



ISSN 2959-1864 (Online)  
ISSN 2958-0536 (Print)  
Volume 3, Number 2  
July 2024

# Acta Botanica Caucasica

ISSN 2959-1864 (Online)  
ISSN 2958-0536 (Print)

MINISTRY OF SCIENCE AND EDUCATION REPUBLIC OF AZERBAIJAN  
**BAKU STATE OF UNIVERSITY**



# **Acta Botanica Caucasica**

Volume 3, Number 2  
July 2024

The purpose of the journal is to stimulate the development of botanical science. The issues posed by the Journal are the publication of the results of research that are relevant for professional botanists.

The journal "Acta Botanica Caucasica" publishes the results of researches in various fields of fundamental Botany: Systematics, phylogeny, floristics, geobotany, morphology, structural Botany, Plant Physiology; articles on protection of the plant world, as well as the study of vegetation in the Caucasus; chronic materials on scientific events (symposiums, conferences); important botanical innovations; articles on the history of Botany. In the journal "Acta Botanica Caucasica" the Articles of Caucasian and foreign authors are published in English. Articles should include the latest, previously unpublished factual information and theoretical considerations.

**EDITOR-IN-CHIEF:**
**ELSHAD GURBANOV**

Baku State University, Department of Botany and  
Plant Physiology

**ASSOCIATE EDITOR:**
**SAYYARA IBADULLAYEVA**

Ministry of Science and Education of the Republic of Azerbaijan. Institute of Botany

**RESPONSIBLE SECRETARY:**
**HUMIRA HUSEYNOVA**

Baku State University, Department of Botany and Plant Physiology

**EDITORIAL BOARD:**

|                      |                                                                                                                      |
|----------------------|----------------------------------------------------------------------------------------------------------------------|
| TARIEL TALIBOV       | Bioresources Institute, Nakhchivan Division of Azerbaijan National Academy of Sciences, Nakhchivan, Azerbaijan       |
| IBRAHIM JAFAROV      | Research Institute of Plant Protection and Technical Plants, Ganja, Azerbaijan                                       |
| VAGIF NOVRUZOV       | Department of Botany, Ganja State University, Ganja, Azerbaijan                                                      |
| AFAT MAMMADOVA       | Faculty of Biology, Baku State University, Baku, Azerbaijan                                                          |
| AYDIN ASGAROV        | Institute of Botany, Ministry of Science and Education, Department of Systematics and Biodiversity, Baku, Azerbaijan |
| MEHRAC ABBASOV       | Genetic Resources Institute, Ministry of Science and Education, Baku, Azerbaijan                                     |
| ISMAT AHMEDOV        | Leading Researcher, Nanoresearch Laboratory, Baku State University, Baku, Azerbaijan                                 |
| TAHIR SULEYMANOV     | Department of Pharmaceutical Chemistry, Azerbaijan Medical University, Baku, Azerbaijan                              |
| VILAYAT ABDIYEV      | Department of Botany and Plant Physiology, Baku State University, Baku, Azerbaijan                                   |
| ZULFIYYA MAMMADOVA   | Department of Botany and Plant Physiology, Baku State University, Baku, Azerbaijan                                   |
| İSMAIL TURKAN        | Department of Botany, Ege University, Izmir, Turkey                                                                  |
| ERSIN YUCEL          | Faculty of Natural Sciences, Department of Botany, Eskisehir Technical University, Eskisehir, Turkey                 |
| MUNIR OZTURK         | Department of Botany, Ege University, Izmir, Turkey                                                                  |
| AYDIN TUFEKCHIOGLU   | Department of Earth Science and Ecology, Artvin Coruh University, Artvin, Turkey                                     |
| SHAHINA GHAZANFAR    | Royal Botanic Gardens, Kew, London, United Kingdom                                                                   |
| MIRZA HASANUZZAMAN   | Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh                                     |
| NAFEES KHAN          | Department of Botany, Aligarh Muslim University, Aligarh, India                                                      |
| SARVAJEET SINGH GILL | Centre for Biotechnology, Maharshi Dayanand University, Rohtak, India                                                |
| DMITRY SOKOLOV       | Department of Higher Plants, Moscow State University Lomonosov, Moscow, Russia                                       |
| OLEXANDER PAKHOMOV   | Department of Zoology and Ecology, Oles Honchar Dnipro National University, Dnipro, Ukraine                          |
| IVAN MOISEENKO       | Department of Botany, Kherson State University, Kherson, Ukraine                                                     |
| NAZIM MAMMADOV       | Department of Plant and Soil Sciences, University of Massachusetts, Amherst, USA                                     |
| VAGIF ATAMOV         | Department of Biology, Recep Tayyip Erdogan University, Rize, Turkey                                                 |
| JESUS GONZALEZ-LOPEZ | University of Granada, Granada, Spain                                                                                |
| KHABIBJON KUSHIEV    | Laboratory of Experimental Biology, Gulistan State University, Gulistan, Uzbekistan                                  |
| ALEXANDER ZERNOV     | Department of Higher Plants, Moscow State University Lomonosov, Moscow, Russia                                       |
| ZAGIRBEG ASADULAEV   | Mountain Botanical Garden of the Dagestan Scientific Center, Russian Academy of Sciences, Makhachkala, Russia        |
| HAMID RAZIFARD       | Department of Plant Biology, Cornell University, Ithaca, USA                                                         |

© Baku State University, 2024

Department of Botany and Plant Physiology

## THE CURRENT STATE OF FOREST AND SHRUBLAND VEGETATION IN THE QANIKH-AGRICHAY VALLEY

Elshad Gurbanov<sup>1</sup>, Gunel Sariyeva<sup>2</sup>, Sadigova Narmina<sup>3</sup>

<sup>1,2,3</sup> Ministry of Science and Education of the Republic of Azerbaijan. Baku State University, Academic Zahid Khalilov str., 23, Baku, Azerbaijan

Correspondence: gsariyeva<sup>1</sup>@gmail.com

DOI: <https://doi.org/10.30546/abc.2024.3.2.305>

Article info: pp. 3-7

Received: 20.03.2024; Received in revised form 13.05.2024; Accepted 10.07.2024

**Abstract.** *The area and NDVI indicators of forest vegetation were estimated via the QGIS application of the stud area. The maximum indicators of the NDVI are 0.45 - 0.59 characteristic of forest vegetation. The results of field studies made it possible to identify a total of 21 associations, 19 formations, and 7 formation classes within the forest and shrubland vegetation types.*

*The projective cover of the forest area is equal to approximately 20% of the total zonal project cover and the fragmentation and shrinking of the distribution area of rare species such as *Punica granatum* L., *Pistacia atlantica* Desf., *Pterocarya fraxinifolia* (Poir). Spach corresponds to the parameters of the dangerous ecological situation, such as indicators characterizing the environmental condition of the area. In the Ganikh-Agrichay valley, lowland forests are highly fragmented, and their condition worsens. Relatively well preserved, 1 km north of Mughanli village, Zagatala district, and Kurmukchay, Gakh district. Despite the small area, these forests are floristically rich and the density of the forest in their untouched areas is 0.9.*

**Keywords:** *Ganikh-Agrichay valley, forest vegetation, shrubland vegetation, alluvial fan.*

### INTRODUCTION

The Ganikh-Agrichay valley (3473.11 km<sup>2</sup>) selected as a research area covers the Alazan-Agrichay region as a botanical-geographic region [Flora of Azerbaijan 1951-1961].

The Ganikh-Agrichay valley has caught the interest of researchers due to its geographical conditions and favorable climate, which are conducive to efficient resource use and agricultural development. The current vegetation in the area includes forest, shrubland, semi-desert, chal-meadow, and wetland vegetation types. [Sariyeva, 2018].

The forests distributed in the Ganikh-Agrichay valley are this area's initial potential vegetation type and are referred to semi-humid subtropical lowland forests [Prilipko, 1954]. Besides, our study area in the territory of Azerbaijan Republic semi-humid subtropical lowland forests distributed in the Samur-Shabran plain, Barda, and Lankaran regions [Prilipko 1954; Huseynova, 2023], the continuation of these forests towards the South-East situated in the territory of Iran Islamic Republic [Hamzeh'ee et

al.2008].

In the northwestern and eastern parts of the valley, the forests are well developed due to the location of groundwater close to the surface and the excess amount of precipitation.

Considering that the population's main occupation in the valley and surroundings is agriculture, the state of the forest and bushland vegetation should be continuously studied and reported for biodiversity conservation [Zimmerman, 2009; Sariyeva & Gurbanov 2016; Togola et al., 2023].

### MATERIALS AND METHODS

Identification of plant species conducted by Flora of Azerbaijan [Flora of Azerbaijan, 1951-1961], Flowers of Turkey [Pils, 2006], Mountain flowers and trees of Caucasus [Shetekauri & Jacoby 2009]. A working list of plant species clarified according to wfoplantlist.org [wfoplantlist.org 2024]. Classification units of phytocoenosis were clarified using accepted methodology [Shennikov, 1964]. Normalized Difference Vegetation Index (NDVI) map created on QGIS

application and calculated by the formula:

$$NDVI = (NIR - Red) / (NIR + Red)$$

## RESULTS

According to satellite images Landsat 8, the total area of forests in the valley was determined to be 550.81 km<sup>2</sup>. This figure is equal to 15.9% of the total area of the Ganikh-Agrichay valley, and 0.005% of the total forests of the Azerbaijan Republic. According to the latest data, the total area of forests in the Republic is

Normalized Relative Vegetation Index (NDVI). The distribution of phytomass suitable for photosynthesis in the vegetation of the area is shown on the NDVI map (Fig. 1). As can be seen from the map, the indicators of the NDVI are various: 1) 0.09-0.16; 2) 0.17-0.25; 3) 0.26-0.35; 4) 0.36-0.44; 5) 0.45 - 0.59.

In addition, to the assessment of forest area using GIS technologies, the forest vegetation of the Ganykh-Agrichay valley was also properly phytosociologically examined in the field. The

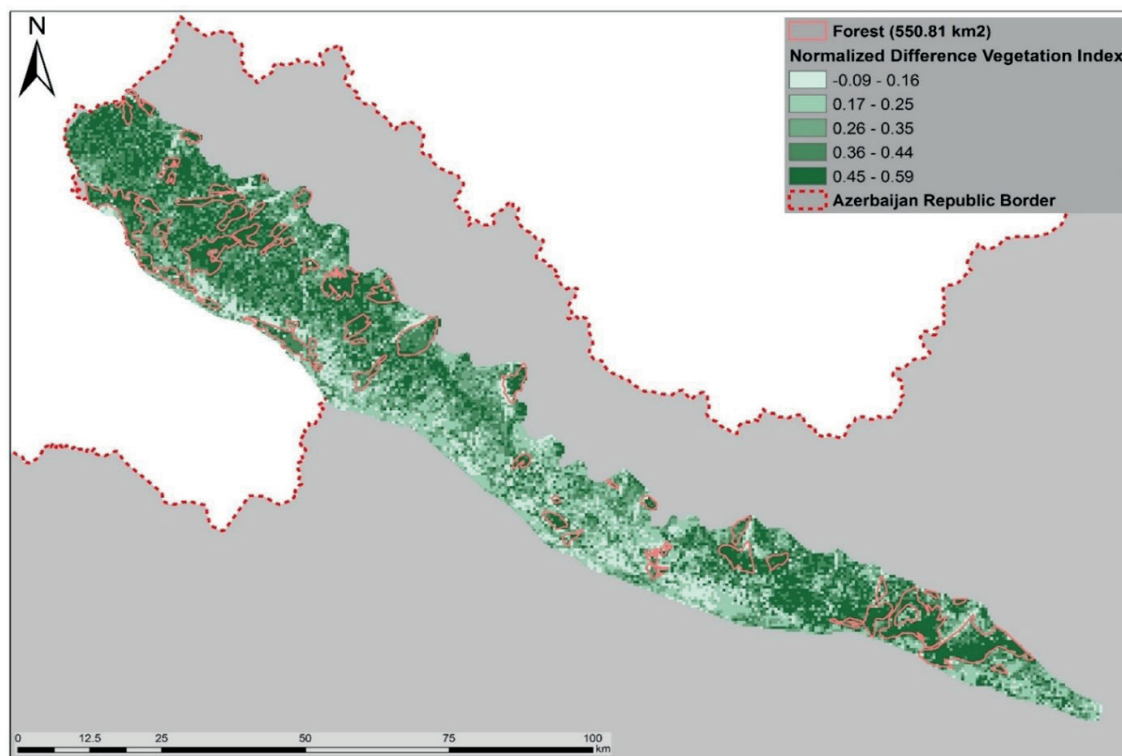


**Figure.1** NDVI map of the study area

10,022 mln. km<sup>2</sup> [Dolkhanov, 2012].

The distribution of forests in the valley was determined based on the calculation of the

results of the conducted studies made it possible to identify 13 associations, 11 formations, and 4 formation classes in the forest vegetation.

### Type: Forest

#### 1 Class formation: Sub-mountain forests;

Formation: *Fageta orientalis*;

Association: *Fagetum orientalis – Carpinosum betulus*

Association: *Fagetum orientalis-Castanosum sativa*

#### 2 Class formation: Riparian forests (Tugay forests);

Formation: *Populeta x hybrida*;

Association: *Populetum x hybrida*

Formation *Saliceta alba*;

Association: *Salixetum alba* (N 40°55'45.1", E 047°34'50.1")

Formation: *Tamarixeta ramossissima*;

Association: *Tamarixetum ramossissima*

#### 3 Class formation: Lowland forests

Formation: *Acereta velutinum*;

Association: *Aceretum velutinum+Oplismenosum undulatifolius*

Formation: *Alneta glutinosa subsp. barbata*;

Association: *Alnetum glutinosa subsp. barbata*+*Caricosum remota*;

Association: *Alnetum glutinosa subsp. barbata*+*Equisetosum telmatia*

Formation: *Pterocaryeta pterocarpa*;

Association: *Pterocaryetum pterocarpa*+*Alnosum glutinosa subsp. barbata*

Formation: *Querceta petraea subsp. iberica*;

Association: *Quersetum petrae subsp. iberica* – *Carpinosum orientalis*

Formation: *Querceta robur subsp. pedunculiflora*;

Association: *Quercetum robur subsp. pedunculiflora*-*Carpinosum betulus*

**4 Class formation:** Arid scrublands,

Formation: *Pistacieta atlantica*;

Association: *Pistacietum atlantica*

Formation: *Celtiseta australis*;

Association: *Celtisetum australis subsp. caucasica*

Accordingly, shrubland vegetation of the study area classified into 8 associations, 8 formations and 3 class formations.

### Type: Shrubland

**1 Class formation:** Xerophytic shrublands in alluvial fans ;

Formation: *Junipereta oxycedrus*;

Association: *Juniperetum oxycedrus* – *Fruticosum*. (N41°04'52.7", E047°21'41.7")

Formation: *Pyracaneta coccinea*;

Association: *Pyracanetum coccinea*-*Paliurosum spina christi*

Formation: *Cotineta coggygria*;

Association: *Cotinetum coggygria* – *Juniperosum rufecens*

Formation: *Elaeganeta rhamnoides*;

Association: *Elaeganetum rhamnoides*-*Rubusosum sanguinea*

**2 Class formation:** Xerophytic shrublands in lowland areas;

Formation: *Atraphaxeta spinosa*;

Association: *Atraphaxetum spinosa*-*Crataegosum orientalis* (N 41°20'50.26" E 46°41'08.22")

Formation: *Puniceta granatum*;

Association: *Punicetum granata* – *Rhamnoso pallasii* – *Paliurosum spina christi*.

Formation: *Paliureta spina-christi*;

Association: *Paliuretum spina-christi*

**3 Class formation:** Xerophytic shrublands in foothill zones;

Formation: *Paliureta spina-christi*;

Association: *Paliuretum-spina christi*– *Rhamnosum pallasii* (N 41°09'34.6" E 047°11'32.7")

### DISCUSSION

The vegetation period of forests in the studied area is from April to October-November. During this period, the forest vegetation has more green phytomass suitable for photosynthesis, unlike other types of vegetation (semi-desert, wetland, chal-meadow) in the area. The lowest indicator is observed in reservoirs, construction areas, bare soil, and areas with sparse vegetation. The highest indicators were determined mainly in areas with dense forests - 0.45-0.59. However, in some areas,

non-forested areas also have high NDVI indicators. This situation is related to the active vegetation of plants at certain times of the year in croplands. Thus, plants cultivated at the peak of vegetation also have a high amount of green phytomass.

The distribution and development of forests in the Ganikh-Agrichay valley, the characteristics of the relief, climate here; are closely related to the regime of rivers and groundwater. Thus, in the Ganikh-Agrichay valley, the alluvial fans formed by the rivers of the southern

slopes of the Greater Caucasus are the main noticeable relief form. Morphologically and lithologically, these alluvial fans can be divided into upper (peak), central, and peripheral parts. While the upper alluvial fans are formed from coarser-grained pebbles and boulders, the second (lower) alluvial fans are formed from medium and small-sized pebbles, gravel, and sand [Museyibov, 1998]. The water holding capacity of each zone is different depending on the mechanical composition of the soil cover. In this regard, the ecological conditions and corresponding floristic composition of the forests characteristic of each zone are different.

In the studied area riparian (Tugay) forests are distributed along Ganikh, Ayrichay, Sincanchay, Alicanchay, Kurmukchay, etc. rivers; *Pterocarya fraxinifolia* (Poir.), *Alnus glutinosa subsp. barbata* (C.A.Mey.) Yalt. forests in conditions of constant excess humidity, where underground water comes to the surface; although essential parts of the forests in the valley are lowland forests, under favorable ecological conditions on the mountain slopes (in some areas) sub mountain forests are also distributed. Such forests include Zagatala (surrounding Mukhax village), Oguz (above Dashagylchay towards Mukhas village and on the edges of the city at 710-740 m a.s.l.) and Ismayilli regions (around Topchu, Khanagah villages).

Shrubs are widespread in the studied area. Shrubland vegetation is formed in the valley area in the alluvial fans of the rivers, plains, and foothills.

Depending on the hydrodynamic properties of the soil and rivers, the composition of the grass cover in the lower and upper parts of the cones differs significantly. Thus, in the lower parts of the cones where there are many pomegranates and small river tributaries are relatively dense, the grass cover consists of mesophytic and hygrophytic elements. In the relatively high (upper) parts of the alluvial fans, hygrophytic

elements are not found in the grass cover of bushes formed on a stable stony substrate, ephemeral and xerophytic plants are common.

Unlike the xerophytic bushlands formed in the foothills, the lianas *Smilax excelsa* L., *Lonicera caprifolium* L, and *Clematis vitalba* L., which are characteristic lowland forests, are distributed in the xerophytic bushlands formed in the alluvial fans.

It was observed that a large part of the xerophytic shrubland was used under cultivation. The rest of the uncultivated parts are being used as rural pastures, mainly small cattle grazed. Depending on the characteristics of the vegetation period of grass plants, such areas are used as pasture in spring from the beginning of April to the beginning of June, and in autumn from the end of September to the end of October. The area of xerophytic shrublands in the bordering part of the study area with the Dashzuz range has significantly decreased due to grazing and logging.

The projective cover of the forest area is equal to approximately 20% of the total zonal project cover and the fragmentation [Golubev, 1999] and shrinking of the distribution area of rare species such as *Punica granatum* L., *Pistacia atlantica* Desf., *Pterocarya fraxinifolia* (Poir). Spach [Red Book of Azerbaijan Republic, 2023] corresponds to the parameters of the dangerous ecological situation, such as indicators characterizing the environmental condition of the study area.

## CONCLUSION

The expanse of lowland forests and xerophytic shrublands in the study area has considerably diminished because of grazing, logging, and construction. Despite recent ecological awareness efforts in our republic, it is unfortunately still common to witness the clearing of forests and bushlands in the valley for cultivation.

## REFERENCES

- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. *Caspian Journal of Applied Science and Research*, 4(3), 74–83.
- Adama T., Yusifova M.M., Sadigova N.A., Akhundova A.A., Karimova L.R., Nuriyeva K.G., Sariyeva

- G.R., Agayeva Z.T., Jafarzadeh S.A., Aghayeva S.A. Anthropogenic impacts on Ajinohur arid forests of Azerbaijan. *Acta Biologica Sibirica*, 2023, Vol 9, 1125–1140. <https://doi.org/10.5281/zenodo.10297250>
- Dolkhanov A., Dadashova L., Garayev A. Fundamentals of sustainable management of Azerbaijani forests [Azərbaycan meşələrinin davamlı idarə edilməsinin əsasları. Bioekoloji tələblər.] Baku, 2012. 138 p.
- Flora of Azerbaijan [Флора Азербайджана] (1951-1961). Baku, AS of Azerb SSR. Vol.1-8.
- Golubev, G.N. Geoecology [Геоэкология]. Moscow: GEOS, 1999. 338 p.
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E. M. (2004). Flora and vegetation of the Atropatena province (within the borders of the Republic of Azerbaijan) [Abstract of doctoral dissertation]. Baku. Гурбанов, Э. М. (2004). Флора и растительность Атропатанской провинции (в пределах Азербайджанской Республики) [Автореф. дис. докт. биол. наук]. Баку.
- Gurbanov, E., & Huseynova, H. (2020). New spreading areas of some species in the botanical-geographical Baku regions of the middle part of the Caspian coast. *Acta Botanica Caucasica*, 1(1), 4–8.
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Gurbanov E.M., Rzaeva A.A. Taxonomic Revision and Distribution of the Genus *Juniperus* (Cupressaceae) in Azerbaijan. *Journal of Food Science and Engineering*, 2019, 9: 139-141.
- Huseynova, H.Z. (2023). New distribution areas of some species of plants on the southern part of the Caspian coast. *Biosystems Diversity*, Biosystems Diversity. Oles Honchar Dnipro National University, Ukraine. 31 (1). p.-123-130. Web of Science, Scopus <https://doi.org/10.15421/012313>
- Museyibov, M.A. Physical geography of Azerbaijan [Azərbaycanın fiziki coğrafiyası]. Baku: Maarif, 1998. 399 p.
- Prilipko, L.I. Forest vegetation of Azerbaijan [Лесная растительность Азербайджана]. Baku: AS Azerbaijan SSR, 1954. 488 p.
- Red Book of the Republic of Azerbaijan, rare and endangered species of plants and mushrooms [Azərbaycan Respublikasının Qırmızı Kitabı, nadir və nəslə kəsilməkdə olan bitki və göbələk növləri]. III edition. Baku, 2023. 507 p.
- Sariyeva G.R. Analysis of the flora of the Ganikh-Agrichay valley (within the Azerbaijan Republic) [Анализ флоры Ганых-Агричайской долины (В пределах Азербайджанской Республики)]. *International Journal of Applied and Fundamental Research*, 2018, No. 1, p. 115-120.
- Sariyeva, G.R. Analysis of the modern state of forests in the Ganikh-Agrichay valley [Qanix-Əyriçay vadisində meşələrin müasir vəziyyətinin təhlili]. *Journal of Young Researcher*, 2018, IV, No. 1, p. 189-194. URL: <https://applied-research.ru/ru/article/view?id=12076>
- Sariyeva, G.R., Gurbanov E.M. Phytocenological structure of arid sparse forest and shrubland landscapes formed in the Ganikh-Eyrichay valley [Qanix-Əyriçay vadisində formalaşmış arid səyrək meşə və kolluq landşaftlarının fitosenoloji quruluşu]. *News of Baku University, Natural sciences series*, 2016, No. 2, p. 44-51.
- Shennikov, A.P. Introduction to geobotany [Введение в геоботанику]. Leningrad: LSU, 1964. 447 p.
- Shetekauri, S., Jacoby M. Mountain flowers & trees of Caucasia: illustrated field guide. Istanbul: Mega Basim, 320 p.
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>
- Zimmermann, M. Ecology and regeneration of forest communities on the alluvial fan near Qakh (Northwestern Azerbaijan) / Diploma thesis in the study program of Landscape Ecology and Nature Conservation, Greifswald, 2009. 61 p.
- World Flora Online. <https://wfplantlist.org/>

## THE DIVERSITY OF IRIS SPECIES IN NAKHCHIVAN

Tariyel Talibov

The Institute of Bioresources of the Ministry of Education of the Republic of Azerbaijan (Nakhchivan)/ Naxchivan State University, AZ 7000, Naxchivan, M.F. Axundov Street 32,

Correspondence: t\_talibov@mail.ru

DOI: <https://doi.org/10.30546/abc.2024.3.2.308>

Article info: pp. 8-13

Received: 05.02.2024; Received in revised form 01.05.2024; Accepted 10.07.2024

**Abstract:** *In this paper, we studied and identified the diversity of Iris species in the Nakhchivan Autonomous Republic. The genus Iris, which belongs to the family Iridaceae, has 2,244 species in the world, 30 in the Caucasus, 40 in Azerbaijan, and 25 in the territory of Nakhchivan. The largest genus in this family is Iris, with 250 species, of which 22 are found in Azerbaijan and 14 in Nakhchivan. Most of these species are used as decorative plants, but some are rare and have been included in the Red Book. Two forms of the Iris lycotis species have been identified: 1. Iris lycotis Woronow magnifica Grossh., and 2. Iris lycotis form. heterochroa Grossh.*

**Key words:** *Iridaceae, Iris, species diversity, taxonomic spectrum, Nakhchivan.*

## INTRODUCTION

The Iridaceae family, belonging to the Asparagales order and the subclass of Liliiflorae, includes 66 genera and over 2,000 species worldwide. It includes several economically important plants like Freesia, Gladiolus, and Crocus. The Iridoideae subfamily, which has the widest distribution, consists of five tribes: *Irideae*, *Sisyrichieae*, *Trimezieae*, *Tigridieae*, and *Diplarreneae*, differing in terms of flower lifespan and nectar production.

The study focused on *Iridaceae* as the object, with *Iris* L. as the chosen species for analysis. Both route-based and stationary methods were employed in the research, incorporating various techniques such as floristic, systematic, phenological, phytocenological, and statistical methods.

The object and methodology of the research.

The object of the study is the species of the genus *Iris* L., which belong to the family Iridaceae Juss. In the research, both route and stationary methods were used, as well as floristic, systematic, phenological, phytosociological and statistical methods.

The discussion of the obtained results.

The stems of the ornamental plants grow upright and have leaves that are similar to grass and are central in shape. Some examples of the species in this category are blue, purple and yellow flowers. In addition to the Irideae genus, other genera produce trixomes that produce oil-like substances called elaiophores, which attract bees. The flowers of the genera related to Irideae have zygomorphic flowers and have stamens of different lengths. The leaves of these plants have a flat shape; they are straight, uniform or uneven, and have parallel veins. The edges of the leaf blades are smooth, with an irregular (uneven) arrangement of cells. There is no secondary thickening in the stem, or if there is, it is abnormal, and if so, it consists of a cambium layer. Fertile flowers are hermaphroditic. There are no pistils. Flower nectar is mostly absent or present. These plants are entomophilous, ornithophilous or rarely anemophilous. Their chromosomes differ, with  $X = 3-19$ .

*Iris* is named after the rainbow, which is called "Iris" in Greek. This is because the flowers of the plants resemble the beauty of the rainbow. Most of these plants are perennials, and they have roots, stems, leaves, and flowers.

Based on the information provided by A.A. Crossheim, there are 40 species of plants in the genus *Sussendia* in Azerbaijan, of which 25 species are native to the territory of Nakhchivan Autonomous Republic (NAR). According to the first data obtained in NAR, 28 species belong to 5 genera. Of these, 8 species have been recommended for inclusion in the Red Book of NAR. As a result of Z.K. Salayev's research, 24 species (3 species in culture) were found on the territory. The largest genus of the species is *Iris* L., which includes approximately 250 species. Of these, 22 species are found in Azerbaijan and 14 in Nakhchivan. Most of them are decorative, but some rare species have also been included in the Red Book.

In the territory of the Autonomous Republic, new forms related to species have been collected, and it is important to study these materials. In general, the possibility of the emergence of a richer variety of geofits in the territory of Nakhchivan Autonomous Republic as a result of development is high. On the territory with a continental climate, where drought often exceeds the norm, the chances of survival for geofits are higher than for other plants. We think that it is necessary to thoroughly study the variety of geofits of the republic. The article presents some varieties of *Iris* L. genus, including some of the varieties mentioned. Recently, the *Iris persica* L., which is a species of iris genus, has been added to the flora of the region. Some varieties have been identified as synonyms after recent research [APG IV, 2016]. Thus, the final classification spectrum looks like this:

**Familia:** Iridaceae Juss., nom. cons.

Subfamily: Iridoideae

Tribe: Irideae

1. Genus: *Iris* L.

1. Subgen.: *Scorpiris* Spach

1(1) *Iris atropatana* Grossh.

2(2) *I. caucasica* Stev.

= *I. c.* Stev. subsp. *caucasica* Bieb.

= *I. c.* Stev. subsp. *schischkinii* Grossh.

3(3) *I. hyrcana* Woronow ex Grossh. .

4(4) *I. pseudocauucasica* Grossh.

5(5) *I. persica* L.

2. Subgen.: *Hermodactyloides* Spach

6(6) *I. reticulata* Bieb.

3. Subgen.: *Iris*

1. Sect. *Xyridion* Tausch

Ser.1. *Spuriae* (Diels) Lawr.

7(7) *I. spuria* subsp. *demetri* (Achv. & Mirzoeva) B. Mathew (*I. prilipkoana* Kem. - Nath., *Xyridion demetri* Achv. & Mirzoeva) Rodionenko

8(8) *I. musulmanica* Fomin

2. Sest. *Iris*

Ser.1. *Elatae* Lawr.

9(9) *I. imbricata* Lindl. (*I. sulphurea* C. Koch)

10(10) \**I. germaniaca* L.

3. Sect. *Oncocyclus* (Siemss.) Baker

Ser.1. *Ibericae* Gawr.

11(11) *I. elegantissima* Sosn.

12(12) *I. lycotis* Woronow

= *Iris lycotis* Woronow forma *magnifica* Grossh.

= *Iris lycotis* Woronow form. *heterochroa* Grossh

Ser.2. *Paradoxae* Gawr.

13(13) *I. paradoxa* Stev.

Ser.3. *Acutilobae* Gawr.

14(14) *I. grossheimii* Woronow ex Grossh.

Subfamily: *Crocoideae*

Tribe: *Gladioleae*

2. Genus: *Gladiolus* L.

15(1) *Gladiolus atroviolaceus* Boiss.

16(2) *G. caucasicus* Herb. (*G. communis* L.)

17(3) *G. halophilus* Boiss. & Heldr.

18(4) *G. kotschyanus* Boiss.

19(5) \**G. gonodavensis* hybr. Hord

20(6) \**G. italicus* Mill.

= *G. kotschyanus* Boiss. subsp. *kotschyanus*

3. Genus: *Crocus* L.

21(1) *Crocus adamii* J. Gay

22(2) *C. artvinensis* (Philippow) Grossh. .



**Figure 1.** *Iris lycotis*; *tipik forma*; 2. *Iris lycotis form. heterochlora*; 3. *İ. lycotis form. Magnifica*;



**Figure 2.** 1. *Iris reticulata*; 2. *Iris persica*; 3. *Iris hyrcana*



**Figure 3.** *Iris paradoxa* (1-typical form ; 2-In the Botanical Garden)



**Figure 4.** *Iris elegantissima* (1. In nature ; 2. In the Botanical Garden)



**Figure 5.** *Iris grossheimii* (1-in nature type; 2-In the Botanical Garden)



**Figure 6.** *Iris caucasica* (1-type); *Iris pseudocaucasica* (3-type); *Iris atropatana* (5-type)



**Figure 7.** *Iris musulmanica*



**Figure 8.** *Iris demetri*

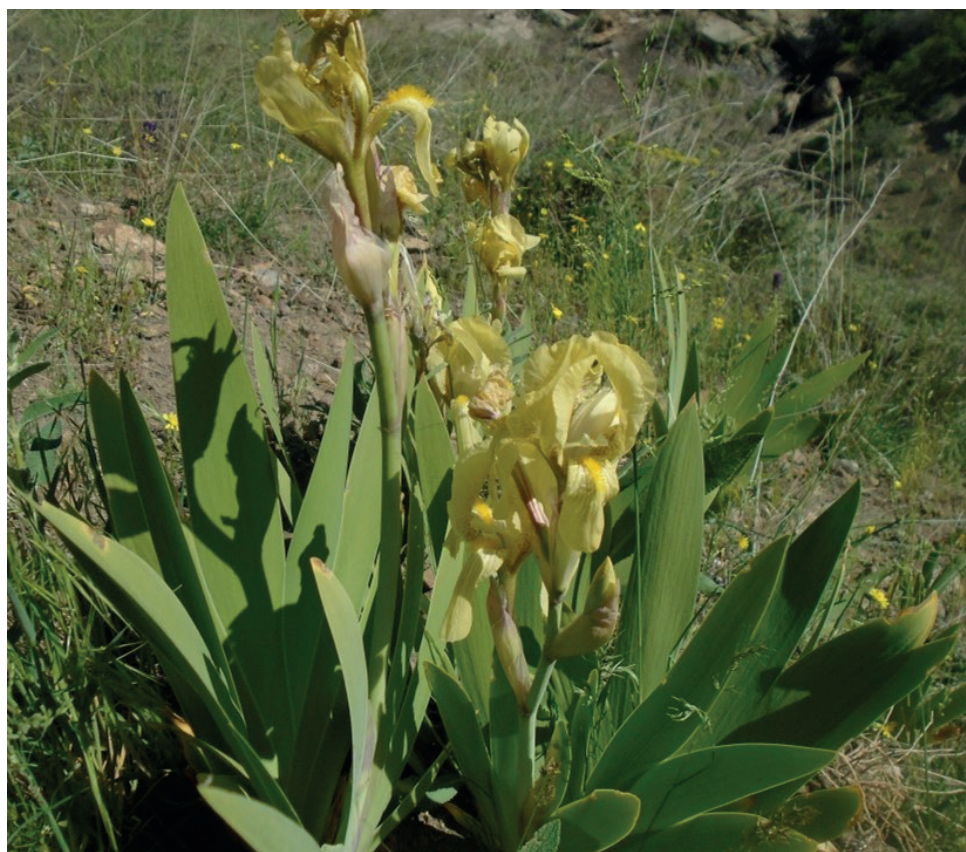


**Figure 9.** *Iris imbricata*

- 23(3) *C. polyanthus* Grossh.  
 24(4) *C. speciosus* Bieb. .  
 25(5) \**C. sativus* L.

### CONCLUSION

Based on the conducted research, it can be concluded that the sonar of the Iridaceae family in the territory of the Nakhchivan Autonomous

Republic includes 3 species belonging to 25 genera. The genus *Iris* includes 14 species, and two of them were discovered by Grossheim: *Iris lycotis* Woronow and *Iris lycotis* forma *magnifica* Grossh. Additionally, a different-colored variety of iris, *Iris lycotis heterochroa*, has been identified.

### REFERENCES

- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. *Caspian Journal of Applied Science and Research*, 4(3), 74–83
- Angiosperm Phylogeny Group - APG IV. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society*, 181(1), 1–20. <https://doi.org/10.1111/boj.12385>
- Christenhusz, M. J. M., Zhang, X.-C., & Schneider, H. (2011). A linear sequence of extant families and genera of lycophytes and ferns. *Phytotaxa*, 19, 7–54. <https://doi.org/10.11646/phytotaxa.19.1.2>
- Flora of Azerbaijan. (1952). Флора Азербайджана. Баки: Из-во АН Азерб. ССР, Т. II, 210-239.
- Flora of the Caucasus. (1940). Флора Кавказа. Баки: Из-во АН Азерб. ССР, Т. II, 200-227.
- Gurbanov, E. M. (2004). Flora and vegetation of the Atropatena province (within the borders of the Republic of Azerbaijan) [Abstract of doctoral dissertation]. Baku. Гурбанов, Э. М. (2004). Флора и растительность Атропатанской провинции (в пределах Азербайджанской Республики) [Автореф. дис. докт. биол. наук]. Баку.
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E., & Huseynova, H. (2020). New spreading areas of some species in the botanical-geographical Baku regions of the middle part of the Caspian coast. *Acta Botanica Caucasica*, 1(1), 4–8.
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Huseynova, H.Z. (2021) The classification of desert and semi-desert vegetation of the Caspian coast (Azerbaijan). *Bulletin of Science and Practise* 7/11: 43–50. <https://doi.org/10.33619/2414-2948/72/05>
- Salayeva, Z. K. (2007). Biodiversity and introduction of the Liliaceae Juss. and Iridaceae Juss. families in the Nakhchivan Autonomous Republic [Naxçıvan Muxtar Respublikasında Zənbaqkimilər və Süsənkimilərin biomüxtəlifliyi, introduksiyası]. Abstract of PhD dissertation, Baku, 23 p.
- Talıbov, T. H., & İbrahimov, A. Sh. (2010). Red Book of the Nakhchivan Autonomous Republic (For higher plants, gymnosperms, and angiosperms) [Naxçıvan Muxtar Respublikasının Qırmızı Kitabı (Ali sporlu, çılpəqtoxumlu və örtülütoxumlu bitkilər üzrə)]. Nakhchivan: Ajamy, Vol. II, 678 p.
- Talıbov, T., İbrahimov, Ə. Sh., & İbrahimov, A. M. (2021). Taxonomic spectrum of the flora of the Nakhchivan Autonomous Republic (For higher plants, gymnosperms, and angiosperms) [Naxçıvan Muxtar Respublikası florasının taksonomik spektri (Ali sporlu, çılpəqtoxumlu və örtülütoxumlu bitkilər)]. Baku: Shirvannashr, 426 p.
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>

## ASSESSMENT OF GENETIC DIVERSITY AMONG WILD POMEGRANATE (*PUNICA GRANATUM* L.) GENOTYPES OF AZERBAIJAN USING ISSR MARKERS

Sabina Hajiyeva<sup>1\*</sup>, Sevda Babayeva<sup>1</sup>, Ziyafat Mustafayeva<sup>1</sup>, Vusala Izzatullayeva<sup>1</sup>,  
Vahid Guvendiye<sup>1</sup>, Elchin Hajiye<sup>1,2</sup>

<sup>1</sup>Institute of Genetic Resources of the Ministry of Science and Education of Azerbaijan

<sup>2</sup>Research Institute of Vegetable growing, Baku, Azerbaijan

Correspondence: sabinahajiyeva@mail.ru

DOI: <https://doi.org/10.30546/abc.2024.3.2.310>

Article info: pp. 14-21

Received: 28.04.2024; Received in revised form 19.05.2024; Accepted 10.07.2024

**ABSTRACT.** *The study aimed to analyze 90 wild pomegranate genotypes collected from six geographical regions of Azerbaijan. A total of 110 PCR fragments were amplified, 86 of which were found to be polymorphic. The number of amplified fragments per primer ranged from 5 to 10, with an average of 7.8. Polymorphic DNA fragments varied from 3 to 9, with a mean of 6.1. Polymorphism percentage ranged from 57% to 100% depending on the primer, averaging 78% overall. The genetic diversity index (GDI) had a mean value of 0.77, with the highest values observed for the IS15 (0.92), UBC811 (0.90), and HB14 (0.90) primers. Cluster analysis grouped accessions into five main clusters, with the genetic similarity index ranging from 0.03 to 1.00. The outcomes of the cluster analysis unveiled the grouping of most accessions based on their collection sites. Results indicate significant diversity in wild pomegranate germplasm in Azerbaijan, suggesting adaptability to various environmental conditions. Further molecular analysis can elucidate the phylogenetic relationships among genotypes, aiding in the understanding of domestication processes in the future.*

**Keywords:** *wild pomegranate, molecular markers, ISSR- primers, genetic polymorphism, cluster analysis.*

### INTRODUCTION

The wild pomegranate (*Punica granatum* L.) exhibits exceptional adaptability across varied climates, leading to its extensive geographical spread. The natural growth of wild pomegranate trees is prominently observed in Central Asia, encompassing Iran, Afghanistan, the South Caucasus, and northwestern India [Teixeira et al., 2011]. Azerbaijan, recognised as a centre of origin for certain plant species, including pomegranate, boasts diverse vegetation due to its strategic location and varying soil-climatic conditions.

