., *V. prunifolium* L., *V. rhytidophyllum* Hemsl., *V. buddleifolium* C.H. Wright, *V. burejaeticum* Rgl. et Herd., *V. lentago* L., *V. rufidulum* Raf., *V. sargentii* Koehne, *V. sargentii* 'Flavum', *V. veitchii* C.H. Wright. Plants grow in open ground in the collection plantations of the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine (Kyiv), O.V. Fomin Botanical Garden of T. Shevchenko National University of Kyiv, The National University of Life and Environmental Sciences of Ukraine (Fig. 1), arboretums 'Syrets'

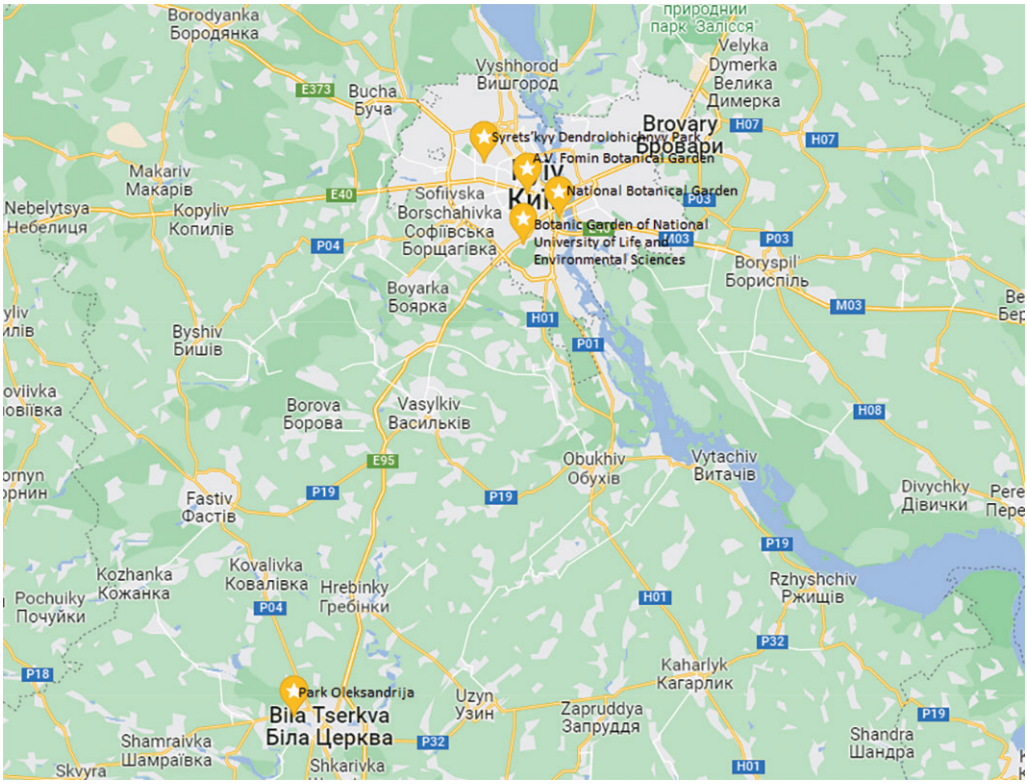

Fig. 1. Location of collection plantations of the genus *Viburnum*.

(Kyiv), 'Olexandriya' (Bila Tserkva), 'Sofiyivka' (Uman). Also, the city parks and gardens of Kyiv, Bila Tserkva, Uman, Vinnitsa, Cherkasy were examined. Stationary studies were conducted in 2009–2013. The age of the studied plants was 26–53 years. Up to 10 plants of each taxon were examined.

We conducted an evaluation of the introduction success in new growth conditions and an assessment of the viability and prospects of the introduction. The work was carried out using two methods based on regular observations of the seasonal development of plants and their ontogenesis.

The method of integral numerical evaluation of the viability and prospects of introduction of trees and shrubs based on visual observations of Lapin and Sidneva (1973) was used and evaluation of the introduction success was done according to Kokhno (1968). The introduction capacity of the area of introduction was determined by the method of Kokhno and Kurdyuk (1994).

