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Research on high genetic resources of oak forests in Karabakh and highlighting benefits of reconstruction of oak forests to our ecology and economic development

G.N. Aliyeva

Institute of Dendrology, Azerbaijan National Academy of Sciences, 89 S.Yesenin Str., Baku AZ1044, Azerbaijan
For correspondence: *bio890@mail.ru*

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The oak is an important part of our natural and cultural heritage. Oak trees had a special place in the formation of biodiversity in the rich flora of Karabakh. Thus, more than 35% of oak forests were distributed in the Lesser Caucasus, and 60% of the ecosystem of the Minor Caucasus is oaks. Of course, this information is based on pre-First Karabakh War data. At present, this percentage has changed, and the biodiversity of Karabakh and the Lesser Caucasus is under serious threat. The reason is the Armenian vandalism known to the world community. The biodiversity of oaks in Karabakh in the pre-occupation period was investigated, the environmental requirements of the species were noted for the restoration of existing oaks in these areas and the benefits of reforestation to the nature and economy of Azerbaijan were brought to attention in this review.

Keywords: *Karabakh, oak, afforestation, economic and environmental benefit*

INTRODUCTION

Oak has a special place in the formation of biodiversity in our country. Thus, oak trees take the third place in the formation of rich forest resources of Azerbaijan after beech and hornbeam (Aliyev et al., 2008; Mammadov and Khalilov, 2002). Oaks have a special symbolic, ecological, and economic value in our republic. The people of Azerbaijan have long regarded the oak tree as a symbol of strength, inflexibility, and longevity. When giving the initial draft of the state emblem during the Azerbaijan Democratic Republic in 1919-1920, oak branches were included in the national emblem symbolizing long-lasting and strong statehood as oak (http:www.anl.az). Therefore, the protection and research of oaks are of special importance for our statehood.

The goal of this article is to study the high genetic resources of oak forests in Karabakh in the pre-occupation period to restore biodiversity in Karabakh and to emphasize the benefits of the restoration of existing oak forests to our ecology and economy in the future.

Biodiversity and distribution area of oaks (Quercus ssp.) in Karabakh. Oak trees had a special place in the rich flora of Karabakh. Thus, more than 35% of oak forests were distributed in the Lesser Caucasus, and 60% of the ecosystem of the Lesser Caucasus consists of oaks (Mammadov and Khalilov, 2002). According to some authors, before the First Karabakh War, there were 5 species of oak in the flora of Karabakh (Bandin and Prilipko, 1964; Menitsky 2005; Mammadov and Khalilov, 2002; Asgarov, 2016; Mammadov, 2016):

Georgian oak (*Quercus petraea* ssp. *iberica* (Stev.)

Caucasian oak (*Quercus macranthera* subsp. *syspirensis* (K.Koch) Menitsky.)

Pedunculate oak (*Quercus robur* ssp. *pedunculiflora* (K.Koch) Menitsky)

Red oak (Qızılı palıd) (*Quercus rubra* L.)

Araz oak (*Quercus infectoria* subsp. *veneris* (A.Kern.) Meikle)

The given Latin names of the species are internationally accepted names (http: www.catalogueoflife.org). With the exception of red oak, the four species mentioned above are endemic to the Caucasus (Menitsky, 1970).

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Georgian oak. The distribution area of Georgian oak occupies the lower and middle part of the Lesser Caucasus mountain range. Georgian oak is found in Karabakh and Lachin regions (1400-1650 m) on the sloping forest strips on different slopes, as well as in Zangilan and Jabrayil regions on dry slopes and in the valleys, mainly in mixed forests (Menitsky, 1970; Mammadov and Khalilov, 2002). It grows under different climatic conditions, is a light-loving tree and is tolerant to drought, heat, and winter frosts (Selahattin, 2020). Georgian oak is not found in the plain regions of our republic, as this species cannot withstand temporary water stagnation and soil salinity. Under such conditions, Georgian oak is replaced by Pedunculate oak. This species is very suitable for planting roadside greenery. None tree species can replace Georgian oak on dry rocky mountain slopes (Ekhvaia, 2018; Bandin and Prilipko, 1964).

