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Abstract

of the dissertation for the degree of doctor of philosophy

INVESTIGATION OF SOME TAXA OF *CHAMAECYPARIS* SPACH. AND *THUJA* L. GENERA, THEIR BIOECOLOGICAL PROPERTIES AND USE IN LANDSCAPE ARCHITECTURE IN THE ABSHERON PENINSULA

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INTRODUCTION

Relevance and degree of completion of the topic. Because of the increase in the scale of construction in the cities and settlements of our country, there is a great need for renovation, which is part of modern construction complexes. One of the important factors in the creation of landscape architecture is the selection of adaptable ornamental plants to improve the environment and normalize the human habitat.

Currently, various plant species (*Chamaecyparis lawsoniana, Chamaecyparis nutkatensis, Thuja occidentalis, Thuja plicata,* etc.) and forms of these species are widely used in the landscaping of many parks, gardens, and facilities. Although research plants are widely used in cold climate zones of some countries, in hot regions, including Azerbaijan, species and varieties of the *Chamaecyparis* Spach. and *Thuja* L. genera have not been studied yet. From this point of view, a comprehensive study of the bioecological characteristics of the studied plant species, identification of opportunities for their introduction and use, and assessment of their prospects are in line with today's requirements and have a certain relevance.

A number of scientists studied biology, diseases, and hot tolerance, photoperiodism, the water-holding capacity of the species of the *Chamaecyparis* Spach. and *Thuja* L. genera, decorative indicators of species used in landscape architecture, possibilities of ecological and physiological adaptation, medical significance, seed quality, fruiting, and pigments in reproductive organs[1, 2, 3].

However, the possibilities of using species and varieties of research material in landscape architecture in Azerbaijan, the origin and

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[1] Сарбаева, Е.В., Воскресенский, О.Л., Воскресенский, В.С. Оценка устойчивости древесно-кустарниковых растений в урбанизированной среде // ж. Современные проблемы науки и образования –2013. –№ 2, – с.421-429.

[2] Савушкина, И.Г., Сеит-Аблаева, С.С., Сейтбуллаева, Э.Ж. Методика оценки декоративности садовых форм туи западной *(Thuja occidentalis* L.*)* // Биология, Химия. –2018, 4 (70). –№ 4, –с. 180-195.

[3] Məmmədov, T.S. Azərbaycanın dendroflorası. Çılpaqtoxumlular şöbəsi (*Gymnospermae, Pinophyta*), I cild./T.S.Məmmədov– Bakı: Elm, – 2011. – 310 s.

agrobiological characteristics of the studied taxa, resistance to diseases and pests, bioecological and adaptation features under Absheron conditions, perspective and economic importance in terms of life indicators have not been studied comprehensively. In this regard, the research topic is relevant and meets today's requirements.

The object and subject of the research. Objects of the dissertation work were 3 species (*Chamaecyparis lawsoniana* (A.Murray) Parl., *Thuja occidentalis L.*, *Thuja plicata L.*) of the *Chamaecyparis* Spach. and *Thuja* L. genera, and 22 varieties and forms of these species.

The subject of the work was to study the biological and adaptive properties of research material used under *ex situ* conditions, the possibilities of their use in landscape architecture, the role of environmental factors affecting them, and to assess their perspective in terms of life indicators.

Purpose and tasks of the research. The main purpose of the research was to determine the taxonomic composition of taxa belonging to the *Chamaecyparis* Spach. and *Thuja* L. genera used for landscaping in the Absheron Peninsula, to study the possibilities of use in landscape architecture and determine the prospects of introduction by comprehensively studying the eco-biological characteristics of plants under study.

In this regard, the following tasks have been set:

- Investigation and determination of the taxonomic composition of species belonging to the *Chamaecyparis* Spach. and *Thuja* L. genera used in the research regions;
- Analysis of biological and ecological characteristics of the studied species and assessment of adaptation potential;
- Assessment of the perspectives of woody plants used in the landscaping of the Absheron peninsula based on life indicators of the plants;
- Identification of the opportunities for the use of the studied plants in landscape architecture and preparation of necessary recommendations for its implementation;
- Research on biological characteristics of species of economic importance, which allows determining the quantitative and qualitative indicators under the conditions of introduction;

- Assessment of the studied species by determining their tolerance to fungal diseases such as *Botrytis cinerea, Lophodermium pinastri* and *Phomopsis juniperovora*, pests, wind, and drought;
- Assessment of the main decorative indicators of the studied plants, selection of perspective taxa and determination of directions of their use in landscaping works;
- Determination of the main forms of use of the taxa studied under Absheron conditions in landscape architecture.

Research methods. The methodology for a comprehensive study for the use of bioecological features of species and varieties belonging to the genus *Chamaecyparis* Spach. and *Thuja* L. in the landscape architecture under the conditions of Absheron is based on the principle of a complex study of the taxa. During the research, biomorphological, phenological, growth, developmental and decorative features, reproduction, prospects, life forms, and ecological sustainability of the studied plants were assessed and mathematical methods of statistics were used.

Main points presented to the defense of the dissertation:

For the first time, theoretical knowledge was obtained about the response of the taxa of the *Chamaecyparis* and *Thuja* species to abiotic, biotic, and anthropogenic factors of the Absheron ecological conditions, their introduction and features during all stages of their life and practical recommendations were made;

- Determining the use opportunities of the studied species in the Absheron Peninsula;
- Determination opportunity of the degree of accuracy of the results obtained by the author using statistical methods;
- Acceptance of practical recommendations reflecting the main results of the research in the dissertation;
- Determining the possibilities of using the studied species in landscaping, taking into account the biometric and decorative indicators;
- For the first time, prospects of plants used in landscaping were assessed in terms of life indicators;
- Detection of pests and pathogens on the studied plants.

Scientific novelty of the research. For the first time in the Absheron peninsula, the growth and development of *Chamaecyparis lawsoniana* and *Thuja occidentalis* species were studied, *Chamaecyparis lawsoniana* taxon was found to occur between 3281°C and 4356°C, at over 10°C of the sum of active temperatures, which causes the prolongation of the plant active vegetation period.

Depending on the climatic conditions of the year, *Thuja occidentalis* was found to start vegetation in the second decade of February. The average sum of active temperatures was 141°C, the average vegetation period was 295 days and relative dormancy amounted to 67 days.

