

Influence of agricultural systems and basic tillage on soil microorganisms number under winter wheat crops of the Right-bank Forest-Steppe of Ukraine

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The results of studying the influence of different systems of agriculture and measures of basic tillage on the number of microorganisms and its phytotoxicity in the field of winter wheat are presented. It is proved that different systems of agriculture and measures of basic tillage do not equally affect the microbiological activity of the rhizosphere of winter wheat in the number and species composition of microorganisms. As a result, the variants created different conditions for the course of biochemical processes in the soil and the formation of crop yields. Moldboard-boardless tillage and the ecological system of agriculture proved to be more promising.

Keywords: microbiological activity; farming systems; soil tillage; winter wheat

Introduction

Soil is a very complex substance in which, depending on the technology of growing crops, selection of these crops in crop rotation and many other factors, specific agrophysical, agrochemical and biological conditions are formed (Didur et al., 2019; Mishchenko et al., 2019; Karbivska et al., 2020). In turn, these conditions affect the species, numerical composition and living conditions of different ecological and trophic groups of microorganisms (Aristovskaya, 1980; Karpenko, 2015; Vekirchik, 2001). The influence of various industrial chemical elements, which are used during the growing season of crops as fertilizers and means of protection against pests, is especially actively (Kolisnyk et al., 2019; Tsyhanskyi et al., 2019). The results of research by many scientists shown that the species and quantitative composition of the microflora changes significantly with increasing or decreasing the depth of tillage, replacement of moldboard plowing on boardless tillage, application of different types of fertilizers, their ratio and quality composition (Zvyagintsev, 1987; Karpenko et al., 2019; Radchenko et al., 2018; Mishchenko et al., 2017). Based on the above, the development of efficient and environmentally balanced cultivation technologies and the entire agricultural system in specific conditions in general is closely related to the study of rational integration of one of its most important parts – tillage of soil and fertilization of crops (Iutinskaya, 2006; Pyrog, 2004). However, such a comprehensive approach in terms of its impact on soil microflora has not been sufficiently studied. This issue is especially relevant today, as there is a problem of obtaining environmentally friendly products (Litvinov et al., 2019; Karbivska et al., 2019a; Butenko et al., 2019).

Thus, the aim of our research was to establish the impact of agricultural systems on the species composition of microorganisms and its change during the growing season of winter wheat against the background of various measures of basic tillage and farming systems in Separated subdivision of NULES of Ukraine "Agronomic Research Station". The research was performed in a ten-field crop rotation, which is part of a long-term stationary experiment of the Department of Agriculture and Herbiology of the National University of Life and Environmental Sciences of Ukraine.

Materials and Methods

The research was carried out in the field of winter wheat after peas in the typical for the Forest-Steppe Zone grain-beet crop rotation with the following crop rotation: clover - winter wheat, oil radish (for green manure) - sugar beet - corn for silage - winter wheat, winter wheat for green manure) - corn for grain - peas - winter wheat, green radish oil - sugar beets - barley with sowing of clover. The soil of the experimental plot is represented by black-soil typical low-humus medium loam coarse-dust with a humus content in the arable layer of 4.34-4.68% (according to Tyurin), a total nitrogen content of 0.27 - 0.31% (according to Keldal), mobile phosphorus 4.5-5.5 mg/100 g of soil (according to Machigin), exchangeable potassium - 9.8-10.3 mg/100 g of soil (according to Maslova).

The industrial system of agriculture (control) to restore soil fertility provided application 300 kg mineral fertilizers ($N_{92}P_{180}K_{108}$) and 12 tons of organic matter per 1 ha of crop rotation area with intensive application of pesticides. Under the ecological system was applied 24 t of organic matter, consisting of 12 t/ha of manure, 6 t/ha of by-products and 6 t/ha of crop green manure, as well as 150 kg of mineral fertilizers ($N_{46}P_{49}K_{55}$) with standard application of pesticides. Biological system included the use of only natural organic fertilizers 24 t/ha to reproduce soil fertility without the introduction of industrial agrochemicals, as well as biological products to optimize plant nutrition and biological means of crop protection against pests.

