Differentation of Soil Bio-Activity Hazelnut Orchards of Zagatala Region

Gunay Mammadova Israphil * [1,2], Firoza Ramazanova Muxurovna [1], Rena Mirzezadeh Islam[1], Vusale Isaqova Gudrat[1], Lala Bunyatova Novruz[2], Sevil Akhundova Maharram[2], Aida Gahramanova Yarish[2], Gulnara Alakbarli Yashar[2]

[1]Institute of Geography Public Legal Entity of Ministry of Science and Education of the Republic of Azerbaijan, Baku, Republic of Azerbaijan
[2]Sumgayit State University, Sumgayit city, Republic of Azerbaijan

gunaymammadova.soilscience@gmail.com

Abstract. The study of bioecological properties of soils formed under hazelnuts is a very important and urgent issue for the economically efficient cultivation of hazelnuts in the Republic of Azerbaijan. The bio-activity of row spacing and tree trunk strips was determined. In ten-year-old hazelnut orchards, the cellulolytic activity of the soil (in the 10–100 cm layer) between rows is lower than in tree trunk strips: on mountain gray-brown soils, gray-brown soils – by 6.8 times, on gray-meadow soils – by 5.8, on forest soil – by 8.5 times. Least significant difference in gray-brown soils (LSD_{05} = 4.5%): in the 0-10 cm layer by 7.1%, 10-40 cm – 11.2%; in the near-trunk strips, compared to the inter-rows, less yeast was noted: in the 0-10 cm layer at 4481 CFU/g, 10-40 cm – 1427 CFU/g (LSD_{05} = 55 CFU/g); fewer mold fungi in the near-trunk strips than in the row spacing in the 0-10 cm layer at 388 CFU/g, 10-40 cm – 63 CFU/g (LSD_{05} = 25 CFU/g). In forest soil, the bacterial content in the inter-row zone is lower than in the near-trunk strip: in the 0-10 cm layer at 15 CFU/g, 10-40 cm – 21 CFU/g (LSD_{05} = 8 CFU/g). The yeast content was lower in the row spacing, relative to the trunk strip (LSD_{05} = 45 CFU/g): in the 0-10 cm layer by 1436 CFU/g, 10-40 cm – 1901 CFU/g. mold fungi are less (LSD_{05} = 22 CFU/g): in the 0-10 cm layer at 337 CFU/g, 10-40 cm – 139 CFU/g. Mountain gray-brown soils in the inter-row zone, relative to the near-trunk strip, there were fewer bacteria (LSD_{05} = 4 CFU/g) in the layer of 10-40 cm by 6 CFU/g. The amount of yeasts in the inter-row zone is lower (LSD_{05} = 32 CFU/g) than in the near-trunk strip: in the 0-10 cm layer by 44246 CFU/g, 10-40 cm – 29014 CFU/g. Mold fungi were counted less (LSD_{05} = 32 CFU/g): in the 0-10 cm layer by 703 CFU/g, 10-40 cm – 2113 CFU/g. It has been established that in all areas of the garden, yeast and mold fungi are usually more abundant in the 0-10 cm layer, and bacteria in the 10-40 cm layer.

Keywords: fungi, microflora, cellulolytic activity, humification

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1 Introduction

The biological activity of the soil in a hazelnut orchard largely determines its fertility. In the rhizosphere of the hazelnut, a specific fungal microflora is formed, accelerating the destruction of cellulose, which is inherent in all forest cenoses [1]. The object of research is soils in hazelnut gardens of the Zagatala region. The research was conducted in 2021–2024 (Fig. 1a-b).