According to the methodology of Lapin and Sidneva (1973), the perspective of the introduction was evaluated according to 7 main indicators determined by regular visual observations of the general and seasonal development of plants: the degree of annual maturation of shoots, winter hardiness, preservation of habitus, shoot-forming ability, regularity of shoot growth, ability to generative development,

available methods of propagation in crop. The method by which the assessment was carried out is given below. All 7 indicators were evaluated in points. The degree of annual maturation of shoots was assessed on a five-point scale: I – shoots ripen completely at 100 % of the length (20 points); II – mature at 75 % of the length (15 points); III – by 50 % of the length (10 points); IV – by 25 % of the length (5 points); V - shoots do not ripen at all (1 point). Winter hardiness was assessed on a seven-point scale: I – no damage (25 points); II – freezes no more than 50 % of the length of annual shoots (20 points); III – freezes 50–100 % of the length of annual shoots (15 points); IV – two-year-old and older parts of the plant frozen (10 points); V - the crown freezes up to the level of snow cover (5 points); VI – the entire above-ground part freezes over (3 points); VII – the plant freezes completely (1 point). Preservation of the habit was evaluated on a three-point scale: I – plants retain the life form characteristic in nature (10 points); II – they freeze partially, but restore the above-ground part to the previous height and volume (5 points); III – does not preserve the characteristic natural form of growth due to annual icing (1 point). Shoot-forming ability was assessed on a three-point scale: I – high shoot-forming ability: 6 or more shoots per two-year-old shoot (5 points); II – average shoot-forming ability: 3–5 shoots per two-year-old shoot (3 points); III – low shoot-forming ability: 2 shoots per one two-year-old shoot (1 point). The regularity of shoot growth was assessed by the presence or absence of annual growth of main shoots and branches, taking into account the age of the plants: annual increase – 5 points, not annual 2 points. The ability of plants to generative development was evaluated according to the scale: I – seeds ripen (25 points); II – the plants bloom, but the fruits do not ripen (20 points); III – bloom, but fruits not formed (15 points); IV – do not bloom (1 point). Available methods of reproduction of experimental plants in culture were evaluated on a five-point scale: I – self-seeding (10 points); II – artificial sowing (7 points); III – natural vegetative reproduction (5 points); IV – artificial vegetative propagation (3 points); V – repeated involvement of plants from the outside (1 point). The overall assessment of the introduction consists of the sum of points. Depending on the general assessment, the prospects of plant introduction are determined on a special scale. According to the methodology of Lapin and Sidneva (1973), six groups of introduction prospects were distinguished: I – quite promising (91–100 points); II – promising (76–90 points); III – less promising (61–75 points); IV – low-promising (41–60 points); V – unpromising (21–40 points); VI – totally unsuitable (5–20 points). Depending on the sum of the points, we determined a group of introduction prospects for each research object. Evaluation of the introduction success according to Kokhno (1968) was carried out by the method of acclimatisation number according to formula (1):

$$A = G \cdot w + Gd \cdot w + Wh \cdot w + D \cdot w, \quad (1)$$

where: A – acclimatisation number, G – growth indicator, Gd – generative development indicator, Wh – winter hardiness indicator, D – drought resistance indicator, w – coefficient of weight of the feature.

The acclimatisation number is the sum of indicators of growth, generative development, winter hardiness and drought resistance of plants; and was calculated by formula (1). Indicators of growth, generative development, winter hardiness and drought resistance were evaluated visually on five-point scales (Kokhno 1968).

The indicator obtained as a result of the visual assessment was multiplied by the indicator of the degree of importance of a specific feature – coefficient of weight (*w*). For winter resistance, its value is equal to 10, for generative development – 5, for drought resistance – 3, for growth – 2.

Depending on the value of the acclimatisation number, its degree of the research objects was determined. According to the methodology of Kokhno (1968), five degrees of acclimatisation were determined by the value of acclimatisation number (*A*): complete acclimatisation *A* equals 100, good *A* equals 80, satisfactory *A* equals 60, weak *A* equals 40, lack of acclimatisation *A* equals 20.

The introduction capacity was determined by formula (2) (Kokhno and Kurdyuk 1994):

$$Ic = \frac{n}{N'}, \qquad (2)$$

where: *Ic* is the introduction capacity, *n* is the number of species of the genus potentially appropriate for introduction in a certain area, *N* is the total number of species of the genus.

Results and Discussion

In consequence of our distribution of species of the *Viburnum* genus introduced to Ukraine by floristic regions (according to Takhtadjan 1978), it was found that the greatest number of introducers are species from the East Asian and Atlantic-North American floristic regions.

The distribution of these species by natural origin is presented in Figure 2.

Studies of the viability and prospects of introduction showed that the studied taxa belong to the groups of quite promising (I) (57.1 %) and promising (II) (42.9 %) for introduction into crop (Table 1). Plants of other groups were not found. We found that the plants of group I retain their natural growth form, have high shoot-forming ability, give annual growth of shoots, the vast majority of them bear fruit, reproduce by seeds and vegetatively. Life form and duration of life in nature and crop for these species were similar. Species of group II are characterised by regular shoot growth and good winter hardiness: no frost injuries, or occasionally no more than 50 % of