The measures of the main tillage were the differentiated tillage (control) provides for one flat-cut loosening under barley, two surface tillage with disc implements for winter wheat (predecessor - peas for grain) and includes six various-deeps of moldboard tillage under other cultures; moldboard-boardless tillage in crop rotation involves deep plowing for sugar beets by 28-30 cm and for other crops - subsurface and surface tillage (for the above field of winter wheat); 3. surface tillage is to carry out disking for all crops by 8-10 cm.

Laboratory tests were carried out on the basis of Ukrainian Laboratory of Quality and safety of Agricultural products National University of Life and Environmental Sciences of Ukraine according to generally accepted current methods and standards. Soil samples were taken in the development phase of winter wheat - exit to the tube and earing. The moisture content in the soil was determined by thermostatic-weight method. Mathematical processing of the obtained experimental data was carried out according to B. Dospekhov (1985).

Results and Discussion

Studies have shown a different effect of different farming systems and measures of basic tillage on the number of microorganisms and individual ecological-trophic and taxonomic groups (Table 1), the analysis of which shows that the phase of exit to the tube under surface tillage is formed more microorganisms of all studied groups than under differentiated and moldboard-boardless tillage. Among agricultural systems, the advantage is ecological one. Our research confirms the opinion of many scientists on the activation of microorganisms under surface treatment of soil (Grodzinsky, 1973; Beresteckiy, 1987; Butenko et al., 2020).

Table 1. The number of major ecological-trophic groups of microorganisms in the winter wheat crops in the tube exit phase, million CFU per of soil.

The system of farming Tillage system of soil	Industrial			Ecological			Biological		
	Differentiated D	Moldboard- boardless tillage, M	Surface tillage, S	D	M	S	D	M	S
Ammoniphic (on MPA)	5.14±0.19	4.03±0.38	5.53±0.33	6.61±0.17	4.58±0.15	7.59±0.46	7.55±0.10	4.14±0.18	6.07±0.49
Amylolytic (on KAA)	3.52±0.16	4.58±0.13	3.04±0.16	6.98±0.29	5.72±0.06	7.59±0.33	4.66±0.26	3.41±0.29	5.81±0.26
Pedotrophic (on PA)	7.22±0.36	5.60±0.67	7.30±0.16	9.93±0.52	9.46±0.13	11.21±0.36	7.74±0.35	6.09±0.18	11.36±0.47
Oligotrophic (on HA)	6.66±0.39	6.07±0.47	5.76±0.26	7.73±0.32	8.65±0.30	10.47±0.51	8.18±0.22	5.46±0.10	9.03±0.10
Nonspore (on IPA with methyl-rot)	4.66±0.11	5.49±0.46	4.77±0.41	6.79±0.33	6.97±0.33	7.14±0.20	5.65±0.22	5.13±0.32	7.77±0.26
Micromycetes (on Chapek)	35.89±4.17	4.42±1.26	45.47±2.64	36.59±0.99	77.00±2.54	69.93±2.56	34.10±2.91	36.67±2.23	65.49±1.70

The biological system of agriculture does not involve the use of chemicals to restore soil fertility, which could adversely affect the number of microorganisms in it. Ecological system involves their use in much smaller quantities, and the industrial system of agriculture due to the influence of mineral fertilizers, herbicides and other plant protection products cannot provide conditions for the maximum number of microorganisms of different ecological-trophic groups. For a more detailed analysis of the processes occurring in the soil, it is necessary to pay attention to the number of non-spore and ammonifying bacteria, pedotrophic myxomycetes. These indicators increased significantly during the earing phase. The ecological system of agriculture provided the best conditions for nitrogen mineralization and the total number of microorganisms.

In the industrial system of agriculture, the total activity is lower compared to the ecological and the salinity ratio is 0.68-1.2. In particular, with surface tillage, the oligotrophic coefficient is 2.27, which indicates the creation of deficient conditions for nutrition crops (Table 2). The coefficient of mineralization in the phase of exit to the tube was the highest in the ecological system of agriculture under the conditions of moldboard-boardless tillage (1.25), and under industrial (1.14), which indicates the intensity of mineralization processes.

Table 2. The ratio of the number of microorganisms of different ecological and trophic groups in crops of winter wheat in the phase of exit into the tube.