While historical exploration of pomegranate genetic diversity relied on morphological features [Mars and Marrakchi, 1999; Zamani et al., 2007], this method falls short in estimating large sample sizes under diverse environmental conditions [Kazemialamuti et al., 2012]. Thus, DNA (Deoxyribonucleic acid) marker analysis

emerges as a promising alternative [Ajal et al., 2014], offering objective assessment independent of growth conditions and revealing high polymorphism levels, crucial for evaluating genetic distances.

Various molecular markers like RAPD (random amplified polymorphic DNA), SSR (simple sequence repeats), ISSR (inter simple sequence repeat), and AFLP (amplified fragment length polymorphism) have been instrumental in assessing genetic relationships among different plant species [Hajiye<sup>1</sup> et al., 2015]. DNA markers provide an informative means of evaluating the genetic diversity and relationships of cultivated and wild pomegranate species from different origins. For instance, AFLP stands out as a prevalent marker utilised in the assessment of the genetic diversity of pomegranate populations from China [Yuan et al., 2007] and Tunisian cultivars [Jbir et al., 2008]. ISSR, a class

of molecular markers based on inter-tandem repeats of short DNA sequences, reveals significant polymorphism, especially among closely related genotypes due to the absence of functional limitations in these noncoding regions [Omayma et al., 2014]. ISSR is recognised as an effective molecular marker showcasing genetic variability in wild pomegranate populations [Zahra et al., 2012]. In several studies ISSR markers, particularly, have shown effectiveness, synthesizing a greater number of polymorphic bands. Recent studies further affirm the utility of ISSR markers in assessing the genetic diversity of pomegranate genotypes [Rehab et al., 2019]. Today, more than 137 microsatellite loci within the pomegranate genome, exhibiting diverse levels of genetic polymorphism among the studied genotypes, have been identified [Soriano et al., 2011].

The primary objective of our current study is to perform molecular characterization using ISSR markers on wild pomegranate genotypes in Azerbaijan, originating from six distinct geographic regions. The data obtained from this investigation hold significant potential for widespread application in future breeding processes.

#### MATERIAL AND METHODS

Plant material for molecular studies

comprised 90 wild pomegranate accessions, as detailed in Table 1. For genomic DNA extraction, 0.1 g samples of freshly harvested leaves were utilized, following the CTAB (cetyltrimethylammonium bromide) protocol initially proposed by Doyle and Doyle [Doyle and Doyle, 1987] with certain modifications. The quality and quantity of the DNA molecules were assessed using a NanoDrop (Thermo, NANO DROP, 2000). The PCR (Polymerase Chain Reaction) reaction mixture, with a final volume of 20  $\mu$ L, consisted of 2  $\mu$ L of 10X PCR buffer, 1  $\mu$ L of a 10 mM dNTP mix, 1.5  $\mu$ L of  $MgCl_2$  (50 mM), 2  $\mu$ L of each primer (15 pmol/ $\mu$ L), 0.1  $\mu$ L of Tag-polymerase enzyme (1 U/ $\mu$ L), and 2  $\mu$ L of isolated DNA (50 ng/ $\mu$ L). Fourteen polymorphic ISSR primers were used in the study. The amplification conditions included a preliminary denaturation at 94°C for 5 min, followed by 35 cycles of denaturation at 94°C (1 min), annealing at a temperature dependent on the primer used (45 s), and elongation for 5 min at 72°C. The final elongation was set at 72°C for 10 min (Applied Biosystems, United States). Electrophoresis of PCR products was conducted on a 2% agarose gel, stained with ethidium bromide, and visualized under ultraviolet light using the BioRad gel documentation system.

**Table 1**

Wild pomegranate genotypes of different regions of Azerbaijan

| №  | Code № | №  | Code № | №  | Code № | №  | Code № | №  | Code № | №  | Code № |
|----|--------|----|--------|----|--------|----|--------|----|--------|----|--------|
| 1  | A1     | 16 | Ga1    | 31 | G1     | 46 | Sa1    | 61 | I1     | 76 | S1     |
| 2  | A2     | 17 | Ga2    | 32 | G2     | 47 | Sa2    | 62 | I2     | 77 | S2     |
| 3  | A3     | 18 | Ga3    | 33 | G3     | 48 | Sa3    | 63 | I3     | 78 | S3     |
| 4  | A4     | 19 | Ga4    | 34 | G4     | 49 | Sa4    | 64 | I4     | 79 | S4     |
| 5  | A5     | 20 | Ga5    | 35 | G5     | 50 | Sa5    | 65 | I5     | 80 | S5     |
| 6  | A6     | 21 | Ga6    | 36 | G6     | 51 | Sa6    | 66 | I6     | 81 | S6     |
| 7  | A7     | 22 | Ga7    | 37 | G7     | 52 | Sa7    | 67 | I7     | 82 | S7     |
| 8  | A8     | 23 | Ga8    | 38 | G8     | 53 | Sa8    | 68 | I8     | 83 | S8     |
| 9  | A9     | 24 | Ga9    | 39 | G9     | 54 | Sa9    | 69 | I9     | 84 | S9     |
| 10 | A10    | 25 | Ga10   | 40 | G10    | 55 | Sa10   | 70 | I10    | 85 | S10    |
| 11 | A11    | 26 | Ga11   | 41 | G11    | 56 | Sa11   | 71 | I11    | 86 | S11    |
| 12 | A12    | 27 | Ga12   | 42 | G12    | 57 | Sa12   | 72 | I12    | 87 | S12    |
| 13 | A13    | 28 | Ga13   | 43 | G13    | 58 | Sa13   | 73 | I13    | 88 | S13    |
| 14 | A14    | 29 | Ga14   | 44 | G14    | 59 | Sa14   | 74 | I14    | 89 | S14    |
| 15 | A15    | 30 | Ga15   | 45 | G15    | 60 | Sa15   | 75 | I15    | 90 | S15    |

Note: A1-A15 – Aghsu; Ga1-Ga15 – Gabala; G1-G15 – Goychay; Sa1-Sa15 – Samukh; I1-I15 – Ismayilli; S1-S15 – Sabirabad.

### STATISTICAL ANALYSIS

To analyze marker polymorphism levels, data were presented as a binary matrix, where the “presence” or “absence” of PCR fragments corresponded to values 1 and 0. Construction of a dendrogram and assessment of genetic distance among samples was performed using the PAST (PAleontological STATistics) computer program [Hammer et al., 2001] based on Jaccard’s similarity index and UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method. The coefficient of genetic diversity was calculated following the Weir formula [Weir, 1990]. Statistical parameters such as Polymorphism Information Content (PIC) [Chesnokov, 2015], the effective multiplex ratio (EMR), and the marker index (MI) [Roldan-Ruiz et al., 2000] were also calculated.

### RESULTS AND DISCUSSION

After multiple DNA amplification rounds, 14 out of the 20 tested primers were selected for their superior efficacy in subsequent analysis. A total of 110 fragments were identified, with 86 (78%) exhibiting polymorphism. The amplified fragments per locus ranged from 5 to 10. On average, each primer initiated the synthesis of 7.8 fragments, with the UBC811 primer yielding the highest number of amplicons. The number of polymorphic DNA fragments varied from 3 (UBC827 and UBC857) to 9 (UBC811 and UBC840), with an average of 6.1.

The polymorphism percentage ranged from 57% to 100%. UBC811 and IS15 primers showed 100% polymorphism in this study (Table 2). A high level of polymorphism at 78%, aligns with results from Narzary et al. [Narzary et al., 2010], who, in a study of 87 pomegranate accessions using 17 ISSR primers, reported a 76.5% level of polymorphism. The effectiveness of ISSR marker systems for determining DNA polymorphism has been previously reported. Notably, Rehab Al-Mousa’s study on Syrian pomegranates using ISSR markers reported the synthesis of 137 DNA fragments, of which 78 were polymorphic (56.93%) [Rehab et al., 2019]. El Amine Ajal et al. [El Amine et al., 2015], in assessing the genetic diversity of 27 pomegranate varieties from Morocco using eight ISSR primers, identified

70 fragments, 61 of which were polymorphic. The high polymorphism of inter-microsatellite markers is attributed to their multiallelic nature and hypervariability. Notably, primers with a dinucleotide repeat (AG)<sub>8</sub> exhibited the highest frequency of polymorphic loci, consistent with the findings of Carvalho et al. [Carvalho et al., 2008].

The genetic diversity index (GDI) was computed for each ISSR locus. An average GDI value across the entire collection was 0.77. Particularly high index values were observed for the IS15, UBC811, and HB14 primers, with 0.92, 0.90, and 0.90 GDI, respectively. The informativeness of these markers aligns with previous studies [Noormohammadi et al., 2012], confirming their robust contribution to genetic diversity assessment. Rehab Al-Mousa et al. in a study of Syrian pomegranates using ISSR markers highlighted a genetic diversity index ranging between 0.56 and 0.80 [Rehab et al., 2019]. The high GDI level affirms the rich genetic diversity within the studied wild pomegranate collection across various regions of Azerbaijan.

Various statistical approaches, such as PIC, EMR, and MI were employed to assess the effectiveness of used marker system (Tab. 2). A critical parameter determining marker informativeness is the polymorphism information content (PIC). For dominant markers, PIC values range from 0 to 0.5 and is influenced by both allele number and allele frequency [Najaphy et al., 2011]. In the current study PIC values were observed to vary from 0.25 to 0.48, with an average of 0.39. 40 out of 86 polymorphic loci exhibited the highest informativeness (PIC > 0.40). The ISSR16 primer, with (CA)<sub>7</sub> dinucleotide repeat, yielded the maximum PIC value at 0.48, while the smallest was noted for ISSR11 locus. The obtained average and high PIC values are deemed sufficient for identifying and distinguishing the studied genotype groups. Our results surpass those reported in previous studies [Narzary et al., 2010; Talebi et al., 2011], where mean PIC values ranged from 0.099 to 0.257 and 0.12 to 0.21, averaging 0.163 and 0.15, respectively. Additionally, our findings align with Noormohammadi et al. [Noormohammadi et al., 2012], showing PIC values ranging from

0.272 (UBC834) to 0.494 (UBC811) when studying 36 pomegranate genotypes with six ISSR primers.

MI and EMR, essential characteristics of marker systems, were computed for each primer, with MI ranging from 0.61 to 3.87 and EMR

from 1.80 to 9, averaging 1.94 and 4.95, respectively. The maximum values for both MI and EMR were detected with the IS15 primer, while the minimum values were associated with the UBC827 and UBC857 primers for each index, respectively.

**Table 2**

Genetic parameters of ISSR primers in wild pomegranate collection

| Primers | Sequence   | NAF | NPF | PIC  | Polymorphism, % | EMR  | MI   | GDI  |
|---------|------------|-----|-----|------|-----------------|------|------|------|
| UBC808  | (AG)8C     | 8   | 7   | 0,39 | 88              | 6.13 | 2.39 | 0.70 |
| UBC810  | (GA)8T     | 7   | 4   | 0,28 | 57              | 2.29 | 0.64 | 0.67 |
| UBC811  | (GA)8C     | 10  | 9   | 0,44 | 90              | 8.10 | 3.56 | 0.90 |
| UBC812  | (GA)8 A    | 7   | 5   | 0,36 | 71              | 3.57 | 1.29 | 0.83 |
| UBC827  | (AC) 8G    | 5   | 3   | 0,28 | 60              | 1.80 | 0.50 | 0.33 |
| UBC834  | (AG) 8YT   | 8   | 6   | 0,36 | 75              | 4.50 | 1.62 | 0.80 |
| UBC840  | (GA)8TT    | 10  | 6   | 0.32 | 60              | 3.60 | 1.15 | 0.81 |
| UBC857  | (AC)8TT    | 5   | 3   | 0,34 | 60              | 1.80 | 0.61 | 0.70 |
| UBC868  | (GAA)6     | 9   | 7   | 0.41 | 78              | 5.44 | 2.23 | 0.85 |
| HB14    | (CTC)3GC   | 8   | 7   | 0.43 | 88              | 6.13 | 2.63 | 0.90 |
| ISSR3   | TGT (AC)7A | 7   | 5   | 0.40 | 71              | 3.57 | 1.43 | 0.70 |
| ISSR16  | CGT(CA)7C  | 8   | 8   | 0.48 | 100             | 8.00 | 3.84 | 0.90 |
| IS 11   | (AGC)6G    | 9   | 7   | 0.25 | 78              | 5.44 | 1.36 | 0.84 |
| IS 15   | (GA)8CG    | 9   | 9   | 0.43 | 100             | 9.00 | 3.87 | 0.92 |
| Total   | -          | 110 | 86  | -    | -               | -    | -    | -    |
| Mean    | -          | 7.8 | 6.1 | 0.39 | 78              | 4.95 | 1.94 | 0.77 |

### CLUSTER ANALYSIS AND GENETIC RELATIONSHIPS

Based on the binary data matrix compiled from ISSR data, a cluster analysis was undertaken, and a dendrogram reflecting the genetic relationships among wild pomegranates was constructed. The genotypes were grouped into 5 main clusters (Fig. 1). The Jaccard similarity index in our study, calculated for 90 wild pomegranate genotypes, ranged from 0.03 to 1.00, with an average value of 0.77.

The number of accessions in each cluster ranged from 14 to 32. The outcomes of the cluster analysis unveiled the grouping of most accessions based on their collection locations. For instance, cluster 3 encompassed 32 genotypes, constituting 35% of all studied genotypes. It is noteworthy that all genotypes collected from Aghsu concentrated within this cluster, along with 13 out of the 15 genotypes from Gabala. Additionally, the cluster comprised 2 genotypes

each from Ismayilli and Goychay. The first cluster predominantly represented genotypes from the Samukh region, with 15 out of 16 studied accessions combined in this cluster. In the second cluster, prevailing representatives hailed from the Ismayilli region among the 19 genotypes. Meanwhile, all genotypes in the fifth cluster were collected from Sabirabad, suggesting the presence of similar allelic variants for the majority of the studied inter-microsatellite loci.

Contrary to Talebi et al.'s findings [Talebi et al., 2003], who did not identify a significant correlation between geographic regions and the genetic structure of studied pomegranate accessions using ISSR data, our study demonstrates distinct groupings based on collection locations. Ercisli et al. investigated Turkish wild pomegranate genotypes using RAPD markers, noting a genetic similarity index ranging from 0.08 to 0.24 [Ercisli et al., 2011].

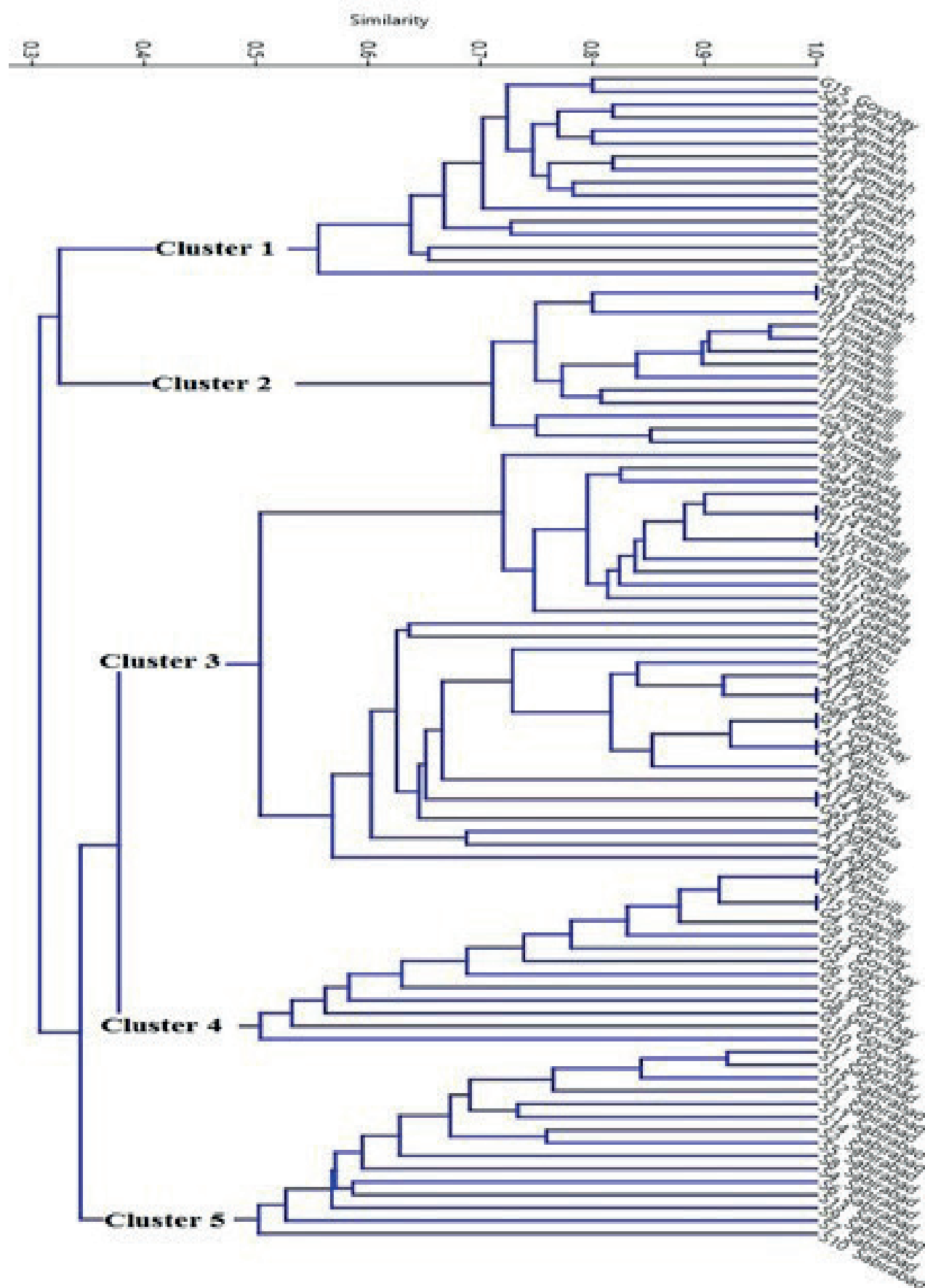


**Figure 1.** Dendrogram of genetic relationship among wild pomegranate genotypes according to ISSR data

## CONCLUSION:

To sum up, this study underscores the existence of diversity within the wild pomegranate germplasm collected from Azerbaijan. The observed high genetic diversity contributes to the adaptability of plants to diverse environmental

conditions. Future molecular analyses on different genotypes can elucidate phylogenetic relationships within genotypes from the same or different locations, aiding in understanding the domestication process shortly.

## REFERENCES

- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. *Caspian Journal of Applied Science and Research*, 4(3), 74–83.
- Ajal E.A., Jbir R., Melgarejo P., et al., (2014). Efficiency of Inter Simple Sequence Repeat (ISSR) markers for the assessment of genetic diversity of Moroccan pomegranate (*Punica granatum* L.) cultivars, *Biochem. Syst. Ecol.*, vol. 56, pp. 24–31.
- Carvalho A., Brito J.L., Macas B., and Pinto H.G. (2008). Genetic variability analysis of a collection of old Portuguese bread wheat using ISSRs, *Options Mediterr., Ser. A. Sem. Medit.*, vol. 81, pp. 35–38.
- Chesnokov Yu.F. (2015). Assessment of the measure of information polymorphism of genetic diversity, *S.-kh. Biol.*, vol. 5, pp. 571–578.
- Doyle J.L. and Doyle J.J. (1987). A rapid DNA isolation procedure for small quantities of fresh leaf tissue, *Phytochem. Bull.*, vol. 19, pp. 11–15.
- El Amine Ajal, Rania Jbir, Pilar Legua, et al. (2015). Genetic diversity of Moroccan pomegranate (*Punica granatum* L.) cultivars using AFLP markers, *Aust. J. Crop Sci.*, vol. 9, pp. 22–29.
- Ercisli S., Gadze J., Agar G., Yildirim N., Hizarci Y. (2011). Genetic relationships among wild pomegranate (*Punica granatum*) genotypes from Coruh Valley in Turkey. *Genetics and Molecular Research* vol.10 (1): pp.459-464.
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E., Huseynova, H. Z., Ibrahimov Sh.İ. (2020). Methods for determining soil contamination by oil and petroleum products and indicator plants in the north of Caspian Sea. *International Journal of agriculture and biological sciences*. Vol.4, № July & Aug., p.84-89. Ijoabs
- Gurbanov, E., & Jabbarov, M. (2017). *Geobotany*. Baku: Baku State University.
- Hajiyev E.S., Akparov, Z.I., Aliev, R.T., et al. (2015). Genetic polymorphism of durum wheat (*Triticum durum* Desf.) accessions of Azerbaijan, *Russ. J. Genet.*, vol. 51, no. 9, pp. 863–870.
- Hammer O., Harper D.A., and Ryan P.D. (2001). PAST: paleontological statistics software package for education and data analysis, *Palaeontol. Electron.*, vol. 4, pp. 1–9.
- Huseynova, H.Z. (2021) The classification of desert and semi-desert vegetation of the Caspian coast (Azerbaijan). *Bulletin of Science and Practise* 7/11: 43–50. <https://doi.org/10.33619/2414-2948/72/05>.
- Jbir R., Hasnaoui N., Mars M., et al. (2008). Characterization of Tunisian pomegranate (*Punica granatum* L.) cultivars using amplified fragment length polymorphism analysis, *Sci. Hort.*, vol. 115, pp. 231–237.
- Kazemialamuti M., Zeinalabedini M., Derazmahalleh M.M., et al. (2012). Extensive genetic diversity in Iranian pomegranate (*Punica granatum* L.) germplasm revealed by microsatellite markers, *Sci. Hort.*, vol. 146, pp. 104–114.
- Mars M. and Marrakchi M. (1999). Diversity of pomegranate (*Punica granatum* L.) germplasm in Tunisia, *Genet. Res. Crop Evol.*, vol. 46, pp. 461–467.
- Najaphy A., Ashrafi Parchin R., and Farshadfar E. (2011). Evaluation of genetic diversity in wheat cultivars and breeding lines using inter simple sequence repeat markers, *Biotechnol. Biotechnol. Equip.*, vol. 25, pp. 2634–2638.

- Narzary D., Rana T.S., and Ranade S.A. (2010). Molecular analysis of genetic diversity in Indian pomegranates using RAPD, DAMD and ISSR, *Fruit Veg. Cereal Sci. Biotechnol.*, vol. 4, pp. 126—143.
- Noormohammadi Z., Fasihee A., Homaee-Rashidpoor S., et al. (2012). Genetic variation among Iranian pomegranates (*Punica granatum* L.) using RAPD, ISSR and SSR markers, *Aust. J. Crop Sci.*, vol. 6, pp. 268—275.
- Omayma M.I., Rania A.A., and Ibrahim A.M. (2014). Morphological and molecular evaluation of some Egyptian pomegranate cultivars, *Afr. J. Biotechnol.*, vol. 13, pp. 226—237.
- Pitsiouni M., Linos A., Hagidimitriou M., Drogoudi P. (2012). Genetic diversity of greek wild and cultivated pomegranate (*Punica granatum* L.) genotypes and cultivars using molecular markers. Lisbon, Portugal, International Symposium on the Challenge for a Sustainable Production, Protection and Consumption of Mediterranean Fruits and Nuts. *Acta Horticulturae*, pp.193-200
- Rehab Al-Mousa, Fahed Al-Biski, Alaa Alshaal. (2019). Molecular Characterization of Some Syrian Pomegranate (*Punica granatum* L.) genotypes. *Jordan Journal of Agricultural Sciences*, Vol. 15, No.3 pp.82-93
- Roldan-Ruiz I., Dendauw J., Vanbockstaele E., et al. (2000). AFLP markers reveal high polymorphic rates in ryegrasses (*Lolium* spp.), *Mol. Breed.*, vol. 6, pp. 125—134.
- Soriano J.M., Zuriaga E., Rubio P., et al. (2011). Development and characterization of microsatellite markers in pomegranate (*Punica granatum* L.), *Mol. Breed.*, vol. 27, pp. 119—128.
- Talebi B.M., Sharifi N.B., and Bahar M. (2003). Analysis of genetic diversity in pomegranate cultivars of Iran, using Random Amplified Polymorphic DNA (RAPD) markers, *Proceedings of the 3d National Congress in Biotechnology*, vol. 2, pp. 343—345.
- Talebi M., Bahar M., Sharifnabi B., and Yamchi A. (2011). Evaluation of genetic diversity among Iranian pomegranate (*Punica granatum* L.) cultivars, using ISSR and RAPD markers, *Taxon. Biosyst.*, vol. 8, pp. 35— 44.
- Teixeira da Silva J., Rana T.S., Narzaryd D., et al. (2013). Pomegranate biology and biotechnology: a review, *Sci. Hort.*, 2013, vol. 160, pp. 85—107.
- Weir B.S. (1990). *Genetic Data Analysis Methods for Discrete Genetic Data*, Sunderland, MA: Sinauer, 337 pp.
- Yuan Z., Yin Y., Qu J., and Zhu L. (2007) Population genetic diversity in Chinese pomegranate (*Punica granatum* L.) cultivars revealed by fluorescent-AFLP markers, *J. Genet. Genom.*, vol. 34, pp. 1061—1071.
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>
- Zahra N., Ali F., Saeed H.-R., et al. (2012). Genetic variation among Iranian pomegranates (*Punica granatum* L.) using RAPD, ISSR and SSR markers, *Aust. J. Crop Sci.*, vol. 6, no. 2, pp. 268—275.
- Zamani Z., Sarkhosh A., Fatahi R., and Ebadi A. (2007). Genetic relationships among pomegranate genotypes studied by fruit characteristics and RAPD markers, *J. Hort. Sci. Biotechnol.*, vol. 82, pp. 11—18.

## THE ACTIVITY OF PEROXIDASE AND SUPEROXIDE DISMUTASE IN PLANT SEEDLINGS UNDER SALT STRESS

Abdiyev Vilayet<sup>2</sup>, Jafarzade Boyukkhanim<sup>1</sup>

<sup>1,2</sup>Ministry of Science and Education of the Republic of Azerbaijan. Baku State University, Academic Zahid Khalilov str., 23, Baku, Azerbaijan

Correspondence: cxanum@mail.ru

DOI: <https://doi.org/10.30546/abc.2024.3.2.315>

Article info: pp. 21-29

Received: 02.03.2024; Received in revised form 13.06.2024; Accepted 10.07.2024

**ABSTRACT.** *The activity of peroxidase (EC 1.11.1.21) and superoxide dismutase (EC 1.15.1.1) was studied in barley and bean seedlings with contrasting salt tolerance grown under extreme salinity conditions. According to our results, the change of peroxidase activity is adequate as the concentration of isolation sodium salts increases in the above-ground parts of barley and bean seedlings grown in water culture. It was found that the activity of SOD in the root system of both barley and bean seedlings was lower than in the shoot part. The activity of SOD in the root system of 7-day-old barley seedlings cultivated in water culture increased with the increasing concentration of chloride and sulfate salts (25-50mM). The subsequent increase in the concentration (75-100mM) resulted in reduced enzyme activity although exceeding the activity in control plants. The enzyme activity in barley seedlings grown in soil culture was weakened by the influence of salts. It should be noted that the linear nature of the increase in SOD activity in the root system of bean seedlings cultivated in water culture when the concentration of salts increases indicates a decrease in the amount of substrate in the root system. The study of enzyme activity in the root and shoot parts of barley and bean seedlings with contrasting salt tolerance grown in soil and water culture under extreme salinity, which allows determining the adequate or specific nature of peroxidase and superoxide dismutase reactions.*

**Keywords:** *salinity, stress, superoxide dismutase, superoxide anion radicals, peroxidase*

### INTRODUCTION

At present, one of the serious problems facing agriculture is the salinization of agricultural lands due to both natural and anthropogenic causes [Gasimov, 2012; Abdiyev, 2017; Velijanov, 2022].

According to modern calculations, 15-23% of the dry area of the Earth, including the lands used in agriculture, are saline soils. Soil salinity, which is one of the main factors of the environment, has a strong effect on the development and productivity of agricultural plants [Sun et al., 2016]. There are over 1.3 million hectares of saline soils in Azerbaijan [Mammadov, 2007], and the tendency of this process to progress is observed [Abdiyev, 2017]. The composition of

salts in the lands of Azerbaijan is quite diverse. Chloride-sulfate or sulfate-chloride types of salinization are more widespread. Besides, carbonate salinity is not uncommon (Mammadov, 2007; Wang Su-Ping et al., 2007).

It should be noted that extreme salinity conditions have a negative impact on the development of cultivated plants, significantly reducing productivity and sometimes leading to their complete destruction [Aliyeva, 2018; Valijanov, 2022].

Currently, the most dangerous salinity in the soil is considered to be sodium-chloride salinity because chemically active ions such as Na<sup>+</sup> and Cl<sup>-</sup> accumulate in plant cells in excess, negatively affect a number of physiological-biochemical

processes, and ultimately reduce productivity sharply [Wang Su-Ping et al., 2007; Flowers, 2008; Ibrahimova, 2015].

Besides, most of the Earth's flora are exposed to salts during their growth cycle. Thus, the study of the mechanism of action of salts on the plant organism is not only theoretical but also of great practical importance. Researchers associate the toxic effect of salts in the plant body with the disruption of the activity of cell enzymes [Shevyakova, 2010; Gasimov, 2012; Abdiyev, 2017]. This is not accidental. If living organisms are self-regulating systems, then enzymes are considered a regulatory component for all physiological-biochemical processes.

Several defence systems are known in the plant body. One of these defense systems is the enzyme system in the cell. From this point of view, the study of the activity of peroxidase and superoxide dismutase, which are widely distributed defense system enzymes in the animal and especially the plant body, is of great importance.

Under salinity conditions, the accumulation of hydrogen peroxide, having a harmful effect on plants [Garifzyanov, 2012] and superoxide anion radicals, which are the source of the formation of reactive oxygen species [Baranenko, 2006] and have toxic effects on cells, occurs.

Peroxidase breaks down hydrogen peroxide into water and atomic oxygen. Superoxide dismutase (SOD) catalyzes the conversion of superoxide anion radicals into molecular oxygen and hydrogen peroxide.

Peroxidase increases the resistance of the plant organism to diseases. Besides, peroxidase plays an important role in the synthesis of polyphenols, as well as in the process of hydroxylation of the benzene ring. On the other hand, peroxidase is very important in the use of the oxygen reserve of the cell [Gasimov, 2008]. Peroxidase is also involved in the regulation of growth and development processes in plants.

Superoxide dismutase (SOD) is also widely distributed in plant tissues and cells. Superoxide anion radicals are the first product of one-electron reduction of molecular oxygen and are the source of the formation of reactive oxygen species that have a more toxic effect on

cells [Baranenko, 2006]. In addition to participating in the formation of other reactive oxygen species, superoxide anion radicals directly oxidize intracellular macromolecules, including proteins, and inactivate enzymes. Therefore, SOD is one of the important enzymes that form the first line of defence protecting intracellular macromolecules from oxidative damage. It also ensures a low concentration of superoxide anion radicals in the cell and reduces the activity of the formation of ROS (reactive oxygen species) [Volikhina, 2009].

The negative effect of salts on plants is more pronounced in the early stages of ontogenesis, and in this period, plants are more sensitive to salinity. Therefore, to clarify the mechanism of the effect of salts on the plant body, the study of physiological-biochemical processes in the first stages of the development of seedlings is of great importance, because the first physiological-biochemical processes occurring in plant cells have a strong impact on the subsequent changes in intracellular metabolism in the plant body. Thus, it is clear from the above that peroxidase and superoxide dismutase enzymes are very actively involved in cell metabolism.

## MATERIAL AND METHODS

7-day-old seedlings of barley (Karabagh 22) and bean (Local pedestrian) varieties, which are widely used in agriculture, served as research objects. The biological characteristics of barley (*Hordeum vulgare* L), belonging to the class of monocotyledons allow the cultivation under different climatic conditions. Therefore, this plant is widely distributed in the world. On a global scale, the cultivated area of barley is close to 100 million hectares. Barley, being an important cereal crop, is cultivated for food, fodder, and technical purposes. Bean belonging to the legume family (*Phaseolus vulgaris*) is a dicotyledonous plant rich in protein. Bean holds a leading place among vegetable crops, both in terms of use scope and nutritional value. Seed germination was carried out in a special chamber with 420 lux lighting, 20°C and normal aeration (0.04 mg O<sub>2</sub>/min) in Knop's solution and soil (dark mountain grey-brown) culture. In experimental variants, the Knop solution with

salt ( $\text{NaCl}$  and  $\text{Na}_2\text{SO}_4$ ) concentrations of 10, 20, and 30 mM for beans, and 25, 50, 75, and 100 mM for barley was used in water culture. In soil culture, artificial medium with 0.2%, 0.4%, 0.6%, 0.8%, and 1% concentrations of salts was created under laboratory conditions.

The activity of peroxidase in plant roots and shoots is based on the rate of oxidation reactions in which a blue oxidation solution is formed. The concentration of the blue oxidation solution was determined with a photoelectric colourimeter (UXL-42) [Yermakov, 1987]. The formation of the superoxide anion radical is based on the formation of the purple colour of nitroblue-tetrazolium. Enzyme activity was measured by the spectrophotometric method [Beauchamp & Fridovich, 1971]. Experiments were performed in 3-4 replicates, the obtained results were processed statically [Kerdyashov, 2018]. In the studies, the accuracy rate was lower than 5%, the obtained results are mathematically reliable.

## RESULTS

Although many scientific studies have been

conducted on the effects of salts on enzymes, most of these data are contradictory. On the other hand, the mechanism of the effect of salts on the activity of enzymes in plant seedlings at the first stages of ontogenesis has not yet been fully clarified. The study of the nature of changes in the activity of peroxidase and superoxide dismutase in the roots and shoots under the influence of salt is of great scientific-theoretical and practical importance.

The activity of peroxidase was found to be higher in the roots than in the above-ground parts of 7-day-old barley and bean seedlings grown in water and soil culture (Fig. 1). It was found that the activity of peroxidase in the roots and shoots of seedlings in water culture was higher than in soil culture. It should be noted that a similar result was obtained for the superoxide dismutase enzyme. In general, physiological-biochemical processes occur faster in plants grown in water culture than in plants grown in soil culture. Besides, the activity of peroxidase in bean seedlings was higher than that of barley seedlings. Physiological and biochemical processes are faster in plants grown in

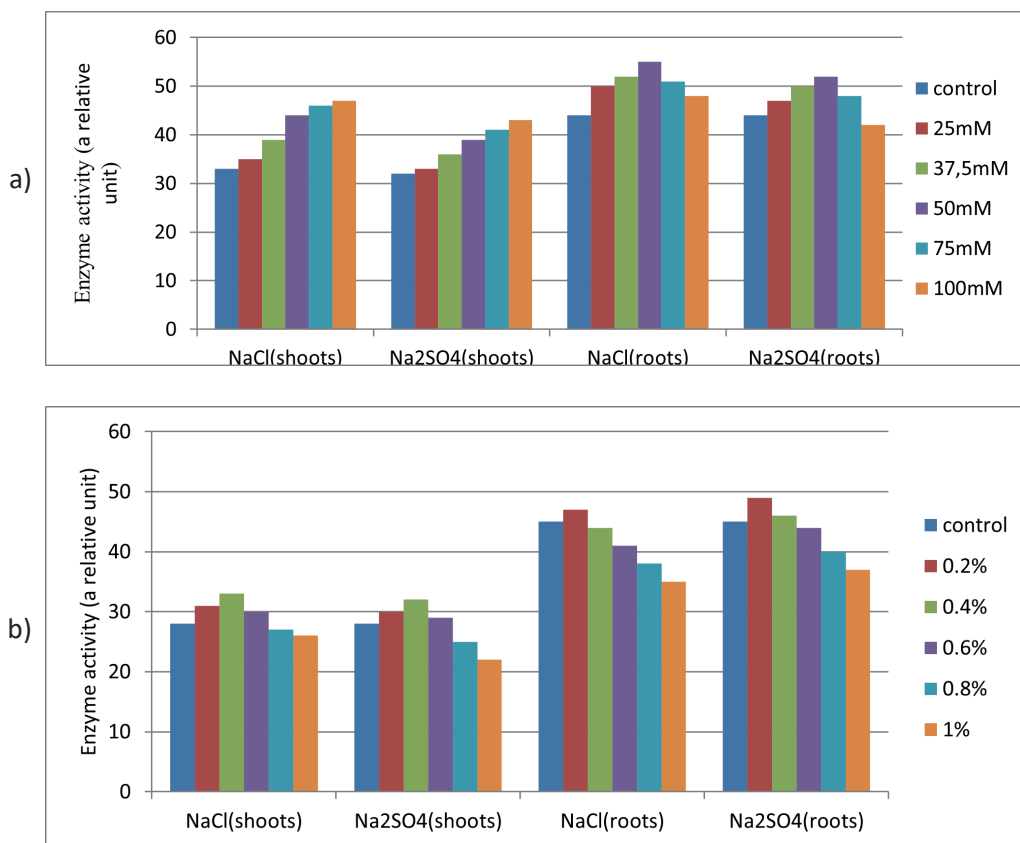


**Figure 1.** Peroxidase activity in roots and shoots of 7-day-old barley seedlings grown in water (a) and soil cultures (b) under different concentrations of  $\text{NaCl}$  and  $\text{Na}_2\text{SO}_4$ .

