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**THE IMPACT OF CHANGES IN SOIL MOISTURE INDICATORS
ON BIOLOGICAL ACTIVITY IN RECENT YEARS ON THE SOUTHERN SLOPE OF
THE GREATER CAUCASUS**

Abstract

The purpose of the study was to study the role of soil moisture in the seasonal change of biological activity, which is one of the main diagnostic indicators of soils in the Sheki-Zagatala region of Azerbaijan in 2020-2022. Studied the same relative change in spectral reflectance coefficients is observed with the change of soil moisture of biological activity. In the spring-summer and spring periods, the most total amount of amino acids was found: in mountain-meadow chernozems: in spring - 13.08 mg per 10 g of soil, in summer - 18.92 mg, in autumn - 11.3 mg, in winter at low temperatures and excessive soil moisture, the amount of amino acids decreases to 7.81 mg, while in brown mountain forest soils it is: in spring - 14.9 mg, in summer - 11.91 mg, in autumn - 10.89, in winter - 7.52 mg. In humidity between 2-37%, the integral reflection coefficient varies from 12 to 33% and in 1% humidity in fidelity in the upper horizon reduces the integral reflection coefficient by 0.96%

Keywords: *biological, activity, fertility reproduction, soil enzymes, moisture content*

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Böyük Qafqazın cənub yamacında son illərdə torpaqların nəmlik göstəricilərinin dəyişməsinin bioloji aktivliyə təsiri

Xülasə

Tədqiqatın məqsədi 2020-2022 ci illərdə Azərbaycanın Şəki-Zaqatala regionunda torpaqların əsas diaqnostik göstəricilərdən olan bioloji aktivliyin mövsümi dəyişməsində torpaq nəmliyinin rolunu öyrənmək olmuşdur. Tədqiq etdiyimiz torpaqlarda bioaktivliyin torpaq nəmliyinin dəyişməsi ilə spektral əks etdirmə əmsallarında eyni nisbi dəyişiklik müşahidə olunur. Yaz-yay və yaz mövsümlərində amin turşularının ən çox ümumi miqdarı aşkar edilmişdir: dağ-çəmən torpaqlarda: yaz aylarında - 10 q torpağa 13,08 mq, yayda - 18,92 mq, payızda - 11,3 mq, qış fəslində aşağı temperaturda və torpağın nisbətən yüksək mliyində amin turşularının miqdarı 7,81 mq-a qədər azalır, qəhvəyi dağ meşə torpaqlarında isə: yazda - 14,9 mq, yayda - 11,91 mq, payızda - 10,89, qışda - 7,52 mq. 2-37% torpaq nəmliyində inteqral əksetmə əmsalı 12-dən 33% -ə qədər dəyişir və tam olaraq yuxarı üfəqdə 1% rütubətdə inteqral əksetmə əmsalı 0,96% azalır.

Açar sözlər: *bioloji, aktivlik, məhsuldarlıq, torpaq fermentləri, nəmlik*

Introduction

The Sheki-Zakatala economic region is located on the southern slopes of the Greater Caucasus Mountains. The lithological and chemical composition of the rock types common in the area is the main reason for the observed diversity of the region's natural resources, mineral composition of river waters, fertile soil types, fauna, and flora (Babayev, 2017).

The biological activity of the soil is an important factor in the formation of its fertility and a sensitive environmental indicator in relation to intense anthropogenic load. The role of biological factors in the preservation and reproduction of soil fertility is gradually increasing. In modern conditions, this is due to a significant reduction in humus reserves in soils and the accumulation in them of physiologically active substances that have toxic properties and reduce the intensity of metabolism in the "soil-plant" system. Among the national wealth of Azerbaijan, forest cover is of particular importance. In terms of mechanical composition, they are mainly medium loamy, on the northern exposures of gentle slopes there are heavy loamy and light loamy varieties (Hasanova, 2015: 130-135; Hasanova, 2021: 110-115; Hasanova, Mammadova, Yarish, 2021: 63-69).

The composition of fine earth is dominated by clastic, sandy or coarse silt fractions. In the humus horizon (A₁, A₂, AB), accumulation of the clay fraction is observed compared to the lower (B, BC, C) horizons, where weathering with the formation and enrichment of the soil with secondary minerals, in the humus horizon of the forest-meadow belt, the processes of soil formation and weathering proceed more intensively and deeper compared to the mountain-meadow belt. The main direction of solving this problem is the intensification and maximum use of biological factors in farming systems, in particular the content and composition of organic matter (plant residues and organic fertilizers), the activity and direction of microbiological and biochemical processes (Hasanova, 2021: 110-115).

