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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ECO-BIOLOGICAL CHARACTERISTICS OF SPECIES OF THE GENUS *PYRUS* L. IN THE NORTHEASTERN PART OF THE GREATER CAUCASUS UNDER *IN SITU* AND *EX SITU* CONDITIONS

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Introduction

Relevance and degree of development of the topic. In the "2017-2020 National Strategy for the Protection and Sustainable Use of Biological Diversity in the Republic of Azerbaijan" approved by the decree of the President of the Republic of Azerbaijan, the protection of flora, repatriation of rare plants, reduction of the impact of the human factor on plants, in specially protected natural areas Tasks such as creating the necessary conditions for conducting scientific research work have been set as a goal[1].

It is known that 467 types of trees and shrubs are naturally distributed in the flora of Azerbaijan, and wild pears make up about 3-5% of these woody plant species. According to recent studies, the areas of 189 species of trees and shrubs in the natural flora of Azerbaijan are shrinking[2]. There are 4 types of pears belonging to the research material among these plant species whose area is shrinking. Eco-biological properties of research materials in ex situ and *in situ* conditions have hardly been studied in comparative conditions. The research and protection of the rare pear species included in the research materials in both cultural and natural conditions are in accordance with today's requirements, have a certain importance and are becoming relevant.

The object and subject of the research. The research objects are *Pyrus* L. species, which is naturally distributed in the northeastern part of the Greater Caucasus. 5 pear species belonging to the *Pyrus* L. genus (*Pyrus communis* L. – Common pear, *Pyrus caucasica* Fed. – Caucasian pear, *Pyrus georgica* Kuth. – Georgian pear, *Pyrus vsevolodii* Heideman – Vsevolod pear, *Pyrus salicifolia* Pall. – Willow-leaf pear). The subject of the study was a comparative study of the eco-biological characteristics of *Pyrus* L. species of the northeastern part of the Greater Caucasus under *in situ* and *ex situ* conditions.

The purpose and tasks of the research. The main purpose of the

[1] Azərbaycan Respublikasında bioloji müxtəlifliyin qorunması və davamlı istifadə¬sinə dair 2017-2020-ci illər Milli Strategiyanın təsdiq edilməsi haqqında [Elektron resurs] /Azərbaycan Respublikasının Prezidentinin sərəncamı. –Bakı, 3 oktyabr 2016. URL: http:/ www.e-qanun.az/framework/33817

[2] Məmmədov, T.S. Azərbaycanın nadir ağac və kol bitkiləri / T.S.Məmmədov, E.O.İsgəndər, T.H.Talıbov. –Bakı: Elm, –2016. –s 3, 197-219.

research work was the comparative study of the eco-biological characteristics of wild pear species common in the northeastern part of the Greater Caucasus under *in situ* and *ex situ* conditions. In this regard, the following tasks have been set:

- Taxonomic composition of wild pear species in the northeastern part of the Greater Caucasus and scientific investigation of their relationship to environmental factors;
- Studying the morphology and viability of pollen of the studied species;
- Study of the growth and development characteristics of the studied plants
- Conducting research on flowering, fruiting characteristics and reproduction of plants under *in situ* and *ex situ* conditions;
- Determining the categories in which they are located based on the criteria of version 3.1 of the IUCN;
- Determining the industrial importance of the investigated wild pear species and the forms of use in greening.

Research methods: Botanical floristic, ecological, mathematical-statistical, visual observation, and laboratory research methods were used during the dissertation work. The coordinates of the research species in natural conditions were carried out with a GPS device, and photos were taken with a Nikon camera. The distribution map of research plants was compiled using ArcGIS 10.5 software.

The main provisions of the dissertation defense:

- According to the condition of the 5 studied wild pear species *in situ,* their eco-biological characteristics and the criteria of the IUCN, 4 species are rare and one of them has the status of Caucasian endemic;
- Proposed theoretical knowledge and practical ideas regarding the revealed attitude of the studied wild pear species to the abiotic, biotic and anthropogenic factors of the ecological environment under *in situ* and *ex situ* conditions, introduction, vegetation, growth-development, ontogenetic and reproduction characteristics;
- Evaluation of the prospect of introduction for the first time according to the vitality indicators of the studied species in *ex situ* conditions;

- Biometric, decorative, etc. of the studied species. determining the possibilities of use based on the indicators.

Scientific novelty of the research. For the first time, the eco-biological and ontogenetic characteristics of 5 wild pear species distributed naturally in the northeastern part of the Greater Caucasus (Azerbaijan) under *in situ* and *ex situ* conditions were studied in a comparative manner.

It was found that research materials were damaged by 11 species of pests, 6 species of pathogenic fungi, and 1 species was infected with bacteria.

Ontogeny is divided into one phenological group in the vegetation of plants in the latent, virginal, reproductive and senile periods and their vegetation period is 236-241 days, depending on the age and growing conditions, virginal and reproductive individuals are included in the same groups according to the growth dynamics, and in the senile period, weakening of generative processes was found.

Plants in *ex situ* conditions were evaluated as high (3 species), medium (2 species) promising species according to their life indicators.

For the first time, pollen morphology and viability were studied comparatively *in situ* and *ex situ*.

Theoretical and practical significance of the research. Since 3 species of the 5 studied taxa are high, and 2 species are promising, the application of the rare species in the research plants in the greening of the cities and towns of the Absheron Peninsula can be the best measure for the protection of those taxa.

One of the most suitable practical measures is to use suitable types of research materials in greening, single planting and group planting.

Approbation and application: Dissertation materials and obtained scientific results were discussed at various scientific symposiums, sessions, all-republic and international level scientific-practical conferences, including, the Republican Scientific Conference dedicated to the 91st birth anniversary of National Leader Heydar Aliyev (Baku, May 7-8, 2014); Conference of Young Scientists and Researchers on Innovation Problems of Modern Biology dedicated to the 91st birth anniversary of Heydar Aliyev (Baku, May 16-17, 2014); Actual problems of biological and chemical ecology, Proceedings of

the IV International Scientific and Practical Conference (Moscow, 2014); Scientific Conference dedicated to the 95th anniversary of Baku State University (Baku, December 10, 2014); Materials of the XI International Symposium (Moscow, 15-19 June 2015); Actual problems of biological and chemical ecology", Proceedings of the V International Scientific and Practical Conference (Moscow, November 21-23, 2016); International scientific conference on Actual problems of contemporary natural sciences (Ganja, May 4-5, 2017); The international conference on Actual problems of contemporary natural and economic sciences (Ganja, May 4-5, 2-18),
The 11th International Conference on Achievements and Challenges in Biology dedicated to the 120th anniversary of Professor Mirali Akhundov (Baku, October 13-14, 2022).