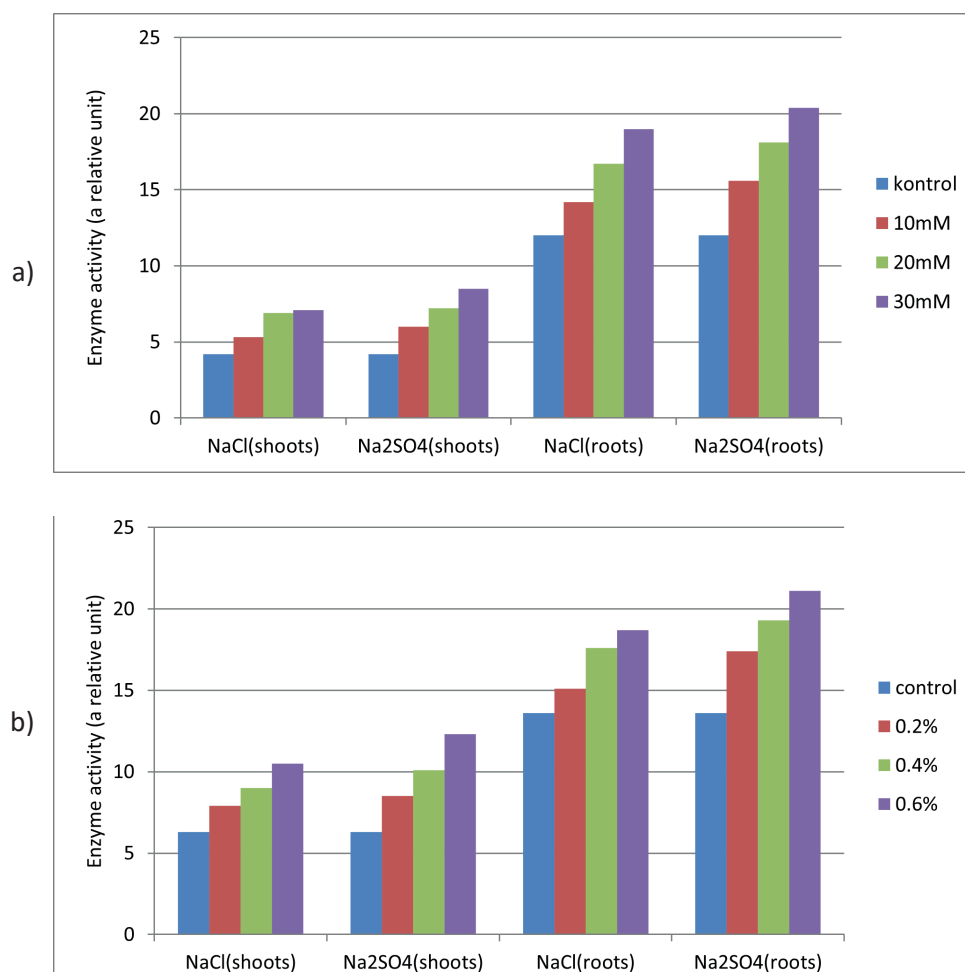


**Figure 2.** Peroxidase activity in the roots and shoots of 7-day-old bean seedlings cultivated in water (a) and soil cultures (b) under different concentrations of NaCl and Na<sub>2</sub>SO<sub>4</sub>.

water culture due to better aeration and water supply.

In addition, peroxidase activity was determined under the influence of different concentrations of Na<sub>2</sub>SO<sub>4</sub> and NaCl. A linear growth in peroxidase activity occurred with the increasing salt concentrations (25-100 mM) in roots and shoots of 7-day-old barley seedlings grown in water culture. In the roots of barley seedlings, a different picture was obtained due to the effect of salts. As seen in the figure, the activity of peroxidase increased when the concentrations of salts in the roots of barley seedlings were relatively low (25-50 mM), and then the activity of peroxidase decreased with the increasing concentrations of salts (75-100 mM) (Fig. 1). It should be noted that a different picture was observed in both roots and shoots of barley seedlings cultivated in the soil under the effect of

salts. Thus, the activity of peroxidase increased when the concentrations of salts were relatively low (0.2%) in the root system of 7-day-old barley seedlings cultivated in soil culture. Then, with the increase in salt concentrations (0.4-1.0%), the activity of peroxidase decreased.

In the above-ground part, at relatively low concentrations of salts (0.2-0.4%), the activity of peroxidase increased and the subsequent increase in salt concentrations (0.6-1.0%) led to a decrease in the activity of the enzyme (Fig. 1). It should be noted that when the concentration of isocation sodium salts increased in the roots and shoots of 7-day-old bean seedlings grown in both water and soil cultures, the activity of peroxidase increased linearly (Fig. 2). It is known that superoxide dismutase is one of the enzymes of the antioxidant defense system that plays the most important role in protecting cells

and tissues from oxidative damage under conditions of salt stress [Baranenko, 2006; Amrahov et al., 2022; Mammadov, 2023]. The activity of superoxide dismutase (SOD) was studied

in barley and bean seedlings cultivated under isocation sodium salinity conditions.

Based on the results, the activity of SOD similar to peroxidase was higher in the 7-day-old

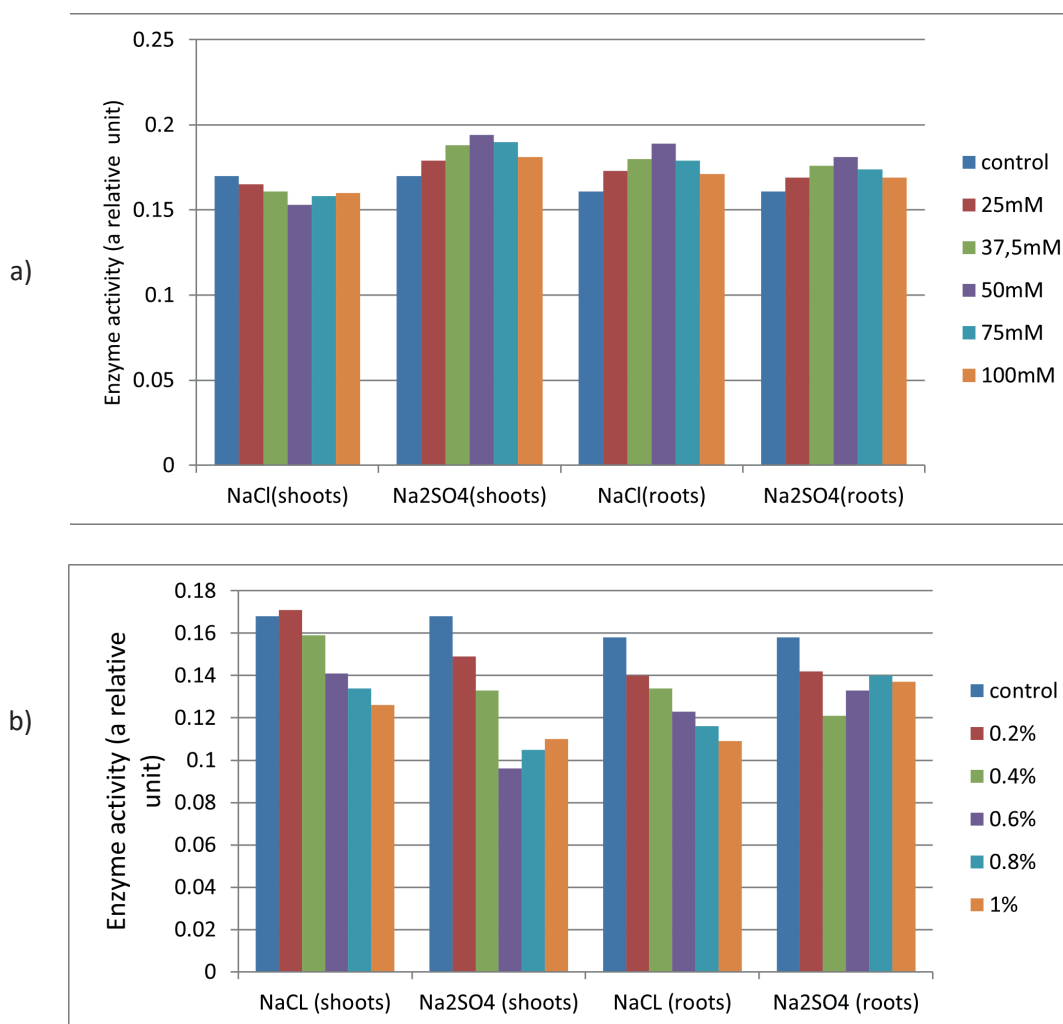


**Figure 3.** Superoxide dismutase activity in roots and shoots of 7-day-old barley seedlings cultivated in water (a) and soil cultures (b) under various concentrations of NaCl and  $\text{Na}_2\text{SO}_4$ .

barley and bean seedlings cultivated in the water environment compared to the plants cultivated in the soil. It was found that the activity of SOD in seedlings depends on the concentration of isocation sodium salts in the environment. Besides, the activity of SOD in the roots of both barley and bean seedlings is lower than in the shoots. The higher activity of SOD in the aerial part compared to the root can be explained by the activity of different isoforms of the enzyme in chloroplasts. The higher activity of SOD in the shoots compared to the roots can be explained by the presence of different isoforms of the enzyme in chloroplasts.

The research revealed that the activity of SOD in the root system of 7-day-old barley seedlings grown in water culture increased as the concentration of chloride and sulfate salt increased (25-50 mM), and the activity of the enzyme was reduced during the subsequent increase in concentration (75-100 mM), but it was lower than in the control. In the above-ground part, the activity of SOD decreased with the increase of NaCl concentration (25-100 mM) compared to the control. In the case of sulfate salinity, the activity of the enzyme increased with the enhancing salt concentrations (25-50 mM), and the activity of the enzyme decreased

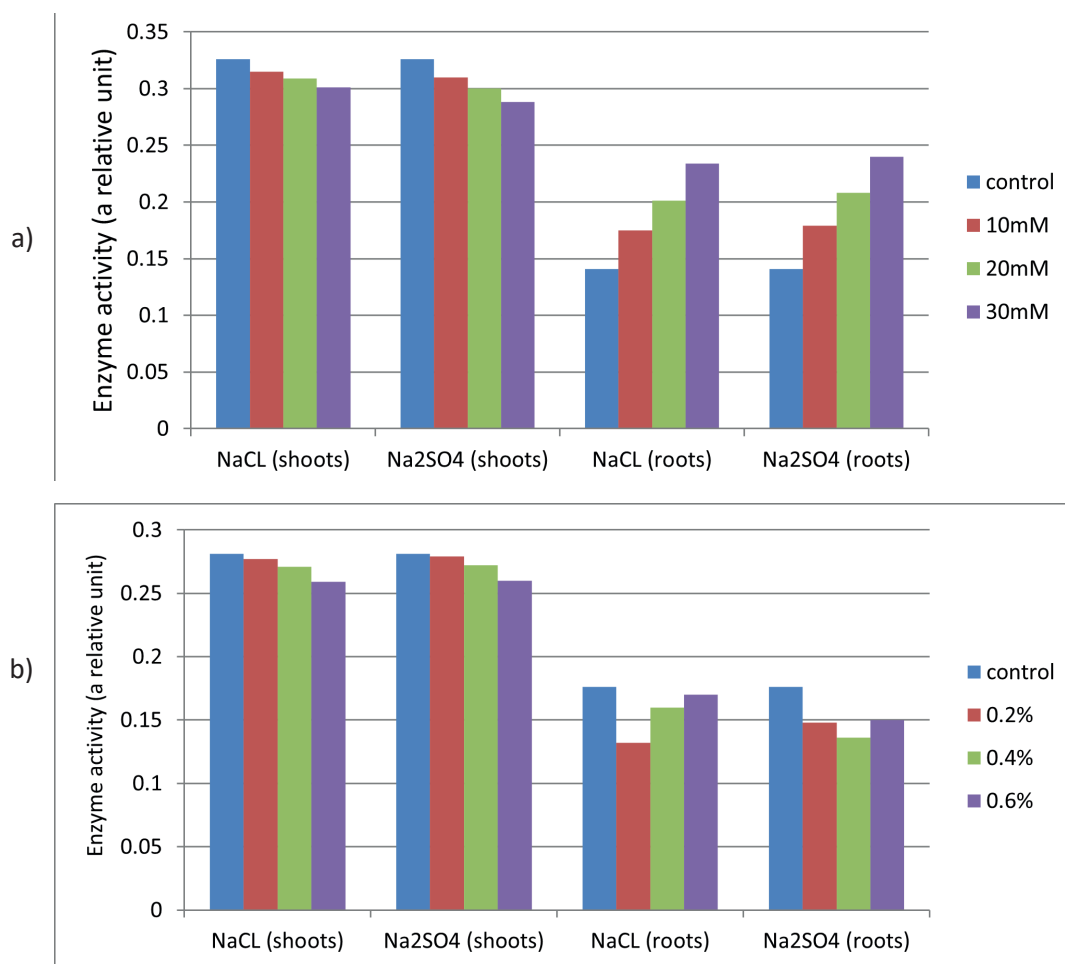


**Figure 4.** The activity of superoxide dismutase in roots and shoots of 7-day-old bean seedlings cultivated in water (a) and soil cultures (b) under various concentrations of NaCl and Na<sub>2</sub>SO<sub>4</sub>.

during the subsequent increase in concentration (75-100 mM) although remained higher than in the control (Fig. 3).

It should be noted that a different picture was obtained from the effect of salts on both the roots and the shoots of barley seedlings cultivated in soil culture. Thus, as the concentration of NaCl increased (0.2-1.0%) in the root system of barley seedlings cultivated in soil culture, the activity of SOD decreased sharply. In the case of sulfate salinity, the activity of the enzyme weakened at relatively low concentrations (0.2-0.4%) of the salt, and although the subsequent increase in concentrations (0.6-1.0%) led to the enhanced activity of the enzyme, it was lower than in the control. In the above-ground parts, the activity of the enzyme decreased sharply when the concentration of salts increased (Fig. 3).

We believe the linear nature of the increase in the activity of SOD due to increased

concentration of salts (10-30 mM) in the root system of bean seedlings cultivated in water culture indicates a decrease in the amount of substrate in the root system. As the concentration of salts (10-30 mM) in the shoots increased, the activity of SOD decreased. Under sulfate salinity, the decrease was sharper (Fig. 4). A similar result was also obtained for the above-ground parts of 7-day-old bean seedlings grown in soil under different concentrations of salts. Thus, as the concentration of salts increased (0.2-0.6%), the activity of SOD in the shoots decreased sharply (Fig. 4). In the root system of bean seedlings, when the concentration of salts was relatively low (0.2%), the activity of SOD weakened, and during the subsequent increase in concentrations (0.4-0.6%) of salts, the activity of SOD increased. However, the activity of SOD was lower than in the control.

During long-term exposure to high-concentration salts, SOD activity may decline due

to a decrease in the amount of superoxide radicals because of their quenching. Besides,  $H_2O_2$  and hydroxyl radical ( $OH\cdot$ ) can cause enzyme inactivation or degradation. The increase in enzyme activity under stress conditions can be attributed to the increase in the synthesis of new enzyme molecules. The obtained results agree with the literature data. Thus, several scientists have noted the declining SOD activity during the protection of cells and tissues from oxidative damage under stress [Santos et al., 2011; Wultal, 2013]. The linear nature of enzyme activity under extreme salinity conditions can be attributed to the fact that the amount of hydrogen peroxide and superoxide anion radicals, which are used as enzyme substrates in tissues, does not reach saturation. Because any enzymatic reactions, including those carried out with the involvement of peroxidase and superoxide dismutase, are the first-order reactions until saturation with the substrate. However, after saturation, the enzymatic reaction becomes zero-order and does not depend on the amount of substrate.

It is important to note that  $H_2O_2$  formed as a result of the effect of SOD is an inhibitor of the enzyme. Thus, the effective functioning of SOD also depends on catalase, and ascorbate-glutathione cycle enzymes, which belong to other defence system enzymes that break down  $H_2O_2$ .

## CONCLUSION

The activity of peroxidase and superoxide dismutase, which play a most important role in protecting cells and tissues from oxidative damage, was determined in barley (tolerant) and bean (sensitive) seedlings with contrasting salt tolerance, grown under isocation sodium salinity conditions. The study revealed that as the concentration of salt increased (25-100mM), the activity of peroxidase increased linearly

in the above-ground parts of 7-day-old barley seedlings grown in water culture. In the roots of barley seedlings, when the concentration of salts was relatively low (25-50mM), the activity of peroxidase increased. The subsequent increase in the salt concentrations (75-100mM) resulted in a decrease in enzyme activity, which is characterized by a two-phase curve. Similar results were obtained in seedlings grown in soil culture.

Comparable results were detected for SOD activity in the roots of barley seedlings. It is worth mentioning that the activity of peroxidase increased linearly with the increasing concentrations of isocation sodium salts in the roots and the shoots of 7-day-old bean seedlings grown in both water and soil cultures. The activity of SOD decreased as the concentration of salts increased in both the root and shoots of barley seedlings grown in soil culture. The linear nature of the increase in SOD activity in the root system of bean seedlings grown in water culture with increasing concentrations of salts can be explained by the fact that the amount of hydrogen peroxide and superoxide anion radicals, which are used as substrates for the enzyme in the root system, does not reach saturation. Therefore, any enzymatic reaction, including those that involve peroxidase and superoxide dismutase, is the first-order reaction until saturation with the substrate. However, after saturation, the enzymatic reaction becomes zero-order and does not depend on the substrate amount.

The research revealed that the change in the activity of peroxidase in the aboveground part of the 7-day-old monocot and dicot plant seedlings cultivated in a water environment is adequate, and the change in the activity of SOD is specific.

## REFERENCES

- Abdiyev, V. B. (2017). Study of alternative ways of biological oxidation in plants under conditions of Abdiyev, V. B. (2017). Study of alternative ways of biological oxidation in plants under conditions of extreme salinity. Abstract of the doctoral dissertation in biology, Baku, 2017, 44 p. [Ekstremal duzluluq şəraitində bitkilərdə bioloji oksidləşmənin alternativ yollarının tədqiqi]/Avtoreferat, 44 s.

- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. *Caspian Journal of Applied Science and Research*, 4(3), 74–83.
- Aliyeva, N. F. (2018). Comparative study of energy efficiency of respiration in the maize plant under water and salt stress. Abstract of the dissertation for PhD degree, Baku, 2018, 21 p. [Su və duz stresləri zamanı qarğıdalı bitkisinde tənəffüsün energetik effektivliyinin müqayisəli tədqiqi.] [Doctoral dissertation, Bakı]. Avtoreferat, 21 s.
- Amrahov, N., Bayramova, S., Mammadova, R., Ojagverdiyeva, S., & Aghazada, G. (2022). The effect of salicylic acid on the content of photosynthetic pigments and the activity of antioxidant enzymes in cotton seedlings. *Advances in Biology & Earth Sciences*, 7(3).
- Baranenko, V. V. (2013). Superoxide dismutase in plant cells. *Cytology*, 48(6), 405-474. [Супероксиддисмутаза в клетках растений. Цитология, 48(6), 405-474.]
- Beauchamp, C., & Fridovich, I. (1971). Superoxide dismutase: Improved assays and an assay applicable to acrylamide gels. *Analytical Biochemistry*, 44(1), 276-287. [https://doi.org/10.1016/0003-2697\(71\)90370-8](https://doi.org/10.1016/0003-2697(71)90370-8)
- Ermakov, L. I. (1987). Methods of biochemical study of plants. Agropromizdat Publishing House, 1987, 424 p. [Методы биохимического исследования растений. Изд-во Агропромиздат, 424 с.].
- Flowers, T. J., & Colmer, T. D. (2008). Salinity tolerance in halophytes. *New Phytologist*, 179, 945-963. <https://doi.org/10.1111/j.1469-8137.2008.02531.x>
- Garifzyanov, A. R., Zhukov, N. N., Pantyukhin, Yu. O., & Ivanishchev, V. V. (2012). Features of NaCl-induced oxidative stress and dynamics of antioxidant enzyme activity in winter triticale organs. *Reports of the Russian Academy of Agricultural Sciences*, 2, 9-12. [Особенности NaCl индуцированного окислительного стресса и динамики активности антиоксидантных ферментов в органах тритикале озимого. Доклады Российской Академии Сельскохозяйственных наук, 2, 9-12.]
- Gasimov, N. A. (2012). Mechanism of salt influence on plant organisms. Lap. Lambert Academic Publishing, Germany, 2012, 175 p. [Механизм действия солей на растительных организмах. Lap. Lambert Academic Publishing, Германия, 175 с.].
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E., & Huseynova, H. (2020). New spreading areas of some species in the botanical-geographical Baku regions of the middle part of the Caspian coast. *Acta Botanica Caucasica*, 1(1), 4–8.
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Huseynova, H.Z. (2021) The classification of desert and semi-desert vegetation of the Caspian coast (Azerbaijan). *Bulletin of Science and Practise* 7/11: 43–50. <https://doi.org/10.33619/2414-2948/72/05>
- İbrahimova, U. F. (2015). Morphological and biochemical characteristics of wheat seedlings exposed to salt stress. Abstract of the dissertation for PhD degree, Baku, 2015, 20 p. [Duz stresinə məruz qalmış buğda cücərtilərinin morfoloji və biokimyəvi xüsusiyyətləri. Avtoref., 20 s.]
- Kerdyashov, N. N. (2018). Tutorial. Penza, 131 p. [Учебное пособие. Пенза, 131 с.]
- Mammadov, G. S. (2007). Basics of soil science and soil geography. Baku: Elm, 2007, 664 p. [Torpaqşünaslıq və torpaq coğrafiyasının əsasları / Bakı: Elm, 2007. 664 s.]
- Mammadov, Z. M., Amrahov, N. R., Mammadova, R. B., Allahverdiyeva, S. N., Aliyev, E. I., Alizada, Sh. R., Aghazada, G. A., & Ojagverdiyeva, S. Y. (2023). Effect of indole-3-butyric acid on the antioxidant enzymes, NO, and chlorophyll content of Agdash-3 and AP-317 genotypes of upland cotton (*Gossypium hirsutum* L.). *Advances in Biology & Earth Sciences*, 8(2), 147-156.
- Santos Campos, A., Azevedo, H., & Caldeira, G. (2011). In situ and in vitro senescence induced by KCl stress: Nutritional imbalance, lipid peroxidation and antioxidant metabolism. *Journal of Experimental Botany*, 52, 351-360. <https://doi.org/10.1093/jxb/erq278>

- Sun, Z. W., Ren, L. K., Fan, J. W., Li, Q., Wang, K. Y., Guo, M. M., Wang, L., Zhang, G. X., Yang, Z. Y., Chen, F., & Li, X. N. (2016). Salt response of photosynthetic electron transport in cucumber leaves. *Environmental and Experimental Botany*, 62, 515-521. <https://doi.org/10.1016/j.envexpbot.2016.06.014>
- Valijanov, Z. V. (2022). Study of the antioxidant defense system in chickpea and maize plants exposed to radiation and salt stress. Abstract of the dissertation for PhD degree, Baku, 2022, 34 p. [Rədiyasiya və duz streslərinin təsirinə məruz qalmış noxud və qarğıdalı bitkilərində antioksidant müdafiə sisteminin tədqiqi. Avtoref., 34 s.]
- Volykhina, V. E., & Shafnanovskaya, E. V. (2009). Superoxide dismutases: Structure and properties. *Vestnik VSMU*, 8(4), 8-69. [Супероксиддисмутаза: Структура и свойства. Вестник ВГМУ, 8(4), 8-69 c.].
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>.
- Wang, S. P., Jia, Y. X., Guo, S. R., & Lhou, G. X. (2007). Influence of polyamines on the content of K<sup>+</sup>, Na<sup>+</sup>, Cl<sup>-</sup>, and distribution in different organs of *Cucumis sativus* sprouts under NaCl stress. *Shentai Ruebao - Acta Ecol. Sin.*, 27(3), 1122-1129.

## MORPHOLOGY DESCRIPTION AND TAXONOMY OF PYRUS L. SPECIES OF NORTH-EASTERN PART OF THE GREAT CAUCASUS

Elman Iskender<sup>1</sup>, Sabina Jafarzadeh<sup>1</sup>, Bahar Mammadova<sup>2</sup>

<sup>1</sup>Ministry of Science and Education of Azerbaijan Republic, Institute of Microbiology, A.Abbaszade 115, AZ 1004, Baku, Azerbaijan.

<sup>2</sup>Institute of Ecology of the National Aerospace Agency of the Ministry of Defense Industry of Azerbaijan Republic, Akhundov street 1, AZ 1115, Baku, Azerbaijan

Correspondence: sabina.cafarzadeh@mail.ru

DOI: <https://doi.org/10.30546/abc.2024.3.2.323>

Article info: pp. 30-39

Received: 06.03.2024; Received in revised form 21.05.2024; Accepted 10.07.2024

**ABSTRACT.** *This work describes the taxonomic contributions of species belonging to the genus Pyrus L. in the northeastern part of the Greater Caucasus region of Azerbaijan. The study includes morphological descriptions, and taxonomic characteristics of five Pyrus species researched in the Guba and Khizi regions. These species are taxonomically recognized as a cohesive group and were examined in their natural habitats. Previous studies indicate that these species can produce viable crops in both natural and cultural environments, highlighting their adaptability. Certain morphological differences among the species align with expected biological variability. This research contributes to the understanding of Pyrus taxonomy and morphology in this unique ecological area, offering valuable insights for conservation and sustainable management of local biodiversity. Certain morphological differences among the species align with expected biological variability. This research contributes to the understanding of Pyrus taxonomy and morphology in this unique ecological area, offering valuable insights for conservation and sustainable management of local biodiversity.*

**Keywords:** *Pyrus L., taxonomy, morphology, Greater Caucasus, biodiversity*

### INTRODUCTION

*Pyrus* L. refers to half of the *Pyrinae* subfamily within the Rosaceae family. The species of pears and apples were first described by Linnaeus, but a more comprehensive presentation of these descriptions was provided by Decaisne [Zamani, 2012]. The genus *Pyrus* includes more than 80 species of pears, with 73 found in Eurasia. Within the Iranian-Turanian and Mediterranean floristic regions, there are 12 varieties of *Pyrus* flora. The Italian flora contains 4 species, while the Syrian flora has 2 species. Additionally, there are 11 endemic species in the Turkish flora. In Europe, 13 species of *Pyrus* have been described [Challice & Westwood, 1973]. Since ancient times, both West Eurasian and East Asian species of *Pyrus* have been concentrated

in the central regions of pear species, primarily in China. In these areas, two distinct groups of pear species are recognized: western and eastern. The western species are predominant in East Asia and are found mainly in Europe, North Africa, Turkey, Iran, Iraq, Syria, Central Asia, Russia, and Afghanistan, as well as in the eastern type [Potter et al., 2007].

The research examines the impact of abiotic factors, including soil composition, temperature, and humidity, on the morphological characteristics of cultivated dendroflora in north-eastern Azerbaijan. The authors emphasize that variations in leaf size, stem thickness, and root structure are adaptive responses to these environmental influences. These morphological adaptations are vital for the survival and growth

of tree species within this diverse ecosystem. [Iskender et al, 2022; Bakshaliyeva et al, 2024].

The Rosaceae family is globally widespread, with its main diversification occurring in the Northern Hemisphere. It comprises approximately 3,000 species across 100 currently recognized genera [Kalkman, 2004]. According to recent nomenclatural changes, it has been classified under the subfamily Maloideae, tribe Maleae Small, and subtribe Malinae [Reveal, 2012 a;b]. However, Christenhusz proposed a significant re-circumscription of *Pyrus*, suggesting the merger of several previously recognized genera into it [Christenhusz et al., 2018]. In this context, we choose to maintain the traditional, moderately narrow definition of *Pyrus*.

*Pyrus* has been classified under the subfamily Spiraeoideae, globally, members of this genus are predominantly shrubs or trees, characterized by shapes that are pyramidal, umbrella-like, or narrow and straight [Zheng et al., 2014].

In the article authors four new records of the genus *Pyrus* from Pakistan are presented. The authors emphasize the importance of these discoveries in broadening the known distribution of *Pyrus* species in the area. They provide detailed descriptions of the morphological traits of the newly identified species, including leaf shape, flower structure, and fruit characteristics. The study highlights the ecological conditions that support these species, enhancing the understanding of their habitat preferences. Furthermore, the authors discuss the potential implications for conservation efforts, particularly in light of the growing threats to biodiversity in Pakistan. The findings illustrate the necessity for continued botanical surveys to document and uncover plant diversity in less-explored regions. Overall, this research contributes valuable information to the existing knowledge of the *Pyrus* genus within the Rosaceae family [Islam et al., 2019].

In this research the significance of plant morphology for adaptation and survival in diverse environments, affecting their ability to flourish under changing conditions. Author points out that a deeper understanding of these morphological traits can enhance conservation efforts

by showcasing plants' resilience and their vital role in sustaining ecological balance [Raven, 2020].

The pear is part of the Rosaceae family, like many cultivated fruit trees, and is the second most produced fruit tree crop after the apple. Over the past few decades, pear production has grown significantly, reaching more than 27 megatons across nearly 1,600,000 hectares worldwide. Pears have been cultivated in Europe and Asia for over 5,000 years. Among all known pear species and interspecific hybrids, five are primarily cultivated: the European pear (*Pyrus communis*) and the Asian pears *P. pyrifolia*, *P. × bretschneideri*, *P. ussuriensis*, and *P. sinkiangensis*. European pear fruits are elongated with a rich texture, while Asian pears are round and have a sandy texture. The genus *Pyrus* falls within the Amygdaloideae subfamily and the Malinae tribe, comprising approximately 75–80 species and interspecific hybrids. The occurrence of various hybridizations among *Pyrus* species makes it challenging to distinguish between some pear species [Smith and Johnson, 2020].

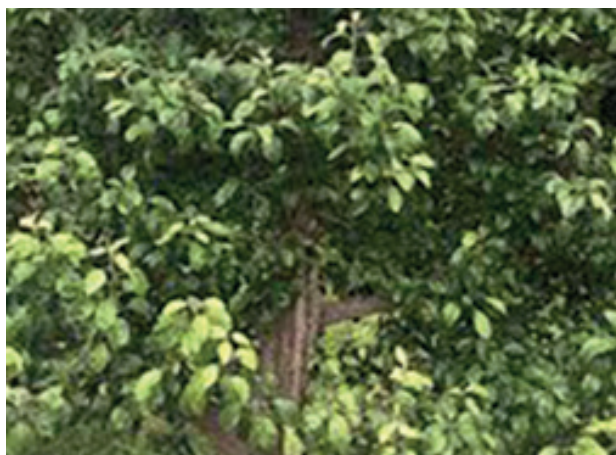
This research work is a comparative study of pollen morphology and fertility in *Pyrus* L. species, evaluating both in situ and ex situ conditions in Azerbaijan's Greater Caucasus. Their results demonstrate notable variations in pollen characteristics and fertility rates, highlighting how environmental factors influence reproductive success in these species [Jafarzadeh & Iskendar, 2024; Jafarzadeh et al, 2022].

## MATERIALS AND METHODS

In our study, we used fresh materials collected from the geographical distribution areas in the northeastern part of the Greater Caucasus. This collection work was conducted from several years. The taxonomy were studied using the some methods [Challice & Westwood, 1973]. The five species included in the study are: *Pyrus caucasica*, *Pyrus communis*, *Pyrus georgica*, *Pyrus vsevolodii*, and *Pyrus salicifolia*.

These methods in taxonomy offer a robust framework for systematically classifying and identifying species [Challice & Westwood, 1973]. Their emphasis on morphological

analysis allows researchers to examine key physical traits, such as leaf shape and flower structure, to differentiate between species. This approach is complemented by anatomical studies, which investigate internal structures like the vascular system and wood anatomy, providing deeper insights into the relationships among taxa.



a



b



c

**Figure 1.** a) General appearance of *Pyrus caucasica* in the field; b) Overview of flowers in Guba; c) Fruit

The ecological context of species, taking into account habitat types and geographical distributions. This ecological perspective helps explain the adaptive significance of various morphological traits. While grounded in traditional methods, they also advocate for the integration of phylogenetic analysis, recognizing the value of molecular data in modern taxonomy. In this taxonomic study of *Pyrus*, we employed three primary methods: Morphometric Analysis, Floral Morphology Examination, and Fruit Morphology Assessment.

Morphometric Analysis involved quantitatively measuring leaf characteristics such as size, shape, and venation patterns, allowing us to identify distinct morphological variations among *Pyrus* species for improved classification.

Floral Morphology Examination focused on analyzing flower structures, including petal arrangement, size, and color. This detailed examination aids in distinguishing closely related species and enhances our understanding of their reproductive adaptations.

Fruit Morphology Assessment involved evaluating the physical traits of fruits, such as shape, size, and texture. These variations are



a



b

**Figure 2.** a) General view of *Pyrus communis* in its habitat; b) Fruit

vital for species identification and offer insights into the ecological roles and dispersal mechanisms of various *Pyrus* species. Collectively, these methods provide a comprehensive approach to understanding *Pyrus* taxonomy and enhance species identification within the Rosaceae family.

## RESULTS

Taxonomy of species of the genus *Pyrus* L. (APG IV)

**Kingdom:** Plantae

**Subkingdom:** Viridiplantae



a



b



c

**Figure 3.** a) Flowers of *Pyrus georgica*; b) Fruit; c) Leaves

**Infrakingdom:** Streptophyta

**Division:** Tracheophyta

**Subdivision:** Spermatophytes

**Class:** Magnoliopsida

**Family:** Rosaceae

**Subfamily:** Amygdaloideae

**Tribe:** Maleae

**Genus:** *Pyrus*

## Species

1. *Pyrus caucasica* Fed.
2. *Pyrus communis* L.
3. *Pyrus georgica* Kuth.
4. *Pyrus vsevolodii* Heideman
5. *Pyrus salicifolia* Pall.

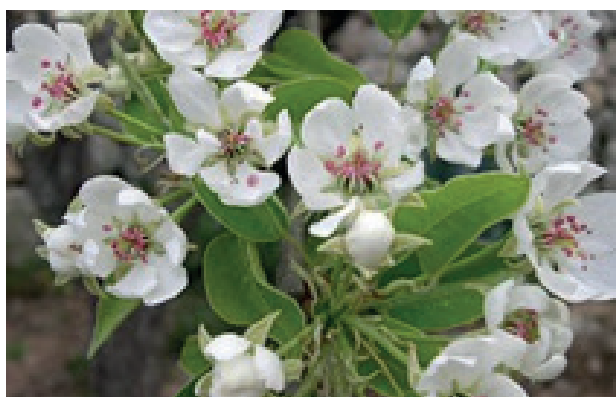
### 1. *Pyrus caucasica* Fed.

**Description:** *Pyrus caucasica* Fed. grows to a height of 25 meters, characterized by its thorny gray bark and a trunk diameter of 60 (up to 80) cm. The leaves are round or ovate, with a fuzzy underside and a dark green upper surface. The flowers are arranged in clusters, with white petals, and the fruits are smooth. The stems are 2 to 36 times longer than the fruits. The bark of the plant is brittle. It typically grows in light mixed forests, rocky slopes, low to medium mountain ranges, and river valleys. The leaf stalks drop off quickly and can be confused with each other. The base of the leaves is either grooved, bulbous, or egg-shaped, with a length of 3-5 cm. The leaf edges are entire, and the petiole is 2-3 times longer than the leaves. The fruit is variable and not prone to damage. Ripe fruits are dark in color. The tree blooms in late April to early May, with fruit development occurring in August to September [Flora of Azerbaijan, 1954; Mammadov, 2016].

