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**THE PHYTOECOLOGICAL CHARACTERISTICS AND RESTORATION OF RIPARIAN FORESTS
ALONG THE KURA RIVER
(IN THE TERRITORY OF THE AGJABADI DISTRICT)**

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Abstract. *The vegetation cover constitutes the composition of the biocenosis and reflects the changes occurring in the natural environment as a result of human activity. Thus, plant communities are subjected to degradation due to anthropogenic factors and technogenic impacts. In this context, the deterioration of the ecological condition of riparian forests leads to disruptions in the ecosystem and necessitates the study of their phytosociological characteristics for the conservation of the vegetation cover. Riparian forests characteristic of forest vegetation have been studied in the Kura-Araxes lowland, as well as in the territory of the Agjabadi district of the Karabakh-Mil plain (riparian forests along the Kura River). The study site or object of the riparian forest within this region was chosen to be the area near the village of Nejafqulubeyli, along the Kura River, following the Kura bridge on the Zardab-Agjabadi highway. Here, riparian forests are encountered in alluvial-meadow type soils in bands along the Kura River. As is known, the floods that continue from the beginning of spring to the middle of summer fill the "axmaz" (non-flowing water bodies) with water, providing a normal moisture source for plants. Thus, the conversion of areas where riparian forests along the Kura are found into agricultural lands for the cultivation of crops leads to salinization and desertification of these areas. Regarding this issue, the riparian forests along the Kura River in the territory of the Agjabadi district have been poorly studied by botanists.*

Keywords: *association, riparian forest, formation, phytocoenosis, aerial*

MATERIALS AND METHODS

The study site for the riparian forest in this region is located near the village of Nejafqulubeyli, along the Kura River, following the Kura bridge on the Zardab-Agjabadi highway. In this area, riparian forests are found in alluvial-meadow type soils in bands along the Kura River. The ecological and afforestation conditions of the area where riparian forests along the Kura river are located were studied using the standard methods from ecology, soil science, and forestry. The initial information about the forest plantings created to restore Riparian forests was obtained by analyzing the forest structure, accounting for forest plantings, and reviewing related reports.

RESULTS

Phytosociological research on the riparian forest has been conducted to classify the vegetation cover. In connection with this, the following are noted according to the classification of the vegetation cover at the research object in the riparian forest in the territory of the Agjabadi district:

Vegetation of the xerophytic forest zone formed on alluvial-meadow soils Type: Forest Formation class: Riparian forests Formation group: *Populeta-Salixetum-Tamarixosum*

Associations:

a) *Populeta alba-Salixetum promoides-Tamarixosum ramosissima*

b) *Populetum alba-Salixetum promoides*



Figure 1. Riparian forests along the Kura river

c) *Salixetum promoides-Tamarixosum ramosissima* Based on the classification, the phytosociological characteristics of the *Populeta-Salixetum-Tamarixesum* formation noted in the vegetation cover of the riparian forest, including species composition and structure, are explained below:

A. Poplar-willow-tamarisk formation

This formation's vegetation cover spreads beyond the "Bridge" along the Zardab-Agjabedi highway within the Agjabedi district (in the Mil

plain part).

In the species composition of the phytocoenosis, 19 species are recorded; of these, 4 species (21.0%) are trees, 4 species (21.0%) are shrubs, 1 species (5.3%) is a shrub-liana, 1 species (5.3%) is a semi-shrub, 1 species (5.3%) is a semi-vine, 1 species (5.3%) is a vine, and 7 species (36.8%) are perennial herbs. Based on the analysis of ecological groups, among these species, 9 species (47.3%) are mesophytes, 5 species (26.3%) are mesoxerophytes, 4 species



Figure 2. The current state of the Riparian forests along the Kura river

(21.1%) are xerophytes, and 1 species (5.3%) belongs to halophytes.

As the geobotanical description indicates, the formation's edificator or dominant species is the *Tamarix ramosissima* with an abundance score of 3-4, the sub-dominant is the dense willow (*Salix promoides*) with a score of 2-3, and the *Populus alba* with a score of 2.

According to the phytosociological structure, in the first layer (I) of the tugay forest's vegetation cover, there are *P. alba*, *S. promoides*, *Ulmus minor*, *Morus alba* trees; from shrubs, the *T. ramosissima* etc.; in the second layer

(II), *Vitis sylvestris*; from semi-vines, *Artemisia Szowitsiana*; from herbs, *Limonium meyeri*, *Glycyrrhiza glabra*, *Alhagi pseudoalhagi*, and in the third (lower) layer (III), *Cynodon dactylon*, *Plantago major*, etc., are found.

Species composition and structure of the *Populueta-Salixetum-Tamarixosum* formation (Dominated by *Tamarix ramosissima* Ledeb). The research site is located 1 km away from the "Bridge" along the Zardab-Agjabedi highway, near the Kura River in the Agjabedi district (May 20, 2023).

Table 1.

Species composition and structure of the *Populueta-Salixetum-Tamarixosum* formation (Dominated by *Tamarix ramosissima* Ledeb).

No	Species	Ecological Groups	Abundance (score)	Layer and Height (cm)	Density	Phenological Phases
TREES						
1	<i>Salix promoides</i> Bieb.	Mesophyte	2-3	I (1500)	0.8	Flowering
2	<i>Populus alba</i> L.	Mesophyte	2	I (1800)	0.7	Flowering
3	<i>Ulmus minor</i> L.	Mesophyte	1-2	I (1400)	0.6	Flowering
4	<i>Morus alba</i> L.	Mesophyte	1	I (1200)	0.4	Fruiting
SHRUBS						
5	<i>Tamarix ramosissima</i> Ledeb.	Mesoxerophyte	3-4	I (300)	0.2	Flowering
6	<i>Grataegus pentagyna</i> Waldst. & Kit.	Xerophyte	1-2	I (600)	0.3	Flowering
7	<i>Rubus anatolicus</i> (Focke)	Xerophyte	1-2	I (350)	0.2	Flowering
8	<i>Paliurus spina-christi</i> Mill.	Xerophyte	1	I (250)	0.1	Vegetative
SHRUB-VINES						
9	<i>Vitis sylvestris</i> G.Gmel.	Mesoxerophyte	1-2	I (150)	0.1	Fruiting
SEMI-SHRUBS						
10	<i>Artemisia szowitsiana</i> (Besser) Grossh.	Mesophyte	1-2	II (90)	-	Vegetative
SEMI-HERBS						
11	<i>Salsola dendroides</i> Pall.	Mesoxerophyte	1	II (70)	-	Vegetative
VINES						
12	<i>Capparis herbacea</i> Willd.	Xerophyte	1-2	III (30)	-	Flowering
PERENNIAL HERBS						
13	<i>Limonium meyeri</i> (Boiss.) O.Kuntze	Halophyte	1-2	II (80)	-	Flowering

14	<i>Glycyrrhiza glabra</i> L.	Mesophyte	1	II (60)	-	Flowering
15	<i>Alhagi pseudoalhagi</i> (Bieb.) Desv.	Mesoxerophyte	1	II (45)	-	Vegetative
16	<i>Cynodon dactylon</i> (L.) Pers.	Mesophyte	1	III (25)	-	Flowering
17	<i>Plantago major</i> L.	Mesophyte	1	III (20)	-	Flowering
18	<i>Alopecurus myosuroides</i> Huds.	Mesophyte	1	III (15)	-	Flowering
19	<i>Gallium spurium</i> L.	Mesoxerophyte	1	III (10)	-	Flowering

The Overall Vegetation Cover Ranges from 30-70%. It should also be noted that the name of the *Vitis sylvestris* found in the species composition of the phytocoenosis has been included in "The Red Book of Azerbaijan." The project coverage and density (coverage by trees and shrubs) in the species composition is low. It is also important to note that the restoration of tugay forests along the Kura River spreading across the Agjabedi district is of great importance.

For the restoration of the sparse tugay forest vegetation within the wide range found along the Kura River in the territory of the Agjabedi district, the use of *Populus alba*, in addition to the *Platanus orientalis*, should be considered. In this context, the Plane tree, due to its growth, alongside White Poplar, is superior in terms of longevity and decorative value. However, in the restoration of tugay forests,

the use of *Quercus*, *Juglans*, and *Pistacia* is negligible.

CONCLUSION: The natural vegetation is on the verge of destruction in the Agjabedi district, along the Kura River, due to the felling of trees and bushes, as well as grazing of livestock in the riparian forests. Therefore, it is necessary to implement protection and conservation measures for the vegetation cover in accordance with forest legislation to prevent the direct and indirect negative impacts of anthropogenic and zoogenic factors on the riparian forests.

Populeta-Salixetum-Tamarixesum formation of the riparian forest spreading along the Kura River in the Agjabedi district can be utilized in the compilation of the "Ecological-Geobotanical Map of Riparian Forests in Azerbaijan."

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DISTRIBUTION AND PHYTOCENOTIC CHARACTERISTIC OF *CAKILE EUXINA* POBED. IN THE COASTAL PART OF AZERBAIJAN (SOUTH CAUCASUS)

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Abstract. The article characterizes the psammophyte-littoral species *Cakile euxina* Pobed, which has recently appeared in Azerbaijan. Data are given on the distribution of the species along the coastal strip, vegetation, and plant communities with the participation of the species are described. The main concentration of the species is observed in the northern, bordering Russia (Dagestan) part of the coastal strip. It has been established that *Argusiya sibirica* + *Convolvulus persica* is a characteristic community for *Cakile euxina* in all parts of the Caspian Sea since both species are ecologically confined to the same sandy habitats as the object of our study. In addition to participation in this main community, *Cakile euxina* in the northern part is found in the communities of *Artemisia annua* + *Convolvulus persica*, *Melilotus officinalis* + *Artemisia annua*, *Xanthium strumarium* + *Cakile euxina*, *Salicornia europaea* + *Suaeda confusa*, *Salsola tragus* + *Convolvulus persica*, *Artemisia arenaria* + *Herbosa*, in central *Astragalus ignarius* + *Calligonum bakuense*, *Juncus acutus* + *Elaeagnus angustifolia*, *Salicornia europaea* + *Suaeda confusa*, and in the south - mainly in the above-mentioned community and in various forb groups. It has been established that *C. euxina* actively participates in annual saltwort communities dominated by *Suaeda confusa* Iljin, common in areas with wet sands and sandstones, typical for the northern and central parts of the coast. For *C. euxina*, the optimal soil moisture conditions were found, which are in the range of 45-75%. Monitoring observations have shown that at present the plant is under the strongest influence of human economic activity. The organization of numerous beach areas, cafes, hotels and other residential complexes limit the range of the species in the coastal strip of the republic.

Keywords: *SeJa* mustard, coastal strip of the Caspian Sea, coastal communities, species composition, occurrence, soil moisture, anthropogenic factor

INTRODUCTION

Currently, research related to the state of flora and vegetation in vulnerable “red” zones is of particular relevance. Coastal ecosystems under the direct influence of human factors and transgression of the Caspian Sea are no exception [Kotlyakov 2004; Kostianoy, Kosarev 2005; Azerbaijan National Encyclopedia 2007; Gasimova, Ismayilov, Najafova 2015]. These territories are of constant interest and remain open for detailed botanical research. Information about the new species that have appeared here and an assessment of their condition is of no small importance since some of them can gain a foothold with the status of aliens, while others, having fallen into stressful (ecological, anthropogenic, etc.) conditions, can become

vulnerable, rare species. One example is the relatively recently discovered species *Cakile euxina* in the Azerbaijani part of the Caspian Sea. In “Flora of the USSR” [Bush 1939] this plant is indicated for the sandy shores of the Baltic, Azov, and Black Seas, in the “Flora of the Caucasus” [Grossheim 1950] this species is characterized as Mediterranean-Atlantic, found on the coastal cliffs of the Black Sea coast of the Caucasus. Regarding the occurrence of *C. euxina* in the coastal zone of the Caspian Sea, the first information is found in [Galushko 1983] “Flora of the North Caucasus”. Those who studied *C. euxina* in the Dagestan part of the coast [Teymurov, Satuyeva, et al., 2013] noted that currently the species is found throughout the Dagestan part of the Caspian Sea, and was also found on the

Nordovy and Chechen islands. The authors also suggest that *C. euxina* may have penetrated into the flora of the Western Pre-Caspian region no earlier than the middle of the 20th century, and the unclear nature of the distribution of this species is emphasized, i.e. perhaps this is a natural expansion of the range or the result of human activity. The authors further indicate that in a number of works by E.G. Pobedimova [1953, 1964] there is information about the genus, its range is outlined, and detailed synonyms are given. Among the cited herbarium specimens (the list is quite large) there is not a single one from the shores of the Caspian Sea."

Until the beginning of the 21st century, not a single researcher who studied the flora and vegetation of the coastal strip of Azerbaijan cited *C. euxina* in their works [Grossheim 1926], "Flora of Talysh", ["Flora of Azerbaijan" 1961], [Aghajanov 1971; Shakhshvarov et al. 1993; Gahramanova 2002]. For the first time in the Azerbaijan part of the Caspian Sea, the species was discovered in 2000–2005 by N.P. Mehdiyeva, in the vicinity of the village of Novkhani on the Absheron Peninsula and in the vicinity of the settlement Mukhtadir of Khachmaz administrative district, bordering Dagestan (Russia). Despite the lack of publication on this issue, N.P. Mehdiyeva's collections are confirmed by herbarium specimens from the Herbarium Fund of the Institute of Botany of the Ministry of Science and Education.

During the same period, in the coastal zone of the Lankaran district and also in Absheron, *C. euxina* was recorded by other local researchers [Hajiyev; Musayev, Karimov 2005]. Later, this species was indicated in the "Synopsis of the Flora of Azerbaijan" (Askerov 2011).

The appearance of *C. euxina* on the territory of Azerbaijan, in our opinion, is associated with its migration by sea to Khachmaz from Dagestan, and to Lankaran from the territory of Central Asia, since the large and light pods of the plant are capable of covering long distances on the surface of seawater, and the wind regime can carry them from sea to shore.

Considering that special studies characterizing the phytocoenotic traits of *C. euxina* in the conditions of the coastal strip of the South

Caucasus have not yet been collected, the purpose of the study was to monitor the condition of *C. euxina* in the Azerbaijani part of the Caspian Sea.

MATERIALS AND METHODS

The object of research is *C. Euxina* (sea mustard), a representative of the family *Brassicaceae* Juss. (Fig. 1 a, b). It is a taproot annual plant, up to 30 cm high. Flowering and fruiting occur in May–October [Timukhina et al. 2007].

The coastal strip unites 11 administrative (Absheron, Astara, Siyazan, Garadagh, Lankaran, Neftchala, Shabran, Shirvan, Masalli,



a)



b)

Figure 1. *Cakile euxina* on a wet sandy substrate in the Samur-Davachi lowland (a), in the Lankaran coast (b)

Khizi, Khachmaz) districts. According to the botanical-geographical division of Azerbaijan ("Flora of Azerbaijan"), it includes 5 botanical-geographical districts: Samur-Davachi, Pre-Caspian lowlands, Absheron, as well as the Kura-Araz and Lankaran lowlands. The first two botanical-geographical districts are located in the northern part of the strip, the Absheron peninsula the Kura-Araz lowland in the central, and the Lankaran lowland in the southern (Fig. 2).

Field observations and material collection were carried out in 2021. The study of habitats was carried out using the route method and the method of establishing sample plots with inspection of all types of ecotopes and associated plant communities with the participation of *C. euxina*. The research did not include sites of SPNA (Specially Protected Natural Areas). The geobotanical description was carried out by generally accepted methods in geobotany (Mirkin, Naumova 2001; Shennikov 1964; Pedrotti 2013). In habitats with the participation of the species, model plots measuring 100 x 100 m were laid out, which were divided into record areas of 1 m². On small plots, mapping and counting the number of individuals of the species were carried out, and on model plots, the community, its species composition were recorded, the total projective cover (%) and abundance were determined on the Braun-Blanquet scale (Braun-Blanquet, 1964).

During the study, the occurrence of *C. euxina* was also determined, by which we mean the frequency of occurrence of a certain species in a phytocoenosis, expressed as the percentage of sample plots with the participation of the species [Bykov, 1973]. To determine the influence of the soil moisture regime, soil moisture (Rh) indicators were taken, which were determined under field conditions. The taxonomic affiliation of the species was determined taking into account the "Flora of Azerbaijan" and the World Flora Online database (<http://www.worldfloraonline.org/>). Statistical calculations and plotting of dependence graphs were carried out in the Past 3 software using the Microsoft Excel package.



Figure 2. Division of the coastal strip into main parts

RESULTS

The structure of the vegetation cover of the coastal strip of the Caspian Sea is characterized by inequality. The Northern and Central parts are the closest in species composition. The main types of vegetation are semi-desert with the participation of annual saltwort communities (Asadova 2019) *Suaeda altissima* (L.) Pall., *S. confusa* Iljin, *Salicornia europea* L., subshrubs with *Salsola dendroides* Pall., *A. arenaria* DC. marshy with *Phragmites australis* (Cav.) Trin. ex Steud., halomesophilic meadow with *Juncus acutus* L., *Limonium meyeri* (Boiss.) Kuntze, *Calamagrostis gigantea* Roshev. and etc., as well as shrubby with the *Tamarix ramosissima* Ledeb., *Rubus caesus* L., *Elaeagnus angustifolia* L.

The southern part is significantly different from the first two. The main communities here are halomesophilic-meadow grass-forb (*Herbosa*, *Junceta*), as well as a coastal forest with the participation of *Pterocaria pterocarpa* (Michx.) Kunth ex. I.Iljinsk., *Alnus barbata* C.A.Mey., *Quercus castaniefoia* C.A.Mey. Herbaceous plant groups and communities are characterized by the presence of ecologically different plants from salt-tolerant to fresh, predominantly herbaceous annuals. In our opinion, this

mosaic pattern is associated with soil conditions of different quality.

If we consider the pattern of distribution of *C. euxina* from the point of view of coastal zonality, the appearance of single plant individuals begins from the zone of wet sand at a distance of 5-10 meters from the water strip with abundance marks of 1-2 points, the density of individuals per 1 m² is minimum 1 / maximum 3 individuals in places. With the distance and transition of wet sands to dry moving sandstones, the number of plants first increases to 4 points, the minimum density makes up 3

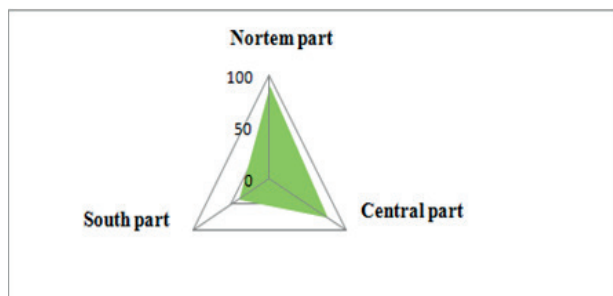
individuals per 1 m², and the maximum -5 individuals. With the transition of sandstone to clayey solonchaks, and from them to semi-desert gray soils, i.e. from a distance of 50-70 m, the abundance of the plant begins to sharply decrease as minimum 1/maximum 2 individuals per 1 m² (1 point in 2 places). The distribution pattern of *C. euxina* is usually diffuse - single or diffuse - group. The species is part of almost all coastal communities, except wetlands and forests (Table 1).

Table 1.

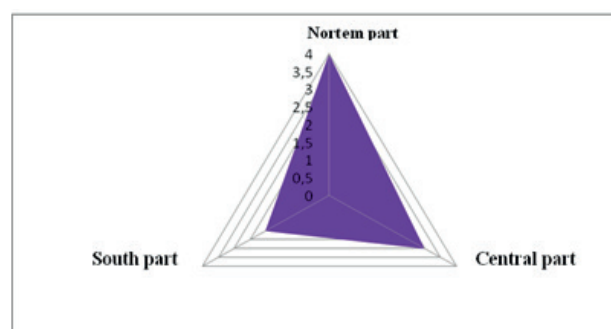
Plant communities of the coastal strip of the Caspian Sea with participation of *Cakile euxina*

Coastal zones	Plant communities
North	<i>Argusiya sibirica</i> + <i>Convolvulus persica</i> , <i>Artemisia annua</i> + <i>Convolvulus persica</i> , <i>Melilotus officinalis</i> + <i>Artemisia annua</i> , <i>Xanthium strumarium</i> + <i>Cakile euxina</i> , <i>Salicornia europea</i> + <i>Suaeda confusa</i> , <i>Salsola tragus</i> + <i>Convolvulus persica</i> , <i>Artemisia arenaria</i> + <i>Herbosa</i>
Central	<i>Argusiyasibirica</i> + <i>Convolvulus persica</i> , <i>Cakile euxina</i> + <i>Argusiya sibirica</i> , <i>Astragalus ignarius</i> + <i>Calligonum bakuense</i> , <i>Juncus acutus</i> + <i>Elaeagnus angustifolia</i> , <i>Salicornia europea</i> + <i>Suaeda confusa</i>
South	<i>Argusiya sibirica</i> + <i>Convolvulus persica</i> , <i>Herbosa</i>

High occurrence and abundance are observed in annual saltwort communities (*Suaedetum*), characteristic of the northern and central parts of the coast. Here, the occurrence of *C. euxina* with high abundance levels of 3-4 points is 70-90%. In the southern part, it is significantly lower than 30-40%, and the abundance is 1-2 points (Fig. 3 a, b). In our opinion, the reason for this pattern consists of the initial penetration of the plant from the northern side of the coast and more favorable edaphic conditions in this part of the coastal region. However, this is the subject of a separate study.



a) Occurrence of *C. euxina* on the coast of the Azerbaijani part of the Caspian Sea



b) Abundance of *C. euxina* on the coast of the Azerbaijani part of the Caspian Sea

Often forms independent groups and communities with an area of 10 x 10 m or more. We have registered the following species as part of phytocenoses with the participation of *C. euxina*: *Artemisia annua* L., *A. arenaria*, *Argusia sibirica* (L.) Dandy, *Salsola tragus* L. *Senecio vernalis* Waldst. et Kit., *Triplolium vulgare* Nees, *Cardaria draba* (L.) Desv., *Convolvulus persicus* L., *Schoenoplectus lacustris* (L.) Palla, *Salsola tragus* L., *S. europea* L., *S. altissima* (L.) Pall., *S. Confusa* Iljin, *Petrosimonia brachiata* (Pall.)

Bunge, *Melilotus caspius* Grun, *Cyperus longus* L., *J. acutus* L., *J. litoralis* C.A.Mey., *Tamarix ramosissima* Ledeb., *Limonium meyeri* (Boiss.) Ktze, *Mentha aquatica* L. and etc. In Absheron and further towards the settlements Gobustan and Alat (Garadagh and Shirvan districts), combinations of these species are most often observed: *C. euxina* c **A. sibirica** and *C. persicus* with participation in their composition *Sphenopus divaricatus*, *Parapholis incurva*, *Myosotis hispida* Schltld., *T. vulgare*, *Capsella bursa-pastoris* (L.) Medik., *Anisantha tectorum* (L.) Nevski, *Psylliostachus spicata* (Willd.) Nevsky, *Astragalus ignarius* M.Pop., *Calligonum bakuense* Litv., *J. acutus*.

In the southern part (Lankaran lowland), the role of *C. euxina* is significantly different. The number of populations here is not so high - abundance 1-2, minimum density 1/maximum 2 individuals per 1 m², the nature of the distribution is mainly diffuse-single, does not form independent groups. In these places, the growth of *C. euxina* begins behind the surf zone as part of weakly formed open herbaceous groups and communities with the participation of annual and perennial forbs. The background plants are *Convolvulus persicus* L., *Schoenoplectus lacustris* (L.) Palla, *A. sibirica*, *Eremopyrum orientale* (L.) Jaub&Spach, *T.vulgare*, *Rapistrum rugosum* (L.) All., *Equisetum ramosissimum* Desf., *Erodium cicutarium* (L.) L'Her., *Convolvulus arvensis* L. *Myosotis hispida* Schltld., *Capsella bursa-pastoris* (L.) Medik., *Digitaria ciliaris* (Retz.) Koel., *Solanum nigrum* L., *Alopecurus myosuroides* Huds, *A. tectorum* and etc. All species are represented with equal abundance from 2-3 and are scattered diffusely.

From Table 1 it is clear that in all parts of the coastal territory of the Caspian Sea, the characteristic communities for *C. euxina* are *Argusiya sibirica*+*Convolvulus persica*, since both species are also ecologically confined to the same sandy habitats as the object of the study and have a zonal coastal distribution.

We also determined the optimal soil moisture conditions for *C. euxina* under local conditions. Measurements of field humidity and analysis of the data obtained showed that the most optimal range for the species is a humidity

range of 50-60% with a lower limit of 20-30% and an upper limit, which allows us to interpret this species about humidity as a saprophytic-littoral xeromesophyte (Fig. 4). As a result, considering the high abundance of the plant in halophytic annual saltwort communities, under local conditions it can be considered a haloxeromesophyte.

In the Caspian coastal strip, there are four main types of coenobitic conditions: wet sands, swampy areas, dry sands (forb and shrub communities), and gray soils of semi-desert type (shrubs, fragmentary forest groups). The first ones are usually located along the shore itself. The latter are mainly adjacent to the watery coastal strip, often occupying quite large areas, or they are fragmentarily scattered along the coast and form more in areas where rivers flow

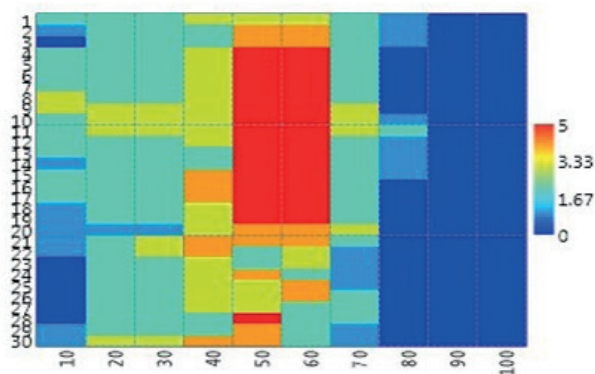


Figure 4. Indicators of optimal soil moisture regime conditions for *Cakile euxina* in the range of 10 - 100% based on 30 sites, taking into account the construction of a matrix based on DCA analysis (X- axis - soil moisture indicators in %, Y- axis - No. of counting sites; color spectrum range from 0 to 5 means the number of individuals of the species on the counting sites).

into the sea.

