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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

**BIOECOLOGICAL CHARACTERISTICS OF SOME
BARBERRY (*Berberis L.*) SPECIES AND THEIR
APPLICATION IN LANDSCAPING**

Speciality: 2417.01 – Botany

Field of science: Biology

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The work was performed at the laboratory "Introduction and acclimatization of trees and shrubs" in the Institute of Dendrology of Azerbaijan National Academy of Sciences.

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GENERAL DESCRIPTION OF THE RESEARCH

Relevance and degree of completion of the topic. To expand international cooperation in the field of biodiversity conservation, the Republic of Azerbaijan acceded to the UN Convention on Biological Diversity in 2000. The National Strategy and Action Plan for the implementation of the “National Strategy for the Protection and Sustainable Use of Biological Diversity in the Republic of Azerbaijan for 2017-2020” are aimed at implementing effective measures in this area and achieving concrete results. For this purpose, the bioecology of *Berberis* L. species was studied to regulate the ecological balance.

Object and subject of research: Nine species of the *Berberis* L. genus belonging to the *Berberidaceae* Juss. family were used as the study objects: *Berberis vulgaris* L. L. (Common barberry), *Berberis iberica* Stev & Fisch. Ex DC. (Georgian barberry), *B. densifolia* Rusby. (Densifolia barberry), *B.amurensis* Rupr. (Amur barberry), *B.levis* L. (Levis barberry), *B.thunbergii* DC. (Japanese barberry), *B.julianae* C.K.Schneid (Chinese barberry), *B.koreana* Palib. (Korean barberry), *B.heteropoda* Schrenk.(Hetreopoda barberry).

The purpose and tasks of the research. The main purpose of our research was to study the introduction, acclimatization, and bioecological characteristics of species belonging to the *Berberis* L. genus in the dry subtropical climate of Absheron, to assess their prospects and their application in landscaping. To achieve this goal, the following tasks were set:

- *Determination of morphological features of seedlings obtained at the initial stage of development (ontogeny);
- * Study of the biorhythm of seasonal growth and development of the species belonging to the *Berberis* L. genus;
- * Study of growth and development dynamics of the root system of 1-3-year-old plants;
- * Research of phenological development stages of barberry species;
- * Determination of biological indicators of flowering and fruit formation;

* Determination of morphological features and productivity of fruits and seeds;

* Study of seed and vegetative propagation methods of *Berberis* L. species;

* Agrotechnics of the studied species, resistance to some environmental factors, diseases, and pests were tested, methods of control against them were developed.

* Possibilities and prospects of introducing *Berberis* L. species were assessed based on landscape architecture and their application in landscaping was proposed.

Research methods: A systematic determinant was used to determine plant species during the implementation of the dissertation work. Different biological and ecological methods were also used to study the bioecological characteristics of the introduced species. For this purpose, various devices such as “Nikon eclipse E100” and “AmScope” microscopes, CI - 202 Portable Laser Leaf Area Meter (CID bio-science), and SOEKS ecotester apparatuses were used.

Main points presented to the defense of the dissertation: 1. Three species (*Berberis vulgaris* L., *Berberis iberica* Stev & Fisch. Ex DC., and *B.densifolia* Rusby.) of the natural flora of the genus *Berberis* L. and species (*Berberis thunbergii* DC., *B.amurensis* Rupr., *B.levis* L., *B.julianae* C.K.Schneid, *B.koreana* Palib. and *B.heteropoda* Schrenk.) imported from foreign countries, the morphology of seedlings obtained under Absheron conditions, dynamic development of the 1-3-year old seedlings, seasonal development stages were researched, and proposals were prepared for their use in landscaping.

2. The phenological development stages of *Berberis* L. species differ depending on the climatic factors of the year. The study of the impact of environmental factors on barberry species showed that these species are adapted to the dry subtropical climate of Absheron.

3. The prospects of some barberry species introduced in Absheron and naturally distributed in the territory of Azerbaijan are superior to the species introduced from foreign countries.

4. Propagation of barberry (*Berberis* L.) species by seeds and vegetative methods (cutting, shrub division, offshoot) to get a lot of planting material gives positive results.

Scientific novelty of the research. For the first time, *Berberis heteropoda* Schrenk. and *Berberis julianae* C.K.Schneid species of the *Berberis* L. genus obtained from the Tashkent Botanical Garden and N.V. Tsitsin Main Botanical Garden of the Russian Academy of Sciences were introduced in Absheron using seeds. Bioecological features of 9 species of *Berberis* L. (seasonal development rhythm, phenological stages of development, vegetation period, tolerance to climatic factors, diseases and pests, fruit and seed productivity) were studied on a scientific basis under Absheron conditions.

The viability of pollen in species of *Berberis* L. has been determined. The radiation background around the studied barberry species was studied. For the first time, diseases and pests of barberry species were identified under the Absheron conditions, and measures to combat them were announced. Barberry species of Absheron were grouped according to perspective criteria.

Theoretical and practical significance of the research. For the first time, bioecological features of new species introduced in Absheron have been studied on a scientific basis. A collection area of species and forms of *Berberis* L. genus and compositions of various shapes were created at the Institute of Dendrology.

By developing suitable methods of propagation of *Berberis* L. species, it is possible to obtain a large quantity and quality of planting material for use in landscaping.

Based on the studies of introduced plants, proposals were made for the use of promising species of *Berberis* L. genus in the landscaping of new parks and gardens in Baku, Sumgayit, and surrounding settlements.

