Эколого-биологическая оценка вьющихся кустарников для вертикального озеленения территорий

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Аннотация

Вьющихся кустарников имеют важное эстетическое и санитарно-гигиеническое значение как виды многоцелевого использования при развитии городских и агроэкосистем в засушливых районах (Волгоградская область). Объекты исследования – 5 видов вьющихся кустарников (*Campsis radicans; Vitis amurensis; Parthenocissus quinguefolia; Celastrus orbiculata; Lonicera Caprifolium*) в коллекциях Федерального научного центра агроэкологии Российской академии наук.

Выявлено, что устойчивы к переносу комплекса зимних факторов североамериканские, европейские и дальневосточные виды (*Vitis amurensis, Parthenocissus quinguefolia, Celastrus orbiculata*), естественный ареал которых расположен в тех же географических широтах, что и Нижнее Поволжье. Ареал кавказско-средиземноморских и восточноазиатских видов значительно южнее. *Campsis radicans* и *Lonicera caprifolium* рекомендуются для южных районов Волгоградской области.

Установлено, что с повышением температуры и падением влажности воздуха и почвы к концу вегетации наибольший дефицит наблюдается у *Vitis amurensis* - 22%. *Celastrus orbiculata rotundifolia* – 18%, *Campsis radicans* – 14%, *Parthenocissus quinguefolia* - 12%. Низкий дефицит воды у *Lonicera Caprifolium* (около 10%). *И*сследования показали, что вертикальное озеленение с использованием вьющихся кустарников улучшает микроклимат в жаркие летние месяцы.

Ключевые слова

вьющиеся кустарники, вертикальное озеленение, жилые районы, биологическое разнообразие, дендроколлекции, адаптация, коллекции Федерального научного центра агроэкологии, комплексной мелиорации и защитного лесоразведения Российской академии наук

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Ecological and biological assessment of climbing shrubs for landscaping residential areas

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Abstract

Promising types of climbing shrubs have important aesthetic and sanitary-hygienic importance as types of multi-purpose use in the development of urban and agroecosystems in arid regions (Volgograd region).

The purpose of the research is to determine the prospects for the use of climbing shrubs in the vertical gardening of residential areas on chestnut soils based on the study of their biological potential.

The object of research was climbing shrubs growing in the collections of the Federal Research Center for Agroecology of the Russian Academy of Sciences and in the landscaping of Volgograd and Kamyshin.

In collection plantings, 5 species of different geographical origin grow: *Campsis radicans; Vitis amurensis; Parthenocissus quinguefolia; Celastrus orbiculata; Lonicera caprifolium.*

Under the conditions of introduction, all types of climbing shrubs bloom and bear fruit. The ability of climbing shrubs to self-reproduce indicates the degree of their adaptation to new environmental conditions. Plants of all studied species reached the generative phase of development.

Studies on the negative effects of low temperatures on plants in the winter showed that they are mostly frost and winter hardy and suitable for vertical gardening of residential areas of Volgograd and Kamyshin.

It was revealed that climbing shrubs are quite resistant to the transfer of a complex of winter factors. North American, European and Far Eastern (*Vitis amurensis, Parthenocissus quinguefolia, Celastrus orbiculata*) winter the best in the collections.

They have a high winter hardiness score. The area of their natural distribution is located at the same geographical latitudes as the Lower Volga. *Campsis radicans* freezes when lowering winter temperatures to -37°C.

It has been established that the climate of the region of their natural distribution is largely similar to the area of introduction, therefore, they turned out to be quite adapted to the new growing conditions.

The distribution range of the Caucasian-Mediterranean and East Asian species is much to the south. *Campsis radicans* and *Lonicera caprifolium* tolerate lower freezing temperatures worse. These species should be introduced into the southern regions of the Volgograd region.

In plants at a young age and with increasing temperature and falling humidity of air and soil by the end of the growing season, the water deficit increases.

The greatest water deficit during drought (July, August) as a percentage is observed in *Vitis amurensis* at about 22%. *Celastrus orbiculata rotundifolia* has a water deficit of about 18%, then *Campsis radicans* within 14%, *Parthenocissus quinguefolia* - 12%. The lowest water deficit is observed in *Lonicera caprifolium* (about 10%).

Studies have shown that vertical landscaping involving climbing shrubs improves the microclimate. Wall plantings of maiden grapes in the hot summer months (July, August) reduce the air temperature by an average of 3 - 4 ° C, increase air humidity to 55 - 60% and bring microclimate parameters closer to the zone of hygienic comfort. A high yield of planting material can be achieved due to the optimal harvesting time of cuttings. The economic efficiency of production, expressed as a percentage, was 186 for *Campsis radicans* and 212% for *Lonicera caprifolium*.