Dry sands are usually located at a distance of 30 - 50 and then up to 100 - 200 m from the seawater line, followed by desert gray soils. The ratio of these areas and the vegetation growing on them is decisive in the distribution of *C. euxina*. In the Northern and Central parts, the dominance of wet and dry sands, in principle, contributes to the favorable development and distribution of the species. Here the limiting

factor is mainly swampy areas occupied by impenetrable thickets with *Phragmites australis* Cav Trin. ex Steud., *Typha latifolia* L., as well as standing waters with *Hydrocotyle vulgaris* L., *Zannichellia pedicillata* Buch. and other plants, which are mainly concentrated at the junction of Samur-Davachi (Khachmaz administrative district) and the Pre-Caspian lowlands (Si-yazan, Shabran administrative districts). These reed swamps are mostly a homogeneous, difficult-to-pass thicket of reeds of gigantic size, which is a limiting factor for the spread of not only *C. euxina*. The remaining representatives of marshy areas are represented singly and sparsely. In the south, due to the presence of a narrow, small sandy strip, the distribution of *C. euxina* is limited.

It should be noted that, along with edaphic factors, human activity also hurts the plant. The coast we studied is currently under its strongest influence. First of all, this includes recreational infrastructure loads, which lead to a reduction in the areas occupied by vegetation, which includes *C. euxina*. The coastal strip in the zone 2-50 m away from the water line is most susceptible to negative influence. It is in this part that beach areas, cafes, spontaneous dumps of garbage, hotels, and summer cottages are organized. Analysis of floristic lists shows that it is in these zones that there is a sharp decrease in the abundance of *C. euxina*, *C. persica*, and annual saltworts.

CONCLUSION

The study showed that the psammophytic-littoral species *C. euxina*, which appeared relatively recently in Azerbaijan, successfully spread throughout the entire coastal zone of the republic within 20 years. Based on the materials of previous researchers and our observations, we can conclude that the expansion of the range of *C. euxina* has the character of progressive and dynamic adaptation to local conditions. If at the beginning of the century *C. euxina* was found singly in two administrative districts of the republic or two botanical-geographical districts, then after twenty years this plant and its groups and communities were registered by us in already ten administrative districts (except the Neftchala district) belonging to five botanical-geographical districts. *C. euxina* behaves like a halo mesophyte about the moisture and salinity regime in the conditions of the Azerbaijan part of the Caspian coast. The dominance of the plant is observed in the northern coastal part. Natural regeneration of the plant proceeds satisfactorily, which is confirmed by the presence of independent communities. However, the development of tourism and the expansion of the infrastructure of the coastal strip hurt the entire coastal vegetation. In this regard, a reduction in the range of *C. euxina*, as well as a number of other species of the coastal zone, is possible.

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FLORA OF THE TIRIL MOUNTAIN (ANDIRIN/KAHRAMANMARAŞ/TURKIYE)**Cihangir Uygun¹, İsmail Kazancı², Sadı Bağcı³**¹Akedaş Primary School, Yamaçtepe mah. 93054 sok. No:6/A Onikişubat/Kahramanmaraş/Türkiye²Cahit Zarifoğlu Primary School, Necip Fazıl Mahallesi 50012. Sokak No:1, Onikişubat / Kahramanmaraş³Karacasu Ferihsu Primary School, Karacasu Kırım mah. Üniversite cd. No:19/3 Dulkadiroğlu/Kahramanmaraş¹ Correspondence: uygunch@gmail.com

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Abstract. *In this study, the flora of Tiril Mountain, located in Andırın district of Kahramanmaraş province, was investigated. The research area is also located on C6 square by P.H.DAVIS's grid system for Türkiye. The area is also on the route of the BTC (Baku-Tbilisi-Ceyhan) pipeline. The mountain's elevation starts from 900 m and rises to 1850 m to the top. The climate of the area is Mediterranean climate type but altitude affects the precipitation periods and types. The major soil type is red-brown forest soil. Research material is the plant samples which are collected from the research area between the years 2010 and 2014. According to the results of the study, 503 taxa were described from 61 families, 285 genera. A percentage of 12,92 which contains 65 species are Endemic. Distribution by phytogeographic regions of taxa is as follows: 86 (%17,09) of Mediterranean elements, 86 (%17,09) of Irano-Turanien elements, 30 (%5,96) of Europea-Siberian Elements, 78 (%15,50) of widespread and 223 (%44,33) are multi-regional. The major family by the genera is Asteraceae with 41 genera, major genera by the species is Vicia with 10 species. Results of the study show a correlation with previous studies from nearby areas.*

Keywords: *Flora, Tiril Mountain, Kahramanmaraş, Andırın, Türkiye***INTRODUCTION**

One of the oldest pursuits in human history is to recognize and classify the natural environment. In this context, many scientists and thinkers have carried out studies and created scientific or personal classifications since ancient times. The concept of classification was first revealed by Aristotle, based entirely on observation. Later, classification became a branch of science and became the common language for almost all branches of science. In all branches of science, from medicine to chemistry, from philosophy to history, data has begun to be filtered through certain filters and each branch of science has begun to develop its own classification rules.

Our country has a very rich and special place

in terms of plant diversity, which is the subject of our study. Our country, which is a gold mine in terms of geographical location, climate, and phytogeographical features, is also one of the few geographies in the world in terms of Endemic species. It is very rich in diversity as it hosts three climate zones, three phytogeographic areas, and very different landforms (Davis and Hedge, 1975).

The first studies on the flora of our country were made by the French botanist Tournefort in the 1700s. Swiss botanist Boissier carried out the first important study in this field covering the flora of Turkey between 1865 and 1888 and published the five-volume work called "Flora Orientalis". Edited by P.H. The work titled Flora of Turkey and The East Aegean Islands, written

by Davis and contributed by many researchers, completely revealed the flora of our country under the conditions of that day and became the main source for floristic studies. New discoveries and revisions were later added to this study, which was conducted between 1965 and 1985, through additional volumes. The total number of taxa included in this work, including additional volumes, was determined as 12006, and 3778 of these taxa were defined as Endemic. This shows us that the endemism rate of our country's flora is 31% (Avcı, 2005). When the studies carried out after the publication of additional volumes and the new species introduced to the scientific world are taken into account, it is seen that this number is increasing day by day (Çirpici, 1987).

The region we chose as the study area can be seen as a mini projection of our country in terms of these features. Especially being a transition zone makes the area more attractive. In this context, we think that our work is important in terms of constituting an ecological resource for the ongoing road, pipeline and dam works in the region. Especially the fact that the BTC oil pipeline passes very close to the region suggests that the works carried out along the line may affect the flora of the region (Özhatay, 2006).

Our study area is Tırıl Mountain, located within the borders of Andırın district, located in the northwest of Kahramanmaraş province. The mountain mass extends in the south - north direction. Its altitude is 900 m at the entrance level and rises to around 1800 m at the summit. The dominant soil type throughout the mountain is red-brown forest soil (Blumental, 1941). However, especially on the eastern side of the mountain, limestone rocks that have been deeply split by rainfall cover a large area. There are maquis and plateau houses at the entrance level of the mountain. Starting from an altitude of 1000 m, mixed forest vegetation containing different tree species covers the mountain mass up to the summit. The dominant climate type in the area is the Mediterranean climate. However, high altitude causes some changes to be seen (Karaosmanoğlu, 2011). Especially the excessive amount of snowfall and the length of time the snow stays on the ground also affect the vegetation. Snow cover can be seen

between the 1500 m altitude and the summit of the mountain until the end of March. The humid air created by the dam lake located at the very beginning of the mountain and the settlements located in the southern part of the mountain are other factors that affect the vegetation.

MATERIALS AND METHODS

The material of our study consists of plant samples collected from the study area between 2011 and 2013. The samples were collected based on height, according to predetermined stations, taking into consideration the flowering and fruiting periods, and were dried using appropriate methods. For the collected samples to be suitable for the classification study, care was taken to ensure that their organs were whole and undamaged. During the drying process, drying cartons were kept thicker and changed more frequently for bulbous plants and species sensitive to certain characteristics (species whose flowers change color or are susceptible to deterioration after drying). Species with high water content, such as members of Orchidaceae and Iridaceae, were also dried using paper towels to ensure maximum protection. Aquatic species were identified immediately after collection and dried with thick drying cardboard.

P.H. DAVIS's "Flora of Turkey and East Aegean Islands" was taken as a reference along with its additional volumes, which were used as the main source for the Flora of Türkiye in the identification of the samples. For species that could not be found in this work, flora of surrounding countries, revision studies (Al-Shehbaz et al., 2007, Boissier, 1867, G.E. Post, 1932), and publications containing species described in recent years were scanned, and samples that could not be identified were separated and kept for detailed study. The identification process was first made at the family level based on stations, and then it was classified and recorded based on genus and species. Additionally, for visual comparisons during classification, Özhatay et al. Visual examples (2008), İlçim (2014), Atay et al. (2009), and Altınayar (1987) were also used. International naming rules were taken into account in naming the species. Cultivated plants and synonyms were not taken into account when preparing floristic lists.

RESULTS

When the study results were examined, a floristic structure similar to the nearby areas and previous studies emerged. There is a clear correlation between climate, soil structure, and vegetation. However, there are also obvious deviations, especially in the upper parts of the mountain and in areas where forests are dense. Deterioration in the floristic structure has been observed in areas where human life is dense and in areas where plateau houses are located.

Approximately 1200 plant samples collected during the study, taking into account seasonal characteristics, were stored under appropriate conditions and identified through floristic resources. As a result of these definitions, 503 species and subspecies taxa belonging to 61 families and 285 genera were identified. 65 of the taxa are Endemic and the endemism rate is 12,92%. In the distribution of taxa according to phytogeographic regions, 86 taxa were determined as Mediterranean Element, 86 taxa as Iran-Turanian element, and 30 taxa as European-Siberian Element. 78 of the taxa are widely distributed. 54 of the described taxa are evaluated in a threat category of LR or higher level. *Cyclamen pseud-ibericum* Hildebr. was evaluated

in the EN category. *Symphytum aintabicum* Hub.&Mor.&Wickens, *Ornithogalum alpigenum* Staph., *Verbascum pinetorum* (Boiss.) O. Kuntze and *Verbascum subnivale* Boiss.&Hausskn. was evaluated in the VU category (Ekim et al., 2000).

When examined on the basis of families, the family containing the most genera is Asteraceae with 43 genera. This is followed by Brassicaceae with 31 genera, Poaceae with 23 genera and Fabaceae with 22 genera. When we look at the families with the most species, Asteraceae comes first with 74 species. This is followed by Fabaceae with 58 species, Poaceae with 44 species, Brassicaceae with 42 species, and Labiatae with 35 species.

When examined based on genera, the genus containing the most species is *Vicia* with 10 species. This is followed by *Astragalus* and *Anthemis* with 7 species each. *Centaurea*, *Salvia*, *Allium*, *Lathyrus*, *Trifolium*, and *Poa* are represented by 6 species each. The most Endemic species are in the Asteraceae family with 11. Based on genera, the genera *Centaurea* (Asteraceae) and *Astragalus* (Fabaceae), represented by 4 Endemic species each, stand out.

Table 1.

Distribution of Tırıl Mountain plant diversity to phytogeographic regions

Phytogeographic Region	Number of Taxa	Rate (%)
Mediterranean	86	17,09
Irano – Turanien	86	17,09
Europea – Siberia	30	5,96
Widespread	78	15,50
Multi regional	223	44,33

Table 2.

Major families by taxa

Family	Number of Genera	Number of Species
Asteraceae	43	74
Brassicaceae	31	42
Poaceae	23	44
Fabaceae	22	58
Apiaceae	19	25
Lamiaceae	17	35
Boraginaceae	11	21
Liliaceae	10	23

Table 3.

Genera with the most species

Genera	Family	Species
Vicia	Fabaceae	10
Astragalus	Fabaceae	7
Anthemis	Asteraceae	7
Centaurea	Asteraceae	6
Salvia	Labiatae	6
Allium	Liliaceae	6
Lathyrus	Fabaceae	6
Trifolium	Fabaceae	6
Poa	Poaceae	6

DISCUSSION

When the study results are compared with previous studies conducted in the immediate area, the flora of the area appears compatible with the surrounding flora. The study of Karakısa (1997); He made a preliminary study on the flora of the Dibek Mountains, which includes the southern end of our study area and is located in the Adana - Osmaniye - Kahramanmaraş triangle. As a result of the study, 665 taxa belonging to 90 families and 357 genera were

identified from the area. Varol's (1997) study; investigated the flora of Başkonuş Mountain, the southeastern neighbor of our study area. As a result of the study, 528 taxa belonging to 67 families and 268 genera were identified from the area. In Yıldız (2001) study; investigated the flora of Berit Mountain, located in the east of our study area. As a result of the study, 1165 taxa belonging to 97 families and 462 genera were identified from the area.

Table 4.

Comparison of the number of families, genera and species with the surrounding flora

	Number of Families	Number of Genera	Number of Taxa
Tırıl Mountain	61	285	503
Sarımsak Mountain*	58	238	411
Kayranlı Mountain*	73	344	625
Berit Mountain (Yıldız, 2001)	97	462	1165
Başkonuş Mountain Varol, 1997)	67	268	528
Dibek Mountains (Karakısa, 1997)	90	357	665

* These studies were carried out simultaneously with Tırıl Mountain by corresponding author in this study.

When we look at the floristic character of Tırıl Mountain, it has been determined that the untouched structure of the mountain has an impact on diversity and that it shows a more complex diversity depending on its geographical location due to its wide altitude range and high vegetation diversity. Although it is

geographically located in the Eastern Mediterranean region, the number of taxa that are more widespread in continental climates is almost as high as Mediterranean plants, which is an indication of this. It is possible to attribute the mountain's lack of maquis, except for its eastern entrance, which has a Mediterranean

profile, to its rocky and steep structure. Especially the rocky belt starting from 1200 m and extending up to 1500 m prevented the spread of maquis plants.

On the southeastern side of the mountain, the influence of both the settlement Yesilyurt Village and the dam lake can be seen. In these regions, steppe areas are more abundant than other parts of the mountain. The strong forest structure, which can be seen starting from 1300 m altitude and the northern slopes, preserves its existence up to 1750 m. *Pinus brutia* members are the main elements in the forest texture, which occasionally includes steppes. It is also possible to see *Cedrus* and *Fagus* belts in places. The alpine steppes between 1750 m and the summit show a weak vegetation cover due to both their rocky structure and long-term snow cover. These areas have become ideal distribution areas, especially for *Astragalus* and *Acanthalimon* members. The western

face of the mountain is completely forested. In this section, *Fabaceae* members, *Viola* and *Potentilla* species, and *Colchicum* members stuck between the rocks are abundantly seen.

The plateau houses in the area, the dam lake that has just started to remain silent, and the extensive sheep farming activities in the surrounding area are the main factors that may hurt the flora of the area. For this reason, the flora of the area can change after a certain period. The high rate of endemism and the existence of threatened species make it necessary to take conservation measures in the area. It is also important to include *Orchidaceae* members in protected areas where there are examples in the immediate vicinity.

GRATITUDE

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STUDYING THE GENE POOL OF THE WILD ANCESTOR OF BARLEY IN AZERBAIJAN

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Abstract. *This study underscores the significance of exploring and studying wild cereal species, with a focus on wild barley, revealing diverse hotspots in Azerbaijan. Expeditions identified regions of high biological diversity and potential threats such as overgrazing and uneven precipitation. Over 200 wild barley accessions, including hybrid forms, were collected, showcasing the versatility of these wild ancestors. The gathered accessions underwent multi-year analysis at the Absheron Experimental Base of GRI, revealing variations in germination time (164 to 186 days), resistance levels to powdery mildew (5-9 points), and yellow rust. Sheaf and spike analysis identified 346 fractions, exposing genotypic variations in plant height (110 to 170 cm), ear shape, glume color, awns, and seeds. Following five years of study and propagation, 337 wild barley samples were transferred to the National Genebank. The study emphasizes the ongoing exploration and preservation of genetic resources in wild barley, essential for enhancing cultivated varieties and developing tolerance to heat, drought, and salt stress.*

Keywords: *barley, Hordeum vulgare, subsp. spontaneum, habitat, genetic diversity*

INTRODUCTION

Modern biology prioritizes collecting, clarifying distribution areas, and studying wild, rare, and endangered species, including indigenous varieties. Drastic changes in biogeocenoses, caused by global warming and unsustainable pasture use, have led to habitat reduction and extinction threats. In the case of annual cereals, the absence of regeneration results in the depletion of seed stocks in the soil, disrupting the delicate balance in biogeocenoses. To address this, ongoing efforts should focus on collecting endangered species, preserving habitats, and storing them in gene banks [Rustamov, 2016].

Barley (*Hordeum* spp.), cultivated for around 10000 years, is one of the oldest crops. It holds the fourth position globally among cereals,

following corn, wheat, and rice. Barley grain serves as a concentrated feed and a key ingredient for beer and whiskey production. With an average of 13.4% protein and 54% starch, barley is valuable for livestock, especially its chaff, superior to wheat straw in nutritional content. Barley straw provides 10g of digestible protein or 0.36 feed units per kg, while barley grain offers 100g of digestible protein or 1.28 feed units [Trofimovskaya, 1991].

Wild barley (*H. spontaneum* C. Koch), the precursor of cultivated barley (*H. vulgare* L.), was a major Neolithic food crop, carrying mutations advantageous for adaptation. Consequently, wild barley stands as a natural reservoir of genetic diversity for plant resistance to abiotic and biotic stresses [Brown et al, 2009].

Several studies confirmed higher genetic diversity in wild barley compared to cultivated barley, suggesting that domestication led to a loss of significant genetic variants. Thus, wild barley, widely distributed from the Middle East to Central and Western Asia and the Tibetan Plateau, offers valuable genetic material for enhancing current cultivars and developing new ones.

Recent studies challenge the notion of a singular origin for barley, suggesting a polyphyletic origin. Transcriptome analysis from 12 *H. spontaneum* and 9 *H. vulgare* accessions reveals the Tibetan Plateau as a center for domestication alongside the Fertile Crescent. Profiling both cultivated and wild barley genotypes indicates multiple origins. Genomic data suggests modern barley originates from Fertile Crescent (primarily on chromosomes 1H, 2H, and 3H) and Tibetan (mainly on chromosomes 4H, 5H, 6H, and 7H) wild barley genotypes. These findings enhance our understanding of early crop spread, intriguing evolutionary geneticists and plant breeders [Fei et al., 2014].

During domestication, mutations in cultivated barley, particularly in the *Ppd-H1*, *vrs1*, *HvAP2*, and *HvCEN* genes on the second chromosome, enhanced cultivation convenience. These mutations influenced flowering time and awn morphology. Wild barley awns are more jagged and durable, and ripe seeds easily detach along with the flower scales. This adaptation is suitable for animal distribution but proves inconvenient for farmers. Additionally, a variant of the *VRN-H3* gene on the seventh chromosome affected seed germination time. On the third chromosome, two mutations made the seeds non-falling, a pattern seen in other early domesticated cereals (<https://elementy.ru/>).

Prikazyuk and Smekalova (2013) utilized Vavilov's (1938) differential geography and systematics method to trace the distribution of intraspecific taxa of wild barley to suggest a possible center of origin of the species. They identified accessions from five botanical varieties of wild barley (out of six): *H. spontaneum* var. *bactrianum* Vav. (brown ears), var. *ishnaterum* (Coss.) Thell. (sharp flower scales), var. *proskowetzii* Nabel. (short awns of flower scales), var. *spontaneum* C.Koch (blunt flower

scales), and var. *transcaspicum* Vav. (black ears and black awns) using materials from the VIR herbarium and genebank seed collection. Collection points were plotted on maps using MapInfo 9.5 software, revealing the highest diversity of *H. spontaneum* in northern Iraq [Prikazyuk and Smekalova, 2013].

Our primary objective was to survey, identify, and discover distribution areas for cultivated cereal crops and their wild relatives. Additionally, our work focuses on a thorough examination of bioecological and agronomic traits, along with breeding characteristics, certification, and subsequent transfer to the Gene Bank.

MATERIALS AND METHODS

Expeditions to collect barley accessions were held in May and June of both 2018 and 2019 with the support of the United Nations Development Fund (UNDP). The collecting activities spanned the lowland and foothill regions of Azerbaijan, encompassing the Nakhchivan Autonomous Republic. Expedition routes were strategically planned to traverse areas with anticipated diversity in cultivated species and their wild relatives of cereal crops. These routes included Gobustan, Shamakhi, Agsu, Kabala, Oguz, Sheki, Salyan, Bilasuvar, Jalilabad, Bahramtapa, Imishli, Saatly, Sabirabad, and Hajikabul, extending to Absheron and the outskirts of Baku (Badamdar). Notably, the expedition to the Nakhchivan Autonomous Republic specifically targeted the Araz lowland and foothill areas.

Experimental work was carried out at the Absheron Experimental Station of the Genetic Resources Institute. More than 200 accessions and hybrid forms of *H. vulgare* subsp. *spontaneum* were studied in the collection nursery, collected during the 2018-2019 years.

RESULTS

Exploring and gathering crop wild relatives holds significant importance, as these resources offer invaluable genetic diversity crucial for enhancing agricultural resilience and sustainability. It is established that Azerbaijan, positioned within the Western Asian center, serves as a primary origin of cultivated plants, including

various cereals.

As a result of the expeditions to different regions of Azerbaijan, hotspots characterized by a diverse array of wild ancestors of cereals, including barley were identified. Regions exhibiting notable biological diversity were pinpointed, and potential adverse impacts were assessed, encompassing concerns such as overgrazing leading to heightened pressure on pastures and hayfields, uneven distribution of precipitation during the growing season, and disturbances in ecological the balance due to soil salinization.

The ancestor of cultivated barley, *Hordeum vulgare* subsp. *spontaneum* (C.Koch) Thell. [*Hordeum spontaneum* C.Koch], is widely distributed across diverse soil and climatic conditions throughout Azerbaijan. During expeditions, over 200 samples of subsp. *spontaneum* was collected from 34 distinct locations, frequently revealing the presence of hybrid forms among them. Connecting to the exploration of wild ancestors, particularly in Mountainous Shirvan, notable hotspots were identified. Specifically, at an altitude of 350 meters above sea level (m.a.s.l.) in the Agsu Pass (48°41'16.1" E, 40°58'56.8" N), dense thickets of wild ancestral species, comprising barley were observed on the outskirts of grain fields. The collected samples included: 1) *Hordeum vulgare* L. ssp. *spontaneum*; 2) *H. bulbosum* L. (*Aegilops cylindrica* Host.); 3) *Ae. tauschii* Coss.; 4) *Ae. biuncialis* Vis.; 5) *Ae. triuncialis* L. and 6) *Triticum montanum* Makush. (= *Triticum araraticum* Jakubz.). Additionally, populations of wild barley and *Aegilops* species (*Ae. cylindrica*; *Ae. tauschii*; *Ae. biuncialis*; *Ae. triuncialis*) were discovered near the Shahzahirli-Arabkadam roads (49°6'24.7" E, 40°28'26.7" N, 640 m.a.s.l.), and the Gobustan traffic police post (48°32'18.1" E, 40°19'9.4" N, 812.6 m.a.s.l.) in Gobustan district.

Subsequent expeditions across the plains, foothills, and mountainous regions of Azerbaijan along the Bahramtepe road (48°9'30.72" E, 39°39'19.44" N) at an altitude of 10 m.a.s.l., allowed to detection of abundant populations of the wild ancestor of barley (ssp. *spontaneum*). Moreover, explorations in the foothills of the Nakhchivan Autonomous Republic, within the territory of the village of Maralik, Shahbuz

region (near the pumping station - 45°28'20" E, 39°22'12" N, 1137 m.a.s.l.) and in the Pirjuvar area of Babek region (45°32'39.23" E, 39°11'38.68" N, 1000 m.a.s.l.) revealed a diverse gene pool encompassing barley (*H. vulgare* L.), and various wheat (*Triticum* L.) and *Aegilops* species (*Ae. cylindrica*; *Ae. tauschii*; *Ae. biuncialis*; *Ae. triuncialis*). Another hotspot for cereals was identified on the right side of the Yevlakh-Zagatali-Georgia road (47°2'21.7" E, 41°7'51.82" N, 270 m.a.s.l.) with abundant populations of wild barley, and *Aegilops* species (*Ae. biuncialis*, *Ae. triuncialis*, *Ae. cylindrica*, *Ae. tauschii*) as well. Similarly, in the village of Jumakand along the Suvalig-Sheki road, particularly above the Babaratma sanctuary (46°57'9.31" E, 41°11'27.08" N, 280 m.a.s.l.), dense populations of these species were also identified.

In addition to collecting, it's crucial to reproduce and thoroughly study the materials gathered during expeditions. Researchers engaged in the study of wild plants encounter notable challenges, particularly in spike analysis and the acquisition of a sufficient seed quantity for deposition in the Gene Bank. In the case of wild barley, the ears gradually break down into spikelets during the ripening process, complicating analytical procedures. Furthermore, obtaining samples during the milky-waxy ripeness stage affects crop structure indicators like grain weight per ear and the weight of 1000 grains.

The accessions gathered during the expeditions were planted and analyzed at the Absher-on Experimental Base of GRI over several years. It's important to note that the time from germination to flowering and heading varied significantly among genotypes, ranging from 164 to 186 days. Additionally, the accessions collected during the expedition manifested distinct levels of resistance to powdery mildew (5-9 points) and yellow rust (from medium sensitive to medium resistant), underscoring the variability within the population.

During the sheaf (reap) and spike analysis of the expedition material, a total of 346 fractions were identified. These identified genotypes exhibited variations in plant height, ear shape, and color of glumes, awns, and seeds.

Plant height ranged widely, from 110 to 170 cm. There were notable differences in yield indicators and structural elements between accessions of wild and cultivated barley. Significant variations were observed in ear density, shape, and color of glumes. Additionally, special attention was given to accessions with large grains. It's worth mentioning that the variety var *transcaspicum* Vav. was not found among the subsp. *spontaneum* accessions.

After studying and propagating seeds over the 5 years, a total of 337 samples of subsp. *spontaneum* was transferred into the National Genebank. Future research will focus on exploring the gene pool of wild barley to develop genetic resources for enhancing heat, drought, and salt tolerance, contributing to the enrichment of the cultivated barley gene pool.