At the same time, through the management of soil biological processes, it is possible to reproduce soil fertility. From this point of view, the study of the enzymatic activity of soil invertase and catalase is of great scientific interest. The invertase enzyme catalyzes the processes of hydrolysis of carbohydrates that enter the soil in the form of plant residues, converting them into forms available to plants and microorganisms, correlates with the amount of humus in the soil (Asgerova, Hasanova, 2022: 12-14).

The activity of invertase better than other enzymes reflects the level of fertility and biological activity of soils. The main biochemical method for determining the biological activity of the soil is to take into account the carbon dioxide released by the soil. The intensity of its release depends on the properties of the soil, hydrothermal conditions, the nature of vegetation and agrotechnical measures. Here microorganisms are more actively developing. In summer, in the soil under virgin vegetation, compared with option 9, the decomposition of linen fabric was 25.4% slower. Recently,

the anthropogenic load on soils has been increasing more and more, which leads to a change in the quantitative and qualitative composition of humus and a decrease in the enzymatic activity of soils. Biochemical transformations of soil organic matter occur as a result of microbiological activity under the influence of enzymes. Biological factors of fertility are the accumulation and conversion of organic matter in soil, microorganisms converting organic matter in soil, enzymes, soil respiration, cellulose-decomposing ability. Enzymes play a special role in the life of animals, plants and microorganisms. Soil enzymes are involved in the breakdown of plant, animal and microbial residues, as well as in the synthesis of humus. As a result, nutrients from compounds that are difficult to digest are converted into easily accessible forms for plants and microorganisms. Enzymes are distinguished by high activity, strict specificity of action and great dependence on various environmental conditions. Thanks to their catalytic function, they allow a huge number of chemical reactions to proceed quickly in the body or outside it. Invertase and amylase are involved in the breakdown of carbohydrates, and the activity of these enzymes can be used to judge the rate of decomposition of carbonaceous organic compounds. Enzymes of the phosphate group decompose organophosphorus compounds in the soil and play an important role in the phosphate regime of the soil (Dey, Mair, Lall, 2008).

Materials and methods. Researches were carried out on raw soils of natural cenoses. The object of research is the territory of the south slope of the Great Caucasus (natural and irrigated gray-brown (chestnut) soils (in WRB Kastanozems and Irragri Kastanozems). Climate with dry hot summers, sum of active temperatures – 4000-4300°C, precipitation – 180-430 mm/year, number of days with air temperature > 10 °C – 240-300 days, with soil temperature > 5 °C – 280-325 days. Gray brown (chestnut) soils (in WRB - Kastanozems), mountain gray-brown, subtype gray-brown (chestnut) are formed on heavy clayey alluvial and proluvial deposits at an altitude of 70–300 m above sea level, carbonate, with a slight chloride-sulphate salinization. The content of humus in the soil layer 0–25 cm is 3.37–3.94%, are heavy loamy and light clayey in terms of granulometric composition. In the 0–25 cm, the degree of silt is 45–51%, water permeability is 1.1-1.2 mm/min, humus content is 2.18–3.45%, gross nitrogen is 0.16–0.17%, phosphorus content is low (0.15–0.18%), potassium is medium (2.3–2.8%), pH is 7.0–8.0 (Khaziev, 2011: 184-190).

Results and discussion. The biological factors of soil fertility reproduction, which are one of the main indicators of the process of soil formation and soil fertility reproduction, are determined by the amount of plant residues and their composition, the balance of humus in the soil, the total content of microorganisms and enzymes in the soil, the intensity of carbon dioxide production, cellulose-decomposing ability, etc. The impact of various agricultural crops and methods of their cultivation on the soil and its fertility is not the same. The entry of phytomass into the soil is one of the main conditions for soil formation in natural conditions. Many researchers associate the effect of plant residues with their positive effect on biological activity, the regime of organic matter in the soil, in particular, on the reproduction of humus (Mammadova, 2022: 202-206). The case of the role of plant residues in the reproduction of humus in the soil cannot be fully resolved if the balance of humus in soils is not taken into account. In the natural variant, in the soil layer of 0–25 cm in summer, the reserves of soil moisture are minimal (127-152 m³/ha). The intensity of CO₂ release in the soil layer of 0–25 cm in spring, summer and autumn when receiving three crops of green mass per year was 276, 212, 228 and 301, 219, 238 mg CO₂/ (m²h). The direction of soil processes can be characterized by such an indicator as the intensity of cellulose decomposition, and the peculiarity of cellulose decomposition determines the specifics of humification and mineralization of soil organic matter. Therefore, in the summer strong desiccation of the soil leads to the complete burnout of vegetation and a sharp decrease in the reserves of plant mass accumulated during the autumn and spring periods. As part of soil fertility control over the biological activity of soils, it is sufficient to determine the total number of microorganisms, soil respiration, cellulose-decomposing and soil enzymatic activity. Soil is a biological system in which the processes of transformation of substances are determined by the vital activity of microorganisms that are sensitive to changes in the conditions of the soil environment, and the most important factor in the abundance of soil

