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EVALUATION OF THE ECOLOGICAL PROPERTIES OF GENUS *VIBURNUM* L. SPECIES UNDER RIGHT-BANK FOREST-STEPPE OF UKRAINE

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Abstract

Under Right-Bank Forest-Steppe of Ukraine, 11 Viburnum species and 5 cultivars of different geographical origin are cultivated. The vast majority of species is property of a limited number of botanical gardens. There is no information about the ecological properties of most of the introduced taxa of genus *Viburnum* L. in condition of the Right-Bank Forest-Steppe of Ukraine. Therefore, the study of the ecological properties of various species of this genus under these conditions is relevant. The purpose of the study is a comparative analysis of the ecological properties of species belonging to the genus *Viburnum* L. in relation to the formation of their taxonomic composition in collections and rational use in greening and gardening. The following ecological indicators of the species were investigated: the duration of the dormant period, winter hardiness, drought resistance and water retention capacity. It was established that the winter hardiness of the species is satisfactory and does not depend on the duration of the period of deep dormancy. Monitoring the winter hardiness of uneven-aged plants of the same species made it possible to trace the change in resistance in ontogenesis. An increase in winter hardiness in all species is observed during the transition from juvenile to mature state, which is reflected by the value of the winter hardiness coefficient. Drought resistance of most species is high, exceptions are *Viburnum lantana '*Aureum*'* and *Viburnum burejaeticum* Rgl. et Herd. Water retention is higher in evergreen species and resistance to dehydration is higher in *V. opulus* L. and *V. rufidulum* Raf. The studied species are promising and quite suitable for further implementation under Right-bank Forest-Steppe of Ukraine.

Key words: dormant period, drought resistance, water retention, winter hardiness.

Introduction

Two aboriginal species – *Viburnum opulus* L. and *Viburnum lantana* L. grow in Ukraine. Over the years 24 species and 11 cultivars of Viburnum of different geographical origin (Kokhno and Kurdyuk 1994) were introduced to the territory of Ukraine. On the territory of the Right-Bank Forest-Steppe of Ukraine, 11 species and 5 cultivars of the genus are cultivated (Demchenko 2000, 2016).

The morphophysiological features of the annual development cycle in connection with the introduction of plants are of great importance.

The state of dormancy and its depth in winter is an important adaptive reaction of

woody plants to the climatic conditions of the temperate zone on which their winter hardiness depends.

The Right-Bank Forest-Steppe of Ukraine is characterized by winters with unstable snow cover. Frequent and prolonged temperature changes are especially dangerous in winter, when plants are in a state of forced dormancy. From the moment plants enter a state of deep and forced dormancy, its duration will depend on their winter hardiness and hence the success of the introduction. Due to climate change, limiting factors in the introduction of plants include their resistance to drought.

High plant productivity under conditions of insufficient water supply and high temperatures is the best feature of drought tolerance.

Lishchuk and Pilkevich (1999) consider that when evaluating plant resistance to drought, it is more methodically appropriate to determine the water-holding capacity for the time during which the leaves give up a certain amount of water while wilting. Recover of turgor with the same dehydration allows to objectively compare leaves of species of different resistance.

Some fragmentary data about winter hardiness of species of the genus *Viburnum* L. in various soil and climatic conditions are found in the works of Rehder 1949, Lypa et al. 1952, Rubtsov et al. 1974, Kolesnikov 1974, Grigoriev 1980, Bozhkova 1989, Plotnikova 1988, Kuznetsov et al. 1994, Aksenov and Aksenova 2001, Robinson and Hamilton 1980a, 1980b. The majority of authors argue that in different botanical and geographical regions of introduction, species such as *V. opulus*, *V. lantana*, *V. lentago* L., *V. burejaeticum* Rgl. et Herd., turned out to be quite resistant to winter conditions, data on other Viburnum species almost not given.

There are contradictory statements about the winter hardiness of certain species. According to data of Rubtsov et al. (1974), *V. rhytidophyllum* Hemsl. in Kiev freezes to the level of snow cover without shelter. Solodukhin (1985) claims that it does not withstand long-term frosts down to -20 °C. According to Lypa et al. (1952), this species has a winter hardiness score I (quite winter hardy).

