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ADAPTATION OF ORNAMENTAL FLOWERING SHRUBS TO THE SHARPLY CONTINENTAL CLIMATE: LANDSCAPING EXPERIENCE IN ASTANA

Under the sharply continental climate of Astana, the selection of resilient ornamental shrub species is especially important for establishing durable and sustainable urban green infrastructure. The aim of this study was to assess the survival and adaptation characteristics of ornamental flowering shrubs in urbanized areas of the capital of Kazakhstan.

The analysis was carried out on several experimental plots that differed in agrochemical soil properties, including nutrient availability, humus content, and acidity. The results showed an average plant loss rate of 28.6%. Glossy cotoneaster (*Cotoneaster lucidus*) demonstrated the highest resilience, with losses below 1%, while common ninebark (*Physocarpus opulifolius*) exhibited moderate tolerance, with losses ranging from 15% to 25%. Panicle hydrangea (*Hydrangea paniculata*) was identified as the least adapted species, with mortality reaching 24.4%. Plant survival was strongly influenced by soil potassium and phosphorus levels, organic matter content, and pH balance.

Based on these findings, it is recommended to prioritize glossy cotoneaster and common ninebark for urban landscaping projects in Astana, whereas panicle hydrangea should be used only in areas with favorable agrochemical conditions. Future research should focus on identifying and testing new drought- and cold-tolerant cultivars to further enhance the sustainability of Astana's urban green spaces.

Keywords: ornamental shrubs, urban ecology, Astana, plant adaptation, landscaping.

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Сәндік гүлді бұталардың қатты континенттік климат жағдайына бейімделуі: Астананы көгалдандыру тәжірибесі

Астананың қатаң континенттік климаты жағдайында ұзақ мерзімді жасыл инфрақұрылымды қалыптастыру үшін тұрақты сәндік бұт түрлерін таңдау ерекше маңызға ие. Бұл зерттеудің мақсаты – Қазақстан астанасының урбанизацияланған аймақтарында сәндік гүлді бұталардың тіршілік етуі мен бейімделу ерекшеліктерін анықтау. Талдау бірнеше тәжірибелік учаскелерде, әртүрлі агрохимиялық топырақ сипаттамалары бойынша жүргізілді.

Нәтижелер көрсеткендей, орташа өсімдік жоғалту деңгейі 28,6 % болды, сонымен қатар Қызыл тұт (*Cotoneaster lucidus*) ең жоғары тұрақтылықты көрсетті (1 %-дан аз), Қабақшабұт (*Physocarpus opulifolius*) орташа жоғалту деңгейінде болды (15–25 %), ал метельді гортензия (*Hydrangea paniculata*) ең төмен бейімделген түр ретінде анықталды. Өсімдіктердің тіршілік етуі тікелей топырақтағы калий мен фосфор мөлшеріне, гумус деңгейіне және қышқылдыққа байланысты болды.

Алынған нәтижелерге сүйене отырып, Астананы жасылдандыру кезінде Қызыл тұт пен Қабақшабұтты басым түрде пайдалану ұсынылады, ал метельді гортензияны тек агрохимиялық жағдайлары қолайлы учаскелермен шектеу қажет. Зерттеу нәтижелері сәндік өсімдіктер ассортиментін таңдауда кешенді тәсілдің және топырақ көрсеткіштерін тұрақты бақылаудың

дылығын растайды, бұл тұрақты қалалық жасыл инфрақұрылымды қалыптастыру үшін маңызды. Болашақта бұл Астананың неғұрлым тұрақты және экологиялық жағынан орнықты жасыл инфрақұрылымын қалыптастыруға мүмкіндік береді.

Түйін сөздер: декоративті бұталар, урбан экологиясы, Астана, өсімдіктердің бейімделуі, ландшафттық көгалдандыру.

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Адаптация декоративно-цветущих кустарников к условиям резко континентального климата: опыт озеленения Астаны

В условиях резко континентального климата города Астаны особое значение приобретает выбор устойчивых видов декоративных кустарников для формирования долговечной зелёной инфраструктуры. Целью данного исследования является выявление особенностей приживаемости и адаптации декоративно-цветущих кустарников на урбанизированных территориях столицы Казахстана.

Анализ проводился на нескольких опытных участках с различными агрохимическими характеристиками почв. Результаты показали, что средний уровень отпада составил 28,6 %, при этом кизильник блестящий (*Cotoneaster lucidus*) продемонстрировал наилучшую устойчивость (менее 1 %), пузыреплодник калинолистный (*Physocarpus opulifolius*) имел средний уровень отпада (15–25 %), тогда как гортензия метельчатая (*Hydrangea paniculata*) оказалась наименее приспособленной (до 24,4 %). Приживаемость растений напрямую зависела от содержания калия и фосфора в почве, уровня гумуса и кислотности. На основании полученных данных рекомендуется приоритетное использование кизильника блестящего и пузыреплодника калинолистного при озеленении Астаны, в то время как применение гортензии метельчатой целесообразно ограничить участками с благоприятными агрохимическими условиями.

Результаты исследования подчеркивают важность комплексного подхода к подбору ассортимента декоративных растений и регулярного мониторинга почвенных показателей для успешного формирования устойчивой городской зелёной инфраструктуры. В перспективе это позволит формировать более стабильную и экологически устойчивую зелёную инфраструктуру города Астаны.

Ключевые слова: декоративные кустарники, городская экология, Астана, адаптация растений, ландшафтное озеленение.