Keywords

climbing shrubs, vertical gardening, residential areas, biological diversity, dendrocollections, adaptation, collections of the Federal Scientific Center of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences

The research was carried out within the framework of state task No. 0713-2019-0004 "To develop scientific bases and methods for preserving the biodiversity of tree species in order to select an adapted gene pool of economically valuable plants for the formation of protective forest stands for various purposes in the steppe and semi-desert" (state registration no. AAAA-A16-116032950058-8) financing of the Ministry of Science and Higher Education of the Russian Federation

Introduction

To improve the sanitary and hygienic indicators of the territories of settlements, it is necessary to have a gardening system as diverse as possible in its composition. One of the components of this system is vertical

gardening, the environment-forming role of which is great in dry steppe regions. The justified use of climbing shrubs in combination with traditional types of plantings will create comfortable living conditions for the population, regulate the optimal temperature balance and create favorable microclimatic conditions (Barinov, 2020; Safikhani, 2014; Wong, 2003).

Where tree planting is impossible due to lack of space, as well as for decorating walls, ceilings, fences, small architectural forms in parks, protecting buildings from noise, dust penetration, etc., it is necessary to use climbing shrubs (Liu, 2013; Xing, 2018; Tereshkin, 2019). The main source of expansion of the poor assortment of climbing shrubs used in the Volgograd region is the introduction of new species (Semenyutina, 2018; Larionov, 2018).

Climbing shrubs have an important aesthetic and sanitary value. They play an important role in the improvement of territories and as types of multi-purpose use in the arrangement of urban and agroecosystems (Peng, 2004; Melikhov, 2017; Jachuła, 2019).

The object of research was climbing shrubs growing in the collections of the Federal Scientific Center of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences and in the landscaping of the city of Volgograd and Kamyshin.

The research objective was to study the growth and development of various types of climbing shrubs with respect to limiting environmental factors and the development of a promising assortment for the vertical gardening of residential areas.

As a result, of the research, acquaintance with literary sources, the study of plants in the collections of the Federal Scientific Center of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences and greenery plantings were carried out. Phenological observations were carried out, growth and development were studied, ecological aspects of flowering and fruiting were revealed, as well as the relationship of various species to the main environmental factors, the reclamation effect of climbing shrubs on the adjacent territory.

During our observations of the resistance of climbing shrubs to air and soil drought in the summer, the degree of adaptation to drought resistance was 0,70-0,81 for *Parthenocissus quinguefolia, Celastrus orbiculatus, Lonicera caprifolium*, and 0,45 for *Vitis amurensis* is the lowest – 0,65. It is undemanding to the soil, but reaches its best development on fairly moist soils.

A comparative assessment of the drought tolerance of climbing shrubs by the electrolytic method allowed us to divide the studied species into two groups - with a high and medium degree of stability. The species of the first group are more stable than the species of the second group, with respect to the general hydration of the leaf during the season, they tolerate dry periods without damage. They are of interest for vertical gardening in the conditions of light chestnut and chestnut soils of the Volgograd region, as the most drought tolerant.

Studies on the negative effects of low temperatures on plants in winter have shown that they are mostly frost and winter hardy and suitable for vertical landscaping of residential areas. The most dangerous for climbing shrubs are not low winter temperatures, but late spring frosts. During this period, species with an early onset of development, as well as young 2-3-year-old plants, are most damaged. In young plants (*Campsis radicans*) during late spring frosts, growth completely dies and further development occurs due to sleeping buds. In Volgograd, Amur and girl's grapes can winter without winter protection.

Green spaces should be multifunctional and perform the following main functions: urban planning, architectural and artistic and aesthetic, sanitary-hygienic, micro-climatic and recreational (Shepeleva, 2017; Barinov, Sokolskaya, 2018).

The range of climbing shrubs in urban ecosystems is poorly represented. Most species are in collections. In particular, in the gardens, parks and squares of Moscow, 12 species of lianas were revealed, in plantings located close to the walls of houses - 7 species. The most common is *Parthenocissus quinguefolia*, the average number of copies of which in the limited-use stands of Moscow is 2 - 4 copies per 1 ha.

In the difficult environmental situation of industrial areas, the hygienic role of plantations occupies a special place.

The possibility of vertical gardening with the use of climbing shrubs in the arid conditions of Volgograd and Kamyshin is determined by a complex of abiotic factors. The most important are climate (Semenyutina, 2016; Semenyutina, 2019).

