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Biological efficiency of biofertilizers on the growth and development of *Pýrus ussuriēnsis* L., introduced in the Botanical Garden of Astana

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The article presents the results of studying the influence of organo-mineral fertilizers and establishing an effective dose on the physiological processes of growth and development of *Pýrus ussuriēnsis* L., introduced into the urban environment. The experiments were conducted on the territory of the Astana Botanical Garden in three areas. The test object was the fertilizers "KazUgleGumus" and "Agrarka". The first fertilizer was obtained from brown coal, the second - by enriching processed bird droppings with microorganisms. Of the two types of fertilizers we used, "KazUgleGumus" showed greater efficiency due to its rich content, including organic humic acids and natural minerals (Ad; Wr; Vd; St; Ct; Ht; Nt; Na; Al; K; Ca; Ti; Fe; Zr). A comparative analysis of the effective doses of the fertilizers used showed that the trees responded best to the effect of the humate fertilizer "KazUgleGumus" at a dose of 1.5%, and "Agrarki" at a dose of 1%. This result indicates the need to study the physicochemical composition and properties of soils and microbiocenoses on the territory of the botanical garden.

Keywords: *Biodiversity, introduction, Pýrus ussuriēnsis* L., *biofertilizer*

INTRODUCTION

Botanical gardens of cities are a place of targeted attraction of wild and cultivated plants from other floristic areas for the purposes of economic and other practical use. In botanical gardens, a lot of work is carried out on the rational use of natural resources of countries with the maximum use of climatic conditions of a particular region in order to grow the most valuable plants of the world flora in it. During the times of the USSR, the arsenal of landscapers of the cities of the Baltic States, Ukraine, the republics of Central Asia and the Caucasus, and the cities of the Russian Federation was significantly enriched.

The expansion of the range of tree and shrub species used in green construction has improved the biodiversity of ornamental species and the aesthetic appearance of many cities and villages (Dorofeeva et al., 2005). At the same time, the main achievement of introduction and acclimatization is the improvement of the quality of the overall reaction of plants to changed environmental conditions or special artificial influences, leading to the emergence of forms with sufficient resistance and productivity for the existence of the species outside its natural range. During the activities, various methods of selection, agricultural technology and other biological and biotechnological work are used, contributing to the increase in the resistance of plants in new conditions. It is known that in the history of the introduction of woody plants in the territory of Caucasus and Northern Kazakhstan, very interesting facts were noted.

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Fig. 1. Sorts Shirvan Beauty grown on the territory of the Institute of Dendrology

Many varieties of *Pyrus* L grow in the southwestern forest zones of the Republic of Azerbaijan. Passion fruit *Pyrus* L. (*P.passiflora*) grows well in dry mountainous areas. Caucasian *Pyrus* L. lives 150-300 years, and grafted *Pyrus* L. trees live 50-70 years. Up to 60 species are known in the temperate and subtropical zones of Eurasia, 11 in Azerbaijan. Common or cultivated *Pyrus communis* L. and late-ripening pear (*P.serotina*) are widespread (Hasanova et al., 2022).

Shirvanskaya Krasavitsa variety cultivated on the territory of the Institute of Dendrology.

Many varieties of *Pyrus* L. grow in the southwestern forest zones of the Republic of Azerbaijan. *Pyrus* L. varieties in Azerbaijan, including Caucasian *Pyrus* L., are obtained from wild plants.

