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COMPARATIVE CHARACTERISTICS OF MICROBIOME OF TYPICAL CHERNOZEM IN AGROCENOSIS OF WINTER WHEAT IN DIFFERENT FARMING SYSTEMS

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Comparative analysis of microbiome of typical chernozem in winter wheats' agrocenosis was conducted. The number of main physiological groups, qualitative composition, biodiversity of bacterial microorganisms under different farming systems and tillage of soil are presented.

Introduction. Microflora is an important component of soil biomes. Its role is defined by active involvement in the metabolism of organic matter and transformation of nutrients, which are vital for other trophic chains of biocenose (S.M. Vinogradsky) [1].

Microorganisms are the main factor in processes of soil formation and preservation of soil fertility. The diversity of microbiota has a much larger story of evolution than plants and animals. The combination of micro-climatic conditions, vegetation cover, physical and chemical properties of the soil has great influenced to the formation of microbocenosis, its size, composition and distribution in soil [2]. Agrotechnical measures: fertilizer system, plant protection, soil tillage, crop rotation have the significant impact on microbial component of soil [3].

In this context, an important task of soil microbiology with rational use of microbiological factors in modern agriculture is objective, complex characteristic of microbial biome of chernozem [4]. The study of biodiversity, spatial and functional structure of microbial complex is essential for understanding the mechanisms in the system soil – microorganisms – plant and is the basis for scientifically-based management of soil-microbiological processes for creating sustainable and highly productive agro-ecosystems [5].

The aim of research was to conduct comparative characteristics of microbial complex of typical chernozem, which formed in the process of growing winter wheat under different farming systems and tillage.

Materials and methods. Studies of microflora of typical chernozem was conducted in the stationary field experiment of Department of Agriculture and Herbology NULES of Ukraine (Agronomy Research Station). The area of studied field is located in the Right of the Forest-Steppe of Ukraine. The terrain is flat. The soil of the field is the typical chernozem with low humus content. On granulometric composition - is rudely dusty medium loam.

Farming systems differed by resource level of nutrients for a balanced potential of agricultural landscape. For industrial system (control) was made 12 tons of organic and 300 kg of active ingredient of fertilizers (N92P100K108) per hectare of arable land in the rotation. In the ecological model of agriculture priority was the use of organic fertilizers — 24 t/ha of crop rotation (12 tons of manure, 6 tons of non-commercial harvest (straw), 6 tons of green manure crop mass (radish). The balance of nutrient was offset by fertilizer (N46P49K35). The model of biological system is based on introducing 24 t/ha of arable land of organic fertilizers in crop rotation without the use of chemicals and using biological means of crop protection [6]. In the context of resource support options were studied system of differentiated and surface tillage of soil.

Taking of soil samples was carried out in a phase of flowering and wax ripeness of winter wheat from the top (0–20 cm) of arable layer of soil by envelope method with 5 of points and in 3 reps [7]. Variations of research were as follows: 1 — industrial farming system + differentiated tillage; 2 — industrial system + surface tillage; 3 — ecological system + differentiated tillage; 4 — ecological system + surface tillage; 5 — biological system + differentiated tillage; 6 — biological system + surface tillage.

The number of microorganisms of different physiological groups was determined by the seeding of soil suspensions on elective solid culture media [8, 9]. Results are expressed as the number of colony forming units to 1 g absolutely dry soil (CFU/g). Soil moisture was determined by thermostatic-weighing method [10]. The description and definition of dominant morphotypes of bacteria was conducted by JP Popova [11]. Were calculated indices of Shannon (H) and Simpson (C) for assessment of ecological biodiversity of microorganisms in the soil by Odum [12].

Results and analysis. According to the research of soil samples was conducted a comparative analysis of the numbers of main physiological groups of microbial cenosis of typical chernozem in agrocenosis of winter wheat.