CONCLUSION

Through expeditions in the lowland, foothill, and mountainous regions of Azerbaijan,

areas with a rich biodiversity of the ancestor of cultivated barley (ssp. *spontaneum*) and other cereals were identified and potential negative impacts were assessed. It was observed that factors such as excessive grazing, increased pressure on pastures and hayfields, uneven distribution of precipitation during the growing season, disturbances in the ecological balance, construction, and expansion of roads, crop rotations, and chemical weed control with herbicides have diminished the natural habitats of wild ancestors of crops. In some regions, these species were on the brink of extinction.

Recommendations for relevant authorities were developed according to international standards and GIS data. Furthermore, a total of 337 accessions of subsp. *spontaneum* was transferred to the National Gene bank as part of our ongoing efforts to preserve and study the genetic diversity of these crucial plant resources

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EFFECT OF GLYCYRRHIZIC ACID COMPLEXES ON GERMINATION OF WHEAT SEEDS (*Triticum aestivum* L.)

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Abstracts. Glycyrrhizic acid (GA): Phytohormones (PH); PH: indole-3-acetic acid (IAA); indole-3-butyric acid (IBA); Supramolecular complexes consisting of naphthalene-1-acetic acid (NAA) and kinetin (100 microns) significantly increase the intensity and volume of water saturation wheat grains "Thunder" in laboratory conditions compared with the control, the energy of grain germination in experimental conditions. salinity (NaCl=200 mM) and has been found to optimize the germination rate. The results obtained show the high prospects of using supramolecular complexes of GA:phytohormones in agricultural practice to optimize the process of germination and development of plants under conditions of stress factors, including salinization.

I. INTRODUCTION

Globally, due to intensive use of land resources, increased crop productivity and excessive use of chemicals in the plant disease control system, as well as the use of unscientific agro-reclamation measures, the level of soil salinization of cultivated crops is increasing. The areas are increasing [Baishanova et al., 2016]. This has a negative impact on plant growth and development, as well as on productivity and crop quality [Belozerovala, 2014]. Accordingly, the selection of salt-resistant varieties of agricultural plants or the improvement of sustainability indicators are noted as one of the directions. current scientific issues.

According to the results of studies related to increasing the salt resistance of plants, a wide range of natural and artificial preparations is recommended. Many of them have been implemented in practice to this day. At the same time, the prospects of using phytohormones that act as mediators of external signals in plant tissue cells are highly appreciated [Kushiev, 2011]. Some results have been recorded to increase the level of stability and the most important biological indicators at the stages of growth

and development of crops using bioregulators under the influence of salinization [Isaev et al., 2007].

Finding out the importance of phytohormones in the formation of mechanisms of resistance of a plant organism under the influence of various stress factors, the development of optimization technologies, methods and approaches is a theoretical/practical task [Abramova, 2016].

In this paper, studies have been conducted on the effect of supramolecular complexes of GA with FH (IAA; IBA; NAA and kinetin) on the parameters of germination of wheat grain of the wheat variety Grom (*Triticum aestivum* L.) under experimental salinization.

II. MATERIALS AND METHODS

2.1. Objects of research

In order to study the biological activity of auxins (IAA, IBA, NAA) and supramolecular complexes of kinetin and GA:FH, which are important in the growth and development of wheat, the wheat variety Grom (*Triticum aestivum* L.), which is grown on large areas in Tajikistan, was used in experiments.

2.2. Extraction/chemical identification of GA from licorice root (*Glycyrrhiza glabra* L.) and synthesis of supramolecular GA complexes:FH

In experiments, preparation of licorice root extract (*Glycyrrhiza glabra* L.) and extraction of GA from its contents (Fig. 2.1), chemical identification, synthesis of supramolecular GA complexes:FH based on standard "PerkinElmer Spectrum IR" methods. (Germany; version 10.6.1) Was carried out using a Fure IR spectrometer [Kondratenko, 2001].

2.3. Study of germination parameters of wheat grain (*Triticum aestivum* L.) in laboratory conditions.

Wheat grains were sterilized with NaClO solution (2% w) [Stanojevic D.,2014] or KMnO₄ solution (1% w) for 5 minutes or ethanol solution (70%) for 2 minutes [Bardina L.E. 2019], then washed in distilled water. Petri dishes were sterilized with a solution of ethanol (70% alcohol). Then the germination of wheat grains was observed in a Petri dish [Alenkina et al., 2016]. To do this, 100 grains were placed in each cup in an amount equal to the diameter of a Petri dish, and distilled water (10 ml) was placed on moistened filter paper [Tagaeva, 2019].

In the experiments, the filter paper "Watman No. 1" ("Sigma–Aldrich"; Germany) va D = 110 ("Chemreaktivkomplekt"; Russia) was used.

Germination of wheat grains was carried out for 10 days (240 hours) in the dark, in a thermostat at a temperature of +22 ° C. At the same time, after 24 hours, the germination process begins in the grains [Katarína Ražná et al.,2020].

During germination, the germination energy was calculated on the 3rd day (72 hours), and the germination level was recorded on the 10th day [Userbaeva B.A. et all. 2015].

A root whose length exceeded half the length of the seed was considered to be a seedling [Userbaeva et al.,2015].

Germination energy is the percentage (%) of grains that have sprouted at a normal level over the past time (3 days) in relation to the total number of grains [Rubets, 2016].

The degree of germination is the percentage (%) of grains sprouted at the standard level, compared with the number of grains used in

the general experiment [Rubets, 2016].

In experiments, germination (GA; Germination rate) it was calculated using the following formula [Hassan, 2015]:

Here, D represents the number of experimental days during which the calculation was performed.

2.4. Experimental model of salinity

In experiments, the germination rates of wheat (*Triticum aestivum* L.) were analyzed by a universal method under experimental salinization in laboratory conditions [Shapulatov et al.,2020].

The experimental salinity was created using incubation of NaCl (200 mM) [I. Belozerova, 2014], and distilled water was used in the control group.

In experiments, solutions of NaCl (Sigma-Aldrich; Germany), glycyrrhizic acid (GA), indolyl-3-acetic acid (IAA), indolyl butyric acid (IBA), kinetin and supramolecular complex GA:FH was prepared using the Techniport method (Poland; maximum 250 mg; accuracy level ± 0.2 mg); Laboratory scales JW-1 (200 ± 0.2 g; Acom; Korea) were used. To create an experimental salinity model, 0.117 g of NaCl was dissolved in distilled water (10 ml) (200 mM).

2.5. Mathematical and statistical processing of the obtained results

The experimental results were processed mathematically and statistically using standard biometric methods [Dospekhov, 2014], using a special software package OriginPro v. 8.5 SR1 (EULA, USA).

III. THE RESULTS OBTAINED AND THEIR ANALYSIS

In the experiments, the average weight of 1 grain of wheat in the control variant was 41.7 ± 2.4 mg, and after the soaking phase (72 hours) increased by $47.5 \pm 3.5\%$ compared with the control, i.e. It turned out to be 4 mg. At the same time, it was noted that the intensity of dehydration is at a high level during the first 16-72 hours (1-3 days). Also under the influence of supramolecular HA complexes:FH (FH: IAA, NAA, IBA and kinetin) (100 microns) during germination in laboratory conditions, the intensity and

dynamics of water absorption of wheat grain “Thunder” increased compared to the control, including the amount of absorbed water for

10 days, respectively - 28.4 ± 2.5 ; 25.5 ± 3.7 ; It turned out to be equal 20.8 ± 2.4 and 26.7 ± 3.8 mg (Table 1).

Table 1

The effect of supramolecular GA complexes: FH (FH: IAA, NAA, IBA and kinetin) on the dynamics of water absorption of wheat grain “Thunder” in laboratory conditions ($M \pm m$)

Variants	Mass dynamics in the process of grain germination (mg)					Amount of absorbed water (mg)
	An ounce of time (hours)					
	6	16	24	72	240	
Control (distilled water)	48,5±3,6	51,3±2,7	54,4±3,8	58,5±3,7	61,5±2,4	19,8±3,2
GA:IAA(4:1) 100 mkM	51,6±4,2	59,8±5,2*	67,5±3,5**	69,6±4,2**	70,1±3,6**	28,4±2,5
GA:NAA(4:1) 100 mkM	49,3±3,4	52,5±4,2*	60,2±4,4**	65,8±5,3**	67,2±4,5**	25,5±3,7
GA:IBA(5:1) 100 mkM	48,7±5,2	59,4±5,7*	60,8±2,5**	61,4±3,1*	62,5±4,4*	20,8±2,4
GA:kinetin (4:1) 100 mkM	50,6±2,6	55,4±4,1*	63,6±5,5**	67,6±4,8**	68,4±5,2**	26,7±3,8

Applications: * – the statistical level of reliability of the difference in the values of the experimental group compared with the control $p < 0.05$, ** – $p < 0.01$.

The results obtained correspond to the literature data [Tagaeva, 2019]. During germination, wheat grain enters the germination phase after water absorption of ~45-50% of its dry weight [Tagaeva, 2019]. Studies have shown that during the germination of wheat grain, the soaking phase lasts (~ 2-6 hours), and in the next phase (~6-16 hours), the water reaches the endosperm. In this phase, the rate of enzymatic reactions increases [Rogozhina, 2011].

In the process of seed germination, endogenous PH regulators perform an important physiological function [Tagaeva, 2019].

Optimization of the permeability of the biological membrane under the influence of HA has been noted in studies [Allaniyazova, al., 2020].

The results obtained can be explained by optimizing the permeability of biological

membranes under the influence of supramolecular GA complexes: FH (FH: IAA, NAA, IBA and kinetin) (100 microns).

In the next series of experiments, the effect of supramolecular HA complexes was analyzed: FH (FH: IAA, NAA, IBA and kinetin) on the parameters of germination of wheat of the Grom variety under experimental salinization.

In experiments, after 72 hours in laboratory conditions, the germination energy of grain in the control variant was $38.9 \pm 4.3\%$, and in experimental salinization ($\text{NaCl} = 200 \text{ mM}$) it decreased to $16.4 \pm 3.5\%$. Under the same conditions, under the influence of the GA:IAA (4:1), GA:NAA (4:1), GA:IBA (5:1), GK: The kinetin (4:1) changed accordingly to $36,4 \pm 7,3 \%$; $34,7 \pm 6,5\%$; $23,4 \pm 3,4\%$; $34,3 \pm 3,3\%$. Also, in experiments, the degree of germination of grain in laboratory conditions was equal to $86.4 \pm 5.7\%$ in the

control variant, and under experimental salinization (NaCl = 200 mM) it decreased to $43.7 \pm 4.2\%$, in turn, under these conditions during incubation of HA:IAA (4:1), GA:NAA (4:1),

GA:IBA (5:1) and GA:Kinetin (4:1) (at a concentration of 100 microns) the value of this indicator was $84.2 \pm 6.5\%$; $58.5 \pm 5.5\%$; $65.7 \pm 4.8\%$ and $76.2 \pm 6.4\%$, respectively (Table 2).

Table 2

The effect of supramolecular GA complexes:FH (FH: IAA, NAA, IBA and kinetin) on the parameters of germination of wheat grain "Thunder" ($M \pm m$)

Experiment options	Seed germination energy(%)		Seed germination rate(%)	
	Control	NaCl (200 mM)	Control	NaCl (200 mM)
Control (distiller. water)	$38,9 \pm 4,3$	$16,4 \pm 3,5^{**}$	$86,4 \pm 5,7$	$43,7 \pm 4,2^{**}$
GA (100 mkM)	$42,4 \pm 5,2^*$	$25,9 \pm 4,8^*$	$87,5 \pm 6,4^*$	$51,5 \pm 4,4^*$
IAA (100 mkM)	$40,5 \pm 6,4^*$	$35,6 \pm 5,5^{**}$	$95,8 \pm 6,3^{**}$	$80,5 \pm 6,6^{**}$
GA:IAA (4:1) 100 mkM	$48,3 \pm 5,3^{**}$	$36,4 \pm 7,3^{**}$	$96,3 \pm 6,5^{**}$	$84,2 \pm 6,5^{**}$
GA:NAA (4:1) 100 mkM	$39,3 \pm 4,5^*$	$34,7 \pm 6,5^{**}$	$92,3 \pm 3,7^{**}$	$58,5 \pm 5,5^{**}$
GA:IBA (5:1) 100 mkM	$24,6 \pm 4,2^*$	$23,4 \pm 3,4^*$	$90,4 \pm 3,5^{**}$	$65,7 \pm 4,8^{**}$
ГК:Кинетин (4:1) 100 мкМ	$45,4 \pm 6,6^{**}$	$34,3 \pm 3,3^{**}$	$95,6 \pm 4,4^{**}$	$76,2 \pm 6,4^{**}$

Applications: * – statistical confidence level relative to the control $p < 0.05$, ** – $p < 0.01$ ($n = 3-4$).

A decrease in the germination of wheat grain under the influence of salinization is noted by many researchers, and this condition is due to a decrease in the osmotic potential, an increase in the concentration of Na^+ ions has a cytotoxic effect, a slowdown in the transport of stored nutrients in the grain, a decrease in the degree of water absorption (absorption) of the seed [Akbarimoghaddam et al., 2011], an imbalance of K^+/Na^+ in the cell membrane and, in turn, the violation of the process of embryonic development [Wilson et al., 2000], as well as on the basis of such mechanisms, the dysfunction of the biological membrane, genetic and other factors are explained [Mass et al., 1990].

In studies, this is explained by a decrease in the morphometric/functional parameters of wheat grain during germination due to the

influence of salinity [Neelambari et al., 2018], a violation of ion homeostasis in cells, cytotoxic effect due to an increase in $[Na^+]$ [Khavarinegad et al., 2014].

Studies have shown an increase in the germination energy of wheat grains under the influence of PH (Auskin et al.) [Turkyilmaz, 2012], and the results obtained are consistent with literature data.

Normalization of morphofunctional parameters of the root under the influence of PH in salinization conditions was also noted [Khavarinegad et al., 2014].

Considering that PH plays an important role in the bioregulation of the enzyme activity of plant seeds during germination [Katarína Ražná, 2020], it is emphasized that the optimizing effect of PH in salinization conditions is

associated with the activation of functional enzymes [Neelambari et al., 2018].

The formation of the mechanism of plant resistance to stress factors is considered as a complex, multicomponent process involving specific/non-specific biochemical reactions [Katarína Ražná, 2020], while emphasizing that phytohormones are one of the central functional components [Aloni, 2004].

Thus, many researchers note that endogenous regulators positively affect the germination parameters of wheat grain under salinization conditions, increase the level of resistance to various abiotic stress factors, including salinization [Djuraev et al., 2018], and it is also noted that the use of PH in optimizing the parameters of germination of wheat grain under salinization conditions gives effective results [Neelambari et al., 2018].

In studies conducted in Uzbekistan, it was noted that the plant *Glycyrrhiza* L. and its derivatives isolated from its roots optimize the fertile properties of the soil under salinization conditions, positively affect the growth and development and productivity indicators of agricultural crops [Kushiev, 2011].

In particular, studies have shown that HA reduces the level of salinity, increases the concentration of phenolic compounds, increases the level of plant resistance to disease, and positively affects the germination and development of wheat due to the formation of a complex with soluble salts in the soil [Kushiev, 2011].

Thus, increasing the yield and quality of agricultural crops, ensuring food security is one of the strategic priority issues [Tagaeva, 2019]. In solving this problem, the prospects of using environmentally safe endogenous phyto regulators with the property of optimizing the germination and development of agricultural seeds are highly appreciated [Tagaeva, 2019].

It has been proven that the use of endogenous phyto regulators in agricultural practice increases growth-development, productivity, as well as the level of resistance to the effects of various phytopathogens and stress factors by stimulating complex biochemical/physiological processes in the plant organism [Tagaeva 2019].

In laboratory experiments, it was found that

supramolecular complexes of GA:FH (FH: IAA, NAA, IBA and kinetin) (at a concentration of 100 microns) significantly increase the intensity and dynamics of water absorption during germination of wheat grain compared with the control. Also, in the process of germination in the laboratory, after 72 hours under experimental salinity conditions (NaCl = 200 mM), significant optimization of grain germination energy and germination level was noted as the most important result. Under the influence of PH, the morphofunctional parameters of wheat grain in the initial phase of ontogenesis are higher than control, which can be explained by metabolic and biochemical changes occurring at the cellular level. The results obtained indicate the high prospects for the use of supramolecular GA complexes:FH in agricultural practice to optimize the process of germination and development of plants under conditions of stress factors, including salinization.

CONCLUSIONS

It can be noted that the germination of wheat grains and the development of the root system in an environment with a salinity level are primarily associated with the indicators of salt resistance of seedlings. According to the results of the conducted studies, it can be noted that supramolecular complexes of GA:FH (FH: indole-3-acetic acid; indole-3-butyric acid; naphthalene-1-acetic acid and kinetin) (100 microns) have a significant effect on the dynamics of water absorption of wheat grains, significantly increases the intensity and quantity compared with the control. Under conditions of experimental salinity (NaCl = 200 mM) under the influence of GA:FH can optimize the germination energy and germination of wheat grain. This situation makes it possible to increase the indicators of biological development based on the formation of vegetative organs of wheat seedlings under salinization conditions. The results obtained show the high prospects for the use of supramolecular GC complexes:FG in agricultural practice to optimize the process of germination and development of plants under conditions of stress factors, including salinization.

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COMPARATIVE STUDY OF THE MORPHOPHYSIOLOGICAL CHARACTERISTICS OF WHEAT AND MAIZE GENOTYPES EXPOSED TO SALT STRESS

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Abstract. *The effect of sodium chloride on the physiological and biochemical parameters of wheat and maize genotypes, the identification of salinity-resistant varieties was studied. The objects of the study were parental and hybrid wheat forms grown under normal and salinity (0,98 % NaCl) conditions. To create new salt-tolerant varieties of wheat and maize, a comparative analysis of the physiological parameters of the parental and hybrid plants was carried out. Physiological parameters such as chlorophyll content, relative water content, and PSII activity have been studied in parental forms and hybrids. When studying salt-tolerance of hybrids and parental forms, differences were detected in the relative amounts of chlorophyll (a+b), carotenoids, RWC, as well as the photochemical activity of chloroplasts. The effect of salt on the amount of chlorophyll a, chlorophyll b, and carotenoids, which are the main physiological indicators, is manifested in different ways in both hybrids and parental forms. Negative effects of salt stress were observed in the content of photosynthetic pigments, photochemical activity of PS II and RWC in parental and hybrid forms. The content of chl a, chl b, the activity of PSII, RWC and grain yield were higher in the parental forms, Garabagh, Gobustan, Barakatli-95, and in the hybrids, ♀Garabagh×♂Gobustan, ♀Barakatli-95×♂Gobustan, ♀Gobustan×♂Gyrmyzygul-1 and ♀Garabagh×♂Mirbashir-128. Due to these advantages, using these varieties for future research. The object of research was also the genotypes of maize Zagatala-420, Zagatala-514, Zagatala-68, Gurur and first generation F1 hybrid Zagatal-68×Gurur. Plant seeds germinated under laboratory conditions in Petri dishes and pots with soil using 150 mmol of sodium chloride solution.*

At concentrations of NaCl solutions of 150 and 200 mmol decreased seed germination, pigments content, and photosystem II activity in seedlings of maize genotypes. Varieties Gurur and Zagatala-68 and hybrid Gurur×Zagatala-68 were resistant to 200 mmol salt concentration.

Keywords: *wheat, maize, salinity, hybrid, chlorophyll, photosystemII, carotenoid, tolerance.*

Keywords: *Glycyrrhizic acid (GA), Phytohormones (PH), supramolecular complexes; wheat variety "Dstlik"; degree of germination, germination energy*

INTRODUCTION

Salinity is one of the abiotic stress factors decreasing plant productivity. The salinization of soils over time is particularly dangerous. The limitation of agricultural and fertile lands is an obstacle to meeting the food requirements of the population [Khan, et al, 2010].

In particular, the rapid growth of the population and the need in ensuring food security make more urgent the development of

salt-tolerant varieties capable to grow in saline soils, and their extensive use.

According to rough estimates, 521,700 hectares of plains in the Azerbaijan Republic were in a saline state in [Azizov, 2002]. In 2007, this parameter increased to 661.9 thousand hectares and accounted for 46.6 % of the land [Mammadov, 2007]. One of the most effective measures taken to achieve high productivity under stress is the development of plants capable to adapt

to salinity. The expression of genes regulating stress tolerance increases under high salt concentrations and ensures salt tolerance of plants [Garrat, et al, 2002].

According to some authors, developing more plastic wheat varieties, suitable for the regions of the republic is required because of the disturbance of ecological balance and the presence of abiotic stress factors.

Therefore, stress tolerance in plant breeding is of great importance [Rustamov, et al, 2017]. Currently, in our country, extensive research has been carried out on salt-tolerance of local wheat varieties as well as brought from abroad [Huseynova, et al, 2008]. Thus, numerous studies conducted in the world and in our country showed the perspectives of the development of the wheat varieties adapted to salinity. The purpose of the research was to study the effect of sodium chloride on the physiological and biochemical characteristics of wheat and corn genotypes, to identify varieties tolerant to salinity.

MATERIALS AND METHODS

The objects of the study were parental and hybrid wheat forms grown under normal and salinity (0,98 % NaCl) conditions. The objects of the study were the genotypes of wheat Gobustan, Mirbashir-128, Barakatli-95, Garabagh, Gyrmyzygul, Sharg and their generation hybrids Garabagh×Gobustan, Gobustan×Barakatli-95, Gobustan×Gyrmyzygul, Barakatli-95×Gobustan, Gobustan×Garabagh, Garabagh×Mirbashir, Garabagh × Sharg.

The second generation (F2) hybrids obtained from seven combinations during the study were planted on the field of 1 m², under normal conditions, on October 25, 2019. For the experiments, 300 g NaCl was added to the soil before sowing during tillering, earing, and grain-filling stages. Sowing was conducted following the scheme P♀-F2-P♂ 5×25 cm. Watering was performed at the tillering, earing, and grain-filling stages. Agrotechnical care was conducted in the experimental field. Samples were taken at the grain filling stage of the vegetation.

Measurements were done in vivo and in vitro for the comparative study of the changes in physiological parameters caused by the salt

effect.

The object of research was also the genotypes of maize Zagatala-420, Zagatala-514, Zagatala-68, Gurur and first generation F1 hybrid Zagatala-68×Gurur. Plant seeds germinated under laboratory conditions in Petri dishes and pots with soil using 150 mmol of sodium chloride solution. Germination energy was determined by counting three days old seedlings, and seed germination ability by counting seven days old seedlings as a percentage. In two-week old seedlings determined the content of photosynthetic pigments and the activity of photosystem II.

0.1 g of leaf samples of hybrid and parental forms taken from plants grown under both normal and saline conditions were homogenized using a pestle and mortar in 96 % alcohol by adding CaCO₃, centrifuged at 200 g, and a pure extract of chlorophyll pigments was obtained. The optical density of a solution of chlorophyll in alcohol was measured on an SP-2000 spectrophotometer at 665, 649, 440 nm, and the amounts of chlorophyll and carotenoids were determined [Wintermans, 1965]. The activity of photosystem II (PSII) was established based on Fv/Fm using a photosynthesis analyzer (PAM Germany).

$$F_v = F_m - F_0, Y = F_v / F_m;$$

where F₀ – fluorescence of leaves illuminated after dark treatment, F_m – fluorescence of light-saturated leaves. Water loss in leaves relative water content (RWC) was determined based on the method of Tambussi and colleagues [Tambussi, et al, 2005].

Data analysis and statistical analysis were conducted using Microsoft Excel. Statistical analysis was performed with the aid of the Statgraphics Plus 5.1 statistical package. The means of values were compared by Duncan's multiple range test (p=0.05).

RESULTS AND DISCUSSION

To develop new, pure lines, salt tolerance of hybrids and parental forms was assessed based on physiological indices in the grain filling stage of the vegetation. When studying salt-tolerance of hybrids and parental forms, differences were detected in the relative amounts of chlorophyll

(a+b), carotenoids, RWC, as well as the photochemical activity of chloroplasts. The effect of salt on the amount of chlorophyll a, chlorophyll b, and carotenoids, which are the main physiological indicators, is manifested in different ways in both hybrids and parental forms.

Based on the changes in the amount of pigments under salinity, the parental forms Garabagh, Gobustan, and Sharg were more tolerant.

Thus, at least a 10 %-decrease in the

amount of chlorophyll (a+b) pigments due to the effect of salt was observed in these parental genotypes. Whereas, the most growth in carotenoids amounted to 4–7 % in these varieties. This process can be attributed to the increase in the protective function of carotenoids under salt stress. Based on RWC values, Garabagh and Gobustan varieties had the highest water content. Water loss in these varieties did not decrease but increased by 3 % (Table 1).

Table1.

Physiological indices (photosynthetic pigments, RWC) of the parental and hybrid forms of wheat under 1 % NaCl* (mg/g fresh weight)

Wheat varieties	Chlorophyll (a+b)		Carotenoids		RWC	
	Control	NaCl	Control	NaCl	Control	NaCl
Gobustan	3.47	2.42	1.04	0.54	70.9	73.1
Mirbashir-128	2.95	2.03	1.03	0.95	75.5	74.9
Barakatli-95	3.29	1.61	1.08	0.97	71.9	74.2
Garabagh	2.55	2.71	1.05	0.69	89.5	83.6
Gyrmyzygul	3.57	1.56	0.87	0.74	88.9	80.8
Shark	3.38	1.50	1.17	0.38	70.5	76.9
Garabagh×Gobustan	2.98	1.50	1.17	0.51	67.9	84.1
Gobustan×Barakatli-95	2.93	2.49	1.04	0.90	98.6	72.8
Gobustan×Gyrmyzygul	2.54	2.24	0.86	1.06	75.5	79.6
Barakatli-95×Gobustan	3.33	1.51	1.35	0.62	67.4	81.8
Gobustan×Qarabagh	2.09	1.63	0.60	0.63	92.3	75.6
Garabagh×Mirbaşir-128	2.26	1.75	0.57	0.29	94.8	79.5
Garabagh×Shark	3.55	1.42	1.72	0.33	74.4	83.5

Note: * Each value represents the mean $\pm$ SD (standard deviation) for the mean n=3 independent experiments p=0.05

Based on the amounts of chlorophyll (a+b), the hybrids, ♀Garabagh×♂Gobustan, ♀Garabagh×♂Mirbashir, ♀Garabagh×♂Sharg are more tolerant to salinity. An increase in the amount of carotenoids was also observed in these hybrids.

