

STUDY OF BIO-ECOLOGICAL INDICATORS OF OAK SPECIES IN AZERBAIJAN

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Abstract

For the first time in Azerbaijan, differences in the morphological parameters of oak trees growing in different regions have been determined, the agrochemical properties of soils under oak trees have been studied, and the influence of environmental pollution on tree leaves has been shown. In different regions of Azerbaijan, morphological polymorphism, caused by the influence of various environmental factors, is different in oak taxa. The level of intrapopulation polymorphism established by dispersion analysis is higher than that of traits with the greatest diversity of variability N (YU/YE) (CV = 111.01%), F (CV = 54.11%) and YS (CV = 35.01%). The Jaccard similarity coefficient is 0.334 with a significant variation of genotypes from each other of 0.827, which indicates its difference in degree and adaptability in the studied taxa. The asymmetry index we calculated (coefficient of fluctuating asymmetry) for *Q. petraea* sp. and *Q. robur* sp. equal to 0.067 is considered a conditional norm. The highest indicators are typical for *Q. petraea* sp. both in areas with intense traffic flow and in the territory of the botanical garden. For *Q. rubra*, the highest coefficient of fluctuating asymmetry was noted in the botanical garden. The stomal fissure width and stomal fissure length of leaves *Q. robur* L. and *Q. rubra* L. are high in the area of Absheron Garadag highway. Intensity of damage to oak leaves spotting and rust high level are registered in Absheron Garadag highway

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region. Indicators obtained through scientific research are conveniently used in preliminary forecasting as a non-invasive test that protects the principles of “green technologies”, without involving other more complex tests that require financial and labour resources, such as an indicative test that is sensitive to small changes within a plant organism.

Key words: soil humus, absorbed bases, fluctuating asymmetry, intensity of damage

Introduction. The genus *Quercus* (oak) is one of the most diversified groups of temperate trees with more than 500 species distributed worldwide [1]. Many *Quercus* species combine sexual reproduction, through acorn production and clonal growth through root suckering [2]. The progeny varies in response to many factors such as: ecology, selection and genetic drift [3].

The common and main feature that arises in the process of adaptation to negative environmental conditions is the change in its parameters. Oaks are of particular importance in the formation of the biodiversity of our republic. Soil erosion, landslide, soil water balance, rivers regulation, global warming are important environment problems. To solve these problems, forests, and in particular oak forests also play an invaluable role. In this regard, oak species research can always be considered relevant [4–6]. These data could be practically used in the creation of new oak forests in Azerbaijan, as well as in the landscaping of parks in Baku city in accordance with the requirements of the geographical area [7].

It has been established that *Q. ilex* is more resistant to environmental stress and *Q. longipes* is comparatively more sensitive to environmental stress. The environment for *Quercus longipes* can be used as a control unit for express diagnostics of its quality. In addition to the *Quercus ilex* species in landscaping, especially road landscaping, it is advisable to use it to protect lands adjacent to roads from wind and water erosion, reduce noise levels, perform sanitary and hygienic and aesthetic functions, and protect moving vehicles from adverse aerodynamic effects. *Quercus macranthera* and *Quercus suber*, the species *Quercus ilex*, *Quercus castaneifolia*, *Quercus longipes*, *Quercus iberica*, and *Quercus pubescens* are capable of accumulating heavy metal elements in plant leaves [8]. The *Quercus suber* and *Quercus ilex* species could be used as phyto indicators and phytoremediators. But these plants cannot be called hyperaccumulators in any case [9].