For the first time, we studied the growth characteristics and revealed 3 developmental stages for the *Chamaecyparis lawsoniana, Thuja occidentalis* and *Thuja plicata* species: a) Intensive growth of the plant is close in time to the phenophase of "sprout growth onset" and this process took place between the II and III decades of March and the III decade of May; b) the growth of sprouts began in the second decade of March and the continued until September; c) it was found that the growth of the sprout in the studied taxa lasted to the end of August and sometimes until the end of September depending on the climatic conditions.

The drought tolerance of taxa of 3 species (*Chamaecyparis lawsoniana, Thuja occidentalis, Thuja plicata)* was studied for the first time, and it was found that the taxon that loses more water is less tolerant to drought, i.e. water evaporation coefficient of the plant is inversely proportional to its drought tolerance.

The life indicators of the plants studied in the Absheron Peninsula were assessed for the first time on a maximum 68-point scale. Life indicators for 10 taxa were found to be high and 12 taxa were considered to be perspective. Taxa belonging to less-perspective, low-perspective, non-perspective, useless groups were not found and the plants did not change their life forms under *ex situ* conditions.

For the first time, the directions of use of research materials in landscaping were studied and it was found that all taxa can be used for bordering, single planting, group planting, live fencing, container gardening, and topiaries, and according to the industrial importance,

22 species with essential oils were found to be medicinal and decorative.

Theoretical and practical significance of the research. For the first time, the adaptation and decorative properties of the newly introduced species were studied, which allowed the identification of highly tolerant and decorative species. For the first time, a table was prepared to determine the adaptability and decorative properties of the studied taxa, forms and varieties of the studied plants were proposed for use in phytodesign under Absheron conditions.

For use in landscape architecture, a database has been compiled that combines the comprehensive characteristics of the species, allowing the selection based on various indicators.

Along with economically valuable indicators, species with high decorative properties and the main directions of their use in landscape architecture have been identified.

Recommendations for the use of the studied species have been made, which can allow the creation of landscaping areas with high decorative content and development projects for landscape architecture.

One of the most suitable practical measures is the use of suitable species of research materials in landscaping, single planting, group planting, live hedges, alpinarium, and flower beds.

The extensive use of the studied species in various fields of agriculture, including the preparation of medicines, the obtainment of essential oils, cosmetology, food industry, etc. can be considered expedient measures.

Approbation and application of the research. The materials of the dissertation and the obtained scientific results were presented at various scientific symposiums, sessions, national and international scientific conferences, including “Landscape architecture in botanical gardens and arboretums”, Proceedings of the International Scientific Conference, (June 29 - 02 July, Yaroslavl, 2015), “Symposium on EuroAsian Biodiversity”, (SEAB, June 01-05, Baku, 2015), “The role of conifers introduced in Absheron in environmental protection and their use in landscape architecture” Academic Science Week dedicated to the 70th anniversary of ANAS, International

Multidisciplinary Forum November (04-05, Baku, 2015), “Azerbaijan Towards Resilient Ecosystems” International conference, (23-27 August, Baku, 2015), Republican scientific-practical conference on "New trends and innovations: Prospects for the development of microbiology in Azerbaijan" (March 29-30, Baku, 2022).

The organization where the dissertation was performed. The experimental parts of the dissertation were carried out in the laboratories of the Institute of Dendrology of ANAS, other experimental work was conducted in the parks and gardens of the cities and settlements of Absheron.

Publications. Eleven scientific works on the topic of the dissertation have been published.

Structure and volume of the dissertation. Dissertation work contains the introduction – 11243 characters, literature review (total volume – 209107 characters, Chapter I – 44442 characters, Chapter II – 6871 characters, Chapter III – 15528 characters, Chapter IV – 64951 characters, Chapter V – 47308 characters, Chapter VI – 14436 characters, conclusions – 3121 characters, practical recommendations – 1207 characters) and a list of references, including 179 sources. The total volume of the work consists of 157 computer pages, including 2 graphs, 31 tables and 29 figures.

CHAPTER I. LITERATURE REVIEW

This chapter presents the results of the studies of the genera *Chamaecyparis* Spach. and *Thuja* L. and the taxa belonging to them performed abroad, in various periods.

This chapter is devoted to the results of the scientific research in the direction of biology, introduction, bioecology, responses to abiotic and biotic stress factors, distribution, phylogeny, decorative indicators, responses to diseases and pests, use of plants in landscape architecture, opportunities and prospects for adaptation to new conditions, reproduction, growth and development.

CHAPTER II. MATERIALS AND METHODS OF THE RESEARCH

The objects of the study were 3 species *(Chamaecyparis lawsoniana (A.Murray) Parl., Thuja occidentalis L., Thuja plicata L.)* of the genera *Chamaecyparis* Spach. and *Thuja* L. and 22 varieties and forms of these species. The work was performed from 2014 to 2020.

The research work was carried out in the laboratories at the Institute of Dendrology of ANAS and other experimental work was carried out in the parks and gardens of the cities and settlements of Absheron.

The research was conducted in a cultural environment. The images provided in the study are original and were taken by us under *ex situ* conditions during the years of the study.

Morphological features of the studied plants are given according to K.G.Khorosh, root system, growth and development of plants according to V.V.Smirnov [4]. To assess the prospects for the introduction of the studied plants in the cultural environment, the scales of objective assessment were used based on P.I.Lapin [5]. Flowering and fruiting of plants were studied according to G.G.Kaper[6], propagation by seeds based on V.V.Ogievskiy and etc.[7], and propagation by cuttings according to T.V.Khromova[8] methods. The classification of the studied plants was verified using Classification USDA Plants, APG III-IV.

To study the heat tolerance of the plants, the method of

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

[5] Лапин, П.И. Оценка перспективности интродукции древесных растений по данным визуальных наблюдений / П.И. Лапин, С.В.Сиднева // Опыт интродукции древесных растений. –М.: ГБС, – 1973. – с. 7-67.

[6] Капер, Г.Г. Шкала глазомерной оценки цветение и плодоношения взрослого дерева и кустарника лесные культуры / Г.Г. Капер -М.: Агропромиздат, – 1985, – с. 12-14.

[7] Огиевский, В.В. Лесные культуры и мелиорация 12-е изд., перераб. и допол / В.В.Огиевский., А.Р.Родин, Н.И.Рувцов. – М.: Лесная промышленность, – 1974.- 376 с.

[8] Хромова,Т.В. Методические указания по размножению интродуцированных древесных растений черенками / Т.В. Хромова, – М.: ГБС, – 1980. – 45 с.

K.A.Akhmatov [9] and for drought tolerance, the method of P.A.Henkel[10] were used.