Thus, the number of ammonifying bacteria was the lowest and amounted to - 4,07 million CFU/g of absolutely dry soil by industrial farming system with differentiated tillage in flowering phase of winter wheat (Fig. 1). Their number increased to 7,33 and 9,29 million by ecological and biological farming systems of differentiated tillage. With surface tillage the number of ammonifying bacteria was 6,03 by industrial, 11,74 by ecological and 13,03 million by biological system.

The correlation of microorganisms that use organic and mineral nitrogen indicates the intensity of mineralization of organic matter in the soil. The number of microorganisms-immobilizers of mineral nitrogen was higher to 2,5 times than ammonifying microorganisms by industrial farming systems with surface tillage of soil. The highest their number was by biological farming system (20,44 with differentiated and 18,93 million with surface tillage of soil).

Under such conditions there is acceleration of mineralization processes the organic matter of soil, especially humic compounds, active using mineral forms of nitrogen by microorganisms and fixing it in microbial biomass. This creates competition plants and microorganisms relative to mineral nitrogen. As a result, there were increasing the number of oligonitrifying bacteria that activate while reducing the content of bound nitrogen in the soil and have the ability to the associative nitrogen fixation. Their number was 6,72–7,12 by industrial system and increased to 16,12 and 15,33 million according to tillage of soil by biological farming system. Was observed

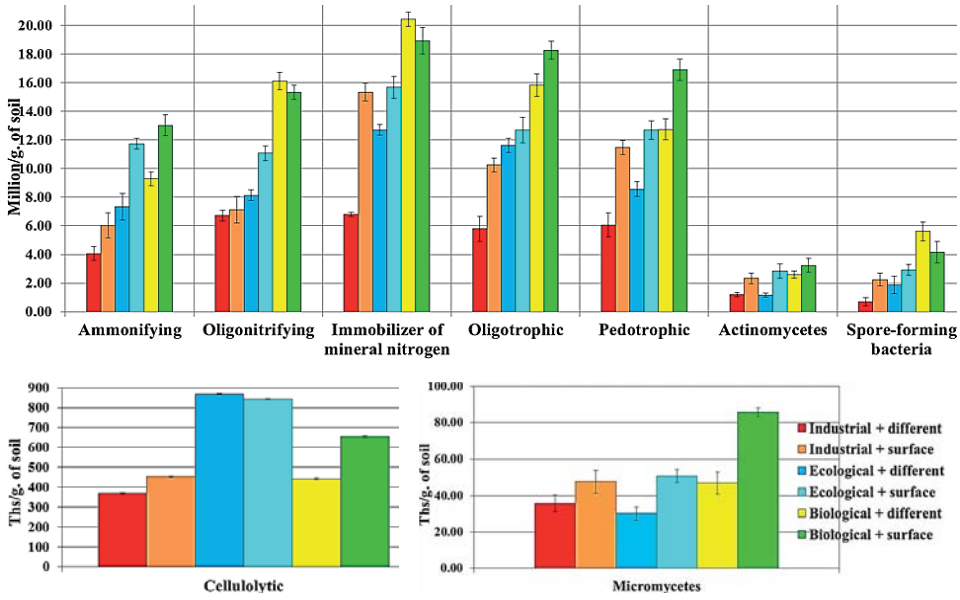

Fig. 1. The number of main physiological groups of microbial complex of typical chernozem in phase of flowering of winter wheat

increase the number of pedotrophic and oligotrophic microorganisms in the active phase of growth by ecological and biological farming systems. This indicates to decreasing content of digestible and organic matters in the soil.

The number of cellulolytic microorganisms that start a process of transformation of organic residues in soil were 368 and 454 thousand by industrial farming system in accordance to soil tillage. The combined application of organic and mineral fertilizers helps to increase their numbers by ecological farming system (868 thousand with differentiated and 842 thousand with surface soil tillage).

