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Introduction

Fertility of the chernozem soils of the Left-Bank Forest-Steppe Ukraine is influenced by a complex set of natural and agronomic factors, including the leading role of microorganisms that provide continuous cycling of matter and energy and determine the orientation of the soil in agrocenosises [Demydenko, Tonkha, Velichko 2013: 20–23]. The intensity of microbiological processes in soil under the influence of soil-conservation technologies of crop growing in agrocenoses, on the one hand, provides a high level of agrophysical conditions of fertility, and, on the other hand, the specific forms of microbiological activity forms microbiological conditions of expanded reproduction of an effective, natural and potential fertility of chernozem soils of the Left-Bank Forest-Steppe Ukraine.

1. The methodology of the research

The studies were conducted (2000–2012 years) in Vorskla – Sulskyy district in its southern part (c. Karlivka). The soil cover within the southern part of the Poltava region is represented by chernozem typical (> 50%) medium-humified (5,55–5,65%) and in Drabiv agro-soil area. Forest-Steppe zone of the Left-Bank Lowland province Northern subprovince by chernozem typical low-humified light-loamy clayey-silty. Soil-biological studies were conducted in the 0–20 cm soil layer. Soil sampling and samples storage for the study of aerobic microbial processes in the laboratory was carried out according to EN ISO10381-6-2001. Different groups of microorganisms were investigated using the method of broad microbiological analysis by sowing of soil suspensions on dense nutrient media. In meat – peptone agar (MPA) was studied the total number of microorganisms that decompose organic compounds. On starch – ammonium medium (SAA) – microorganisms that assimilate mineral forms of nitrogen. In starvation agar (SA) – number of oligotrophs, and on the Ashby Medium (AM) – number of olygonitrophils [Zvyahyntsev 1991]. Methods of calculations of microorganisms colonies in soil and composition of mediums according to D.H. Zvyagintsev,

content of actual humic substances (AHS) and detritus (D) – by Shpringer, total humus content – by I.V. Tyurin in the modification of Simakov (ISO 4289: 2004).

2. Results of Studies

An important factor in improving of the microbiological activity and structure of chernozems is detritus, which, on the one hand, is the adsorbent is the actual humic substances, on the other hand, serves as a "fixture" in the formation of agronomically valuable structural units. Under non-plowing cultivation manure and crop residues transform to detritus more actively, because of higher humifying coefficients on 15–23% (Table 1), and under plowing there is less detritus accumulation due to enhanced mineralization. Under non-plowing cultivation in 0–50 cm soil layer the accumulation of detritus is in 1,35–1,40 times higher over the crop rotation, and at the surface (0–20 cm soil layer) – in 1,7–1,9 times higher than under plowing.

Table 1

Long-term (10 years) effect of tillage method on detritus stocks in 0–50 cm layer of chernozem typical medium-humified of the southern part of the Left-Bank Forest--Steppe of Ukraine

Soil tillage system	Detritus, t/ha	Active humus, t/ha	General content of humus, t/ha	Of detritus to the general content of humus,%
Plowing to 22–32 cm	105	3,3	327	32,0
Non-plowing cultivation to 5–12 cm	130	8,0	350	37,0
$LSD_{0,5}$ (the least significant difference)	15,0	2,5	5,0	–

Improving of thy humifying of the upper soil horizon under the systematic soil – conservation tillage is connected to the increase in microorganisms content. Compared with plowing, the number of micromycetes and streptomycetes in 0–15 cm soil layer was in 1,15–1,22 and 1,23–1,49 times higher, and 15–30 cm soil layer – in 1,05–1, 15 and 1,08–1,22 times smaller.

