

Introduction assessment of highly ornamental shrubs and forms in the conditions of the Tashkent Botanical Garden (Uzbekistan)

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Abstract. The article presents data on the growth and development, flowering dynamics and introduction assessment of highly ornamental shrubs introduced into the Tashkent Botanical Garden – *Cotoneaster adpressus* Bois., *C. horizontalis* Decne, *C. dammeri* C.K. Schneid., *Spiraea japonica* L., *Symphoricarpos dorenbosii* Krüssm., *Hydrangea macrophylla* Thunb. and forms – *Viburnum tinus* f. *stricta*, *Weigela florida* f. *Bristol ruby*, *Deutzia scabra* f. *plena*, *Hibiscus syriacus* f. “*Duc de Brabant*”, *Spiraea prunifolia* f. *plena*, *Physocarpus opulifolius* f. *diabola*. According to the results of the introduction assessment, it turned out that the ornamental species *Cotoneaster horizontalis*, *Symphoricarpos dorenbosii* are completely promising, receiving the highest (95) score. Of the species, only *Hydrangea macrophylla* was less promising, scoring 54 points. It was revealed that the species are superior to the forms in terms of resistance to diseases and pests. Through an introduction assessment of trees, their characteristics were taken according to 7 indicators and noted as promising species and forms for our republic. The studied introduced species are an important factor in choosing the assortment and compiling a compositional group of ornamental plants in urban planning.

1 Introduction

The increase in the world population and, in turn, the expansion of residential areas, requires the widespread introduction of landscape design and landscaping in accordance with modern urban planning traditions. In this regard, the range of ornamental shrubs that are biologically resistant to urban conditions, the determination of their resistance to environmental factors, as well as the assessment of ornamentality, and the development of propagation methods in various conditions are of great scientific and practical importance.

One of the urgent tasks in our country is the greening of cities and towns, improvement and protection of the environment. The sharply continental climate of Uzbekistan requires the wide use of tree and shrub species and their ornamental forms that are resistant to environmental factors.

As a result of research in this area, new ornamental plant forms are being created, which are promising. In landscape works, the perspectives, durability, and ornamentality of

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created new forms are explored. Methods of vegetative propagation are being developed. It should be noted that the species and forms of representatives of the families Adoxaceae, Caprifoliaceae, Hydrangeaceae, Malvaceae, Rosaceae, considered ornamental, are also of particular importance due to their high ornamental value, easy propagation by vegetative means and widespread use in landscape design. The genera and forms of these families are also widely used in landscape design in many countries due to their hardiness and high ornamental value. In subsequent years, numerous applications in Central Asia, in particular in our republic, led to the development of effective methods for identifying, propagating and growing representatives of these families, their resistance to drought, heat, cold, as well as to environmental factors. For this reason, the introduction of representatives of the above families, the study of bioecological characteristics under conditions of introduction and the improvement of propagation methods acquire important scientific and practical significance. Today, 200 species and 63 forms from 123 genera belonging to 58 families are used in landscaping in Uzbekistan, of which 10.6% (28 species) are local species, and 89.32% (234 species) are introduced species.

In our republic, introduced species and forms of shrubs are used not only in landscaping, but also in forestry, chemical industry, pharmaceuticals, and in the food and medicinal fields. The process of introduction is a purposeful human activity aimed at cultivating a selected plant species. The main function of introduction is the identification and cultivation of ornamental, medicinal, food, essential oil, honey-bearing and forage plants existing in the natural flora [1]. The object of study of the introduction process is plants imported from abroad or selected from the local natural flora (genus, species, variety and forms) [2]. Introduction makes it possible to expand the composition and gene pool of plants in a given region, as well as select plant species necessary for humans.