There was an increase of spore-forming bacteria in 2,6 times by ecological and almost 8 times by biological farming systems with differentiated tillage compared to industrial system (0,71 and 1,88 respectively with differentiated and surface tillage of soil). Increasing numbers of actinomycetes that actively participate in the process of humification of plant residues was observed by ecological and biological farming systems to 2,84–3,24 million. The number of micromycetes of typical chernozem in flowering phase of winter wheat was from 30,1 to 46,8 thousand CFU/g. depending on the farming systems with differentiated tillage of soil. Their number increased with surface tillage, especially by biological system (85,7 thousand).

There are significant changes in the structure of microbiome typical chernozem in ripeness phase of winter wheat (Fig. 2), this determines the direction of microbial processes in soil. There was observed leveling of the structure of microbial cenosis by numbers' redistribution of certain physiological groups of microorganisms. The number of ammonifying microorganisms increased to 9,08 at differentiated tillage and 8,20 mln. at surface tillage by industrial farming system, compared with the phase of flowering. Their number also somewhat increased and amounted 14,72 and 12,87 million by ecological farming system depending on soil tillage. Was ob-

served an increase the number of ammonifying microorganisms to 12,54 million at differentiated tillage and decrease to 9,67 million at surface tillage of soil by biological system.

Reducing the total number of microorganisms that use mineral forms of nitrogen are important. This helps to balance of ammonification and mineralization processes in soil. The number of assimilators of mineral nitrogen increased to 11,03 million by the industrial system with differentiated tillage and decreased to 9,33 and 10,65 by ecological and to 8,28 to 14,49 by biological system according to soil tillage.

Alignment the number of oligonitrifying bacteria in variants of the experiment was due to their increasing by industrial (8,22–10.43) and ecological (11,35–12,69) farming systems and decreasing by biological (6,52 and 9,30 million, according to tillage of soil). Should be noted, decrease of oligotrophic microorganisms occurred by differentiated tillage in ripening phase of winter wheat. This indicates the availability of easily digestible substances, improving trophic relationships in microbial complex and reduces the number of pedotrophic microorganisms in these variants of the experiment. The number of oligotrophic microorganisms was higher and amounted to 10,86 – industrial, 10,52 – ecological and 9,45 million – biological farming system by surface tillage of soil. The number of pedotrophic microorganisms was higher by surface tillage than by differentiated. This is explained by a significant increase of cellulolytic microorganisms at surface tillage, especially by the ecological and biological farming systems (181 and 190 thousand CFU/g of soil, respectively). That accompanied of active nitrogen assimilation by microorganisms [13]. But, the number of cellulolytic microorganisms decreased greatly on to all variants of the experiment compared with the flowering phase of winter wheat.

Was observed increase the number of spore-forming microorganisms on all variants of the experiment, their number was

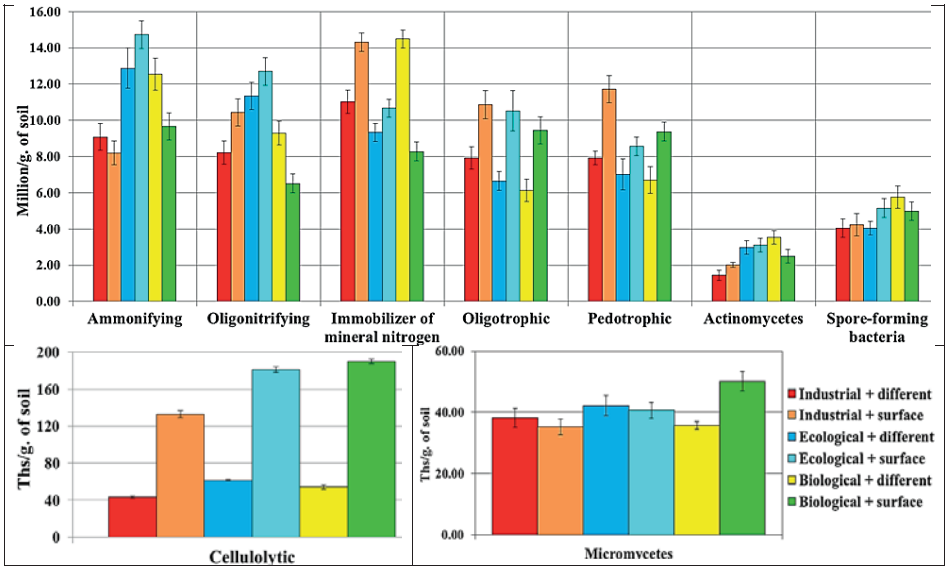

Fig. 2. The number of main physiological groups of microbial complex of typical chernozem in phase of ripeness of winter wheat