Introduction

Astana is the capital of Kazakhstan, a modern and dynamically developing metropolis with a population of about 1,392 people, embodying advanced urban ideas and architectural innovations. The climate of Astana belongs to the sharply continental type, which is one of the most important characteristics of the region. This type is due to the geographical location of the city in the center of the Eurasian continent, far from the seas and large bodies of water. Therefore, Astana is characterized by sharp temperature fluctuations and the formation of weather anomalies: in winter – from severe frosts to thaws and rains, in summer – from heat above +35 °C to frosts [16]. The sharply continental climate influences urbanization, architecture, transport system, landscaping and lifestyle of the city. Despite the harsh climatic conditions, the development of

the capital of Kazakhstan requires new approaches to landscape design, landscaping, ecologically sustainable and aesthetically attractive urban environment. Typical vegetation characteristic of the city is represented by the following plants: fescue (*Festuca valesiaca*), feather grass (*Stipa*), fescue (*Festuca*), wormwood (*Artemisia*), couch grass (*Elytrigia*), reed grass (*Calamagrostis*), bluegrass (*Poa*), yarrow (*Achillea*), rose hips (*Rosa*) and other plant species. In the parks, squares and alleys, trees such as poplar (*Populus*), birch (*Betula*), ash (*Fraxinus*), pine (*Pinus*) and others are common. You can also find plantain (*Plantago*), dandelion (*Taraxacum*), chamomile (*Matricaria*). The total number of trees in the city is about 500 thousand pieces. Their number increases annually due to plantings as part of landscaping, due to the construction and reconstruction of parks and squares, as well as landscaping of the territories of new construction projects. The average

survival rate of trees in the capital is 92% [7]. However, sustainable urban green infrastructure based only on landscaping with native tree species is not feasible due to the limited number of native flora species. In addition, the list of resistant tree species in a given region may be too limited to provide ecosystem services and sustainable development of landscape architecture objects. Active introduction processes, primarily of ornamental plants, are observed in the Mediterranean region [19], in Europe [6], and other regions of our planet. Introduction processes are actively manifested in the Asian part of Russia.

Materials and methods

Classical methods for assessing the success of the introduction of a particular plant species are determining its winter hardiness, drought resistance and ability to germinate seeds. One of the main indicators of plant introduction is the study of the chemical and physicochemical properties of the soil. Including the study of the properties of the soils on which the introduced species grow is a necessary condition for the reliability of the assessment of the success of the introduction [2].

Due to the fact that the urbanization process requires the introduction of new plant species, since 2020, landscaping activities in Astana have been actively carried out by Astana-Zelenstroy LLP across the five administrative districts of the city (Fig-

ure 1). In particular, ornamental flowering shrubs such as Cossack juniper (*Juniperus sabina*), glossy cotoneaster (*Cotoneaster lucidus*), Panicle hydrangea (*Hydrangea paniculata*), Japanese spirea (*Spiraea japonica*), Common ninebark (*Physocarpus opulifolius*), and Shrubby cinquefoil (*Potentilla fruticosa*), along with many other species, have been introduced and planted in containers with C5 and C3 seedlings. C5 seedlings are obtained after transplanting (transshipment) of C3 seedlings into a larger container (from C3 to C5). This type of transplant does not disturb the integrity of the root ball, which is already intertwined with roots. This method is particularly well suited for the cultivation of ornamental shrubs. The letter “C” in container labeling designates a round pot, and the number indicates its volume in liters (1 liter = 1000 cm³). For example, C3 corresponds to a 3-liter pot measuring 18 × 15 cm, where 18 cm is the upper diameter of the container and 15 cm is its height; C5 corresponds to a 5-liter container with a diameter of 22 cm and a height of 18 cm. The containers are most commonly round in shape [23].

For the purposes of this study, three types of ornamental flowering shrubs were selected: panicle hydrangea (*Hydrangea paniculata*), glossy cotoneaster (*Cotoneaster lucidus*), and common ninebark (*Physocarpus opulifolius*). These species are highly ornamental, tolerate pruning well, and are resistant to urban environmental conditions.



Figure 1 – Administrative districts of Astana (as of 2023)

Cotoneaster lucidus

This culture is distinguished (Figure 2), first of all, by dark green glossy numerous leaves, glossy cotoneaster plantings are beautiful in spring, when the bushes are strewn with small pink flowers, which form black fruits in autumn [1]. Due to the abun-

dant foliage, numerous shoots, glossy cotoneaster presents great prospects for topiary haircuts, it can be given absolutely any shape – balls, cubes, trapezoids, various animal figures, etc.; and also form hedges when creating parks, squares and decorate highways.



Figure 2 – Cotoneaster lucidus planted in flowerbeds near the “Baiterek” monument, Astana

Hydrangea paniculata

Hydrangea paniculata- this is enough large by his own sizes shrub (Figure 3). The height can reach one and a half to two meters. It got its name due to its spectacular inflorescences – large panicles of an elongated or spherical shape. In some cases, the size of the inflorescences can reach 25 or even 30 centimeters.

Hydrangea is highly valued for several key traits, including ease and cost-effectiveness of cultivation, frost tolerance even in northern regions where temperatures can drop to $-25\text{ }^{\circ}\text{C}$, low sensitivity to environmental conditions, resistance to pests and diseases, and suitability for growth in urban environments, including locations adjacent to busy roads and highways.



Figure 3 – Hydrangea paniculata flowering on the Green-Water Boulevard, Astana

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Hydrangeas are distinguished by a variety of shapes and sizes. Flowers are collected in spectacular spherical inflorescences – corymbs or panicles at the ends of stems. Most species have two types of flowers in the inflorescences: small fertile ones in the center and large sterile ones at the edges.

Physocarpus opulifolius

Physocarpus viburnifolia (Figure 4) belongs to the genus of deciduous shrubs of the Rosaceae family. The branches are flexible and drooping. The leaves are round-ovate, up to 4 cm long, with 3-5 blunt lobes, of which the middle one is larger. The edge of the leaf is serrate-toothed. Depending on the species, the leaf blades of the physocarpus can have a color from bright green to bright red shades. The flowers are pink or white, collected in convex corymbose inflorescences. Blooms in June-July. Fruits from 3-4 swollen leaflets, which ripen in September-October. Begins to bloom and bear fruit from the age of four [13].

