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ANALYSIS OF THE ECOLOGICAL STATE OF THE SOIL MICROBIOME IN THE KYIV REGION

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Abstract. *The agricultural soils are under constant anthropogenic impact, and therefore it is important to know how human actions affect the intensity and direction of microbiological processes that are the basis for soil fertility. The aim of the study was to demonstrate the state of the soil microbial ecosystem in Kyiv region using an integrated approach. The study revealed distinct differences between the two systems under research. In the mineral system, the total microbial biomass and most groups of microorganisms were correlated with humus carbon and the carbon pools associated with it.*

Keywords: *soil microorganisms, microbial ecosystems, organic farming, soil fertility, CO_2 emission.*

Due to the growing human impact on the soil ecosystem, attention to the greening of the agricultural sector is also increasing, which is why there is a growing need to improve the understanding of the concept of ecology in soil microbiology. Knowledge of the laws of soil microbiota functioning in a natural ecosystem allows us to quickly identify and understand the causes of changes that occur in it and find ways to regulate them in the direction we are looking for. The most significant focus is usually on studies of the structure of bacterial communities at the taxonomic level. Agricultural soils are under constant anthropogenic influence, and therefore it is important to know how human actions affect the intensity and direction of microbiological processes that are the basis for soil fertility [1].

However, as is well known, the potential capabilities of microorganisms found on nutrient media often do not allow us to observe a full picture of all soil processes, which is largely due to the multifunctionality and taxonomic heterogeneity of the microbial world. Determination of soil biochemical and agrochemical indicators in many cases gives a more complete idea of the functioning of the microbial community in specific conditions [2].

The combination of microbiological parameters along with chemical, physical, etc., and their integration using mathematical analysis will allow us to demonstrate the microbial ecosystems of a particular landscape depending on various specified factors - fertilisation systems, applied agrotechnical methods and, on this basis, to assess the specifics of soil microbiological processes in each case [3]. Therefore, we took a comprehensive approach to soil analysis, which included an analysis of the number and activity of ecological and trophic groups of soil microorganisms, the pool of organic carbon, and used carbon and nitrogen of the total microbial biomass as integral microbial indicators, as well as CO_2 emission.

Therefore, *the aim of the study was* to demonstrate the state of the soil microbial ecosystem in Kyiv region using a comprehensive approach to soil analysis.

The soil of Kyiv region with the following characteristics was used for the study: typical chernozem with a humus content of 4.3%, hydrolysable nitrogen – 110 mg/kg, mobile phosphorus – 240, exchangeable potassium – 85 mg/kg of soil, pH of the salt extract – 6.5. The samples were taken in the spring before the agricultural activities. In previous years, corn was grown and $N_{90}P_{60}K_{90}$ (mineral fertiliser system) and $N_{70}P_{40}K_{70}$ + humus (organic-mineral fertiliser system) was applied. The studies showed that the microbial community of the used soil under the influence of both fertilisation systems showed different effects on the formation of microbial populations. Bacterial forms of microorganisms capable of ammonification, amylolytic, oligonitrophilic and oligocarbophilic microorganisms predominate in both the mineral and mixed systems, but their higher numbers were found in the first fertilisation system. The use of mineral fertilisers also contributes to an increase in the number of diazotrophs in the soil. Under the mixed fertiliser system, a high number of cellulose-degrading microorganisms, micromycetes and ammonifiers were observed. The use of additional organic fertilisers has a positive effect on the development of nitrogen fixers: their number increases by 5-6 times. It is well known that the number of ammonifying microorganisms and their significant development is determined by the presence of organic matter in the soil. The high number of ammonifiers found under the conditions of mineral fertilisers may indicate mineralisation of complex organic compounds, in particular humus, due to the lack of fresh organic matter in the soil.

