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THE MICROBIAL TRANSFORMATION OF CARBON COMPOUNDS IN SUGAR BEET RHIZOPHERE IN VARIOUS AGROCENOSIS

It was conducted the comparative analysis of numerical and functional diversity of microbial complex of typical chernozem, which is involved in the transformation of soil carbon compounds. It is studied the accumulation of microbial biomass and microbiological activity from emission of CO_2 in the rhizosphere of sugar beet in different farming systems and soil tillage. It is found that the application of the surface soil tillage is optimizes the condition of soil microbial coenosis, which is reflected in the number and proportion of bacterial and fungal organisms, which includes functional groups of microorganisms.

Keywords: *microbial cenosis, total number of functional diversity, microbial biomass, CO_2 emissions, typical chernozem, sugar beet, agrarian systems, soil tillage*

Introduction. Soil microorganisms are an important component of any agroecosystem. They define the various key functions of circulation of substances in the soil, due to the complicated and intensive enzymic activity. It is contributes to the construction of trophic chains with specific functions, that allows to provide the constant functioning and homeostasis of the ecosystem as a whole [1]. Thus, the functional role of microbial cenosis provides the organization of the course of biological cycles of nutrients and, as a result, it defines «soil health» [2]. However, there are qualitative and quantitative changes in structure of soil microbiota, which are not always controlled and have a positive effect, under conditions of increased pollution, due to intensive use of agricultural technologies [3]. Therefore the study of functioning of microbial cenosisis is necessary for understanding of the processes which occur in soil, in order to preserve soil fertility and prevent the decrease of crop productivity.

The aim of researches was to study a numerical and functional diversity of microbial complexes of typical chernozem, which are involved in transformation of carbon-containing substances, microbial biomass and intensity of CO_2 emission in the rhizosphere of sugar beet at the various agrarian systems.

Materials and methods. Sampling and microbiological analysis of soil samples of typical chernozem were conducted on the stationary field experiment of Agriculture and Herbology Department of NUBiP of Ukraine «Agricultural Experiment Station» (v. Pchenychnoe, Vasilkovsky area, Kyiv region) in the sugar beet rhizosphere *(Beta vulgaris)* (phase of the leaves closing in space between rows) in grain-beet crop rotation during 2012-2013 years.

The scheme of experiment includes three agrarian systems (AS) and two soil tillage (ST):

1) industrial AS (it is includes an applying of 12 tons of manure, 300 kg of NPK fertilizers per one hectare of crop rotation, intensive using of chemical measures of plant protection);

2) ecological AS (it is includes the applying of 24 tons of organic matter (12 tons of manure, 6 tons of not commodity part of crop, 6 tons of stubble remains), 150 kg of NPK fertilizers per hectare of crop rotation, the using of chemical and biological products of plant protection according to the criterion of ecological - economical threshold of harmful microorganisms);

3) biological AS (it is includes the applying of 24 tons of organic matter per hectare of crop rotation, using of biological means of plant protection);

a) surface ST (tillage is conducted by disk implements to a depth of 8-10 cm under all cultures of crop rotation);

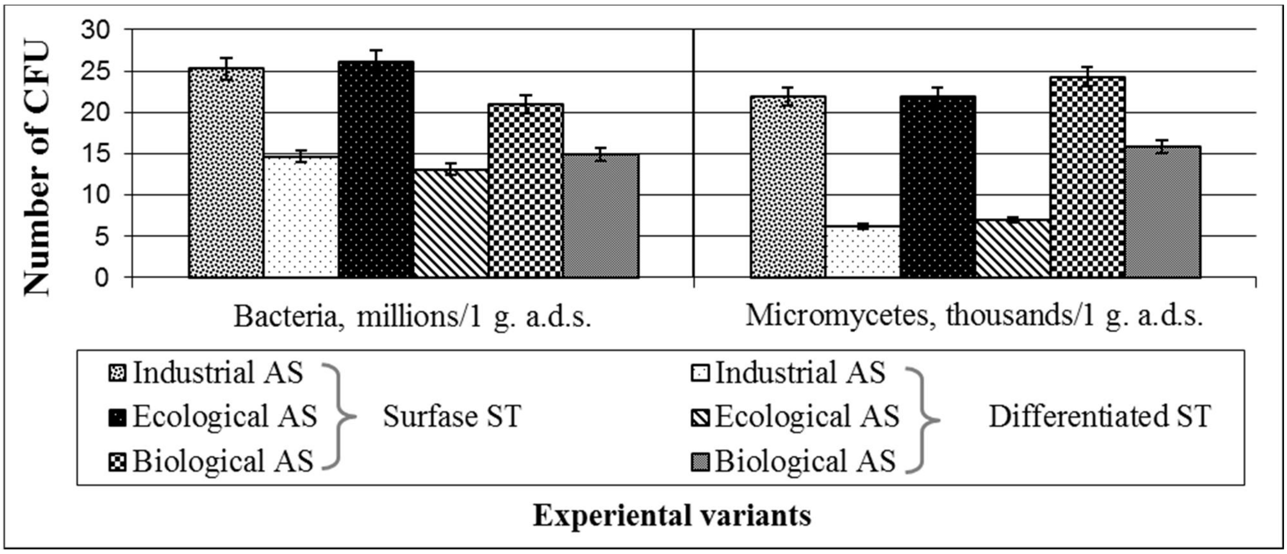
b) differentiated SP (it is includes the conducting of the plowing by 6 times on different depth, 2 times the surface tillage under winter wheat after pea and silage corn and 1 time – the flat-cat tillage under barley per crop rotation) [4].