In 1898, an arboretum was established in the city of Shchuchinsk in the Akmola region, and in 1900-1905, arboretums were created in the region at the estates of foresters. At the same time, more than 150 tree and shrub species were introduced. In 1912, a botanical garden was created in the city of Petropavlovsk. In 1961, a laboratory for selection, seed production and introduction was established at the Kazakh Research Institute of Forestry and Agroforestry, an arboretum was created in Shchuchinsk, and in 1966 an arboretum was created. Over the course of more than a century of introduction, more than 2,000 species, forms and varieties of woody plants were tested in the arboretum and arboretum. The transfer of the capital of the Republic of Kazakhstan to Astana from Almaty increased interest in the introduction of woody plants, which contributed to the creation of an arboretum at the Ak Kaiyn forest nursery, as well as the opening of the Astana Botanical Garden in 2018. Also, the center of introduction work on the territory of Kazakhstan is currently the botanical gardens, arboretums and arboretums in the cities of Almaty, Karaganda, Petropavlovsk, Shchuchinsk, Ridder, Balkhash, Turkestan, Aktau and others (Krekova et al., 2019).

For effective acclimatization of plants during their introduction, various fertilizers are often used. This is one of the most common agricultural practices in world practice (Lamanos et al., 2023). The mineral fertilizer market in Kazakhstan is dependent on foreign countries. 90% of the fertilizers needed for agriculture come from near and far abroad, and about 10% are produced within the country. Fertilizer products are supplied to Kazakhstan from Russia, China, Germany, EU countries, and Brazil. Russian and Belarusian fertilizers are in the greatest demand since they are the most promoted by agents, have a long history of use, and are suitable for both the climate and relief of our country (Mukhanbet, 2016).

Kazakhstan is a net importer of fertilizers and a net exporter of mixed fertilizers. Kazakhstan's exports are concentrated in neighboring countries: Russia, Kyrgyzstan, Uzbekistan, etc. Fertilizer consumption in Kazakhstan has grown significantly, reaching 313 thousand tons in 2021. However, fertilizer consumption remains low compared to other countries in terms of kg/ha, amounting to 4.4 kg/ha in 2021. The agricultural sector needs fertilizers that are not produced in Kazakhstan, such as urea, ammonium sulfate, complex (nitrogen-phosphorus-potassium) fertilizers, liquid and microfertilizers, organomineral with microorganisms (Report on the economic complexity…, 2024).

Astana Botanical Garden is a new center for the introduction and acclimatization of world flora species since 2018, organized for the introduction of world, domestic and cultural flora plant species in the Central and Northern regions of Kazakhstan in the conditions of the Astana Botanical Garden. The Botanical Garden has a total area of 89.177 hectares. Of these, the park area is 42.9 hectares and the scientific zone is 46.3 hectares for scientific research and preservation of plant gene pool collections (16 hectares), which are used to conduct scientific research and preserve plant gene pool collections; the exhibition area for plant cultivation and visitor access occupies 9.6 hectares; the public area is 7.8 hectares for serving visitors. The garden is planted with 89,648 trees and shrubs belonging to 606 taxa and more than 300 collection plants. A modern greenhouse complex, similar to a climate chamber, with fully automated drip irrigation and fogging systems, has been built in the Astana Botanical Garden (https://www.astanabotsad.kz/ru/o-nas). The aim of the proposed research is to evaluate the biological effectiveness of biofertilizers on the growth and development of *Pýrus ussuriēnsis* L., introduced in the Astana Botanical Garden.

MATERIALS AND METHODS

The research objects were samples of *Pýrus ussuriēnsis* L., imported from Russia. Trees of the species were planted in three areas of the botanical garden: 32 trees in the first area, 34 in the second, and 38 in the third. (Figure 1). The approximate area of each area is 1 ha. For the experiment, we selected 27 individuals in each area, and 9 trees in each variant.

a **b** **c**

Fig. 2. *Pýrus ussuriēnsis* L. growing areas on the territory of the Astana Botanical Garden. Sections: a – first, b – second, c – third.

Fig. 3. Appearance of fertilizer samples (KazUgleGumus - A, Agrarka - V).

The first plot served as a control and traditional agricultural technology used irrigation without any treatments. In the second plot, humate fertilizers "KazUgleGumus" in liquid form, developed and produced at the Research Institute of Coal Chemistry (Astana), were used. Humate fertilizers were preliminarily diluted with water in concentrations of 1%, 1.5%, 2.5%.