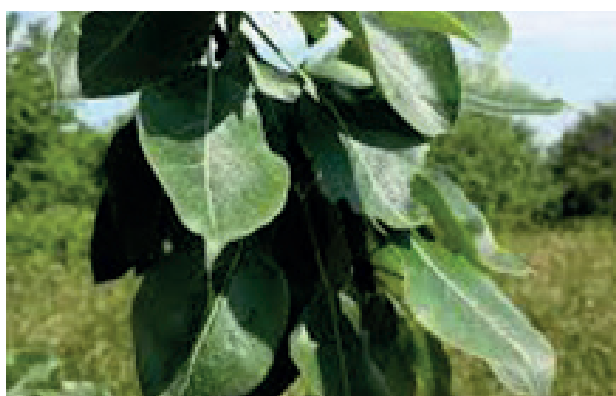
**Distribution and habitat:** Under natural conditions, *Pyrus caucasica* is found in Russia (Dagestan), Armenia (Dilijan), and Georgia. In Azerbaijan, it is naturally distributed in the Guba region and in the forests of the Nakhchivan Autonomous Republic (specifically in the village of Bichanek, Shakhbuz district). This species is rare in Azerbaijan and has limited habitats. It is cultivated in the Botanical Garden. The decline in natural populations is primarily due to human activity. The extensive plain of the northeastern



a



b



c



d

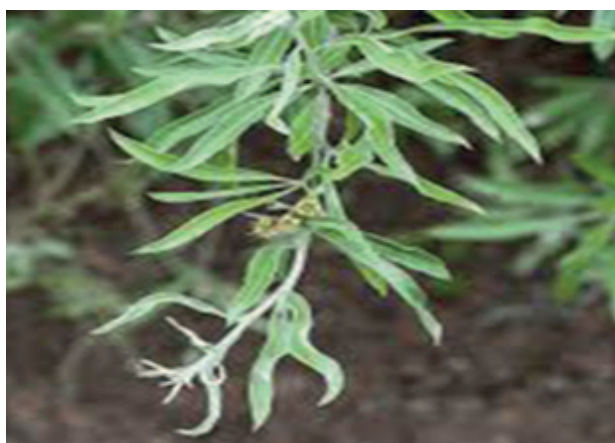
**Figure 4.** a) General appearance of *Pyrus vsevolodii* in its habitat; b) Flower; c) Leaves; d) Fruit

slopes of the Greater Caucasus, particularly in the southeastern forest known as Altyagach, has been cleared of its fertile forest areas, which did not produce fruit, while pear trees were preserved. Local people harvest abundant fruits from this area each year. Isolated specimens of pears can also be found in the forests of the Samur-Shabran plain. Additionally, it is known that pears thrive at high altitudes, specifically between 1600 and 1800 meters. This species is primarily found in these natural habitats [ Flora of USSR, 1934-1960, Mammadov, 2016].

## 2. *Pyrus communis* L.

**Description:** The approximate height of *Pyrus communis* is 15-20 meters. It flowers from April to May, with seeds dispersing from October to December. The flowers are hermaphroditic (containing both male and female organs) and are pollinated by insects. This is a leaf-bearing plant. The leaves are elliptical, measuring 3.5 x 1.5-4 cm, smooth and serrated initially, then becoming smooth and green, with a length of about 5 cm. The flowers are borne in clusters of 5-9, each measuring 2-3 cm, with a stem length of 1.5-3 cm. The flowers, which open before the leaves, have five white petals and exhibit red spots on the throat. The color of the flowers is white. The fruit is yellow and curly, measuring 2-4 cm in size, with a thickness of 1-1.5 cm. [Flora of Azerbaijan, 1954, Mammadov, 2016]. This species prefers humus-rich soils and fertile garden lands, thriving particularly in moist conditions.

**Distribution and habitat:** In Azerbaijan's Guba district, *Pyrus communis* thrives in the lush mixed forests and fertile river valleys, creating an ideal environment for pear trees. The Khizi district features a unique microclimate that supports the growth of *Pyrus communis* in both natural habitats and cultivated areas. Numerous orchards in Shamakhi focus on cultivating *Pyrus communis*, taking advantage of the region's fertile soil and favorable agricultural conditions. Similarly, in Georgia, the Adjara region offers abundant landscapes where *Pyrus communis* flourishes in both wild and cultivated settings [Flora of USSR, 1934-1960; Mammadov, 2016].



a



b



b



c



d



a



e

**Figure 5.** a) Leaves of *Pyrus salicifolia*; b) Fruits  
In general, leafy herbs of the genus *Pyrus* L. were collected for herbarium preparation. This preparation was completed in July 2017, although the collection process occurred at various times throughout several years.

**Figure 6.** Leaf Herbarium of the Genus *Pyrus* L.  
a-*P.communis*, b-*P.georgica*, c-*P.caucasica*, d-*P.vsevolodii*, e-*P.salicifolia*

### 3. *Pyrus georgica* Kuth.

**Description:** In its natural range, *Pyrus communis* reaches a height of 5-9 meters. The bark is gray or brown and smooth. The leaves are broad, elliptical, and lenticular, with an acute tip, featuring a dull gray color on both the upper and lower surfaces. The leaves measure 5-10 cm in length and 1.5-3 cm in width. The petiole is hollow and ranges from 1.6 to 4.5 cm long. The overall appearance of the stem is appealing. The fruit is yellowish, elongated, and slightly flattened. The fruits of seedlings measure 2-4 cm in length and are found in clusters along the stem. The tree blooms in April, with fruit development occurring by August. The fruit is typically round or slightly elongated, changing to a chestnut or greenish color as it matures. This species is less demanding regarding light and drought conditions. It grows naturally through both vegetative and generative methods, primarily from seeds [Flora of Azerbaijan, 1954; Mammadov, 2016].

**Distribution and habitat:** In Georgia and Armenia (specifically in Derelaz), there are natural habitats. In Azerbaijan, it is found in rocky areas of the Guba region, as well as in natural locations in Khizi (Altyagach), Shamakhi (Goyler-Meul & Gushcha villages), the Shabran district (slopes of the Chiragkala mountains), Ordubad (Bist village on the right bank of the Gilanchay), and the Shahbuz region (in the Batchanek forest) [Flora of Azerbaijan, 1954; Flora of USSR, 1934-1960; Mammadov, 2016]. This species typically grows on low to medium mountain slopes with dry, stony terrain. It is also cultivated in the Botanical Garden. The decline of its natural populations is primarily due to human activity.

### 4. *Pyrus vsevolodii* Heideman

**Description:** *Pyrus vsevolodii* Heideman is a low-density tree with a height of 7-8 meters. The bark is dark green and gray, while the branches are light gray and brittle. The leaves are either lens-shaped or leaf-like, with a sparse venation on the underside. The fruits are round, measuring 1.8-2.0 cm in diameter. Initially, the flesh is flaky, becoming fibrous and brittle as it matures, and the stem is long and hairy, measuring 1.5-2 times the length of the fruit [Flora of

Azerbaijan, 1954; Mammadov, 2016]. This species is endemic to Azerbaijan and is drought-resistant, thriving in light and well-drained soils. It blooms in April and May, with fruit ripening in August. The ripe fruit has a bluish hue. In nature, it primarily reproduces through seeds and root propagation.

**Distribution and habitat:** In Azerbaijan, *Pyrus vsevolodii* is naturally found in the Gubustan and Khizi (Altyagach) districts. This species is considered rare in Azerbaijan, with limited habitats. It is cultivated in the Botanical Garden. The plant was first described by T.S. Heideman in 1941, near the village of Altiagach [Flora of Azerbaijan, 1954, Flora of USSR, 1934-1960 Mammadov, T -2016]. The decline of its natural populations is primarily due to human activity. It was included that this species in the "Red Book" of Azerbaijan [Red Book of Azerbaijan, 2023].

### 5. *Pyrus salicifolia* Pall.

**Description:** *Pyrus salicifolia* Pall. is a tree or shrub that reaches heights of 7-12 meters and can have a diameter of up to 40 cm. The pale stems initially have a light color but turn red over time, and the stems and branches are quite prickly. The leaves can be 5-10 cm long and up to 1 cm wide. The upper and lower surfaces of the leaves are scaly and can peel. The leaves are pointed, often serrated, and exhibit a scarlet color. The flowers are found in numerous clusters, while the fruits are broad and can be either elongated or round, with a yellowish or brown hue. They typically measure 2.0-2.5 cm in length and 1.5-2.0 cm in width. The fruits start off fluffy and then become smooth as they mature. Seedlings produce fruits that are 2-3 cm in size. *Pyrus salicifolia* is drought-resistant and less demanding in terms of light. When cultivated, it is used for both decorative purposes and as an ingredient in herbal decoctions. It blooms in April-May and bears fruit in August-September. In nature, it reproduces both vegetatively and generatively, primarily through seeds and root propagation [Flora of Azerbaijan, 1954; Mammadov, 2016].

**Distribution and habitat:** *Pyrus salicifolia* is naturally found in regions of Russia, Turkey, and Iran. In Azerbaijan, it occurs in the

Samur-Shabran plain, as well as in the Lankaran, Nakhchivan Autonomous Republic, Astara, and Gobustan regions. This species is considered one of the rare plants in Azerbaijan, with limited habitats.

It can be found in the Nakhchivan Mountains on dry, rocky slopes, as well as in low to middle mountain areas or sparse forests. The species is cultivated in the Botanical Garden [Flora of USSR, 1934-1960; Mammadov, 2016].

The decline of its natural populations is primarily due to human activity. It was included in the Red Book of Azerbaijan [Red Book of Azerbaijan, 2023].

The diagnostic indicators of the genus *Pyrus* L. are related to its morphological structure and seasonal rhythm [Abbasova & Iskender, 2018]. Furthermore, the diagnostic characteristics of the genus *Pyrus* L. have been briefly studied and summarized in Table 1.

**Table 1.**

Morphological Characteristics of the Genus *Pyrus* L.

| No | Species               | Shape of leaf            | Floral group        | Length of the leaf (sm) | Leaf edges      | Fruit shape         | Fetus size (sm) |
|----|-----------------------|--------------------------|---------------------|-------------------------|-----------------|---------------------|-----------------|
| 1. | <i>P. caucasica</i>   | Round or Broad Egg       | Shield Floral Group | 3-5                     | Entire          | Round               | 3-4             |
| 2. | <i>P. communis</i>    | Egg or Elliptical        | Shield Floral Group | 3.5-4.5                 | Entire or Broad | Spherical           | 2-4             |
| 3. | <i>P. georgica</i>    | Elliptical or Lanceolate | Shield Floral Group | 5-10                    | Pointed         | Tuber or Pear       | 2-3             |
| 4. | <i>P. vsevolodii</i>  | Long Lantern or Wide     | Shield Floral Group | 4-8                     | Entire          | Round Shaved Pearls | 3-3.5           |
| 5. | <i>P. salicifolia</i> | Long Narrow              | Shield Floral Group | 4.5-9                   | Blunt or Sharp  | Wide Circular       | 2.5-3           |

The APG IV system is a modern taxonomic classification system for flowering plants developed by the Angiosperm Phylogeny Group (APG) and published in March 2016 in the Botanical Journal of the Linnean Society in the article "Update of the Angiosperm Phylogeny Group for the Orders and Families of Flowering Plants: APG IV" [APG IV, 2016]. In our study, we examined the taxonomy of the species *Pyrus* L. within the APG IV system. While there are some differences between the APG III and APG IV systems, there are minor changes were made to the genus *Pyrus* L. as studied in our research [APG IV, 2016].

## CONCLUSION

As highlighted earlier, our study focuses on the genus *Pyrus* L. in the northeastern part of the Greater Caucasus. We explored the morphological descriptions and taxonomic characteristics of these plants. Our results reveal that while *Pyrus* L. displays morphological variation

within the same taxonomic group, *Pyrus salicifolia* is particularly distinct due to its specific soil preferences and unique fruit features.

These differences are closely related to the traits observed in both cultivated and wild populations. The emergence of certain morphological variations can be attributed to a combination of natural and anthropogenic environmental factors, emphasizing the adaptability and ecological relevance of this genus. Our research enhances the understanding of the taxonomy and morphology of *Pyrus* L., highlighting its significance in the region's biodiversity.

## GRATITUDE

We would like to express our heartfelt gratitude to the Botanical Institute of MSERA and the Central Botanical Garden for their invaluable support and resources during our research. Their dedication to botanical science has significantly contributed to the advancement of our understanding of the genus *Pyrus* L.

## REFERENCES

- Abbasova, S. A., & Iskender, E. O. (2018). Morphology of the seedlings of *Pyrus* L. species spread in the northeast of the Greater Caucasus. Scientific Works of ANAS Central Botanical Garden, Volume XVI, 121-126. (Abbasova, S. A., & Iskender, E. O. (2018). Şimali-Şərqi Böyük Qafqaz, *Pyrus* L. cinsinə aid növlərin yayılma arealı və morfologiyası. AMEA Mərkəzi Nəbatat Bağının Elmi Əsərləri, Cild XVI, 121-126.)
- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. Caspian Journal of Applied Science and Research, 4(3), 74–83.
- Bakshaliyeva, K. F., Arabova, G. G., Iskandar, E. O., & Muradov, P. Z. (2024). General characteristics of some fruit plants included in the flora of Azerbaijan and their mycobiota. Advanced Studies in Biology, 16(1), 35–43.
- Challice, J. S., & Westwood, M. N. (1973). Numerical taxonomic studies of the genus *Pyrus* using both chemical and botanical characters. Botanical Journal of the Linnean Society, 67, 121–148.
- Christenhusz, M. J. M., Fay, M. F., & Byng, J. W. (2018). The Global Flora (Vol. 4: Special Edition, GLOVAP Nomenclature Part 1). Plant Gateway Ltd.
- Flora of Azerbaijan: [in 8 volumes]. (1954). Baku: Academy of Sciences of Azerbaijan. USSR, V.5. (Azərbaycan florası: [8 cildə]. (1954). Bakı: Azərbaycan SSR Elmlər Akademiyası, Cild V.)
- Flora of the USSR: [in 30 volumes]. (1934-1960). M. – L.: V. III, 1954. (Флора СССР: [в 30 томах]. (1934-1960). М. – Л.: Том III, 1954.)
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E., & Huseynova, H. (2020). New spreading areas of some species in the botanical-geographical Baku regions of the middle part of the Caspian coast. Acta Botanica Caucasica, 1(1), 4–8.
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Iskender, E., Aliyeva, A., & Baghirova, S. (2022). Analysis of the relationship of the cultivated dendroflora of the northeastern part of the Greater Caucasus (Azerbaijan) to some abiotic factors. Acta Botanica Caucasica, 1(2), 57-67. <https://doi.org/10.17584/abc.2022.1.2.12553>
- Islam, M., Ahmad, H., Alam, J., Ali, H., Fahim, M., & Hanif, M. (2019). Four new records of the genus *Pyrus* (Rosaceae) from Pakistan. The Journal of Animal & Plant Sciences, 29(2), 483-491. ISSN: 1018-7081.
- Jafarzadeh, S. A., & Iskandar, E. O. (2024). Comparative study of pollen morphology and fertility in *Pyrus* L. species under in situ and ex situ conditions in Greater Caucasus, Azerbaijan. BIO Web of Conferences, 100, 03006, 1-5.
- Jafarzadeh, S. A., Aghayeva, S. A., Karimova, N. Y., & Humbatov, M. F. (2022). The attitude of species of the genus *Pyrus* L. of the northeastern part of the Greater Caucasus to abiotic factors. Annals of Forest Research, 65(1), 6873-6877.
- Kalkman, C. (2004). Rosaceae. In K. Kubitzki (Ed.), The Families and Genera of Vascular Plants (Vol. 6, pp. 343-386). Springer.
- Mamedov, T. S., Iskander, E. O., & Talibov, T. H. (2016). Rare tree and shrub species of Azerbaijan. Baku: Elm, 380 pp. (Məmmədov, T. S., İskəndər, E. O., & Talibov, T. H. (2016). Azərbaycanın Nadir Ağac və Kolları. Bakı: Elm, 380 s.)
- Potter, D., Eriksson, T., Evans, R. C., Oh, S., Smedmark, J. E. E., Morgan, D. R., ... & Dickinson, T. A. (2007). Phylogeny and classification of Rosaceae. Plant Systematics and Evolution, 266, 5–43.
- Raven, P. H. (2019). Saving plants, saving ourselves. Plants, People, Planet, 1, 8–13. <https://doi.org/10.1002/ppp3.3>
- Reveal, J. L. (2012a). Newly required infrafamilial names mandated by changes in the Code of nomenclature for algae, fungi, and plants. Phytoneuron, 33, 1-31.

- Reveal, J. L. (2012b). An outline of a classification scheme for extant flowering plants. *Phytoneuron*, 37, 1-221.
- Red Book of the Republic of Azerbaijan, Rare and Endangered Plant and Mushroom Species, II Edition. (2023). Baku, 507 pp. (Azərbaycan Respublikasının Qırmızı Kitabı, Nadir və Nəslə Kəsilməkdə Olan Bitki və Göbələk Növləri, II nəşr. (2023). Bakı, 507 s.)
- Smith, J., & Johnson, A. (2020). Botany and taxonomy of pear (*Pyrus* L.). *Journal of Horticultural Science*, 45(2), 101-115. <https://doi.org/10.1234/jhs.2020.456>
- The Angiosperm Phylogeny Group. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society*, 181(1), 1–20. <https://doi.org/10.1111/boj.12385>
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>
- Zamani, A., Attar, F., & Maroofi, H. A. (2012). Synopsis of the genus *Pyrus* (Rosaceae) in Iran. *Nordic Journal of Botany*, 30, 310–332.
- Zheng, X., Cai, D., Potter, D., Postman, J., Liu, J., & Teng, Y. (2014). Phylogeny and evolutionary history of *Pyrus* L. revealed by phylogenetic trees and networks based on data from multiple DNA sequences. *Molecular Phylogenetics and Evolution*, 80, 54-65.

## EFFECTS OF STRESS FACTORS ON BIOPHYSICAL AND GENETIC PARAMETERS IN C3 and C4 PLANTS

Aygun Nasibova<sup>1,2</sup>, Majnun Babayev<sup>2</sup>, Rovshan Khalilov<sup>1,2</sup>

<sup>1</sup>Azerbaijan Republic Ministry of Science and Education, Institute of Radiation Problems, Baku, Azerbaijan.

<sup>2</sup>Baku State University, Baku, Azerbaijan.

Correspondence: aygun.nasibova@mail.ru

DOI: <https://doi.org/10.30546/abc.2024.3.2.326>

Article info: pp. 40-45

Received: 29.05.2024; Received in revised form 13.06.2024; Accepted 10.07.2024

**ABSTRACT.** *Researches were conducted with wheat (*Triticum durum*), barley (*Hordeum vulgare*) and corn (*Zea mays indentata*) plants irradiated with gamma radiation at different doses. In the studies conducted by Electron Paramagnetic Resonance spectroscopy (EPR) method, some biophysical parameters were studied in control and ten-day-old sprouts of wheat and corn seeds irradiated with different doses of ionizing gamma radiation, and a detailed explanation of the obtained regularities was given. At the same time, cytogenetic analyzes were carried out with seedlings of wheat (*Triticum durum*), barley (*Hordeum vulgare*) and corn (*Zea mays indentata*) plants irradiated with different doses of ionizing gamma radiation, and chromosomal aberration was determined. The regularity observed in the results obtained during the experiments was explained by the working mechanism of the photorespiration process in plants belonging to the C3 type of photosynthesis. Germination dynamics were determined in the studied plants. Prepared samples were studied on a ZEISS Axio Imagez A2 electron microscope. Compared with control samples, the effect of different doses of ionizing gamma radiation on the mitosis process in plant roots was studied.*

**Keywords:** *stress factor, gamma radiation, EPR signals, cytogenetic analyses*

### INTRODUCTION

Many scientific studies have been conducted on the effects of various stress factors, including individual and combinatory stress factors, ionizing gamma radiation, salt solutions of different concentrations [Aliyeva et al., 2023; Nasibova et al., 2016; Amrahov et al., 2023]. A number of parameters have been studied during the influence of these factors in wheat (*Triticum* L.) and corn (*Zea mays* L.) plants belonging to the C3 and C4 types of photosynthesis [Khalilov et al., 2022; Nasibova et al., 2020]. The results of the research conducted in this field are of great importance both from a practical and theoretical point of view in medical and biological research, agriculture, pharmacy and other fields.

The effects of environmental pollution factors on various plant species collected from different areas of Azerbaijan have been

investigated [Nasibova et al., 2021]. In some microorganisms, paramagnetic centers were studied by the EPR method during the influence of radiation factors [Kazimli et al., 2022].

During the research conducted with higher plants and microorganisms, it was determined that under the influence of stress factors, nano-sized iron oxide particles are generated in them as a result of biomineralization.

The obtained results were also confirmed in experiments conducted with some animal organisms [Nasibova, 2019].

In the presented article, biophysical and genetic parameters were studied in plants belonging to the C3 and C4 types of photosynthesis exposed to control and gamma radiation. The regularities we found in the results obtained by the EPR method were also observed in the study of cytogenetic analyses.

## MATERIAL AND METHODS

The research materials in the studies were wheat (*Triticum* L.), barley (*Hordeum vulgare* L.) and corn (*Zea mays* L.) seeds from cereal plants. Plant seeds were irradiated at different doses in MRX -  $\gamma$  25 (source  $\text{Co}^{60}$ ) device.

After 10-day-old sprouts of control and irradiated seeds were dried at room temperature, the paramagnetic centers formed in them were studied by the EPR method. At the same time, the EPR spectra of wheat and corn sprouts grown in control and radioactively contaminated soils were investigated.

For the purpose of cytogenetic analysis, 100 irradiated seeds were placed in Petri dishes, 40 ml of distilled water was added to them, and they were kept at room temperature for 20 hours to swell. After washing, they were germinated in a thermostat at a temperature of 24-25°C. At the next stage, seed sprouts were fixed in Carnoy's fixative (six parts of absolute ethyl alcohol, three parts of chloroform and one part

of acetic acid). Barley, wheat and corn sprouts were cut to 1-1.5 mm in size and fixed.

## RESULTS

When studying the effect of ionizing gamma radiation on wheat and corn plants by the EPR method, it was found that the increase in the dose of gadolinium causes an increase in the intensity of the broad EPR signal generated in the wheat plant. No such result was obtained in the corn plant.

While studying the effect of radioactive pollution on wheat and corn plants, we found that the growth and density of the 10-day-old sprouts of the control, i.e., corn plant grown in clean soil is significantly higher than that of the plant grown in radioactively contaminated soil. The results we obtained in our experiments with wheat seeds were completely different.

Changes in the amplitudes of the recorded EPR signals were determined depending on the radiation dose.

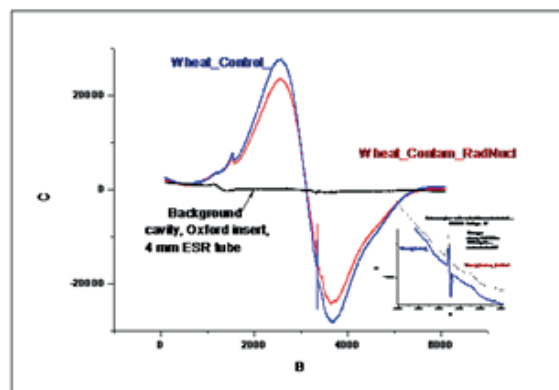
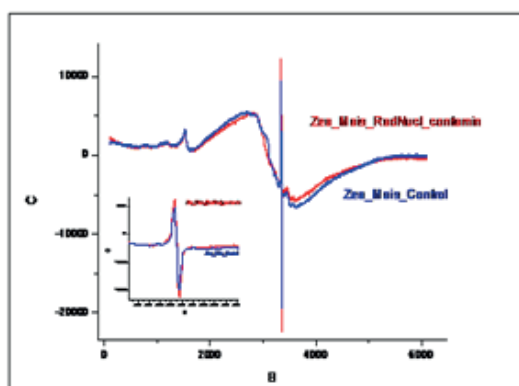


**Figure 1.** Growing in control and radioactively contaminated soil EPR signals of corn and wheat seeds

It was determined that radioactive contamination leads to an increase in the amplitude of the free radical signal ( $g=2.0023$ ) generated in these plants.

The comparative analysis of the signals we received showed that the amplitude of the EPR signal ( $g=2.0023$ ) characterizing the free radical obtained from the plant samples grown in the radioactive contaminated area is higher than the amplitude of the signal obtained from the plant samples collected from the control area.

This result can be directly used as a bioindicator parameter in environmental monitoring.

Of course, free radicals can often be used as an indicator of the destruction of biological processes. The next experiments were devoted to cytogenetic analysis. Germination of control and seeds irradiated with different doses of gamma radiation were recorded for three days. For further studies, 1-1.5 mm seed sprouts were cut from the sprouts and fixed. The number of fixed 1-1.5 mm seedlings of all three plant seeds (barley (*Hordeum vulgare* L.), wheat (*Triticum* L.) and corn (*Zea mays* L.)) is shown in table 1.

**Table 1**

The number of stable roots of barley, wheat and corn

| Nº | Samples | Barley ( <i>Hordeum vulgare</i> L.) | Wheat ( <i>Triticum</i> L.) | Corn ( <i>Zea mays</i> L.) |
|----|---------|-------------------------------------|-----------------------------|----------------------------|
| 1  | Control | 15                                  | 15                          | 16                         |
| 2  | 100 Gy  | 9                                   | 10                          | 10                         |
| 3  | 200 Gy  | 17                                  | 12                          | 8                          |
| 4  | 300 Gy  | 8                                   | 10                          | 5                          |

Then, the total number of germinated seeds in barley, wheat and corn seeds exposed to different doses of gamma radiation for three days was recorded (Tab. 2; 3; 4).

**Table 2**

| Nº | Samples | Number of seeds | The number of germinated seeds with a root size of 1-1.5 mm | The number of germinated seeds with a root size of 0.1 - 0.8 mm | Total number of germinated seeds |
|----|---------|-----------------|-------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------|
| 1  | Control | 100             | 15                                                          | 10                                                              | 25                               |
| 2  | 100 Gy  | 100             | 17                                                          | 16                                                              | 33                               |
| 3  | 200 Gy  | 100             | 9                                                           | 10                                                              | 19                               |
| 4  | 300 Gy  | 100             | 8                                                           | 6                                                               | 14                               |

**Table 3**

| Nº | Samples | Number of seeds | The number of germinated seeds with a root size of 1-1.5 mm | The number of germinated seeds with a root size of 0.1 - 0.8 mm | Total number of germinated seeds |
|----|---------|-----------------|-------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------|
| 1  | Control | 100             | 15                                                          | 22                                                              | 37                               |
| 2  | 100 Gy  | 100             | 10                                                          | 45                                                              | 55                               |
| 3  | 200 Gy  | 100             | 12                                                          | 50                                                              | 62                               |
| 4  | 300 Gy  | 100             | 10                                                          | 24                                                              | 34                               |

**Table 4**

| Germination of corn seeds<br>( <i>Zea mays</i> L.) |         |                 |                                                             |                                                                 |                                  |
|----------------------------------------------------|---------|-----------------|-------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------|
| Nº                                                 | Samples | Number of seeds | The number of germinated seeds with a root size of 1-1.5 mm | The number of germinated seeds with a root size of 0.1 - 0.8 mm | Total number of germinated seeds |
| 1                                                  | Control | 100             | 16                                                          | 15                                                              | 31                               |
| 2                                                  | 100 Gy  | 100             | 10                                                          | 2                                                               | 12                               |
| 3                                                  | 200 Gy  | 100             | 8                                                           | 1                                                               | 9                                |
| 4                                                  | 300 Gy  | 100             | 5                                                           | -                                                               | 5                                |

Diagrams of germination dynamics of control and irradiated barley (*Hordeum vulgare* L.), wheat (*Triticum* L.) and corn (*Zea mays* L.) seeds were drawn (Fig. 2; 3; 4).

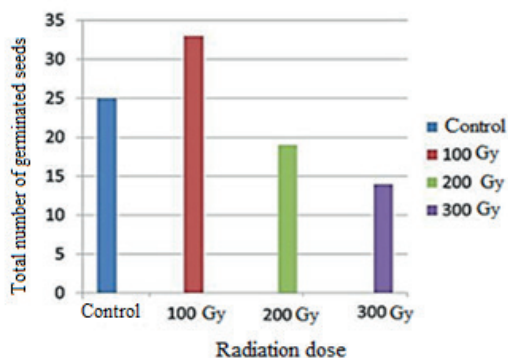


**Figure 2.** Germination dynamics of barley seed (*Hordeum vulgare* L.).

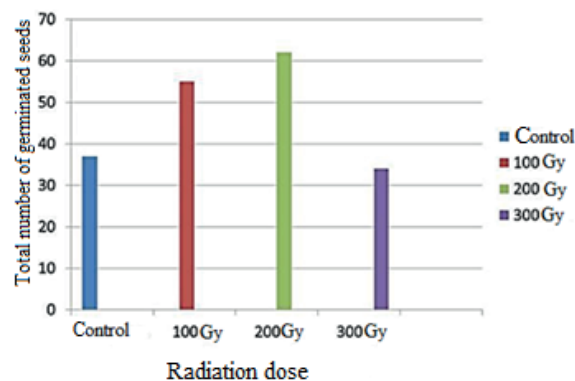


**Figure 3.** Germination dynamics of wheat seed (*Triticum durum* L.).

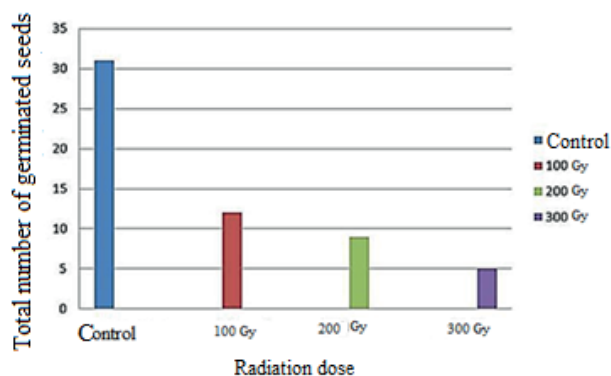


**Figure 4.** Germination dynamics of corn seed (*Zea mays* L.).

## CONCLUSION

It is clear from Figure 3 that in C3 plants, for example, in the studied object of barley, seeds irradiated with gamma radiation at a dose of 100 Gy caused a significant increase in the number of germinated seeds compared to control samples. As a result of 200 Gy and 300 Gy doses of ionizing radiation, the number of germinated seeds significantly decreased. In wheat objects from C3 plants, radiation at a dose of 100 Gy caused an increase in the germination percentage of wheat seeds compared to the control samples. A dose of 200 Gy of ionizing radiation caused further activation of germination, while a dose of 300 Gy of radiation decreased the percentage of seed germination. For C4 plants, for example, in the maize study (Fig. 5), doses of 100 Gy, 200 Gy and 300 Gy caused a corresponding reduction in the germination percentage of

irradiated seeds compared to the control.

The next stage of research was cytogenetic analysis. Using cytogenetic analysis, changes in the chromosomal apparatus, especially the formation of abnormalities in the number of chromosomes and restructuring of the structure, were determined.

In the first stage, the roots of control and irradiated seeds were stained according to the following stage: cut roots were treated with Carnoy's fixative, then 1% acetocarmine dye was added. Preparation of acetocarmine: 1-2 g of carmine was dissolved in 100 ml of 45% acetic acid (45 ml of acetic acid and 55 ml of distilled water).



**Figure 5.** Root staining of seed samples: barley, wheat.

Prepared samples were studied on a ZEISS Axio Imagez A2 electron microscope (Fig. 6). Compared to control samples, the effect of different doses of ionizing gamma radiation on the mitosis process in plant roots was studied.

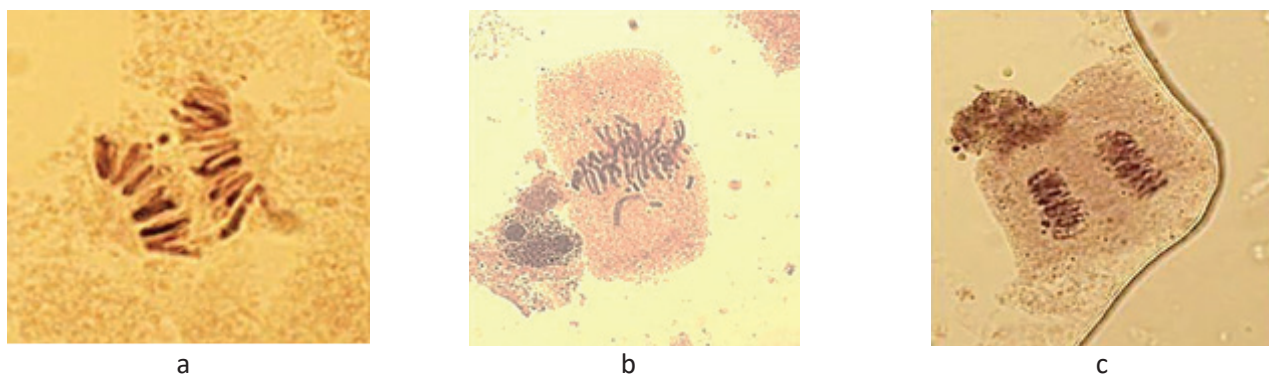


**Figure 6.** Magnification of meristem cells under a microscope, A - barley (*Hordeum vulgare*), B - wheat (*Triticum durum*), C - corn (*Zea mays indentata*).

Calculation of the Mitotic Period was carried out in the following manner:

Mitotic I - indicates the intensity of cell division in the growth phase (cell division). The higher the value, the more intensive the process of cell division and vice versa. The index can indicate the normal course of mitosis, the inhibition of the cell division process or, on the

contrary, the increase in the mitotic activity of tissues. Cytogenetic analysis was performed to calculate the mitotic period of the seeds. Cytogenetic analysis of seeds: barley (*Hordeum vulgare*), wheat (*Triticum durum*) and corn (*Zea mays indentata*) is shown in Tables 5, 6, 7, respectively.

**Table 5**

Cytogenetic analysis of barley (*Hordeum vulgare* L.)

| Cytogenetic analysis of barley ( <i>Hordeum vulgare</i> L.),<br>Chromosome number, $2n=14$ |         |                            |                                        |                                         |                                        |                                         |                                |                             |
|--------------------------------------------------------------------------------------------|---------|----------------------------|----------------------------------------|-----------------------------------------|----------------------------------------|-----------------------------------------|--------------------------------|-----------------------------|
| No                                                                                         | Samples | Total number of seed roots | Number of cells in prophase stages (P) | Number of cells in metaphase stages (M) | Number of cells in anaphase stages (A) | Number of cells at telophase stages (T) | Total number of cells analyzed | Mitotic cycle (Mitotic I %) |
| 1                                                                                          | Control | 15                         | 32                                     | 16                                      | 11                                     | 6                                       | 322                            | 20,18%                      |
| 2                                                                                          | 100 Gy  | 10                         | 39                                     | 19                                      | 13                                     | 7                                       | 266                            | 29,32%                      |
| 3                                                                                          | 200 Gy  | 12                         | 36                                     | 17                                      | 10                                     | 8                                       | 278                            | 25,53%                      |
| 4                                                                                          | 300 Gy  | 10                         | 12                                     | 6                                       | 3                                      | 1                                       | 204                            | 10,78%                      |

**Table 6**

Cytogenetic analysis of wheat (*Triticum* L.)

| Cytogenetic analysis of wheat ( <i>Triticum</i> L.)<br>Chromosome number, $2n=14$ |         |                            |                                        |                                         |                                        |                                         |                                |                             |
|-----------------------------------------------------------------------------------|---------|----------------------------|----------------------------------------|-----------------------------------------|----------------------------------------|-----------------------------------------|--------------------------------|-----------------------------|
| No                                                                                | Samples | Total number of seed roots | Number of cells in prophase stages (P) | Number of cells in metaphase stages (M) | Number of cells in anaphase stages (A) | Number of cells at telophase stages (T) | Total number of cells analyzed | Mitotic cycle (Mitotic I %) |
| 1                                                                                 | Control | 16                         | 29                                     | 22                                      | 14                                     | 8                                       | 431                            | 16,93%                      |
| 2                                                                                 | 100 Gy  | 10                         | 11                                     | 6                                       | 7                                      | 4                                       | 393                            | 7,12%                       |
| 3                                                                                 | 200 Gy  | 8                          | 6                                      | 5                                       | 3                                      | 5                                       | 382                            | 4,97%                       |
| 4                                                                                 | 300 Gy  | 5                          | 5                                      | 3                                       | 2                                      | 2                                       | 298                            | 4,02%                       |

Table 7

Cytogenetic analysis of corn (*Zea mays* L.)

| Cytogenetic analysis of corn ( <i>Zea mays</i> L.)<br>Chromosome number, 2n=20 |         |                            |                                        |                                         |                                        |                                         |                                |                             |
|--------------------------------------------------------------------------------|---------|----------------------------|----------------------------------------|-----------------------------------------|----------------------------------------|-----------------------------------------|--------------------------------|-----------------------------|
| No                                                                             | Samples | Total number of seed roots | Number of cells in prophase stages (P) | Number of cells in metaphase stages (M) | Number of cells in anaphase stages (A) | Number of cells at telophase stages (T) | Total number of cells analyzed | Mitotic cycle (Mitotic I %) |
| 1                                                                              | Control | 15                         | 32                                     | 16                                      | 11                                     | 6                                       | 322                            | 20,18%                      |
| 2                                                                              | 100 Gy  | 10                         | 39                                     | 19                                      | 13                                     | 7                                       | 266                            | 29,32%                      |
| 3                                                                              | 200 Gy  | 12                         | 36                                     | 17                                      | 10                                     | 8                                       | 278                            | 25,53%                      |
| 4                                                                              | 300 Gy  | 10                         | 12                                     | 6                                       | 3                                      | 1                                       | 204                            | 10,78%                      |

## REFERENCES

- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. *Caspian Journal of Applied Science and Research*, 4(3), 74–83.
- Aliyeva, N., Nasibova, A., Mammadov, Z., Eftekhari, A., & Khalilov, R. (2023). Individual and combinative effect of NaCl and  $\gamma$ -radiation on NADPH-generating enzymes activity in corn (*Zea mays* L.) sprouts. *Heliyon*, 9(11), e22126. <https://doi.org/10.1016/j.heliyon.2023.e22126>
- Amrahov, N.R., Allahverdiyev, V.Y., Agharzeyeva, Y.I., Mammadova, R.B., Omarova, S.N., Khudayev, F.A., Nasibova, A.N., Shoaib, M., Khalilov, R.I., & Mammadov, Z.M. (2023). Effect of *Verticillium* wilt on the antioxidant system and formation of iron nanoparticles in cotton genotypes. *Journal of Animal & Plant Sciences*, 33(6), 1322-1332.
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Kazimli, L., Nasibova, A., & Khalilov, R. (2022). Study of the morpho-cultural characteristics of some microorganisms irradiated with ionizing gamma radiation. *Advances in Biology & Earth Sciences*, 7(2), 95-103.
- Khalilov, R., & Nasibova, A. (2022). The EPR parameter's investigation of plants under the influence of radiation factors. *Acta Botanica Caucasica*, 1(1), 48-52. <https://doi.org/10.30546/abc.2022.1.1.48>.
- Nasibova, A.N. (2020). Effect of stress factors on plants: EPR research. In *Correlation interaction of science and practice in the new world: Collection of scientific articles on the results of the international scientific and practical conference*. (pp. 28-32). Publishing House of SPbSUE.
- Nasibova, A.N., Fridunbekov, I.Y., Nabiliev, N.N., & Khalilov, R.I. (2016). Influence of UV and GAMMA radiation on paramagnetic properties in fragments of photosystem 2. *International Journal of Pharmacy and Pharmaceutical Research*, 7(4), 24-32.
- Nasibova, A., Khalilov, R., Abiyev, H., Kavetsky, T., Trubitsin, B., Keskin, C., Ahmadian, E., & Eftekhari, A. (2021). Study of endogenous paramagnetic centers in biological systems from different areas. *Concepts in Magnetic Resonance Part B, Magnetic Resonance Engineering*, (2021), 5. <https://doi.org/10.1002/cmr.b.21512>
- Nasibova, A. (2019). The use of EPR signals of snails as bioindicative parameters in the study of environmental pollution. *Advances in Biology & Earth Sciences*, 4(3), 196-205.
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>

## FLORA OF SARIMSAK MOUNTAIN (ANDIRIN/KAHRAMANMARASH/TURKIYE)

Cihangir Uygun<sup>1</sup>, Ahmet Ilchim<sup>2</sup>, Shengul Karaman<sup>3</sup>, Ismail Kazanchi<sup>4</sup>, Sadi Bagci<sup>5</sup><sup>1</sup>Akedash Primary School, Yamachtepe mah. 93054 sok. No:6/A Onikishubat/Kahramanmara/Turkiye<sup>2</sup>Mustafa Kemal University, Tayfur Sökmen Kampüsü (31060) Alahan-Antakya/Hatay<sup>3</sup>Kahramanmarash Sutcu Imam University, Avshar Mah. Batı Chevreyolu Blv. No: 251/A 46040 - Onikishubat/ Kahramanmarash<sup>4</sup>Cahit Zarifoglu Primary School, Necip Fazıl Mahallesi 50012. Sokak No:1 Onikişubat / Kahramanmarash<sup>5</sup>Karacasu Ferhush Primary School, Karacasu Kırım mah. Üniversite cd. No:19/3 Dulkadiroglu/ Kahramanmarash<sup>1</sup>Correspondence: uygunch@gmail.comDOI: <https://doi.org/10.30546/abc.2024.3.2.330>

Article info: pp. 46-63

Received: 15.03.2024; Received in revised form 13.04.2024; Accepted 10.07.2024

**ABSTRACT.** *In this study, we investigated the flora of Sarımsak Mountain, located in the Andırın district of Kahramanmaraş province in Turkey. The research area falls within square C6 of the P.H. Davis grid system. The mountain lies along the route of the Baku-Tbilisi-Ceyhan (BTC) pipeline and has an elevation ranging from 900 to 1,580 meters.*

*The climate is Mediterranean, but altitude influences precipitation patterns and types. Red-brown forest soils are the main soil type.*

*Our research material consists of plant samples collected between 2010 and 2014 from the study area. Based on our results, we identified taxa from 58 plant families and 238 genera. Of these, 48 species (11.92%) are endemic to the area. The distribution of plant taxa across phytogeographic regions shows that 77% (18.73%) are Mediterranean elements, 70% (17.03%) are Iran-Turan, 15% (3.65%) are Europea-Siberian, 60% are widespread, and 18% (4.59%) are multi-regional.*

*The major family of plants by genus is Asteraceae Giseke, which has 31 different genera. The most common genera are Geranium, Ceteaurea, and Allium, each with 7 different species. The results of this study are consistent with previous studies conducted in nearby areas.*

**Keywords:** *Flora, Sarımsak Mountain, Plant Diversity, Kahramanmarash, Türkiye*

## INTRODUCTION

Plant diversity is a vast and diverse field of study throughout the world. Floristic research is conducted globally, and scientists discover new taxa on a daily basis. Turkey is a country located at the crossroads of Asia and Europe, and its plant diversity reflects this geographical location.