The content of labile carbon was determined by the method of E. Schultz and M. Cershesn [5], the number of bacteria and micromycetes - by the inoculation of soil suspension on the solid nutrient medium (the method of Zvyagintsev and Chapek) [6], microbial biomass and the intensity of CO_2 emission - by the method of substrate-induced respiration [7], the number of microorganisms which utilize of carbon sources in their metabolism - by the method of multisubstrate testing [2]. Statistical data processing was performed in the program Exel.

Results and discussion. The labile carbon is one of the indicators of soil organic matter in terrestrial ecosystems. It influences on the processes of mineralization and intensity of heterotrophic respiration and can limit the processes of catabolism of organic matter. It has been revealed that a typical chernozem has the optimum indicators of labile carbon (302,1-354,8 mg/kg) [8]. The content of labile carbon on the typical chernozem was higher by 11,3 % at application of surface tillage (ST) than at differentiated ST. The influence of agrarian systems (AS) on the content of this element in the soil was insignificant.

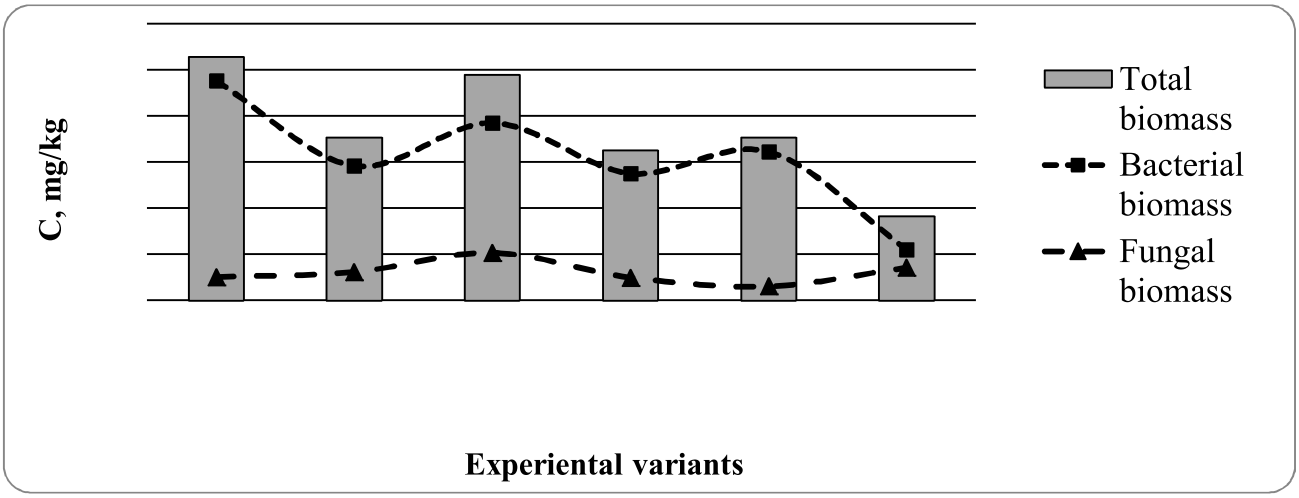
The ratio of number of bacterial and fungal microflora is an important factor that determines soil processes, including the transformation of organic and mineral substances in the soil and is also an indicator of its phytosanitary status. The study of microbial complex of typical chernozem has shown that the number of bacteria was varied within 13,1-26,1 million, micromycetes - 6,4-24,3 thousand CFU/g a.d.s. (pic.1). Thus, the application of surface ST is promoted to increase the number of bacteria and fungi in 1,7 and 2,4 times in comparison with the differentiated ST. The application of industrial and ecological AS is promoted to increase the number of bacteria on 11,1 % and 9,2 %, and to decrease the number of micromycetes on 42,5% and 39,0 % in comparison with the biological AS.