In the third section, the organo-mineral biopreparation "Agrarka" developed by Professor A.P.Nauanova and produced at the BioKATU scientific center in the Kazakh Agrotechnical Research University named after S. Seifullin was used. This fertilizer was also diluted with water in a concentration of (1%, 1.5%, 2.5%). Before the flowering period, all pear trees were treated three times with an interval of 10 days in the second and third sections (during April). Figure 2 shows packaged samples of the fertilizers used (Figure 2). Two weeks later, approximately in the second ten-day period of May, after the last treatment of all trees, measurements were taken of the length, thickness of trees at a height of 1 m, the value of annual growth, the length of the leaf blade of large and small leaves. Leaf blades from each tree were selected in 5 pieces from the northern, eastern, southern, western sides at a height of 150 cm. The diameters of trees were measured with a measuring fork, the heights - with a taxation pendulum altimeter. Phenological observations were carried out according to the method (Methodology of phenological observations …, 1975). All results were subjected to standard statistical processing. During the monitoring, observations were also made of tree damage by phytopathogens.

RESULTS AND DISCUSSION

Pyrus ussuriensis L. is a woody plant of the genus Pyrus, family Rosaceae. In natural conditions, the height of the tree can reach up to 10-15 m with dark gray bark, sometimes almost black. With good lighting, the crown can be dense, has a spherical-oblong or ovoid shape. The roots of the Ussurian pear spread in the surface layers of the soil, penetrating to a depth of 0.7-1.1 meters. Active moisture-sucking roots are located at a depth of 10-50 cm, and in terms of distribution in the horizontal direction, they coincide with the size of the crown or go beyond it by about 1 meter.

The leaves are broadly oval or rounded, with a shallow cordate or rounded base and a sharp tip, sharply serrated; leathery, - bare, slightly glossy on top, turning black when dried. The flowers are large, up to 3-4 cm in diameter, white, in numerous shields. It blooms before the leaves bloom, in May. The fruits are round, elongated, the stalks are short, 1.5-6.7 cm long. They ripen in late August — early September. Covered with thick skin, juicy, but with a tough, tart-sour and astringent pulp containing many stone cells.

The range covers northeastern China, the Korean Peninsula. In the Russian Federation, it is found almost throughout Primorye and a significant part of the Amur region. The northern boundary of the range is a conditional line connecting the area of Blagoveshchensk, Khabarovsk. Down the Amur River, it is found as far as Komsomolsk-on-Amur.

Many species of Pyrus L. are widespread in Azerbaijan, including *Pyrus caucasian* L., *Pyrus wild* L., *Pyrus passiflora* L. grow well in dry mountainous areas. *Pyrus caucasian* L. lives 150-300 years, and *Pyrus grafted* L. trees live 50-70 years. Up to 60 species are known in the temperate and subtropical zones of Eurasia, 11 in Azerbaijan. Common or cultivated *Pyrus communis* L. and late-ripening pear (*P.serotina*) are widespread.

Many varieties of *Pyrus* L. grow in the southwestern forest zones of the Republic of Azerbaijan. Many sorts, cultivated on the territory of the Institute of Dendrology.

It grows singly or in groups along flood-free river banks, islands, forest edges and in shrub thickets. It loves light, and is undemanding to the soil, but requires fresh, fertile and deep soil for good growth and fruiting. It does not tolerate wet soils and stagnant moisture. In the best growing conditions, trees reach 10-12 meters in height and 30-50 centimeters in trunk diameter. Flowers are pollinated only by pollen from another tree, so solitary specimens, despite abundant annual flowering, usually do not bear fruit. It reproduces by seeds, layering and root suckers. The seeds are eaten by mice. The seeds retain their germination capacity for only one year. Seedlings grow quickly: at one year of age, they grow up to 20-25 cm. It begins to bear fruit at 9-11 years.