16 works (7 articles and 9 conference materials) were published on the subject of the dissertation. Of them, 2 articles and 3 conference materials were published abroad.

It was decided to include some of the results obtained from the dissertation “Eco-biologıcal characteristıcs of species of the genus *Pyrus* L. in the northeastern part of the Greater Caucasus under *in sıtu* and *ex situ* conditions” in the subject program "Flora and Fauna of Azerbaijan" taught at the undergraduate level of study at the Department of Bioecology, Faculty of Ecology and Soil Science, Baku State University (Excerpt from protocol No. 07 dated 15.07.2020 of Scientific Council of the Faculty).

Personal participation of the author: Field and laboratory research, analysis and generalization of the results of the dissertation were performed by the author.

Organization where the dissertation was performed. Dissertation work was carried out between 2014 and 2020. The dissertation work was carried out at the Department of Bioecology of Baku State University, Institute of Botany and the Central Botanical Garden of ANAS, under natural conditions, in the territories of Khizi (Altiaghaj) and Guba regions.

Volume and structure of the dissertation: The dissertation consists of 184 pages, including an introduction, 6 chapters, conclusions, practical recommendations, and a list of 183bibliography, as well as

a list of abbreviations. There are 1 scheme, 1 map, 1 map scheme, 28 tables, 7 graphs, and 20 figures. The total volume of the work (excluding pictures, tables, graphs, and the bibliography) is 264,927 characters.

CHAPTER I. LITERATURE REVIEW

In this chapter, based on the literature sources, the analysis of the scientific research works related to the study of the genus *Pyrus* L. by local and foreign scientists is given. Thus, from the analysis of literature data, it is clear that the eco-biological characteristics of *Pyrus* L. species under *in situ* and *ex situ* conditions have not been studied in detail.

CHAPTER II. MATERIALS AND METHODS OF THE RESEARCH

2.1. Research material. The research objects are *Pyrus* L. species, which is naturally distributed in the northeastern part of the Greater Caucasus. 5 pear species belonging to the *Pyrus* L. genus (*Pyrus communis* L. – Common pear, *Pyrus caucasica* Fed. – Caucasian pear, *Pyrus georgica* Kuth. – Georgian pear, *Pyrus vsevolodii* Heideman – Vsevolod pear, *Pyrus salicifolia* Pall. – Willow-leaf pear).

2.2. Research Methods. A number of methods were used while performing the research work.

The morphological characteristics of the studied plants were studied based on the method of I.T. Vasilchenko[3], the root system of the species related to the research material, V.A. Kolesnikov[4], and the growth and development of the plants, V.V. Smirnov[5]. Clarification of systematic taxa to the APG (IV) system[6], to the Latin name the

[3] Васильченко, И.Т. Всходы деревьев и кустарников. Определитель / И.Т. Васильченко. -М.: АН СССР, -1960. -301 с.

[4] Колесников, В.А. Методы изучения корневых системы древесных растений / В.А. Колесников. -М.: Лесная промыш., -1971. -152 с.

[5] Смирнов В.В. Сезонный рост главнейших древесных пород. М.: Наука, 1964, 165 с.

[6] APG IV (Angiosperm Phylogeny Group): An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV// Botanical Journal of the Linnean Society, -2016. Vol. 181, Is. 1, -p.1-20.

plant list (2013) database[7], using the revised objective evaluation scale of E.O. Isgandarov[8] has been done to assess the perspective of the introduction of the studied plants in cultural conditions.

While studying the heat resistance of plants, K.A. Akhmatov[9] drought resistance was studied using P.A. Henkel[10] methods. In the comparative study of pollen morphology, Harley's[11] method was used with the help of a light microscope. Granulometric composition of soil samples taken from research areas - N.A. Kachinski[12]; humus - I.V. Tyurin[13]; total nitrogen -Kjeldahl; total phosphorus - Lawrence; total potassium – Smith's method; reaction of the environment - with a pH meter, dry residue by Ivanov's method (according to specific gravity); absorbed bases (Ca+Mg) – D.V. Ivanov method, CO_2-Scheibler method; Carbonation is determined by CO_2[14]. In order to determine the criteria of the studied rare plant species according to the categories of danger, version 3.1 (2001) of the IUCN was taken as a basis[15].

Mathematical statistical calculation of experimental results was

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[7] The Plant List. Version 1.1. Published on the Internet: [Electronic resource] -1st January, 2013. URL: http://www.theplantlist.org.

[8] Искендеров, Э.О. Оценка перспективности интродукции редких и исчезающих древесных видов Кавказа в условиях Апшерона // -Москва: Бюлл. ГБС, -1993. Вып. 168, – с.124-130.

[9] Ахматов, К.А. Полевой метод определения жароустойчивости растений // -Баку: Бюлл. ГБС, -1972. Вып. 86, -с.73-74.

[10] Генкель, П.А. Диагностика засухоустойчивости культурных растений и способы ее повышения (методические указания) / П.А. Генкель. – М.: АН СССР, – 1956. – 69 с.

[11] Harley, M.M. The potential value of pollen morphology as an additional taxonomic character in subtribe *Ociminae (Ocimeae: Nepetoideae: Labiatae).* In Harley RM, Reynolds T eds., Advances in Labiatae Science: Royal Botanic Gardens. Kew, Richmond, Surrey, UK. p. 1992. p-125-138.

[12] Качинский, Н.А. Механический и микроагрегатный состав почвы, методы его изучения / Н.А.Качинский. –Москва: Изд-во Ак. наук СССР, –1958. – 91с., s.100-106.

[13] Практикум по агрохимии / Под ред. В.Г.Минеева. -М.: Изд-во МГУ, –1989. – 304 с., s.39-46; s.56-58.

[14] Аринушкина, Е.В. Руководство по химическому анализу почв / Е.В.Аринушкина. –Москва: Изд-во Московского университета, -1970. -488 с.

[15] IUCN 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission. -IUCN, Gland, Switzerland and Cambridge:–2001.–30 p.

performed using the method by G.N. Zaytsev[16] and N.A. Plokhinsky[17]. The method by M.K. Firsova[18] was used for the reproduction of plants by seeds. The flowering and fruiting features was studied by the method of G.G. Kaper[19]. The H. Walter[20] method was applied to divide plants into ecological groups. The following literature was used as a methodical tool and determinant for the botanical description, identification, and distribution of the studied plants. "Flora of Azerbaijan"[21], "Flora of USSR"[22] and works of Askerov A.M. (2016)[23] were used.