Some fragmentary data about the drought resistance of species of the genus *Viburnum* in different regions of introduction can be found in the works of Lypa et al. (1952), Kormilitsyn and Marchenko (1960), Kolesnikov (1974), Rubtsov et al. (1974), Grigoriev (1980), Panova (1982), Aksenov and Aksenova (2001), Bussmann et al. (2020). Most of the authors consider that Viburnum in various soil and climatic conditions turned out to be quite drought-resistant. Some authors believe that some species are quite drought-resistant, but development is better on sufficiently moist soil conditions.

It became necessary to conduct such research due to the lack of data about the ecological features of most species of the genus *Viburnum* in the conditions of the Right-Bank Forest-Steppe of Ukraine.

A study of the ecological properties of species of the genus *Viburnum* in sheltered ground conditions is presented in some works (Chen et al. 2020, Sun et al. 2020). Some issues of the ecological features of species of the genus are highlighted (Zimmerman et al. 2005, Gómez-Bellot et al. 2015, Sifola et al. 2017, Cirillo et al. 2019).

The purpose of the study is a comparative analysis of the ecological properties of species of the genus *Viburnum* in connection with the formation of their taxonomic composition in collections and rational use in landscaping and gardening

of such ecological indicators of species of the genus as winter hardiness, duration of dormancy, drought resistance and water-holding capacity in the conditions of the Right-Bank Forest-Steppe of Ukraine.

Materials and Methods

The studies were carried out with the following taxa of the genus *Viburnum*: *V. opulus* L., *V. opulus* 'Roseum', *V. opulus* 'Nanum', *V. lantana* L., *V. lantana* 'Aureum', *V. lantana* 'Variegatum', *V. carlesii* Hemsl., *V. prunifolium* L., *V. rhytidophyllum* Hemsl., *V. buddleifolium* C.H. Wright, *V. burejaeticum*, *V. lentago*, *V. rufidulum* Raf., *V. sargentii* Koehne, *V. sargentii* 'Flavum', *V. veitchii* C.H. Wright. The objects of study 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, arboretums 'Syrets' (Kyiv), 'Oleksandriia' (Bila Tserkva), 'Sofiivka' (Uman). Also, city parks and gardens of Kyiv, Bila Tserkva, Uman, Vinnitsa, and Cherkasy were examined.

The duration of the period of deep and forced dormancy of *Viburnum* species was determined according to the method of Nesterov (1957). The duration of the period of deep dormancy was studied on cut 1-2-year-old shoots of the objects of study. From mid-November to mid-February, 2 to 3 shoots of each species were cut 1–2 times a month and placed in water at room temperature; the winter hardiness of the studied species was determined according to a seven-point scale of icing adopted by the MBG Academy of Sciences of the USSR (Plotnikova 1988). The coefficient of winter hardiness of Viburnum, depending on the age of plants, was determined by the formula (1) proposed by Kosenko (2002).

$$W = \frac{ADV}{DSG}, \quad (1)$$

where: W is winter hardiness coefficient; ADV is average duration of vegetation, days; DSG is duration of shoots growth, days.

Drought resistance was evaluated using the scale of Pyatnitsky (1961). Measurement of water retention capacity and resistance of leaves to dehydration was carried out according to the method of Lishchuk and Pilkevich (1999). During the vegetation season, monthly studied samples of leaves were taken and weighed, then subjected to wilting. At regular intervals (2, 4, 8 hours) they were weighed again.

After the leaves had lost 40 % of the water, their ability to restore turgor was determined. For this purpose they were laid between layers of filter paper, previously moistened with water. After keeping the leaves in humid conditions, wilting results were reported. Leaves, resistant to dry conditions and withstood wilting, after absorbing water, acquire a green colour and normal turgidity. The leaves tissues of drought-resistant species after transfer in the same conditions and during the same period of wilting, turgor is not restored and in most cases in the process of restoring turgor turn brown. Sometimes the leaves partially restore turgor, ie partially damaged.

Results and Discussion

A characteristic feature of the end dormant period is a rapid and simultaneous budding of the objects of study (Table 1).

Table 1. Determination the duration of the release of *Viburnum* spp. buds from a state of deep dormancy.

