

DETERMINATION OF MAIN PROPERTIES
AND FERTILITY CAPACITY OF SOILS
UNDER HAZELNUT CULTIVATION IN AZERBAIJAN

Gunay Israphil Mammadova^{1,2}✉, Aida Yarish Gahramanova²,
Lala Novruz Bunyatova², Tunzala Mammad Babayeva³,
Lala Abuyeli Huseynova⁴

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Abstract

The main priority of our research is the proper development of agriculture, optimal use and protection of soil resources. Hazelnut is an important crop in the study area, a benchmark indicator of the ecological condition of the soil. The purpose of the research is to determine the indicators of the main diagnostic edifiers in gray-brown soils under hazelnuts (*Corylus avellana* L.) in different seasons in 2022–2023. Mature trees grown without irrigation and fertilizers can produce 15–20 kg/tree, and with intensive care the yield can reach 40 kg/tree. As a result of our research into determining the main levels of productivity of agricultural soils in the southern region of the Greater Caucasus, it was found that 72.0% of agricultural lands are loamy soils, and their pH values range between 4.8 and 7.2, most soils have average organic matter content, 50.15% less calcareous and all soils are salt-free. Soil quality scale rating is 87 points in soils under hazelnuts. It has been established that the soils are 40% slightly acidic, 25% neutral, 70% less calcareous, loamy in texture and sufficient in organic matter content. The soils of the walnut orchard were 49% and 26% slightly and moderately acidic, 76% were less calcareous, and 9% were deficient in organic matter.

Key words: soil texture, microbiological composition, bacterial communities, erosion process, biological indicators

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Introduction. The data obtained is valuable information for work in the field of agriculture. The purpose of the research is to conduct investigations in the field of proper development of agriculture in Azerbaijan and provide the population with quality food products. The study of qualitative agrochemical indicators of soils, biologically active substances, and microbiological properties is a very important and topical issue for Azerbaijani soil scientists. For the development of soil science in the Republic of Azerbaijan, it is very important to carry out soil research widely and comprehensively. In the southern parts of the Greater Caucasus, soil-ecological conditions have been poorly studied [1,2]. Butternut, White pawnshop, Ashrafi, Galib, Ata-bala, Arzu, Golden walnut, Circassian, Curly, Fringe, Azeri, Ataulla, Barli, Gaffarash, Nasimi, Topgara, Parzivan ginari varieties of hazelnut are grown in the Balakan and Zagatala regions. In a few years 20–25 thousand tons of hazelnuts are grown in this region. Mature trees grown without irrigation or fertilizers can produce 15–20 kg/tree. With intensive management, yields can be up to 40 kg/tree. Twenty-five soil samples were taken from hazelnut orchards in Balakan region. Soil assessment: Bonitet 87 points. It has been determined that the soils were 40% slightly acid and 25% with neutral reaction, 70% were less calcareous, clay loamy textured and sufficient in terms of organic matter. Zagatala region (2022–2023) reported that the hazelnut orchard soils were 49% and 26% mildly and moderately acidic, 76% were less calcareous, and 9% deficient in organic matter. As a result of our study by taking soil samples to determine the basic productivity levels of agricultural soils in the southern region of the Great Caucasus Mountains it was found that 72.0% of the agricultural lands are loamy soils and their pH values vary between 4.8 and 7.2, the majority of the soils are medium in terms of organic matter, 50.15% were less calcareous, and all of the soils were salt-free.