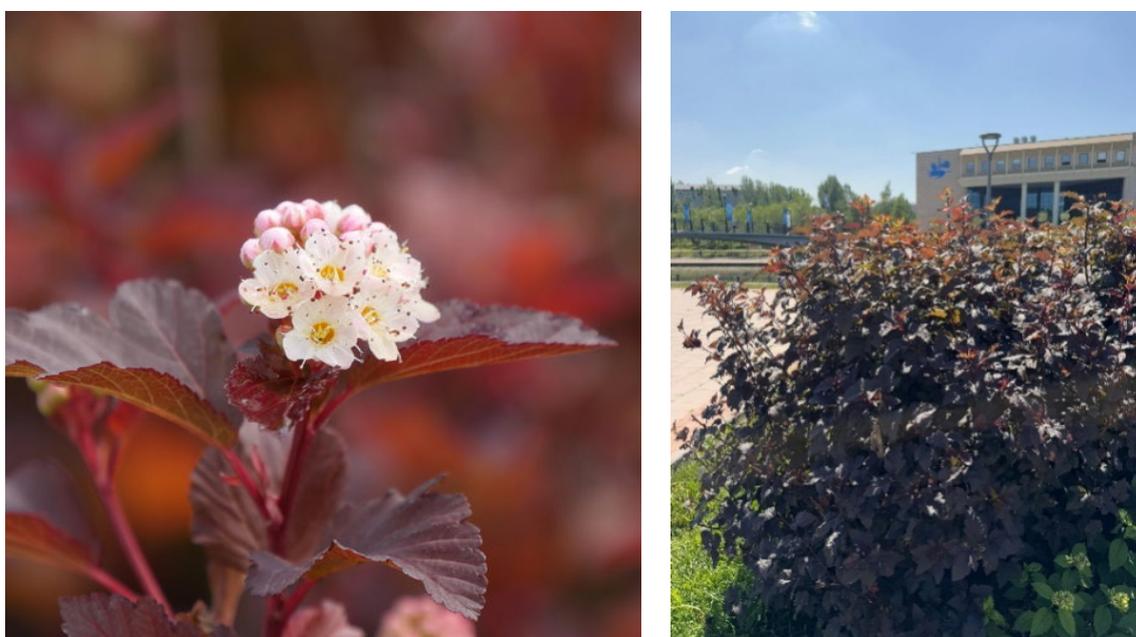


Figure 4 – *Physocarpus opulifolius* in flowerbeds of “Teachers’ Square”, Astana

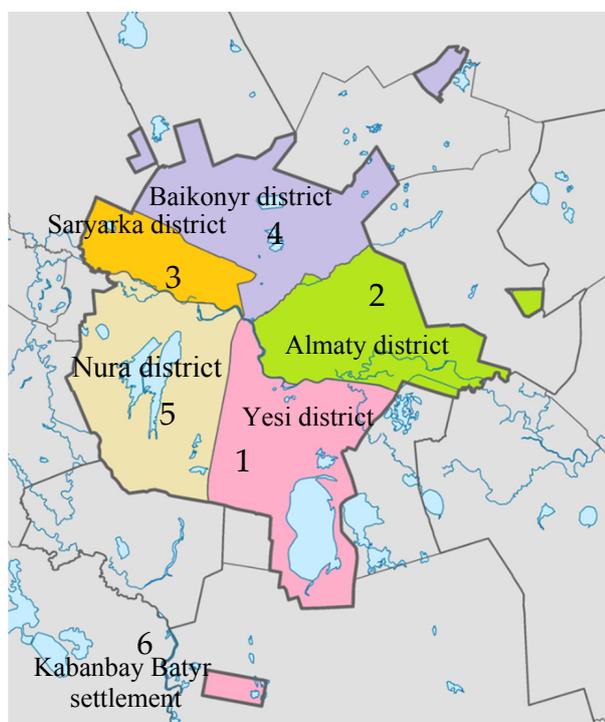
The genus has about 10 species growing in East Asia and North America. In culture, the bladder senna shrub is a fast-growing plant, quite shade-tolerant, frost-resistant, undemanding to soil conditions, gas-resistant, tolerates pruning well, and is used in group plantings and hedges. By 2015, the number of bladder senna varieties already exceeded three dozen. And this is only the beginning, since the shrub has a large untapped genetic potential. The bladder senna is popularly called meadowsweet, and sometimes viburnum-leaved spirea (*lat. Spiraea opulifolia*) [12].

Agrochemical and physicochemical properties of soils where selected species of ornamental flowering shrubs grow were studied at the Analytical Center of the A.I. Barayev Scientific and Production Center for Agriculture and Chemicalization. The studies covered areas located in five administrative districts of Astana – Yesil, Saryarka, Almaty, Nurinsky and Baikonur (Figure 5) – where shrubs grow in urban conditions, as well as in the Tselinograd district of the Akmola region (Kabanbay Batyr settlement, Maybalyk street, 22/1), where plants are grown in green house environment (Table 1).

Table 1 – Sampling locations for soil collection in habitats of ornamental flowering shrubs in Astana

№	District research	Object of study	Soil layer, cm
1	Yesil	Park area of the Bayterek monument	0 – 20
2	Almaty	st.Satpayev (from Kuishi Dina st. to Momyshuly avenue)	0 – 20
3	Saryarka	The square in front of the city Akimat	0 – 20
4	Baikonur	The territory of the «Teachers» square	0 – 20
5	Nura	Park area «Astana-Opera»	0 – 20
6	Kabanbay Batyr settlement.	Maybalyk st. 22/1	0 – 20

Soil samples were collected from a depth of 20 cm by forming pit-like excavations. All samples after collection were hermetically sealed, appropriately labeled and sent to a specialized laboratory for complex agrochemical analysis.

