Dependence of the content of microbial biomass in typical black soil on agrogenic factors and year season

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Abstract. The authors of the paper found that the nature and direction of the seasonal dynamics of the content of microbial biomass in typical black soil in grain-fallow crop rotation differ depending on the slope direction, the cultivation system and the soil layer. The characteristics of the dynamics of the content of microbial biomass in typical black soil in the agroecosystem of grain-fallow crop rotation, depending on the slope direction and the type of soil cultivation are revealed. The influence of the slope direction on the dynamics of the microbial biomass in the soil is more pronounced in the layer of 10-20 cm. The need to ensure the supply of a sufficient amount of post-harvest residues and organic fertilizers to the soil is shown. The increase in the uniformity of the upper layer of typical black soil is associated with the constant mechanical man-made impact on it. The obtained results about the nature of the impact of the studied factors on the seasonal and spatial variability of microbial biomass can be used in the development of systems for the management of the biological activity and reproduction of organic matter in black soils in order to improve their ecological state. The results of studies of the ecologically and agronomically important soil component i.e. microbial biomass are necessary for the development of systems for the regulation of soil fertility in order to increase their productivity, as well as for the development of a control system for the content of microbial biomass in black soils. The experimental data can serve as the basis for a database on the microbial pool of various soils and ecosystems, which is advisable to use for model predictive calculations, including in different ecological scenarios. The assessment of the state of organisms living in the soil and their biodiversity are important in the solution of the problems of environmental practice: identification of zones of ecological disadvantage, calculation of damage caused by man-made activities, determination of the stability of the ecosystem and the impact of certain anthropogenic factors.

1. Introduction

In the modern world, agriculture has to adapt to constantly changing conditions and to solve emerging problems simultaneously and in a timely manner. Today one of such fundamental tasks of agriculture is the preservation of the ecological role of soil, its stable and sustainable fertility [1].

In the modern world, climatic changes increase the productivity of plants, which, together with anthropogenic activity, leads to the increase in the amount of exogenous carbon in cultivated soils [2]. The indicator of the level of organic carbon in soils is highly dependent on the biological participation
of the soil in the growth of crops. The decomposition, transformation and stabilization of organic matter are the indicator of soil fertility and ecological and biological activity [3].

Many scientists in their works showed that soil microorganisms play a key role in all processes associated with the biotransformation of organic matter [4]. One of the important components of the organic matter of black soils is microbial biomass, which mediates the transformation of the most important nutrients and compounds, that is, plays an important role in plant nutrition [5].

In the conditions of agricultural intensification, the anthropogenic impact on the soil and its fertility increases. As a result, there is a gradual degradation of soils, the decrease in their fertility and productivity.

Soil microorganisms are one of the most important components of the soil, making a huge contribution to the formation of substance fluxes in the soil - plants - atmosphere system. The microbial community of the soil is involved in many biogeochemical processes, converting compounds of carbon, nitrogen, phosphorus, sulfur and other biophilic elements.

The importance of the study of the issues of the content of microbial biomass in black soil is that this aspect is a necessary condition for the management of soil fertility and increase in the productivity of agroecosystems, the long-term and fruitful use of which is possible only with an environmentally competent approach to the regulation of their functions.

The purpose of the research is to study the features of the seasonal dynamics of the content of microbial biomass in typical black soil in grain-fallow crop rotation, depending on the slope direction and soil cultivation system.

2. **Conditions, materials and methods**

The research was carried out in 2006-2008 in the multifactorial field experiment (MFE) of All-Russian Research Institute of Agriculture And Soil Protection From Erosion, started in 1984, in a grain-fallow four-field (barley - pure fallow - winter wheat - corn) crop rotation (GFCR). Moldboard and non-moldboard soil cultivation was carried out to a depth of 25-27 cm for corn and 20-22 cm for the rest of the crop rotation.

The seasonal dynamics of the content of microbial biomass was studied in the 6th rotation of the GFCR in the pure fallow (2007) and in the crops of winter wheat (2008), depending on the slope direction (northern and southern) and the tillage system (moldboard and non-moldboard). In soil samples, the microbial biomass was determined by the rehydration method [6]. The obtained experimental data were processed by statistical and mathematical methods [7].