CHAPTER III. NATURAL-ECOLOGICAL CONDITIONS AND MODERN CHARACTERISTICS OF THE RESEARCH AREAS

3.1. Natural-ecological conditions of the research areas.

3.1.1. Natural-ecological conditions of the Absheron area. The total area of the Absheron peninsula is 2110 km2, although it is not very large, it differs in its terrain, various physical and geographical conditions, including climate.

The sub-chapter also provides information on the climate, relief, soil cover and vegetation of the studied area.

Soil cover- Ex situ research in the Central Botanical Garden of ANAS in 2016. Highly cultivated (N40°21'18.1", E49°48'51.0"), cultivated (N40°21'18.0", E49°48'42.0") and poorly cultivated (N41°12'5.65", E48°48'2.54"), 3 cuts were placed under the soil.

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[16] Зайцев, Г.Н. Математическая статистика в экспериментальной ботанике / Г.Н. Зайцев. – М.: Наука, – 1984. – с. 20-43

[17] Плохинский, Н.А. Биометрия / Н.А. Плохинский. – М.: МГУ, –1998. -с.9-14.

[18] Фирсова, М.К. Методы исследования и оценки качества семян / М.К. Фирсова. – М.: Сельхозгиз, – 1955. – 375 с.

[19] Капер, Г.Г. Шкала глазомерной оценки цветение и плодоношения взрослого дерева и кустарника лесные культуры / Г.Г. Капер. -М.: Агропромиздат, -1985. - с.12-20.

[20] Walter, H. Klimadiagram-weltatlas / H. Walter. – Cena: – 1967, – 49 p.

[21] Флора Азербайджана: [в 8 томах] – Баку: Из-во АН Азерб. ССР,Т.5, – 1954, с.37-49

[22] Флора СССР: [в 30 томах]. – М.-Л.: – 1934-1960. Т. III 1954 с.378-414.

[23] Əsgərov, A. M. Azərbaycanın bitki aləmi (Ali bitkilər-Embryophyta) / A. M. Əsgərov,-Bakı : TEAS Press Nəşriyyat evi, -2016-s.228.

According to the results of the laboratory analysis of the samples, the amount of humus in the cultivated layer of highly cultivated soils (AUa 25-45 cm) is 1.48-2.67%, in cultivated gray-brown soils it is 1.38-1.85%, in the weakly cultured version, it varies between 0.44-0.75%. The amount of total nitrogen is 0.07-0.20%; and the ratio of C:N varies in the range of 5.6-7.2, the amount of carbonates is high in the upper layer (16-18%), and a decrease is observed along the profile (9-14%). The mechanical composition of the gray-brown soils of the area, which have been cultivated to different degrees, have a medium granular and sandy character According to the degree of provision of absorbed bases, the highly and medium cultivated gray-brown soils of the Central Botanical Garden are moderately (23.1-23.2 mg-eq), and the poorly cultivated variant is provided to a low extent (15.0-15.7 mg-eq). The amount of Na+ cation in the profile of these soils is 6.5-8.0%, indicating that the soils are fertile.

3.1.2. Natural and ecological conditions of the northeastern part of the Greater Caucasus. This area includes Khachmaz, Guba, Shabran, Gusar, Khizi, Siyazan districts and its area is 7.66 thousand km^2

The sub-chapter also provides information on the climate, relief, soil cover and vegetation of the studied area.

Soil cover- Based on the monograph[24] "Modern soil cover of the Greater Caucasus" prepared by the team of the Institute of Soil Science and Agrochemistry of ANAS (M.P. Babayev, Ch.M. Jafarova, A.M. Jafarov, X.M. Gasimov and others) and the 1:100000 scale soil map, we determined that Pyrus L. species are distributed *in situ* on the northeastern slope of the Greater Caucasus mainly on carbonate mountain-brown, grayish mountain-brown, mountain brown-meadow and mountain gray-brown soils. We placed 4 cuts in Khizi (Altiaghaj str. N40°33'10.60", E48°37'47.04", June 2017) and Guba (Ikinci Nugadi k. N41°18'47.01", E48°35'47.97" 2017, July) mountain-brown grass, in Siyazan (Dağ Gushchu k. N40°59'46.09", E48°57'38.20", 2017, July) and in Shabran (Pirabadil k N41°12'5.65", E48°48'2.54", 2017, August) under mountain-gray-brown soils.

[24] Böyük Qafqazın müasir torpaq örtüyü / Babayev M.P., Cəfərov Ə.M., Cəfərova Ç.M. [və b.] - Bakı: Elm, - 2017. – 188s.

Carbonate mountain-brown soils are mainly distributed at an altitude of 500-800 m, the amount of humus is 1.5-1.7% in the upper layer, the structural composition is granular in the upper layer, nut-like in the lower layers, the granulometric composition is granular and the amount of clay particles are 50-60%. The profile of these soils is completely carbonated, the amount varies between 8-15%. The absorption capacity of carbonate mountain-brown soils is 22-28 mg-equiv, and the pH value is 6.7-8.3.

Steppey mountain-brown soils. The amount of humus in the top layer of these soils is 1.4-1.5%. The amount of carbonates is 16-18%, the reaction of the soil solution (7.0-7.8) is neutral and weakly alkaline. The amount of physical clay in these soils is 30-65%, it has a medium-, heavy granular and clay mechanical composition.

Mountain brown-meadow lands. Spreading in the foothills of the Greater Caucasus, in the Guba-Khachmaz sloping plain, they were formed mainly in hydromorphic conditions. Laboratory analyses revealed that the amount of humus in mountain brown-meadow soils is 2.3-3.2% in the upper layer, and a sharp decrease is observed towards the depth - 0.6%. The amount of total nitrogen is 0.16-0.21% in the upper layer and decreases to 0.10% towards the lower layers, the amount of carbonates is the same throughout the profile, and an increase is observed in the deep layers - 7.0-22.4%. The absorption capacity of mountain brown-meadow soils varies between 18-24 mg-eq on average, and a decrease is observed along the profile. In mountain brown-meadow soils, the reaction of the environment is pH 7.9-8.2 in the upper layers, increasing alkalinity towards the lower layers. Due to their mechanical composition, these soils are medium- and heavy-loamy, and the increase of loamyness is observed towards the depth.