**Figure 5** – Research address on the city map (as of 2024)

The following methods were used in laboratory conditions:

1. The determination of nitrates followed the TsINAO method specified in GOST 26488–85, which is based on the reduction of nitrates to nitrites followed by photometric measurement [12].

2. Determination of mobile forms of phosphorus and potassium was carried out according to the

Machigin method using a 1 M solution of ammonium acetate (pH 4.8) as an extractant. Phosphorus was determined colorimetrically, potassium – using a flame photometer.

3. Organic matter content was evaluated using the Tyurin method modified by TsINAO, which relies on the oxidation of organic carbon with potassium dichromate followed by titration.

4. Measurement of pH, specific electrical conductivity and solid residue were performed in an aqueous extract (soil:water ratio 1:5) in accordance with generally accepted methods of agrochemical analysis [14].

5. The content of fulvic and humic acids was assessed through sequential alkaline extraction, followed by fractionation under decreasing pH. Humic acids precipitate at pH 1, whereas fulvic acids remain in solution [10].

Results and discussion

A comprehensive analysis of the granulometric composition of soils in the urban microdistricts of Saryarka, Baikonur, Almaty, Yesil and Nura was conducted, covering sixty control points and resulting in the identification of four main soil types: dark chestnut, meadow chestnut, solonchaks, and urban soils. Heavy, medium and light loams were found to predominate in terms of mechanical composition [31]. A recent study examined the engineering and geotechnical characteristics of sulfate-rich soils in Astana, revealing that a considerable portion of the urban territory is dominated by solonetz–chloride clays, clayey sandy loams, and glaciated sediments. Another investigation focused on the dynamics of humus, total nitrogen, mobile phosphorus, and exchangeable potassium in the soils of Northern Kazakhstan, including the suburban areas of Astana [9,3]. Over 33 years, a gradual decrease in these indicators has been observed, which emphasizes the relevance of the transition to sustainable agriculture

[3]. According to the study “Study of the soil of green areas of Astana” (2023), the chemical parameters of soils in the city’s parks and squares vary depending on the landscape approach and soil-hydrological conditions.

The study assessed the content of the main plant nutrients – nitrate nitrogen (N-NO_3), phosphates (P_2O_5) and potassium (K_2O) – in soils in different areas of the city. The analysis was conducted at six points with varying degrees of greenery and anthropogenic load: from central parks and squares to the surrounding area of residential buildings (Figure 6).

In the Teachers’ Square, the highest potassium content (approximately 1350 mg/kg) and elevated phosphate levels (approximately 230 mg/kg) were recorded, with an average level of nitrate nitrogen. Such agrochemical characteristics of the soil indicate its high nutrient availability, which contributes to the successful landscaping using ornamental plants that are sensitive to mineral nutrition [15].

At 22/1 Maibalyk Street, the highest content of nitrate nitrogen, as well as elevated levels of phosphates and potassium, were observed. This may be associated with increased anthropogenic pressure, intensive maintenance, and fertilizer application typical for residential and public areas [32].

Thus, Teachers’ Square and 22/1 Maibalyk Street stand out as sites with the best agrochemical indicators, where as Astana-Opera Park requires

reclamation measures and improvement of plant nutrition conditions.

The park area around the Bayterek Monument and the site along Satpaev Street exhibited an average level of nutrient availability, which is considered acceptable for introduced woody and shrub species that do not have high fertility requirements [29].

In the soil of the square in front of the City Akimat, a sufficient potassium content (approximately 760 mg/kg) was detected, but phosphate levels were low (less than 70 mg/kg), which may limit root system development, particularly in young plants [25]. The Astana-Opera park area is characterized by the lowest concentrations of all studied macronutrients: K_2O – approximately 410 mg/kg, P_2O_5 – less than 50 mg/kg, and N-NO_3 – at minimal levels.

For the quantitative assessment of organic matter content in the soils of the studied sites, the classical Tyurin oxidation method modified by TsINAO was used, as recommended for agrochemical soil analysis.

The content of total humus and its fractional composition – humic acids (C_h) and fulvic acids (C_f) – in the soils of the studied green areas of Astana varies over a wide range (Figure 7). Determinations were carried out using the Tyurin method modified by TsINAO. These methods remain among the most accurate and widely applied in agroecological research [11,18].

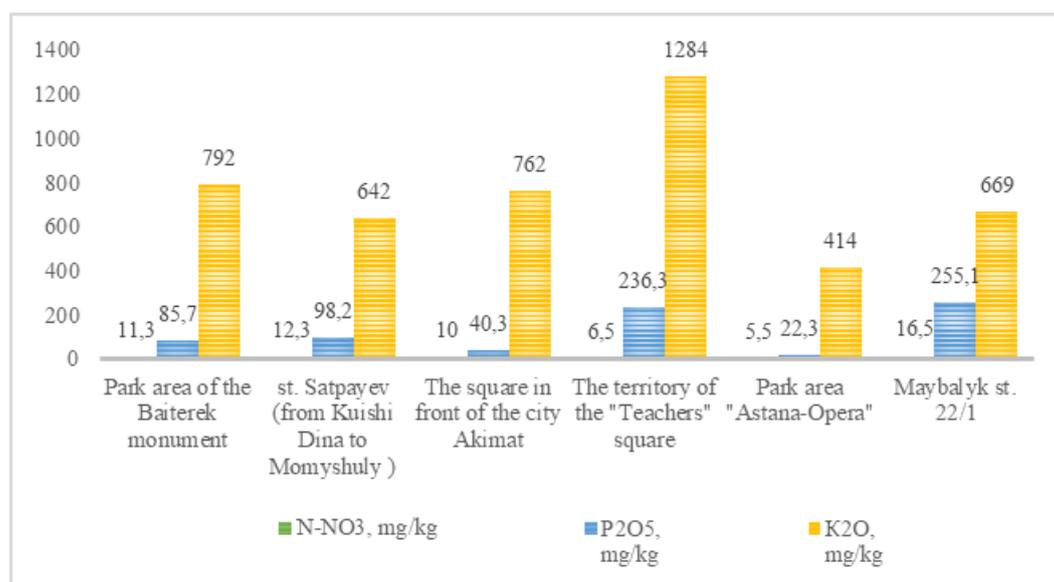


Figure 6 – Assessment of the content of the main plant nutrients – nitrate nitrogen (N-NO_3), phosphates (P_2O_5) and potassium (K_2O) – in the soils of various zones of the city