The pH of the soil samples was between 5.5–6.9 and it was determined that it ranged from moderately acidic to slightly alkaline. It was determined that 10% of the soil samples were moderately acidic, 22.5% neutral, and 62.5% slightly acidic. The organic matter levels of the soils changed between, 1.9–4.8% and averaged 2.9%. When the organic matter of the soils was compared with the limit values, it was determined that the total samples were classified as 15% “low”, 32.5% “moderate” and 55% “good”. Irrigated agriculture should specialize in valuable crops such as *Corylus avellana* L. *Corylus* is one of the six genera belonging to the birch family. The hazelnut (*Corylus avellana* L.) forms the basis for the more important commercial cultivars. The hazelnut is one of the world’s most widely cultivated hard-shell fruits [2,3]. Hazelnuts have been grown in Azerbaijan since the 7th century. Since the end of the 10th century, hazelnuts have been considered one of the main sources of income in the Balakan and Zagatala regions. The natural and climatic conditions of the Caucasus are very suitable for cultivation of hazelnuts and other plants. Given these conditions, hazelnut orchards were planted in large areas in Azerbaijan, and later the local population selected and

cultivated the most productive varieties [4–6]. For this reason, all foreign trees growing in the garden in autumn should be cut and removed from the garden. The uniqueness of natural resources as a habitat for zonal plants and animals requires the measures developed for the conservation of genetic biological diversity; therefore appropriate measures are necessary for the successful solution of pasture resources rational use [7–9].

At present, the ecological direction in the use of natural resources is clearly defined in the world. These resources give preference to the preservation of the natural environment and the development on this basis of resource-saving programmes and projects of rational nature management. The relief of the southern slopes of the Greater Caucasus Mountains, the richest regions of the Republic of Azerbaijan, is divided into high-mountain, mid-mountain, and foothill parts. In geomorphological terms, the large difference in altitudes in the region determined the diversity of its natural conditions. A mild warm semi-desert and steppe climate is characteristic, accompanied by a dry winter and a uniform distribution of precipitation in the foothills. Important studies of soils on the southern slopes of the Greater Caucasus were carried out. The frost-free period is 235–265 days [10,11].

The amount of annual precipitation is 250–300 mm, falling mainly in the spring and autumn months. Soil fauna and flora are essential components of all soils. The area is mainly used as pasture. Ephemeris, ephemerides, wormwood, and perennial xerophytic herbs are common. *Nubian acacia*, *Corylus maxima*, *Malus sylvestris*, *Tamarix gallica*, *Calligonum elantum*, *Calligonum arborenses*, *Juniperus communis*, *Astragalus microcephalus*, *Astragalus picnophyllus*, *Pistacia mutica*, *Olea europaea*, *Ficus carica*, *Acacia dealbata*, *Artemisia absinthium*, *Asparagus acutifolius*, *Echinacea paradoxa*, *Echinacea angustifolia*, *Geum rivale* L., *Geum urbanum* L., *Panax quinquefolius* L., *Populus alba*, *Prinus divaricata*, *Ficus carica*, *Cerasus avium*, *Paliurus* L., *Fagus* L., *Ulmus* L., *Mespilus* L., *Crataegus* L., *Cornus mas*, *Punica granatum*, *Vassilium vitis*, *Juglans regia*, *Castanea* M., *Rhus* L., *Pinus* L., *Pterocarya* K. are widespread. The thickness and hardness of the grass cover is 7–10 cm. The layer where the root system extends is 10–30 cm. Granulometric composition – < 0.001 mm 10–24%; < 0.01 mm 40–50%. Structure of layer A' granular-globular. Humus layer thickness: 12–20 cm. Layer and form of distribution of gypsum crystals – 90–100 cm [12,13].

Methods. The first stage is the camera preparation stage. At the first stage of the study, materials were collected from literary and stock sources, the scientific works of individual authors were studied, systematized and analyzed. The second stage is the stage of field research. According to the methodology, samples of soil, plants and invertebrates were taken from different points along a pre-selected route. The third stage is laboratory. For laboratory analysis, soil samples were prepared, herbariums were prepared from plant samples, and invertebrates were extracted from alcohol solutions and dried. Third stage was the final stage in which generally accepted modern methodologies of soil science and soil biology