Caucasian oak. Caucasian oaks created high-yielding forests in the south-eastern part of the Lesser Caucasus in Lachin and Gubadli regions, low-moisture, various herbaceous oakery under juniper forest in the rocky slope over the Shaplar village in the Kalbajar region, on the left bank of Garadirnagchay in Kalbajar regions, oakery with steppe grass cover on the dry steep stony slope in Tursusu plateau of the Shusha region, and has created low-density meadow-steppe grass-covered hornbeam-oak ecosystems on a steep slope with low humidity near the village of Alkhasli. Caucasian oak forests are replaced by Georgian oak forests on the lower border, in the territory of the Lachin-Gubadli regions (Mammadov and Khalilov, 2002; Menitsky, 1970; Peter, 2014).

Caucasian oak is sometimes called "high mountain oak" because it grows in high mountains (Bandin and Prilipko, 1964). Caucasian oak can grow under different conditions. It can outlive in the coldest days and 30 degrees below zero, the need for heat is low, the need for moisture is moderate (Papını et al., 2011; Ekhvaia, 2018). The average annual temperature in the distribution areas of Caucasian oak is 1.8-6°C, the average annual rainfall is 600-1400 mm (Mammadov and Khalilov, 2002).

Pedunculate oak is involved in the formation of mixed forest formations in the south of the Lesser Caucasus, starting from the plains to 500-700 m above sea level (Menitsky, 1970). According to Agamirov, Pedunculate oak is the main forest-forming tree species in the Karabakh plain along the Kura-Araz. The oak forests in Karabakh were considered the main seed base of Pedunculate oak in Azerbaijan (Agamirov, 1961). The oak acorns collected from these forests were used in the creating of protective forest strips and forest massifs in the lower regions of the republic. Creates clean and mixed oak forests in plains and valleys (Agamirov, 1961, Bandin and Prilipko, 1964).

This species is drought-tolerant, light-loving. It loves heavy clayey, sandy, high water content soils. Moderately sensitive to autumn and winter frosts. Prefers plains, high groundwater areas, river valleys, does not like flows. Can grow in wet and humid places. Old trees are very resistant to flooding. Can grow in dry and dry sandy soils (Boratynski et al., 2008; Gabitova, 2012).

Araz oak is a part of the forests at an altitude of 500-1100 m on the southern slope of the Lesser Caucasus - Zangilan (Bargushadchay) and Gubadli regions. Araz oak is very drought tolerant and can be used for afforestation in the dry foothills and plains of the southern part of the republic (Bandin and Prilipko, 1964; Menitsky, 1970; Mammadov, 2016). Araz oak is included in the "Red Book" (Red book of Azerbaijan SSSR**,** 1989) as a rare and endangered plant species in Azerbaijan.

Red oak is found only in the Lachin region of Azerbaijan. Red oak was distributed in Azerbaijan only in the Hajishamli forest and Shelve gorge in the territory of Garagol State Nature Reserve and State Nature Reserve, located in the Lachin region (Lachin yurdu, 2014). Although there is not any information in scientific literature, a survey conducted among the local population of Lachin and an article published in the "Lachin yurdu" journal confirm this. Red oaks were covered more than 4,000 hectares in these areas prior to the occupation. Since the highest quality wine was made in barrels made of red oak, the Armenians after the First Karabakh War, cut down these forests en masse and carried them to France (Lachin yurdu, 2014).

Unfortunately, the nature and vegetation of Karabakh also got a share from Armenian vandalism. The enchanting nature has been destroyed and the area has become a ruin. The world community also witnessed that Armenian creatures, who did

not receive a share from humanity, burned the forests in Shusha using white phosphorus bombs in the last days of the Second Karabakh War. As in the whole Karabakh region, we have very rich and valuable forests in Shusha. The total area of the forest fund was 8,526 hectares before the occupation. Destruction of a unique ecosystem created by dense forests consisting mainly of valuable and perennial oak, juniper, beech, hornbeam, pine, ash-tree, walnut-tree, the vandal acts**,** which is a serious blow to mainly endemic biodiversity, all of these are considered a crime against humanity for all international environmental conventions to which Armenia is a party. The fires caused by white phosphorus bombs are impossible to put out, nor can they be extinguished naturally, and such fires last a long time.