Approbation and application of the work. The main points and results of the research were presented at the International Symposium on “SEAB 2015: Biodiversity in Eurasia” (Baku, 2015); “III (XI) International Botanical Conference of Young Scientists” (St. Petersburg, 2015); “International Multidisciplinary Forum:

Academic Science Week dedicated to the 70th anniversary of ANAS” (Baku, 2015), “Innovative approaches to modern Biology: VIII International Scientific Conference” (Baku, 2018); International Scientific Conference on "Actual problems of modern natural and economic sciences" (Ganja, 2018); Conference on “Modern problems of biology” (Sumgayit State University, 2018); The VIII International Scientific Conference on "Innovative Approaches to Modern Biology" (Baku State University, 2018), “Innovation and Traditions in Modern Botany” conference of young scientists and researchers dedicated to the 130th anniversary of A.A. Grossheim, (Institute of Botany of ANAS, 2019); the II International Conference of Young Scientists and Specialists (ANAS and Socar, 2020); The Scientific-Practical Conference on "Environmental problems and strategies for its protection: vision of the future", Institute of Soil Science and Agrochemistry of ANAS (June 17, 2020); The IV International Scientific Conference of Young Scientists organized by the Baku Engineering University (2020), reports were made at scientific seminars.

Name of the organization where the dissertation was performed: The research was conducted in the field of the laboratory "Introduction and acclimatization of trees and shrubs" of the Institute of Dendrology of ANAS, in 2015-2019.

Publications. Twenty scientific works reflecting the main points of the research were published, including 14 in local (10 theses, 4 articles) and 6 in foreign (4 articles, 2 thesis) scientific journals.

Structure and volume of the dissertation. The dissertation consists of the Introduction (6 pages), 6 chapters (Chapter I-14, Chapter II-20, Chapter III-90, Chapter IV-22, Chapter V-23, Chapter VI-18, conclusions, practical suggestions-2 page). It covers 213 pages of computer-typing, containing 195 sources, including 166 publications (18 pages) in foreign languages. 31 tables, 110 figures, 8 graphs, 1 diagram, and 1 phenospectrum have been presented in the dissertation.

CHAPTER 1. LITERATURE REVIEW: HISTORY OF INTRODUCTION, BOTANICAL AND ECOLOGICAL CHARACTERISTICS, DISTRIBUTION AREAL AND VALUE OF *BERBERIS* L. SPECIES

The literature review provides information on the history of introduction, botanical and ecological features, distribution areal and value of 9 species of the *Berberis* L. genus. The *Berberis* L. genus has an ancient origin. A comparative study of archaeological remains and the determination of the geographical distribution of modern species have shown that barberry species most likely originated during the Cretaceous period (65 million years ago) before the collapse of the Gondwana continent.

According to the results of researches on the introduction and acclimatization of plants in the Central Botanical Garden of ANAS after the 1970s, 114 species of East Asia belonging to 19 families and 29 genera, more than 200 species of trees and shrubs belonging to 35 families, and 65 genera of the North American flora were collected in the collection areas. During this period, 28 species of the barberry genus were introduced: *B.japonica* C.K.Schneid., *B.gilgiana* Fedde., *B.lycium* Royle, *B.girajdii* Hesse., *B.canadensis* Mill., *B.brachypoda* Maxim., etc. Some of these species (*Berberis brachypoda* Maxim., *B.girajdii* Hesse., *Berberis koreana* Palib., *B.japonica*) could not resist soil and climatic conditions of Absheron and became extinct. C.K.Schneid studied the stages of phenological development of the barberry species, *Berberis koreana* Palib., *B.japonica* *B.gilgiana* Fedde., *B.lycium* Royleit and noted that these species entered the flowering stage, fully bloomed, and gave quality seeds for 4-5 years¹.

Since 2000, T.S.Mammadov^{2,3} has been conducting comprehensive monitoring of the current state of the Azerbaijan

¹ Агамиров У.М. Новые древесные породы Апшерона / У.М. Агамиров. - Баку: Азернешр, -1986. -62 с.

² Мəммədov Т.С. Абşeronun ađac və kolları./ Т.С.Мəммədov - Bakı: Elm və Təhsil nəşr.- 2010. -s. 318-324.

³ Мəммədov Т.С. Azərbaycan dendroflorası. [3 cilddə]. /Т.С.Мəммədov -Bakı, Səda nəşr., -c 2.-2015. -s. 196-222.

dendroflora, including Absheron. The areal distribution, botanical description, application possibilities, taxonomic content of cultivated and wild trees and shrubs have been studied and identification keys have been proposed.

Chapter 2. OBJECTS, METHODOLOGY, AND CONDITIONS OF THE RESEARCH

2.1. Research objects: Nine species of the *Berberis* L. genus belonging to the *Berberidaceae* Juss. family were used as the study objects: *Berberis vulgaris* L. (Common barberry), *Berberis iberica* Stev & Fisch. Ex DC. (Georgian barberry), *B. densifolia* Rusby. (Densifolia barberry), *B. amurensis* Rupr. (Amur barberry), *B. levis* L. (Levis barberry), *B. thunbergii* DC. (Japanese barberry), *B. julianae* C.K.Schneid (Chinese barberry), *B. koreana* Palib. (Korean barberry), *B. heteropoda* Schrenk. (Hetrepoda barberry).

2.2. Research methods. The methods of M.K. Firsova⁴ and V.V. Ogievski⁵ and others were used in seed propagation. The morphology of seedlings was described according to the methods of I.G. Serebryakov⁶ and I.T. Vasilchenko⁷.

Studies on the annual growth of plants were conducted according to the methods of A.A. Molchanov and V.V. Smirnov⁸. Vegetative propagation was performed according to the methods of D.I. Komissarov⁹, R.H. Turetskaya¹⁰, L.S. Plotnikova and T.V.

⁴ Фирсова М.К. Методы исследования и оценки качества семян / М.К. Фирсова. -Москва: Сельхозгиз, -1955. -376 с.

⁵ Огиевский В.В. Лесные культуры и мелиорации. В.В.Огиевский, А.Р. Родин -Москва: Лесн. про-сть, -1974. - 376 с.

⁶ Серебряков И.Г. Морфология вегетативных органов высших растений / И.Г. Серебряков -Москва: Советская наука, -1952, -с.140-143.

⁷ Васильченко И.Т. Всходы деревьев и кустарников. Определитель. / И.Т. Васильченко. -Москва-Ленинград: изд. АН СССР, -1969. -302 с.