were applied. The studies were carried out on virgin soils of natural cenoses. The object of study is the territory of the southern slope of the Greater Caucasus (natural and irrigated gray-brown (chestnut) soils – Kastanozems WRB and Irragri Kastanozems). At the sampling points for microbiology analysis, the weeds are cleaned by digging and a 50 cm deep V-shaped pit is opened. Microbiological studies were carried out in the spring and autumn of 2022. The microbiological composition was determined under laboratory conditions by classical methods of soil microbiology (in an agar medium with meat peptone). The methods for determining N, P, K, Ca, Mg, soil pH, humus content, etc. are as follows: Total humus in collected soil samples according to Tyurin's method; water-soluble humus by using the KMnO_4 reagent according to Kubel's method; total nitrogen according to Keldahl's method; easily hydrolyzed nitrogen by Tyurin and Konova's method; determination of ammonia nitrogen using Nessler's reagent $\text{K}_2[\text{HgI}_4]$; total phosphorus according to Meshcheryakov's method; determination of nitrate nitrogen using the disulfophenol Granval–Lajun method; water-soluble P_2O_5 according to Denizhe's method; activated phosphorus according to Machigin's method; water-soluble K_2O by flame photometric analysis; C:N, CO_2 ratio according to Golubev's method; content of absorbed bases (Ca^{2+} , Mg^{2+}) according to Ivanova's method; carbonization in a calcimeter according to Scheibler's method; granulometric composition pipette Kaczynski's method; complete water weight analysis according to Arinushkina; pH (in soil solution) – with a pH potentiometer (mix 6 g of soil with 30 ml of water); hygroscopic moisture drying at a temperature of 105 °C by thermal method; Smith's potassium; water-soluble potassium according to Alexandrov's method; by flame photometry in 1% of the mass of ammonium carbonate; activated Mn according to Krupsky and Alexandrova; water-soluble boron according to Berger–Trugow method; sucrose was determined optically on a saccharimeter. Mathematical calculation of the report solution was carried out using Meshcheryakov's method.

Discussion of results. It has been reported that soils with slightly acidic reactions are ideal for hazelnut cultivation. Twenty-five soil samples were taken from hazelnut orchards in the Balakan region. It has been determined that the soils are with 40% slightly acid and 25% with neutral reaction, 70% are less calcareous, clay loamy textured, and sufficient in terms of organic matter. Zagatala region reported that the hazelnut orchard soils were 49% and 26% mildly and moderately acidic, 76% were less calcareous, and 9% deficient in organic matter. As a result of our study by taking soil samples to determine the basic productivity levels of agricultural soils in the southern region of the Great Caucasus Mountains, 72.0% of the agricultural lands are loamy soils and their pH values vary between 4.8 and 7.2, most of the soils are medium in terms of organic matter, 50.15% are less calcareous and it was found that all of the soils were salt-free. P, K, Ca, and Mg concentrations of the soils used in the study were determined. It was determined that the P concentrations of the soils varied between 0.5 mg kg^{-1} and

48.3 mg kg⁻¹, with an average of 4.3 mg kg⁻¹. It has been determined that the K concentration of the soils varies between 28 mg kg⁻¹ and 367 mg kg⁻¹, with an average of 123 mg kg⁻¹. It was determined that the Zn concentration of the soils varied between 0.1 mg kg⁻¹ and 2.3 mg kg⁻¹, and the average value was 0.8 mg kg⁻¹. Mean Fe, Mn, and Cu concentrations were found to be 42, 21, and 1.5 mg kg⁻¹. The lowest B concentration of the soils was determined as 0.4 mg kg⁻¹, while the highest B concentration was determined as 2.7 mg kg⁻¹, and the average B concentration was found to be 1.1 mg kg⁻¹. When the microelement concentrations in the soils are compared with the limit values, 41.8% of the soil samples taken were insufficient in zinc. It has been determined that 100% of the soils are sufficient in terms of Fe, 95% of them are high in Mn, and 55% in Cu.