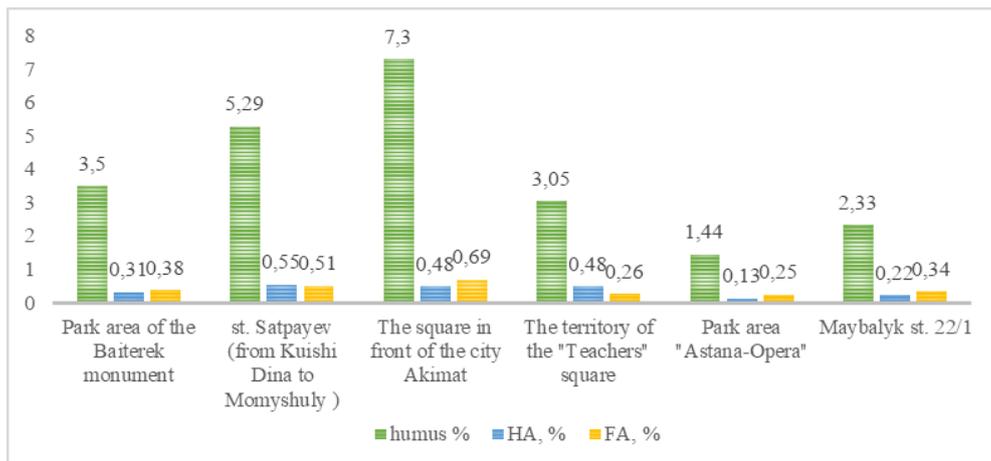


Figure 7 – The content of total humus and its fractional composition – humic (HgA) and fulvic acids (FFA) – in the soils of the studied green areas of the city of Astana

The Satpaev Street site (from Kuishi Dina to Momyshuly) is characterized by an elevated humus level (5.29%) with a relative balance between humic acids (0.55%) and fulvic acids (0.51%), which is typical for soils with an active microbiological cycle and recent organic matter inputs (Lehmann et al., 2020). In the park zone of the Bayterek Monument, humus content was 3.5%, and the humus fractions (humic acids – 0.31%, fulvic acids – 0.38%) indicated a predominance of mobile forms of organic matter, characteristic of surface horizons with regular organic inputs.

Teachers' Square also demonstrated a moderate humus content (3.05%), with the proportion of humic acids (0.48%) exceeding that of fulvic acids (0.26%), suggesting stabilization of organic matter and its partial fixation within the soil mineral matrix (Ding et al., 2021). At 22/1 Maibalyk Street, a low overall humus content was recorded (2.33%), along with low concentrations of humic acids (0.22%) and fulvic acids (0.34%), reflecting poor organic enrichment and possibly the effects of soil compaction and insufficient vegetation cover [34]. The lowest humus values (1.44%) were registered in the Astana-Opera park area, where the humus fraction content was also minimal (humic acids – 0.13%; fulvic acids – 0.25%). Such values are typical for urbanized territories with low bio productivity and anthropogenic disturbance of the upper soil horizon [21].

A comparative analysis of the soil pH values across six landscaped areas of Astana (Figure 8) showed that all samples exhibited an alkaline reaction, which is typical for soils of arid regions in Central Kazakhstan. The pH values ranged from 8.28 (Teachers' Square) to 8.77 (square in front of the City Akimat). Other sites also demonstrated high values: Bayterek Monument park zone – 8.76, Satpaev Street – 8.41, Astana-Opera park area – 8.61, and 22/1 Maibalyk Street – 8.57. Variations in soil pH may be attributed both to natural factors (particle size distribution, parent material) and to anthropogenic impacts, such as differences in irrigation intensity, fertilizer application, and urbanization effects [30,33]. Elevated pH values reduce the mobility and bioavailability of several micronutrients (Fe, Mn, Zn, Cu), which may negatively affect the growth and development of both introduced and native plants, especially during the initial stages of establishment [24,21]. Under such conditions, the use of organic fertilizers and acidifying amendments is recommended to improve soil buffering capacity, as well as the selection of tree and shrub species tolerant to alkaline environments [34,8]. Thus, the soil pH level is a crucial factor determining the adaptation of vegetation in urban environments and should be taken into account when planning landscaping projects and selecting plant assortments.