There is a close correlation between the indicators of microorganisms quantity and stocks of the labile carbon in soil (r = 0,80 (bacteria) and 0,92 (micromycetes)). That is, the number of microorganisms is being increased with the increasing of content of organic carbon in the accessible form to microorganisms.



Pic. 1.The number of bacterial and fungal microflora in the rhizosphere of sugar beet at the various agrarian systems and soil tillages

Microbial biomass is the important living and labile component of soil. The ratio of bacteria and micromycetes in soil microbial biomass gives a notion about accumulation (sequestration) of carbon in soils and can be characterized metabolic properties of soil microorganisms and can be the factor that regulates the emission of CO_2 and N_2O in soils [9]. The highest content of the total active microbial biomass in rhizosphere of sugar beet was identified at the surface ST with the industrial and ecological AS (264,3 and 245,1 C mg/kg) (pic. 2). The close correlation between indices of the total microbial biomass and the number of bacterial microflora (r = 0,82) has been revealed. The application of surface ST promotes to increase of the total microbial biomass on 58,9 % due to increases of bacterial biomass, that corresponds to the general tendencies of course of metabolic processes in the soil. It is established, that the number of active microbial biomass is higher at the industrial and the ecological AS on 64,3 % and 51,9 % compared to the biological ST. That is connected with the activity of microorganisms which is directed at insertion of mineral compounds in biological cycling of nutrients.



Pic. 2. The influence of agrarian systems and soil tillage on the content of active microbial biomass in the rhizosphere of sugar beet

The integral indicator of stability of soil microbial complex can be the microbial metabolic coefficient, which is varied within 0,38-0,7 (table. 1) [10]. There is an inverse correlation between the indicator of microbial metabolic coefficient, the total microbial biomass (r = - 0,94) and the number of bacteria (r = - 0,72), i.e. experiments with high active of the microbial biomass and large number of the bacterial microflora have a slight metabolic rate, and vice versa.

Emission of CO_2 from a soil surface is one of the important indicators of carbon exchange of plant communities due to microbial activity [11]. The main source of natural income of carbon in the atmosphere is the total soil respiration. It is determined by the activity of interactions between microorganisms and breath of the root system of plants [12]. The intensity of microbial respiration at the expense of CO_2 emissions in the rhizosphere of sugar beet is 62,1 - 111,2 mg C-CO_2/kg/day (table. 1). The microbiological activity and the CO_2 emission at the industrial and the ecological AS were on 22,7 % and 15,5 % more than at the biological AS.