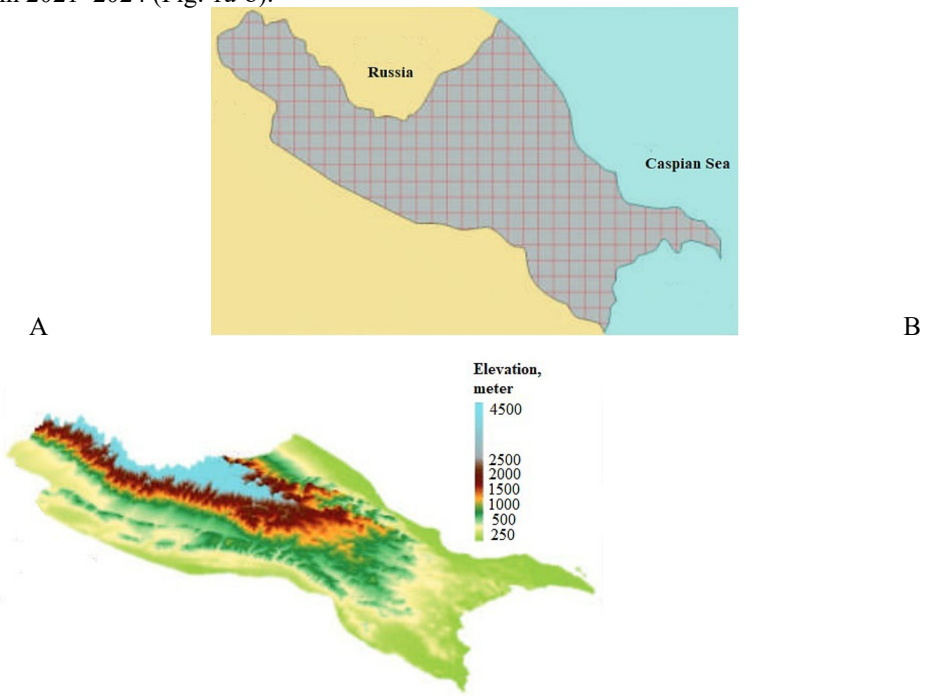


Fig. 1. Research object in Greater Caucasus (a) Vector map model; (b) 3D model based on GIS (Sheki-Zagatala economic region)

On meadow soil, in an experiment with mulching of tree trunk strips, it was established that the inhabitants of the macro-, meso- and microfauna that inhabited the litter participate in the decomposition, crushing and processing of humified material, transporting organic residues within the soil profile and beyond it. The content of soil saprotrophs and cellulolytics is twice as high in the root zone of young hazelnuts [2,3]. Root secretions of plants affect the distribution of eco-trophic groups of fungi. Under the grass in the soil of an apple orchard, the development of the mycelium of micromycetes is more fully ensured, nutrients and an abundance of fungal mycelium contribute to the development of the maximum number of actinomycetes [4,5]. In the irrigated hazelnut gar-

den of the Zagatala region, the greatest number of actinomycetes and bacteria, micromycetes, cellulose-destroying bacteria and anaerobic nitrogen-fixing bacteria was found in the fertilized soil ($N_{30}P_{60}K_{60}$) with green manure crops of vetch and oats. Humic substances of both natural and artificial origin greatly increase the content of all groups of microorganisms in the soil (Fig. 2 I-III).