Microorganisms. The applied substrate contained equal amounts of carbon (6 mg/g soil) using purified polysaccharides. Soils moistened by water were used as control variants. The model experiments lasted for one month. Microbial communities were assessed in two simultaneous experiments at different temperatures (5, 27, and 45 °C) and humidity conditions (25, 50, 100% of the field capacity). Since the studied humidity and temperature ranges were quite wide and their impact at extreme values could cause succession in the native soil microbial complex, preliminary incubation of soil samples was done under fixed conditions to form sufficiently stable microbial communities in the control options before the start of the experiment. The studied soils consist of sand by 11.92%, silt by 24.34%, and clay fraction of 63.74%; according to the class of mechanical composition they are called clayey (Table 3). Also, the characteristics of the soil of the experimental plot are given in Tables 1 and 2. *Proteobacteria*, *Actinobacteria*, *Acidobacteria*,

T a b l e 1
Indicators of biological activity in gray-brown soils

	Genetic layers and depth, cm	
	AI'a 0-25	AI''a 25-50
Organic carbon, %	3.5	3.2
Humidity, %	Average annual > 30	
CO ₂ , %	0.2	0.4
The phase of biological activity	Highly	Optimal
Soil biogenicity		
Microorganisms mg-g	In 1 g humus sample 22112	
	In 1 g soil sample 2690	
Soil invertebrates sum., exp/m ²	36.3	20.5
Activity of enzymes		
Invertase mg. gl. in 1 g of soil	7.4	5.8
Protease mg. thior. 1 g	0.10	0.47
Catalase mg. O ₂ 1 min.	3.6	2.0

T a b l e 2
Chemical composition of gray-brown soils

	Genetic layers and depth, cm				
	A'T _{vpz} 0–17	A'T _{vz} 17–35	A/B _p 35–55	B/C 55–80	C 80–100
Humus, %	3.98	2.87	1.36	1.19	0.10
Total nitrogen. %	0.38	0.27	0.19	0.11	0.08
h _t , %	21.9	15.4	6.6	5.2	3.1
f _t , %	16.1	20.9	19.0	16.4	11.0
C _{ht} : C _{ft}	1.40	0.70	0.80	0.49	0.12
Unhydrolyzed residue, %	56.7	58.2	64.0	59.0	32.0
Sum of absorbed bases m.ekv.	34	37	40	32	18
Ca/Mg	2.8	2.4	2.7	1.8	1.4

T a b l e 3
Main water-physical properties

	Genetic layers and depth, cm				
	A'T _{vpz} 0–17	A'T _{vz} 17–35	A/B _p 35–55	B/C 55–80	C 80–100
Granulometric composition					
< 0.001	23.72	22.64	25.72	23.70	20.03
< 0.01	58.16	57.10	55.18	46.70	43.09
Volumetric weight, g/cm ³	1.01	1.22	1.33	1.82	0.68
Special weight, g/cm ³	2.20	2.18	2.40	2.45	1.80
Porosity, mm	63.0	61.4	55.0	51.1	38.0
Water permeability, mm/min	1st hour	2nd hour	3rd hour		
	588	193	139		

T a b l e 4
Indicators of the erosion process influence on the soil microbiological activity of soil

Erosion rate of soil crops No. 5 and No. 7	Depth, cm	Spring				Autumn			
		Total number of microorganisms (10 ³)	Bacteria	Ray fungi	Other microscopic fungi	Total number of microorganisms (10 ³)	Bacteria	Ray fungi	Other microscopic fungi
Non-eroded soils	0–15	10.059	8.786	3.009	73	11.423	9.020	2.414	78
	15–30	8.558	6.542	1.858	67	9.485	7.994	1.352	69
	30–45	5.966	4.986	1.170	41	5.138	6.000	1.097	42
Moderately eroded soils	0–15	8.927	5.895	1.874	68	8.344	6.775	1.511	70
	15–30	6.552	4.882	1.635	55	6.898	5.380	1.017	63
	30–45	3.911	3.781	1.085	34	4.219	3.200	1.007	37