Minimization of soil tillage in soil conservation technologies somewhat inhibits the mobilization processyi, as evidenced by reduced mineralization coefficients, which are set by the ratio of groups of microorganisms of SAA to MPA:

in 0–15 cm soil layer this ratio is in 1,09–1,18, and in 15–30 cm – in 1,11–1,18 times lower in comparison with the systematic plowing, and the absolute number of microorganisms MPA and SAA under soil-conservation tillage at the surface part of humus horizon is higher in 1,21–1,44 and in 1,09–1,18 times compared with plowing. In 15–30 cm soil layer the pattern is reversed: the contents of these groups of organisms is higher in 1,05–1,14 and 1,15–1,33 times under plowing. This fact explains the phenomenon of increase of detritus and active humus in 0–30 and 0–50 cm layers of chernozem typical under soil-conservation tillage in agrocenosises. In chernozem typical low-humified pattern appears set for a chernozem typical light-clayey. In both cases, the 0–20 cm layer of chernozem is going an active humus renewal.

Analysis of percentage of correlation coefficients (table 2) of varying strength and direction indicates that the use of non-plowing cultivation increases the number of correlation coefficients of mean force and higher ($R \geq \pm 0,45$) in the 0–15 cm soil layer in 1,3–1,7 times. The correlation coefficients of direct action under non-plowing cultivation was in 1,53–1,68 times more, and the inverse – in 1,06–1,6 times more, and the number of correlation coefficients of weak force naturally decreased in 1,4–2,4 times, compared with plowing. In the 15–30 cm soil layer forming the general pattern of correlations of varying strength and direction remained: the number of links $R \geq \pm 0,45$ increases under non-plowing cultivation in 1,2–1,7 times, and inverse orientation – in 2,6–5 times; of direct action – in 1,2 times, compared to plowing.

Factor of moisture in that range is the actual self-regulatory factor, the strength of which increases with the minimization of soil tillage. When plowing, correlation coefficients $R \geq –0,45$ was – 44%, under non-plowing cultivation – 56 %, under minimum cultivation – 89 %. Under plowing between the factor of the moisture and of detritus content was found a significant inversion relation ($R = –0,72$), whereas under non-plowing cultivation power of link is reduced e to the weak force ($R = –0,32–0,45$). The intensity of carbon dioxide assimilation under plowing had a direct connection, which is amplified to values of $R = +0,45$. For minimum tillage field uniform relationship between humidity and the intensity of assimilation amplified to $R = +0,85$, indicating strengthening the role of moisture in the active microbial environment of fertility.

Between the coefficients of mineralization and moisture level the connection amplified from plowing to minimum cultivation, indicating the stabilizing role of moisture in the process of mineralization of soil organic matter. In chernozem soil under soil conservation technology assimilation of CO_2 of soil air by saprophytic microflora is more intensely manifested in the 0–15 cm soil layer – between the intensity of assimilation and humus content found inverse connection which increases under the minimum tillage cultivation.

Table 2

Effect of soil tillage system on the percentage (%) distribution of correlation coefficients of varying strength and direction between microbiological parameters in 0–30 cm layer of chernozem typical

The value of the correlation coefficient	Plowing to 22–32 cm	No-plowing to 5–12 cm
$R \geq \pm 0,45$	46,7 / 54,0	77,7 / 92,0
$R \geq +0,45$	17,7 / 7,0	28,7 / 36,0
$R \geq -0,45$	29,0 / 46,4	49,0 / 56,0
$R < \pm 0,45$	53,3 / 46,0	22,3 / 8..0

* 0–15 см / 15–30 cm

When plowing, mineralization coefficients (MC) of organic matter are higher than under non-plowing cultivation, so the relationship between the intensity of assimilation and MC in 0–15 cm layer is strong inverse, and when non-plowing cultivation – negligible direct, that is associated with a lower coefficient of mineralization in the latter case. In 15–30 cm layer pattern is inverse, which is associated with attenuation of biological activity in this layer.

Amount of moisture for microorganisms in pore space of chernozem is a crucial issue for the reason that the development and the number of bacteria closely related to moisture in the soil. Relations between microorganisms and soil moisture are different from relationships of moisture from plants. The difference lies in the fact that organisms function in soil moisture and may be localized in the most shallow cracks in the soil.