⁸ Молчанов А.А. Методика изучения прироста древесных растений / А.А.Молчанов, В.В.Смирнов -Москва: Наука, -1967. -100 с.

⁹ Комиссаров Д.А. Биологические основы размножения древесных растений черенками. Д.А. Комиссаров -Москва, Лесная пром-сть, -1964. -292 с.

¹⁰ Турецкая Р.Х. Инструкция по применению стимуляторов роста при вегетативном размножении растений / Р.Х. Турецкая. -Москва: Изд-во АН СССР, -1962. -71 с.

Khromova¹¹.

The morphology and development of the root system were studied in 1-3-year-old plants using the method of "complete digging out and washing of roots" according to V.A.Kolesnikova¹².

Evaluation of flowering and productivity was performed by V.G. Kapper's¹³ 3-point scale. Besides, the productivity of fruits and seeds was determined by the "fruit mass unit" of a medium-sized tree.

The research on the morphological properties of the fruit and seed was performed according to the methods of I.A.Ivanova and N.M.Dudik¹⁴, S.A.Smirnov¹⁵. The color of fruits and seeds was determined Based on the A.S Bondarchev¹⁶ scale. The morphological characteristics of the leaves were studied using CI-202 Portable Laser Leaf Area Meter (CID bio-science) equipment.

In the laboratory, the morphology and viability of pollen were studied using "Nikon eclipse E100" and "AmScope" microscopes.

Frost tolerance in barberry species introduced to Absheron was visually assessed according to the Klimov's¹⁷ theory. Heat and drought tolerance of the studied barberry species was determined according to the methodology of K.A. Akhmatov¹⁸.

¹¹ Плотникова Л.С. Размножение древесных растений черенками / Л.С. Плотникова, Т.В. Хромова –Москва: Наука, -1981. -56 с.

¹² Колесников В.А. Методы изучения корневой системы древесных растений / В.А. Колесников -Москва: Лесн. пром-сть, -1972. -152 с.

¹³ Шкала глазомерной оценки цветения и плодоношения взрослого дерева и кустарника. Лесные культуры. / Каппер В.Г., Редько Г.И., Родин А.Р. [и др.] – Москва: Агропромиздат. - 1985. -с.12-14.

¹⁴ Иванова И.А. К методике описания морфологических признаков семян. Составление определений растений по плодам и семенам. И.А. Иванова, Н.М. Дудик. -Киев: Наукова думка, -1974. -с. 43-54.

¹⁵ Смирнов В.В. Сезонный рост главнейших пород / В.В. Смирнов. -Москва: Наука, -1964, -165с.

¹⁶ Бондарцев А.С. Шкала цветов / А.С. Бондарцев. - Москва-Ленинград.: изд-во Наука, -1954. -27 с.

¹⁷ Климов С.В. Пути адаптации растений к низким температурам // Успехи современной биологии, -2001, том 121, № 1, -с.3-22.

¹⁸ Ахматов, К.А. Полевой метод определения жароустойчивости растений Бюллетень главного ботанического сада // -Москва: Наука, -1972. № 86, -с. 24-26.

The degree of infection of barberry species studied under the conditions of Absheron was determined according to the methodology of M.K. Khokhryakov¹⁹ and others. In determining the pest of these species, the reports by L.M. Kapaneva²⁰, V.P.Vasilyev, I.Z. Livshits²¹ and BioLib²² were used.

To study the prospects of barberry species, the assessment method of E.O. Isgandarov²³ was also used.

Mathematical-statistical calculations of the results of the research were carried out according to the methodology of G.N. Zaychev²⁴.

2.3. Soil and climatic conditions of Absheron. The research was conducted in the experimental fields of the Institute of Dendrology of ANAS located in the Absheron Peninsula and in the laboratory "Introduction and acclimatization of trees and shrubs in 2015-2019".

In this sub-chapter of the dissertation, detailed information is presented on the relief of the Absheron peninsula and the Institute of Dendrology, climatic conditions, soil and vegetation of the area, etc.

¹⁹ Хохряков М.К. Определитель болезней растений. Хохряков М.К., Доброзракова Т.Л., Степанов К.М. [и др.] -Москва – Краснодар: СПб // Лань, -2003, -592 с.

²⁰ Копанева Л.М. Определитель вредных и полезных насекомых и клещей плодовых и ягодных культур в СССР L./ Л.М. Копанева –Ленинград: “Колос”, -1984, -288 с.

²¹ Васильев В.П. Вредители плодовых культур / В.П.Васильев, И.З. Лившиц; -Москва: Колос, -1984, -с 53-54.

²² BioLib.cz: [Electronic resource] Taxonomic tree of plants and animals with photo, 2020. URL: <https://www.biolib.cz/en/>

²³ Искендеров Э.О. Оценка перспективности интродукции редких и исчезающих древесных видов Кавказа в условиях Апшерона // Москва: Бюлл.ГБС Наука, -1993, вып.169, -с.8-11.

²⁴ Зайцев Г. Н. Математическая статистика в экспериментальной ботанике / Г.Н. Зайцев -Москва: Наука, -1984. - 424 с.

CHAPTER 3. BIOLOGICAL CHARACTERISTICS OF SPECIES OF THE *BERBERIS* L. GENUS UNDER ABSHERON CONDITIONS

3.1. Botanical description of the studied species. To study the introduction and adaptation of *Berberis* L. species to the Absheron conditions on a scientific basis, it is important to evaluate the biological and morphological features of these species at individual stages of development.

The species we studied were divided into 2 groups according to their natural geographical origin (Table 3.1.1):

1. Species belonging to the flora of the Caucasus and Mediterranean countries: *Berberis vulgaris* L., *B. iberica* Stev&Fisch ex DC., *B. densifolia* Rusby.

2. Species belonging to the flora of East and Central Asia: *Berberis amurensis* Rupr., *B. levis* L., *B. thunbergii* DC., *B. julianae* C.K.Schneid., *B. koreana* Palib., *B. heteropoda* Schrenk.