2 Methods

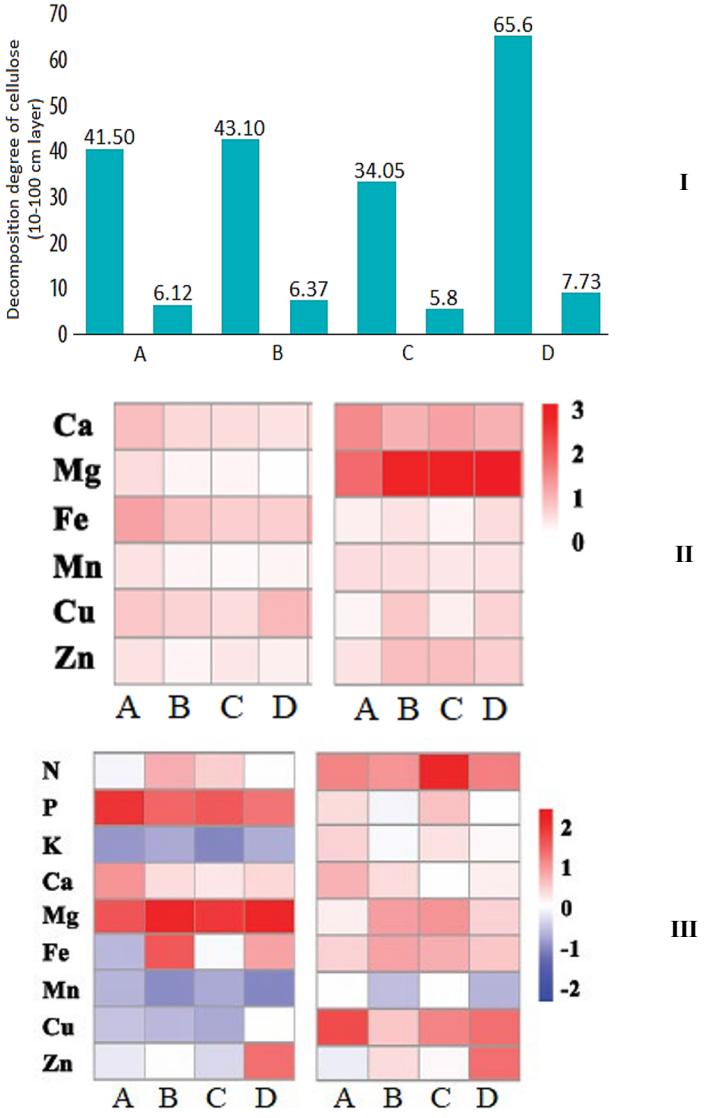
The studies were conducted in 2023–2025. Planting pattern – 4.5×2.5 m. Drip irrigation and trellis were not used in the gardens. The row spacing of all gardens was kept under black fallow: spring harrowing with tooth harrows to a depth of 3…5 cm and five-six-fold cultivation (10…12 cm) during the summer, which consisted of alternating cultivation and harrowing [6]. Once every four years, autumn moldboard plowing was carried out to a depth of 20…25 cm. The Ata Bala and Oily hazelnut variety was studied. The soils had a medium loamy granulometric composition. They were analyzed before uprooting intensive gardens, i.e. when the trees were ten years old. The intensity of fiber destruction was determined by the application method according to D.Q. Zvyagintsev's method, the number of microorganisms in the soil - by sowing on nutrient media (nutrient agar for bacteria and Czapek medium for fungi and yeast) at a dilution of 10.000 and 100.000 times, agrochemical analyses - according to the instructions generally accepted in soil science, humus content - by the titrimetric method according to I.V. Tyurin [7]. The repetition was fourfold. The data were mathematically processed using D.A. Dospekhov's method, statistical analysis was performed using the Statistica 8.0 program [8].

3 Results

Gray-brown soils had an average supply of mobile phosphorus, potassium and a slightly acidic reaction of the environment; gray forest soils had a weak supply of mobile phosphorus, exchangeable potassium (acidic reaction of the environment) [9,10]. On average, in the 0-60 cm layer, the humus content in the inter-row zone on mountain gray-brown leached soil was 5.0%, in the trunk strip 6.0%; on gray-brown soil - 5.1 and 6.5%; gray meadow soil - 3.4 and 4.6%, forest soil - 5.5 and 6.7% (Fig. 2 I-II). In the near-trunk strips of the orchards, due to leaf litter of hazelnut trees and the absence of mechanical tillage, the soil contained significantly more humus (LSD_{05} = 1.0%).