***Forming a new oakery*.** Oak species can be successfully used to restore the existing biodiversity in Karabakh. To forestall the loss of ecological values associated with forests, land managers need to consider where and when to prioritize active reforestation following major disturbance events (White et al., 2019). Direct seeding of acorns is generally more flexible than planting oak seedlings. If properly done, for example, direct seeding can be successfully accomplished any time of year. Direct seeding may be the only means available to establish oak stands on sites that are frequently flooded during winter and spring planting periods (Bullard et al., 1992). Laying of new oak strips should be carried out in an appropriate sequence and in a planned manner: site selection and preparation, planting, care, and protection (General Directorate of Forestry Strategic Plan 2017-2021, 2016). First of all, the soil needs of oaks should be taken into account. Oak grows in different soils. The largest area of oak is located in the dark brown, alkaline and light brown ash-mountain soils. A small area of oak is located in primitive soils, which turn brown and grayish-brown soils, in yellow river forests and other soils. Oaks do not like sour and saline soils (Bandin and Prilipko, 1964; Peter, 2004; Menitsky, 2005; Magnus et al., 2021, rastenievod.com). It should not be forgotten that the area to be planted has been turned into a steppe due to anthropogenic influences, the soil structure has changed, and as a result, the chances of success in afforestation are very low. Therefore, the soil must be brought into a form suitable for planting (Rural Environment, 2019). It is the responsibility of soil scientists to make proposals in this direction.

It is necessary to supply the latest acorns for planting, as acorns damaged by disease and pests shed more quickly (Fig. 1A) (Bandin and Prilipko, 1964). Collected acorns should be mixed by pouring them into tubs filled with water so that the acorns damaged by disease and pests will rise to the surface, and healthy cones will remain at the bottom of the water (Bandin and Prilipko, 1964). After discarding damaged acorns, healthy acorns are slightly dried in the shade and prepared for autumn planting. Acorns set aside for spring planting are stored in moist sand at a temperature of 0-3°C during the winter (rastenievod.com, Bandin and Prilipko, 1964) (Fig. 1B). It is better to bury the sprouted acorns in the spring in moist soil for planting. Spring planting completely eliminates the risk of freezing. The germination rate reaches 90-96% if the acorns are stored properly during the winter (Rural Environment, 2019, rastenievod.com). The oak acorns are often destroyed by wild boar, mice, and other rodents after being planted for reforestation. Seed sowing may be a cheap and efficient reforestation method that can yield high-quality seedlings for many woody species, but this option is usually discarded against seedling planting due to the high seed losses to mammal predators (Castro et al., 2015). It is recommended to smear acorns with zinc phosphide before planting to prevent them to be eaten by rodents. Acorns give good results when mixed with small crushed glass before planting. The surface of oak plantations must be covered with dried leaves, tree remains, and other materials under drought conditions (Bandin and Prilipko, 1964). Castro and his colleagues offered a new device to protect new seed sowings. They tested the effectiveness of a new device to prevent small mammals from consuming large seeds such as acorns and its effect on initial seedling performance. The device consists of a capsule made of two truncated pyramids joined at the bases, with two small openings at the top and the bottom where the stem and root can exit but rodents cannot enter. They conducted a field seed-predation experiment using fenced plots (only rodents present) and unfenced plots (rodents + wild boar present) and a nursery experiment to check seedling emergence and growth. Acorn predation by rodents was almost nil when protected by the device (1.1 vs. 53.4

% without seed shelter), whereas predation by wild boar in the unfenced plots was not reduced by the device (12.4 %) (Castro et al., 2002). In the nursery experiment, there was no effect of the device on seedling emergence or growth. These results suggest that physical protectors like the one used in this study could represent a cheap method to foster the restoration of tree cover via seed sowing, especially if used in combination with fences or habitat features to reduce predation by large animals (Castro et al., 2015).