The system of farming	Tillage system of soil	Pedotrophic index	Oligotrophic index	Mineralization coefficient immobilization
Industrial (control)	Differentiated (control)	1.40	1.29	0.68
	Moldboard-boardless tillage	1.38	1.5	1.14
	Surface tillage	1.39	2.27	1.12
Ecological	Differentiated (control)	1.50	1.17	1.06
	Moldboard-boardless tillage	2.06	1.88	1.25
	Surface tillage	1.48	1.38	1.00
Biological	Differentiated (control)	1.02	1.08	0.61
	Moldboard-boardless tillage	1.47	1.32	0.82
	Surface tillage	1.87	1.49	0.96

Table 3. The results of the number of the main ecological-trophic groups of microorganisms in winter wheat crops in the earing phase, CFU per of soil.

The system of farming Tillage system of soil	Industrial			Ecological			Biological		
	Differentiated D	Moldboard-boardless tillage M	Surface tillage S	Di	M	S	D	M	S
Ammoniphic (on MPA)	16.72±0.16	13.99±0.19	20.01±0.49	17.59±0.30	14.37±0.13	14.26±0.25	11.56±0.15	8.83±0.17	7.38±0.16
Amylolytic (on KAA)	1.25±0.22	1.49±0.20	1.83±0.09	3.58±0.28	2.38±0.19	2.45±0.10	2.94±0.07	11.66±0.19	2.18±0.06
Pedotrophic (on PA)	13.64±0.42	14.02±0.38	12.36±0.36	12.19±0.69	13.16±0.35	14.54±0.22	10.70±0.49	9.45±0.22	11.41±0.13
Oligotrophic (on HA)	1.43±0.13	1.05±0.04	14.75±0.27	3.54±0.11	14.45±0.46	15.73±0.54	11.79±0.46	7.63±0.35	10.61±0.31
Nonspore (on IPA with methyl-rot)	8.25±0.23	10.72±0.69	11.57±0.36	8.99±0.33	9.20±0.45	12.46±0.50	6.700±0.26	5.16±0.16	7.05±0.35
Micromycetes (on Chapek), thousand CFU per of soil	46.20±1.91	46.87±2.52	35.47±2.27	43.79±4.03	50.23±1.32	49.32±1.57	41.43±4.25	44.33±0.73	64.67±2.02

The biological system has the lowest coefficient of nitrogen mineralization, which indicates its lack in the soil and in general the number of microorganisms was smaller. Thus, we can conclude that the biological system of agriculture uses the natural fertility of the soil. Obviously, the amount of organic fertilizers and post-harvest residues used in the experiment is low and does not provide extended reproduction of soil fertility (Table 3). The coefficient of mineralization in the phase of exit to the

tube was the highest in the ecological system of agriculture under the conditions of moldboard-boardless tillage (1.25), and under industrial (1.14), which indicates the intensity of mineralization processes. The biological system has the lowest coefficient of nitrogen mineralization, which indicates its lack in the soil and in general the number of microorganisms was smaller. Thus, we can conclude that the biological system of agriculture uses the natural fertility of the soil. Obviously, the amount of organic fertilizers and post-harvest residues used in the experiment is low and does not provide extended reproduction of soil fertility (Table 3). During the earing phase, the nature of microbiological activity changed somewhat, but under the biological system the advantage remained relative to the coefficient of mineralization immobilization of nitrogen (1.32) against the background of moldboard-boardless tillage (Table 4).

During the decomposition of plant residues in the soil, as a result of the activity of microorganisms, free organic substances accumulate, which create a certain allopathic potential of the root environment (Iutinskaya, 2006; 2004; Karbivska et al., 2019b; Litvinov et al., 2020). The method of direct biotesting allows to observe the content of physiologically active substances in the soil. We conducted a study of root growth cress-salad (%) under different farming systems and measures of basic tillage in winter wheat crops. The study of the influence of different farming systems and measures of basic tillage showed that in the phase of exit to the tube of winter wheat (Table 5) stimulation of cress-salad`s roots was observed, while in the earing phase it decreases against the background of increasing microorganisms, especially myxomycetes. As can be seen from the table, in winter wheat crops differentiated tillage showed almost the same effect on soil phytotoxicity regardless of the farming system, while under the surface tillage system differed slightly. The largest increase in cress-salad roots was under the ecological system of agriculture.