In the aisles of intensive hazelnut orchards, on the contrary, the destruction of the soil structure occurs due to frequent mechanical tillage at the same depth in the layer of 0…10 cm and over-compaction from the passage of equipment (10…40 cm). This led to differentiation of biological activity of soils [11]. At the age of ten years in the layer of 10…100 cm the intensity of decomposition of cellulose between rows was much

lower than in the near-trunk strips (LSD_{05} = 5.0%): on mountain gray-brown soils – by 35.4%, gray-brown soil – 36.8, gray-meadow soils – 28.1, forest soils – 57.8%.
We have established a close correlation between the humus content in the humus horizon of soils and the intensity of cellulose destruction (r = 0.98). The total number of bacteria in the row spacing was significantly lower than in the near-trunk strips (LSD_{05} = 4.5%): in the 0…10 cm layer by 7.1%, 10…40 cm – 11.2% (Fig. 3 a-c). On the same soil, in the near-trunk strips, compared to the inter-rows, less yeast was noted: in the layer 0…10 cm at 4481 CFU/g, 10…40 cm – 1427 CFU/g (LSD_{05} = 55 CFU/g). There were fewer mold fungi in the near-trunk strips than in the inter-rows in the 0…10 cm layer by 388 CFU/g, 10…40 cm – 63 CFU/g (LSD_{05} = 25 CFU/g). In forest soil, the content of bacteria in the inter-row zone is lower than in the near-trunk strip: in the 0…10 cm layer by 15 CFU/g, 10…40 cm – 21 CFU/g (LSD_{05} = 8 CFU/g). The yeast content in the gray forest soil was lower in the row spacing, relative to the trunk strip (LSD_{05} = 45 CFU/g): in the 0…10 cm layer by 1436 CFU/g, 10…40 cm – 1901 CFU/g. In the same soil, relative to the trunk strips, there were fewer mold fungi in the row spacing (LSD_{05} = 22 CFU/g): in the 0…10 cm layer by 337 CFU/g, 10…40 cm – 139 CFU/g. On mountain gray-brown soils in the inter-row zone, relative to the near-trunk strip, there were fewer bacteria (LSD_{05} = 4 CFU/g) in the 10…40 cm layer by 6 CFU/g. On the same soil, the number of yeasts in the inter-row zone was lower (LSD_{05} = 32 CFU/g) than in the near-trunk strip: in the 0…10 cm layer by 44246 CFU/g, 10…40 cm – 29014 CFU/g (Fig. 4a-c). In the same soil in the inter-rows relative to the near-trunk strip, there were fewer mold fungi (LSD_{05} = 32 CFU/g): in the 0…10 cm layer by 703 CFU/g, 10…40 cm – 2113 CFU/g. It has been established that in all areas of the garden, yeast and mold fungi are usually more abundant in the 0-10 cm layer, and bacteria in the 10-40 cm layer (Fig. 5a-c).



Note: A – mountain gray-brown soils; B – gray-brown soils; C – gray-meadow soils; D – forest soils

Fig. 2. I- Cellulolytic activity of soils, CFU/g; II - a heatmap of soil micromineral element contents in wet (left) and dry (right) soil under hazelnut trees; III - nutrient contents of soils (left – wet; right – dry) under young hazelnut trees