The highest values for RWC were found in the hybrid forms, ♀Garabagh×♂Gobustan, ♀Barakatli-95×♂Gobustan, ♀Garabagh×♂Sharg. RWC was 10 % higher in these hybrids compared to others under stress. A 20 %-decrease in RWC was observed in the hybrid form, ♀Gobustan×♂Gyrmyzygul.

The first indicator of fluorescence in varieties grown in a saline environment is light energy. Energy loss occurs under salinity. In this

case, the activity of the photosystem is reduced, which leads to the weakening development of the plant.

Based on the PS II activity, the parental forms, Garabagh, Gobustan, and the hybrids ♀Gobustan×Barakatli-95,, ♀Gobustan×♂Garabagh, and ♀Gobustan×♂Sharg are more salt-tolerant. High salt concentrations contributed to a decrease in grain yield. Among the genotypes, according to this indicator, the most salt tolerant were the hybrids Barakatli-95×Gobustan and Garabakh×Mirbashir-128(Table 2).

Table 2.

Effect of NaCl on elements of the yield structure of durum and bread winter wheat varieties under the conditions of a growing experiment

wheat varieties	Plant height, sm		number of grains per ear		grain weight, g		crop losses, %
	control	NaCl	control	NaCl	control	NaCl	
Gobustan	90±2	68±1	62±3	45±4	3,6	1,4	62
Mirbashir-128	105±4	73±1	42±2	18±1	4,6	1,2	74
Barakatli-95	85±2	75±2	68±3	29±2	3,5	1,7	52
Garabagh	80±2	62±1	41±1	32±2	2,2	1,5	32
Gyrmyzygul	72±1	57±2	46±2	22±1	3,1	2,4	23
Shark	110±4	70±3	32±2	19±1	4,2	1,4	67
Garabagh×Gobustan	120±3	65±2	52±3	36±2	1,4	1,1	22
Gobustan×Barakatli-95	76±2	100±4	32±2	20±1	2,8	2,2	22
Gobustan×Gyrmyzygul	118±4	70±2	34±1	27±2	2,9	2,3	21
Barakatli-95×Gobustan	78±1	63±1	40±2	21±1	1,9	1,6	10
Gobustan×Qarabagh	80±1	60±2	38±1	34±2	4,2	2,8	34
Garabagh×Mirbaşir-128	90±2	60±1	54±3	33±3	1,9	1,7	11
Garabagh×Shark	90±2	70±2	60±2	22±2	3,2	1,3	60

Note: * Each value represents the mean ±SD (standard deviation) for the mean n=3 independent experiments p=0.05.

Table 3.

Influence of various sodium chloride on seed germination, pigment content, and photosystem II activity in seedlings of maize varieties*

Varieties	NaCl, mM	Germination, %	Chl(a+b) (mg/g) fresh leaf weight	Carotenoids (mg/g) fresh leaf weight	Fv/Fm
Gurur	0	90±1	11,4±1,2	2,8±0,9	0,75
	50	85±2	16,9±1,3	3,4±0,5	0,70
	100	70±4	10,4±1,2	2,3±0,3	0,65
Zagatala-514	0	86±1	14,5±1,4	3,5±0,5	0,72
	50	50±4	12,0±1,1	3,3±0,6	0,66
	100	20±3	4,5±0,9	1,4±0,4	0,55
Zagatala-68	0	88±2	10,0±0,9	2,8±0,2	0,73
	50	70±1	13,6±1,2	3,5±0,5	0,71
	100	65±1	10,7±1,5	2,3±0,6	0,64
Zagatala 420	0	90±2	11,4±2,1	2,9±0,5	0,75
	50	60±4	8,6 ± 1,6	2,6±0,6	0,65
	100	25±3	5,8±1,2	1,3±0,7	0,59
F1 Gurur ×Zagatala-68	0	90±3	12,6±2,1	3,2±0,5	0,81
	50	86±2	15,2±3,2	4,8±0,4	0,72
	100	75±5	12,3±2,1	3,9±0,5	0,69

Note: * Each value represents the mean ±SD (standard deviation) for the mean n=3 independent experiments p=0.05.

It revealed that under the influence of salt, germination and germination energy of maize seeds reduced. With the increase of sodium chloride concentration decreased the photochemical activity of chloroplasts and the content of photosynthetic pigments in seedlings. Differences between maize cultivars in the content of chlorophylls, carotenoids and in the parameters of fluorescence induction of leaves under salt action were revealed (Table 3).

As seen from the table 3, with increasing concentration, the percentage of seed germination, the content of chlorophyll and carotenoids, and the activity of photosystem II decreased. At a salt concentration of 150 mmol the pigment content and the activity of chloroplasts in the genotypes Zagatala 420 and Zagatala 514, while in varieties Gurur and Zagatala 68 remains at the control level. At a salt concentration of 200 mmol, the activity of photosystem II of genotypes Zagatala 420 and Zagatala 514 decreases to a greater extent than that of varieties Gurur and Zagatala 68.

Salinity could affect chlorophyll concentration of leaves through inhibition of synthesis of chlorophyll or an acceleration of its degradation. Impairment of the carboxylation capacity, which in turn inhibits electron transport, is indicated by the measurements of chlorophyll fluorescence. A reduced quantum yield may result from a structural impact on PS II although some authors [Lu, et al, 2002] found PS II to be highly resistant to salinity stress. Salinity has been concluded to affect reaction centers of PS II either directly or via an accelerated senescence. High external salt concentrations could affect thylakoid membranes by disrupting lipid bilayer or lipid-protein associations and thus, impair electron transport activity. The efficiency of the photochemical conversion of the PS II energy decreased with increasing salt concentrations. Some authors indicate the decrease of the root system function in plants exposed to salt stress. They assumed a more important role of toxic effects of ions [Wang, et al, 2012].

Previous measurement of linear electron transport revealed that salinity does not affect electron transport in wheat. Effect of salinity on rate of electron transport could, however, be

species specific [Lutts, et al, 1996].

In general, the growth and development of plants depend on the process of photosynthesis in their green organs. Therefore, environmental stressors affecting photosynthesis also affect growth and development [Azizov, et al, 2019; Villora, et al, 1997]. A positive correlation between the rate of photosynthesis and productivity has been found in various plants under salinity [Perez-Alfocea, et al, 1996].

The decrease in RWC due to stress indicates that the cell does not have the turgor necessary for the tension process to take place [Kateri, et al, 1997]. The response of plants to stressors is different, depending on the genetic material. Thus, the genetic material regulates the speed and consistency of protein synthesis required under stress. Some difficulties in the cultivation of salt-tolerant forms are attributed to the complexity and polygenic nature of genes. It known that under the salt stress, the external water potential decreases, the absorption of biogenic metal ions by the roots becomes difficult, and the chlorine and sodium ions have a toxic effect on plant metabolism. These three possible effects of salt stress have a detrimental effect on plant growth, development and yield. [Muhammad, et al, 2015; Munns, et al, 2006]. Osmotic stress is associated with the accumulation of ions in the soil solution, while malnutrition and the specific effects of ions are associated to the accumulation of ions, mainly sodium and chloride, to toxic levels which inhibits the availability of other important elements such as calcium and potassium. Toxic levels of sodium in plant organs damage biological membranes and subcellular organelles, reducing growth and causing abnormal development before plant death. Several physiological processes, such as photosynthesis, respiration, starch metabolism and fixation of nitrogen also disrupted in salt conditions, which leads to a decrease in crop productivity. In response to this, the plant synthesizes low molecular weight solutes, including soluble carbohydrates for better absorption of water during salinity. Genotypes with a powerful genetic apparatus cope with this task and grow well in salt conditions. In the process of evolution, protective mechanisms

against environmental stressors are formed in all organisms, including plants. Therefore, when assessing tolerance to stress factors, it is necessary to consider the individual characteristics of each plant genotype[9]. NaCl (0.98 %) in the soil has been found to affect physiological parameters of parental and hybrid forms differently.

CONCLUSION

Negative effects of salt stress were observed in the content of photosynthetic pigments, photochemical activity of PS II and RWC in parental and hybrid forms. The content of chl a, chl b, the activity of PSII, RWC and grain yield were higher in the parental forms, Garabagh,

Gobustan, Barakatli-95, and in the hybrids, ♀Garabagh×♂Gobustan, ♀Barakatli-95×♂Gobustan, ♀Gobustan×♂Gyrmyzygul-1 and ♀Garabagh×♂Mirbashir-128. Due to these advantages, using these varieties for future research on the development of salt-tolerant forms can be considered expedient.

At concentrations of NaCl solutions of 150 and 200 mmol decreased seed germination, pigments content, and photosystem II activity in seedlings of maize genotypes. Varieties Gurur and Zagatala-68 and hybrid Gurur×Zagatala-68 were resistant to 200 mmol salt concentration.

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INVESTIGATION OF *LIMODORUM ABORTIVUM* AND *STEVENIELLA SATYRIOIDES* (ORCHIDACEAE) COENOPOPOPULATIONS IN THE GREATER CAUCASUSNigar Mursal ¹, Naiba P. Mehdiyeva²^{1,2}Institute of Botany of the Ministry of Science and Education of the Republic of Azerbaijan, Badamdar highway 40, Baku, Azerbaijan¹ Correspondence: nigar_mursal@yahoo.com

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Abstract: *The cenopopulations of Limodorum abortivum (L.) Sw. and Steveniella satyrioides (Spreng) Schltr. were studied for the first time in the northeastern part of the Greater Caucasus (Azerbaijan) by population-ontogenetic methods. To determine the ontogenetic status of individuals, the concept of a discrete description of ontogeny was used. The indexes of age, recovery and replacement, aging, and efficiency were calculated. The cenopopulation type was determined according to the delta-omega (Δ - ω) classification. The ontogenetic structure of coenopopulations of Limodorum abortivum, Steveniella satyrioides in the study area shows that all coenopopulations are normal, CP 2, and CP 3 are incomplete due to the absence of senile individuals. Based on the Δ and ω indices, CP 1, CP 4-8 are maturing, CP 2, CP 3 are mature, and CP 9 is transitional type. As a result of the conducted research, it was revealed that L. abortivum distributed in the Greater Caucasus from 31 m to 1229 m a.s.l., and S. satyrioides from 988 m to 1511 m a.s.l. Looking at the number of individuals and the type of population of these species at that altitude, it can be said that they do not have a special dependence on altitude. This species mainly spreads in forests dominated by oak-beech-hornbeam trees.*

Keywords: rare species, ontogenetic structure, demographic structure, cenopopulation, ecology.

INTRODUCTION

Species loss caused by anthropogenic impacts and climate change are among the most concerning contemporary issues for nature conservation [Mantyka-Pringle et al., 2015; Attorre et al., 2018]. To halt the decline of species, it is crucial to have accurate knowledge of population size, distribution, and occupied habitats, as well as to assess the causes of population decline at the global and local scales [Pedersen et al., 2013; Mantyka-Pringle et al., 2015; Asamoah et al., 2022].

Population-based surveys of endangered plant species are the main methods for assessing the status of these plants in any area. Plant species of Orchidaceae Juss. families are sensitive components of natural ecosystems. That is why determining the status of their populations can be considered an indicator of the state of the natural ecosystem as a whole [Khapugin,

2016].

These species include *Steveniella satyrioides* (Spreng) Schltr. and *Limodorum abortivum* (L.) Sw. They belong to monotypic genera. *Steveniella* species are distributed in the north and south of the Black Sea, Northern Iran, and the Caucasus region [Nevski, 1935; Renz and Taubenheim, 1984]. Its natural habitats are coniferous and deciduous, mostly *Quercus* forests. Individuals of the species can be found at altitudes ranging from 1300 meters a.s.l. [Renz and Taubenheim, 1984]. Several individuals in the populations of *Steveniella satyrioides* which it formed in the past were quite high, but now very rare in the areas where it is distributed [Fateryga et al., 2013]. Studies on *Steveniella satyrioides* are mostly on the pollination of the species [Brodmann et al., 2009]. Although general anatomical studies have been carried out on the family [Şeker et al., 2016; Şenel et

al., 2019] there is no detailed anatomical study on the species. Many studies have been carried out in different fields on plants belonging to the family. Taxonomic studies come first among these studies [Shipunov and Bateman 2005]. Despite these studies, the taxonomic and systematic problems of the family have not yet been fully resolved. The main reasons for this are that the species of the family are distributed in a wide geography and their flowers have many variations [Dressler, 1993]. For this reason, problems for the family are increasing as a result of incorrect plant identifications and different taxonomic practices that vary from person to person [Nordström and Hedrén, 2009].

As a result of the ecological conditions of the natural habitats study of *Limodorum abortivum* in the North-West Caucasus by E.A. Perebora, it was determined that all the natural habitats of the plant groups where the coenopopulations of this species developed were recorded in the mountain belt from 100 to 550 m below sea level. The main part of them is a broad-leaved and mixed forest located in the belt at an altitude of 350-450 m. It is the good development of the forest canopy (diversity of its composition and dense structure), as well as the relatively small steepness of the slopes, which helps to preserve moisture in the top layer of the soil and the development of fungal mycelia, which are generally quite favorable conditions for the *L. abortivum* plant in different parts of its natural environment [Perebora, 2008].

It is known that the tuberous representatives of Orchids have long been used and are currently used as sources of salep for the treatment of diabetes, the prevention of epilepsy, as a tonic, and for the preparation of drinks and ice cream. According to the literature, phenolic compounds (loroglossin) have been isolated from the aerial parts of *Limodorum abortivum* [Delauney, 1926], and anthocyanins (chrysanthemum, cyanine, seranine, ofrysanin, etc.) from flowers [Strack et al., 1989], as well as nectar or carbohydrates and related compounds (sorbitol, maltose, fructose, glucose, etc.) [Pais et al., 1986]. Thus, therapeutic potential and increasing food consumption have led to sharp declines in the populations of some species.

The collection of Orchid tubers to obtain salep has been carried out quite intensively in recent years. Unfortunately, we encountered this picture more than once during our field research. In this regard, we have been studying the status of populations of some rare species for 8 years. Two of them are *Limodorum abortivum* (L.) Sw. and *Steveniella satyrioides* (Spreng) Schltr. listed in the Red Book of the Republic of Azerbaijan [2013]. It should be noted that studies of these species at the population-ontogenetic level have not yet been carried out. In connection with this, we set a goal to identify new habitats of these rare species, study their ontogenetic characteristics and the state of populations, as well as the influence of anthropogenic and climatic factors on them.

MATERIALS AND METHODS

The current research work was conducted in the northern-eastern part of the Greater Caucasus in June-July 2017-2022 (Fig. 1).

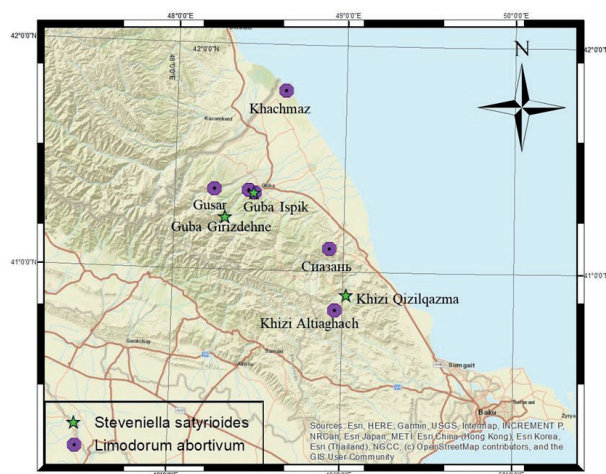


Figure 1. The routes of researches

The area of research

Investigations were carried out in Khizi, Siyazan, Guba, Gusar, and Khachmaz, located in the northeastern part of the Greater Caucasus.

Relief. The Greater Caucasus region is characterized by Alpine landforms and the presence of glacier cover in small areas at an altitude of 3800-3900 m (Bazarduzu, Shahdag, etc.). The lowering of the mountain ranges from the northwest to the southeast is related to the tectonic burial of the East Caucasus in the same direction. In this regard, the northeastern slope

is open to the entry of cold air masses moving from the north, while the southern slope is better protected in this respect. The river network of the province is generally well-developed, the largest rivers are located on the northeastern slope. Among them, Samur and Gusarchay are fed by glacial waters. In contrast to the north-eastern slope, the southern slope was more exposed to flood processes that formed the relief. The low mountainous and foothill parts of the province's Gobustan area are characterized by mud volcanoes, clay karsts, and badland landforms with a fragmented surface

structure [Ecological Atlas 2010].

Climate types. Guba-Gusar regions have a mild-hot climate with almost evenly distributed rainfall, Khachmaz and Siyazan have a semi-desert and dry-desert climate with mild winters and dry-hot summers, and Khizi has a mild-hot climate with dry summers [Mammadov 2007].

Humus amount in soils. The amount of humus in the soils of Guba, Gusar, and Khizi regions is 250-300 t/ha. In the Khachmaz and Siyazan regions, it is 150-200 t/ha [Mammadov 2007] (Table 1).

Table 1.

Climatic and edaphic characteristics of the researched areas (Babayev 2011)

Regions	Climate			Edaphic				
	Temperature (°C)	The amount of precipitation (mm)	Evaporation (mm)	Hummus (%)	N (%)	C:N	pH	Type
Guba Ispik	6.2–9.0	570–950	500–700	12.7	0.62	12	5.9	Mountain-brown
Gusar-Piral	8.4–10.8	450–600	530–970	7.41	0.52	8.2	7.2	Mountain-brown
Khizi-Gizilqazma	6.2–9.0	570–950	500–700	12.7	0.62	12	5.9	Mountain-brown
Khizi-Altiaghach	8.4–10.8	450–600	530–970	7.66	0.49	9.1	6.4	Mountain-black
Siyazan Galaalti	8.4–10.8	450–600	530–970	7.41	0.52	8.2	7.2	Mountain-brown
Guba Giriz-dehne	7–10	570–950	500–700	12.7	0.62	12	5.9	Brown-mountain-forest
Khachmaz	11.7–13.2	250–450	900–1000	6.45	0.37	10	7.1	Alluvial-meadow-forest

MATERIAL OF RESEARCH

The object of the research is *Limodorum abortivum* (L.) Sw. and *Steveniella satyrioides* (Spreng) Schltr. included in the Red Book of Azerbaijan [Red Book of the Republic of Azerbaijan, 2013].

Limodorum abortivum (L.) Sw. is a perennial plant with a height of 30–60 (80) cm. The rhizome is short and horizontal, with many thick roots. The stem is covered with a thick, greenish-purple, gray, sharp sheath. The flower group is a large, loose cluster of 6–20 flowers. The flowers are large, purple in color, 20–25 mm long.

The lip is light purple. Corolla thin, 15 mm long, equal to or longer than the ovary. The ovary is cylindrical, untwisted on a short leg. Flowering occurs in May, and fruiting in May–June [Flora of Azerbaijan, 1952; Euro+Med PlantBase, 2006], (Fig. 2).

Steveniella satyrioides (Spreng) Schltr. is a whole root tuber with a length of 1.0–2.5 cm, a perennial herb. The stem is 20–40 cm high, it has one developed, oblong-oval - shaped, brown-green leaf with red-brown spots. The flower group is elongated, quite dense, 4–10 (13) cm long, the number of flowers is 5–18

(20), and it is curved. The lip is green-brown, reddish-brown at the base, the side slices are rhombic, and the oblong line in the middle is 4-4.5 mm long. Flowering occurs in April-May, and fruiting occurs in June [Flora of Azerbaijan, 1952; Euro+Med PlantBase, 2006], (Fig. 2).

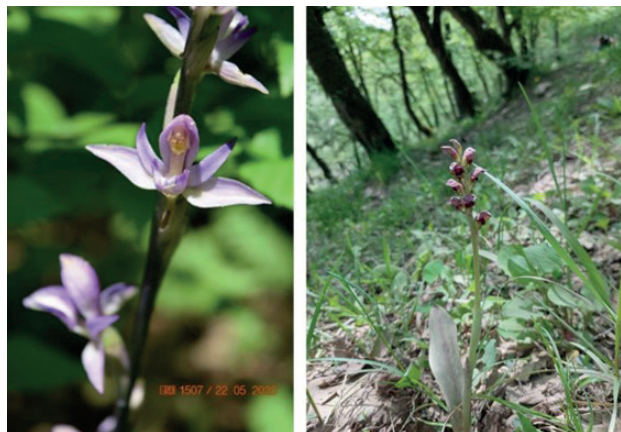


Figure 2. *Limodorum abortivum* (L.) Sw., *Steveniella satyrioides* (Spreng) Schltr.

THE METHOD OF RESEARCH

Description of vegetation and phytocenosis was carried out by generally accepted geobotanical methods [Field geobotany, 1960].

During the study of the ontogenetic and demographic structure of coenopopulations (CP) were used the principles and methods of A.A. Uranov and followers of this school [Uranov, 1975; Zlobin et al., 2013]. The ontogenetic spectrum was determined based on the demographic parameters of the coenopopulation. To study the individuals and the ontogenetic structure of the coenopopulations of the species, 10-15 small plots (1x1 m) were placed in the model plots (10x10 m). The total number of individuals in the fields and the total number of individuals in each age group were calculated. The type of cenopopulation was determined based on L.A. Zhivotovsky's $\Delta-\omega$ (delta-omega) classification of the normal population [Zhivotovsky, 2001]. To determine the taxonomic status of the species involved in the coenosis were used literature data [Asgarov, 2016], The Euro + Med Plantbase [Euro+Med PlantBase, 2006]. Electronic maps of the researched places were compiled in ArcGIS 10.5 software.

RESULTS

CP 1 – was studied in the Carpinuseto-Quercusetum forest at an altitude of 861 m a.s.l. in Ispik village of Guba region. The soil is black and wet. The slope is 30 degrees. The projective cover of grasses was 80%. The number of individuals of the plant in a 1 m² area is 9-11. From trees with *Limodorum abortivum* in the cenosis – *Fagus orientalis*, *Carpinus betulus*, *Quercus petraea* subsp. *polycarpa*, *Acer campestre*, from shrubs *Crataegus rhipidophylla*, *Rubus idaeus*, from grasses: *Arum elongatum*, *Leontodon hisbidus*, *Onobrychis bobrovii* Grossh., *Primula acaulis*, *Orchis purpurea*, *Ophrys apifera* Huds., *Platanthera chlorantha*, *Epipactis palustris* (L.) Crantz, *Neottia nidus-avis* (L.) Rich., *Neottia ovata* (L.) Bluff & Fingerh., *Corydalis angustifolia* were involved.

CP 2 – was investigated in an oak forest at an altitude of 797 m a.s.l. in the village of Uchkun-Kupchal, Guba region. It is a tall forest. The soil is brown and has little moisture. The canopy created by trees is 60%. The slope is 20 degrees. The projective cover of grasses was 85-90%. The number of individuals of the plant is 7-8 of a 1 m² area. *Carpinus betulus*, *Fraxinus excelsior*, *Acer campestre*, *Cornus mas*, *Pyracantha coccinea* M. Roem., *Mespilus germanica* species formed the tree layer. From the bushes were found *Rubus caesius* and *Crataegus rhipidophylla*. *Geum urbanum*, *Cephalanthera rubra*, *Limodorum abortivum*, *Primula acaulis*, *Euphorbia boissieriana* (Woronow) Prokh., *Cephalanthera grandiflora*, *Vicia narbonensis* L. were present in the grass layer.

CP 3 – was studied in the forest at an altitude of 1229 m a.s.l. in the village of Piral in Gushar district. The soil is black and wet. The slope of the area is 20 degrees. The projective cover of grasses was 75%. Among trees, *Carpinus betulus* and *Fagus orientalis* dominated in the cenosis. *Cornus mas*, *Fraxinus excelsior*, *Acer campestre* were recorded from other trees. From shrubs *Crataegus* sp., *Rosa* sp., from herbs *Fragaria vesca*, *Mentha longifolia* (L.) L., *Orchis purpurea*, *Primula acaulis*, *Asplenium adiantum-nigrum* L., *Viola odorata*, *Salvia glutinosa*, *Plantago major*, *Galium verum* L., *Lonicera caprifolium* species take part.

CP 4 – was discovered in the forest of *Carpinus betulus* at an altitude of 31 m a.s.l. in Khudat village of Khachmaz district. The soil is brown and moist. The total projective cover was 50-60%. From trees *Acer campestre*, *A. laetum*, *Quercus pedunculiflora* C. Koch, *Fraxinus excelsior*, from shrubs *Crataegus kyrtostyla*, *Rubus caesius*, *Cornus mas*, *Mespilus germanica*, *Corylus colurna*, *Smilax excelsa*, and *Hedera caucasigena* Pojark., from grasses - *Geum urbanum* L., *Sambucus ebulus*, *Euphorbia amygdaloides* L. species participated together with this plant in the cenosis.

CP 5 – was studied in the forest massif at an altitude of 697 m a.s. l. in Galalati village of Siyazan district. The forest was dark and close to the oil tanks. The soil is dark brown and moist. The slope of the area is 20. The total projective cover of grass was 70%. *Quercus iberica* Stev. ex M.B. Fl., *Carpinus betulus*, *Fraxinus excelsior* L., *Acer cappadocicum* Gled., *Acer campestre* species were present in tree layer. Around the forest from bushes were *Crataegus pentagyna*, and *Rubus sanctus* Schreb. In the grass layer *Platanthera chlorantha*, *Lathyrus pratensis* L., *Dactylorhiza romana* subsp. *georgica* (Klinge) Soó ex Renz & Taubenheim, *Geranium sylvaticum* L., *Calystegia sepium* (L.) R. Br., *Anacamptis pyramidalis* (L.) Rich., *Lonicera caprifolium*, *Limodorum abortivum* (L.) Sw., *Cephalanthera longifolia* (L.) R.M. Fritsch, *Primula acaulis*, *Orchis purpurea*, *Viola arvensis* species were represented.

CP 6 – was investigated in a forest edge at an altitude of 713 m a.s.l. It is a low, light forest. The soil is brown and dry. The slope is 30. Here, the number of individuals of this plant was from 2 to 5 in 1 m² area. Among the trees in the cenosis, *Quercus pubescens* subsp. *crispata*, *Pyrus salicifolia*, from shrubs *Crataegus monogyna* Jacq., from herbs *Ranunculus repens* L., *Thlaspi perfoliatum*, *Muscari neglectum* Guss. ex Ten., *Orchis purpurea*, *Platanthera chlorantha* species were present.