The following table provides botanical descriptions and morphological indicators of 9 barberry species in the collection areas.

3.2. Morphology of seedlings. The morphology of seedlings of 9 barberry species was studied in detail.

Our observations show that the first seedlings appear 31-43 days after sowing. Similar processes of seed germination and seedling development occur in the species we studied. The seeds germinate on the surface. Hypocotyl is developed and has two cotyledons.

The epicotyl is very poorly developed, the juvenile leaves emerge directly between the cotyledons. The first true leaves appear in late April, and the subsequent ones in early May²⁵.

The studied species are difficult to distinguish by morphological traits. They differ only in the size of the hypocotyl, cotyledons, and juvenile leaves. The lifespan of the cotyledons of the studied barberry species varies between 54 ± 2 and 73 ± 3 days.

²⁵ Mammadov T.S., Salakhova E.Kh. The Propagation and Morphogenesis of Sprouting of Some *Berberis* L. Species // - Bhopal: International Journal of Agriculture Innovations and Research (IJAIR), -2018. Volume 7, Issue 3, - p. 308-311.

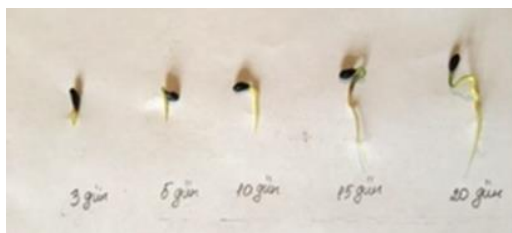


Figure 3.2.1. Appearance of the first seedlings of *Berberis julianae*

3.3. Growth and development of the above-ground parts of the studied species. The study of the growth dynamics and annual growth of barberry species under the conditions of Absheron is of theoretical and practical importance. For this purpose, we examined the seasonal growth and annual growth of barberry species for 1-3 years, as well as in the following period.

Growth in 1-3-year-old plants is divided into 2 periods: the first period of the intensive height growth from the second decade of May to the end of June and the second height growth period from mid-August to the first or second decade of October. The vegetation period varies between 168-185 days.

The height of individual barberry species varies between 7.5-19.5 cm in the first year, 13.0-23.0 cm in the second year, and 20.0-29.0 cm in the third year. An intensive increase in height and canopy diameter is observed after the third year (Table 3.3.1). The height of 4-year-old plants varies between 35.0 ± 2.0 cm and 48.0 ± 3.0 cm.

In fruiting older individuals of the same species of barberry, the maximum annual growth in lateral branches was observed in the species *Berberis thunbergii* DC., *B.densifolia* Rusby., and *B. vulgaris* L.: 25.0 ± 4.5 cm - 28.5 ± 4.5 cm. The period of intensive growth varies between 60-70 days.

3.4. Growth and development of the root system of 1-3-year-old plants. Our research showed that under irrigated conditions of Absheron, *Berberis vulgaris* L. (17.5 cm), *B. thunbergii* DC.(15.0 cm) and *B. densifolia* Rusby.(14.0 cm) have well-developed primary roots in the first year. The main root branches at a depth of 5-20 cm in the soil, forming a large number of thread-shaped sucking roots.

In the studied species, the diameter of the main root is between 2.5-3.0 mm, 3-5 cm below the upper root. The length of the first-degree lateral roots reaches 2.5-5.3 cm. In 2-3-year-old plants, the main root extends to a depth of 11.5-18.0 cm in the soil. An increase in the number, length, and thickening of secondary and tertiary lateral roots occurs. The number of lateral roots is 3-7, the length is 4.0-12.0 cm. The lateral roots are mostly spread in the layer close to the top surface of the soil.



Figure 3.4.1. Root system of 3-year-old seedlings of *Berberis amurensis*

The study revealed that 1-3-year-old barberry species have a distinct main root system. The first-degree lateral roots appear from the main root at a depth of 5 cm. Better development of the root system is observed in two- and three-year-old plants. During this period, secondary and tertiary lateral roots are formed and spread horizontally in the soil on both sides. It is very rare for these roots to spread in only one direction (*Berberis iberica* Stev & Fisch. Ex DC.). The main part of the root is spread at a depth of 5-20 cm in the soil. In these cultivated plants, the root is spread close to the surface of the soil. The root system formed in II-III years ensures normal growth of the above-ground parts of plants.²⁶

²⁶ Salahova E.X. Abşeron yarımadasına introduksiya olunan 1-3 illik zirinc növlərinin kök sistemi // -Gəncə: Azərbaycan Texnologiya Universiteti (UTECA) Elmi Xəbərlər, -2019. №1(28), -s. 42-48.

3.5. The seasonal development rhythm of the barberry species. The following results were obtained when studying the stages of phenological development of barberry species in the dry subtropical climate of the Absheron Peninsula:

* In older individuals of *Berberis* L., the vegetation period ranged from 222 ± 3 days to 255 ± 3 days, depending on climatic factors. According to the vegetation onset time, barberry species are divided into 3 groups:

Species with the early-onset of vegetation - *Berberis vulgaris* L., *B. iberica* Stev & Fisch. Ex DC., and *B.densifolia* Rusby. Vegetation in these species begins in the second decade of March and lasts until the first decade of November.

Species with the middle onset of vegetation - *Berberis amurensis* Rupr., *B.thunbergii* DC., *B.koreana* Palib., and *B.heteropoda* Schrenk.. Vegetation in these species begins in the third decade of March and ends in the second decade of November.

Species with the late-onset of vegetation - *Berberis levis* L. and *B.julianae* C.K.Schneid. Vegetation in these species begins late - in the third decade of March and lasts until the third decade of November.

*The first flowering was observed in 5-6-year-old barberry species under Absheron conditions.