4,04 - 5,77 million at the end of vegetation of winter wheat. This shows the active part these microorganisms in processes of transformation of organic residues. The number of micromycetes of typical chernozem decreased slightly, compared with the flowering phase of winter wheat and amounted 35,24 - 50,16 thousand CFU/g of soil. But their increase was observed by industrial and ecological farming systems with differentiated tillage. The number of fungal microflora was the highest (50,16 thousand) by biological farming system with surface soil tillage.

By considerable difference in numbers of main physiological groups of microorganisms the qualitative composition and the structure of distribution dominant forms of soil microflora are very important. Based on the description of morphological and cultural types of bacterial microflora established that the largest number the identified morphotypes were by ecological farming system and amounted 17 and 15 pieces with differentiated and surface tillage of soil according to the phase of flowering winter wheat (Fig. 3). Among them, species 4 and 5 have respectively the degree of saturation > 10%.

Application of industrial farming system affect negatively to the biodiversity of bacterial microflora and leads to a decrease in the number of dominant morphotypes

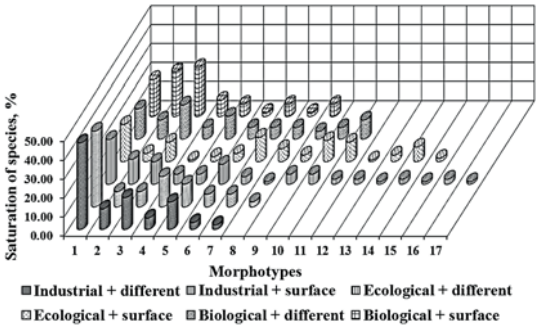

Fig. 3. The qualitative composition of bacterial microflora of typical chernozem in the flowering phase of winter wheat

(7 pcs. with differentiated and 8 pcs. with surface tillage of soil), among them there are a clearly expressed dominants with degree of saturation of species over 40%.

There is reducing the overall diversity of the bacterial microflora at the end of vegetation of winter wheat (phase ripeness). This is evidenced by reduction in the number of identified morphotypes on all variants of research (Fig. 4). There is a redistribution dominant forms of microbial complex depending on farming systems and increasing diversity at the surface soil tillage in all farming systems. The greatest number of morphotypes with uniform distribution of species middle-saturation (10 - 20%) was described by biological farming system with surface soil tillage (11 pieces). This indicates to the formation of a favorable balance between environmental conditions and the development of microbial complex. The number of identified morphotypes increased to 10 pieces by the industrial system with surface tillage and decreased to 6 with differentiated tillage, compared with the flowering phase of winter wheat.

Comparative evaluation of ecological indices of microbiota of typical chernozem showed inversely proportional correlation between the biodiversity of the Shannon and dominance of Simpson in phases of flowering and wax ripeness of winter wheat (table).

According to research established that the increase of biodiversity and population of bacterial microflora occurs as follows in the flowering phase of winter wheat: industrial system + differentiated tillage → Industrial system + surface tillage → biological system + surface tillage → biological system + differentiated tillage → ecological system + surface tillage → ecological system + differentiated tillage of soil.