Mountain gray-brown soils. The results of the analysis revealed that although the amount of humus in mountain gray-brown soils is 2.2-3.1% in the upper layer, a strong decrease is observed below 30 cm - 1.2%. The amount of total nitrogen in the top layer is 0.17-0.20% It is noteworthy that these soils are highly carbonated and the illuvial-carbonate layer is located in the deep layers of the soil profile: 13.5-22.7%. The amount of exchanged bases in mountain gray-brown soils

is 17-23 mg - eq. Among the absorbed cations, Ca+2 predominates (9.81-14.4 mg-eq). The mechanical composition of mountain gray-brown soils is clayey and heavy loamy.

3.2. Current ecological status of the research areas. In this subchapter, the modern ecological problems of Absheron and the northeastern part of the Greater Caucasus are described, respectively.

CHAPTER IV. ECOLOGICAL CHARACTERISTICS OF THE STUDIED PLANTS

4.1. Effect of abiotic factors on the studied plants. *Light*– it was determined that all the studied plants are light-loving due to their relationship to light. From the observations, it became clear that the biological development of those plants is retarded in shady places with poor light conditions[25].

Temperature – The effect of daily temperature changes on the plants was studied. The highest temperature was observed at the closest distance to the soil almost before 14-15 o'clock in the afternoon. A decrease in the amount of heat was observed with increasing distance from the earth's surface. When comparing the effect of temperature changes on the plants, it was recorded that the temperature was higher on the surface closest to the soil. Of course, this feature has some differences depending on the species (table 1).

Table 1

Effect of temperature on the studied plant species (July 2017)

№	Species	Height above the ground (trunk)		
		rhizome	medium	top
		Temperature, °C		
1	*Pyrus caucasica* Fed.	31.0±1.5	27.0±1.3	24.0±1.2
2	*Pyrus communis* L.	32.0±1.6	27.0±1.3	25.0±1.3
3	*Pyrus georgica* Kuth.	32.0±1.6	27.0±1.3	25.0±1.2
4	*Pyrus vsevolodii* Heideman	33.0±1.6	28.0±1.4	26.0±1.3
5	*Pyrus salicifolia* Pall.	33.0±1.6	29.0±1.4	27.0±1.3

[25] Cəfərzadə, S.A Ekoloji amillərin bitki örtüyünə təsiri // Heydər Əliyevin anadan olmasının 91-ci il dönümünə həsr olunmuş Gənc Alimlərin və Tədqiqatçıların "Müasir Biologiyanın İnnovasiya Problemləri" mövzusunda IV Beynəlxalq Elmi Konfransın materialları, -2014. -s.165-166.

Our observations have shown that, depending on the species, the temperature at the height from the soil surface to the top of the plant is 7-9°C lower than the area near the soil surface.

In July 2017, when we conducted the research, the temperature indicator was in the range of 36-42°C, so it was found that burns appeared on the leaves. It was clear from experience that the leaves of plants are damaged by heat in the range of 52-54°C. General results showed that the heat resistance feature of plants is related to their individual biological characteristics. As a result of the conducted experiments, they were divided into 2 groups according to the heat resistance of the leaves of the studied plants. (table 2).

Table 2. Lethal effect of heat on the leaves of the studied plants

№	Species	Temperature, °C
1	*Pyrus caucasica* Fed.	52.0±2.6
2	*Pyrus communis* L.	52.0±2.6
3	*Pyrus georgica* Kuth.	52.0±2.6
4	*Pyrus vsevolodii* Heideman	54.0±2.7
5	*Pyrus salicifolia* Pall.	54.0±2.7

Humidity- It was found that 2 xerophytic species - *Pyrus vsevolodii* Heideman, *Pyrus salicifolia* Pall. - were included in the group with low water needs. As a result of our observations, it became clear that these plants grow and develop normally in arid regions. Experiments have shown that *Pyrus georgica* Kuth. is a xeromesophyte, and *Pyrus caucasica* Fed. is a mesoxerophyte. 1 species of the studied plants - *Pyrus communis* L. mesophyte belongs to the group living in moderately humid places.

Edaphic and orographic factors – As a result of the influence of environmental factors, a certain part of the soil of the research area has been subjected to erosion. Temperature and annual rainfall were mainly affected by irregular grazing, rainfall and other factors. It has become clear from our studies that the relief did not have much effect on the reduction of their areas within the research objects. However, weather conditions, which are an environmental factor, and the

general climate variations associated with it, naturally create conditions for the displacement of vegetation cover.

4.2. The attitude of plants belonging to the research object to biotic factors. During the research, 11 species of pests, 6 species of pathogenic fungi and one species of bacterial cancer were observed in the studied plants under natural and cultural conditions[26].

4.3. The attitude of plants belonging to the research object to anthropogenic factors. In general, the forest areas in the mountainous regions of Azerbaijan continue to be destroyed almost due to human activities**.** This happens mostly in forest areas in the upper mountain belt. As a result of the observations, it can be said that in places where anthropogenic influences are strong, the forest is replaced by bush- type vegetation. Thus, people's illegal cutting of plants, complete collection of its fruits, overgrazing of that area with cattle, expansion of agricultural areas, construction of new settlements, fires, etc. works lead to the reduction of the generation of pear species, which are research material, to the plant world. The conducted studies have proven once again that the main factor causing the reduction of plant areas is a man.

CHAPTER V. INTRODUCTION AND BIOLOGICAL CHARACTERISTICS OF THE PLANTS STUDIED

5.1. A brief history of the introduction of the studied plants. While researching the introduction history of Absheron, it was found that in addition to decorative trees and shrubs, 460 types of plants were cultivated in Baku and its surrounding villages at the beginning of the 20th century. Among these plants, pear species have a special place. Guba, Gusar, Shabran, Khizi, Siyazan, etc. located in the northeastern part of the Greater Caucasus. there are many introduced species adapted to local conditions in the regions, and many of them adapt to local conditions and continue their development normally. The plants brought to the new environment quickly or gradually

[26] Abbasova, S.A., Məmmədova, G.T., İsgəndər, E.O. Böyük Qafqazın şimal-şərq hissəsində yayılmış *Pyrus* L. cinsinə aid növlərdə zərərverici və xəstəlik törədicilər // "Müasir Təbiət Elmlərinin Aktual problemləri" Beynəlxalq elmi konfransı, -Bakı: -2017, -s.65-68.

changed their nature without human influence and adapted to the new environment[27].