3. **Results and discussion**

The studies showed that the nature and direction of the seasonal dynamics of the microbial biomass (MB) content in typical black soil in the GFCR differ according to the slope direction, cultivation system and soil layer (Figure 1).

The tendency towards a decrease in MB was noted by the end of August and a subsequent increase in the post-harvest period towards the end of October on the southern slope in pure fallow during moldboard processing in layers of 0-10 cm, 20-30 cm and on the northern slope in layers of 0-10 cm, 10-20 cm, 20-30 cm of typical black soil. A different nature of the dynamics on the studied slope was noted in the 10-20 cm layer regardless of the soil cultivation system and in the case of non-moldboard tillage and in the 0-10 cm layer: the tendency towards the decrease in the soil content of MB from July to October. On the northern slope, in all the studied soil layers, with non-moldboard tillage, there was a tendency to the decrease in the microbial biomass by the end of August and its maintenance at approximately the same level by the end of October.

At the same time, the seasonal variation of MB in typical black soil was insignificant ($K_{var}$ - up to 8%) on the northern slope with moldboard-free cultivation (regardless of the soil layer), and on the southern slope - with moldboard cultivation in a layer of 10-20 cm. In the soil layer of 0-10 cm in the last variant, there was an average level of seasonal variability of MB ($K_{var} = 14\%$). The average degree of seasonal variation of MB was found in the soil on the southern slope during moldboard-free
processing, and on the northern slope during moldboard cultivation ($K_{\text{var}} = 21-28\%$, depending on the soil layer), and on the contrary a low degree was found on the southern slope during moldboard cultivation (MC) and on the northern slope during non-moldboard cultivation (NMC).

Figure 1. Dynamics of the content of microbial biomass in typical black soil in grain-fallow crop rotation (GFCR) in pure fallow (2007) and under winter wheat (2008) depending on the slope direction

In the typical black soil under winter wheat in the agroecosystem of grain-fallow crop rotation (GFCR), the nature and direction of the seasonal dynamics of MB were determined by the slope direction (Figure 2). Thus, on the northern slope during moldboard tillage, the MB content in the soil decreased during the active vegetation of plants on the variant with moldboard tillage by 21% in the soil layer of 0-10 cm and by 62% in the layer of 10-20 cm. It increased by harvest, respectively by 41% and 52% and decreased in the post-harvest period by 25% and 5%. Such changes correspond to the average level of seasonal variability of the MB content ($K_{\text{var}} = 14\%$ and $K_{\text{var}} = 20\%$). In the case of non-moldboard tillage, the seasonal variation in the MB content in the soil was less pronounced.

On the southern slope, the seasonal dynamics of the MB content in typical black soil under winter wheat as a whole arable layer is characterized by a one-peaked curve with a maximum in mid-June. Thus, the amount of MB increased during the period of active vegetation of plants by 15-19% depending on the soil layer with the use of moldboard cultivation and decreased in the post-harvest period by 58-67% ($K_{\text{var}} = 18-21\%$). Firstly, the use of non-moldboard tillage on typical black soil
changed the degree of time variation of the MB content from medium to low, and secondly, in the post-harvest period, the content of microbial biomass in the studied soil layers did not actually change.

**Figure 2.** Dynamics of the content of microbial biomass in typical black soil in grain-fallow crop rotation (GFCR) under winter wheat (2008) depending on the slope direction

4. **Conclusion**

The characteristics of the dynamics of the content of microbial biomass in typical black soil in the agroecosystem of grain-fallow crop rotation (GFCR), depending on the slope direction and the type of soil cultivation were determined. The influence of the slope direction on the dynamics of the microbial biomass in the soil was more pronounced in 10-20 cm layer. The use of non-moldboard tillage in most cases reduced the seasonal variability of the MB content, changing from a significant or medium degree to an insignificant one.

The revealed characteristics of the impact of the studied factors on the seasonal and spatial variability of microbial biomass can be used in the development of systems for the management of the biological activity and reproduction of organic matter in black soils in order to improve their ecological state.
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