microflora is the entry or presence of organic matter in the soil (Nasirova, Mammadova, Aliyeva, Hasanova, 2022: 202-206). Analyzing seasonal changes in the number of microorganisms according to the variants, the influence on this indicator of the quantity and quality of plant residues entering the soil was noted. These data indicate that the soils in these variants are characterized by a low intensity of mineralization processes due to the high content of microorganisms that developed due to the utilization of organic substances and the direction of biochemical processes in the soil towards humification. Soil fertility is determined by the intensity and direction of enzymatic reactions. The activity of these processes is a universal indicator of the physiological state of the soil biocenosis. The soil enzyme pool characterizes not only the current level of biochemical processes in the soil, but also the intensity of soil biota activity in the past, since enzymes are able to immobilize and accumulate in the soil and, under certain conditions, exhibit biocatalytic functions. To elucidate the intensity of biochemical processes and the rational use of soils in agriculture, the study of their enzymatic activity is of great importance. For this purpose, the activities of hydrolase, invertase, catalase, phosphatase, urease, and oxidoreductase dehydrogenase in natural cenoses have been studied for several years. The activity of enzymes serve as an indicator of the intensity and direction of biological processes in soils and characterize the level of natural fertility. At the same time, to characterize the intensity of biochemical processes in the soil by enzymatic reactions, it is necessary to use a complex of the most common enzymes associated with the metabolism of basic nutrients (Nasirova, Mammadova, Aliyeva, Hasanova, 2022: 392-397). Enzyme activity was determined in fresh soil samples of field moisture and re-read on absolutely dry soil. The soil contains an average of 3.5% humus, 0.30% nitrogen, pH aqueous solution - 7.2. The average indicators obtained on the basis of regime observation show that in the studied soils, the activity of the processes of hydrolytic cleavage of glycosides is quite intense. In the upper horizons (0-15 cm soil layer), invertase activity is 17.9 mg of glucose per 1 gram of soil. According to the soil profile, the activity decreases and reaches 4.2 mg of glucose in the lower (40-100 cm) layers. In these soils, a high activity of the redox enzyme catalase is observed, which is a characteristic feature for the soils of the dry steppe zone. Catalase activity of 0-5 cm soil layer is 18.5cm per 1 g of soil and gradually decreases along the soil profile. Dehydrogenase activity in dark gray-brown soils is high, which indicates an increased focus of reduction processes and the synthesis of humic substances in the soil. It is active in the humus-accumulative horizons (6.9 mg per 10 grams of soil) and then decreases quite sharply (Nasirova, Hasanova, 2022: 30-31). Urease activity is (0-5 cm layer) 2.1 mg NH_3 , which is an indicator of relatively intense mineralization of complex nitrogen-containing organic compounds. The seasonal dynamics of enzyme activity in chestnut soils shows that hydrothermal conditions in spring and autumn are very favorable for biochemical processes. Phosphatase cleaves organophosphorus compounds and is an important indicator of biochemical transformations of phosphorus compounds. The aim of our research was to study in the soils of the vertical zones of Azerbaijan (brown mountain-forest, dark chestnut, light chestnut, gray-brown, and others) patterns of change in the nature and intensity of phosphatase activity. The study of the seasonal dynamics of phosphatase activity in various types of soils showed that, depending on the specific features of the annual course of the hydrothermal regime, the nature and productivity of plant cenoses, and their action undergoes certain changes. Studies have shown that in lowland and foothill soils, high activity of enzymes is found in the spring and autumn seasons. In winter and especially in summer periods, phosphatase activity sharply decreases. Plant residues accumulated during the autumn and spring periods, under the conditions of a long dry and hot summer period, quickly mineralized. Whereas in mountain chernozems and brown mountain forest soils, the most intensive biochemical processes occur in spring, summer and autumn periods (Lobkov, 2016: 67-72). The average results obtained by dynamic observations (2019-2022) show that mountain chernozems have a high phosphatase activity (P_2O_5 -12.3 mg/soil). In brown mountain forest soils (P_2O_5 -8.2 mg/soil), dark chestnut soils (P_2O_5 -6.6 mg/soil), and meadow soils (P_2O_5 -5.7 mg/soil), the activity is lower compared to mountain chernozems, while it is very low in light chestnut soils (P_2O_5 -4.2 mg/soil). High activity of phosphatase was noted in the