5.2. Study of biological properties of research materials under *in situ* and *ex situ* conditions. 5 species of the genus *Pyrus* L. are distributed in the northeastern part of the Greater Caucasus. This subchapter describes the biological characteristics of each species included in the genus *Pyrus* L.

In the table below, the natural distribution areas of the *Pyrus* L. species studied in the northeastern part of the Greater Caucasus and their coordinates determined by GPS device are listed (table 3).

5.2.1. Ontogenetic characteristics of the studied plants. While studying the ontogenetic characteristics of the studied plants, their complete life cycle is divided into 4 periods (latent, virginal, reproductive, and senile periods). When studying the x-ray morphological structure and characteristics of the seeds of the studied plants, it was found that there is no free endosperm in the seed cavity. From our research, it has been found that the quality indicators of the seeds *in situ* conditions are relatively high when compared to the quality indicators of the seeds formed in both cultural and natural conditions[28].

5.2.2. Propagation of studied plants. Seeds collected in natural conditions as well as from plants introduced in Absheron (Central Botanical Garden) were sown in open and closed places during autumn and spring months.

The average percentage of germination given by the seeds of the researched plant species was known from the results of the conducted experimental works.

The conducted analyses showed that the highest percentage of germination under ex situ conditions among the species studied for reproduction by seeds is *Pyrus salicifolia* Pall. (86%).

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[27] Cəfərzadə, S.A. Böyük Qafqazın şimal-şərq hissəsində ağac bitkilərin introduksiyası // Bakı Dövlət Universitetinin 95 illik yubileyinə həsr olunmuş Elmi Konfransın Materialları, -2014. -s.93-94.

[28] Abbasova, S.A., İsgəndər, E.O., Nəcəfova, C.N. Azərbaycanda Böyük Qafqazın şimal-şərq hissəsinin *Pyrus* L. cinsinə aid növlərin ontogenetik xüsusiyyətləri // -Bakı: AMEA Mərkəzi Nəbatat Bağının Elmi əsərləri, -2015. XIII cild, -s.105-108.

Table 3. Distribution areas and coordinates of the studied species (http://www.theplantlist.org).

№	Latin name of the species	Azerbaijani name of the spcies	Distribution areas	Coordinates	
1.	*Pyrus communis* L.	Common pear	Khizi r., Dizavar v.	N40°48'10.10"	E49°7'41.50"
			Gusar r., Yasab v.	N41°28'20.59"	E48°17'29.93"
			Gusar r., Hil v.	N41°26'19.06"	E48°20'2.59"
			Gusar r., Mujug v.	N41°28'15.84"	E48°13'40.20"
			Guba r., Digah v.	N41°24'26.28"	E48°29'39.00"
2.	*Pyrus caucasica* Fed.	Caucasus pear	Khizi r., Altiaghaj settl.	N40°33'10.60"	E48°37'47.04"
			Khizi r., Dizavar v.	N40°47'56.56"	E49°8'7.65"
			Guba r., Alpan k	N41°22'21.84"	E48°24'1.48"
			Guba r., Digah k	N41°22'53.27"	E48°27'57.86"
			Gusar r., Hazra v.	N41°29'36.20"	E48°14'58.68"
			Shabran rn, Pirabadil v.	N41°12'18.04"	E48°48'30.39"
			Gusar r., Mujug v.	N41°29'7.84"	E48°14'30.29"
3.	*Pyrus georgica* Kuth.	Georgian pear	Khizi r, Altiaghaj settl.	N40°55'38.82"	E49°0'49.22"
			Guba r., Ikinji Nughadi v.	N41°18'47.01"	E48°35'47.97"
			Guba r., Alpan v.	N41°23'47.26"	E48°24'58.83"
			Gusar r., Hazra v.	N41°30'52.84"	E48°16'11.06"
			Shabran r., Pirabadil v.	N41°12'5.65"	E48°48'2.54"
			Shabran r., Dagh Biliji v.	N41°13'9.45"	E48°50'46.84"
4.	*Pyrus vsevolodii* Heideman	Vsevolod pear	Khizi r, Altiaghaj settl.	N40°54'1.71"	E48°57'58.75"
			Siyazan r., Dagh Gushchu	N40°59'46.09	E48°57'38.20"
			Siyazan r., Sadan v.	N41°3'33.98"	E49°1'54.63"
			Khachmaz, Hajialibay v.	N41°24'29.49"	E48°41'4.53"
5.	*Pyrus salicifolia* Pall.	Willowleaf pear	Khizi r, Altiaghaj settl.	N40°52'37.30"	E48°55'24.16"
			Guba r., Ikinji Nughadi v.	N41°18'48.65"	E48°35'47.58"
			Gusar r., Hil v.	N41°26'50.76"	E48°19'37.70"
			Khachmaz r., Hajialibay v	N41°24'14.43"	E48°41'47.20"
			Siyazan r., Sadan v.	N41°3'19.56"	E49°2'13.94"

As a result of the research work, it was found that the percentage of germination from seeds of the studied plants in both conditions was between 57-86%.

The lowest germination percentage (57%) was found to be *Pyrus vsevolodii* Heideman, whose seeds were sown *in situ*[29].

During the research carried out by us, the morphometric indicators of the kernel leaves were determined. The results of the measurements showed that the length of the pith leaf varies between 8-13 mm in the studied pear species. The results of phenological observations showed that hypocotyl germination is observed in all the studied species (picture 1).

Picture 1. Seedlings of studied plants under greenhouse conditions

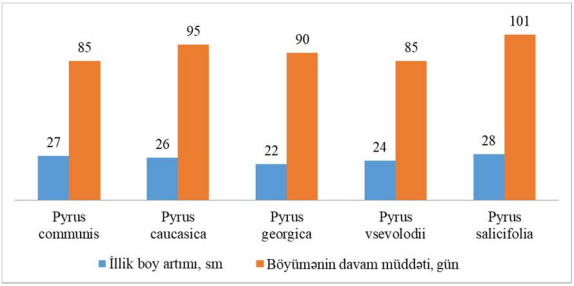
The conducted studies have shown that the main difference between the morphological structure of the sprouts of the seeds collected from the *ex situ* and *in situ* conditions of the seeds. There is no difference. During the next period of germination, some slight changes in the shape of vegetative organs were observed in some species compared to *in situ* conditions. These changes are related to the difference of climatic factors existing in two different conditions[30].

[29] Abbasova, S.A. Böyük Qafqazın şimal-şərq hissəsində yayılmış *Pyrus* L. cinsinə aid növlərin çoxaldılması // -Bakı: AMEA Mərkəzi Nəbatat Bağının Elmi əsərləri, -2016. XIV cild, -s.185-189.