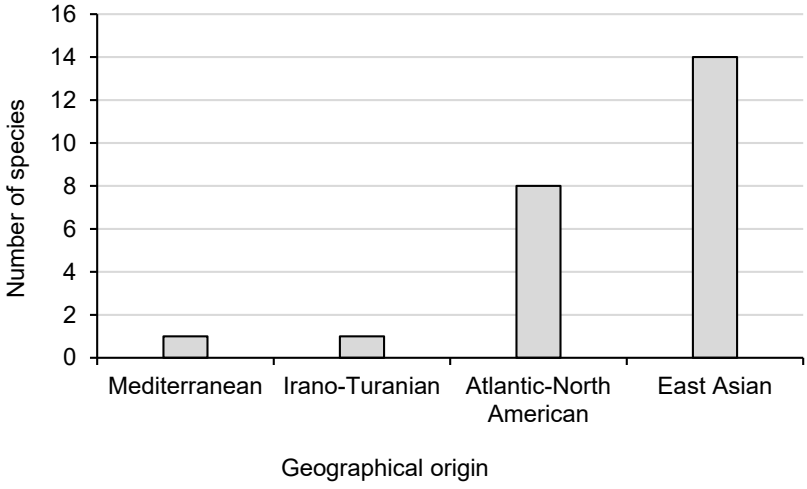

Fig. 2. Geographical origin of Viburnum species.

Table 1. Evaluation of viability of *Viburnum* spp. and the prospect of their introduction based on visual observations.

Species, cultivar	Viability indicators, points							General rating	
	Degree of shoot maturation	Winter hardiness	Preservation of habitat	Shoot-forming ability	Regularity of growth shoots	Ability to generative development	Methods of reproduction in culture	Sum of viability, points	Perspective group
V. burejaeticum	20	25	10	3	5	25	7	95	I
V. lentago	20	25	10	3	5	25	7	95	I
V. rhytidophyllum	20	20	10	3	5	25	7	90	II
V. carlesii	20	25	10	3	5	15	3	81	II
V. prunifolium	20	25	10	5	5	25	7	97	I
V. rufidulum	20	25	10	5	5	25	5	95	I
V. veitchii	20	20	10	3	5	25	7	90	II
V. buddleifolium	20	20	10	1	5	25	3	84	II
V. sargentii	20	25	10	5	5	25	7	97	I
V. sargentii ‘Flavum’	20	25	10	3	5	25	3	91	I
V. lantana ‘Aureum’	20	25	10	3	5	25	3	91	I
V. lantana ‘Variegatum’	20	25	10	3	5	25	3	91	I
V. opulus ‘Nanum’	20	25	10	3	5	15	3	81	II
V. opulus ‘Roseum’	20	25	10	3	5	15	3	81	II

annual growth freezes during severe winters (*V. buddleifolium*, *V. veitchii*). For species of group II, it is possible to propagate by seeds of local reproduction, except for non-fruiting *V. carlesii*, and cultivars that propagate vegetatively.

We estimated the degree of shoot maturation in all species by 20 points, as it was established that the shoots become woody along the entire length of the shoots. The winter hardiness of most taxa was estimated at 25 points (I no damage), the exceptions were the evergreen species *V. rhytidophyllum* and *V. buddleifolium*, as well as *V. veitchii*, in which no more than 50 % of the annual growth freezes (II 20 points). Preservation of the habit of all species was assessed at 10 points, as they preserve the life form characteristic of them in nature. The shoot-forming ability of most taxa was rated as medium (3 points), the exceptions being *V. prunifolium*, *V. rufidulum* and *V. sargentii*, which have a high shoot-forming ability (5 points). It should be noted *V. buddleifolium*, which has a low shoot-forming ability (1 point). The regularity of shoot growth was evaluated at 5 points in all research sites, as they all have annual shoot growth. The ability to generative develop-

ment was estimated at 25 points in most of the research objects, since the seeds of these species were maturing. Exceptions were *V. carlesii*, *V. opulus* 'Roseum', *V. opulus* 'Nanum' which do not bear fruit (15 points). The available methods of reproduction in culture are estimated at 7 points for most taxa, since they are propagated by artificial sowing of seeds. Exceptions were *V. rufidulum*, which naturally reproduces vegetatively (5 points), *V. buddleifolium*, *V. carlesii* and cultivars that are artificially propagated vegetatively (*V. sargentii* 'Flavum', *V. lantana* 'Aureum', *V. lantana* 'Variegatum', *V. opulus* 'Nanum', *V. opulus* 'Roseum'), (3 points).

Table 2 presents the assessment of the introduction success of research objects conducted using the method of acclimatisation number. Data show that the studied species were well acclimatised in local conditions (acclimatisation number from 83 to 95).

We estimated the growth rate of most of the research objects at 5 points; with the exception of *V. lentago*, *V. rufidulum* and *V. buddleifolium*, the growth of which was less intensive than in the natural range, but relatively good (4 points). We rated the generative development of most research objects at 4 points; exceptions were *V. carlesii* and cultivars *V. opulus* 'Roseum', *V. opulus* 'Nanum', which do not bear fruit (2 points). We assessed the winter hardiness of most of the research objects as 5 points, with the exception of *V. rhytidophyllum*, *V. buddleifolium* and *V. veitchii*, in which partial freezing of annu-

Table 2. Success assessment of the introduction of *Viburnum* spp.