Research materials and methods

The research areas are located in the Volgograd region in the arid climate zone and are well provided with heat. Limiting factors for the growth and development of climbing shrubs in arid conditions are high summer and low winter temperatures, dry air and low rainfall.

The most characteristic feature of the climatic conditions of the region is a clear system of seasons with typical weather features, atmospheric phenomena, and humidification conditions.

The average annual air temperature varies from 5,1 to 5,4°C in the northern regions of the region, to 7,5-8,2°C in the south of the territory. In some years, this value can vary greatly.

The warmest month on the territory is July. The average air temperature in this month rises from the northwest and in the northern regions to the southeast and south. In the northern and northwestern regions, the influence of Atlantic air is more often felt, therefore the temperature of the summer months is lower there.

It is impossible to assess the prospects of climbing shrubs for vertical gardening in the arid zone of the Volgograd region without knowledge of the ecological and biological features. In this regard, climbing shrubs have not been sufficiently studied, which limits their use.

The purpose of the research is to determine the prospects for using climbing shrubs in the vertical gardening of residential areas on chestnut soils based on the study of their biological potential.

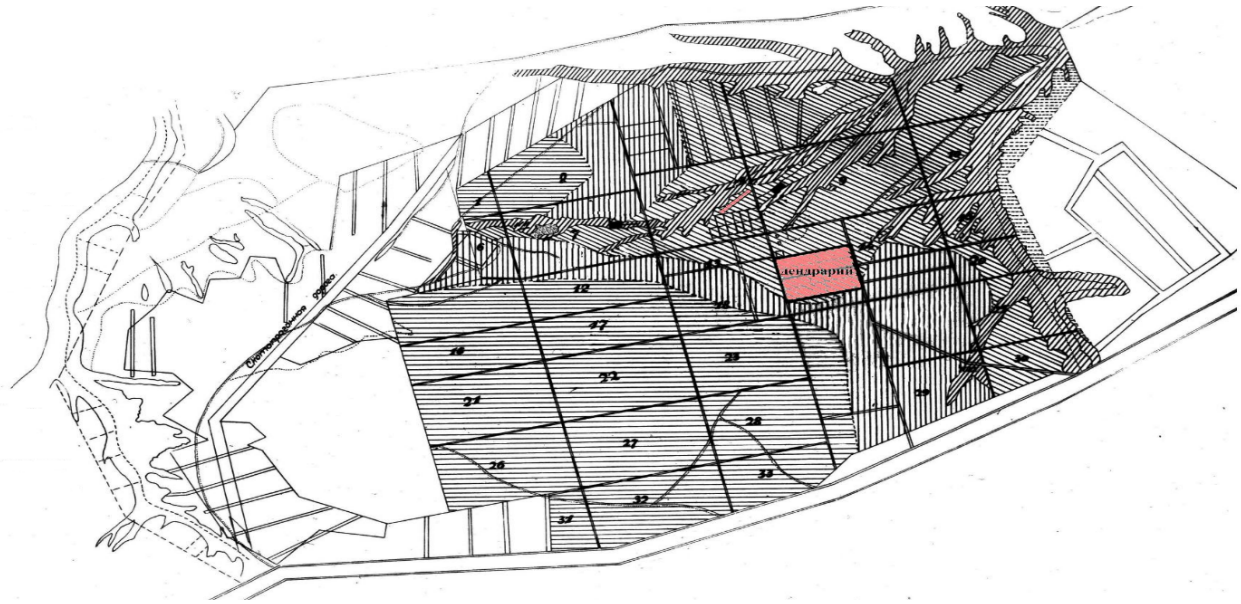
The research program included the following questions:

1) Determining the relationship of species to the main environmental factors and identifying the ecological and biological characteristics of various types of climbing shrubs with the prospect of their further use in planting greenery;

2) Environmental justification for the use of climbing shrubs for the vertical gardening of settlements in the Volgograd region;

3) The business case for growing planting stock.

The objects of research are located on chestnut and light chestnut soils of the collection sites of the Federal Scientific Center of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences (Volgograd, Kamyshin).



Legend

the soil:

powerful, undeveloped sandy on buried chestnut

thin, undeveloped sandy on buried chestnut

chestnut, light loamy and loamy

alluvial

southern sandy chernozems

weakly saline dark chestnut

shelterbelts

Lower Volga tree breeding station (Kamyshin)

Volgograd

Figure 1. Location scheme of research objects

Lonicera caprifolium

Parthenocissus quinguefolia

Parthenocissus quinguefolia in vertical gardening (autumn coloring)

Figure 2. General view of the objects of research

The objects of research were climbing shrubs belonging to different families:
CELASTRACEAE
Celastrus orbiculatus. Thunb.
BIGNONIACEAE
Campsis radicans (L.) Seem
VITACEAE
Vitis amurensis Rupr.