upper horizons (0-5 cm soil layer) of the studied soils. With the depth of the soil profile (40-100 cm), the activity of enzymatic processes decreases sharply. This is due to the fact that the upper layers of the soil contain a large number of microorganisms and root residues of vegetation, which are the source of soil phosphatases. In connection with the important role of amino acids in the nitrogen nutrition of plants, the study of the amino acid composition of soils is of undoubted interest. As a result of the analysis, we identified 16 amino acids, among which predominate: histidine, aspartic acid, threonine, alanine, phenylalanine and leucine. The seasonal dynamics of the qualitative and quantitative composition of amino acids in the studied soils depends on the specific features of the annual hydrothermal regime, the nature and productivity of plant cenoses. In the spring-summer and spring periods, the most total amount of amino acids was found: in mountain-meadow chernozems: in spring - 13.08 mg per 10 g of soil, in summer - 18.92 mg, in autumn - 11.3 mg, in winter at low temperatures and excessive soil moisture, the amount of amino acids decreases to 7.81 mg, while in brown mountain forest soils it is: in spring - 14.9 mg, in summer - 11.91 mg, in autumn - 10.89, in winter - 7.52 mg. The amino acid composition of soils in mountain chernozems is mainly represented by lysine (3.10 mg), histidine (2.02 mg), aspartic acid (2.09 mg), and alanine (1.70 mg); methionine (1.37 mg), phenylalanine (2.09 mg) and leucine (3.09 mg); in brown mountain forest soils: histidine (1.28 mg), aspartic acid (1.30 mg), threonine (1.81 mg), phenylalanine (1.87 mg) and leucine (3.35 mg). It was revealed that the qualitative composition of amino acids in mountain chernozems and in brown mountain-meadow soils is homogeneous and does not depend on soil type. With an increase in the pH of the reagent, the total yield of humic substances increases in all types of soils. The C_{ph} ratio in chernozem soils is much wider than in brown forest soils. In the humus-accumulative horizon of all types of soils, when they are sequentially treated with solutions with different pH values, the largest amount of carbon is extracted mainly by sodium pyrophosphate with a neutral and alkaline reaction. The results of the experiments showed that the optical properties of all studied soil horizons follow the same patterns as the upper horizons. So, if in the upper horizon of chestnut soils, with a change in humidity between 2-37%, the integral reflection coefficient varies from 12 to 33%, and in the horizon of 40-65 cm, with a change in humidity from 5.9 to 37.9%, the integral reflection coefficient changes within 15- 25%, and in the 60-95cm horizon, when the humidity changes from 3.7 to 34.70%, the integral reflection coefficient changes to 23 to 40%. So if 1% humidity in fidelity in the upper horizon reduces the integral reflection coefficient by 0.96%, then in the horizons of 40-65 cm and 65-95 cm by 0.090 and 0.56%. If in the first horizons the influence of humidity on the formation of optical characteristics can be considered close, then in the 65-95 cm horizon it differs by almost 2 times. In contrast to chestnut soils, the differences in meadow-serozem soils are insignificant and are approximately 0.60–0.70% per 1% moisture content. The amount of ash elements in phytomass are presented in below (Table 1).

Table 1. The amount of ash elements in the plant mass (kg/ha)

Fractions	N	Si	Ca	K	Mg	P	Al	Fe	Mn	S	The sum of the elements	
											With N %	Without N %
Above ground part	2.07	0.89	1.98	1.77	0.36	0.09	0.11	0.14	0.09	0.28	7.70	5.64
Roots	0.69	0.85	1.72	1.12	0.29	0.08	0.32	0.38	0.07	0.09	5.56	4.88
Dead remains	0.51	1.50	1.67	0.79	0.44	0.07	0.65	0.73	0.05	0.11	6.83	6.32

Conclusion

In a field experiment, a positive effect of microbial and amino acid products on the chemical composition of meadow plants was established. Based on the results obtained, it was concluded that the moisture significantly increased the content of total protein and dry matter compared to the control, while the moisture content of the soil was less.

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