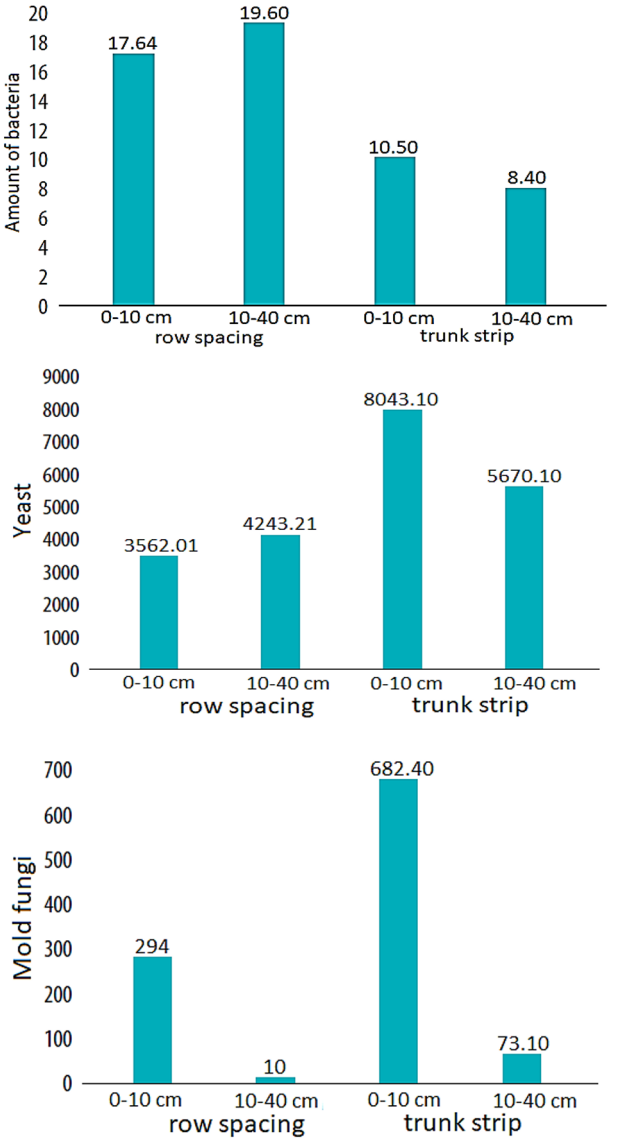


Fig. 3. Parameters of the gray-brown soils, CFU/g. (A) amount of bacteria; (B) amount of yeast; (C) amount of mold fungi

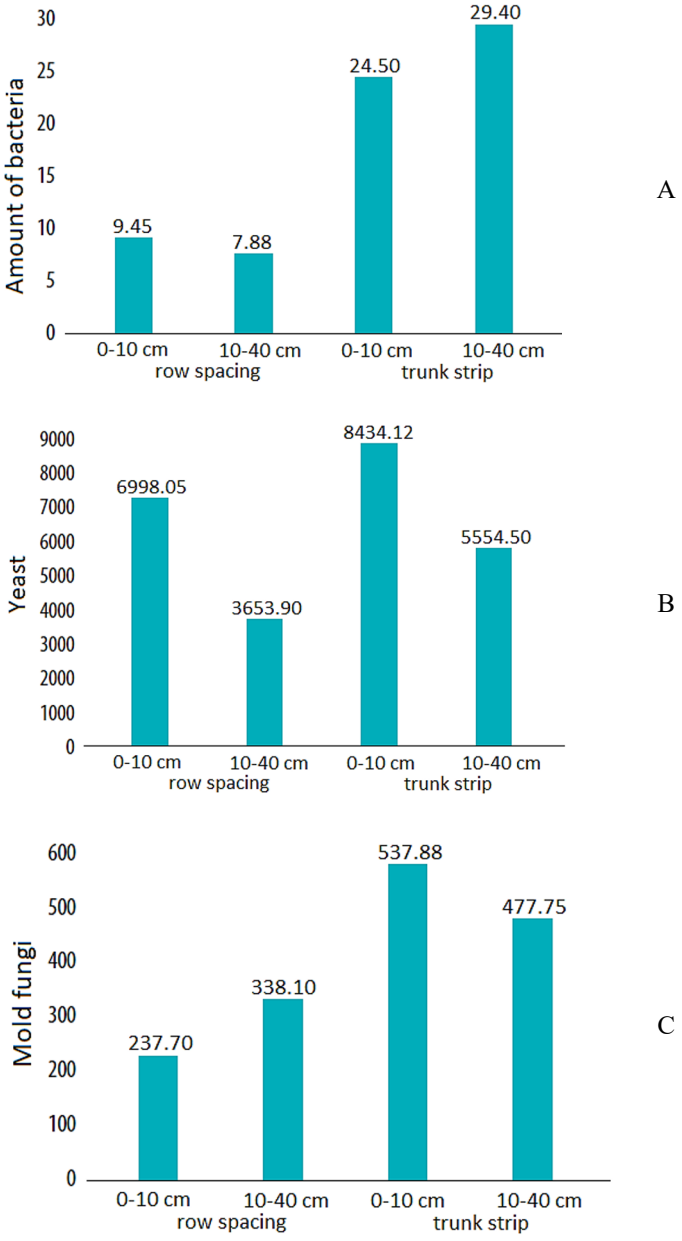


Fig. 4. Parameters of forest soils (CFU/g) under hazelnut trees. (A) amount of bacteria; (B) amount of yeast; (C) amount of mold fungi

