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RESEARCH ARTICLE

The activity of the microbial groups of maize root-zone in different crop rotations

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The influence of short crop rotations on the formation of the number of microorganisms of the main taxonomic groups of the maize root zone is shown. The biological activity of soil under maize, depending on its predecessor, was studied. Analysis of the development of microbial coenosis showed that at saturation of crop rotations with different plants, is taking place balancing of the microbial coenosis of the soil, the activation of enzymatic processes and the mitigation of the effects of soil exhausting, which occurs at constant cultivation of corn. The reliability and stability of highly productive agrophytocenoses can be achieved through choosing of tolerant crops in rotation.

Keywords: *Zea mayz* L.; Microorganisms; Cellulosolytic activity; *Azotobacter*

Introduction

Changes in land relations actualize the issues of optimizing of the structure of sowing areas and creating on their basis of scientifically justified crop rotations, taking into account the soil-climatic conditions and specialization of the farms of Ukraine (Grodzinsky et al., 1990). This problem cannot be solved without observation of soil microbial coenosis (Patyka et al., 2004).
Changing the quantitative and qualitative composition of root secretions, which occurs during crop rotation, causes a regrouping of actively metabolizing forms of microorganisms, and also leads to changes in the intensity of biochemical processes in the soil (Andreiuk et al., 2001; Karpenko et al., 2019; Vorokhova et al., 1997; Van Der Heijden et al., 2008). The study of the structure, number and dynamics of ecological-trophic groups of microorganisms, functional activity of microbial soil complexes makes it possible to make conclusions on changes in trophic conditions of soil coenosis.

Materials and Methods

The study was devoted to the study of the influence of predecessor in crop rotation on the microbiological activity of the soil and the yield of corn on the grain. The experimental part was carried out at the Agronomy Research Station of the National University of Life and Environmental Sciences. The soils are black soil typical low humus. The following crop rotation schemes were applied: control - corn is unchanged; 1 - peas - winter wheat - corn; 2 - peas - winter wheat - buckwheat - corn; 3 - buckwheat - spring wheat - corn. The tillage was carried out by plowing to a depth of 25-30 cm. The studies were performed in three repetitions.
Soil samples consisting of 4-5 individual samples were collected in the corn root zone at a depth of 0-20 cm twice during the growing season (in the germination phase and before harvesting) (Zvyagintsev, 1991). The extraction of microorganisms from freshly selected samples was carried out by the method of seeding soil suspensions in appropriate dilutions on agar nutrient substance (Mikhalsky et al., 2002). The total number of colonies counted in the soil suspension crops was determined by the number of CFUs (colony forming units). pH of soil suspensions is 6 and 6.5. The number of micromycetes (Chapek medium); spore-forming bacteria (meat-peptone agar + wort-agar); actinobacteria (starch-ammonia agar); cellulose-destructive microorganisms (Hutchinson's medium), are taking into account here. Cellulolytic activity was determined by the Pushkin method (Mikhalsky et al., 2002; Litvinov et al., 2019; Butenko et al., 2019). Biological activity of the root zone was determined by direct biotestingmaking use of a vegetable test with application of watercress and the microorganism *Azotobacter chroococcum* (% foliation of soil in Ashby substance) (Zvyagintsev, 1991; Rozhko and Makarenko, 2010).
Statistical processing of data was performed through standard programs Statistica 6.0, Microsoft Ex1_97. In the tables and figures mean values and standard errors, are shown.