Oak seedlings grow and branch slowly towards the height in the first year (Fig. 1C). Their main root system develops rapidly during this period. Horizontal lateral roots are developed instead of the main root system in oaks in the rocky foothills. The oaks begin to grow rapidly in length after roots are formed (Steven and Vladan, 2017). Success in afforestation depends on post-planting care and protection (Steven and Vladan, 2017; Jie and Dilnur, 2021; General Directorate of Forestry Strategic Plan 2017-2021, 2016). Reforestation often suffers heavy plant losses due to summer drought. Several techniques are used to alleviate this problem, such as the construction of a water-catchment basin around each plant, planting seedlings having rootballs, applying water-retention gels in the root zone, mycorrhizal inoculation, and providing individual tree shelters (Mesón & Montoya 1993; García-Salmerón 1995; Castro et al., 2002).

Fig. 1. Planting new oak forests. A - Oak acorns suitable for planting;
B - Storage of oak acorns for spring planting;
C - Annual oak seedling; D - Oak forest

The technology, timing, and amount of care provided for plantations vary because each region has its own climate, vegetation, and soil conditions. Necessary technical measures should be taken to reduce competition with weeds. Afforest areas formed with great effort, money and time, must be protected from humans, animals, insects, and fungal pests. Fencing has a strong positive effect on growth in length, especially for planted seedlings that are taller than the other seedlings and more frequently browsed in non-fenced plots (Birkedal et al., 2009; Magnus et al., 2021). Every precaution must be taken in fire-sensitive areas, especially, a group of workers must be ready to put out the fire at any time. The planting area must be constantly monitored against insect and fungal damage and if yellowing, drying of shoots, or leaves are observed, immediate action must be taken.

The benefits which can provide with reconstructıon of oak forests to our ecology and economıc development in future. Oak is a plant with special ecological, economic and cultural value (Jie and Dilnur, 2021). The establishment of new oak strips in Karabakh is of special importance for the formation and protection of biodiversity. The planting strategy should pay close attention to local land-use issues, to intra- and interspecific genetic diversity, and should adopt relevant, pluri-annual funding schemes and planting contracts rather than letting market opportunities govern the future of forest tree plantations (Fady et al., 2021). Society demands that forests provide a wide range of ecosystem services, from timber products, raw materials, and renewable energy to sociocultural amenities and habitats for nature conservation (Jie and Dilnur, 2021).

The leaves of the plant prevent global warming by eliminating the greenhouse effect by absorbing solar energy and carbon dioxide, and forests are the only hope for solving this global environmental problem. Forests regulate the gas balance and purify the air by absorbing carbon dioxide and other air pollutants through a large adsorbent field (an oak tree absorbs 4.5 kg of carbon dioxide per year), as well as releasing large amounts of oxygen and bactericidal substances into the atmosphere (ucanr.edu). The highly developed root system of oaks prevents landslides by creating a strong network in the soil and reducing the corrosive energy of raindrops during downpours due to the large umbrella, regulating the water balance of soils and rivers. Oak forests create complex ecosystems, which are indispensable for the preservation of ecological diversity and the food chain. The above reflects the ecological value of the oak plant. The forests formed by the ethnobotanical oak plant can be a rich raw material base at a time when the development of the pharmaceutical industry is planned. Forests to be planted with precious woody oak trees can contribute to the Azerbaijani economy after a few decades by leading to the development of industries such as shipbuilding, furniture, coal, wine production. High-quality meat, milk, and eggs can be obtained by using oak acorns, which are rich in organic matter**,** in livestock and poultry (Akkemik, 2020). Oak trees are widely used in the landscaping of parks and alleys in foreign countries, as they form a wide, dense and beautiful decorative umbrella, and the use of oak species in the landscaping may be successful by taking advantage of this experience (ucanr.edu).