Species, cultivar	Growth	Generative development	Winter hardiness	Drought resistance	Acclimatisation number (A)	Acclimatisation degree
V. burejaeticum	5	4	5	4	92	good
V. lentago	4	4	5	5	93	good
V. rhytidophyllum	5	4	4	5	85	good
V. carlesii	5	2	5	5	85	good
V. prunifolium	5	4	5	5	95	good
V. rufidulum	4	4	5	5	93	good
V. veitchii	5	4	4	5	85	good
V. buddleifolium	4	4	4	5	83	good
V. sargentii	5	4	5	5	95	good
V. sargentii 'Flavum'	5	4	5	5	95	good
V. lantana 'Aureum'	5	4	5	4	92	good
V. lantana 'Variegatum'	5	4	5	5	95	good
V. opulus 'Roseum'	5	2	5	5	85	good
V. opulus 'Nanum'	5	2	5	5	85	good

al shoots was observed (4 points). The drought resistance of most of the research objects was estimated at 5 points. The exceptions were *V. burejaeticum*, in which a temporary loss of leaf turgor during drought was observed (4 points) and *V. lantana* 'Aureum', in which leaf edge damage was observed (4 points). The degree of acclimatisation of all research objects was determined by us as good.

They grow intensively, are winter-hardy (only some of them have sometimes damaged annual shoots), bear fruit regularly, and form similar seeds, except for *V. rufidulum*, which bears fruit not annually, but reproduces well by root shoots, and *V. carlesii*, which flowers profusely but does not bear fruit in Kyiv conditions. According to literature data, flowering and fruiting were observed for this species in the conditions of Kyiv in previous years (Rubtsov et al. 1974; Malyugin 1985; Kokhno et al. 1986, 2005). We observed the formation of single fruits on young plants of this species, but they soon fell. The reasons for the lack of fruiting require further research. When comparing the degrees of acclimatisation of *Viburnum* species, we found that the highest values were found in *V. prunifolium* and *V. sargentii*, which turned out to be the most plastic under the conditions of introduction.

The Right-Bank Forest-Steppe of Ukraine belongs to the zone of relatively wide introduction of species of the genus *Viburnum*.

The introduction capacity as a quantitative assessment was determined according to formula (2) and is 0.85. The number of potentially suitable *Viburnum* species (*n*) is 213 species, the total number of species of the genus (*N*) is 250.

The experience of the successful introduction of viburnum indicates the possibility of significantly expanding the assortment of viburnum. According to literature data (Rubtsov et al. 1974, Kokhno et al. 1986, Mamushkina 1988), *Viburnum* species were presented in the collection plantations of botanical institutions of Ukraine, which were considered promising for further introduction into landscaping, however, over time, they did not become widespread. Currently, some of these species are represented in a limited number of botanical gardens and arboretums. Perhaps this is due to the lack of a sufficient number of queen cells for reproduction.

For further introduction work and prospects for use in the region, we offer an assortment of 22 species and 7 cultivars of *Viburnum*, common in the countries of Western Europe, from among species potentially suitable for introduction. First of all, these are species from North America: *V. cassinoides* L., *V. dentatum* L. *V. pubescens* (Ait.) Pursh., *V. xjuddii* Rehd., *V. xjackii* Rehd., *V. alnifolium* Marsh. *V. molle* Michx., V*. trilobum* Marsh. Species of interest from East Asian region are *V. fragrans* Bge., *V. mongolicum* (Pall.) Rehd., *V. utile* Hemsl., *V. macrocephalum* Fort., *V. phlebotricum* Sieb. et Zucc, *V. wrightii* Miq**.,** *V. sieboldii* Miq., *V. setigerum* Hance., *V. betulifolium* Batal., *V. hupehense* Rehd, *V. cotinifolium* D.Don., *V. dasyantum* Rehd., *V. dilatatum* Thunb., *V. orientale* Pall.

Some of the mentioned taxa have been tested in M.M. Gryshko National Botanical Garden, but there is no information about the causes of failure.

Conclusions

The results of the introduction of the researched species and cultivars of viburnum in the Right Bank Forest Steppe of Ukraine are summarised, the prospects

for the further introduction of representatives of this genus are determined.

According to the results of the studies of viability and prospects of introduction, we found that the studied viburnum taxa belong to the groups that are quite promising and promising for introduction into culture. As a result of the assessment of the introduction success by the method of acclimatisation number, it was determined that all the studied taxa were well acclimatised in the research region and are promising for further introduction.

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