This is due to the fact that organic matter was in the upper layer of the soil, and a balanced combination of organic matter and mineral fertilizers stimulates the development of soil microflora, as well as reduces the phytotoxicity of the soil

Table 4. The ratio of the number of microorganisms of different ecological-trophic groups in winter wheat crops in the earing phase.

The system of farming	Tillage system of soil	Pedotrophic index	Oligo-trophic index	Mineralization coefficient immobilization
Industrial (control)	Differentiated (control)	0.82	0.08	0.07
	Moldboard-boardless tillage	1.00	0.08	0.11
	Surface tillage	0.62	0.73	0.09
Ecological	Differentiated (control)	0.69	0.20	0.20
	Moldboard-boardless tillage	0.91	1.00	0.17
	Surface tillage	1.02	1.10	0.17
Biological	Differentiated (control)	0.92	1.02	0.25
	Moldboard-boardless tillage	1.07	0.86	1.32
	Surface tillage	1.55	1.44	0.29

Table 5. Phytotoxicity of soil in winter wheat crops (growth of cress-salad`s roots, %).

The system of farming	Tillage system of soil	In the phase of exit into the tube, % to control	In the earing phase, % to control
Industrial (control)	Differentiated (control)	110	104.8
	Moldboard-boardless tillage	113	107.0
	Surface tillage	122	118.1
Ecological	Differentiated (control)	125	114.4
	Moldboard-boardless tillage	125	115.0
	Surface tillage	128	120.0
Biological	Differentiated (control)	114	110.0
	Moldboard-boardless tillage	114	112.0
	Surface tillage	118	112.0

Conclusion

The dynamics of microbiological activity of the soil is an indicator of its fertility and indicates changes in its properties. The biological system of agriculture has the lowest coefficient of nitrogen mineralization, which indicates a decrease in natural soil fertility. Therefore, it is believed that the amount of organic matter that is provided, in this case today, was very small.

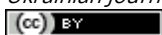
The coefficient of mineralization is the highest under the ecological system of agriculture, under the conditions of moldboard-boardless tillage (1.25), and - industrial (1.14), which indicates the intensity of mineralization processes due to natural fertility. In the industrial system of agriculture the general microbiological activity is lower, in comparison with ecological and the coefficient of mineralization is 0.68-1.2, therefore for effective improvement of soils and reception of ecologically safe production it is necessary to introduce under winter wheat (predecessor peas for grain) ecological system of agriculture using surface tillage as the main.