In addition to the species that existed in the flora of Karabakh, the transfer of Holm Oak (*Q. Ilex* L.) to natural flora in Azerbaijan, including Karabakh is desirable due to its tolerance to frost, heat, and drought, and fewer requirements for the soil (Gunal, 2011; Akkemik et al., 2020). Holm oak acorns are used as fodder for livestock in Spain, therefore, they are cultivated as fruit trees and cover an area of 4 million hectares. The most expensive truffle fungus forms ectomycorrhiza with holm oak roots (Fischer and Colinas, 1996). In addition, the wood of holm oak is very valuable and has been used since ancient times in shipbuilding, constructions, wagons, wine barrels, etc. (Schirone et al., 2019).

Recent studies have shown that oak species distributed in other regions of Azerbaijan have a high morphological and genetic polymorphism (Aliyeva et al., 2020a, 2020b; Aliyeva 2021; Aliyeva et al., 2021a, 2021b). Genetic diversity is a key component of resilience and adaptability (Fady et al., 2016). This suggests that the studied oak species have a high potential for the formation of new species and adaptability. These results are a promising indicator of the success of the restoration of oak biodiversity in Karabakh. Special projects for the restoration of oak biodiversity in Karabakh should be prepared and implemented in a planned

manner. We, scientists and young researchers are ready to do our best to support our state in the reconstruction of Karabakh (Fig. 1, D) and its transformation into "Paradise Karabakh".

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Qarabağda mövcud olmuş palıd meşlərinin yüksək genetik resurslarının araşdırılması və palıdlıqların bərpasının ekologiya və iqtisadiyyatımıza verəcəyi töhvələrin vurğulanması

G.N. Əliyeva

AMEA-nın Dendrologiya İnstitutu, Bakı, Azərbaycan

Palıdlar təbii və mədəni irsimizin vacib bir hissəsidir. Qarabağın zəngin florasında biomüxtəlifliyin formalaşmasında palıd ağaclarının özünəməxsus yeri vardı. Belə ki, palıd meşələrinin 35%-dən çoxu Kiçik Qafqazda yayılmışdı, Kiçik Qafqazın ekosisteminin 60%-i məhz palıdlıqların payına düşürdü. Təbii ki, bu göstəricilər I Qarabağ müharibəsindən əvvəlki ədəbiyyat materiallarına əsaslanır. Hazırda bu faiz nisbəti dəyişmiş, Qarabağın- Kiçik Qafqazın biomüxtəlifliyi ciddi təhlükə altındadır. Səbəb dünya ictimaiyyətinə məlum olan erməni vandalizmidir. Məqalədə işğaldan öncəki dövrdə Qarabağda palıdların biomüxtəlifliyi araşdırılmış, həmin ərazilərdə mövcud olmuş palıdlıqların bərpası üçün növlərin ekoloji xüsusiyyətləri qeyd edilmiş və salınacaq yeni palıd meşələrin Azərbaycan təbiətinə və iqtisadiyyatına verəcəyi faydalar diqqətə çatdırılmışdır.

***Açar sözlər**: Qarabağ, palıd, meşəsalma, iqtisadi və ekoloji töhvə*

Исследование генетических ресурсов ныне существующих в Карабахе дубовых лесов и о значении восстановления дубрав для развития нашей экологии и экономики.

Г.Н. Алиева

Институт дендрологии НАН Азербайджана, Баку, Азербайджан

Дубы являются важной частью нашего природного и культурного наследия. В богатой флоре Карабаха дубы занимали особое место в формировании биоразнообразия. Так, 35% дубовых лесов было распространено на Малом Кавказе, причем 60% экосистемы Малого Кавказа приходится на долю дубов. Конечно, эти цифры основаны на докарабахской литературе. В настоящее время этот процент изменился, и биоразнообразие Карабаха и Малого Кавказа находится под серьезной угрозой. Причина - известный мировой общественности армянский вандализм. В статье исследуется биоразнообразие карабахских дубов в дооккупационный период, отмечаются экологические характеристики различных видов для восстановления некогда распространенных на этих территориях дубов, а также подчеркиваются преимущества новых дубовых лесов для природы и экономики Азербайджана в ближайшем будущем.

***Ключевые слова:** Карабах, дуб, лесоразведение, экономическая и экологическая выгода*

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