The climate in Turkey is also highly varied, making it an ideal location for plant diversity. According to Avcı (2005), approximately 12,000 plant species have been described in Turkey, and about 31% of them are endemic to the country. This makes Turkey a valuable resource for scientists and conservationists studying

plant diversity.

The research area is located in the eastern Mediterranean region and northwest of the province of Kahramanmarash (Fig. 1). The mountain lies on the eastern side of the center of the district of Andırın. It has an altitude of approximately 900 meters and rises to 1,550 meters. The main body of the mountain is divided into four sections by shallow valleys formed by streams. The dominant climate type is the Mediterranean type [Akman, 1990], and the dominant soil type is Red-Brown Mediterranean forest [Atalay, 1989].

The west and east sides of the mountain exhibit very different characteristics in terms

of flora and vegetation. On the west side, there is a step-machine formation up to 1,250 meters, and at the upper part of this area, a sub-alpine-like formation can be observed. The east side has more condensed macchia vegetation up to 1,350 meters and a steppe up to 1,450 meters. Both sides share the same soil type, and tree formations are similar.

The Baku-Tbilisi-Ceyhan (BTC) pipeline passes through the area from north to south, near the entrance altitude [Ozhatay, 2006]. The area is laterally corrupted along the entire length of the pipeline.

### MATERIAL AND METHODS

The material of our research is plant samples collected seasonally and at different altitudes from areas between 2011 and 2014. Prior to field studies, four collection sites were identified based on climatic, soil, and altitude criteria. Samples were dried using appropriate methods and prepared for identification. Sensitive and delicate species such as orchids and

discolored flowers were treated specially and preserved using paper towels. After preparation, the samples were classified first by family, then by genus, and finally by species, and lower categories. During the identification process, P. H. Davis's Flora of Turkey and the East Aegean Islands were used as the primary reference materials. During determination, Al-Sehbaz et al. (2007), Atay et al. (2009), Boisser (1867-1888), Ilcim (2013), İlçim et al. 2008, Ozhatay et al., 209 were also referred to. For the identification of nearly described taxa, such as *Stachys marascus* (Ilçim, et al.), publications were also consulted. In case of any problems with the description, nearby flora such as the flora of Syria or Europe are also studied. After the description, the samples are converted into herbarium material at KSUH (Kahramanmarash Sutcu Imam University Herbarium), and labelled by the author. Synonyms and cultivated samples are not taken into account during the categorization and description process.

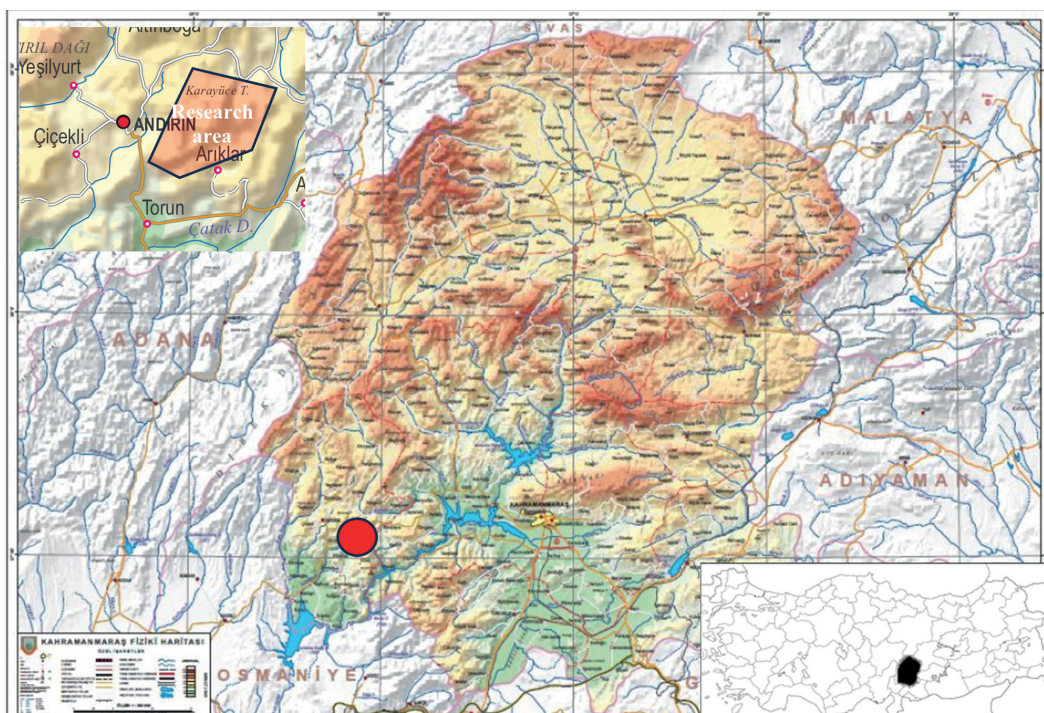


**Figure 1.** Location of the research area

### RESULTS AND DISCUSSION

410 taxa were described from Sarımsak Mountain, which belongs to 58 families and 238 genera. Of these taxa, 48 are endemic, accounting for 11.92%. The flora of the area exhibits a balanced diversity between Mediterranean and Iran-Turan elements. The distribution of

taxa by phytogeographic regions is as follows: 77 (18.73%) of Mediterranean elements, 70 (17.03%) of Iran-Turan elements, 15 (3.65%) of European-Siberian elements, 60 (14.60%) of widespread, and 189 (45.98%) are multi-regional. (Tab. 1) The major family in terms of genera is Asteraceae Giseke, with 31 genera.

(Tab. 2) Major genera in terms of species are *Geranium* L., *Centaurea* L., and *Allium* L., with 7 species each. (Tab. 3) Three of the endemic species-*Cyclamen pseudibericum* Hildebr., *Erodium absinthoides* Willd., subsp. *haradjianii* (Davis), and *Verbascum germanicae* Haussk. - are listed as EN (Endangered), while eight other endemic

species are listed as VU (Vulnerable). A total of 108 species are classified as threatened. [Ekim et al., 2000]. In 2000, the floristic records for various areas were compiled and are presented in Appendix A. The list includes information such as the collection date, altitude, location, and herbarium code.

Table 1.

Distribution of taxa to phytogeographic regions

| Phytogeographic region | Number of Taxa | Percentage (%) |
|------------------------|----------------|----------------|
| Mediterranean          | 77             | 18,73          |
| Iran – Turan           | 70             | 17,03          |
| Europea-Siberia        | 15             | 3,65           |
| Widespread             | 60             | 14,60          |
| Multiregional          | 189            | 45,98          |

Table 2.

Major families by genera

| Family                    | Genus | Species |
|---------------------------|-------|---------|
| Asteraceae Giseke         | 31    | 56      |
| Brassicaceae Burnett.     | 25    | 32      |
| Fabaceae Juss.            | 19    | 45      |
| Apiaceae Lindl.           | 15    | 21      |
| Lamiaceae Martinov        | 14    | 29      |
| Poaceae Barnhart Barnhart | 14    | 20      |

Table 3.

Major genera by species

| Family            | Genus            | Species |
|-------------------|------------------|---------|
| Geraniaceae Juss. | <i>Geranium</i>  | 7       |
| Asteraceae Giseke | <i>Centaurea</i> | 7       |
| Liliaceae Juss.   | <i>Allium</i>    | 7       |
| Fabaceae Juss.    | <i>Vicia</i>     | 6       |
| Asteraceae Giseke | <i>Anthemis</i>  | 6       |

Table 4.

Comparison of number of endemic taxa and endemism rates with prior researchs

| Phytogeographic region              | Number of Endemic taxa | Rate of Endemism (%) |
|-------------------------------------|------------------------|----------------------|
| Sarımsak Mountain                   | 48                     | 11,92                |
| Tiril Mountain                      | 61                     | 12,08                |
| Kayranlı Mountain                   | 90                     | 14,40                |
| Berit Mountain<br>(Yıldız, 2001)    | 200                    | 17,60                |
| Başkonuş Mountain<br>Varol, 1997)   | 55                     | 10,42                |
| Dibek Mountains<br>(Karakisa, 1997) | 78                     | 11,70                |

Table 5.

Comparison of family, genera and species number with prior researchs

| Phytogeographic region              | Family | Genus | Species |
|-------------------------------------|--------|-------|---------|
| Sarımsak Mountain                   | 58     | 238   | 410     |
| Tırıl Mountain                      | 61     | 285   | 505     |
| Kayranlı Mountain                   | 73     | 344   | 625     |
| Berit Mountain<br>(Yıldız, 2001)    | 97     | 462   | 1165    |
| Başkonuş Mountain<br>Varol, 1997)   | 67     | 268   | 528     |
| Dibek Mountains<br>(Karakisa, 1997) | 90     | 357   | 665     |

Table 6.

Comparison of distribution to phytogeographical regions with prior researchs

| Phytogeographic region              | Mediterranean Elements | Iran-Turan Elements | Europea-Siberia Elements |
|-------------------------------------|------------------------|---------------------|--------------------------|
| Sarımsak Mountain                   | 77 (18,73[u3]%)        | 70 (17,03%)         | 15 (3,65%)               |
| Tırıl Mountain                      | 99 (19,60%)            | 87 (17,23%)         | 30 (5,94%)               |
| Kayranlı Mountain                   | 107 (17,12%)           | 121 (19,36%)        | 28 (4,48%)               |
| Berit Mountain<br>(Yıldız, 2001)    | 170 (15,0%)            | 320 (28,20%)        | 63 (5,60%)               |
| Başkonuş Mountain<br>Varol, 1997)   | 145 (27,46%)           | 76 (14,39%)         | 23 (4,36%)               |
| Dibek Mountains<br>(Karakisa, 1997) | 162 (24,5%)            | 91 (13,81%)         | 40 (6,05%)               |

## CONCLUSION

The results of the research are similar to those of previous studies conducted in nearby locations. However, there are some differences that can be attributed to the intersectional characteristics of the area (Tab. 4, 5, and 6). Major plant groups are consistent with Mediterranean Region specifications, including macchies and species that prefer semi-wet conditions. The presence of *Pinus brutia* Ten, *Juniperus*

spp., and *Quercus* spp. also indicates the Mediterranean region. However, due to altitude and intersectional climatic conditions, Europea-Siberian species are able to grow in the area as well.

The settlement area, located on the outskirts of the southern end of the mountain, and its proximity to the district, have caused a slight deterioration of the flora in the entrance areas of the mountain (Tab. 2). Other threats to plant



Figure 2. Settlement areas near the entrance of the mountain

life in the area include changing climate conditions and human activities, such as excessive grazing. Because of these factors, the flora may need to be reevaluated in the future. The high-land culture of Turkish lifestyle may also affect the area in the future [Toroğlu & Gürbüz, 2008].

#### GRATITUDE

This study was supported by Kahramanmaraş Sutcu Imam University Scientific Research Projects Support unit.

#### REFERENCES

- Akman, Y. (1990). Climate and Bioclimate (Methods of Bioclimate and Climate of Turkey). Palme Yayın Dağıtım, Ankara. 319 pp. (İklim ve Biyoiklim (Biyoiklim Metodları ve Türkiye İklimleri). Palme Yayın Dağıtım, Ankara. 319 s.)
- Al-Shehbaz, I. A., Mutlu, B., & Dönmez, A. A. (2007). The Brassicaceae (Brassicaceae) of Turkey, updated. Turkish Journal of Botany, 31(4), 327-336. <https://doi.org/10.3906/bot-0705-11>
- Atalay, İ. (1989). Soil Geography. Ege Üniversitesi Fen – Edebiyat Fakültesi Yayınları No: 8. Ege Üniversitesi ve Matbaası Basımevi, İzmir. 444 pp. (Toprak Coğrafyası. Ege Üniversitesi Fen – Edebiyat Fakültesi Yayınları No: 8. Ege Üniversitesi ve Matbaası Basımevi, İzmir. 444 s.)
- Atay, S., Güler, G., Orhun, C., Seçmen, Ö., & Vural, C. (2009). The Richness in Our Mountains: 120 Alpine Plants of Turkey. ISBN: 978-90-814408-1-3, İstanbul. 96 pp. (Dağlarımızdaki Zenginlik Türkiye'nin 120 Alpin Bitkisi. ISBN: 978-90-814408-1-3, İstanbul. 96 s.)
- Avcı, M. (2005). Vegetation of Turkey in Terms of Diversity and Endemism. İstanbul Üniversitesi Edebiyat Fakültesi Coğrafya Bölümü Coğrafya Dergisi, 13, 27-55. ("Çeşitlilik ve Endemizm açısından Türkiye'nin bitki örtüsü." İstanbul Üniversitesi Edebiyat Fakültesi Coğrafya Bölümü Coğrafya Dergisi, 13, 27-55.)
- Boissier, E. (1867-1888). Oriental Flora (Vol. 1-6). Genova.
- Davis, P. H. (1965-1988). Flora of Turkey and The East Aegean Islands (Vol. 1-11). Edinburgh University Press, Edinburgh, UK.
- Davis, P. H., & Hedge, I. C. (1975). Flora of Turkey: Past, Present, and Future. Candollea, 30, 19-30.
- Duman, H., & Aytaç, Z. (1994). High Mountain Flora and Vegetation of Ahır, Berit, Binboğa, and Öksüz Mountains (Kahramanmaraş-Kayseri). TÜBİTAK, TBAG-940, Ankara. 186 pp. (Ahır, Berit, Binboğa ve Öksüz Dağları (Kahramanmaraş-Kayseri), Yüksek Dağ Flora ve Vegetasyonu, TÜBİTAK, TBAG-940, Ankara. 186 s.)
- Ekim, T., Koyuncu, M., Vural, M., Duman, H., Aytaç, Z., & Adıgüzel, N. (2000). Red Data Book of Turkish Plants. Türkiye Tabiatını Koruma Derneği Yayınları, Ankara. 246 pp. (Türkiye Bitkileri Kırmızı Kitabı. Türkiye Tabiatını Koruma Derneği Yayınları, Ankara. 246 s.)
- Goney, S. (1976). Adana Plains 1. İstanbul Üniversitesi Yayın No: 2162, Coğrafya Enstitüsü Yayın No: 88, İstanbul. 179 pp. (Adana Ovaları 1. İstanbul Üniversitesi Yayın No: 2162, Coğrafya Enstitüsü Yayın No: 88, İstanbul. 179 s.)
- Gurbanov, E., & Huseynova, H. (2020). New spreading areas of some species in the botanical-geographical Baku regions of the middle part of the Caspian coast. Acta Botanica Caucasica, 1(1), 4–8.
- Gurbanov, E., Huseynova, H. Z., Ibrahimov Sh.İ. (2020). Methods for determining soil contamination by oil and petroleum products and indicator plants in the north of Caspian Sea. International Journal of agriculture and biological sciences. Vol.4, № July & Aug., p.84-89. Ijoabs
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Huseynova, H.Z. (2021) The classification of desert and semi-desert vegetation of the Caspian coast (Azerbaijan). Bulletin of Science and Practise 7/11: 43–50. <https://doi.org/10.33619/2414-2948/72/05>
- İlçim, A. (2014). Silent Beauties of Hatay: "900 Wild Flowers." ISBN: 987-605-149-566-8, Hatay. 996 pp. (Hatay'ın Sessiz Güzelleri "900 Yabancı Çiçek." ISBN: 987-605-149-566-8, Hatay. 996 s.)

- İlçim, A., Çenet, M., & Dadandı, M. Y. (2008). *Stachys marashica* (Lamiaceae), A New Species from Turkey. *Annales Botanici Fennici*, 45, 151-155. <https://doi.org/10.5735/085.045.0306> (*Stachys marashica* (Lamiaceae), A New Species From Turkey. *Annales Botanici Fennici*, 45, 151-155. <https://doi.org/10.5735/085.045.0306>)
- Karakisa, İ. (1997). Preliminary Study on the Flora of Dibek Mountains and Surroundings (Kahramanmaraş). Master's Thesis, Yüzüncü Yıl University Institute of Science, Van. 140 pp. (Dibek Dağları ve Çevresi (Kahramanmaraş) Florası Üzerine Bir Ön Araştırma, Yüksek Lisans Tezi, Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü, Van. 140 s.)
- Karaosmanoğlu, F. (2011). Physical Geography of the Keşiş Stream Basin (Andırın-Kahramanmaraş) and Its Surroundings. Master's Thesis, Yüzüncü Yıl University Institute of Social Sciences, Van. 152 pp. (Keşiş Çayı Havzası (Andırın-Kahramanmaraş) ve Yakın Çevresinin Fiziki Coğrafyası, Yüksek Lisans Tezi, Yüzüncü Yıl Üniversitesi Sosyal Bilimler Enstitüsü, Van. 152 s.)
- Özhatay, N. (2006). Important Plant Areas Along Turkey's BTC Pipeline. İstanbul University Publications, İstanbul. 303 pp. (Türkiye'nin BTC Boru Hattı Boyunca Önemli Bitki Alanları. İstanbul Üniversitesi Yayınları, İstanbul. 303 s.)
- Özhatay, N., İlçim, A., & Ok, T. (2009). Silent Beauties of Ahır Mountain: "200 Wild Flowers." Kahramanmaraş Valiliği İl Çevre ve Orman Müdürlüğü Yayınları, İstanbul. 96 pp. (Ahır Dağı'nın Sessiz Güzelleri "200 Yabani Çiçek." Kahramanmaraş Valiliği İl Çevre ve Orman Müdürlüğü Yayınları, İstanbul. 96 s.)
- Toroğlu, E., & Gürbüz, M. (2008). Recreational Plateaus in Andırın District. *Doğu Coğrafya Dergisi*, 19, 281-300. (Andırın İlçesi'nde sayfiye yaylaları. *Doğu Coğrafya Dergisi*, 19, 281-300.)
- Varol, Ö. (1997). Flora of Başkonuş Mountain (Kahramanmaraş). *Turkish Journal of Botany*, 27, 117-139. <https://doi.org/10.3906/bot-27-2-6> (Başkonuş Dağı (Kahramanmaraş) Florası. *Turkish Journal of Botany*, 27, 117-139. <https://doi.org/10.3906/bot-27-2-6>)
- Yıldız, B. (2001). Floristic Characteristics of Berit Mountain (Kahramanmaraş). *Turkish Journal of Botany*, 25, 63-102. <https://doi.org/10.3906/bot-25-2-2> (Berit Dağı'nın (Kahramanmaraş) Floristik özellikleri. *Turkish Journal of Botany*, 25, 63-102. <https://doi.org/10.3906/bot-25-2-2>)

## APPENDIX A. FLORISTIC LIST OF THE RESEARCH AREA.

### Polypodiaceae J.Presl & C.Presl

1. *Polypodium vulgare* L. subsp. *prionodes* Rothmaler, 19/05/2011, 1000-1100 m, rocky slopes, UYGUN-1601

### 2. Pinaceae Spreng. ex Rudolphi

2. *Cedrus libani* A.Rich., 09/04/2011, 1400-1500 m, below top, UYGUN-1602
3. *Pinus nigra* Arn. subsp. *pallasiana* (Lamb.) Holmboe, 21/04/2012, 1400-1500 m, below the top with *C. libani* groups, UYGUN-1603
4. *P. brutia* Ten., 21/04/2012, 1000-1100 m, Medit. Element, mixed forest, UYGUN-1604
5. *P. pine* L., 21/04/2012, 1000-1100 m, environs of villages, UYGUN-1605

### 3. Cupressaceae Gray

6. *Juniperus drupacea* Lab., 19/05/2011, 900-1000 m, steppes, UYGUN-1606
7. *J. oxycedrus* L. subsp. *oxycedrus*, 06/05/2012, 1000-1100 m, macchie field, UYGUN-1607
8. *J. foetidissima* Willd., 04/06/2011, 1000-1100 m, macchie field, UYGUN-1608
9. *J. excelsa* Bieb., 04/06/2011, 1000-1100 m, Widespread, macchie field, UYGUN-1609

### 4. Ranunculaceae Juss.

10. *Delphinium peregrinum* L., 04/06/2011, , 1200-1300 m, east side basin, UYGUN-1610
11. *Anemone blanda* Schott&Kotschy, 09/04/2011, 1100-1200 m, dried stream, UYGUN-1611
12. *A. coronaria* L., 09/04/2011, 900-1000 m, Medit. Element, field side, UYGUN-1612
13. *Adonis flammea* Jacq., 14/05/2011, 900-1000 m, Widespread, field side, UYGUN-1613
14. *Ranunculus constantinopolitanus* (DC.) d'Urv., 04/06/2011, 900-1000 m, stream side, UYGUN-1614
15. *R. arvensis* L., 21/04/2012, 900-1000 m, Widespread, stream side, UYGUN-1119
16. *R. ficaria* L. subsp. *ficariiformis* Rouy.&Fouc., 21/04/2012, 1300-1400 m, steppes over the peak, UY-

## GUN-1615

17. *R. ficaria* L. subsp. *calthifolius* (Reichb.) Arc., 21/04/2012, 1300-1400 m, steppess over the peak, UYGUN-1616

18. *Ceratocephalus falcatus* (L.) Pers., 16/04/2011, 1000-1100 m, near of forestry depot, UYGUN-1617

19. *Thalictrum minus* L. var. *microphyllum* Boiss., 23/05/2013, 1100-1200 m, near the settlements, UYGUN-1618

### 5. *Paeoniaceae* Raf.

20. *Paeonia mascula* (L.) Miller subsp. *mascula*, 08/05/2011, 1200-1300 m, steppess, UYGUN-1620

### 6. *Papaveraceae* Juss.

21. *Glaucium leiocarpum* Boiss., 04/06/2011, 1100-1200 m, Widespread, near the forestry depot, UYGUN-1619

22. *Roemeria hybrida* (L.) DC subsp. *hybrida*, 04/06/2011, 1300-1400 m, Widespread, steppess, UYGUN-1620

23. *Papaver rhoeas* L., 21/04/2012, 1000-1100 m, widespread, macchie field, UYGUN-1621

24. *P. syriacum* Boiss.&Balanche, 21/04/2012, 1000-1100 m, steppess, UYGUN-1622

25. *Hypecoum imberbe* Sibth.&Sm, 14/04/2012, 1100-1200 m, widepread, macchie field, UYGUN-1623

26. *Corydalis solida* (L.) Swartz. subsp. *tauricola* Cullen&Davis, 19/05/2011, 1200-1300 m, endemic, mediterranean, east side basin, UYGUN-1624

27. *Fumaria parviflora* Lam, 21/04/2012, 1000-1100 m, steppess, UYGUN-1625

### 7. *Brassicaceae* Burnett. Burnett

28. *Sinapis arvensis* L., 09/04/2011, 900-1000 m, widespread, road and field sides, UYGUN-1627

29. *Raphanus raphanistrum* L., 17/04/2011, 900-1000 m, road and field sides, UYGUN-1628

30. *Crambe orientalis* L. var. *orientalis*, 19/05/2011, 1100-1200 m, widespread, Ir-Tur. element, macchie field, UYGUN-1629

31. *Conringia orientalis* (L.) Andrzej., 19/03/2011, 1200-1300 m, macchie field, UYGUN-1667

32. *Lepidium spinosum* Ard., 17/04/2011, 1100-1200 m, dried stream side on southeast downwards, UYGUN-1630

33. *Cardaria draba* (L.) Desv. subsp. *draba*, 14/05/2011, 1300-1400 m, widespread, rocky slopes, UYGUN-1631

34. *Isatis candolleana* Boiss., 14/05/2011, 1200-1300 m, endemic, ir-tur. element, near of church ruins, UYGUN-1632

35. *Iberis sempervirens* L., 06/05/2012, 1300-1400 m, mediterranean. element, rocky places between the church ruin and fountain, UYGUN-1633

36. *Aethionema heterocarpum* J. Gay, 08/05/2011, 1100-1200 m, macchie field, UYGUN-1634

37. *A. eunomioides* (Boiss.) Bornm., 16/06/2012, 1200-1300 m, endemic, steppess, UYGUN-1635

38. *Thlaspi perfoliatum* L., 19/05/2011, 1300-1400 m, widespread, steppess, UYGUN-1636

39. *T. oxyceras* (Boiss.) Hedge, 19/05/2011, 1200-1300 m, east side basin, UYGUN-1637

40. *Capsella bursa-pastoris* (L.) Medik., 06/05/2012, 900-1000 m, cosmopolit, widespread, UYGUN-1638

41. *Boreava orientalis* Jaub.&Spach., 16/06/2012, 1300-1400 m, widespread, rocky places, UYGUN-1639

42. *Peltaria angustifolia* DC. 21/04/2012, 1100-1200 m, macchie fields, UYGUN-1640

43. *Fibigia eriocarpa* (DC) Boiss., 07/04/2011, 1000-1100 m, widespread, steppess, UYGUN-1650

44. *Alyssum alyssoides* (L.) L., 05/03/2011, 1000-1100 m, field sides, UYGUN-1651

45. *A. desertum* Stapf. var. *desortum*, 14/05/2011, 1000-1100 m, widespread, near macchie field, UYGUN-1652

46. *A. strictum* Willd., 21/04/2012, 1400-1500 m., Ir-Tur. Element, steppess near the top, UYGUN-1653

47. *A. samariferum* Boiss.&Hausskn., 10/07/2011, 1200-1300 m, east side basin steppess, UYGUN-1654

48. *Draba bruniifolia* Stev. subsp. *bruniifolia*, 19/05/2011, 1400-1500 m, steppess near the top, UYGUN-1655

49. *Erophila verna* (L.) Chevall subsp. *verna*, 19/03/2011, 1100-1200 m, widespread, macchie field, UYGUN-1656

50. *Arabis caucasica* Willd. subsp. *caucasica*, 09/04/2011, 1200-1300 m, widespread, dried stream on southeast downward, UYGUN-1657

51. *A. nova* Vill., 16/04/2011, 1100-1200 m, border of macchie field, UYGUN-1658

52. *Nasturtium officinale* R.Br., 19/03/2011, 900-1000 m, widespread, water side, UYGUN-1659  
53. *Chorispora syriaca* Boiss., 09/04/2011, 1200-1300 m, rocky places, UYGUN-1660  
54. *Hesperis matronalis* L. subsp. *matronalis*, 16/06/2012, 1200-1300 m, east side rocky slopes, UYGUN-1661  
55. *Erysimum alpestre* Kotschy ex Boiss., 14/05/2011, 1400-1500 m, endemic, ir-tur. element, steppess near the top, UYGUN-1662  
56. *Sisymbrium officinale* (L.) Scop, 07/04/2012, 1100-1200 m, macchie field, UYGUN-1663  
57. *S. septulatum* DC., 25/06/2011, 1100-1200 m, macchie field, UYGUN-1664  
58. *Arabidopsis thaliana* (L.) Heynhold, 19/03/2011, 900-1000 m, macchie field, UYGUN-1666
- 8. Capparaceae Juss.**  
59. *Capparis spinosa* L. var. *spinosa*, 26/08/2012, 900-1000 m, settlements, UYGUN-1668
- 9. Violaceae Batsch**  
60. *Viola suavis* Bieb., 05/03/2011, 1100-1200 m, South slopes bottom of the rocky places, UYGUN-1669  
61. *V. occulta* Lehm., 21/04/2013, 1000-1100 m, steppess, UYGUN-1670
- 10. Portulacaceae Juss.**  
62. *Portulaca oleraceae* Gris. ex Fenzl., 14/05/2011, 900-1000 m, water side, UYGUN-1671
- 11. Caryophyllaceae Juss.**  
63. *Arenaria sabulinea* Gris. ex Fenzl, 14/05/2011, 1100-1200 m, endemic, ir-tur elementi, macchie field, UYGUN-1672  
64. *A. acerosa* Boiss., 16/06/2012, 1200-1300 m, endemic, east side basin, UYGUN-1673  
65. *Minuartia picta* (Sibth.&Sm) Bornm., 05/03/2011, 1000-1100 m, border of macchie field, around spike fence, UYGUN-1674  
66. *M. globulosa* (Lab.) Schinz&Thell, 09/06/2012, 1200-1300 m, E.Medit. element, edge of dried stream, UYGUN-1675  
67. *M. montana* L., 04/06/2011, 1000-1100 m, ir-tur elementi, macchie field, UYGUN-1676  
68. *Lepyrodiclis holosteoides* (C.A. Meyer) Fenzl ex Fisch., 14/05/2011, 1000-1100 m, around forestry depot, macchie field, UYGUN-1677  
69. *Cerastium kotschy* Boiss., 14/05/2011, 1300-1400 m, rocky places, UYGUN-1678  
70. *Holosteum umbellatum* L. var. *umbellatum*, 16/06/2012, 1300-1400 m, rocky places, UYGUN-1679  
71. *Moenchia graeca* Boiss.&Heldr., 14/05/2011, 1000-1100 m, macchie field, UYGUN-1680  
72. *Sagina procumbens* L., 10/07/2011, 1400-1500 m, steppess over the top, UYGUN-1681  
73. *Telephium imperati* L. subsp. *orientale* (Boiss.) Nyman, 16/06/2012, 1200-1300 m, edge of the water rift, UYGUN-1682  
74. *Dianthus strictus* Banks&Sol. var. *strictus*, 10/07/2011, 1400-1500 m, steppess over the top, UYGUN-1683  
75. *D. floribundus* Boiss., 04/06/2011, 1100-1200 m, ir-tur. element, rocky places, UYGUN-1684  
76. *D. orientalis* Adams., 10/07/2011, 1200-1300 m, east side rocky slopes, UYGUN-1685  
77. *D. zonatus* Fenzl. var. *zonatus*, 14/05/2011, 1000-1100 m, macchie field, UYGUN-1686  
78. *Velezia rigida* L., 14/05/2011, 1000-1100 m, steppes, UYGUN-1687  
79. *Saponaria glutinosa* Bieb., 05/03/2011, 900-1000 m, steppes, UYGUN-1688  
80. *Sa. tridentata* Boiss., 16/04/2011, 1000-1100 m, ir-tur. elementi, macchie field, UYGUN-1690  
81. *Vaccaria pyramidata* Medik. var. *pyramidata*, 21/04/2012, 900-1000 m, road sides, UYGUN-1691  
82. *Silene vulgaris* (Moench) Gracke, 04/06/2011, 1000-1100 m, macchie field, UYGUN-1692  
83. *S. conoidea* L., 14/05/2011, 1200-1300 m, rocky places, UYGUN-1693  
84. *S. aegyptica* (L.) L. subsp. *aegyptica*, 30/04/2011, 1000-1100 m, border of macchie field, UYGUN-1694  
85. *Agrostemma githago* L., 09/04/2011, 1000-1100 m, around the settlement, UYGUN-1695
- 12. Illecebraceae R.Br.**  
86. *Scleranthus annuus* L. subsp. *annuus*, 16/06/2012, 1200-1300 m, widespread, near the church ruin, UYGUN-1696
- 13. Polygonaceae Juss.**  
87. *Rumex acetosella* L., 16/06/2012, 1200-1300 m, cozmopolit, all over the area UYGUN-1697  
88. *R. tuberosus* L. subsp. *tuberosus*, 19/05/2011, 1200-1300 m, east side basin, UYGUN-1698
- 14. Hypericaceae Juss.**