To study the rhythm of seasonal growth on plants belonging to the research material, the methods of G.N.Zaytsev[11] and I.N.Beydman[12] were applied.

The methods by J.Raunkier[13] were used to study plant life forms and to divide plants into ecological groups, the method of H.Walter[14] was applied.

Mathematical methods of statistics were also used in the study. To determine diseases and pests in the studied plants were used some of the methods[15].

For a comprehensive assessment of the economic and biological characteristics, adaptability and decorative properties of the studied species, "Methodology of state varietal tests of agricultural crops"[16], by N.E.Buligin [17] and etc., as well as methodological recommendations and methods were used.

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[9] Ахматов, К.А. Полевой метод определения жароустойчивости растений // М.: 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] Зайцев, Г.Н. Фенология древесных растений. / Г.Н. Зайцев. – М.: Наука, – 1981. – 119 с.

[12] Бейдеман, И.Н. Изучение фенологии растений // –М.-Л.: Полевая геоботаника., – 1960. т. 2, – с. 333-366.

[13] Raunkier, C. The life forms of plants and station plant geography / Raunkier. Oxford: Clarendon Press, -1934. – 632 p.

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

[15] Опредитель болезней растений. / М.К. Хохряков, Т.Л. Доброзракова, К.М. Степанов [и др.] – СПб: Лань, – 2003. – 592 с.

[16] Методика государственного сортоиспытания декоративных культур. – М.: Изд-во Мин-вас/х РСФСР, 1960. – 182 с.

[17] Булыгин, Н.Е. Дендрология / Н.Е. Булыгин, В.Т. Ярмишко.– М.: МГУ, – 2001. – 156 с.

To evaluate the decorative characteristics of the research plants the methods of Bebiya S.M[18] and others were used.

The water-holding capacity of conifers was determined using the modified method of D. Kushnirenko.

A 5-point scale was used to assess the tolerance of plants to cold and drought.

CHAPTER III. GEOGRAPHY, PHYSICAL CHARACTERISTICS AND CONDITIONS OF THE ABSHERON PENINSULA

The environmental factors of the new conditions are known to be a crucial factor in determining the adaptability of the introduced plant. The information obtained from the literature on the climate, relief, soil structure, flora and vegetation of the Absheron Peninsula is reflected in Chapter III.

CHAPTER IV. CURRENT STATUS OF THE RESEARCH AND APPLICATION OF SPECIES AND VARIETIES UNDER STUDY IN LANDSCAPE ARCHITECTURE

4.1 The role and importance of conifers (*Chamaecyparis lawsoniana (A.Murray) Parl., Thuja occidentalis* L., *Thuja plicata* Donn ex D.Don.) used in modern landscape architecture

In modern times, when creating compositions based on the landscape architecture of our cities and settlements, ecological, geographical, systematic, phytocenological and other principles are taken into account.

In addition to the esthetic importance of the studied plants and the above, they are cleaning up the environment. Besides, they hold more dust from the atmosphere than broadleaf plants and release phytoncides into the atmosphere more than twice as much as leaf-

[18] Бебия, С.М., Джакония Е.Ф., Титов И.Ю. Методика комплексной оценки декоративности и экологической устойчивости древесных растений на Черноморском побережье Кафказа // Биология, Химия, – 2018, 4 (70), – № 3, – с. 35-50.

shedding woody plants, which increases their importance[19].

Species belonging to the *Chamaecyparis* Spach. and *Thuja* L. genera are also widely used in modern landscape architecture. Populations of species belonging to these genera are distinguished from other plant groups by their high ecological plasticity and polymorphism, and they have an extensive distributional range, allowing the emergence of new varieties and forms.

Recently, coniferous plants, mainly species and varieties of foreign origin are widely used in landscape architecture. Many hybrid generations obtained in Europe are brought and widely used for landscaping in Azerbaijan.

4.2. Origin and agrobiological characteristics of the *Chamaecyparis lawsoniana* species and its taxa The *Chamaecyparis lawsoniana* plant differs from the *Thuja occidentalis* species by small horizontal or curved down branches.This species was first cultivated by the Americans near the port of Orford in Oregon and was named Lawson Cypress in honor of a collector Charles Lawson (1795-1873) in Edinburgh, Scotland. The plant was first described by botanist Andrew Murray.

Chamaecyparis lawsoniana is native to North America (Oregon and California) and Asia. This plant species was brought to Europe from America in 1854. The US Department of Agriculture officially named the plant "Port Orford". However, some botanists still prefer to use the name Lawson Cypress instead and rarely the name Port Orford Cedar.

Wooden material obtained from *Chamaecyparis lawsoniana* is especially valued in East Asian countries because of its light weight and resistance to decomposition. In Japan, wood from this plant is used in the construction of tombs and temples.

Recently, Lawson Cypress is one of the most popular species used for indoor and outdoor landscaping in our country. Many varieties and forms of the species are widely used in landscaping in different countries around the world.

[19] Novruzov, V.M. Influence of Some Environmental Factors on the Phanerophytes in *ex situ* Conditions / V.M.Novruzov, E.O.Iskender, F.N.Rustamova [et al.] // Bulletin of Science and Practice, – 2020 , 6 (3). – p.60-68.

4.3. *Thuja occidentalis, Thuja plicata* species, origin and agrobiological characteristics of their taxa. In Azerbaijan, three species of the *Thuja* L. genus, varieties, and forms of these species (*Thuja occidentalis*, *Thuja orietalis*, *Thuja plicata*) are used in landscaping.

Thuja occidentalis is distinguished from other *Thuja* species by its slow growth. This species has been known in Europe since 1545. It was first brought to France from Canada.

After knowing the biological characteristics of the Western *Thuja*, such as tolerance, decorativeness, etc., King Francis I of France eagerly called it the "tree of life." Therefore, they began to propagate *Thuja* in France and use it more extensively in landscaping.

Western *Thuja* is used more in architectural landscapes than other conifers because its trunk is very plastic and is suitable for creating certain shapes. Also, varieties belonging to this species have an immune-stimulating effect.

Undersized, dwarf and hanging forms of the Western Thuja are mainly used in the landscape architecture of our country.

4.4. Main diseases and pests in the varieties and forms of the studied species (*Chamaecyparis lawsoniana, Thuja occidentalis, Thuja plicata)*. Recently, the temperature regime in the world, as well as in Azerbaijan, has changed dramatically, causing physiological and biochemical disorders due to an increase in the number of stressors affecting plants, which leads to increased susceptibility of them to some diseases and pests.