Similar works on the introduction and bioecological characteristics of some ornamental species, such as *Chamaecyparis lawsoniana* (Murr.) Parl., *Js communis* L., *J. oblonga* M. B., *J. squamata* Lamb. and forms: *Platycladus* (*Biota*) *orientalis* f. *compacta* Unger, Beissn., *B. orientalis* f. *aurea* (Dauvesse) Hornibr., *Thuja occidentalis* f. *columna* Spaeth., *T. occidentalis* f. *smaragd* Beissn., *T. occidentalis* f. *aurea spicata* Beissn. were also carried out in the Tashkent Botanical Garden by E.E. Temirov et al [3, 4], where data on propagation and cultivation, ontogenesis, phenology, growth and development of species and forms, as well as on introduction assessment, are presented.

2 Materials and Methods

The objects of the study are: 6 promising ornamental species (*Cotoneaster adpressus* Bois., *Cotoneaster horizontalis* Decne, *Cotoneaster dammeri* C.K. Schneid., *Spiraea japonica* L., *Symphoricarpos dorenbosa* Krüssm, *Hydrangea macrophylla* Thunb.), as well as 6 forms (*Viburnum tinus* f. *stricta*, *Weigela florida* f. *Bristol ruby*, *Deutzia scabra* f. *plena*, *Hibiscus syriacus* f. “*Duc de Brabant*”, *Spiraea prunifolia* f. *plena*, *Physocarpus opulifolius* f. *diabola*) from 9 genera of the families Adoxaceae, Caprifoliaceae, Hydrangeaceae, Malvaceae va Rosaceae, introduced into the Tashkent Botanical Garden.

***Weigela florida* f. “Bristol Ruby”** is an ornamental flowering shrub belonging to the Caprifoliaceae family. The most important feature of weigela is that it blooms twice a year. Species of the genus are distributed in East and Southeast Asia. One species is found on the island of Java, and 3 species are found in Russia in the forests of the Far East. Weigela is mainly propagated by stem cuttings; when propagated by seeds, valuable biological characteristics are not preserved. Weigela is planted singly or in groups in landscape design and gardening, and is used to create compositions with other ornamental plants [5-8]. In the conditions of the city of Tashkent, it blooms ornamentally and is well adapted to the gas and smoke environment. The form *Weigela florida* “*Bristol Ruby*” reaches a height of up to

2 m. It grows well in sunny or semi-shaded areas on fertile soils. The leaves are green, simple, ovate or elliptical. The flowers are small, dark red. It blooms twice a year in May-June and August-September [9].

Viburnum tinus* f. *stricta – laurestinus viburnum f. *stricta*. Representative of the Adoxaceae family. The natural habitat is the Mediterranean region. Evergreen, densely branched ornamental shrub up to 3 m tall. Young branches are brown. The leaves are dark green, elliptical in shape (12 x 5.5 cm), with jagged edges, the upper side is bright green, the lower side is light green, with veins. The flowers are pink-white, fragrant, umbrella-shaped. The fruits are black-blue, spherical or ovoid. Drought-resistant, can withstand temperatures down to -15 °C. Photophilous, not demanding of soil conditions. Resistant to shaping and cutting [10].

Symphoricarpos doorenbosii Originally from North America. Deciduous ornamental shrub reaching 1.5 m in height. Grows and develops well in sunny and semi-shaded places. Frost-resistant, withstands up to -25 -34 °C [11]. Resistant to cutting and shaping. Leaves are round in shape, up to 4-7 cm long, dark green in color. Small pale pink flowers are inconspicuous. Fruits that can be preserved even in winter acquire a magnificent appearance.

***Deutzia scabra* f. "Plena"** – Fuzzy deutzia form "Plena" is a deciduous, large, tall ornamental shrub, reaching 3 m in height. Representative of the Hydrangeaceae family. The leaves are rough, ovate, about 3-8 cm, dark green on both sides. The flowers are white, pale pink, multi-layered, blooming obliquely. It is unpretentious to soil fertility and does not require special care. If damaged in winter frosts, it tends to recover quickly. It is recommended to plant individually and in groups [12, 13].