89. *Hypericum spectabile* Jaub.&Spach, 04/06/2011, 1200-1300 m, endemic, ir-tur element, central peak, rocky places, UYGUN-1699
90. *H. hyssopifolium* Chaix. var. *elongatum*, 23/05/2013, 1300-1400 m, ir-tur element, rocky places, UYGUN-1700
91. *H. scabrum* L., 04/06/2011, 1200-1300 m, ir-tur. element, rocky places, UYGUN-1701
- 15. Malvaceae Juss.**
92. *Malva neglecta* Wallr., 16/06/2012, 900-1000 m, steppess, UYGUN-1702
93. *Alcea apterocarpa* (Fenzl.) Boiss., 04/06/2011, 1000-1100 m, endemic, ir-tur element, road sides, UYGUN-1703
94. *A. pallida* Waldst&Kitt., 04/06/2011, 1000-1100 m, road sides, UYGUN-1704
- 16. Tiliaceae Juss.**
95. *Tilia argentea* Desf. ex DC., 16/06/2012, 1100-1200 m, Euro-sib element, around the South rift, macchie field, UYGUN-2018
- 17. Geraniaceae Juss.**
96. *Geranium glaberrimum* Boiss.&Heldr., 14/05/2011, 1100-1200 m, endemic, e.medit element, over the rocks, UYGUN-1706
97. *G. lucidum* L., 14/05/2011, 1100-1200 m, rocky places, UYGUN-1707
98. *G. columbinum* 14/05/2011, 900-1000 m, steppess, bottom of the rocky places, UYGUN-1708
99. *G. tuberosum* L. subsp. *tuberosum*, 19/03/2011, 900-1000 m, steppes, UYGUN-1709
100. *G. libanoticum* Schenk, 14/05/2011, 1000-1100 m, steppes, UYGUN-1710
101. *G. asphodeloides* Burnm., subsp. *asphodeloides*, 08/05/2011, 1100-1200 m, macchie field, UYGUN-1711
102. *G. pyrenaicum* Burnm., 16/04/2011, 1300-1400 m, rocky places, UYGUN-1712
103. *Erodium cicutarium* (L.) L'Herit subsp. *cutarium*, 09/04/2011, 900-1000 m, steppes, UYGUN-1713
- 19. Oxalidaceae R.Br.**
104. *Oxalis corniculata* L., 16/04/2011, 900-1000 m, wet places near entry point, UYGUN-2001
- 20. Rhamnaceae Juss.**
105. *Paliurus spina-christi* Miller, 14/05/2011, 1000-1100 m, macchie field, UYGUN-1715
- 21. Fabaceae Juss.**
106. *Sophora alopecuroides* var. *alopeuroides*, 09/04/2011, 1000-1100 m, road sides, UYGUN-1716
107. *Genista albida* Willd., 08/05/2011, 1000-1100 m, macchie field, UYGUN-1717
108. *Colutea cilicica* Boiss.&Bal., 21/04/2012, 1400-1500 m, widespread, rocky places near the top, UYGUN-1718
109. *Astragalus angustiflorus* C.Koch. subsp. *amanus* (Boiss.) Chamberlain, 04/06/2011, 1000-1100 m, endemic, e.medit element, steppes, UYGUN-1719
110. *A. schizopterus* Boiss., 09/04/2011, 1000-1100 m, endemic, steppes, UYGUN-1720
111. *A. macrocephalus* Willd. subsp. *finitimus*, 16/06/2012, 1200-1300 m, Ir-Tur. Element, around the rift on downwards, UYGUN-1721
112. *A. elongatus* Willd. subsp. *elongatus*, 10/07/2011, 1200-1300 m, east side rocky places, UYGUN-1722
113. *A. angustifolius* Lam. subsp. *angustifolius* var. *angustifolius*, 16/06/2012, 1100-1200 m., stony places around first rift on North side, UYGUN-1723
114. *Glychyrrhiza glabra* var. *glabra*, 16/06/2012, 1200-1300 m, east side basin, UYGUN-1724
115. *Psoralea bituminosa* L., 07/04/2012, 1100-1200 m, Medit. element, macchie field, UYGUN-1725
116. *Vicia cassia* Boiss., 12/05/2013, 1300-1400 m, E.Medit element, rocky places over the center peak, UYGUN-1726
117. *V. cypria* Kotschy ex Unger&Kotschy, 10/07/2011, 1000-1100 m, steppe fields, UYGUN-1727
118. *V. hirsuta* (L.) S.F.Gray, 19/05/2011, 1300-1400 m, east side wood opening over the cliffs, UYGUN-1728
119. *V. hybrida* L., 04/06/2011, 1100-1200 m, widespread, roadside on downwards, UYGUN-1729
120. *V. sativa* L. subsp. *incisa* Bieb. var. *cordata* (Vulfen ex Hoppe) Arc., 09/04/2011, 1000-1100 m, macchie field, UYGUN-1730
121. *V. galilea* Plitm.&Zoh., 14/05/2011, 1000-1100 m, macchie field near entry point, UYGUN-1731
122. *Lathyrus variabilis* (Boiss.&Ky.) Maly, 16/04/2011, 1100-1200 m, E.Medit Element, macchie field,

## UYGUN-1732

123. *Lathyrus inconspicuus* L., 14/05/2011, 1300-1400 m, widespread, near the church ruin, UYGUN-1733
124. *L. laxiflorus* (Desf.) O. Kuntze subsp. *angustifolius* (Post. ex Dinsm.) Davis, 16/06/2012, 1000-1100 m, Endemic, E.Medit. Element, steppe fields, UYGUN-1734
125. *L. boissieri* Sirj., 16/06/2012, 1300-1400 m, near the mountain fountain, UYGUN-1735
126. *L. brachypterus* Cel. var. *brachypterus*, 08/05/2011, 1200-1300 m, Endemic, ENDEMİK, Ir-Tur. Element, near the church ruin, UYGUN-1736
127. *Pisum sativum* L. var. *brevipedunculatum* Davis&Miekle, 04/06/2011, 1000-1100 m, steppe fields, UYGUN-1737
128. *Trifolium repens* L. var. *repens*, 21/04/2012, 1200-1300 m, macchie field, UYGUN-1738
129. *T. speciosum* Willd. 04/06/2011, 1300-1400 m, rocky places, UYGUN-1739
130. *T. nigrescens* Viv. subsp. *petrosavii* (Clem.) Holmboe, 25/06/2011, 1200-1300 m, widespread, rocky fields, UYGUN-1740
131. *T. purpureum* Lois var. *purpureum*, 04/06/2011, 1000-1100 m, road sides, UYGUN-1741
132. *T. stellatum* L. var. *stellatum*, 14/05/2011, 1000-1100 m, steppe field, UYGUN-1742
133. *Melilotus officinalis* (L.) Desr., 04/06/2011, 1200-1300 m, downwards on southern rift, UYGUN-1743
134. *Trigonella plicata* (Boiss.&Ball.) Boiss., 19/05/2011, 1200-1300 m, endemic, E.Medit. Elementi, openings of forest, UYGUN-1744
135. *T. kotschyi* Fenzl., 08/05/2011, 1200-1300 m, endemic, Ir-Tur. Element, rocky slopes of the southern rift, UYGUN-1745
136. *T. spicata* Sibth.&Sm., 08/05/2011, 1200-1300m, Medit. Element, macchie field, UYGUN-1746
137. *Medicago radiata* L., 29/03/2011, 1100-1200 m, Ir-Tur. Element, steppe field, UYGUN-1747
138. *M. sativa* L. subsp. *sativa*, 09/04/2011, 900-1000 m, widespread, UYGUN-1748
139. *M. falcata* L., 16/06/2012, 1200-1300 m, around middle rift, UYGUN-1748
140. *M. turbinata* (L.) All. var. *chiotica*, 09/04/2011, 1200-1300 m, southern downward above mini peaks, UYGUN-1749
141. *Lotus corniculatus* L. var. *corniculatus*, 16/06/2012, 100-1200 m, widespread, above the settlements, UYGUN-1750
142. *Hymenocarpus circinnatus* (L.) Savi, 09/04/2011, 1200-1300 m, Medit. Element, macchie field around the middle rift, UYGUN-1751
143. *Coronilla grandiflora* Boiss. 04/06/2011, 1100-1200 m, endemic, E.Medit. element, rocky places, UYGUN-1752
144. *C. varia* L. subsp. *libanotica*, 04/06/2011, 1200-1300 m, rocky places, UYGUN-1753
145. *Hammatolobium lotoides* Fenzl., 16/04/2011, 1200-1300 m, E.Medit. element, steppe field near southern down road, UYGUN-1754
146. *Hedysarum varium* Willd., 04/06/2011, 1400-1500 m, Ir-Tur. Element, rocky places around the top, UYGUN-1755
147. *H. syriacum* Boiss., 19/05/2011, 1100-1200 m, Ir-Tur. Element, macchie field, UYGUN-1756
148. *Onobrychis cornuta* (L.) Desv., 19/05/2011, 1100-1200 m, Ir-Tur. Element, macchie field, UYGUN-1757
149. *O. gracilis* Besser, 04/06/2011, 1000-1100 m., macchie field, UYGUN-1758
150. *O. sulphurea* Boiss&Bal. var. *pallida* (Boiss.&Ky) Hedge, 14/05/2011, 1400-1500 m, endemic, E.Medit. Element, rocky places around middle rift, UYGUN-1759

**23. Rosaceae Juss.**

151. *Cerasus mahaleb* (L.) Miller, 08/05/2011, 1200-1300 m, macchie field over the southern entrance, UYGUN-1761
152. *Rubus canescens* DC. var. *canescens*, 13/05/2012, 1200-1300 m, widespread, macchie field, UYGUN-1762
153. *Potentilla recta* L. Grup B, 08/05/2011, 1000-1100 m, steppe field, UYGUN-1763
154. *P. incliniata* Vill., 16/06/2012, 1300-1400 m, rocky places, UYGUN-1764
155. *P. meyeri* Boiss., 18/06/2011, 1200-1300 m, Ir-Tur. Element, rocky places, UYGUN-1765
156. *Fragaria vesca* L., 19/03/2011, 1200-1300 m, stony and rocky places around southern rift, UYGUN-1766
157. *F. viridis* L., 19/03/2011, 1100-1200 m, macchie field above forestry depot, UYGUN-1767

158. *Geum urbanum* L., 08/05/2011, 1300-1400 m, hillside over water fountain, UYGUN-1768
159. *Rosa canina* L., 08/05/2011, 1100-1200 m, around the southern rift, UYGUN-1769
160. *Aphanes arvensis* L., 16/09/2011, 1100-1200 m, steppe field around down road, UYGUN-1770
- 24. Cucurbitaceae Juss.**
161. *Ecballium elaterium* (L.) A.Rich., 04/06/2011, 900-1000 m, road sides, UYGUN-1771
- 25. Crassulaceae J.St.-Hil.**
162. *Rosularia serpentina* (Werderman) Muirhead, 10/07/2011, 1300-1400 m, Endemic, E.Medit Element, Rocky slopes on east side, UYGUN-1772
163. *Sedum acre* L., 16/06/2012, 1300-1400 m, stony and rocky places, UYGUN-1773
164. *S. hispanicum* L. var. *hispanicum*, 19/05/2011, 1200-1300 m, rocky places, UYGUN-1774
165. *S. cepaea* L., 25/06/2011, 1200-1300 m, rocky places around the southern rift, UYGUN-1775
- 26. Saxifragaceae Juss.**
166. *Saxifraga kotschy* Boiss., 04/06/2011, 1400-1500 m, rocky slopes around the top, UYGUN-1776
- 27. Apiaceae Lindl.**
167. *Eryngium falcatum* Delar., 26/08/2013, 1000-1100 m, road sides, UYGUN-1777
168. *E. glomeratum* Lam., 26/08/2013, 1000-1100 m, road sides, UYGUN-1778
169. *Lagoecia cuminoides* L., 05/03/2011, 1000-1100 m, wet shadows of rocky slopes, UYGUN-1779
170. *Echinophora tenuifolia* L., 17/08/2013, 1100-1200 m, macchie field, UYGUN-1780
171. *Scandix stellata* Banks&Sol., 16/06/2012, 1000-1100 m, widespread, steppe field, UYGUN-1781
172. *S. pecten-veneris* L. 16/04/2011, 1000-1100 m, widespread, steppe field, UYGUN-1782
173. *Coriandrum sativum* L., 14/05/2011, 1300-1400 m, rocky places, UYGUN-1783
174. *Bunium paucifolium* DC. var. *junceum* (Boiss.) Hedge&Lamond, 10/07/2011, 1000-1100 m, macchie field, UYGUN-1784
175. *B. brachyactis* (Post.) Wolf, 10/07/2012, 1400-1500 m, endemic, rocky places around the top, UYGUN-1785
176. *Pimpinella corymbosa* Boiss., 04/06/2011, 1200-1300 m., Ir-Tur. Element, down road around the little cave, UYGUN-1786
177. *Lecokia cretica* (Lam.) DC, 14/05/2011, 1300-1400 m, rocky places over the fountain, UYGUN-1787
178. *Bupleurum falcatum* L. subsp. *persicum* (Boiss.) Koso-Pol, 10/07/2011, 1200-1300 m, rocky slopes around the southern rift, UYGUN-1788
179. *Ammi visnaga* (L.) Lam., 19/05/2011, 1100-1300 m, Medit Element, macchie field, UYGUN-1789
180. *Ferulago cassia* Boiss., 10/07/2012, 1300-1400 m, Medit Element, rocky places around the northern rift, UYGUN-1790
181. *Heracleum persicum* Desf., 10/07/2011, 1200-1300 m, Ir-Tur. Element, macchie field openings, UYGUN-1791
182. *H. humile* Sm., 10/07/2011, 1400-1500 m, E.Medit. Element, steppes over the top, UYGUN-1792
183. *Zosima absinthifolia* (Vent.) Link, 09/04/2011, 1300-1400 m, Rocky slopes on east side, UYGUN-1793
184. *Tordylium syriacum* L., 08/05/2011, 1000-1100 m, steppe field around the forestry depot, UYGUN-1794
185. *Torilis arvensis* (Huds.) Link. subsp. *neglecta* (Sprengel) Thellung, 16/06/2012, 1100-1200 m, steppe – macchie border, UYGUN-1795
186. *T. arvensis* (Huds.) Link. subsp. *elongata* (Hoffmans&Link) Cannon, 19/07/2012, 1000-1100 m, macchie field, UYGUN-1796
187. *T. leptophylla* (L.) Reichb., 19/05/2011, 1300-1400 m, atony places, UYGUN-1797
- 28. Cornaceae Bercht. ex J.Presl**
188. *Cornus mas* L., 17/04/2011, 1200-1300 m, Euro-Sib. Element, macchie field, UYGUN-1798
- 29. Caprifoliaceae Juss.**
189. *Sambucus ebulus* L., 19/07/2012, 1300-1400 m, Euro-Sib. Element, around the water spring, UYGUN-2014
- 30. Valerianaceae Batsch**
190. *Valeriana alliariifolia* Adams, 16/06/2012, 1300-1400 m, widespread, rocky places over east side, UYGUN-1800
191. *V. sisymbriifolia* Vahl., 04/06/2011, 1300-1400 m, Ir-Tur. element, rocky places, UYGUN-1799

192. *V. dioscoridis* Sm., 29/03/2011, 1200-1300 m, E. Medit. Element, rocky places in macchie field on the left top of the northern rift, UYGUN-1800

### 31. Dipsacaceae Juss.

193. *Cephalaria setosa* Boiss.&Hohen, 16/06/2012, 1100-1200 m, Ir.-Tur. Element, rocky places, UYGUN-1801
194. *C. syriaca* (L.) Schareder, 23/06/2012, 1200-1300 m, macchie field, UYGUN-1802
195. *Knautia integrifolia* L. var. *integrifolia*, 21/04/2013, 1300-1400 m., Medit. Element, rocky places on east side, UYGUN-1803
196. *Scabiosa micrantha* Desf., 16/06/2012, 1200-1300 m, rocky places in macchie field, UYGUN-1804
197. *S. calocephala* Boiss., 04/06/2011, 900-1000 m, Ir.-Tur. Element, steppe field, UYGUN-1805

### 32. Asteraceae Giseke

198. *Xanthium spinosum* L., 18/08/2013, 1000-1100 m, road sides, UYGUN-1806
199. *X. strumarium* L. subsp. *strumarium*, 10/07/2011, 1000-1100 m, around the settlements, UYGUN-1807
200. *Helichrysum chionophilum* Boiss.&Bal, 16/06/2012, 1300-1400 m, Endemic, rocky slopes on east side, UYGUN-1808
201. *H. plicatum* DC. subsp. *plicatum*, 19/07/2012, 1400-1500 m, wide spread, steppes over the top, UYGUN-1809
202. *H. arenarium* (L.) Moench. subsp. *aucherii* (Boiss.) Davis&Kupicha, 19/05/2011, 1400-1500 m, Endemic, Ir.-Tur. Element, steppes over the top, UYGUN-1810
203. *Bellis perennis* L., 05/03/2011, 900-1000 m, Euro-Sib. Element, steppes, UYGUN-1811
204. *Doronicum orientale* Hoffm., 23/05/2012, 1400-1500 m, Cedrus opennings, UYGUN-1812
205. *Senecio mollis* Willd., 19/07/2012, 1100-1200 m, Ir.-Tur. element, around the settlements, UYGUN-1813
206. *S. pseudo-orientalis* Schischkin, 18/06/2011, 1300-1400 m, Ir.-Tur. Element, Forward from the fountain through to the rock shades, UYGUN-1814
207. *Anthemis cretica* L. subsp. *pontica* (Willd.) Grierson, 08/05/2011, 1200-1300 m, macchie fields, UYGUN-1818
208. *A. cretica* L. subsp. *cassia* (Boiss.) Grierson, 16/06/2012, 1100-1200 m, steppes around the northern rift, UYGUN-1819
209. *A. fumariifolia* Boiss., 25/06/2011, 1200-1300 m, Ir.-Tur. element, around the church ruins, UYGUN-1820
210. *A. tinctoria* L. var. *pallida* DC, 04/06/2011, 1200-1300 m, steppes on downroad, UYGUN-1815
211. *A. hyalina* DC., 04/06/2011, 1000-1100 m, steppes, UYGUN-1816
212. *A. cotula* L., 14/05/2011, 900-1000 m, widespread, steppes, UYGUN-1817
213. *Achillea aleppica* DC. subsp. *aleppica*, 10/07/2011, 1100-1200 m, Ir.-Tur. Element, macchie fields, UYGUN-1821
214. *A. kotschyii* Boiss. subsp. *kotschyii*, 10/07/2011, 1300-1400 m, around the fountain, UYGUN-1822
215. *A. biebersteinii* Afan., 16/06/2012, 1300-1400 m, Ir.-Tur. element, around the fountain, UYGUN-1823
216. *Ac. grandiflora* Friv., 25/06/2011, 1200-1300 m, rocky places around macchies over northern rift, UYGUN-1825
217. *Matricaria aurea* (L.) Schultz Bip., 16/06/2011, 1300-1400 m, over valley steppes on east side, UYGUN-1824
218. *Gundelia tournefortii* L. var. *armata* Freyn&Sint., 09/06/2012, 1000-1100 m, Ir.-Tur. Element, steppe fields, UYGUN-1826
219. *Onopordum anatolicum* (Boiss.) Eig., 04/06/2011, 1000-1100 m, Endemic, Ir.-Tur. element, steppe fields, UYGUN-1827
220. *Cirsium arvense* (L.) Scop. subsp. *vestitum* (Wimmer&Grab) Petrak, 16/06/2012, 1100-1200 m, around the cave on downroad, UYGUN-1828
221. *C. elodes* Bieb., 10/07/2011, 1200-1300 m, Ir.-Tur. Element, macchie opennings, UYGUN-1829
222. *Ptilostemon afer* (Jacq.) Greuter subsp. *eberneus* Greuter, 10/07/2011, 1300-1400 m, Endemic, wide-spread, subsidence steppes over the peak, UYGUN-1830
223. *Notobasis syriaca* (L.) Cass., 08/05/2011, 1000-1100 m, Medit. Element, steppe fields, UYGUN-1831

224. *Carduus nutans* L. subsp. *nutans*, 04/06/2011, 1000-1100 m, widespread, around the forestry depot, UYGUN-1832
225. *Serratula cerinthifolia* (Sm.) Boiss., 16/06/2012, 1100-1200 m, steppe – macchie border, UYGUN-1833
226. *Centaurea virgata* Lam. Grup A., 24/07/2011, 1000-1100 m, widespread, steppe fields, UYGUN-1834
227. *C. lycopifolia* Boiss.&Kotschy, 04/06/2011, 1300-1400 m, Endemic, E.Medit. Element, rocky places, UYGUN-1835
228. *C. cataonica* Boiss.&Hausskn., 10/07/2011, 1400-1500 m, Endemic, steppes over the top, UYGUN-1836
229. *C. depressa* Bieb., 19/05/2011, 1200-1300 m, widespread, rocky places around the northern rift, UYGUN-1839
230. *C. aggregata* Fish&Mey. ex DC subsp. *aggregata*, 23/08/2013, 1300-1400 m, rocky places on east side, UYGUN-1840
231. *C. urvillei* DC. subsp. *urvillei*, 16/06/2012, 1100-1200 m, E.Medit Element, macchie field over the forestry depot, UYGUN-1837
232. *C. solstitialis* L. subsp. *carneola* (Boiss.) Wagenitz, 10/07/2011, 1000-1100 m, Endemic, steppes around the forestry depot, UYGUN-1838
233. *Crupina crupinastrum* (Moris) Vis., 14/05/2011, 900-1000 m, widespread, steppe fields, UYGUN-1841
234. *Cnicus benedictus* L. var. *benedictus*, 16/06/2012, 1000-1100 m, steppe fields, UYGUN-1842
235. *Xeranthemum inapertum* (L.) Miller, 10/07/2011, 1000-1100 m, steppe fields, UYGUN-1843
236. *Echinops ritro* L., 17/07/2012, 1000-1100 m, steppe fields, UYGUN-1844
237. *E. orientalis* Trautv., 16/06/2012, 1000-1100 m, Ir-Tur. element, around the settlements, UYGUN-1844
238. *Scolymus hispanicus* L., 16/06/2012, 1000-1100 m, Medit. Element, around the forestry depot, UYGUN-1845
239. *Cichorium pumilum* Jacq., 14/05/2011, 1000-1100 m, E.Medit. Element, steppe fields, UYGUN-1846
240. *Scorzonera cana* (C.A. Meyer) Hoffman. var. *radicosa* (Boiss.) Chamberlain, 18/06/2011, 1200-1300 m, east side basin, UYGUN-1847
241. *S. papposa* DC., 04/06/2011, 1200-1300 m, Ir-Tur. Element, rocky places around the northern rift, UYGUN-1848
242. *Tragopogon pterocarpa* DC., 04/06/2011, 1300-1400 m, Ir-Tur. element, rocky places, UYGUN-1849
243. *Picris strigosa* Bieb., 16/06/2012, 1200-1300 m, Ir-Tur. element, steppe – macchie border, UYGUN-1850
244. *Rhagadiolus stellatus* L. var. *stellatus*, 14/05/2011, 1100-1200 m, steppes around downroad, UYGUN-1851
245. *Sonchus asper* (L.) Hill. subsp. *glaucescens* (Jordan) Ball., 10/07/2011, 1000-1100 m, steppe fields, UYGUN-1852
246. *Taraxacum aleppicum* Dahlst, 19/03/2011, 1000-1100 m, E. Medit Medit. Element, around the middle rift, UYGUN-1853
247. *T. sintenisii* Dahlst, 19/03/2011, 1200-1300 m, macchie field, UYGUN-1854
248. *T. crepidiforme* DC. subsp. *crepidiforme*, 16/04/2011, 1200-1300 m, Ir-Tur. element, east side basin, UYGUN-1855
249. *Chondrilla juncea* L. var. *juncea*, 23/08/2013, 1300-1400 m, rocky fields, UYGUN-1856
250. *Crepis foetida* L. subsp. *rhoadifolia* (Bieb.) Celak, 19/05/2011, 1000-1100 m, widespread, steppe fields, UYGUN-1857
251. *C. sancta* (L.) Babcock, 16/04/2011, 1100-1200 m, widespread, macchie field, UYGUN-1858
252. *C. micrantha* Cizr., 25/06/2011, 1200-1300 m, steppe field, UYGUN-1859
- 33. Campanulaceae Juss.**
253. *Campanula strigosa* Banks&Sol., 04/06/2011, 1100-1200 m, E.Medit Element, shady places near the fence, UYGUN-1860
254. *Michauxia campanuloides* L'Herit ex Aiton, 04/06/2011, 1100-1200 m, E.Medit. Element, shady places near the fence, UYGUN-1861
255. *Legousia falcata* (Ten.) Fritsch, 09/04/2011, 1000-1100 m, Medit. Element, around the forestry depot, UYGUN-1862
- 34. Primulaceae Batsch ex Borkh.**

256. *Primula vulgaris* Huds. subsp. *vulgaris*, 09/04/2011, 1300-1400 m, Euro-Sib. Element, rocky and stony places around the middle rift, UYGUN-1863
257. *Cyclamen persicum* Miller, 09/04/2011, 1400-1500 m, E.Medit Element, Steppes over the top, UYGUN-1864
258. *C. pseud-ibericum* Hildebr., 29/03/2012, 1400-1500 m, Endemic, E.Medit. Element, steppes over the top, UYGUN-1865
259. *Lysimachia atropurpurea* L., 19/05/2011, 900-1000 m, E.Medit Element, steppe fields, UYGUN-1866
260. *Anagallis foemina* Miller, 04/06/2011, 1000-1100 m, Medit. Element, steppe fields, UYGUN-1867
- 35. Styracaceae DC. & Spreng.**
261. *Styrax officinalis* L., 19/05/2011, 1100-1200 m, macchie field, UYGUN-1868
- 36. Oleaceae Hoffmanns. & Link**
262. *Jasminum fruticans* L., 19/05/2011, 1000-1100 m, Medit. Element, macchie field, UYGUN -1869
37. *Convolvulaceae* Juss.
263. *Convolvulus dorycnium* L. subsp. *oxysepalus* (Boiss.) Rech., 19/05/2011, 1100-1200 m, E.Medit. Element, macchie field, UYGUN-1871
264. *C. lineatus* L., 08/05/2011, 1000-1100 m, *Quercus* opennings, UYGUN-1872
265. *C. betonicifolius* Miller subsp. *betonicifolius*, 08/05/2011, 1000-1100 m, widespread, road sides, UYGUN-1874
266. *Calystegia sepium* (L.) R.Br., 14/05/2011, 1200-1300 m, widespread, rocky places, UYGUN-1870
- 38. Boraginaceae Juss.**
267. *Heliotropium haussknechtii* Bunge, 16/06/2012, 1100-1200 m, Endemic, E.Medit. Element ?, around the settlements, UYGUN-1871
268. *H. europaeum* L., 16/08/2013, 1000-1100 m, Medit. Element ?, steppe fields, UYGUN-1872
269. *Myosotis incrassata* Guss., 16/04/2011, 1100-1200 m, Medit. Elementi, steppe fields, UYGUN-1873
270. *M. lithospermifolia* (Willd.) Hornem, 16/04/2011, 1300-1400 m, rocky places on east side, UYGUN-1874
271. *Cynoglossum creticum* Miller, 14/05/2011, 1000-1100 m, steppe field, UYGUN-1875
272. *Buglossoides arvensis* (L.) Johnstone, 19/05/2011, 1200-1300 m, widespread, rocky places, UYGUN-1876
273. *Echium glomeratum* Poiret, 04/06/2011, 900-1000 m, E. Medit element, steppe fields, UYGUN-1877
274. *E. italicum* L., 14/05/2011, 900-1000 m, road sides, UYGUN-1877
275. *Onosma orientale* (L.) L., 16/04/2011, 1200-1300 m, Ir.-Tur Element, on the rocks around middle rift, UYGUN-1878
276. *O. albo-roseum* Fish.&Mey. subsp. *albo-roseum* var. *albo-roseum*, 16/04/2011, 1300-1400 m, Ir.-Tur. element, rocy places, UYGUN-1879
277. *O. rascheyanum* Boiss., 14/05/2011, 1400-1500 m, Ir.-Tur. Element, rocky places, UYGUN-2017
278. *O. giganteum* Lam., 14/05/2011, 1100-1200 m, E.Medit Element, above settlements, UYGUN-1880
279. *Symphytum brachycalyx* Boiss., 16/06/2012, 1400-1500 m, E. Medit. Element, steppes around the top, UYGUN-1881
280. *Anchusa officinalis* L. Grup A, 16/04/2011, 1000-1100 m, steppe fields, UYGUN-1882
281. *A. azurea* Miller var. *azurea*, 14/05/2011, 1000-1100 m, steppe fields, UYGUN-1883
282. *A. strigosa* Labill., 14/05/2011, 900-1000 m, steppe fields, UYGUN-1884
283. *Nonea pulla* (L.) DC. subsp. *scabrisquamata* A.Baytop, 16/06/2012, 1100-1200 m, Ir.-Tur. Element, macchie field, UYGUN-1885
284. *Alkanna tinctoria* (L.) Tausch. subsp. *anatolica* Hub.Mor., 14/05/2011, 1000-1100 m, steppes around the forestry depot, UYGUN-1886
- 39. Scrophulariaceae Juss.**
285. *Verbascum orientale* (L.) All., 21/04/2012, 1200-1300 m, E.Medit. Element, widespread, east side basin steppes, UYGUN-1887
286. *V. subnivale* Boiss.&Hauskn., 29/08/2013, 1400-1500 m, Endemic, Ir.-Tur. Element, steppes over the top, UYGUN-1888
287. *V. oreophilum* C.Koch. var. *joannis* (Bordz.) Hub.-Mor., 10/07/2011, 1100-1200 m, Ir.-Tur. Element, steppe fields, UYGUN-1889

288. *V. germanicae* Hausskn., 04/06/2011, 1300-1400 m, Endemic, E. Medit. Element, steppes over the northern top, UYGUN-1890
289. *V. macrosepalum* Boiss.&Kotschy ex Murb., 23/08/2013, 1200-1300 m, Endemic, Ir.-Tur. Element, steppes around the southern rift, UYGUN-1891
290. *Scrophularia libanotica* Boiss. subsp. *libanotica* var. *libanotica*, 08/05/2011, E.Medit. Element, rocky places around middle rift, UYGUN-1892
291. *S. xanthoglossa* Bieb., 14/05/2011, 1200-1300 m, Ir.-Tur. Element, East side basin, rocky places, UYGUN-2015
292. *Veronica arvensis* L., 09/04/2011, 1100-1200 m, macchie fields, UYGUN-1893
293. *V. pusilla* Kotschy var. *pusilla*, 14/05/2011, 900-1000 m, Ir.-Tur. Element, steppe fields, UYGUN-1894
294. *V. anagalloides* Gus., 14/05/2011, 900-1000 m, steppe fields, UYGUN-1895
295. *V. intercedens* Bornm., 21/05/2012, 1200-1300 m, east side basin steppes, UYGUN-1896
40. *Orobanchaceae* Vent.
296. *Orobanche nana* Noe ex G.Beck, 09/04/2011, 1300-1400 m, rocky places, UYGUN-1897
297. *O. mutellii* F. Schultz, 09/04/2011, 1200-1300 m, macchie fields, UYGUN-1898
298. *O. purpurea* Jacq., 10/07/2011, 1100-1200 m, steppe fields, UYGUN-1899
299. *O. oxyloba* (Reuter) G.Back, 14/05/2011, 900-1000 m, steppe fields, UYGUN-1900
41. *Lamiaceae* Martinov
300. *Ajuga orientalis* L., 09/04/2011, 900-1000 m, steppe fields, UYGUN-1901
301. *A. chamaepitys* (L.) Schreber subsp. *laevigata* (Banks&Sol) P.H.Davis, 08/05/2011, 1300-1400 m, Ir.-Tur. Element, around the fountain, UYGUN-1902
302. *Teucrium chamedrys* L. subsp. *tauricum* Rech., 19/07/2012, 1100-1200 m, Endemic, E. Medit. Element, shady places near the fence, UYGUN-1903
303. *T. polium* L., 07/07/2012, 1300-1400 m, Widespread, rocky places, UYGUN-1904
304. *T. divaricatum* Sieber subsp. *divaricatum*, 25/06/2011, 1300-1400 m, macchie fields, UYGUN-1917
305. *Scutellaria orientalis* L. subsp. *santolinoides* (Hausskn. ex Bornm.) Edmondson, 04/06/2011, 900-1000 m, Endemic, steppes by the water, UYGUN-1905
306. *S. salviifolia* Benth, 25/06/2011, 1100-1200 m, Endemic, macchie fields, UYGUN-1906
307. *Phlomis longifolia* Boiss.& Bl., subsp. *longifolia*, 25/06/2011, 1100-1200 m, macchie fields, UYGUN-1908
308. *P. viscosa* Poiret, 18/06/2011, 900-1000 m, E.Medit. Element, road sides, UYGUN-1907
309. *Lamium garganicum* L. subsp. *rectum* (Schenk) R.Mill, 08/05/2011, 1200-1300 m, around the church ruin, UYGUN-1909
310. *L. amplexicaule* L., 29/03/2012, 1000-1100 m, Euro-Sib. element, steppe fields, UYGUN-1910
311. *L. truncatum* Boiss., 16/04/2011, 1200-1300 m, E.Medit. Element, steppes around church ruin, UYGUN-1911
312. *Stachys longispicata* Boiss.&Kotschy, 25/06/2011, 1100-1200 m, Ir.-Tur. Element, macchie field, UYGUN-1912
313. *S. cretica* L. subsp. *anatolica* Rech., 14/05/2011, 1400-1500 m, Endemic, Ir.-Tur. Element, rocky places, UYGUN-1913
314. *S. burgsdoffiorides* (Benth) Boiss. subsp. *burgsdoffiorides*, 25/06/2011, 1100-1200 m, Ir.-Tur. Element, macchie field, UYGUN-1914
315. *St. marashica* A.İLÇİM, M.ÇENET & DADANDI, 04/06/2011, 1200-1300 m, Endemic, rocky places, UYGUN-1915
316. *Melissa officinalis* L. subsp. *inodora* (Bornm.) Bornm., 25/06/2011, 1000-1100 m, E. Medit. Element, shady places, UYGUN-2031
317. *Nepeta cilicica* Boiss., 04/06/2011, 1300-1400 m, Medit. Element, rocky places, UYGUN-1916
318. *Prunella vulgaris* L., 19/05/2011, 1100-1200 m, Euro-Sib. Element, widespread, road sides, UYGUN-1918
319. *Marrubium astracanicum* Jacq. subsp. *astracanicum*, 25/06/2011, 1200-1300 m, rocky places around the southern rift, UYGUN-1922
320. *Micromeria myrtifolia* Boiss.&Hohen, 10/07/2011, 1000-1100 m, E. Medit. Element, shady places, UYGUN-1919

321. *Mentha aquatica* L., 23/08/2013, 900-1000 m, by the water, UYGUN-1920
322. *M. longifolia* (L.) Hudson subsp. *typhoides* (Briq.) Harley var. *typhoides*, 10/07/2011, 1000-1100 m, widespread, by the water, UYGUN-1921
323. *Ziziphora capitata* L., 07/07/2012, 1000-1100 m, Ir.-Tur. element, macchie field, UYGUN-1923
324. *Salvia recognita* Fisch.&Mey., 25/06/2011, 1100-1200 m, Endemic, Ir.-Tur. Element, macchie field, UYGUN-1924
325. *S. multicaulis* Vahl., 14/05/2011, 1100-1200 m, Ir.-Tur. Element, macchie field, UYGUN-1925
326. *S. virgata* Jacq., 10/07/2011, 1300-1400 m, Ir.-Tur. Element, steppe field, UYGUN-1926
327. *S. tomentosa* Miller, 04/06/2011, 1200-1300 m, Medit. Element, macchie field, UYGUN- 1927
328. *S. sclerae* L., 25/06/2011, 1300-1400 m, near fountain, UYGUN-1928
- 42. Plumbaginaceae Juss.**
329. *Acantholimon kotschyi* (Jaub.&Spach) Boiss. subsp. *kotschyi*, 10/07/2011, 1400-1500 m, Endemic, Ir.-Tur. Element, UYGUN-1929
- 44. Plantaginaceae Juss.**
330. *Plantago major* L. subsp. *intermedia* (Gilib) Lange, 19/04/2012, 1000-1100 m, road sides, UYGUN-1930
331. *P. lanceolata* L., 19/04/2012, 900-1000 m, stream side, UYGUN-1931
- 44. Lauraceae Juss.**
332. *Laurus nobilis* L., 25/06/2011, 1100 m, Medit. element, macchie field, UYGUN-2003
- 45. Euphorbiaceae Juss.**
333. *Euphorbia petiolata* Banks.&Sol., 04/06/2011, 1100-1200 m, Ir.-Tur. element, around the fence, UYGUN-1932
334. *E. macrostegia* Boiss., 16/04/2011, 1200-1300 m, steppes around down road, UYGUN-1933
335. *E. falcata* L. subsp. *falcata* var. *falcata*, 16/04/2011, 1200-1300 m, widespread, macchie field on South, UYGUN-1934
336. *E. apios* L., 16/04/2011, 1200-1300 m, E.Medit. elementi, east side basin steppes, UYGUN-1935
337. *E. szovitsii* Fisch.&Mey., 21/04/2012, 1300-1400 m, Ir.-Tur. Element, South summit steppes, UYGUN-1936
- 46. Urticaceae Juss.**
338. *Urtica dioica* L., 25/06/2011, 1100-1200 m, Euro.-Sib. Element, inside the cave on South down road, UYGUN-1948
- 47. Ulmaceae Mirb.**
339. *Celtis australis* L., 16/04/2011, 1100-1200 m, Medit. Element, macchie field, UYGUN-2002
- 48. Platanaceae T.Lestib.**
340. *Platanus orientalis* L., 09/04/2011, 1000-1100 m, Widespread, UYGUN-1937
- 49. Fagaceae Dumort.**
341. *Quercus cerris* L. var. *cerris*, 16/08/2013, 1000-1100 m, macchie field, UYGUN-1938
342. *Q. coccifera* L., 16/08/2013, 1000-1100 m, Medit. Element, macchie field, UYGUN-1939
- 50. Salicaceae Mirb.**
343. *Salix caprea* L., 14/05/2011, 1000-1100 m, Euro-Sib. Element, macchie field, UYGUN-1940
344. *Populus alba* L., 14/05/2011, 1000-1100 m, Euro-Sib. Element, around the settlement, UYGUN-1941
- 51. Rubiaceae Juss.**
345. *Galium scabrifolium* (Boiss.) Hausskn., 10/07/2011, 1400-1500 m, Endemic, E. Medit Element, over the top, UYGUN-1942
346. *G. verum* L. subsp. *glabrescens* Ehrend, 04/06/2011, 1300-1400 m, Ir.-Tur. Element, rocky places, UYGUN-1943
347. *G. humifusum* Bieb., 04/06/2011, 1200-1300 m, near the church ruin, UYGUN-1944
348. *Cruciata mixta* Ehrend.&Schönd, 16/04/2011, 1000-1100 m, Endemic, Medit. Element, steppe fields, UYGUN-1945
349. *C. taurica* (Pallas ex Willd.) Ehrend., 14/05/2011, 1000-1100 m, steppe fields, UYGUN-1946
- 52. Araceae Juss.**
350. *Arum dioscoridis* Sm. var. *syriacum* (Blume) Engler, 09/04/2011, 1300-1400 m, E. Medit. Element, steppe fields, UYGUN-1947