Materials and methods. The object of the study is some developing taxa of oak trees in various ecological conditions of Azerbaijan Republic. The morphological polymorphism of the following taxa has been studied: *Quercus petraea*, *Quercus castaneifolia*, *Quercus macranthera* subsp. *macranthera*, *Quercus ilex*, *Quercus robur* subsp. *pedunculiflora*, *Q. rubra* L., and *Q. rubor* L. A total of 15 populations were investigated (long-stemmed oak from Ganja, Baku, Absheron), eastern oak from Goygol, Baku Central Botanical Garden and Absheron, Georgian oak from Ismayilli, Gabala and Baku, chestnut-leaved oak Lankaran plain – 1169 leaves, stone oak from Baku Central Botanical Garden and Absheron. These leaves have

five morphometric parameters (YU-leaf length, Y4AE-leaf width, YS-leaf area, YP-leaf perimeter, N-ratio ($N = YU/YE$) and F-factor – leaf shape coefficient YE/YP) CI-202. They were measured using LESER AREA METER instrument 6. Diversity of intrapopulation variability of oaks is presented in [10–13]. The width, length and mass of cones were measured for the study. The mass of cones was indicated on an electronic scale (EK-610i-electronic type scaler) with an accuracy of 0.01 g, the widest part and the length from the base of the cone to the tip were measured with a High Contrast Vernier caliper (with an accuracy of 0.1 cm). When preparing the soil for analysis, all visible organic residues were selected in order to exclude all those groups of organic substances that were not part of the humus. In the present study, the Tyurin method was applied, which is based on the oxidation of humus with a 0.4 N solution of potassium dichromate ($K_2Cr_2O_7$), prepared with sulphuric acid diluted in water in a volume ratio of 1:1 (wet combustion).

Results. With a change in the indicators (mass of a unit area of a leaf, salinity, moisture capacity, precipitation average annual amounts and a positive dependence on altitude, average annual temperature, relative moisture capacity), a change in the size of the leaves occurs, especially the leaf surface, which is the main indicator of plant adaptability and has a positive correlation [7, 8, 14, 15]. The average value of polymorphism in the studied oak taxa was 78.99%. The amount of humus is calculated by the amount of chromic acid used for its oxidation. The sum of absorbed bases is understood as the main physical and chemical property of the soil, characterizing its absorption capacity, expressed through the total content of Ca^{2+} and Mg^{2+} , displaced by hydrogen ions of hydrochloric acid, in mmol/100 g of soil (Fig. 1). Materials are collected after the growth of leaves from plants that have reached the generative age state has stopped. Leaves of average size for a given tree species are selected. For the initial assessment, the damage incidence rate is used (the percentage of leaves damaged by a certain group of phyllophages). The phytopathogenic state of woody plants is compared based on the integral indicator. Rust, spotting, aphid damage, hole shaped gnaws, gnaws in the edges were investigated (Fig. 2). In all sections of the experimental object, ten model trees were randomly selected, from which taxation parameters (height, diameter, height to the beginning of the crown), parameters of acorns and leaves were measured. The length and width of the stomatal fissure of leaves were studied in different regions (Fig. 3). There is an approximate similarity of 0.334 by Jaccard's similarity coefficient. It fluctuated within the range of 0.827. The results of the study showed that genotypes *Q. robur* subsp. *pedunculiflora* (Baku) and *Q. robur* subsp. *pedunculiflora* (Absheron) are closely related to each other and have the highest genetic similarity (0.827). Genotypes *Q. castaneifolia* and *Q. ilex* (Absheron) had the lowest genetic identification rate, followed by genotypes *Q. robur* subsp. *pedunculiflora* (Baku) *Q. castaneifolia* (Absheron), *Q. robur* subsp. *pedunculiflora* (Absheron) and *Q. castaneifolia* (Absheron) with a value of