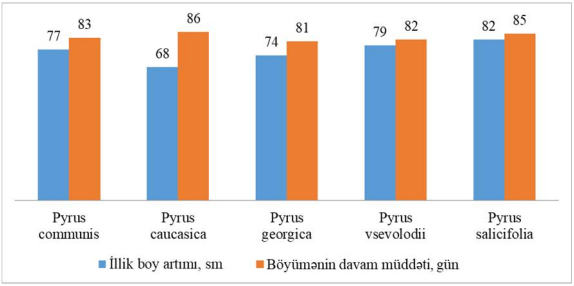
[30] Abbasova, S.A., İsgəndər, E.O. Böyük Qafqazın şimal-şərq hissəsində yayılmış *Pyrus* L. növləri cücərtilərinin morfologiyası // -Bakı: AMEA Mərkəzi Nəbatat Bağının Elmi əsərləri, -2018. XVI cild, -s.121-126.

5.3. Growth and development characteristics of the studied plants under *in situ* and *ex situ* conditions. The maximum height of the one-year-old plants under in *ex situ* conditions was observed in *Pyrus salicifolia* Pall. (28 cm). The duration of growth in this species was 101 days[31]. *Pyrus georgica* Kuth. (22 cm) was observed to grow the least, and it was determined that the growth lasted 90 days (graph 1).

General analyzes showed that height growth in the studied species was 22-28 cm in one-year seedlings. It was observed between 68-82 cm in two-year-old tochmagyars (graph 2).



Graph 1. Growth dynamics of one-year-old seedlings under *ex situ* conditions



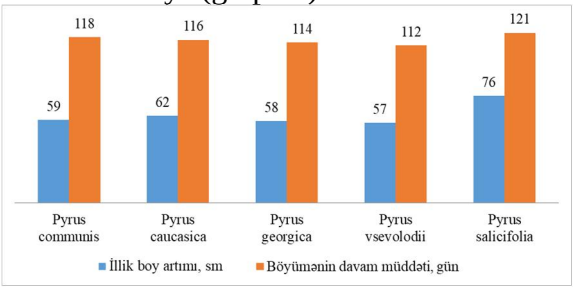
Graph 2. Growth dynamics of two-year-old seedlings under *ex situ* conditions

During the study, the annual height growth among three-year-old sedges studied under *ex situ* conditions was observed in the weakest *Pyrus vsevolodii* Heideman (57 cm), and the highest in the *Pyrus salicifolia* Pall. (76 cm) (graph 3).

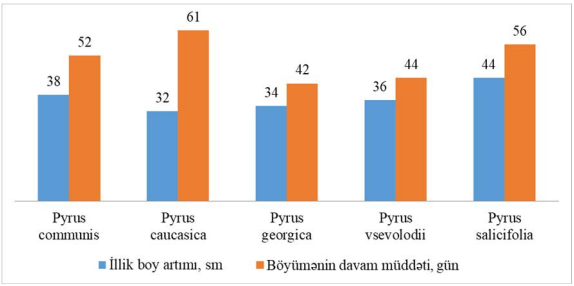
In three-year seedlings, it was determined that the duration of

[31] Аббасова, С.А Изучение роста и развития видов *Pyrus* L. в условиях *ex situ* на Северо-Востоке Большого Кавказа // -Нижневартовск: Бюллетень науки и практики, -2019. Том 5, №12, -с.111-118.

vegetation is 112-121 days, depending on the species, and in perennial plants, between 42-61 days (graph 4)



Graph 3. Growth dynamics of three-year plants under *ex situ* conditions



Graph 4. Growth dynamics of perennial plants under *ex situ* conditions

5.3.1. Flowering and fruiting characteristics of plants studied under *in situ* and *ex situ* conditions. As can be seen, the studied plant species bloom at the age of 6-7 years in cultivated conditions, and between 8-11 years in natural conditions.

During the research, it became clear that the age of entering the flowering and fruiting phase in the studied plant species under *in situ* conditions starts 2-4 years later than under *ex situ* conditions, depending on the species[32].

The results of the analyzes showed that among the studied species, the lowest fruit storage capacity under *ex situ* conditions was found in *Pyrus communis* L. (11%) and *Pyrus caucasica* Fed. (11%), and the

[32] Abbasova, S.A., Novruzov, V.M., Abasova, T.S, İskender, E.O. The characteristics of flowering in *in situ* and *ex situ* condition of species *Pyrus* L. gender of north-eastern part of the Greater Caucasus // -Baku: PANAS Proceedings of the Azerbaijan National Academy of Sciences (Biological and Medical Sciences), -2017. Vol. 72, Num.3, -p.162-165.

highest 14% in *Pyrus salicifolia* Pall. and *Pyrus georgica* Kuth. (14%). Types have been determined. *In situ* conditions, the lowest fruit storage capacity was found in *Pyrus communis* L. and *Pyrus caucasica* Fed. species (14%), and the highest in *Pyrus salicifolia* Pall. species (22%). It was clear that plants under *in situ* conditions compared to *ex situ* 3-8% have higher fruit retention (table 4).

Table 4. Fruiting characteristics of species of the genus *Pyrus L.* in the northeastern part of the Greater Caucasus under *ex situ* and *in situ* conditions

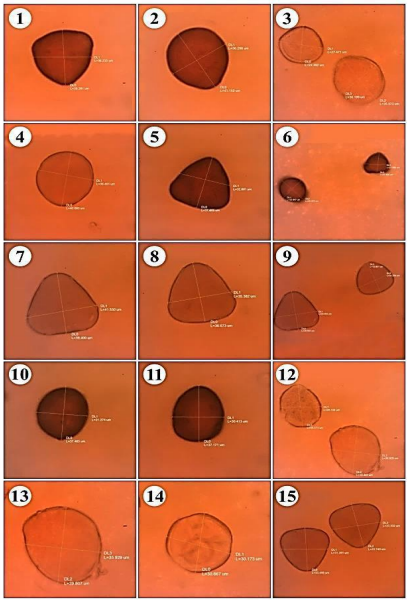
№	Species	The number of bloomed flowers per plant	The number of fruit		Fruit ripening time	The number of bloomed flowers per plant	The number of fruit		Fruit ripening time
			piece	%			piece	%	
		ex situ				*in situ*			
1.	*Pyrus communis* L.	1331	141	11%	11.09	1350	186	14%	25.09
2.	*Pyrus caucasica* Fed.	1120	122	11%	25.09	1225	167	14%	12.10
3.	*Pyrus georgica* Kuth.	1296	143	14%	21.09	1571	235	15%	08.10
4.	*Pyrus vsevolodii* Heideman	1227	139	12%	20.09	1235	187	15%	06.10
5.	*Pyrus salicifolia* Pall.	2122	297	14%	08.09	2225	511	22%	18.09

According to the research results, depending on the botanical-geographical location of the plants that are spread almost under natural conditions, the ripening of the fruit in the pear varieties is delayed by 10-17 days. Thus, while studying the flowering and fruiting characteristics of the species growing under both *in situ* and *ex situ* conditions, it was found that the species of the genus *Pyrus* L. distributed in the north-eastern part of the Greater Caucasus, bloom and bear fruit normally both under *ex situ* and *in situ* conditions.