**53. Liliaceae Juss. Juss. Juss.**

351. *Asphodelus aestivus* L., 24/04/2011, 1000-1100 m, Medit. Element, around the settlement, UYGUN-1949
352. *Allium tchihatschewii* Boiss., 25/06/2011, 1200-1300 m, Endemic, Ir.-Tur. Element, macchie field, UYGUN-1954
353. *A. paniculatum* L. subsp. *paniculatum*, 18/06/2011, 1300-1400 m, Medit. Element, flats on southern top, UYGUN-1950
354. *A. pallens* L. subsp. *pallens*, 10/07/2011, 1200-1300 m, Medit. Element, macchie field, UYGUN-1955
355. *A. tauricola* Boiss., 23/08/2013, 1300-1400 m, Endemic, Ir.-Tur. Element, rocky places, UYGUN-1951
356. *A. scorodoprasum* L. subsp. *rotundum* (L.) Stearn, 18/06/2011, 1200-1300 m, Medit. Element, Widespread, rocky places, UYGUN-1952
357. *A. vineale* L., 10/07/2011, 1200-1300 m, macchie field, UYGUN-1953
358. *A. macrochaetum* Boiss&Hausskn. subsp. *macrochaetum*, 10/07/2011, 1000-1100 m, rocky places, UYGUN-1956
359. *Scilla bifolia* L., 21/04/2012, 1300-1400 m, Medit. Element, rocky places around middle rift, UYGUN-1957
360. *Ornithogalum narbonense* L., 18/06/2011, 1200-1300 m, Medit. Element, macchie field, UYGUN-1958
361. *O. montanum* 16/04/2011, 1300-1400 m, E. Medit. Element, rocky places on east side, UYGUN-1959
362. *O. ulophyllum* Hand.-Mazz., 25/06/2011, 1100-1200 m, macchie field, UYGUN-1960
363. *O. umbellatum* L., 21/04/2012, 1000-1100 m, steppe fields, UYGUN-1961
364. *O. alpigenum* Staph., 08/05/2011, 1200-1300 m, Endemic, E. Medit. element, East side basin steppes, UYGUN-1962
365. *Muscari armeniacum* Leichtline ex Baker, 19/05/2011, 1200-1300 m, Widespread, rocky places, UYGUN-1963
366. *M. neglectum* Guss., 29/03/2011, Sarımsak-4, Widespread, UYGUN-1964
367. *Hyacinthus orientalis* L. subsp. *orientalis*, 19/03/2011, 1300-1400 m, Endemic, Ir.-Tur. Element, rocky places, UYGUN-1965
368. *Fritillaria alfreda* Post. subsp. *glaucoviridis*, 16/04/2011, 1300-1400 m, Endemic, E. Medit. Element, base of the dried stream, UYGUN-1974
369. *Tulipa armena* L. var. *lycica* (Baker) Marais, 09/04/2011, 900-1000 m, Endemic, steppe fields, UYGUN-1966
370. *Gagea fibrosa* (Desf.) Schultes&Schultes, 19/03/2011, 1200-1300 m, macchie field, UYGUN-1967
371. *Colchicum szowitsii* Fisch.&Mey, 29/03/2011, 1300-1400 m, Medit. element, East side basin, UYGUN-1968

**54. Амариллисовые J.St.-Hil.**

372. *Galanthus elwesii* Hooker, 29/04/2012, 1000-1100 m, E. Medit. Element, on the shades of rocky places around the forestry depot, UYGUN-1969

**55. Iridaceae Juss.**

373. *Iris persica* L., 19/03/2011, 1000-1100 m, Ir.-Tur. Element, steppe fields, UYGUN-1970
374. *I. unguicularis* Poir., 21/04/2013, 1000-1100 m, Ir.-Tur. Element, around the settlement, UYGUN-2016
375. *Crocus biflorus* Miller subsp. *pseudonubigena* Mathews, 29/03/2011, 1300-1400 m, Endemic, Ir.-Tur. Element, rocky places near southern rift, UYGUN-1971
376. *C. ancyrus* (Herbert) Maw., 29/04/2012, 1300-1400 m, Endemic, Ir.-Tur. Element, near the top, UYGUN-1972
377. *Gladiolus italicus* Miller, 10/07/2011, 1400-1500 m, near the top, UYGUN-1973

**56. Typhaceae Juss.**

378. *Typha latifolia* L., 16/06/2012, 1000-1100 m, stream side, UYGUN-1975

**57. Cyperaceae Juss.**

379. *Cyperus longus* L., 14/05/2011, 900-1000 m, Widespread, stream side, UYGUN-1976
380. *C. fuscus* L., 10/07/2011, 900-1000 m, Euro.-Sib. Element, stream side, UYGUN-1977
381. *Carex divulsa* Stokes subsp. *divulsa*, 18/06/2011, 1400-1500 m, Euro.-Sib. Element, flats on the top, UYGUN-1978

382. *C. melanostachya* Bieb. ex Willd., 10/07/2011, 1200-1300 m, sides of dried stream, UYGUN-1979  
383. *C. elata* All. subsp. *omskiana* (Meinsh.) Jalas, 16/06/2012, 1400-1500 m, Euro.-Sib. Element, flats on the top, UYGUN-1980

**58. Poaceae Barnhart Barnhart Barnhart**

384. *Agropyron cristatum* (L.) Gaertner subsp. *pectinatum* (Bieb.) Tzvelev var. *pectinatum*, 21/05/2012, 1100-1200 m, steppe field, UYGUN-1981  
385. *Crithopsis delileana* (Schultes) Rosev, 08/05/2011, 1200-1300 m, Ir.-Tur. Element, macchie field, UYGUN-1982  
386. *Aegilops columnaris* Zhukovksi, 04/06/2011, 1100-1200 m, Ir.-Tur. Element, road sides, UYGUN-1983  
387. *Bromus madritensis* L., 04/06/2011, 1100-1200 m, macchie field border, UYGUN-1984  
388. *B. alopecuroides* subsp. *alopecuroides*, 08/05/2011, 1200-1300 m, Medit. Element, steppes over the church ruin, UYGUN-1985  
389. *B. danthoniae* Trin., 16/06/2012, 1300-1400 m, rocky slopes on east side, UYGUN-1986  
390. *Avena barbata* Pott. ex Link. subsp. *barbata*, 23/05/2012, 1100-1200 m, Medit. Element, Widespread, macchie field, UYGUN-1987  
391. *A. sterilis* L. subsp. *ludoviciana* (Durieu) Gillet, 08/05/2011, 1100-1200 m, around the cave on down road, UYGUN-1988  
392. *Polypogon viridis* (Gouan) Breistr., 14/05/2011, 1200-1300 m, Euro.-Sib. Element, Widespread, steppe field, UYGUN-1989  
393. *Alopecurus myosuroides* Hudson var. *myosuroides*, 09/04/2011, 1100-1200 m, Euro.-Sib. Element, Widespread, steppe field, UYGUN-1990  
394. *Phleum montanum* C. Koch subsp. *montanum*, 16/06/2012, 1300-1400 m, steppe field, UYGUN-1991  
395. *Lolium temulentum* L. var. *temulentum*, 19/05/2011, 1300-1400 m, around the mountain spring, UYGUN-1992  
396. *Vulpia myuros* (L.) C.C.Gmelin, 19/05/2011, 1100-1200 m, Widespread, macchie field, UYGUN-1993  
397. *Poa annua* L., 14/05/2011, 1200-1300 m, Cosmopolit, steppe field, UYGUN-1994  
398. *P. pratensis* L., 09/06/2012, 1000-1100 m, Widespread, road sides, UYGUN-1995  
399. *P. sterilis* Bieb., 16/08/2013, 1000-1100 m, steppe field, UYGUN-1996  
400. *P. bulbosa* L., 14/05/2011, 1100-1200 m, macchie field, UYGUN-1997  
401. *Briza humilis* Bieb., 20/05/2012, 1100-1200 m, Widespread, road sides, UYGUN-1998  
402. *Echinaria capitata* (L.) Desf., 06/05/2012, 1100-1200 m, Widespread, UYGUN-1999

## MYRIOSTOMA COLIFORME (PERS.) CORDA - A NEW SPECIES FOR THE MYCOBIOTA OF AZERBAIJAN

Hamida Seyidova<sup>1</sup>, Anvar Ibrahimov<sup>1,2\*</sup>

<sup>1</sup>Ministry of Science and Education of the Republic of Azerbaijan. Nakhchivan State University, Nakhchivan city, University Campus, AZ7012, Nakhchivan, Azerbaijan

<sup>2</sup>Ministry of Science and Education of the Republic of Azerbaijan. Institute of Bioresources (Nakhchivan), M.F.Akhundov st. 32, AZ 7000, Nakhchivan, Azerbaijan

\*Correspondence: enver\_ibrahimov@mail.ru

DOI: <https://doi.org/10.30546/abc.2024.3.2.331>

Article info: pp. 64-67

Received: 22.05.2024; Received in revised form 14.06.2024; Accepted 10.07.2024

**ABSTRACT.** *Through long-term research in the Nakhchivan Autonomous Republic and literary sources, we studied the species composition of the gasteromycetes group and determined their distribution zones. We found that 21 species from 14 genera of the gasteromycetes group are present in the region. Among these, 6 species are newly recognized as part of Azerbaijan's mycobiota and 15 species are specific to the Nakhchivan Autonomous Republic. As a result of research conducted in 2022, a new monotypic genus and species were identified for the mycobiota of Azerbaijan – Myriostoma coliforme (Pers.) Corda. The article provides information on the range, ecological and trophic characteristics and the description of Myriostoma coliforme (Pers.) Corda.*

**Key words:** *gasteromycetes, Myriostoma coliforme (Pers.) Corda, new monotypic genus and species, basidiospores, monotypic, humus saprotrophs.*

### INTRODUCTION

The relief, geological structure, climate and soil cover of the Nakhchivan Autonomous Republic have created favorable conditions for the development of mycobiota, including gasteromycetes, as well as rich plant species diversity in this region. Gasteroid fungi belong to the group of polyphyletic fungi and have characteristic features as morphological features, as well as the development, maturation and reproduction of spores.

A common feature that unites all Gasteromycetes is that they have an angiocarp-type fruiting body, in which the basidiospores in such fruiting bodies remain covered until the fruiting body is fully mature, and mature basidiospores can be released only after the fruiting body bursts. Fungi of the Gasteromycete group are predominantly soil saprotrophs, but some form mycorrhiza on the roots of various trees. Most of them are cosmopolitan. In relation to

the substrate, they are divided into 4 groups - lignophiles, soil saprotrophic gasteromycetes, underground gasteromycetes and open soil gasteromycetes.

There are about 1000 known species of gasteromycetes in the world, which are united into 11 orders [Sadygov, 2007]. Among them are Lycoperdales - about 200, Sclerodermatales - 100, and Phallales - 50 species [Rebriev, 2005]. Also known are 400 species of fungi with the development of angiocarp and hemiangiocarp in the order *Boletales*, *Russulales*, *Cortinariales* and *Agaricales* [Bougher, Castanella, 1993]. According to literary data, 250 genera and up to 40 species have been found in the CIS and Europe [Sosin, 1973], in Azerbaijan - 13 genera and up to 40 species [Sadygov, 2010]. Based on the studies conducted in the territory of the Nakhchivan Autonomous Republic [Sadygov, 2007; 2008], the distribution of 21 species of gasteromycetes was established, of which one species

was identified by Akhundov T.M. [1979], and 20 species by Seidova H.S. [2010; 2017; 2012].

Despite extensive research conducted in the Nakhchivan Autonomous Republic, the taxonomic composition of the Gasteromycetes group has not been fully studied, despite the discovery of new species and their distribution zones. The studies have shown that the diversity of climatic conditions and soil cover provides opportunities for the discovery of new genera and species of gasteromycetes. As a result of these studies, a new monotypic genus and species, *Myriostoma coliforme* (Pers.) Corda, was discovered as part of the Azerbaijani mycobiota belonging to the gasteromycetes group.

### MATERIALS AND METHODS

The samples were collected in 2022 in the village of Bichenak, Shahbuz district. Morphological and ecological characteristics of the fungus specimens were recorded and photographed in their natural habitat. Spores were examined and photographed using Ideal and Smart 3 mode T2/L microscopes, and Soptop Instruments.

The species was identified based on literature data [Gorlenko et al., 1980; Yusaf et al., 2013; Amalia et al., 2020].

The species name has been confirmed based on the information from the Index Fungorum website ([www.indexfungorum.org](http://www.indexfungorum.org)). Specimens of the species *Myriostoma coliforme* (Pers.) Corda are kept in the mycological herbarium of the Institute of Botany of the Ministry of Science and Education of the Republic of Azerbaijan.

### RESULTS

The genus *Myriostoma* Decv. is a monotypic genus belonging to the family *Geastraceae* Corda. One species of the genus is distributed worldwide. The genus name was first given in 1809 by the French botanist Devaux in the Parisian journal "Journal de Botanique". The species included in the genus was first described in 1776 as *Lycoperdon coliforme* Dicks. given as Then the binomial name of the species was first introduced into science in 1842 by Corda as *Myriostoma coliforme* (Pers.) Corda. The genus name *Myriostoma* comes from the Greek word

(*mycros*) - countless and (*stoma*) - mouth. The species name *coliforme* comes from the Latin word *colis* - stem, stick, form.

The fruiting body of the species included in the genus *Myriostoma* Decv. is spherical, closed, and has a diameter of 10 cm.

The exoperidis is thick, and scaly, and later quickly breaks and disintegrates into pointed feathers. These feathers are usually curved downwards. The endoperid, surrounding the gleban, opens with numerous round openings. There is one species of the genus – *Myriostoma coliforme* (Pers.) Corda [Gorlenko et al., 1980]. Since this species is shown for the first time in the mycobiota of Azerbaijan, we provide its description below.

*Myriostoma coliforme* is a fungus of the family Geastraceae, the basidiocarps of which resemble starfish, but the spore sac is supported by multiple columns. In the UK, the recommended English name is "Pepper Pot". The young fruiting body is aboveground, rarely first developing underground and then emerging on the soil surface. The endoperidia are greyish or brown, silvery-shiny, opening at the top with 5-50 small round holes. Gleba brown. It differs from the outwardly similar fungi of the genera *Geastrum* and *Astraeus* by the presence of several holes in the endoperidium.

### Macroscopic and microscopic features:

The fruiting body before opening has a diameter of 1-5 cm, after opening - 3.5-10 cm in diameter. The exoperidium is divided into 4-12 wings. Most often they bend downwards. It has a gleba surrounded by endoperidia. At this time, the endoperidia together with the gleba are located on legs, collected in 5-30 cylindrical or angular bundles. Before opening, the exoperidia are attached to the substrate by a brown smooth or slightly scaly rhizomorphic bundle. No false legs. The exoperidium is thick, and consists of three layers - mycelial, fibrous and pseudoparenchymatous layer, in mature mushrooms it is divided into pointed branches, often bent downwards, which gives the fruiting body a star-shaped form. The mycelium layer is light brown or yellowish, not covered with substrate residues, usually longitudinally cracked

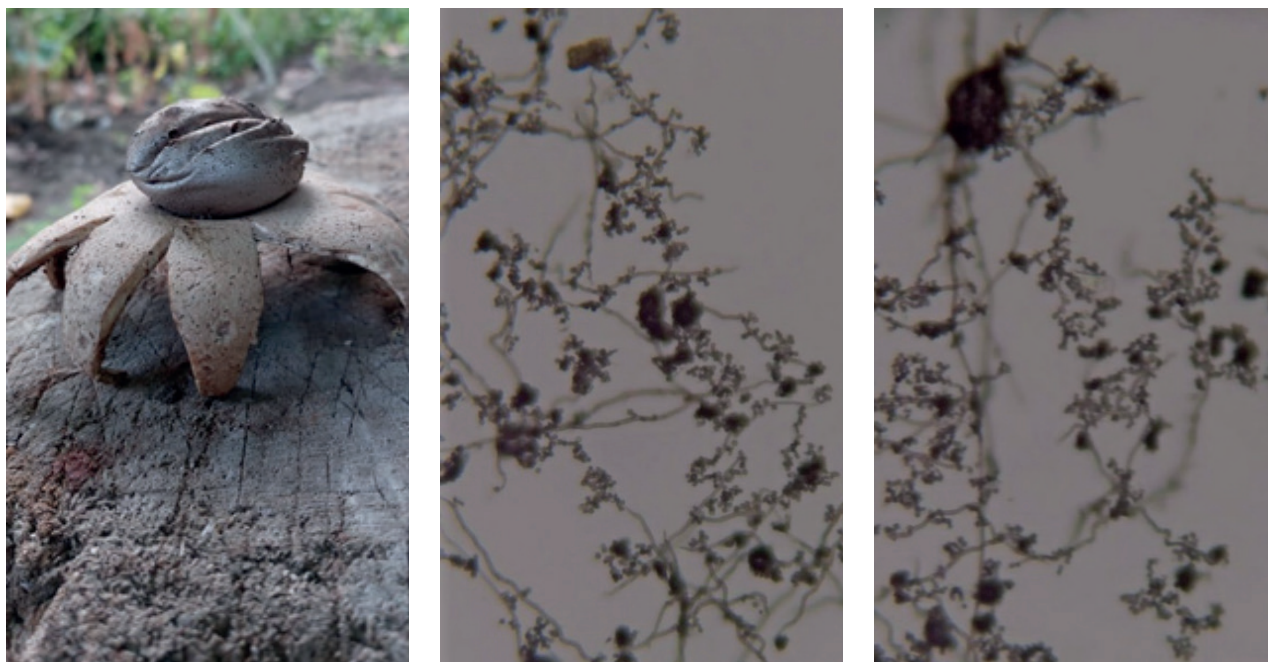


**Figure 1.** *Myriostoma coliforme* (Pers.) Corda: Fruit bodies, Spores.

and scaly, and is even partially preserved in overwintering specimens. The fibrous layer is leathery, from whitish to yellowish-brown, sometimes with longitudinal cracks. In young mushrooms, the pseudo parenchymatous layer is 5-6 mm thick, whitish or yellowish, then dry, brittle, brown, and dark (Fig. 1).

Spores are spherical, 2-3  $\mu\text{m}$  in diameter, brown, reddish-brown. The fungus is distributed mainly in humus soils and oak groves.

Not poisonous. There is no information on whether it is edible. It mainly appears in summer and autumn.

Areal: Humus is a saprotroph, that grows singly or in small groups, on sandy soils, in mixed forests, in cultivated fields, and sometimes among grasses.

Distribution: Collected from the soil in the village of Bichenak, Shahbuz district, on 03.XI.2022.

According to the literature, this species is widespread in the temperate and subtropical zones of the Northern Hemisphere. Currently, it is found in Northern and Southern Europe, including Southern England, Afghanistan, Iran, Pakistan, India, South Africa, Brazil, Hawaii and Australia, the European part of Russia, the

North Caucasus [<https://www.wikidata.ru-ru.nina.az/Myriostoma.html>].

### CONCLUSION

The research revealed that there are 21 species from 14 genera of the gastromycete group that are common in the mycobiota of the Nakhchivan Autonomous Republic. Among these, 6 species are new to the mycobiota of Azerbaijan, and 15 species are new to the Nakhchivan Autonomous Republic. *M. coliforme* is a rare species, currently found only in the territory of the Nakhchivan Autonomous Republic. It is mainly located in the Zangezur National Park named after Hasan Aliyev, and its conservation requires special attention. *Myriostoma coliforme* is listed in the Red Book of 12 European countries as a rare species. This is one of 33 species proposed for protection under the Bern Convention by the European Fungal Protection Council in 2004 [Dahlberg, Croneborg, 2006; [https://en.wikipedia.org/wiki/Myriostoma\\_coliforme](https://en.wikipedia.org/wiki/Myriostoma_coliforme)]. Considering that *Myriostoma coliforme* is a rare species, in the future, it may be considered appropriate to include it in the new edition of the Red Book of the Republic of Azerbaijan.

## REFERENCES

- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. *Caspian Journal of Applied Science and Research*, 4(3), 74–83.
- Akhundov T.M. (1979). *Mikoflora Nakhchivanskoj ASSR*. Baku: Элм. 166 p.
- Amalia Ferretti, Irja Saar, Arnold Knijn. (2020). On two endangered species (*Myriostoma coliforme* and *Battarrea* sp.) sharing the same microhabitat. *Italian Journal of Mycology*, 49:1-7. <https://doi.org/10.6092/issn.2531-7342/10039>
- Bougher N.L., Castanella M.A. (1993). Delimitation of *Hymenogaster* sensu stricto and four new segregate genera. *Mycologia*, Vol. 85, № 2, p. 272-293.
- Dahlberg A., Croneborg H. (2006). *The 33 Threatened Fungi in Europe (Nature and Environment)*. Strasbourg, France: Council of Europe. 88 p. ISBN 978-9-28715-928-1.
- Gorlenko M.V., Bondartseva M.A., Garibova L.V., Sidorova I.I., Sizova T.P. (1980). *Griby SSSR*. Moskva: Nauka. 303 p.
- Gurbanov, E. M. (1996). *Plant world of Nakhichevanchay river basin*. Baku: Baku State University.
- Gurbanov, E., & Huseynova, H. (2020). New spreading areas of some species in the botanical-geographical Baku regions of the middle part of the Caspian coast. *Acta Botanica Caucasica*, 1(1), 4–8.
- Gurbanov, E., & Jabbarov, M. (2017). *Geobotany*. Baku: Baku State University.
- Gurbanov, E., Huseynova, H. Z., Ibrahimov Sh.İ. (2020). Methods for determining soil contamination by oil and petroleum products and indicator plants in the north of Caspian Sea. *International Journal of agriculture and biological sciences*. Vol.4, № July & Aug., p.84-89. [Ijoabs](https://doi.org/10.15421/012222)
- Huseynova, H. Z. (2022). Vegetation of the southern part of the Caspian Coast and its nutritional value. *Biosystems Diversity*, v. 30, n. 3, p. 205-212, 2022. <https://doi.org/10.15421/012222>
- Sadigov A.S. (2007). *Edible and poisonous mushrooms of Azerbaijan*. Baku: Elm. 124 p.
- Sadigov A.S., Seyidova H.S. (2007). *Battarea phalloides* Pers. the new species for the mycobiota of Nakhchivan Autonomous Republic. *News of Nakhchivan Section of Azerbaijan National Academy of Sciences. The Series of Natural and Technical Sciences*, № 4, p. 60-77.
- Sadigov A.S., Seyidova H.S. (2008). New mushrooms for the Nakhchivan Autonomous Republic. *Transaction of the Institute of Microbiology of Azerbaijan National Academy of Sciences*, Vol. 5, p. 225-227.
- Sadigov A.S., Seyidova H.S. (2010). A new monotypic genera for mycobiota of Azerbaijan from Shahbuz district. *Transaction of the Institute of Microbiology of Azerbaijan National Academy of Sciences*, Vol. 8, p. 67-70.
- Seyidova H.S. (2010). Spreading *Gastromycetes* in Nakhchivan Autonomous Republic. *News of Nakhchivan Section of Azerbaijan National Academy of Sciences. The Series of Natural and Technical Sciences*, № 4, p. 146-149.
- Seyidova H.S., Huseyin E. (2012). *Macrofungi of Nakhchivan (Azerbaijan) Autonomous Republic*. *Turkish Journal of Botany*, Vol. 36, № 6, p. 761-768. <https://doi.org/10.3906/bot-1101-43>
- Seyidova H.S. (2017). *Distribution mushrooms in Shahbuz of Nakhchivan Autonomous Republic*. Baku: Leman Publishing House Polygraphy LLC. 168 p.
- Rebriev Y.A. (2005). The *Gasteromycetes*. Modern views on the boundaries of the group and its position in the system of *Basidiomycetes*. *Mycology and Phytopathology*, Vol. 39, No. 1, p. 3-10.
- Sosin P.E. (1973). *Opredelitel Gasteromitsetov SSSR*. Leningrad-Moskva: Nauka. 164 p.
- Yousaf N., Niazi A.R., Khalid A.N. (2013). *Myriostoma coliforme*, first record of a rare and endangered gasteroid basidiomycetes from Pakistan. *International Journal of Microbiology and Mycology*, Vol. 1, No. 2, p. 1-6.
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>
- [www.indexfungorum.org](http://www.indexfungorum.org)
- Wikipedia: *Myriostoma coliforme*. [https://en.wikipedia.org/wiki/Myriostoma\\_coliforme](https://en.wikipedia.org/wiki/Myriostoma_coliforme)
- Wikidata: *Myriostoma coliforme*. <https://www.wikidata.ru-ru.nina.az/Myriostoma.html>

## STUDY OF GENOMES OF FRUIT PLANTS CULTIVATED IN SOME REGIONS OF AZERBAIJAN

<sup>1</sup>Nazakat Huseynova, <sup>2</sup>Basti Asadova

<sup>1</sup>Ministry of Science and Education of the Republic of Azerbaijan. Baku State University, Academic Zahid Khalilov str., 23, Baku, Azerbaijan

<sup>2</sup>Ministry of Science and Education of the Republic of Azerbaijan. Azerbaijan State Pedagogical University, Uzeir Hajibaili, 68, Baki, Sabail, Baku, Azerbaijan

<sup>1</sup>Correspondence: etibiolog-bdu@rambler.ru

DOI: <https://doi.org/10.30546/abc.2024.3.2.340>

Article info: pp. 68-72

Received: 13.03.2024; Received in revised form 23.05.2024; Accepted 10.07.2024

**ABSTRACT.** *The article deals with the cultivation of some cultural varieties of Apple and pear trees growing in the orchards of the northern regions of Azerbaijan. The research was carried out in close cooperation with the staff of the Guba Research Institute of fruit growing and tea growing in the Guba-Khachmaz region of the Republic in 2019-2021. The article notes that with the correct Organization of an intensive garden, its economic efficiency can be many times higher than with traditional technologies that are not highly efficient in modern conditions. The main purpose of the study was to study the genetic characteristics of a number of Apple and pear varieties and other fruits introduced earlier and recently in these areas, to study their genome in a comparative way. Here we have studied the latest achievements in genomic research and its practical applications in fruit trees belonging to the Rosaceae family, especially pears, apples, peaches.*

**Keywords:** *fruit crops, introduction, wild, genome, biotechnology, genome sequencing*

### INTRODUCTION

The most economically important members of the Rosaceae family are the apple (*Malus × domestica* Borkh.) and pear (*Pyrus* spp.). The annual global production of apples exceeds 80 million tons (FAOSTAT 2013), making them the third most important fruit (after citrus fruits and bananas). The pear is the Rosaceae family's second most important fruit, and its global production is approximately 25.2 million tons (FAOSTAT, 2013). For edible fruits, four important pear (*Pyrus*) varieties are grown commercially: Japanese pear (*P. pyrifolia* Nakai), European pear (*P. communis* L.), Chinese pear (*P. the bretschneideri* Rehd. and *P. Ussuriensis* Maxim.). *Eriobotrya japonica* (Thunb.) Lindl.) is also an important fruit plant belonging to the Pyreae tribe, along with pears and apples. Some species of *Prunus* ("stone fruit") are also important

fruit trees and include peaches and nectarines (*P. persica* (L.) Batsch), plum (*P. domestica* L., *P. salicina* Lindl.), apricot (*P. armeniaca* L., *P. mume* Siebold et Zucc.), and cherry (*P. avium* L., *P. cerasus* L.). Belongs to the subfamily Amygdaloideae of the amygdaleae tribe. Annual World fruit production (in million tons) is as follows: peach and nectarine, 21.6; plum, 11.5; apricot 4.1; and cherry 2.3 (FAOSTAT 2013). Gardening in the northern regions of Azerbaijan has an ancient history, so up to 50% of fruit production in the country falls on this region. Ensuring the development of Regional gardening on an innovative basis, including meeting the growing demand for environmentally friendly products, achieving the production of high-quality products suitable for entering the world market, is considered one of the urgent problems of our time [Asadov, et.al., 2001], [Beyakhmadov,

2017]. The following issues were laid on the basis of the study: analysis of the current state of the studied groups of fruit crops; application of technology for the production of progressive seedlings; obtaining traditional and new varieties of Apple and pear varieties, comparative analysis of their genomes.

The second and more accurate method of assessing Genetic Resources is the active screening path. In this case, apart from the main complex of agrobiological signs of the studied samples, their molecular level identification is carried out, the genetic composition of varieties and hybrid populations is studied, pure linear samples obtained by inbreeding or analytical cross-linking are selected, mutated genes in mutant forms are detected. Selected samples are widely used in the study of formation processes in plants. At present, molecular marker methods are widely used in the passport of plants in the developed countries of the world.

#### MATERIALS AND METHODS

In 2019-2021, the soil and climatic conditions of the Guba-Khachmaz region of Azerbaijan were analyzed and it was noted that they are fully suitable for growing the studied fruit crops-apples and pears. The economic and biological characteristics of several previously and newly introduced varieties of 2 fruit breeds (Apple and pear) in the conditions of the northern region of our republic, in different cultivation bases, in different planting schemes and types of orchards have been studied. Phenological characteristics, bio morphological signs, and main components of the studied plants were analyzed. At this time, apple varieties - the initial material for grafting - m-9, MM-106, and wild forest apple trees, grafting apple varieties Gala, Simirenko Renet, Conagored, Golden Reinders, Granny Smith, Idared were introduced into our research., Red Winter, Fuje, Golden Delicious x 972, Pijam. Experiments also include pear varieties: Williams white, Williams red, Sir, Sir Nadiri, Trout, Guyot, Kure, Conference, Talgar beauty, and Lesnaya. Wild Pear bushes, as well as the VA-29 Variety, were taken as the basis for grafting (mother plant). The issues raised in the

study were mainly studied based on generally accepted methods in gardening.

#### RESULTS

One of the main conditions for intensifying gardening is the small size of the crown of fruit crops and their projection area. To do this, first of all, you need to choose the right soil. At the same time, it should be borne in mind that in all cases it is impossible to use a standard type of mulch, so it must be selected by the soil and climatic conditions of the Region [Gurbanov, et al., 2014]. If at that time the survival rate of buds when grafting on a wild forest apple tree was 81.9%, then in introduced grafted apple trees this indicator was 87.7-93.7%. Among the introduced apple trees according to this indicator, "Pajam-1" (88.0%) is the leader. In a pear plant, the percentage of preservation of buds grown on vegetatively propagated shoots is less than on shoots that are not propagated vegetatively. If the capture of buds when grafting on the VA-29 rhizome was 85.0 - 87.0%, then in the varieties Sir and Sir Nadiri grafted on the forest pear, the capture of shoots was significantly less - 76.7 - 79.3%. The entire genome sequence of Chinese pears [Wu et al., 2013], European pears [Chagné et al., 2014], apples [Velasco et al., 2010], peaches [Verde et al., 2013], and apricots [Zhang et al., 2012] has been studied, wild strawberries, cultivated strawberries [Hirakawa et al., 2014]. A total of 2,103 scaffolds cover 512.0 Mb (527% of the estimated 97.1 Mb genome size) and are not bound to 17 chromosomes. The genome of the Chinese pear contains 42,812 protein-encoding genes, and about 28.5% of them encode numerous isoforms.

The identified repeating sequences (271.9 Mb in total) make up 53.1% of the genome. The difference in size between the pear and Apple genomes is mainly due to the presence of repetitive sequences (mostly transposed elements), while gene regions and protein-coding genes are similar in both species. The European pear 'Bartlett' genomic composition Project [Chagné et al., 2014] consists of 142,083 scaffolds and covers a total of 577.3 Mb (600% of the estimated genome size of 96.2 Mb). In total, 43,419

probable genes were identified, of which 1,219 are characteristic of the European pear and are not found in the genomes of other dicotyledonous plants. Analysis of the family of expansin genes and other genes associated with the cell wall showed their participation in softening the fruits of both the European pear and the Apple. It is expected that the genome sequence of the Chinese and European pear will be attributed to 17 pseudochromosomes, which will greatly help us in conducting genetic-genomic studies of pears.

The International Consortium has published a draft of the genome sequence of the presented "Golden-tasting" apple variety, the founder variety often used in many selection programs (Velasco et al. 2010). The composition of the Golden Delicious genome consists of 603.9 kontigs, covering a total of 81.3 Mb (742.3% of the estimated genome-122146 Mb). Seventeen pseudochromosomes (GDR, *Malus × domestica* Genome v1.0p) were derived from these contigs. A total of 57,386 probable protein-encoding genes were predicted. The family of MADS-box genes involved in the development of flowers and fruits in the Apple plant has been expanded to 15 members. Other families of genes associated with the transport and assimilation of sorbitol are also expanding and are involved in the specific metabolism of Rosaceae.

Simple Sequence Repeats (SSR) markers or micro patches provide a reliable method for assessing genetic diversity and constructing genetic maps based on codominant inheritance and allele abundance [Weber & May 1989]. More than 1000 SSR markers were found in Japanese and European pears from genomic sequences [Inoue et al. 2007], from pests and next-generation sequence (NGS) data [Yamamoto et al., 2013]. Relatively recently, a large number of SSR markers have been developed from the entire genome sequence of the Chinese pear "Dangshansuli" [Chen et al., 2015]. SSR markers derived from pears have often been used as reference sites for pear genetic linkage reference maps [Chen et al., 2015], [Yamamoto et al., 2007]. Hundreds of SSR markers for apples have been developed and used to create high-quality genetic linkage maps with a high

marker density. Among the varieties of *Prunus*, a large number of SSR markers have been developed for peaches and almonds, cherries, and apricots [Lopes et al., 2002].

Nucleotide repeats were found in reinforced pear and Apple fragments both by Sequence and by Southern blotting, and differences in fragment size between pear and Apple are mainly due to differences in the number of such repeats. SSR markers apple, pear, quince (*Cydonia oblonga* Mill.), and mushmulla [Yamamoto et al., 2007]. When pear genetic relationship maps (Bartlett and La France) are compared with Apple reference maps (Discovery & Fiesta), pear homologous LGS may have 66 Apple SSR locations [Yamamoto, 2007].

In addition, the position of the SSR locus inside the LG was almost the same in the pear and Apple, which indicates good colinearity in all 17 Gisbert et al., (2009) used Apple and pear SSR markers to construct genetic linkage maps for Algeria and Zaozhong-6 medlar varieties. At the same time, when using fixed SSR markers, medlar maps showed high synthesis with pickup maps. [Fukuda et al., 2014] found almost complete collinearity of LG10 in mushmulla, pears, and apples. These data show that, despite significant differences in genome sizes ranging from 1.11 pg/2C to 1.57 pg/2c, the chromosomes of the offspring in the pyrene tribe exhibit colinearity.

## CONCLUSION

In this work, we focused on recent advances in whole genome sequencing, genome-wide SNP and SSR markers, genetic linkage reference maps, and research on synesthesia in Rosaceae fruit trees, which will help researchers develop new varieties with desirable traits using MAS and Roman. genomic strategies.in programs for the development of new, more efficient, and economical varieties of fruit trees. Genetic improvement of fruit trees belonging to the family of flower growers is very difficult due to the large size of the tree, the ripening time of new generations, and the long stage of maturity for seedlings.

Thus, it is believed that MAS and marker assisted breeding will help speed up selection and

reduce the time it takes to obtain a new generation and the cost of raising individuals grown in the field. However, mass attempts in fruit tree breeding programs remain limited for a few hereditary traits, as the development of markers for MAS through biparental QTL mapping is also difficult due to the same complications.

The development of high-throughput genotyping technologies such as SNP arrays and NGS-assisted genotyping has enabled the use of new genomic strategies such as genome-wide association research (GWAS), an alternative to

biparental QTL mapping in long-lived perennials. Genomic breeding selection based on value predictions, i.e. genomic selection (GS) is another alternative to MAS. Reliable and evenly distributed SNP markers across the genome, together with reference genetic linkage maps, help us use new genomic strategies, GWAS and GS, which have become powerful tools in pear, apple and forest tree breeding programs.

## REFERENCE

- Asadov, K. S., & Asadov, A. K. (2001). Wild fruit plants of Azerbaijan [Дикорастущие плодовые растения Азербайджана]. Azerbaijan National Encyclopedia, Baku. 256 p.
- Beyakhmadov, I. A. (2017). Net photosynthetic productivity of different apple variety combinations [Чистая продуктивность фотосинтеза у разных сортово-сортовых комбинаций яблони]. Collection of News, Ganja, 1, 86–92.
- Beyakhmadov, I. A., & Gasanov, Z. M. (2009). Evaluation of newly introduced apple varieties [Оценка сортов для вновь интродуцированных сортов яблони]. In Proceedings of the International Scientific Conference dedicated to the 75th anniversary of the ANAS Horticulture Institute, Baku, II, 47–50.
- Gasanov, Z. M., & Beyakhmadov, I. A. (2015). Current state of horticulture in the Guba-Khachmaz region and ways to develop it on an intensive basis [Современное состояние садоводства Губа-Хачмазского района и пути развития на интенсивной основе]. In Innovative Development of Agricultural Science and Education: World Experience and Modern Priorities. Proceedings of the International Scientific and Practical Conference (pp. 23–27). Ganja.
- Gurbanov, I. S., Aliyev, V. M., & Beyakhmadov, I. A. (2014). Current state and prospects for the development of horticulture in Azerbaijan [Современное состояние и перспективы развития садоводства в Азербайджане]. Azerbaijan Agrarian Science, Baku, 3, 32–34.
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E., & Huseynova, H. (2020). New spreading areas of some species in the botanical-geographical Baku regions of the middle part of the Caspian coast. *Acta Botanica Caucasica*, 1(1), 4–8.
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Sedova, E. N., & Ogoltsova, T. P. (Eds.). (1999). Program and methods of varietal study of fruit, berry, and nut crops [Программа и методика сортоизучения плодовых, ягодных и орехоплодных культур]. Orel: VNIISPK. 608 p.
- Chagné, D., Crowhurst, R. N., Pindo, M., Thrimawithana, A., Deng, C., Ireland, H., Fiers, M., Dzierzon, H., Cestaro, A., Fontana, P., et al. (2014). The draft genome sequence of European pear (*Pyrus communis* L. 'Bartlett'). *PLoS ONE*, 9, e92644. <https://doi.org/10.1371/journal.pone.0092644>
- Chen, H., Song, Y., Li, L. T., Khan, M. A., Li, X. G., Korban, S. S., Wu, J., & Zhang, S. L. (2015). Construction of a high-density simple sequence repeat consensus genetic map for pear (*Pyrus* spp.). *Plant Molecular Biology Reporter*, 33, 316–325. <https://doi.org/10.1007/s11105-014-0769-9>
- Dirlwanger, E., Claverie, J., Iezzoni, A. F., & Wunsch, A. (2009). Sweet and sour cherries: Linkage maps, QTL detection, and marker-assisted selection. In Gardiner, S. E., & Folta, K. M. (Eds.), *Plant Genetics/Genomics: Genetics and Genomics of Rosaceae* (Vol. 6, pp. 291–313). Springer.