Hydrangea macrophylla – Large-leaved hydrangea. Homeland - East Asian countries (China, Japan). Deciduous, erect, tall ornamental subshrub, reaching 1-1.5 m in height. Annual branches are green, perennial branches are brown. Sun-loving, but can also comfortably grow in partially shaded areas. Heat-loving, but demanding on soil moisture. Drought resistant. It grows well in semi-arid areas, but blooms abundantly only on the side where the sun shines well [10].

***Hibiscus syriacus* "Duc de Brabant"** is a form of Sharon rose "Duc de Brabant". Representative of the Malvaceae family. Origin: China, Korea and Western Asian countries. Tall ornamental shrub, reaching up to 2.5 m in height. In its homeland it blooms in August–September. In the conditions of the city of Tashkent - from July to September. The flowers are large, white, pink-purple, and purple. Grows and develops well in fertile soils. Heat-loving, prefers places protected from the wind [14, 15, 16]. ***Cotoneaster adpressus* Bois.** – Creeping cotoneaster. Found naturally in the western regions of China. It belongs to the Rosaceae family. Evergreen low-growing ornamental shrub. Small, dark green leaves. Flowers are white or pale pink. Fruits are red. It grows and develops well in sunny places [10].

***Cotoneaster horizontalis* Decne** – Rockspray cotoneaster. Homeland - China. The leaves are small, green, turning purple in autumn. The fruits are bright red, spherical, 4-5 mm in diameter. Ripens in September, remains on the branches until December, which makes the plant more ornamental. Resistant to drought and harmful gases [10].

Cotoneaster dammeri - Bearberry Cotoneaster, found naturally in the mountainous regions of China - Gansu, Guizhou, Hubei. Evergreen, tall ornamental shrub. Height 20-30 cm. In the conditions of the city of Tashkent it reached 35-45 cm. Reaches up to 1.5 meters in width. The upper part of the leaves is dark green and shiny. Leaves are 1-2 cm long (in the experimental field up to 3 cm), 0.7-2.2 cm wide. The fruits are bright red, spherical, 6-7 mm in diameter. The fruits are preserved until spring. Ripens in September. Frost-resistant (down to -23 °C) [11].

Spiraea japonica - Japanese Spirea. Deciduous ornamental shrub reaching 1 m in height. The leaves are lanceolate, light green. The flowers are bright pink, crimson. Blooms from June to September. It may bloom a second time, but not always. Photophilous, not demanding of soil. Resistant to urban conditions. Can be planted individually or in groups [13, 14].

***Spiraea prunifolia* “Plena”** – Bridal Wreath Spirea Plena. It grows naturally in East Asia (China, Japan, Korea). Cultivated since 1843. Deciduous ornamental shrub reaching 2 m in height. The leaves are lanceolate, green. The flowers are white, tiered. Resistant to urban conditions, fast-growing shrub [10].

***Physocarpus opulifolius* “Diabolo”** – Diabolo Ninebark. Homeland: North America and East Asia. Ornamental deciduous shrub reaching 3 m in height. The leaves are similar to the 3-5 palmate leaves of viburnum. In its homeland it blooms at the beginning of the summer season. The flowers are white and pink. The branches are widely spread. Photophilous. A fast-growing plant resistant to harmful gases [14, 16].

Introduction assessment of plants - indicators of their growth, development, yield, and resistance in different ecological conditions were studied using the method of P.I. Lapin et al. [17] and N.I. Shtond [18].

According to these methods, when assessing the success of growing trees and shrubs, 9 indicators are taken as a basis, from 2 to 7 criteria. Introduced species are divided into 6 groups on a 100-point scale: I – completely promising (91-100), II – promising (76-90), III – less promising (61-75), IV – less promising (41-60), V – unpromising (21-40), VI – absolutely unpromising (5-20). During the conducted research, the days of growth, development, phase changes of the selected objects during the growing season, and the necessary sum of effective temperatures for them were determined. The life form of these species and forms is a shrub with a long growing season [167; 50-51 b]. The dynamics of plant growth was carried out using the method of A.A. Molchanov and V.V. Smirnov [19].