CP 7 – was studied in the Carpinuseto-Quercusetum forest at an altitude of 988 m a.s.l. in Ispik village of Guba region. The forest is dense and dark. The soil is black and wet. It is assumed that there is a flood in the area. The slope is 20

degrees. The projective cover of grasses was 60%. From trees together with *Steveniella satyrioides* were *Fagus orientalis*, *Acer campestre*, from shrubs *Crataegus rhipidophylla*, from grasses: *Galanthus alpinus* Sosn. var. *alpinus*, *Platanthera chlorantha*, *Orchis purpurea*, *Galium odoratum* (L.) Scop., *Corydalis cava* subsp. *marshalliana* (Willd.) Hayek, *Scilla siberica* Haw. were involved. At the edges of the forest *Ajuga genevensis* L., *Orobanch* sp. species are distributed in groups with 2-3 individuals.

CP 8 – was recorded in the beech forest (Faguseto-Carpinusetum) at an altitude of 1511 m a.s.l around the village of Guba Girizdahna. The soil is black and wet. The slope is 40 degrees. The projective cover of grasses was 80%. *Astrantia maxima* Pall., *Stachys macrantha* (K.Koch) Stearn, *Serratula quiquifolia* Bieb., *Achillea millefolium*, *Salvia glutinosa*, *Malva thuringiaca* (L.) Vis., *Arctium minus* (Hill) Bernh., *Campanula rapunculoides* L., *Hypericum perforatum* L., *Pimpinella peregrina* species were also present.

CP 9 – was studied in the Quercuseto-Carpinusetum forest at an altitude of 1043 m a.s.l. in Gizilgazma village of Khizi district. The soil is brown and wet. The slope is 30 degrees. The projective cover of grasses is 70%. *Carpinus betulus*, *Acer campestre*, *Fagus orientalis*, *Quercus pubescens* subsp. *crispata* (Steven) Greuter & Burdet, in the shrub layer *Rubus aetniscus*, *Rosa corymbifera* Borkh., *Crataegus kyrtostyla*, and the grass layer *Orchis purpurea*, *Primula acaulis*, *Cephalanthera rubra* (L.) Rich., *Phelipaea coccinea* (M. Bieb.) Poir., *Ophrys sphegodes*

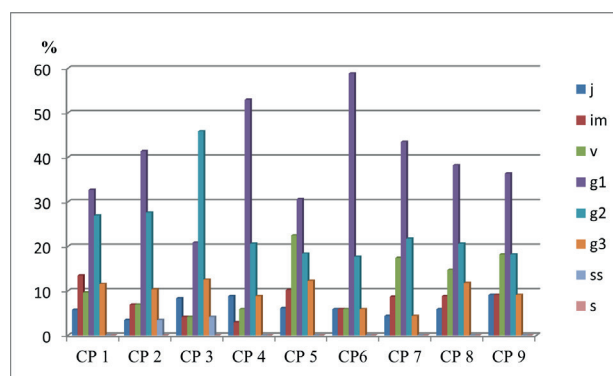


Figure 3. Ontogenetic spectrum of coenopopulations of *Limodorum abortivum* (L.) Sw. (CP 1-6) and *Steveniella satyrioides* (Spreng) Schltr. (CP 7-9).

subsp. *mammosa*, *Arum elongatum* taxa were represented.

The ontogenetic structure of coenopopulations of *Limodorum abortivum*, *Steveniella satyrioides* in the study area shows that all coenopopulations are normal, CP 2, CP 3 are incomplete due to the absence senile individuals, other CPs subsenile and senile individuals (Fig.3).

The highest value of pregenerative individuals is observed in CP 5, and the least in CP 6.

The highest value of generative individuals was observed in CP 1, and the least in CP 9. Post-generative individuals were not recorded in CP 1, CP 4-9.

Spatial and demographic values of the studied 9 coenopopulations are described in table 2. Based on the Δ and ω indices, CP 1, CP 4-8 are maturing, CP 2, CP 3 are mature, and CP 9 is transitional type (Table 2).

Table 2.

Spatial and demographic indicators of coenopopulations of *Limodorum abortivum* (L.) Sw. (CP 1-6) and *Steveniella satyrioides* (Spreng) Schltr. (CP 7-9)

No	n	X_a	X_{pre}	X_g	X_{post}	I_r	I_a	I_{rep}	Δ	ω	Type of CP
CP 1	52	3,47	1	2,47	0	0,405	0	0,405	0,345	0,685	maturing
CP 2	29	1,93	0,33	1,53	0,07	0,217	0,034	0,208	0,380	0,741	mature
CP 3	24	1,6	0,27	1,27	0,07	0,210	0,042	0,2	0,458	0,769	mature
CP 4	34	2,27	0,4	1,87	0	0,214	0	0,214	0,349	0,727	maturing
CP 5	49	3,27	1,27	2	0	0,633	0	0,633	0,315	0,637	maturing
CP 6	17	1,13	0,2	0,93	0	0,214	0	0,214	0,318	0,725	maturing
CP 7	23	1,53	0,47	1,07	0	0,437	0	0,437	0,295	0,685	maturing
CP 8	34	2,27	0,67	1,6	0	0,417	0	0,417	0,333	0,681	maturing
CP 9	11	0,73	0,27	0,47	0	0,444	0	0,444	0,379	0,661	transitional

Note. n—number of individuals; X_a — total average density of plants. individuals /1 m²; X_{pre} —density of the pregenerative individuals. individuals/1m²; X_g —density of generative individuals/1m²; X_{post} —density of postgenerative individuals/1m²; I_r —recovery index; I_a — aging index, I_{rep} — replacement index; Δ —age index; ω —efficiency index.

CONCLUSION

According to the literature, it is noted that *L. abortivum* grows in the lower mountain belt, sometimes up to the middle mountain belt, mainly in sparse forests, among bushes, in forest edges, while *S. satyrioides* is found in the lower and middle mountain belt, mainly among bushes in the forest [Flora of Azerbaijan, 1952]. However, as a result of the research conducted by us, it was revealed that *L. abortivum* is found from 31 m to 1229 m a.s.l., and *S. satyrioides* from 988 m to 1511 m a.s.l. Looking

at the number of individuals and the type of population of these species at that altitude, it can be said that they do not have a special dependence on altitude. The cenopopulation of *L. abortivum* with the largest number of individuals was recorded in the forest in Ispik village of Guba region. Mountain-brown soils prevail here. Soils are acidic, rich in humus, nitrogen, and C:N ratio. This area also differs in the amount of humidity. So, the annual amount of precipitation here is 570-950 mm. The largest cenopopulation of *S. satyrioides* was found

in the village of Girizdahna, Guba region. There are brown mountain-forest soils in this area. In terms of environment, the lands correspond to the village of Ispik, Guba region. The climate is mostly harsh and frosty.

Limodorum abortivum is found mainly in forests dominated by oak-beech-hornbeam trees. Along with this plant, *Cephalanthera grandiflora*, *C. damasonium*, *Platanthera chlorantha* and *Orchis purpurea* species from the Orchidaceae family often spread in the grass layer. This plant is mostly found in the form of a group with several individuals. Looking at the phytocenological characteristics of *Steveniella satyrioides* species, it can be seen that this plant is mostly found in the oak-beech-hornbeam forest. Individuals of the plant spread individually

in a spaced form. *Scilla siberica*, *Primula acaulis*, *Corydalis cava* subsp. *marschaliana*, *Arum elongatum* species are found together with this plant in the grass cover.

In general, when analyzing the situation of cenopopulations of *Limodorum abortivum*, *Steveniella satyrioides* species in the studied region and looking at the density of individuals per 1 m², it can be seen that there may be a threat to these species shortly. Because they are harvested by people for their decorative and medicinal properties, and they are collected together with their roots, as well as the self-regeneration process of plant species is slow, so there is a danger of a decrease in their number in the future.

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BIODIVERSITY, BIOGEOGRAPHY AND ENDEMISM OF THE FOREST AND HIGH MOUNTAIN FLORA OF THE AZERBAIJAN PART OF GREATER CAUCASUS

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Abstract. *In the present paper, we studied plant species diversity and distribution patterns of forest and high-mountain landscapes of the Greater Caucasus. The flora of the area comprises 1787 vascular plant taxa belonging to 181 families and 719 genera. In the Azerbaijan part of the Greater Caucasus, 648 species belonging to 90 families and 308 genera are distributed in the forest landscapes. The alpine-subalpine landscapes have 975 plant species belonging to 66 families and 321 genera. the subnival landscapes of Azerbaijan consist of 136 species belonging to 28 families and 83 genera. The total number of endemic species distributed in the area is 715. Of them, 432 species are distributed in alpine-subalpine landscapes, 197 species in forest landscapes, and 83 species in subnival landscapes. Among them, species are endemic to the Caucasus, species are endemic to the South Caucasus, and species are endemic to Azerbaijan. The remaining species are macroendemic species and are spread within the boundaries of the ecoregion. Altitude increases, the number of species first increases and then sharply decreases. However, the percentage of endemic species increases with altitude. The number of endemic species in forest landscapes is 29%, in alpine-subalpine landscapes 44%, and in subnival landscapes 63%.*

Keywords: *Greater Caucasus, flora, forest, alpine, subnival, endemism, biogeography.*

INTRODUCTION

The study of endemism is considered an important issue in the study of flora history. The ecological characteristics, taxonomic structure, and geographical and genetic relationships of these plants are a valuable database on the formation of the local flora. On the other hand, they represent a significant global conservation responsibility for countries.

In recent times, due to the influence of natural and anthropogenic factors, biological diversity is decreasing rapidly. This negative trend also affects human well-being [Shivanna K.R., 2022]. In this regard, it is important to study, study, and protect the flora and its sensitive species.

Currently, the total number of higher plants on the planet is estimated to be between 223,000 and 420,000. [Govaerts R., 2003; Scotland R.W. and Wortley A.H., 2003]. Theoretical

calculations and practical observations show that the main factors determining species richness are energy, water, the topography of the area, edaphic heterogeneity, historical factors, existing geometric limitations («Latitudinal Gradients of Biodiversity») and area size [Jiménez, 2009; Distler et al., 2009].

The study of endemism, biogeography of endemism, and the factors that create it have important theoretical and practical importance in terms of preservation of biological diversity. Theoretical calculations show that there are more than 300,000 vascular plants on average on the planet. According to the result of this model, the habitat of each endemic species requires a 12875 km² area [Carsten Hobohm et al., 2019].

The flora of Azerbaijan has a rich diversity of flora in the region. The flora of Azerbaijan covers 70 percent of the flora of the Caucasus.

It ranks third after Turkey (11,400 species) and Iran (8,000 species) among the countries of the Caucasus ecoregion in terms of flora richness. [Noroozi J., 2016; Ibadullayeva S.C. and Huseynova I.M., 2021; Adil Guner, 2022;]. With more than 4,500 species, it is ahead of the flora of Georgia (4,100 species) and Armenia (3,800) among the South Caucasus countries. [Gagnidze R., 2000; Fayvush G., 2023].

MATERIALS AND METHODS

The paper includes the results of botanical research on the Azerbaijan part of the Greater Caucasus carried out by the author over many years and also other existing botanical materials. Different floristic complexes such as dendrology, tall herbaceous cover, high mountain meadows, alpine carpets, pteridophytes, tundra vegetation, and different expositions were selected as sample areas. For verification of endemic species, used additional sources [Grossheimm A.A., 1961; Solomon J. et al., 2014; Askerov A.A., 2016; Noroozi J. et al., 2016, Ivanov A.L., 2019; Adil Guner., 2022;] and other botanical literature about the regional investigations.

The analysis of the flora diversity of the forest, alpine-subalpine, and subnival landscapes of the Greater Caucasus was carried out by us within the boundaries of the Caucasus Ecoregion. Because the main elements that determine the flora of the area are located in these limits. This area is a macroregion between the Black Sea and the Caspian Sea, the Greater Caucasus Mountains, the Eastern Anatolian Mountains, and the Elburs Mountains. (Figure 1).

648 species belonging to 90 species and 308 genera are distributed in the forest landscapes of the Greater Caucasus. Among them, 187 species are endemic and 131 species are woody trees and shrubs [Yusifov E., 2020; Yusifov E., 2024]. In the Azerbaijani part of the Greater Caucasus, subalpine landscapes, depending on the position of the area, relief, and climatic features, cover the height interval of 1700 - 2000 m and 2300 - 2400 m, and the alpine zone covers the heights of 2400 - 2700 and 3200 - 3500 m. [Mammadov R., 2015].



Figure 1. The Caucasus Ecoregion (580000 km²)

The alpine-subalpine landscapes of the Greater Caucasus extend from the Main Caucasus and Said ridges (north) to the Sudur, Beyuk Suval, Yerfi, and Gaytargoja ridges (east), to the Dubrar, Meysari, and Niyaldag ridges (south), and the Gubek, Gaflan, and Fiy ridges (west). The temperatures of the coldest month are -8-12°C, the warmest - +7-12°C, respectively, and the average annual temperature ranges from 2-2.5°C in the subalps to -2.5°C in the Alps. In addition, the minimum temperature in some areas falls in February, and the maximum in August, although “oceanicity” is often expressed only in one of the seasons. Temperature fluctuations are lower in alpine landscapes, but here the maximum temperatures of the warm period do not reach 10°C. The amount of precipitation generally ranges from 600 to 1800 mm per year. The climate of this zone, which belongs to the high mountainous climate zone, is characterized by short and humid summers, long cold and snowy winters. In the subalpine-alpine meadows of Azerbaijan, mainly turf mountain-meadow, primitive and turf mountain-meadow, bare rocks, and clayey rocks exposed to the surface are spread. It was determined that the alpine-subalpine landscapes of Azerbaijan are 975 plant species and subspecies belonging to 6 classes, 66 families and 321 genera and make up 22% of the country's flora. [Ibadullayeva S. and Yusifov E., 2022].

High mountain subnival landscapes in Azerbaijan, mainly in the Greater Caucasus, cover

areas from 3,200 - 3,500 m to 4,000 m, depending on the terrain and climatic features of the area. The average temperature of the hottest month is 0 - 50C and below, the temperature of the coldest month is 150C and below, and the average annual temperature is below 00C. The average annual rainfall is 900 - 1200 mm [Mammadov R., 2015]. As a result of the conducted research, it was found that the vegetation of the subnival landscapes of Azerbaijan consists of 136 species belonging to 28 families and 83 genera, and makes up 3% of the country's flora. Among the families, *Asteraceae* (25), *Poaceae* (15), *Caryophyllaceae* (13), *Brassicaceae* (8), *Saxifragaceae* (7), *Ranunculaceae* (6),

Lamiaceae (5) are the richest and dominant ones [Yusifov E.F. , 2022].

Summarizing the above, we get a general pattern of flora diversity and endemism of the forest, alpine-subalpine, and subnival landscapes of the Greater Caucasus (Table 1.). As can be seen, the number of species varies with altitude. The maximum number of species diversity falls on alpine-subalpine landscapes. In forest ecosystems, the inertial and homogeneous ecological environment created by tree species (solar radiation, soil moisture, length of vegetation period, etc.) creates an island effect.

Table 1.

Plant diversity and enemism of forest and high mountain landscapes of Greater Caucasus (Azerbaijan part)

Landscapes	Elevation, m	Species	Genus	Families	Endemism	
					Number	%
Subnival	3500 - 4000	136	83	28	85	63
Alpine-subalpine	1800 - 3500	975	321	66	432	44
Forest	500 - 1800	648	308	90	197	29
Total	500 - 4000	1787	719	181	714	40

Endemism of the area. The biogeography of the flora species found in the mentioned landscapes and their quantitative indicators and endemism are given in Diagram 1. As can be seen, some seasons are represented at all altitudes. Those families are stable and evolving taxa.

Due to its endemism, Caucasian flora is one of the richest areas of Europe's temperate zone vegetation. 2700 endemic species belonging to 13 endemic genera are mentioned here [Solomon J. et al., 2014]. According to the number

of endemic species (950 endemic species), Azerbaijan is in the top three among the states of the Caucasian ecoregion (Table 2.). Endemic genera found in each area indicate that this area is one of the important centers of origin. Eight out of 13 endemic genera found in the Greater Caucasus flora are found in the country [1]. Information about the endemic genera found in the flora of the Greater Caucasus is given in Table 3.

Table 2.

Distribution of endemic species of the Caucasus among the six Caucasian countries [Solomon J. et al., 2014].

Countries	Endemics of the Greater Caucasus (including endemics of states)	Endemics of the state	Total species of flora
Georgia	1320	276	4100
Russia/Caucasus	1300	280	3700
Azerbaijan	950	200	4500
Armenia	850	126	3600
Iran/Caucasus	420	178	3300
Turkey/Caucasus	400	210	4000

Table 3.

Endemic genera of the Greater Caucasus flora found in Azerbaijan

Family	Genus	Species
Apiaceae	<i>Agasyllis</i> Spreng.	<i>A.caucasica</i> Spreng.
	<i>Symphyoloma</i> C. A. Mey.	<i>S.graveolens</i> C. A. Mey.
Asteraceae	<i>Cladochaeta</i> DC.	<i>C.candidissima</i> DC.
	<i>Grossheimia</i> Sosn. et Takht.	<i>G.macrocephala</i> Sosn. et Takht.
	<i>Kemulariella</i> Tamamsch.	<i>K.rosea</i> (Stev. ex Bieb) Tamamsch.
Boraginaceae	<i>Trigonocaryum</i> Trautv.	<i>T.involucratum</i> (Steven) Kusn.
Brassicaceae	<i>Pseudovesicaria</i> Rupr.	<i>P.digitata</i> Rupr.
Valerianaceae	<i>Pseudobetckea</i> (Höck) Lincz.	<i>P.caucasica</i> (Boiss.) Lincz.

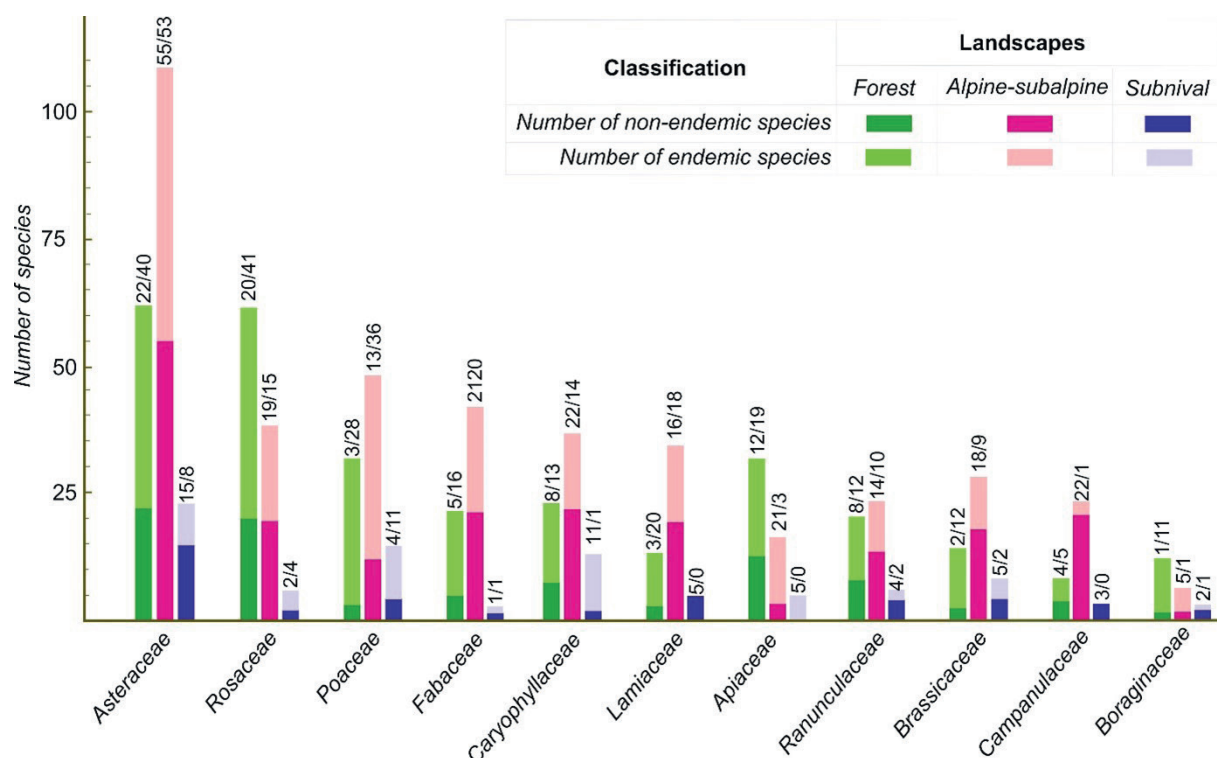


Diagram 1. Distribution of the main endemic and non-endemic species of the flora diversity of the forest and highland landscapes of the Greater Caucasus across landscapes

RESULTS OF THE STUDY

Table 5. shows the list of different categories of endemic species found in the territory of Azerbaijan. As can be seen, 443 species are macroendemic, 178 species are subendemic, and 52 species are endemic to the South Caucasus in the mentioned landscapes of Azerbaijan. The above-mentioned 443 macro-endemic species are relatively wide-ranging endemics found in Azerbaijan, Russia, Georgia, Armenia,

Turkey, and Iran, in other words, in the Caucasus Ecoregion. The next 219 subendemic species are conditionally divided into 2 parts. A group of them are subendemics of the North Caucasus and also spread in the territories of Georgia and Russia. The remaining species are found in Armenia and Iran as well as in Azerbaijan. The other 52 species are found only in the South Caucasus republics. Let's take a look at these endemics.

Table 5.

The scale of endemism of the forest and highland landscapes of the Greater Caucasus on the borders of Azerbaijan

Landscapes	Makro-endemic species	Endemics of Caucasus	Endemics of South Caucasus	Endemics of Azerbaijan	Non-endemic species	Total number of endemic species
Subnival	46	37	-	-	48	83
Alpine-subalpine	196	141	2	3	321	342
Forest	114	36	6	1	516	157

Caucasian endemic species found in forest and highland landscapes of Azerbaijan (178 species):

Polypodiopsida (3 families, 3 species):

Aspleniaceae (*Woodsia caucasica* (C.A.Mey.) J.Sm.), **Dryopteridaceae** (*Polystichum fominii* Askerov & A.E.Bobrov), **Woodsiaceae** (*Woodsia caucasica* (C.A.Mey.) J.Sm.).

Liliopsida (7 families, 15 species):

Amaryllidaceae (*Galanthus lagodechianus* Kem.-Nath.), **Asparagaceae** (*Ornithogalum magnum* Krasch. Schischk.), **Colchicaceae** (*Merendera eichleri* (Regel) Boiss.), **Juncaceae** (*Luzula abchasica* Novikov, *Poa iberica* Fisch., C.A.Mey. & Avé-Lall.), **Iridaceae** (*Crocus adami*, *C.speciosus*), **Liliaceae** (*Gagea germaniae* Grossh., *Lilium monadelphum* M.Bieb.), **Poaceae** (*Alopecurus ponticus* C.Koch, *Calamagrostis caucasica* Trin., *Dactylis woronowii* Ovcz., *Melica minor* Hack., *Poa caucasica* Trin., *Trisetum transcaasicum* Seredin syn. *T.distichophyllum* P.Beauv.).