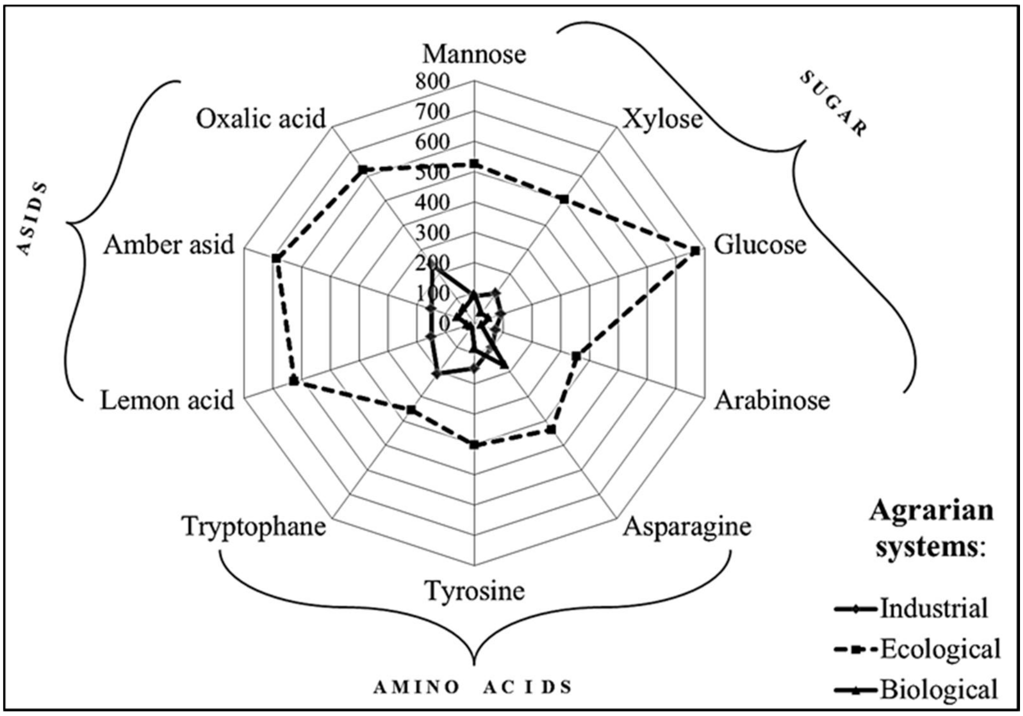
Table 1

The influence of various agrarian systems and soil tillage on the intensity of CO_2 emission and microbial metabolic coefficient in the rhizosphere of sugar beet

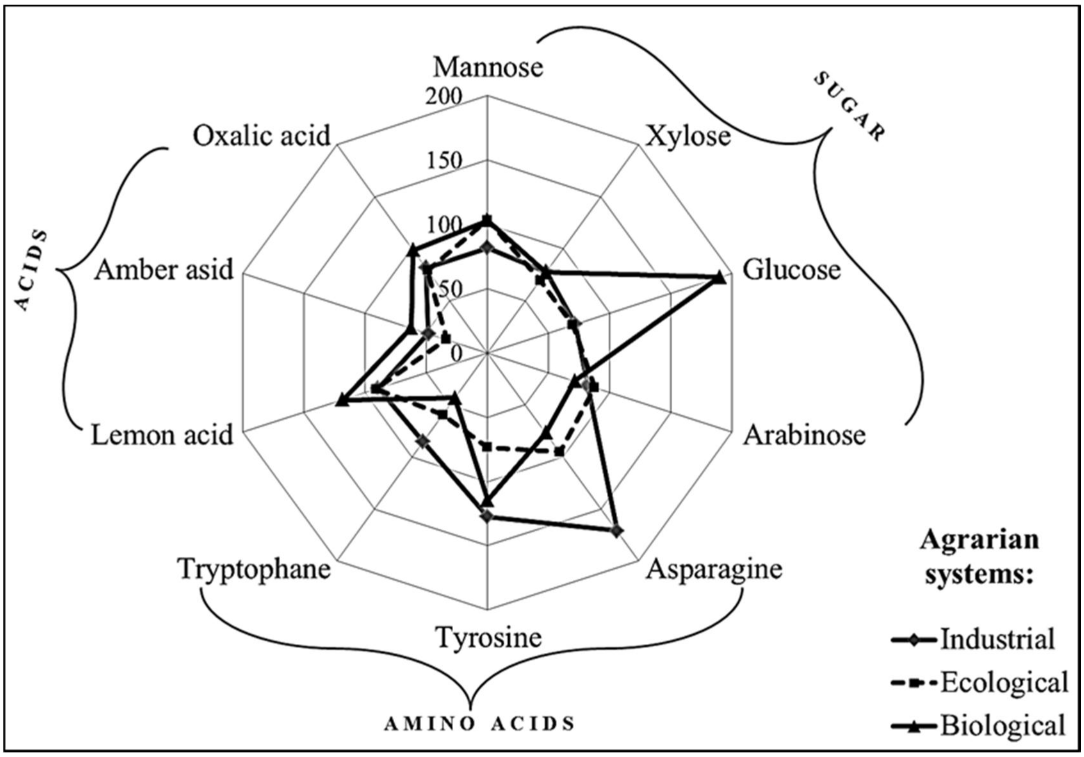
Index	Experimental variants					
	Industrial AS		Ecological AS		Biological AS	
	Sur. ST	Diff. ST	Sur. ST	Diff. ST	Sur. ST	Diff. ST
CO_2 emission, mg/kg*day	110,6	73,6	111,2	62,1	79,6	70,5
Metabolic coefficient	0,38	0,53	0,48	0,62	0,62	0,70

It has been established that there is a close correlation between the indicator of CO_2 emission and the number of bacterial (r = 0,96), fungal microflora (r = 0,72), the activity of microbial biomass (r = 0,85), the metabolic coefficient (r = - 0,83), the functional biodiversity (r = 0,7) (see below) and the content of labile carbon in the soil (r = 0,67). The obtained results has been shown, that the number of microorganisms, their biomass and soil respiration are increasing with the increase of organic matter stocks in the soil in accessible form for microorganisms. Thus, the favorable conditions for the microbiota functioning are being created, the trophic mode and the ecological condition of soil, the conditions for growth and crop development are being improved.