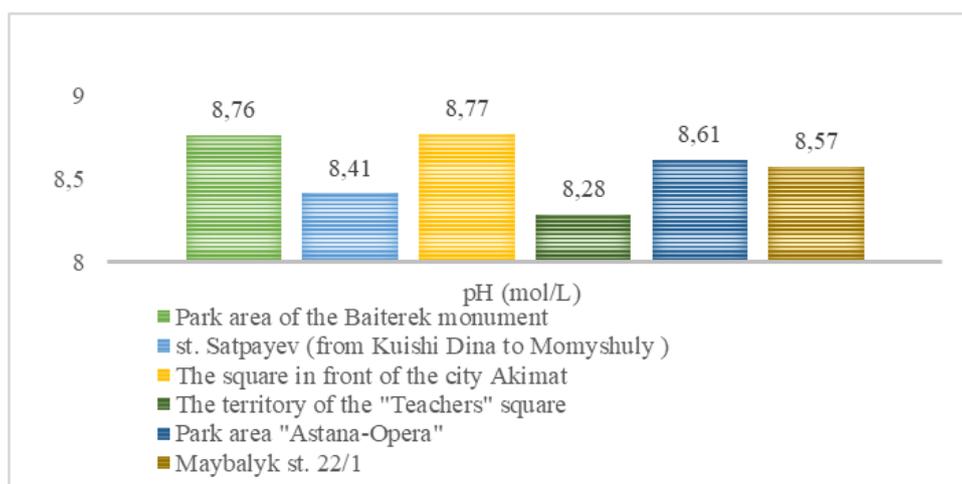


Figure 8 – Acid-base reaction (pH) of soil solution in green areas of Astana city

Based on the collected data (Figure 9) on humus content, a comparative analysis of the following locations can be made: in the park area of the Bayterek Monument and along Satpaev Street, humus content exceeds 0.4 g/kg, indicating high soil quality [5]. In contrast, in Teachers'

Square, humus content is below 0.2 g/kg, signaling the need for soil improvement measures [28]. These results highlight the importance of monitoring and analyzing humus content to maintain ecosystems and develop effective agronomic practices.

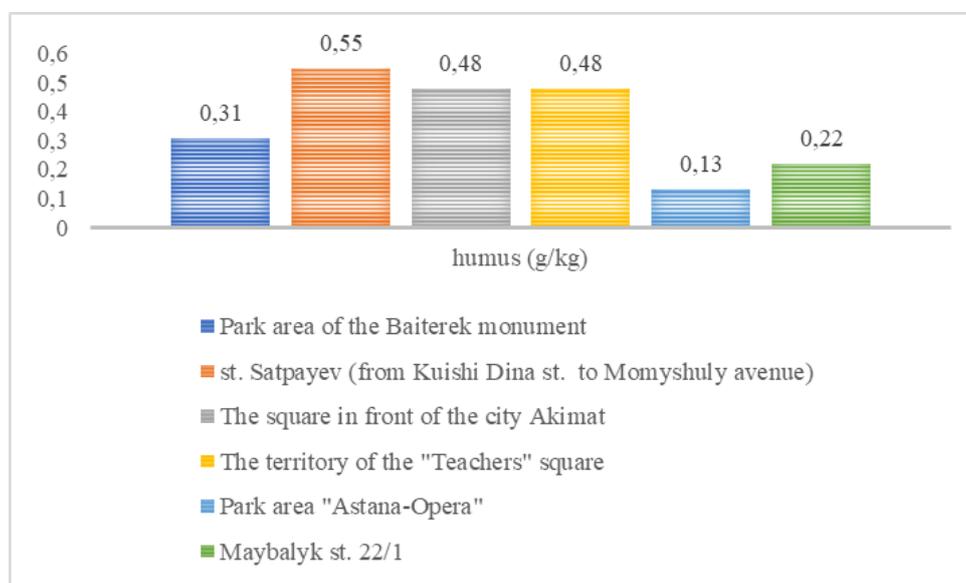


Figure 9 – Determination of the group composition of humus (humic acids) by the pyrophosphate method according to MM Konova and NP Belchikova (g/kg)

According to the report of Astana-Zelenstroy LLP for 2023 65,471 specimens of ornamental flowering shrubs and perennial flowers were planted in five districts of the city. However, out of the total number of planted material, 18,746 specimens

were considered fallen. This paper presents table 2, which demonstrates the ratio between planted and fallen material for 2023 and 2024. These data are key to assessing the effectiveness of city greening and identifying factors affecting plant survival.

Table 2 – Information on planting and cutting of ornamental flowering woody shrubs and perennial flowers in Astana for 2023-2024

№	Name of the district	Planted in 2023	Mortality during 2023–2024
		number of specimens (pcs)	number of specimens (pcs)
1	«Almaty»	11 075	4 305
2	«Baikonur»	18 336	5 816
3	«Yesil»	12 404	5 050
4	«Saryarka»	8 566	2 172
5	«Nura»	15 090	1 403
	Total	65 471	18 746

Table 2 presents data on the planting and loss of ornamental flowering woody shrubs and perennial herbaceous plants across the districts of Astana for 2023–2024. These indicators serve as important measures of the effectiveness of landscaping activities and allow for the identification of factors affecting plant survival in different urban microdistricts [27].

According to the data, the highest number of planting material was introduced in the “Baikonur” district – 18,336 specimens, followed by the “Nura” district – 15,090 specimens. At the same time, the “Baikonur” district also exhibited the highest number of plant losses in 2023 – 5,816 specimens, representing approximately 31.7% of the total planted material. High loss rates were also recorded in the “Yesil” district – 5,050 specimens.

Overall, 65,471 ornamental plants were planted in the city in 2022, of which 18,746 did not survive the winter period. The average loss rate across the city was approximately 28.6%.

The analysis results confirm the need for a comprehensive approach to the selection of woody and shrub plant species for urban landscaping, taking into account the climatic and soil conditions of each district [1]. An important step to increase the survival rate of planting material is the development of adaptive measures, including agrotechnical techniques aimed at enhancing the resilience of plantings [23].

In the “Almaty” district of Astana, the study focused on the area along K. Satpaev Street. Table 3 presents data on the number of planted ornamental shrubs and perennial flowers, as well as the number of plants that failed to establish in this area.