Magnoliopsida (29 families, 160 species):

Amaranthaceae (*Axyris caucasica*), **Apiaceae** (*Agasyllis latifolia* (M.Bieb.) Boiss., *Angelica tatianae* Bordz., *A.sachokyania* (Karjagin) Pimenov & V.N.Tikhom, *Astrantia biebersteinii* Trautv., *A.trifida*, *Chaerophyllum humile* Steven & M.Bieb. syn. *Ch.kiapazi* Woronov ex Schischk., *Ch.roseum* M.Bieb., *Heracleum asperum* (Hoffm.) M.Bieb., *H.roseum* Steven, *H.sosnowskyi* Manden., *Seseli alpinum* M.Bieb., *Symphyloloma graveolens* C.A.Mey.), **Asteraceae** (*Achillea ptarmicifolia* (Willd.) Rupr. & Heimerl, *Aetheopappus causicus* Sosn., *Anthemis sosnovskyana* Fed., *Centaurea transcaucasica*

Sosn., *Cicerbita deltoidea* Beauverd, *Cirsium argillosum* Petrov & Kharadze, *C.macrocephalum*, *Cladochaeta candidissima* DC., *Hieracium macrolepis* Boiss., *Inula grandiflora* Willd., *Kemulariella rosea* (Steven) Tamamsch., *Lactuca georgica* Grossh., *Psephellus daghestanicus* Sosn., *P.dealbatus* K.Koch, *P.paucilobus* (Trautv.) Boiss., *Senecio caucasicus* DC., *S.cladobotrys* Ledeb., *S.karjagii* Sofieva, *S.lapsanoides* DC., *S.leucanthemifolius* subsp. *caucasicus*, *S.pojarkovae* Schischk., *S.sosnowskyi* Sofieva, *Serratula caucasica* (Boiss.) Greuter, *Tanacetum leptophyllum* Sch. Bip., *Taraxacum confusum* Schischk., *T.stevenii* DC., *T.tenuisectum* Sommer & Levier, *Tragopogon tuberosus* K.Koch), **Betulaceae** (*Betula raddeana* Trautv.), **Boraginaceae** (*Nonea alpestris* G.Don, *Omphalodes rupestris*, *Trigonocaryum involucreatum* (Steven) Medw.), **Brassicaceae** (*Barbarea grandiflora* N.Busch., *Eruca leptophyllum* (M. Bieb.) Andr., *Erysimum babadagense* Prima, *Eunomia rotundifolia* C.A.Mey., *Isatis latisiliqua* Steven, *Pseudovesicaria digitata* (C.A.Mey.) Rupr., *Sisymbrium erucastrifolium* Trautv., *Sobolewska caucasica* M.Bieb.), **Campanulaceae** (*Asyneuma campanuloides* (M.Bieb.) Bornm., *Campanula akhverdovii* Kharadze syn. *C.kolensatiana* C.A.Mey. & Rupr., *C. biebersteiniana* Schult., *C.caucasica* Kharadze, *C.ciliata* Thumb., *C.daghestanica* Fomin syn. *C.fedorovii*, *C.hypopolia* Trautv., *C.lezgina* (Alex.) Kolak. & Serdyuk., *C.meyeriana* Rupr. syn. *C.saxifraga* subsp. *meyeriana* (Rupr.) Ogan., *C.petrophila* Rupr., *C.sarmatica* Ker Gawl.), **Caprifoliaceae** (*Valeriana cardamines* M.Bieb., *V.tiliifolia* Troitsky),

Caryophyllaceae (*Cerastium holostium* Fisch. ex Hornem., *C.dagestanicum* Schischk., *C.kasbek* Parrot, *C.multiflorum* C.A.Mey., *C.undulatifolium* Sommier & Levier, *Dianthus awaricus* Kharadze, *D.fragrans* Adams ex Adams, *D.kusnezowii* Marcow, *D.ruprechtii* Schischk., *D.subulosus* Freyn & Conrath, *D.vladimirii* Galushko, *Minuartia biebersteinii* (Rupr.) Schischk., *M.inamoena* (C.A.Mey.) Woronow, *M.biebersteinii* Schischk., *M.oreina* Schischkin, *Silene akinfjewii* Schmalh., *S.daghestanica* Rupr., *S.humilis* C.A.Mey., *S.lacera* (Steven) Sims, *S.pygmaea* Less. & Ledeb), **Crassulaceae** (*Sedum stevenianum* Rouy & E.G.Camus, *Sempervivum caucasicum* Rupr. & Boiss., *S.pumilum* Bieb.), **Gentianaceae** *fəsiləsi* (*Gentiana angulosa* M.Bieb.), **Geraniaceae** (*Erodium fumarioides* Steven., *Geranium ruprechtii* Woronow & Grossh.), **Fabaceae** (*Astragalus brachytropis* (Steven) C.A.Mey., *A.elizabethiae* Tutcher, *A.ruprechtii* (Tamamsch. & Fed.) Ro skov, *A.beckerianus* Trautv., *A.brachytropis* Reiche., *A.kazbeki* Kharadze, *A.onobrychioides* Bieb. syn. *A.owerinii* Bunge, *A.sanguinolentus* M.Bieb., *Onobrychis biebersteinii* Sirj., *O.dasyopoda* Rupr. & Boiss., *Vicia caucasica* Ekutim., *V.grossheimii* Ekutim.), **Lamiaceae** (*Ballota grisea* Pojark., *Betonica nivea* Steven. subs. *nivea*, *Dracocephalum botryoides* Steven, *Marrubium goktshaicum* L., *M.plumosum*, *Scutellaria daghestanica* Grossh., *S.oreophila* Grossh., *Stachys pauli* Grossh., *Teucrium nuchense* K.Koch., *Thymus collinus* Salisb., *Ziziphora puschkini* Adams syn. *Z.karyajinii* Ter-Chatsch), **Malvaceae** (*Alcea kusariensis* (Iljin ex Grossh.) Iljin), **Orobanchaceae** (*Euphrasia ossica* Juz., *Orobanche grossheimii* Novopokr.),

Paeoniaceae (*Paeonia mlokosewitschii* Lomakin), **Plantaginaceae** (*Veronica caucasica* M.Bieb., *V.minuta* C.A.Mey. syn. *V.telephiifolia* subsp. *telephiifolia*, *V.petraea* Steven, *V.propinqua* Boriss. syn. *V.vendettadeae* Albach), **Polygalaceae** (*Polygala alpicola*), **Polygonaceae** (*Polygonum dshawachischwili* Kharkev., *P.pan-jutinii* Kharkev.), **Primulaceae** (*Androsace raddeana* Sommier & Levier, *Primula juliae* Kusn., *P.ruprechtii* Kusnez.), **Ranunculaceae** (*Delphinium caucasicum*, *D.tomentellum* N. Busch, *Helleborus caucasicus* A.Braun, *Ranunculus arachnoideus* C.A.Mey., *R.baidarae* Rupr. syn. *R.dzhavakheticus* Ovcz.), **Rosaceae** (*Alchemilla amicta* Ashe (endem), *A.diversipes*, *A.epipsila* Juz., *A.jaroschenko* Grossh., *Cerasus pallasii* Griseb., *Rosa oxyodon* Boiss., *Rubus buschiana* Chrshan, *R.brotherorum* Chrshan., *R.teberdensis* Chrshan., *Sibbaldia semiglabra*), **Rubiaceae** (1 cins, 2 növ): *Galium anfractum* Sommier & Levier., *G.valantioides* M.Bieb., **Salicaceae** (*Salix kazbekensis* A.K.Skvortsov, *S.kuznetzowii* Laksch. & Goerz), **Saxifragaceae** (*Saxifraga flagellaris* Willd. ex Sternb., *S.pseudolaevis* Oett.), **Scrophulariaceae** (*Scrophularia lateriflora* Trautv., *S.minima* M.Bieb., *S.ruprechtii* Boiss.), **Thymelaceae** (*Daphne caucasica*), **Valerianaceae** (*Pseudobetckea caucasica* (Boiss.) Lincz., *Valeriana cardamines* M.Bieb., *V.daghestanica* M.Bieb.), **Violaceae** (*Viola caucasica* Kolenati, *V.minuta* M.Bieb., *V.vespertina* Klovok).

The taxonomic spectrum and biogeography of endemic species distributed in forest, alpine-subalpine, and subnival landscapes are given in Tables 6, 7, and 8.

Table 6.

Endemics of the South Caucasus, found in the forest and highland landscapes of the Azerbaijan part of the Greater Caucasus.

№	Families	Species
	Asphodelaceae	<i>Eremurus azerbajdzhanicus</i>
	Asparagaceae	<i>Fessia hohenackeri</i> (Fisch. & C.A.Mey.) Speta
	Asteraceae	<i>Psephellus transcausicus</i>
	Campanulaceae	<i>Campanula meyeriana</i> syn. <i>C.saxifraga</i> subsp. <i>meyeriana</i>
	Caryophyllaceae	<i>Dianthus kusnezowii</i>
	Fabaceae	<i>Astragalus kubensis</i> Grossh., <i>Lathyrus leptophyllus</i> M.Bieb.
	Geraniaceae	<i>Erodium fumarioides</i>

	Orobanchaceae	<i>Euphrasia daghestanica</i> Juz., <i>E.karjaginii</i> Kem.-Nath., <i>E.nisami</i> Kem.-Nath., <i>E.ossica</i> Juz.
	Rosaceae	<i>Alchemilla epipsila</i> , <i>A.jaroschenkoi</i> , <i>Pyrus vsevolodii</i> , <i>P.eldarica</i> Grossh., <i>Rosa alexeenkoi</i> Crep. ex Juz., <i>R.biebersteiniana</i> , <i>R.sosnovskyi</i> Chrshan.
	Rubiaceae	<i>Asperula azerbaijanica</i> Mam, Shach & Velib., <i>Galium anfractum</i> Sommier & Levier., <i>G.valantioides</i> M/Bieb., <i>Galium vartanii</i> Grossh.
	Valerianaceae	<i>Valeriana cardamines</i> M.Bieb.

The species marked in bold in the table are the endemic species of Azerbaijan.

Table 7.

The pre-dominant families distributed in the forest and highland landscapes of the Greater Caucasus and quantitative indicators of their endemism

Families	Number of species			Total number of species	Endemism			Total number of endemic species	Exological scale
	Forest	Al-pine-sub-alpine	Subnival		Forest	Al-pine-sub-alpine	Subnival		
Asteraceae	66	143	25	234	24	61	15	100	2.34
Rosaceae	72	53	6	131	20	27	2	49	2.67
Poaceae	22	66	15	103	3	14	5	22	4.68
Fabaceae	29	61	2	92	6	27	1	34	2.71
Caryophyllaceae	21	49	13	83	9	28	12	49	1.69
Lamiaceae	29	47	5	81	4	26	5	35	2.31
Brassicaceae	18	38	8	64	5	23	6	34	1.88
Apiaceae	30	29	5	64	10	26	5	41	1.56
Ranunculaceae	20	33	6	59	9	22	4	35	1.69
Boraginaceae	11	8	3	22	1	7	2	10	2.20
Scrophulariaceae	7	10	5	22	1	7	2	10	2.20

Table 8.

Dominant families and their endemism spread in the forest and high mountain landscapes of the Greater Caucasus within the borders of Azerbaijan.

Land-scapes	Predominant families and number of species	Predominant families and number of endemic species
Subnival	Asteraceae (25), Poaceae (15), Caryophyllaceae (13), Brassicaceae (8), Saxifragaceae (7), Rosaceae (6)	Caryophyllaceae (12), Asteraceae (15), Brassicaceae (6), Poaceae (5), Apiaceae (5), Lamiaceae (5)
Alpine-sub-alpine	Asteraceae (143), Poaceae (66), Fabaceae (61), Rosaceae (53), Caryophyllaceae (49), Lamiaceae (47)	Asteraceae (61), Caryophyllaceae (28), Fabaceae (27), Rosaceae (27), Apiaceae (26), Brassicaceae (23)
Forest	Rosaceae (72), Asteraceae (66), Orchidaceae (36), Apiaceae (30), Fabaceae (29)	Asteraceae (24), Rosaceae (20), Apiaceae (10), Asparagaceae (10), Ranunculaceae (9), Caryophyllaceae (9)

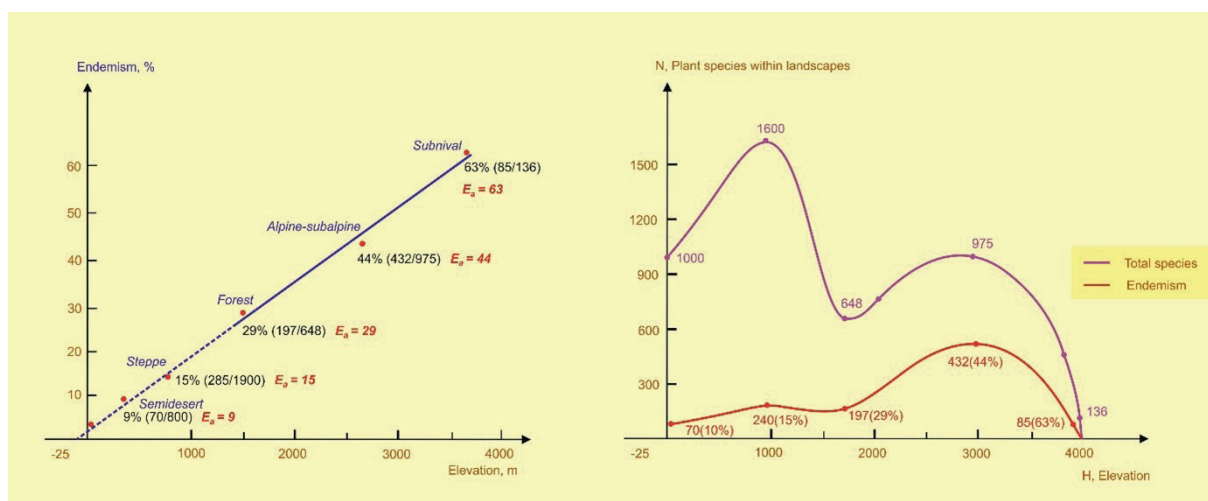


Figure 3. Hypsometric dependence of flora diversity and endemism and ecological autochthony index.

Figure 2. presents the diversity of flora of the studied area and the hypsometric dependence of endemism. As can be seen from the figure, with increasing altitude, species diversity first increases, and then sharply decreases. However, the flora endemism of the area is directly proportional to the elevation. As can be seen from the picture, endemism in our semi-desert landscapes is 9%, while in subnival landscapes this indicator is 63%.

DISCUSSION OF RESULTS.

Within the Caucasian endemics, relatively stable and less dangerous species are the families and their species represented in all 3 landscapes. These are the families Apiaceae, Asteraceae, Brassicaceae, Campanulaceae, Caryophyllaceae, Lamiaceae, and Ranunculaceae. If we take the ecological index scale of each landscape equal to 4, the ecological index of these seasons becomes 9. Since their hypsometric areas are very wide, they will withstand the impact of global warming for a long time. It seems that the Asteraceae family is the leader in hypsometric distribution, endemism, and pioneer species. 193 species of flora found in forest and high mountain landscapes belong to the Asteraceae family. Within these species, 99 species are endemics with different areas. As can be seen, species belonging to the

Asteraceae family dominate both in terms of latitude, non-endemic, and hypsometric dreyf.

The main pollinators of asters in subnival landscapes are butterflies such as *Aglaia urticae*, *Parnassius apollo*, and *Colias thisoa* and bears such as *Arctia caja*, belonging to the order scaly-winged of the insect class. Some small rodents and predators are also involved in the spread of seeds. An excess of pollinating material, their sufficient content in the carrier bodies of insects, is also one of the factors that increase the effectiveness of pollination, in the end, reproduction.

According to the total number of species of the family represented in all landscapes, the Asteraceae, Rosaceae, Fabaceae, and Poaceae families are distinguished. However, according to the coefficient of regular representation in all landscapes, the families Caryophyllaceae, Poaceae, and Brassicaceae are distinguished. The genera Asteraceae, Caryophyllaceae, Rosaceae, Lamiaceae, and Apiaceae are distinguished by endemism. In the subnival, which is an acute radical environment, the families Asteraceae, Caryophyllaceae, and Brassicaceae predominate on endemism.

Some of the pioneer plants are glareophytes, adapted to stony-gravel sheds, with a powerful root system, drought-resistant glareophytes, and chasmophytes, which penetrate

rock cracks with long roots, resistant to the harsh water-temperature regime, moisture and lack of nutrients (Figure 4.). These are *Campanula ciliata*, *C. lezgina*, *C. petrophila* Rupr., *C. saxifraga*, *Epilobium anagallidifolium*, *Erigeron uniflorus*, *Nepeta supina*, *Veronica caucasica*. The tree forms of the chasmophytic plants (*Punica granatum*, *Ficus carica*, *Celtis glabrata*, *Juniperus polycarpos*, *Rhamnus pallasii*, etc.) it is also found in the lower, semi-desert and steppe areas of Azerbaijan.

In high-mountain landscapes, individual mutations occur in each isolated population during microgeographic and edaphic isolation of populations from each other. As a result of these mutations, different evolutionary processes are taking place. In the end, this difference differs

from each other so sharply and moves away that, as a result, the process leads to the emergence of a new species. A radical and wide-interval change in Climatic Factors in the subnival leads to the formation of a difference between populations, creating an "island of isolation". For example, the northern and southern parts of the rock, habitats at the top and cracks of the rocks differ sharply. These differences eventually lead to the fact that different populations are less likely to cross with each other. Or, as a result of crossing, the viability of these hybrids against the radical environment is different. Thus, populations do not participate in gene exchange, but become a new different species as a result of adaptive changes and natural selection.



Figure 4. The highest elevation reached by vascular plants in the area: a - *Anthemis sosnovskyana*; b - *Cirsium tomentosum*; c - *Cynoglossum holosericeum*; d - *Erigeron uniflorus*; e - *Jurinella subacaulis*; f - *Pseudovesicaria digitata*; g - *Ranunculus arachnoideus*; h - *Vavilovia formosa*.

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THE EFFECT OF METAL-BASED NANOPARTICLES ON THE SYNTHESIS OF PHOTOSYNTHETIC PIGMENTS IN WHEAT PLANT LEAVES DEPENDING ON THE SPECTRAL COMPOSITION OF LIGHT

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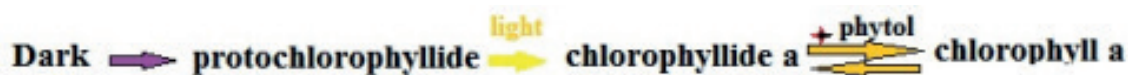
Abstract. *The present study analyses chlorophyll biosynthesis in leaves of young wheat seedlings and the effect of zinc oxide (ZnO) and iron oxide (Fe₃O₄) nanoparticles on the pigment composition in different light spectra (white, red, and blue). Wheat seeds were first kept in a suspension solution of iron and zinc oxide nanoparticles for 24 hours and planted in pots. The amount of Chla in the leaves of seedlings treated with ZnO nanoparticles is higher than that of the control variant in all light spectrums. This result indicates that ZnO nanoparticles stimulate the synthesis of Chla. This stimulation is more effective in blue light. Fe₃O₄ nanoparticles are effective only in red light. ZnO nanoparticles stimulate the synthesis of Chlb better only in blue light. ZnO nanoparticles have little effect on the synthesis of carotenoids in red light, and their effect does not differ much in white and blue light. The effect of Fe₃O₄ nanoparticles on the synthesis of Chlb is more effective only in blue light. The effect of Fe₃O₄ nanoparticles on the synthesis of carotenoids does not depend on the spectral content of light.*

Key words: *nanoparticles, chlorophyll synthesis, wheat seedling, red and blue light.*

INTRODUCTION

Specific pigments (various types of chlorophyll, carotenoids, cryptos, and phytochromes) that ensure the process of photosynthesis in green plants and their functions have been widely studied. Chlorophylls and carotenoids, which are the main pigments of the photosynthetic apparatus of plants, are vital pigments for assessing the influence of physical and chemical environmental factors on the development and productivity of plants. The synthesis of these pigments, which provide absorption in all spectral ranges of white light, and the factors influencing the process are very well studied. Chla and Chlb, as well as carotenoids, are the most important of these pigments. Chl a and Chl b pigments differ in function and quantity depending on the type of plants. The ratio of Chl a/Chl b in light-loving species of plants usually ranges from 3.3 to 4.2 under normal nutritional conditions. But in shade-loving species

that grow in low light, this ratio can be 2.2 or lower. Both forms of chlorophyll are involved in intense absorption of light (Endredi, 1985). Chlorophylls are one of the most important tetrapyrroles responsible for converting light energy into chemical energy during photosynthesis. Chlorophyll biosynthesis in green plants is a vital physiological process that occurs in several stages (Tripathy et al., 2011). The precursor of chlorophyll molecules is aminolevulinic acid (ALA), common to all tetrapyrroles, and the synthesis of this molecule itself is a complex process, including a large number of intermediate products. It is well known that when plants are grown in the dark, chloroplasts are not fully formed and contain less chlorophyll in the form of protochlorophyllide. When leaves with low concentrations of protochlorophyllide are exposed to red or blue light, the protochlorophyllide is rapidly converted to chlorophyllide. This transformation includes the following steps:



The main factors that regulate the synthesis of chlorophyll in plants are physical and chemical factors such as light, temperature, water, nitrogen, carbon dioxide, magnesium, iron manganese deficiency, etc. In practical conditions, the effect of these factors is rarely optimal. The amount of chlorophyll in leaf tissue is affected by several environmental stress factors, including the availability of nutrients, and stresses such as drought, salinity, cold, and heat. Therefore, measuring the amount of chlorophyll in leaves is an important tool for assessing plant condition and ultimately productivity. When leaves are continuously irradiated with red or blue light, chlorophyll accumulates slowly during the first hour, after which the leaves rapidly turn green. Experiments have shown that the synthesis of Chla and Chlb as well as other pigments and their amount depends on the spectral composition of light. For example, when oat (*Avena sativa*) seedlings were grown under a 16/8 red light-dark regime for 9 days, the amount of Chla and also Chlb was higher than the other variants. Interestingly, the amount of pigments reaches its maximum value during 5 days, but during the following days, the ratio of Chl a/Chl b remains unchanged, while the ratio of carotenoids Chl a and Chl b decreases. (Kuleshova et al., 2018).

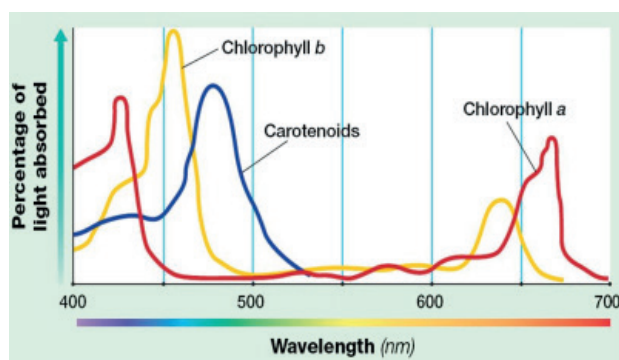


Figure 1. Absorbance spectra of chlorophyll a, chlorophyll b and carotenoids

Nanotechnology is a technology that acts as one of the promising and innovative applications in plant physiology. Applications of nanotechnology materials, especially nanoparticles in plant physiology, require new insights into

the mechanism of several biological and biochemical processes at a new level. The application of nanoparticles plays an important role in the development of plants, resistance to stress factors, and their protection against various diseases and toxic factors of the environment. Since plants are known to be a key component of all ecosystems, the effects of nanoparticles on plants may provide new insight into ecosystems (Landa et al., 2021). So far, a large number of articles have been published on the effects of nanoparticles on plants (both positive and negative), and research in this area is still a matter of debate. In these discussions, studies of the effect of nanoparticles on the photosynthesis process at the molecular and organism level are of special interest.

Nanoparticles can be used as fertilizers, enhancers, pesticides, and other applications in agriculture. However, the concentration to be used should be determined beforehand. Because different amounts of nanoparticles have different effects on each plant. After giving the non-toxic concentration to the plants, it was found that there was rapid growth and an increase in productivity in them. Also, nanoparticles can be used to prevent the accumulation of heavy metal ions in plants and increase tolerance (Landa et al., 2021). In recent years, researchers have been interested in how nanoparticles affect chloroplasts and the photosynthesis process, and observations have been made in this direction. As a result of research, it was found that low concentrations of Fe₃O₄ and ZnO nanoparticles increased the amount of chlorophyll in mature rice plants (*Oryza Sativa* L.) (Liu et al., 2006), magnetite nanoparticles coated with aspartic acid (A-MNP) of 9.17 nm mean diameter size with different concentrations increased chlorophyll content [Antioxidants 2022, 11(6), 1193; <https://doi.org/10.3390/antiox11061193>], SPIONS which were entered and translocated in the soybean, increased chlorophyll levels, which no trace of toxicity. The positive effect of Fe nanoparticles at doses of 0.0125-0.1 M on the level of

chlorophyll a and b in sprouts was established; its content s increased by more than 57%-98% . An increase in chlorophyll was caused by iron ions isolated from their composition (Ghafariyan et al., 2013). Application of ZnO nanoparticles significantly increased chlorophyll a and b contents by 24.6 and 10% in wheat (*Triticum aestivum*) (Ahmad et al., 2013). ZnO nanoparticles alleviated Pb-induced stress by promoting plant growth, and improved chlorophyll and carotenoid contents (Hussain et al., 2021). After coating with Al nanoparticles, cotton plant seeds were cultured in vegetative pots under laboratory conditions. When analyzing the pigment content of cotton leaves (in the three-leaf stage of seedlings), it was determined that the amount of chlorophyll and other pigments increased significantly compared to the control plants (Hasanova, 2023). The incorporation of TiO₂ nanoparticles at 60 mg/kg into the cultivated soil of *Triticum aestivum* L increased the amount of chlorophyll in the plants by 32.3% compared to the control (Rafique et al., 2018). The amount of chlorophyll increased in wheat (*Triticum aestivum* cv. Cumhuriyet-75) plants treated with Fe₂O₃ nanoparticles with a size range of 20–40 nm and a dose of 500 mg/L. According to researchers, nanoparticles collected in plants stimulated the synthesis of chlorophyll as a source of Fe (Al-Amri et al., 2018). Both nano- and non-nanoform of ZnO applied on leaves increased the content of chlorophyll, relative water content, soluble protein content, and peroxidase (POD) and catalase activities, which resulted in a higher yield of flowers in comparison with untreated control in the field experiment (Rostami et al., 2019). Spraying leaves of saffron (*Crocus sativus* L.) with both non-nano and nano forms of ZnO increases the amount of chlorophyll, relative water, soluble protein content, and peroxidase (POD) and catalase activity. As a result, better fertilization of flowers occurs compared to the control, leading to higher yields (Rostami et al., 2019). When sprayed with graphene oxide or ZnO, the growth of plants is stimulated, the amount of chlorophyll, carotenoids and proline increases and the growth of plants is accelerated.

From the analysis of the scientific literature

on the effect of nanoparticles on plants, it is clear that depending on the type, dose, duration and type of exposure, nanoparticles can have both positive and negative effects on the amount of photosynthetic pigments in white light. Experiments related to the study of the effect of nanoparticles on the synthesis of photosynthetic pigments depending on the spectral composition of light are very few and such experiments are needed.

MATERIALS AND METHODS

Wheat *Triticum aestivum* L. The leaves of 7-day-old sprouts of the Mirbashir-128 soft wheat variety (*Triticum aestivum* L) were used as the research object. The local Mirbashir-128 wheat variety was obtained from intraspecific hybridization of the “Bezostaya-1” variety with the “S-271” variety of Pakistani origin. This wheat variety is resistant to spreading and has a height of 95-100 cm. The variety has a short growing season, medium maturity, and ripens at the same time as the Bezosta-1 variety. The spike is compact, medium length, and medium density. Spike scales are semicircular, spikes are short, poorly spread, and rough. Shoots and plants are dark green. The average productivity of the variety in irrigation is 63.4 s/ha. The potential yield is 60-70 s/ha.

Design of experiments. The selected wheat seeds were disinfected in hydrogen peroxide (H₂O₂) solution for 2-3 minutes, after washing, they were kept in distilled water in the control variant and the suspension solution of ZnO and Fe₃O₄ nanoparticles in the experimental variants for 24 hours. For this purpose, 250 mg of each ZnO and Fe₃O₄ nanoparticles were mixed in 50 ml of distilled water and processed in an ultrasound machine for 10 minutes. Swollen wheat seeds were planted in soil in plastic planting pots, watered every 3 days and germinated for 7 days in Plant Growth Chamber (GVS 940) at 25 °C temperature in dark conditions. From the 8th day of the experiment, the seedlings were illuminated with normal white light, blue and red light for 90 minutes. As a white, red, blue light source, model-B1110-B, ac220-240 V, 50/60 Hz, 9 Watt lamps were used. Each variant of the plants grown in the dark was illuminated

with white, red and blue light for 90 minutes each time for 3 days, and leaf samples were taken to determine the amount of pigments in them 24, 48, 72 hours after the illumination. For this, 0.1 g of leaves are crushed in 10 ml and a solution is prepared in 95% acetone. The extract was centrifuged at 5000 revolutions/min for 5 minutes in the NF 200 apparatus and the leaf extracts were precipitated. The amount of chlorophylls and carotenoids was determined by a standard spectrometric method at wavelengths of 440, 645, 663 nm using a SPECORD 250 plus spectrophotometer. [Dilber Abdullaeva et al., 2023].

Nanoparticles. The nanoparticles (Fe₃O₄, and ZnO) in powder form were purchased from Sky Spring Nanomaterials, Inc (USA). The characteristics of the particles were as follows. Average particle size: 18 nm Fe₃O₄ and 10-30 nm ZnO, purity: 99.9%, and surface area > 80 (m²/g) as reported by the commercial agent. Cotton seeds were dusted with nanoparticle powder before sowing. For this, 1 mg of each nanoparticle was added to a 50 ml glass for 10 seeds, and the seeds were processed in a shaker for 10 minutes.