- Hirakawa, H., Shirasawa, K., Kosugi, S., Tashiro, K., Nakayama, S., Yamada, M., Kohara, M., Watanabe, A., Kishida, Y., Fujishiro, T., et al. (2014). Dissection of the octoploid strawberry genome by deep sequencing of the genomes of *Fragaria* species. *DNA Research*, 21, 169–181. <https://doi.org/10.1093/dnares/dsu004>
- Lopes, M. S., Sefc, K. M., Laimer, M., & Da Camara Machado, A. (2002). Identification of microsatellite loci in apricot. *Molecular Ecology Notes*, 2, 24–26. <https://doi.org/10.1046/j.1471-8286.2002.00142.x>
- Velasco, R., Zharkikh, A., Affourtit, J., Dhingra, A., Cestaro, A., Kalyanaraman, A., Fontana, P., Bhatnagar, S. K., Troggio, M., & Pruss, D. (2010). The genome of the domesticated apple (*Malus × domestica* Borkh.). *Nature Genetics*, 42, 833–839. <https://doi.org/10.1038/ng.654>
- Verde, I., Abbott, A. G., Scalabrin, S., Jung, S., Shu, S., Marroni, F., Zhebentyayeva, T., Dettori, M. T., Grimwood, J., Cattonaro, F., et al. (2013). The high-quality draft genome of peach (*Prunus persica*) identifies unique patterns of genetic diversity, domestication, and genome evolution. *Nature Genetics*, 45, 487–494. <https://doi.org/10.1038/ng.2586>
- Wu, J., Wang, Z., Shi, Z., Zhang, S., Ming, R., Zhu, S., Khan, M. A., Tao, S., Korban, S. S., Wang, H., et al. (2013). The genome of the pear (*Pyrus bretschneideri* Rehd.). *Genome Research*, 23, 396–408. <https://doi.org/10.1101/gr.142663.112>
- Yamamoto, T., Kimura, T., Terakami, S., Nishitani, C., Sawamura, Y., Saito, T., Kotobuki, K., & Hayashi, T. (2007). Integrated reference genetic linkage maps of pear based on SSR and AFLP markers. *Breeding Science*, 57, 321–329. <https://doi.org/10.1270/jsbbs.57.321>
- Youssef, N. A., Markert, B., Gurbanov, E. M., Hacıyeva, S. R., & Wünschmann, S. (2013). Bioindication of trace metal pollution in the atmosphere of Baku city using *Ligustrum japonicum*, *Olea europea*, and *Pyracantha coccinea* leaves. *Journal of Environmental Engineering and Landscape Management*, 22(1), 14–20. <https://doi.org/10.3846/16486897.2013.807807>
- Zhang, Q., Chen, W., Sun, L., Zhao, F., Huang, B., Yang, W., Tao, Y., Wang, J., Yuan, Z., Fan, G., et al. (2012). The genome of *Prunus mume*. *Nature Communications*, 3, 1318. <https://doi.org/10.1038/ncomms2310>

## ANALYSIS OF THE ANATOMICAL STRUCTURE OF SOME GENERATIVE AND VEGETATIVE ORGANS OF THE PLANT SPECIES *PORTULACA OLERACEA* L. DISTRIBUTED IN THE MOUNTAINOUS AREAS OF THE LESSER CAUCASUS

Aygun Sardarova

Azerbaijan State Agricultural University, Ozan st., Ganja, AZ2007, Azerbaijan

Correspondence: aygun.sardarova4442@gmail.com

DOI: <https://doi.org/10.30546/abc.2024.3.2.345>

Article info: pp. 73-79

Received: 11.04.2024; Received in revised form 13.05.2024; Accepted 10.07.2024

**ABSTRACT.** In the conducted research, several works have been carried out to study the anatomical structures of plant specimens and various structures encountered within the plant. After the collected plant samples underwent preliminary treatment, their anatomical cross-sections were obtained, and the permanent preparations of the acquired sections were analyzed using a light microscope. The anatomical sections of the sepal from generative organs and the leaf, petiole, stem, and root from vegetative organs were analyzed, and their internal structures were provided. The results allow for determining the structure of tissues with the same function in different plant organs, comparing these structures between organs, and identifying their arrangement throughout the plant. When examining the vascular bundles, it is determined that they are composed of primary structural elements in the leaf. The vascular bundle of the leaf passes through the petiole and enters the stem's central cylinder. In the root, the xylem extends toward the center of the root, transporting water and dissolved substances, while the phloem adjacent to the xylem plays a direct role in the transportation of organic materials. During the microscopic analyses, similar studies were investigated, and references to specific points were made when necessary.

**Keywords:** Cross-section, vascular bundle, collenchyma, druse, periderm.

### INTRODUCTION

*Portulaca oleracea* L. is a cosmopolitan species widespread in low-yield areas, mountainous regions, and many other habitats [Asgarov, 2016]. The plant studied in this article was

collected from the mountainous area of Qab-aqtapa village in the Dashkasan district of Azerbaijan. The fleshy leaves and stems of the plant maintain high water reserves, ensuring the plant's drought resistance (Fig. 1). Its soft stems

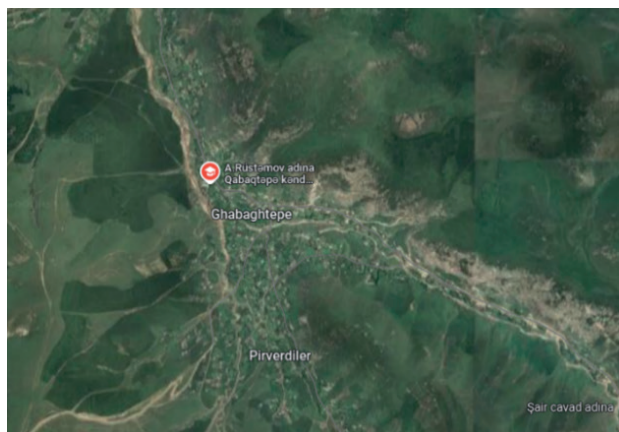


**Figure 1.** General view of the *Portulaca oleracea* and the map of the area where it was collected.

are sprawling, branching from the points where the leaves attach to the stem, allowing the plant to spread laterally in the area it occupies [Novruzov, 2010]. The leaves are oval-shaped with a smooth surface; as seen in anatomical cross-sections, they are thick and possess water-storing tissues, attaching to the stem via a small petiole [Gurbanov, 2009b] [Karimov et al., 2010]. The stem also has a smooth surface, with longitudinal stripes corresponding to the internal vascular bundles. The branches of the main stem initiate generative buds at the points where several leaves are clustered at the tips; however, further branching can occur, leading to the formation of new lateral stems. The main stems are connected to a single central part, which is attached to a single root at the bottom, and the root system is a tap root system. The plant is widely used in medicine and folk remedies due to its rich composition, which includes minerals, vitamins, and omega-3 fatty acids [Qurbanov, 2009a] [Ibadullayeva, 2010]. Furthermore, because of its anatomical structure characteristics, this plant with a soft texture is also used as food [Ibadullayeva, 2023].

## MATERIALS AND METHODS

### Collection of plant samples.

To elucidate the anatomical structure of *Portulaca oleracea*, samples were collected from healthy plants located in the Qabaqtapa village area of the Dashkasan region [Asgarov, 2011]. This scientific study focused on the generative organs, specifically the sepal, and the vegetative organs, including the leaf, petiole, stem, and root, to determine their anatomical characteristics.

### Preparation of samples for sectioning.

Specific histological methods were employed to preserve and pre-process the carefully selected plant samples. The samples were fixed in a specialized solution to maintain the integrity of their internal structures and tissue organization [Tutayuy, 1967]. Following fixation, they were immersed in alcohol solutions of varying concentrations to facilitate the removal of water from the tissues.

### Sectioning and staining process.

Thin cross-sections, approximately 5-10  $\mu\text{m}$

thick, were taken from selected parts of the sepal, leaf, petiole, stem, and root with hand microtome, and mounted on glass slides for staining. The sections were stained with safranin dye to emphasize different tissue types. Since safranin specifically stains lignin, elements that have undergone lignification, or wood formation, appear red [Jana, 2003]. Consequently, during microscopic analysis of the anatomical sections, xylem vessels, including tissues with thickened cell walls such as libriform fibers and sclerenchyma, are visibly stained red [Sardarova, 2022a].

### Analysis of prepared specimens.

Light microscopes (ZEISS and MOTIC) were utilized to examine the anatomical structures present in the sections, and micrographs were taken of individual parts. The analysis involved identifying the epidermis, parenchyma, vascular elements, and other tissue types, clarifying their structural characteristics, arrangement, and the interplay between structure and function [Humbatov, 2017]. During the measurement process using the microscope, both the eyepiece micrometer and the stage micrometer were utilized. In this context, both micrometers were placed in their appropriate positions within the microscope to facilitate the calibration process. The degree to which the divisions of the eyepiece micrometer corresponded to those of the stage micrometer was determined at various magnification levels of the objectives. The stage micrometer had a 1 mm section divided into 100 equal parts, each measuring 10 micrometers in width. During the calibration process, the number of divisions of the stage micrometer that corresponded to each division of the eyepiece micrometer was recorded. Accordingly, the width in micrometers of one division of the eyepiece micrometer at each specific magnification level was established. Following this, the measurement process was conducted on the preparations.

## RESULTS

The analysis of preparations made from the cross-sections of the generative and vegetative organs of the *Portulaca oleracea* species, conducted under a light microscope, along with the

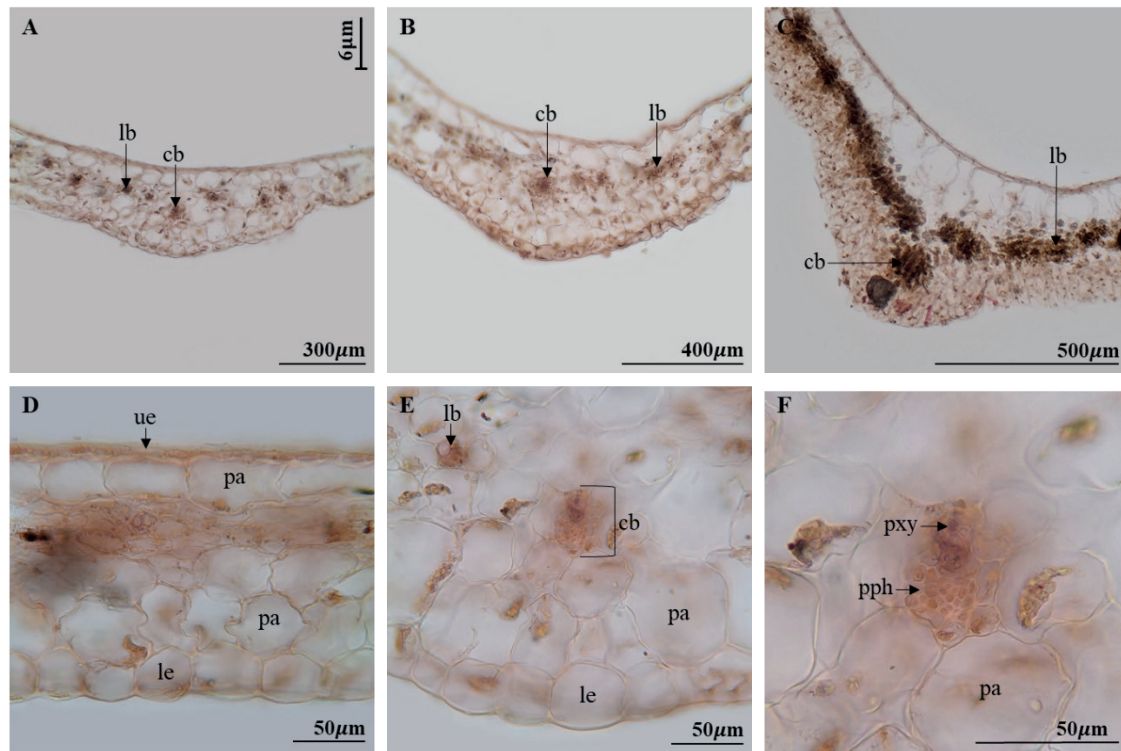


**Figure 2.** *Portulaca oleracea*. Sepal

**A,B,C**-the general appearance of the cross-section of the sepal; **D**-the lateral part of the sepal; **E,F**-the central part of the sepal; **ue**-upper epidermis; **le**-lower epidermis; **pa**-parenchyma; **cb**-central bundle; **lb**-lateral bundle; **pxy**-protoxylem; **pph**-proto-phloem.

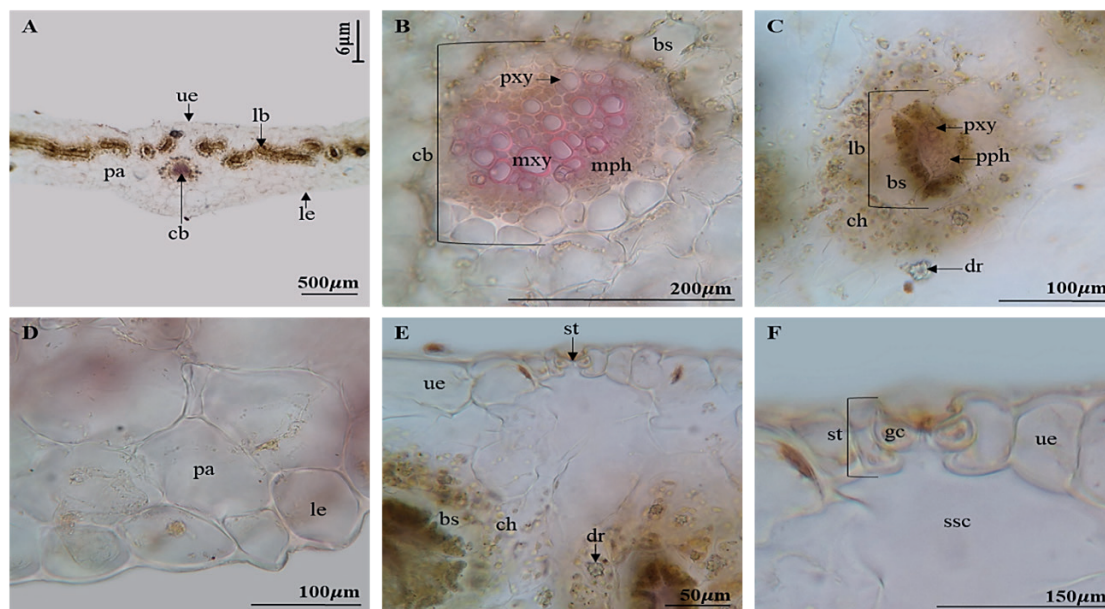


**Figure 3.** *Portulaca oleracea*. Leaf

**A**-the general appearance of the cross-section of the leaf; **B**-the structure of the central bundle; **C**-the structure of the lateral bundle; **D**-lower epidermis zone **E,F**-upper epidermal zone and stoma; **ue**-upper epidermis; **le**-lower epidermis; **pa**-parenchyma; **bs**-bundle sheath; **ch**-chlorenchyma; **st**-stoma; **ssc**-sub-stomatal cavity; **gc**-guard cell; **cb**-central bundle; **lb**-lateral bundle; **pxy**-protoxylem; **pph**-proto-phloem; **mxy**-metaxylem; **mph**-metaphloem; **dr**-druse.

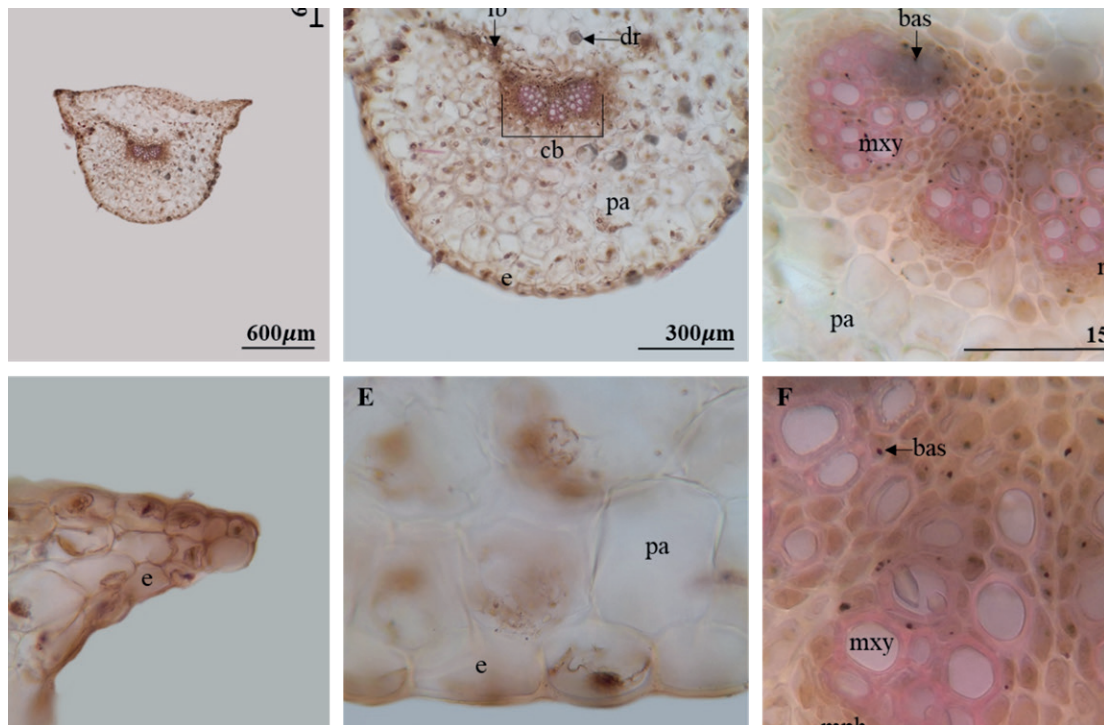


**Figure 4.** *Portulaca oleracea*. Petiole

**A,B**-the general appearance of the cross-section of the petiole; **C,F**-the structure of the central bundle; **D**-the petiolar wing of the petiole; **E**-lower area; **e**-epidermis; **pa**-parenchyma; **cb**-central bundle; **lb**-lateral bundle; **mxy**-metaxylem; **mph**-metaphoem; **dr**-druse; **bas**-biological active substances.

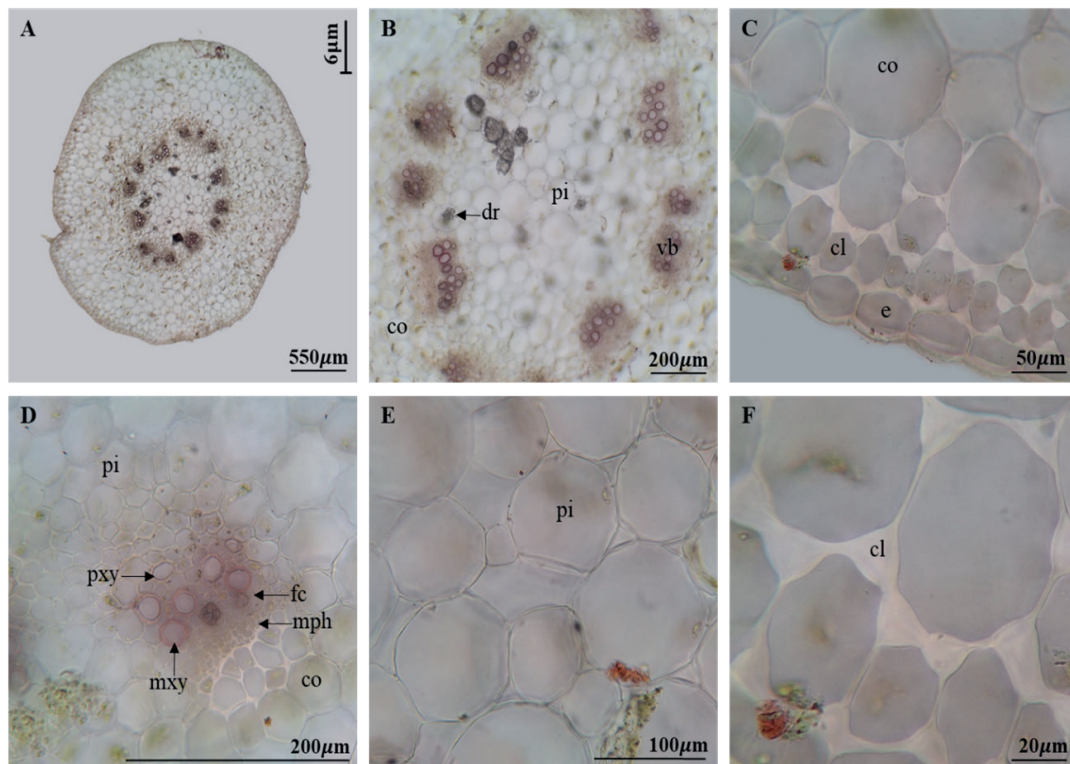


**Figure 5.** *Portulaca oleracea*. Stem

**A**-the general appearance of the cross-section of the stem; **B**-the structure of the stele; **C,F**-the epidermal area where collenchyma is located; **D**-the structure of the vascular bundle; **E**-pith; **e**-epidermis; **cl**-collenchyma; **co**-cortex; **vb**-vascular bundle; **pxy**-protoxylem; **mxy**-metaxylem; **mph**-metaphoem; **fc**-fascicular cambium; **dr**-druse; **pi**-pith.

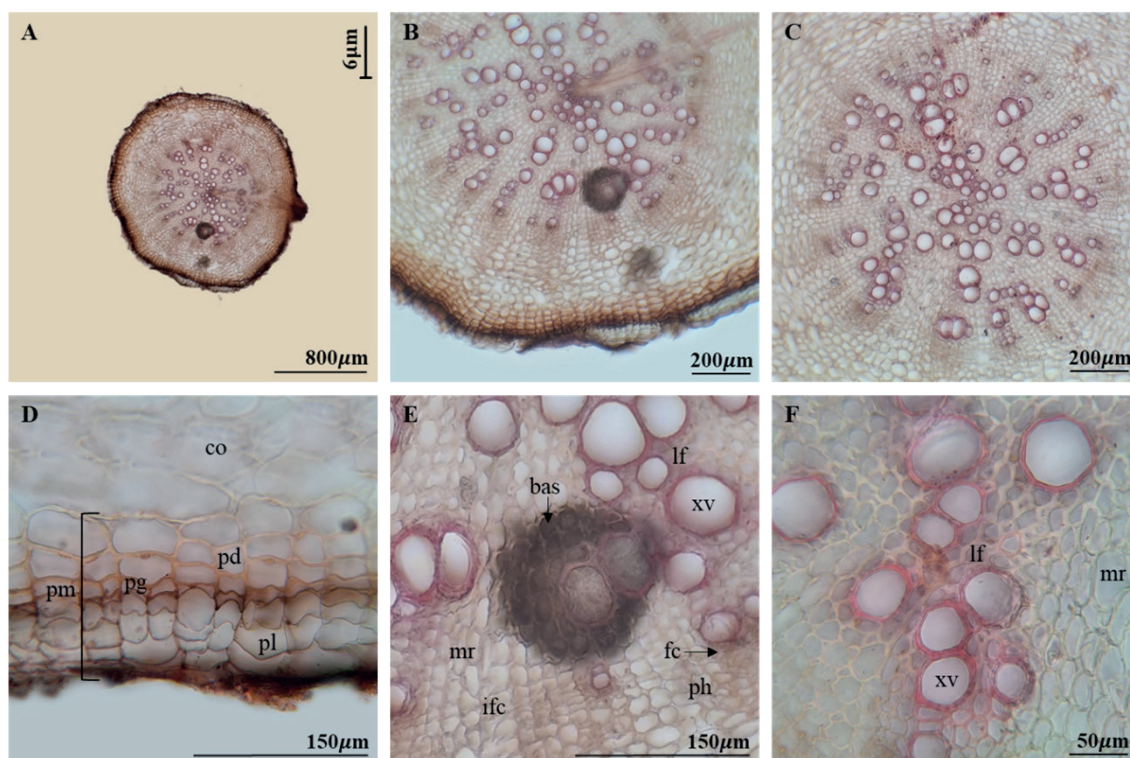


**Figure 6.** *Portulaca oleracea*. Root

**A**-the general appearance of the cross-section of the root; **B**-peripheral zone of the root; **C**-the structure of the stele; **D**-the structure of the periderm; **E**, **F**-parts of the xylem; **pm**-periderm; **pl**-phel-lem; **pg**-phellogen; **pd**-phelloderm; **co**-cortex; **ph**-phloem; **fc**-fascicular cambium; **ifc**-interfascicular cambium; **xv**-xylem vessels; **lf**-libriform fibres; **mr**-medullary ray; **bas**-biological active substances.

obtained micrographs, is presented below:

**Sepal.** In the sepal, the first noticeable difference is the distinct structure of the upper and lower epidermal cells. The upper epidermal cells are flattened and arranged in a thin layer, while the lower epidermal cells are considerably larger (fig 2). A thick layer composed of large parenchyma cells extends along the subepidermal zone of the upper epidermis, and the vascular bundles are located among smaller, flattened chloroplast-containing cells near this layer [Sardarova, 2022b]. Internally from the lower epidermis, several layers of large, irregularly shaped cells with poorly developed chloroplasts occupy the area up to the bundles. The bundle elements are poorly developed, consisting of several protoxylem and proto-phloem elements located in the central bundle. Additionally, complex structures containing calcium oxalate druses and various tissue aggregates can be observed around the bundles.

**Leaf.** The leaf is thick, and this thickness is provided by the parenchyma composed of large

cells that fill the main part of the leaf and store water. Along the leaf blade, lateral bundles are arranged within this parenchyma, closer to the upper epidermis, while the main, relatively larger central vascular bundle is located below these lateral bundles in the center [Ocampo et al., 2013]. Examining the structure of the central bundle, it is evident that its primary xylem consists of smaller tubular elements, visible as protoxylem, and the metaxylem, which forms below it. Above the primary xylem, there are cell aggregates with slightly thickened walls which also can be observed below the primary phloem. The structural elements of the lateral bundles are composed of protoxylem and protophloem, and all the bundles are surrounded by large bundle sheath cells (fig 3). Within these cells, dense accumulations of chloroplasts are located in the areas directed toward the bundles. Additionally, chloroplast-containing chlorenchyma tissue cells are arranged around the bundle sheath cells, separating them from the parenchyma [Hernandes-Lopes et al., 2016]. In

these tissue cells, calcium oxalate druse crystals can be observed. The leaf is amphistomatic, meaning that stomata can be found on both the lower and upper epidermis, with the guard cells being relatively smaller and surrounded by subsidiary cells. The outer walls of the epidermis show weak cutinization.

### **Petiole**

The petiole is semi-circular in shape with petiolar wings extending outward. Its central bundle consists of xylem vessels, libriform fibers filled with substances and having non-woody walls located in between, and thin phloem aggregates found in the lower part of the xylem that also contain tannins. A couple of small lateral bundles can also be observed on the sides of the central bundle. The parenchyma that occupies the remaining space contains chloroplasts, druses, and accumulations of biologically active substances. The epidermis surrounds the organ from the outside, and it is noted that certain substances are also accumulated within some of its cells (Fig. 4).

**Stem.** The stem has a eustele structure and the cortical cells connecting to outer part of that stele are smaller, enlarging in the central part of the cortex and then becoming smaller again towards the subepidermal zone. Many of the cortical cells contain chloroplasts and transition into a couple of layers of collenchyma located directly beneath the epidermis in the subepidermal zone. The thickening at the corners of the angular collenchyma cells gives it a distinctive appearance resembling nodes (Fig. 5). The collateral type bundles surround pith parenchyma consisting of thin-walled cells with isodiametric structure, containing large granular substance accumulations and druses. The bundles separated from one another by medullary rays. Within the stele, the primary xylem is located in the inner part, while the primary phloem is found in the outer part, with fascicular cambium between them and larger, thicker-walled cell aggregates are located on the outer side of the phloem [Qasimov et al., 2010]. It is also possible to observe substance accumulations within the bundles.

**Root.** The cross-section of the root reveals

the xylem vessels forming the central cylinder. In between the vessels are libriform fibers with non-lignified walls. In some areas, these fibers appear to be filled with substances in their cytoplasm. Additionally, parenchymal rays composed of parenchyma cells extend inward along the xylem. At the outer edge of the xylem, you can see the fascicular cambium, which gives rise to both xylem and phloem, as well as the interfascicular cambium, which continues from the vascular cambium along the parenchymal rays. The phloem is surrounded by the parenchyma cells of the cortex, which become more loosely arranged in the peripheral zone, forming large intercellular spaces. The root is surrounded by the periderm, with its layers clearly distinguishable [Sardarova, 2022b]. On the outermost layer, there is the cork (or phellem), consisting of dead cells that have undergone suberization, preventing substances from entering the root. Beneath this layer, there is the cork cambium (or phellogen), made up of meristematic cells, and from these living cells, inward, the pheloderm or cork parenchyma forms (Fig. 6). As seen in the image, the xylem contains a rounded black spot formed by the accumulation of substances in several cells.

### **CONCLUSION**

The epidermal characteristics of the sepal are a result of adaptation, with the upper epidermis forming a layer that encloses the flower bud from the inside, while the outer epidermis serves a protective function by being in contact with the external environment.

The parenchymal tissue filling the internal space of the leaf blade serves a water storage function, which is an adaptation acquired over time. The positioning of the vascular bundles closer to the upper surface, within this parenchyma, ensures greater exposure to sunlight and maintains photosynthetic activity.

The arrangement of the vascular bundles in the petiole and stem complement each other, aligning with the opposite leaves on the stem. The bundles entering the leaves are also positioned opposite one another.

Since the stem is sprawling, there are no

sclerenchymal elements to provide upright support in this plant. Instead, the collenchyma in the subepidermal zone ensures the overall structural integrity and elasticity of the stem.

## REFERENCES

- Abdallah, Y. N., & Mejnun, G. E. (2013). Change of the morpho-anatomical structure of leaves of *Ligustrum japonicum* and *Olea europea* caused by heavy metal pollution. *Caspian Journal of Applied Science and Research*, 4(3), 74–83.
- Asgarov, A. (2011). Synopsis of the Flora of Azerbaijan (with additions and revisions, 1961-2009). Baku: Elm. 204 p. (Əsgərov, A. (2011). Azərbaycan florasının konspekti (əlavələr və dəyişikliklərlə, 1961-2009). Bakı: Elm. 204 s.)
- Asgarov, A. (2016). Plant Kingdom of Azerbaijan. Baku: Teas Press. 444 p. (Əsgərov, A. (2016). Azərbaycanın bitki aləmi. Bakı: Teas Press. 444 s.)
- Gasimov, N.A., Əliyeva, N.Ş., Tahirli, S.M., & Abduyeva, S.M. (2010). Plant Anatomy. Baku: Bakı Universiteti. 387 p. (Qasimov, N.A., Əliyeva, N.Ş., Tahirli, S.M., & Abduyeva, S.M. (2010). Bitki anatomiyası. Bakı: Bakı Universiteti. 387 s.)
- Gurbanov, E.M. (2009). Medicinal Plants. Baku: Bakı Universiteti. (Qurbanov, E.M. (2009). Dərman bitkiləri. Bakı: Bakı Universiteti.)
- Gurbanov, E.M. (2009). Systematics of Higher Plants. Baku: Bakı Universiteti. 430 p. (Qurbanov, E.M. (2009). Ali bitkilərin sistematikası. Bakı: Bakı Universiteti. 430 s.)
- Gurbanov, E. M. (1996). Plant world of Nakhichevanchay river basin. Baku: Baku State University.
- Gurbanov, E., & Jabbarov, M. (2017). Geobotany. Baku: Baku State University.
- Hernandes-Lopes, J., Oliveira-Neto, M. A., & Melo-de-Pinna, G. F. A. (2016). Different ways to build succulent leaves in *Portulacineae* (Caryophyllales). *International Journal of Plant Sciences*, 177(2), 198-208. <https://doi.org/10.1086/684252>
- Humbatov, Z. I. (2017). Plant Morphology and Anatomy. Baku. 691 p. (Hümbətov, Z. İ. (2017). Bitki morfolojiyası və anatomiyası. Bakı. 691 s.)
- Ibadullayeva, S.C. (2010). Medicinal Plants. Baku: Elm. (İbadullayeva, S.C. (2010). Dərman bitkiləri. Bakı: Elm.)
- Ibadullayeva, S. (2023). Forgotten Recipes of Folk Medicine (From the Memories of Western Azerbaijan, Eastern Zangezur, and Karabakh Communities). Baku: Elm. 268 p. (İbadullayeva, S. (2023). Xalq təbabətinin unudulmuş reseptləri (Qərbi Azərbaycan, Şərqi Zəngəzur və Qarabağ icmaları yaddaşlarından). Bakı: Elm. 268 s.)
- Jana, A. (2003). Plant Anatomy in Environmental Studies. Prague. 36 p.
- Karimov, Y.B., Süleymanov, T.A., İsayev, C.İ., & Xəlilov, C.S. (2010). Pharmacognosy. Baku: Herba Flora. 741 p. (Kərimov, Y.B., Süleymanov, T.A., İsayev, C.İ., & Xəlilov, C.S. (2010). Farmakoqnoziya. Bakı: Herba Flora. 741 s.)
- Novruzov, V.S. (2010). Fundamentals of Phytosociology. Baku: Elm. 306 p. (Novruzov, V.S. (2010). Fitosenologiyanın əsasları. Bakı: Elm. 306 s.)
- Ocampo, G., Sage, T. L., Koteyeva, N. K., & Voznesenskaya, E. V. (2013). Evolution of leaf anatomy and photosynthetic pathways in *Portulacaceae*. *American Journal of Botany*, 100(12). <https://doi.org/10.3732/ajb.1300058>
- Sardarova, A.S. (2022). Anatomy of Medicinal Plants. Baku. 678 p. (Sərdarova, A.S. (2022). Dərman bitkilərinin anatomiyası. Bakı. 678 s.)
- Sardarova, A.S. (2022). Pharmaceutical Botany. Baku. 852 p. (Sərdarova, A.S. (2022). Əczaçılıq botanikası. Bakı. 852 s.)
- Tutayuyq, V.X. (1967). Plant Anatomy and Morphology. Baku. 193 p. (Tutayuyq, V.X. (1967). Bitki anatomiyası və morfolojiyası. Bakı. 193 s.)





# CONTENT

|                                                                                                                                                                                                                                                        |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>ELSHAD GURBANOV, GUNEL SARIYEVA, SADIGOVA NARMINA</b><br>THE CURRENT STATE OF FOREST AND SHRUBLAND VEGETATION IN THE QANIKH-AGRICHAY VALLEY ...                                                                                                     | 3  |
| <b>TARIYEL TALIBOV</b><br>THE DIVERSITY OF IRIS SPECIES IN NAKHCHIVAN .....                                                                                                                                                                            | 8  |
| <b>SABINA HAJIYEVA, SEVDA BABAYEVA, ZIYAFAT MUSTAFAYEVA, VUSALA IZZATULLAYEVA, VAHID GUVENDIYEV, ELCHIN HAJIYEV</b><br>ASSESSMENT OF GENETIC DIVERSITY AMONG WILD POMEGRANATE (PUNICA GRANATUM L.)<br>GENOTYPES OF AZERBAIJAN USING ISSR MARKERS ..... | 14 |
| <b>ABDIYEV VILAYET, JAFARZADE BOYUKKHANIM</b><br>THE ACTIVITY OF PEROXIDASE AND SUPEROXIDE DISMUTASE IN PLANT SEEDLINGS<br>UNDER SALT STRESS .....                                                                                                     | 21 |
| <b>ELMAN ISKENDER, SABINA JAFARZADEH, BAHAR MAMMADOVA</b><br>MORPHOLOGY DESCRIPTION AND TAXONOMY OF PYRUS L. SPECIES OF NORTH-EASTERN PART<br>OF THE GREAT CAUCASUS .....                                                                              | 30 |
| <b>AYGUN NASIBOVA, MAJNUN BABAYEV, ROVSHAN KHALILOV</b><br>EFFECTS OF STRESS FACTORS ON BIOPHYSICAL AND GENETIC PARAMETERS IN C3 and C4 PLANTS .....                                                                                                   | 40 |
| <b>CIHANGIR UYGUN, AHMET ILCHIM, SHENGUL KARAMAN, ISMAIL KAZANCHI, SADI BAGCI</b><br>FLORA OF SARIMSAK MOUNTAIN (ANDIRIN/KAHRAMANMARASH/TURKIYE) .....                                                                                                 | 46 |
| <b>HAMIDA SEYIDOVA, ANVAR IBRAHIMOV</b><br>MYRIOSTOMA COLIFORME (PERS.) CORDA - A NEW SPECIES FOR THE MYCOBIOTA OF AZERBAIJAN ....                                                                                                                     | 64 |
| <b>NAZAKAT HUSEYNOVA, BASTI ASADOVA</b><br>STUDY OF GENOMES OF FRUIT PLANTS CULTIVATED IN SOME REGIONS OF AZERBAIJAN.....                                                                                                                              | 68 |
| <b>AYGUN SARDAROVA</b><br>ANALYSIS OF THE ANATOMICAL STRUCTURE OF SOME GENERATIVE AND VEGETATIVE ORGANS<br>OF THE PLANT SPECIES PORTULACA OLERACEA L. DISTRIBUTED IN THE MOUNTAINOUS AREAS<br>OF THE LESSER CAUCASUS .....                             | 73 |

Baku State University Publishing House.

Signed for printing: 18.07.2024

Font headset: Calibri

Format: 64x90 1/8

Copies: 50



ISSN 2958-0536



[www.botanic.az](http://www.botanic.az)