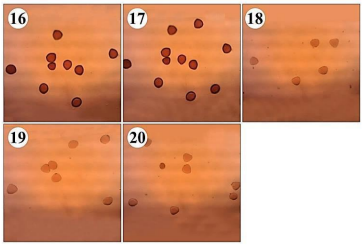
From here it can be concluded that the narrowing of the range of

the studied rare species belonging to the genus *Pyrus* L. depends more on anthropogenic factors than on their biological characteristics[33].

5.3.2. Pollen morphology and viability of studied species. In the study, pollen from 5 common pear species in the northeastern part of the Greater Caucasus was collected under *ex situ* and *in situ* conditions. Pollen morphology and viability were studied using a Humo Scope microscope, photographs were taken with an AM 7023 Dino-Eye microscope camera. The morphometric measurements of the pollen of the studied species and their appearance under light microscopes are shown in picture 2, and the vitality indicators are reflected in picture 3.



Picture 2. Morphometric parameters of the *Pyrus* L. species seedlings images under *ex situ* conditions: 1-3 – *Pyrus caucasica*; 4-6 – *P. communis;* 7-9 – *P. vsevolodii*; 10-12 – *P. georgica;* 13-15 – *P. salicifolia*



Picture 3. Vitality indicators of the *Pyrus* L. species seedlings under *ex situ* conditions: 16 – *Pyrus vsevolodii;* 17 – *P.caucasica;* 18 – *P.georgica;* 19 – *P.communis;* 20- *P. salicifolia*

[33] Abbasova, S.A, İgəndər, E.O. Böyük Qafqazın şimal-şərq hissəsində yayılmış *Pyrus* L. cinsi növlərinin *in situ* və *ex situ* şəraitlərində meyvəvermə xüsusiyyətləri // AR Təhsil Nazirliyi NDU Elmi əsərlər, Təbiət və Tibb elmləri seriyası, -2020. № 3, -s.71-75.

The conducted analyses showed that, depending on the species, the fertility of the pollen of the studied species under *ex situ* conditions varied between 72-86%. As a result of the conducted analysis, it was found that *Pyrus georgica* Kuth. (72%) and *Pyrus communis* L. (73%) had the lowest pollen viability among the studied species, while the pollen viability of *Pyrus vsevolodii* Heideman (86%) was the highest. Other species had taken an intermediate position[34].

As can be seen from tables 5 and 6, the morphometric indicators of the pollen of the studied pear species under *ex situ* and *in situ* conditions show differences from each other in terms of both equatorial and polar dimensions.

Table 5. Morphological parameters of pollens of species belonging to the genus *Pyrus L.* under *ex situ* conditions

№	Species	Morphometric indicators (μm)		Pollen vitality
		equatorial	polar	%
1	*Pyrus communis* L.	21.98–40.09	20.40-36.45	73
2	*Pyrus caucasica* Fed.	27.47–41.15	24.49–36.29	82
3	*Pyrus georgica* Kuth.	32.17–39.80	29.10–37.46	72
4	*Pyrus vsevolodii* Heideman	34.25–41.53	33.85–39.69	86
5	*Pyrus salicifolia* Pall.	27.99–39.80	25.48–35.92	78

Table 6. Morphological parameters of pollens of species belonging to the genus *Pyrus L.* under *in situ* conditions

№	Species	Morphometric indicators (μm)		Pollen vitality
		equatorial	polar	%
1	*Pyrus communis* L.	24,12–44,11	27,12–39,45	76
2	*Pyrus caucasica* Fed.	28,32–41,52	29,25–39,67	84
3	*Pyrus georgica* Kuth.	39,15–42,56	34,17–41,12	74
4	*Pyrus vsevolodii* Heideman	37,23–47,11	35,24–43,65	89
5	*Pyrus salicifolia* Pall.	29,34–43,45	28,45–38,57	81

[34] Аббасова, С.А Морфология и жизнеспособность пыльцы рода *Pyrus* L. *ex situ* в Северо-Восточной части Большого Кавказа // -Нижневартовск: Бюллетень науки и практики, -2019. Том 5, №12, -с.14-18.

As a result of general microscopic analysis and mathematical calculations, it was found that the difference between the morphometric indicators of the studied species (equatorial, polar) is not so great. Thus, from the conclusion of the conducted research, it was concluded that environmental conditions can change the viability of pollen.

CHAPTER VI. ASSESSMENT AND SIGNIFICANCE OF THE THREAT CATEGORIES OF IUCN FROM THE PERSPECTIVE OF THE PLANTS STUDIED

6.1. The prospect of the introduction of the studied species. E.O. Isgandarov's scale[35] was used during the evaluation of the prospects of tree and shrub plants introduced to *ex situ* conditions (Absheron).

Group I: Perspective plants (3 species) – *Pyrus salicifolia* Pall., *Pyrus georgica* Kuth., *Pyrus vsevolodii* Heideman are the most drought-resistant plants in both natural and cultivated conditions. *Pyrus georgica* Kuth. was included in the group of young plants due to its young age (9 years). From this point of view, this species has a high degree of perspective. In our opinion, this species would receive a low perspective rating due to the indicators of old plants. The other 2 studied species (*Pyrus communis* L., *Pyrus caucasica* Fed.) were included in the II group (perspective) because they scored 87 points according to the life indicators (table 7).

6.2. Danger categories of studied rare pear species. Threat categories of rare pear species distributed in the northeastern part of the Greater Caucasus studied in the research study are 3.1 of the IUCN (2001) was evaluated by categories. From the analysis of the classification of taxa, it was clear that 2 out of 4 species were included in the VU (vulnerable species) category, and 2 species were included in the NT (near threatened) category. It can be concluded that the rare

[35] Искендеров, Э.О. Оценка перспективности интродукции редких и исчезающих древесных видов Кавказа в условиях Апшерона // -Москва: Бюлл. ГБС, -1993. Вып. 168, – с.124-130.

pear species spread in the research area need protection[36].