Methods for measuring pigments. The amount of chlorophylls and carotenoids was determined by a standard spectrometric method. For this, 0.1 g of leaves are crushed in a mortar, and 10 ml of 95% acetone is added and mixed. After the extract was centrifuged at 6000 cycles for 5 minutes, the amount of pigments was measured at wavelengths of 440, 645, and 663 nm using SPECORD 250 plus spectrophotometer. The amount of pigments was determined according to the following formulas:

Chl a (mg/g-fresh weight) = $9,784 \times A_{663} - 0,990 \times A_{645}$

Chl b (mg/g) = $21,426 \times A_{645} - 4,650 \times A_{663}$

Chl a + Chl b (mg/g) = $5,134 \times A_{663} + 20,436 \times A_{645}$

Carotenoids (mg/g) = $4,695 \times A_{440} - 0,288 \times (a + b)$

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A - absorbency at corresponding wave length, values 9.784, 0.990, 21.426, 4.650 and

0.288 is the molar absorptivity coefficient according to Holm (1954) and Wetstein (1957) for acetone (absorption of 1 cm). After calculating the concentrations, the amounts of pigment per g of fresh matter were calculated applying the formula:

$$C = \frac{c1Vr}{m}$$

C - content of pigment (mg/g) of fresh matter; **c1**- the concentration of pigment calculated by the previous formula (mg/l); **V**- the starting volume of extract (ml); **r** - dilution; **m**- the weighed fresh plant (g).

RESULTS

According to the methodology of experiments, wheat seeds stored in ordinary distilled water and nanoparticles were planted in vegetation pots and germinated in the dark for 8 days in a laboratory phytotron. Since sprouts develop in the dark, synthesis of chlorophyll does not occur. After 90 minutes of simultaneous illumination in chambers equipped with white, red, and blue lamps, these seedlings were grown in natural light for 24 hours under normal room conditions. After 24 hours, samples were taken from the leaves of the seedlings, and the amounts of Chla, Chlb, and carotenoids were determined. The results of this experiment are shown in Figures 2, 3 and 4. Figure 2 shows the kinetics of Chla pigment synthesis depending on the spectral composition of light. It is clear from the graph that the synthesis of Chla pigment in seedlings illuminated with white light is slightly higher in seedlings treated with ZnO nanoparticles than in the control variant, but it is significantly less synthesized in seedlings treated with Fe₃O₄ nanoparticles. Under red light, Chla synthesis is greater with both nanoparticles compared to the control and is significantly higher with Fe₃O₄ nanoparticles than under white light. Interestingly, the synthesis of Chla in the control variant is weakened in red light compared to white light.

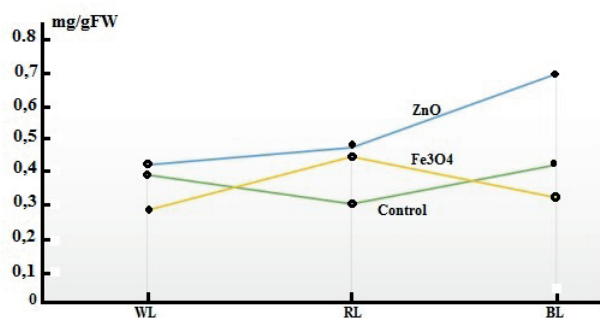


Figure 2. Effect of nanoparticles (after 24 h) on the synthesis of **Chla** depending on the spectral composition of light: **WL**- white light; **RL**-red light; **BL** -blue light

Compared to the control variant, the ZnO nanoparticle increases the synthesis of Chla, but the Fe3O4 nanoparticle decreases it in the seedlings illuminated with blue light. ZnO nanoparticles accelerate the synthesis of Chla under both red and blue light. Fe3O4 nanoparticles are more effective in red light.

Figure 3 shows the change in kinetics of Chlb in different light spectra in wheat sprouts cultivated with the application of nanoparticles. The results show that the amount of Chlb in the seedlings exposed to white light is the highest in the seedlings exposed to ZnO nanoparticles. In the sprouts treated with Fe3O4 nanoparticles, the amount of Chlb is lower than in the control. The amount of Chlb in red light decreases compared to white light in seedlings treated with both nanoparticles, ZnO and Fe3O4, but increases compared to white light in the control variant. But in blue light, the amount of Chlb in all variants is higher than in red light and white light. In the sprouts where ZnO nanoparticles are applied, the amount of Chlb is still higher than in the other variants.

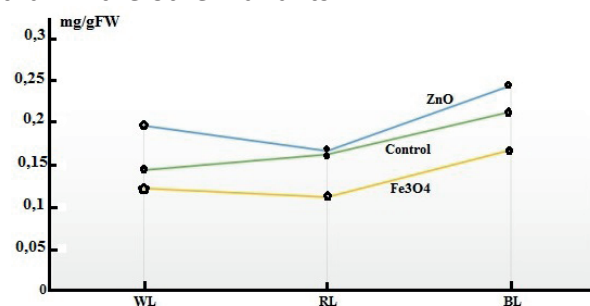


Figure 3. Effect of nanoparticles (after 24 h) on the synthesis of **Chlb** depending on the spectral composition of light: **WL**- white light; **RL**-red light; **BL** -blue light

Figure 4 shows the kinetics of changes in carotenoids in different light spectra in wheat sprouts cultivated with the application of nanoparticles. It is clear from the figure that the amount of carotenoids in the seedlings illuminated with white light was the same in both control and Fe3O4 nanoparticles. When ZnO nanoparticles treated seedlings were exposed to white light, the amount of carotenoids was significantly higher. In the red light, the amount of carotenoids decreased sharply in the ZnO variant, but in the blue light, it was much more than the other variants. The amount of carotenoids in blue light was less in both the control and Fe3O4 variants compared to the light and red light.

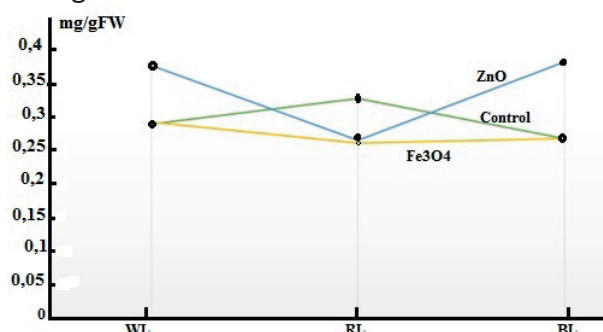


Figure 4. Effect of nanoparticles (after 24 h) on the synthesis of **carotenoids** depending on the spectral composition of light: **WL**- white light; **RL**-red light; **BL** -blue light

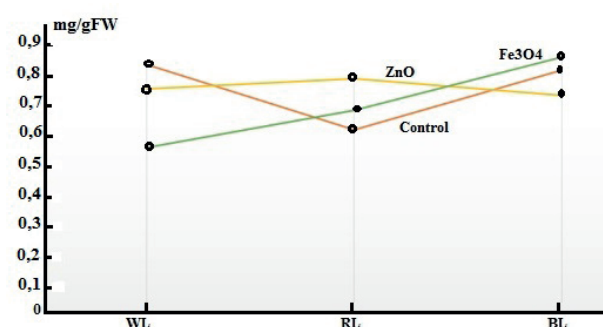


Figure 5. Effect of nanoparticles (after 72 h) on the synthesis of **Chla** depending on the spectral composition of light: **WL**- white light; **RL**-red light; **BL** -blue light

After the wheat sprouts were grown in normal light for another 72 hours, they were again irradiated in different spectrums of light and the amounts of Chla, Chlb, and carotenoids were determined. In this case, the leaves on the seedlings were fully developed and turned

green. Figure 5 shows the kinetic plot of changes in the amount of Chla in both white-light and red-blue light irradiated seedlings at 72 hours. From the result of this experiment, it was clear that the synthesis of Chla was different in different spectrums of light in the nanoparticle-applied variants, even in already green leaves. Thus, when both ZnO and Fe₃O₄ nanoparticles are illuminated with white light for 90 minutes, the amount of Chla is less compared to the control variant. However, in the red light, the amount of Chla is significantly reduced in the control variant, and the amount of Chla is higher in the ZnO and Fe₃O₄ variants compared to the control. In nanoparticle-treated seedlings, Chla content increases in all variants relative to red light, but not as high relative to white light.

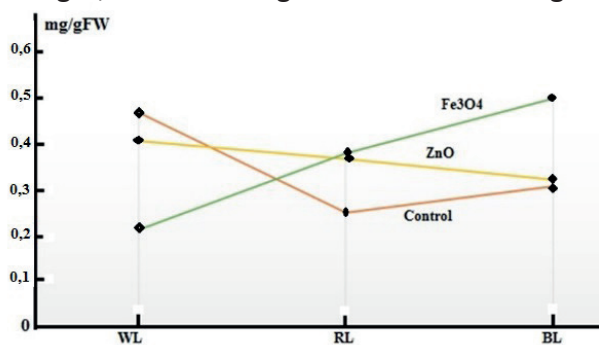


Figure 6. Effect of nanoparticles (after 72 h) on the synthesis **Chlb** depending on the spectral composition of light: **WL**- white light; **RL**-red light; **BL** -blue light

Figure 6 shows the kinetic plot of changes in the amount of Chlb in 72-hour-old seedlings, both in white light and in red, blue light-irradiated seedlings. It was clear from the results that when the sprouts were illuminated with white light for 90 minutes, the amount of Chlb in the sprouts treated with nanoparticles was lower than in the control. It should be noted that the amount of Chlb is less in the Fe₃O₄ version. In red light, the amount of Chlb in both nanoparticle variants is higher than in the control, but the amount of Chlb is reduced in all variants compared to the variants illuminated with white light. In blue light, the amount of Chlb is higher in both ZnO and Fe₃O₄ variants than in the control. The amount of Chlb in blue light is significantly higher in seedlings treated with Fe₃O₄ nanoparticles than in both white light and red

light. In the application of ZnO nanoparticles, the amount of Chlb decreases in both red and blue light.

Figure 7 shows the kinetics of changes of carotenoids in different light spectra in 72-hour-old wheat sprouts cultivated with the application of nanoparticles. It can be seen from the graph that the amount of carotenoids is the highest in the ZnO variant when illuminated with white light. In the Fe₃O₄ version, it is less than the control version. In red light, the amount of carotenoids in the ZnO variant is still higher than both the control and the Fe₃O₄ variant. In blue light, the amount of carotenoids in seedlings treated with Fe₃O₄ nanoparticles is lower than in other options.

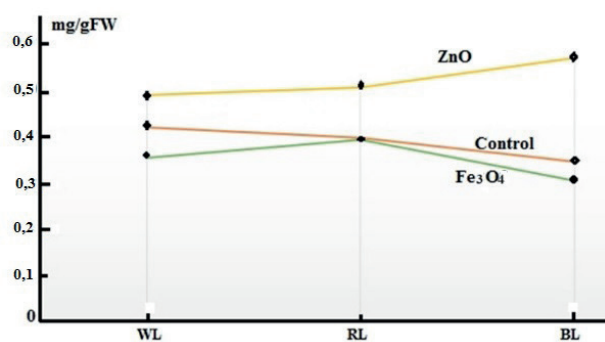


Figure 7. Effect of nanoparticles (after 72 h) on the synthesis caratinoids depending on the spectral composition of light: **WL**- white light; **RL**-red light; **BL** -blue light

DISCUSSIONS

Zinc and iron is one of the important micro-nutrients for plant development and growth. Zinc plays an important role in the activity of several important enzymes, including RNA polymerases and superoxide dismutase, in the process of photosystem II regeneration. Zinc deficiency slows plant growth, reduces tolerance to stressors, and reduces chlorophyll synthesis (Sharma et al., 2013). Since ZnO nanoparticles are relatively well soluble in aqueous media (Nath et al., 2018), they can serve as a source of zinc. Foliar application of ZnO NPs (and to a lesser extent ZnSO₄) increased the zinc content of wheat (*Triticum aestivum*) grains, showing that zinc is present in the form of zinc phosphate, which may be beneficial where zinc is insufficient in the diet (Zhang et al., 2018). Experiments showed that ZnO nanoparticles

increase the biosynthesis of chlorophyll and the intensity of photosynthesis under normal conditions as well as under stress conditions. In a greenhouse experiment, Rossi et al. observed that it increased. (Rossi et al., 2019). They also observed that ZnO nanoparticles increase the amount of chlorophyll in mung bean plants (Ralia et al., 2016). Iron nanoparticles treatment regulated the expression of respiratory burst oxidase homologue D gene, chlorophyll synthase and protochlorophyllide oxidoreductase (Anis Ali et al., 2022). Foliar treatment of plant *Moringa oleifera* increased photosynthetic pigments (Chla, Chlb, Chla/b and carotenoids) contents comparing with control (Tawfik et al., 2021). Thus, the effect of ZnO and Fe₃O₄ nanoparticles on the synthesis of photosynthesis pigments can be explained by their acting as trace elements or by their effects on metabolic processes and enzyme activity. The dependence on the spectral composition of light is related to the different stages of formation of pigments in different light spectra, in which case nanoparticles can play a certain positive role.

CONCLUSION

The results of the experiments show that the synthesis of pigments in wheat sprouts treated with nanoparticles depends on the type of nanoparticles and the spectral composition of light. It turns out that the synthesis of Chla, Chlb, and carotenoids differs dramatically in terms of quantity, both with the application of nanoparticles and depending on the spectral content of the substance. The amount of Chla in the leaves of seedlings treated with ZnO nanoparticles is higher than that of the control variant in all light spectrums. This result indicates that ZnO nanoparticles stimulate the synthesis of Chla. This stimulation is more effective in blue light. Fe₃O₄ nanoparticles are effective only in red light. ZnO nanoparticles stimulate the synthesis of Chlb better only in blue light. ZnO nanoparticles have little effect on the synthesis of carotenoids in red light, and their effect does not differ much in white and blue light. The effect of Fe₃O₄ nanoparticles on the synthesis of Chlb is more effective only in blue light. The effect of Fe₃O₄ nanoparticles on the synthesis of carotenoids does not depend on the spectral content of light.

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TAXONOMIC ANALYSIS OF THE GENUS *SENECIO* L., S.L. (ASTERACEAE) IN AZERBAIJAN

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Abstract. The article provides a systematic analysis of the species of the genus *Senecio* L., belonging to the Asteraceae family, distributed in Azerbaijan. As a result of the analysis of literature data, internet resources, materials in Herbarium Fund, as well as herbarium material collected by the authors during the expeditions organized in recent years as well as monitoring data, it was determined that there are 21 species of this genus belonging to 8 sections in the wild flora of Azerbaijan ("18 species belonging to the genus are given in "Flora of Azerbaijan"). The authors consider it appropriate to keep the genus into a wide extent as accepted by classical and modern botanists (currently, some European botanists divide this genus into 5-7 independent genera, and most of them are accepted in the World Flora Online database). The article clarifies the controversial points in the distribution of several species (*S. cladobotrys*, *S. thyrsochorus*, *S. pojarkoviae*, *S. paucilobus*, *S. noeanus*, *S. kubensis*, *S. racemosus*) of the genus. The endemism of the species of the genus was also analyzed and it became clear that 17 of the 21 species of the *Senecio* genus distributed in Azerbaijan are of Caucasian origin (endemic and subendemic species), this indicates that the Caucasus, including Azerbaijan, is one of the main species formation centers of the genus. The article provides information on the detailed nomenclature of each species, their types, distribution in Azerbaijan and the world, and environmental characteristics.

Keywords: Asteraceae, groundsel, taxonomy, nomenclature, range.

INTRODUCTION

Senecio L. (Asteraceae) is one of the large-flowered plant genera distributed in most countries of the world. There are 3000 species of this genus in the world, 100 in the former USSR, and 32-38 in the Caucasus (Sofiyeva, 1954; Yu. L. Menitsky, G.Yu. Konecnaya, 2001; Asgarov, 2016). The main species formation centers of the genus are considered to be Central America, the Andes, East and South Africa, South Asia, and Australia. North America and Eurasia are areas where it is relatively poorly distributed (Menitsky et al., 2001). Many classical botanists studied the taxonomy of the genus. A.P. De Candolle (De Candolle, 1836-1838) divided the Caucasian species of the genus into 10 groups (series) according to the morphological

characteristics and areological characteristics of the species. A.I. Poyarkova (Poyarkova, 1950) showed the characteristics that distinguish this genus from the close genus *Ligularia* Cass and accepted them as independent genera. M.B. Bieberstein (1808 – 1819), K. Meyer (1849), D.I. Sosnovsky (Sosnovsky, 1929), A.A. Grossheim (Grossheim, 1934 and later), R. Sofiyeva (Sofiyeva, 1954) studied the Caucasian species of the genus in more detail.

Although many botanists (A.P. De Candolle, 1838; E. Boissier, 1875; Grossheim, 1934, 1949; Sofiyeva, 1961) accept the genus to a wide extent (sensu lato), some authors divided it into small subgenera and even independent genera. In this case, reference was made to small morphological traits. The most frequently cited

traits were traits of the pistillate stile, stamen, and also the leaf in the flower.

Species of the genus are found in most regions of Azerbaijan, from the middle mountain belt to the subalpine belt. Only a few species are found in the plains and lower mountain belt. In general, groundsel species are elements of the high mountain belt. They can be found in mountain meadows, tall grasses, forest clearings, stony and rocky slopes, and less commonly in gardens and plantations.

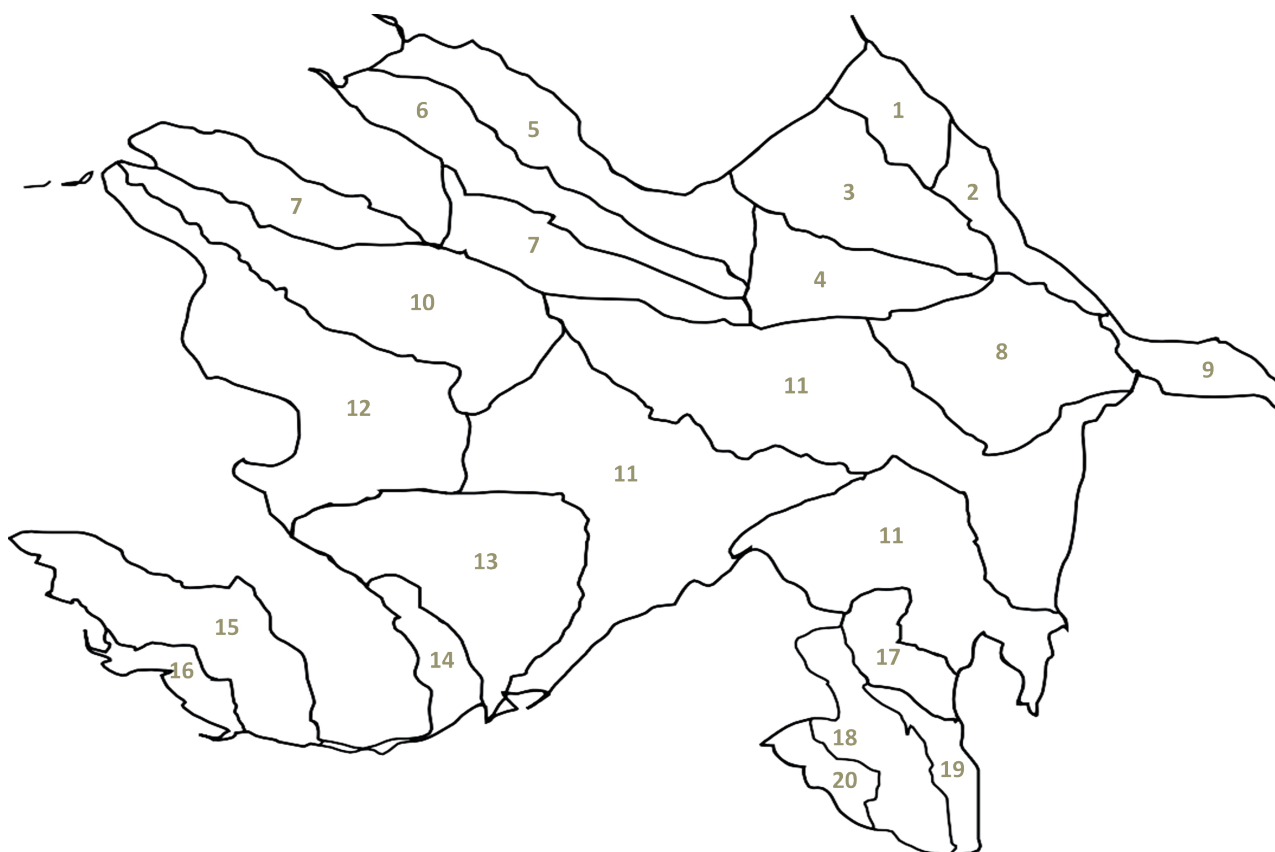
Most of the groundsel species are medicinal plants and they have been used in the treatment of various diseases since ancient times. All parts of the plant are suitable for obtaining medicinal products. Alkaloids of various origins are considered the main active substances. It is used in the treatment of bronchial asthma, blood pressure, and eye diseases, and at the same time is a hemostatic agent. There are also vitamin-containing and decorative species. Besides these, some species of the genus are poisonous plants.

MATERIALS AND METHODS

Comparative, morphological, systematic,

and chronological methods were used during the research. The herbarium specimens stored in the Herbarium Fund of the Institute of Botany, MSE RA (BAK), and newly collected ones were processed under cameral conditions, and their morphological characteristics and monitoring data related to their distribution area were studied. The distribution of species in Azerbaijan is given according to the botanical-geographic zoning scheme adopted in the "Flora of Azerbaijan" (Sofiyeva, 1961) (Map 1). If the species is found in all the sub-regions (e.g., GC Guba, east, west) within the large regions of Azerbaijan (e.g., Greater Caucasus) then the main region is given (in this case, GC). The general distribution of the species is given based on the information presented in "Conspectus of the Flora of Caucasus" (Menitsky, et al. 2008).

In providing synonyms, "Flora of the USSR" (Shishkin, 1961), "Flora of Azerbaijan" (Sofiyeva, 1961), "Conspectus of Caucasian flora" (Menitsky, et al., 2008), and "Plant World of Azerbaijan" (Asgarov, 2016) and research articles are used as a basis.



Map - 1

Botanical - geographical regions of Azerbaijan

Sam. – Shab. lowl.....Samur-Shabran lowland
 Caspian coast. lowl.....Caspian coast lowland
 GC (Guba).....Greater Caucasus (Guba massif)
 GC (East).....Greater Caucasus (East)
 GC (West).....Greater Caucasus (West)
 Alaz. – Ayrich.val.....Alazan-Ayrichay valley
 Boz.plat.....Bozgir plateau
 Gob.....Gobustan
 Absh.....Absheron
 Kur. pl.....Kur plain

11. Kur-Ar.lowl.....Kur-Araz lowland
 12.LC (north.).....Lesser Caucasus (north)
 13.LC (center)... Lesser Caucasus (center)
 14.LC (south).....Lesser Caucasus (south)
 15.Nakh.mount Nakhchivan mountainous areas
 16.Nakh.pl.....Nakhchivan plain
 17.Lank.Mugh.....Lankaran-Mughan
 18.Lank.mount...Lankaran mountainous areas
 19.Lank.lowl.....Lankaran lowland
 20.Diab.....Diabar (Zuvand)

RESULTS

R.M.Sofiyeva (Sofiyeva, 1961) worked on this genus in the “Flora of Azerbaijan”. She noted that there are 18 species of this genus in Azerbaijan.

Currently, there have been many changes in the macro taxonomy of the genus and the status of the species. The species of this genus found in Azerbaijan are divided into several independent genera from many sources (E.Hamzaoghlu, Turhan Çetin, 2016; Jeffrey et al., 1977; Nordenstam, 1997; Nordenstam and Rechinger, 1989; Jeffrey, 1992; Heller and Heyn, 1993; Pelser et al., 2006, 2007; Hamzaoghlu et al., 2011; Matthews, 1975; Arslan et al., 2013). (*Turanecio* Hamzaoghlu, *Iranecio* B.Nord., *Caucasalia* B.Nord., *Pojarkovia* Askerova, *Adenostyles* Cass., *Dolichorrhiza* (Pojark.) Galushko, *Jacobaea* Mill.).

Thus, various researchers (Jeffrey et al., 1977) believe that the characteristics of the groundselgenus species are too many one genus and it should be divided into several independent genera. In particular, they cited the sign of the tubular flowers in the antherode and divided them into *Pojarkovia* (Askerova, 1984) for the form of leaf blade and *Iranecio*, *Caucasalia* (Nordenstam, 1989), *Adenostyles* (S.Chirpanov, 1981) for the sizes of flower and other genera.

Sometimes the spatial indicators (geographical distribution) of the species are also shown as the main ones. For example, species from Turan range are divided into *Turanecio* genera,

species from Iran range into *Iranecio* genera and etc.

In order to search for new constant traits associated with the division of the genus into a number of independent genera, along with comparative macromorphological studies, anatomical (Drury et al., 1964) and palynological (Efterkarian et al., 2017) studies were also carried out.

Below is a conspectus of the genus according to the more common system (Menitsky et al., 2001).

Sect. 1. *Jacobaea* (Mill.) Dumort.

1. *S. grandidentatus* Ledeb. 1845, Fl. Ross. 2: 636; Shishkin, 1961, Fl. USSR26: 711;

Sofiyeva, 1961, Fl. Azerb. 8:341; Menitsky et al., 2008, Consp. Fl. Cauc. 3(1):217; Asgarov, 2016,. Plant world of Azerb.: 379. - *Jacobaea arenaria* (M.Bieb.) E.Wiebe: 2000, Turczaninowia 3(4):62. – *Senecio arenarius* Bieb. ex Bess. 1816, Cat. Horto Cremen.: 129; – Large-toothed groundsel (Figure 1).

Described from Talysh. Typus: “Ins. Sara, Kieseritzky” (LE).

Distribution in Azerbaijan: Sam. Shab. lowl, GC–Kur lowl., LC north, LC center, Nakh. mount., Lank. lowl. From lowland to mid-mountain belt (up to 1800 m). In forests and bushes, forest clearings, Caspian coastal areas, gardens, and river banks.