The most frost-resistant pear species in the world withstand temperatures down to -50°C (Vorobyov, 1968). During bioecological monitoring in botanical gardens in the USA, Argentina, Italy, France, and Belarus, specialists noted a very high endurance of pear species, compared to apple trees (Guseva, 2010).

Table 1 presents the results of experimental studies in determining the morphometric parameters of *Pýrus ussuriēnsis* L. The obtained analysis shows that the most positive effect was obtained when influencing fruit trees when using humate fertilizer compared to the biofertilizer "Agrarka". The developers of humate fertilizer noted that their chemical composition contains a high content of humic substances up to 60% and such elements as Ad 66.09; Wr 5.73; Vd 17.78; St d 0.71; Ct d 21.01; Ht d 1.68; Ntd 2.09; Na 0.61; Al 0.89; K 0.58; Ca 0.31; Ti 0.22; Fe 1.11; Zr 0.08 (in %) (Yermagambet et al., 2023).

The maximum use of humate fertilizer components by pear is probably due to the depleted chemical composition of the soil in the Astana Botanical Garden. Pear can tolerate weak alkalinity of the soil and the presence of carbonates in it better than other fruit crops. The tolerance of this crop to carbonates is almost twice as high as that of apple trees and slightly higher to salinity (Bandurko, 2016). The effects formed in *Pýrus ussu*riēnsis L. when exposed to humate fertilizer showed stimulation of growth and development of all vegetative parts of the pear. Apparently, the rich organomineral composition of the KazUgleHumus fertilizer showed the most effective effect on the physiological processes of growth and development of *Pýrus uss*uriēnsis L. compared to the site where the Agrarka fertilizer was used.

A comparative analysis of the effective doses of the fertilizers used showed that the trees responded best to the effect of the humate fertilizer "KazUgleGumus" at a dose of 1.5%, and "Agrarka" at a dose of 1%. Figures 3-4 show diagrams of the biological efficiency of the fertilizers "KazUgleGumus" and "Agrarka".

As shown in Figure 3, the most effective dose for all selected parameters was 1.5% of the KazUgleGumus fertilizer. We noted slightly increased annual growth, leaf blade area, and tree trunk thickness.

Table 1. Average values of morphological parameters of *Pýrus ussuriēnsis* L. treated with different fertilizers, n=27

Parameters	Tree height, cm	Trunk thickness, cm	Growth length, cm	Length of large leaf blades, cm	Length of small leaf blades, cm
Treatment with humate	244.7±27.6	24.3±0.5	15.16±1.67	6.7±0.5	2.3±0.5
Treatment with the biopre-paration"Agrarka"	224.28±7.19	23.8±0.1	13.3±0.18	6.1±0.1	1.9±0.1
Control	182.3±34.7	23.1±0.3	12.0±1.48	5.82±0.38	1.7±0.2

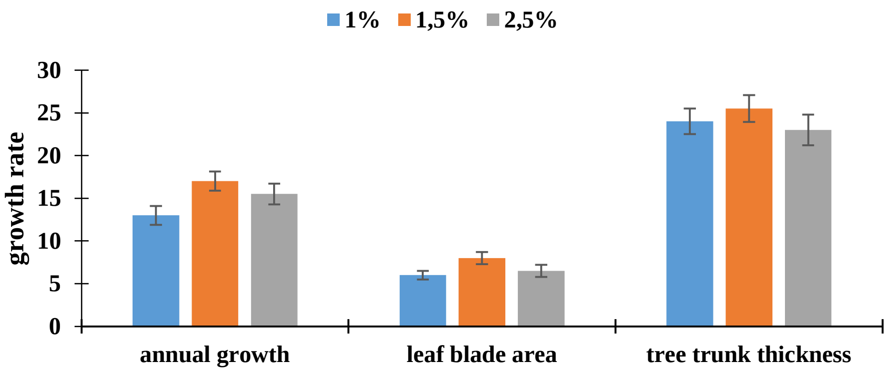

Fig. 4. Effect of "KazUgleGumus" fertilizer doze on the growth parameters of *P. ussuriēnsis* L. trees.