In recent years, due to increasing exposure to stressors, the resistance of many conifers to fungal diseases has decreased. These fungal diseases (*Botrytis cinerea* Pers., *Lophodermium* Chev., *Herpotrichia juniperi* (Duby) Petr., *Puccinia recondita* Dietel & Holw., *Phytophthora cinnamomi* Rands., *Phytophthora lateralis* Tucker & Milbrath, *Kabatina juniperi* R. Schneid. & Arx, *Phomopsis juniperovora* Hahn., *Cytospora chrysosperma* (Pers.) Fries. etc.) cause damage and even drying of some morphological organs of the plants under study.

In addition to many diseases, species belonging to the genera *Chamaecyparis* Spach. and *Thuja* L. are also damaged by pests. Some

pests (*Carulaspis juniperus, Cinara juniperina, Argyresthia thuiella,* etc.), which damage the leaves, sprouts, branches and trunk of the plants, and even immature green cones, have been observed on the studied plants[20].

Given that the Absheron Peninsula is a region where the different climatic stresses cause diseases every year, it is clear that there is a need to introduce new varieties and species that are the most resistant to diseases and have a wide amplitude.

4.4.1. Evaluation of resistance of some varieties belonging to the *Chamaecyparis* Spach. and *Thuja* L. genera against fungal diseases

The resistance of plants under study to fungal diseases was assessed based on their crown damage rate between 5% and 50%. According to the results of the research, *Columnaris* and *Ellwoodii* varieties of the genus *Chamaecyparis* Spach. were less damaged due to diseases caused by the fungi *Botrytis cinerea* and *Lophodermium pinastri* (Figure1).

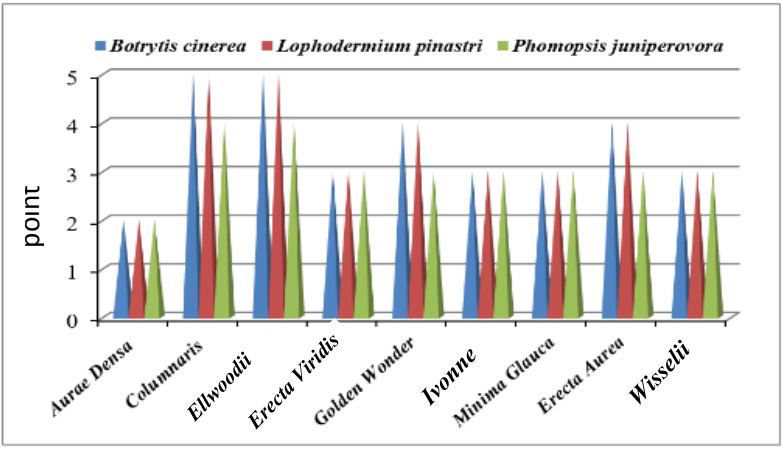


Figure 1. Evaluation of the resistance of varieties of the *Chamaecyparis lawsoniana* species againist fungal diseases under Absheron conditions.

[20] Rüstəmova, F.N. *Chamaecyparis* Spach. və *Thuja* L. cinslərinə aid bəzi növlərdə zərərverici və xəstəliktörədicilər // AMEA-nın Mikrobiologiya İnstitutunun elmi əsərləri, – Bakı: – 2018,- c.16 (2), – s. 39-45.

It was found that the disease caused by the *Botrytis cinerea* fungus damaged about 9% of the crown of the *Golden Wonder* variety and the plant was scored 4 points, while the varieties *Aurae Densa, Erecta Viridis, Minima Glauca* and *Wisselii* were scored 3 points.

As a result of the disease caused by the pathogenic fungus *Lophodermium pinastri,* less than 5% of the crowns of the taxa *Columnaris* and *Ellwoodii* were damaged and they scored 5 points, whereas, the varieties *Golden Wonder, Erecta Aurea* were scored 4 points. *Aurea Densa, Erecta Viridis, Ivonne, Minima Glauca and Wisselii* varieties were included in the group of moderately resistant plants.

The resistance of the studied plants against the diseases caused by the pathogenic fungus species *Phomopsis juniperovora* was assessed and scored lower points compared to previous taxa.

The resistance of varieties belonging to the *Thuja* L. genus against gray mold rot was also assessed under Absheron conditions. The varieties *Fastigiata* and *Mikу* of the *Thuja occidentalis* species, and the varieties *Atrovirens* and *Martin* of the species *Thuja plicata* were scored 4 points. The varieties *Danica, Hoseri, Little Gem, Golden Globe, Tiny Tim* and *Woodwardii* were scored 4 points and the variety *Smaragd Variegata* was scored 2 points.

The resistance of the varieties of the *Thuja* L. genus against diseases caused by the fungus *Lophodermium pinastri* was assessed. The varieties *Fastigiata, Miky* and *Tiny Tim* were scored 4 points, *Danica, Hoseri, Golden Globe, Little Gem,* and *Woodwardii* 3 points. The variety *Smaragd Variegata* belongs to the group of weakly resistant plants because diseases damage more than 30% of needle leaves and young sprouts.

The assessment of the resistance of the plants showed that the varieties belonging to the *Thuja* L. genus were more resistant to a disease caused by the pathogenic fungus *Phomopsis juniperovora* compared to the varieties of the *Chamaecyparis* Spach. genus.

4.5. Modern varieties of the species *Chamaecyparis lawsoniana, Thuja occidentalis* and *Thuja plicata* used in landscaping. European countries, the United States and Canada are the leading countries in terms of the use of species of the genus *Chamaecyparis* Spach. in

landscape architecture. The *Chamaecyparis lawsoniana* taxon currently has over 250 varieties and forms in the world.

"*Alumii*", "*Van Pelt's Blue*", "*Columnaris*", "*Blue Surprise*", "*Minima Glauca*", and other varieties and forms are widely used in landscaping. "*Minima Glauca*" grows up to 2 m high. "*Ivonne*", "*Kelleriis Gold*" is light green and has yellow spots. "*Gold Flake*" is variegated, the branches are yellowish or white. "*Golden King*" has branches bent downwards and is golden. "*Globosa*" and "*Sunkist*" have hanging branches and are yellow. These two varieties differ in the color of the spots. Thus, the "*Globosa*" variety has blue spots and the second variety has golden spots.

Due to a large number of varieties and forms, *Thuja occidentalis* is distinguished from other species of the genus *Thuja* L. Different varieties and forms of Western *Thuja* are used to create different compositions.