Below are the brief details of the changes in the growth and development phases of the selected objects.

3 Results and Discussion

The beginning and end of the growing season of the research objects depends on the air temperature, at which in some years the growing season of *Cotoneaster horizontalis* occurs in the first ten days of February (12.02.2021), for other species and forms the beginning of the growing season occurs in the period from the 2nd ten days of February to the 1st ten days of March.

In 2021-2022, due to the relatively warm winter season, bud swelling occurs in the first ten days of February (5.02.2021); this is the earliest beginning of the growing season of ornamental shrubs in the conditions of Uzbekistan in the years when the research was conducted.

The duration of the growing season of the species varied depending on the season, with the sum of the lowest useful temperatures for *Viburnum tinus* f. *stricta* in the conditions of Uzbekistan. The late start and early end of the growing season is explained by the low sum of effective temperatures (4800-5000 °C), while for *Weigela florida* “Bristol Ruby”, which continues the growing season the longest, the sum of seasonal effective temperatures is high (from 5800 °C up to 6100 °C). However, for other species, the sum of effective temperatures ranged from 5200 to 5800 °C. One of the main indicators determining the ornamental qualities of introduced species in altered conditions is the peculiarity of their flowering. In the conditions of the Tashkent Botanical Garden, the daily and seasonal dynamics of flowering of the above-mentioned objects was studied; below are the data using the example of *Cotoneaster dammeri* and *Weigela florida* f. “Bristol Ruby”.

During phenological observations of *Cotoneaster dammeri* at the beginning of the flowering phase (10.04.2023), 21 flowers opened on one bush per day (Fig. 1).



Fig. 1.
Cotoneaster dammeri and *Weigela florida* f. *Bristol Ruby* during flowering

In the phase of mass flowering (20.04), 77 flowers opened on one bush of the plant per day, and on the square in front of the Palace of Forums in Tashkent, it was noted that in this phase 65 flowers bloomed. At the end of flowering (3.05), it was noted that a total of 17 flowers opened on one bush of the plant. The longest time for flowers to bloom during the day was observed in the second ten days of April from 10 am to 4 pm, which corresponds to 67% of flowers blooming during the day. The air temperature at this time was 25-32 °C, and the relative humidity was 25-45% (Fig. 2).