Parthenocissus quinguefolia

CAPRIFOLIACEAE

Lonicera caprifolium L.

Acquaintance with plants carried out in the form of a route survey of landscaping and collection sites. To identify promising species for landscaping, a study conducted of reference books, catalogs. Studies on the water regime and colloidal osmotic properties of protoplasm carried out in laboratory conditions. The main attention was paid to the characteristics of the growth and development of plants, their resistance to the environment, and economical use (Jiang-bao, 2011; Novikova, 2019; Baumgartner, 2020).

The characteristics of the factors of the abiotic environment taken from the reference literature. When studying the seasonal development of climbing shrubs, the methods of the Main Botanical Garden of the Russian Academy of Sciences used. Phenological observations carried out for the same specimens of each species, the taxonomic affiliation of which is precisely established. The development of climbing shrubs studied in age and seasonal dynamics. The following indicators used for bioecological assessment of species: winter hardiness, drought tolerance, the nature of flowering, fruiting and reproduction. The ranking made it possible to identify the most stable species and establish the pattern of their variability in adaptation to the climatic conditions of the environment and its conjugation with thermal and water regimes (Semenyutina, 2018).

Assessment (in points) of winter hardiness of plants, their flowering, fruiting and drought tolerance was carried out according to generally accepted methods. Quantitative and qualitative indicators of fruiting indicate the possibility of using one or another species for introduction and seed production in a particular area. The length of the growing season is calculated from budding to massive leaf fall (in days). Species with a high degree of adaptation are recommended for all types of protective afforestation, medium adapted species can be grown on the best soils and everywhere in landscaping, subject to the use of optimal ecological niches with high agricultural cultivation techniques and additional soil moisture.

Microclimatic parameters were measured using a digital hot-wire anemometer. The resulting materials were processed using statistical methods. Experiments on creeping of climbing shrubs carried out in stationary greenhouses, with boxes of concrete, covered with frames with a polyethylene coating (Figure 3). The necessary temperature and humidity conditions created. Sand or sand + humus (1: 1) used as a substrate for propagation. The landing pattern is 5-7 cm in a row, 10 cm - between rows.

Figure 3. Experiments on rooting cuttings of climbing shrubs

The economic assessment of the cultivation of planting material of lianas carried out according to generally accepted methods, based on the calculation of technological maps. Profitability and profit from the sale of rooted cuttings were determined.

Results and discussion

As a result, of the route inspection of the objects, types of climbing shrubs and their characteristics identified with a clarification of the systematic affiliation (table 1).

Table 1. Characteristics of climbing shrubs

Name of species	Area of natural distribution	Height, m	Availability as a part
Campsis radicans	India, South America	up to 15	As part of limited use, collections (V) *
Celastrus orbiculata	Primorsky Krai, Japan, China	6 - 7	As part of limited use collections (V, K).
Vitis amurensis	Northeast China, North. Korea	до 20	As part of urban plantations, limited use, collections (V, K).
Parthenocissus quinguefolia	North America	15 - 20	As part of urban plantations, limited use, collections (V, K).
Lonicera caprifolium	Wed and South. Europe, Caucasus, Asia Minor	3 - 5	As part of plantations, limited use, collections (V, K).

*B - Volgograd, K - Kamyshin

In the landscaping of Volgograd and Kamyshin, 5 species of climbing shrubs belonging to 4 genera and 4 families were identified. In rural settlements on the territory of the Volgograd region, 2 species of climbing shrubs are found everywhere: Parthenocissus quinguefolia and Vitis amurensis. On the territory of individual sites, several other climbing shrubs are singly represented. The use of climbing shrubs reduced to landscaping the walls of buildings. Landscaping by climbing shrubs of fences and hedges is widespread. Isolated cases of the use of perennial vines (Parthenocissus quinguefolia) in container gardening of balconies have been noted. Climbing shrubs practically not used for decorating little interesting architectural structures and household objects.

The rhythms of the growth and development of climbing shrubs are very different from other plant species. Climbing shrubs characterized by long growth (until October – November), i.e., they actually have a very short rest period. Most tree vines develop shoots of three types: elongated non-bearing growth shoots, shortened non-bearing growth shoots, and relatively short non-specialized generative shoots. Long growth characterized by shoots of the first type. The growth of climbing shrubs does not always fit into the framework of the Sachs law on the single-peak nature of the growth of shoots, but it can also go multi-vertically.