Currently, many persons engaged in landscape and design are more interested in green coniferous forms with circular and semicircular crowns ("*Danica", "Globosa", "Champion", "Recurva Nana")* and varieties golden in color ("*Golden Globe"* and "*Sunksit"*). Because the above-mentioned varieties and forms can be used to create any composition.

Over 15 varieties and forms of the *Thuja* L. species are used under cultural conditions of the Absheron Peninsula.

CHAPTER V. BIOLOGICAL AND ADAPTABILITY PROPERTIES OF TAXA BELONGING TO THE GENERA *CHAMAECYPARIS* SPACH. *AND THUJA* L.

5.1. Characteristics of the phenological phases of the studied species during the seasonal developmental period. The main indicators influencing the introduction of research plants are the rainfall and temperature of the area.

It is known that the development of most conifers begins at a temperature between 5°C and 10°C and is completed at the sum of active temperatures 2100-4200°C, and when the hydrothermal coefficient (HTC) of humidity is between 0.4 and 0.9[21].

[21]Гидротермический коэффициент увлажнения Селянинова [Electron resurs] –

The average annual sum of active temperatures in the Absheron Peninsula varies between 3700°C and 3900 °C, and the hydrothermal coefficient of humidity ranges from 0.2 to 0.4.

For the first time, we conducted phenological observations during the vegetation and dormancy periods of *Chamaecyparis lawsoniana* and determined the sum of the active temperatures and the main phenological phases.

Analyzing the dynamics of the temperature, it was found that the annual increase in active temperature tends to exceed the multi-year average. Thus, in 2016 the sum of active temperatures was close to the multi-year average, but in 2017-2018 it was found to be higher than that (Figure 2).

Based on our observations, the completion of vegetation in *Chamaecyparis lawsoniana* can vary depending on the year, i.e. the enhanced sum of active temperatures leads to an increase in the vegetation period of the plant.

The vegetation of *Chamaecyparis lawsoniana* was found to begin in the first decade of March, when the average sum of active temperatures reached 77.5 ° C (Figure 2).

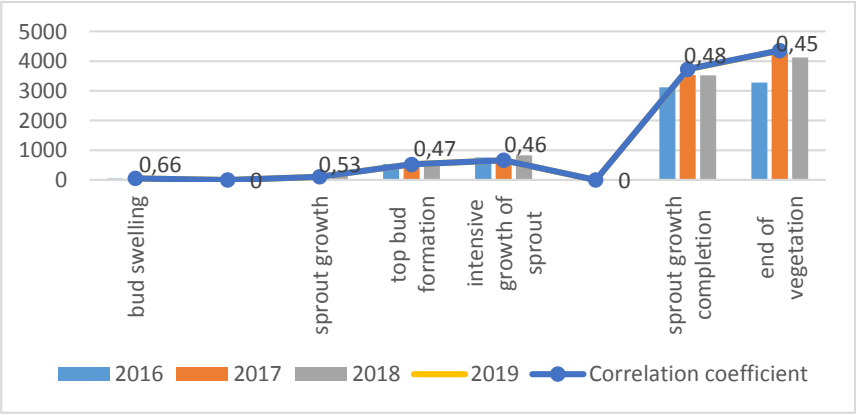


Figure 2. Total active temperature during the growing season of *Chamaecyparis lawsoniana* species used for landscaping in Absheron (2016-2019)

URL:https://ru.wikipedia.org/wiki/(müraciət olunub 16.08.2019)

The results of the analysis showed that in the *Chamaecyparis lawsoniana* species, the stages of bud swelling, the onset of sprout growth and the end of vegetation depend more on the sum of active temperatures than on other stages, which is confirmed by the correlation coefficient (0.45-0.66).

To evaluate the seasonal developmental rhythm of the *Thuja occidentalis* species, the sum of active temperatures over 5°C was taken as a criterion.

The analysis of the experimental results showed that the stages of bud swelling, the onset of sprout growth and intensive sprout growth can vary from 12 to 15 days on average depending on the year. It was found that the earliest completion of vegetation was on November 5, 2016, and the latest was on November 13, 2019. The sum of active temperatures on this date was found to be 4543^{0}C (Figure 3).

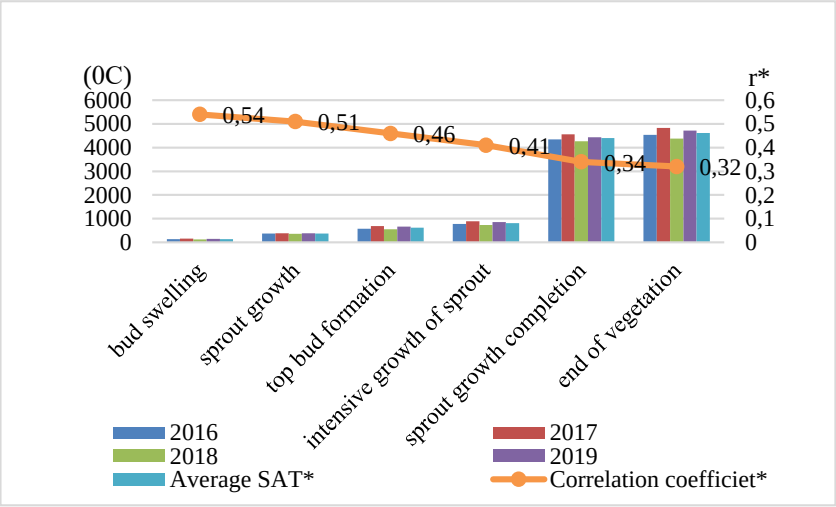


Figure 3. The sum of active temperatures during the vegetation of the *Thuja occidentalis* species used for landscaping in Absheron (2016-2019)

As a result of the analysis, it was found that the intensive growth of the Western *Thuja* was between the third decade of April and the first decade of May. As a result of phenological observations, it became clear that among the phenological stages, the growth of

sprouts was the longest stage. It was found that the growth of the plant under study lasted until the first decade of October, and the sum of active temperatures at this stage was between 4273 and 4404^{0}C.

The results of the analysis showed that the start and end dates of the vegetation in *Thuja occidentalis* species can vary depending on the climatic conditions of the year. When the temperature is above 5°C, it begins when SAT is 141°C (correlation coefficient 0.54) and ends at 4620° C (correlation coefficient 0.32) (Figure 3).

5.2. Growth and development characteristics of the species and their varieties studied under Absheron conditions. The study of the growth process of conifers used in landscape architecture is of particular importance. Experiments showed that the growth of the *Chamaecyparis lawsoniana* species and its varieties occurs in the third decade of April and lasts until the third decade of September (Figure 4).