*The flowering period of *Berberis* L. species was 13-23 days. According to the flowering period, the species are divided into the following groups:

Species with a short-term flowering period - *Berberis iberica* Stev & Fisch. Ex DC., *B.vulgaris* L., *B.densifolia* Rusby. and *B.koreana* Palib.(13-15 days);

Species with a long-term flowering period - *Berberis heteropoda* Schrenk.(23 days);

Species with a medium flowering period (varied between 17-20 days).

3.6. Morphological traits of pollen in the studied barberry species. In 2018-2019, the viability and germination of pollen in 9 barberry species in the collection area of the Institute of Dendrology

were studied. For this purpose, the method of I.N.Golubinski²⁷ was used.

Table 3.6.1

Study of the pollen viability in some barberry species

Species	Fertility, (%)	Morphological traits of pollen (μm)		Pollen length (In 20% sucrose solution), μm
		meridial diameter	equatorial diameter	
<i>Berberis vulgaris</i> L.	79.5	56	34	68.0
<i>Berberis iberica</i> Stev & Fisch. Ex DC.	60.0	50	28	47.6
<i>B.densifolia</i> Rusby.	75.0	55	32	64.0
<i>B.amurensis</i> Rupr	58.0	48	31	40.3
<i>B.levis</i> L.	50.5	40	23	25.3
<i>B.thunbergii</i> DC.	68.5	46	30	45.0
<i>B.julianae</i> C.K.Schneid	73.0	52	32	57.6
<i>B.koreana</i> Palib.	63.5	44	30	42.0
<i>B.heteropoda</i> Schrenk.	67.5	46	31	46.5

The species studied for the viability of pollen are divided into 3 groups:

Group I - highly viable pollen: Such pollen was observed in *Berberis vulgaris* L., *B.densifolia* Rusby., and *B. julianae* C.K.Schneid -73.0 - 79.5%.

Group II - pollen of moderate viability: *B.amurensis* Rupr.,

²⁷ Голубинский И.Н. Биология прорастания пыльцы / И.Н. Голубинский - Киев: Наукова Думка, -1974. -362 с.

B.koreana Palib., *B.heteropoda* Schrenk., *B.thunbergii* DC., *Berberis iberica* Stev & Fisch. Ex DC. - 58.0-68.5%.

Group III - pollen of weak viability: *B. levis* L.- 50.5%.

Thus, our research has shown that the viability of pollen, germinating in a nutrient medium, is a biological process and one of the main indicators of obtaining a high-quality seed product²⁸.

3.7. Biological features of flowering and fruiting in barberry species. Flower clusters of different shapes were observed on the species we studied: sparse, simple cluster (*Berberis vulgaris* L., *B.amurensis* Rupr.), sparse, swinging cluster (*Berberis iberica* Stev & Fisch. Ex DC., *B.koreana* Palib.), dense, swinging cluster (*B.densifolia* Rusby.), cluster adjacent to the leaf axils (*B.levis* L., *B.julianae* C.K.Schneid), rare or sparse clusters (*B.thunbergii* DC.), pile cluster with different stalks (*B.heteropoda* Schrenk.).

Seed productivity of the studied species received 3-5 points on a 6-point scale of V.G. Kapper.

Thus, no species corresponding to non-productive (0-point), rare (1-point), sparse crop (2-point) groups were observed. The barberry species we studied were divided into the following groups according to the methodology based on the seed yield:

1) 3 points - average productive species - *Berberis levis* L. and *B.heteropoda* Schrenk. The productivity of these species is estimated to be 30-40%. Fruit clusters on the plant are sparse.

2) 4 points-good productive species- *Berberis julianae* C.K.Schneid, *B. iberica* Stev & Fisch. Ex DC., *B. koreana* Palib. 50-60% productivity is observed in these species. The fruit covers more than half of the shrub.

3) 5 points – highly productive species - *Berberis vulgaris* L., *B. thunbergii* DC., *B.amurensis* Rupr., and *B.densifolia* Rusby. In these species, fruit clusters cover 70-80% of the plant.

The productivity of 1 bush was studied on the studied species.

²⁸ Salakhova E.Kh. The viability of pollen in some species of *Berberis* L. in Absheron conditions // - Петрозаводск: Hortus botanicus, -2020. T.15, -p. 175-179.

In 6-year-old barberry species, the average seed yield per tree was 120-240 grams. From the middle age bushes of *B. vulgaris* L., *B. thunbergii* DC., *B. densifolia* Rusby. up to 1 kg of fruits can be harvested.

The seed mass was 30% of the total fruit mass (average). Seed mass varied from 6.5g to 10.0g for the species studied. The mass of 100 seeds was higher in *Berberis thunbergii* DC. and less in *Berberis iberica* Stev & Fisch. Ex DC..

The number of fruits containing 1-2 seeds was higher than those containing 2-3 seeds. Thus, the number of seeds in large fruits exceeds the number of seeds in small fruits.

CHAPTER IV. PROPAGATION OF THE STUDIED *BERBERIS* L. SPECIES

4.1. Seed propagation.

It was found that the optimal sowing depth of barberry seeds should be 1.5-2 cm in the open field. According to our results, 8 grams of seeds per 1 m² area should be accepted as the sowing norm.

Seeds were sown in the open field in 2 variants: in the first decade of November and December, in specially prepared beds, taking into account the norm and depth of sowing.

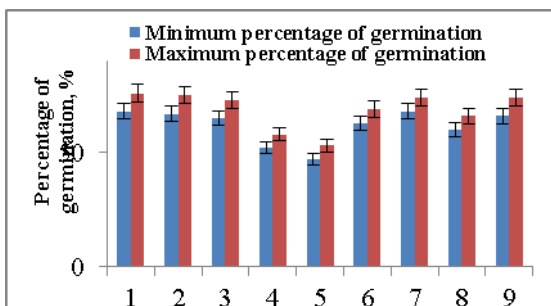
In the first variant, the first seedlings from the sown seeds were observed in the I and II decades of April (10.04-20.04), and the massive seedlings were observed in the II-III decades of April (18.04-26.04).