The seasonal rhythm of development expressed not only in visible morphological changes in plants, but also in the processes of intrarenal development of the shoot. Flower stems in climbing shrubs formed in the sequence corresponding to the scheme of organogenesis of higher seed plants. The meteorological conditions of the spring and summer vegetation have a significant impact on the timing and duration of the stages. In the winter, the damaging effects of low temperatures are more susceptible to generative kidneys, which have reached a higher degree of development.

Depending on the geographical location, the difference between the onset of the growing season in individual species of vines is 5 - 10 days, between the end - 1 - 13 days (earlier in Volgograd begins and later ends, in Kamyshin vice versa. The phase of kidney swelling in the studied species of climbing shrubs occurs in the second, third decade of April, except Lonicera caprifolium, in which kidney swelling occurs in the second decade of March.

The growth of shoots begins almost simultaneously with the blooming of leaves. The completion of the leafing observed during May. During this period, climbing shrubs acquire decorative features, especially medium-texture woody vines forming the background (Parthenocissus quinguefolia, Vitis amurensis, Celastrus orbiculatus).

The beginning of the flowering phase occurs at the beginning of May - the end of June. The largest number of days in the flowering phase is Campsis radicans (40-45 days), then Lonicera caprifolium, the flowering time of which is about 20 days, then Parthenocissus quinguefolia about 15 days, Parthenocissus quinguefolia 12 and the shortest flowering time is Celastrus orbiculatus about 10 days (table 2, figure 4).

Table 2. Calendar flowering and ripening seeds

Name of species	Flowering time		Flowering period, days	Fruit ripening	
	start	end		start	end
Campsis radicans	25.06	01.08	40-45	30.08	05.09
Celastrus orbiculatus	18.05	25.05	8-10	15.08	20.09
Vitis amurensis	4.06	15.06	10-12	20.08	18.09
Parthenocissus quinguefolia	1.06	15.06	10-15	25.08	18.09
Lonicera caprifolium	10.06	28.06	17-20	20.07	10.08

The leaf falls period for various species of climbing shrubs lasts 12-37 days (the last decade of October and the first decade of November). The longest growing season is typical for *Campsis radicans* (210 days), *Vitis amurensis* (208 days), *Lonicera caprifolium* (205 days). The shortest growing season observed in *Celastrus orbiculatus* (195 days) and *Parthenocissus quinguefolia* (180 days). In the conditions of the Volgograd region, the studied species of climbing shrubs undergo a complete development cycle. *Parthenocissus quinguefolia, Vitis amurensis, Lonicera caprifolium* considered promising.

Figure 4. *Parthenocissus quinguefolia* (spring), during shoot growth

In a sharply continental climate, species can grow that have a wide amplitude of adaptive ability for winter and drought tolerance. The degree of winter hardiness of various types of climbing shrubs in the conditions of the Volgograd region revealed harsh winters (1978/79, 1993/94 and 2005/06). Vines are quite resistant to the transfer of a complex of winter factors. The best winters in the collections are North American, European and Far Eastern (*Vitis amurensis, Parthenocissus quinguefolia, Celastrus orbiculatus*). They have a high winter hardiness score. The area of their natural distribution is located at the same geographical latitudes as the Lower Volga.

Climate of the region of their natural distribution is in many respects similar to the region of introduction, so they turned out to be quite adapted to the new growing conditions. The distribution range of the Caucasian-Mediterranean and East Asian species is much to the south. *Campsis radicans* and *Lonicera caprifolium* tolerate lower freezing temperatures worse. These species should be introduced into the southern regions of the Volgograd region. A comparative assessment of the drought tolerance of climbing shrubs by the electrolytic method allowed us divide the studied species into two groups (table 3).

Table 3. Degree of drought resistance of lianas by electrolytic method

Group	Species	Relative electrolyte yield	Student confidence criterion between groups	Degree of drought tolerance
I	*Parthenocissus quinguefolia*	1,59±0,07	t I-II=4,89	High
	Celastrus orbiculatus	1,58±0,05		
	Lonicera caprifolium	1,41±0,06		
	Average value	1,52		
II	*Campsis radicans*	1,99±0,04		Average
	Vitis amurensis	1,96±0,08		
	Average value	1,97		

They are of interest for vertical gardening on light chestnut and chestnut soils of the Volgograd region, as the most drought tolerant. The species of the first group are more stable than the species of the second group, with respect to the general hydration of the leaf during the season, they tolerate dry periods without damage. They have the ability to regulate water exchange during critical periods by changing the width of the stomatal openings. As our studies have shown, the water content of all studied species during the growing season did not change significantly, which indicates the drought tolerance of climbing shrubs in the conditions of the Volgograd region (table 4).