References

- Aristovskaya T.V. (1980). Microbiology of soil formation processes. Leningrad: Nauka, Leningrad Branch.
- Beresteckiy O.A. (1987). Phytotoxic properties of soil microorganisms. Leningrad.
- Butenko A.O., Masyk I.M., Sobko M.G., Tykhonova O.M. (2020). Formation of soybean crop of different ripeness groups depending on sowing time and row spacing. Irrigated agriculture: interdepartmental thematic scientific collection. Kherson: Helvetica Publishing House, 73, 9-13.
- Butenko A.O., Sobko M.G., Ilchenko V.O., Radchenko M.V., Hlupak Z.I., Danylchenko L.M., Tykhonova O.M. (2019). Agrobiological and ecological bases of productivity increase and genetic potential implementation of new buckwheat cultivars in the conditions of the Northeastern Forest-Steppe of Ukraine. *Ukrainian Journal of Ecology*, 9 (1), 162-168.
- Didur I.M., Tsyhanskyi V.I., Tsyhanska O.I., Malynka L.V., Butenko A.O., Klochkova T.I. (2019). The effect of fertilizer system on soybean productivity in the conditions of right bank forest-steppe. *Ukrainian Journal of Ecology*, 9 (1), 76-80.
- Dospekhov B.A. (1985). The methodology of field experiment (with the basics of statistical processing of research results). - 5th revised and enlarged edition. Moscow. Agropromizdat.
- Grodzinsky A.M. (1973). Fundamentals of chemical interaction of plants. Kyiv. Naukova Dumka.
- Iutinskaya G.O. (2006). Soil microbiology: Textbook. Kyiv. Aristei.
- Karivska U., Kurgak V., Gamayunova V., Butenko A., Malynka L., Kovalenko I., Onychko V., Masyk I., Chyrva A., Zakharchenko E., Tkachenko O., Pshychenko O. (2020). Productivity and quality of diverse ripe pasture grass fodder depends on the method of soil cultivation. *Acta Agrobotanica*, 73(3), 1-11.
- Karivska U.M., Butenko A.O., Onychko V.I., Masyk I.M., Hlupak Z.I., Danylchenko O.M., Klochkova T.I., Ihnatieva O.L. (2019a). Effect of the cultivation of legumes on the dynamics of sod-podzolic soil fertility rate. *Ukrainian Journal of Ecology*, 9(3), 8-12.
- Karivska U.M., Butenko A.O., Masyk I.M., Kozhushko N.S., Dubovyk V.I., Kriuchko L.V., Onopriienko V.P., Onopriienko I.M., Khomenko L.M. (2019b). Influence of Agrotechnical Measures on the Quality of Feed of Legume-Grass Mixtures. *Ukrainian Journal of Ecology*, 9(4), 547-551.
- Karpenko O.Yu., Rozhko V.M. (2015). Influence of precursors on soil phytotoxicity in corn crops. Scientific reports of NULES, 4(53). Available from: http://irbis-nbu.gov.ua/cgi-bin/irbis_nbu/cgiirbis_64.exe?C21COM=2&I21DBN=UJRN&P21DBN=UJRN&IMAGE_FILE_DOWNLOAD=1&Image_file_name=PDF/Nd_2015_4_15.pdf
- Karpenko O.Yu., Rozhko V.M., Butenko A.O., Masyk I.M., Malynka L.V., Didur I.M., Vereshchahin I.V., Chyrva A.S., Berdin S.I. (2019). Post-harvest siderates impact on the weed littering of maize, 9(3), 300-303.
- Kolisnyk O.M., Butenko A.O., Malynka L.V., Masik I.M., Onychko V.I., Onychko T.O., Kriuchko L.V., Kobzhev O.M. (2019). Adaptive properties of maize forms for improvement in the ecological status of fields. *Ukrainian Journal of Ecology*, 2019, 9(2), 33-37.
- Litvinov D., Litvinova O., Borys N., Butenko A., Masyk I., Onychko V., Khomenko L., Terokhina N., Kharchenko S. (2020). The Typicality of Hydrothermal Conditions of the Forest Steppe and Their Influence on the Productivity of Crops. *Journal of Environmental Research, Engineering and Management*, 76(3), 84-95.
- Litvinov D.V., Butenko A.O., Onychko V.I., Onychko T.O., Malynka L.V., Masyk I.M., Bondarieva L.M., Ihnatieva O.L. (2019). Parameters of biological circulation of phytomass and nutritional elements in crop rotations. *Ukrainian Journal of Ecology*, 9(3), 92-98.
- Mischenko Yu.G., Masik I.M. (2017). Control of soil weediness and sugar beets by after crop green manure and different tillages. *Ukrainian Journal of Ecology*, 7(4), 517-524.
- Mishchenko Yu.G., Zakharchenko E.A., Berdin S.I., Kharchenko O.V., Ermantraut E.R., Masyk I.M., Tokman V.S. (2019). Herbological monitoring of efficiency of tillage practice and green manure in potato agrocenosis. *Ukrainian Journal of Ecology*, 9(1), 210-219.
- Pyrog T.P. (2004). General microbiology. Kyiv. NUHT.
- Radchenko M.V., Butenko A.O., Glupak Z.I. (2018). Effect of fertilizer system and efficiency of growth regulator on buckwheat productivity in the conditions of the northeastern forest-steppe of Ukraine. *Ukrainian Journal of Ecology*, 8(2), 89-94.
- Tsyhanskyi V.I., Didur I.M., Tsyhanska O.I., Malynka L.V., Butenko A.O., Masik I.M., Klochkova T.I. (2019). Effect of the cultivation technology elements on the activation of plant microbe symbiosis and the nitrogen transformation processes in alfalfa agrocoenoses. *Modern Phytomorphology* 13, 30-34.
- Vekirchik K.M. (2001). Workshop on microbiology. Kyiv. Lybid.
- Zvyagintsev D.G. (1987). Soil and microorganisms. Moscow. Moscow Publishing House. University.

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