There is a redistribution of biodiversity of bacterial microflora in the phase of wax

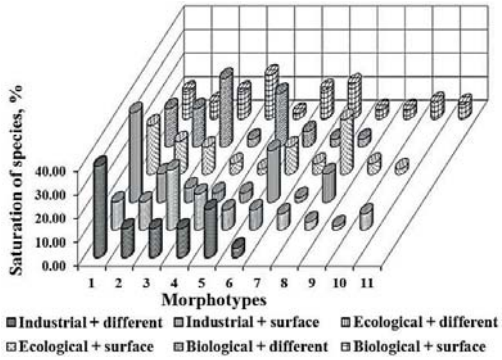

Fig. 4. The qualitative composition of bacterial microflora of typical chernozem in the wax ripeness phase of winter wheat

ripeness, which is confirmed of qualitative analysis of structure microbial complex. It was established that the increase in biodiversity occurs at the surface tillage of soil to all farming systems, compared with differentiated tillage. This indicates an increase in the number of easily digestible nutrient substances in soil under these conditions that stimulate the growth and activity of microorganisms.

Highest index of Shannon biodiversity was observed by biological farming system with surface tillage (0,98).

Simpson dominance indexes indicate to the formation of a homogeneous microbial complex of typical chernozem with a high degree of dominance of certain bacterial morphotypes by industrial farming system with differentiated tillage. Their functional properties relative to plants, processes of soil formation and the texture in profile of soil need studying further.

Conclusions. So, established that the application of ecological and biological farming systems allows increasing the number of ammonifying microorganisms to 2 times, oligonitrifying – 1,5–2,4, microorganisms that use mineral forms of nitrogen – 1,9–3, spore-forming bacteria – 2,6–7,9, cellulolytic microorganisms – 1,4–2,4 times in the flowering phase and reduction the number of microorganisms that use mineral forms of nitrogen to the 1,3–1,7 and oligotrophic to 1,5 times in wax ripeness phase of winter wheat. This indicates to the optimization of microbiological processes and trophic regime of typical chernozem under these conditions.

The systematic application of organic fertilizers for playback the resource potential and scientifically justified of tillage systems are promoted for the formation of homeostasis of microbial biome of soil, preservation of biodiversity, structure of microcenosis and general bioactivity of typical chernozem. The systematic applying of large quantities of chemical fertilizers leads to disruption of trophic relationships in the microbial complex, of structure of number the main physiological groups of microorganisms, of reducing biodiversity and the formation of a homogeneous microbioms of typical chernozem with a high degree of dominance of certain species of microorganisms.

Table. Ecological indices of biodiversity and dominance of bacterial complex of typical chernozem in agrocenoses of winter wheat

Farming system	Tillage of soil	Phase of flowering		Phase of wax ripeness	
		Indexes			
		Shannon	Simpson	Shannon	Simpson
Industrial	Differentiated	0,68	0,28	0,69	0,24
	Surface	0,77	0,22	0,92	0,14
Ecological	Differentiated	1,07	0,11	0,74	0,23
	Surface	1,05	0,11	0,89	0,15
Biological	Differentiated	0,99	0,11	0,78	0,19
	Surface	0,83	0,18	0,97	0,12

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АННОТАЦИЯ

Колодяжный А.Ю., Патыка Н.В. *Сравнительная характеристика микробиома чернозема типичного в агроценозе озимой пшеницы при разных системах земледелия// Биоресурси и природокористування. – 2014. – **6**, № 3–4. – С. 81–87.*

Проведен сравнительный анализ микробиома чернозема типичного в агроценозе озимой пшеницы. Представлены результаты численности основных физиологических групп, качественного состава и биоразнообразия бактериальной и грибной микрофлоры при различных системах земледелия и обработки почвы.

АНОТАЦІЯ

Колодяжний А.Ю., Патика М.В. *Порівняльна характеристика мікробіому чорнозему типового в агроценозі пшениці озимої за різних систем землеробства// Біоресурси і природокористування. – 2014. – **6**, № 3–4. – Р. 81–87.*

Проведено порівняльний аналіз мікробіому чорнозему типового в агроценозі пшениці озимої. Представлено результати чисельності основних фізіологічних груп, якісного складу та біорізноманіття бактеріальної й грибної мікрофлори за різних систем землеробства та обробітку ґрунту.