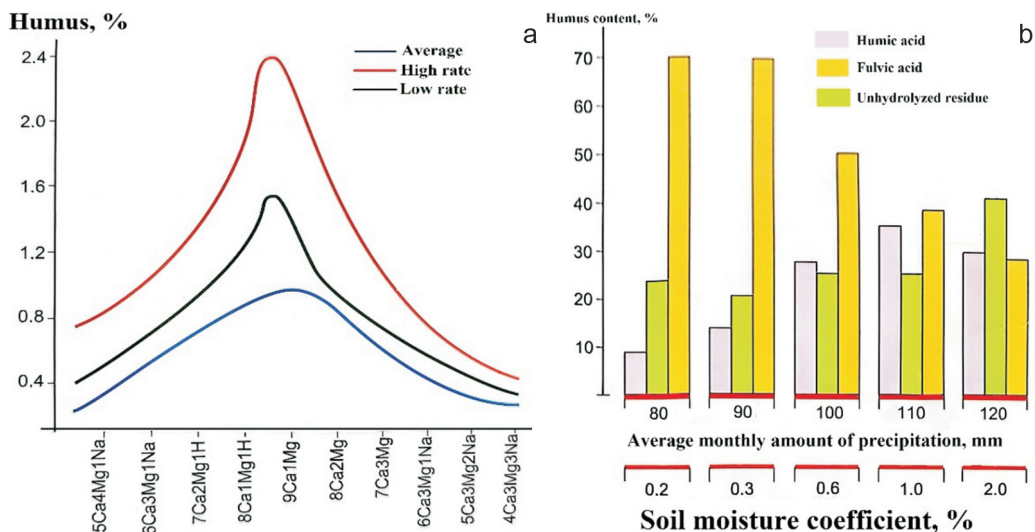


Fig. 1. a – Dependence of humus amount in soil on the content of absorbed bases;

b – Relationship between precipitation and humus group composition

Note: The dependence of absorbed bases and soil moisture coefficient in gray-brown soils were compiled for all the regions (Gabala, Absheron, Baku, Garadag, Lankaran, Goygol, Ganja). These are typical data indicators for Absheron. According to statistical information, only 43.1% of the soil fund of the Absheron Peninsula (227 406 ha) is used or allocated for industrial facilities and infrastructure 98 012 ha, of which 42.9×10^3 ha or 43.8% of the soil is allocated for agriculture and livestock farming.

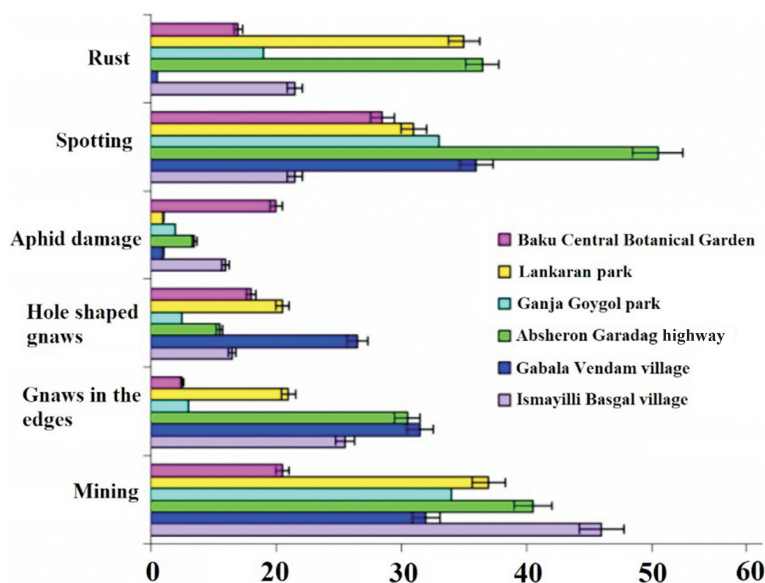
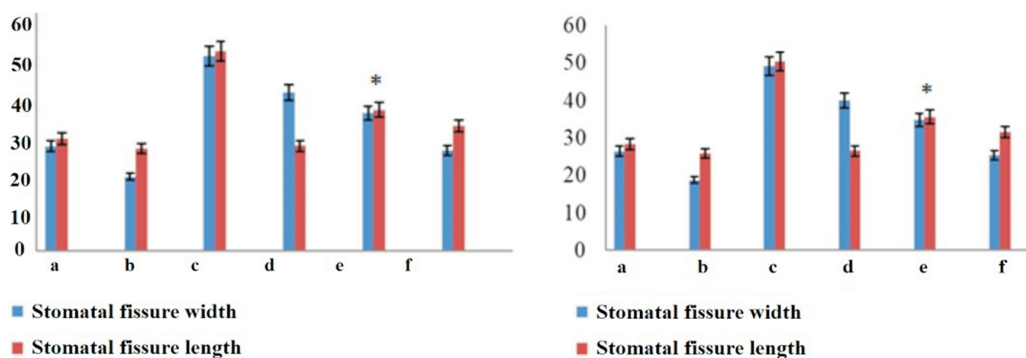