Table 3 – Data on the Planting and Loss of Ornamental Flowering Woody Shrubs and Perennial Flowers on K. Satpaeva Street in “Almaty” district for 2023–2024

№	Planting material	Planting in 2023, pcs.	Root ball/ pot size, cm × cm	Plant height, cm	Loss in 2024, pcs
1	<i>Juniperus sabina</i>	901	0.3x0.3 (5 L)	20-30	0
2	<i>Juniperus sabina</i>	100	0.3x0.3 (5 L)	30-50	0
3	<i>Cornus alba</i>	500	0.3x0.3 (5 L)	40-60	25
4	<i>Cotoneaster lucidus</i>	2690	0.3x0.3 (5 L)	40-60	0
5	<i>Spiraea japonica</i>	935	0.3x0.3 (5 L)	30-50	0
6	<i>Hydrangea paniculata</i>	215	0.3x0.3 (5 L)	30-50	153
7	<i>Rosa rugosa</i>	78	0.3x0.3 (5 L)	40-60	0
8	<i>Physocarpus opulifolius</i>	163	0.3x0.3 (5 L)	40-60	8
	Total	5582			186

A total of 5,582 specimens were planted, of which 186 did not survive the winter period. These data indicate the need for improved agrotechnical measures and adaptive practices to increase plant survival under urban conditions.

Within the framework of the study on planting ornamental flowering shrubs in the “Baikonur” district, a site was selected for detailed analysis – Teachers’ Square (Table 4). This square, located on Alexander Pushkin Street near L. N. Gumilyov Eurasian National University, represents an important element of urban infrastructure and serves as an example of successful implementation of sustainable landscaping principles in an urban context.

In 2023, a total of 1,650 plants were planted. The highest loss rates were recorded for Common ninebark (*Physocarpus opulifolius*)–160 specimens, Panicle hydrangea “Daimonstrush” (*Hydrangea paniculata*) – 89 specimens, and Cossack juniper (*Juniperus sabina*) – 60 specimens. Some species, such

as Rowan-leaved cotoneaster, Rugosa rose (*Rosa rugosa*), and Japanese spirea (*Spiraea japonica*), experienced no losses.

Analysis of plant survival indicators allows the development of effective landscaping strategies and enhances the resilience of urban green spaces. Assessing plant losses also enables the optimization of landscaping planning and ensures more efficient improvement of the urban environment.

The study site in the Yesil district of Astana is the area surrounding the Bayterek Monument. As part of landscaping activities carried out in 2022, ornamental shrubs were planted, including Glossy cotoneaster (*Cotoneaster lucidus*), Cossack juniper (*Juniperus sabina*), Panicle hydrangea (*Hydrangea paniculata*), and Japanese spirea (*Spiraea japonica*). The root ball size (0.3 × 0.3 m, C5 category) and plant height at the time of planting (30–60 cm) are indicated. Information on the number of planted specimens and their survival rate is presented in Table 4.

Table 4 – Data on the Planting and Loss of Ornamental Flowering Woody Shrubs and Perennial Flowers on “Teachers’ Square” in “Baikonur” district for 2023–2024

№	Planting material	Planting in 2023, pcs.	Root ball/ pot size, cm × cm	Plant height, cm	Loss in 2024, pcs
1	<i>Cotoneaster scutellaris</i>	182	0.3x0.3(5 L)	20-30	0
2	<i>Juniperus sabina</i>	136	0.3x0.3(5 L)	30-50	60
3	<i>Cotoneaster lucidus</i>	127	0.3x0.3(5 L)	40-60	48
4	<i>Hydrangea paniculata</i>	315	0.3x0.3(5 L)	40-60	89
5	<i>Rosa rugosa</i>	420	0.3x0.3(5 L)	30-50	0
6	<i>Spiraea japonica</i>	105	0.3x0.3(5 L)	30-50	0
7	<i>Physocarpus opulifolius</i>	365	0.3x0.3(5 L)	40-60	160
	Total	1650			357

The object of the study in the Yesil district of Astana is the area around the Baiterek monument. As part of the landscaping work carried out in 2022, ornamental shrubs were planted here, including: glossy cotoneaster (*Cotoneaster lucidus*), Cossack juniper (*Juniperus sabina*), panicle hydrangea (Hy-

drangea paniculata) and Japanese spirea (*Spiraea japonica*), the dimensions of the planting ball (0.3 × 0.3 m, category C-5) and the height of the plants when planted (30–60 cm) are indicated. Information on the number of planted plants and their survival rate is presented in Table 5.

Table 5 – Data on the planting and loss of ornamental flowering woody shrubs and perennial flowers in Monument “Baiterek” in the Yesil district for 2023–2024

№	Planting material	Planting in 2023, pcs.	Root ball/ pot size, cm × cm	Plant height, cm	Loss in 2024, pcs
1	<i>Cotoneaster lucidus</i>	8778	0.3x0.3(5 L)	40-60	10
2	<i>Juniperus sabina</i>	1684	0.3x0.3(5 L)	30-50	439
3	<i>Hydrangea paniculata</i>	8579	0.3x0.3(5 L)	40-60	429
4	<i>Spiraea japonica</i>	2525	0.3x0.3(5 L)	30-50	127
	Total	12 788			1005

This material allows for the assessment of plant survival: the overall loss rate is approximately 7.9%, which corresponds to successful landscaping practices under the continental climate of the capital, where, with proper maintenance, loss rates typically do not exceed 5–11%.

In 2023, ornamental shrubs in the “Saryarka” district of Astana were planted in the square located in front of the City Akimat building. The composition of the ornamental shrubs planted in this area is detailed in Table 6.

The use of perennial ornamental shrubs provides not only aesthetic appeal but also resilience of plantings to urban conditions, including air

pollution, soil compaction, and temperature fluctuations. According to studies (Smagulova et al., 2020; Baitursynova, 2018), the use of native and acclimatized shrub species contributes to reduced maintenance requirements and increased plant survival. Based on the data in Table 6, a total of 5,101 ornamental shrubs were planted in the area in 2023, of which 995 plants did not survive by 2024, representing approximately 19.5% of the total plantings.