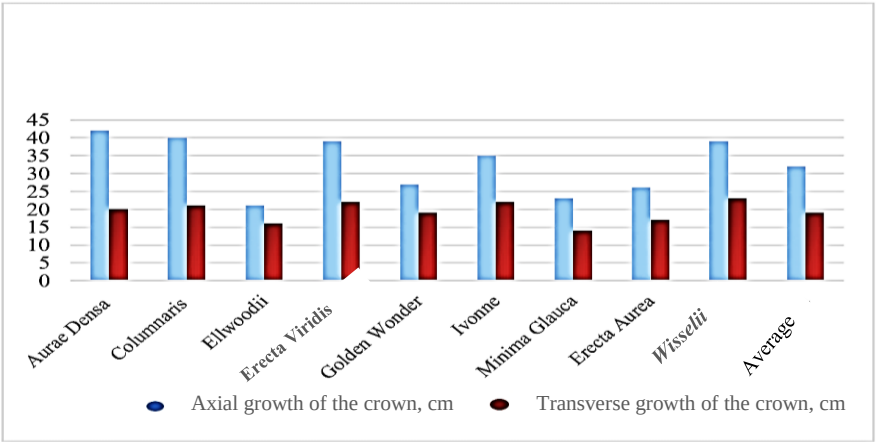


Figure 4. Biometric indicators of the varieties belonging to the *Chamaecyparis lawsoniana* species grown under Absheron conditions

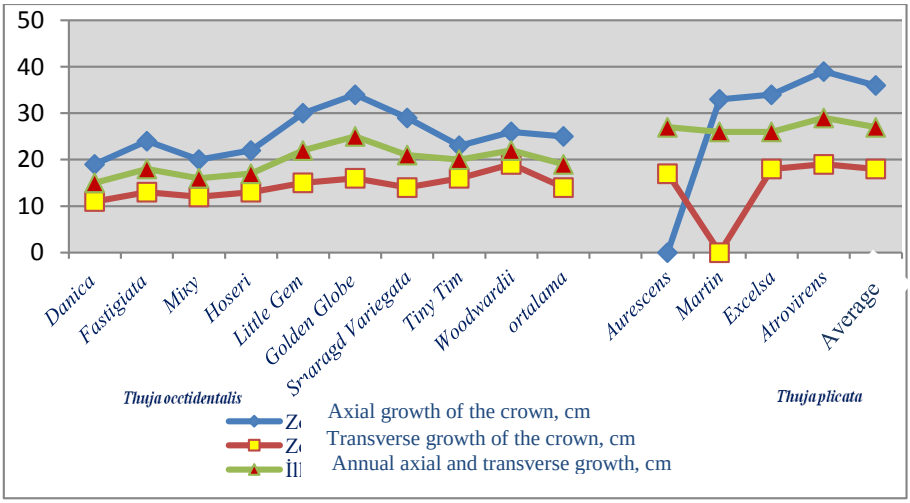
The biometric measurements revealed that the average annual axial growth of the crown was 32 cm and the transverse growth was 19 cm in the varieties belonging to Lawson cypress. Among the studied varieties, the annual growth of *Minima Glauca* was found to be 23 cm, while the annual growth of *Aurae Densa* was 42 cm.

The analysis showed that *Ellwoodii* taxon has the lowest

annual growth intensity. From the analysis of the transverse growths of the crown part of the studied varieties, it was clear that this size was between 14-23 cm depending on the varieties[22].

The study of the growth process of varieties belonging to the genus *Thuja* L. revealed that intensive growth in these plants occurred mainly between the third decade of April and the second decade of May, depending on the year. The growth process in these plants was found to last until the third decade of September, depending on the climatic conditions of the year.

The results of the analysis showed that the intensity of growth of varieties belonging to the genus *Thuja* L. was higher than that of taxa of the genus Lawson Cypress. In all varieties of *Thuja occidentalis* studied, the average axial growth was 25 cm and transverse growth was 14 cm, and in the varieties belonging to *Thuja plicata*, the respective values were 36 cm and 18 cm (Graph 1).



Graph 1. Biometric indicators of the varieties of the *Thuja* genus grown under Absheron conditions

[22] Rüstəmova, F.N. Abşeron şəraitində *Chamaecyparis lawsoniana* (A.Murray) Parl. və *Thuja occidentalis* L. növlərinin böyümə və inkişaf dinamikasi // Naxçıvan Dövlət Universitetinin Elmi əsərləri, Təbiət və Tibb elmləri seriyası, – Naxçıvan:2020. – №8 (109), – s.35-43.

As seen in Graph 1, in the varieties belonging to the *Thuja occidentalis* species, the axial growth was 19-34 cm depending on the taxa, while the transverse growth was 11-19 cm and 18 cm on average in giant *Thuja* varieties.

5.3. Assessment of adaptation potential of the plants studied under Absheron conditions

5.3.1. Drought tolerance of plants belonging to the research material. A 5-point rating scale was used to study the drought tolerance of plants. The evaluation of the tolerance of the *Chamaecyparis lawsoniana* varieties to thermal stress revealed low tolerance of these plants. Drought-tolerance of these plants was scored between 2 and 4 points.

The results of the analysis showed that the varieties *Ivonne, Minima Glauca* and *Wisselii* belonging to the species *Chamaecyparis lawsoniana* were less tolerant to drought, while the varieties *Aurae Densa*, *Erecta Viridis*, *Golden Wonder* and *Erecta Aurea* were moderately drought-tolerant. The color change was observed in the needle leaves of these taxa.

Then, the water-holding capacity and the amount of water loss of the needle leaves of the varieties were studied. Experiments were conducted at different times of the day. The results showed that in the morning (10.00-11.00), the plant leaves had higher water content than in the afternoon (15.00-16.00). On the contrary, the water content of the leaves gradually decreased in the afternoon compared to the morning.

The results showed that in the morning (10.00-11.00) the leaves of the plant evaporate less water than in the afternoon (15.00-16.00).

The analysis of the research results showed that among the studied plants, the greatest evaporation of water occurred in the species *Erecta Viridis* (0.09 mg), followed by *Aurae Densa, Golden Wonder, Ivonne, Wisselii* (0.08 mg), *Columnaris* (0.07 mg) *Minima Glauca* and *Erecta Aurea* (0.04 mg).