Fig. 2. Comparison of the intensity of damage to oak leaves (%) in populated regions of Azerbaijan



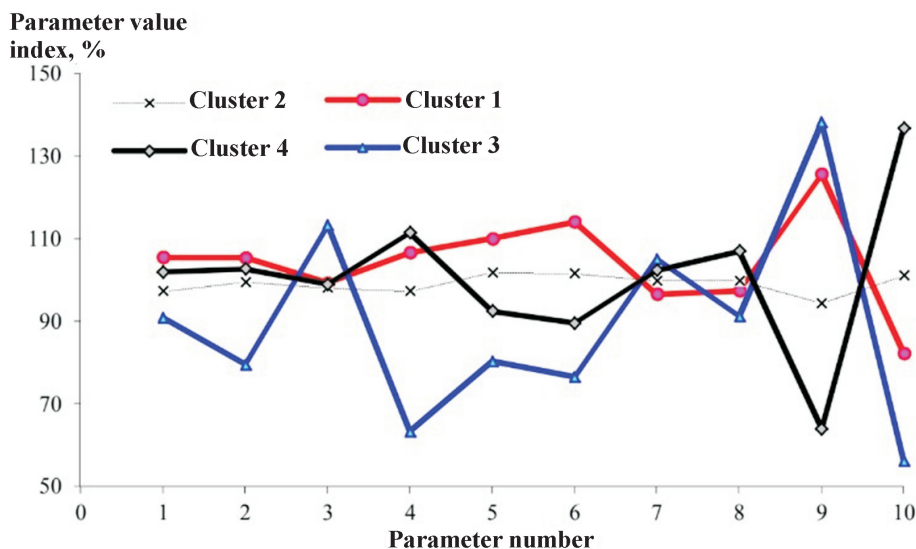
a – *Q. robur* L. in Baku central botanical garden; b – *Q. rubra* L. in Baku central botanical garden; c – *Q. robur* L. in Absheron Garadag highway; d – *Q. rubra* L. in Absheron Garadag highway; e – *Q. robur* L. in Lankaran park; d – *Q. rubra* L. in Lankaran park; e – *Q. robur* L. in Ganja Goygol park; f – *Q. rubra* L. in Ganja Goygol park

Fig. 3. Left: Length and width of the stomatal fissure in *Q. robur* L. and *Q. rubra* L., μm (June 2022). Right: Length and width of the stomatal fissure in *Q. robur* L. and *Q. rubra* L., μm (September 2022). *Designated data are not significantly different $p \leq 0.05$

0.374. Genotypes *Q. petraea* subsp. *iberica* (Ismayilli) and *Q. ilex* (Absheron) were evaluated as the most genetically distant genotypes from each other. The most suitable soil is well-drained loam, loam or sandy loam. In some alluvial and muddy soils, excellent oak stands are found. The reason for this is well-drained soil, since oaks do not tolerate stagnant water (Fig. 1, 2). Soil moisture coefficient is formed based on climatic conditions, amount of precipitation, air temperature, type of fertile surface and crops grown. The main factor limiting the distribution of oak trees in the studied ecosystems is sodium salinization of soils. In soils under plantings in horizons with a sum of easily soluble salts of more than 0.3% of the soil weight (from a depth of approximately 50 cm), salinization is calcium sulphate at all studied points.

The asymmetry index we calculated (coefficient of fluctuating asymmetry) for *Q. petraea* sp. and *Q. robur* sp. equal 0.067 is considered a conditional norm. The highest indicators are typical for *Q. petraea* sp. both in areas with intense traffic flow and in the territory of the botanical garden. For *Q. rubra* L., the highest coefficient of fluctuating asymmetry was noted in the botanical garden. Among the damage caused by viruses and fungi, spotting (44.7%) and rust (25.3%) stand out; chlorosis and necrosis occurred sporadically, but powdery mildew was not detected. The distribution of damage groups on oak leaves shows that the number of leaves on which mining insects live reaches its minimum in the study area, which is located in Lankaran and Gabala. Compared to other areas, the damage to oak by blight was significantly greater in Absheron, where the population and industry are largest (Fig. 3).