Species, cultivars	Cutting shoots dates				
	15.11	3.12	20.12	29.01	15.02
V. opulus	46	20	14	5	4
V. opulus 'Roseum'	30	13	5	5	4
V. opulus 'Nanum'	41	26	11	10	5
V. lantana	–	19	10	9	4
V. lantana 'Aureum'	–	18	9	9	4
V. lantana 'Variegatum'	–	–	12	10	5
V. carlesii	–	–	17	7	3
V. rhytidophyllum	51	24	8	10	6
V. lentago	–	56	39	8	4
V. rufidulum	–	33	15	8	4
V. prunifolium	–	39	21	8	4
V. buddleifolium	–	–	25	10	7
V. burejaeticum	–	38	21	8	4
V. veitchii	–	–	19	8	4
V. sargentii	28	13	14	4	4
V. sargentii 'Flavum'	30	9	12	4	4

It was found that most of the studied species leave the state of deep dormancy in the second half of December – early January, the only exception being *V. lentago*, which leaves the state of deep dormancy on 28.01. There is a delay in the exit from the state of deep dormancy in *V. opulus* 'Nanum' in comparison with the main species *V. opulus* and *V. opulus* 'Roseum'.

Most of the introduced Viburnum species in the conditions of the Right-Bank Forest-Steppe of Ukraine finish their growing season at the end of October – beginning of November and pass into a state of dormancy, which lasts until the end of March – beginning of April. The duration of the dormant period and its depth in the studied species are different, 140–185 days. The shortest dormant period is in *V. burejaeticum* (140) and V. *lantana* 'Aureum' (148), the longest – in the native *V. opulus* (185) and its cultivar *V. opulus* 'Nanum' (181). The period of deep dormancy in *Viburnum* species lasts 60–70 days, then all these species enter a period of forced dormancy, which lasts 80–110 days depending on temperature conditions. Direct relationship between winter hardiness of species of the genus *Viburnum* and the duration of deep dormancythe period has not been established.

During the years of our monitoring, the winter hardiness of the species of the genus *Viburnum* was quite satisfactory and was estimated at point I. Damage to parts of one-year shoots of *V. veitchii* and *V. buddleifolium* is occasionally observed (winter hardiness score II). Evergreen species tolerate a drop in temperature to -23–25 °C. At lower temperatures, leaves freeze over, we observed it in winter of 2012–2013.

Rubtsov et al. (1974) claim that in Kyiv conditions one-year shoots of *V. prunifolium* freeze, but this species is quite winter-hardy according to Lypa et al. (1952). Some authors (Kolesnikov 1974, Rubtsov

et al. 1974) consider that *V. carlesii* can withstand frosts down to -18–20 °C, but damage to one-year shoots is observed. Over the years of monitoring, we have not recorded damage to *V. rhytidophyllum*, *V. prunifolium* and *V. carlesii* by low temperatures (up to -32 °C).

Monitoring of the winter hardiness of uneven-aged plants of the same species made it possible to track the changes in resistance in ontogenesis (Table 2). The dynamics of the values of the coefficient of winter hardiness of perennial species is presented in Figure 1. An increase in winter hardiness in all species is observed during the transition from juvenile to mature state, which is reflected by the value of the winter hardiness coefficient. According to Table 2, we can conclude that one-year seedlings have the lowest winter hardiness. Winter hardiness increases with age, the values of the coefficients of winter hardiness of three-year summer plants approach those of adult species. For young plants, the first two years of life are critical in terms of winter hardiness.

Table 2. Coefficient of winter hardiness of introduced *Viburnum* spp.

Species	Age, years	Duration of shoots growth, days	Average duration of growing period, days	Winter hardiness coefficient
V.lentago	46	69	204	2.95
	1	95	204	2.14
	2	75	204	2.72
	3	70	204	2.91
V.carlesii	28	96	210	2.18
	1	121	210	1.73
	2	102	210	2.05
	3	98	210	2.14
V.prunifolium	20	71	202	2.84
	1	99	202	2.04
	2	79	202	2.55
	3	74	202	2.72
V.veitchii	20	116	212	1.82
	1	141	212	1.50
	2	124	212	1.70
	3	117	212	1.81
V.burejaeticum	7	109	225	2.06
	1	135	225	1.66
	2	115	225	1.95
	3	110	225	2.04
V.sargentii	30	68	214	3.14
	1	96	214	2.22
	2	75	214	2.85
	3	70	214	3.05