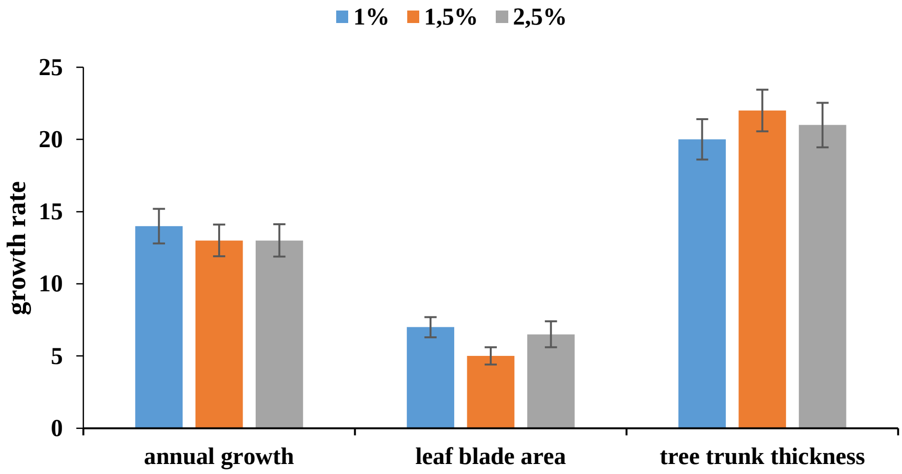

Fig. 5. Effect of the "Agrarka" fertilizer dose on the growth parameters of the P. *ussuriēnsis* L. trees

Fig. 6. External appearance of *Pýrus ussuriēnsis* L. in the fruiting phase.

The Agrarka fertilizer affected the growth and development of tree crowns more than the trunk thickness at a dose of 1% (Figure 4). The trunk increased in thickness at the other two doses of 1.5% and 2.5%.

The conducted preliminary experiment shows that when introducing plants on the territory of the Astana Botanical Garden, it is necessary to conduct a full biocomplex analysis of soils for their agrochemical indicators, for the composition of microbiocenoses. In our experiment, only biologically effective doses of two types of fertilizers of different natures were determined. Fertilizer "KazUgleGumus" is obtained from brown coals and in addition to organic (humic) substances contains many types of mineral elements. Apparently, such a composition had the most effective impact on the parameters considered. The fertilizer "Agrarka" was obtained by processing bird droppings with the addition of a complex of microorganisms. Apparently, the rich organo-mineral composition of "KazUgleGumus" had a greater biological effect on soil processes and the physiology of *Pýrus ussuriēnsis* L. development. Figure 5 shows trees during the period of active fruiting. The fruits began to ripen from the second ten days of August until the end of September. They are slightly oblong or round in shape, approximately 6-8 cm in diameter, with a pleasant smell. The fruits are mostly undamaged. During the fruit ripening phase, pear trees showed leaf chlorosis, indicating an increased content of carbonates in the soil (Bandurko, 2016).

Thus, the study of the biological efficiency of biofertilizers on the growth and development of Pýrus ussuriēnsis L., introduced in the botanical garden of Astana, showed the need for careful care of the plants introduced into the culture.

Of the two types of fertilizers we used, "KazUgleGumus" showed greater efficiency due to its rich content. This organo-mineral fertilizer, obtained by processing brown coal from deposits of Kazakhstan, includes organic humic acids and natural minerals (Ad; Wr; Vd; St; Ct; Ht; Nt; Na; Al; K; Ca; Ti; Fe; Zr).

This result indicates the need to study the physicochemical composition and properties of soils and microbiocenoses on the territory of the botanical garden (Makenova et al., 2023).

Moreover, the determination of the biological efficiency of biofertilizers on the growth and development of *Pýrus ussuriēnsis* L. requires further biocomplex studies.

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