Table 7. Evaluation of the prospects of pear species studied under cultural conditions according to the vitality indicators

№	Species	Life form	Plant age, year	Vitality indicators							General assessment	
		Cultural condit.		Lignification	Drought tolerance	Cold tolerance	Maintenance of	Shoot formation	Growth	Generative	Propagation in	Sum of vitality indicators	perspectivity group
1	*Pyrus communis* L.	A	48	20	10	10	5	5	5	25	7	87	II
2	*Pyrus caucasica* Fed.	A	55	20	10	10	5	5	5	25	7	87	II
3	*Pyrus georgica* Kuth.	A	9	20	10	10	5	5	5	25	5	86	I
4	*Pyrus vsevolodii* Heideman	A	8	20	20	10	5	5	5	25	5	95	I
5	*Pyrus salicifolia* Pall.	A	45	20	20	10	5	5	5	25	7	97	I

6.3. Industrial importance of studied wild pear species and forms of use in greening. The researched wild pear species are used in various fields of industry. Various organs of the studied pear species contain a number of biological compounds, including proteins 0.4%, carbohydrates 10.7%, and sugars 9%. The leaves of these plants contain a large amount of arbutin (1.4-3.0%), hydroquinone, flavonoid (10-20 times more than the fruits)[37].

Due to their resistance to local soil and climate conditions, it was determined that the studied wild pear species can be used in 2 out of 6 forms of greening (single planting, group planting).

[36] Jafarzadeh S.A. Dangerous categories of *Pyrus* L. species of the north-eastern part of Greater Caucasus// 11th International conference achievements and challenges in Biology devoted to 120 TH anniversary of professor Mirali Akhundov, Baku State University October 13-14, 2022,- p.326-327.

[37] Новрузов, Э.Н. Флавоноиды репродуктивных органов некоторых растений флоры Азербайджана // Изв. НАН Азербайджана, сер. биол. наук,- 2004, №3-4,-с. 16-28.

CONCLUSION

1. All studied wild pear types are light-loving (5 species), high (2 species), medium (3 species) resistant to heat; According to the relationship to water, the ecological groups are mesophytes (1 species), xerophytes (2 species), mesoxerophytes (1 species), and xeromesophytes (1 species).
2. It was determined that the vegetation of plants in the latent, virginal, reproductive and senile periods of ontogenesis is divided into 1 phenological group and their vegetation period is 236-241 days. Depending on the age and termination conditions, virginal and reproductive individuals are included in the same groups in terms of growth dynamics, and in the senile period, the weakening of generative processes was found.
3. For the successful introduction of the studied wild pear species in *ex situ* conditions, taking into account the phylogeny of the introducers *in situ* conditions, collecting and mobilizing planting and sowing material from individuals with different genotypic and phenotypic indications *in situ* conditions was considered more appropriate.
4. Research materials were found to be damaged by 11 species of pests, 6 species of pathogenic fungi and 1 species of bacteria.
5. Plants under *ex situ* conditions were evaluated as high (3 species), medium (2 species), and promising species according to their life indicators. Generative reproduction methods were developed and 4 species were found to be rare and 1 species endemic to the Caucasus, based on the criteria of the danger of the IUCN.
6. According to the phytogeographic region, it was determined that the 5 wild pear species studied are elements of the Iran-Turan phytogeographical region.
7. When studying the directions of use of research materials in greening, it is possible to grow all taxa in the form of single and group plantings, but it is impossible to use them to create border, living fence, container and topiary forms, it has been determined due to their industrial importance, all species are food and honey-

bearing medicinal, essential oil and ornamental plant.

PRACTICAL RECOMMENDATIONS

1. Among the studied plants, plant species included in the I-II perspective group can be widely used in greening works in Absheron and Azerbaijan regions, and the use of these plants in greening works would be the best measure for the protection of those taxa.
2. The use of single planting and group planting in the greening of suitable types of research materials can be one of the most suitable practical measures.
3. Among the studied species, they are used in various fields of the national economy, including the preparation of medicinal preparations, culinary, cosmetology, food, etc. widespread use in places is considered one of the appropriate measures.
4. It would be the best measure to strengthen the protection of these "rare plant" species by creating a reserve for *Pyrus caucasica* Fed., *Pyrus georgica* Kuth., *Pyrus vsevolodii* Heideman, *Pyrus salicifolia* Pall. in Altiaghaj, which is the territory of the Khizi region.

LIST OF PUBLISHED SCIENTIFIC WORKS ON THE TOPIC OF THE DISSERTATION

1. Cəfərzadə, S.A. Ətraf mühitin mühafizəsində bioekoloji tədqiqatlar // Ümummilli lider Heydər Əliyevin anadan olmasının 91 illik yubiliyenə həsr olunmuş Respublika Elmi Konfransı, 7-8 may,2014, -s.149-150.
2. Cəfərzadə, S.A. Ekoloji amillərin bitki örtüyünə təsiri // Heydər Əliyevin anadan olmasının 91-ci il dönümünə həsr olunmuş Gənc Alimlərin və Tədqiqatçıların “Müasir Biologiyanın İnnovasiya Problemləri” mövzusunda IV Beynəlxalq Elmi Konfransın materialları, 16-17 may -2014. -s.165-166.

3. Искендер, Э.О., Джафарзаде, С.А., Багирова, Г.Г., Алиева, ГА., Гулиева, Г.Г. Охрана редких древесных видов флоры Азербайджана // Сборник материалов IV Международной научно–практической конференции «Актуальные проблемы биологической и химической экологии», -Баку, 4-5 декабря, 2014, -с.27-30.
4. Cəfərzadə, S.A. Böyük Qafqazın şimal-şərq hissəsində ağac bitkilərin introduksiyası // Bakı Dövlət Universitetinin 95 illik yubileyinə həsr olunmuş Elmi Konfransın Materialları,-10 dekabr -2014, -s.93-94.
5. Искендер, Э.О., Велиева, Л.П., Аббасов, Р.М., Багирова, Г.Г., Джафарзаде, С.А. Редкие растения флоры Азербайджана в озеленении г. Баку // Материалы XI Международного симпозиума «Новые и нетрадиционные растения и перспективы их использования», -Пущино, 15-19 июня-2015, -с.47-48.
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