In the first variant, the germination percentage of the sown seeds varied from 45.0% to 65.0% depending on the species. High germination percentage was observed in *Berberis iberica* Stev & Fisch. Ex DC., *B. heteropoda* Schrenk., *B. densifolia* Rusby., *B. julianae* C.K.Schneid and *B. vulgaris* L.: 58.0-65.0%.

In the II variant, the first seedlings were observed 3-5 days later than in the I variant. The germination percentage of the seeds was lower than in the I variant and varied between 38.4 and 60.5%.

The germination percentage of barberry seeds sown in spring without stratification varied between 20.6 and 38.0%. The highest

germination percentage was recorded for *Berberis vulgaris* L. (38.0%) and the lowest for *B. levis* L.(20.6%) during spring sowing.



Graph 4.1.1. Germination percentage of some barberry species under laboratory conditions: 1. *Berberis vulgaris* L.; 2. *Berberis iberica* Stev & Fisch. Ex DC.; 3. *B.densifolia* Rusby.; 4. *B.amurensis* Rupr.; 5. *B.levis* L.; 6. *B.thunbergii* DC.; 7. *B.julianae* C.K.Schneid.; 8. *B.koreana* Palib.; 9. *B.heteropoda* Schrenk..

Natural regeneration. During the study, spontaneous seedlings were observed around the old barberry plants. In our study, natural regeneration was observed mainly around local flora species (*Berberis vulgaris* L., *Berberis iberica* Stev & Fisch. Ex DC.), as well as some introduced barberry species (*B.heteropoda* Schrenk.)²⁹.



Figure 4.1.2. Naturally regenerated seedlings of *Berberis iberica*

²⁹ Salahova E.X. Abşeronunda *Berberis* L. cinsinə aid bəzi növlərdə təbii bərpa // Gənc Alimlərin IV beynəlxalq elmi konfransı, - Bakı: Bakı Mühəndislik Universiteti, -5 iyun, -2020, -s.154-156.

During the observations, 1m² areas around each plant were selected and marked, and 1-3-year-old seedlings in that area were counted and measured. The results of the study are given in Table 4.1.1.

Table 4.1.1

Natural regeneration of some barberry species

Species	Average number of seedlings per 1 m ²			Average height of seedlings, cm		
	1 year old	2-year old	3-year old	1-year old	2-year old	3-year old
<i>Berberis vulgaris</i> L.	18	13	8	4.0	8.0	14.5
<i>Berberis iberica</i> Stev & Fisch. Ex DC.	12	8	6	3.0	7.5	12.0
<i>B.densifolia</i> Rusby.	10	6	5	4.5	6.5	10.0
<i>B.heteropoda</i> Schrenk.	6	4	2	3.0	5.0	8.5

4.2. Vegetative propagation. In addition to seed propagation, barberry species reproduce vegetatively by green and hardwood cuttings, stems, and root sprouts, as well as by shrub division.

Propagation with a cutting. The research has been conducted on the propagation of some species of the Barberry genus with hardwood cuttings. Hardwood cuttings of *Berberis densifolia* Rusby., *B.amurensis* Rupr., *B.thunbergii* DC., and *B.koreana* Palib. species were used in the study. The results of the study are given in Table 4.2.1.

Thus, keeping the cuttings in a solution of 0.005% heteroauxin for 24 hours increases their rooting and subsequent development.

In *Berberis thunbergii* DC. and *B. densifolia* Rusby., the root formation rate was higher than in other species: 64.0-75.0%. At the end of the first vegetation period, the height of the seedlings formed

from the cuttings was 9-15 cm and 1-2 small sprouts were formed on them (Graph 4.2.1).

Table 4.2.1
Effect of heteroauxin solution of different concentrations on the root formation of barberry cuttings, %

Species	Heteroauxin solution (indoleacetic acid)				Control (water)
	0.01%		0.005%		
	12 hours	24 hours	12 hours	24 hours	
<i>Berberis densifolia</i> Rusby.	55.0	60.0	64.0	75.0	50.0
<i>B.amurensis</i> Rupr.	44.0	48.0	50.0	55.0	40.0
<i>B.thunbergii</i> DC.	48.0	52.0	56.0	64.0	45.0
<i>B.koreana</i> Palib.	40.0	44.0	47.0	52.0	38.0

Propagation by shrub division. During the study, some barberry species were propagated by shrub division. The division of the shrubs was carried out in early spring before the plants shed their leaves, or in autumn after the plants shed their leaves completely. Older individuals of *Berberis vulgaris* L. and *B.thunbergii* DC. were taken for propagation.

Offshoot propagation. We studied also the offshoot propagation of barberry shrubs. Last year's woody branches were used for this purpose. *Berberis vulgaris* L. and *Berberis iberica* Stev & Fisch. Ex DC. were taken for the research. The study was conducted in early spring. The branches of these species located in the lower tier were cut, provided that they were not separated from the mother plant, bent over and planted in the soil to a depth of 15-20 cm and watered. The independent plant, which appeared in late autumn, was separated from the mother plant and planted in a permanent place. The individual obtained when propagated by this method retains the varietal characteristics of the mother plant. Flowering and fruiting were observed in independent plants in the

second year³⁰.

CHAPTER V. AGROTECHNICS OF *BERBERIS* L. SPECIES, RESISTANCE TO SOME ENVIRONMENTAL FACTORS, DISEASES AND PESTS

5.1. Agrotechnics of the studied species. During our research in 2015-2019, cultivation, feeding, irrigation, fertilization, pruning, etc. of the barberry species, introduced to the local soil and climatic conditions following the agrotechnical measures, were also studied³¹.

Complex agrotechnical measures were followed to ensure normal growth, development, and high productivity of the studied species in the soil and climatic conditions of the Absheron Peninsula.

