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SEASONAL VARIABILITY OF ENZYME ACTIVITY AND HUMIFICATION IN TYPICAL RAINFED GRAY SOILS

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Abstract. This study examines the seasonal dynamics of catalase, peroxidase, and polyphenol oxidase activities in typical rainfed gray soils (sierozems) of a semi-arid foothill region. Soil samples collected during 2024–2025 from depths of 0–15, 15–30, and 30–50 cm were analyzed in spring, summer, and autumn. The results indicated that enzyme activities were highest in spring and lowest in summer, demonstrating a strong dependence on soil moisture and hydrothermal conditions. The humification coefficient, calculated from the ratio of polyphenol oxidase to peroxidase activity, reflected seasonal changes in humus formation and decomposition processes. The findings demonstrate that the enzymatic status of these soils is shaped by their genetic properties and is sensitive to agrotechnical practices.

Keywords: soil enzymes, catalase, peroxidase, polyphenol oxidase, enzymatic activity, seasonal dynamics, humus, humification coefficient, rainfed typical gray soils, hydrothermal conditions, microbial activity.

Annotatsiya. Tadqiqotda yog‘ingarchilik bilan yarim ta’minlangan qir-adirlik mintaqasidagi lalmi tipik bo‘z tuproqlarda katalaza, peroksidaza va polifenoloksidaza fermentlari faolligining mavsumiy dinamikasi o‘rganildi. 2024–2025 yillarda olingan tuproq namunalari (0–15, 15–30, 30–50 sm) bahor, yoz va kuzda tahlil qilindi. Fermentlar faolligi bahorda maksimal, yozda minimal ekani, ularning namlik rejimi va gidrotermik sharoitlar bilan kuchli bog‘liqligi aniqlandi. Polifenoloksidaza peroksidaza nisbati asosida hisoblangan gumifikatsiya koeffitsienti gumus hosil bo‘lish-parchalanish jarayonlarining mavsumiy o‘zgarishini ko‘rsatdi. Natijalar fermentativ faollikning tuproq genetik xususiyatlari va agrotexnik tadbirlar ta’sirida shakllanishini tasdiqladi.

Kalit so‘zlar: tuproq fermentlari, katalaza, peroksidaza, polifenoloksidaza, fermentativ faollik, mavsumiy dinamika, gumus, gumifikatsiya koeffitsienti, lalmi tipik bo‘z tuproqlar, gidrotermik sharoit, mikroorganizmlar faolligi.

Аннотатсия. В исследовании изучена сезонная динамика активности каталазы, пероксидазы и полифенолоксидазы в богарных типичных серозёмах полузасушливой предгорной зоны. Почвенные образцы, отобранные в 2024–2025 годах из горизонтов 0–15, 15–30 и 30–50 см, анализировали весной, летом и осенью. Установлено, что активност ферментов максимална весной и минимална летом и тесно связана с влагообеспеченностью и гидротермическими условиями. Коеффитсиент гумификатсии, рассчитанный по соотношению активности полифенолоксидазы и пероксидазы, отражает сезонные изменения протсессов образования и разложения гумуса. Результаты подтверждают, что ферментативное состояние серозёмов определяется их генетическими свойствами и реагирует на агротехнические мероприятия.

Ключевые слова: почвенные ферменты, каталаза, пероксидаза, полифенолоксидаза, ферментативная активност, сезонная динамика, гумус, коеффитсиент гумификатсии, богарные типичные серозёмы, гидротермические условия, активност микроорганизмов

Introduction. Biochemical processes in soil occur directly with the participation of enzymes. Soil enzymatic activity is understood as the sum of catalytic processes of intracellular and extracellular

enzymes within the soil biota. In a soil profile, there exists a specific set of enzymes characteristic of a given soil type, distinguished by both quantitative and qualitative composition.

The intensity of enzymatic processes in soil horizons depends on specific environmental conditions, namely the concentration of substrates required for a given enzyme, as well as soil temperature, moisture, and pH. In typical rainfed gray soils, timely implementation of agrotechnical measures and scientifically justified application of organic and mineral fertilizers can lead to the restoration of the total microbial population, improvement of humus content and soil aggregation, and consequently an increase in enzyme activity.