General distribution: South-eastern Europe, Eastern Europe; North Asia; South-western Asia (Iran); Central Asia. Azerbaijan subendemic.



Figure 1. *Senecio. grandidentatus* Ledeb.

Sect.2. Quadridentati Boiss.

2. *S. kubensis* Grossh., 1933, Proc. of the Azerb. div. of the Transcauc. branch AS USSR, sect. bot.1:59; Shishkin, l.p. 1961, 26: 724; Sofiyeva, 1961, l.p. 8:340; Menitsky et al., 2008, l.p. 3,1 :218; Asgarov, 2016, l.p.: 379. - *Iranecio kubensis* (Grossh.) C. Jeffrey. Kew Bull. 47 (1): 102 (1992). - *Turanecio kubensis* (Grossh.) Hamzaoghlu 2016, Biol. Diversity Conservation 9,1: 77 – Guba groundsel (Figure 2).

Described from the Eastern Caucasus. Holotypus: "Distr. Kuba, in pasc. alpinis p.p. Aput, 26 VII 1930, M. Sachokia" (BAK; isotypus – LE).

Distribution in Azerbaijan: GC Guba. Subalpine zone, stony - rocky slopes.

General distribution: Caucasus. Azerbaijan endemic.

Botanists E. Hamzaoghlu (2011), E. Hamzaoghlu and T.Çetin (2016), C.Jeffrey et al.(1977), C.Jeffrey (1992) who studied *Turanecio* genus combined both the species *S.kubensis* Grossh. (1933) described from Azerbaijan and the species *S.massagetovii* Schischk. (1961) described from Georgia (Barjomi) under the name *T. kubensis* (Grossh.) Hamzaoghlu. Rather, they considered the last species to be a synonym of the *S.kubensis* species. The range map given in one of these sources (E. Hamzaoghlu and T. Çetin, 2016) shows that these species have isolated populations from each other: *S.kubensis* is spread in the Guba floristic region of Azerbaijan and *S.massagetovii* is spread on the Georgia-Turkey border. The conducted studies show that it is appropriate to consider the population



Figure 2. *Senecio kubensis* Grossh. (Holotypus) of the species in Azerbaijan as *S. kubensis* species, which is an endemic plant of Azerbaijan, as accepted by most botanists.

3. *S. lipskyi* Lomakin, Proc. Tifl. Bot.Garden, 3: 51; Shishkin, 1961, l.p. 26: 722; Sofiyeva, 1961, l.p. 8:340; Menitsky et al., 2008, l.p.3(1):218;Asgarov, 2016, l.p.: 379. - *Iranecio lipskyi* (Lomakin) C.Jeffrey, 1992, Kew Bull. 47 (1): 103. – Lipsky groundsel.

Described from the South Caucasus. (near Bichanak village, Nakhchivan).

Typus: "Mount Takali, 7000', 10 VII [18] 95, A.Lomakin" (LE).

Distribution in Azerbaijan: Nakh. mount. – In the upper mountain and subalpine zones. On dry gravelly slopes and rock outcrops.

General distribution: South-west Asia (Iran). Azerbaijan subendemic.

4. *S. taraxacifolius* (Bieb.) DC. 1838, Prodr. 6: 348.- *Cineraria taraxacifolia* Bieb. 1808. Fl.

Taur.– Cauc. : 313; Shishkin, 1961, l.p. 26: 725; Sofiyeva, 1961, l.p. 8:341; Menitsky et al., 2008, l.p.3(1):219; Asgarov, 2016, l.p.: 379. - *Iranecio taraxacifolius* (Bieb.) C.Jeffrey, 1992, Kew Bull. 47, 1: 103. - *Turanecio taraxacifolius* (M.Bieb) Hamzaoghlu, 2011, Turk J. Bot. 35: 49. – Dandelion-leaved groundsel.

Described from Georgia. Typus: " Ex Iberia, 1806, Steven" (LE).

Distribution in Azerbaijan: GC Guba , GC west, LC north., LCcenter, Nakh.mount. subalpine and alpine belts, in high mountain meadows, on stony - rocky slopes and rock outcrops.

General distribution: South-western Asia (Turkey, Iran). Caucasian subendemic.

Sect. 3. Reniformes (Boiss.) Menitskiy et

Konechn.

5. *S. caucasicus* (Bieb.) DC. 1838, Prodr. 6: 348. – *Cineraria caucasica* Bieb; 1808, Fl.

Taur. – Cauc. 2: 313; Sofiyeva, 1961, l.p. 8: 334; Menitsky et al., 2008, l.p.3,1: 220; Asgarov, 2016, l.p.: 380. – *Ligularia caucasica* (Bieb.) G.Don, 1839, in Sweet, Hort. Brit. Ed. 3: 382; Poyark. 1961, Fl. USSR, 26: 855. – *Dolichorrhiza caucasica* (Bieb.) Galuschko, 1970, News of Tax. of High. Pl. 6: 210. – Caucasian groundsel.

Described from Georgia. Typus: “ Ex Iberia, 1806, Steven” (LE).

Distribution in Azerbaijan: GC Guba, GCwest, LCnorth. In the subalpine zone, in wet meadows, in rock crevices and on the banks of mountain rivers.

General distribution: Caucasian endemic.

Sect. 4. Doria (Rchb.) Godr.

6. *S. pseudoorientalis* Schischk., 1961, Fl. USSR, 26: 727; Menitsky et al., 2008, l.p.3,1:

221; Asgarov, 2016, l.p.: 380. – *S. orientalis* Willd. 1803, Sp. Pl. 3, 3: 2006; Sofiyeva, 1961, l.p. 8: 332, non Mill. 1768; – Oriental groundsel.

Described from Armenia. (“Habitat in Armenia”)

Distribution in Azerbaijan: Nakh. mount., LC center, Diab. From the upper mountain forest zone to the subalpine zone. In mountain meadows, forest clearings, stony - gravelly slopes.

General distribution: South-western Asia (Turkey, Iran). Caucasian subendemic.

7. *S. racemosus* (Bieb.) DC. 1838, Prodr. 6: 358; Shishkin, 1961, l.p. 26: 731;

Sofiyeva, 1961, l.p. 8: 332; Menitsky et al., 2008, l.p.3,1: 221; Asgarov, 2016, l.p.: 380. – *Cineraria racemosa* Bieb. 1798, Tabl. Prov. Casp.: 119. – *Senecio caspicus* (Pers.) Less. 1834, Linnaea 9: 170. – *S. pseudoracemosus* Grossh. 1933, Proc. of the Azerb. div. of the Transcauc. branch AS USSR, 1: 60. – Racemose groundsel.

It is described on the basis of materials collected from the Eastern and Southern Caucasus. Lectotypus (Menitsky, Konechnaya, 2001: 95; Shishkin, 1961, in herb. LE): “Ex montibus Schirvanicis (a. 1796), M.[Bieberstein]” (LE).

Distribution in Azerbaijan: GC Guba, GC east, Nakh. mount. From the mid-mountain zone to the sub-alpine zone. In mountain meadows, sometimes in crops.

“In Flora of Azerbaijan” (Sofiyeva, 1961), this species is given for the floristic regions of the Guba massif of the Greater Caucasus, the east of the Greater Caucasus and the Nakhchivan highlands. In “Conspectus of Caucasus flora” (Menitsky et al., 2008) it is noted that this species is found in Talysh, as well as in Absheron and Gobustan (Shirvan) in addition to the indicated regions, and it is not indicated for the territory of Nakhchivan. T. Talibov (2021) gave this species for Nakhchivan.

General distribution: South-western Asia (Iraq, Iran). Caucasian subendemic.

8. *S. thyrsophorus* C.Koch, 1851, Linnaea, 24 : 362; Shishkin, 1961, l.p. 26: 732; Menitsky

et al., 2008, l.p.3,1: 222; Asgarov, 2016, l.p.: 380. – *S. racemosus* auct. non (Bieb.) DC.; Sofiyeva, 1961, l.p. 8: 332. – *S. schelkovnikovii* Grossh. (Grossh.) 1933, Proc. of the Azerb. div. of the Transcauc. branch AS USSR, 1: 60. – Pyramidal groundsel.

Described from the South Caucasus. Typus: “In Gaue Daratschitschak auf Trachyt, c. 5000` hoch.” (B?).

Distribution in Azerbaijan: Nakhchivan (Menitsky et al., 2008; Talibov, 2021).

There is no herbarium specimens collected from Azerbaijan in the Herbarium Fund (BAK) of the Institute of Botany.

General distribution: South-western Asia (eastern Turkey, Iran, and northern Iraq). Caucasian subendemic.

This species is very similar to *S. racemosus* (Bieb.) DC. species. It is distinguished by being taller than it, the stem and spathes are mostly bare, the ray flowers are shorter, and it has a paniced inflorescence.

The status of the species *S. racemosus* and *S. thyrsophorus* requires clarification with further research. So, the similarities and differences of both species are not constant enough. Therefore, different authors consider them either as independent species (Shishkin, 1961; Menitsky et al., 2001; Grossheim, 1949; Lotfi et al. 2010) or, on the contrary, combine them under one species (Sofiyeva, 1961).

Sect. 5. Oliganthi (Boiss.) Schischk.

9. *S. rhombifolius* (Adams ex Willd.) Sch. Bip. 1845, Flora (Regensb.), 28: 499. – *Cacalia*

rhombifolia Adams ex Willd. 1809, Enum. Pl. Horti Berol.: 850; Shishkin, 1961, l.p. 26: 739; Menitsky et al., 2008, l.p.3,1: 222; Asgarov, 2016, l.p.: 380.; - *Senecio platyphyllus* DC.;1838, Prodr. 6: 352; Sofiyeva, 1961, l.p. 8: 336 - *Pojarkovia macropylla* (Bieb.) Askerova, 1984, News of Tax. of High Pl.21: 186. - *Caucasalia macrophylla* (M.Bieb.) B.Nord. 1977, Pl. Syst. Evol. 206, 1,4: 23. - Rhomb-leaved groundsel.

Described from the Caucasus ("Habitat ad Caucasum").

Distribution in Azerbaijan:GC. In upper mountain, forest and subalpine zones. In meadows and forest clearings.

General distribution:South-western Asia (north-eastern Turkey).Caucasian subendemic.

10. *S.pojarkoviae* Schischk. 1953, Bot. mat. (Leningrad), 15: 409; Shishkin, 1961, l.p. 26:

739; Menitsky et al., 2008, l.p.3,1: 223; Sofiyeva, 1961, l.p. 8: 336;Asgarov, 2016, l.p.: 380. - *Pojarkovia stenocephala* (Boiss.) Askerova) 1984, News of Tax. of High Pl.21: 186. - *Pojarkovia* groundsel.

Described from the Eastern Caucasus. Typus: "Descensus montis Dindiadagh ad fluv. Muchach, 3600 – 6000` (Ruprecht) " (G?).

Distribution in Azerbaijan:GC east, GC west. In the upper forest belt, forest clearings and rock outcrops.

General distribution: Caucasus.Azerbaijan subendemic species.

11. *S. paucilobus* DC. 1838, Prodr. 6: 352; Shishkin, 1961, l.p. 26: 741; Sofiyeva, 1961, l.p.

8: 338; Menitsky et al., 2008, l.p.3,1: 223; Asgarov, 2016, l.p.: 380. - *Pojarkovia pauciloba* (DC.) Askerova,1984, News of Tax. of High Pl.21: 187.- *Iranecio paucilobus* (DC) B.Nord. 1989, in Rech. F. Fl. Iran. 164 : 56. - Small-lobated groundsel

Described from Iran. Syntypi : "In itinere a Persia ad Indiam legit cl.Belanger; ad Zerdkou, cl. Aucher – Eloy" (G?).

Distribution in Azerbaijan: Nakh. In stony and gravelly places.

General distribution:South-western Asia (Turkey, Iran).

12. *S. othonnae* Bieb. 1808, Fl. Taur. – Cauc. 2: 308. Shishkin, 1961, l.p. 26: 741; Menitsky et al.,2008, l.p.3,1: 224; Sofiyeva, 1961, l.p.

8: 338;Asgarov, 2016, l.p.: 380. - *Jacobaea othonnae* C.A.Mey. 1831, Verz. Pfl. Casp. Meer.: 81. – Otongroundsel.

Described from Georgia. Typus: " Ex Iberia, 1806, Steven" (LE).

Distribution in Azerbaijan:GC east, LC north, LC center, Nakh. mount., Lank. mount. Upper mountain – in forest and subalpine zones. In forests and shady places, on rocks. Upper mountain-forest and subalpine zones.

General distribution:South-eastern Europe, south-western Asia (Turkey, Iran). Caucasian subendemic.

13. *S.lapsanoides*DC. 1838, Prodr. 6: 348 ; Shishkin, 1961, l.p. 26: 741; Sofiyeva, 1961, l.p.

8:334; Menitsky et al., 2008, l.p.3,1: 224;Asgarov, 2016, l.p.: 380. – Warty groundsel.

Described from the Central Caucasus. Typus: "Habitat alpestribus Caucasi circa Kasbek" (?)

Distribution in Azerbaijan:GC Guba, GCast. Upper mountain – forest and subalpine zones. In forest clearings and subalpine meadows.

General distribution:Caucasian endemic.

Sect.6. Pseudooliganthi Sofieva

14. *S. propinquus* Schischk. 1953, Bot. mat. (Leningrad), 15: 406; Shishkin, 1961, l.p. 26: 743; Sofiyeva, 1961, l.p. 8: 333. - *S. jacquinianus* Rchb. 1825, Pl. Crit. 3: 80; Menitsky et al., 2008, l.p.3,1: 224; Asgarov, 2016, l.p.: 380. - Allied groundsel. (Figure 3)

Described from the Caucasus - Mount Kazbek (LE).

Distribution in Azerbaijan:GC. It is found in the meadow vegetation of the subalpine zone.

General distribution:Central and Eastern Europe.Caucasian subendemic.



Figure 3. *Senecio propinquus* Schischk.

Sect.7.Senecio

15. *S.vulgaris* L. 1753, Sp. Pl.: 867 ; Shishkin, 1961, l.p. 26: 780; Sofiyeva, 1961, l.p. 8:

343; Menitsky et al., 2008, l.p.3,1: 225; Asgarov, 2016, l.p.: 380. – Common groundsel.

Described from Europe.

Distribution in Azerbaijan: Absh. - Among the weeds.

General distribution: Europe, Mediterranean, North, South, West and Central Asia.

16. *S.vernalis* Waldst.et Kit. 1802, Pl. Rar. Hung. 1: 23. Shishkin, 1961, l.p. 26: 783;

Sofiyeva, 1961, l.p. 8: 342; Menitsky et al., 2008, l.p.3,1: 225; Asgarov, 2016, l.p.: 380. – *Jacobeia vernalis*(Waldst. et Kit.) C.A.Mey.1831, Verz. Pfl. Cauc.Casp. Meer.: 81. – Eastern groundsel.

Described from Hungary.

Distribution in Azerbaijan: In all regions.

Widely distributed from lowland to subalpine zone. In wormwood semi-deserts, riverbanks, thickets, forests and crops, littered areas, coastal sandy places.

General distribution: Europe, Mediterranean, North, South, West and Central Asia.

17. *S.sosnovskyi* Sofiyeva 1957, Proc. ASAzerbUSSR, 1: 89; Shishkin, 1961, l.p. 26: 784;

Sofiyeva, 1961, l.p. 8: 343; Menitsky et al., 2008, l.p.3,1: 226; Asgarov, 2016, l.p.: 380. – *Senecio leucanthemifolius subsp. caucasicus* (DC.) Greuter 2005, Willdenowia 35, 2 : 238. – Sosnovsky groundsel.

It is described on the basis of materials collected from the Central and Eastern Caucasus. Lectotypus (Menitsky, Konechnaya, 2001:100:) “Caucasus orientalis, Tuschetia , pr. Dano 1670 ped. in m. Kopritos – Zweri, 4 VIII 1861, Ruprecht” (LE!). Syntypi: “Mons Mammisson distr. Alagir, Maistis Mtha Chewsuriæ, Dano Tuschetia et Alaschur Dag Daghestaniae (Rupr.)” (LE).

Distribution in Azerbaijan: GC Guba, GC west – LC north. In the alpine zone. On gravel slopes and rock outcrops.

General distribution: Caucasian endemic.

18. *S.noëanus* Rupr. 1856, Bull. Phys. – Math. Acad. Sci. (Petersb.), 14: 231; Shishkin,

1961, l.p.26: 787; Menitsky et al., 2008, l.p.3,1: 226; Asgarov, 2016, l.p.: 380. – *Senecio*

glaucus subsp. coronopifolius (Maire) C. Alexander 1979. Notes Roy. Bot. Gard. Edinburgh 37 (3) : 412. – Noya groundsel.

Described from Iran. Typus: “Kutt, V 1851, legit D. Noë” (?).

Distribution in Azerbaijan: Nakh.(Menitsky et al., 2008; Talibov, 2021)

General distribution: South-western Europe, Eastern Europe, South-western Asia (Iran, Iraq), Central Asia.

Note: It is not given in “Flora of Azerbaijan” (Sofiyeva, 1961). There is no herbarium specimens collected from Azerbaijan in the Herbarium Fund of the Institute of Botany (BAK).

Sect 8. Tephroseris Rchb.

19. *Senecio cladobotrys* Ledeb. 1845, Fl. Ross. 2 : 644. Shishkin, 1961, l.p. 26: 759;

Asgarov, 2016, l.p.: 380. – *Tephroseris cladobotrys* (Ledeb.) Griseb. et Schenk, 1852, Arch. Naturg. (Berlin), 18, 1: 342; Menitsky et al., 2008, l.p.3,1: 226. – Branchy groundsel.

Described from the Western Caucasus. Lectotypus (Menitsky, Konechnaya, 2001: 98; Kukkonen, 1975, in sched.): “Guria, Nordmann” (LE!).

Distribution in Azerbaijan: In the “Conspectus of Flora of Caucasus” (Menitsky et al. 2008) this species is indicated for the “Alazan-Ayrichay” floristic region. This region includes eastern and western regions of the Greater Caucasus within Azerbaijan. Taking this into account, we (Asgarov, 2016) gave the distribution of *S. cladobotrys* species in Azerbaijan. However, in “Flora of Azerbaijan” (Sofiyeva, 1961), this species is not given for the territory of Azerbaijan. There is no herbarium specimens collected from Azerbaijan in the Herbarium Fund of the Institute of Botany (BAK). Thus, the distribution of this species in Azerbaijan requires clarification.

General distribution: Caucasian endemic.

20. *Senecio subfloccosus* Schischk, 1953. Bot. mat. (Leningrad), 15: 402; Shishkin, 1961, l.p.

26: 760; Sofiyeva, 1961, l.p. 8: 339; Asgarov, 2016, l.p.: 380. – *Tephroseris subfloccosa* Schischk. Czer. 1995. Vasc. Pl. Russ. Adj. Stat.: 108; Menitsky et al., 2008, l.p.3,1: 226. – Tufted groundsel

Described from Georgia. Typus: “Caucasus,

Tiflis prov., Gori d., env. Bakuriani, forest meadow, 27 VI 1916, P.N.Krylov, E.I.Steinberg" (LE)

Distribution in Azerbaijan:GC, LC north, LC center. – In upper forest and subalpine zones. In mountain meadows, hayfields, forests and forest clearings.

General distribution: Caucasian endemic.

21. *Senecio caucasigenus* 1954, Bot. mat (Leningrad), 16 : 427; Shishkin, 1961, l.p. 26: 769;

Sofiyeva, 1961, l.p. 8: 339;Asgarov, 2016, l.p.: 380. - *Tephroseris caucasigena* (Schischk.) Czer. 1995. Vasc. Pl. Russ. Adj. Stat.: 107; Menitsky et al., 2008, l.p.3,1: 227. –Caucasian groundsel.

Described from Georgia. Typus: "Prov. Tiflis,

distr. Gori, Montes Tschra -Tscharo prope Bakuriani, in alpibus, 11 VII 1920, B. Schischkin" (LE).

Distribution in Azerbaijan:GC, LC north, LC center – In subalpine zones, high mountain meadows, summer pastures and gravelly places.

General distribution:Caucasian endemic.

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PROPAGATION OF GRAPE PLANTING MATERIAL USING BIOLOGICAL METHODS

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Abstract. *To produce national brands from local grape varieties that meet the modern requirements and interests of producers, it is necessary to organize rapid propagation and planting of local and introduced grape varieties by selecting rootstocks using biotechnological methods. The rapid development of viticulture, and the successful implementation of economic, agrotechnical, agrochemical, protective, and other measures largely depend on the correct choice of grape varieties when planting vineyards. To develop competitive viticulture, obtain environmentally friendly products, and solve the problem of environmental cleanliness of vineyards, winegrowing scientists are doing a lot of work to create high-yielding and high-quality grape varieties. To develop viticulture, as a rule, when planting vineyards, seedlings of zoned and promising valuable grape varieties are used. In addition to rooted seedlings, it is advisable to use grafted planting material in phylloxera-infected areas.*

Keywords: *grape, approbation, seedling, variety, grafting, plant, scion.*

INTRODUCTION

One of the main tasks of winegrowing scientists is to organize the rapid propagation and planting of local and introduced grape varieties using biological methods for the production of national brands. After the creation of a new specialized complex for the production of grafted grape seedlings in the Shemakha region, seedlings of local phylloxera-resistant and zoned technical grape varieties Madrasa, Bayanshira, Shirvanshahy, Khindogny, Hamashara, table grape varieties Marandi, Ag Kishmish, Gara Kishmish, Ag Shany, Gara Shany, etc. are produced. At the same time, scientists and specialists of the institute provide advisory services to winegrowers on growing grapes according to agrotechnical rules to fully use the potential of the industry. Conducting scientific research and introducing it into production is carried out by generally accepted methods. Based on the results of expeditions carried out in vineyards in various regions of the country, suitable planting

material is selected by variety and stored. This expands the opportunities for scientifically based development of viticulture in our country. To obtain high-quality planting material for vineyards located in different soil and climatic conditions, we carried out work on mass and individual selection, as well as assessing the prospects of planting material of popular, valuable varieties from specially selected, well-developed, highly productive, phytopathologically clean bushes. When selecting promising varieties, special attention was paid to the study of their morphological, technological, biological and economic characteristics.

To study the prospects of varieties in viticulture, several methods are used - bio-morphological, economic-technological, economic, and mathematical-statistical. These methods and techniques are used taking into account the specific conditions of the regions; the characteristics of the zoned variety are compared with other varieties [6.7].

Cuttings of a grape variety intended for propagation must be of average size, characteristic for this variety, in length and width. Thus, plants with very long internodes have weaker rooting ability than trees with short internodes. Although the regenerative capacity of thin stems is high, the yield of seedlings is less when exposed to unfavorable conditions. One of the most important tasks when testing plants is to determine the level of development and health of shoots. This operation is carried out by cutting the shoots crosswise. When cutting the shoots transversely, if the eyes inside are light green and juicy, then the shoot is healthy. If, when cutting, a dark color of the eye is observed, then the shoot is considered completely unsuitable for planting [3.9].

Viticulture requires grape varieties that are resistant to pure abiotic and biotic factors, high-yielding, suitable for local conditions, insensitive to diseases and pests, and fully satisfying the consumer demand of the population. From this point of view, it is necessary to carry out extensive research work for the development of selection and crop production in the republic on a scientific basis [4.8]. In this regard, the institute conducts extensive scientific research on local and introduced varieties; Agro-technical care work is carried out in accordance with the methods of the nursery and vineyard. The varieties are under constant control. In viticulture, it is necessary to carry out mass selection and testing in order to obtain large-fruited, productive and high-quality varieties. Approbation should also be carried out for the purchase of clean and healthy planting material. The time of testing in vineyard production is the time of complete physiological ripening of grapes [5.10].

MATERIALS AND METHODS

The object of the study was seedlings of 13 varieties planted in the Ampelographic collection of the Scientific Research Institute of Viticulture and Winemaking, located on the territory of the Absheron region. In addition, research was carried out at the Shemakhy Experimental Station on the Madrasa variety, and at the Ganja Experimental Station on the Bayanshira

variety. All work was carried out by researchers and specialists of the institute.

The purpose of the research was to organize, on a scientific basis, accelerated propagation and breeding of local and introduced technical and table grape varieties grown in different soil and climatic conditions.

Carrying out research work and introducing it into production was carried out by the "Field Experience Methodology" of Professor B.A. Dospehov (statistical processing of research results) and the standard of the Republic of Azerbaijan - AZS-911:2022 "Grape seedlings. Technical specifications", implemented by the new GOST [1.2].

Currently, after the opening of the grafting complex in the Shemakhy region, the agenda is to produce a sufficient number of seedlings of valuable local varieties for planting new vineyards, as well as for export.

RESULTS

The study of development phases, adaptability, environmental friendliness, productivity, resistance to biotic and abiotic factors, and organoleptic and phenological characteristics is of great scientific and experimental importance for determining the prospects of local and introduced varieties in the conditions of Absheron. Among the studied varieties, the best variety in the Absheron conditions, adapted to specific soil and climatic characteristics, was the Ag Kishmish variety, in which all organs developed well. During the initial observation, it was revealed that the germination of rooted seedlings for the 13 varieties studied was 70-80%. In the conditions of Absheron, during the years of research, very hot, dry summers were observed, which resulted in a lack of irrigation water and a decrease in soil fertility, which, in turn, hurt the development of plants and led to the drying out of some cuttings. As a result, according to estimates, 50-60% of seedlings were obtained from the planted varieties. The seedlings obtained were used to restore the rows and plant new vineyards in the experimental plots of the institute. In a comparative study of the above-ground and root parts of seedlings, the technical variety Khindogny, universal Moldova, and

table grape varieties Ag Shany and Gara Shany differed from other varieties in terms of growth vigor.

According to the methodology, all agrotechnical activities should be carried out in the vineyard. Summarizing the research results on the

above varieties, it can be noted that the cultivation and planting of the table and technical grape varieties are favorable in the soil and climatic conditions of the Absheron peninsula.

Table 1.

Seedlings of grape varieties planted in the Apsheron Ampelographic Collection.

Table varieties	Yield of seedlings, %	Technical varieties	Yield of seedlings, %
Marandi	55	Hamashara	55
Sultanina	50	Khindogny	55
Ag Shany	60	Moldova	50
Gara Shany	60	-	-
Ag kishmish	55	-	-
Gara kishmish	55	-	-
Agadayi	50	-	-
Mahmudu	52	-	-
Centennial seedless	50	-	-
Crimson seedless	52	-	-

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