Drought tolerance of the species *Thuja occidentalis* and *Thuja plicata* were scored between 2 and 4 points. The varieties *Fastigiata, Mikу, Hoseri* and *Thuja plicata* of the *Thuja occidentalis* species and the varieties *Aurescens, Excelsa, Atrovirens* of the *Thuja plicata*

species were considered to be drought-tolerant in Absheron because they evaporate the least water (0.02-0.03 mg). However, the varieties *Little Gem* and *Martin* (0.05-0.07 mg) are less drought-tolerant due to relatively high water evaporation.

5.3.2. Resistance to wind effects in the studied plants under Absheron conditions. Due to the location of the Absheron Peninsula in a place with strong winds, one of the tasks was to select wind-resistant, non-deformable, or less susceptible taxa of the studied species and to use sustainable varieties in landscape architecture.

The varieties *Ellwoodii, Columnaris, Erecta Viridis, Golden Wonder, Ivonne* of the *Chamaecyparis lawsoniana* species and the varieties *Danica, Fastigiata, Mikу, Hoseri* of the *Thuja occidentalis* species and the varieties *Aurescens, Atrovirens, Martin* and *Excelsa* of the *Thuja plicata* species manifested no deformation in the crown parts, few broken branches and falling needle leaves, and cones 1-2 hours after strong winds and were scored 4 points (resistant to wind); The *Aurae Densa, Erecta Aurea* and *Minima Glauca of the Chamaecyparis lawsoniana* species, *Little Gem, Golden Globe, Woodwardii* taxa of *Thuja occidentalis* species were scored 3 points (moderately resistant to wind) under Absheron conditions due to the change in the shape of the crown and the shedding of a certain amount of sprouts, shoots and needle leaves. The *Wisselii* variety of *Chamaecyparis lawsoniana*, *Smaragd Variegata* and *Tiny Tim* varieties of *Thuja occidentalis* were scored 2 points (less resistant) for being more damaged by wind and taking longer to return to their previous forms.

Although *Fastigiata, Mikу,* and *Hoseri* varieties of the *Thuja occidentalis* species have a relatively high score (4) in terms of drought tolerance and wind resistance, they were scored relatively low points (3-4) in terms of resistance to pathogenic fungi. Thus, it is concluded that there is no direct correlation between plant resistance to wind, tolerance to drought, and resistance to pathogenic fungi.

According to the research results, under conditions of Absheron, the varieties belonging to the genus *Thuja* are more resistant to wind than the varieties of the genus Lawson Cypress.

5.3.3. Evaluation of decorativeness indicators of research materials under Absheron conditions. It is known that plants have a large number of decorative features, and the plants to be used in landscape architecture are selected and used according to specific decorative features. Plants were evaluated using a 5-point scale based on the main decorative indicators (crown shape, attractiveness, branching features of sprouts and branches; the color of needle leaves in spring and winter, the nature of the change depending on the climatic conditions of the year, the smell of needle leaves, the maximum decorative period of plants).

All varieties of the *Chamaecyparis lawsoniana* species were scored 4 points for the color and duration of decorativeness of leaves. However, the *Minima Glauca* variety was scored 3 points, because the plant crown was sometimes symmetrical and the density of the morphological organs in the crown was about 60%.

According to the result of the analysis, no marked discoloration occurred in the needle leaves of *Fastigiata* and *Hoseri* varieties of western *Thuja* L., in summer and winter and they were scored 5 points. All varieties of *Thuja occidentalis* and *Thuja plicata* were scored 4 points because the crown retained its symmetrical shape and the density of sprouts and branches in the crown was close to 80%.

The assessment of the needle leaves of the studied varieties based on color changes showed that these indicators were highly dependent on the climatic conditions of the year.

CHAPTER VI. EVALUATION OF THE PROSPECTS OF THE STUDIED PLANTS UNDER CONDITIONS OF ABSHERON BASED ON THEIR LIFE INDICATORS AND IMPORTANCE IN AGRICULTURE

6.1. Prospects for the introduction of the studied plants. The results of the study showed that no taxon belonging to the III group (low-perspective) was detected among studied plants introduced in Absheron. Some of the studied plants were included in group II – i.e. perspective, as they were rated low for drought tolerance, sprout germination and other indicators.

The 12 varieties (*Aurae Densa, Erecta Viridis, Golden Wonder,*

Danica, Miky, Aurescens, etc.) studied for generative reproduction in culture were scored the lowest point (0 points). Thus, the generative reproduction of these plant species is not satisfactory.

The analysis showed that there are no taxa included in groups III, IV, V, and VI.

6.2. The main directions and industrial significance of the use of varieties belonging to the genus *Chamaecyparis* Spach. and *Thuja* L. in landscape architecture under the conditions of Absheron. Based on the adaptability of the studied plants to the conditions of Absheron, economic importance and decorative indicators, the main directions of the use of these plants in landscape architecture were identified in the research.

A 5-point scale was used to determine the use directions of the varieties during the study. The taxa that are most suitable and can be used in phytodesign in landscaping were scored 5 points, and the plants that are least suitable for use in all forms of landscape architecture were rated 1 point.

Due to their tolerance to local soil-climatic conditions, the use of introduced plants used in landscaping was studied in 6 forms (for bordering, single planting, group planting, live fence, container planting, making topiary forms). The results of the analysis showed that all the studied taxa were identified for use in landscaping due to their decorative properties. Based on the analysis, the directions of use in landscaping for decorative purposes were determined for all taxa studied.

CONCLUSIONS

1. The growth and development of *Chamaecyparis lawsoniana* in the Absheron Peninsula occurred at a temperature above 10°C when the sum of active temperatures ranged between 3281°C and 4356°C. The high sum of active temperatures led to a prolonged vegetation period. The duration of vegetation of *Thuja occidentalis* varied from year to year, averaging 295 days, and the average dormancy period of the plant was 67 days.
2. The study of the growth characteristics revealed 3 developmental stages for the varieties of the *Chamaecyparis lawsoniana* species belonging to the *Thuja* L. genus: a) Intensive growth of the plant

is close in time to the phenophase of "sprout growth onset" and this process took place between the II and III decades of March and the III decade of May; b) the growth of sprouts begins in the second decade of March and intensive growth lasts until the third decade of May; c) general growth, depending on climatic conditions, lasts until late August and mid-September.