Researches of D.H. Zvyahintsev [1991] showed that the soil is dominated by cells (74%) the size of 0,4–0,6 microns, but their volume is 14% of total cell volume, whereas large cells (1–4 microns) occupy 75% of the total cell volume. From this perspective, soil moisture is more accessible to microorganisms than for plants, but bacteria that got in the adsorbed state, leaving it with great difficulty. Adsorbed state is very depressing activity of microorganisms in soil: rate of reproduction reduces, changing their morphology, rate of oxygen consumption, carbon dioxide excretion, the amount and nature of metabolites formed. Accordingly, researches of D.H. Zvyahintsev per unit mass of chernozem with decreasing particle size of the soil from 3 to 0,001 mm, adsorption of microorganisms increases in 3–4 times. It was found that when the water film thickness is 1–2 mm there is a sharp slowdown in the intensity of cell reproduction. A sharp slowdown reproduction of soil microorganisms occurs in the capillaries

of 90 to 30 microns. In most cases, between the intensity of oxygen consumption by microorganisms and the activity of moisture is established a direct link, and the specified parameters define quantitative parameter of microorganisms kserofility. Bacteria need to breath higher values of soil moisture than yeast and fungi, indicating their hihrofility as yeast and fungi are kserofills. Saturation of the soil absorbing complex by Ca^{2+} and especially by K^{+} increase the growth of microorganisms.

The boundary of thickness of micropores, at which dramatically reduces the mobility of soil moisture, is the pore size of 60 microns, and a negative manifestation of the physical properties of adsorbed moisture are especially evident when the thickness of soil pores is 8–4 microns or less. Evaluation of soil cracks to microorganisms in many ways not consistent with its assessment for plants: it explains various functions of capillary cracks size of 3–60 microns. If for plants they serve as the provider of moisture, so they cannot supply microorganisms by oxygen.

The value of field moisture (W,%) in most droughty period of season for rotation indicates that minimizing of soil tillage to 5–12 cm creates the most favorable conditions to maintain active status in the activity of soil microflora. By optimizing the moisture regime, the period of biological activity (PBA) in humus soil strata under minimum tillage extended to 20–25 days more in comparison with the systematic plowing. During this period, soil moisture doesn't lose its mobility, and is in the middle and the upper limit of moisture in easily movable condition.

Stage of moisture in the soil with minimum soil moisture corresponds to the flow in the capillary, due to the enhancement of mass transfer in the system of solid phase – soil moisture, soil air. When easily-movable moisture condition occurs stationary convective motion of the flow of matter – is self-organization of mass transfer, which may be increased by 150–200. The active state of soil moisture under non-plowing cultivation provides soil microorganisms with nutrients and oxygen, which increases the rate of increase in the number of cells of microorganisms in the soil to 4–6 against 1–1,5 in thin capillaries (less than 60 microns) under plowing. In the latter case, the driest period of the year shows significantly negative impact properties of adsorbed moisture in soil cracks of 8–4 microns size, which coincides with the specified interval of wilting moisture in most droughty season.

Conclusions

Found that soil protection technology inhibits the mobilization processyi, as evidenced by reduced mineralization coefficients, improve and optimize the ratio of structural categories of micropores in 0–30 cm layer of chernozem, thereby reducing the rate of evaporation of soil moisture by 25–30%. Stage of moisture in the soil with minimum soil moisture corresponds to the flow in the

capillary, due to the enhancement of mass transfer in the system of solid phase – soil moisture, soil air. When easily-movable moisture condition occurs stationary convective motion of the flow of matter – is self-organization of mass transfer, which may be increased by 150–200%.

Literature

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Abstract

Investigated the microbial transformation of organic matter in the typical black soil under the influence of different types of processing. Found that soil protection technology inhibits the mobilization processyi, as evidenced by reduced mineralization coefficients, improve and optimize the ratio of structural categories of micropores in 0–30 cm layer of chernozem, thereby reducing the rate of evaporation of soil moisture by 25–30%. Stage of moisture in the soil with minimum soil moisture corresponds to the flow in the capillary, due to the enhancement of mass transfer in the system of solid phase – soil moisture, soil air. When easily-movable moisture condition occurs stationary convective motion of the flow of matter – is self-organization of mass transfer, which may be increased by 150–200%.

Key words: ecological-trophic groups of microorganisms, the typical black soil, micropores, soil moisture.