The functional biodiversity is the main feature of soil microbial complex, which characterizes the activity of microbial systems on biosphere level and determines a way of transformation of soil organic matter in the global cycles of carbon and nitrogen. Researches of scientists-microbiologists testify that in different soils with the application of various agrarian systems are complexes of soil microorganisms which differently use the carbon sources in their metabolism [13]. It has been established by multisubstrate testing, that the total number of functional groups of microorganisms in the rhizosphere of sugar beet was higher on substrates that contain sugar glucose (1,24 million) and oxalic acid (1,18 million CFU/g a.d.s.) (pic. 3, 4). The greatest number of microorganisms-transformers of carbon of all functional groups in the rhizosphere was found in experimental variant of ecological AS + surface ST (5,29 million), that reveals the activation of the transformation of organic carbon. The least number was found in variant of biological AS + surface ST (0,63 million CFU/g a.d.s.). The increase of the total number of microorganisms in chernozem typical was found at the ecological AS (6,05 million CFU/g a.d.s). This indicates that the use of organic fertilizers contributes to maintain ecological and trophic relationships and to raise the functional activity of soil microorganisms. It has been established that the number of microorganisms, which use the carbon sources in the metabolism, was higher in 2,8 times at the surface ST than at the differentiated ST. It is connected with the accumulation of organic compounds and nutrients in the upper layer of soil.



Pic. 3. The influence of agrarian systems and surface soil tillage on the number of microorganisms of various functional groups in the rhizosphere of sugar beet



Pic. 4. The influence of agrarian systems and differentiated soil tillage on the number of microorganisms of various functional groups in the rhizosphere of sugar beet

Conclusions. Thus, the application of different agrarian systems and soil tillage promotes differentiation of number, redistribution of functional activity of the soil microbial component, structure of the microbial biomass, change of the intensity of CO_2 emission, the number of microorganisms and direction of the microbial metabolic processes of transformation of carbon compounds. It is established, that the application surface ST of chernozem typical helps to increase the numbers of bacteria in 1,7 times, the numbers of micromycetes in 2,3 times, the functional groups of microorganisms in 2,8 times, the total microbial biomass in 1,6 times and the intensity of microbial emission of CO_2 in 1,5 times.

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Анотація

Москалевська Ю.П., Патика М.В.

Мікробна трансформація вуглецьвмісних речовин ризосфери цукрового буряка в різних агроценозах

Проведено порівняльний аналіз кількісного і функціонального різноманіття мікробного комплексу чорнозему типового, який бере участь у трансформації вуглецевих сполук ґрунту. Вивчено накопичення в ризосфері буряка цукрового мікробної біомаси та мікробіологічну активність по інтенсивності емісії CO_2 за різних систем землеробства та способів обробітку ґрунту. Встановлено, що при застосуванні поверхневому обробітку ґрунту оптимізується стан мікробного ценозу ґрунту, що виражається у збільшенні чисельності і співвідношенню бактеріальної і грибної мікрофлори, в тому числі і функціональних груп мікроорганізмів.

Ключові слова: *мікробний ценоз, чисельність і функціональне різноманіття, мікробна біомаса, емісія CO_2, чорнозем типовий, буряк цукровий, системи землеробства, способи обробітку ґрунту*

Аннотация

Москалевская Ю.П., Патыка Н.В.

Микробная трансформация углеродсодержащих веществ ризосферы сахарной свеклы в различных агроценозах

Проведен сравнительный анализ численного и функционального разнообразия микробного комплекса чернозема типичного, участвующего в трансформации углеродных соединений почвы. Изучено накопление в ризосфере сахарной свеклы микробной биомассы и микробиологическую активность по интенсивности эмиссии CO_2 при различных системах земледелия и способах обработки почвы. Установлено, что при применении поверхностной обработки почвы оптимизируется состояние микробногоценоза почвы, которое выражается в численности и соотношении бактериальной и грибной микрофлоры, в том числе и функциональных групп микроорганизмов.

Ключевые слова: *микробный ценоз, численность и функциональное разнообразие, микробная биомасса, эмиссия CO_2, чернозем типичный, сахарная свекла, системы земледелия, способы обработки*