Monitoring the results of overwintering of the studied species allowed us to make adjustments to the idea of winter hardiness. 7 species, in accordance with the zoning proposed by Rehder (1949), were considered for zones IV and V (*V. carlesii* – IV, *V. veitchii* – V, *V. buddleifolium* – V, *V. burejaeticum* – V or IV, *V. rhytidophyllum* – V, *V. sargentii* – V or IV, *V. rufidulum* – V), turned out to be quite winter hardy in

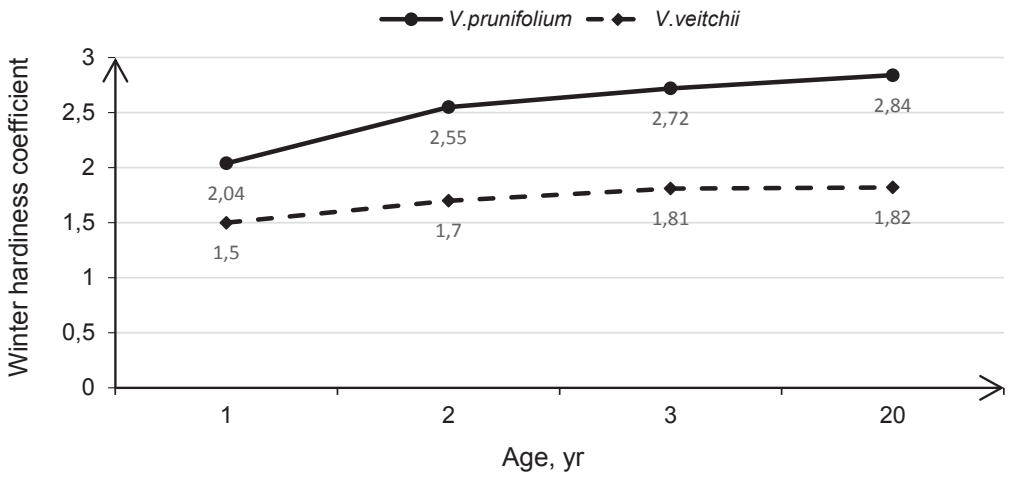

Fig. 1. Coefficient of winter hardiness of introduced *Viburnum* spp.

Kyiv, which is located in zone III. This is especially true of species occurring from the East Asian floristic region (according to Takhtajan 1978), the complexity of the formation and development caused a wide range of adaptive properties of the species in the historical aspect.

Rubtsov et al. (1974) believe that *V. prunifolium* can't stand summer drought in Kyiv conditions. According to our monitoring, this species is quite drought-resistant. Solodukhin (1985) considers that the drought resistance of Viburnum increases with the ability of the leaf to protect itself from sunlight. He thinks that *Viburnum lantana* with outgrowths on leaves, as well as *Viburnum lentago* with glossy leaves, are less damaged by high temperatures than Viburnum with thin and delicate leaves. Burning of the leaves edges and their dropping is a damage, which can be noticed. According to our data, all studied species are quite drought-resistant in Kyiv conditions. All of them can withstand short dry periods without noticeable damages. However, burning of the edges of *V. lantana* 'Aureum' leaves and a temporary loss of turgor by the leaves of *V. burejaeticum* were observed during long summer droughts. So the damage was observed for those species whose leaves were covered with outgrowths.

The percentage of leaves that regained turgor and green color after suffering the same conditions and wilting time is one of the main indicators of the resistance of species to drought conditions (Table 3).

Since no signs of wilting were observed in adults and young seedlings of the studied species, we estimate the drought resistance of these species and cultivars at 5 points. The only exceptions are *V. burejaeticum* and *V. lantana* 'Aureum'. Leaves and shoots do not suffer from drought in *V. burejaeticum*, there is only a temporary loss of turgor – 4 points. In most of the leaves of *V. lantana* 'Aureum', which is partially damaged, such as leaves change colour at the edges – 3 points. The distribution of species that restored turgor after wilting is presented in Figure 2.