The water content in the leaves of climbing shrubs during the growing season ranges from 70.5 - 56.2%. In a drier period, water content is lower.

Table 4. Water content in the leaves of climbing shrubs, % of wet weight

Species	2016			2017		
	June	July	August	June	July	August
Parthenocissus quinguefolia	73,5±1,09	69,6±1,43	67,2±1,29	75,0±2,03	70,5±1,42	68,5±2,84
Celastrus orbiculatus	65,3±2,10	62,7±2,71	58,4±0,92	62,5±1,98	59,7±1,54	56,2±0,96
Lonicera caprifolium	64,2±1,98	62,5±2,04	59,2±1,45	65,5±3,04	62,3±2,36	60,8±1,23
Campsis radicans	65,1±2,09	62,4±2,71	57,1±2,10	67,3±2,53	60,8±1,07	57,4±1,03
Vitis amurensis	70,7±2,87	68,1±3,26	64,2±2,24	69,1±2,38	67,9±3,02	64,7±3,00

The highest water content in the leaves observed in June, which is associated with the reserves of active moisture in the soil. Over the next two months, leaf water content in all species decreased by several percent, following a decrease in soil moisture. With increasing age, species are more stable with respect to hydration of leaf tissue and water deficiency in leaves (table 5).

Data on the water regime of climbing shrubs during droughts showed that they have a low water deficit of leaves during the growing season (from 10 to 22%), are able to regulate their water metabolism in the dry season. In plants at a young age and with increasing temperature and falling humidity of air and soil, the water deficit increases by the end of the growing season. The greatest water deficit during drought (July, August) as a percentage observed in Amur grapes about 22%. *Celastrus orbiculatus* has a water deficit of about 18%, then *Campsis radicans* within 14%, *Parthenocissus quinguefolia* - 12%. The lowest water deficit is observed in *Lonicera caprifolium* (about 10%).

Table 5. Water deficit in the leaves of vines in light chestnut soils in 2017 (in% of the total content in a state of full saturation)

Species	Months		
	June	July	August
Parthenocissus quinguefolia	7,3±0,15	10,0±0,32	12,1±0,43
Celastrus orbiculatus	10,4±0,17	14,2±0,25	18,3±0,57
Lonicera caprifolium	7,3±0,10	15,2±0,21	10,5±0,38
Campsis radicans	7,0±0,21	13,3±0,19	16,5±0,44
Vitis amurensis	6,4±0,21	8,9±0,23	12,2±0,54
Air temperature during the experiment, ° C	26,5	30,5	33,0

Climbing shrubs are not demanding on moisture and soil richness; they grow on almost all soils, even on the poorest, if they are loose and well aerated. However, the best growth and development observed on fertile loose soils. The most winter-hardy - in the conditions of chestnut soils (Volgograd, Kamyshin) - *Vitis amurensis* and *Parthenocissus quinguefolia* belong to the family VITACEAE, and *Lonicera caprifolium* is more drought-resistant (table 6).

Table 6. Degree of adaptation of climbing shrubs for winter hardiness and drought tolerance

Species	Extremely low temperatures	Extremely high temperatures	Degree of winter hardiness adaptation	Degree of adaptation for drought tolerance
Campsis radicans	-37ºC	+39ºC	0,59-0,79	0,70-0,80
Parthenocissus quinguefolia			0,81-0,95	0,71-0,83
Celastrus orbiculatus			0,81-0,90	0,71-0,81
Vitis amurensis			0,91-1,0	0,45-0,65
Lonicera caprifolium			0,82-0,93	0,75-0, 88

The Volgograd region is characterized by difficult soil and climatic conditions: the frequent recurrence of droughts, dry winds, frosty winters, insufficient rainfall, salinization, and solonetzic soils. These factors limit the growth and development of planting and forestation and afforestation plants and require careful selection of the range of tree species. The differentiated use of various types of climbing shrubs based on the correspondence of species bioecology to environmental factors. A factor limiting the possibility of growing climbing shrubs is frost resistance, this is the main reason for slight freezing in extreme years (minus 37 °C) of species of southern origin (Campsis radicans).