5.2. Tolerance of barberry species to some environmental factors. Our observations show that barberry shrubs require light, even in areas exposed to direct sunlight, they grow normally, the canopy is wider and more scattered, the branches grow in all directions, the leaves are dark green, the fruits are well-reddened. The barberry species studied for heat tolerance are divided into 3 groups:

1. Tolerant species (49.0 ± 2.0 - 50.0 ± 2.0): no burns were observed on the leaves of *Berberis vulgaris* L. and *B. iberica* Stev & Fisch. Ex DC.;

2. Moderately tolerant species (47.0 ± 3.0 - 48.0 ± 2.0): only slight burns were observed at the edges of the leaves of *Berberis densifolia* Rusby., *B. julianae* C.K.Schneid, *B. thunbergii* DC., *B. levis* L., *B. heteropoda* Schrenk. and *B. koreana* Palib.;

3. Susceptible species (46.0 ± 3.0): burns were observed on half of the leaves of *B. amurensis* Rupr.

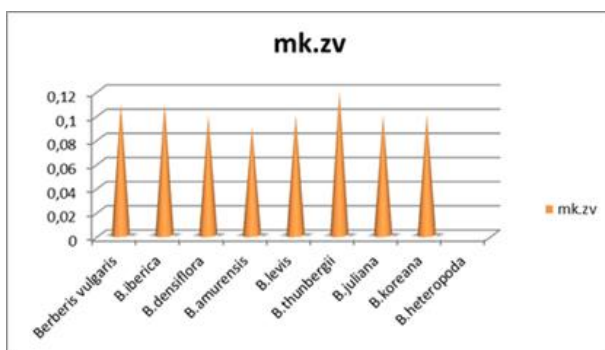
³⁰ Salahova E.X. *Berberis* L. cinsinə aid bəzi növlərin Abşeron şəraitində vegetativ çoxaldılması // -Naxçıvan: AMEA Naxçıvan Bölməsi Elmi Əsərlər Təbiət və texniki elmlər seriyası, -2020. № 2, c. 16., -s. 167-171.

³¹ Соколова Т.А. Декоративное растениеводство: Цветоводство: учебник для студ. вузов. 4-е изд., стер. / Т.А.Соколова, И.Ю.Бочкова. -Москва: Академия, -2010 - 432 с.

The results of our research in 2015-2018 showed that the barberry species we studied are cold-tolerant under the conditions of Absheron, and only 1-3-year-old seedlings spend the winter with very little damage.

The study revealed that the barberry species continue to develop in the background of various radiation. *Berberis thunbergii* DC. and *Berberis amurensis* Rupr. continue their life activities at 0.11 μ / Zv and 0.08 μ / Zv radiation background, respectively³².

5.3. Identification of pathogens and pests of barberry species under Absheron conditions and application of control measures against them. As a result of monitoring and research conducted to study the phytosanitary situation in barberry species of Absheron, powdery mildew disease popularly known as "ash disease" was found to be widespread in these plant species³³.



Graph 5.2.2. Radiation background around different barberry species determined by SOEKS ecotester, μ .Zv / h

³² Mammadov T.S., Salakhova E.Kh. Resistance to the environmental factors of *Berberis* L. species // -Baku: Agricultural & Veterinary Sciences, -2020. Vol. 4/ No. , -p. 138-143.

³³ Salakhova E.Kh. Diseases and pests species of *Berberis* L. in Absheron condition // – Moscow: Bulletin of Science and Practice., -2020. T. 6. №9, -p.69-73.

The causative agent of powdery mildew in barberry species is a fungus species *Microsphaera berberidis* (DC.) Lev belonging to the *Microsphaera* Lev. genus, *Erysiphaceae* family, *Erysiphales* order, *Leotiomycetes* class, *Ascomycota* phylum, *Mycota* kingdom.



Şəkil 5.3.1. *Stictocephala bisonia* Kopp & Yonke pest in the *Berberis thunbergii* species

In the experimental field, consecutive observations of the barberry species were made during the vegetation period and the degree of infection of plants with powdery mildew was determined. To determine the infection degree, the 5-point scale of M.K. Khokhryakov was used (Table 5.3.1.)

According to our observations, in the experimental field of the Institute of Dendrology under Absheron conditions, the pest insect forming swelling is a *Stictocephala bisonia* Kopp & Yonke species, belonging to the *Stictocephala* genus, *Membracidae* family, *Hemiptera* order, *Insecta* class.

Table 5.3.1

Degree of infection of barberry species with powdery mildew in Absheron, points

Species	Degree of plant infection (mainly leaves)				
	I	II	III	IV	V
<i>Berberis vulgaris</i> L.				+	
<i>Berberis iberica</i> Stev & Fisch. Ex DC.	+				
<i>B.densifolia</i> Rusby.		+			
<i>B.amurensis</i> Rupr.		+			
<i>B. levis</i> L.	+				
<i>B.thunbergii</i> DC.			+		
<i>B.julianae</i> C.K.Schneid	+				
<i>B. koreana</i> Palib.	+				
<i>B.heteropoda</i> Schrenk.		+			

Control measures. Mechanical, chemical, biological, and also integrated control methods should be applied against pathogens and pests in barberry.

CHAPTER VI. EVALUATION OF THE PERSPECTIVE OF BERBERIS L. SPECIES AND APPLICATION IN GREENING

6.1. Perspective of barberry species. Viability of the species studied under the Absheron conditions was evaluated and they were divided into 3 groups based on the obtained points.

Group I includes highly promising species: The species included in this group are rated 91-100 points for viability: *Berberis vulgaris* L., *Berberis iberica* Stev & Fisch. Ex DC.

Group II: promising species. In this group, the species were rated 76-90 points for viability. They are tolerant to drought (except *Berberis*

amurensis Rupr.) and frost. However, the vegetative propagation level is relatively low and they are not widely cultivated (*Berberis densifolia* Rusby., *B.amurensis* Rupr., *B.julianae* C.K.Schneid, *B.levis* L., *B.thunbergii* DC., *B.koreana* Palib., *B.heteropoda* Schrenk.).

Group III: Barberry species belonging to this group occupy a low place on the scale and are not cultivated (landscaping). They were rated 60-70 points. No barberry species among the studied ones corresponds to this group.