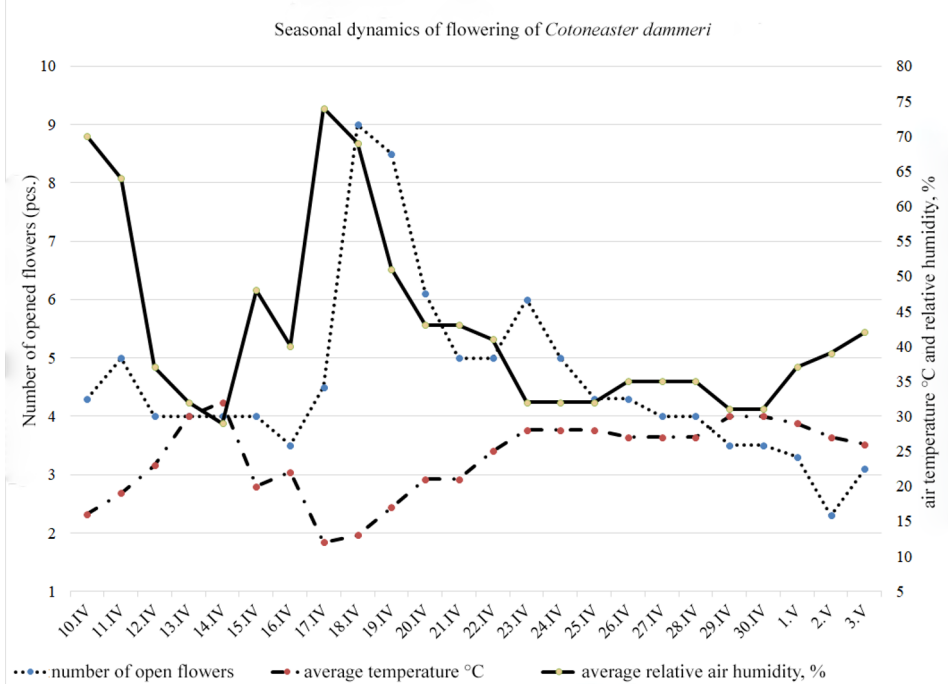


Fig. 2. Seasonal dynamics of flowering of *Cotoneaster dammeri*

All studied species of the genus *Cotoneaster* are very ornamental during the flowering phase, especially the species *C. dammeri* acquires a magnificent appearance during the flowering period.

The beginning of the flowering period of the 3-year-old bush *Weigela florida* f. *Bristol ruby* was observed in the second ten days of April. The budding and flowering phases were 31-43 days. It has been noted that 5-7 shoots of the first order and 2-4 shoots of the second order are formed on the stem of the plant. Flowering is observed twice a year (April-May and mid-August) (Fig. 1).

Based on observations for 2022-2023, it was noted that during the daily flowering of this form, 50-55 flowers opened, while in the mass flowering phase only 70 flowers opened. The longest daily opening time of the plant's flowers is observed in the third ten days of April from 10 am to 4 pm, which corresponds to 70% of the flowers opening during the day. The air temperature at this time was 25-32 °C, and the relative humidity was 25-45%. While a small number of flowers opened between 4 and 6 pm, no flowering was observed after 6 pm. This, in turn, indicates that this species belongs to those that bloom only during the daytime (Fig. 3).

Plants show an increase in the number of second and third order shoots, the number of flowers, and an extension of the flowering period as they age.

With the increase in temperature and decrease in relative humidity, there was an increase in the number of blossoming flowers. A decrease in air temperature by 3-4 °C and an increase in relative humidity caused a decrease in the number of opened flowers. The duration of flowering averaged 26-30 days in spring and 18-20 days in summer (in 2022-2023). Based on the analysis of the results obtained for 6 ornamental species and 6 forms selected as objects of study, an introduction assessment of plants was carried out on frost and heat resistance, self-healing, ability to shoot, resistance to diseases and pests, as well as other indicators (Table).

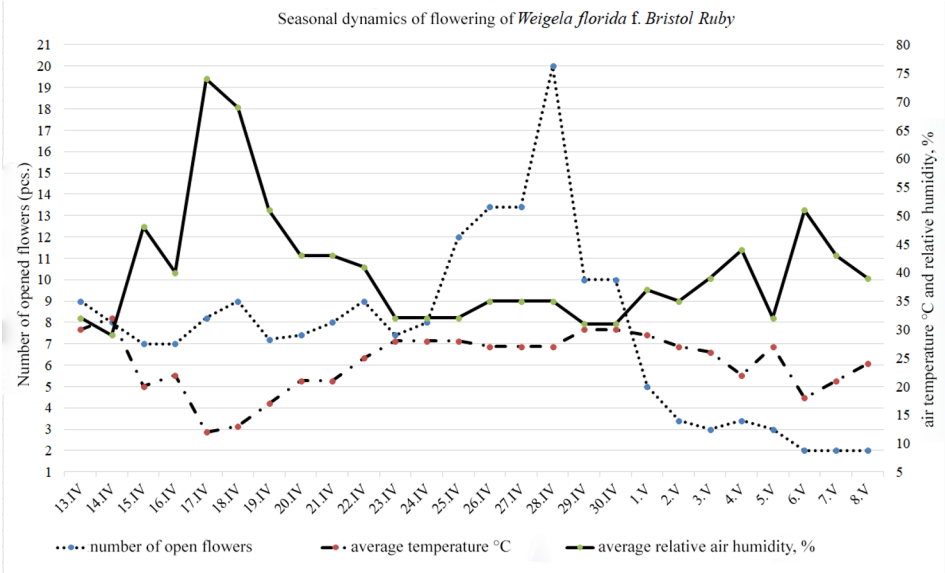


Fig. 3. Seasonal dynamics of flowering of *Weigela florida* f. *Bristol Ruby*
Table - Introduction assessment of research objects