It has been revealed that the most decorative are flowering species: Lonicera caprifolium, Campsis radicans. Parthenocissus quinguefolia, Vitis amurensis, Celastrus orbiculatus are medium decorative. However, in certain periods, their indices are higher than that of flowering plants, due to earlier blooming of leaves and colorful autumn coloring. In particular, Parthenocissus quinguefolia and Vitis amurensis painted in autumn in bright orange, scarlet, purple, purple shades, which are quite rare in the landscaping of settlements.

The dominant composition should be medium texture climbing shrubs, usually forming the background (Parthenocissus quinguefolia). Rough texture plants (Parthenocissus quinguefolia, Celastrus orbiculatus) recommended use where it is necessary to emphasize compositionally and strengthen a certain part of a building or structure. Much attention should be paid to such factors as abundant and prolonged flowering, decorativeness and duration of autumn coloring of leaves and fruits, leaf cover density, and flowering maintenance (figure 6).

Due to the sharp deterioration of environmental conditions, optimization of the environment with the help of plants is of particular practical importance. Particularly in need of this are degraded aground urban ecosystems, which are characterized by a poor species composition of flora and fauna, which leads to a decrease in their stability, durability and deterioration of sanitary and hygienic and recreational functions.

a) *Parthenocissus quinguefolia*

6) *Vitis amurensis*

Figure 5. Climbing shrubs in landscaping

Significant theoretical and practical interest in this regard represented by climbing shrubs. They have drought tolerance and winter hardiness, which allows them to be recommended for further use in landscaping residential areas of the Volgograd region (table 7).

Table 7. Ecological and biological characteristics of species of woody vines

Species	Age, years	Height, m	Winter hardiness, point	Drought resistance, point	Flowering, point	Fruiting, point
Lonicera caprifolium	8	1,3	6	6	5	5
Campsis radicans	10	4,0	5	5	5	5
Parthenocissus quinguefolia	13	6,5	7	6	5	4
Vitis amurensis	18	4,3	7	5	4	5
Celastrus orbiculatus	17	1,0	7	6	4	4

Climbing shrubs favorably affect the microclimate of the territory especially - in the summer period of time, during the period of complete obstruction. They reduce air temperature by an average of 3-4ºC. Vines also

reduce wind speed by 2 - 3 m / s. In the humidity mode, vertical gardening is reflected as follows: next to all kinds of climbing shrubs, there is an increase in air humidity up to 55-60%. Climbing shrubs bring microclimatic parameters closer to the zone of hygienic comfort. The lack of decorative climbing shrubs must be filled with high-quality domestic planting material. A large amount of planting material of ornamental plants imported from abroad by private firms, but their safety is not always ensured in the new living conditions.

Climbing shrubs as fast-growing plants are relatively easy to propagate vegetatively (Jeberean, 2018). Therefore, for most climbing shrubs, it is most convenient to obtain planting material by cuttings. Cuttings are cut from the middle and lower part of the side shoots. The length of the cut is equal to two internodes. Lignified cuttings of climbing shrubs are harvested from mother plants, in the resting phase. After cutting, the cuttings are bundled and treated with root formation stimulants. 100-150 mg of stimulant is added per 1 liter of aqueous solution, then the cuttings are kept in it for 15-16 hours.

For cuttings, stationary greenhouses are used, with boxes of concrete, covered with frames with a polyethylene coating. The necessary temperature and humidity conditions are created by fogg. As a universal substrate for reproduction, sand or sand + perlite, sand + humus (1:1) is used. The landing pattern is 5-7 cm in a row, 10 cm - between rows. After rooting, the cuttings are planted in the open ground of the breeding department.

The costs of growing planting material consist of the procurement of cuttings of climbing shrubs from mother plants, the cost of fertilizers, preparing them for planting, care, digging and sorting. Analysis of the structure of production costs showed that wages with accruals account for 33,1%. This is due to the use of manual labor during operations such as cuttings, sorting plants, arranging a greenhouse, etc. (table 8).

Table 8. The structure of the material costs of growing climbing shrubs per 100 m²

Indicators	The amount of costs, rub.
Labor costs, people - hours	675,24
Salary with accruals	26476,63
Combustive-lubricating materials	1894,41
Fertilizers, growth stimulants (heterooxin)	404,12
Polyethylene coating	2475,05
Electric power	1098,32
Depreciation and maintenance of fixed assets	951,57
Vehicle operation	825,22
Water costs	9600,35
Substrate (sand with humus)	11745,00
Other costs (2%)	1109,41
Direct costs, total	56580,10
General and general production costs (36%)	20368,84
Total manufacturing costs	76948,94

The calculation of economic efficiency by the main indicators determined the profitability of the production of seedlings of climbing shrubs. The change in net profit per 100 m2 is defined as the product of the volume of sales by the difference between the selling price of seedlings and the cost of their production. The planned profit from the sale of commercial products for *Campsis* is 143619 rubles. For *Lonicera caprifolium* - 163040 rubles. The production efficiency of climbing shrubs seedlings varies, due to the rooting of cuttings, which was 73.5% for *Campsis radicans* and 80% for *Lonicera caprifolium* (table 9).