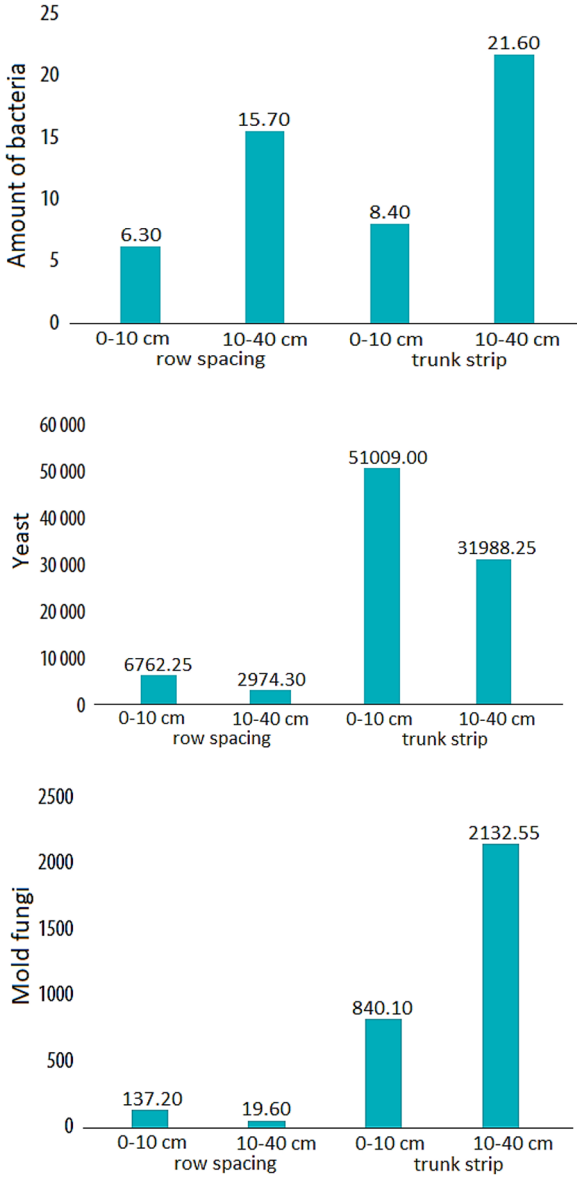


Fig. 5. Parameters of mountain gray-brown soils. (A) amount of bacteria; (B) amount of yeast; (C) amount of mold fungi.

4 Conclusion

In ten-year-old hazelnut orchards, the cellulolytic activity of the soil in the 10...100 cm inter-row layer is lower than in the tree trunk strips on mountain gray-brown soils - 6.8 times, gray-brown soils - 6.8, gray-meadow soils - 5.8, forest soils - 8.5 times. A close correlation was established between the humus content in the humus horizon of soils and the intensity of cellulose destruction (r = 0.98). In the gray-brown soil of the inter-row zone of hazelnut orchards, compared to the near-trunk strips, there were fewer bacteria (0...40 cm) by 1.7...2.3 times, yeast (0...10 cm) by 2.2, mold fungi (0...10 cm) by 2.3, 10...40 cm - by 7.3 times. On forest soil in the inter-row zone of hazelnut orchards, compared to the near-trunk strips, there were 2.6 times fewer bacteria (0…10 cm), 3.7 times fewer 10…40 cm, 1.2…1.5 times fewer yeast (0…40 cm), and 1.4…2.4 times fewer mold fungi (0…40 cm).

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