Indicators	points	<i>Viburnum tinus</i> f. <i>stricta</i>	<i>Weigela florida</i> f. <i>Bristol Ruby</i>	<i>Deutzia scabra</i> f. <i>plena</i>	<i>Spiraea prunifolia</i> "Plena"	<i>Hibiscus syriacus</i> "Duc de Brabant"	<i>Physocarpus opulifolia</i> f. <i>diabola</i>	<i>Spiraea japonica</i>	<i>Cotoneaster horizontalis</i>	<i>Cotoneaster adpressus</i>	<i>Cotoneaster dammeri</i>
1. Branch wood, length											
100%	20			20							
75%	15	15	15		15	15		15	15		
50%	10						10			10	10
25/%	5										
Does not lignify	1										
2. Frost resistance											
Doesn't freeze	10			10	10	10	10	10	10	10	10
Less than half of annual shoots freeze	8	8	8								
Annual shoots freeze 50–100%	6										
Annual shoots freeze along with old shoots	4										
The above-ground part is freezing, until everything is covered with snow.	2										
The above-ground part freezes completely	1										
3. Heat resistance											
Resistant	10			10	10	10	10	10	10	10	10
Medium resistant	7	7	7								
Not resistant	5										
4. Resistance to diseases and pests											
Resistant	5	5	5	5	5	5	5	5	5	5	5
Medium resistant	3										
Not resistant	0										
5. Preservation of shape (habitus)											
Preserved	10	10	10	10	10	10	10	10	10	10	10
Not preserved	5										
Recovering	1										
6. Ability to shoot											
High	5			5	5	5	5	5	5	5	
Medium	3	3	3								3

Low	1										
7. Ability of shoots to grow in height											
Growing every year	5	5	5	5	5	5	5	5	5	5	5
Doesn't grow every year	2										
8. Ability for generative development											
The seeds ripen	25								25	25	25
The plant blooms, but the fruits and seeds do not ripen	20	20	20	20	20	20	20	20			
The plant blooms, but the fruits do not form	15										
The plant does not bloom	1										
9. Self-propagation											
Planted artificially	10								10		
Reproduces naturally and vegetatively	7					7	7	7			
Propagated artificially and vegetatively	5									5	5
Seeds or plants are brought from other regions	3	3	3	3	3						
Total score	100	76	76	88	83	87	82	87	95	85	88

According to the scale for assessing the success of introduction, the species scored the following points. *Cotoneaster horizontalis* and *Symphoricarpos dorenbosa* scored high (95) and are considered fully promising. These species had the maximum results in all indicators. This indicates the full potential of the species, as both species grow and develop well under introduction conditions. Also, the species *Spiraea japonica*, *Cotoneaster adpressus*, *Cotoneaster dammeri* scored 85-88 points, which are also promising. The species *Hydrangea macrophylla* turned out to be less promising, scoring 54 points. This species was found to be unpromising due to low scores in criteria 1, 2, 3, 5, 8 (woodiness of branches, frost resistance, heat resistance, preservation of plant shape, ability for generative development).

The ratings of the forms were as follows: the highest score was for *Deutzia scabra* f. *plena* (88) and *Hibiscus syriacus* "Duc de Brabant" (87), positive results for criteria 2, 3, 4, 5, 6, 7 (cold and heat resistance, as well as resistance to diseases and pests, plant form preservation (habit), shoot formation, ability of shoots to grow in height) showed their potential. The remaining 4 forms - *Viburnum tinus* f. *stricta* (76), *Weigela florida* f. *Bristol ruby* (76), *Spiraea prunifolia* "Plena" (83), *Physocarpus opulifolia* f. *diabola* (82) scored

from 76 to 83 points, which are also promising. These species and forms can be widely used in the field of landscape design and improvement of Uzbekistan.