Both soil variants, regardless of the differences in the number of microorganisms, were characterised by almost the same indicator of total microbial biomass. This is most likely due to the fact that in the presence of humus in the soil, most of the biomass is introduced by mycelial fungi, representatives of the cellulose-degrading group of microorganisms. Indirect evidence of the latter is the soil's CO_2 emission («respiration»), which is higher than with a mineral fertilisation system. It is known that bacteria have a higher ratio of body surface to volume (as in smaller organisms) and, accordingly, a higher metabolic rate, i.e., energy requirements per unit body weight.

A direct and correlated relationship between the abundance of a particular ecological and trophic group and the total microbial biomass may indicate that this particular group of microorganisms is involved in changes in the total biomass. An inverse relationship may indicate a decrease in the number of a particular group with an increase in total biomass, which is possible both due to the depletion of certain nutrients and its active consumption by competitive microorganisms. The absence of a significant connection between these indicators (the number of microorganisms and total biomass) most likely indicates a less active state of microorganisms. If we consider both of the systems we studied, the mixed-type variant, the groups of microorganisms found there and the other indicators (biomass, soil CO_2) associated with them, is the system that is in a state of relative calm. However, it should be noted that soil microorganisms are engaged in active physiological processes not only during growth and reproduction, but also in the process of maintaining cell viability, which also consumes a large amount of organic matter.

The analysis of correlations between the detected groups of microorganisms and different carbon pools helps to assess the biological significance of the latter as a source that provides structural and energy costs of microorganisms under specific conditions. For example, we found distinct differences between the two systems used in the research. Under the mineral system, the total microbial biomass and most microbial groups correlated with humus carbon and the carbon pools associated with it. The high content of copiotrophs, microorganisms that prefer high concentrations of nutrients, may be an indirect confirmation of soil enrichment with monomeric compounds. These compounds are signalling metabolites of enzymatic hydrolysis of polymers and contribute to the inhibition of hydrolytic and oligotrophic growth. This is demonstrated by the inverse relationship between the

number of cellulose-degrading and oligocarbophilic microorganisms and those carbon pools with which their competitors had close positive connections. A lack of structural and energy materials for the above-mentioned microorganisms leads to an inverse relationship with all integral indicators. The mixed fertilisation system showed the closest positive correlation of most groups of microorganisms with plant residues.

That is, the previously noted imbalance between the stock of total microbial biomass and the number of microorganisms is associated with different ways of using soil organic matter. This is what determined the different structure of the microbial community in the soils tested under different fertilisation systems. All this indirectly indicates that the mineral system has a higher mobility of soil organic matter, which was confirmed by biochemical analysis.

Therefore, using an integrated approach to soil analysis, it was shown that under the mineral fertilisation system, a mobile balance between the synthesis and decomposition of humus is observed in the soil, which is moved towards decomposition. Probably, this is the reason for the «preservation» of plant residues in this variant, as the microbial community prefers humus as a substrate (due to its availability) to plant residues. Distinct differences were found between the two systems tested. In the mineral system, the total microbial biomass and most microbial groups were correlated with humus carbon and the carbon pools associated with it.

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АНАЛІЗ ЕКОЛОГІЧНОГО СТАНУ МІКРОБІОМУ ҐРУНТІВ КИЇВСЬКОЇ ОБЛАСТІ

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Ключові слова: *ґрунтові мікроорганізми, мікробні екосистеми, органічне землеробство, родючість ґрунту, емісія* CO_2.

Анотація

Сільськогосподарські ґрунти перебувають під постійним антропогенним впливом, а тому важливо знати, як дії людини впливають на інтенсивність і спрямованість мікробіологічних процесів, що є основою родючості ґрунту. Метою дослідження було продемонструвати стан мікробної екосистеми ґрунтів Київської області за допомогою комплексного підходу. Дослідження виявило чіткі відмінності між двома досліджуваними системами. У мінеральній системі загальна мікробна біомаса та більшість груп мікроорганізмів корелювали з вуглецем гумусу та пов'язаними з ним пулами вуглецю.