Numerous studies have shown that the seasonal dynamics of enzyme activity in soils of different regions vary in different directions (G.I. Jumaniyozova, L.D. Saydalieva [1]; L.A. Gafurova, S.S. Murodova [2]; O.V. Myachina [3]; E.V. Dadenko [4]; Y.S. Ananyeva, Y.O. Volozhanina [5]; D.A. Kodirova, Sh. Temirov, D. Kodirova [6]; G.M. Nabieva [7]). These studies mainly investigated the relationships between enzymatic activity and agrophysical, agrochemical, and physicochemical properties of desert soils, mountain brown soils, and mountain slope soils affected by varying degrees of erosion, as well as the impact of erosion processes on the ecological and genetic status of mountain soils.

However, the enzymatic activity of typical rainfed gray soils under semi-humid precipitation conditions has not been sufficiently studied. In this study, the dynamics of catalase, peroxidase, and polyphenol oxidase activities in typical rainfed gray soils with semi-sufficient precipitation were investigated in relation to soil moisture content and seasonal changes.

Materials and methods. Based on the above-mentioned objectives, soil analyses were carried out according to E.V. Arinushkina's "Manual of Chemical Analysis of Soils". The determination of soil enzyme activity was performed following the methods described in F.Kh. Khaziev's "Methods of Soil Enzymology", while statistical analysis of the obtained results was conducted according to B.A. Dospekhov's "Methodology of Field Experiments".

Soil samples were collected from experimental plots established at the Central Experimental Farm during 2024–2025. Laboratory determination of soil enzyme activity was conducted using samples collected in autumn (October), spring (April), and summer (June). Prior to analysis, the natural moisture content of soil layers at depths of 0–15, 15–30, and 30–50 cm was determined. The collected soil samples were air-dried, cleared of plant residues, roots, and other foreign materials, and then sieved through a 1 mm mesh.

Results and their discussion. The enzyme catalase plays an important role in the oxidation-reduction process that takes place in the soil. Together with this, it stores complex protein and biologically active group substances in itself. Catalase fermentation includes the fermentation of nitrogen, microorganisms, organic substances, sludge particles, solid particles and particulates, hydrochloric acid fermentation, hydration, and ecological status.

In typical sierozem soils with semi-suficcient precipitation , catalase activity was low soil density, high porosity and high organic matter in the spring season at 26.0 cm^3 O_2/min in a layer of 0-15 cm, 25.3 cm^3 O_2/min in a layer of 15-30 cm, and 17.7 cm^3 O_2/min in a layer of 30-50 cm.In the summer season, when the moisture content decreased, 23.0 cm3 O_2/min in a 0-15 cm layer, 18.3 cm3 O_2/min in a 15-30 cm layer, and 16.3 cm3 O_2/min in a 30-50 cm layer. By autumn, the catalase enzyme was found to be in the 25.7-24.3 cm3 O2/min range, respectively.

It can be seen from this that as a result of a decrease in organic matter and porosity along the soil cross section, an increase in the activity of the catalase enzyme due to a decrease in the activity of the catalase enzyme, an increase in the amount of moisture per year.

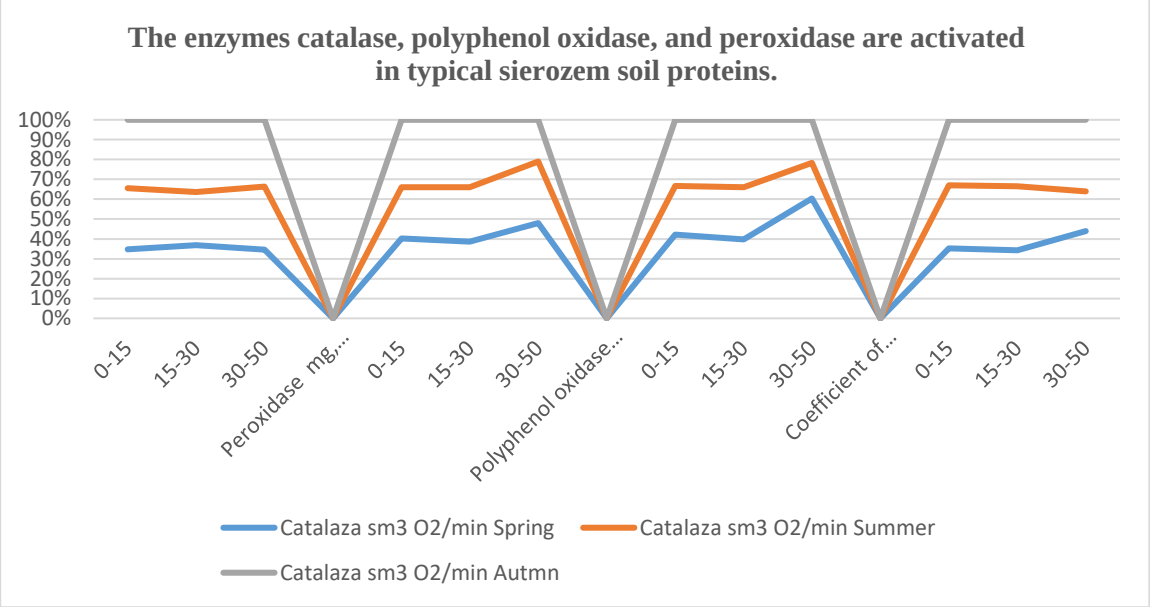
Peroxidase and polyphenoloxidase accelerate the oxidation of phenols, that is, this acceleration leads to the formation of oxygen. Due to oxygen, phenol and oxygen, organic substances are formed in humus. These enzymes promote the release of humic oils from the soil and their subsequent release into the soil. Peroxidase catalyzes the oxidation of polyphenols. Thus, he performed the same duties as his predecessor.