Plant resistance to stress characterizes the ability of plant organisms to fully perform their basic vital functions in unfavourable environmental conditions. Re-



Parameters: 1 – acorn length, 2 – acorn diameter, 3 – ratio of acorn length to its diameter, 4 – acorn mass, 5 – leaf length, 6 – leaf width, 7 – ratio of leaf length to its width, 8 – leaf recess depth, 9 – leaf petiole length, 10 – ratio of leaf length to the length of its petiole

Fig. 4. Average values of morphometric parameters for oak climatypes of different clusters

ducing the size of the leaf blade negatively affects the assimilation activity of leaves. For *Q. robur* L. this decrease is compensated by an increase in the number of stomata. The parameters of the stomatal fissure also change. Over time (September), the linear dimensions of the stomatal fissure decrease on all four sites (Fig. 3).

Discussion. The greatest differences between clusters are noted in diameter acorns, their weight, leaf length and width, leaf petiole length and the ratio of leaf length to petiole length. These parameters are independent, since their values do not correlate with each other (Fig. 4). Their fruiting score changes most significantly ($V = 74.6\%$) and height from the ground to the beginning of the crown ($V = 59.4\%$). The height and diameter of trees, as well as the sizes of acorns and leaves vary the least ($V = 6.6 - 15.1\%$). The coefficient of variation of other parameters varies from 20 to 38% (V – coefficient of variation sign). Many of the morphometric parameters of oak climatypes are weakly correlated with each other, reflecting qualitatively different information about their state in geographical cultures. Cluster analysis of oak genotypes according to biomorphological traits resulted in genotypes in seven clusters, and according to genetic data they were grouped into three clusters. In general, both analyses suggest that *Q. robur* subsp. *pedunculiflora* and *Q. petraea* subsp. *iberica* are phylogenetically close to each other. One of the methods for assessing the quality of the environment in urban conditions can be the indicator of fluctuating asymmetry of the leaf blade. The asymmetry index we calculated (fluctuating asymmetry coefficient) for

Q. robur L. and *Q. rubra* L. plants equal to 0.068 was considered a conditional norm (1 point). On shoots and leaves of plants *Q. robur* sp., galls formed by gall mites were found in the botanical garden, which also leads to weakening of plants. Urban conditions affect the development of plants, which leads to changes in the seasonal rhythm of life. Phenological observations in 2020–2023 showed that *Q. robur* has a longer growing season (from the beginning – swelling of the buds to the end – leaf fall) than *Q. rubra*. This increase in the duration of the growing season occurs due to the rather late leaf fall of *Q. robur* with a difference of about 15 days.

Conclusion. In the course of scientific research conducted over many years, the bioecological properties of oak species, which are of great importance in various landscapes of Azerbaijan, have been widely studied. The stomatal fissure width and stomatal fissure length of leaves *Q. robur* L. and *Q. rubra* L. are high in Absheron Garadag region. Intensity of damage to oak leaves spotting and rust high level were registered in Absheron Garadag region. The study of morphogenetic features in different clusters, comparative study of damage occurring in the leaves, as well as the results of analyses of the main properties of the soil under these tree species will become important literary material that can be used by young researchers in the future. The asymmetry index we calculated (coefficient of fluctuating asymmetry) for *Q. petraea* sp. and *Q. robur* sp. equal to 0.067 is considered a conditional norm. The highest indicators are typical for *Q. petraea* sp. both in areas with intense traffic flow and in the territory of the botanical garden. The response to any disturbances occurring inside can be manifested phenotypically. These processes depend on the intensity of the photosynthetic apparatus, while the regulatory function of the genetic apparatus is regulated and directly sensitive to the influence of the environment. All studied species of the genus *Quercus*, due to their morphometric characteristics, could be used as indicators in biological monitoring during environmental assessment.

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