Firmicutes, *Chloroflexi* are dominant under hazelnuts. *Verrucomicrobia*, *Planctomycetes*, *Bacteroidetes*, *Nitrospirae*, *Gemmatimonadales*, and others are relatively rare. Characterization of the structure of micromycetes registered in the course of research in terms of frequency of occurrence made it possible to identify dominant, frequent, random, or rare species both in general and in individual biotopes. In general, 5.9% of registered fungi are characterized as dominant, 28.8% as common, and 65.3% as rare or occasional species. *Aspergillus niger* incidence of fungus is 60.0% in soils under hazelnut, 56.4% in irrigated soils, and 50.6% in natural cenoses soils. In non-eroded fertile soils, the number of microorganisms at a depth of 0–15 cm in spring was 10.059×10^3 , 7.786×10^3 bacteria, 3.009×10^3 ray fungi, and 73×10^3 other microscopic fungi. In moderately eroded areas, the total number of microorganisms in spring was 8.927×10^3 , bacteria 5.895×10^3 , ray fungi 1.874×10^3 , and other microscopic fungi – 68×10^3 . In non-eroded fertile soils, the number of microorganisms at a depth of 0–15 cm in autumn was 8.020×10^3 , 5.246×10^3 bacteria, 1.789×10^3 radiant fungi, and 5.8×10^3 microscopic fungi (Table 4). In moderately eroded areas, the total number of microorganisms in autumn was 8.344×10^3 , bacteria – 6.775×10^3 , ray fungi – 1.511×10^3 , and other microscopic fungi – 70×10^3 . The silty fraction of gray-brown soils is characterized by a lower content of SiO_2 compared to the soil as a whole, with an increased amount of sesquioxides. Hazelnuts begin to bear at approximately two years old and at six years yields should approach 2 to 2.5 kg/tree. Mature trees grown without irrigation or fertilizers can produce 15–20 kg/tree. Comprehensive research allows for obtaining accurate information about the ecological state of the soil and using it in agriculture. The highest number of microorganisms was identified on the 7th–15th days of the experiment. It has been determined that 100% of the soils are sufficient in terms of Fe, 95% of them are high in Mn, and 55% in Cu. Since the study of soils under varieties of hazelnuts in Azerbaijan has been a very important issue in recent years, the results of these studies are used in the farms of the village of Gabizdara, the village of Mishlesh, the village of Aliabad, and recommendations were given to farmers. Soil assessment: Bonitet scale under cultivated cenoses 87 points.

Conclusion. The main priority of our research is the proper development of agriculture, optimal use and protection of soil resources. As a result of our research to determine the main levels of productivity of agricultural soils in the southern region of the Greater Caucasus, it was found that 72.0% of agricultural lands are loamy soils, and their pH values range from 4.8–7.2, most soils have an average organic content substances are 50.15% less calcareous, all soils are salt-free. The soil quality rating under the hazelnut scale is 87 points. It has been established that the soils are 40% slightly acidic, 25% neutral, 70% less calcareous, loamy in mechanical composition, with a sufficient content of organic matter. The soils of the walnut orchard were 49% and 26% slightly and moderately acidic, 76% less calcareous and 9% deficient in organic matter.

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¹*Ministry of Science and Education of the Azerbaijan Republic, Institute of Soil Science and Agrochemistry, Baku, Azerbaijan*
 e-mail: gunaymammadova.soilscience@gmail.com
 (<https://orcid.org/0000-0001-5196-4684>)

²*Biology and Teaching Methods, Faculty of Chemistry and Biology, Sumgayit State University, Sumgayit, Azerbaijan*
 e-mails: kaqramanovaa@mail.ru, examples@mail.ru

³*Department of Ecology, Faculty of Chemistry and Biology, Sumgayit State University, Sumgayit, Azerbaijan*
 e-mail: tunzale.babayeva.84@mail.ru

⁴*Department of Soil Science and Real Estate Cadastre, Faculty of Ecology and Soil Science, Baku State University, Baku, Azerbaijan*
 e-mail: lalehuseynova12345@mail.ru