Table 9. Economic efficiency of propagation of climbing shrubs

Indicators	Campsis radicans	Lonicera caprifolium
The output of seedlings, pcs.	14700	16000
Gross output per 1 person –h.	326,55	355,43
The cost of production per 1 p. expenses, rub	2,86	3,12
Cost of 1 seedling, rub.	5,23	4,81

Selling price of 1 seedling, rub.	15,0	15,0
Net income (p.) at: – 100 м 2 – 1 seedling	 143619,00 9,77	 163040,00 10,19
Profitability level, %	186	212

The experience of vegetative propagation of climbing shrubs has shown that a high yield of standard planting material can be achieved with optimal harvesting time of cuttings. The increase in production productivity will positively affect economic indicators. The projected profitability of production, found as the ratio of profit per unit of production to the cost of production per unit, expressed as a percentage was 186 for *Campsis radicans* and 212% for *Lonicera caprifolium*.

Conclusion

Ecological and biological assessment of climbing shrubs in order to identify promising species for vertical gardening of residential areas was carried out under conditions of chestnut soils (collection plantings of the Federal Research Center of Agroecology of the Russian Academy of Sciences, landscaping of the cities of Kamyshin and Volgograd). In the collection landings, 5 species of various geographical origin were revealed: Campsis radicans; Vitis amurensis; Parthenocissus quinguefolia; Celastrus orbiculata; Lonicera caprifolium. Under the conditions of introduction, all types of climbing shrubs and bear fruit. The ability of climbing shrubs to self-reproduce indicates the degree of their adaptation to new environmental conditions. Plants of all studied species reached the generative phase of development. Propagated by seeds, root cuttings, layering, forms - vaccinations. Climbing shrubs - Campsis radicans, Vitis amurensis, Vitis amurensis, Lonicera caprifolium mainly propagate by seeds and rooting of cuttings.

Studies on the negative impact of low temperatures on plants in winter have shown that they are mostly frosted- and winter-hardy and suitable for vertical gardening of residential areas in Volgograd and Kamyshin. Campsis radicans when winter temperatures drop to -37 °C is freezing.

The most dangerous for climbing shrubs are not low winter temperatures, but late spring frosts. During this period, the most damaged species with early onset of development, as well as young 2-3-year-old plants. In young plants (Campsis radicans) during the late spring frosts, growth is completely lost and further development occurs due to dormant buds. In the conditions of Volgograd and Kamyshin, Vitis amurensis, Parthenocissus quinquefolia, Lonicera caprifolium, Celastrus orbiculatus can winter without winter protection.

The ratio of climbing shrubs to air and soil drought in the summer period revealed the degree of adaptation to drought resistance, which was 0,70-0,83 in Parthenocissus quinguefolia, Celastrus orbiculatus, Campsis radicans, Lonicera caprifolium, and 0,45 – 0,65 in Vitis amurensis. It is undemanding to the soil, but it reaches its best development on fairly moist soils.

Studies have shown that vertical gardening with the participation of climbing shrubs improves the microclimate. Wall plantings of Parthenocissus quinquefolia in the hot summer months (July, August) reduce the air temperature by an average of 3-4°C, increase the humidity to 55-60% and bring the microclimatic parameters closer to the zone of hygienic comfort.

Ecological and biological assessment of climbing shrubs for vertical landscaping of residential areas has revealed promising species: Parthenocissus quinguefolia, Lonicera caprifolium, Campsis radicans, Vitis amurensis, Celastrus orbiculatus.

Vertical gardening of residential areas using climbing shrubs in modern cities with large areas that are inconvenient for gardening has a definite prospect. Selection of the assortment of climbing shrubs should be carried out taking into account the limiting factors of growth and development, decorative and sanitary properties for specific expositions and landscaping objects.

High yield of planting material can be achieved due to the optimal timing of harvesting cuttings. The economic efficiency of production, expressed as a percentage, was 186 in Campsis radicans and 212 % in Lonicera caprifolium.

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