3. Depending on the climatic conditions of the year, the vegetation of *Thuja occidentalis* began on February 12-19 (average on February 16) and the sum of active temperatures averaged 141°C. The intensive growth process of the *Chamaecyparis lawsoniana* species occurred in the second decade of May, varied between 21-42cm depending on the variety, averaging 34 cm.
4. Two of the studied three species (*Thuja occidentalis, Thuja plicata*) turned out to be of North American origin and one species (*Chamaecyparis lawsoniana*) is of American origin. When studying the drought tolerance of taxa of these species, it was found that the taxon, which loses more water, is less tolerant to drought, i.e. its tolerance to drought was inversely proportional to the evaporation coefficient of water.
5. The directions of use of research materials in landscaping were studied and it was found that all taxa can be used for bordering, single planting, group planting, live fencing, as containers and topiaries. Indicators of the plants scored different points and according to the industrial importance, 22 species with essential oils were found to be medicinal and decorative.
6. The study of the growth and development during the life cycle of woody plants used in landscaping showed that senescence in ontogenesis is not a straight-line process. It was found that sometimes in the virginal and reproductive periods, vegetative organs are discrete with regeneration and renewal, and some taxa are not included in the reproductive stage due to poor development of generative organs under the conditions of introduction, contrary to the natural conditions.
7. To successfully introduce the trees and shrubs used in landscaping, it is expedient to collect the planting and sowing material from productive individual plants of different geographical origins with

diverse genotypic and phenotypic characteristics in their natural areal, taking into account the bioecological characteristics in their natural habitat and historical past of the species, i.e. their phylogenesis.

8. The life indicators of plants studied in the Absheron Peninsula (lignification of sprouts, drought, and cold tolerance, habitus maintenance, sprout formation, growth, reproduction, etc.) were assessed on a maximum 68-point scale and 10 species were identified as completely perspective and 12 species as perspective. Taxa belonging to less-perspective, low-perspective, non-perspective, useless groups were not found and the plants did not change their life forms under *ex situ* conditions.

PRACTICAL RECOMMENDATIONS

1. Except for the plant species belonging to the III-IV perspective groups, the studied species can be widely used in landscaping works in Absheron, as well as in the regions of Azerbaijan with favorable climatic conditions.
2. One of the most suitable practical measures is the use of suitable species of the research materials in landscaping, single planting, group planting, live hedges, alpinarium, and flower beds.
3. The extensive use of the studied species in various fields of agriculture, including the preparation of medicines, the obtainment of essential oils, cosmetology, food industry, etc. is considered one of the appropriate measures.
4. For the successful introduction of the trees and shrubs used in landscaping, it is expedient to collect the planting and sowing material from productive individual plants of different geographical origins with diverse genotypic and phenotypic characteristics in their natural areal, taking into account their phylogenesis.
5. On the other hand, these plants are widely used in landscaping due to their high decorative and phytoncide properties. These plants of agricultural importance are recommended for wide use in the territory of Baku because they prevent anthropogenic pollution and create species richness.

List of published scientific works on the topic of the dissertation:

1. Rüstəmova, F.N. Abşeronda introduksiya olunmuş iynəyarpaqlı bitkilərin ətraf mühitin mühafizəsində rolu və landşaft memarlığında istifadəsi // AMEA-nın 70 illiyinə həsr edilmiş Akademik Elm həftəliyi, Beynəlxalq Multidissiplinar forum, – Bakı: – 04-05 noyabr, – 2015, – s. 400–401.
2. Mamedov, T.S., Rustamova, F.N. Monitoring and use of conifers (*Coniferopsida*) in landscapling of Azerbaijan // Towards Resillent Ecosystems international conference, – Manchester UK: – 23-27 Auqust, – 2015, – p. 38.
3. Мамедов, Т.С., Рустамова, Ф.Н. Использование голосеменных видов в ландшафном озеленение г. Баку // Материалы Международной научной конференции, «Ландшафтная архитектура в ботанических садах и дендропарках», – Ярославль: – 29 июня-02 июля, – 2015, – с. 58-62.
4. Rustamova, F.N. Useful propertes of *Juniperus foetidissima* Willd. and using in landscape // Symposium on EuroAsian Biodiversity (SEAB-2015), – Baku: – 01-05 June, – 2015, – p. 82.
5. Мамедова, З.А., Рустамова, Ф.Н. Биоекологические свойства, эфиремасличность и использование в ландшафной архитектуре можжевельника обыкновенного (*Juniperus communis* L.) // Успехи современнолй науки и образования, – 2016, – 1 (5), – с. 6-9.
6. Рустамова, Ф.Н. Рост и развитие *Cycas revoluta* Thunb. в условиях Апшерона // – Баку: Известия АН Аз. ССР, серия биол. наук, – 2016, – 71(3), – с. 62-66.
7. Rüstəmova, F.N. *Chamaecyparis* Spach. və *Thuja* L. cinslərinə aid bəzi növlərdə zərərverici və xəstəliktörədicilər // – Bakı: AMEA-nın Mikrobiologiya İnstitutunun elmi əsərləri, – 2018, 16 (2), – s. 39-45.
8. Rüstəmova, F.N. Abşeron şəraitində *Chamaecyparis lawsoniana* (A.Murray) Parl. və *Thuja occidentalis* L. növlərinin böyümə və inkişaf dinamikasi // – Naxçıvan: Naxçıvan Dövlət Universitetinin Elmi əsərləri, təbiət və tibb elmləri seriyası, – 2020. – №8 (109), – s. 35-43.
9. Novruzov, V.M., Iskender, E.O., Veliyeva, L., Abbasov, R.,

Rustamova, F.N. Influence of some environmental factors on the phanerophytes in *ex situ* conditions // Bulletin of Science and Practice, – 2020, 6 (3), – p. 60-68.
10. Novruzov, V.M., Iskender, E.O., Mammadov, T.S., Abbasov, R., Rustamova, F.N., Bagirova, Sh. Analysis of the rare woody plants used in greenery for phytogeographic region life form and IUCN categories // Bulletin of Science and Practice, – 2020, 6 (4), – p. 66-73.
11. Rüstəmova, F.N., Mahmudov, N.A. *Chamaecyparis* Spach. və *Thuja* L. cinsinə bəzi sortların göbələk xəstəliklərinə qarşı davamlılığının qiymətləndirilməsi // Akademik Məmməd Salmanovun anadan olmasının 90 illiyinə və AMEA Mikrobiologiya Institutunun 50 illiyinə həsr olunmuş "Yeni tendensiyalar və innovasiyalar: Azərbaycanda mikrobiologiyanın inkişaf perspektivləri" mövzusunda Respublika elmi-praktiki konfransının materialları, – Bakı: – 29-30 mart, – 2022, – s.121-122.

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