6.2. Application in landscaping and various fields of the food industry. The species we studied can be used for the following purposes in landscape design, as they are decorative and highly tolerant to external environmental factors:

- In flower compositions along with perennial grasses (*Berberis julianae* C.K.Schneid, *B.thunbergii* DC., *B.heteropoda* Schrenk.);

- In the construction of hedges due to quick growing and forming an impenetrable barrier with thorns (*Berberis vulgaris* L., *B.densifolia* Rusby., *B.koreana* Palib.);

- Solitary (single) in the middle of lawns (*Berberis thunbergii* DC., *B.amurensis* Rupr., *B.koreana* Palib.);

- In compositions consisting of alpinaries and river stones (rockaria) (*Berberis thunbergii* DC., *B. levis* L.);

- In compositions with conifers (*Berberis thunbergii* DC.).

- Alternate arrangement of forms with dark, edged leaves and forms with green leaves (*Berberis thunbergii* DC. vø *Berberis vulgaris* L.).

- In topiaries - the creation of various figures using 1 species and its application in compositions (because the barberry species grow quickly, and take any shape by pruning) (*Berberis vulgaris* L., *Berberis iberica* Stev & Fisch. Ex DC., *B. thunbergii* DC.);

- Alternation of evergreen and deciduous species in the design of different compositions (*Berberis julianae* C.K.Schneid, *B.levis* L., *B.heteropoda* Palib. vø *B.amurensis* Rupr.).

- Alternation of *Berberis thunbergii* DC. with *Euonymus japonicus*, scarlet *Pyracantha angustifolia* species or planting it in their background in the construction of hedges.

Therapeutic value of barberry. All vegetative and generative organs of the *Berberis vulgaris* L. species are used for therapeutic purposes. Alkaloids in the roots and bark can be used for therapeutic purposes without increasing the dose. The roots are harvested in autumn, the bark of the stem in May, the leaves at the time of flowering (April-May), and the fruits at the time of full ripening (October-November). Roots, leaves, and bark contain berberine, organic acids, vitamins C and E, flavonoids, tannins, and microelements. Fruit contains microelements, organic acids, vitamins C and K, and leaves contain vitamin P³⁴.

Thus, it is clear from the above that the studied barberry species are of great importance both for the greening of cities and settlements and for use in various sectors of the economy. Given the prospects of these species, their cultivation and application in various regions of Azerbaijan, including Absheron, is very important.

I would like to thank the staff of the laboratories "Introduction and acclimatization of trees and shrubs", "Plant ecology", "Plant protection", "Herbarium and seed production" for their assistance on the research.

CONCLUSIONS

1. For the first time, the biological characteristics of 9 species of *Berberis* L. genus - morphological description, and growth dynamics of 1-3-year-old seedlings, the correlation between aboveground and underground parts have been studied under Absheron conditions. The aboveground part (9.0 cm-29 cm) was

³⁴ Kərimov Y.B., Süleymanov T.A. və b. Farmakoqnoziya. Bakı. "Herba flora" nəşr., 2010, 741 s.

found to develop better than the underground part (7.0 cm - 26.5 cm) in 1-3-year-old seedlings.

2. For the first time, in the Absheron Peninsula, the viability of pollen of the species belonging to the *Berberis* L. genus has been studied and divided into 3 groups: Group I - pollen with high viability: 73.0% - 79.5% (*Berberis vulgaris* L., *B. densifolia* Rusby. and *B. julianae* C.K.Schneid); Group II - pollen with moderate viability: 58.0-68.5% (*B.amurensis* Rupr., *B.koreana* Palib., *B.heteropoda* Schrenk., *B.thunbergii* DC. and *Berberis iberica* Stev & Fisch. Ex DC.); Group III - pollen with weak viability: 50.5. (*B.levis* L.).
3. Favorable methods of reproduction of barberry species have been studied in Absheron. The best time for sowing was found to be autumn. Seeds sown under such conditions give 45.0 ± 3 - $65.0\% \pm 2$ seedlings. During vegetative propagation, the highest root formation of cuttings was observed in *Berberis thunbergii* DC. and *B. densifolia* Rusby. species when kept in 0.005% heteroauxin solution (IAA) (for 24 hours): 64.0%-75.0%.
4. For the first time in the Absheron Peninsula, the background radiation around *Berberis* L. species was analyzed. It was found that barberry species continue to develop at various radiation doses (*Berberis thunbergii* DC. at 0.11 μ /Zv, *Berberis amurensis* Rupr. at 0.08 μ /Zv).
5. The powdery mildew disease and the *Stictocephala bisonia* Kopp & Yonke pest were identified in the barberry species studied in Absheron.
6. For the first time, the degree of perspective for the use of *Berberis* L. species in Absheron landscaping was determined and the studied species were divided into 2 groups: promising (*Berberis vulgaris* L., *Berberis iberica* Stev & Fisch. Ex DC.) and more promising (*B.densifolia* Rusby., *B.heteropoda* Schrenk., *B.koreana* Palib., *B.julianae* C.K.Schneid, *B.levis* L., *B.thunbergii* DC., *B.amurensis* Rupr.).

PRACTICAL RECOMMENDATIONS

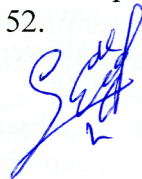
1. In the propagation of productive and ornamental species of the genus *Berberis* L., it is expedient to use the methods of cutting, shrub division, and offshoot.
2. Given that the root system of barberry species is located close to the soil surface and densely branched, it is possible to use them in some areas to prevent soil erosion.
3. In areas with a high radiation background, it is more expedient to plant barberry species, including *Berberis thunbergii* DC.
4. As barberry species are decorative and highly tolerant to external environmental factors, they can be used in the design of various compositions in landscaping.
5. Considering the possibilities of adaptation, biological and decorative features, perspective criteria, as well as therapeutic and nutritional value, it is expedient to cultivate the *Berberis* L. species in large farms.

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