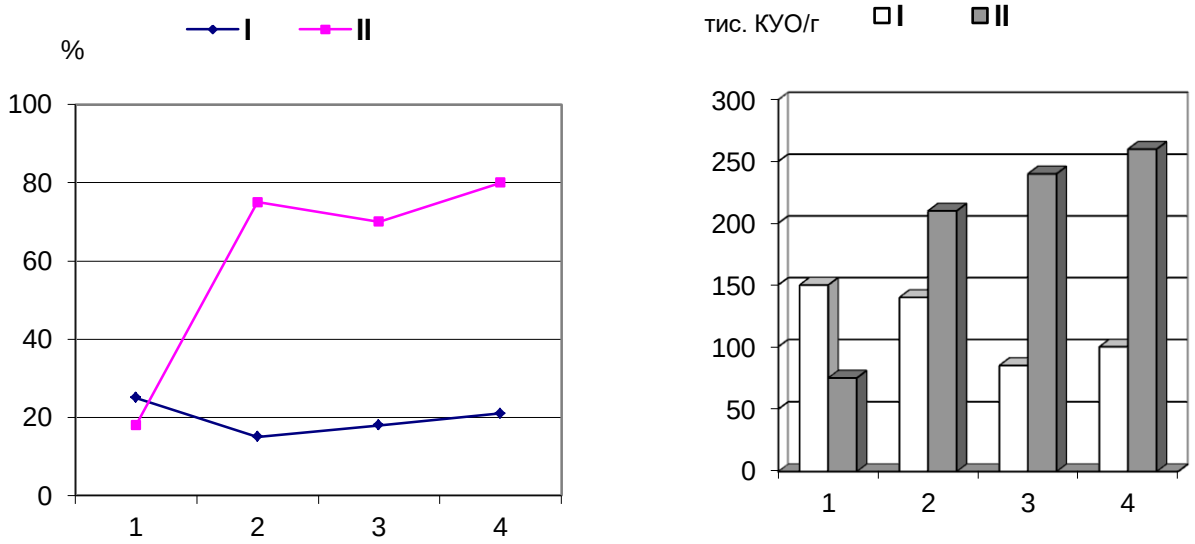
Results and Discussion

In our studies, the biogenicity of the root zone was determined by the activity of the main groups of microorganisms, which are the most labile and active part of the soil microflora (Patyka et al., 2004; Svirskene, 2003).
Analysis of the microbiocenosis of the maize root zone under different crop rotations showed that the use of spring wheat and buckwheat aspredecessor contributed to the development of individual groups of microorganisms (Table 1). Vegetable residues of spring wheat mineralized more intensively, as evidenced by the number of non-spore bacteria testify to it. In addition to bacteria that affect soil fertility, microscopic fungi, spore-forming bacteria and actinobacteria are important consorts. All of them are actively involved in the processes associated with the conversion of organic matter, especially heavy-hydrolysis ones. Under the influence of predecessoran increase number of micromycetes in the soil compared to the control was noticed, especially in crop rotation with alternation of crops: peas - winter wheat - buckwheat - corn. Vegetable residues of winter wheat after pea stimulated the development of spore-forming bacteria and actinobacteria.

Table 1. The number of microorganisms in soil samples after corn at different crop rotations.

Options experience	**Micromycetes, thousand CFU/g ofsoil**		**Undisputed bacteria,million CFU/g ofsoil**		**Spore-forming bacteria,thousand CFU/g ofsoil**		**Actinobacteria, thousand CFU/g ofsoil**	
	I	II	I	II	I	II	I	II
Maize constant (control)	52.1 ± 2.3	40.4 ± 1.9	7.7 ± 0.9	1.9 ± 0.5	236.4 ± 5.0	144.9 ± 3.8	760.2 ± 10.7	168.4 ± 4.2
Peas – winter wheat - corn	34.1 ± 1.6	46.9 ± 1.7	1.7 ± 0.4	6.0 ± 0.8	311.5 ± 5.5	310.8 ± 5.6	310.2 ± 5.2	914.3 ± 13.2
Peas – winter wheat - buckwheat corn	-39.5 ± 1.9	61.0 ± 3.0	4.4 ± 0.4	11.9 ± 3.6	176.8 ± 4.3	279.1 ± 5.3	463.0 ± 6.2	701.1 ± 11.3
Buckwheat – spring wheat -corn	30.9 ± 1.7	57.9 ± 2.8	3.1 ± 0.3	27.8 ± 1.8	234.8 ± 5.0	199.2 ± 4.5	370.8 ± 5.8	602.4 ± 10.4

It is known that cellulolytic activity is associated with the activity of cellulosic microorganisms, on which the processes of humus formation and formation of structural aggregates depend. The more intensive is the decomposition of cellulose, the faster is the circulation of elements and the plants are provided with nutrients more fuller (Karpenko et al., 2019; Kolisnyk et al., 2020). At the beginning of the vegetation of plants, in the control with constant cultivation of corn, the number of cellulosolytic microorganisms and their activity exceeded the parameters of the experimental variants. At the end of the vegetation period, in the crop rotation variants, cellulosolytic activity was quite high and amounted to 70-80%, while at cultivation no changing plant it was on the level of 15%. Cellulolytic activity coincided with the quantitative distribution of cellulose-destructive microorganisms, the number of which in the test samples exceeded the control by 3.4 times (Figure 1). Group composition of cellulose-destroying microorganisms is an important indicator of soil toxicity. In our studies, cellulose-destroying microorganisms were represented by all taxonomic groups dominated with dominating of micromycetes. It is known that the predominance of this group of microorganisms indicates on unfavorable soil conditions. In the variants: peas - winter wheat - corn and peas - winter wheat - buckwheat – corn, cellulose decomposition occurred mainly due to the bright orange pigmented bacteria with high cellulosolytic activity. In our opinion, the presence of pigmented microorganisms may be caused using legumes (peas) in the rotation.