These species were the most abundant in the planting assortment and were likely selected for their high ornamental value and resilience to urban environmental conditions.

Table 6 – Data on the planting and loss of ornamental flowering woody shrubs and perennial in front of the building of the City Akimat on the “Saryarka” district for 2023–2024

№	Planting material	Planting in 2023, pcs.	Root ball/ pot size, cm × cm	Plant height, cm	Loss in 2024, pcs
1	<i>Pinus mugo</i>	193	0.3x0.3(10 L)	40-60	0
2	<i>Cotoneaster scutellaris</i>	90	0.3x0.3(5 L)	40-60	0
3	<i>Hydrangea paniculata</i>	215	0.3x0.3 (5 L)	40-60	0
4	<i>Cotoneaster lucidus</i>	716	0.3x0.3 (5 L)	40-60	262
5	<i>Philadelphus spp.</i>	422	0.3x0.3 (5 L)	40-60	0
6	<i>Physocarpus opulifolius</i>	120	0.3x0.3 (5 L)	40-60	0
7	<i>Spiraea japonica</i> ‘Anthony Waterer’	209	0.3x0.3 (5 L)	30-50	0
8	<i>Spiraea japonica</i> ‘Little Princess’	558	3x0.3 (5 L)	30-50	0
9	<i>Spiraea cinerea</i>	300	0.3x0.3 (5 L)	30-50	220
10	<i>Spiraea japonica</i> ‘Golden Prince’	627	0.3x0.3 (5 L)	30-50	0
11	<i>Juniperus sabina</i>	444	0.3x0.3(10 L)	30-50	7
12	<i>Cornus alba</i>	390	0.3x0.3 (5 L)	40-60	0

Continuation of the table

№	Planting material	Planting in 2023, pcs.	Root ball/ pot size, cm × cm	Plant height, cm	Loss in 2024, pcs
13	<i>Potentilla spp.</i>	207	0.3x0.3 (5 L)	40-60	0
14	<i>Physocarpus opulifolius</i> ‘Diablo	607	0.3x0.3 (5 L)	40-60	150
	Total	5 098			639

Table 7 – Data on the planting and loss of ornamental flowering woody shrubs and perennials in the “Nura” district at the “Astana Opera” site for 2023–2024

№	Planting material	Planting in 2023, pcs.	Root ball/ pot size, cm × cm	Plant height, cm	Loss in 2024, pcs
1	<i>Hydrangea paniculata</i>	30	0.3x0.3(5 L)	40-60	120
2	<i>Cotoneaster lucidus</i>	770	0.3x0.3(5 L)	40-60	75
	Total	800			195

Based on observations in the “Nura” district at the “Astana Opera” 2024 (Table 7), the total plant loss amounted to 195 specimens, corresponding to 24.4% of the total number planted. The highest loss rate was recorded for Panicle hydrangea (*Hydrangea paniculata*), with 120 specimens lost out of 30 planted, indicating its low resilience at this study site. In contrast, Glossy cotoneaster (*Cotoneaster lucidus*) demonstrated significantly higher survival, with a loss of 75 specimens, confirming the findings of other researchers regarding its adaptability to urban conditions [27].

The results indicate that adaptation of ornamental flowering shrubs under Astana’s sharply continental climate is strongly influenced by species-specific traits and the agrochemical properties of soils. The overall loss rate of 28.6% reflects the presence of several limiting factors, including low frost resistance of certain species, nutrient deficiencies, and elevated soil alkalinity.

Species with high ecological tolerance, such as Glossy cotoneaster and Common ninebark, showed superior performance, confirming their suitability for urban landscaping. Conversely, Panicle hydrangea exhibited substantially lower survival, especially in nutrient-poor sites such as Astana-Opera.

Soil properties played a decisive role: high potassium and phosphorus levels at Teachers’ Square corresponded with better plant survival, whereas

low nutrient availability and high alkalinity at Astana-Opera were associated with increased plant mortality. Alkaline soil conditions (pH 8.28–8.77) likely reduced micronutrient accessibility, further limiting plant growth.

These findings align with previous research [27,1], emphasizing the necessity of selecting resilient shrub species and conducting comprehensive ecological assessments when planning urban green spaces.

Conclusion

The analysis of the adaptation of ornamental flowering shrubs to Astana’s sharply continental climate revealed several important trends relevant to the planning of urban green infrastructure. Survival rates varied widely—from 75% to 99%—depending on both the species and the soil conditions of the planting sites. The smallest losses were observed for Glossy cotoneaster (*Cotoneaster lucidus*), where mortality remained below 1%, while the greatest losses were recorded for Panicle hydrangea (*Hydrangea paniculata*), reaching up to 24.4%.

Soil characteristics played a decisive role: areas enriched with potassium and phosphorus—such as Teachers’ Square, where concentrations reached 1,350 mg/kg K₂O and 230 mg/kg P₂O₅—showed

higher plant survival. In contrast, sites with low humus content (1.44%) and strongly alkaline soil conditions (pH up to 8.77) exhibited notably higher mortality rates.

The practical value of this research lies in providing evidence-based recommendations for improving urban landscaping practices. These include:

- increasing the use of species with consistently high resilience, such as Glossy cotoneaster and Common ninebark;
- restricting the planting of Panicle hydrangea to ecologically favorable sites;
- integrating soil agrochemical indicators into the planning and selection of ornamental shrubs;

- implementing regular monitoring and corrective measures to enhance soil quality and plant survival.

Overall, the findings help optimize the selection of ornamental shrubs and support the development of scientifically grounded landscaping strategies, which is particularly important for the extreme climatic conditions of Kazakhstan's capital [1].

Acknowledgments

The authors would like to thank all colleagues and institutions who contributed to the development of this research through their support and constructive discussions.

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Поступила 12 ноября 2025 года

Принята 25 декабря 2025 года