Table 3. Water holding capacity and resistance to dehydration of leaves of species of the genus *Viburnum spp*.

Species	The water content in the leaves before withering, %	The time during which the leaves emit 40% water	Leaves that restored turgor after wilting, %
V. opulus	56.2 ±2.0	16 h	90
V. lantana	55.8 ±1.3	9 h 30 min	58
V. burejaeticum	51.4 ±1.7	10 h 10 min	17
V. rufidulum	58.6 ±1.0	18 h	82
V. prunifolium	58.4 ±1.2	32 h 30 min	42
V. lentago	56.9 ±1.5	10 h	30
V. carlesii	61.7 ±2.1	16 h 15 min	48
V. veitchii	60.4 ±1.8	9 h 40 min	74
V. rhytidophyllum	64.3 ±1.6	18 h 30 min	35
V. buddleifolium	63.8 ±2.2	52 h	26

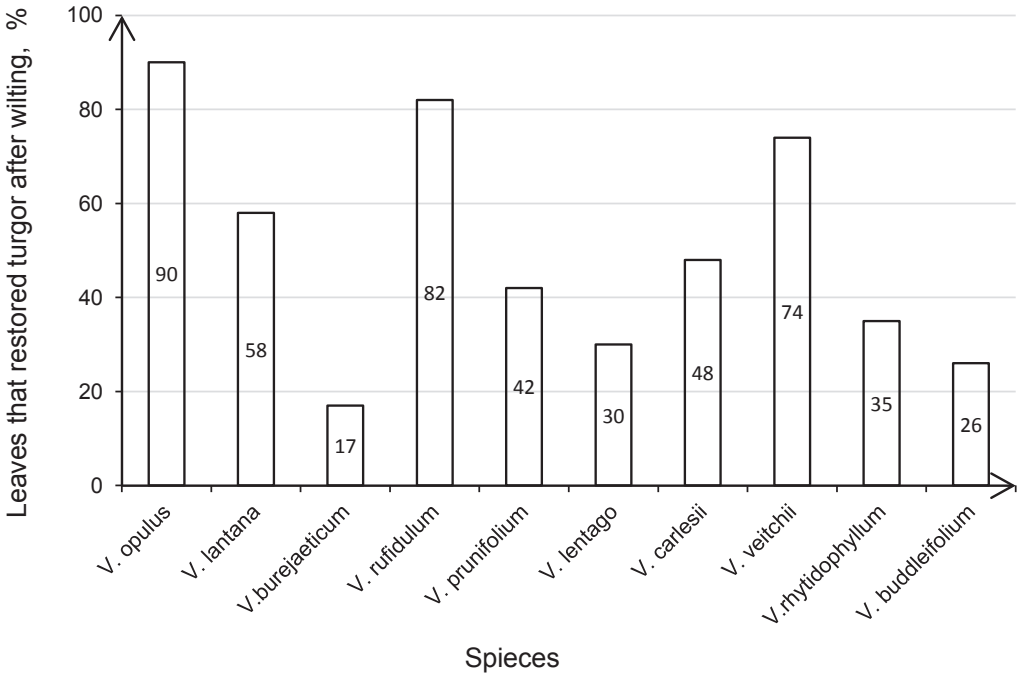

Fig. 2. Water holding capacity and resistance to dehydration of leaves of species of the genus *Viburnum spp*.

According to the data in the Table 3, it can be concluded that the evergreen species of Viburnum (*V. rhytidophyllum* and *V. buddleifolium*) have the highest water-holding capacity, and the resistance to dehydration is the highest in *V. opulus* and *V. rufidulum.*

Conclusions

The investigated species of the genus *Viburnum* turned out to be quite winter-hardy in the conditions of the Right-Bank Forest-Steppe of Ukraine due to the timely termination of vegetation and the short growth period of shoots, which have time to lignify and enter a state of dormancy even before the cold starts. Most species and cultivars of Viburnum are quite drought-resistant in the conditions of the Right-Bank Forest-Steppe of Ukraine.

As a result of research about the resistance of *Viburnum* species, it can be concluded that they have high ecological plasticity, winter hardiness and drought resistance, which ensures their successful cultivation in the Forest-Steppe of Ukraine.

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