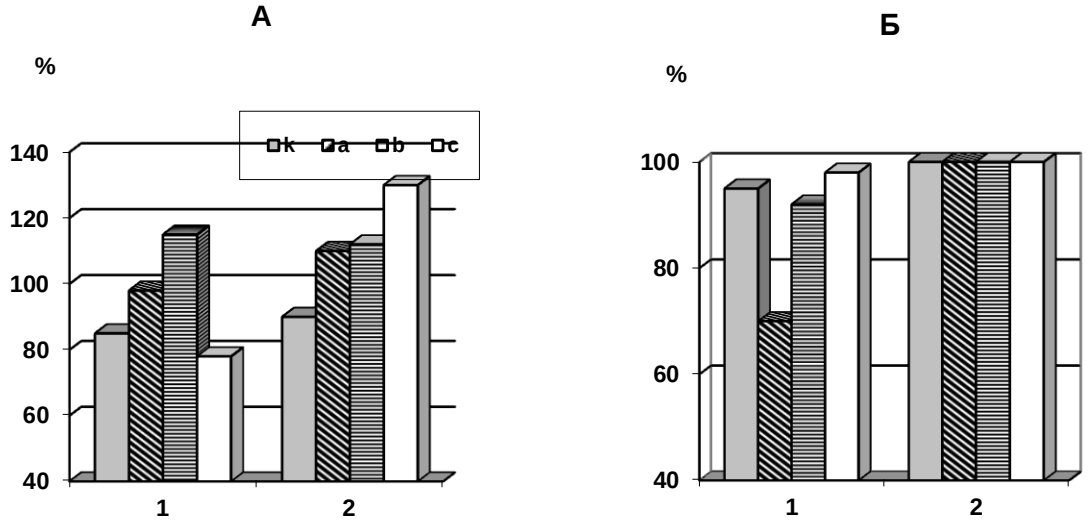


1 – Maize constant; 2 – Peas – Winter Wheat – Corn; 3 – Peas – Winter Wheat – Buckwheat – Corn; 4 – Buckwheat – Spring Wheat – Corn. I – Maize Ladder Phase; II – Before Harvesting.

Figure 1. The number of cellulose-destroying microorganisms (histogram, thousand CFU in 1 g of dry soil) and the intensity of cellulose decomposition (graph, weight of reduction,% of baseline) in the corn root zone at different crop rotations.

The effect of allelopathically active substances on some cultures is determined by their chemical structure and concentration. To observe the reaction of plants to the soil content of physiologically active substances makes it possible to apply the simplest for perform and at the same time quite sensitive method of determining biological activity - the method of direct biotesting with the help of vegetable test - the roots of cres-salad (Andreiuk et al., 2001; Kolisnyk et al., 2019). In all prototypes, no inhibition of the growth of the test culture was detected, and by the end of the maize growing season, the growth of the watercress roots was 130.9% in the variant where the maize previously cultivated plants were buckwheat and spring wheat (Figure 2A).

All variants of the experiment were favorable for the development of free-living nitrogen-fixing microorganism *Azotobacter chroococcum*, which is a sensitive indicator of changes in soil conditions, the presence of phosphorus, potassium, calcium in the soil and its phytotoxicity, and is an integral component of the species Andreiuk et al., 2001; Svirskene, 2003). This was especially noticed at the end of the growing season of maize (100% overgrowth of lumpies of soil) (Figure 2B).



А - Growth of cres-salad roots, % to control, Б - Development of *azotobacter*, % overgrowth of lumpies of soil.
1 - The ladder phase; 2 -Before harvesting. к - Control (cornis constant); a – Peas-Winter Wheat -Corn; b - Peas –Winter Wheat - Buckwheat -Corn; c - Buckwheat – Spring Wheat - Corn.

Figure 2. Biological activity of corn root zone at different crop rotations.

At the constant cultivation of corn, there was a change in the group composition of the microbiota of the root zone of plants, which significantly affected the properties of the soil. In particular, the development of beneficial microorganisms producing vitamins, enzymes and organic acids was slowed down, as well as a monotonous microbiota was formed, which led to the accumulation of toxic metabolites in the soil. All this affected the yield (Table 2).

Table 2. Effect of different predecessor cultivated crop on corn yield on grain.

Variants of the experiment	**Yield, t/ha**	**% to control**
Corn is permanent (control)	5.7	-
Peas - Winter Wheat - Corn	8.5	49.1
Peas - Winter Wheat - Buckwheat - Corn	8.2	43.9
Buckwheat - Spring Wheat - Corn	7.5	39.6
LSD 0.5	0.12	

The largest corn crop for grain was an option Peas - winter wheat - corn (8.5 t/ha), this is more than control on 49.1%.

Conclusion

Thus, the microbiological activity of the maize root zone was positively influenced by all the predecessor cultivated crop. Of the variants studied in the experiments, the crop rotation was the most optimal: peas - winter wheat - buckwheat - corn. Analysis of the development of microbial coenosis showed that at saturation of crop rotations with different plants, is taking place balancing of the microbial coenosis of the soil, the activation of enzymatic processes and the mitigation of the effects of soil exhausting, which occurs at constant cultivation of corn. The reliability and stability of highly productive agrophytocenoses can be achieved through choosing of tolerant crops in rotation.

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