Activation of enzymes that affect metabolism and protein metabolism leads to a decrease in the activity of enzymes involved in metabolism

Activation of peroxidase and polyphenol oxidase enzymes leads to the cleavage of humic substances during their synthesis, and their ratio can be determined by the humification coefficient.

Oxidases are enzymes involved in metabolic dynamics, which allows them to synthesize enzymes under hydrothermal conditions.

The activity of the enzyme polyphenoloxidase in typical sierozem soils with semi-suficcient precipitation , catalase activity with ingestion was high soil porosity in the spring season and 0.124 mg purpurgallin/100 g soil in a layer of organic matter abundant 0-15 cm, 0.083 mg purpurgallin/100 g soil in a layer of 15-30 cm, and 0.064 mg purpurgallin/100 g soil in a layer of 30-50 cm. In the summer season, when moisture content was reduced, 0.072 mg purpurgallin/100 g of soil in a 0-15 cm layer, 0.055 (mg purpurgallin/100 g of soil) in a 15-30 cm layer, and 0.019 mg purpurgallin/100 g of soil in a 30-50 cm layer. By autumn, the enzyme polyphenoloxidase was found to be within 0.098-0.023 mg purpurgalline/100 g of soil range, respectively. Peroxidase enzyme activity was 0.084 mg purpurgalline/100 g soil in 0-15 cm layer of soil, 0.065 mg purpurgalline/100g soil in 15-30 cm layer, and 0.048 mg purpurgalline/100 g soil in 30-50 cm layer. (3.6.1-graph).



Based on these data, it can be concluded that the enzymes involved in the metabolism of soil-climate affect their genetic characteristics.

Data on the seasonal dynamics of typical typical sierozem soils shows that in these types of precipitation there is a minimum, and in the mountains there is a maximum. In this way, the enzymes involved in protein synthesis can be activated during fermentation.

The enzymes of the enzyme reduce the humus content in soils, which leads to its deceleration, which leads to an increase in the humus content in soils, a decrease in the content of elements, pH, carbonates, mechanical destruction, and a decrease in soil fertility.The genetic properties of the soils are unknown.

Conclusion. The study of the seasonal and conditional activity of catalase, peroxidase, and polyphenol oxidase enzymes in typical rainfed gray soils distributed in semi-humid foothill regions demonstrated that the functioning mechanisms of these enzymes are closely related to the physicochemical and agrobiological properties of the soil. Based on the research findings, the following conclusions were drawn:

1. Enzymatic activity was highest in the upper soil layers and decreased sharply with increasing depth due to a reduction in humus content, decreased porosity, and increased bulk density.

2. Spring was identified as the season during which enzyme activity reached its maximum. Under these conditions, optimal soil moisture, temperature, and microbiological activity ensured efficient enzyme functioning.
3. Seasonal variations in the activity of catalase, peroxidase, and polyphenol oxidase were strongly dependent on hydrothermal conditions, highlighting the critical importance of regulating the soil moisture regime in rainfed agricultural systems.
4. The humification coefficient calculated based on polyphenol oxidase and peroxidase activities reflected the seasonal rhythm of humus formation and decomposition processes, showing higher values in spring and autumn and lower values in summer. This confirms that these enzymes serve as key biochemical indicators of organic matter turnover in soils.
5. The obtained data indicate that the enzymatic status of typical rainfed gray soils reflects their genetic characteristics. Furthermore, agrotechnical measures, fertilization, and moisture conservation practices play a decisive role in restoring microbiological processes and enhancing enzyme activity.

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