4 Conclusion

Due to the fact that all research objects are introduced species, the indicators in point 9 of this methodology, i.e. “self-reproduction” turned out to be low in our climatic conditions. In the “Methodology for introduction assessment of plants”, N.I. Shtonda, researcher at the Tashkent Botanical Garden, in 2016 added 1 point on heat resistance of plants depending on the climatic conditions of our republic and increased it to 9 points [18]. According to this added point, 11 research objects received high scores, meaning that 11 species and forms were heat-resistant, while the species *Hydrangea macrophylla* received a low score in this regard.

It is noted that the species are superior to the forms in terms of resistance to diseases and pests. Through an introduction assessment of trees, their characteristics were taken according to 7 indicators and noted as promising species and forms for our republic. The above-mentioned ornamental species and forms are characterized by branching, shape, and high ornamental value. These introduced species are an important factor in choosing the assortment and compiling a compositional group of ornamental plants in urban planning.

Acknowledgment

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References

1. N.V. Trulevich, Ecological and Phytocenotic Basis of Plant Introduction (1991)
2. Y.N. Karpun, Fundamentals of plant introduction. Hortus botanicus, 2 (2004)
3. E.E. Temirov, N.K. Rakhimova, The bioecological features of some species of the Cupressaceae introduced in the conditions of Tashkent city (Uzbekistan). Biodiversitas, Journal of Biological Diversity, **23/10** (2022)
4. L. Jakhbarova, E. Temirov, S. Turdiev, F. Chorshanbiev, Study and Reproduction of the Representatives of the Cupressaceae Family Attitude to Bioecological Factors Used in Landscaping. XV International Scientific Conference “Interagromash-2022”. Lecture Notes in Networks and Systems, **575** (2023)
5. A. Vorobyeva, History of territorial development and formation of urban landscape in the South of Russia Web of Conferences, **106** (2017)
6. D. Brochard, All About Trees and Shrubs (2016)
7. N.A. Shenmayer, M.M. Litvinova, V.V. Konyukhova, S.S. Romanova, The linen factory park of “Biysk linen company OAO” (open joint-stock company) landscape gardening redesign project in Biysk city. E3S Web of Conferences. **296** (2021)
8. A. Komin, P. Komin, V. Usov, A. Gridnev, Forest resources of the Far East, their use and reproduction. E3S Web of Conferences, **203** (2020)
9. N. Ivanova, O. Ganzha, The methodological aspect of the landscape and ecological forming of a comfortable environment for the Smart City. Web of Conferences, **106** (2016)
10. D. Brochard, All About Trees and Shrubs (2016)
11. A. Rehder, Manual of cultivated trees and shrubs hardy in North America (1949)

12. A.S. Sakharova, N.A. Yakupov, Beautiful flowering trees and shrubs for green building in Bashkiria. Wild and introduced useful plants in Bashkiria (1968)
13. N.A. Babich, O.S. Zalyvskaya, G.I. Travnikova, Introduced trees and shrubs in green building of northern cities: a monograph (2008).
14. G.T. Maksutbekova, Formation of tree and shrub plant funds of Zhezkazgan industrial region: history and prospects of development. Vestnik KRSU, 19/12 (2019)
15. Assortment of ornamental plants for landscaping of Jezkazgan industrial region (1979)
16. G.T. Maksutbekova, Recommendations on the creation and care of green spaces in the conditions of Zhezkazgan industrial region. Training and methodological manual. Zhezkazgan (2017)
17. P.I. Lapin, S.V. Sidneva, Assessment of the prospectivity of woody plant introduction based on visual observations. Experience of introduction of woody plants (1973)
18. N.I. Shtonda, Introduction evaluation of new ornamental woody plants, 33-38 (2016)
19. A.A. Molchanov, V.V. Smirnov, Methods of studying the growth of woody plants (1967)